RX Family

HOCO Calibration Using the CAC

Introduction

This application note describes the way of adjusting the frequency of the high-speed on-chip oscillator (HOCO) using the clock frequency accuracy measurement circuit (CAC) on the RX Family.

Target Device

- RX13T Group
- RX140 Group
- RX231 Group
- RX671 Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to match the specifications of the alternative MCU.

Contents

1. Specifications

The HOCO oscillation frequency may deviate from the factory-configured frequency due to external factors such as ambient temperature. Calibration needs to be performed to compensate for the frequency error. The high-speed on-chip oscillator trimming register (HOCOTRRn, n = 0 to 3) is used to adjust the HOCO oscillation frequency. The HOCO frequency error can be compensated for by adjusting the value of the HOCOTRRn register at regular intervals.

The sample program described in this application note uses the CAC and the compare match interrupt occurred from compare match timer to measure the HOCO oscillation frequency and adjusts the value of the HOCOTRRn register based on the results obtained. It also outputs a clock equivalent to HOCO divided by 4 on the MTIOC0B pin.

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

The external clock shown in the block diagram is used as a measurement reference clock, and it affects the calibration accuracy. Therefore, a signal generator that is as accurate as possible should be used to produce the external clock. For example, when using a signal generator with absolutely no error for the measurement reference clock, the error in the HOCO frequency after calibration would be within ±0.1% (the default setting in the sample code).

If the error of the signal generator is large, the calibration error is even larger, so select a signal generator such that the error is within the acceptable range in the actual usage environment.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
CAC	Measures the HOCO frequency based on the CACREF pin input.
CMT	Starts HOCO measurement when a compare match interrupt occurs.
MTU	Outputs a clock equivalent to HOCO divided by 4.

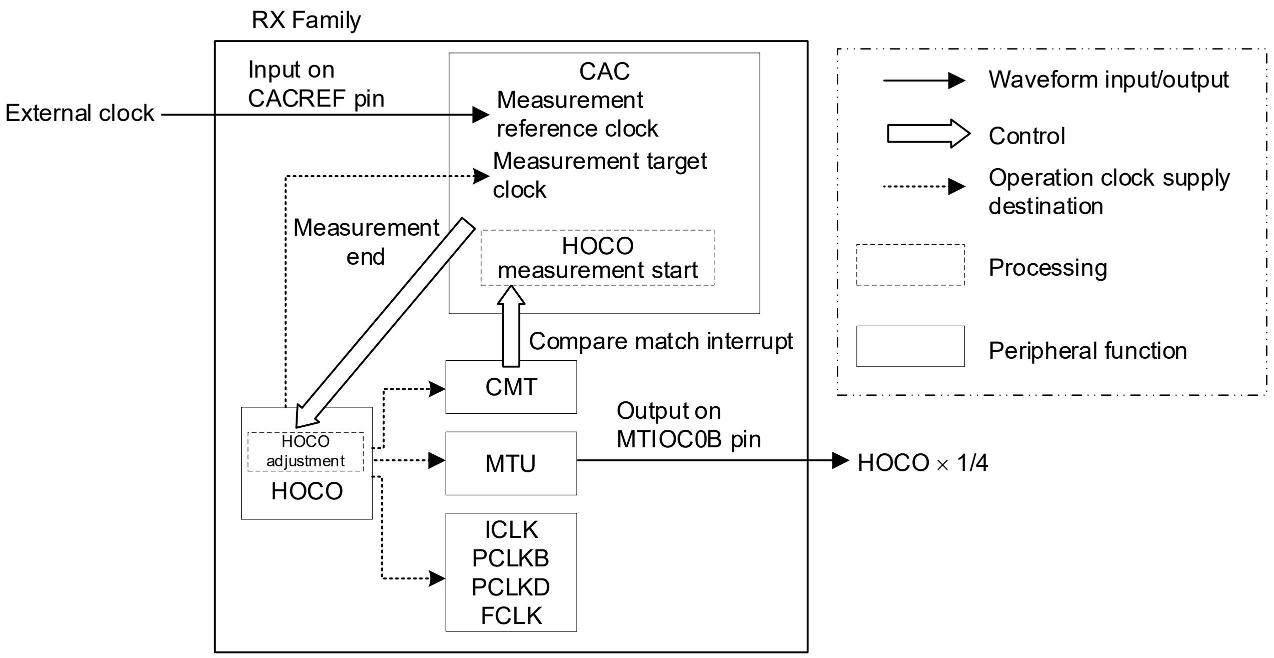


Figure 1.1 Block Diagram

2. Operation Confirmation Environment

Sections 2.1 through 2.4 summarizes the conditions under which the operation of the sample code referenced in this application note has been confirmed.

2.1 RX13T

Table 2.1 Operation Confirmation Conditions for RX13T

Item	Description
MCU used	R5F513T5ADFL (RX13T Group)
Operating frequency	HOCO: 32MHz System clock (ICLK): 32 MHz (HOCO x 1/1) Peripheral module clock B (PCLKB): 32 MHz (HOCO x 1/1) Peripheral module clock D (PCLKD): 32 MHz (HOCO x 1/1) FlashIF clock (FCLK): 32 MHz (HOCO x 1/1)
Operating voltage	5.0V
Integrated development environment	Renesas Electronics e² studio 2022-04
C compiler	Renesas Electronics C/C++ Compiler for RX Family V.3.04.00
	Compiler option Default settings of integrated development environment
iodefine.h version	Version 1.00A
Endian order	Little endian or big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.10
Board used	RX13T CPU card (product number: RTK0EMXA10CxxxxxBJ)
Function generator	Use a signal generator equipped with analog signal output pins and capable of outputting rectangular waves at a frequency accuracy of 2 ppm (±0.0002%, at 18°C to 28°C). The output signal should have a bias of 2.5 V relative to GND. Output a 32 Hz rectangular wave with an amplitude setting of 5.0 Vpp. Figure 2.1 shows the output waveform.

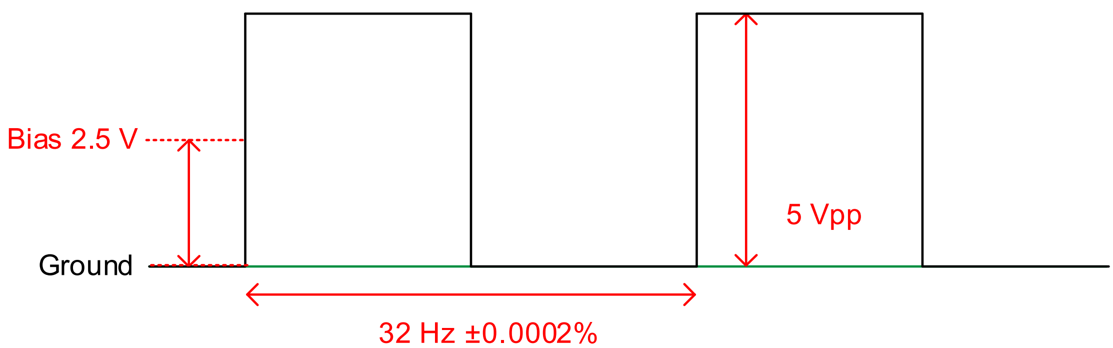
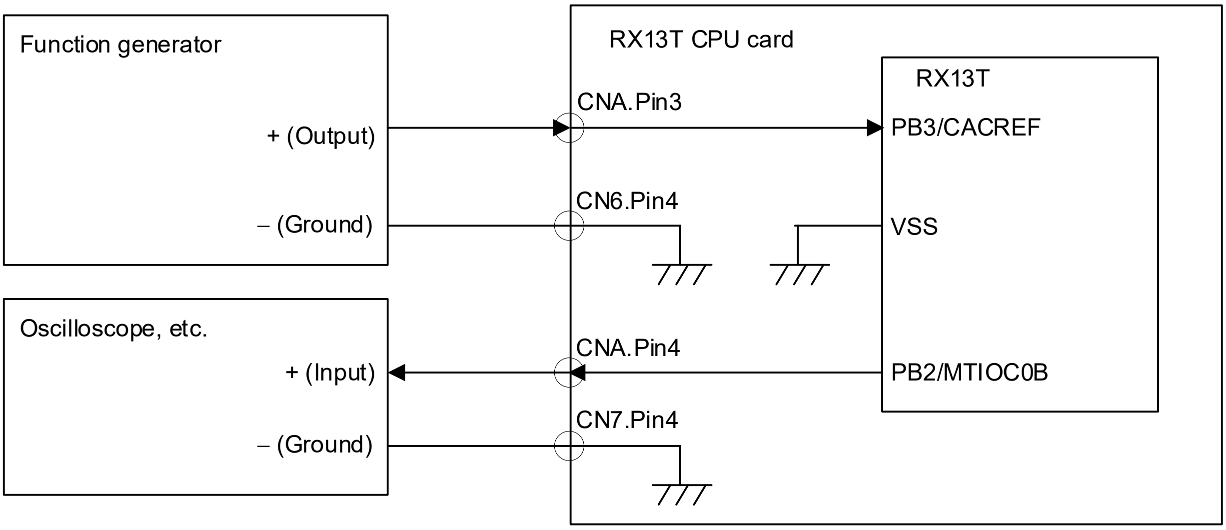


Figure 2.1 Function Generator Output Waveform



The arrows in the figure indicate input/output directions.

Figure 2.2 Pin Connections for RX13T

Table 2.2 Pins Used for RX13T and Their Functions

Pin Name	I/O	Description
PB3/CACREF	Input	Measurement reference clock input
PB2/MTIOC0B	Output	Outputs a clock equivalent to HOCO divided by 4.

2.2 RX140

Table 2.3 Operation Confirmation Conditions for RX140

Item	Description
MCU used	R5F51403ADFM (RX140 Group)
Operating frequency	HOCO: 48 MHz System clock (ICLK): 48 MHz (HOCO x 1/1) Peripheral module clock B (PCLKB): 24 MHz (HOCO x 1/2) Peripheral module clock D (PCLKD): 48 MHz (HOCO x 1/1) FlashIF clock (FCLK): 48 MHz (HOCO x 1/1)
Operating voltage	3.3V
Integrated development environment	Renesas Electronics e2 studio 2022-04
C compiler	Renesas Electronics C/C++ Compiler for RX Family V.3.04.00
	Compiler option Default settings of integrated development environment
iodefine.h version	Version 1.10A
Endian order	Little endian or big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.10
Board used	Target Board for RX140 (Part number: RTK5RX1400CxxxxxBJ)
Function generator	Use a signal generator equipped with analog signal output pins and capable of outputting rectangular waves at a frequency accuracy of 2 ppm (±0.0002%, at 18°C to 28°C). The output signal should have a bias of 1.65 V relative to GND. Output a 32 Hz rectangular wave with an amplitude setting of 3.3 Vpp. Figure 2.3 shows the output waveform.

