

Current Consumption Tuning Solution for RX Family

R20AN0483EJ0100

Rev.1.00

Jan. 16, 2018

 (E2 Emulator, e² studio)

Introduction

This application note introduces the current consumption tuning solution using the E2 emulator.

The E2 emulator allows you to easily measure the dynamically changing current drawn by the user system.

Various conditions can be specified to stop the program when excessive current is detected (e.g. when the current exceeds a threshold value at a point or over a specified period).

Monitoring points can also be used, in a similar manner to the setting of breakpoints, to monitor the relationship between the behavior of the program and changes of current. This will shorten work time required for the current-tuning process.

This application note covers how to measure the current consumption using the E2 emulator and integrated development environment (e² studio). If you intend to use another integrated development environment (CS+ for CC), refer to the application note for CS+ (document No.: R20AN0484).

Target Device

RX100/RX200 series

Contents

1. Overview	5
2. Description of Functions	7
2.1 Measuring the Current Consumption	7
2.2 Monitoring Point.....	8
2.3 External Trigger Input and Output Functions	9
2.3.1 Specifications of the External Trigger Inputs and Outputs.....	9
2.3.2 Assignments of the External Trigger Input and Output Pins	10
3. Setup	11
3.1 Installing the Emulator Debugger	11
3.2 Executing the Self-Check Program (SCP)	11
3.3 Setting the Hardware Environment	12
3.3.1 Pin 11 of the User Interface.....	13
3.3.2 Connecting the E2 Emulator to the User System	13
3.4 Turning on the E2 Emulator and User System.....	13
4. Method for Using the Emulator Debugger	14
4.1 Setup when Starting the Emulator Debugger	14
4.2 Method for Measuring the Current Consumption.....	15
4.2.1 How to Open the [Measuring Current Consumption (QE)] View.....	15

- 4.2.2 Description of the [Measurement Condition Settings] Dialog Box..... 16
- 4.3 Setting Trigger Conditions for Measuring the Current Consumption..... 20
 - 4.3.1 Use Case (1) Abnormal Current: Equal to or Greater than the Specified Level 22
 - 4.3.2 Use Case (2) Abnormal Current: Current Increase for a Short Period in Low Power Consumption Mode 22
 - 4.3.3 Use Case (3) Abnormal Current: Equal to or Longer than the Specified Time 23
- 4.4 Setting Monitoring Points 24
 - 4.4.1 Setting Monitoring Points 24
 - 4.4.2 Link between Monitoring Point and Program 27
- 4.5 Setting the [Current Consumption Measurement Search] Dialog Box..... 28
- 4.6 Setting External Trigger Input and Output 30
- 5. Usage Notes31
 - 5.1 Correspondence between the E2's Extended Functions and Other Debugging Functions 31
 - 5.2 When Measuring the Current Consumption is Not Possible..... 32
 - 5.3 Power Supply..... 32
 - 5.4 Monitoring Point..... 32
 - 5.4.1 Cases in Which Monitoring Points Cannot be Used 32
 - 5.4.2 Setting Monitoring Points 32
 - 5.4.3 Effect of Monitoring Points on User Programs..... 33
 - 5.4.4 Times of Monitoring Points..... 33
 - 5.5 External Trigger Output..... 34
 - 5.6 Break by Condition for Measuring the Current Consumption 34
 - 5.7 Operation during Execution of the User Program 35
 - 5.8 Display on the PC during Measurement of Current..... 35
 - 5.9 Waveform of the Measured Current 35
 - 5.10 Waveform of Measured Current Drawn when a Condition for the Acquisition of Current Values is in the Range of the Monitoring Points 35
 - 5.11 Measuring the Current Consumption 35
 - 5.12 Difference between the Measurement Result of Current Consumption and the Ammeter36
 - 5.13 Other Characteristics of Measurement Result of Current Consumption 38

Configuration of Manuals

The documents related to the current consumption tuning solution, which is an extended function of the E2, consist of the following.

- E2 Emulator User's Manual
- E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User's Manual
- User's manual and help for the emulator debugger
- Application Note for the Current Consumption Tuning Solution for RX Family (E2 Emulator, e² studio) (this document)

(1) E2 Emulator User's Manual (document No.: R20UT3538)

The E2 emulator user's manual has the following contents:

- Components of the E2 emulator
- Hardware specifications of the E2 emulator
- Connection to the E2 emulator and the host machine and user system

(2) E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User's Manual (RX User System Design)

Target device: Device in the RX family (document No.: R20UT0399)

The E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User's Manual (RX User System Design) describes information necessary for connection of the E2 emulator to the user system, user resources, and notes on using the emulator.

(3) User's manual and help for the emulator debugger

The user's manual and help for the emulator debugger describe the functions of the E1/E20/E2/E2 Lite emulator debugger and the operating instructions.

Refer to the following.

- Help for the e² studio

When using C-SPY made by IAR Systems, also refer to "IAR C-SPY Hardware Debugger System User Guide issued by IAR Systems" published by IAR Systems.

(4) Application Note for the Current Consumption Tuning Solution for RX Family (E2 Emulator, e² studio) (this document)

The Application Note for the Current Consumption Tuning Solution for RX Family (E2 Emulator, e² studio) covers how to measure current consumption and usage notes.

Terminology

Some specific words used in this user's manual are defined below.

Integrated development environment

This tool provides powerful support for the development of embedded applications for Renesas microcomputers. It has an emulator debugger function allowing the emulator to be controlled from the host machine via an interface. Furthermore, it permits a range of operations from editing a project to building and debugging it to be performed within the same application. In addition, it supports version management.

Emulator debugger

This means a software tool that is started up from the integrated development environment, and controls the emulator and enables debugging.

Host machine

This means a personal computer used to control the emulator.

Target device

This means the device to be debugged.

User system

This means a user's application system in which the device to be debugged is used.

User program

This means the application program to be debugged.

User system interface

This means an interface that connects the target device to the E2 emulator.

SCP

This is an abbreviation of "self-checking program".

Extended function of the E2

This means an extended function which is provided with the E2 emulator.

E2 expansion interface

This means the interface required for extended functions of the E2 emulator.

OCD

This means on-chip debugging.

1. Overview

This chapter introduces the features of the current consumption tuning solution using the E2 emulator. This solution can be used in cases as follows:

- To perform development being conscious of current consumption from the software design phase
- To confirm the current consumption without remodeling the board
- To isolate software causes from hardware causes for points of unexpected amount of current consumption
- To investigate what causes the current consumption to be larger than the expectation

(1) Feature 1: "Easy measurement" with an E2 emulator alone

Power is supplied from the E2 emulator to the user system and current drawn by the user system can be easily measured (hereafter, referred to as measuring the current consumption).

Remodeling, such as applying a pattern cut or inserting a shunt resistance to the board of the user system is unnecessary. Alteration of the user program is also unnecessary.

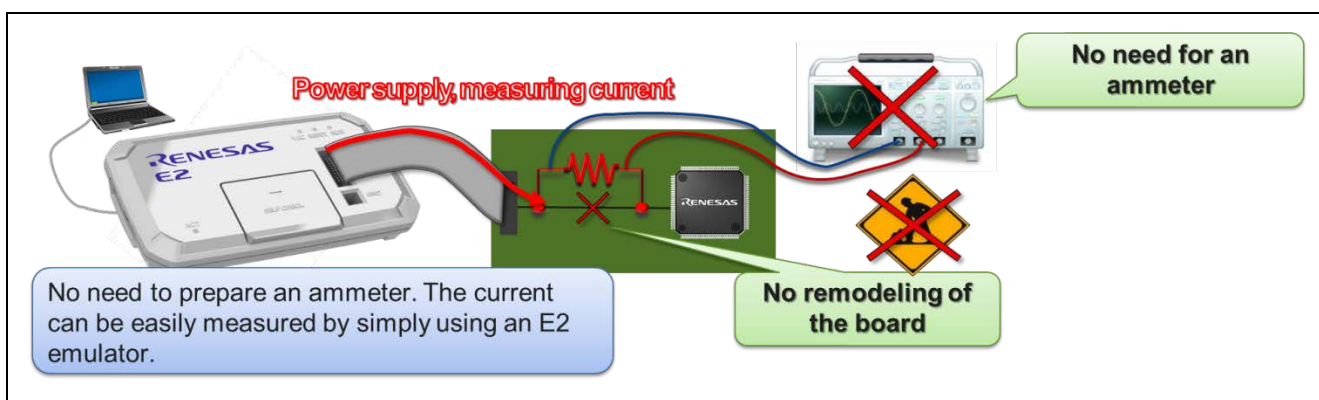


Figure 1-1 Easy Measurement

(2) Feature 2: "Automatic detection" of an excessive current

A current value and time can be specified in combination as various trigger conditions to detect changes in current consumption. The user program can be stopped or an external trigger can be output when a trigger condition is satisfied.

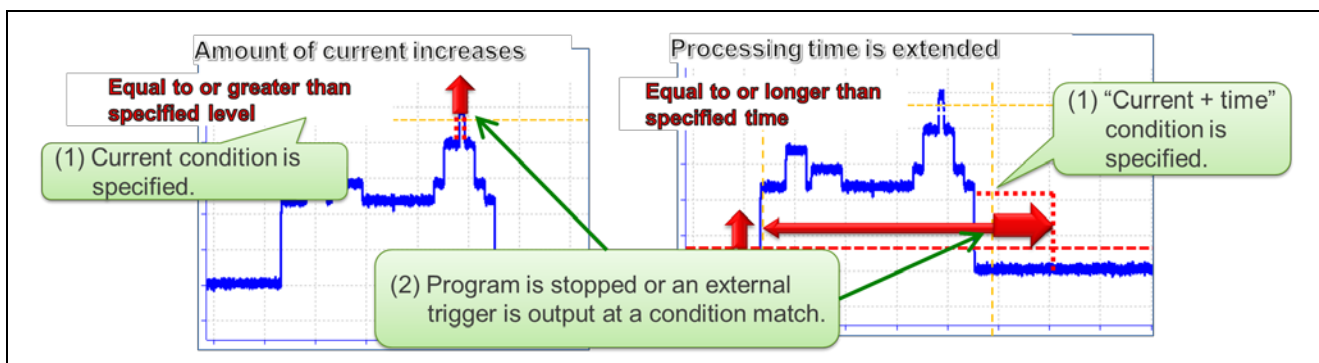


Figure 1-2 Automatic Detection

(3) Feature 3: "Quick analysis" of point of increased current

The current waveform and user program can be easily associated by setting monitoring points in the user program.

