RL78/G23

Connecting AWS Cloud with FreeRTOS Getting Started Guide for RL78/G23-128p Fast Prototyping Board

Contents

1. Overview

This tutorial provides instructions of connecting AWS Cloud with FreeRTOS for getting started with RL78/G23-128p Fast Prototyping Board. If you do not have the RL78/G23-128p Fast Prototyping Board, visit the AWS Partner Device Catalog, and purchase one from our partners.

This document explains how to configure AWS IoT Core and FreeRTOS to connect your device to the AWS Cloud.

2. Hardware Description

2.1 DataSheet

Table 2-1 DataSheet

Device	Link
RL78/G23-128p Fast Prototyping Board	https://www.renesas.com/document/mat/rl78g23-128p-fast-prototyping-board-users-manual-rev100?language=en&r=1496636
Wi-Fi-Pmod-Expansion-Board	https://www.renesas.com/document/qsg/wi-fi-pmod-expansion-board-quick-start-guide?r=1261746

2.2 Schematic

Table 2-2 Schematic

Device	Link
RL78/G23-128p Fast Prototyping Board	https://www.renesas.com/document/bdf/rl78g23-128p-fast-prototyping-board-schematics-rev100?language=en&r=1537821
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 Wi-Fi Pmod-Design Package → wi-fi-pmod-v2-schematics.pdf

2.3 Hardware requirements to run FreeRTOS demo

2.3.1 Standard Kit Contents

Table 2-3 Standard Kit Contents

Device	Link
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
E2 emulator Lite	https://www.renesas.com/software-tool/e2-emulator-lite-rte0t0002lkce00000r

2.3.2 User Provided items

1. Mini-B USB cables x2.
   These cables can be used to connect the PC to the RL78/G23-128p Fast Prototyping Board.
2. E2 emulator Lite (required).
   For supported devices of RL78/G23, please check the specification of E2 emulator Lite.
3. The Digilent Pmod USBUART.
4. Jumper wires x3.
5. 14-pin connector.

2.3.3 3rd Party purchasable items

The Digilent Pmod USBUART

Purchase from https://digilent.com/reference/pmod/pmodusbuart/start?redirect=1.

2.4 Additional Hardware References

See Documentation section in the following RL78/G23 page.

https://www.renesas.com/products/microcontrollers-microprocessors/rl78-low-power-8-16-bit-mcus/rl78g23-new-generation-rl78-general-purpose-microcontrollers-further-refined-low-power-performance-and

3. Set up your Development Environment

3.1 Support IDEs

We support e^2 studio as IDE.

1. Go to the Renesas e^2 studio installer download page and download the offline installer.
2. You are directed to a Renesas Login page.
   If you have an account with Renesas, enter your username and password and then choose **Login**.
   If you do not have an account, choose **Register now**, and follow the first registration steps.
   You should receive an email with a link to activate your Renesas account. Follow this link to complete your registration with Renesas, and then login to Renesas.
3. After you log in, download the e^2 studio installer to your computer.
4. Open the installer and follow the steps to completion.

For more information, see the e^2 studio on the Renesas website.

Note: Host machine running Windows 8.1 or 10. Linux and MacOS are not supported.

3.2 Toolchains

1. Go to the RL78 Family C Compiler Package, and download the v1.10.00 package.
   https://www.renesas.com/document/ucm/rl78-compiler-cc-rl-v11000?language=en&r=488776

2. Open the executable and install the compiler.
   For more information, see the C RL78 Family C Compiler Package Family on the Renesas website.

Note: The compiler is available free for evaluation version only and valid for 60 days. On the 61st day, you need to get a License Key. For more information, see Evaluation Software Tools.

3.3 Establishing a serial connection

Serial communication is used for communication. Configure the serial port settings as follow:

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

3.4 Other software required to develop and debug applications for the device

3.4.1 To download SharkSSL

Following free software program to convert certificate data to the required format. Go to https://realtimelogic.com/downloads/sharkssl/ and choose **SharkSSL for Windows** to download the software.

3.4.2 To download Tera Term

Go to https://ttssh2.osdn.jp/index.html.en to download the software.

4. Set up your hardware

In this section, provide instructions for setting up the platform's hardware.

Note that administrator privileges are required to install the drivers.

4.1 Before soldering

Following board pictures are original board that need to be soldered to establish connections between pins. The purpose of soldering is to set up the connection for emulator. To connect the emulator, change circuit as follow:

- J11: 14-pin connector must be mounted.
- J15, J16, and J19: pins 2-3 are short-circuit
- Pattern for cutting [TOOL0_USB]: removed
- Pattern for cutting [RESET]: removed
- Pattern for cutting [T_RESET]: removed

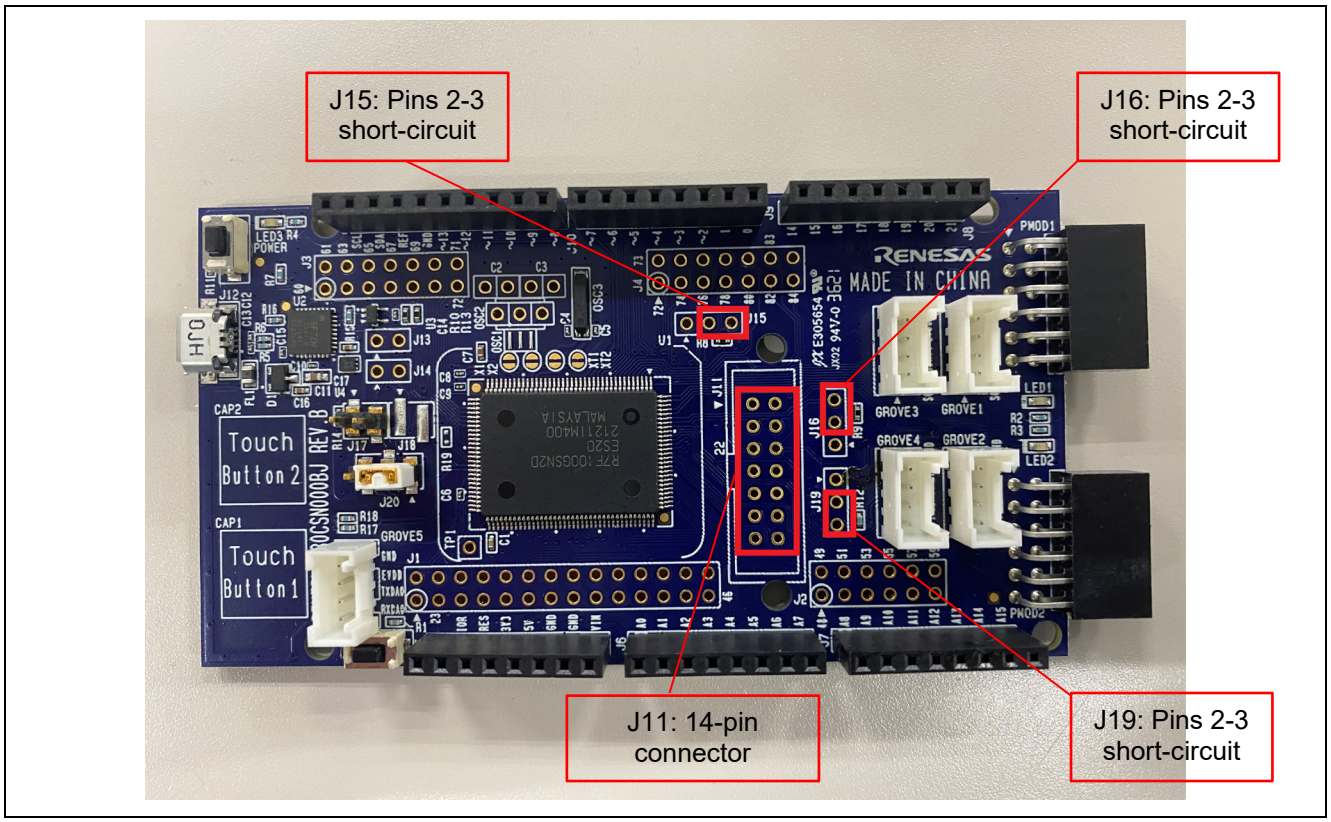

Figure 4-1 Settings for Use with the Emulator Connector (Top Side)

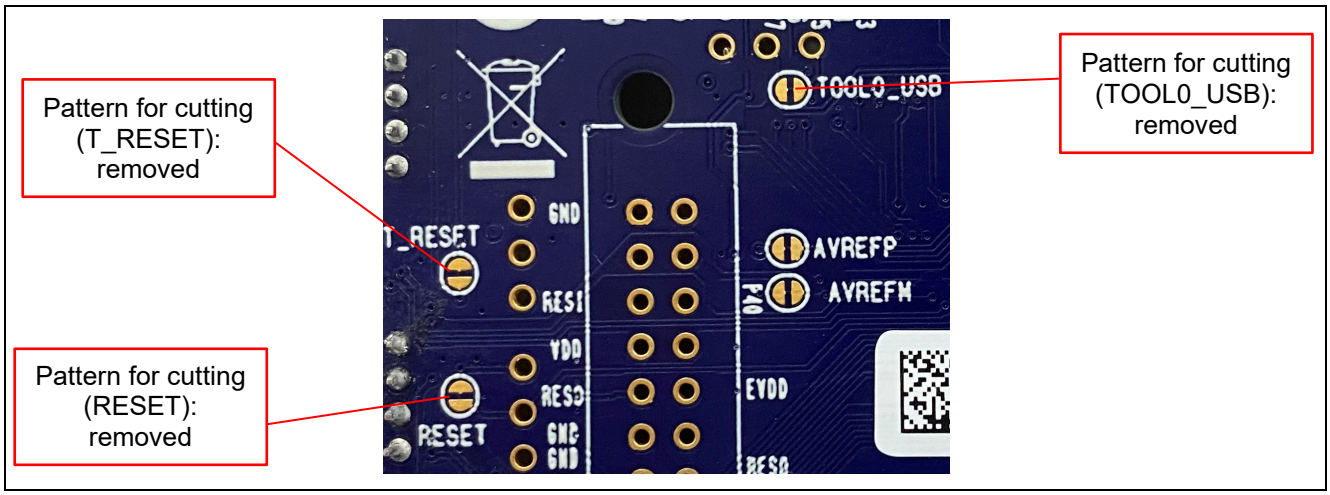

Figure 4-2 Settings for Use with the Emulator Connector (Soldered Side)

4.2 After soldering

The following pictures indicate RL78/G23-128p Fast Prototyping Board after soldering.

