RX72M Group

EtherCAT EoE Sample Program

Introduction

This document explains Sample Program setup procedures for EtherCAT® slave functionalities with the adapted EtherCAT Stack Code for Renesas RX72M platform. This describes steps to confirm slave behavior and stack features using TwinCAT®Master Configuration tool.

Target Device

RX72M

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1. Overview

This document describes the procedure for testing the EtherCATof Ethernet over EtherCAT function using EtherCAT stack code compatible with the Renesas RX72M platform. The scope of the documentation is limited to explaining how to use the SSC tool for EtherCAT slave stack code generation and testing its behavior against TwinCAT masters and test applications.

EtherCAT(Ethernet for Control Automation Technology) is an Ethernet based fieldbus system, developed by Beckhoff Automation. Development of EtherCAT was to apply Ethernet for automation applications (e.g., for motion control, I/O, sensors) requiring short data update times with low communication jitter and reduced hardware costs.

Tools to generate EtherCAT Slave Stack Code (SSC Tool) are available to the ETG members free of charge. This can be downloaded from the ETG website. SSC tool can be used to generate customized stacks, device description files (ESI) and individual source code documentation to suit the developer's own needs.

1.1 Abbreviations/Definitions

Table 1.1 Abbreviations/Definitions

Index	Abbreviations /Definitions	Description
1	CoE	CAN application protocol over EtherCAT
2	EEPROM	Electrically Erasable Programmable Read-Only Memory
3	ESC	EtherCAT Slave Controller
4	ESI	EtherCAT Slave Information
5	FoE	File Access Over EtherCAT
6	I2C	Inter-Integrated Circuit
7	MB	Mail Box
8	PDO	Process Data Object
9	SSC	Slave Stack Code
10	EoE	Ethernet Over EtherCAT

1.2 Reference

Technical information about EtherCAT is available via ETG member site, and information about RX72M is available via Renesas.

Table 1.2 Technical Inputs

Index	Technical Inputs
1	R01UH0804xxxxx-rx72m
2	REN_r20ut4391xxxxxx-rsk+rx72m-usermanual_MAT_20190731.pdf
3	REN_r20ut4388xxxxxx-rsk+rx72m-qsg_MAT_20190731.pdf

2. Features

EtherCAT slave stack code generated by SSC Tool provides the functionality of EtherCAT slave controller.

Includes the following features:

- ESM (EtherCAT State Machine)
- Mailbox protocols:
  - CoE (CAN application protocol over EtherCAT)
- Synchronization Modes:
  - Free Run
  - Sync Manager Synchronization
  - DC Synchronization
- Ethernet over EtherCAT Profile:
  - M3S-T4-Tiny

3. Software structure

Table 3. shows the software structure of the sample program.

The sample program consists of the EtherCAT sample part and the TCP/IP sample part.

EoE enables Ethernet-based services and protocols to be used by encapsulating Ethernet communication frames in EtherCAT communication data.

The fragmentation of the Ethernet communication frame during assembly and transmission of the segmented Ethernet communication frame at the time of reception due to the encapsulation of the communication data is implemented as the EoE service of the SSC.

The virtual Ethernet driver replaces the Ethernet driver on the physical layer of the normal TCP/IP stack and is responsible for passing the Ethernet communication frame between the TCP/IP protocol stack and the EoE service.

The TCP/IP sample has the function of an echo server and echoes back received TCP or UDP packets.

The EtherCAT sample has the function of an I/O controller, and it is possible to check input/output control from the master with the LEDs and DIP SW on the RSK board.

Table 3. Software structure

Layer / Sample	EtherCAT Sample	TCP/IP Sample
Application layer	I/O Controller*	TCP Echo Server*
Protocol stack layer	EtherCAT Slave Stack (SSC)**	M3S-T4-Tiny
	including EoE Service	
Wrapper to driver layer	EtherCAT SSC port	M3S-T4-Tiny Ethernet driver
Driver layer	EtherCAT Slave Controller driver	Virtual Ethernet*

*: provided by sample project
**: provided by Beckhoff, patched by sample project
unmarked: provided by FIT

4. Operating Environment

The sample programs described in this manual run in the following environment.

4.1 Testing Environment

Table 4.1 Testing environment

Supported MCU	RX72M Group
Evaluation board	Renesas Starter Kit+ for RX72M (product type name: RTK5572MNxCxxxxxBJ)
	RX72M evaluation board TS-RX72M-COM from Tessera Technology
	RX72M CPU Card with RDC-IC
Integrated development environment (IDE)	e^2 studio 2024-07 from Renesas Electronics
Cross tool	C/C++ Compiler Package for RX Family V3.06.00 from Renesas Electronics
Emulator	GCC for Renesas RX 8.3.0.202405

4.2 FIT Module Configuration

The sample program covered in this application note is configured with the use of the following FIT modules.

Table 4-1 FIT Module Configuration

Type	Module Name	FIT Module Name	Rev.
Board Support Package	Board support package (BSP)	r_bsp	7.50
Device Driver	Compare-match timer (CMT)	r_cmt_rx	5.60
Middleware	M3S-T4-Tiny	r_t4_rx	2.10
Device Driver	EtherCAT	r_ecat_rx	1.31

4.3 Support Projects

Projects covered in this application note are listed below.

Table 4-2 List of Projects

MCU	Evaluation Board Name	Project Name
RX72M	RSK board	ecat_eoe_demo_comrx72m
	Communications board	ecat_eoe_demo_cpurx72m
	CPU card	ecat_eoe_demo_rskrx72m

The following sections use the RX72M communications board project as an example. If you are using an RSK board or CPU card project, please modify the communications board statements as necessary.

5. Board Setting and Connection

5.1 Setting up and connecting the Communication board

For detailed information on the evaluation board, refer to "RX72M Communication Board Hardware Manual".

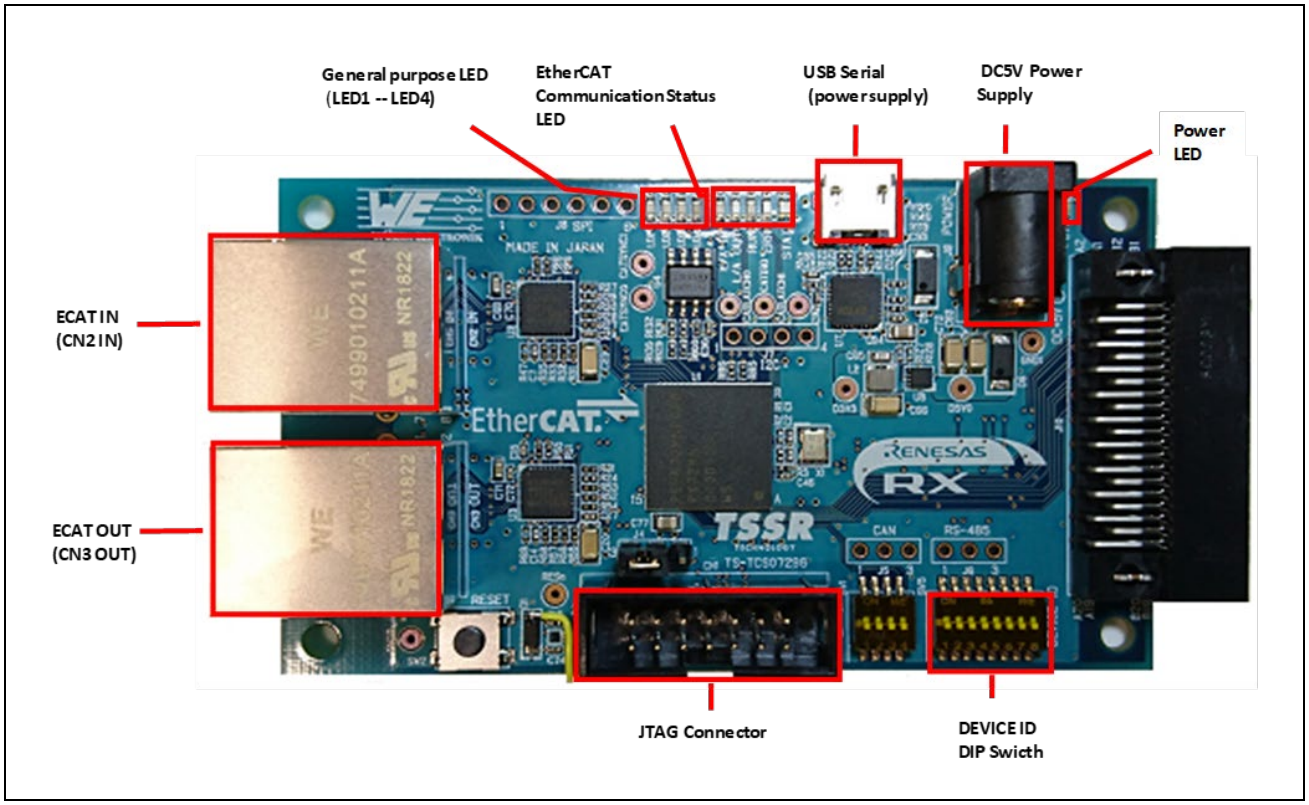


Figure 5.1 RX72M Communication board configuration

5.1.1 Communication board setting

Before powering on the evaluation board, make jumper settings and connect each cable. Configure the configuration mode of JTAG. Usually, it is used at 2-3 short of jumper pin. To use the hot plug-in function, change it to 1-2 short and use it.

For more information about the position of the relevant parts, refer to the [RX72M communication board hardware manual].

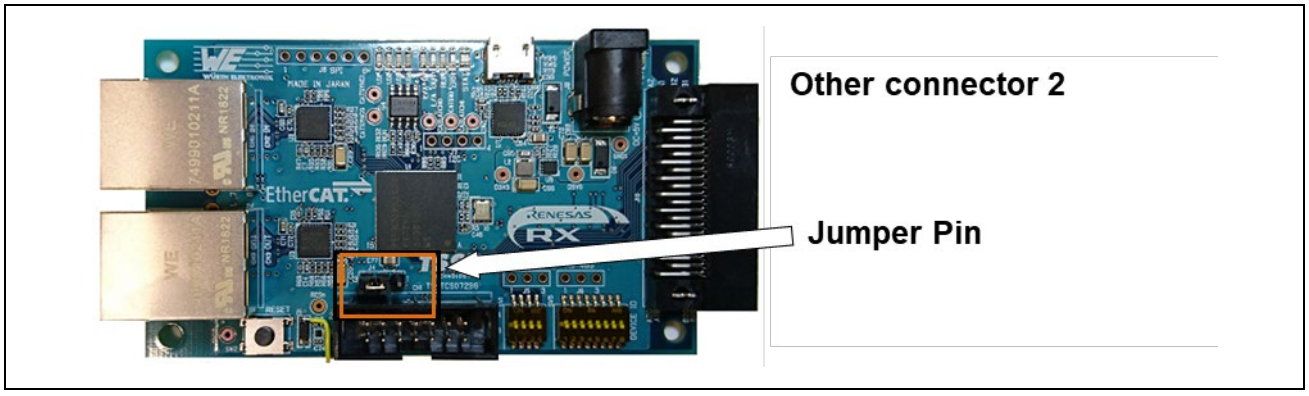


Figure 5.2 Jumper pin setting

5.1.2 Power supply selection

This board can supply power for RX 72 M by inputting DC 5 V by DC Jack or USB. select either.

5.1.3 Connection of communication board

Connect each cable as follows.

(1) Connect Ethernet cable (category 5 or higher recommended) to Ether port (CN 2 IN).
(2) Connect JTAG connector of ICE to JTAG Connector, USB connection with host computer.
(3) Connect DC 5 V from DC Jack or USB and turn on the power.

