Current Consumption Tuning Solution

(E2 Emulator, CS+)

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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 (CS+ for CC). If you intend to use another integrated development environment (e^2 studio), refer to the application note for the e^2 studio (document No.: R20AN0456).

Target Device

RL78 Family

Contents

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 (E2 Emulator, CS+) (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 (document No.: R20UT1994)
Target device: Device in the RL78 family other than RL78/G10 (document No.: R20UT1994)
Target device: RL78/G10 (document No.: R20UT2937)

The E1/E20/E2 Emulator, E2 Emulator Lite Additional Document for User's Manual (Notes on Connection of RL78) 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.

- CS+ User's Manual: RL78 Debug Tool
- CS+ Online Help

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 (E2 Emulator, CS+) (this document)
The Application Note for the Current Consumption Tuning Solution (E2 Emulator, CS+) 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.

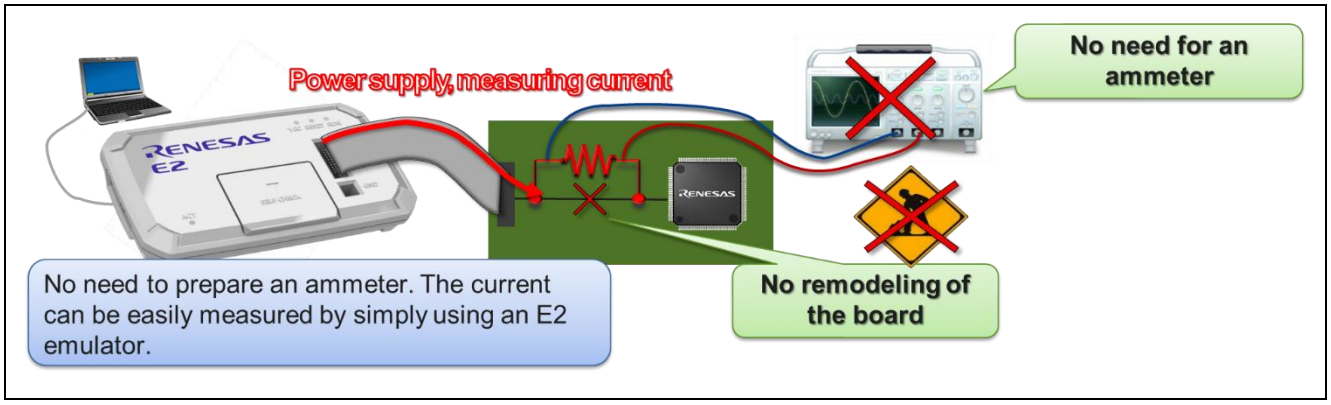


Figure 1-1 Easy Measurement

(2) Feature 2: "Detection in detail" 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.

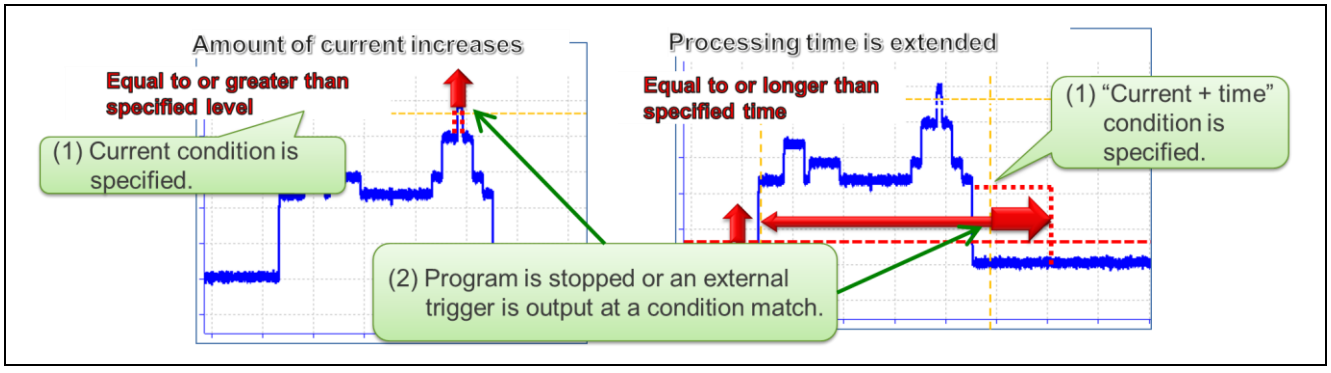


Figure 1-2 Detection in Detail

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

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

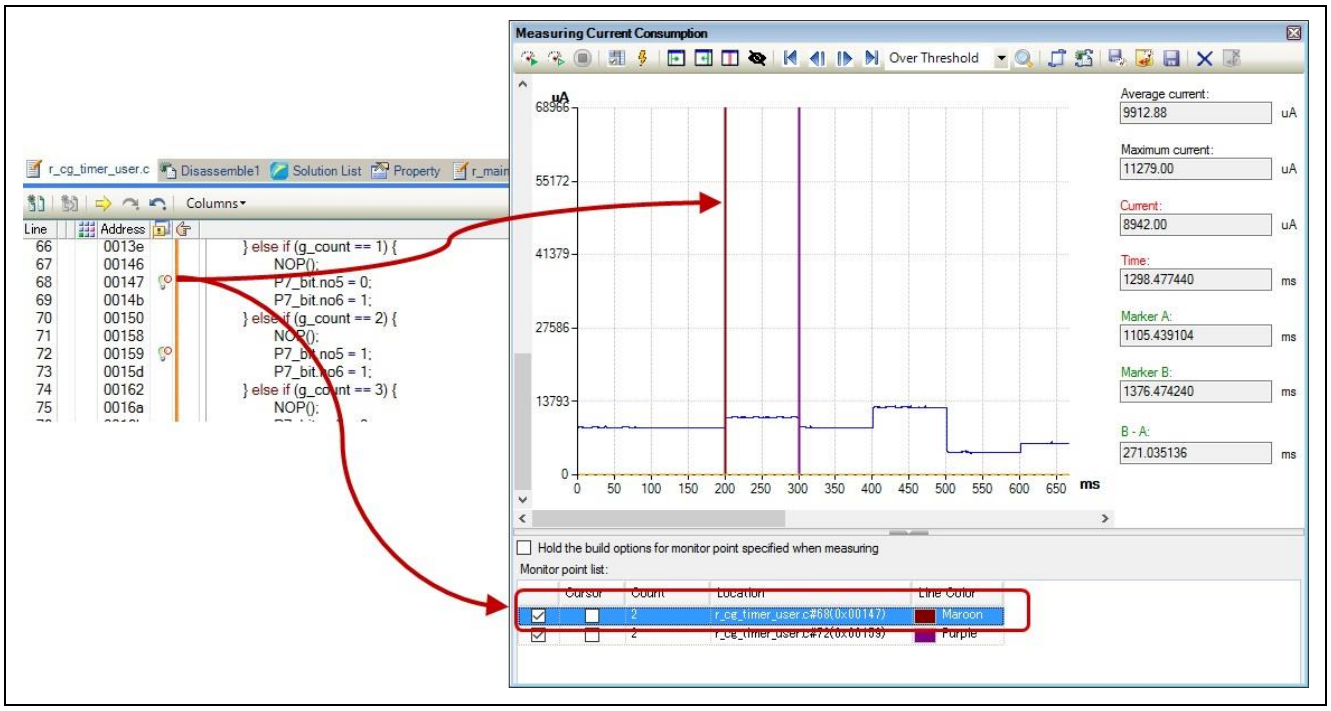


Figure 1-3 Quick Identification

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
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
	Sampling: 1 ms, measurement time: approx. 1000 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. • Successive recording is continued until a break occurs (overwrite recording) • Recording is stopped upon reaching the upper limit of recording size. • Recording is stopped and the user program is stopped upon reaching the upper limit of recording size.
Saving the recorded data	Recorded data can be saved in the CSV format.
Acquisition condition	• 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	• 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	• 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 MCU	RL78 family	RL78/G10 is not supported.
Number of monitoring point	16 points	—
Data recording	Total of Max. 2M points including the measurement result of current consumption	—
Recorded data	• Timestamp information • Monitoring point number	—
Time during which the program is stopped when passing a monitoring point	Up to 150 cycles	Approx. 4.7 us with the maximum speed (32 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.	—
Flash ROM	512 bytes after the end address of ROM	Example (device with 256 Kbytes of internal ROM): The monitor program is located in the range from 0x3FE00 to 0x3FFFF (512 bytes).
RAM	6 bytes after the stack area	*1

*1 When a monitoring point is used, extra six bytes are used for the stack area used by the user program. An example in which "the start address of internal RAM is 0xFCF00" and the stack area is increased is shown below.

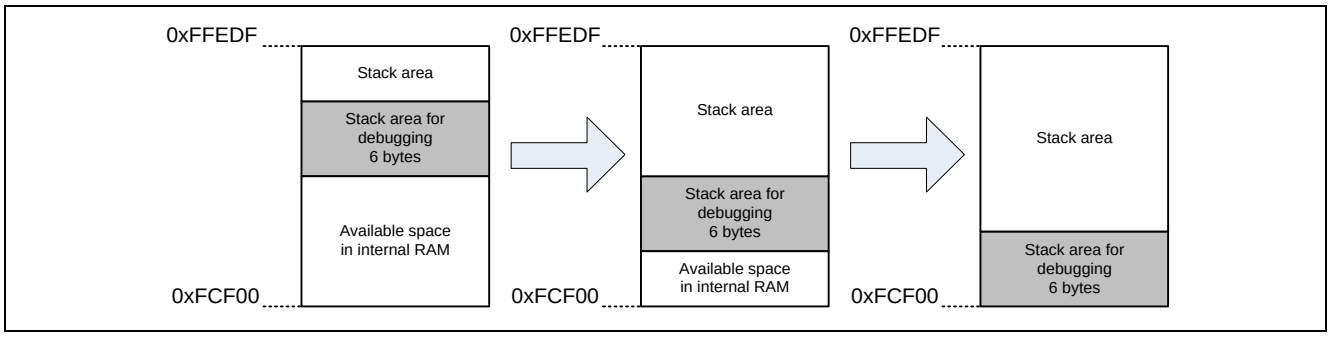


Figure 2-1 Variation of Address of Stack Area for Debugging

2.3 External Trigger Input/Output Functions

2.3.1 Specifications of the External Trigger Inputs and Outputs

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

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	• When the function for supplying power to the user system is not in use: VDD voltage (any voltage from 1.8 V to 5.0 V) • When the power-supply function for the user system is in use: supply voltage (specified by the debugger)
Conditions for detecting an external trigger input	• Detecting edges (rising, falling, or both) • Detecting a level (low or high)
Operation during the input of an external trigger	• Break • Recording the data from measuring the current consumption while the low or high level is being input
Input characteristics	VIH: 0.7 × VDD, VIL: 0.3 × VDD
From the detection of a condition for an external trigger input being satisfied until the user program is stopped	For other than RL78/G10: approx. 12 us For RL78/G10: approx. 100 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	• 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: VDD-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.

