RL78/G23

Connecting to Amazon Web Services Using FreeRTOS with RL78/G23-128p Fast Prototyping Board

Introduction

Amazon FreeRTOS is a real-time operating system that augments the FreeRTOS kernel with libraries for connectivity, security, and over-the-air (OTA) updates. Amazon FreeRTOS also includes some demo applications that demonstrate Amazon FreeRTOS features on qualified boards.

Renesas e^2 studio is a development environment based on the popular Eclipse CDT (C/C++ Development Tooling), covers build (editor, compiler, and linker control) as well as debug interface. It also supports to integrate the Amazon FreeRTOS demo applications and run them on Renesas boards.

This document describes a system combining the Renesas board RL78/G23-128p Fast Prototyping Board and a Wi-Fi module (SX-ULPGN (from Silex Technology)). This system implements Amazon FreeRTOS in the RL78/G23-128p to enable communication with Amazon Web Services (AWS) using the MQTT protocol via Wi-Fi.

In addition, the general-purpose API for TCP/IP is provided in Amazon FreeRTOS. Communication with a general-purpose Wi-Fi is also facilitated by using this API.

Objectives

This document helps users to be familiar with the procedures to run the Amazon FreeRTOS demo applications using e^2 studio (from downloading the Renesas GitHub Amazon FreeRTOS projects to running the demos).

Operating Environment

Operation was confirmed in the following environments.

IDE	e^2 studio 2021-07 (21.07.0) https://www.renesas.com/software-tool/e-studio
Board	RL78/G23-128p Fast Prototyping Board https://www.renesas.com/rl78g23-128p_fpb Wi-Fi Pmod Expansion Board https://www.renesas.com/products/microcontrollers-microprocessors/ra-cortex-m-mcus/wi-fi-pmod-expansion-board-80211bgn-24g-wi-fi-pmod-expansion-board
Toolchains	CCRL Compiler v1.10.00 https://www.renesas.com/products/software-tools/tools/compiler-assembler/compiler-package-for-rl78-family.html
Emulators	E2 Emulator Lite https://www.renesas.com/products/software-tools/tools/emulator/e2-emulator-lite.html

Contents

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- AWS™ is a trademark of Amazon Web Services, Inc. (https://aws.amazon.com/trademark-guidelines/)
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- GitHub® is a trademark of GitHub, Inc. (https://github.com/logos)

1. Outline

This document describes the procedures from preparing the Amazon FreeRTOS projects using the Renesas RL78/G23-128p Fast Prototyping Board to running the demos.

2. Preparing Amazon FreeRTOS projects

You need to download the source code of FreeRTOS from GitHub managed by Renesas and import the projects.

2.1 Downloading FreeRTOS and importing demo

The e² studio allows you to download FreeRTOS and import demo project into the workspace of e² studio.

1. Launch e² studio from the Start menu of Windows.
2. On the **Select a directory as a workspace** window, browse to the folder that you want to work in, and choose **Launch**.
3. The first time you open e² studio, the **Toolchain Register** window opens. Choose **Renesas Toolchains** and confirm that **CC-RL v1.10.00** is selected. Choose **Register**, and then choose **OK**.
4. If you are opening e² studio for the first time, the **Code Generator Registration** window appears. Choose **OK**.
5. The **Code Generator COM component register** window appears. Under **Please restart e² studio to use Code Generator**, choose **OK**.
6. The **Restart e² studio** window appears. Choose **OK**.
7. e² studio restarts. On the **Select a directory as a workspace** window, choose **Launch**. Note folder path which is described in end of this section.
8. If showing welcome screen after launching e² studio, close welcome screen.
9. Click **File** menu, then choose **Import**.
10. In the import wizard, choose **General, Renesas GitHub FreeRTOS (with IoT libraries) Project**, and the choose **Next**.
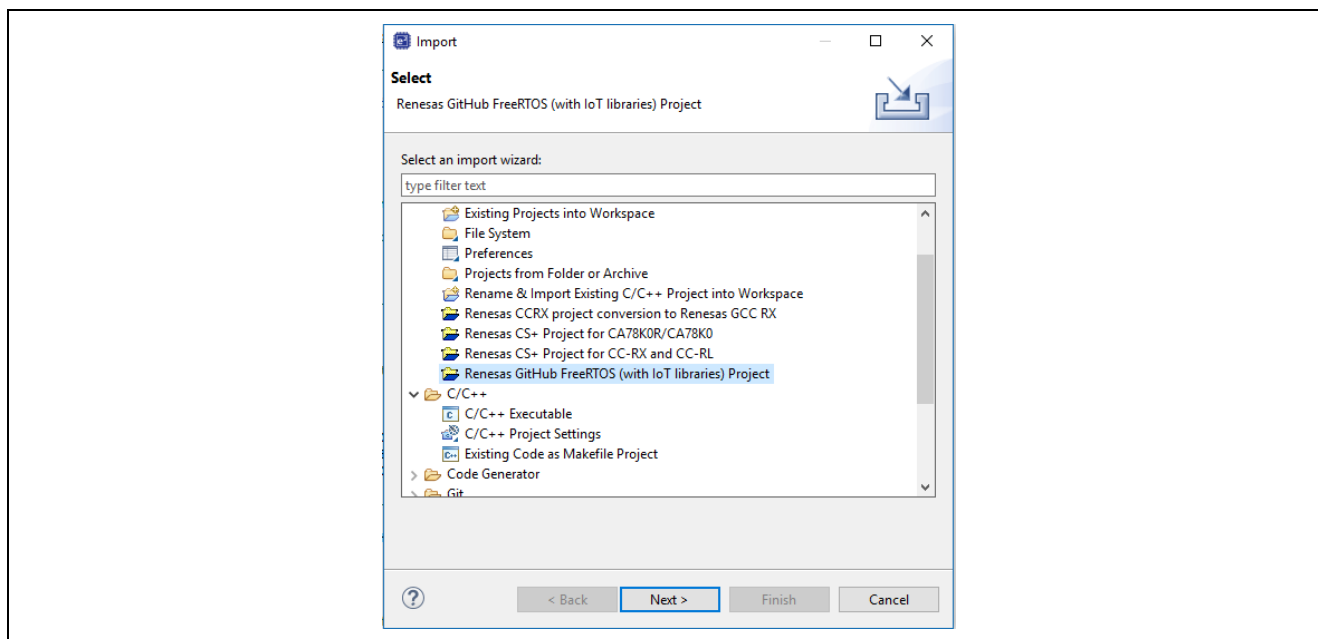

Figure 2.1   General, Renesas GitHub FreeRTOS (with IoT libraries) Project

11. Choose **Browse** to specify a folder to copy downloaded RTOS content in order to import project.
    Note folder path which is described in end of this section.