5.2 Setting up and connecting the RSK board

For detailed information on the evaluation board, refer to " Renesas Starter Kit + for RX72M Board User's Manual".(REN_r20ut4391jg0100-rsk+rx72m-usermanual_MAT_20190731.pdf)

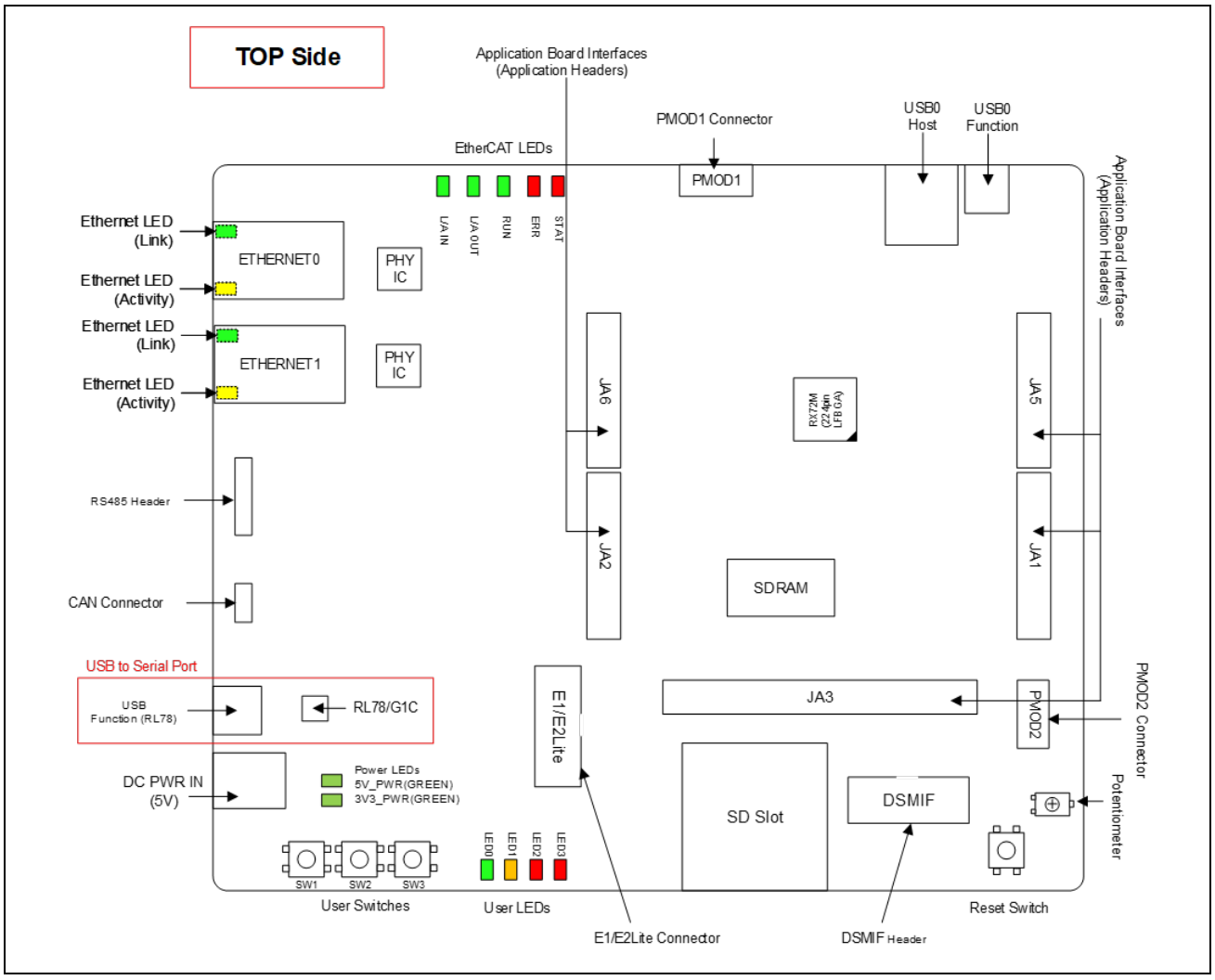


Figure 5.3 RX72M RSK board configuration

5.2.1 Power supply selection

This board can supply power for RX72M by inputting DC 5 V by DC Jack.

5.2.2 Connection of RSK board

Connect each cable as follows.

(1) Connect Ethernet cable (category 5 or higher recommended) to Ether port (ETHERNET0).
(2) Connect JTAG connector of ICE to JTAG Connector, USB connection with host computer.
(3) Connect DC 5 V from DC Jack and turn on the power.

5.3 Setting up and connecting the CPU Card

For detailed information on this board, refer to the "RX72M CPU Card with RDC-IC User's Manual" (R12UZ0098EJ0100).

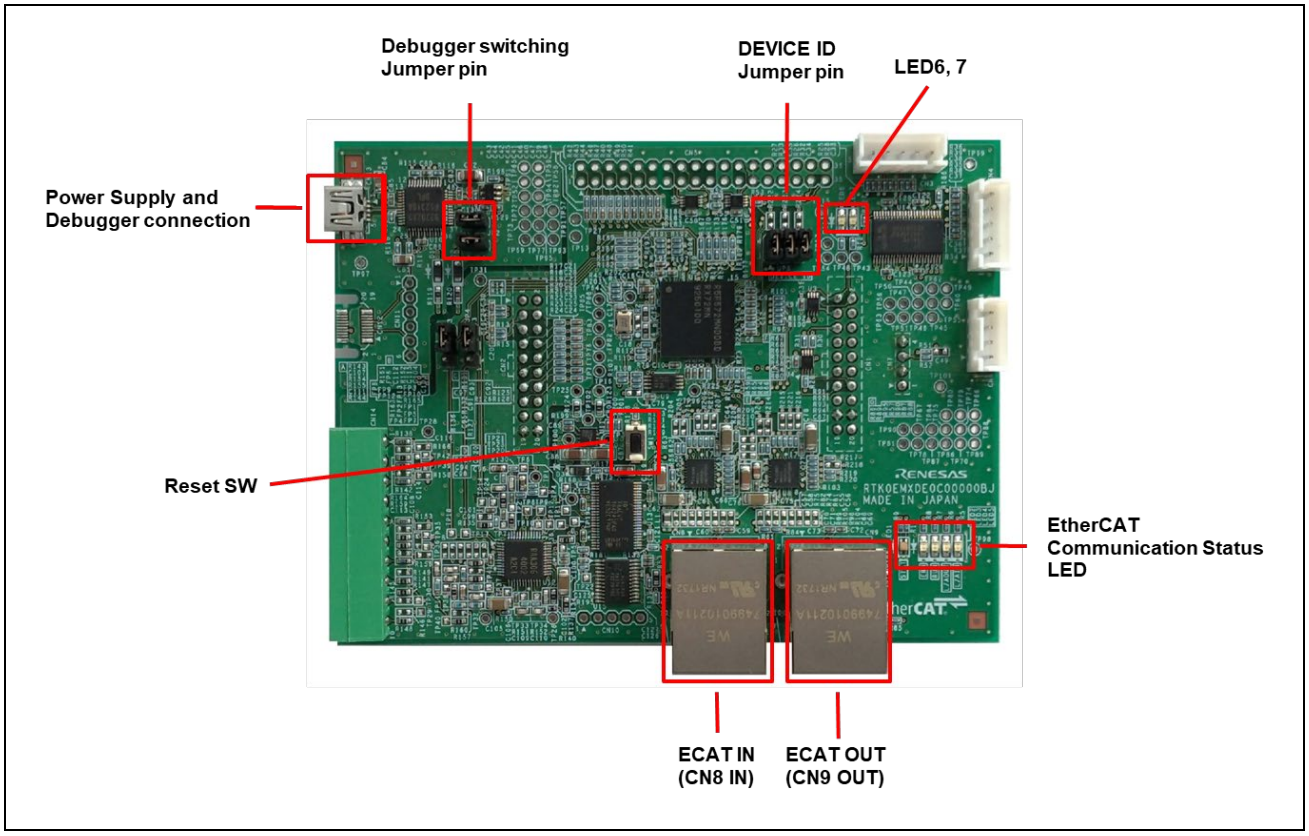


Figure 5.4 RX72M CPU Card configuration

5.3.1 CPU Card setting

Set the jumper pins before powering on the CPU Card.
Using E2OB : Short the Debugger switching Jumper pin.
Setting the device ID: Install the jumper pins (JP2,3) according to the ID. Equivalent to Bit "1" in short.

5.3.2 Power supply selection

CPU Card does not have DC Jack, input DC5V from USB connector.

5.3.3 Connection of communication board

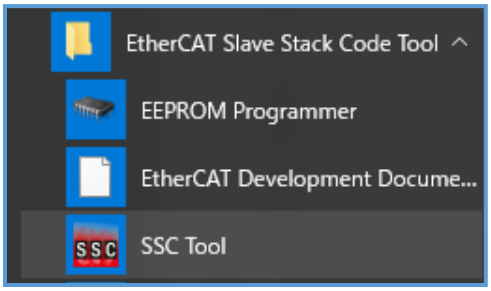
Connect each cable as follows.

(1) Connect an Ethernet cable (Category 5 or higher is recommended) to Ether port (CN8 IN).
(2) Connect the common USB connector for the emulator and power supply to the host computer.

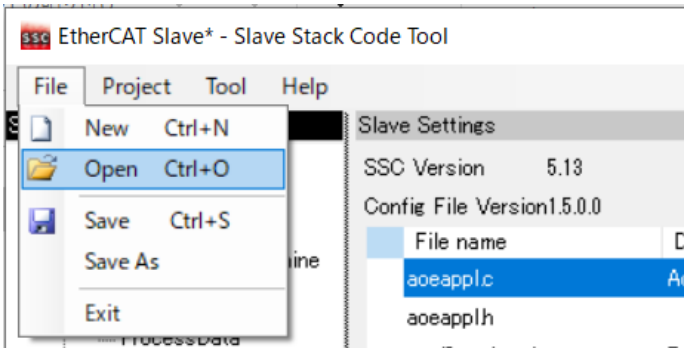
5.4 Generating the Slave Stack Code

SSC Tool is used for generating the slave stack code.
Note). Replace the folder name in the following description according to the tool to be used.

1. Start the SSC Tool from the Windows Start menu.



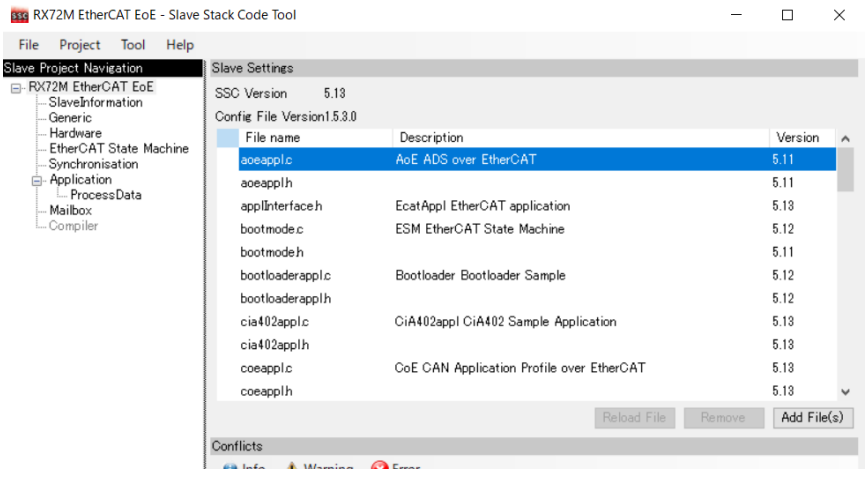
2. Select File > Open.



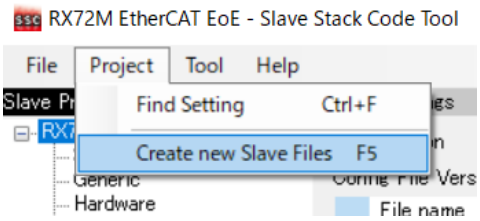
3. Select and double-click the following file,
   "FITDemos\ecat_eoe_demo_xxxrx72m\utilities\ssc_config\ RX72M EtherCAT EoE.esp"

   Note). xxx is "com" or "rsk" or "cpu."