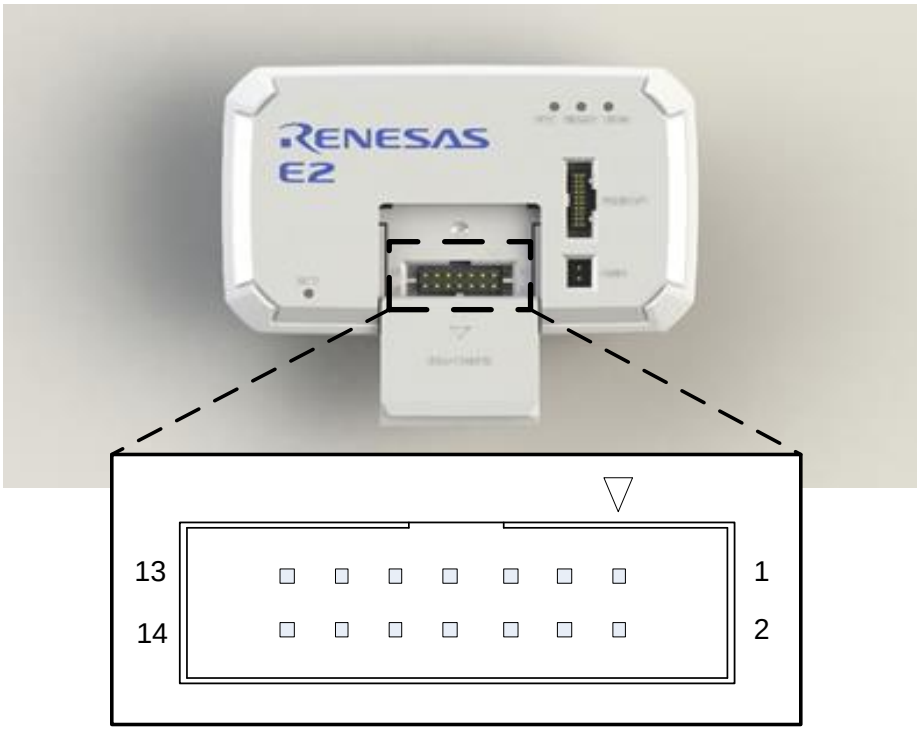


Figure 2-2 E2 Expansion Interface

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.

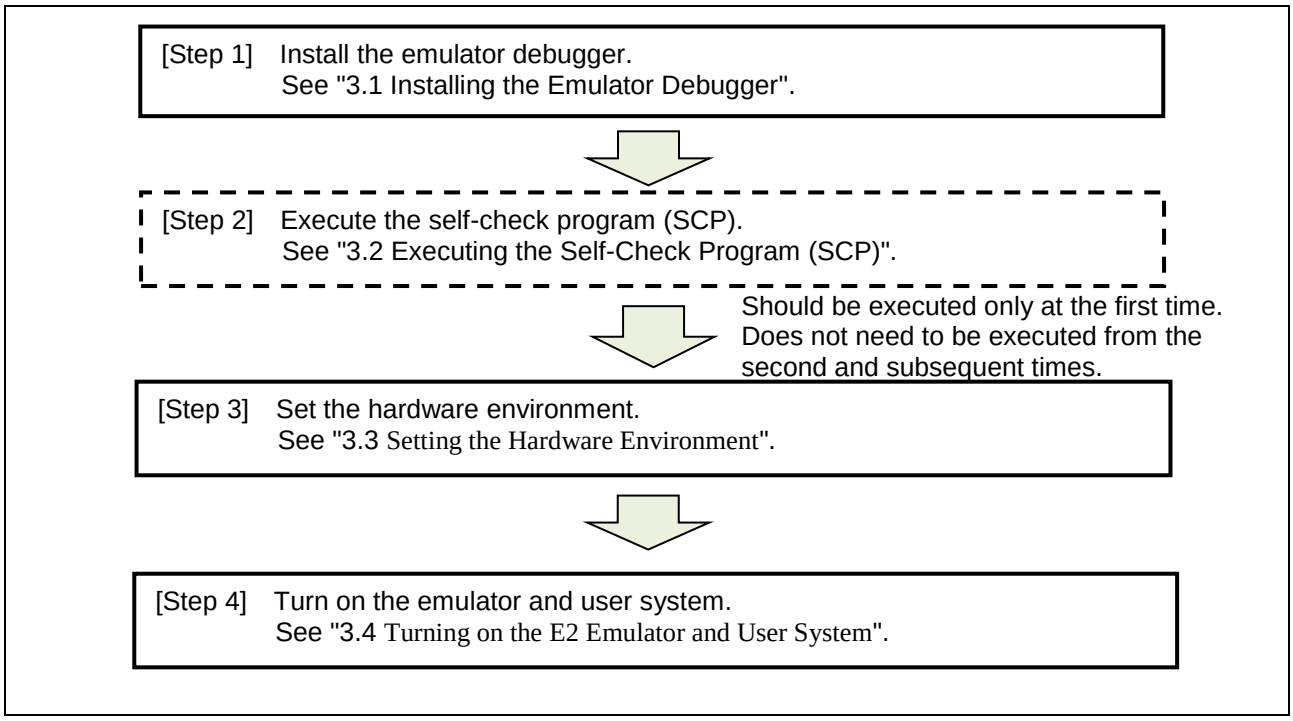


Figure 3-1 Setup Procedure

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.

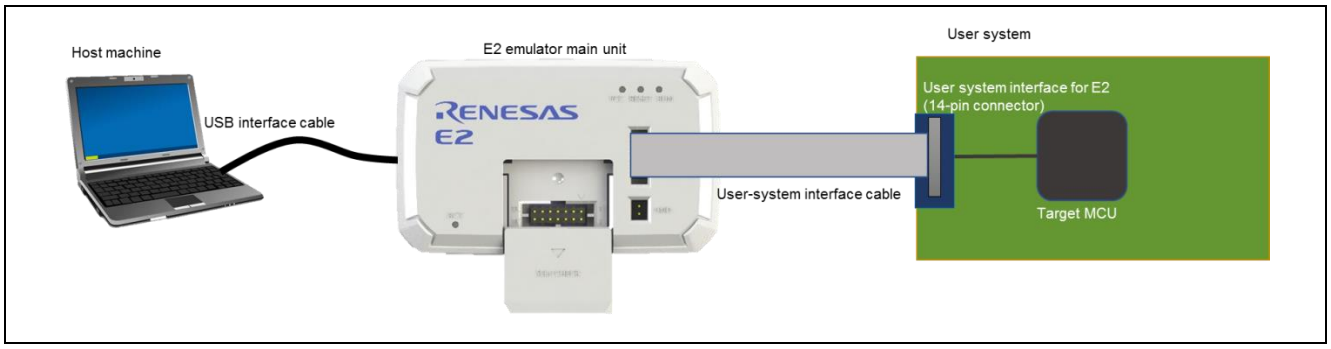


Figure 3-2 System Configuration Example (1)

- 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.

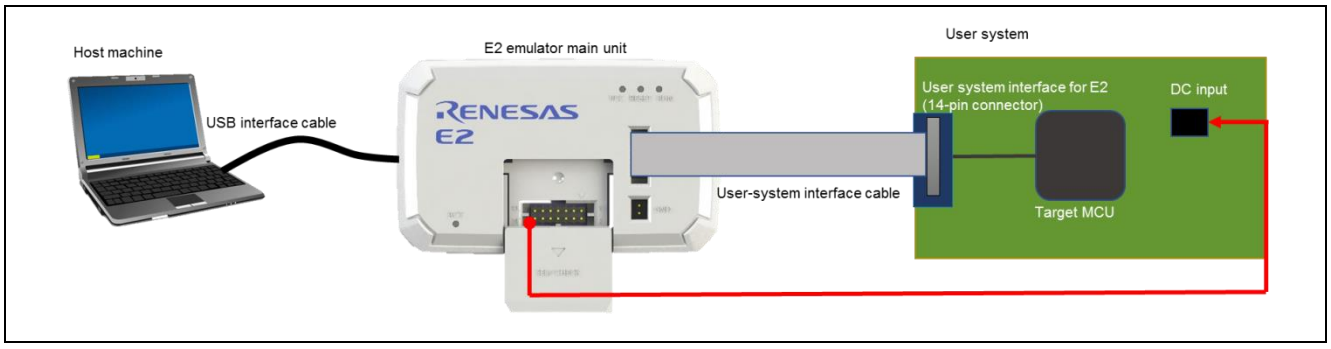


Figure 3-3 System Configuration Example (2)

(1) 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 “3”.