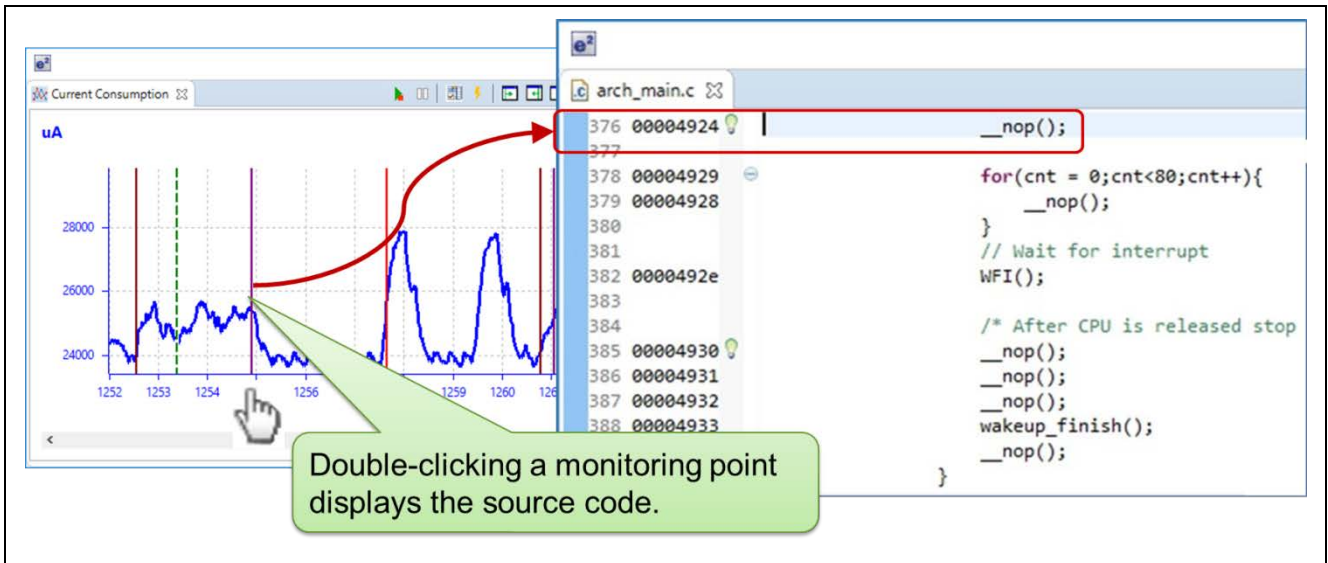


Figure 1-3 Quick Analysis

2. Description of Functions

The performance or specifications of the main functions used by the current consumption tuning solution using the E2 emulator are shown.

2.1 Measuring the Current Consumption

The specifications of the functions for measuring the current consumption are shown in the table below.

Table 2-1 Specifications for Measuring the Current Consumption

Item	Specification
Target MCUs	RX100/RX200 series
Monitoring point	Power supplied from the user system interface or power supplied from the E2 expansion interface
Supply voltage that can be measured	1.8 V to 5.0 V, Max. 200 mA Note however that the supply voltage during user program execution cannot be changed while measuring the current consumption.
Maximum current consumption that can be measured	Max. 200 mA
Resolution of current consumption	80 uA
Sampling time and maximum time that can be measured	Sampling: 1.06 us, measurement time: approx. 1 s
	Sampling: 2 us, measurement time: approx. 2 s
	Sampling: 5 us, measurement time: approx. 5 s
	Sampling: 10 us, measurement time: approx. 10 s
	Sampling: 20 us, measurement time: approx. 20 s
	Sampling: 50 us, measurement time: approx. 50 s
	Sampling: 100 us, measurement time: approx. 100 s
	Sampling: 200 us, measurement time: approx. 200 s
	Sampling: 500 us, measurement time: approx. 500 s
Recorded data	Timestamp + Amount of current consumption
Timestamp	Counting source of 8.3 ns (120 MHz)
Recording mode	The following three recording modes are supported. <ul style="list-style-type: none"> • After the recording memory is full, execution is continued and the memory is overwritten from the earliest values. • Recording stops after the recording memory is full. • The program is stopped after the recording memory is full.
Saving the recorded data	Recorded data can be saved in the CSV format.
Acquisition condition	<ul style="list-style-type: none"> • Data is acquired at all times. • Data is acquired only during the active-level period by an external trigger. • Data is acquired only during the period from an acquisition start event of a monitoring point to an acquisition end event.
Trigger condition	<ul style="list-style-type: none"> • Current condition: Equal to or more, equal to or less, inside of a range, outside of a range • Time condition: Equal to or longer, inside of a range
Specification of behavior when a trigger condition is satisfied	<ul style="list-style-type: none"> • Program is stopped • External trigger output (level/pulse)

2.2 Monitoring Point

The specifications of monitoring points are shown in the following.

Table 2-2 Specifications of Monitoring Points

Item	Description	Remarks
Target MCUs	RX100/RX200 series	
Number of monitoring point	16 points	—
Locations which can be set as monitoring points	Addresses to which NOP instructions are allocated	—
Data recording	Total of Max. 2M points including the measurement result of current consumption	—
Recorded data	<ul style="list-style-type: none"> Timestamp information Monitoring point number 	—
Time during which the program is stopped when passing a monitoring point	Up to 193 cycles	Approx. 3.9 us at the rate (50 MHz) of the CPU clock
Acquisition condition for measuring the current consumption	The period between two monitoring points can be specified as the range for measuring the current consumption.	—
Occupied user resource	There are occupied user resources.	—
RAM	256 bytes from the last address of RAM	Example (device with 64 Kbytes of RAM): 0x0000FF00 to 0x0000FFFF If there are multiple RAM areas, this is the 256 bytes from the last address of RAM area which starts with address 0.
ISP	24 bytes	—

2.3 External Trigger Input and Output Functions

2.3.1 Specifications of the External Trigger Inputs and Outputs

Table 2-3 Specifications of the External Trigger Inputs and Outputs

Target MCUs	RX100/RX200 series
Input signal channels	E2 expansion interface: 2 (ch. 0: pin 11, ch. 1: pin 12)
Output signal channels	E2 expansion interface: 2 (ch. 0: pin 9, ch. 1: pin 10)
Voltage of the E2 expansion interface	<ul style="list-style-type: none"> When power is being supplied from the emulator <ul style="list-style-type: none"> If the user interface is selected: VCC voltage If the E2 expansion interface is selected: Supplied voltage (1.8 V to 5.0 V) When the power is not being supplied from the emulator: VCC voltage
Conditions for detecting an external trigger input	<ul style="list-style-type: none"> Detecting edges (rising, falling, or both) Detecting a level (low or high)
Operation during the input of an external trigger	<ul style="list-style-type: none"> Break Recording the data from measuring the current consumption while the low or high level is being input
Input characteristics	VIH: $0.7 \times$ E2 expansion interface voltage, VIL: $0.3 \times$ E2 expansion interface voltage
From the detection of a condition for an external trigger input being satisfied until the user program is stopped	At FINE bit rate of 2 Mbps: approx. 60 us At FINE bit rate of 250 Kbps: approx. 400 us
Condition for detecting an external trigger output	Detecting a break or a trigger condition for measuring the current consumption
Operation during the output of an external trigger	<ul style="list-style-type: none"> When a break is detected, a low- or high-level pulse is output (the pulse width can be set to times in the range from 1 μsec to 65535 μsec). When a trigger condition for measuring the current consumption is detected, a high-level pulse is output (the pulse width can be set to times in the range from 1 μsec to 65535 μsec). Otherwise, a high level is output while a condition is being satisfied.
Output characteristics	VOH: E2 expansion interface voltage: -0.1V, VOL: 0.1V (@ Io = 100 uA)
Output delay	Max. 100 ns from condition satisfaction to pulse output

2.3.2 Assignments of the External Trigger Input and Output Pins

The following figure and table show the assignments of the external trigger input and output pins for the E2 expansion interface.

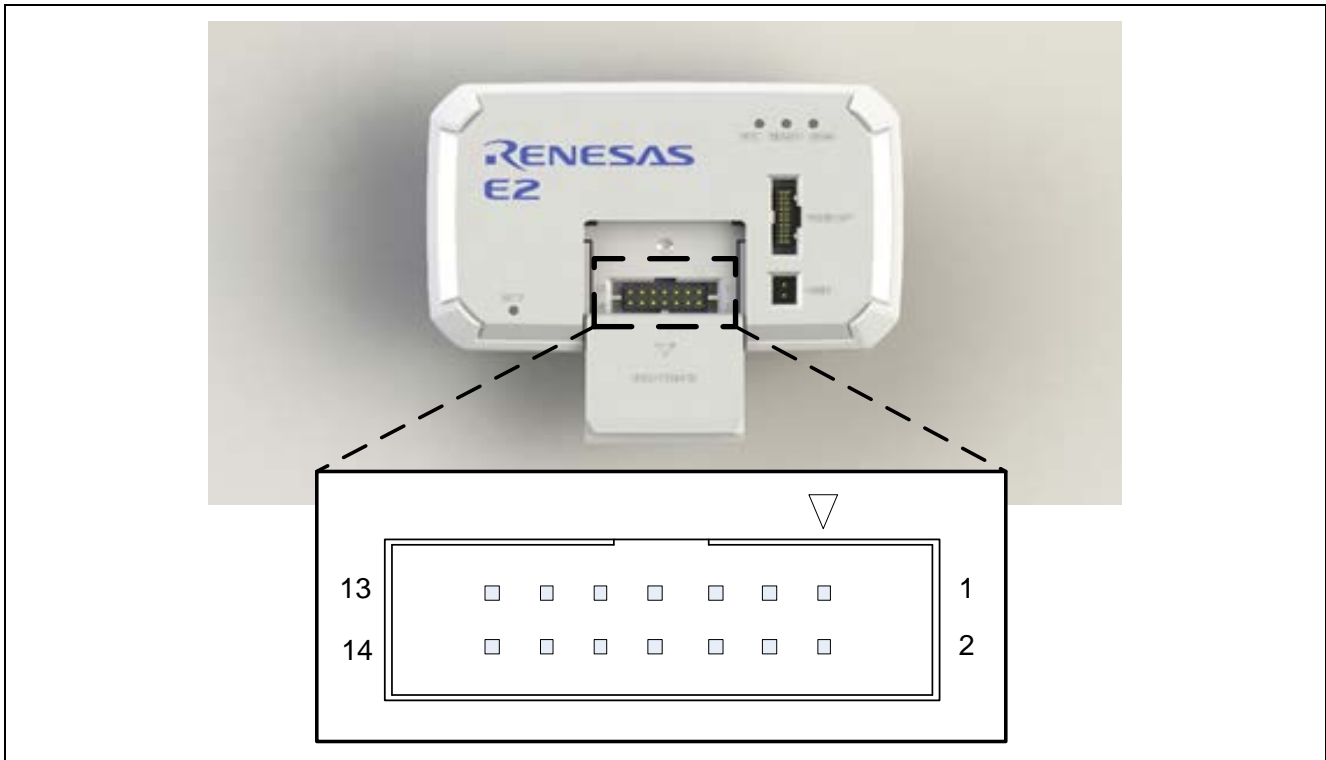


Figure 2-1 E2 Expansion Interface

Table 2-4 Assignments of the External Trigger Input and Output Pins for the E2 Expansion Interface

Pin No.	Input/Output	Description
1	-	Pin Nos. 1 to 8 are not used. These pins must be left open-circuit.
2	-	
3	-	
4	-	
5	-	
6	-	
7	-	
8	-	
9	Output	External trigger output (ch. 0)
10	Output	External trigger output (ch. 1)
11	Input	External trigger input (ch. 0)
12	Input	External trigger input (ch. 1)
13	-	GND
14	Output	A pin for output of the power-supply voltage for the E2 expansion interface (1.8 V to 5.0 V)

3. Setup

The setup procedure is given below.

