Application Note

Renesas RA 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 RA Family.

Target Device

RA2E3 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

Hardware requirements

- 1 x board of FPB-RA2E3.
- 1 x system of Function generator.
- 1 x digital oscillator scope.
- 1 x Micro USB cable.

Software requirements

- Renesas e^2 studio Version: 2024-04 (24.4.0).
- RA Flexible Software Package version 5.4.0 (FSPv5.4.0)
- J-Link Viewer V7.96F or higher.

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 HOCOUTRM[7:0] is used to adjust the HOCO oscillation frequency. The HOCO frequency error can be compensated for by adjusting the value of the HOCOUTRM[7:0] register at regular intervals.

The sample program described in this application note demonstrates using the CAC and its compare-match interrupt operation to measure the HOCO oscillation frequency. If the HOCO frequency is outside of the acceptable range then the program updates the value of the HOCOUTRM[7:0] register to adjust the HOCO's frequency to within the acceptable range. The program also outputs a clock equivalent to the HOCO oscillation frequency divided by 64 on the CLKOUT pin.

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

The LOCO clock shown in the block diagram is used as a measurement reference clock and affects the calibration accuracy. For example, when using a LOCO clock signal 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).

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
CAC	Measures the HOCO frequency based on the External Clock frequency input

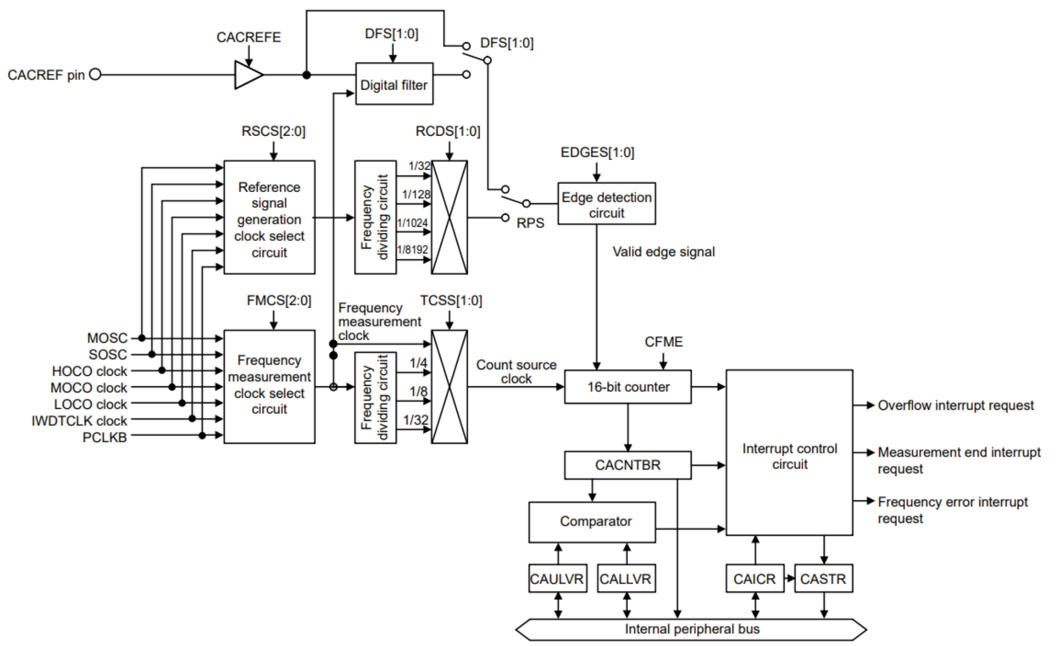


Figure 1. CAC Block Diagram

2. Operation Confirmation Environment

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

2.1 RA2E3 Project Operation Conditions

Table 2.1 Operation Confirmation Conditions for RA2E3

Item	Description
MCU used	R7FA2E3073CFL (RA2E3 Group)
High-speed on-chip oscillator	HOCO: 24/32/48/64 MHz
Operating frequency	HOCO: 64MHz System clock (ICLK): 32 MHz (HOCO x 1/2) Peripheral module clock B (PCLKB): 32 MHz (HOCO x 1/2) Peripheral module clock D (PCLKD): 64 MHz (HOCO x 1/1)
Operating voltage	5.0V
Integrated development environment	Renesas Electronics e^2 studio 2024-01.1 (24.1.1)
C compiler	Renesas Electronics C/C++ Compiler for RA Family
iodefine.h version	FSP ver. 5.4.0
Endian order	Little endian or big endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Board used	FPB-RA2E3 CPU card (product number: RTK7FPA2E3S00001BE)
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 1kHz rectangular wave with an amplitude setting of 3.3 Vpp. Figure 2.1 shows the output waveform.