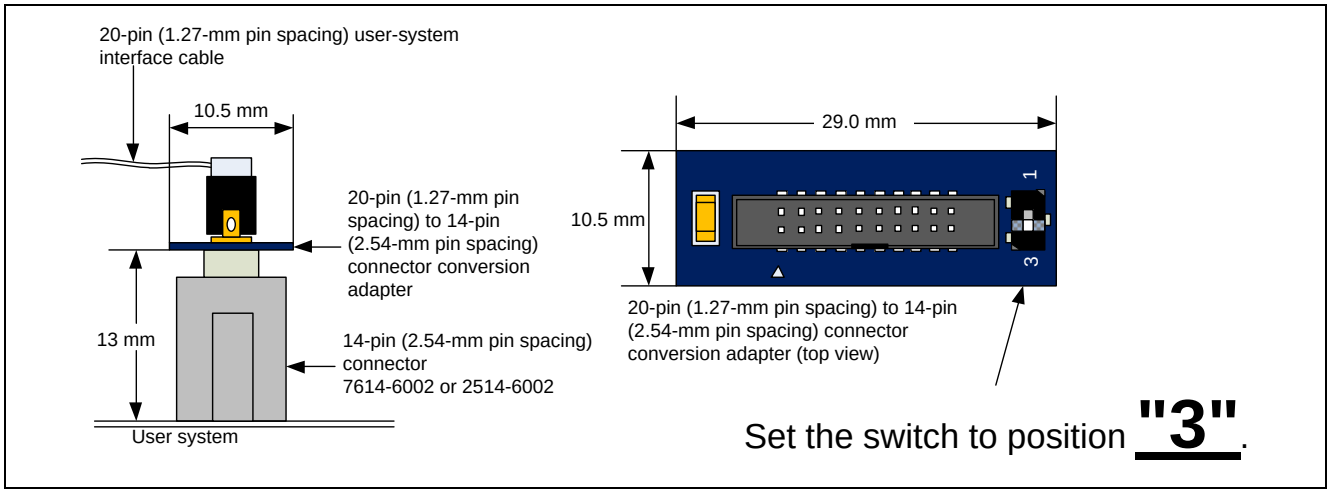


Figure 3-4 Connecting the User-System Interface Cable to the 14-Pin Connector

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/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 [Connect Settings] tabbed page on the [Property] panel of the RL78 E2 debug tool.

- [Power target from the emulator]: [Yes]
- [Interface for supplying the power]
  - When power is supplied from a power supply pin of the user system interface: [USER I/F]
  - When power is supplied from a power supply pin (pin 14) of the E2 expansion interface: [E2 expansion I/F]
- [Supply voltage]: Any voltage from 1.8 V to 5.0 V

[Use supplied power from the emulator] should be set in [E2 Expansion Interface].

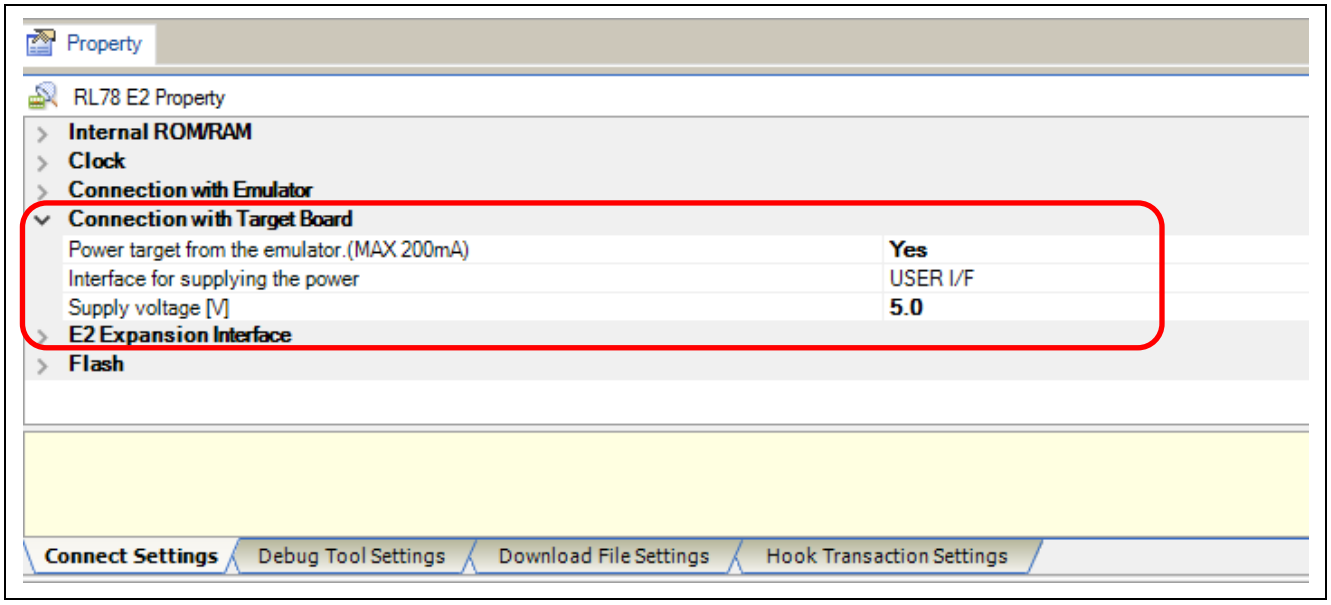


Figure 4-1 Connection Settings of E2 Emulator Debugger

(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] Panel

(1) When opening the [Measuring Current Consumption] panel from the menu

From the [Debug] menu, select [Debug Solutions], and click on [Measuring Current Consumption].

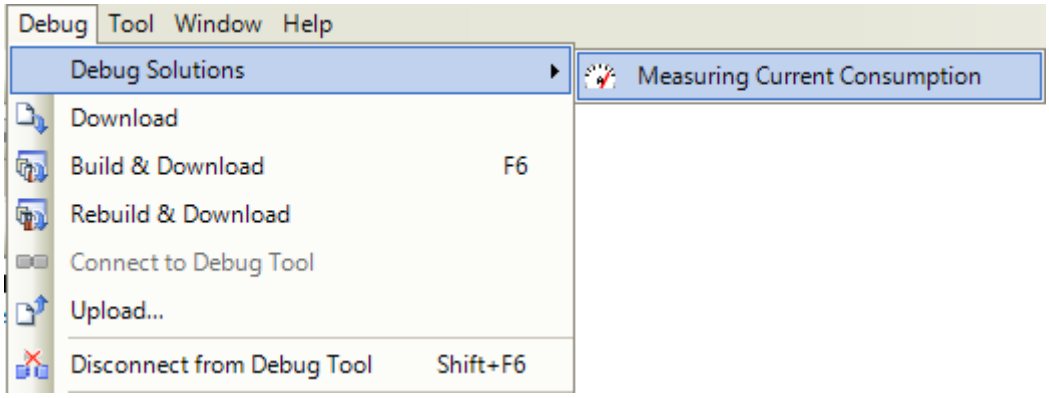


Figure 4-2 Opening the [Measuring Current Consumption] Panel (1)

(2) When opening the [Measuring Current Consumption] panel from the solution list.

1. From the [View] menu, click on [Solution List].

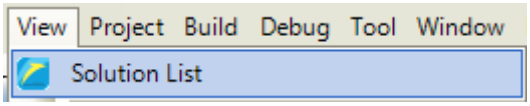


Figure 4-3 Opening the [Measuring Current Consumption] Panel (2)

2. Click on [Current] (surrounded by a red line in the figure below) to open the [Measuring Current Consumption] panel.

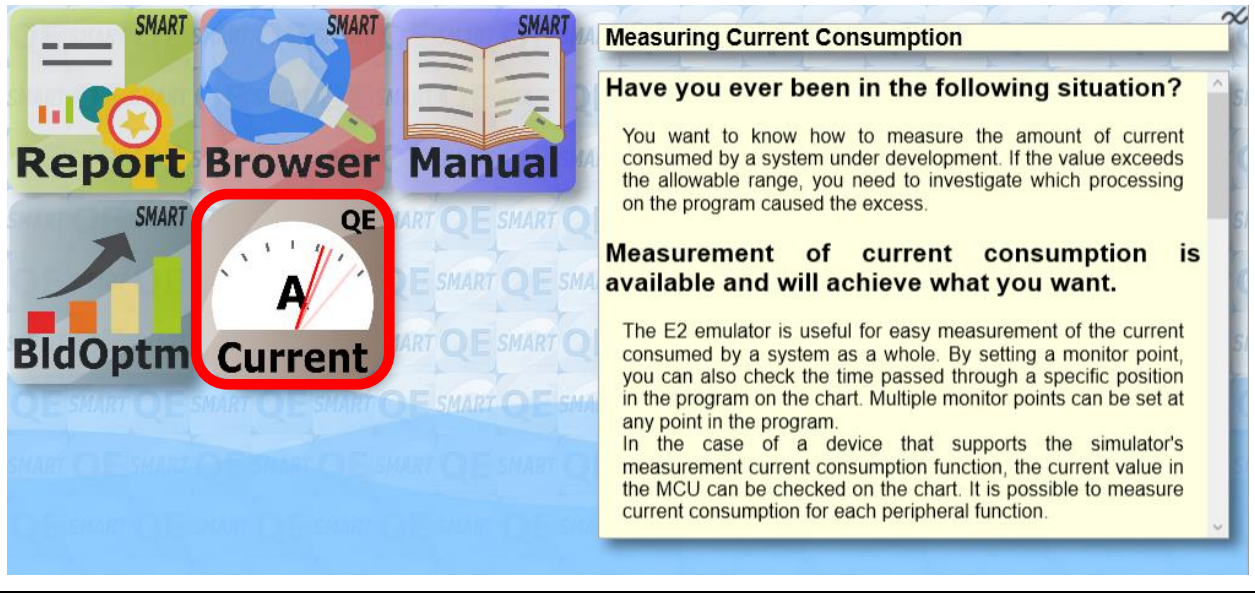


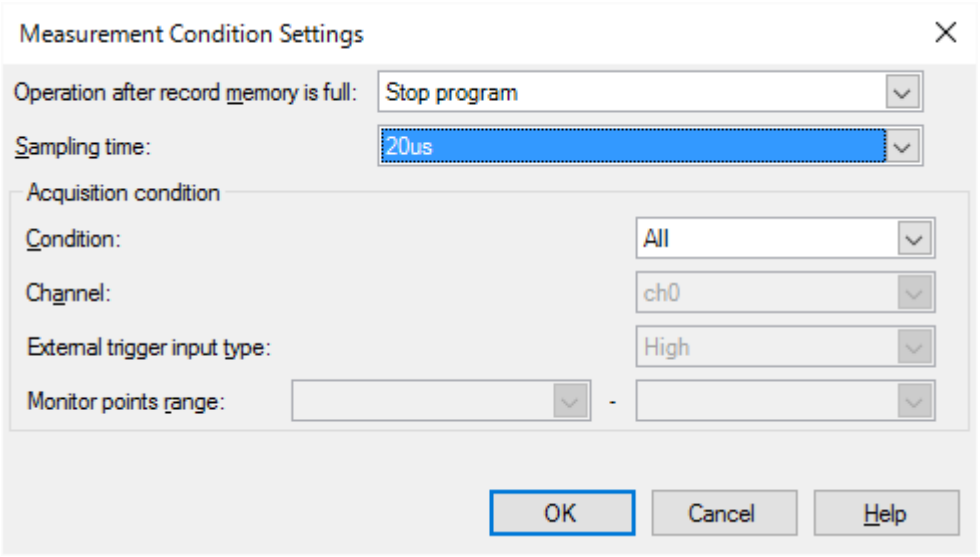
Figure 4-4 Opening the [Measuring Current Consumption] Panel (3)

4.2.2 Description of the [Measurement Condition Settings] Dialog Box

(1) Open the Measurement Condition Settings dialog box.