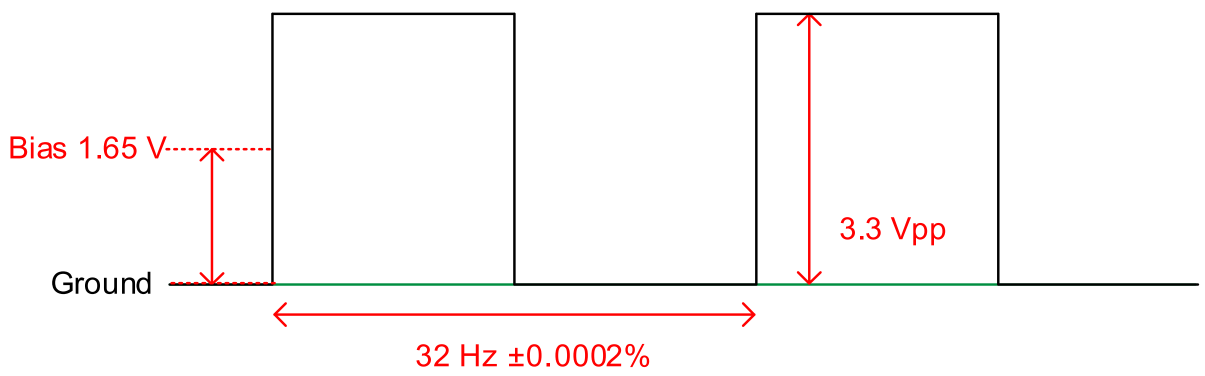
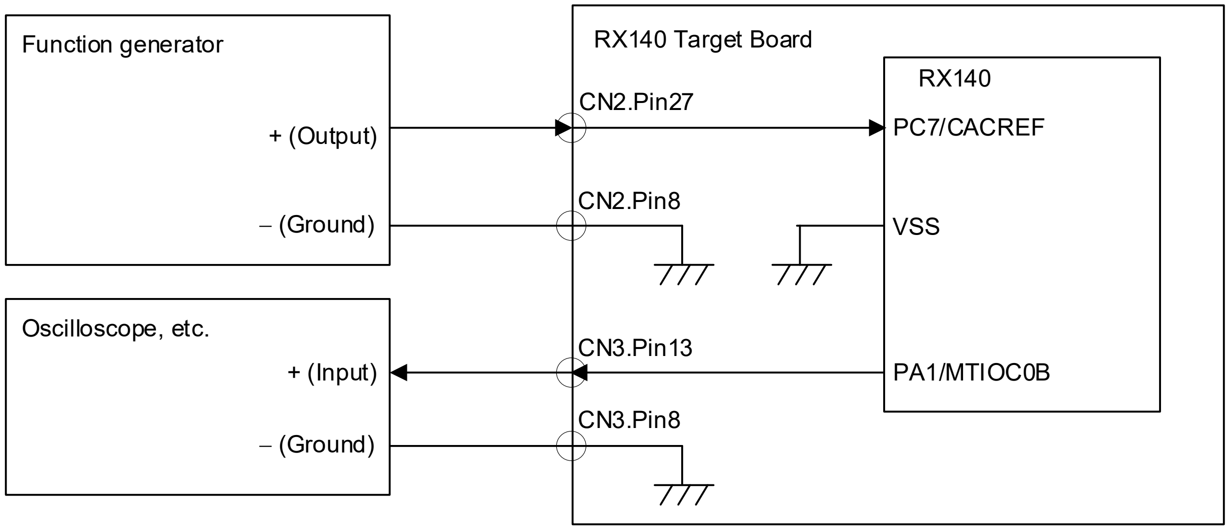


Figure 2.3 Function Generator Output Waveform



The arrows in the figure indicate input/output directions.

Figure 2.4 Pin Connections for RX140

Table 2.4 Pins Used for RX140 and Their Functions

Pin Name	I/O	Description
PC7/CACREF	Input	Measurement reference clock input
PA1/MTIOC0B	Output	Outputs a clock equivalent to HOCO divided by 4.

2.3 RX231

Table 2.5 Operation Confirmation Conditions for RX231

Item	Description
MCU used	R5F52318ADFP (RX231 Group)
Operating frequency	HOCO: 54MHz System clock (ICLK): 54 MHz (HOCO x 1/1) Peripheral module clock A (PCLKA): 54 MHz (HOCO x 1/1) Peripheral module clock B (PCLKB): 27MHz (HOCO x 1/2) Peripheral module clock D (PCLKD): 27MHz (HOCO x 1/2) FlashIF clock (FCLK): 27MHz (HOCO x 1/2)
Operating voltage	3.3V
Integrated development environment	Renesas Electronics e2 studio 2022-04
C compiler	Renesas Electronics C/C++ Compiler for RX Family V.3.04.00
	Compiler option Default settings of integrated development environment
iodefine.h version	Version 1.00I
Endian order	Little endian or big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.10
Board used	Target Board for RX231 (Part number: RTK5RX2310CxxxxxBR)
Function generator	Use a signal generator equipped with analog signal output pins and capable of outputting rectangular waves at a frequency accuracy of 2 ppm (±0.0002%, at 18°C to 28°C). The output signal should have a bias of 1.65 V relative to GND. Output a 32 Hz rectangular wave with an amplitude setting of 3.3 Vpp. Figure 2.5 shows the output waveform.

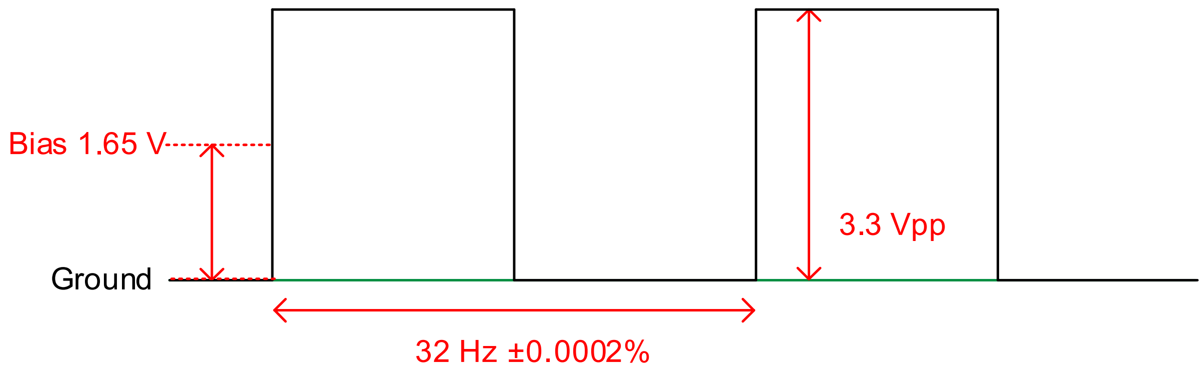
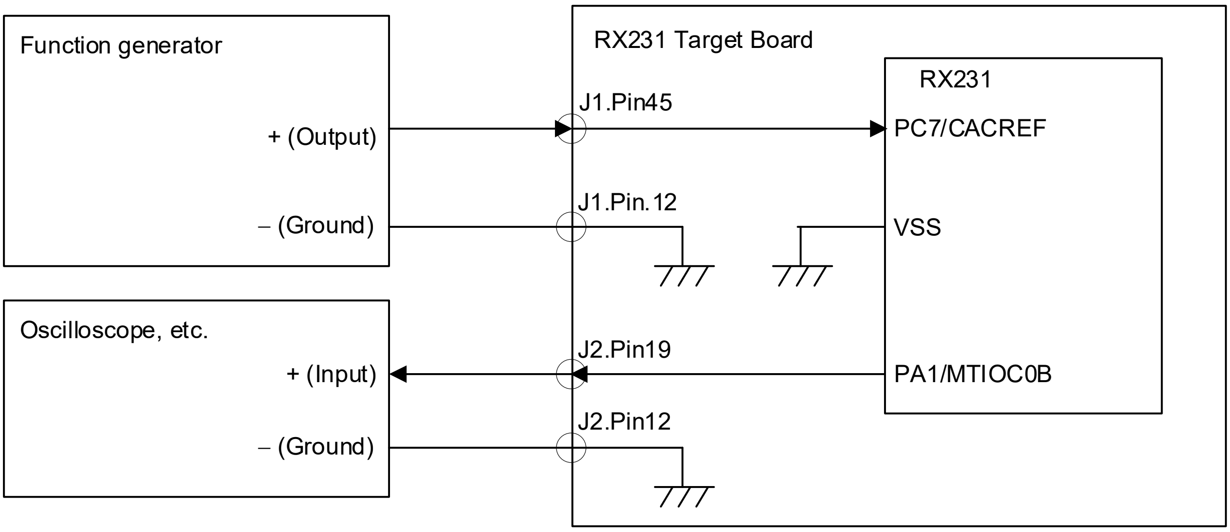


Figure 2.5 Function Generator Output Waveform



The arrows in the figure indicate input/output directions.

Figure 2.6 Pin Connections for RX231

Table 2.6 Pins Used for RX231 and Their Functions

Pin Name	I/O	Description
PC7/CACREF	Input	Measurement reference clock input
PA1/MTIOC0B	Output	Outputs a clock equivalent to HOCO divided by 4.

2.4 RX671

Table 2.7 Operation Confirmation Conditions for RX671

Item	Description
MCU used	R5F5671EHAFP (RX671 Group)
Operating frequency	HOCO: 16MHz PLL: 240MHz (HOCO x 15) System clock (ICLK): 120 MHz (PLL x 1/2) Peripheral module clock A (PCLKA): 120 MHz (PLL x 1/2) Peripheral module clock B (PCLKB): 60 MHz (PLL x 1/4) Peripheral module clock C (PCLKC): 60 MHz (PLL x 1/4) Peripheral module clock D (PCLKD): 60 MHz (PLL x 1/4) FlashIF clock (FCLK): 60MHz (PLL x 1/4)
Operating voltage	3.3V
Integrated development environment	Renesas Electronics e2 studio 2022-04
C compiler	Renesas Electronics C/C++ Compiler for RX Family V.3.04.00
	Compiler option Default settings of integrated development environment
iodefine.h version	Version 1.00
Endian order	Little endian or big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.10
Board used	Target Board for RX671 (Part number: RTK5RX6710CxxxxxBJ)
Function generator	Use a signal generator equipped with analog signal output pins and capable of outputting rectangular waves at a frequency accuracy of 2 ppm (±0.0002%, at 18°C to 28°C). The output signal should have a bias of 1.65 V relative to GND. Output a 32 Hz rectangular wave with an amplitude setting of 3.3 Vpp. Figure 2.7 shows the output waveform.