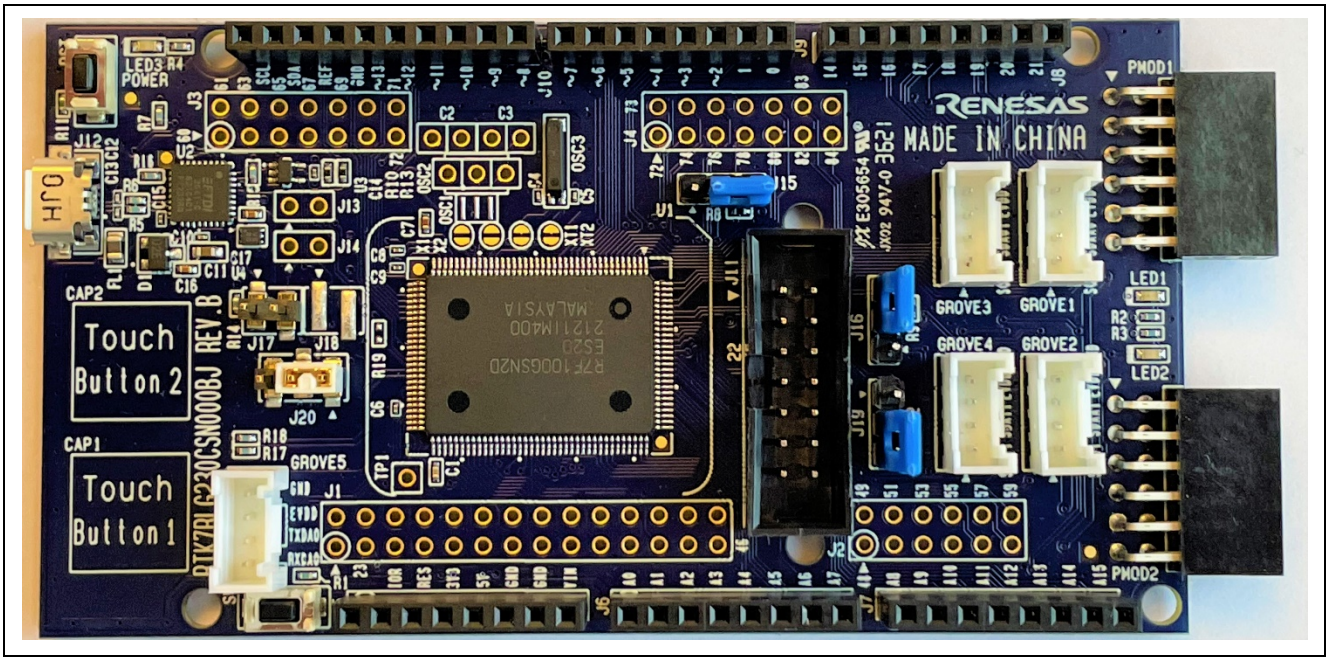

Figure 4-3 RL78/G23-128p Fast Prototyping Board after soldering (Top Side)

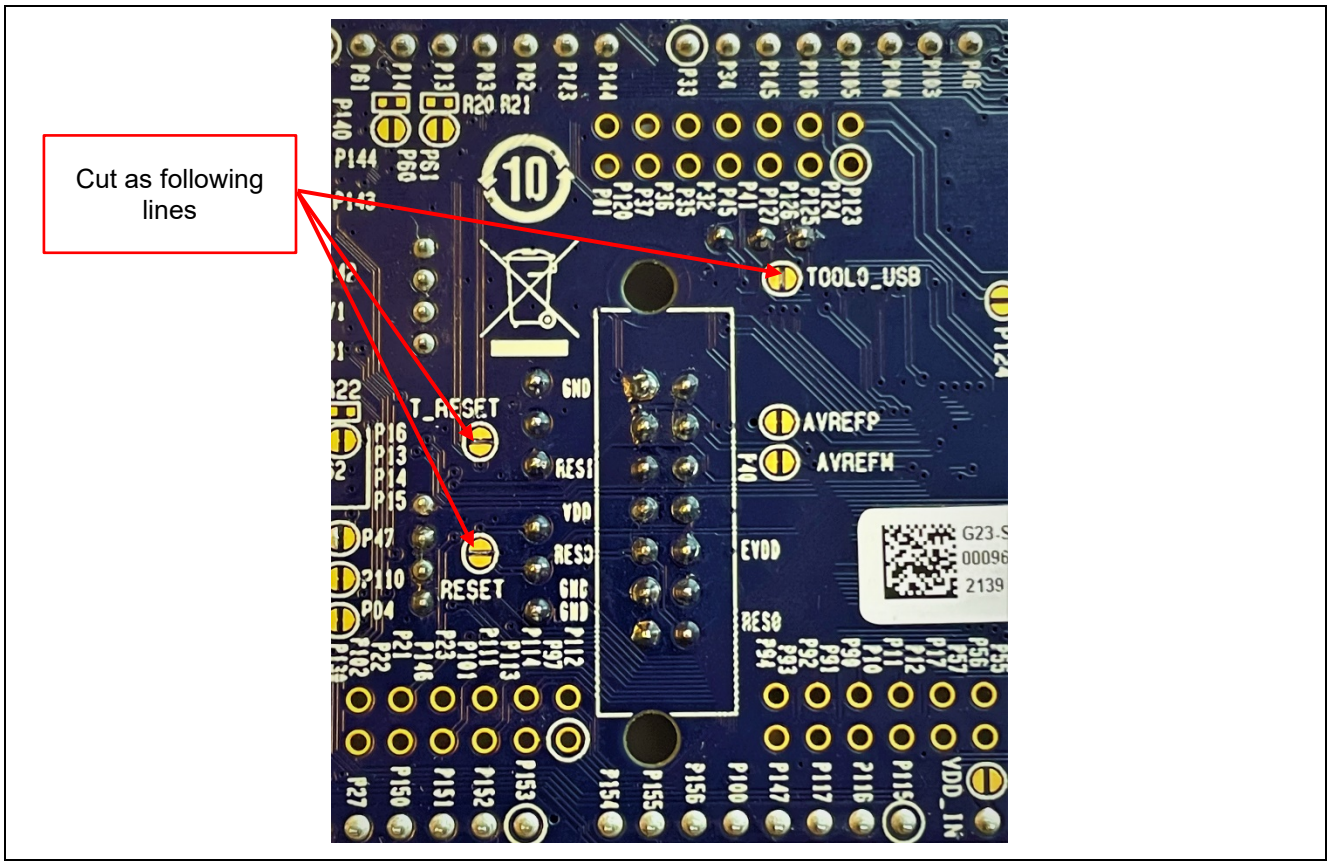

Figure 4-4 RL78/G23-128p Fast Prototyping Board after soldering (Soldered Side)

For the detail, see to section 5.20 Emulator Connector in user's manual of RL78/G23-128p Fast Prototyping Board.

4.3 To connect the Wi-Fi-Pmod-Expansion-Board

Connect the Wi-Fi-Pmod-Expansion-Board to the RL78/G23-128p Fast Prototyping Board. The Wi-Fi-Pmod-Expansion-Board connects to PMOD1.

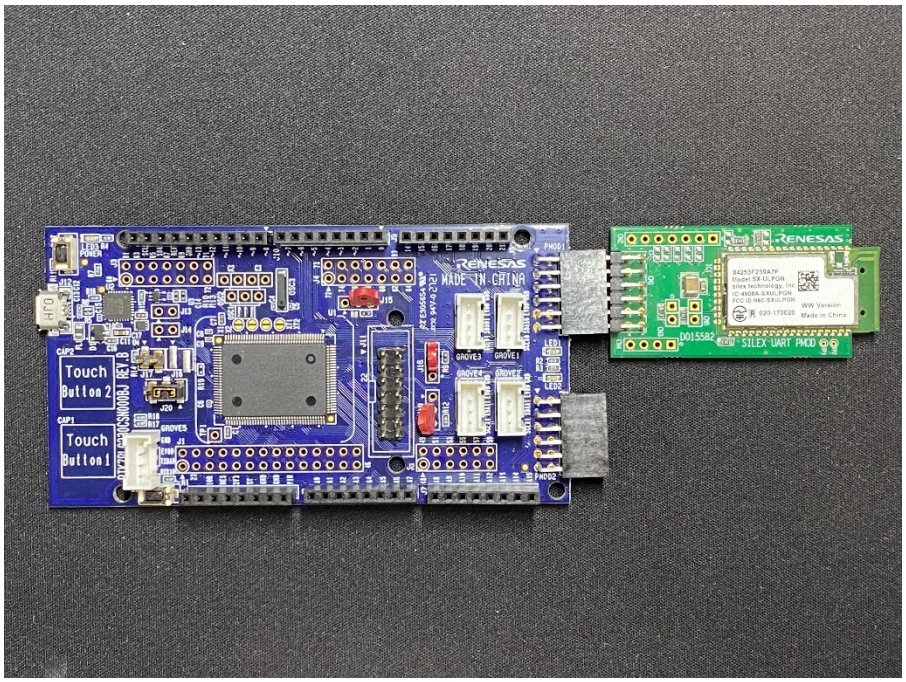

Figure 4-5 Connect the Wi-Fi-Pmod-Expansion-Board to the RL78/G23-128p Fast Prototyping Board

4.4 To receive Debug Logs

Connect the Digilent Pmod USBUART to the RL78/G23-128p Fast Prototyping Board to PMOD2, that leads to receive debug logs.

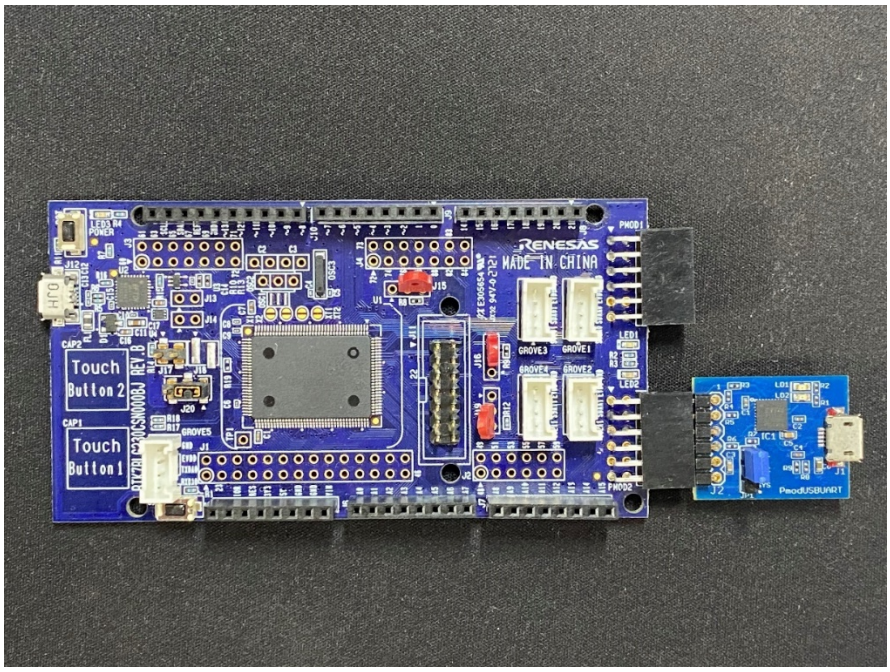

Figure 4-6 Connect the Digilent Pmod USBUART to the RL78/G23-128p Fast Prototyping Board

4.5 Whole system

The following picture indicates whole system.