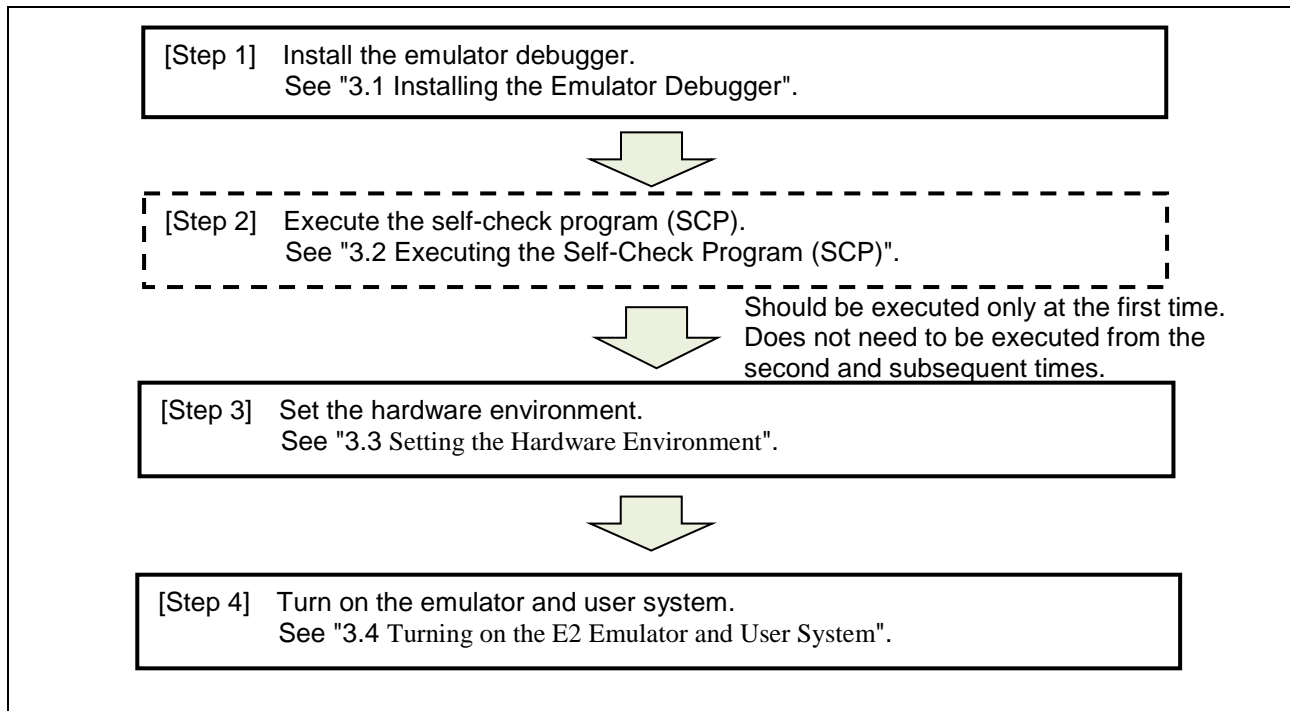


Figure 3-1 Setup Procedure

3.1 Installing the Emulator Debugger

If you are using the E2 emulator, download and install the latest integrated development environment from the following Web site.

<https://www.renesas.com/e2-download>

3.2 Executing the Self-Check Program (SCP)

The self-check program (SCP) must be executed when using an E2 emulator for the first time.

Parameters are written to for correcting the errors in measuring the current consumption. The next time when executing an E2 emulator for which the SCP has been executed once, the SCP does not have to be executed.

For the method of executing the SCP, refer to Appendix A in the E2 Emulator User's Manual (document No.: R20UT3538).

3.3 Setting the Hardware Environment

- System configuration when power is supplied from a power supply pin of the user system interface
 Assumed usage: The assumed system debugged the user system with the single power voltage supplied from the emulator up to now. The current can be measured as is with the conventional usage method.

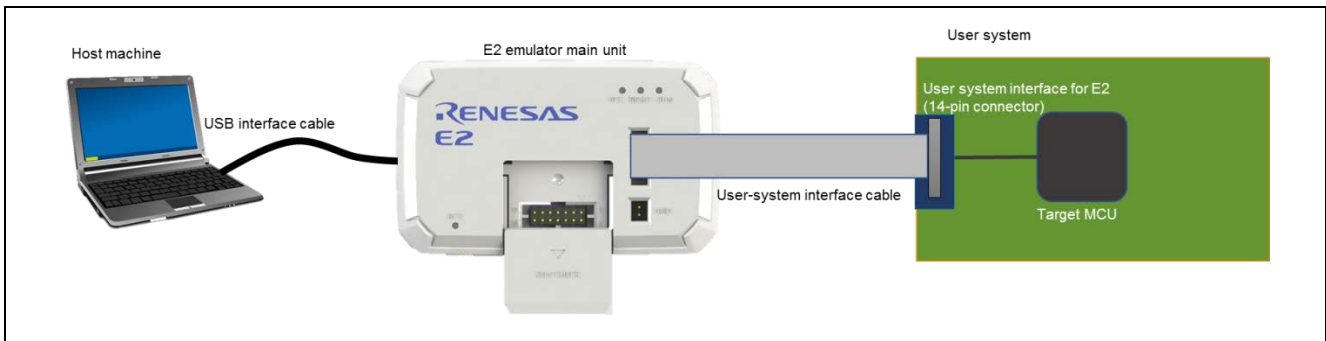


Figure 3-2 System Configuration Example (1)

- System configuration when power is supplied from pin 14 of the E2 expansion interface
 Assumed usage: The assumed system debugged the user system with the multiple power voltages (e.g., 5.0 V and 3.3 V) on the board using a power supply, such as a battery or AC adapter. Power can be supplied from the E2 expansion interface instead of a battery or AC adapter, and that current can be measured.

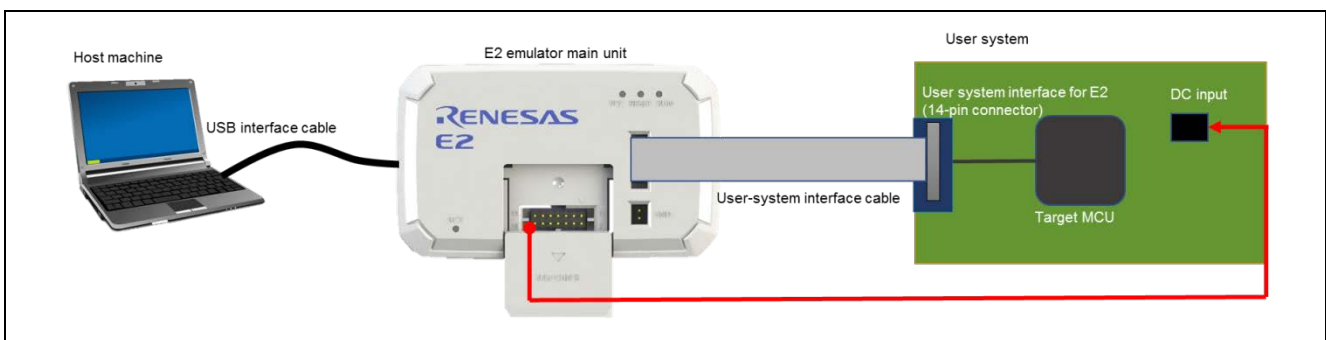


Figure 3-3 System Configuration Example (2)

3.3.1 Pin 11 of the User Interface

When using the current consumption tuning solution of the E2, pin 11 of the user interface (14-pin connector) is a CMOS output from the emulator rather than Hi-Z. Check the following conditions before use.

- (1) When programming flash memory via an SCI

Connect pin 11 to the RxD1 pin of the 14-pin connector.

When using the current consumption tuning solution of the E2, the MCU peripheral functions of the pin which is connected to pin 11 are not available. Set the MCU peripheral function to “input”, and do not use the given peripheral function of the MCU.

If you need to use the given MCU peripheral function, you cannot use the current consumption tuning solution of the E2, since doing so may lead to contention between signals and breakdown.

- (2) When not programming flash memory via an SCI

Leave pin 11 of the 14-pin connector open-circuit.

You can use the current consumption tuning solution of the E2 and program flash memory via the FINE interface.

3.3.2 Connecting the E2 Emulator to the User System

Connect the E2 emulator to the user system with the user-system interface cable.

Set the switch on the 20-pin (1.27-mm pin spacing) to 14-pin (2.54-mm pin spacing) connector conversion adapter to position “1”.

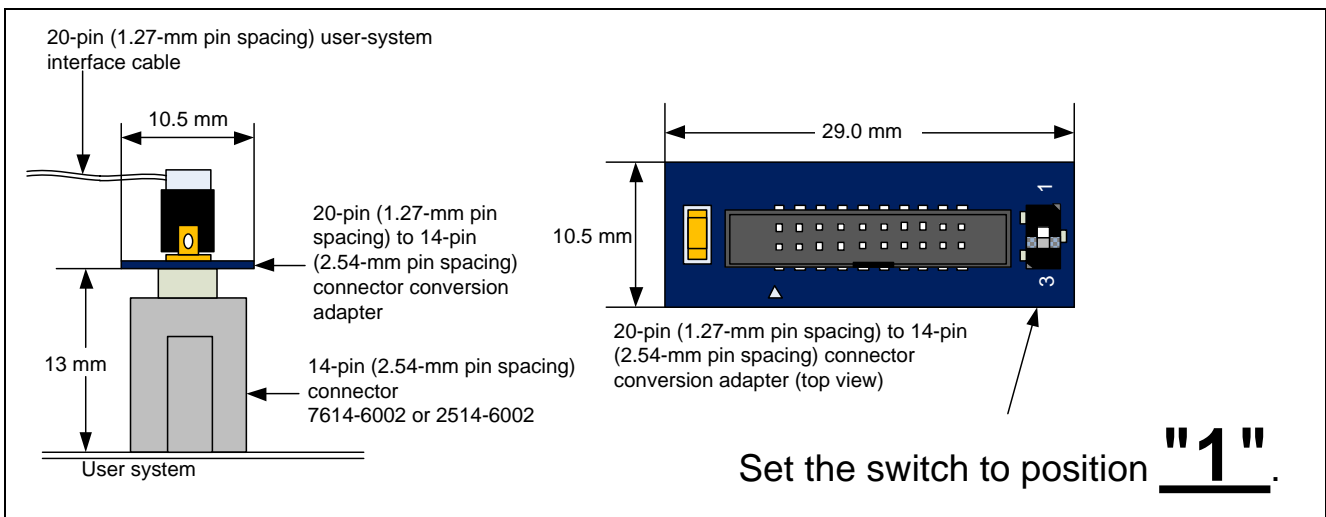


Figure 3-4 Connecting the User-System Interface Cable to the 14-Pin Connector

When power is supplied from pin 14 of the E2 expansion interface, connect it to the DC power input line of the user system.

When the external trigger input and output function is used, connect the pin to be used.

3.4 Turning on the E2 Emulator and User System

1. Connect the A plug of the USB interface cable to the USB interface connector of the host machine.
2. Connect the mini-B plug of the USB interface cable to the USB interface connector of the E2 emulator. The power of the E2 emulator is turned on by connecting the emulator to the host machine with a USB interface cable.
3. Start the emulator debugger and select the method for supplying power to the user system. Power supply to the user system is started when it is connected to the E2 emulator.

4. Method for Using the Emulator Debugger

4.1 Setup when Starting the Emulator Debugger

(1) Connection settings

Make the following settings in [Connection with Target Board] on the [Connection Settings] tabbed page.