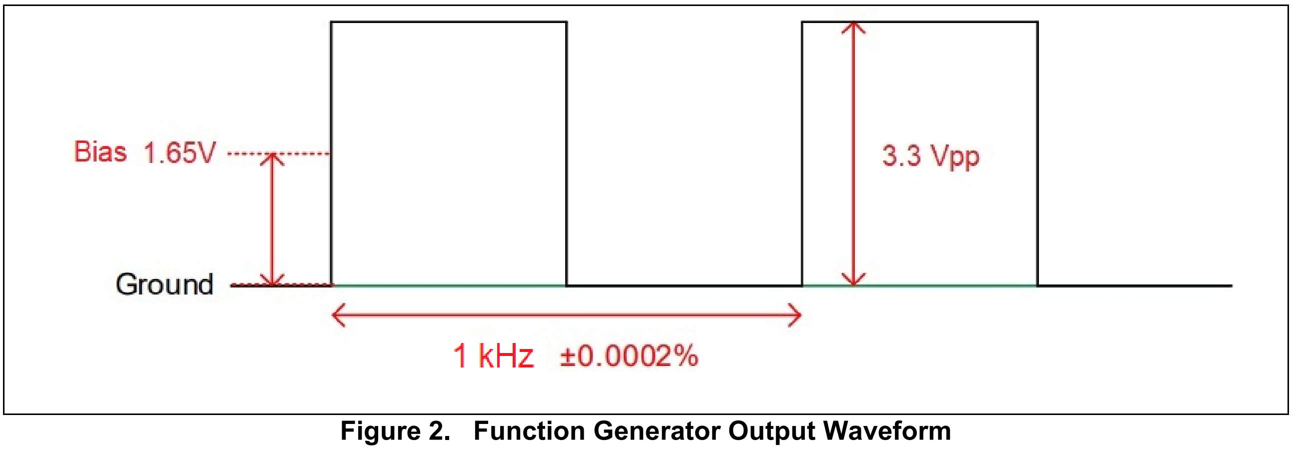


Figure 2. Function Generator Output Waveform

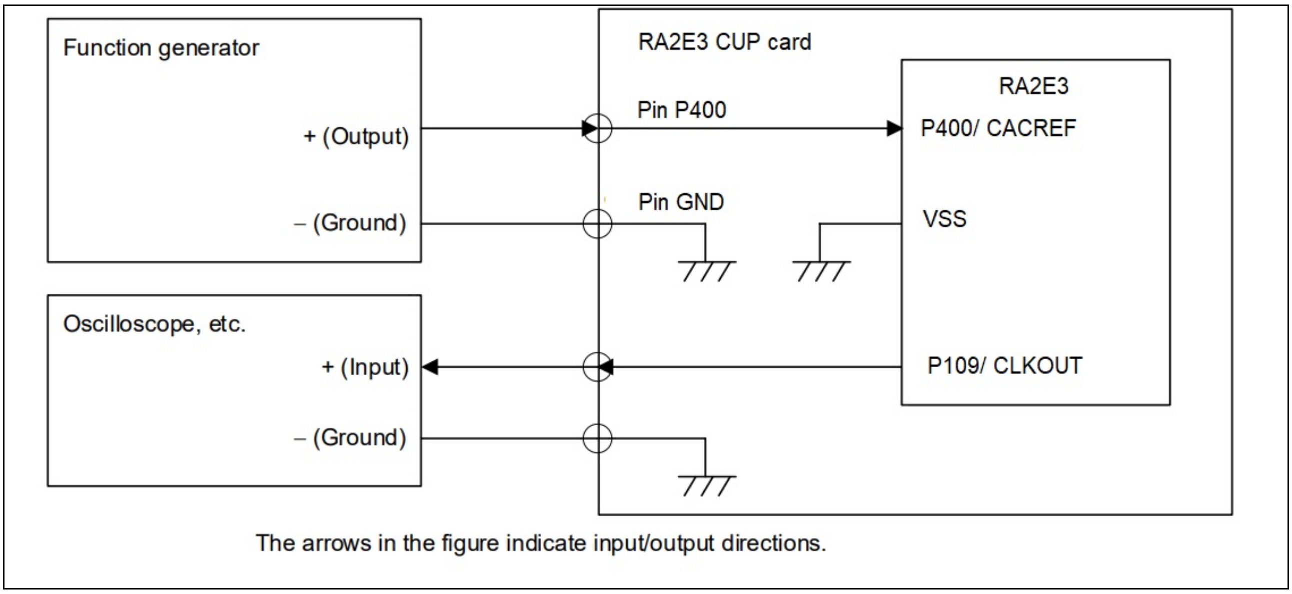


Figure 3. Pin Connection for RA2E3

Table 2.1.1 Pins Used for RA2E3 and Their Functions

Pin Name	I/O	Description
P400/ CACREF	Input	Measurement reference clock input
P109/ CLKOUT	Output	Outputs a clock equivalent to HOCO divided by 64

3. Software Modules Used

Figure 4 shows the structure of the example code, and Table 3.1 lists the Flexible Software Package (FSP) modules used. For the settings of the software modules used in the sample code, see 7.1 Software Module Settings.

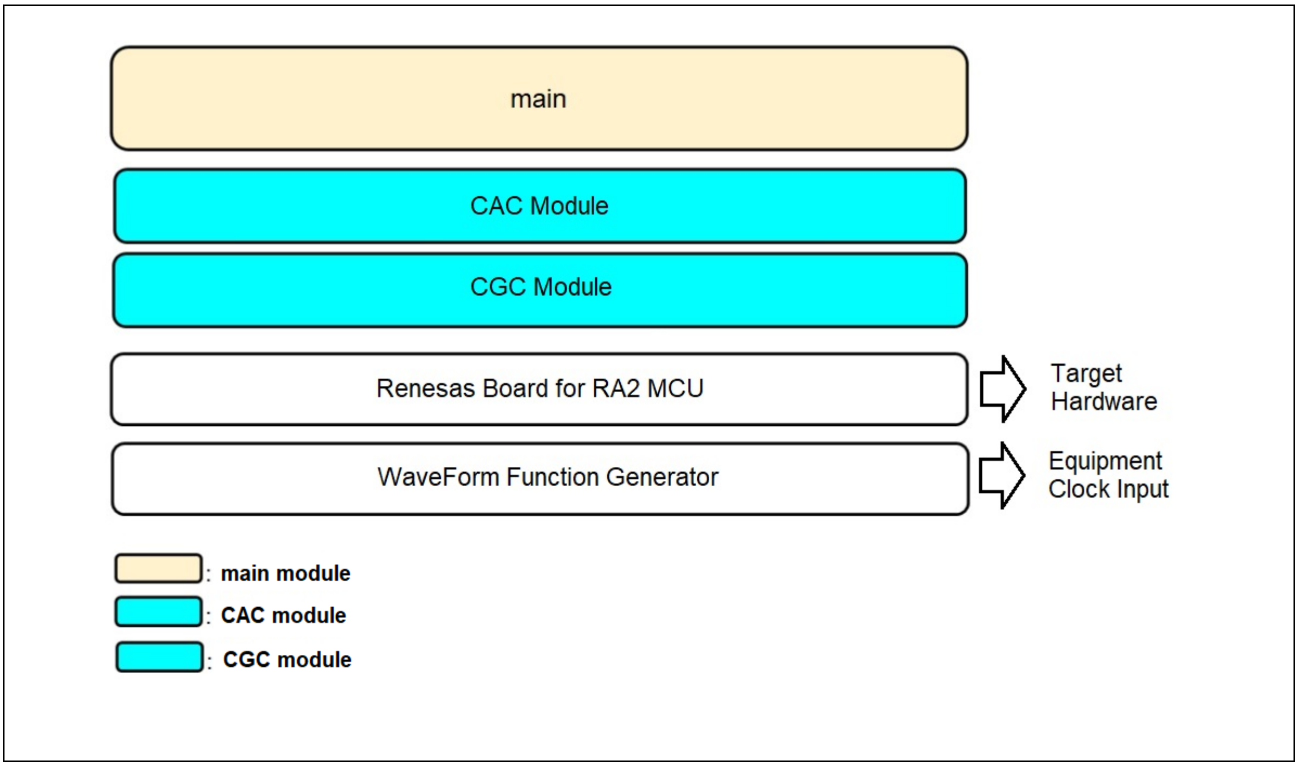


Figure 4. Structure of Sample Code

Table 3.1 Software Modules Used

Module	Document Title	Document No.	Type
R_IOPORT	Renesas Flexible Software Package (FSP V5.4.0). Driver for I/O Ports peripheral on RA MCUs.	R11UM0155EU0540 Revision 4.40	e^2 studio's Hal/ Common Stacks Module selected generator I/O pins for peripheral modules.
R_CAC	Renesas Flexible Software Package (FSP V5.4.0). Driver for the CAC peripheral on RA MCUs	R11UM0155EU0540 Revision 4.40	e^2 studio's Hal/ Common Stacks Module selected generator Clock Accuracy Circuit module.
R_CGC	Renesas Flexible Software Package (FSP V5.4.0). Driver for the CGC peripheral on RA MCUs	R11UM0155EU0540 Revision 4.40	e^2 studio's Hal/ Common Stacks Module selected generator Clock Generation Circuit module

4. Project Composition

Figure 5 shows the project composition, including application note Hoco_calibration_using_the CAC on RA2E3.pdf and project cac_fpb_ra2e3_ep_ext_clik.zip file.