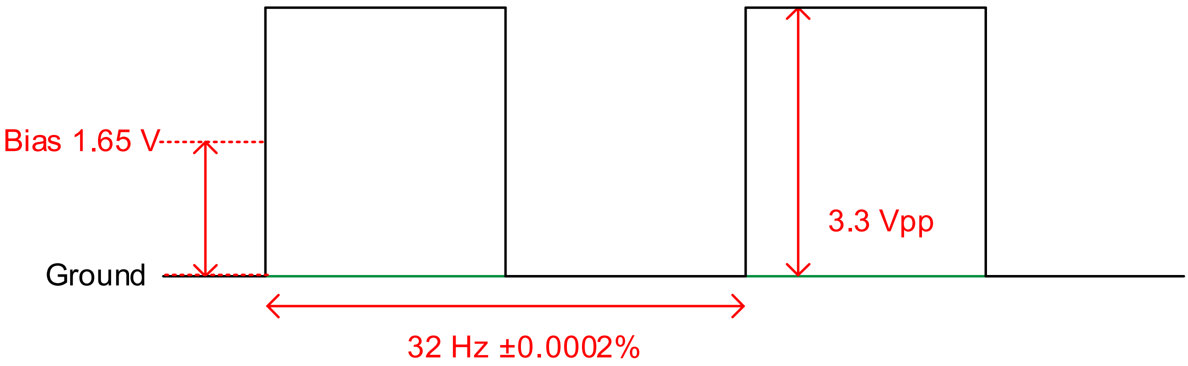
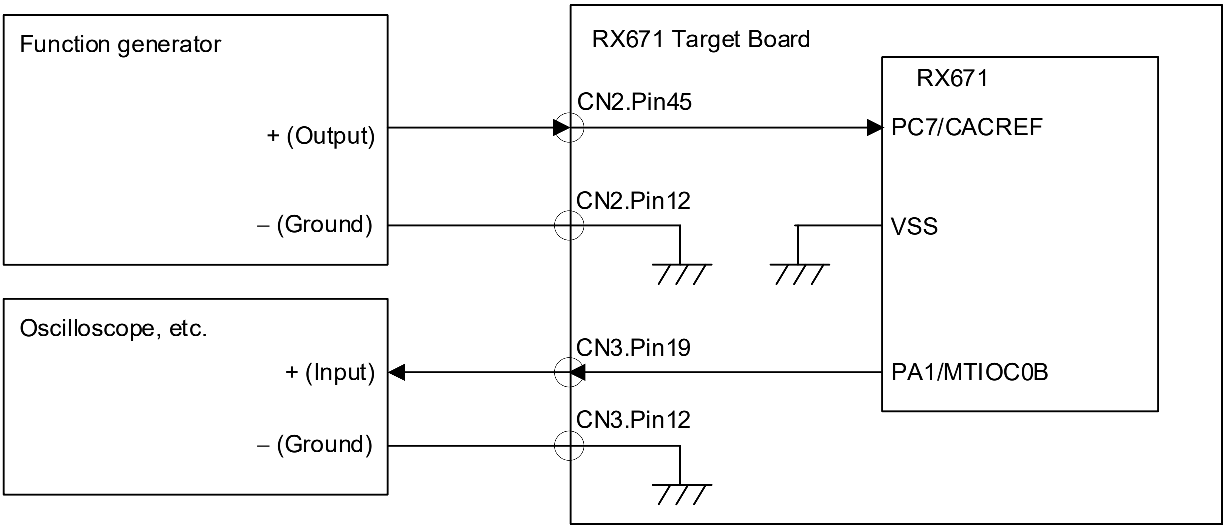


Figure 2.7 Function Generator Output Waveform



The arrows in the figure indicate input/output directions.

Figure 2.8 Pin Connections for RX671

Table 2.8 Pins Used for RX671 and Their Functions

Pin Name	I/O	Description
PC7/CACREF	Input	Measurement reference clock input
PA1/MTIOC0B	Output	Outputs a clock equivalent to HOCO divided by 4.

3. Software Modules Used

Figure 3.1 shows the Structure of Sample Code, and Table 3.1 lists the Software Modules Used. For the settings of the software modules used in the sample code, see 7.2 Software Module Settings.

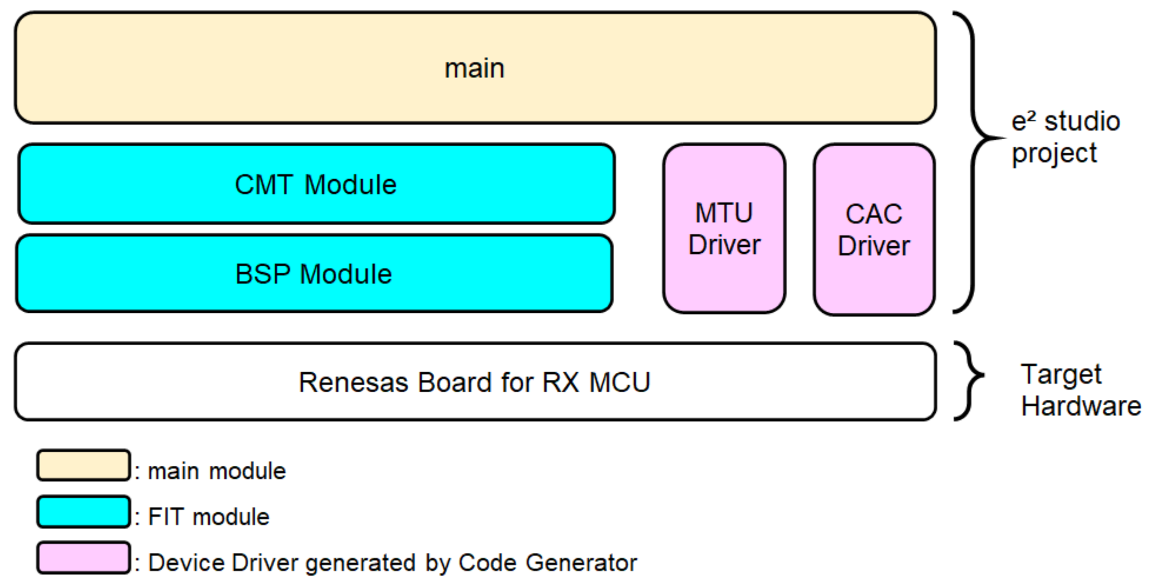


Figure 3.1 Structure of Sample Code

Table 3.1 Software Modules Used

Module	Document Title	Document No.	Type
main	-	-	Module containing the main function developed for this program described in this application note
r_bsp	RX Family Board Support Package Module Using Firmware Integration Technology	R01AN1685	FIT module
Config_CAC	Smart Configurator User's Manual: RX API Reference	R20UT4360	Code generator
Config_MTU	Smart Configurator User's Manual: RX API Reference	R20UT4360	Code generator
r_cmt_rx	RX Family CMT Module Using Firmware Integration Technology	R01AN1856	FIT module

4. Project Composition

4.1 shows the Project Composition.

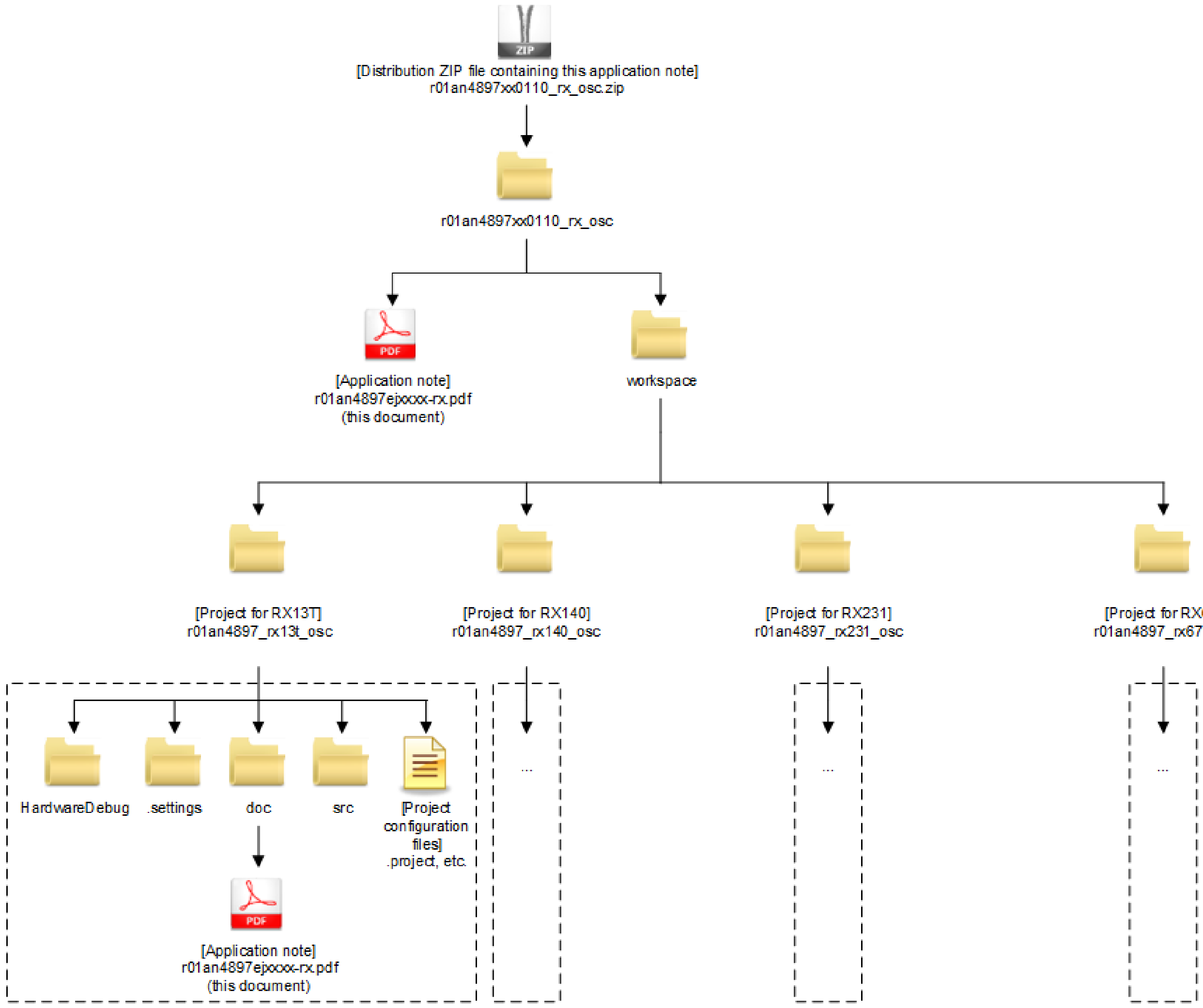


Figure 4.1 Project Composition

Unzipping the ZIP archive in which this application note is distributed creates a folder of the same name that contains the folders and files shown above.

The “r01an4897_rx_osc” folder contains separate folders for each target device. Each project can be imported into the e^2 studio workspace and then run.

5. Software

5.1 Operation Overview

In this chapter, RX13T is used as an example.

This sample program measures the frequency of the clock generated by the MCU relative to the measurement reference clock provided from outside the MCU, and adjusts it to reduce the frequency deviation. (See Figure 1.1.)

- Measurement reference clock:
  A function generator set to output a 32 Hz rectangular wave is used (see Figure 2.1).
- Measurement target clock:
  A HOCO (32 MHz) divided by 32 is used.
- CAC:
  Counts valid edges of the measurement target clock in the period from a rising edge to the next rising edge of the measurement reference clock.

Measurement starts when a compare match interrupt is occurred from the compare match timer (CMT) and is performed five times in succession. Of the five measurements, the second to the fifth are averaged and used as the measurement result, and then the calibration state transitions. Table 5.1 lists the States of Calibration, and Figure 5.1 shows the Calibration State Transitions.