- [Power Target From The Emulator]: [Yes]
- [Power Target via]
 - When power is supplied from a power supply pin of the user system interface: [User Interface]
 - When power is supplied from a power supply pin (pin 14) of the E2 expansion interface: [E2 Expansion Interface]
- [Supply Voltage]: Any voltage from 1.8 V to 5.0 V

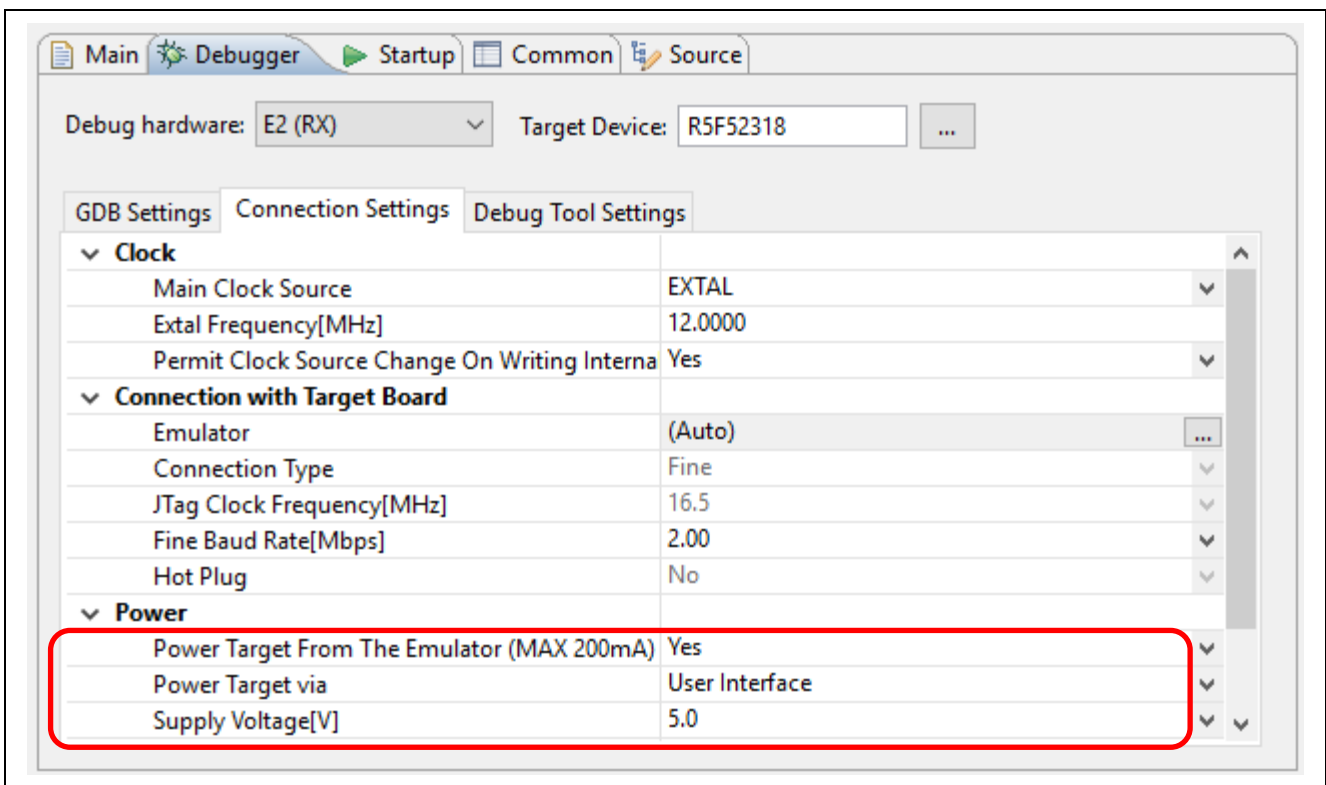


Figure 4-1 Connection Settings of E2 Emulator Debugger

(2) Connection of emulator debugger

Power supply to the user system is started when the emulator debugger is connected to the E2 emulator.

4.2 Method for Measuring the Current Consumption

4.2.1 How to Open the [Measuring Current Consumption (QE)] View

(1) From the [Renesas Views] menu, select [Renesas QE], and click on [Measuring Current Consumption (QE)].

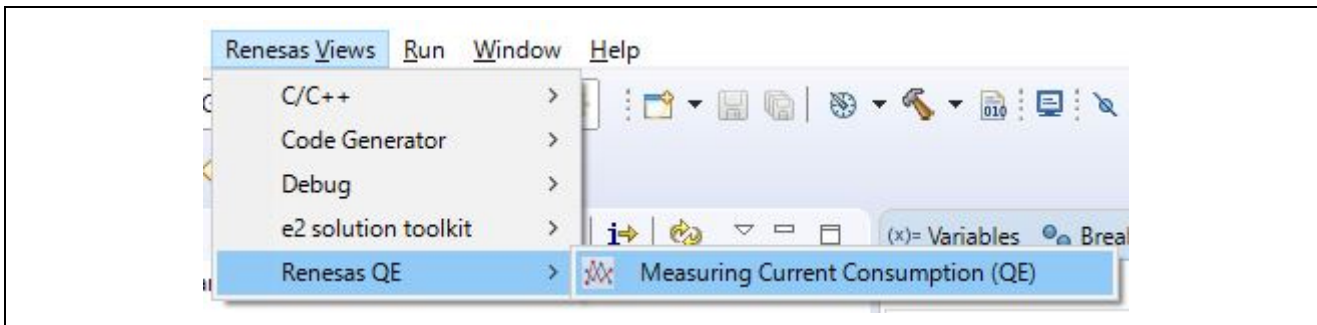


Figure 4-2 Opening the [Measuring Current Consumption (QE)] View

(2) After the [Measuring Current Consumption (QE)] view appears, click on the button for enabling measuring the current consumption to enable measurement.



Figure 4-3 Enabling Measuring the Current Consumption

4.2.2 Description of the [Measurement Condition Settings] Dialog Box

(1) Open the [Measurement Condition Settings] dialog box.



Figure 4-4 Opening the [Measurement Condition Settings] Dialog Box

(2) Make settings for measuring the current consumption.

A screenshot of the 'Current Consumption Acquisition' dialog box. The 'Monitoring Mode' dropdown is set to 'Stop program when full'. The 'Sampling Rate[us]' dropdown is set to '1'. Under 'Acquisition Term', the 'Acquire all data' radio button is selected. The 'While signal' option is partially visible with 'L' in a dropdown and 'is inputted' text. The 'from the external trigger' dropdown is set to 'ch0'. There are empty dropdowns for 'From fetching' and 'to fetching'. 'OK' and 'Cancel' buttons are at the bottom.

- [Monitoring Mode]
Select from [Fill until stop], [Fill until full], or [Stop program when full].
- [Sampling Rate]
Select the sampling time from the pull-down menu. It can be selected from 1us, 2us, 5us, 10us, 20us, 50us, 100us, 200us, 500us, or 1000us.
Note: When "1us" is selected, the actual sampling time is 1.06 us.

Figure 4-5 Setting Conditions for Measuring the Current Consumption (1)

(3) Start measuring the current consumption.

Start measuring by clicking on the button for starting measurement in the [Measuring Current Consumption (QE)] view. The current consumption in the period from program execution to break occurrence will be measured.



Figure 4-6 Start of Measuring the Current Consumption

(4) Cursor and Marker

(a) Clicking on the button for showing the cursor displays the cursor (red vertical line).

The current value at the cursor location and the time are shown.

(b) Clicking on the buttons for showing markers A and B displays the markers (green vertical dashed lines).

The average current and maximum current of current consumption between markers A and B are shown.

The time at the locations of markers A and B and the time between markers A and B are also shown.

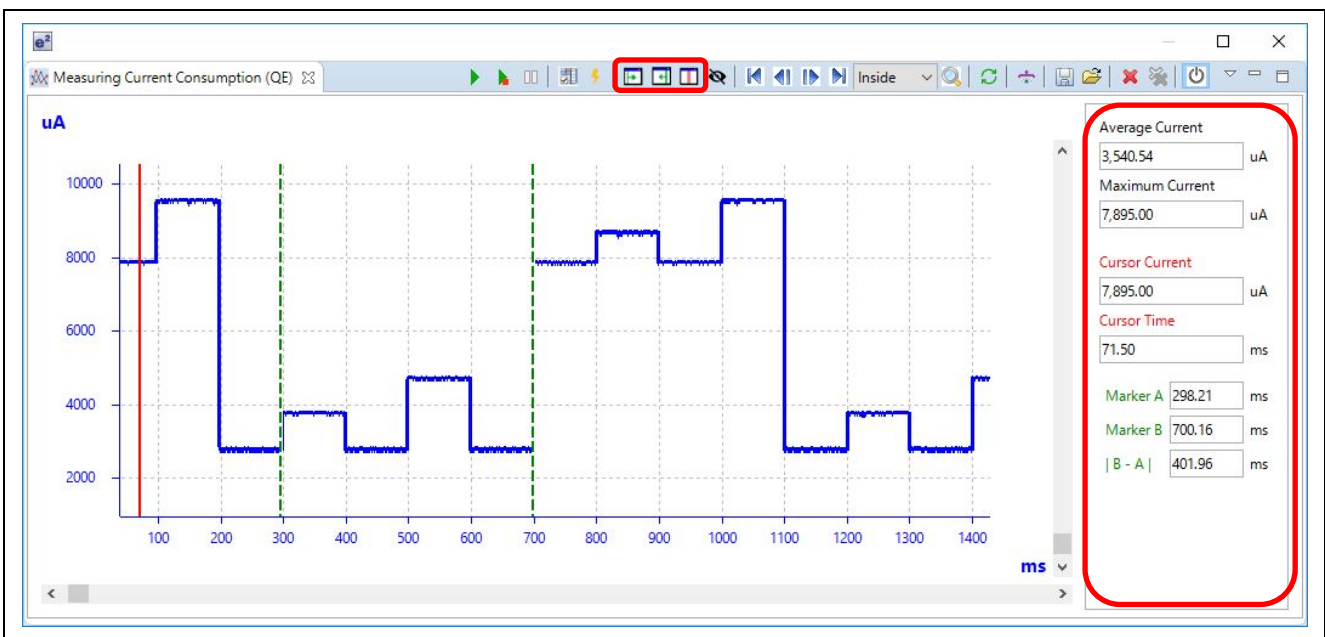


Figure 4-7 Cursor and Marker

(5) Adjusting the displayed waveform

- Zoom in: "Ctrl and +" keys
Zoom in of the X axis: "Ctrl and Right" keys, zoom in of the Y axis: "Ctrl and Up" keys
- Zoom out: "Ctrl and -" keys
Zoom out of the X axis: "Ctrl and Left" keys, zoom out of the Y axis: "Ctrl and Down" keys
- The waveform location can be adjusted by using the scrollbar.

(6) Saving and loading the measurement result

- (a) Clicking on the button for saving the measurement result in a file saves the measurement result in a CSV file.
Note: It may take time to save a large amount of recorded data.

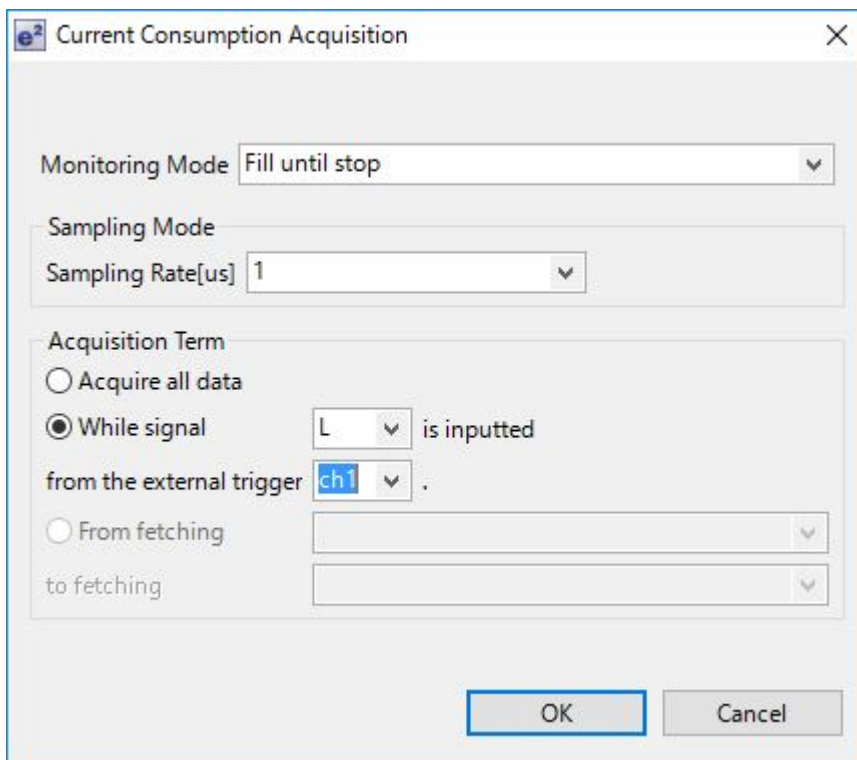
- (b) Clicking on the button for loading a file loads data of the saved measurement result.