12. In RTOS version setting, choose **Check for more version…** to see a list of all supported RTOS version.
    On the **FreeRTOS (with IoT libraries) Module Download** window, choose **v202012.00-rl78-x.x.x** FreeRTOS version by clicking the checkbox, then choose **Download**.
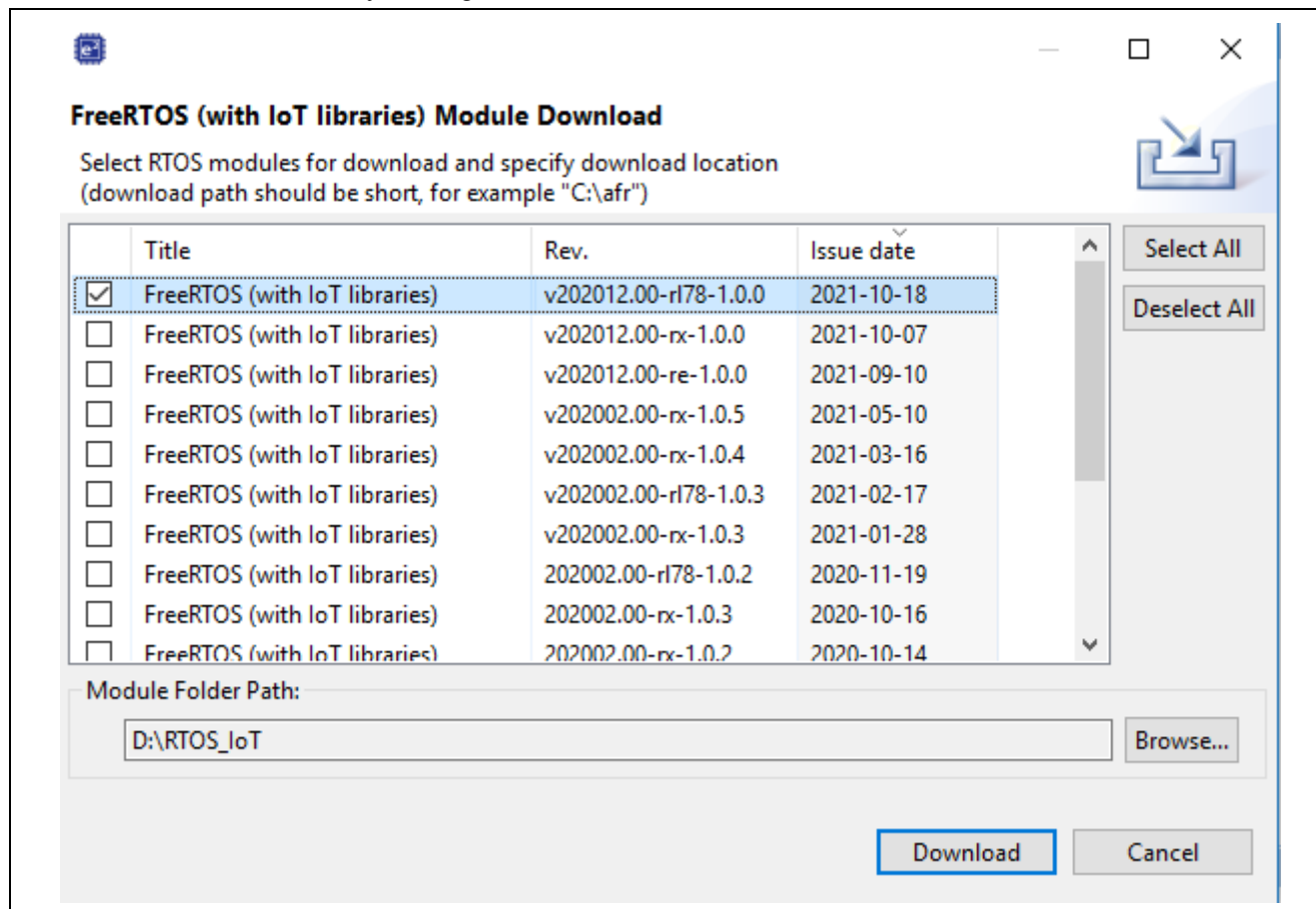

Figure 2.2   FreeRTOS (with IoT libraries) Module Download

13. Once download is completed, choose **Next** in the **Renesas GitHub FreeRTOS (with IoT libraries) Project** window.

14. If you are not using an empty folder, the **Copy Resources** warning message appears.
    When choose **Yes**, downloaded RTOS content is copied to the workspace of e^2 studio.

15. Choose the project **aws_demos** (${FOLDER_DIR}/projects/renesas/rl78g23-fpb-sx-ulpgn/e2studio/aws_demos), then choose **Finish**.

Note

Windows has a path length limitation of 260 characters. The path structure of package is many levels deep, so if you are using Windows, keep your file paths under the 260-character limit.

Supplement

You can also download the FreeRTOS project for the RL78 MCU v202012.00-rl78-1.0.0 from the release page on GitHub.
https://github.com/renesas/amazon-freertos/releases/tag/v202012.00-rl78-1.0.0
-> v202012.00-rl78-1.0.0.tar.gz

3. Preparing AWS

Perform the preparation work required to run the demos in AWS. Configure the settings of AWS in reference to the following tutorial.

- Register device to AWS IoT
  https://github.com/renesas/amazon-freertos/wiki/Register-device-to-AWS-IoT

Also, set the four macros in aws_demos -> demos -> include -> aws_clientcredential.h of the demo projects.

- Name of endpoint confirmed in clientcredentialMQTT_BROKER_ENDPOINT -> "Register device to AWS IoT"
- Name of thing registered in clientcredentialIOT_THING_NAME -> "Register device to AWS IoT"
- clientcredentialWIFI_SSID (when using Wi-Fi) -> SSID of access point to which to connect
- clientcredentialWIFI_PASSWORD (when using Wi-Fi) -> Password of access point to which to connect

```
 ⊕  * FreeRTOS V202002.00

⊝#ifndef __AWS_CLIENTCREDENTIAL__H__
  #define __AWS_CLIENTCREDENTIAL__H__

 ⊕  * @brief MQTT Broker endpoint.
  #define clientcredentialMQTT_BROKER_ENDPOINT          ""

 ⊕  * @brief Host name.
  #define clientcredentialIOT_THING_NAME                ""

 ⊕  * @brief Port number the MQTT broker is using.
  #define clientcredentialMQTT_BROKER_PORT        8883

 ⊕  * @brief Port number the Green Grass Discovery use for JSON retrieval from cloud is using.
  #define clientcredentialGREENGRASS_DISCOVERY_PORT     8443

 ⊕  * @brief Wi-Fi network to join.
  #define clientcredentialWIFI_SSID                     ""

 ⊕  * @brief Password needed to join Wi-Fi network.
  #define clientcredentialWIFI_PASSWORD                 ""
```