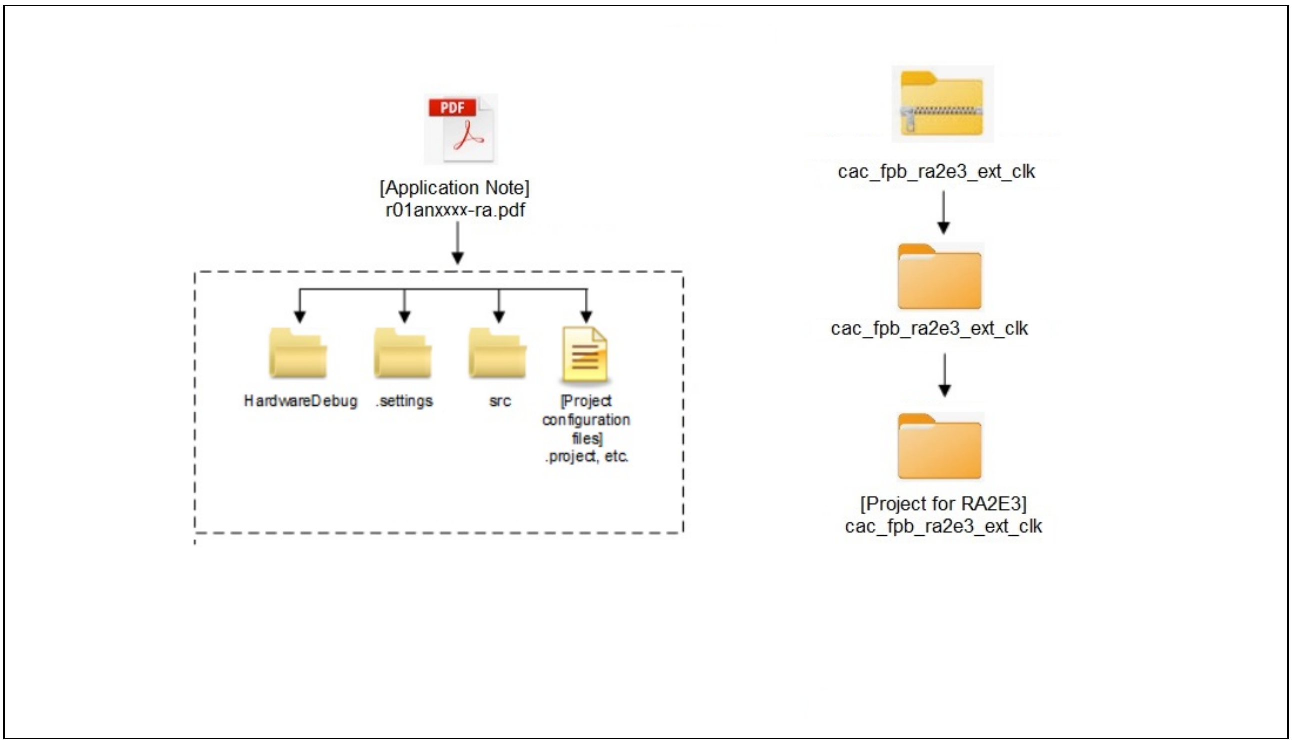


Figure 5. Project Composition

5. Software

5.1 Operation Overview

In this chapter, RA2E3 is used as an example.

The provided 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).

- Measurement reference clock: A function generator set to output a 1kHz rectangular wave is used (see Figure 2).
- Measurement target clock: A HOCO (64 MHz) divided by 64 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.
- The CAC HAL module API interfaces with a clock frequency-measurement circuit capable of monitoring the clock frequency based on a reference-signal input. The reference signal may be an externally supplied clock source or one of several available internal clock sources. An interrupt request may optionally be generated by a completed measurement, a detected frequency error, or a counter overflow. A digital filter is available for an externally supplied reference clock, and dividers are available for both internally supplied measurement and reference clocks. Edge detection options for the reference clock are configurable as rising, falling, or both.