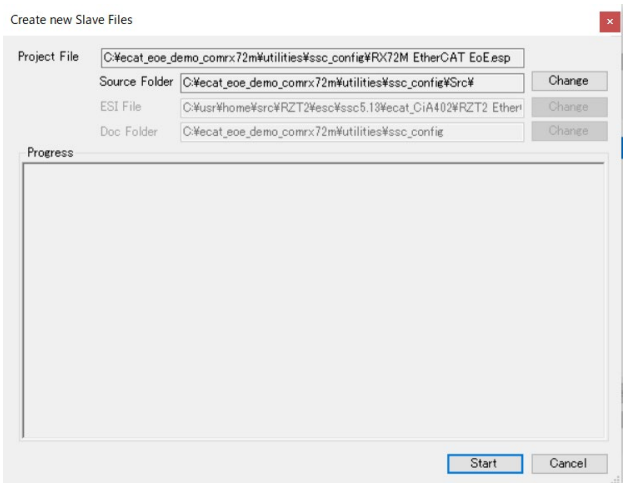
4. After clicking, the following window opens.



5. Select Project > Create new Slave Files.

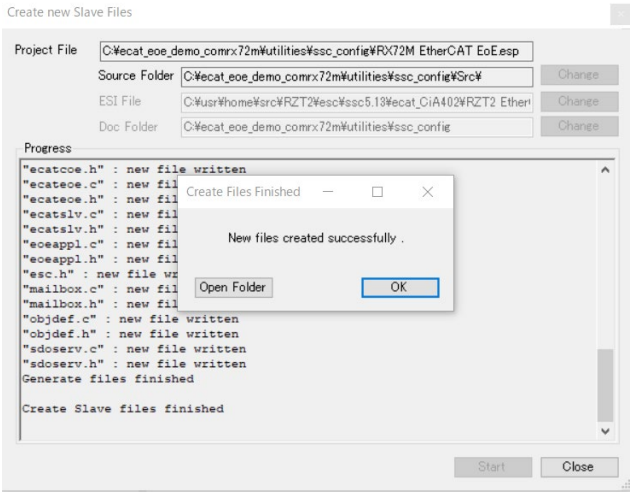


6. Click the [Start] button to start creating the EtherCAT Slave Stack Code.



7. When a message “New file created successfully” appears, the creation processing is completed, and the source files are located in the following folder.
“FITDemos\ecat_eoe_demo_xxxrx72m\utilities\ssc_config\ssc_config”

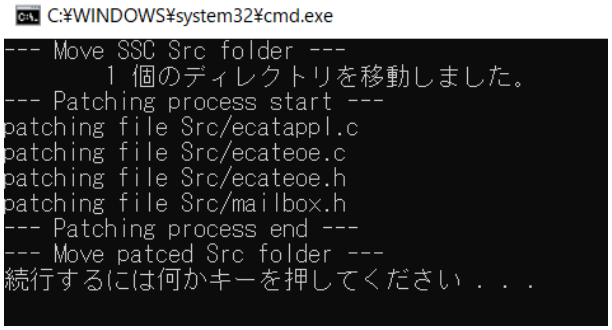
Note). xxx is “com” or “rsk” or “cpu.”



Note), If an error occurs during generation, uncheck "Create device description" in [Tool]-> [Option]-> [Create Files] of the SSC tool.

8. Right-click on the apply_patch.bat file and select [Run as an administrator] → [Yes].
   The patch file contains modifications to make the SSC source file suitable for the RX72M.
   "FITDemos\ecat_eoe_demo_xxxrx72m\utilities\patch\apply_patch.bat"

   Note). xxx is "rsk" or "cpu."



After execution of the patch, the modified source file is stored in the following folder.

"FITDemos\ecat_eoe_demo_xxxrx72m\project\src\application\ecat\beckhoff"

Note). If the patch command is not installed on your PC, you will need to install it (see Appendix A). If it is already installed, skip this step.

Note). xxx is "com" or "rsk" or "cpu."

6. Setting up a TwinCAT3

6.1 Copying the ESI Files

Before starting TwinCAT, copy the ESI files that are included in the release folder to TwinCAT destination **"\TwinCAT\3.x\Config\IO\EtherCAT"**

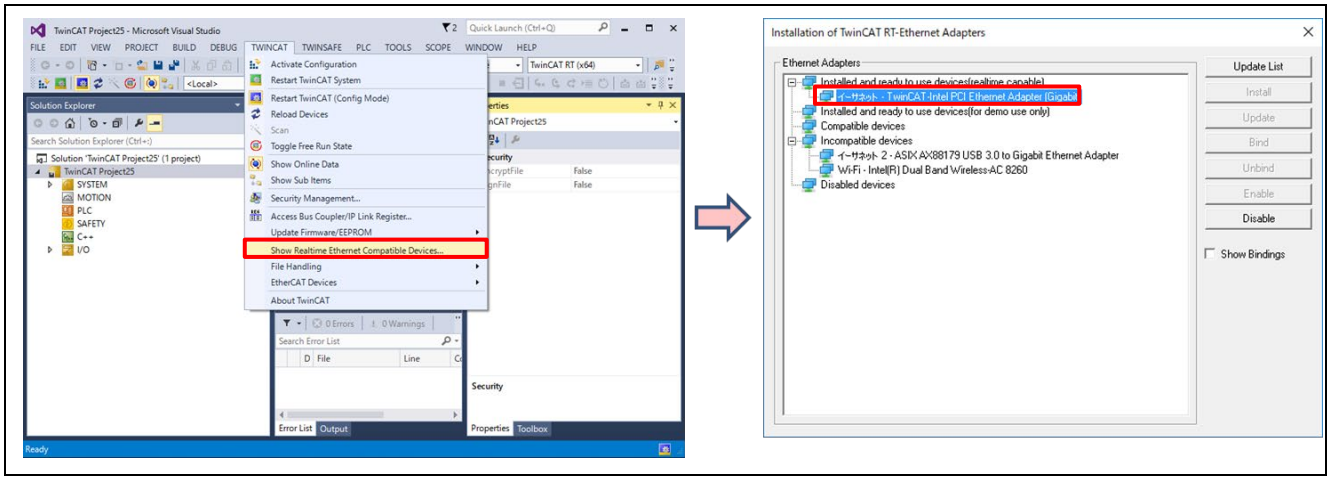
ESI file for current release available at,
"FITDemos\ecat_eoe_demo_xxxrx72m\utilities\esi\ESI\RX72M EtherCAT EoE.xml"

Note). xxx is "com" or "rsk" or "cpu."

6.2 Add Driver

Add the Ether driver for TwinCAT. (First time only)
From the start menu, select [TwinCAT3] → [Show Realtime Ethernet Compatible Devise].

Select the connected Ether port from the communication ports and install it.



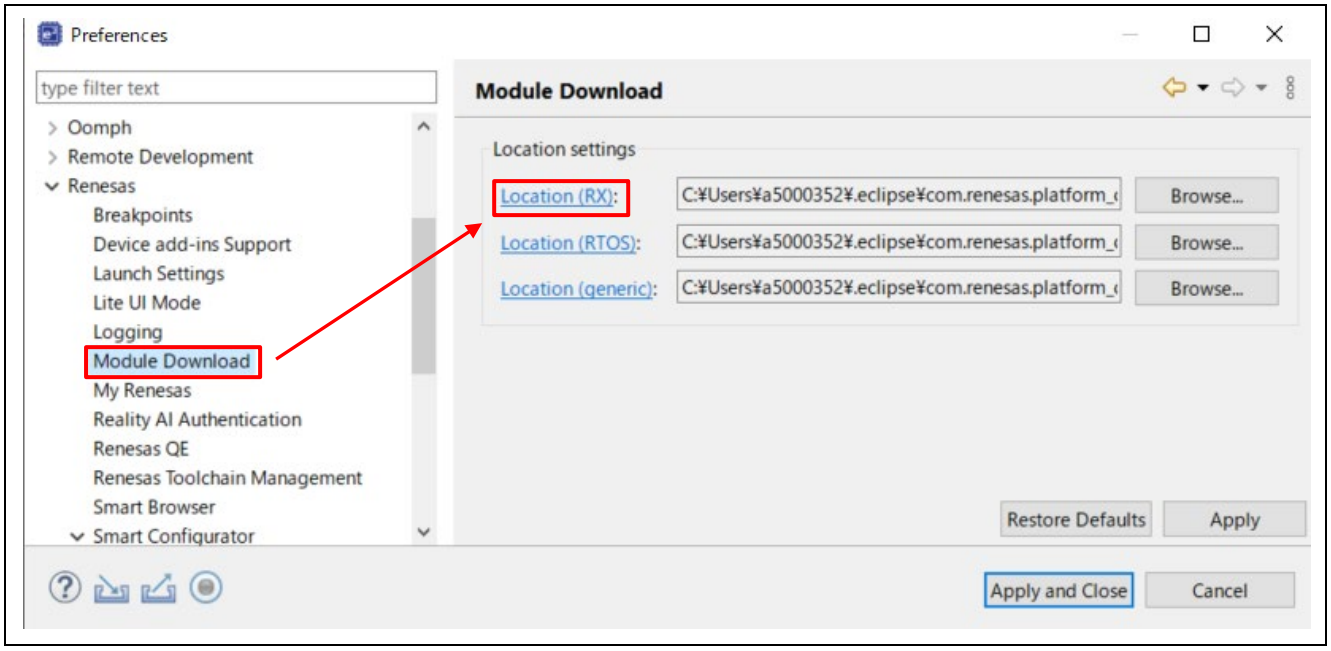
Note). Depending on the network card installed in your PC,
it may not be "Installed and ready to use device (realtime capable)" but
it may be "Installed and ready to use device (for demo use only)".

7. Adding the FIT Module to Your Project

By adding the EtherCAT FIT module to e2 studio, it can be used with Smart Configurator.
Here is how to add it manually.
Copy the EtherCAT FIT module to the folder where the FIT module of e2 studio is saved.

Check the location of the FIT module in e2 studio.
[Window]→[Preferences]→The Preferences window opens.
[Renesas] →[Module Download]→[Location (RX)]

"Location (RX):" is the folder where the FIT module of e2 studio is saved.



EtherCAT FIT module is stored in the FITModules folder of the sample program.
Copy the files in the **"r01an7520xx0100-rx72m-ecat-eoe\FITModules"** folder to the location where the FIT modules are saved.

r_ecat_rx_v*N.NN*.xml

r_ecat_rx_v*N.NN*.zip

r_ecat_rx_v*N.NN*_extend.mdf

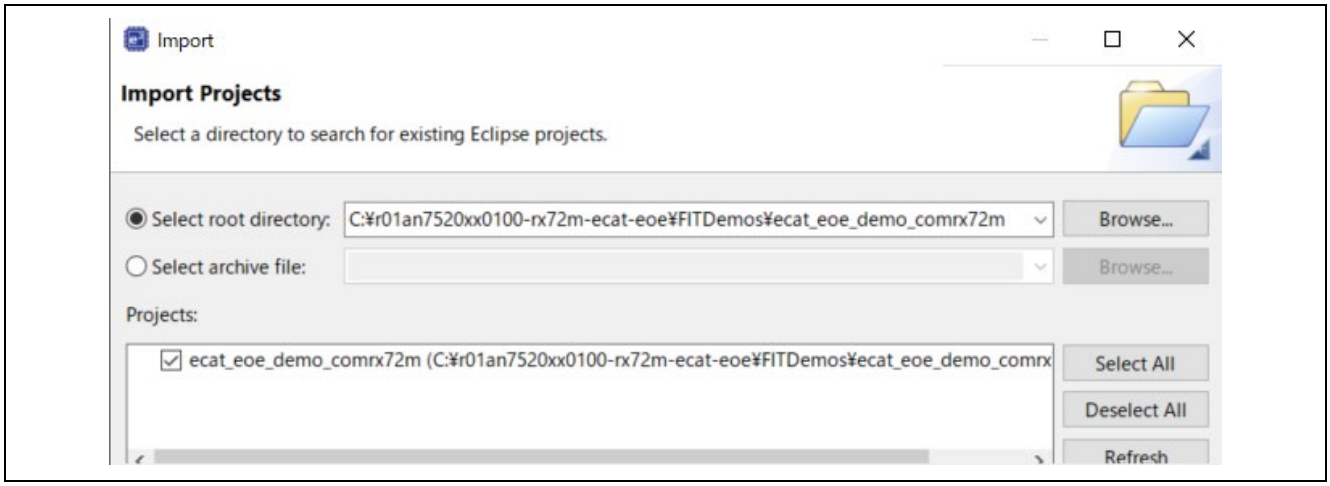
N.NN is numerical values that represent the version.