Figure 4-5 Opening the [Measurement Condition Settings] Dialog Box

(2) Make settings for measuring the current consumption.



- [Operation after record memory is full]
  Select from [Overwrite to the record memory and continue execution], [Stop recording], or [Stop program].
- [Sampling time]
  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 4-6 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] panel.

The current consumption in the period from program execution to break occurrence will be measured.

Figure 4-7 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.

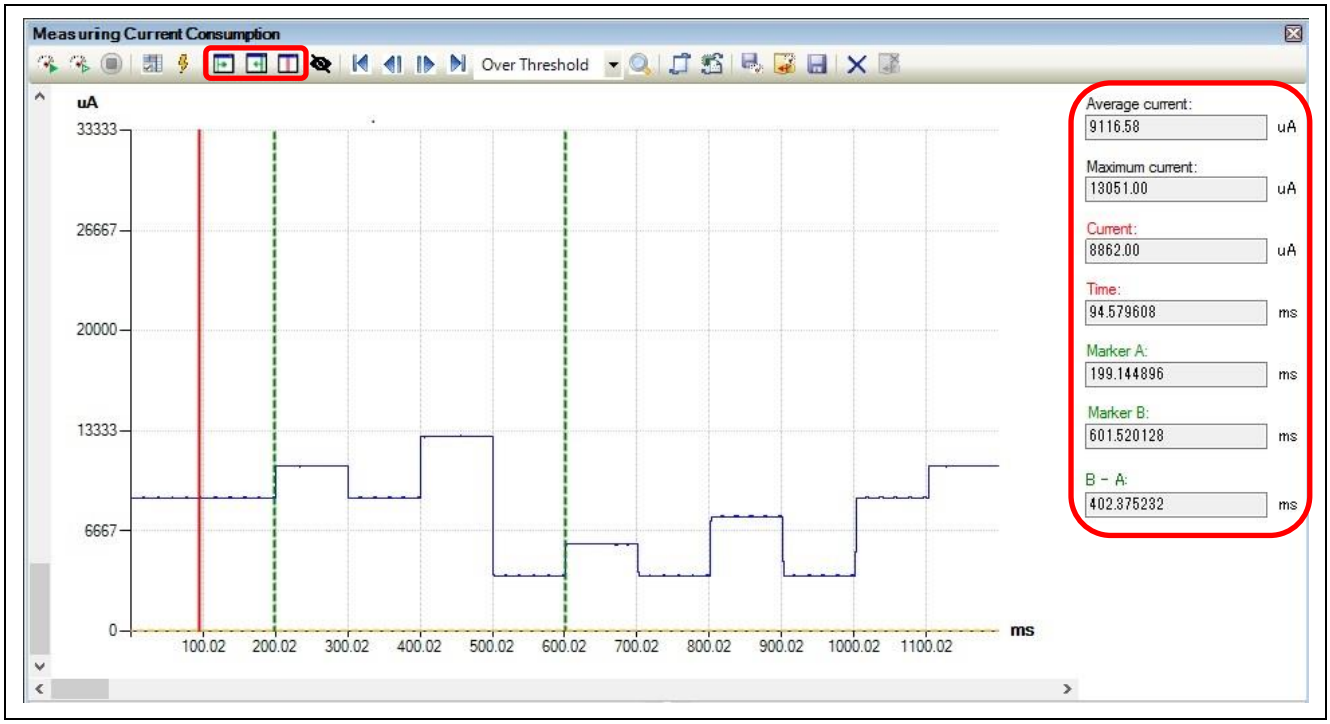


Figure 4-8 Cursor and Marker

(5) Adjusting the displayed waveform

- Zoom in of the X axis: "Ctrl and Right" keys, zoom in of the Y axis: "Ctrl and Up" 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.

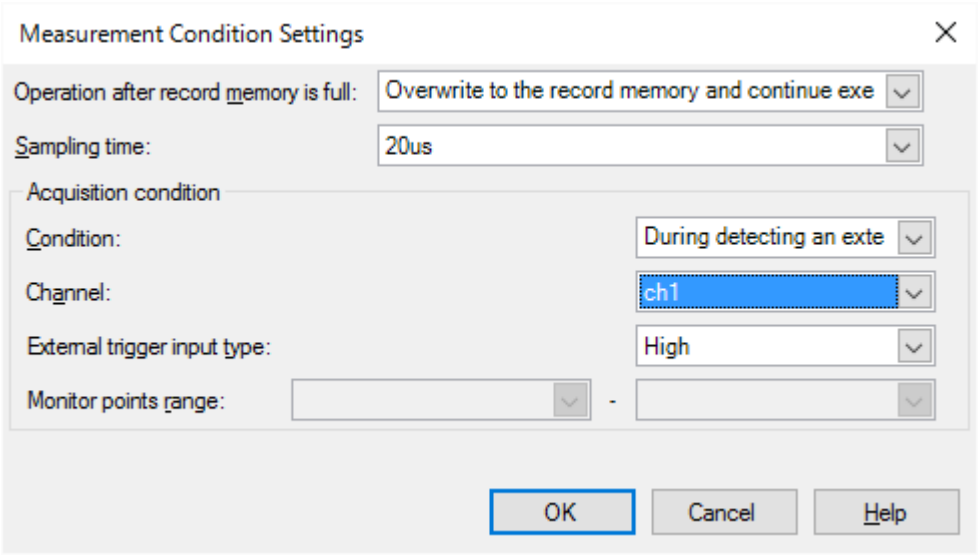
(b) Clicking on the button for loading a file loads data of the saved measurement result.

Note: It may take time to load data containing a result that was measured with a short sampling time set as the condition.

Figure 4-9 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.



- [External trigger input type] of [Acquisition condition]
  - 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 the active level for the external trigger input.
- [Monitor points range] of [Acquisition condition]
  - This can be used when two or more monitoring points have been set.
    The current consumption is measured between two points: monitoring point set to start measuring and monitoring point set to end measuring.

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.

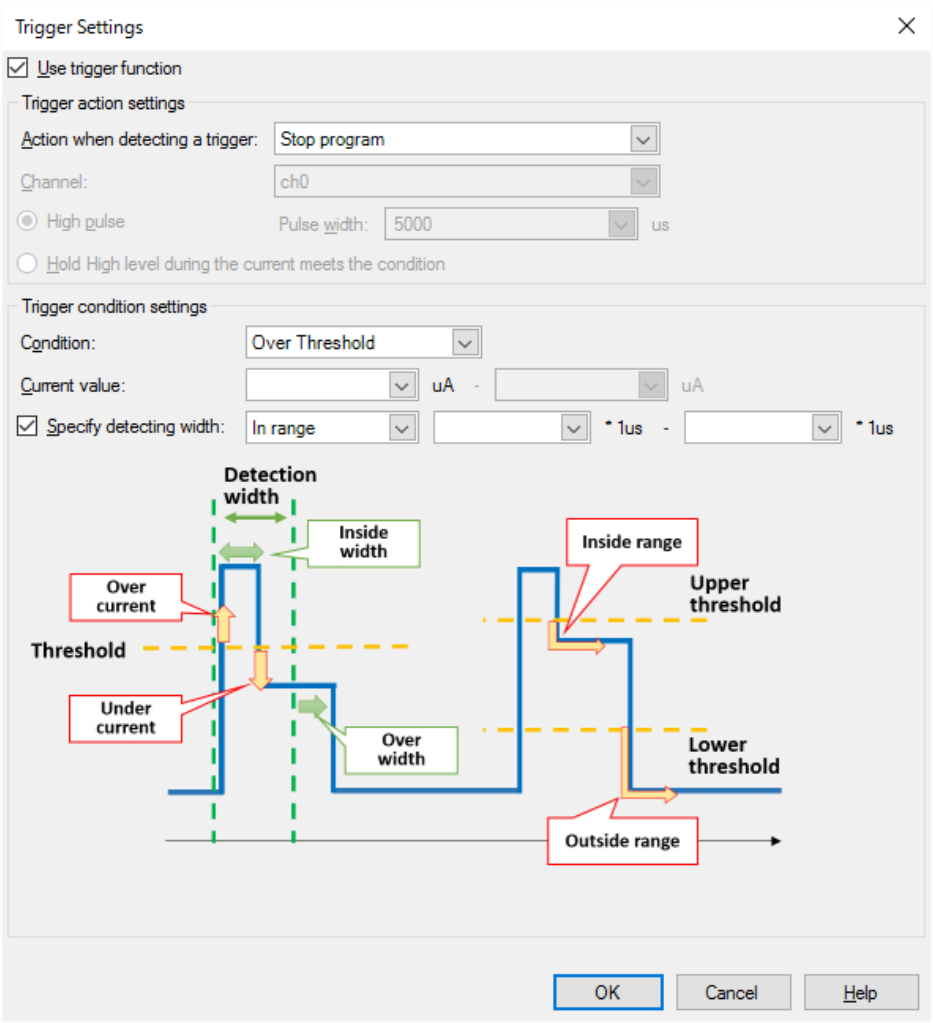
Figure 4-10 Setting Conditions for Measuring the Current Consumption (2)

4.3 Setting Trigger Conditions for Measuring the Current Consumption

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

Figure 4-11 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.