Figure 3.1   Setting macros

4. Preparing the hardware

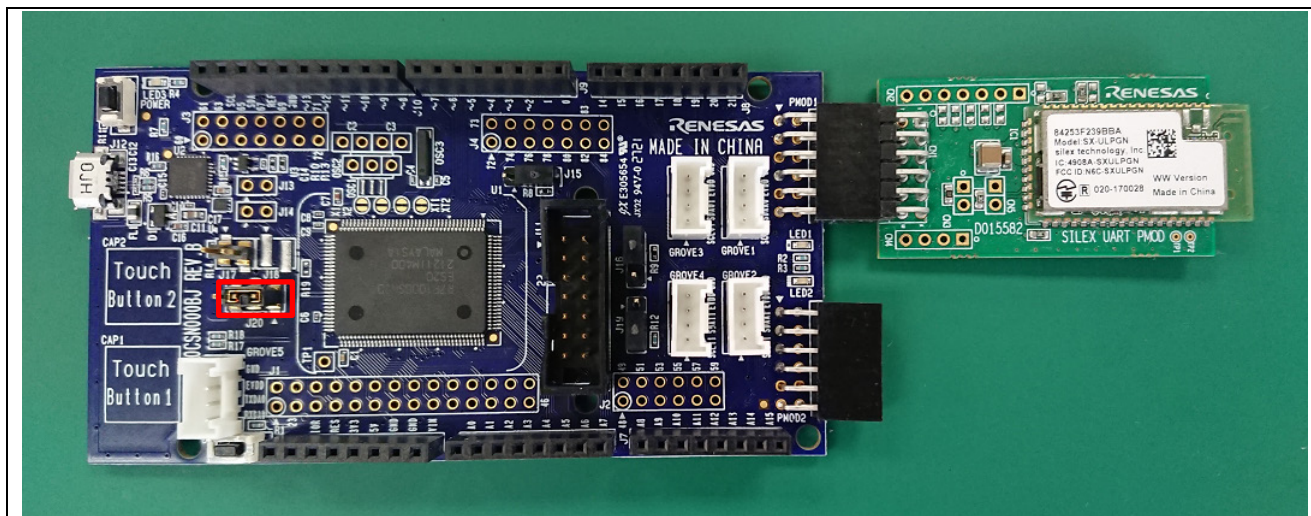Prepare the hardware for running the demos of Amazon FreeRTOS.

Figure 4.1   RL78/G23-128p Fast Prototyping Board and a Wi-Fi module (SX-ULPGN (from Silex Technology))

4.1   RL78/G23-128p Fast Prototyping Board

The RL78/G23-128p Fast Prototyping Board is required to run the RL78/G23-128p demos of Amazon FreeRTOS. You can purchase it from the following URL.

https://www.renesas.com/rl78g23-128p_fpb

You need to configure 3.3V power-supply by being short-circuit 2-3 of the power-supply selection header (the J20 in Figure 4.1   RL78/G23-128p Fast Prototyping Board and a Wi-Fi module (SX-ULPGN (from Silex Technology))).

Demo project needs to connect with E2 Lite emulator, so it is necessary to attach an emulator connector to board. For attach method, please refer to "RL78/G23-128p Fast Prototyping Board User's Manual" (R20UT4870xxxxxx).

https://www.renesas.com/document/mat/rl78g23-128p-fast-prototyping-board-users-manual-rev100?language=ja&r=1537821

4.2   SX-ULPGN

A wireless LAN module is required to connect to the RL78/G23-128p Fast Prototyping Board. The operation of the RL78/G23-128p demos of Amazon FreeRTOS can be checked using the SX-ULPGN.

You can purchase the SX- ULPGN from the following URL.

https://www.renesas.com/products/software-tools/boards-and-kits/eval-kits/wi-fi-pmod-expansion-board.html#productInfo

4.3   DIGILENT Pmod usbuart

Use DIGILENT Pmod usbuart to write the certificate and CA list to the SX-ULPGN, and to receive the debug log when running the RL78/G23-128p demos.

You can purchase DIGILENT Pmod usbuart from the following URL.

https://www.renesas.com/products/microcontrollers-microprocessors/ra-cortex-m-mcus/wi-fi-pmod-expansion-board-80211bgn-24g-wi-fi-pmod-expansion-board

4.4   Writing the certificate

Write the certificate and CA list to the SX-ULPGN. The certificate data to be written to the SX-ULPGN needs to be converted to SharkSSLParseCert binary format and the CA list needs to be converted to SharkSSLPerseCAList binary format beforehand.

The procedure to write the certificate from Tera Term will be described later in this document.

4.4.1   Downloading SharkSSL

The format can be converted using the free software "SharkSSL".

https://realtimelogic.com/downloads/sharkssl/

1.   Download and install the software as described in the instructions for the software.

4.4.2   Obtaining the certificate data

1.   Prepare the certificate and private key that you obtained in "Preparing AWS".

4.4.3 Obtaining the CA list (Class 2 Root CA)

1. In Microsoft Edge, select **Settings** -> **Privacy, search, and services** -> **Manage certificates** -> **Certificates** -> **Trusted Root Certification Authorities**, then export **Starfield Class 2 Certification Authority**.
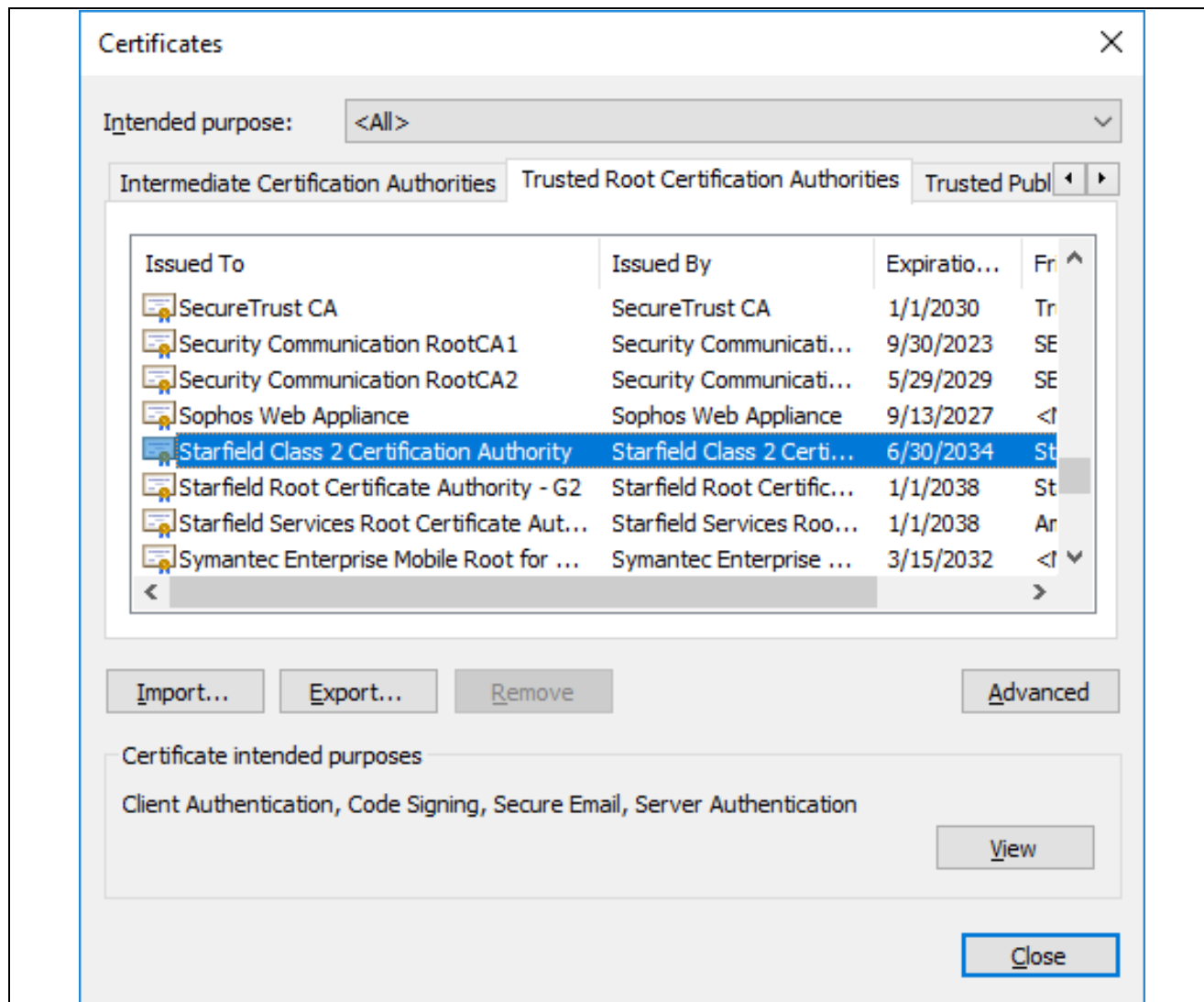