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

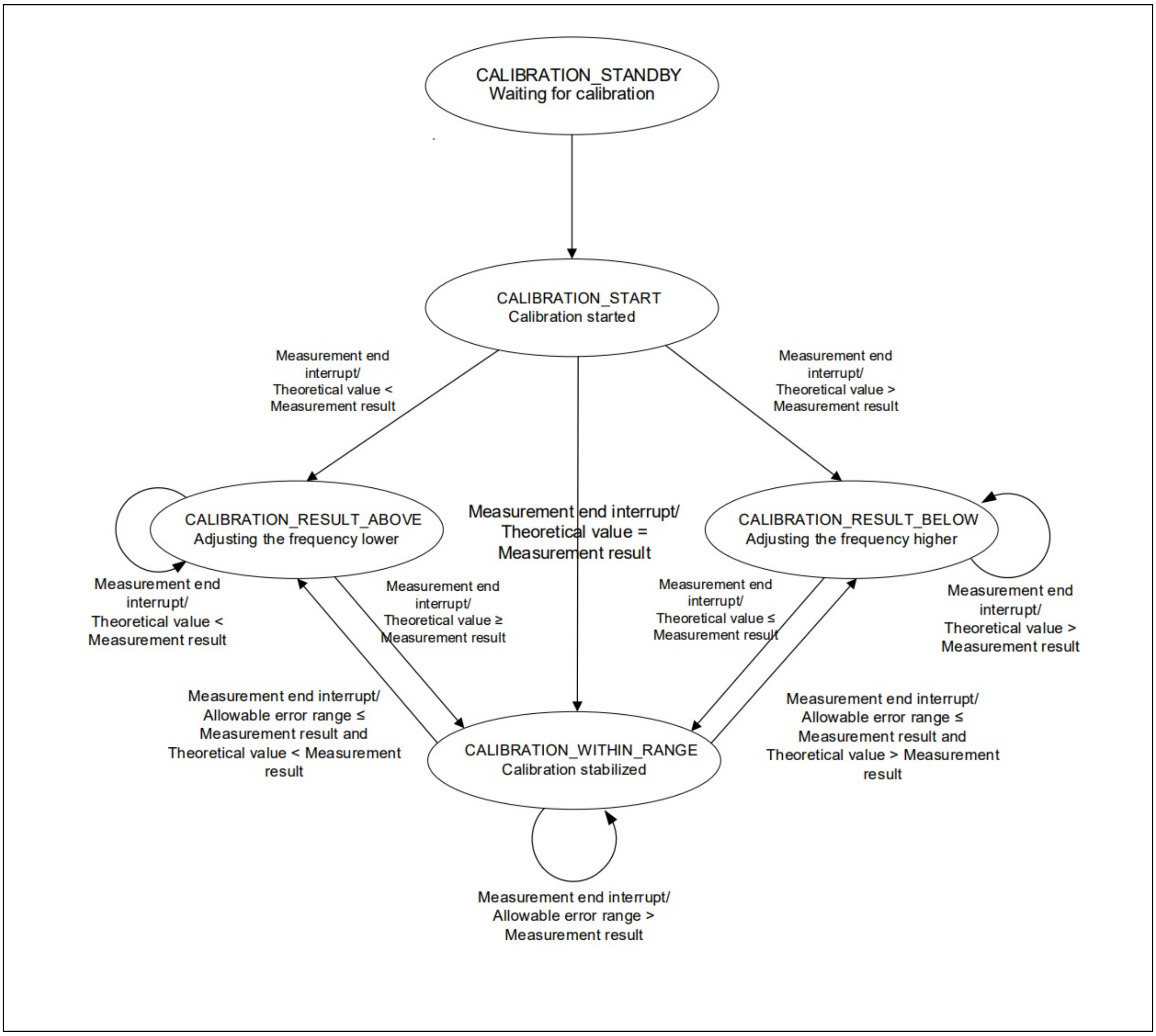


Figure 6. Calibration State Transitions

After the calibration state transition, the value of the HOCOUTRM[7:0] register is added or subtracted depending on the difference between the theoretical value and the calibration state. Table 5.2 lists the Register Value Adjustment Patterns, Figure 7 and Figure 8 show calibration examples, and Figure 9 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*5

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 0.005 (Digits after the decimal point are discarded.)

The CAC measures the clock frequency using the CACREF pin input or an internal clock as a reference. Figure 9 shows an operating example of the CAC.

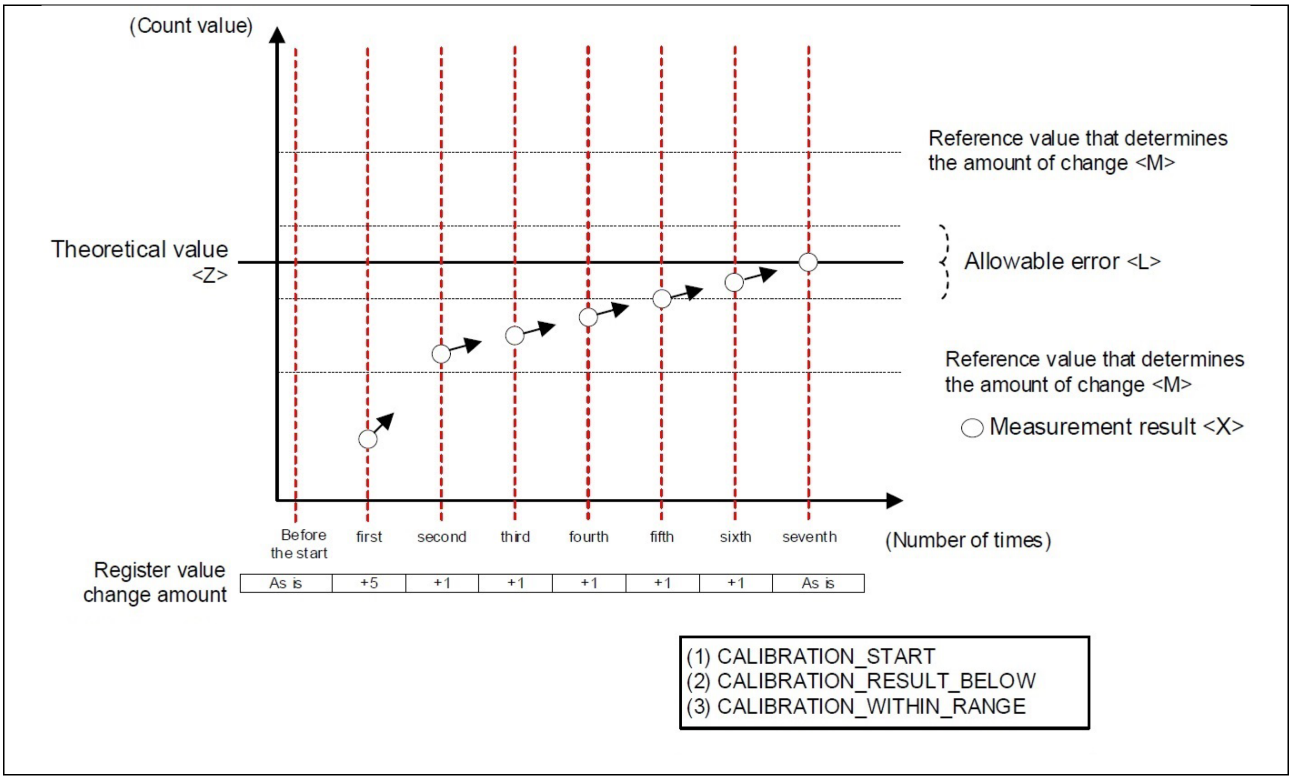


Figure 7. Example of Calibrating a HOCO Frequency Smaller Than the Theoretical Value

