RL78/G14 Group

Visualization of Sensor Information on Amazon Web Services using RL78/G14 Fast Prototyping Board and FreeRTOS

Introduction

Amazon FreeRTOS is a realtime operating system that enhances the FreeRTOS kernel with functionality for connections, security, and over-the-air (OTA) updates. It includes demo applications for demonstrating the functionality of Amazon FreeRTOS.

e^2 studio is a development environment based on the open-source Eclipse CDT (C/C++ Development Tooling) project. In addition to a debugging interface, it provides support for building projects (editor, compiler, linker control). It also supports integration of Amazon FreeRTOS demo applications, enabling them to run on Renesas evaluation boards.

This document describes a system combining the RL78/G14 Fast Prototyping Board from Renesas, a Wi-Fi module (SX-ULPGN (from Silex Technology)), and a Relative Humidity Sensor Pmod Board (US082-HS3001EVZ (from Renesas)). In this system, Amazon FreeRTOS runs on the RL78/G14, and sensor information (temperature and humidity data) is sent via Wi-Fi to Amazon Web Services (AWS) for visualization.

Purpose of This Document

This document provides an easy-to-understand description of how to use e^2 studio to run an Amazon FreeRTOS demo application (from downloading the Renesas GitHub Amazon FreeRTOS project to running the demo).

Operating Environment

Operation on the following environment has been confirmed.

Integrated development environment	e^2 studio 2021-07 (21.07.0) https://www.renesas.com/software-tool/e-studio
Board	RL78/G14 Fast Prototyping Board https://www.renesas.com/rl78g14-fast-prototyping-board Wi-Fi Pmod expansion board https://www.renesas.com/wi-fi-pmod-expansion-Board Relative Humidity Sensor Pmod Board US082-HS3001EVZ https://www.renesas.com/us/en/products/sensor-products/humidity-sensors/us082-hs3001evz-relative-humidity-sensor-pmod-board-renesas-quick-connect-iot Digilent Pmod USBUART https://store.digilentinc.com/pmod-usbuart-usb-to-uart-interface/
Toolchain	CCRL Compiler v1.10.00 https://www.renesas.com/software-tool/c-compiler-package-rl78-family
Emulator	E2 Emulator Lite (onboard) https://www.renesas.com/software-tool/e2-emulator-lite-rte0t0002lkce00000r

Contents

Notes:

- AWS™ is a trademark of Amazon.com, Inc. or its affiliates. (https://aws.amazon.com/trademark-guidelines/)
- FreeRTOS™ is a trademark of Amazon Web Services, Inc. (https://freertos.org/copyright.html)
- GitHub® is a trademark of GitHub, Inc. (https://github.com/logos)
- Pmod is a trademark of Digilent Inc. (https://store.digilentinc.com/)

1. Overview

This document describes the procedure from preparation of Amazon FreeRTOS projects on the Renesas RL78/G14 Fast Prototyping Board to running the demos.

1.1 System Diagram

The system diagram below shows the steps from acquisition of temperature and humidity sensor information to visualization.