Figure 4.2   Get the CA list
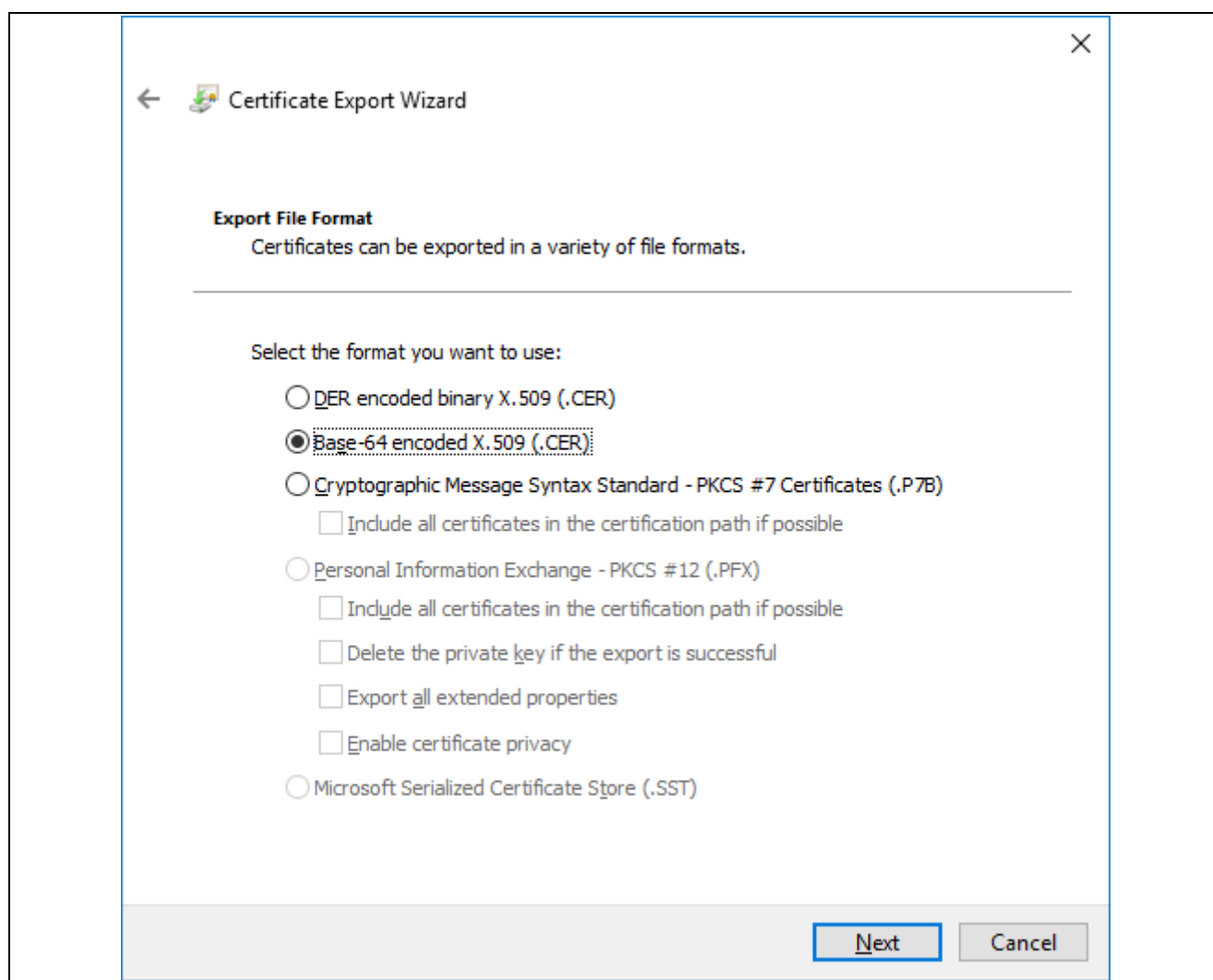
2. Choose "Base 64 encoded X.509 (.CER)".

Figure 4.3 Choose "Base 64 encoded X.509 (.CER)"

3. Enter a file name "calist1" and export the certificate. The exported file will have the extension c added to it as "calist1.cer".
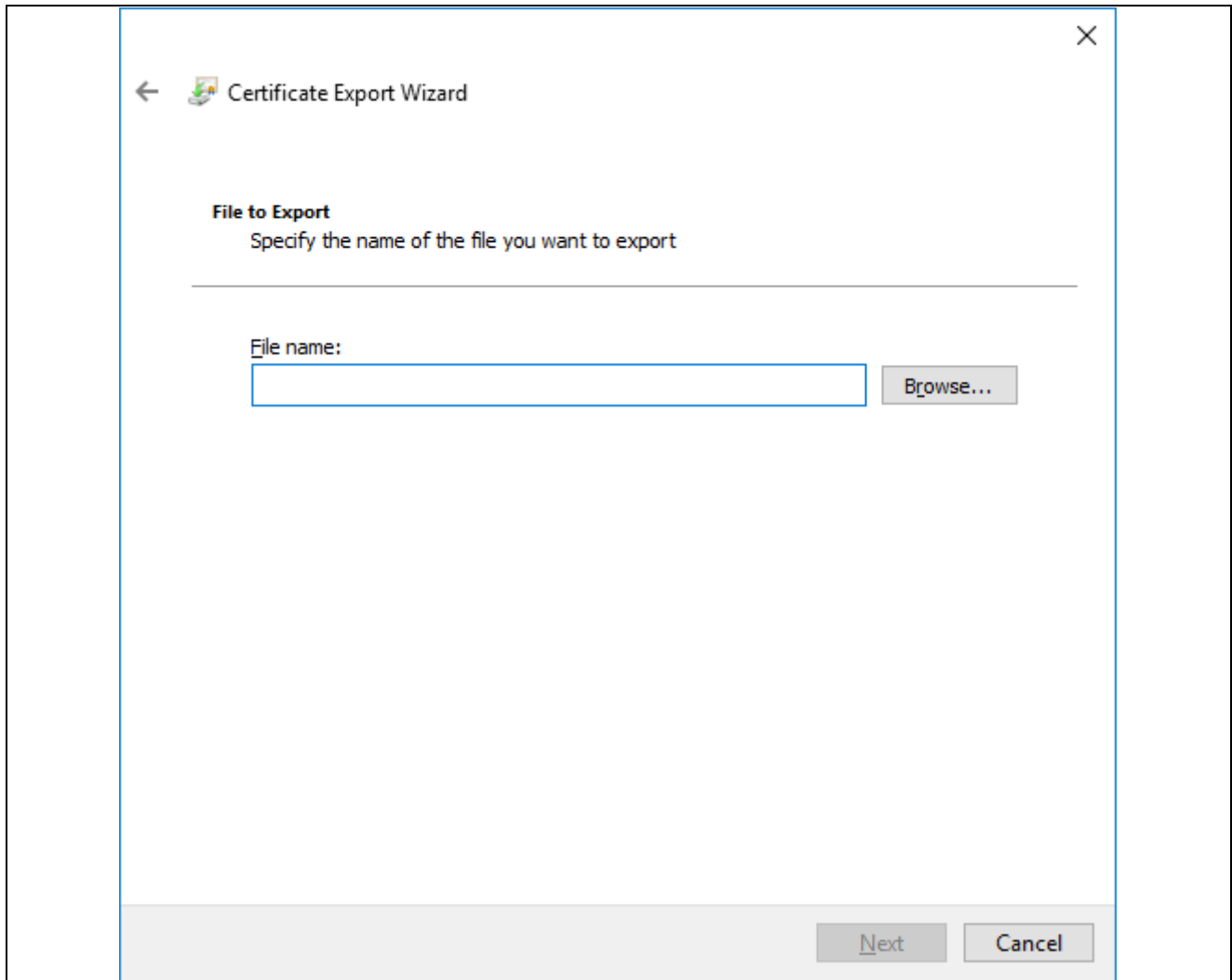