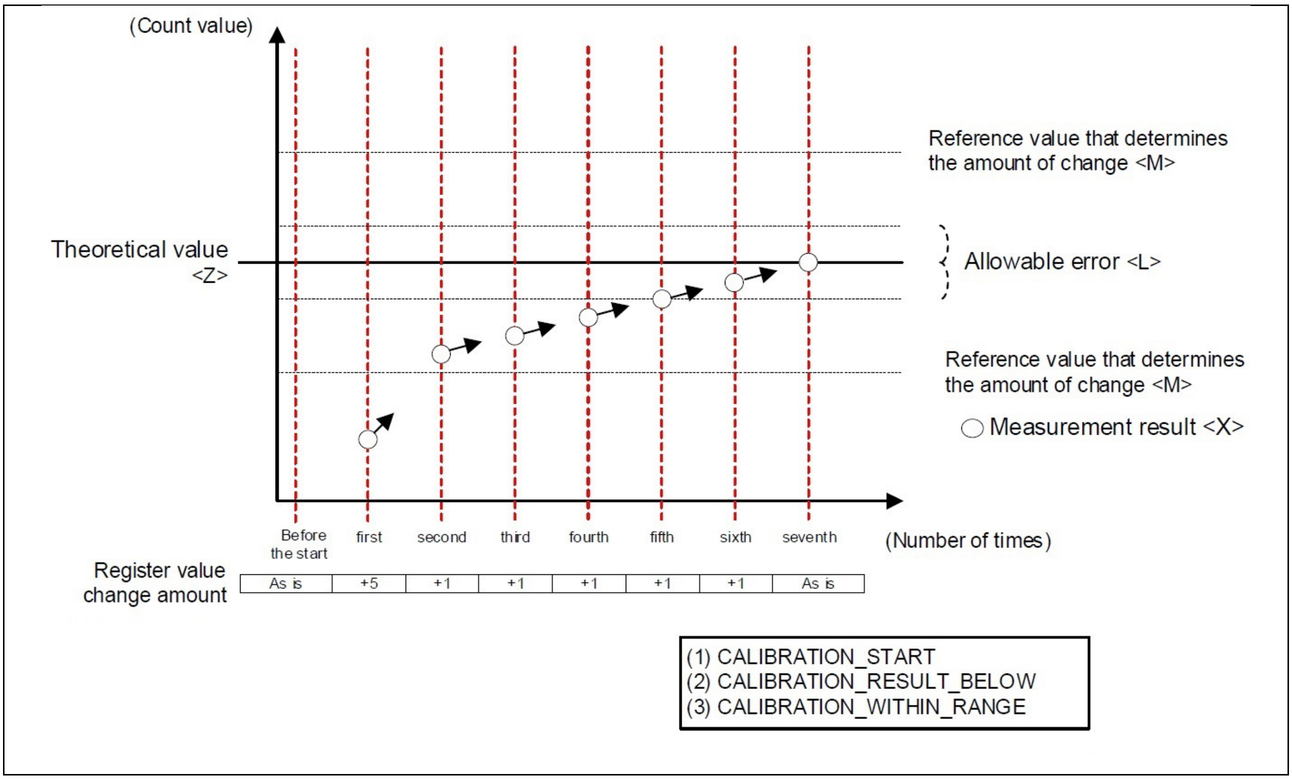


Figure 8. Example of Calibrating a HOCO Frequency Smaller Than the Theoretical Value

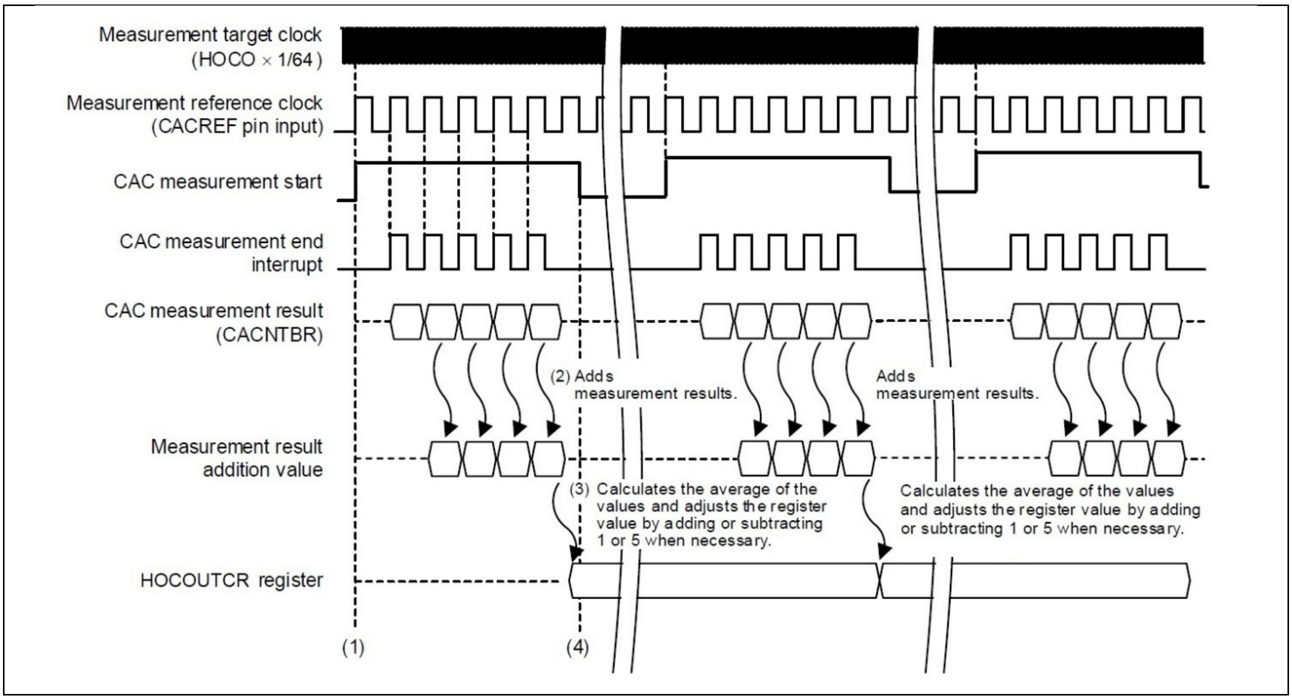


Figure 9. Timing Diagram of Calibration

(1) When CAC startup settings are made and measurement starts.