- [Action when detecting a trigger]
  - — 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.
- [Trigger condition settings]
  - — Select the condition for detecting current from [Over Threshold], [Under Threshold], [In Range], or [Out of Range].
  - — If [Over Threshold] or [Under Threshold] is selected, set the threshold of current.
    If [In Range] or [Out of Range] is selected, set the lower limit and upper limit of current.
- [Specify detecting width]
  - — Selecting the detection width adds the length of time during which the condition for current was detected to the condition.
  - — Select [Over Threshold] or [In Range].
    If [Over Threshold] is selected, set the upper limit of time.
    If [In Range] is selected, set the lower limit and upper limit of time for the range.
    The unit differs according to the sampling time.

Figure 4-12 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 Threshold] in [Condition] as the trigger condition for curren and set the current value to be detected.

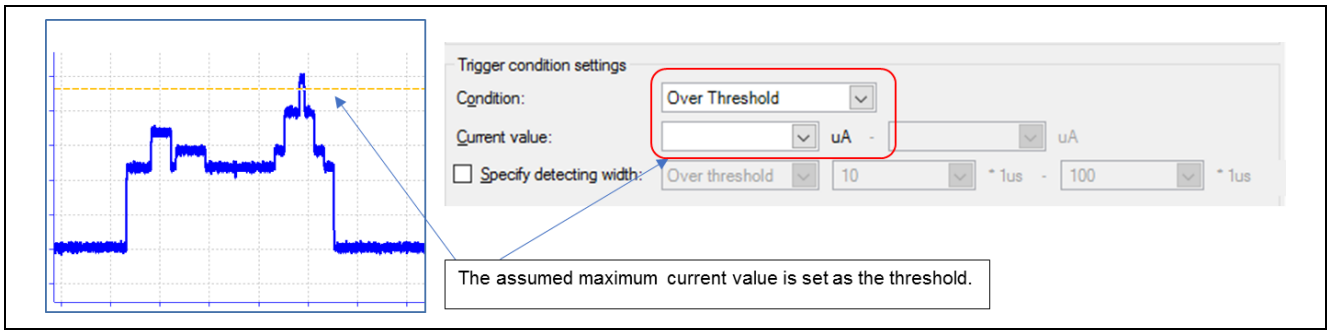


Figure 4-13 Use Case (1)

4.3.2 Use Case (2) Abnormal current: Current increase for a short period in STOP mode

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

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

(2) Select [In Range] in [Specify detecting 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 STOP 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.

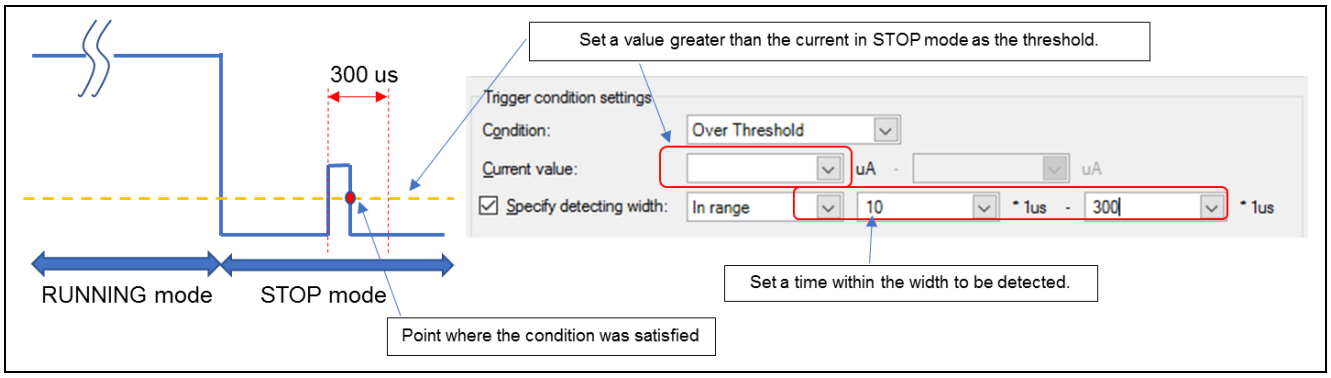


Figure 4-14 Use Case (2)

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 [In Range] in [Condition] 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 [In Range] in [Specify detecting 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.

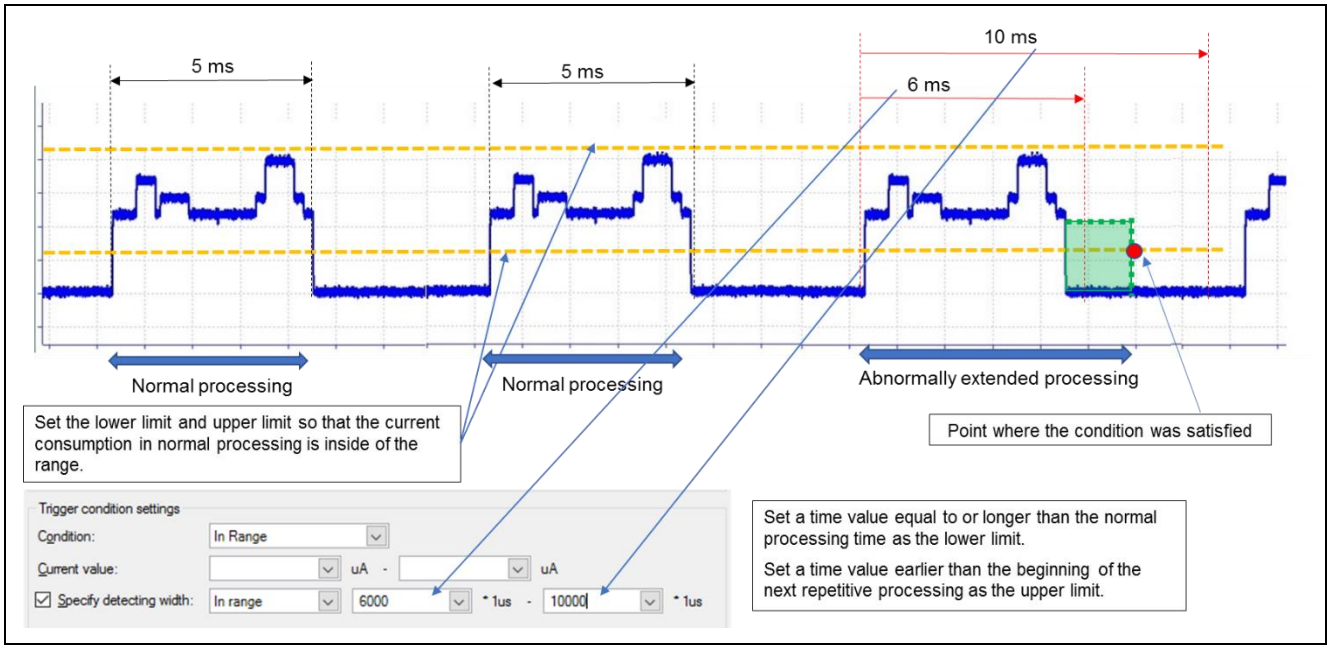


Figure 4-15 Use Case (3)

4.4 Setting Monitoring Points

4.4.1 Setting Monitoring Points

Up to 16 monitoring points can be set.

(1) In the Editor panel, move the cursor to a source line at which you want to set a monitoring point.

(2) Select [Monitor Point Setting] in the menu that is displayed by right-clicking on the source code, and then click on [Set Monitor Point].
A mark standing for a monitoring point will appear on the line to which an event was set.

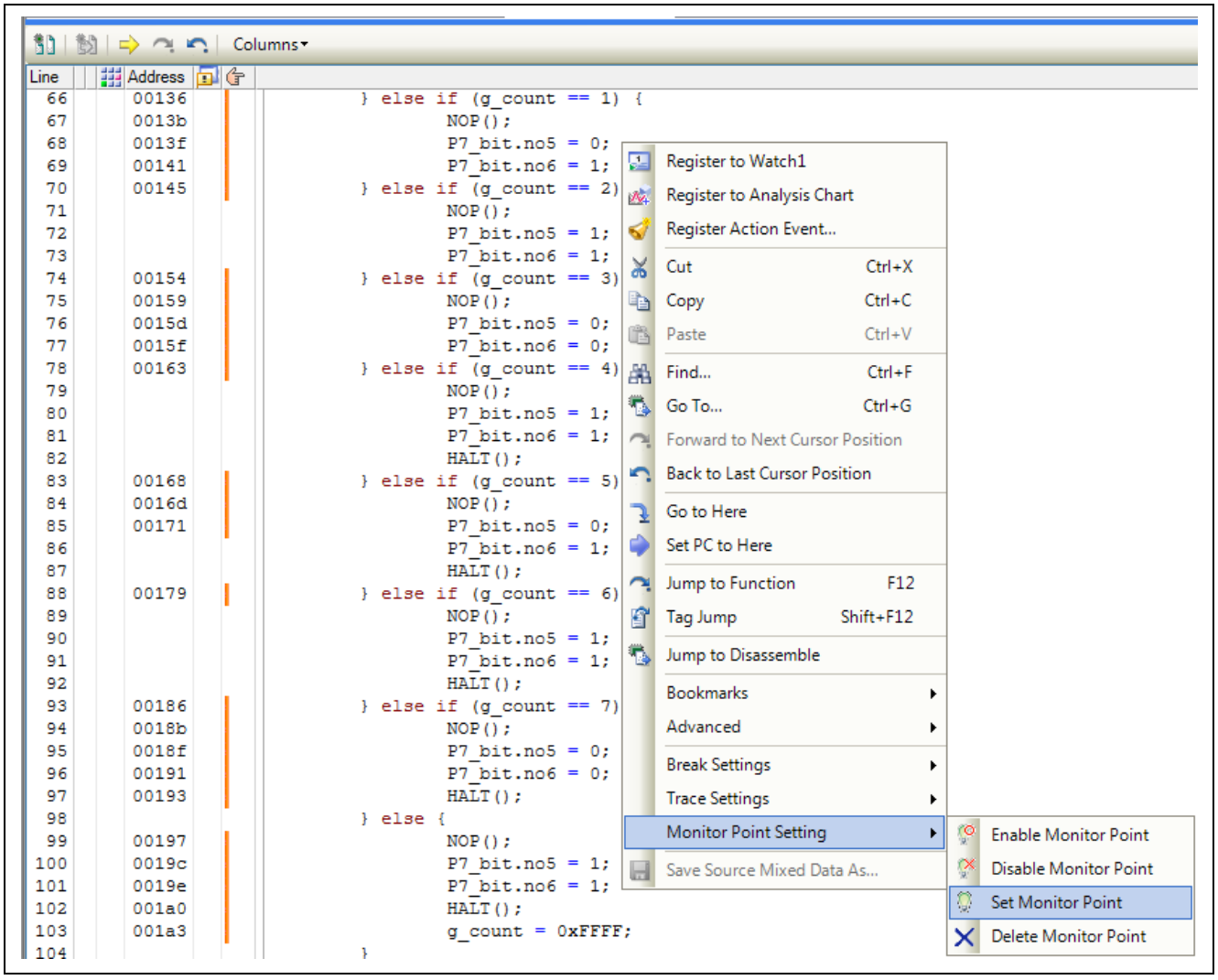


Figure 4-16 Setting Monitoring Points

(3) Deleting monitoring points

In the Editor panel, similar as to when setting a monitoring point, move the cursor to a source line from which you want to delete a monitoring point.