Figure 4.4 Certificate export

4.4.4   Converting the certificate and private key to SharkSSL binary format

1.   In the Command Prompt, run the following command to convert the certificate and private key to SharkSSL binary format.
     SharkSSLParseCert xxxxx-certificate.pem.crt xxxxx-private.pem.key –b cert1.bin

Note:

   xxxxx is a fragment of the hash value such as "d666c26201"in a file name of a private key and device certificate obtained from AWS in "3 Preparing AWS".
   Need to fill in the exact name "cert1".

4.4.5   Converting the CA list to SharkSSLPerseCAList binary format

1.   In the Command Prompt, run the following command to convert the CA list to SharkSSLPerseCAList binary format.
     SharkSSLParseCAList.exe -b calist1.bin yyyyy.cer

Note:

   Need to fill in the exact name "calist1".
   yyyyy is a CA List file name that created in Figure 4-4   Certificate export.

4.4.6   Writing the certificate to SX-ULPGN

Write the converted certificate and CA list (binary files) to the SX-ULPGN. Connect the PC and the TX and RX terminals of the Wi-Fi module via USB serial conversion, then write the data using an AT command. Set the baud rate to 115200 bps for writing.

The following shows the settings for writing the certificate and CA list using a terminal emulator (Tera Term) as an example.

When writing, use version 4.105 or later of Tera Term.

[Setup tab -> Serial port setup]

- Baud rate: 115200 bps
- Data: 8 bit
- Parity: none
- Stop bits: 1 bit
- Flow control: none

[Setup tab -> Terminal setup]

- New-line code Receive: CR
- New-line code Transmit: CR
- Local echo: Clear the check box

Furthermore, the following shows connecting DIGILENT Pmod usbuart and SX-ULPGN as an example.

There are two levels of connectors on the SX-ULPGN. Connect the wires from DIGILENT Pmod usbuart to the upper level of connectors on the SX-ULPGN.

- Short the VCC and SYS on DIGILENT Pmod usbuart by using a jumper
  (supply power from DIGILENT Pmod usbuart to SX-ULPGN).
- DIGILENT Pmod usbuart 2-pin (RxD) and SX-ULPGN 3-pin (TxD)
- DIGILENT Pmod usbuart 3-pin (TxD) and SX-ULPGN 2-pin (RxD)
- DIGILENT Pmod usbuart 5-pin (GND) and SX-ULPGN 5-pin (GND)
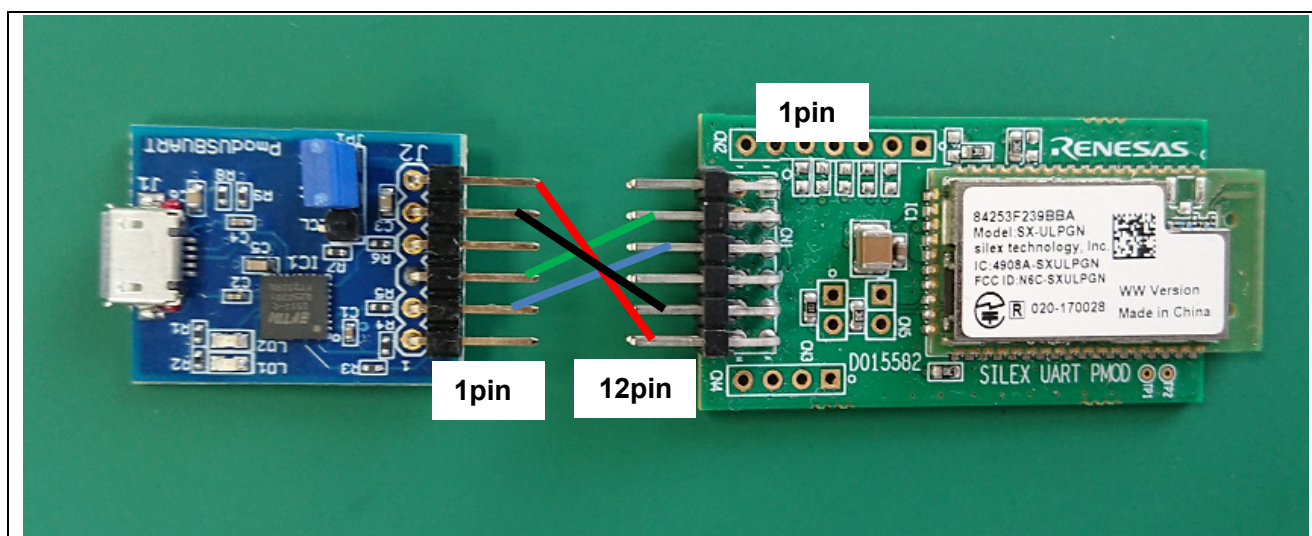- DIGILENT Pmod usbuart 6-pin (VCC) and SX-ULPGN 6-pin (VCC)

Figure 4.5   Connection between DIGILENT Pmod usbuart and SX-ULPGN

The following shows how to register the certificate using a terminal emulator (Tera Term).

1. Run the following command.
    ATNSSLCERT= cert1.crt,<Binary file size of converted certificate>
    Example: *ATNSSLCERT=cert1.crt,1768*

2. Transfer the binary file that you converted in "Converting the certificate and private key to SharkSSL binary format" from "Send file" of Tera Term within 30 seconds.

Note

   When sending the file, add a check to the Binary check box of Option.
   The extension of file name shown on PC is ".bin".