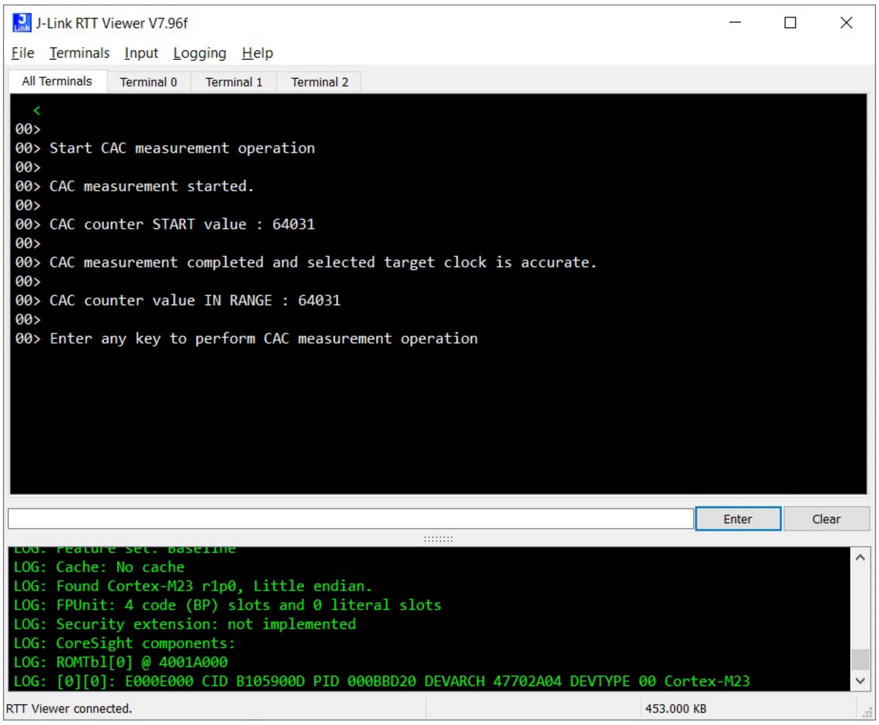
(2) Valid edges of the measurement target clock are counted in the period from a rising edge to the next rising edge of the measurement reference clock. When an interrupt is occurred at the measurement end, the measurement results are obtained.

(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 HOCOUTRM[7:0] register.

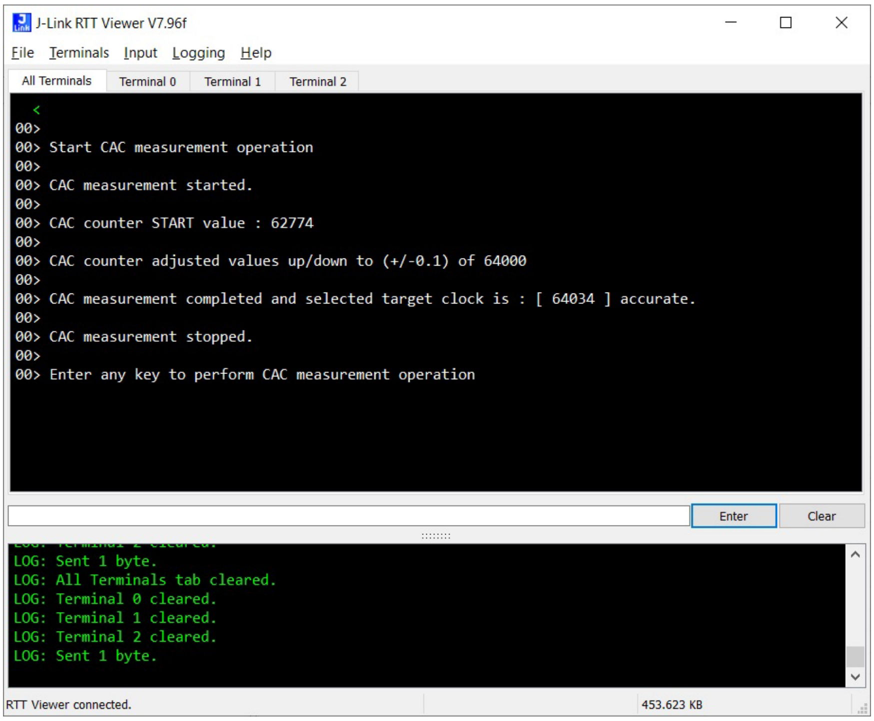
(4) When adjustment of the HOCO oscillation frequency ends, CAC measurement stops. The HOCO clock is supplied as ICLK, etc., to the CPU and peripheral functions until the next calibration interrupt occurs.

HOCO Calibration processed from RTT Viewer: In Range, Above the Range, and Below the Range.

In Range



Above the Range



Below the Range

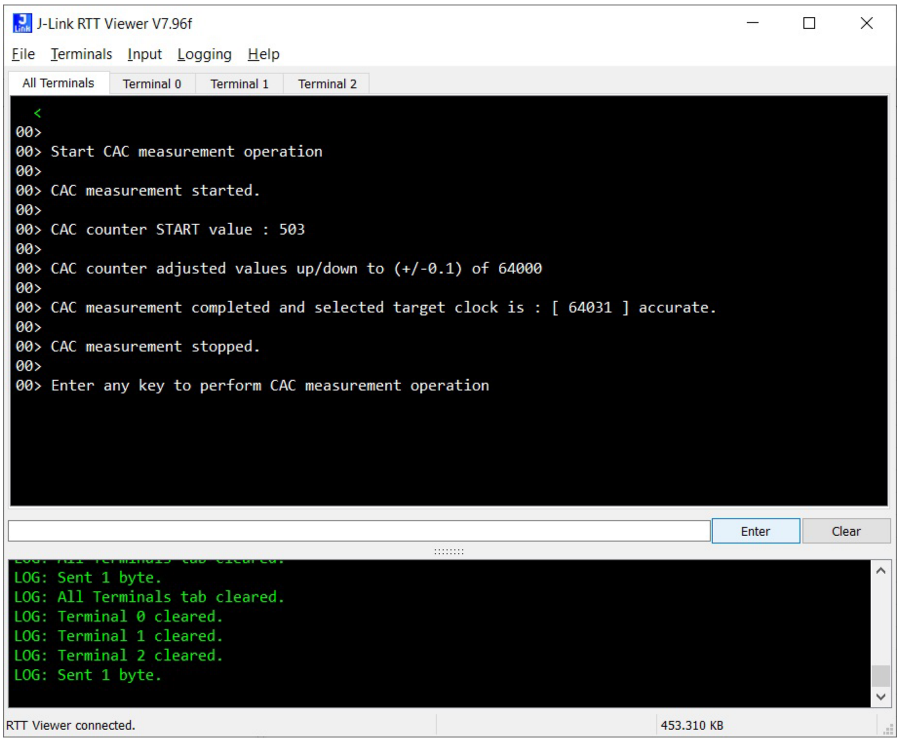


Figure 10. HOCO Calibration results output from RTT Viewer

5.2 File Composition

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

File Name	Outline	Remarks
hal_entry.c	Calibration settings and CAC measurement end interrupt handling	
cac_ep.h	Header file for r_cac and r_cgc api used	

5.3 Constants (User Changeable) Used by Sample Code

Table 5.4 lists the constants used and created this application note.