8. Execution of EtherCAT EoE Sample Program

This section describes the instructions for communicating with the Modbus sample application.
Refer to section 4 ,Operating Environment and section 5, Board Setting and Connection in advance to complete tool installation and hardware connection.

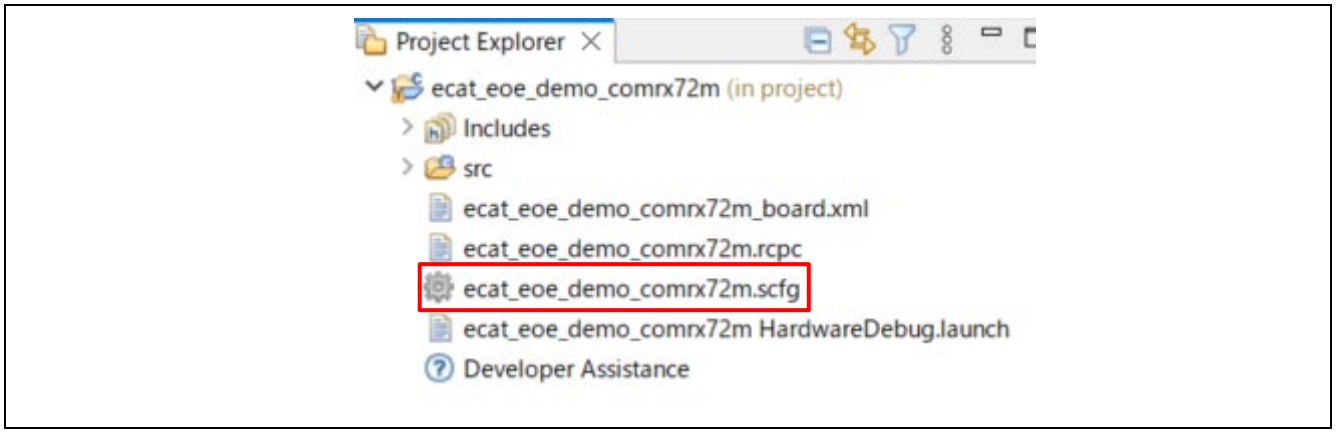
1. Import the sample project after starting the e^2 studio by selecting
   File > **Import** > **Existing Projects into Workspace**.
   Click Select root directory and select "**01an7520xx0100-rx72m-ecat-eoe\FITDemos \ecat_eoe_demo_xxxrx72m"** folder.

   Note). xxx is "rsk" or "cpu."

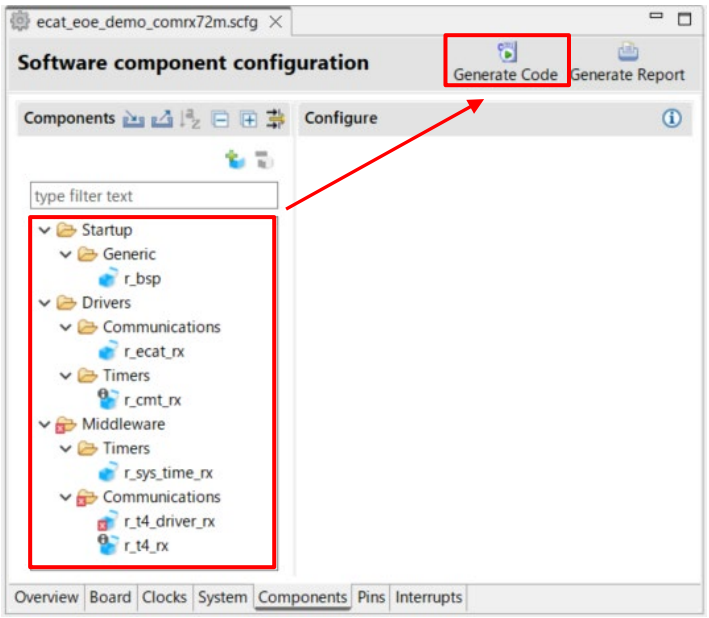


2. Open "**ecat_eoe_demo_xxxrx72m.scfg**" in the " **ecat_eoe_demo_xxxrx72m** " project

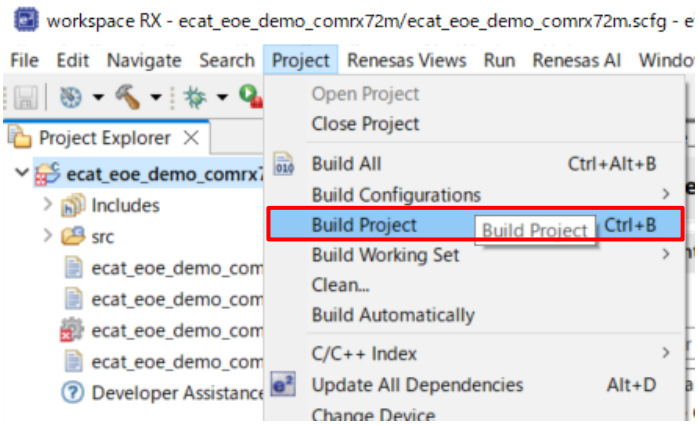
   Note). xxx is "com" or "rsk" or "cpu."



3. Open the Components tab.
   Make sure all components are enabled and then run code generation.



4. Execute the build.
   At this time, confirm that there are no build errors.



Note). If build error occurs during build, please correct the following.

Error:

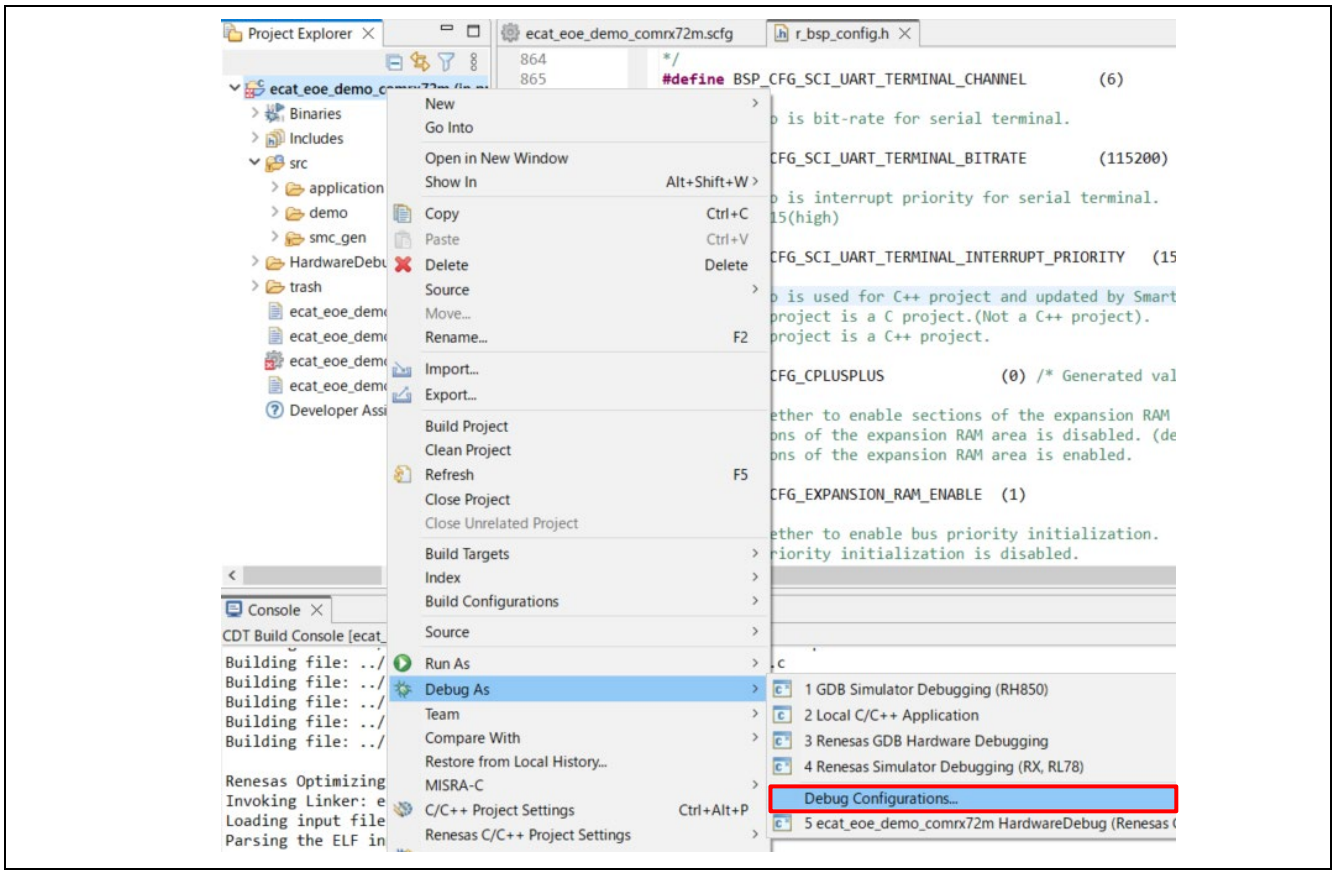
```
E0562132:Cannot find "DEXRAM" specified in option "rom"
```

Code location to be modified:
"ecat_eoe_demo_xxxrx72m\src\smc_gen\r_con fig\r_bsp_config.h"

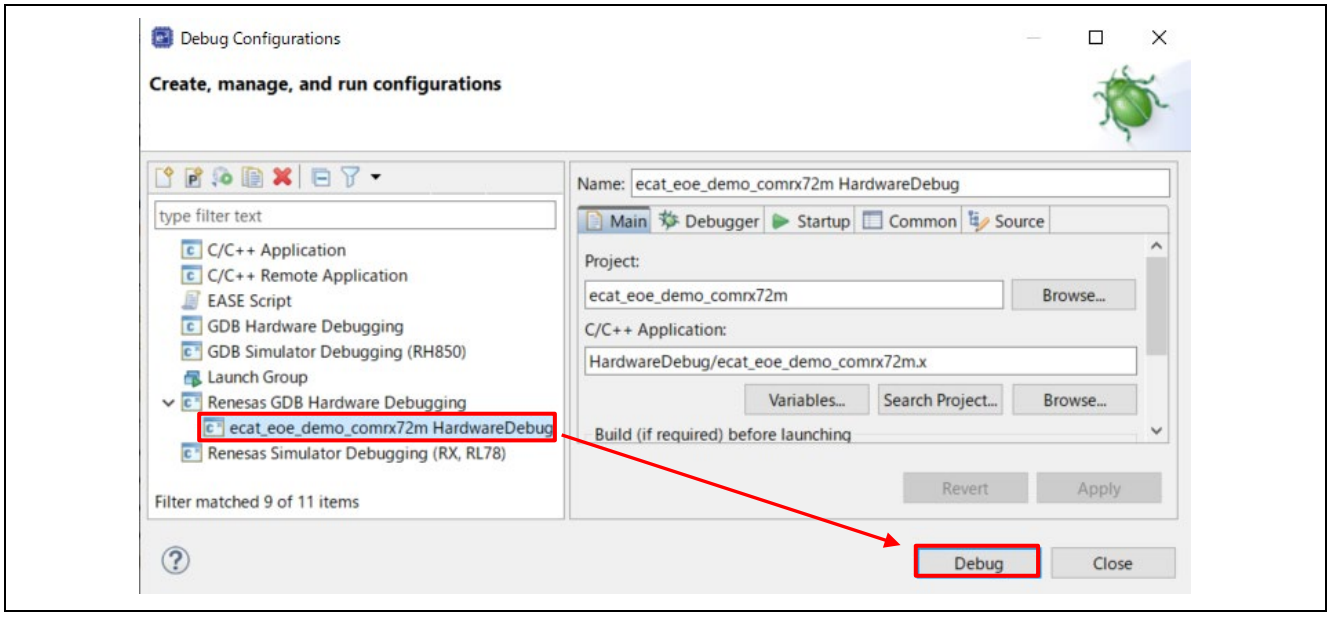
#define BSP_CFG_EXPANSION_RAM_ENABLE (0) → (1)

Note). Component dependencies give errors, but no issues

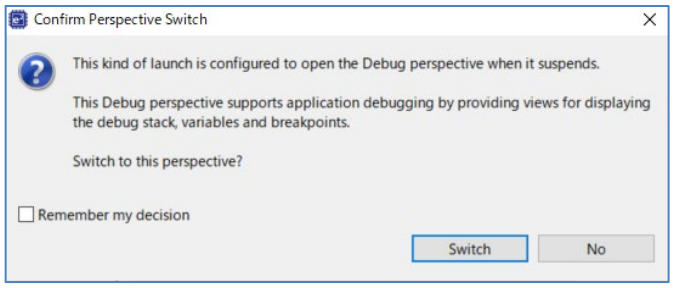
5. Download the application and run the debugger.
   After connecting the board and J-Link, start debugging using the following procedure.
   In **Project Explorer** view, right-click the node of project to be debugged and select **Debug As** > **Debug Configurations**.