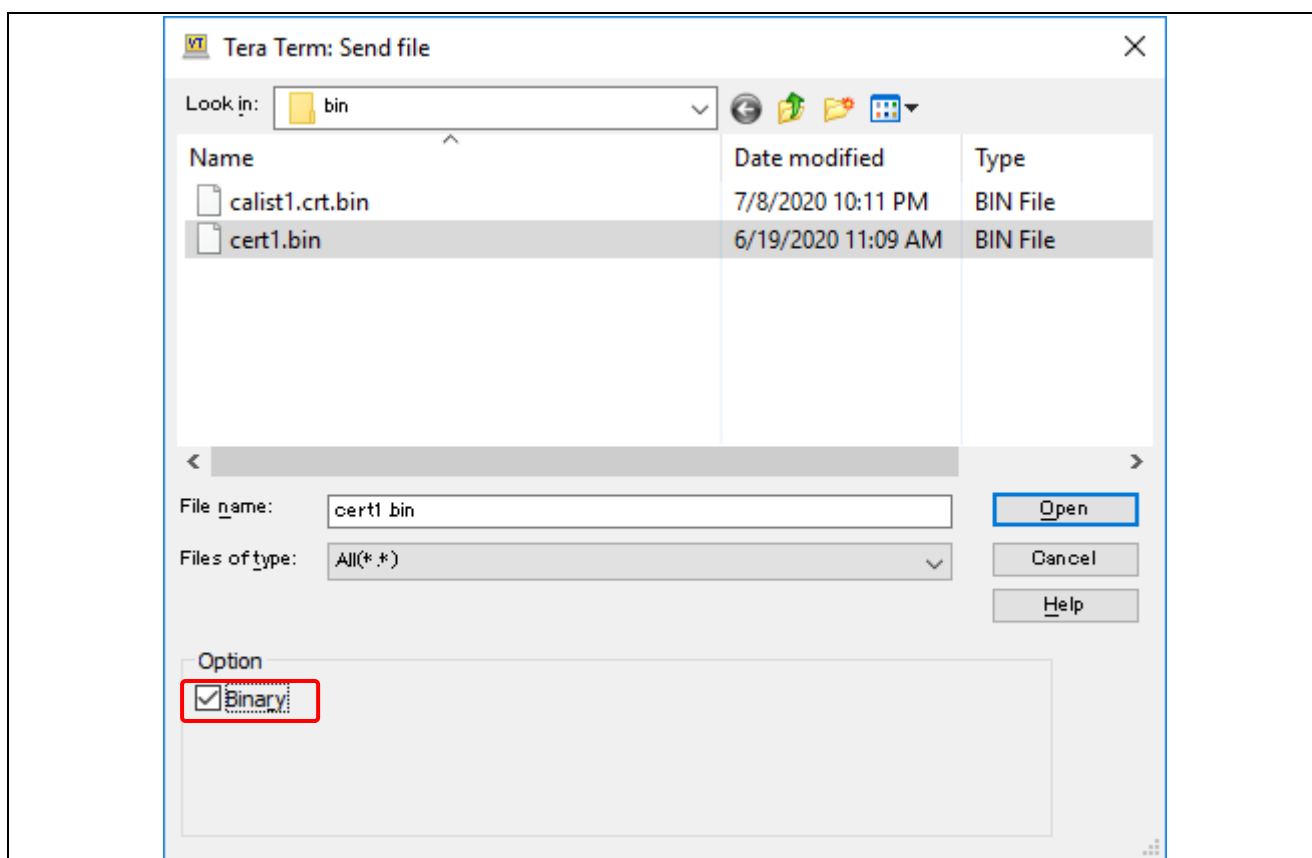**Figure 4.6 register the certificate**

3. Run the following command.
    ATNSSLCERT= calist1.crt,<Binary file size of converted CA list>
    Example: *ATNSSLCERT=calist1.crt,1059*

4. Transfer the binary file that you converted in "Converting the CA list to SharkSSLPerseCAList binary format" from "Send file" of Tera Term within 30 seconds.

Note

   Add a check to the Binary check box of Option.

5. Run the "*ATNSSLCERT=?*" command, then check that the following are displayed.
    - calist1.crt
    - cert1.crt

Note

If you accidentally register a certificate, you can delete it by running the
"*ATNSSLCERT=<filename>,0*" command.

4.4.7 Connecting the SX-ULPGN

Connect the SX-ULPGN to the RL78/G23-128p Fast Prototyping Board. Connect the SX-ULPGN to the
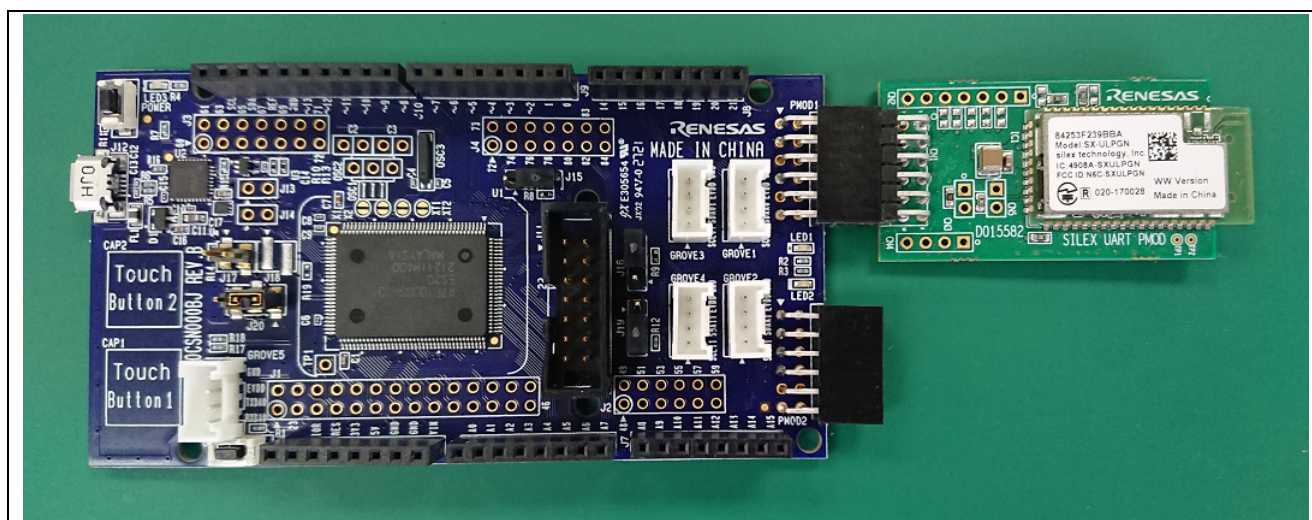PMOD1.

Figure 4.7 Connect SX-ULPGN to RL78/G23-128p Fast Prototyping Board

4.5 Preparing to receive the debug log

The demo outputs debug log via SCI port. If you wish to check the debug log, connect a terminal emulator (e.g., Tera Term) to the serial port which is used by the SCI driver.

The following shows connecting DIGILENT Pmod usbuart and RL78/G23-128p Fast Prototyping Board as an example.

Power does not need to be supplied from DIGILENT Pmod usbuart because power is supplied to the RL78/G23-128p Fast Prototyping Board from the PC via the USB cable.