Constant Name	Setting Value	Description
Name	g_cac	Named r_cac configuration
Reference clock divider	32, 128, 1024, 8192	Set clock divide
Reference clock source	External	Select reference clock
Reference clock digital filter	Disable	Enable/Disable filter
Reference clock edge detect	Rising	Select Falling/Rising edge
Measurement clock divider	1, 4, 8, 32	Select clock divide
Measurement clock source	Main_clock, Sub_clock, HOCO, MOCO, LOCO, PCLKB, IWDT	Select clock measurement
Upper Limit Threshold	Setting HOCO's value clock	+0.xx% upper limit of HOCO clock
Lower Limit Threshold	Setting HOCO's value clock	- 0.xx% upper limit of HOCO clock
Frequency Error Interrupt Priority	Priority 0 – 3/disable	Set priority
Measurement End interrupt Priority	Priority 0 – 3/disable	Set priority

Overflow Interrupt Priority	Priority 0 – 3/disable	Set priority
Callback	cac_callback	Name the call back function
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%.
REFERENCE_VALUE_PERCENT	50	This setting is changed, use a setting value of 50 (0.5%) or greater.

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

Constant Name	Setting Value	Description
HOCOUTRM[7:0]	MAX : 0x7F and MIN : 0x80	Trimming Control Register

5.4 Variables

Table 5.5 lists the Local Variables used in the source files created for this application note.

Type	Variable Name	Description	Used by Function
uint32_t	cac_counter_value	Frequency measurement counter	cac_measurement_process
uint32_t	cac_time_out	Waiting time	cac_measurement_process
uint32_t	clock_percent	Calculate 0.1 percent frequency value	cac_measurement_process
uint32_t	amount_of_change	Calculate 0.5 percent frequency value	cac_measurement_process
uint32_t	i	Variables used to increase or decrease	cac_measurement_process

5.5 Functions

Table 5.6 lists the Functions used in the source files created for this application note.

Function Name	Outline
hal_entry	Main_processing
cac_measurement_process	CAC calibration measurement
cac_callback	CAC call back
deinit_cac	CAC HAL driver close
deinit_cgc	CGC HAL driver close
clean_up	Close CAC and CGC modules

5.6 Function Specifications

The following tables list the sample code function specifications.

Hal_entry	
Outline	Hal_entry processing
Header	None
Declaration	Main
Description	Calls the CAC and CGC modules setting. I/O ports and registers setting.
Arguments	None

Return Value	None
cac_measurement_processing	
Outline	Perform CAC measurement operation
Header	None
Declaration	**static** fsp_err_t **cac_measurement_processing (void)**
Description	Start measurement, Wait for measurement complete or error generation event,
Arguments	None
Return Value	None
cac_callback	
Outline	Defined CAC_callback
Header	None
Declaration	CAC callback
Description	Call back CAC module
Arguments	None
Return Value	None
deinit_cac	
Outline	Close the CAC modules
Header	cac_ep.h
Declaration	CAC modules
Description	Close the CAC modules
Arguments	None
Return Value	None
deinit_cgc	
Outline	Close the CGC modules
Header	cac_ep.h
Declaration	CGC modules
Description	Close the CGC modules
Arguments	None
Return Value	None
clean_up	
Outline	Close the CGC modules
Header	cac_ep.h
Declaration	CGC modules
Description	de-initialize all the opened modules
Arguments	None
Return Value	None

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 note supports the following development tools.

- e² studio Version: 2024-04 (24.4.0) or higher and RA Compiler.
- Flexible Software Package (FSPv5.4.0 or higher).

6.1 Importing a Project into e^2 studio

Follow the steps below to import your project into the e^2 studio. (Windows/dialogs may differ depending on the e^2 studio version used.