Figure 4-8 Saving and Loading the Measurement Result of Current Consumption

(7) Other settings for measuring the current consumption

The conditions for acquiring the measurement result of current consumption can be set.



- [While signal x is inputted] of [Acquisition Term]
 - Select the active level for the external trigger input.
 - Select the channel to be used for external trigger input.
 - ch0: Connect pin 11 of the E2 expansion interface.
 - ch1: Connect pin 12 of the E2 expansion interface.
 - [From fetching]/[to fetching] of [Acquisition Term]
 - This can be used when two or more monitoring points have been set. The current consumption is measured between two points: monitoring point set as an event to start acquisition and monitoring point set as an event to end acquisition.
- Note: Though current consumption is measured only between monitoring points, a straight line connecting two points in a blank period sometimes appears in the displayed graph.

Figure 4-9 Setting Conditions for Measuring the Current Consumption (2)

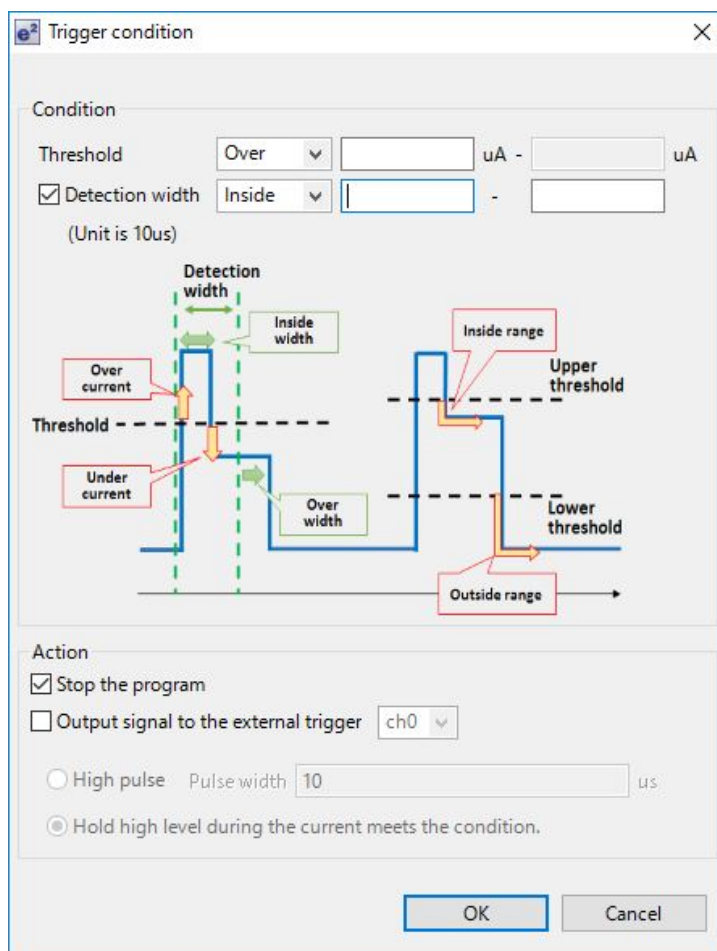
4.3 Setting Trigger Conditions for Measuring the Current Consumption

(1) Open the [Current Consumption Measurement Trigger Condition Setting] dialog box.



Figure 4-10 Opening the [Current Consumption Measurement Trigger Condition Setting] Dialog Box

(2) Set the threshold of current or time of detection width as trigger conditions, and also set the operation to be performed when detecting a condition was satisfied.



- [Threshold]
 - Select the condition for detecting current from [Over], [Under], [Inside], or [Outside].
 - If [Over] or [Under] is selected, set the threshold of current.
 - If [Inside] or [Outside] is selected, set the lower limit and upper limit of current.
- [Detection width]
 - Selecting the detection width adds the length of time during which the condition for current was detected to the condition.
 - Select [Over] or [Inside].
 - If [Over] is selected, set the upper limit of time.
 - If [Inside] is selected, set the lower limit and upper limit of time for the range.
 - The unit differs according to the sampling time.
- [Action]
 - Stopping the program or outputting an external trigger signal can be set.
 - Select the channel to be used for external trigger output.
 - ch0: Connect pin 9 of the E2 expansion interface.
 - ch1: Connect pin 10 of the E2 expansion interface.
 - Select the external trigger output signal from [High pulse] or [Hold high level during the current meets the condition].
 - When [High pulse] is selected, set the pulse width.

Figure 4-11 Setting Trigger Conditions

4.3.1 Use Case (1) Abnormal Current: Equal to or Greater than the Specified Level

This use case explains the method for setting a trigger condition to detect when the assumed maximum current is exceeded.

Select [Over] in [Threshold] as the trigger condition for current and set the current value to be detected.

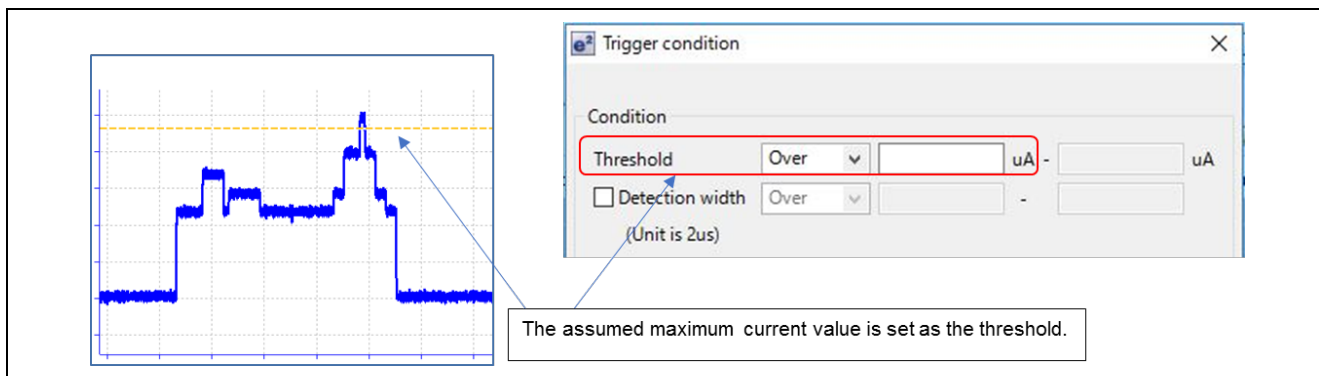


Figure 4-12 Use Case (1)

4.3.2 Use Case (2) Abnormal Current: Current Increase for a Short Period in Low Power Consumption Mode

This use case explains the method for setting a trigger condition to detect the increase in current for a short period in low power consumption mode which is caused by an unexpected external cause and not by the program of the target device.

- (1) Select [Over] in [Threshold] as the trigger condition for current and set a value greater than the current provided in low power consumption mode.
(Set a value with a margin because if the set value is too near the current value provided in low power consumption mode, false detection will occur.)

- (2) Select [Inside] in [Detection width] as the trigger condition for time. Set a time value within the width you want to detect as the upper limit of detection width. A time value of at least several dozens of microseconds is suitable for the lower limit in order to avoid false detection.

In the following example, current that increases abnormally but within the limit of 300 us is detected in low power consumption mode.

The point where a condition was satisfied is the single point where the current fell below the threshold within 300 us. Since the point where a condition was satisfied does not have any width, set [High pulse] for the output signal to the external trigger when using external trigger output.

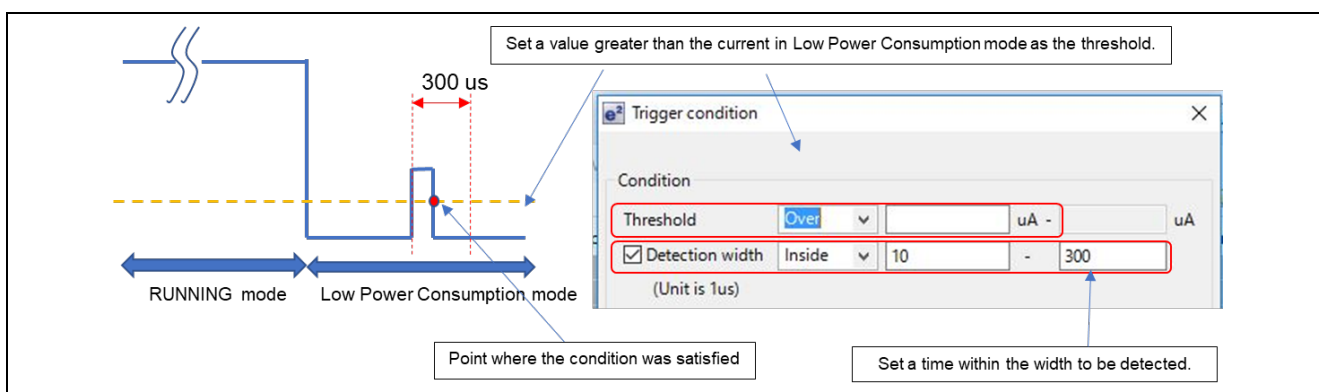


Figure 4-13 Use Case (2)

4.3.3 Use Case (3) Abnormal Current: Equal to or Longer than the Specified Time

This use case explains the method for setting a trigger condition to detect a point where the processing time is unintentionally extended and current is increased on the assumption that the same processing is repeated.

- (1) Select [Inside] in [Threshold] as the trigger condition for current and set the lower limit and upper limit so that the current consumption during the normal repetitive processing is kept inside of the range. Set a value with a margin to avoid false detection.
- (2) Select [Inside] in [Detection width] as the trigger condition for time.

Set a time value longer than the time required for the normal repetitive processing as the lower limit of detection width.

Set a value with a margin to avoid false detection.

Set a time value that will make processing end before the next repetitive processing is started as the upper limit of detection width.

In the following example, the normal repetitive processing takes 5 ms. Points where the processing time is abnormally extended to range between 6 ms and 10 ms will be detected.

The point where a condition was satisfied is the single point where the current being inside of the specified range continued for at least 6 ms but then it fell below the threshold without lasting for 10 ms. Since the point where a condition was satisfied does not have any width, set [High pulse] for the output signal to the external trigger when using external trigger output.

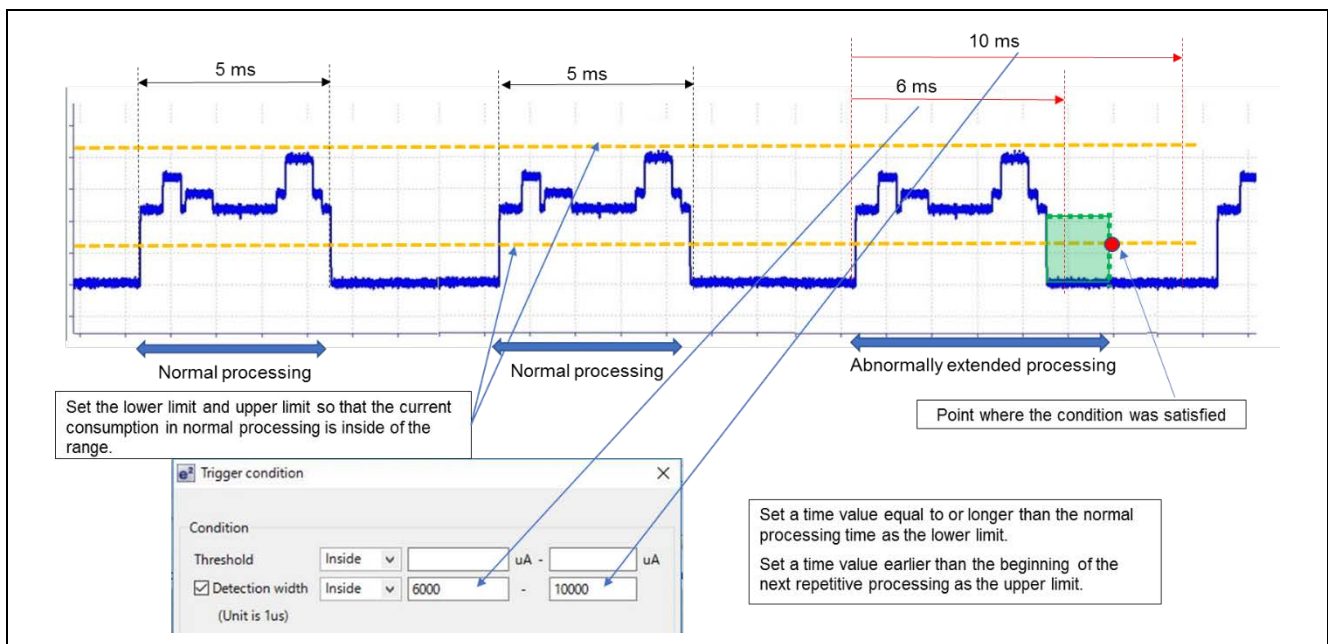


Figure 4-14 Use Case (3)

4.4 Setting Monitoring Points

4.4.1 Setting Monitoring Points

Up to 16 monitoring points can be set.