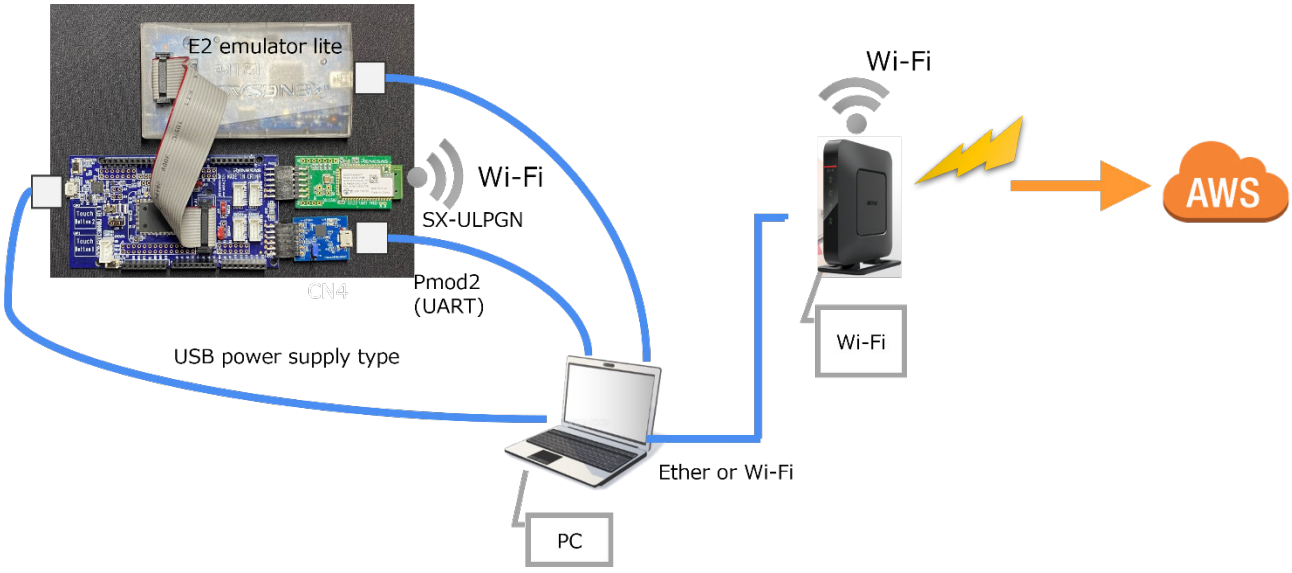

Figure 4-7 Whole system

5. Setup your AWS account and Permissions

To create an AWS account, see Create and Activate an AWS Account

User needs to create AWS account. Refer to the instructions at Set up your AWS Account. Follow the steps outlined in these sections to create your account and a user and get started:

- Sign up for an AWS account.
- Create a user and grant permissions.
- Open the AWS IoT console.

Pay special attention to the Notes.

If user created AWS account already in the past, please skip this step.

To add an IAM user to your AWS account, see IAM User Guide. To grant your IAM user account access to AWS IoT and FreeRTOS, attach the following IAM policies to your IAM user account:

- AmazonFreeRTOSFullAccess
- AWSIoTFullAccess

Note:

The policy examples in this document are intended only for dev environments. All devices in your fleet must have credentials with privileges that authorize only intended actions on specific resources. The specific permission policies can vary for your use case. Identify the permission policies that best meet your business and security requirements. For more information, refer to Example policies and Security best practices.

For more information about IAM and user accounts, see IAM User Guide.

For more information about policies, see IAM Permissions and Policies.

5.1 To attach the AmazonFreeRTOSFullAccess policy to your IAM user

1. Browse to the IAM console, and from the navigation pane, choose **Users**.
2. Enter your user name in the search text box, and then choose it from the list.
3. Choose **Add permissions**.
4. Choose **Attach existing policies directly**.
5. In the search box, enter AmazonFreeRTOSFullAccess, choose it from the list, and then choose **Next: Review**.
6. Choose **Add permissions**.

5.2 To attach the AWSIoTFullAccess policy to your IAM user

1. Browse to the IAM console, and from the navigation pane, choose **Users**.
2. Enter your username in the search text box, and then choose it from the list.
3. Choose **Add permissions**.
4. Choose **Attach existing policies directly**.
5. In the search box, enter AWSIoTFullAccess, choose it from the list, and then choose **Next: Review**.
6. Choose **Add permissions**.

6. Provision the device with AWS IoT

Refer to Registering MCU board.

6.1 To create an AWS IoT policy

Follow 1→ 6 under the heading **To create an AWS IoT policy**.

1. Note that the AWS region for your account can also be found in the drop-down between the account name and Support drop-downs in the top menu bar.

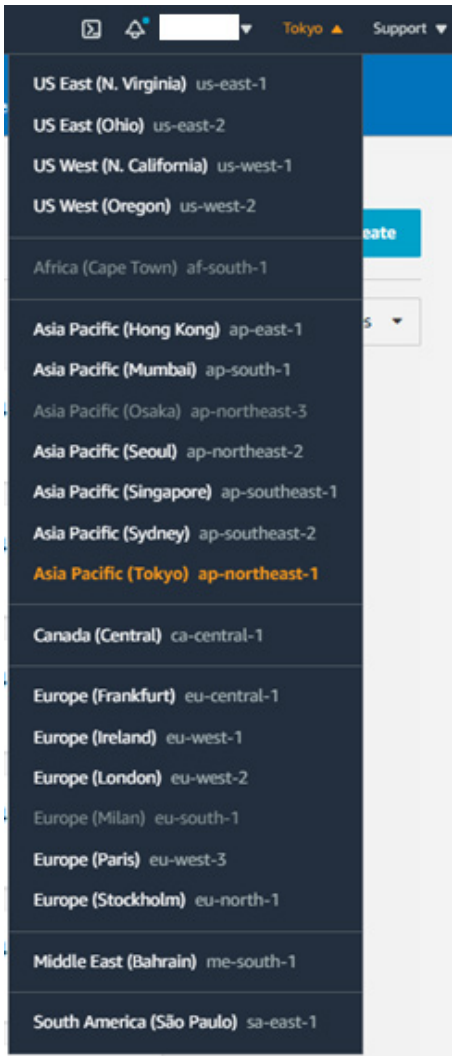

Figure 6-1 AWS region

2. Type IoT Core in search bar and click **IoT Core**.

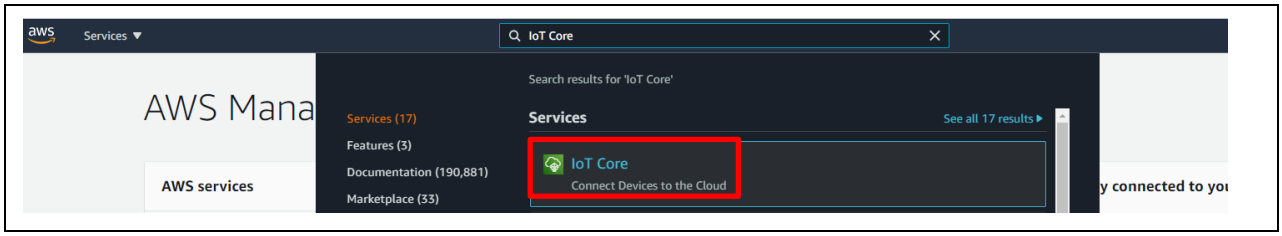

Figure 6-2 AWS IoT Core Selection

3. Go to Secure→Policies.
   Click on **Create** to create a policy

Figure 6-3 Create policy

4. In the **Name** field, enter a name for the policy.
   Then, change to **Advanced mode**

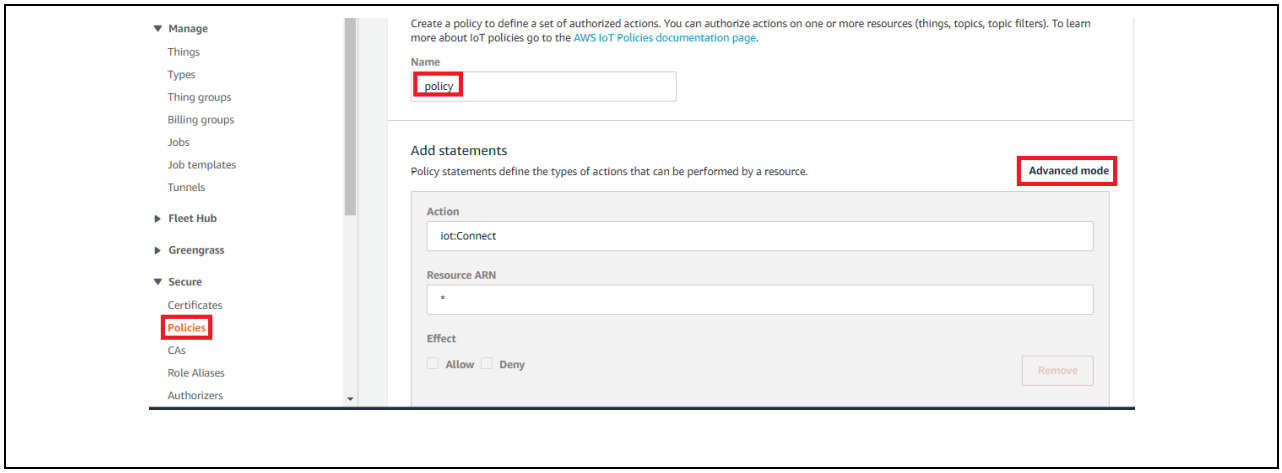

Figure 6-4 Give a policy name

5. Add following text to **Advanced mode**.

```
{
        "Version": "2012-10-17",
        "Statement":
        [
                {
                        "Effect": "Allow",
                        "Action": "iot:Connect",
                        "Resource": "*"
                },
                {
                        "Effect": "Allow",
                        "Action": "iot:Publish",
                        "Resource": "*"
                },
                {
                        "Effect": "Allow",
                        "Action": "iot:Subscribe",
                        "Resource": "*"
                },
                {
                        "Effect": "Allow",
                        "Action": "iot:Receive",
                        "Resource": "*"
                }
        ]
}
```

Figure 6-5 Add statements for policy

6. Create a policy.

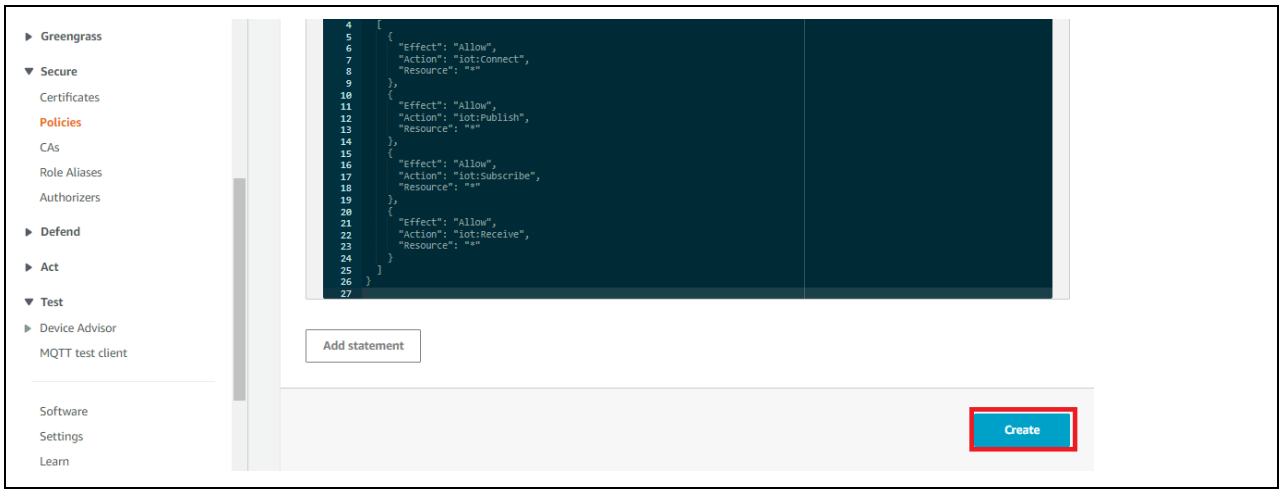

Figure 6-6 Create a policy

Note:

The examples in this document are intended only for dev environments. All devices in your fleet must have credentials with privileges that authorize only intended actions on specific resources. The specific permission policies can vary for your use case. Identify the permission policies that best meet your business and security requirements. For more information, refer to Example policies and Security Best practices.