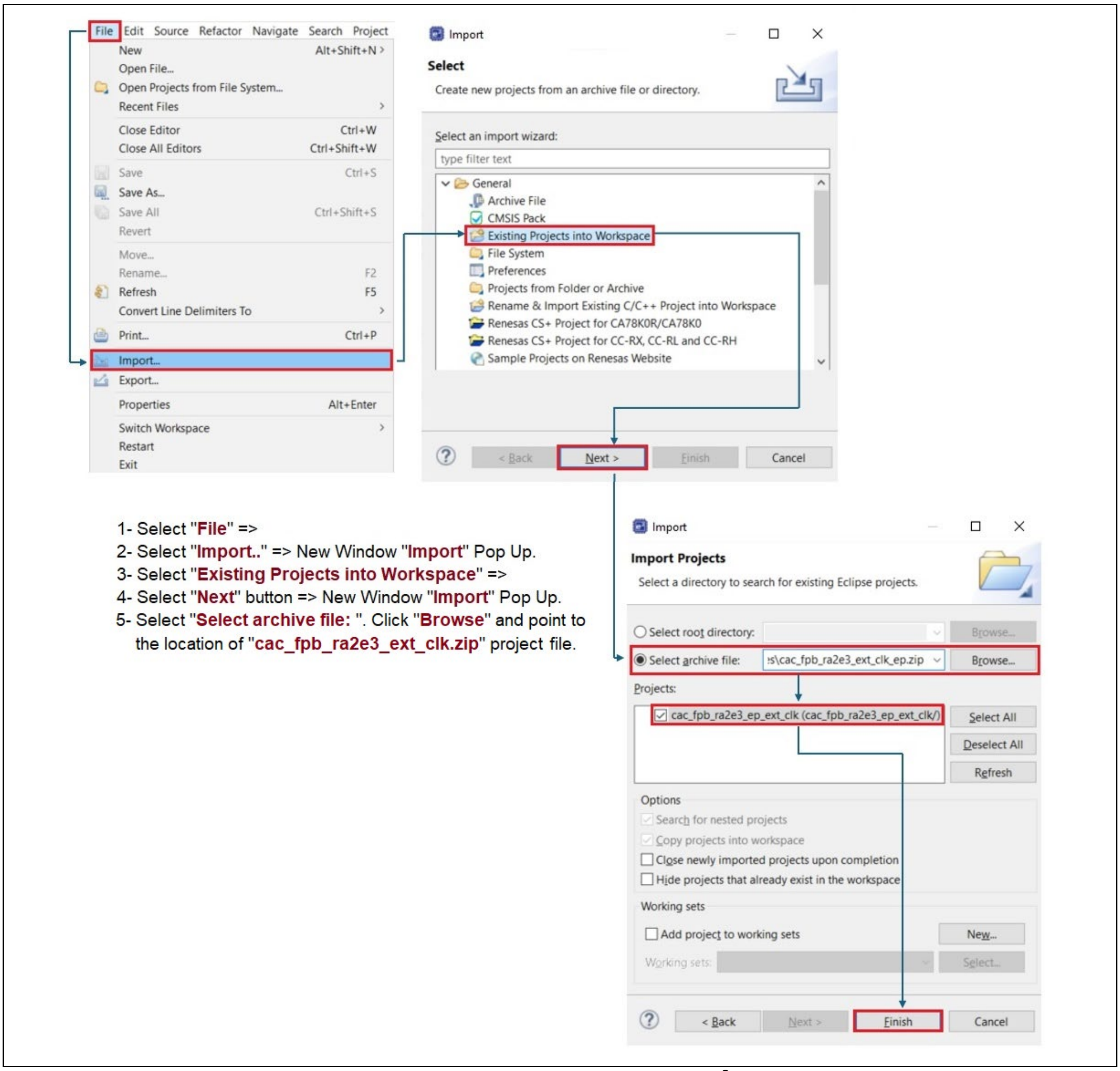


Figure 11. Importing a Project into e^2 studio

7. Appendix

7.1 Software Module Settings.

The FSP configuration settings used in the sample program for the r_cac module are listed in the table below. The module configurations can viewed and set in e^2 studio by opening the project's configuration.xml file, navigating to the FSP Configuration View > Stacks tab, and selecting the g_cac Clock Accuracy Circuit (r_cac) module. The configuration is available in the Properties tab of the FSP Configuration View. For details of the FSP modules, refer to the associated FSP module documents.

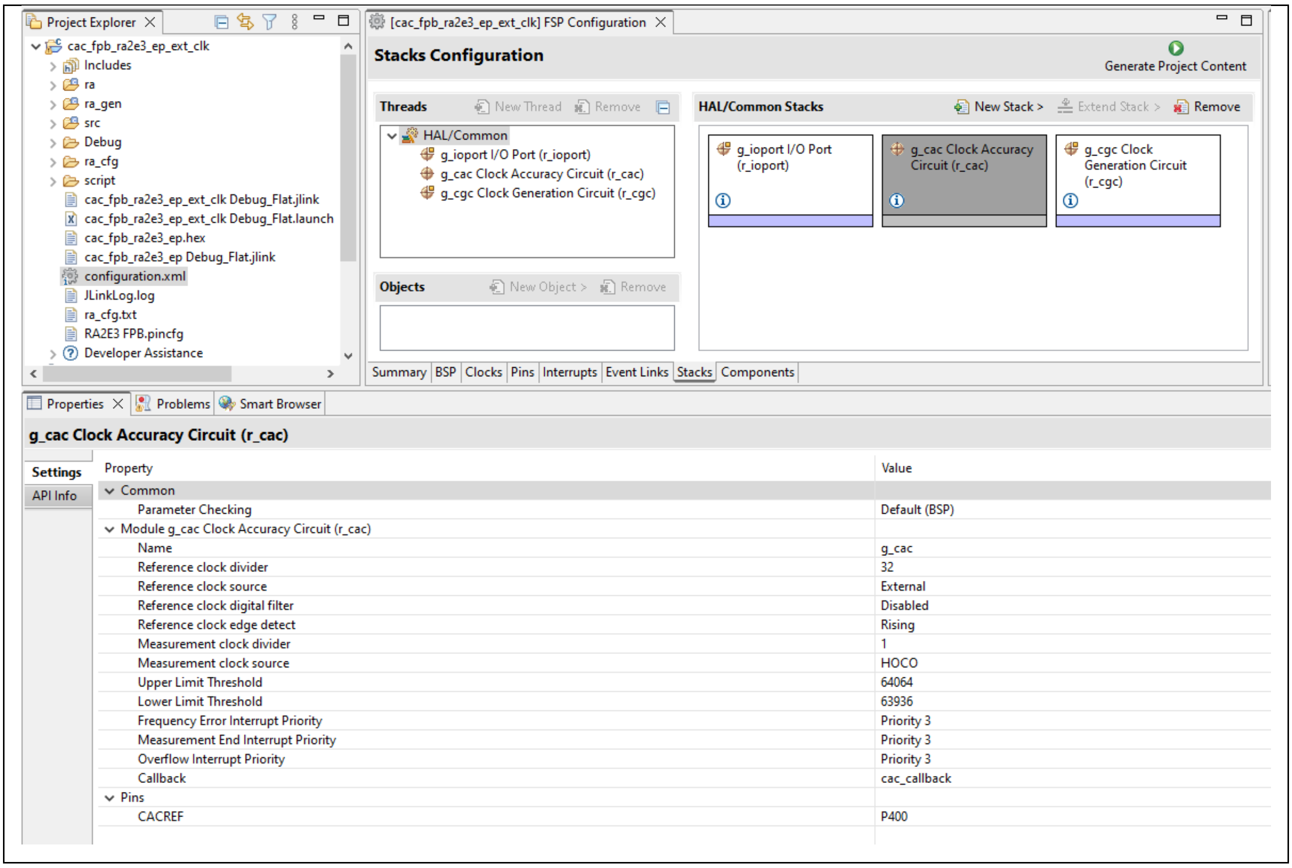


Figure 12. Setting r_cac properties Module

Table. 7.1

g_cac Clock Accuracy Circuit (r_cac) Property	Value
Name	g_cac
Reference clock divider	32
Reference clock source	External
Reference clock digital filter	Disable
Reference clock edge detect	Rising
Measurement clock divider	1
Measurement clock source	HOCO
Upper Limit Threshold	64064
Lower Limit Threshold	63936
Frequency Error Interrupt Priority	Priority 3
Measurement End interrupt Priority	Priority 3
Overflow Interrupt Priority	Priority 3
Callback	cac_callback

8. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

9. Reference Documents

User's Manual: Hardware

RA2E3 Group User's Manual: Hardware (r01uh0992ej0110-ra2e3.pdf)

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

RA2E3 Group User's Manual: Hardware (renesas.com)

User's Manual: Development Tools

RA Family Compiler User's Manual

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

RA2E3 - 48MHz Arm® Cortex®-M23 Entry Level, Ultra-Low Power General-Purpose Microcontroller | Renesas

10. Website and Support

Visit the following URLs to learn about key elements of the RA family, download components and related documentation, and get support:

RA Product Information	renesas.com/ra
RA Product Support Forum	renesas.com/ra/forum
RA Flexible Software Package	renesas.com/FSP
Renesas Support	renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sept.04.2024	—	Initial release

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.

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 or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving 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, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. 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 shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended 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; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or 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 damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, 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 and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall 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 shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

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

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit: www.renesas.com/contact/.

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.