- (1) In the Editor view, move the mouse pointer to the left side (area where line number or PC is displayed) of a source line at which you want to set a monitoring point.
- (2) Click on [Toggle Monitor Point] in the menu that is displayed by right-clicking on the source code. A mark standing for a monitoring point will appear on the bar on the left of the source code.

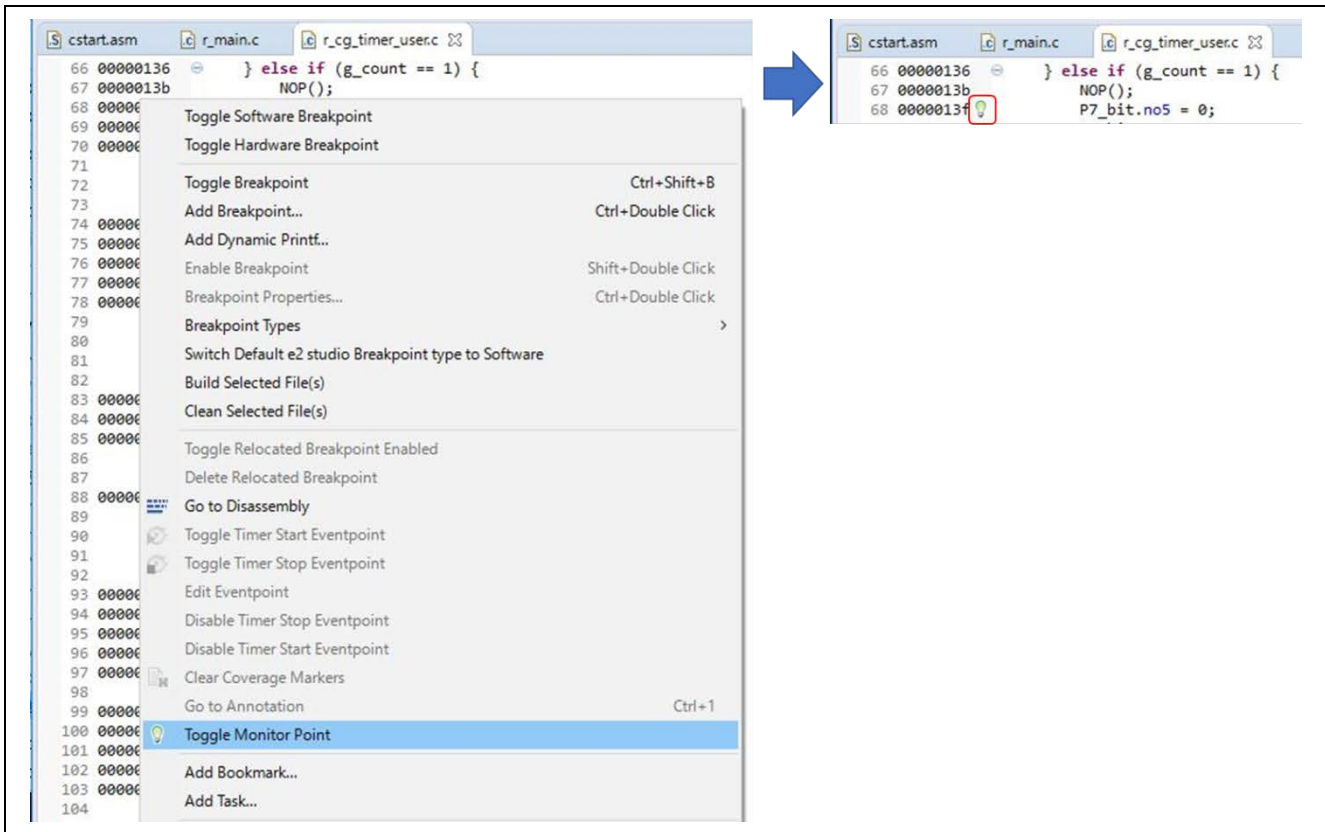


Figure 4-15 Setting Monitoring Points

(3) Deleting monitoring points

Click on the button for showing [Monitor Points table] to show a list of monitoring points.

Right-click on [Monitor Points table] and delete monitoring points by clicking [Delete Selected Monitor Point] or [Delete All Monitor Points].

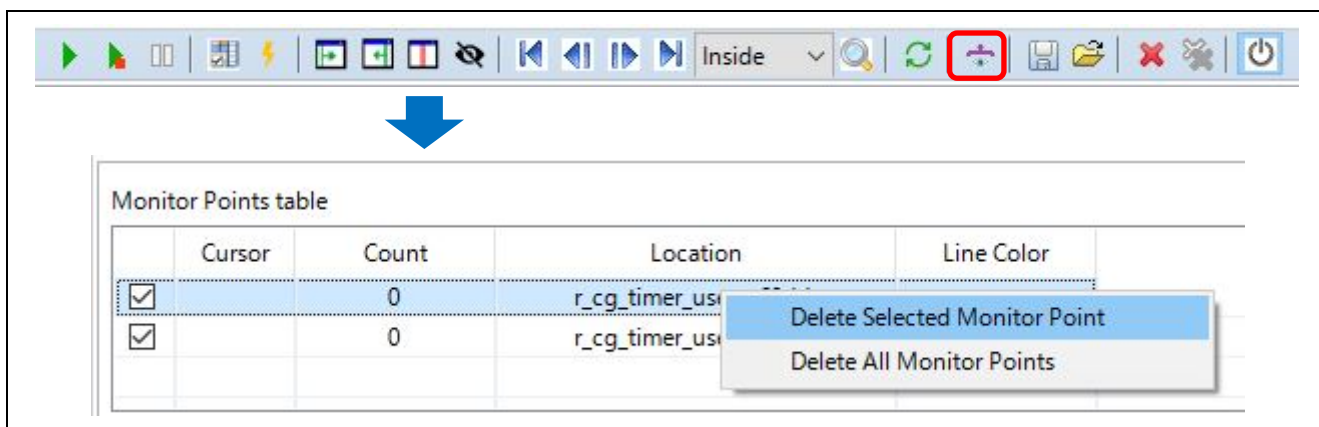


Figure 4-16 Deleting Monitoring Points

(4) Execution after monitoring points are set

- When using a version earlier than CC-RX compiler V2.08.00
Monitoring points can be set to only addresses in which the NOP instruction has been set.
- When using a version later than CC-RX compiler V2.08.00
The NOP instruction is automatically inserted at points to which monitoring points have been set.
At the first execution after setting or changing the monitoring points, execution needs to be started using the button for execution that includes build.
Note: This execution is performed after issuing a reset following "Rebuild & Download".



Figure 4-17 Execution with Build

At the second or subsequent execution without any monitoring points being set or changed, execution is started using the button for execution that does not include rebuild.



Figure 4-18 Execution without Rebuild

4.4.2 Link between Monitoring Point and Program

- (1) In the waveform of the measurement result of current consumption, a vertical line is shown at the time when a monitoring point was passed.
The amount of current consumption or the time when a monitoring point was passed can be confirmed using the cursor.
- (2) Double-clicking on a vertical line of a monitoring point shows the source code in which that monitoring point was set.

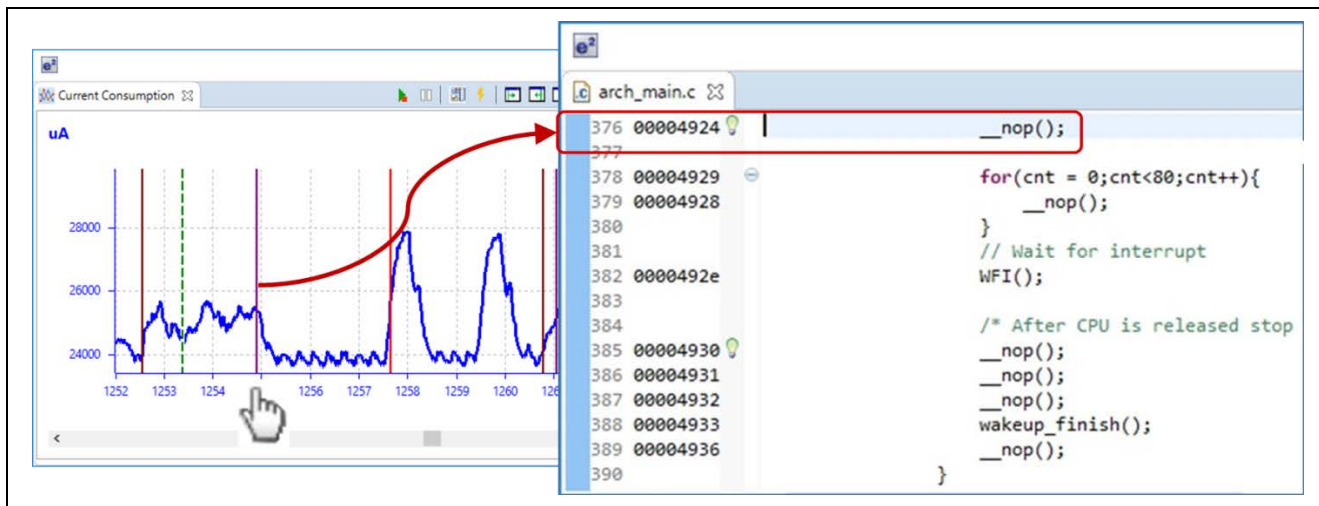


Figure 4-19 Link between Monitoring Point and Program

4.5 Setting the [Current Consumption Measurement Search] Dialog Box

(1) Open the [Current Consumption Measurement Search] dialog box.



Figure 4-20 Opening the [Current Consumption Measurement Search] Dialog Box

(2) Set the monitoring point, threshold of current, or time of detection width as searching conditions.

- [Monitor point]
 - Select [All] or a specific monitoring point as the monitoring points to be searched for.
- [Threshold]
 - Select the searching condition for current from [Over], [Under], [Inside], or [Outside].
 - If [Over] or [Under] is selected, set the threshold of current.
 - If [Inside] or [Outside] is selected, set the lower limit and upper limit of current.
- [Detection width]
 - Selecting the detection width adds the length of time during which the condition for current was satisfied to the condition.
 - Select [Over] or [Inside].
 - If [Over] is selected, set the upper limit of time. If [Inside] is selected, set the lower limit and upper limit of time for the range.
 - The unit differs according to the sampling time.

Figure 4-21 Setting Searching Conditions

Note: When [Inside] is set for the detection width, it may take time to search within a large amount of recorded data.