6.2 To create an IoT thing, private key, and certificate for your device

Follow steps 1→6 under the heading **To create an IoT thing, private key, and certificate for your device**.

1. Create a Thing
   Select **Manage→ Things→Create** to create a thing

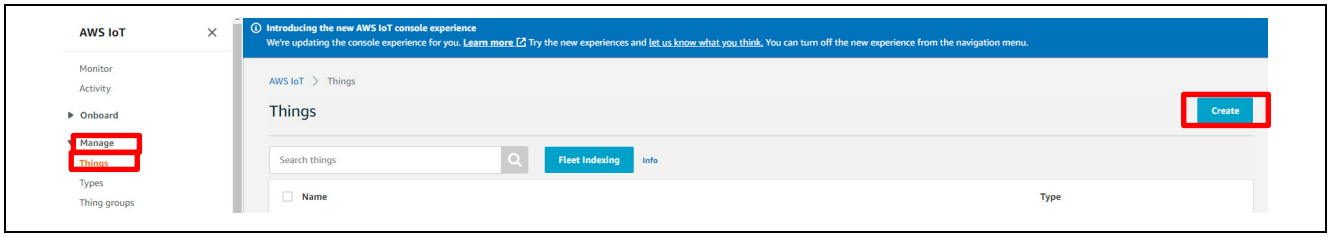

Figure 6-7 Create a thing

2. Select the Create a single thing

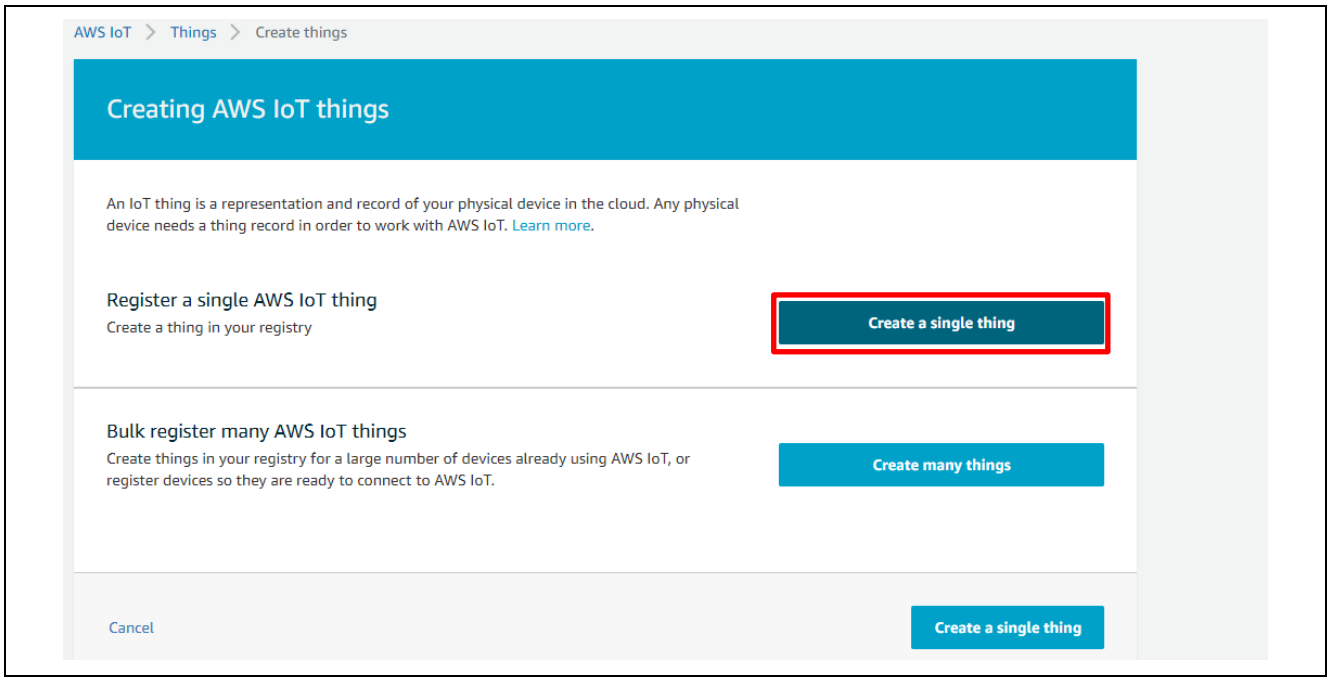

Figure 6-8 Create a single thing

3. Add name to thing and **Next**

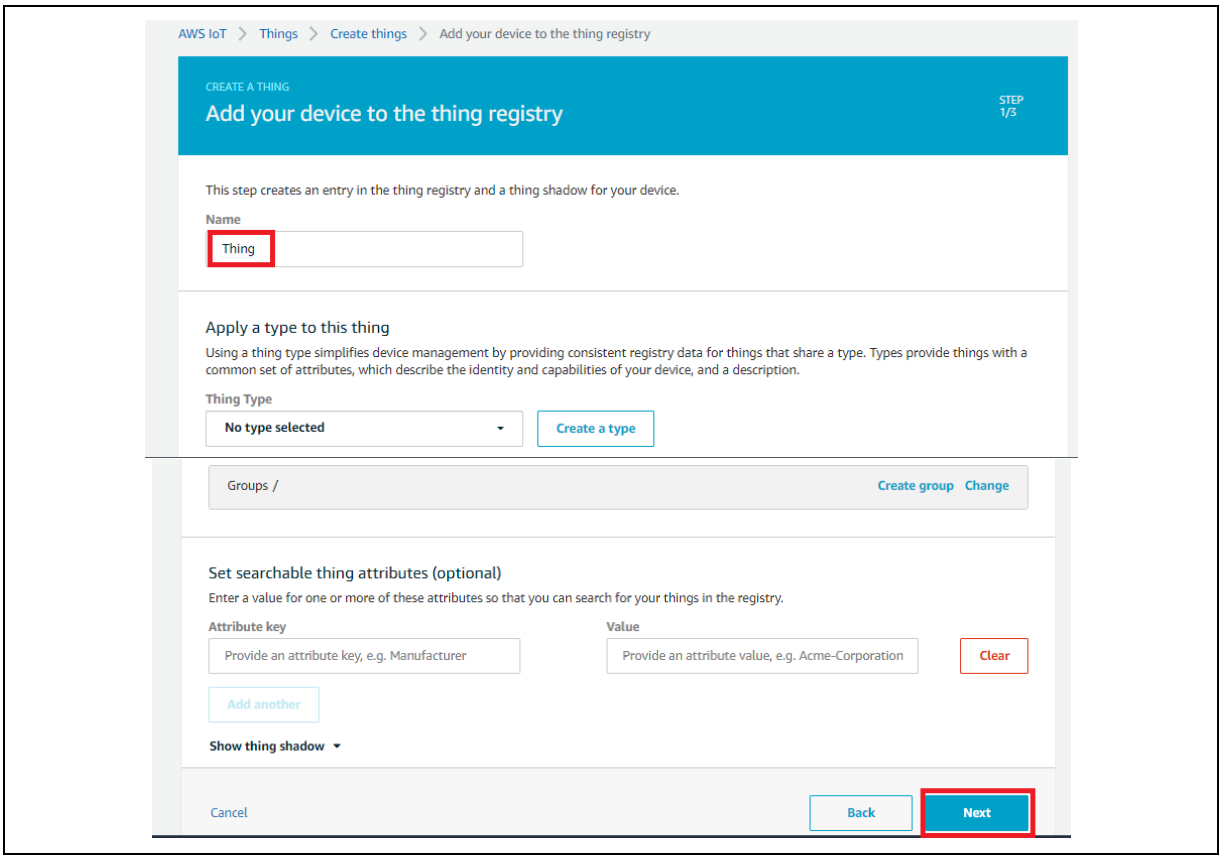

Figure 6-9 Add name to a single thing

4. Add a certificate for thing

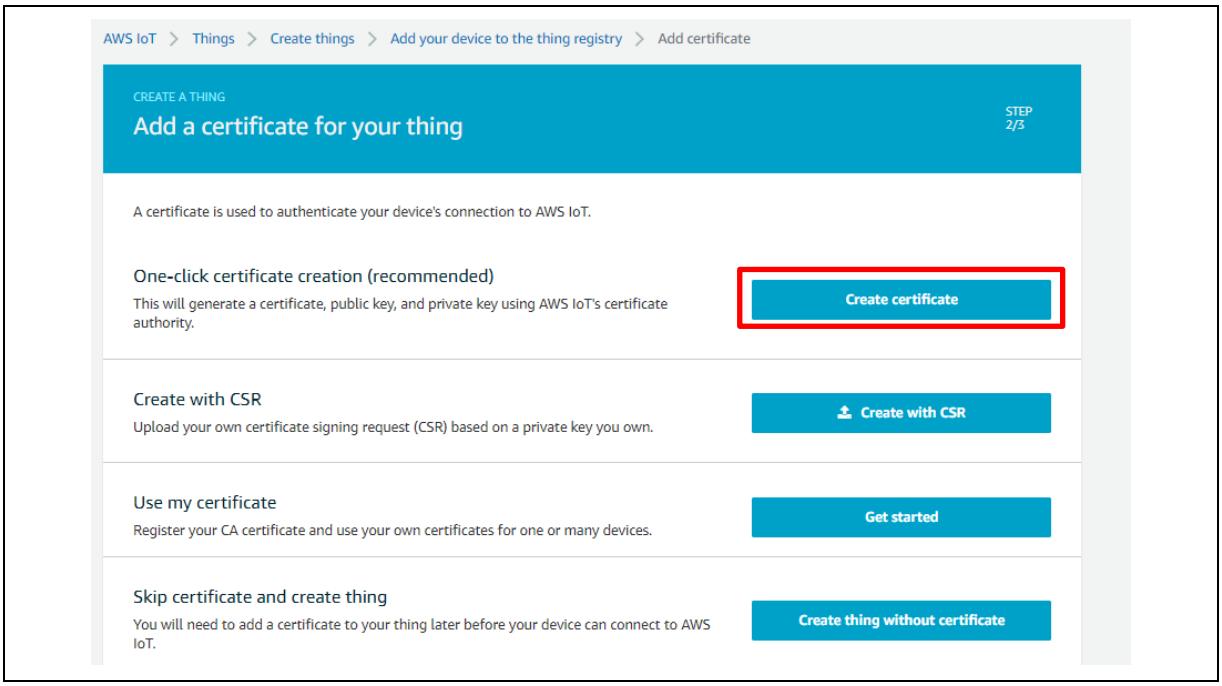

Figure 6-10 Create a certificate for thing

5. Attach a policy to thing:
   - Click the **Download** button next to each of the certificates, keys and save in local PC or host machine.
   - Click the **Activate** button to activate the certificate.
   - Select **Attach a policy** and choose the policy you created in 6.