Table 5.1 States of Calibration

Calibration State Name	Description
CALIBRATION_STANDBY	Waiting for calibration
CALIBRATION_START	Calibration started
CALIBRATION_RESULT_ABOVE	Adjusting the frequency lower
CALIBRATION_RESULT_BELOW	Adjusting the frequency higher
CALIBRATION_WITHIN_RANGE	Calibration stabilized

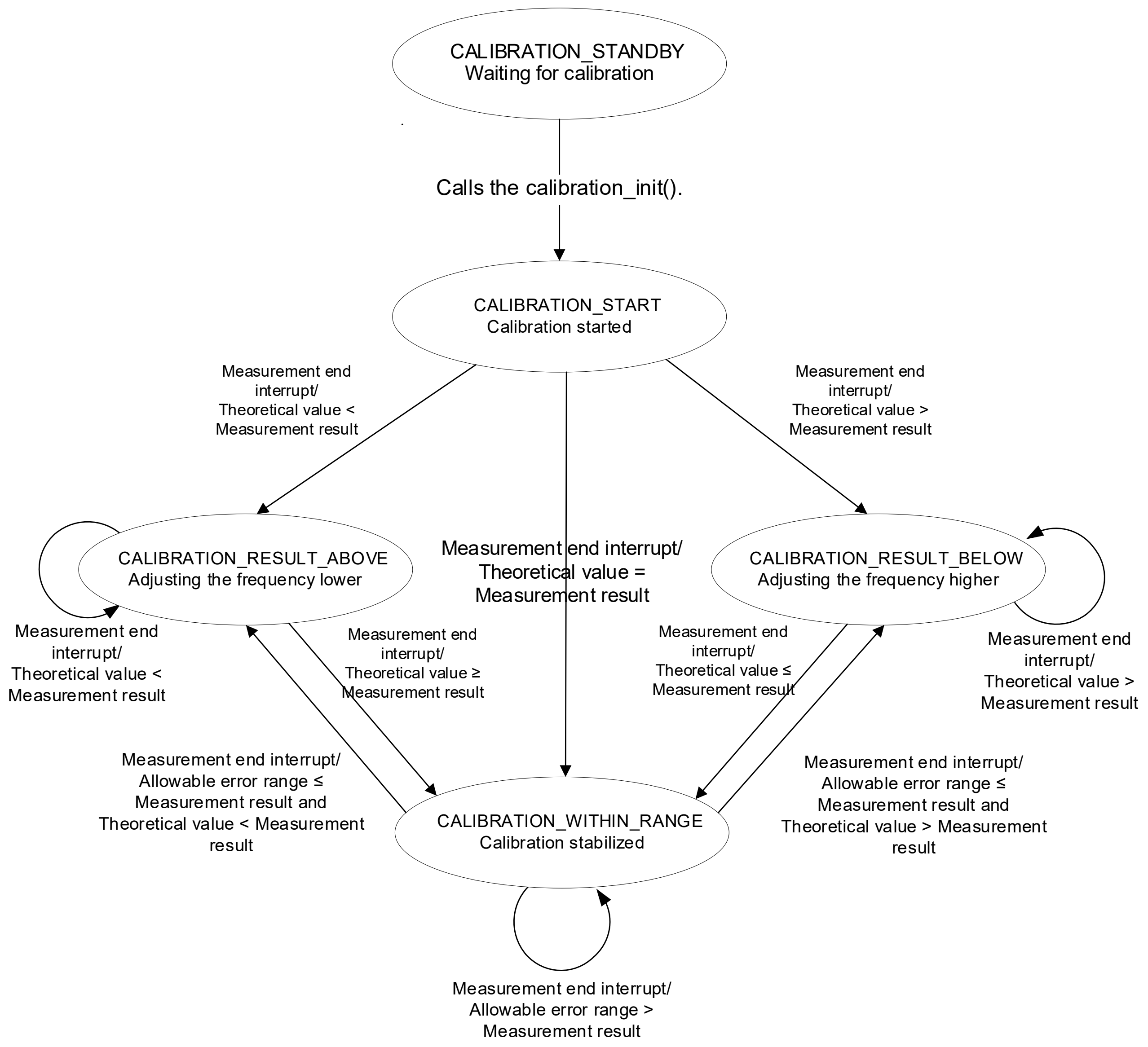


Figure 5.1 Calibration State Transitions

After the calibration state transition, the value of the HOCOTRRn register is added or subtracted depending on the difference from the theoretical value and the calibration state. Table 5.2 lists the Register Value Adjustment Patterns, Figure 5.2 and Figure 5.3 show calibration examples, and Figure 5.4 shows the Timing Diagram of Calibration.

Table 5.2 Register Value Adjustment Patterns

Pattern	Calibration State	Condition	Adjustment Value
1	CALIBRATION_RESULT_ABOVE	X ＜ (Z＋M)	－1
2		X ≧ (Z＋M)	－5
3	CALIBRATION_RESULT_BELOW	X ＞ (Z－M)	＋1
4		X ≦ (Z－M)	＋5
5	CALIBRATION_WITHIN_RANGE	(Z＋M) > X > (Z＋L)	－1
6		X ≧ (Z＋M)	－5
7		(Z－M) ≦ X < (Z－L)	＋1
8		X ＜ (Z－M)	＋5
9		(Z－L) ≦ X ≦ (Z＋L)	0

X: Measurement result, Z: Theoretical value*1, L: Allowable error range*2,
M: Reference value for determining the amount of change*3

Notes: 1. The following formula is used to calculate the theoretical value:
Theoretical value (Z) = measurement target clock frequency ÷ measurement reference clock frequency (Digits after the decimal point are discarded.)
2. The following formula is used to calculate the allowable range:
Allowable range (L) = Z x ACCEPTABLE_PERCENT / 10000 (Digits after the decimal point are discarded.)
3. The following formula is used to calculate the amount of change:
Reference value for determining the amount of change (M) = Z x 0.003 (Digits after the decimal point are discarded.)

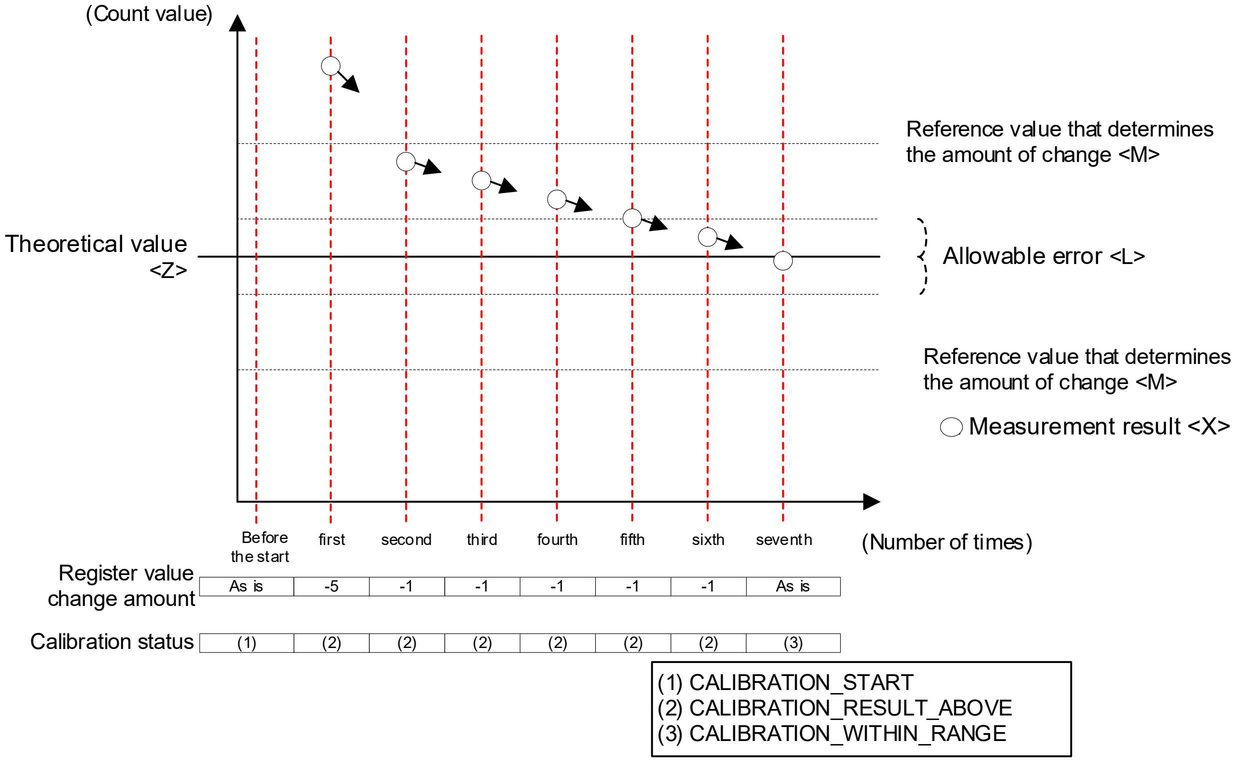


Figure 5.2 Example of Calibrating a HOCO Frequency Greater than the Theoretical Value

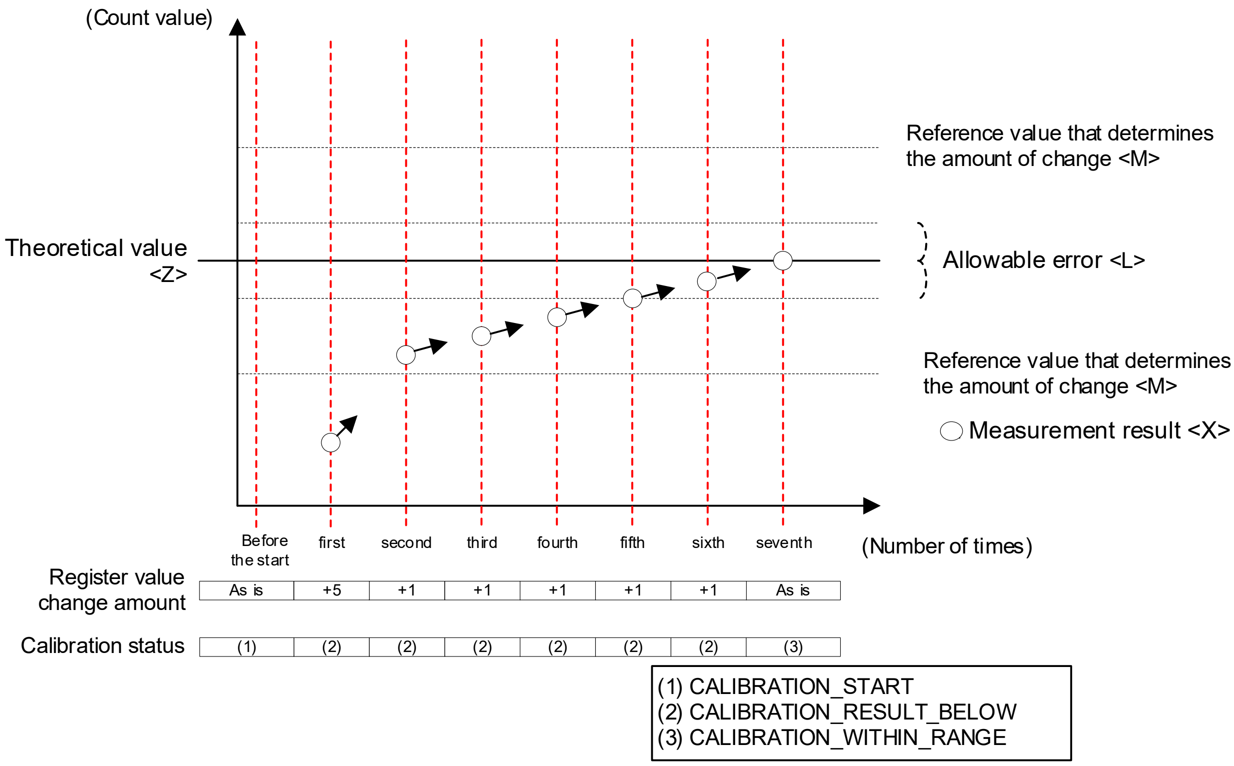


Figure 5.3 Example of Calibrating a HOCO Frequency Smaller Than the Theoretical Value