(A jumper of DIGILENT Pmod usbuart shorts between LCL and VCC.)
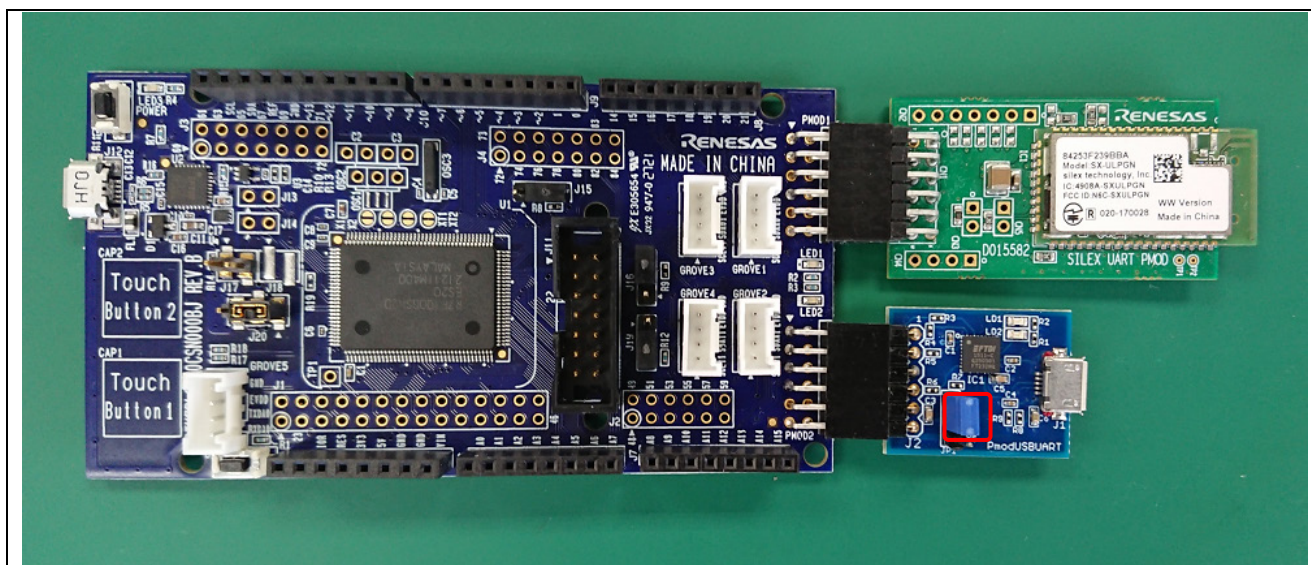
Figure 4.8 Connecting DIGILENT Pmod usbuart and RL78/G23-128p Fast Prototyping Board

When using Tera Term to receive the debug log, use version 4.105 or later of Tera Term.
The following shows the settings of Tera Term.

[Setup tab -> Serial port setup]

- Baud rate: 115200 bps
- Data: 8 bit
- Parity: none
- Stop bits: 1 bit
- Flow control: none

[Setup tab -> Terminal setup]

- New-line code Receive: CR
- New-line code Transmit: CR
- Local echo: Clear the check box

5.   Building and running

After performing all above setups, continue following steps to build and run the demo.

1.   Right click on the project in Project Explorer, select [Build].
2.   From top menu, select [Run] → [Debug Configuration].
3.   Expand [Renesas GDB Hardware Debugging] and choose "aws_demos HardwareDebug".
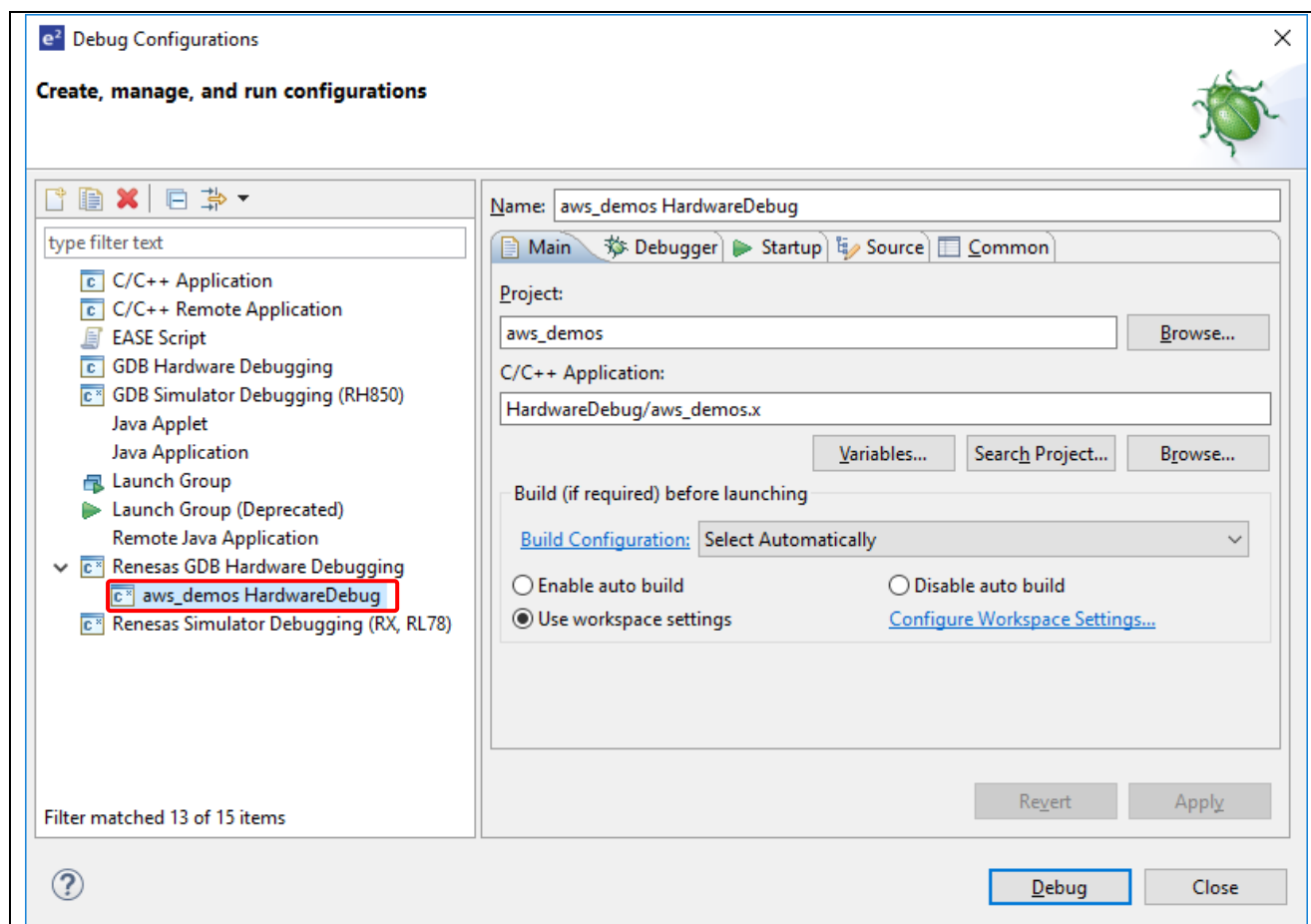
Figure 5.1 Select launch configuration