(3) Description of search buttons

Clicking on a search button moves the cursor to a location where a searching condition matches.

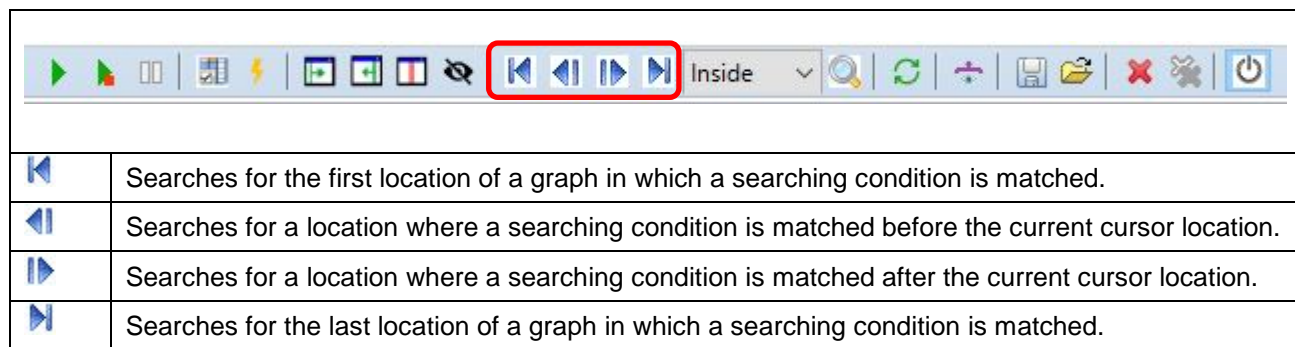


Figure 4-22 Description of Search Buttons

4.6 Setting External Trigger Input and Output

(1) Click on the button for setting the external trigger on the toolbar of the [Eventpoints] view.

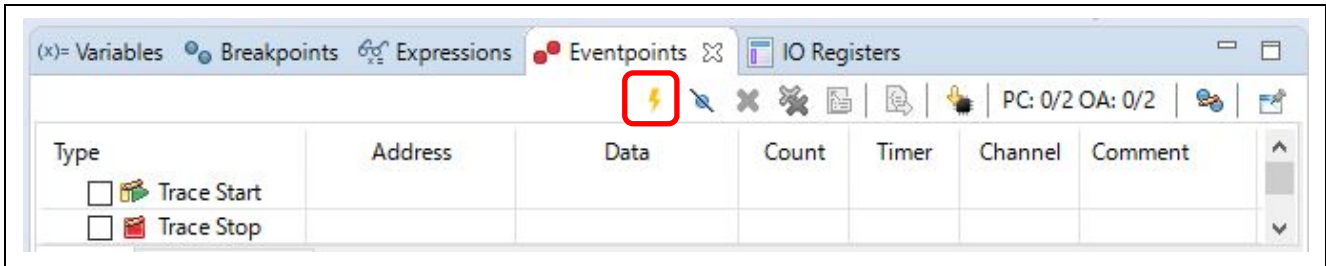


Figure 4-23 Opening the [External Trigger Input/Output Setting] Dialog Box

(2) Make settings for external trigger input and output.

- [Stop the program by input trigger]
 - Select the channel to be used for external trigger input.
ch0: Connect pin 11 of the E2 expansion interface.
ch1: Connect pin 12 of the E2 expansion interface.
 - Select [Rising Edge], [Falling Edge], or [Edges] for the edge condition to be detected.

- [Output signal from trigger by stop]
 - Select the channel to be used for external trigger output.
ch0: Connect pin 9 of the E2 expansion interface.
ch1: Connect pin 10 of the E2 expansion interface.
 - Select the width of the high pulse to be output. Set any value from 1 us to 65535 us.

Figure 4-24 Setting External Trigger Input and Output

5. Usage Notes

The usage notes for the current consumption tuning solution using the E2 emulator are given here.

5.1 Correspondence between the E2's Extended Functions and Other Debugging Functions

The possibility of combinations of the E2's extended functions and other debugging functions are shown in the table below.

Table 5-1 List of Possible/Impossible Combinations of the E2's Extended Functions and Debugging Functions

		E2's Extended Functions		
		Measuring Current	Monitoring Points	External Trigger Inputs and Outputs
Debugging functions other than the E2's extended functions	When the start/stop function is enabled.	√	X	√
	Standard I/O functions from the debugging console	X	X	√
	Debugging function for rewriting on-chip program ROM	√	X	√
	Supply of power to the E2 emulator by the user system (including when an isolator is in use).	X	X	√
	Other than the above	√	√	√

√: Available, X: Not available

5.2 When Measuring the Current Consumption is Not Possible

Measuring the current consumption cannot be performed when the setting for supplying power to the E2 emulator from the user system has been made. Relevant cases are shown below.

- Startup by the power of the user system
- Isolator is used

5.3 Power Supply

Voltage from 1.8 V to 5.0 V can be set as the power supply.

The supply voltage cannot be changed during user program execution while measuring the current consumption.

Though the supply voltage can be changed during user program execution by the E2 emulator, measuring the current consumption must be disabled when the change is made.

The supplied voltage becomes lower than the setting due to current consumption by the user system. Configure the supply voltage in consideration of such changes.

5.4 Monitoring Point

5.4.1 Cases in Which Monitoring Points Cannot be Used

(1) Monitoring points cannot be used when any of the following debugging functions is enabled.

- Start/Stop function
- Standard I/O functions from the debugging console
- Using the debugger to rewrite on-chip program ROM

5.4.2 Setting Monitoring Points

- Monitoring points can be set to only addresses in which the NOP instruction has been set.
 Note: When using a version later than CC-RX compiler V2.08.00, the NOP instruction is automatically inserted at points to which monitoring points have been set at build.
- Monitoring points might not be set when a version later than CC-RX compiler V2.08.00 is in use and is to automatically insert NOP instructions at the points where the monitoring points have been set.
 When a monitoring point could not be set, the address will not be displayed in the list of monitoring points.

Cursor	Count	Location	Line Color
<input type="checkbox"/>	0	r_cg_timer_user.c:190 (-)	

Figure 5-1 Example of Failure in Setting a Monitoring Point

To solve this problem, manually insert the NOP instruction and then set that location as a monitoring point.

- A software break cannot be set at an address which has been set as a monitoring point. If a monitoring point is set at an address at which an event break was set, the event break will occur.
- When setting multiple monitoring points or setting a software break after a monitoring point, the interval between them should correspond to at least the following times:
 - At FINE bit rate of 2 Mbps: approx. 40us
 - At FINE bit rate of 250 Kbps: approx. 280usIf the required interval is not secured, monitoring points might not be displayed.
- To change the HOCO frequency, switch the frequency of the HOCO before setting monitoring points or breaks after an interval of at least 1.1 sec.
 - If a monitoring point is encountered within 1.1 sec after the setting for HOCO frequency is changed, that point might be displayed with a delay on the [Measuring Current Consumption (QE)] view.
 - When a break occurs within 1.1 sec, the displayed results for measured current will be incorrect for 1.1 sec after the break.
 - If a break and a monitoring point are encountered within 1.1 sec, the monitoring point will not be displayed.If the interval is no more than 1.1 sec, place the break after changing the peripheral setting, then restart the measurement.

5.4.3 Effect of Monitoring Points on User Programs

The user program will be temporarily stopped when a monitoring point is encountered.

The period of the temporary stop is up to 193 operating clock cycles.
(Example: Max. 3.9 us with a 50-MHz operating clock)

5.4.4 Times of Monitoring Points

The time at which a monitoring point is displayed might not be correct in comparison with the actual timing.

At FINE bit rate of 2 Mbps: approx. 40us

At FINE bit rate of 250 Kbps: approx. 280us

5.5 External Trigger Output

After a trigger condition for measuring the current consumption is satisfied, there is a delay before the external trigger is output.

At pulse output: Max. 100 ns

At level output: Up to four times of sampling time (Max. 4 ms when the sampling time is 1 ms)

5.6 Break by Condition for Measuring the Current Consumption

After a trigger condition for measuring the current consumption is satisfied, there is a delay before the user program is stopped.

If [Stop program when full] is set for [Monitoring Mode] when setting measurement conditions, similarly there is a delay between recording being stopped due to recording memory becoming full and the user program being stopped.

The delay times are as follows.

At FINE bit rate of 2 Mbps: approx. 60 us

At FINE bit rate of 250 Kbps: approx. 400 us

5.7 Operation during Execution of the User Program

When the following operations proceed during the execution of the user program, the display of the time at which monitoring points are encountered might be delayed, or the measured values for current drawn might be higher or lower than the actual current. To obtain correct measured values for current drawn and the display of monitoring points with the right timing, avoid the following operations.

- Automatic updating or scrolling up and down of, or new registration in the memory view*
- Scrolling the disassembly panel up and down
- Setting or deleting events

* Regarding how to disable automatic updating of the memory view, refer to the help system for the e² studio.

5.8 Display on the PC during Measurement of Current

The display on the PC cannot be updated while current is being measured.

5.9 Waveform of the Measured Current

The value for current shown on the waveform display in the [Measuring Current Consumption (QE)] view during a break is the current immediately before execution of the user program starts.

After the user program has been stopped by a software or event break, the value during the break is displayed.

5.10 Waveform of Measured Current Drawn when a Condition for the Acquisition of Current Values is in the Range of the Monitoring Points

When an event to start or end the acquisition of values for current is selected as a monitoring point, a time lag occurs between the actual time the current value is obtained and the time the monitoring point is shown in the [Measuring Current Consumption (QE)] view.

The following are the delay times from a monitoring point that starts (or terminates) the measurement of current until the value obtained is reflected in the current waveform.

At FINE bit rate of 2 Mbps: approx. 40 us

At FINE bit rate of 250 Kbps: approx. 280 us

5.11 Measuring the Current Consumption

The current consumption tuning solution using the E2 emulator is an easy method for measuring the current with the aim of efficiently tuning the dynamically changing current drawn by the user system. This is done by linking display of the measurement result with that of program operation of the target device. It is not a function suitable for measuring the current consumption with high accuracy.

The current measured by the E2 emulator will differ from the current drawn by the original user system due to the following causes.