Select [Monitor Point Setting] in the menu that is displayed by right-clicking on the source code, and then click on [Delete Monitor Point].

(4) Execution after monitoring points are set

- When using a version earlier than CC-RL compiler V1.05.00
  Monitoring points can be set to only addresses in which the nop instruction has been set.

- When using a version later than CC-RL compiler V1.05.00
  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.

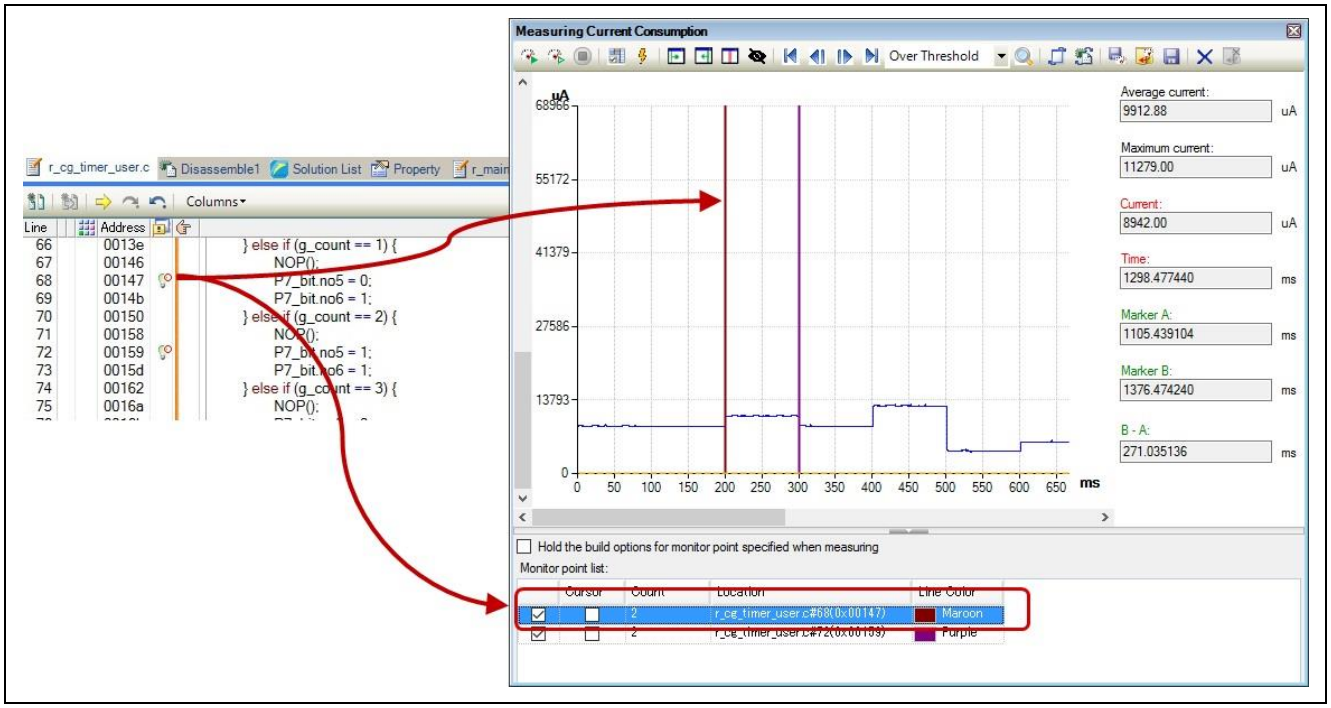


Figure 4-19 Link between Monitoring Point and Program

4.5 Setting the [Current Consumption Measurement Search] Dialog Box

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

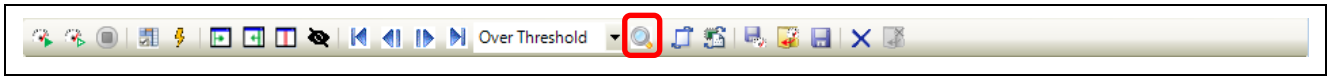
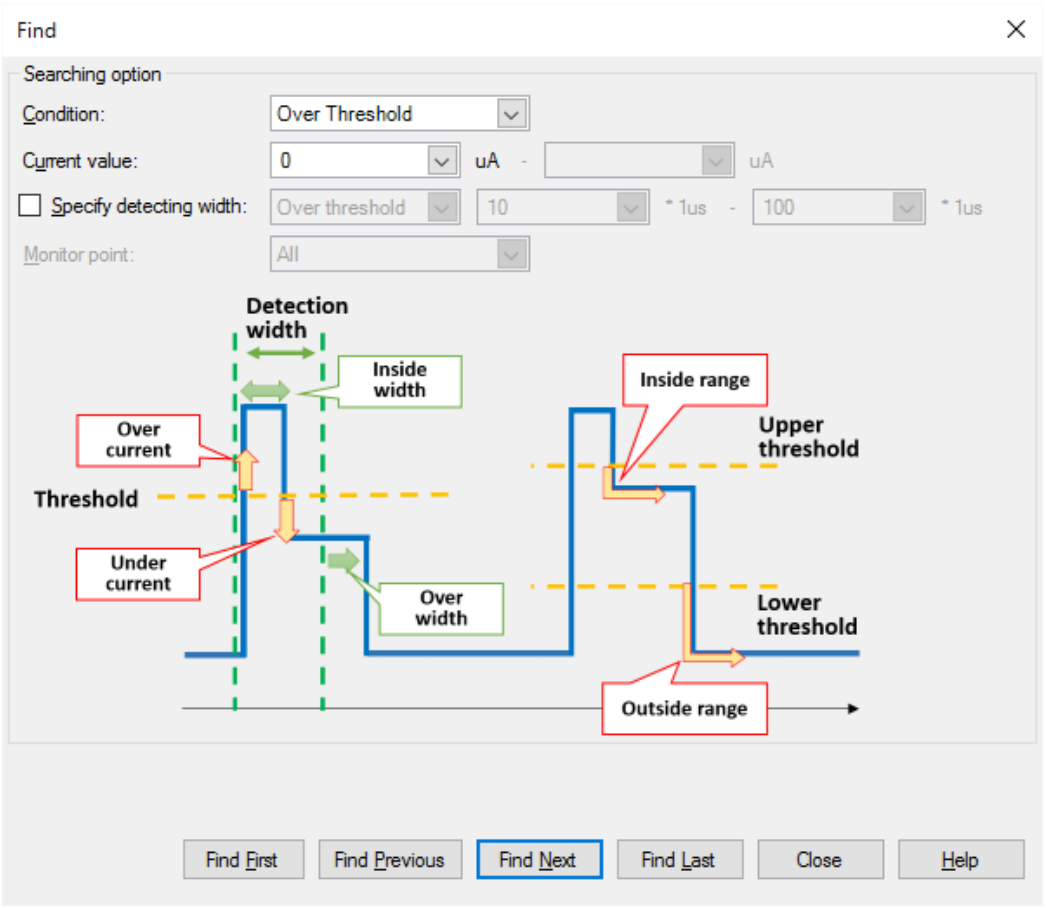


Figure 4-20 Opening the [Current Consumption Measurement Search] Dialog Box

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



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

Figure 4-21 Setting Searching Conditions

Note: When [In Range] 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.

	Searches for the first location of a graph in which a searching condition is matched.
	Searches for a location where a searching condition is matched before the current cursor location.
	Searches for a location where a searching condition is matched after the current cursor location.
	Searches for the last location of a graph in which a searching condition is matched.

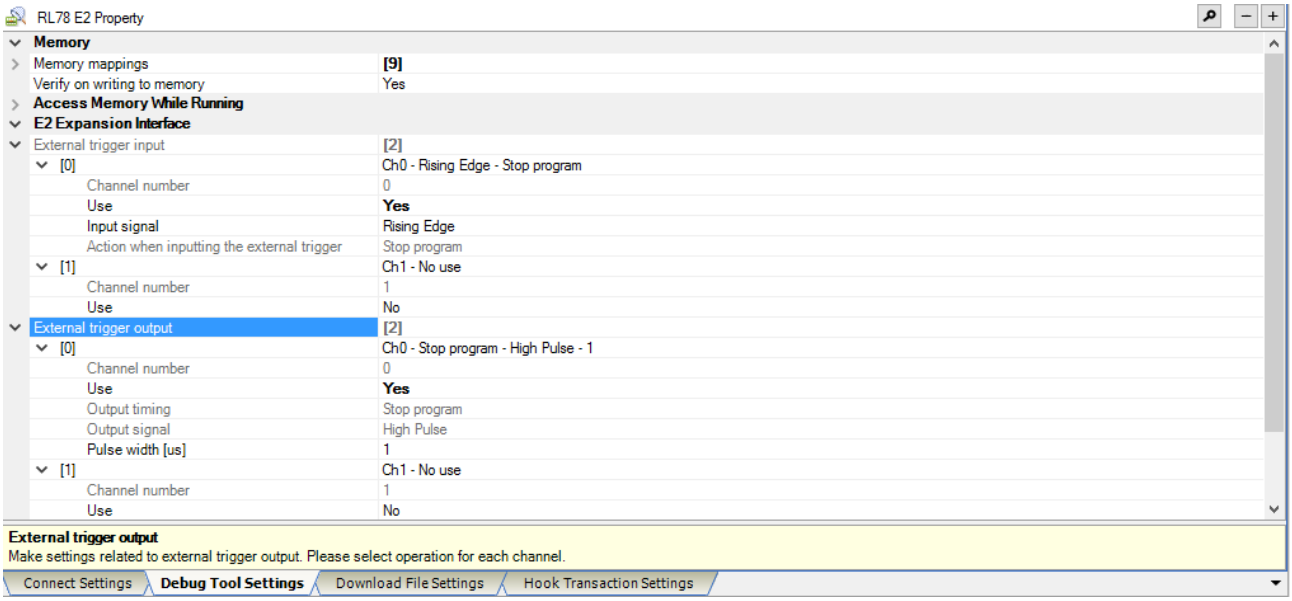
Figure 4-22 Description of Search Buttons

4.6 Setting External Trigger Input/Output

(1) Click on the [Debug Tool Settings] tab on the [Property] panel of the [RL78 E2 (Debug Tool)] debug tool.