4. Choose the Debugger tab, and then choose the Connection Settings tab. Confirm that your connection settings are correct.
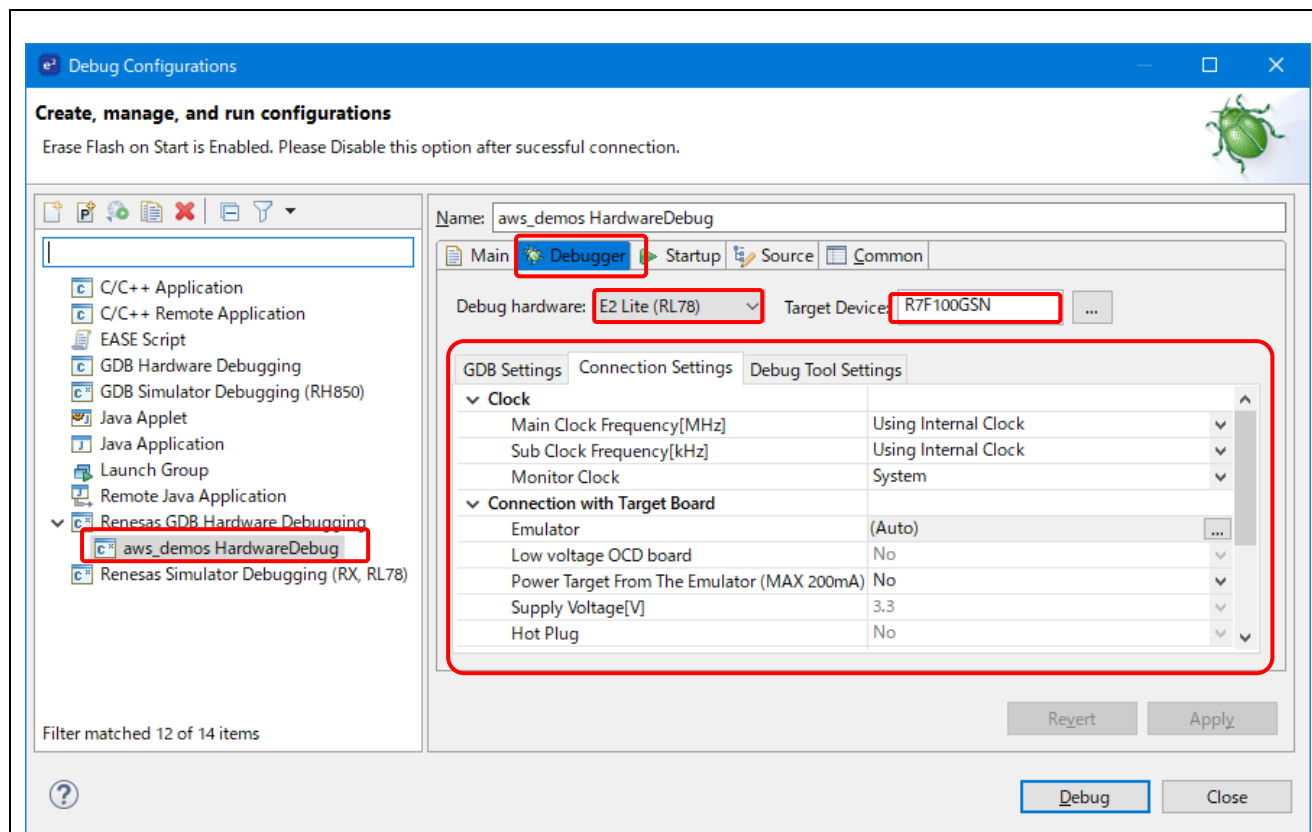
Figure 5.2 Hardware debug configuration

5. Choose Debug to download the code to your board and begin debugging.
6. e^2 studio might ask to change to Renesas Debug Perspective. Choose [Yes].
7. After the code is downloaded to the board, choose [Resume] to run the code up to the first line of the main function. Choose [Resume] again to run the rest of the code.
8. Check the debug log shown in terminal emulator.
9. Check the message on the AWS console.

6. Demo operations confirm in AWS IoT console

This demo application uses the Amazon FreeRTOS MQTT library to connect to the AWS Cloud and then periodically publish messages to an MQTT topic hosted by the AWS IoT MQTT broker.

This setup is to check the messages sent by this demo.

1. Sign into the AWS IoT console.
2. In the navigation pane, choose [Test] to open the MQTT client.
3. Choose [Subscribe to topic] tab and enter "<IoT Things name>/#" in the [Topic Filter].
   <IoT Things name>: Name of things registered by Register device to AWS IoT in Preparing AWS.
4. The messages that are sent to AWS Cloud can now be checked.
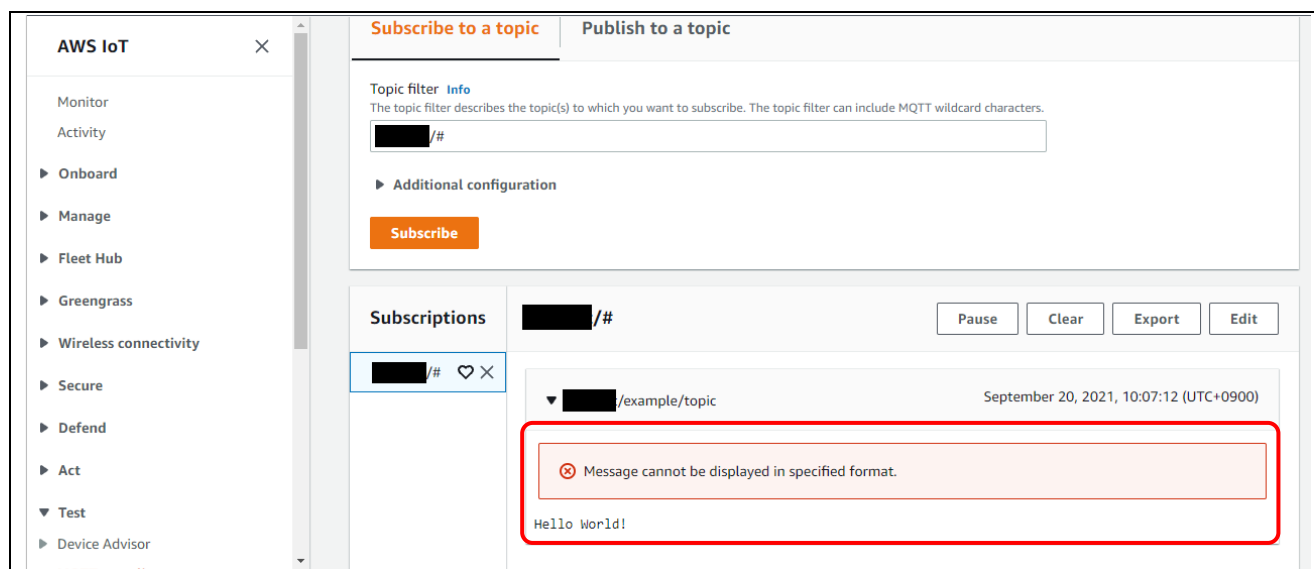
Figure 6.1 Message sent by the demo

7. Appendix

7.1 How to upgrade drivers

This section describes how to upgrade drivers into a demo project.

Please refer to the section "Appendix" in the application note "RL78/G23 Visualization of Sensor Information on Amazon Web Services using RL78/G23-128p Fast Prototyping Board and FreeRTOS" (R20AN0660EJxxxx).

Website and support

AWS Amazon FreeRTOS forum: http://forums.aws.amazon.com.

Renesas Amazon FreeRTOS GitHub: https://github.com/renesas/amazon-freertos.

Revision History

Rev.	Date	Description		
		Page	Summary	
1.00	Oct.15.21	-	First edition issued	
1.01	Dec.01.21	-	Fixed typo RL78/G23 -> RL78/G23-128p	
		6	Added description about configuration of 3.3V power-supply on RL78/G23-128p Fast Prototyping Board	
		19	Added a section Appendix – How to add drivers	

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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(Rev.5.0-1 October 2020)

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