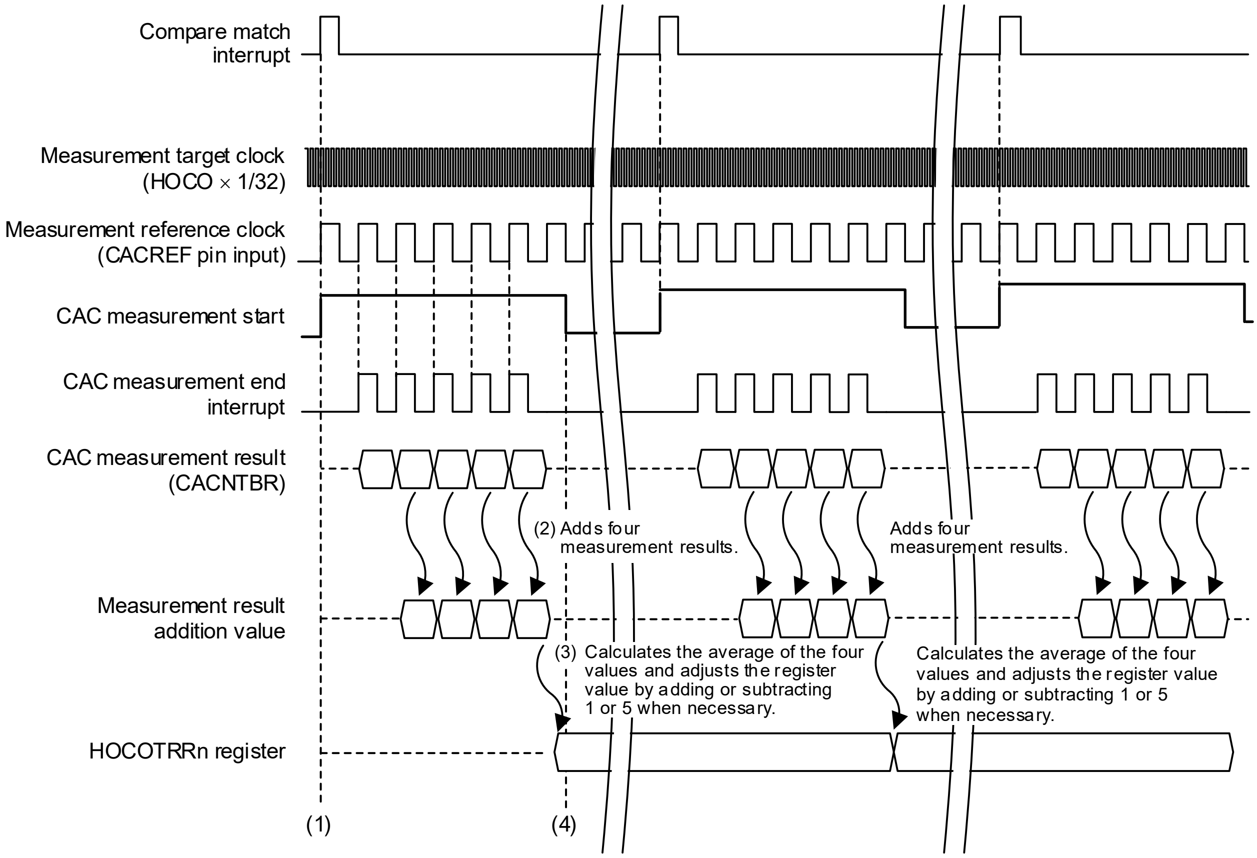


Figure 5.4 Timing Diagram of Calibration

(1) When a compare match interrupt is occurred from CMT, CAC startup settings are made and measurement starts.

(2) Valid edges of the measurement target clock are counted in the period from a rising edge to the next rising edge of the measurement reference clock. When an interrupt is occurred at measurement end, the measurement results are obtained. The measurement results consist of a set of five measurements.

(3) The second to the fifth of the five measurements in the set are averaged. Based on this value and the calibration state, adjust the value of the HOCOTRRn register.

(4) When adjustment of the HOCO oscillation frequency ends, CAC measurement stops. The HOCO clock is supplied as ICLK, etc., to the CPU and peripheral functions until the next CMT compare match interrupt occurs.

5.2 File Composition

Table 5.3 lists the source files created for this application note.

Table 5.3 Files Used in the Sample Code

File Name	Outline	Remarks
main.c	Main processing	
r_calibration_api.c	Calibration settings and CAC measurement end interrupt handling	
r_calibration_api.h	Header file for r_calibration_api.c	

5.3 Constants

Table 5.4 and Table 5.5 list the constants used in the source files created for this application note.

Table 5.4 Constants (User Changeable) Used by Sample Code

Constant Name	Setting Value	Description
REG_HOCOTRR	SYSTEM.HOCOTRR0.BIT.HOCOTRD[*1] SYSTEM.HOCOTRR3.BIT.HOCOTRD[*2]	The HOCOTRRn register corresponding to the HOCO being operated.
ACCEPTABLE_PERCENT	10	Allowable range percentage (in 0.01% increments) relative to the measurement result. A setting of 10 corresponds to an allowable range of 0.1%. If this setting is changed, use a setting value of 5 (0.05%) or greater.
CHECK_CNT	4	Number of times the measurement results are added.

Notes 1. This value is set in the sample codes for RX13T, RX140, and RX671.

2. This value is set in the sample code for RX231.

Table 5.5 Constants (Non-User Changeable) Used by Sample Code

Constant Name	Setting Value	Description
REG_HOCOTRR_MIN	0x00000000	Minimum value that can be set in the HOCOTRRn register
REG_HOCOTRR_MAX	0x000001FF*1 0x0000003F*2	Maximum value that can be set in the HOCOTRRn register
HOCOTRR_CHANGE_AFTER_WAIT_US	65	Wait time after the HOCOTRRn register is changed*3
CALIBRATION_STANDBY	0	Waiting for calibration
CALIBRATION_START	1	Calibration started
CALIBRATION_RESULT_ABOVE	2	Adjusting the frequency lower
CALIBRATION_RESULT_BELOW	3	Adjusting the frequency higher
CALIBRATION_WITHIN_RANGE	4	Calibration stabilized
ACCEPTABLE_OVER_PERCENT	30	Percentage of the reference value for determining the amount of change to be made to the measurement result (in 0.01% increments)
CMT_INTERRUPT_PERIOD_HZ	2*1 1*2	CMT compare match interrupt periodically.
MEND_FINISH	0	Frequency measurement is stopped
MEND_START	1	Frequency measurement is started
MEND_CHECK_FINISH	(CHECK_CNT + 1)	Frequency measurement is completed

Notes 1. This value is set in the sample code for RX671.
2. This value is set in the sample codes for RX13T, RX140, and RX231.
3. This is defined only for the RX671 project.

5.4 Variables

Table 5.6 list the Global Variables used in the source files created for this application note.

Table 5.6 Global Variables

Type	Variable Name	Description	Used by Function
static uint8_t	s_buffer_counter	Frequency measurement counter	calibration_init cac_mendf_cb
static uint32_t	s_result_buffer	Storage buffer for frequency measurement results	calibration_init cac_mendf_cb
static int32_t	s_result_diff	Storage buffer for result	calibration_init cac_mendf_cb
static uint32_t	s_acceptable_range	Allowable error range of the measurement results	calibration_init cac_mendf_cb
static uint32_t	s_reference_value	Reference value for determining the amount of change in the HOCOTRRn register.	calibration_init cac_mendf_cb
static uint8_t	s_freq_calibration_status	Calibration State	calibration_init cac_mendf_cb

5.5 Functions

Table 5.7 list the Functions used in the source files created for this application note.

Table 5.7 Functions

Function Name	Outline
main	Main processing
cmt_event_cb	CMT compare match interrupt handling
calibration_init	Calibration settings
cac_mendf_cb	CAC measurement end interrupt handling

5.6 Function Specifications

The following tables list the sample code function specifications.

main	
Outline	Main processing
Header	None
Declaration	void main (void)
Description	Calls the CMT settings and MTU settings.
Arguments	None
Return Value	None

cmt_event_cb	
Outline	CMT compare match interrupt handling
Header	None
Declaration	static void cmt_event_cb(void)
Description	Periodically calls the calibration_init function when the CMT compare match interrupt occurs.
Arguments	None
Return Value	None

calibration_init	
Outline	Initial calibration settings
Header	r_calibration_api.h
Declaration	void calibration_init(void)
Description	Makes CAC settings and calibration settings. This function is periodically called by cmt_event_cb.
Arguments	None
Return Value	None

cac_mendf_cb	
Outline	CAC measurement end interrupt handling
Header	r_calibration_api.h
Declaration	void cac_mendf_cb(void)
Description	Adjusts HOCO frequencies based on the measurement results.
Arguments	None
Return Value	None

5.7 Flowcharts

5.7.1 Main Processing

Figure 5.5 is a flowchart of the Main Processing.

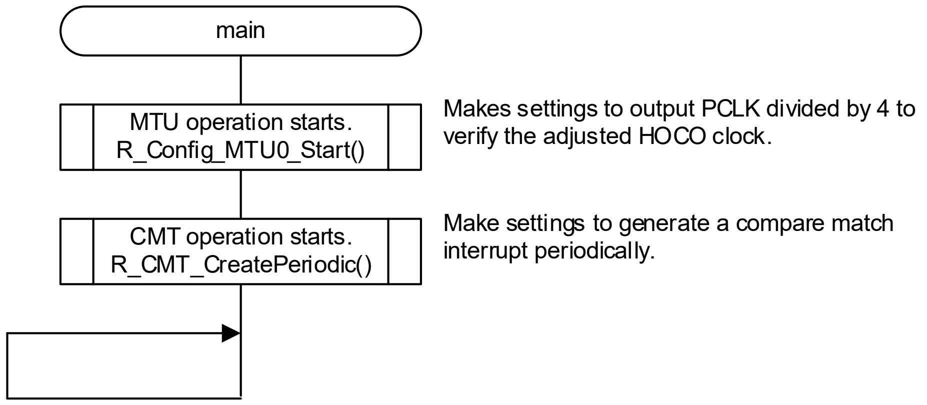


Figure 5.5 Main Processing

5.7.2 CMT Compare Match Interrupt

Figure 5.6 is a flowchart of the CMT Compare Match Interrupt Handling.