(2) Expand [E2 Expansion Interface] by clicking on it.

(3) Make settings for external trigger input/output.



- [External trigger input]
  - — [Use]
    Specify whether to use the external trigger input for this channel with [Yes] or [No].
    ch0: Connect pin 11 of the E2 expansion interface.
    ch1: Connect pin 12 of the E2 expansion interface.
  - — [Input signal]
    Select [Rising Edge], [Falling Edge], or [Both Edges] for the edge condition to be detected.

- [External trigger output]
  - — [Use]
    Specify whether to use the external trigger output for this channel with [Yes] or [No].
    ch0: Connect pin 9 of the E2 expansion interface.
    ch1: Connect pin 10 of the E2 expansion interface.
  - — [Pulse width]
    Select the width of the high pulse to be output.
    Set any value from 1 us to 65535 us.

Figure 4-23 Setting External Trigger Input/Output

5. Usage Notes

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

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

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

Table 5-1 List of Possible/Impossible Combinations of E2's Extended Functions and Debugging Functions (Other than RL78/G10)

		E2's Extended Functions		
		Measuring the Current Consumption	**Monitoring Point**	**External Trigger Input/Output**
Debugging functions other than E2's extended functions	When power is not supplied from the E2 emulator (including hot plug-in initiation*1 or usage of an isolator)	X	X	√
	When the RAM monitor function or DMM function is used	√	X	√
	Mode in which flash programming is not possible	√	X	√
	When the Start/Stop function is enabled	√	X	√
	Other than above	√	√	√

√: Available, X: Not available

*1 Only for RL78/F13, RL78/F14, RL78/F15, and RL78/F1A

Table 5-2 List of Possible/Impossible Combinations of E2's Extended Functions and Debugging Functions (RL78/G10)

		E2's Extended Functions		
		Measuring the Current Consumption	**Monitoring Point**	**External Trigger Input/Output**
Debugging functions other than E2's extended functions	When power is not supplied from the E2 emulator (including usage of an isolator)	X	X	√
	When the low-voltage OCD board is used	X	X	X
	When the RAM monitor function or DMM function is used	√	X	√
	Mode in which flash programming is not possible	√	X	√
	Other than above	√	X	√

√: Available, X: Not available, Shaded area: Monitoring points cannot be used in G10.

5.2 When Measuring the Current Consumption is Not Possible

Measuring the current consumption cannot be performed when the E2 emulator does not supply power to the user system. Relevant cases are shown below.

- Startup by the power of the user system (all microcontrollers of RL78 family)
- Hot plug-in initiation (RL78/F13, RL78/F14, RL78/F15, RL78/F1A)
- Low-voltage OCD board is used (RL78/G10)
- Isolator is used (all microcontrollers of RL78 family)

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 level becomes lower than the setting due to current drawn by the user system. Use a tester to confirm the actual supply voltage before usage.

5.4 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
- 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 1.4 mA in the case of RL78/G13 (R5F100LE), 32 MHz, 5 V, STOP mode
- Difference associated with response characteristics for current changes (filtering characteristics on current-measuring circuit)

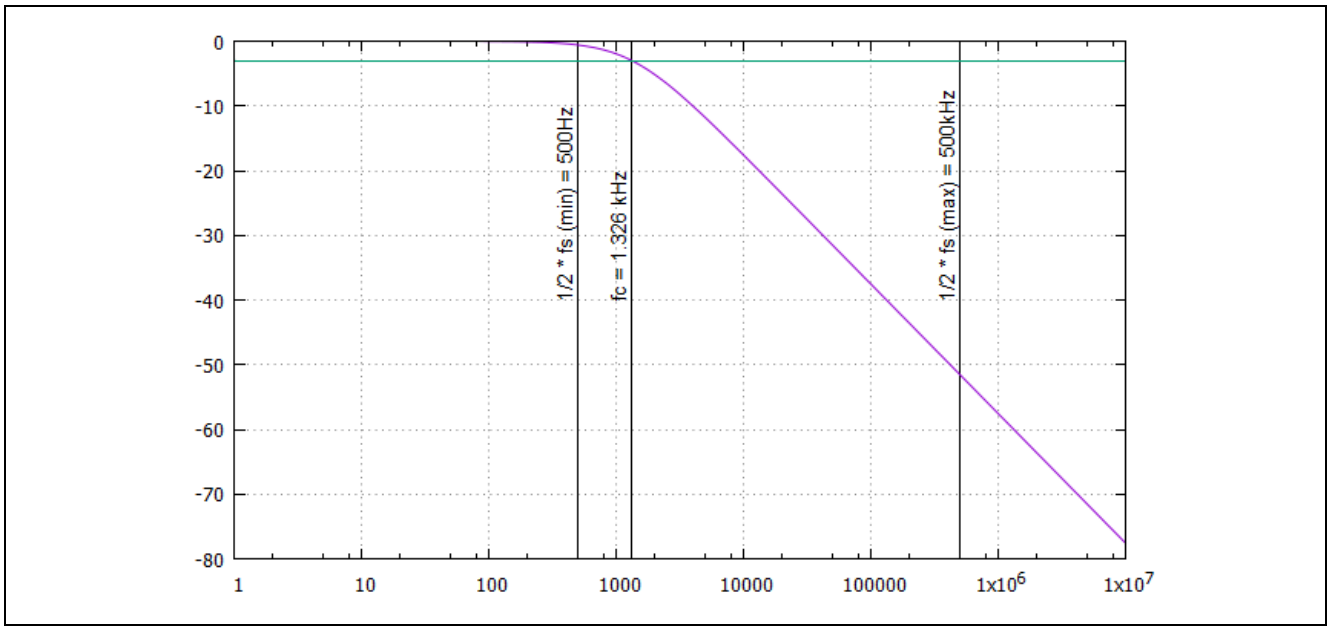


Figure 5-1 Response Characteristics for Current Changes

5.5 Monitoring Point

5.5.1 Cases in Which Monitoring Points Cannot be Used

(1) Monitoring points cannot be used when RL78/G10 is the target device.

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

— Hot plug-in initiation
— RAM monitor function or DMM function
— Mode in which flash programming is not possible
— Start/Stop function

5.5.2 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-RL compiler V1.05.00, the nop instruction is automatically inserted at points to which monitoring points have been set at build.
- When using Monitoring points, execution needs to be started using the button for execution that includes build.
  If execution is started using the button for execution that does not include rebuild, monitoring points cannot be set sometimes.
  When a monitoring point could not be set, the address will not be displayed in the list of monitoring points.

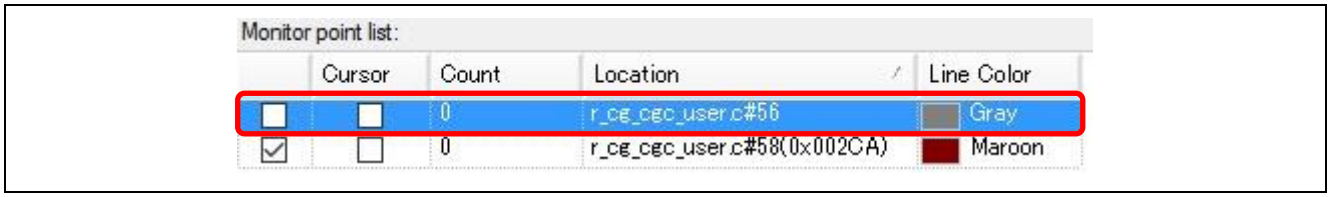


Figure 5-2 Example of Failure in Setting a Monitoring Point

- Monitoring points can be set only in the code flash memory area. They cannot be set in a RAM area.
- Do not set a software break at an address to which a monitoring point has been set. The program is not stopped at the breakpoint that was set. If a monitoring point is set at an address to which an event break was set, the event break will occur.
- When setting multiple monitoring points, the interval should be at least 30 us of execution time.
  If the required interval is not ensured, there is deviation in the recording time of monitoring points.
  If monitoring points are repeatedly passed in a short interval, it will become impossible to forcibly terminate the user program.
  <Example>

```
while(1) {
 NOP();        ← When a monitoring point is set here, a forcible break is not possible during the infinite loop.
}
```

- In the range where the waveform of the measurement result of current consumption is not displayed, Monitoring points is not displayed.
- Do not set monitoring points immediately before (within 10 us) the STOP instruction.
  If a monitoring point is set immediately before (within 10 us) the STOP instruction, the user program will be abnormally stopped immediately after transiting to the STOP mode.

5.5.3 Effect of Monitoring Points on User Program

When a setting is made to stop emulation of timer-related or serial communication-related peripheral functions when the user program is stopped, some peripheral functions will be temporarily stopped when a monitoring point is passed.

The temporary stop period is a maximum of 150 operating clock cycles. (Example: Max. 4.7 us for a 32-MHz operating clock)

5.6 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)

5.7 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] is set for [Operation after record memory is full] 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 time is approximately Max. 12 us for devices other than RL78/G10 and approximately Max. 100 us for RL78/G10.