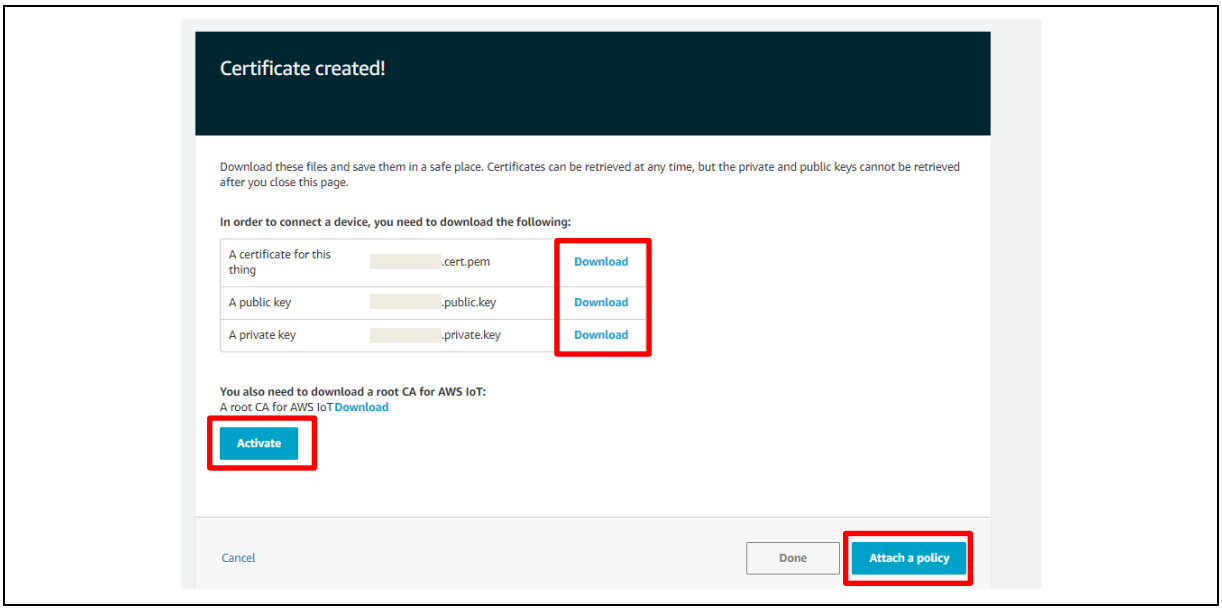

Figure 6-11 Attach a policy

6. Register policy to thing

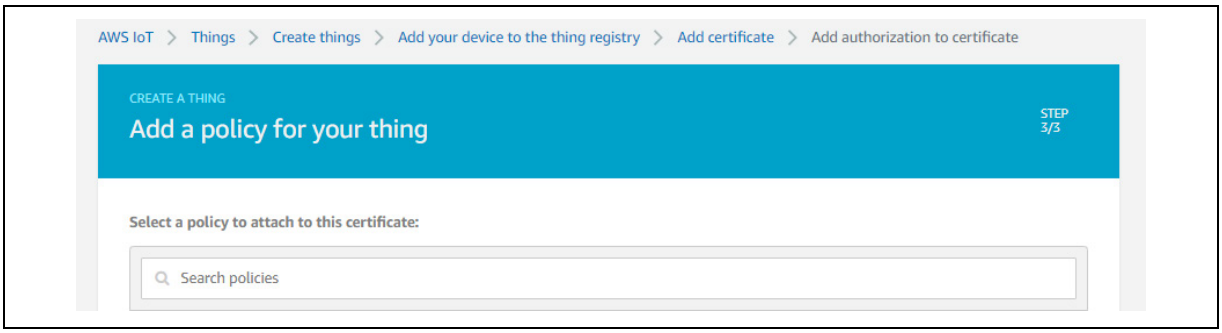

Figure 6-12 Register policy to thing

If the device has a secure element, provide explicit details with examples. Refer to Developer-mode key provisioning for an example.

7. To write the private key and certificate into Wi-Fi-Pmod-Expansion-Board

Follow 1→5 under the heading **To write the private key and certificate into Wi-Fi-Pmod-Expansion-Board**.

We need to write the certificate and private key to Wi-Fi module to connect to AWS servers. The TCP/IP and SSL/TLS with mutual authentication and secure storage are offloaded to the Wi-Fi module. This architecture allows to build secure connected Internet of Things (IoT) devices using small MCU like RL78.

1. Obtain a CA List (Class 2 Root CA)
   - In Microsoft Edge, **Settings** -> **Privacy, search, and services** -> **Manage certificates** -> **Certificates** -> **Trusted Root Certification Authorities**, then export **Starfield Class 2 Certification Authority**.

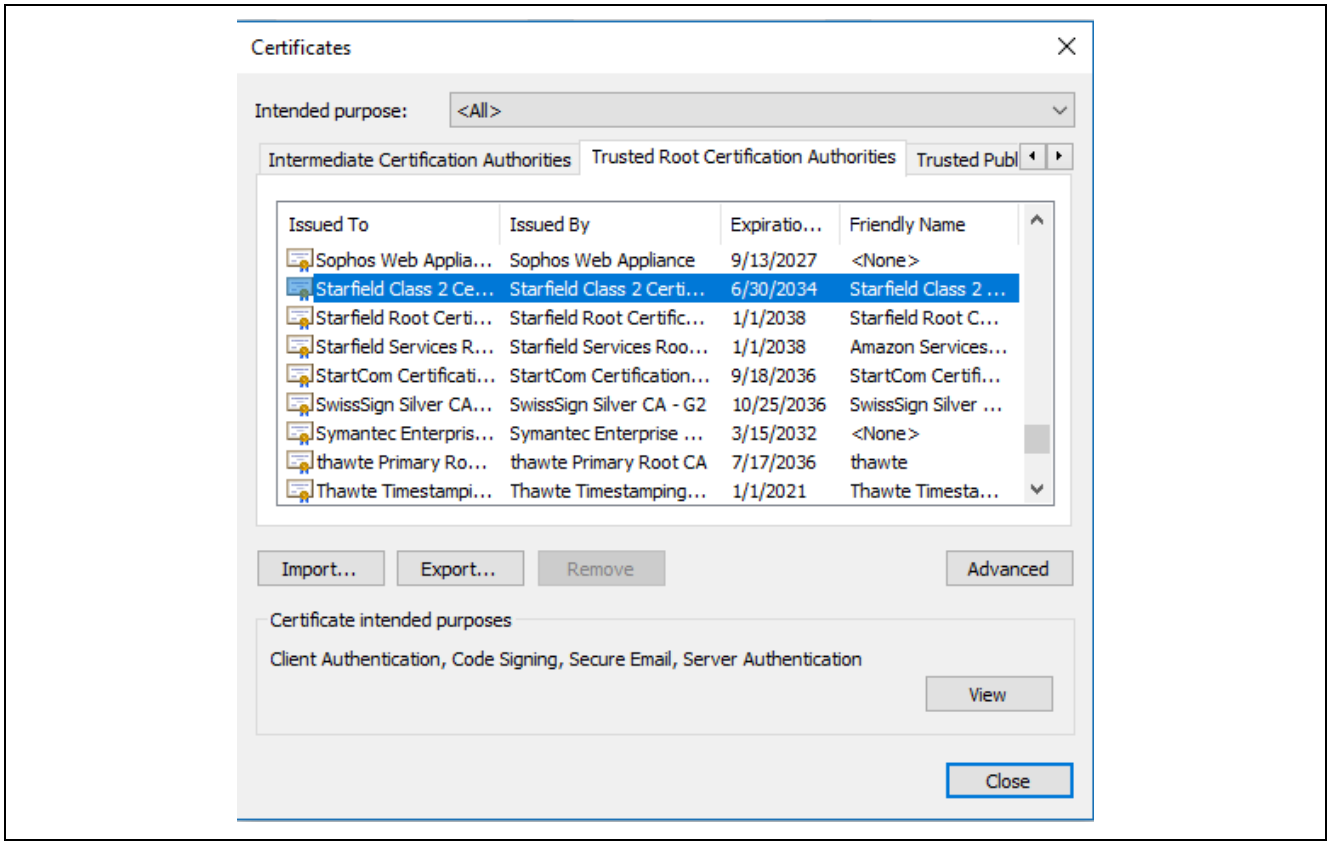

Figure 7-1 Export Starfield Class 2 Certification Authority

- Select Base 64 encoded X.509 (.CER).