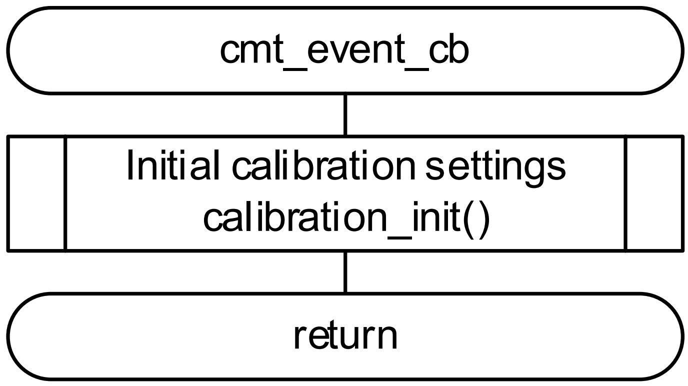


Figure 5.6 CMT Compare Match Interrupt Handling

5.7.3 Calibration Settings

Figure 5.7 is a flowchart of the Calibration Settings.

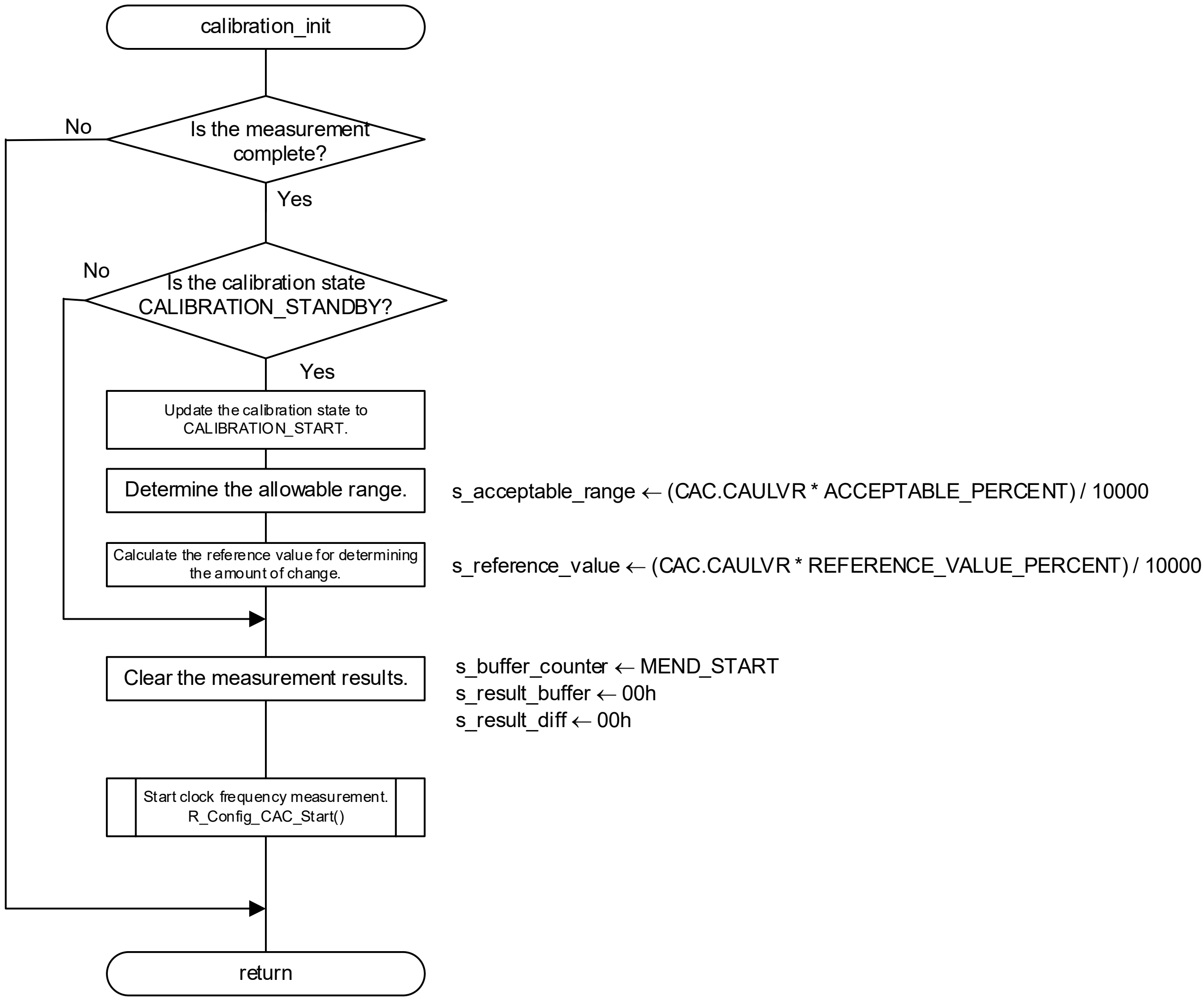


Figure 5.7 Calibration Settings

5.7.4 CAC Measurement End Interrupt

Figure 5.8 is a flowchart of the CAC Measurement End Interrupt Handling.

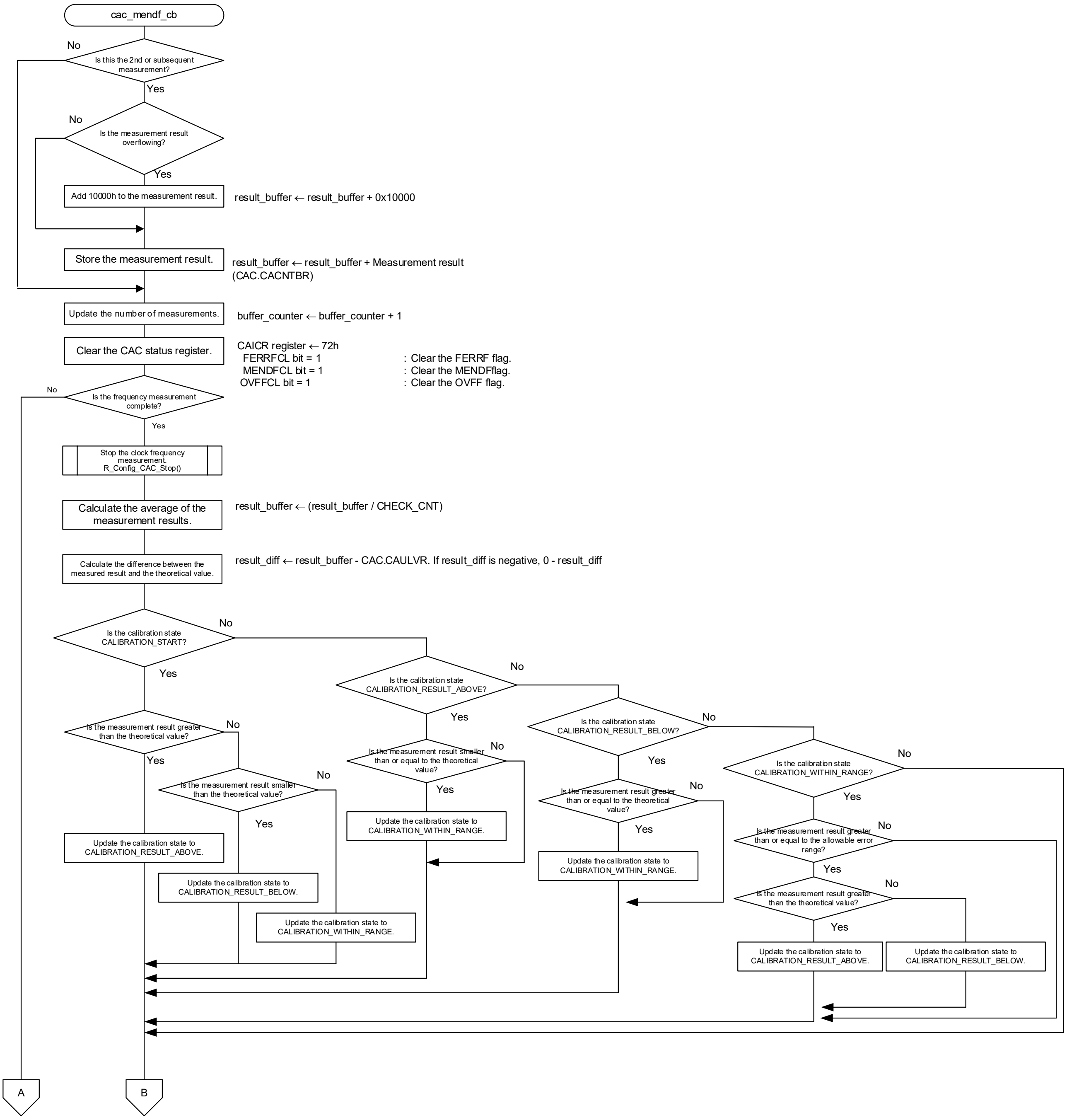


Figure 5.8 CAC Measurement End Interrupt Handling (1/2)