- Increase in current consumption associated with debugging communication with the E2 emulator
Reference value: Increased by approximately 1.1 mA at 5.0 V when the value of the pull-up resistor on the FINED line is 4.7 k Ω
- Increase in current consumption caused by the target device operating in OCD mode
The amount of increase differs depending on the target device type, operating frequency, operating voltage, and operating mode.
Reference value: Increased by approximately 0.4 mA in the case of RX231 (R5F52318), 32.768 KHz, 3.3 V, sleep mode

Difference associated with response characteristics for current changes (filtering characteristics on current-measuring circuit)

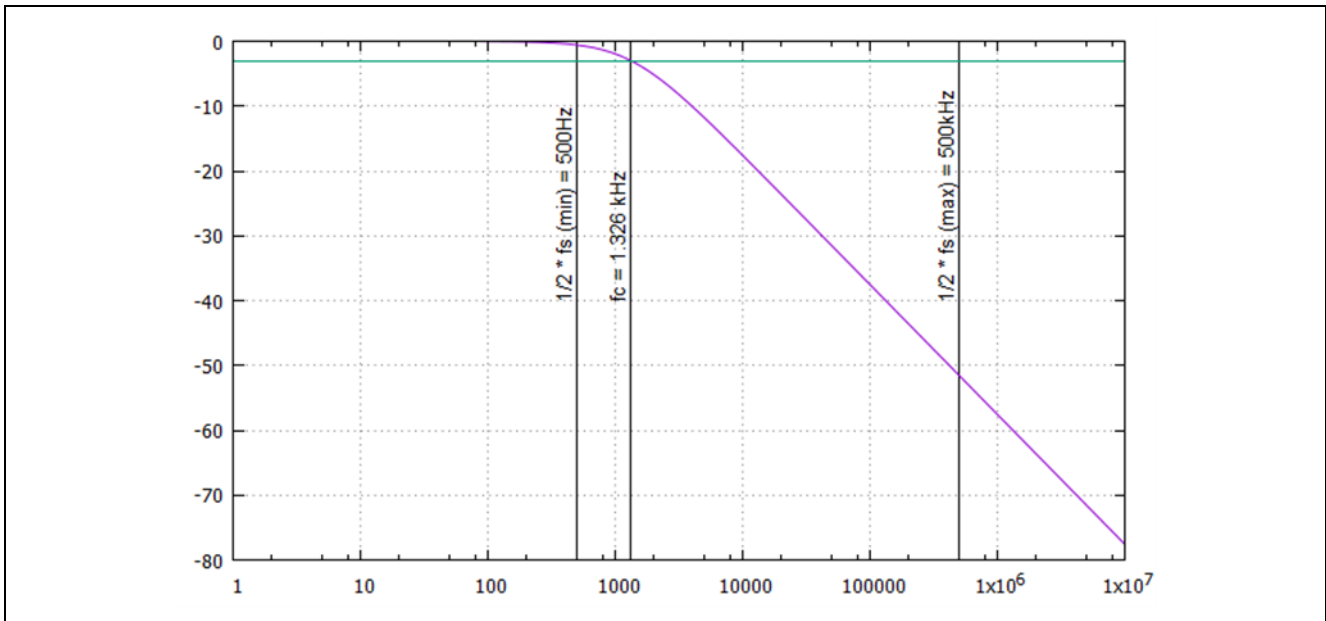


Figure 5.2 Characteristic of Response to Changes in Current

5.12 Difference between the Measurement Result of Current Consumption and the Ammeter

The following graph is a plot of the difference between the results for current measured by the E2 emulator and by an ammeter when power is being supplied from a power supply pin of the user system interface.

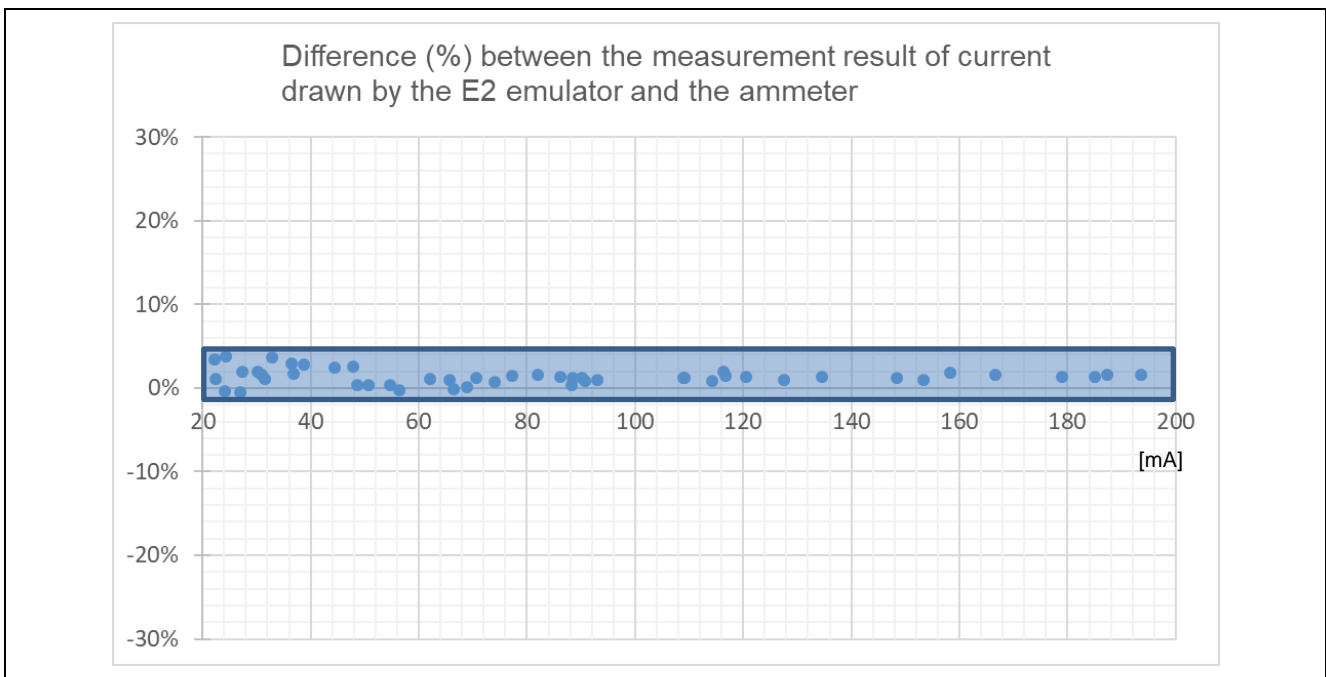


Figure 5-3 Difference between the Measurement Result of Current Consumption and the Ammeter (1)

For current consumption within the range from 20 mA to no greater than 200 mA, the difference between the results from the ammeter and the E2 emulator is a mere -2% to +5%.

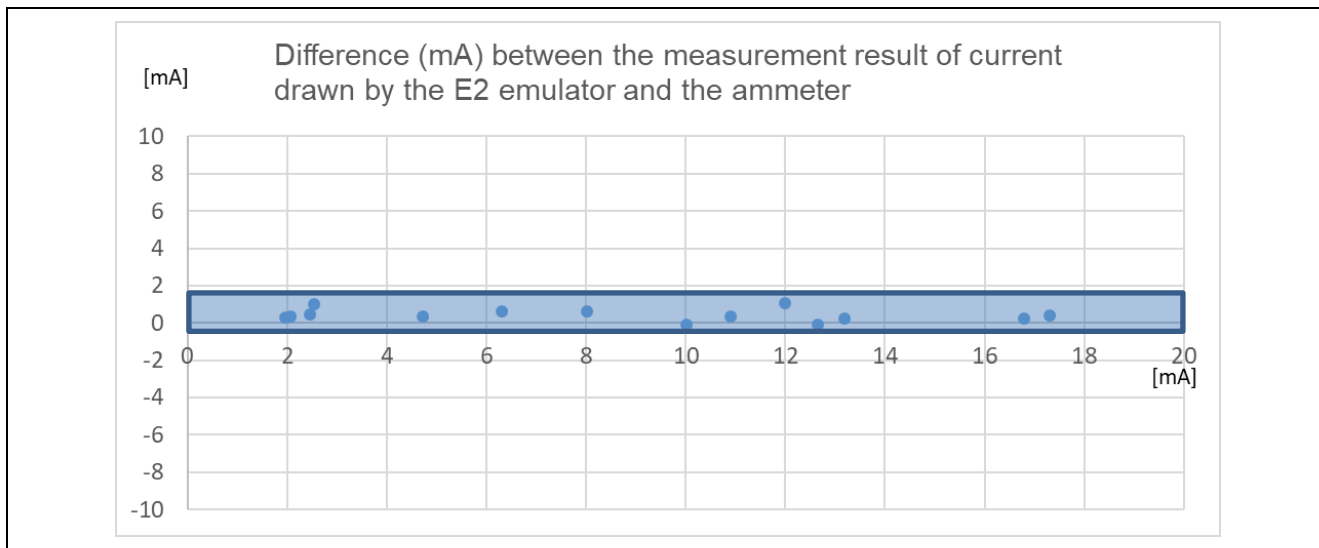


Figure 5-4 Difference between the Measurement Result of Current Consumption and the Ammeter (2)

For current consumption within the range from 0 mA to no greater than 20 mA, the difference between the measurement results from the ammeter and the E2 emulator is a mere -0.5 mA to +1.5 mA.

5.13 Other Characteristics of Measurement Result of Current Consumption

(1) Fluctuation caused by a noise in AC power supply

Fluctuation that was caused by a noise in the AC power supply is sometimes visible in the measurement result of current consumption. Reinforce each ground with the ground potential of the host machine and the ground potential of the user system kept at the same potential.

(2) Variation in measurement results of current consumption

Variation is sometimes visible in the waveform of measured current consumption. This is caused by the measuring circuit of current consumption in the E2 emulator, and it does not indicate that variation has occurred in the current consumption by the actual user system.

The degree of variation is a mere ± 0.5 mA.

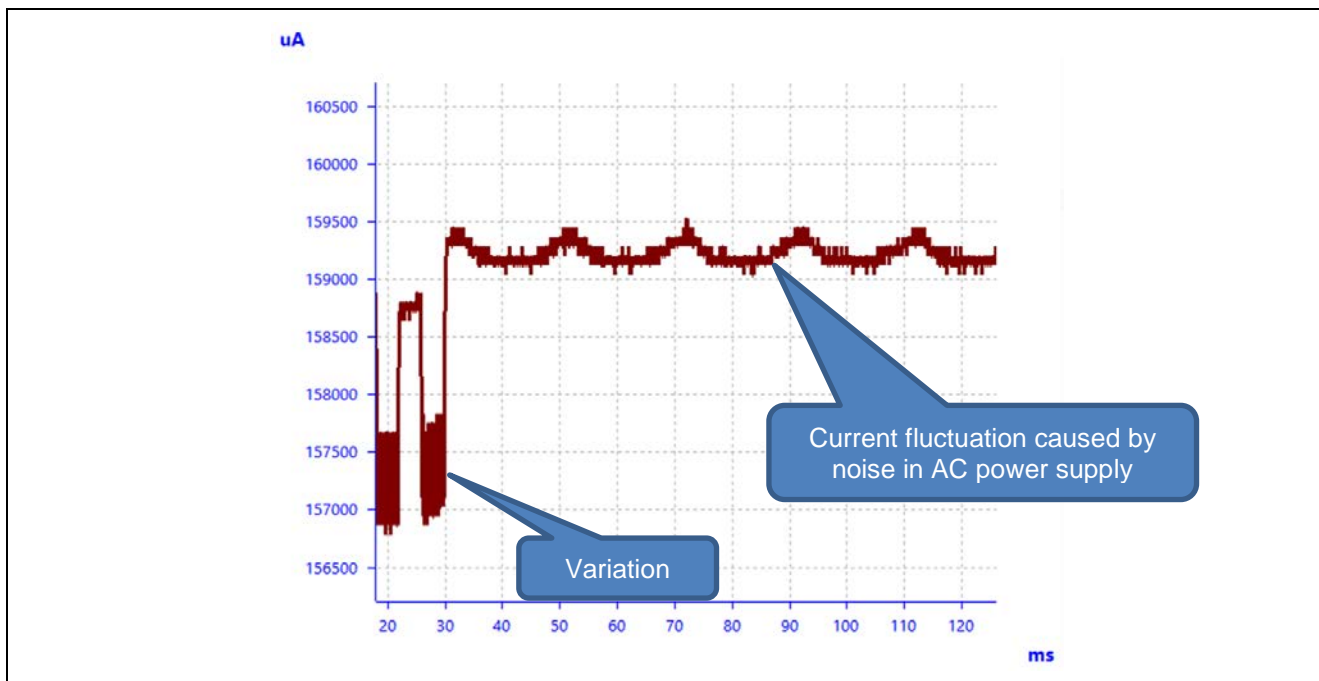


Figure 5-5 Characteristics of Measurement Result of Current Consumption

Website and Support

Renesas Electronics Website

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

Inquiries

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

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

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jan. 16, 2018	—	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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

1. Handling of Unused Pins

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

- 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 Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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 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 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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.
11. This document shall not be reprinted, 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.
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



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.

1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited

9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

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, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited

Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

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 1207, Block B, Menara Amcorp, Amcorp 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 India Pvt. Ltd.

No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.

17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338