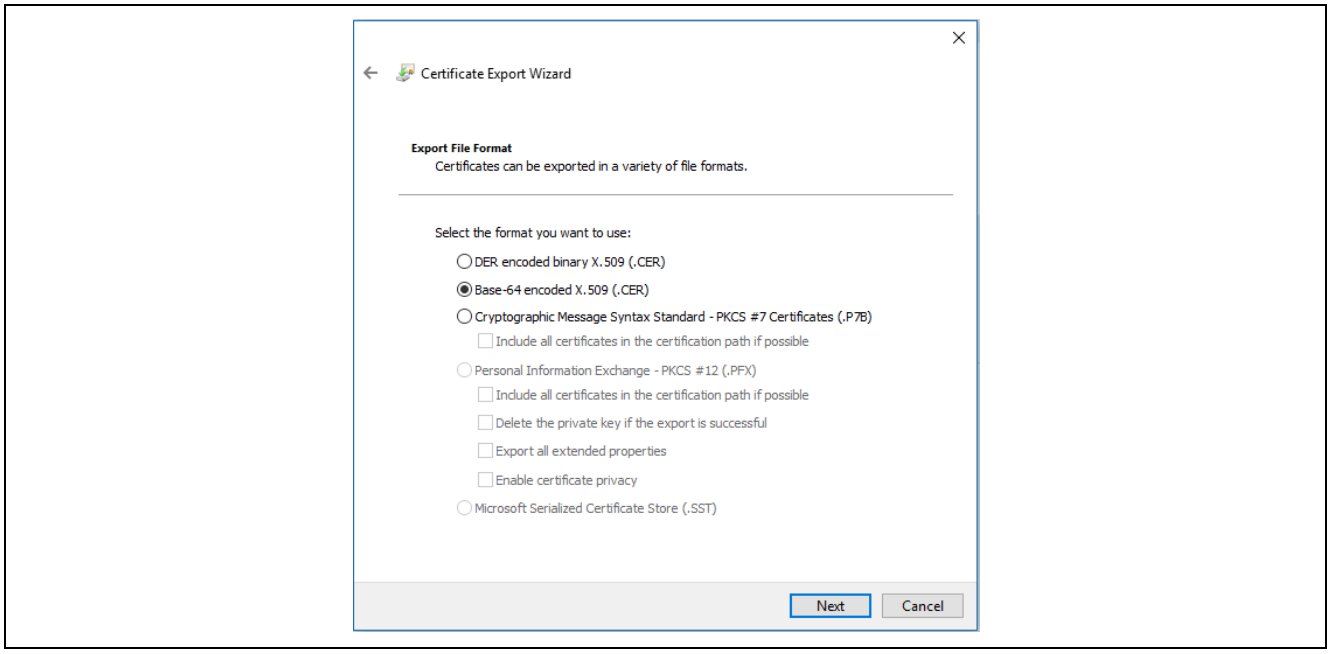

Figure 7-2 Select Base 64 encoded X.509 (.CER)

- Enter a file name of your choice, and export the certificate

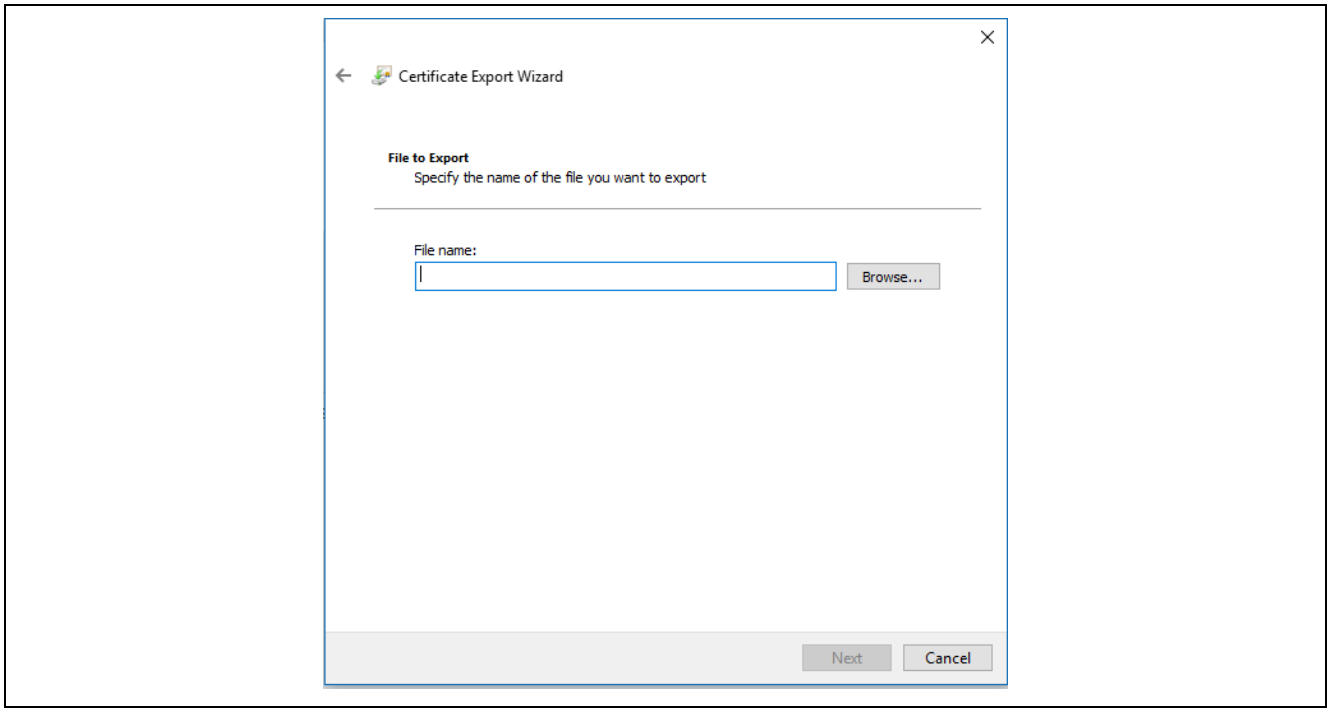

Figure 7-3 Enter a file name

2. Convert the Certificate and Secret Key to SharkSSL Binary Format
   Run the following command from the command prompt 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 represents the file name of certificate.pem.crt and private.pem.key.
Need to fill in the exact name “cert1”.

3. Convert the CA List to SharkSSLPerseCAList Binary Format
   Run the following command from the command prompt to convert the CA list to SharkSSLPerseCAList binary format.
   SharkSSLParseCAList.exe -b calist1.bin yyyyy.cer

Note:
yyyyy represents the CA List file name that created in previous section Figure 7-3 Enter a file name.
Need to fill in the exact name “calist1”.

4. Connect Wi-Fi module to PC to write the Certificate to the Wi-Fi-Pmod-Expansion-Board
   Write the converted certificate and CA list (binary files) to the Wi-Fi-Pmod-Expansion-Board. Connect the PC to the TX and RX pins of the Wi-Fi-Pmod-Expansion-Board via a USB-to-serial converter and use AT commands to write the data. Use a baud rate of 115200 bps.
   As an example, settings for writing the certificate and CA list using a terminal emulator (Tera Term) are given below. Make sure to use version 4.105 or later of Tera Term.

   [Serial port settings in Setup tab]
   - Baud rate: 115200 bps
   - Data: 8 bits
   - Parity: none
   - Stop: 1 bit
   - Flow control: none

   [Terminal settings in Setup tab]
   - New line code Receive: CR
   - New line code Transmit: CR
   - Local echo: Unchecked

   As an example, connections between the Digilent Pmod USBUART and Wi-Fi-Pmod-Expansion-Board are shown below. The connector on the Wi-Fi-Pmod-Expansion-Board has two rows. Connect wires from the Digilent Pmod USBUART to the **top-row connectors** on the Wi-Fi-Pmod-Expansion-Board.
   - Short the VCC and SYS jumpers of DIGILENT Pmod usbuart
     (power supply from Digilent Pmod USBUART to Wi-Fi-Pmod-Expansion-Board).
   - DIGILENT Pmod usbuart 2-pin (RxD) and Wi-Fi-Pmod-Expansion-Board 3-pin (TxD)
   - DIGILENT Pmod usbuart 3-pin (TxD) and Wi-Fi-Pmod-Expansion-Board 2-pin (RxD)
   - DIGILENT Pmod usbuart 5-pin (GND) and Wi-Fi-Pmod-Expansion-Board 5-pin (GND)
   - DIGILENT Pmod usbuart 6-pin (VCC) and Wi-Fi-Pmod-Expansion-Board 6-pin (VCC)

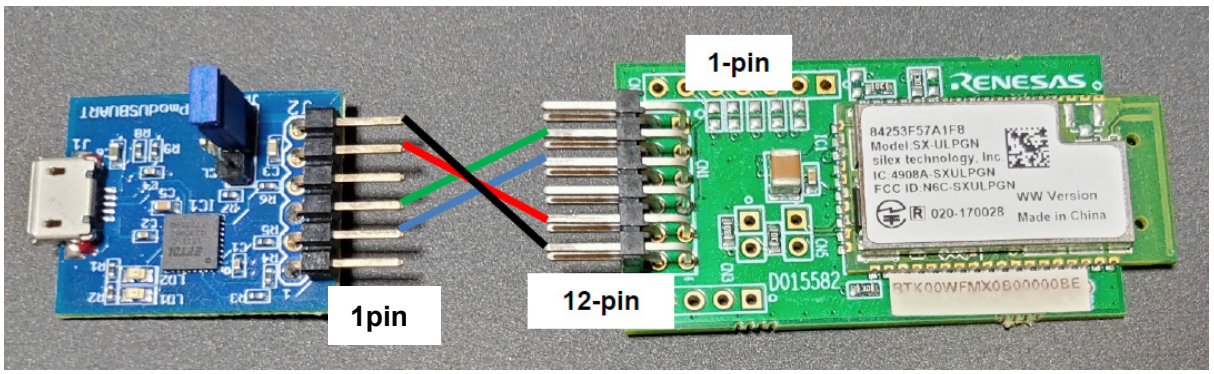

Figure 7-4 Connect between the Digilent Pmod USBUART and Wi-Fi-Pmod-Expansion-Board

Write the Certificate to the Wi-Fi-Pmod-Expansion-Board

Run the following command to write certificate and private key.

ATNSSLCERT=cert1.crt, < binary file size of converted certificate>

Example: *ATNSSLCERT=cert1.crt,1768*

Within 30 seconds, send the binary file converted as described in “Converting the Certificate and Secret Key to SharkSSL Binary Format” by file transfer from Tera Term.

Note: Make sure that Binary is checked under Option.

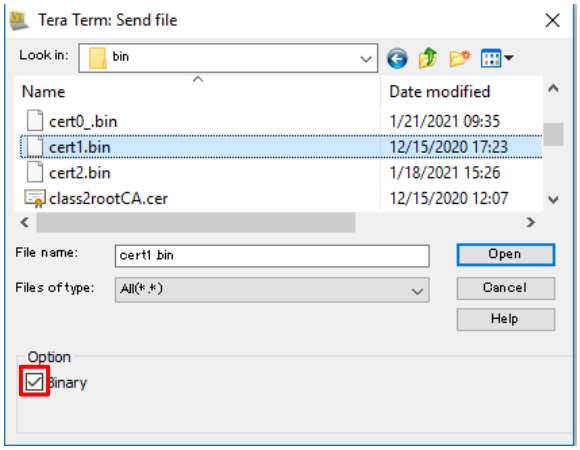

Figure 7-5 Transfer .bin file to Wi-Fi-Pmod-Expansion-Board

Run the following command to write **CA List (Class 2 Root CA)**

ATNSSLCERT= calist1.crt,< binary file size of converted CA list>

Example: *ATNSSLCERT=calist1.crt,1059*

Within 30 seconds, send the binary file converted as described in “Converting the CA List to SharkSSLPerseCAList Binary Format” by file transfer from Tera Term.

Note:

Make sure that Binary is checked under Option.

Need to fill in the exact name “cert1”and “calist1”.

To confirm certificate/private key and CA List are written properly.

Run the “*ATNSSLCERT=?*” command and confirm that the following lines are displayed.

- calist1.crt
- cert1.crt

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

8. Download FreeRTOS and import demo project

You can download FreeRTOS release package from e² studio and import demo project into workspace.