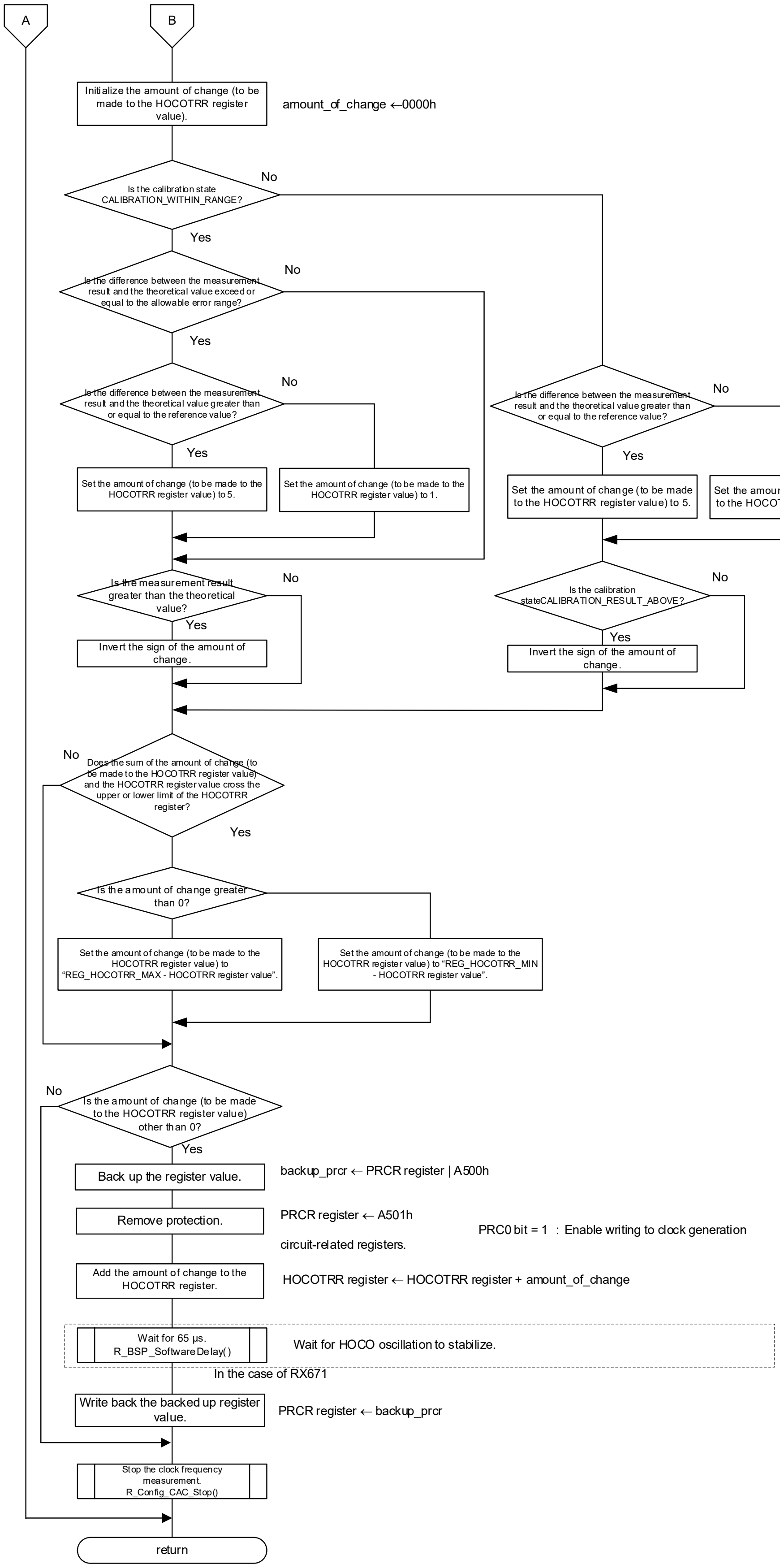


Figure 5.9 CAC Measurement End Interrupt Handling (2/2)

6. Importing a Project

The sample code is provided as the e² studio project. This section describes importing a project into the e² studio. After importing a project, confirm that the build settings and the debug settings are correct.

This application notes support the following development tools.

- e² studio Version: 2022-04 and RX Compiler CC-RX V3.04.00
- CS+ V8.07.00 and RX Compiler CC-RX V3.04.00

6.1 Importing a Project into e² studio

Follow the steps below to import your project into the e² studio.
(Windows/dialogs may differ depending on the e² studio version used.)

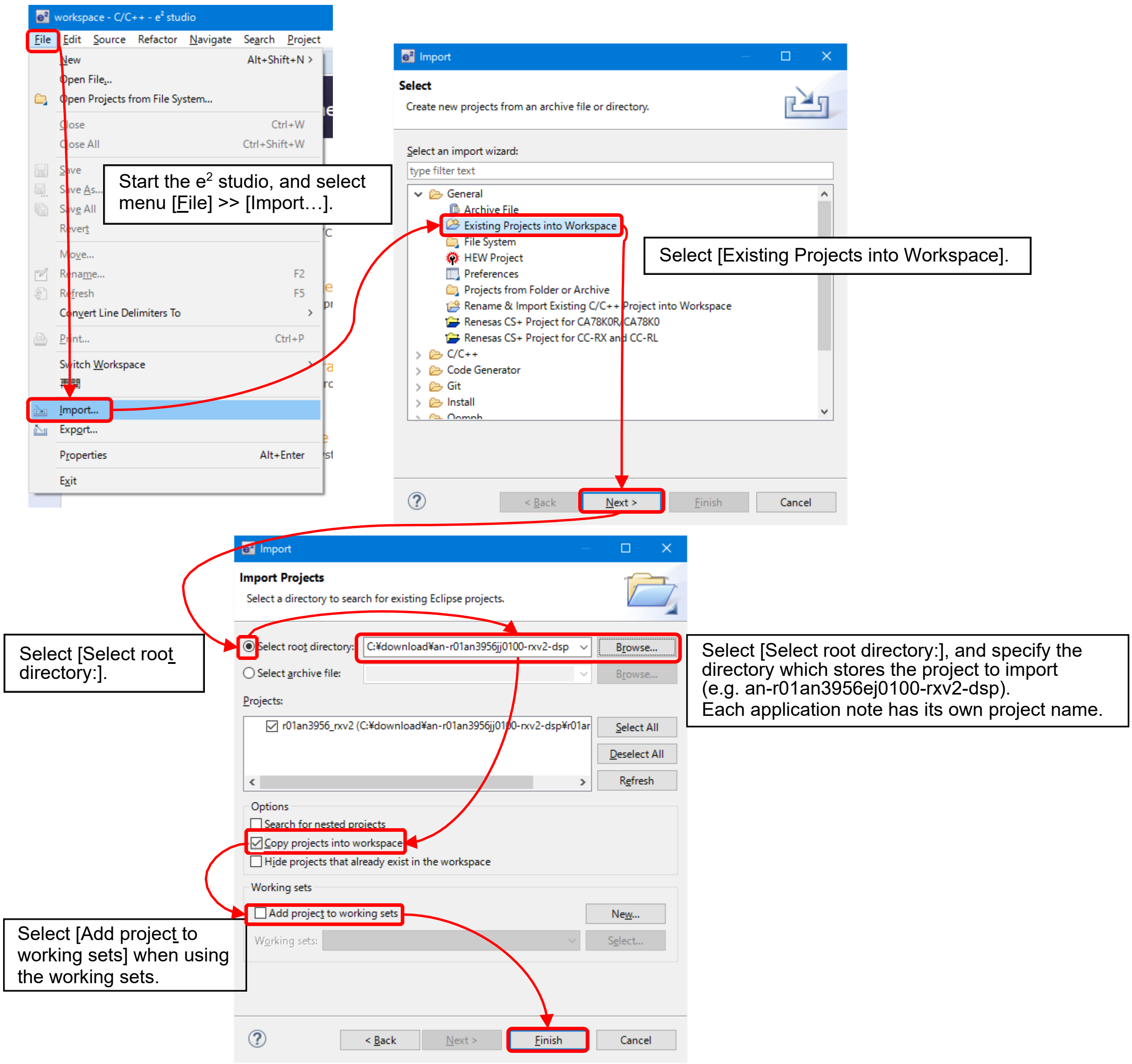
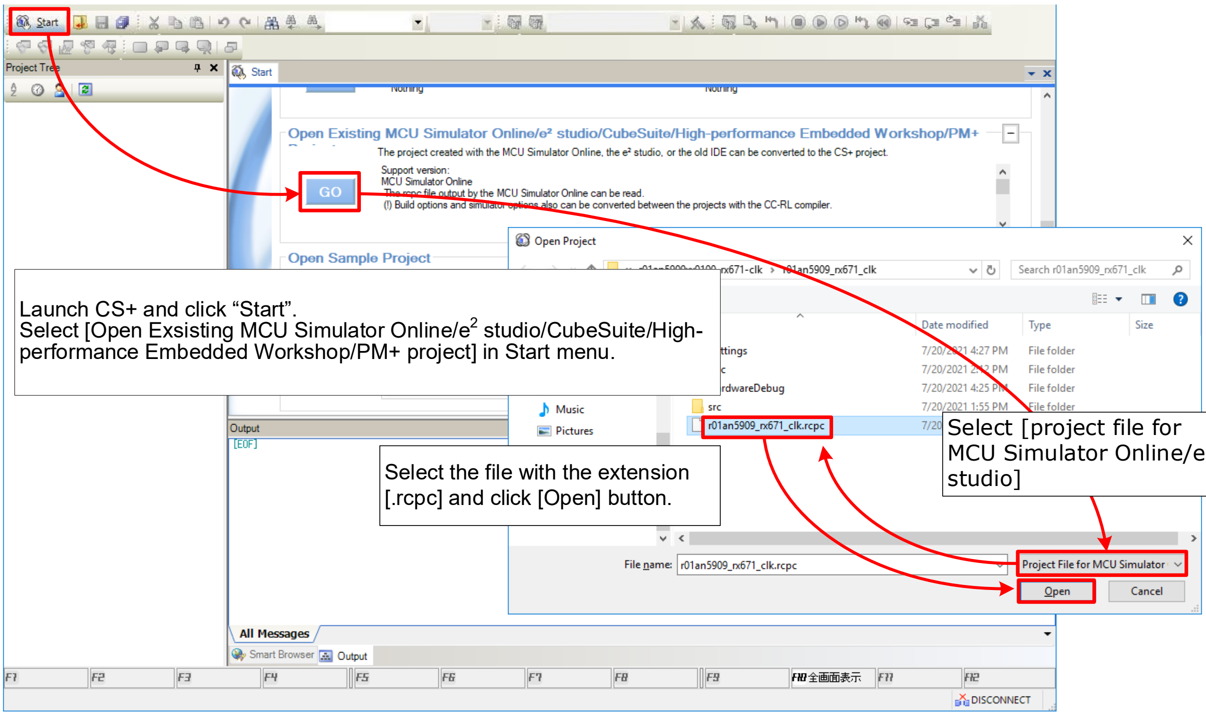


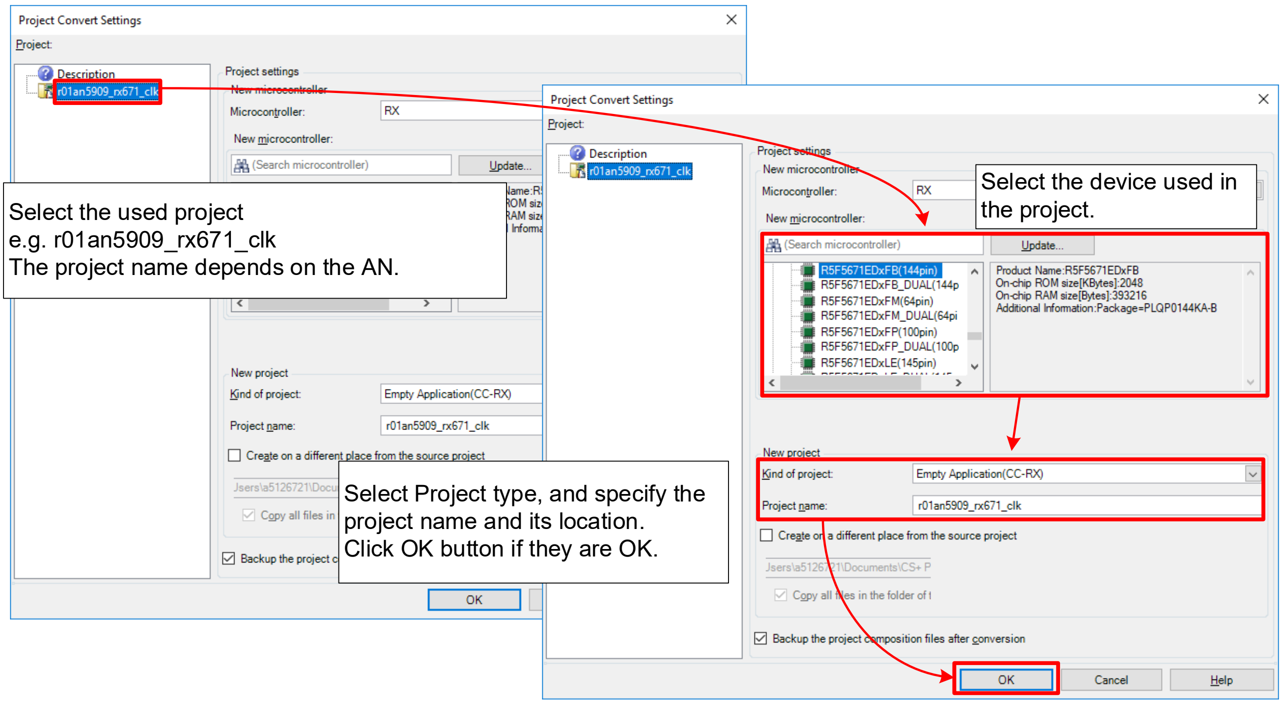
Figure 6.1 Importing a Project into e² studio

6.2 Procedure for Using Sample Code in CS+

Using this application note with CS+

This application note contains a project only for e2 studio. When you use this project with CS+, import the project to CS+ by following procedures.