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

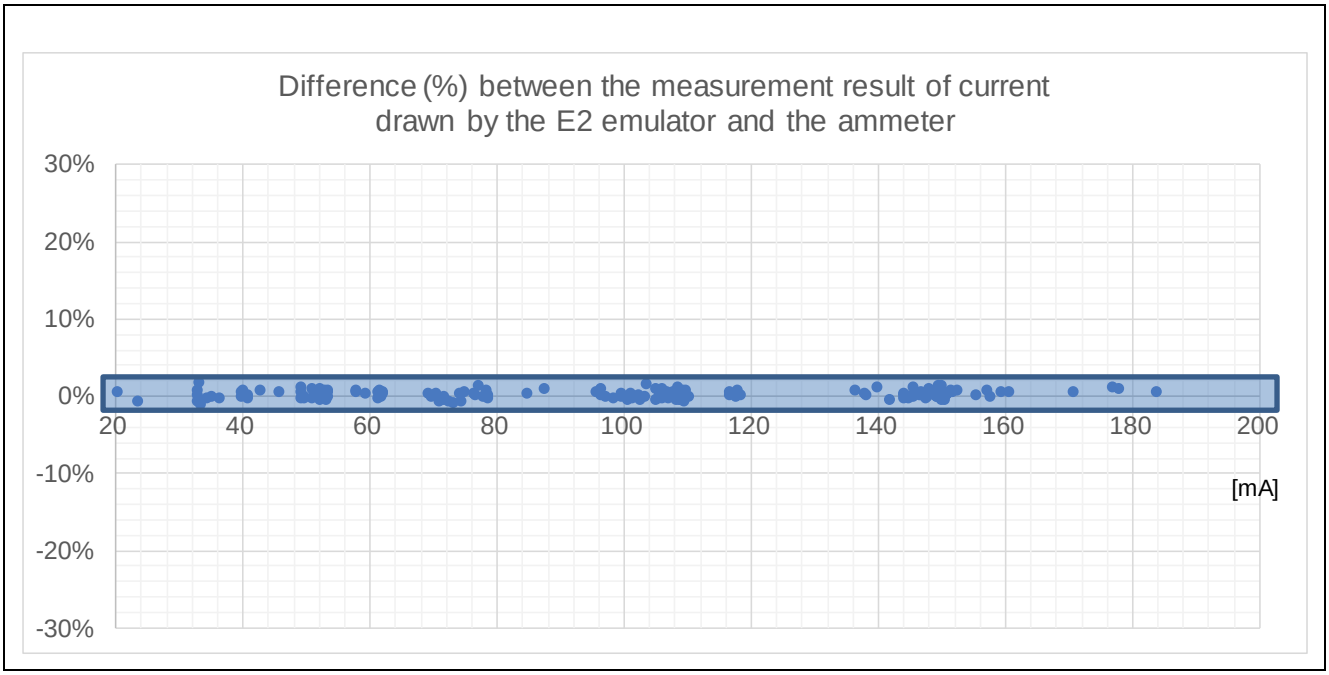


Figure 5-3 Difference between the Measurement Result of Current Consumption and the Ammeter (1)

For current consumption within the range of 20 mA and 200 mA, the difference between the ammeter and the measurement result of current drawn by the E2 emulator is a mere ±2%.

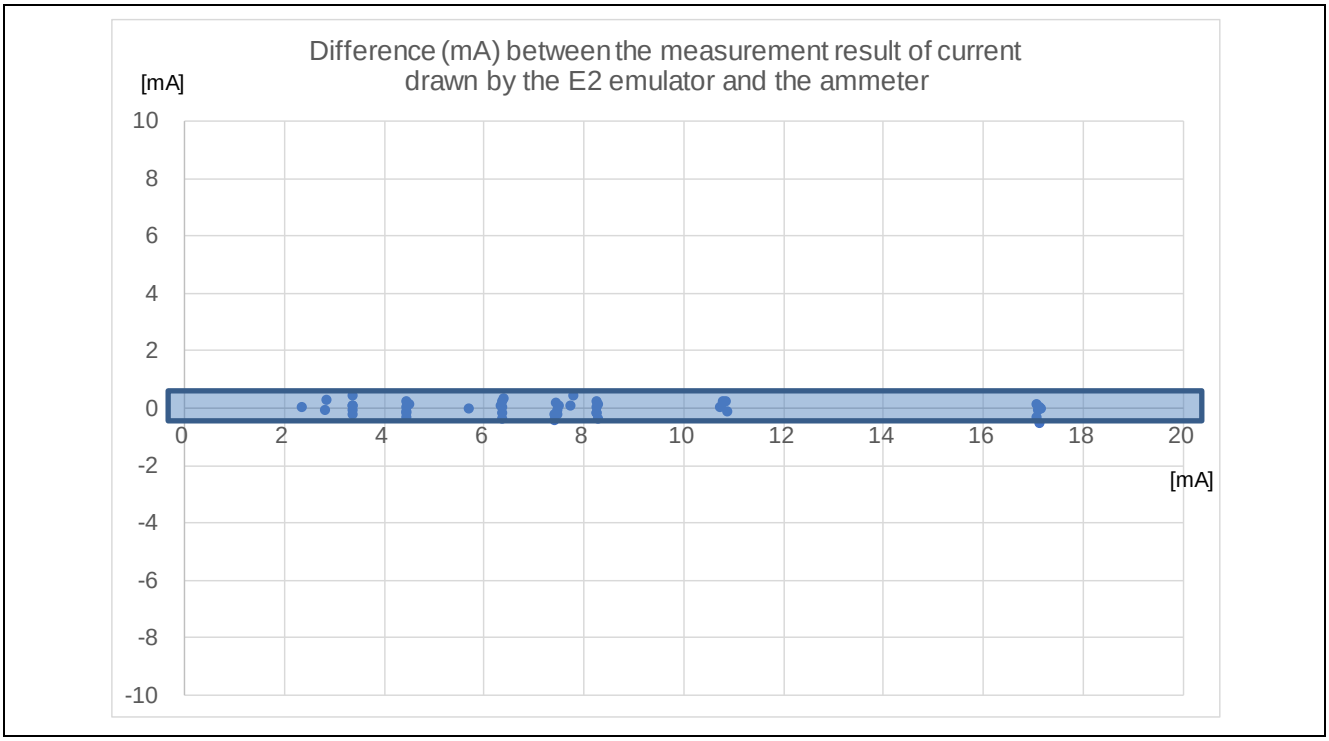


Figure 5-4 Difference between the Measurement Result of Current Consumption and the Ammeter (2)

For current consumption within the range of 0 mA and 20 mA, the difference between the ammeter and the measurement result of current drawn by the E2 emulator is a mere ±0.5 mA.

5.9 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 drawn in the E2 emulator, and it does not indicate that variation has occurred in the current drawn by the actual user system.

The degree of variation is a mere ±0.5 mA.

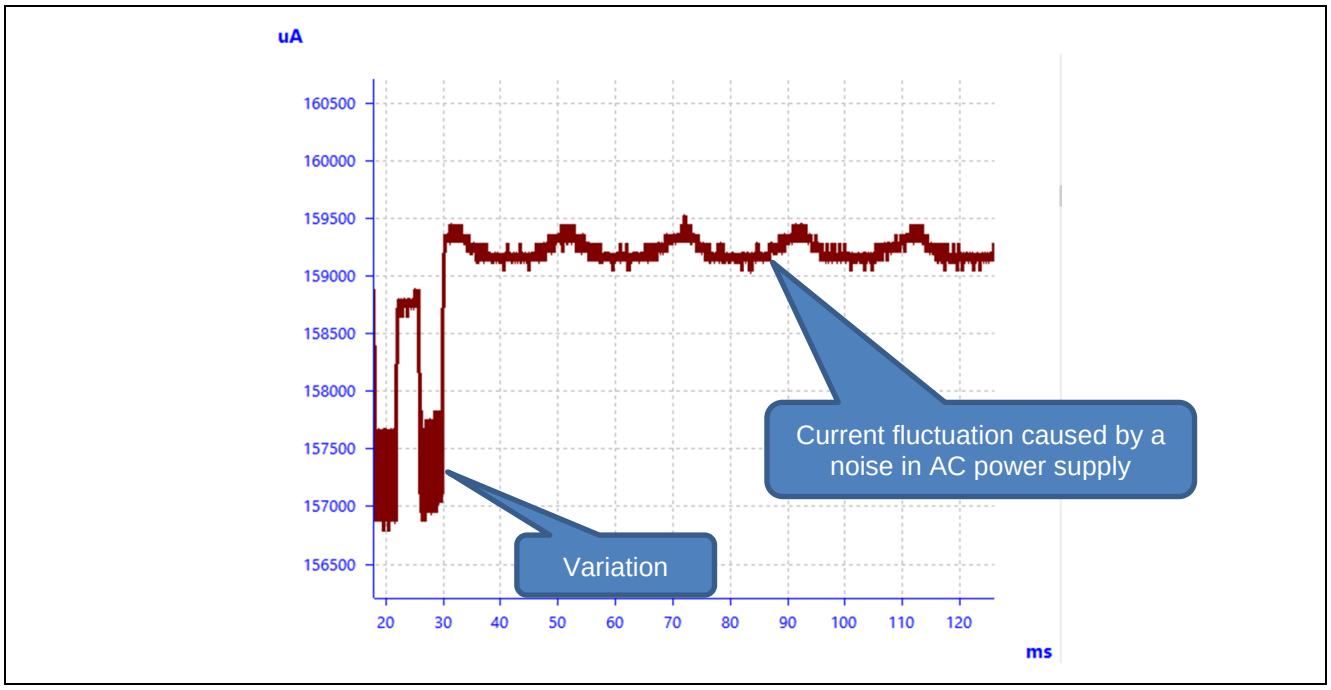


Figure 5-5 Characteristics of Measurement Result of Current Consumption

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Jul. 16, 2017	—	First edition issued

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

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

1. Handling of Unused Pins

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

   ¾ The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

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

   ¾ The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   ¾ The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

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

   ¾ When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   ¾ The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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