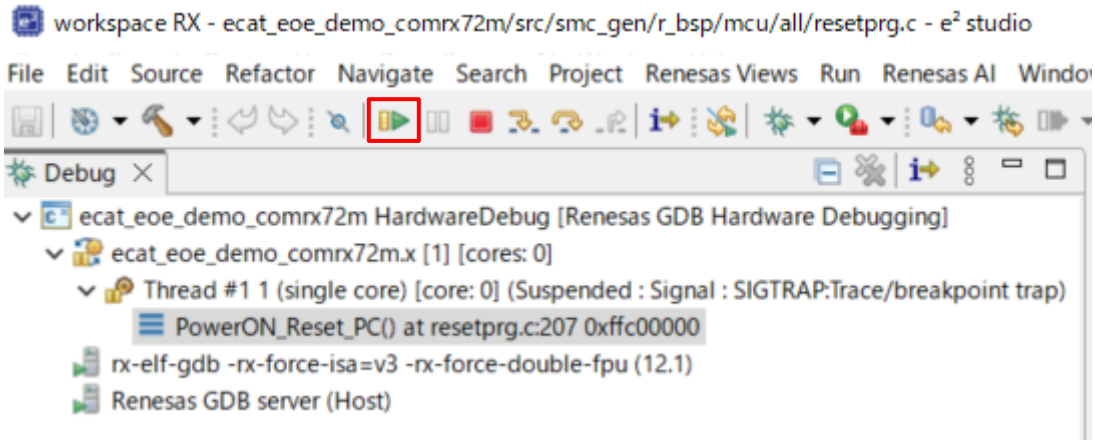
6. Program download.
   Select **Renesas GDB Hardware Debugging** > **ecat_eoe_demo_comrx72m**, then click **Debug**.



The following dialog appears, switch to the debug screen.



7. Program starts.
   Click the **Resume** button.
   When debugging starts, the program is interrupted at `main.c;`
   Click the **Resume** button again to run the program.



9. Evaluation of EoE

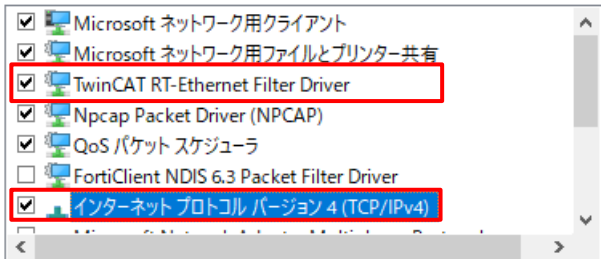
This section describes the steps to use the evaluation tool to evaluate the sample program.

9.1 IP Address Setting

In order to operate the EoE sample program, it is necessary to set the IP address of the EtherCAT master and the EtherCAT slave as fixed IP addresses.

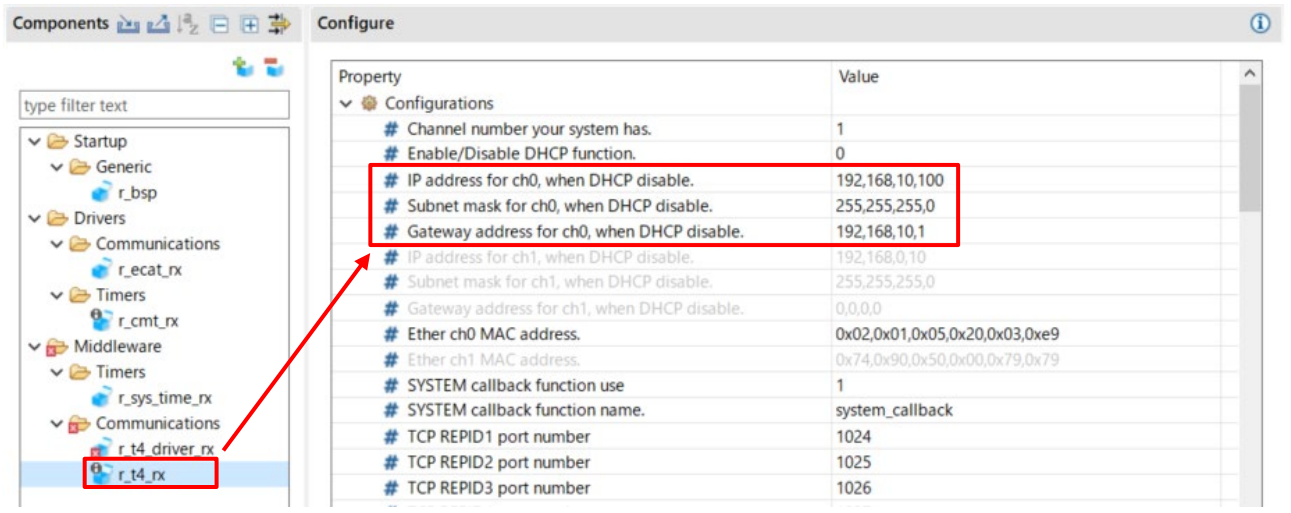
Set the IP address of the EtherCAT slave in the network configuration file of the TCP/IP stack of the sample program at the same time.

1. Enable EtherCAT and TCP/IP in the network connection settings as below figure.



2. Configure the host PC network connection as below figure.

3. When changing the IP address, etc, change it using the FIT T4 settings.



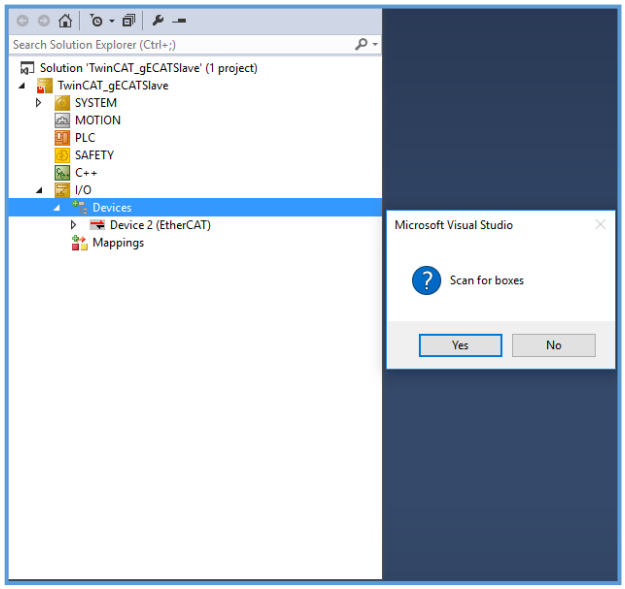
9.2 Connecting to TwinCAT3

Start TwinCAT3 by using the procedure described below,
From the start menu, select [Beckhoff] → [TwinCAT3] → [TwinCAT XAE].

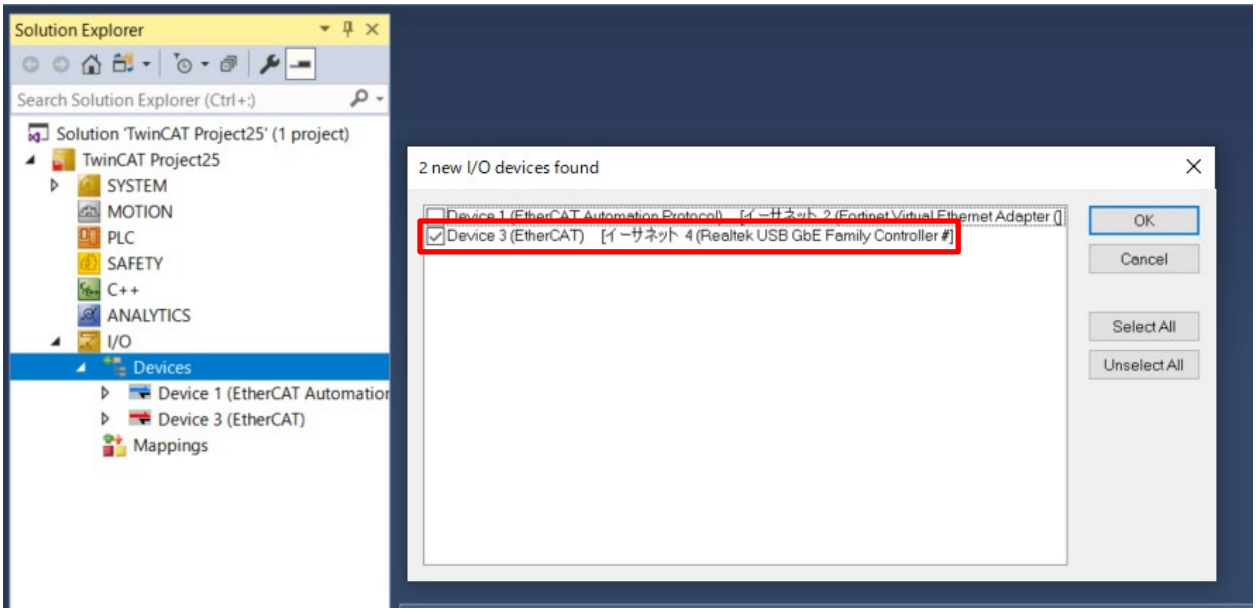
After the program is started, by selecting [File] → [New] → [Project], create a new project of the TwinCAT XAE Project type. The subsequent procedure is described below.