1. Launch e² studio from the Start menu.
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 Registry** 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**.
8. If showing welcome screen after launching e² studio, close welcome screen
9. Right-click the **Project Explorer** window and choose **Import**.
10. In the import wizard, choose **General**, **Renesas GitHub FreeRTOS (with IoT libraries) Project**, and the choose **Next**.

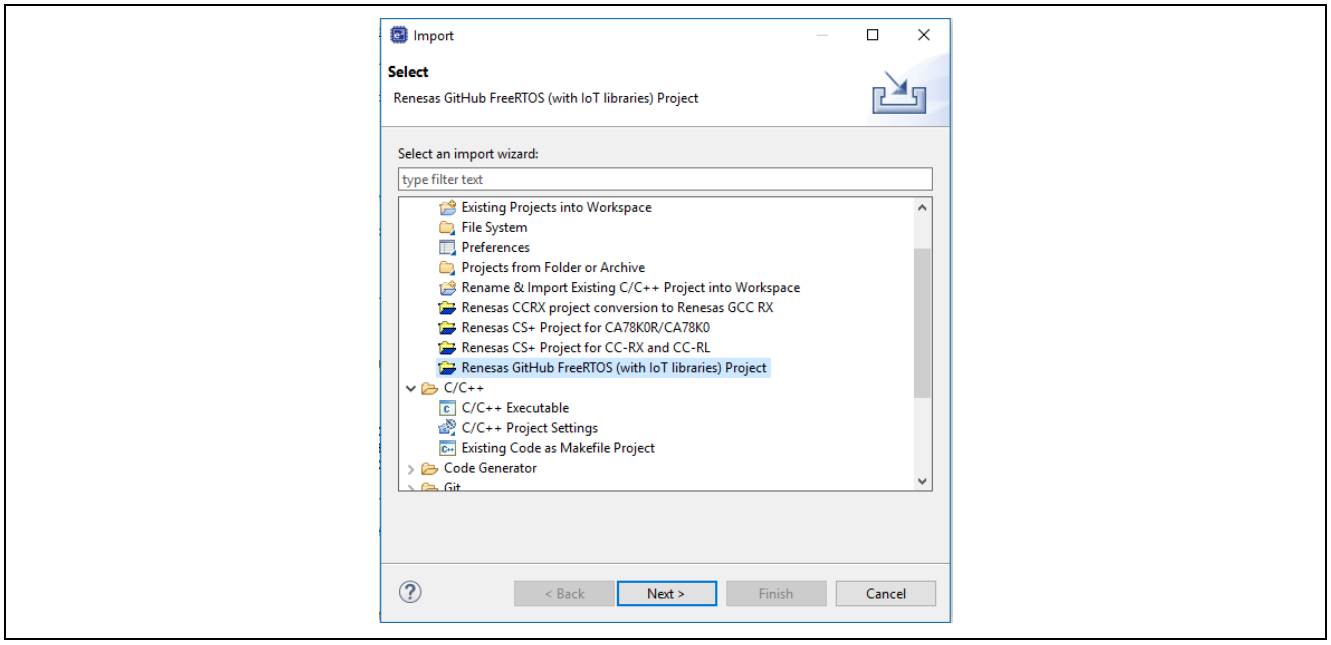

Figure 8-1 General, Renesas GitHub FreeRTOS (with IoT libraries) Project

11. Choose **Browse** to specify a folder to copy downloaded RTOS content in order to import project.

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, select the FreeRTOS version (recommended: **v202012.00-rl78-1.0.0**) you want to work on by clicking the checkbox, then choose **Download**.

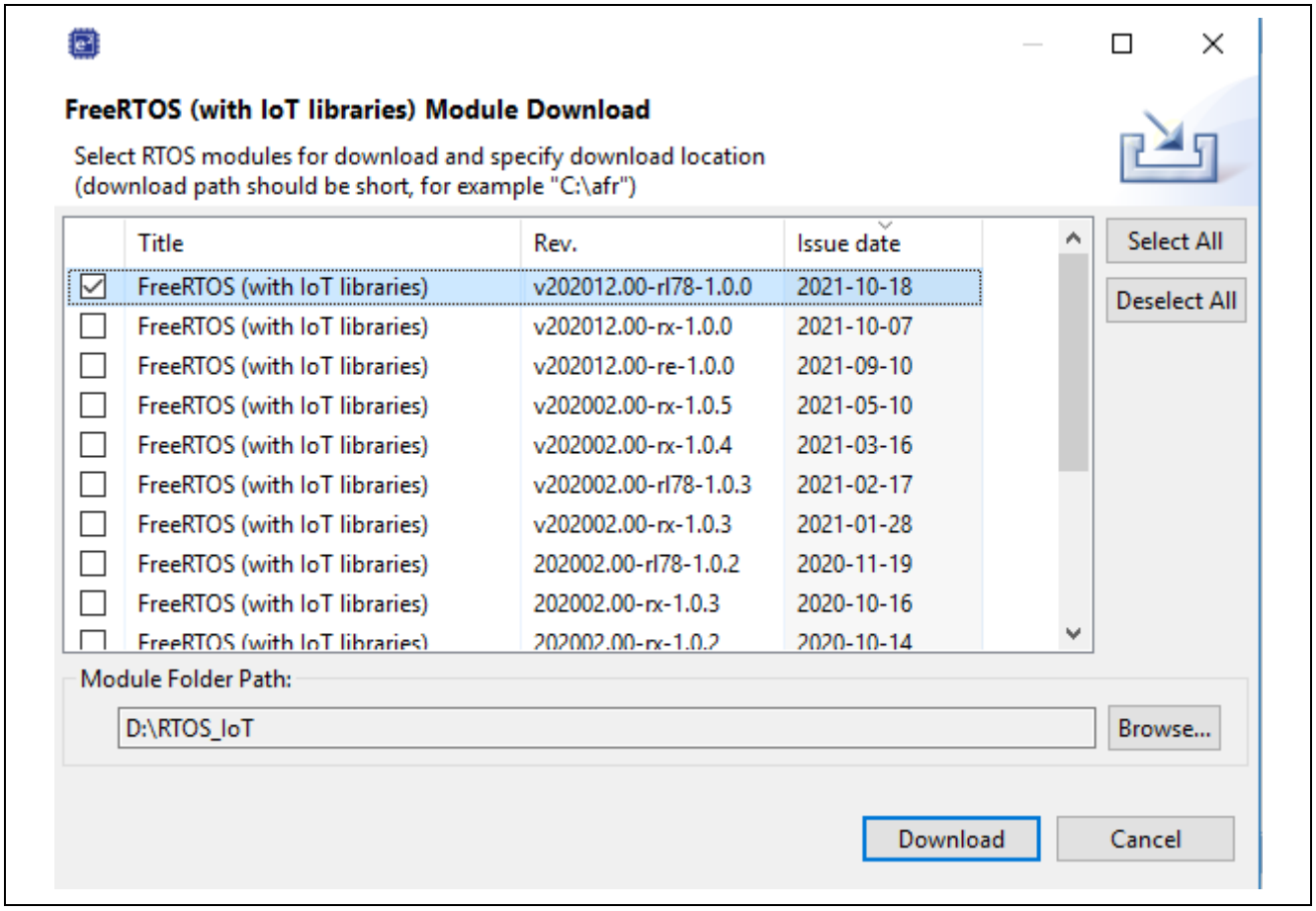

Figure 8-2 FreeRTOS (with IoT libraries) Module Download

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. Choose **Yes**.
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. For example, download package to C:\ or D:\ or etc.

- You can also download the release from the release page on GitHub.
  https://github.com/renesas/amazon-freertos/releases/tag/v202012.00-rl78-1.0.0
  Download the attached tar.gz which contains the source code in this repo and its submodules.

9. Configure FreeRTOS

Follow the instructions under the heading Configuring the FreeRTOS demos for more details.

9.1 Header file

- Check aws_demos/demos/include/aws_clientcredential.h and confirm 4 settings:
  - clientcredentialMQTT_BROKER_ENDPOINT
  - clientcredentialIOT_THING_NAME
  - clientcredentialWIFI_SSID
  - clientcredentialWIFI_PASSWORD