7. Appendix

7.1 When the MTU Pin Output Is Not Used

Comment out the R_Config_MTU0_Start function.

7.2 Software Module Settings

The FIT module and e^{2}studio SC settings used in the sample program are listed below. For SC settings, the items and settings details match those displayed on the setting menu. For details of the FIT modules, refer to the associated FIT module documents.

7.2.1 RX13T

Table 7.1 BSP Module Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_bsp		Default settings are used (no changes).
Smart Configurator >> Clock		The following settings are made on the “Clocks” tab and reflected in r_bsp_config.h.
	HOCO clock >> HOCO oscillation enabled after reset	HOCO oscillation was disabled after a reset: Unchecked

Table 7.2 Clock Frequency Accuracy Measurement Circuit Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_CAC		Other than the changes listed below, properties are left in the default settings.
	Measurement reference setting	
	Clock select	Changed to the CACREF pin.
	Frequency	Changed to 0.000032 (MHz).
	Measurement target setting	
	Clock select	Changed to the high-speed on-chip oscillator.
	Frequency	Changed to 1/32.
	Counter value comparison setting	
	Maximum positive deviation	Changed to 0%.
	Maximum negative deviation	Changed to 0%.
	Interrupt setting	
	Enable frequency error interrupt (FERRI)	Not used: Unchecked
	Enable measurement end interrupt (MENDI) >> Priority (MENDF)	Changed to Level 2.
	Enable overflow interrupt (OVFI)	Not used: Unchecked
Smart Configurator >> Pins >> Clock frequency accuracy measurement circuit		Other than the changes listed below, properties are left in the default settings.
	CACREF	Pin assignment: Set to PB3.

Table 7.3 PWM Mode Timer (PWM Mode 2) Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_MTU0		Other than the changes listed below, properties are left in the default settings.
	Output setting	
	MTIOCB0 pin	Output initial 0, 1 at compare match, 0 at counter clearing
	PWM output setting	
	PWM period	Changed to 4 counts.
	TGRB initial value	Changed to 1.
Smart Configurator >> Pins >> Multifunction timer pulse unit 3 >> MTU0		Other than the changes listed below, properties are left in the default settings.
	MTIOC0B	Pin assignment: Set to PB2.

Table 7.4 r_cmt_rx Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_cmt_rx		Other than the changes listed below, properties are left in the default settings.
	Configurations	
	CMT interrupts priority level	Changed to 1.

7.2.2 RX140

Table 7.5 BSP Module Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_bsp		Default settings are used (no changes).
Smart Configurator >> Clock		The following settings are made on the “Clocks” tab and reflected in r_bsp_config.h.
	HOCO clock >> HOCO oscillation enabled after reset	HOCO oscillation was disabled after a reset: Unchecked

Table 7.6 Clock Frequency Accuracy Measurement Circuit Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_CAC		Other than the changes listed below, properties are left in the default settings.
	Measurement reference setting	
	Clock select	Changed to the CACREF pin.
	Frequency	Changed to 0.000032 (MHz).
	Measurement target setting	
	Clock select	Changed to the high-speed on-chip oscillator.
	Frequency	Changed to 1/32.
	Counter value comparison setting	
	Maximum positive deviation	Changed to 0%.
	Maximum negative deviation	Changed to 0%.
	Interrupt setting	
	Enable frequency error interrupt (Group BL0)	Not used: Unchecked
	Enable measurement end interrupt (MENDI) >> Priority (Group BL0)	Changed to Level 2.
	Enable overflow interrupt (Group BL0)	Not used: Unchecked
Smart Configurator >> Pins >> Clock frequency accuracy measurement circuit		Other than the changes listed below, properties are left in the default settings.
	CACREF	Pin assignment: Set to PC7.

Table 7.7 PWM Mode Timer (PWM Mode 2) Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_MTU0		Other than the changes listed below, properties are left in the default settings.
	Output setting	
	MTIOCB0 pin	Output initial 0, 1 at compare match, 0 at counter clearing
	PWM output setting	
	PWM period	Changed to 4 counts.
	TGRB initial value	Changed to 1.
Smart Configurator >> Pins >> Multifunction timer pulse unit 3 >> MTU0		Other than the changes listed below, properties are left in the default settings.
	MTIOC0B	Pin assignment: Set to PA1.

Table 7.8 r_cmt_rx Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_cmt_rx		Other than the changes listed below, properties are left in the default settings.
	Configurations	
	CMT interrupts priority level	Changed to 1.

7.2.3 RX231

Table 7.9 BSP Module Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_bsp		Default settings are used (no changes).
Smart Configurator >> Clock		The following settings are made on the “Clocks” tab and reflected in r_bsp_config.h.
	HOCO clock >> HOCO oscillation enabled after reset	HOCO oscillation was disabled after a reset: Unchecked
	HOCO clock >> Frequency : 32MHz	Frequency : Change to 54MHz

Table 7.10 Clock Frequency Accuracy Measurement Circuit Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_CAC		Other than the changes listed below, properties are left in the default settings.
	Measurement reference setting	
	Clock select	Changed to the CACREF pin.
	Frequency	Changed to 0.000032 (MHz).
	Measurement target setting	
	Clock select	Changed to the high-speed on-chip oscillator.
	Frequency	Changed to 1/32.
	Counter value comparison setting	
	Maximum positive deviation	Changed to 0%.
	Maximum negative deviation	Changed to 0%.
	Interrupt setting	
	Enable frequency error interrupt (Group BL0)	Not used: Unchecked
	Enable measurement end interrupt (MENDI) >> Priority (Group BL0)	Changed to Level 2.
	Enable overflow interrupt (Group BL0)	Not used: Unchecked
Smart Configurator >> Pins >> Clock frequency accuracy measurement circuit		Other than the changes listed below, properties are left in the default settings.
	CACREF	Pin assignment: Set to PC7.

Table 7.11 PWM Mode Timer (PWM Mode 2) Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_MTU0		Other than the changes listed below, properties are left in the default settings.
	Output setting	
	MTIOCB0 pin	Output initial 0, 1 at compare match, 0 at counter clearing
	PWM output setting	
	PWM period	Changed to 4 counts.
	TGRB initial value	Changed to 1.
Smart Configurator >> Pins >> Multifunction timer pulse unit 3 >> MTU0		Other than the changes listed below, properties are left in the default settings.
	MTIOC0B	Pin assignment: Set to PA1.

Table 7.12 r_cmt_rx Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_cmt_rx		Other than the changes listed below, properties are left in the default settings.
	Configurations	
	CMT interrupts priority level	Changed to 1.

7.2.4 RX671

Table 7.13 BSP Module Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_bsp		Default settings are used (no changes).
Smart Configurator >> Clock		The following settings are made on the “Clocks” tab and reflected in r_bsp_config.h.
	HOCO clock >> HOCO oscillation enabled after reset	HOCO oscillation was disabled after a reset: Unchecked

Table 7.14 Clock Frequency Accuracy Measurement Circuit Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_CAC		Other than the changes listed below, properties are left in the default settings.
	Measurement reference setting	
	Clock select	Changed to the CACREF pin.
	Frequency	Changed to 0.000032 (MHz).
	Measurement target setting	
	Clock select	Changed to the high-speed on-chip oscillator.
	Frequency	Changed to 1/32.
	Counter value comparison setting	
	Maximum positive deviation	Changed to 0%.
	Maximum negative deviation	Changed to 0%.
	Interrupt setting	
	Enable frequency error interrupt (Group BL0)	Not used: Unchecked
	Enable measurement end interrupt (MENDI) >> Priority (Group BL0)	Changed to Level 2.
	Enable overflow interrupt (Group BL0)	Not used: Unchecked
Smart Configurator >> Pins >> Clock frequency accuracy measurement circuit		Other than the changes listed below, properties are left in the default settings.
	CACREF	Pin assignment: Set to PC7.

Table 7.15 PWM Mode Timer (PWM Mode 2) Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> Config_MTU0		Other than the changes listed below, properties are left in the default settings.
	Output setting	
	MTIOCB0 pin	Output initial 0, 1 at compare match, 0 at counter clearing
	PWM output setting	
	PWM period	Changed to 30 counts.
	TGRB initial value	Changed to 14.
Smart Configurator >> Pins >> Multifunction timer pulse unit 3 >> MTU0		Other than the changes listed below, properties are left in the default settings.
	MTIOC0B	Pin assignment: Set to PA1.

Table 7.16 r_cmt_rx Settings

Category	Item	Setting/Description
Smart Configurator >> Components >> r_cmt_rx		Other than the changes listed below, properties are left in the default settings.
	Configurations	
	CMT interrupts priority level	Changed to 1.

8. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

9. Reference Documents

User's Manual: Hardware

RX13T Group User's Manual: Hardware (R01UH0822)
RX140 Group User's Manual: Hardware (R01UH0905)
RX231 Group User's Manual: Hardware (R01UH0496)
RX671 Group User's Manual: Hardware (R01UH0899)

(The latest version 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 CC-RX Compiler User's Manual (R20UT3248)
(The latest version can be downloaded from the Renesas Electronics website.)

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.30.19	-	First edition issued
1.10	Jun.30.22	3	Revised “1. Specifications” for the RX family.
		4 - 11	Added operation confirmation conditions for RX140, RX231, and RX671 to “2.1 Operation Confirmation Conditions”.
		4 - 11	Added Pin Connections for RX140, RX231, and RX671 to “2.1 Operation Confirmation Conditions”.
		12	Replaced “3. Related Application Note” to “3. Software Modules Used”.
		13	Added “4. Project Composition”
		14 - 18	Modified “5.1 Operation Overview” to reflect changes in the specifications.
		19	Removed “5.4 Option-Setting Memory”.
		19 - 22	Modified “5.3 Constants”, “5.4 Variables”, “5.5 Functions”, and “5.6 Function Specifications” to reflect changes in the specifications.
		22 - 26	Modified “5.9 Flowcharts” to match the processing of the functions.
		27, 28	Added “6. Importing a Project”
		29 - 35	In “7. Appendix”, removed “Changing the Measurement Reference Clock Frequency” and “Changing the Compare Match Timer Count Value” and added “Software Module Settings”.

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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