9.2.1 Scanning I/O Devices

1. Under solution explorer -> I/O -> Devices, select 'Scan' as in Figure below.

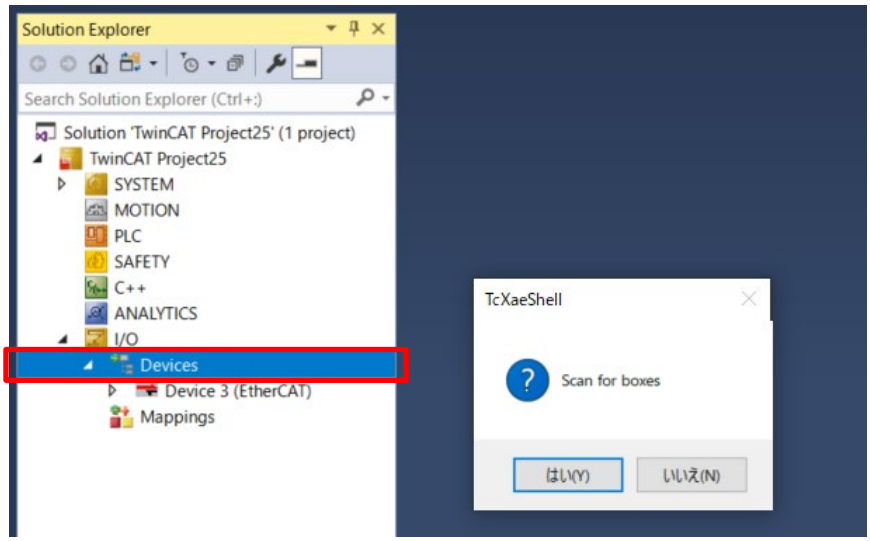


2. EtherCAT port will be displayed as below. Select and press OK.



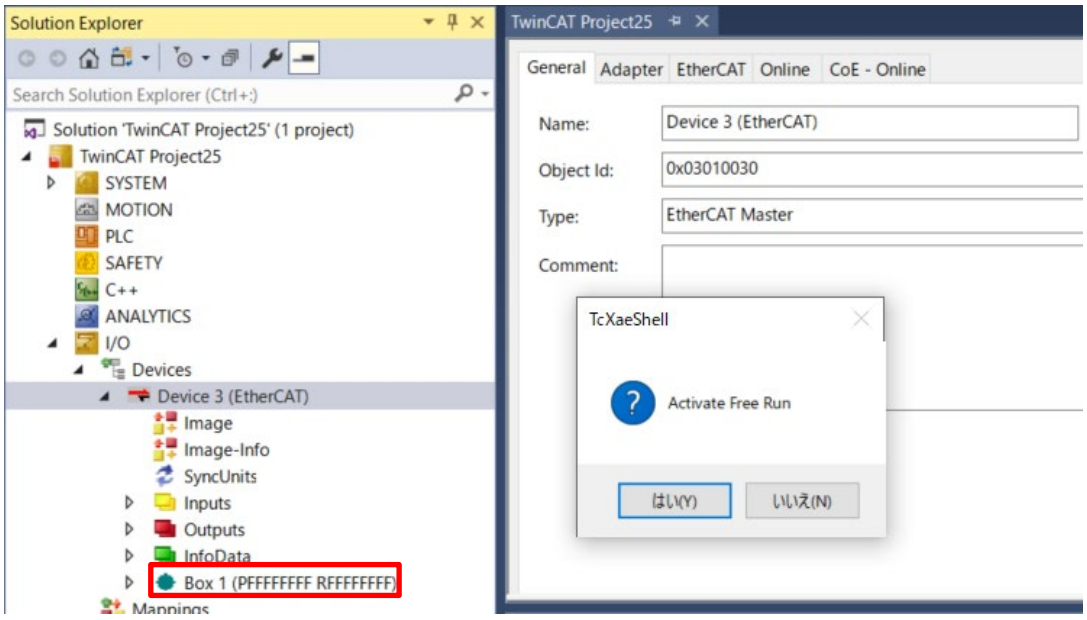
Note). If a valid slave exists in the network, TwinCAT will display the candidate with a checkbox.

3. Start scanning the device.



4. If the detected device is "Box1 (PFFFFFFFF)" as shown in the figure, ESI file has not downloaded, so, proceed without Free Run.

   If the detected device shows desired ESI filename like "Box1 (Renasas EtherCAT xxxx)", select Free run.



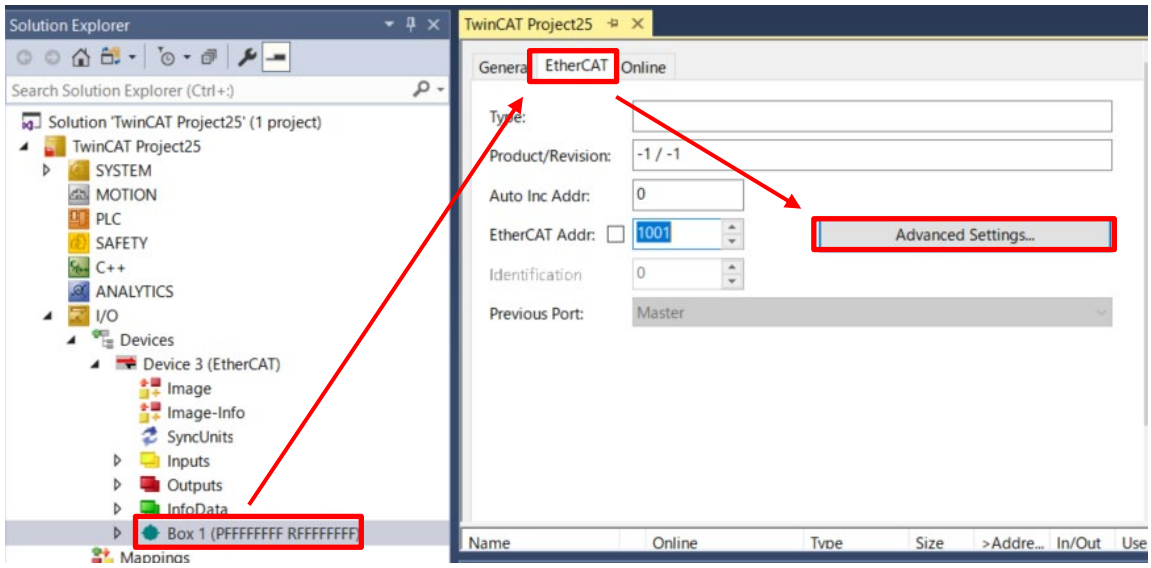
9.2.2 Updating EEPROM Data

If the data of another application has already been written to the EEPROM, replace the data.
The following shows the procedure for replacing the data on the EEPROM:

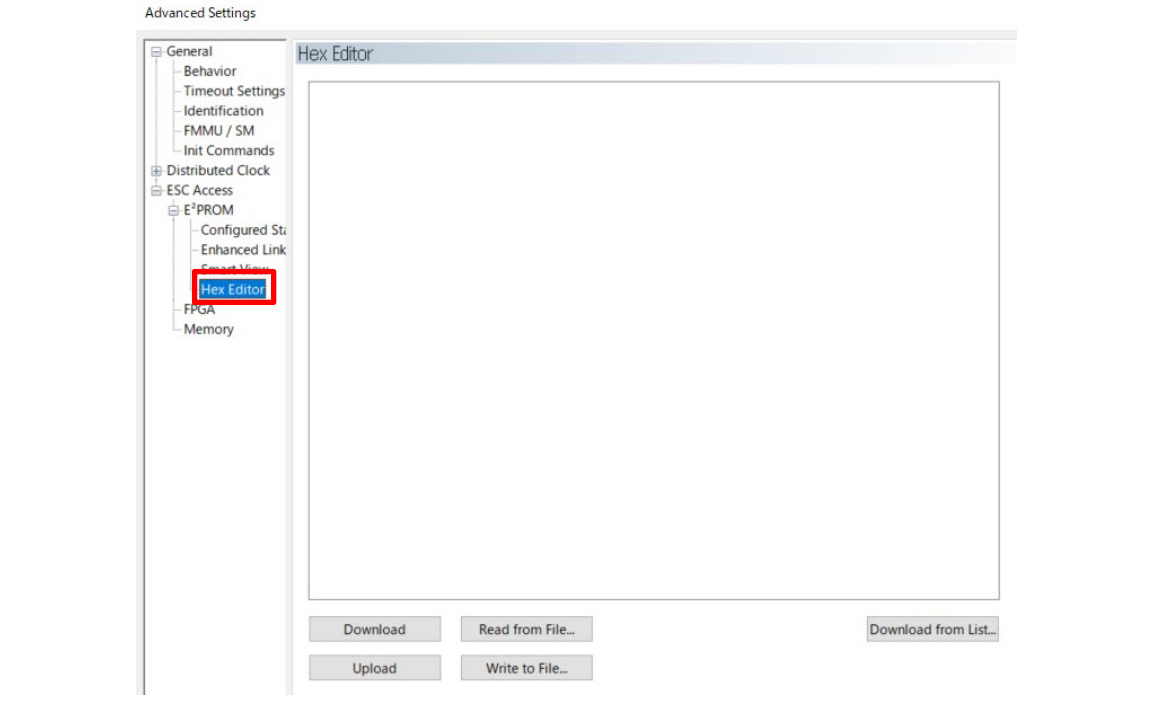
1. Double-click [Box 1] to display a panel on the right side of the window.