  For “clientcredentialIOT_THING_NAME”, input name of the thing you created in section 6.2 To create an IoT thing, private key, and certificate for your device.

```
 * 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 9-1 aws_clientcredential.h

9.2 The endpoint in AWS IoT

To find the endpoint for your account, use the AWS IoT console at console.aws.amazon.com/iot. In the left panel, choose Settings. The endpoint is listed under Custom endpoint as following snapshot:

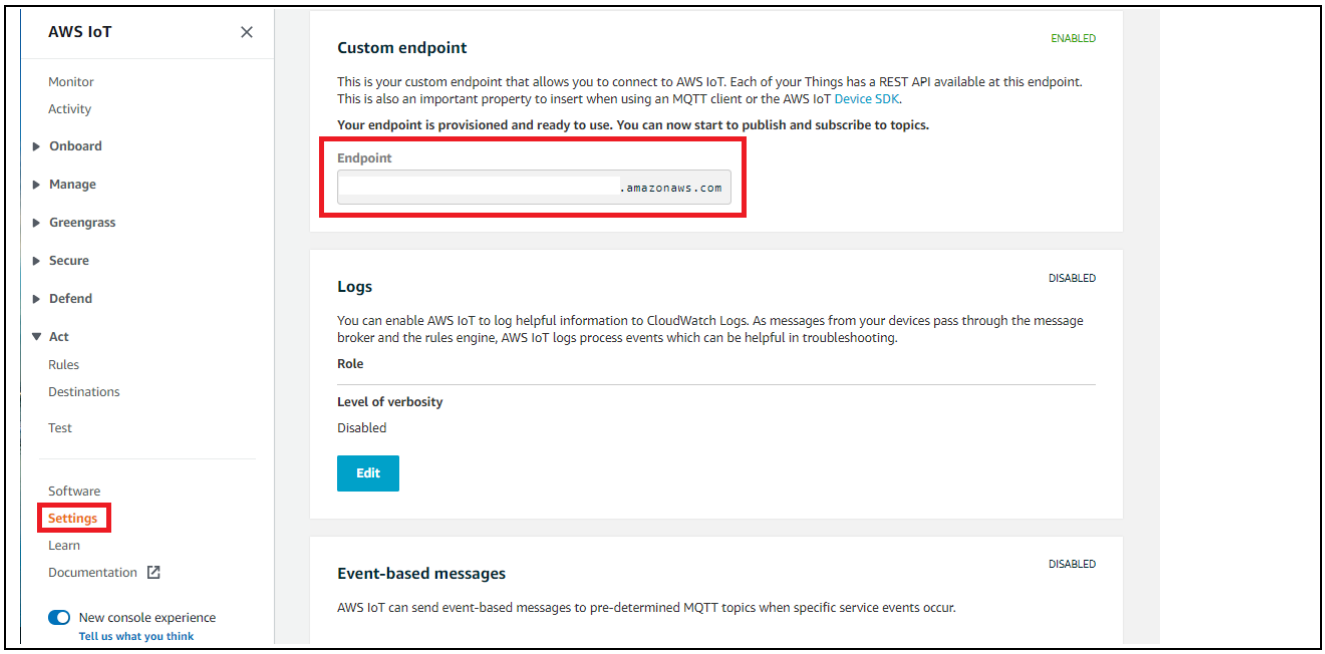

Figure 9-2 The endpoint in AWS IoT

10. Build the FreeRTOS demo

Go to e^2 studio, from **Project** menu, choose **Build All**  .

11. Run the FreeRTOS demo project

11.1 Flash demo code

Step-by-step instructions to flash and run the FreeRTOS demo code:

1. Confirm that you have connected your computer to the USB-to-serial port on RL78/G23-128p Fast Prototyping Board.
2. From the top menu, choose **Run**, **Debug Configurations…**.
3. Expand **Renesas GDB Hardware Debugging** and choose **aws_demos HardwareDebug**.
4. Choose the **Debugger** tab, and then choose the **Connection Settings** tab. Confirm that your connection settings are correct.
5. Choose **Debug** to download the code to your board and begin debugging.
   You might be prompted by a firewall warning for e2-server-gdb.exe. Check Private networks, such as my home or work network, and then choose Allow access.
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.

11.2 Receive MQTT messages by AWS IoT

Step-by-step instructions to verify that the FreeRTOS demo works successfully and MQTT messages are being received by AWS IoT.

You can use the MQTT client in the AWS IoT console to monitor the messages that your device sends to the AWS Cloud.

To subscribe to the MQTT topic with the AWS IoT MQTT client

1. Sign in to the AWS IoT console.
2. In the navigation pane, choose **Test** and then MQTT Test Client to open the MQTT client.
3. In **Subscription topic**, enter **iotdemo/#**, and then choose **Subscribe to topic**.
4. Successful demo run looks like following the picture.

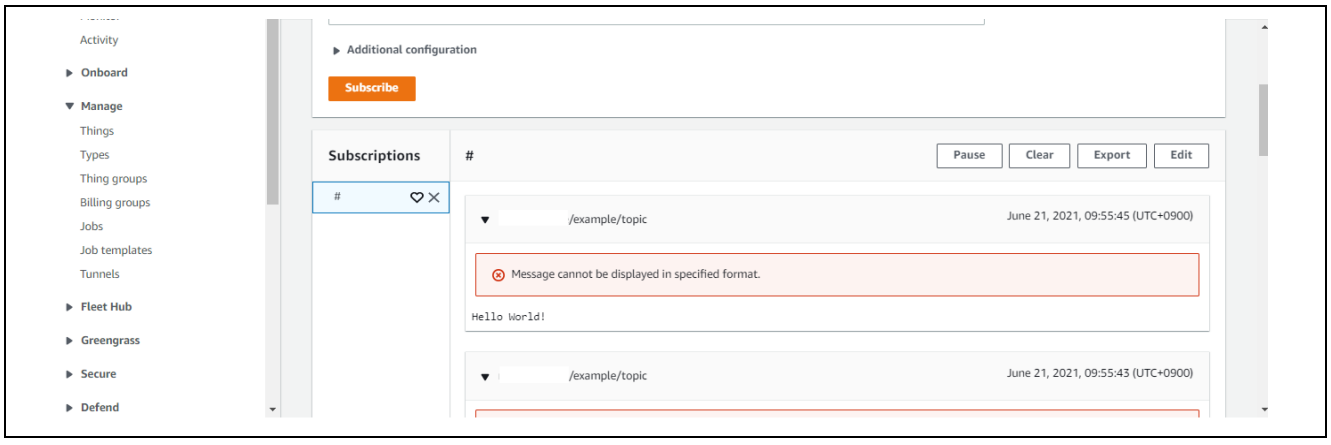

Figure 10-1 Successful demo run

For the latest projects released by Renesas, see the renesas fork of the amazon-freertos repository on GitHub.

12. Debugging

12.1 Open e2 studio to debug

Make sure that debug configuration is same as the following setting.

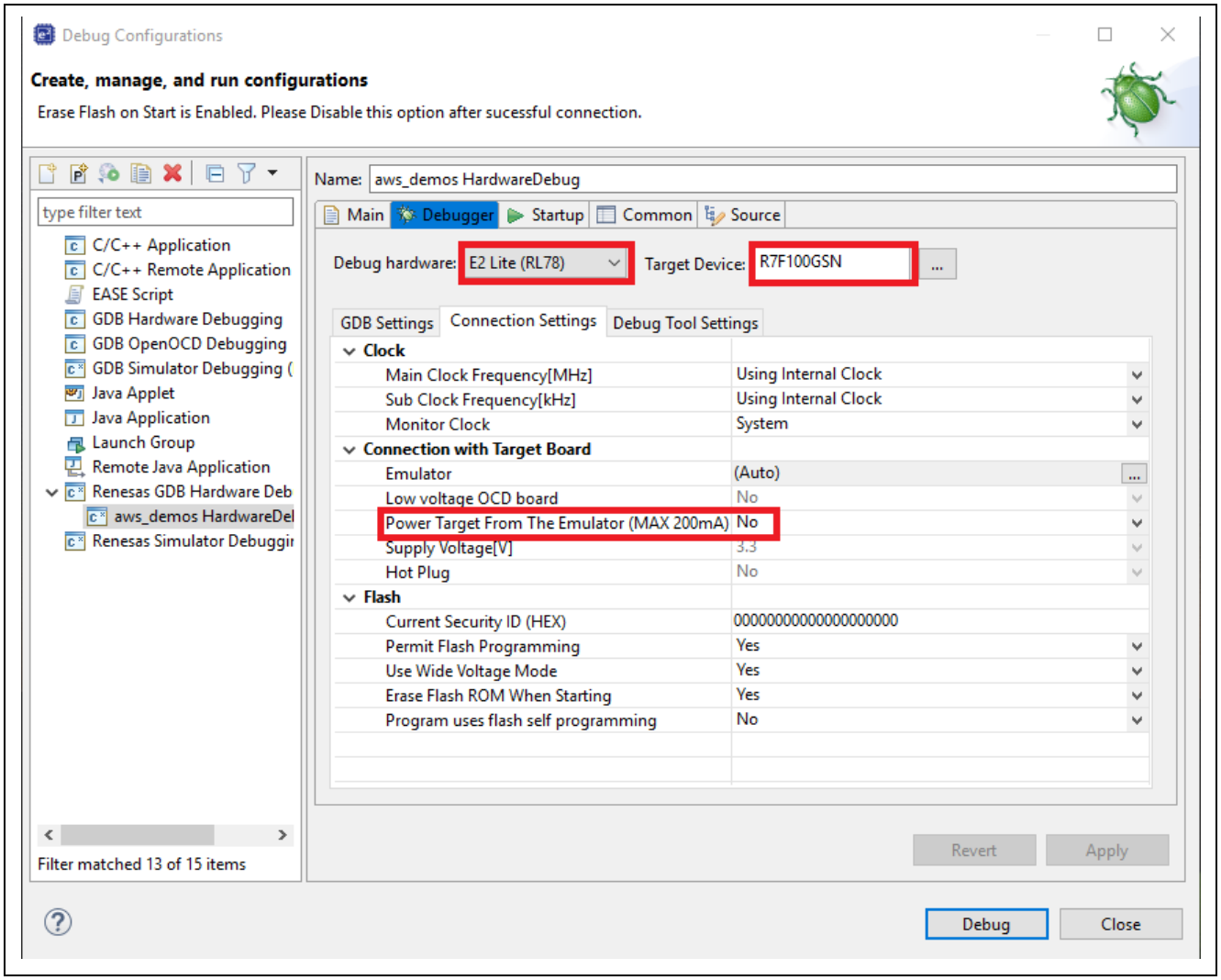

Figure 12-1 e2 studio debug setting

12.2 Tera term

Open tera term to check port, baud rate, Data, Parity, Stop and Flow control.

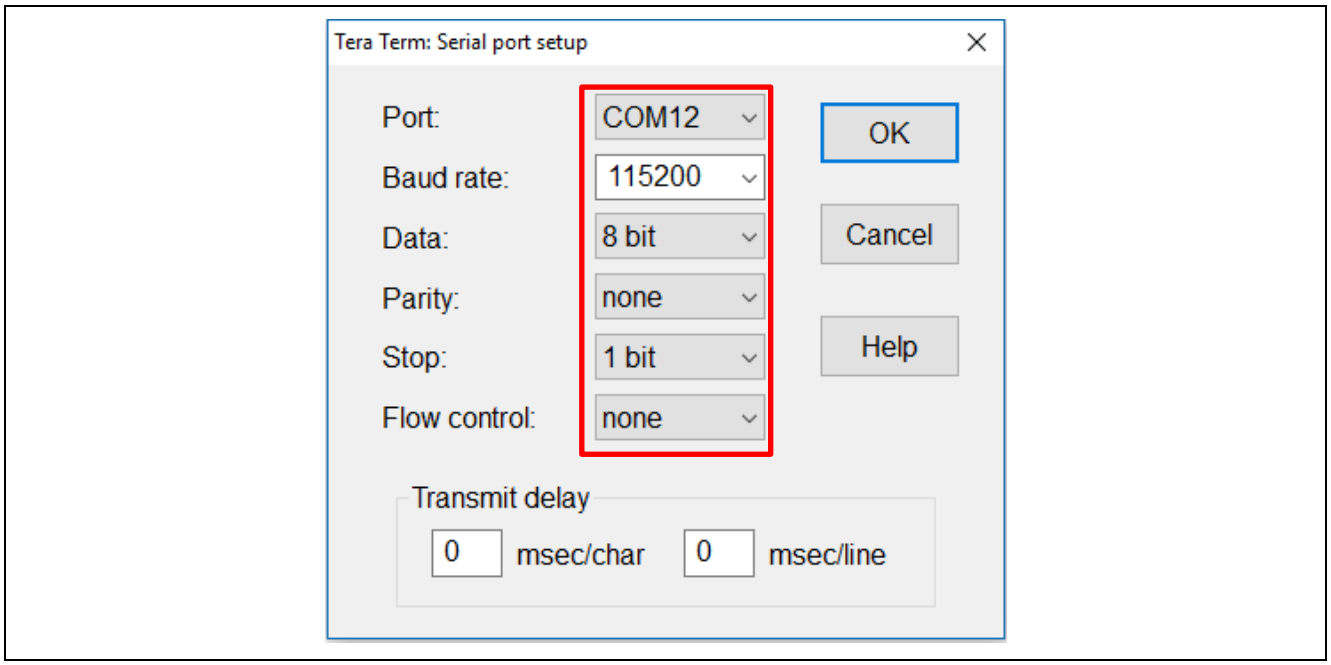

Figure 12-2 Tera term setting

13. Troubleshooting

13.1 The Build errors

Make sure that **v202012.00-rl78-1.0.0** is located to C:\ or D:\ drive or etc. Windows has a path length limitation of 260 characters. The path structure of FreeRTOS is many levels deep, so if you are using Windows, keep your file paths under the 260-character limit. The build will be passed if file paths under the 260-character.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Oct.20.21	-	First published

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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