2. Select the [EtherCAT] tab.

3. Click the [Advanced Setting] button.

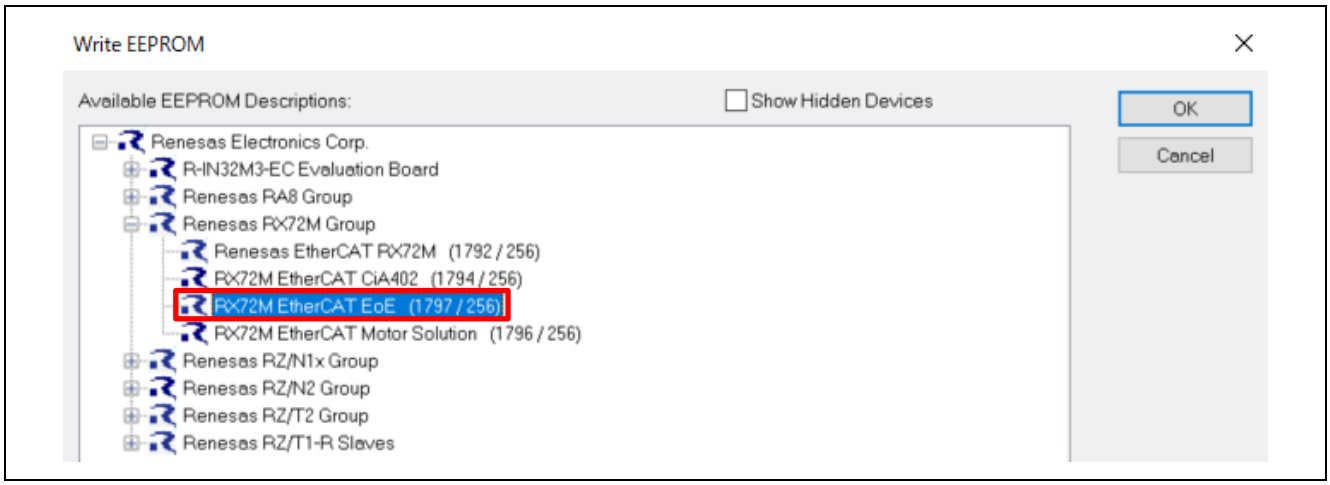


4. Select [ESC Access] → [EEPROM] → [Hex Editor].

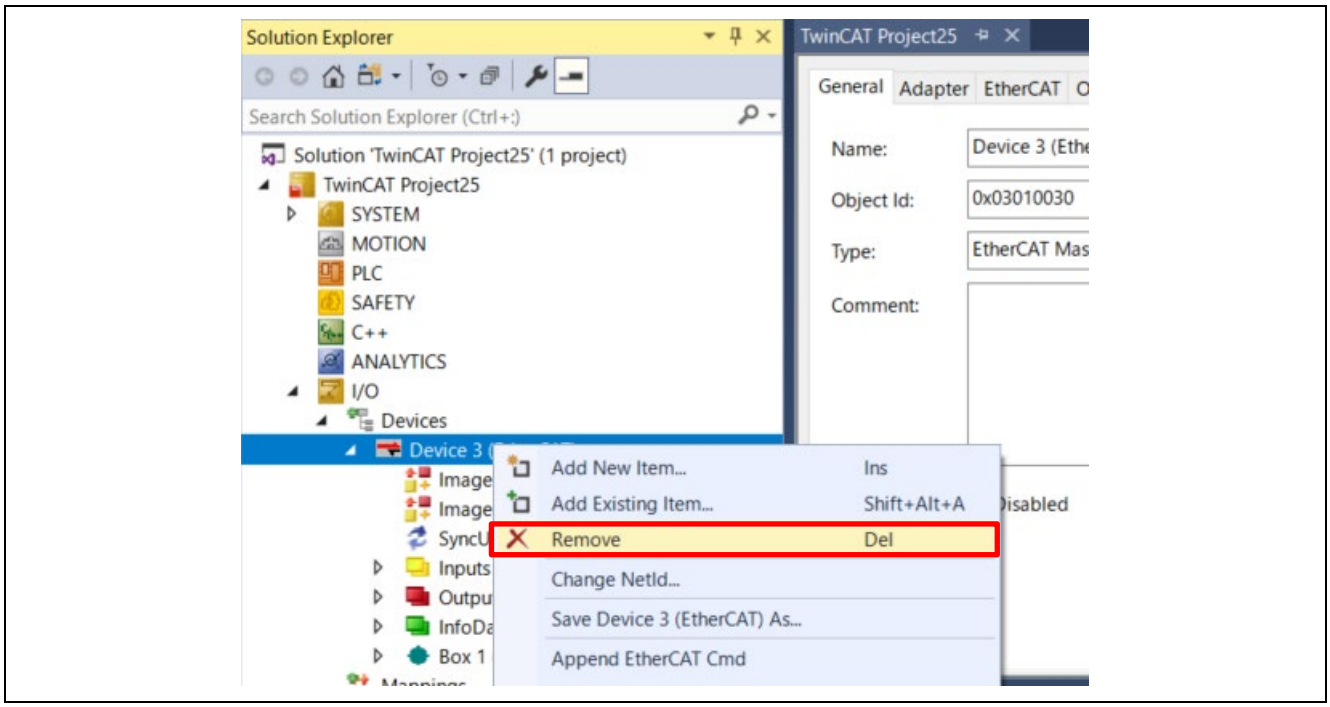


5. Select [Download from List] → Select ESI File
   "FITDemos\ecat_eoe_demo_xxxrx72m\utilities\esi\ RX72M EtherCAT EoE.xml"

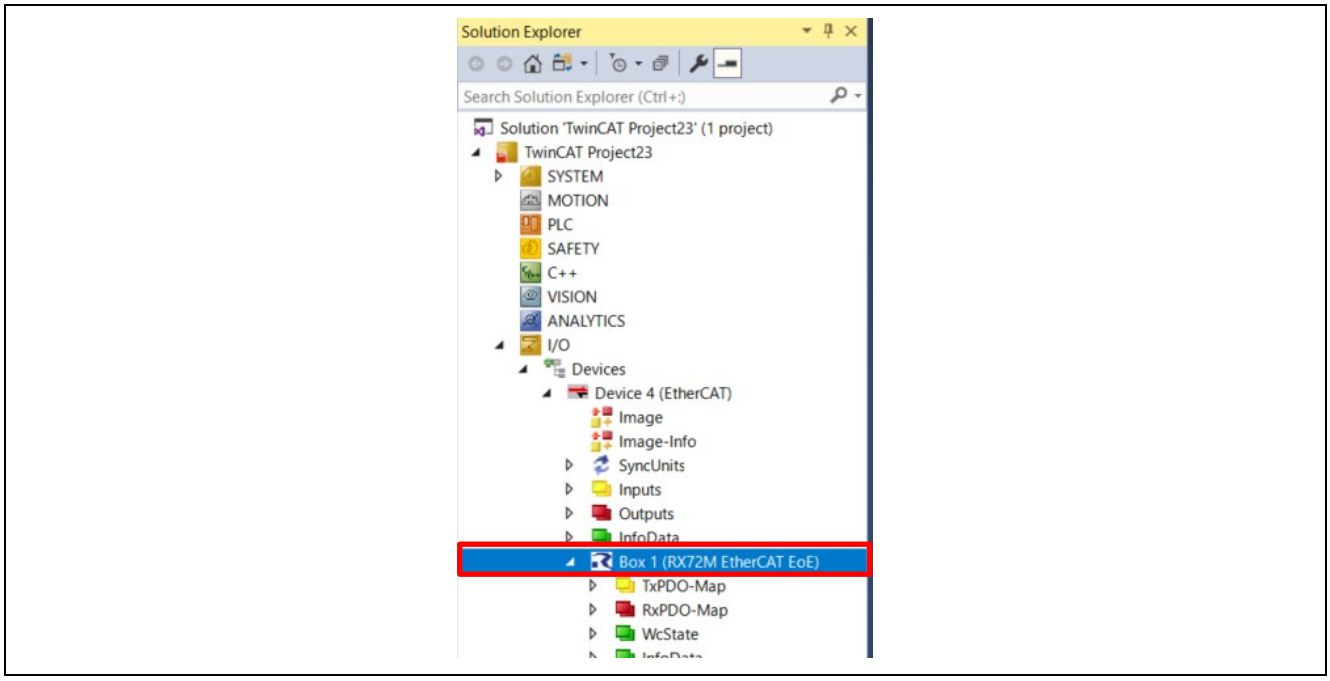
6. OK and Download.



7. Apply the ESL file settings.
   Select the device and remove it.



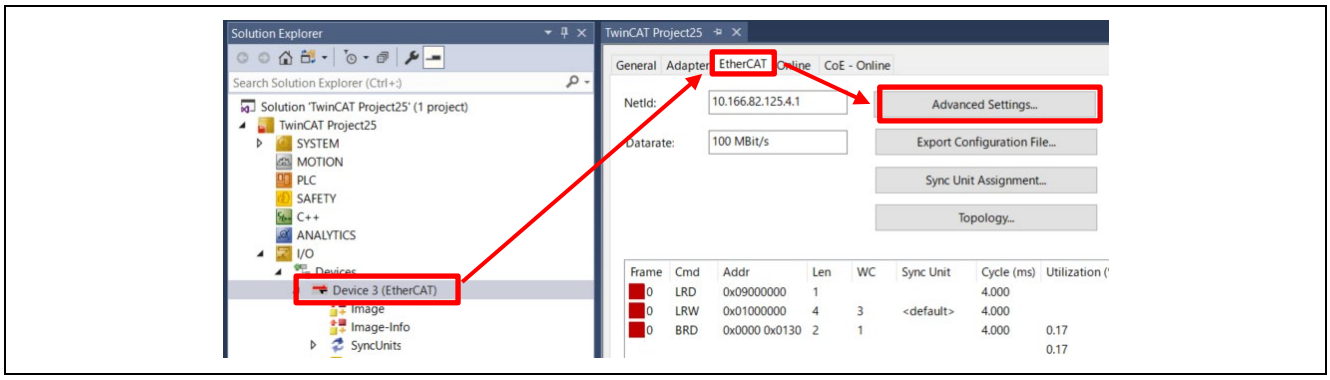
8. Scan the device again.
   If the desired ESI file is displayed, it is correct operation.



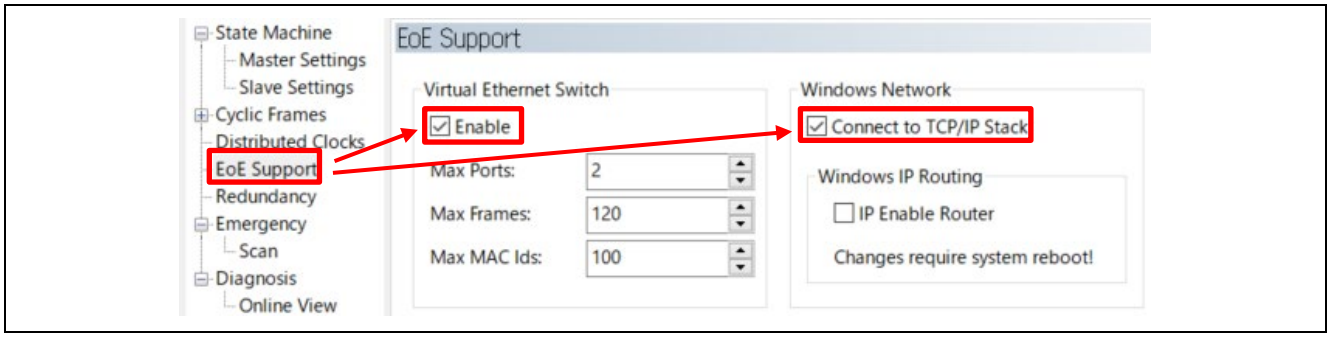
9.2.3 TwinCAT3 setting for EoE

Set TwinCAT3 for EOE operation.

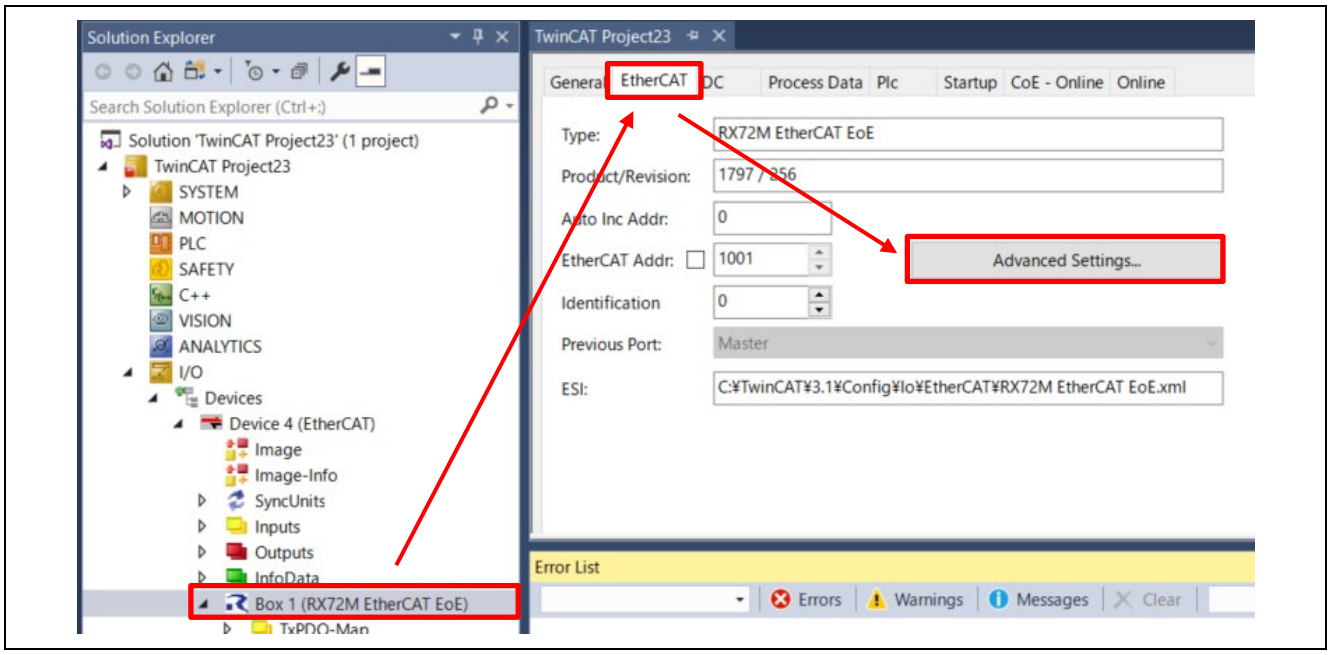
1. Double-click [Device], and Click [EtherCAT tab] → [Advanced Settings] button.



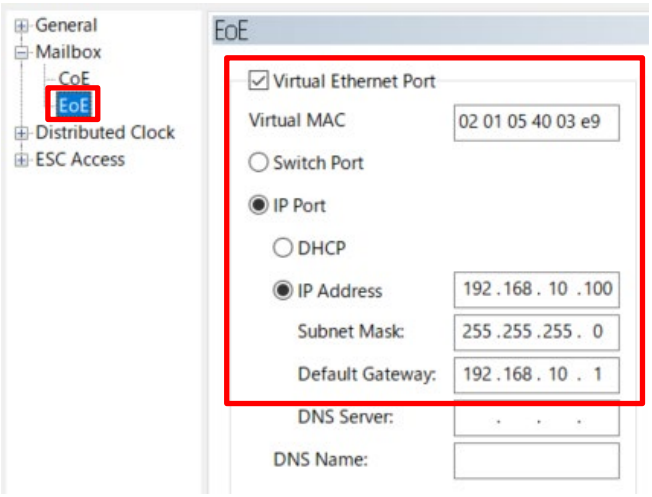
2. Check the [EoE Support] items→[Virtual Ethernet Switch Enable] and [Connect TCP/IP Stack].



3. Set the slave information.
   Double-click [Renesas EtherCAT RZ/N2 EoE], and Click [EtherCAT tab] → [Advanced Settings]



4. Select [Mailbox] →[EoE]
   Select IP Port and set the following:
   IP Address: 192.168.10.100
   Subnet Mask: 255.255.255.0
   Default Gateway: 192.168.10.1



5. Check TCP/IP operation. Start the command prompt and execute ping **192.168.10.100**, If get a response, connection is complete.

9.2.4 Checking operation with echo server

Check the operation of the TCP echo server.

Start SockV

Select socket type → [TCPClient] Enter the following settings

Host IP: 192.168.10.100

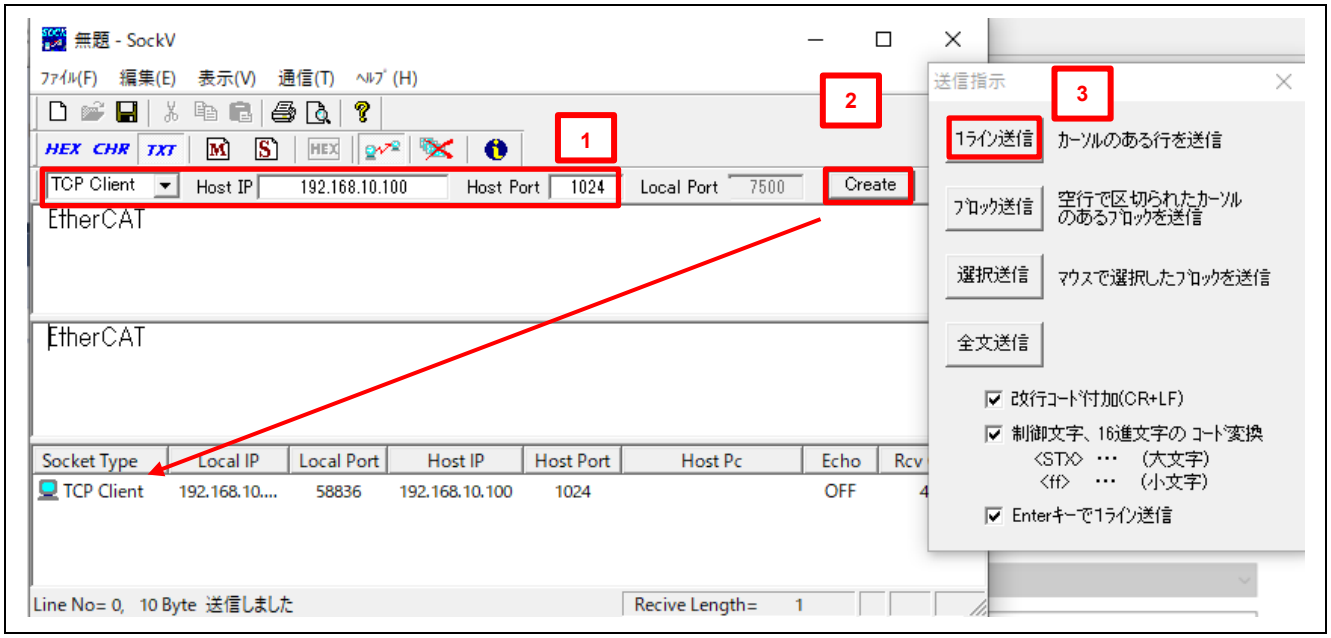
Host Port: Enter 1024

and click the [Create] button. TCP client socket will appear under the console.

Open the send instruction console.

Select [Communication] → Check the [send instruction dialog] ,Open the send instruction window.

Enter text in the main window (upper area) and click the 1-line send button in the send instruction window, the same text you entered will be displayed in the sub-window (lower area).



10. Appendix

10.1 Appendix A : How to install patch

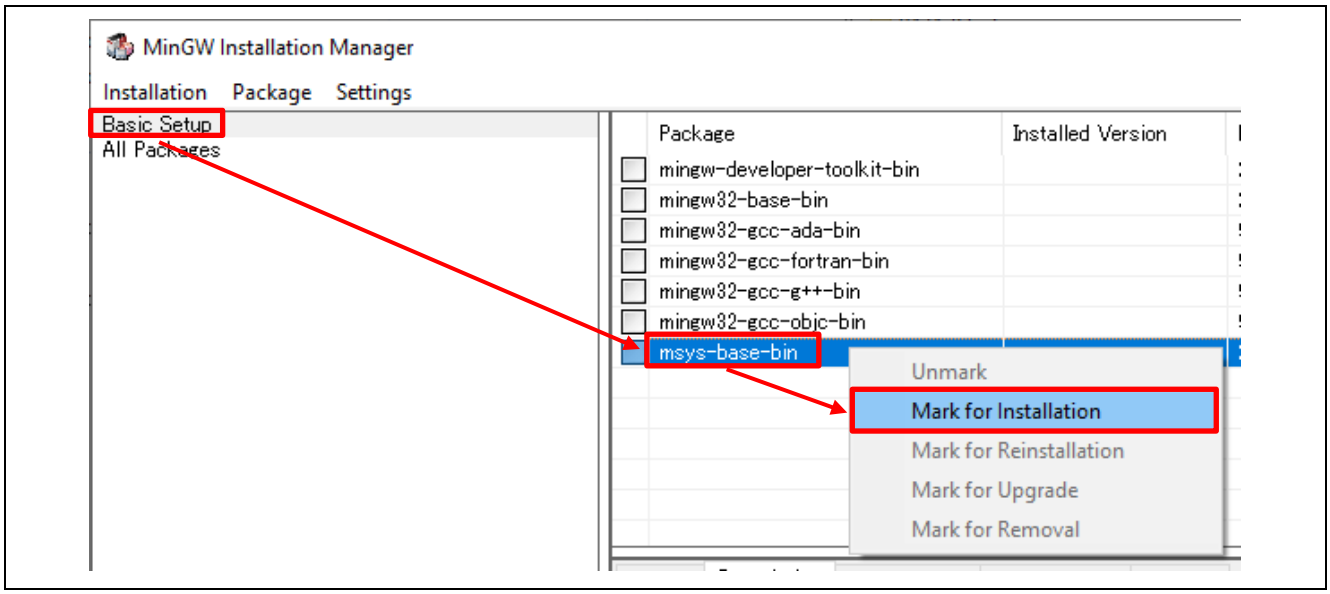
This section describes how to install patch in MinGW.

1. Download “mingw-get-setup.exe” from the following URL.

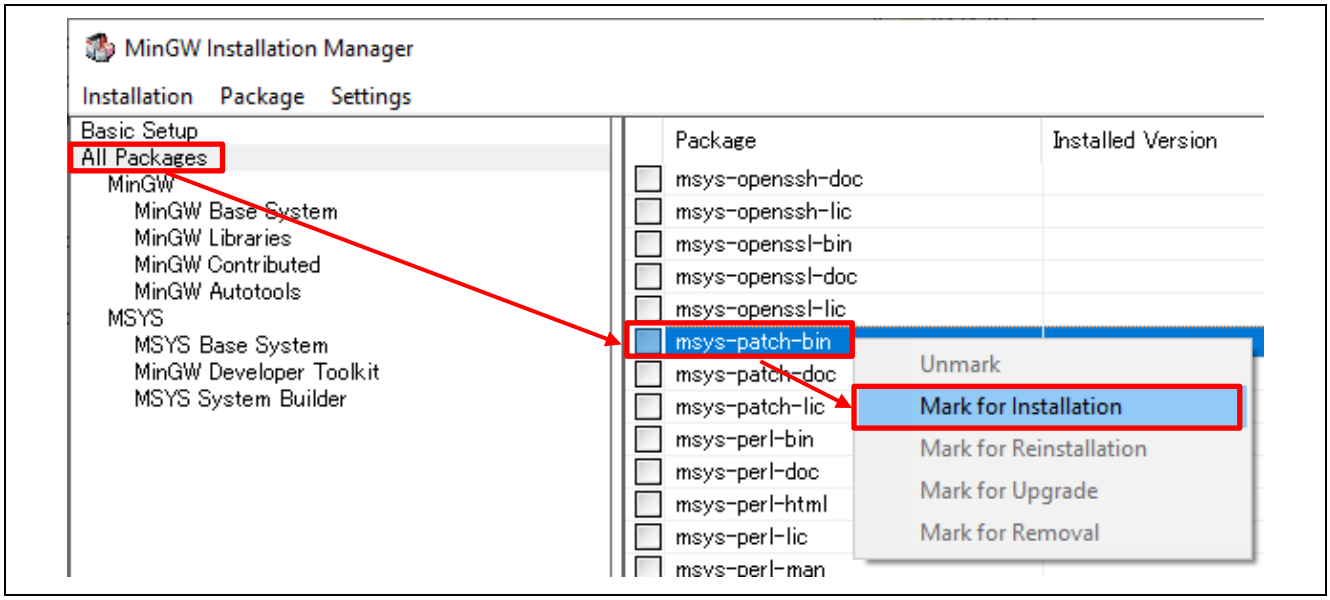
   https://osdn.net/projects/mingw/downloads/68260/mingw-get-setup.exe/

2. Execute “mingw-get-setup.exe”, install “Mingw-installation-manager” according to the dialog.

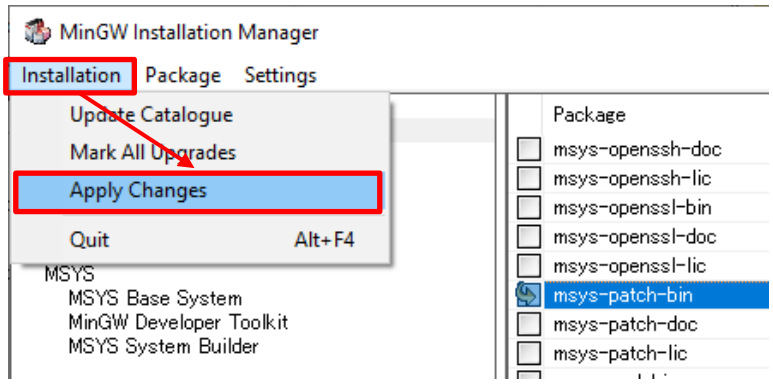
3. If It’s completed and the Mingw-installation-manager window is displayed, select “Basic Setup” in the left window, right-click on “msys-base-bin” in the right window, and select “Mark for Installation”.



4. Select “All Packages” in the left window, right-click on “msys-patch-bin” in the right window, and select “Mark for Installation”.



5. Select “Apply Changes” in “Installation” in the above menubar.

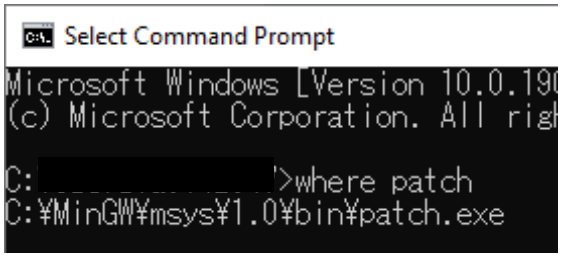


6. “Schedule of Pending Actions” window is displayed, click “Apply” button.

7. If “All changes were applied successfully; you may now clone this dialogue.” is displayed, Installing patch.exe is succeeded.

8. Register the path to the installed patch.exe into system environment variables.
After registering, reboot your PC.

9. Start Command Prompt, enter “where patch”.
If the path to the installed patch.exe is displayed, there are no problem.



Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Oct.15.24	-	First version

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

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

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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