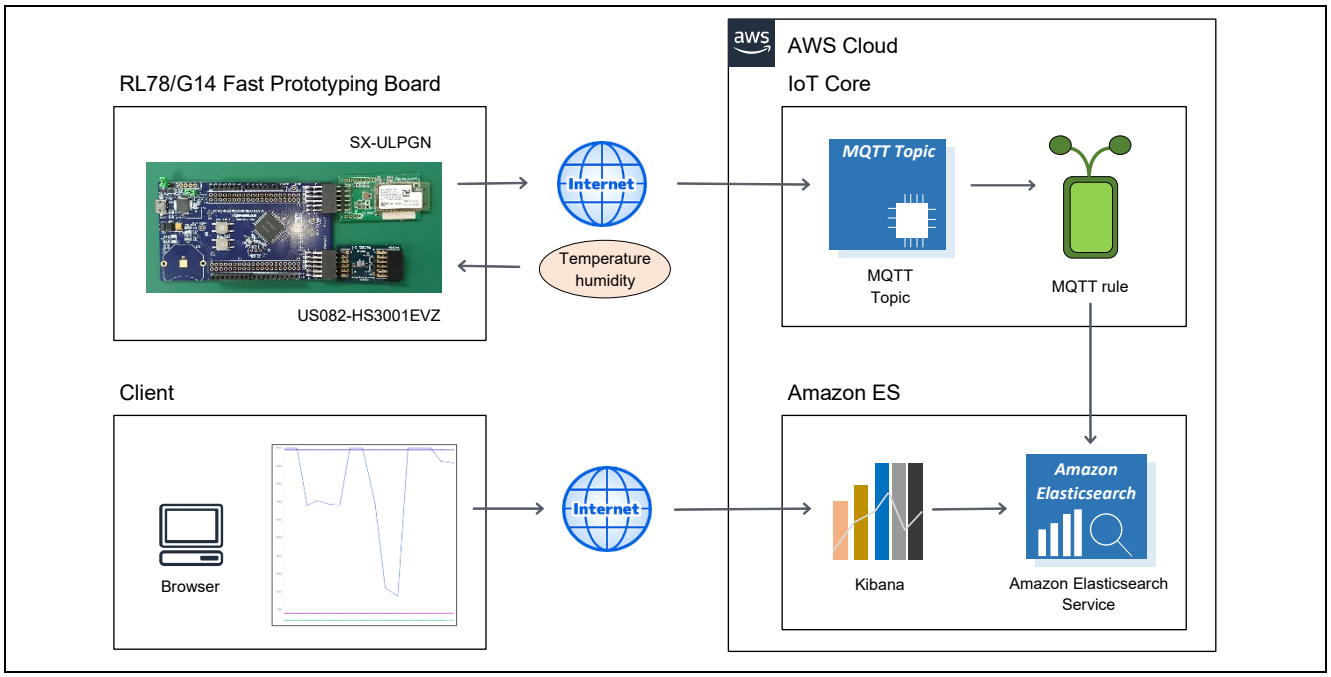

Figure 1.1 System Diagram from Acquisition of Sensor Information to Visualization

2. Amazon FreeRTOS Project Preparation

Amazon FreeRTOS projects for RL78 MCUs can be downloaded from the following GitHub repository.

GitHub repository

https://github.com/renesas/amazon-freertos/tree/rl78_development_202002.00

Alternatively, you can use amazon-freertos.zip, which is contained in the .zip file accompanying this application note.

2.1 Downloading Source Code from GitHub

After downloading the source code from GitHub, you will need to import the project into the workspace in e^2 studio. Use Git to download the source code from GitHub. In this document, we recommend using Git for Windows (https://gitforwindows.org/).

An example of the procedure for downloading from GitHub is shown below.

1. Create a clone of the master branch.
   git clone https://github.com/renesas/amazon-freertos.git

Note: After cloning the files, copy them to a location with a short file path, such as the root folder on the C: drive. If the file path is too long, a build error may result.

2. Change the directory to the master branch.
   cd amazon-freertos
3. Check out the release tag.
   git checkout 202002.00-rl78-1.0.4-sensor
4. Update the submodules.
   git submodule update --init --recursive

2.2 Sample Code Accompanying This Application Note

You can also use amazon-freertos.zip, which is contained in the .zip file accompanying this application note.

Please unzip this file.

Note: After unzipping the files, copy them to a location with a short file path, such as the root folder on the C: drive. If the file path is too long, a build error may result.

2.3 Importing Demo Project

Import the following RL78/G14 demo project in e² studio.

1. Launch e² studio and specify a workspace directory.

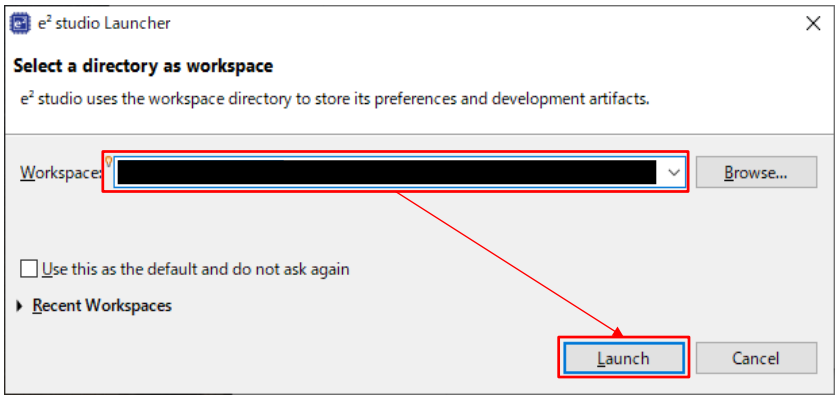

Figure 2.1 Workspace Selection Menu

2. Select [File] -> [Import…].

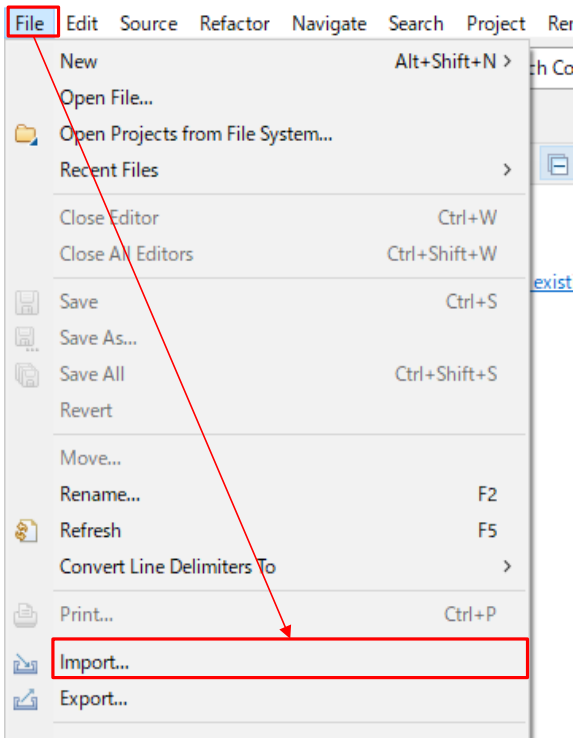

Figure 2.2 Select Import

3. Click [General] -> [Existing Projects into Workspace] -> [Next >].

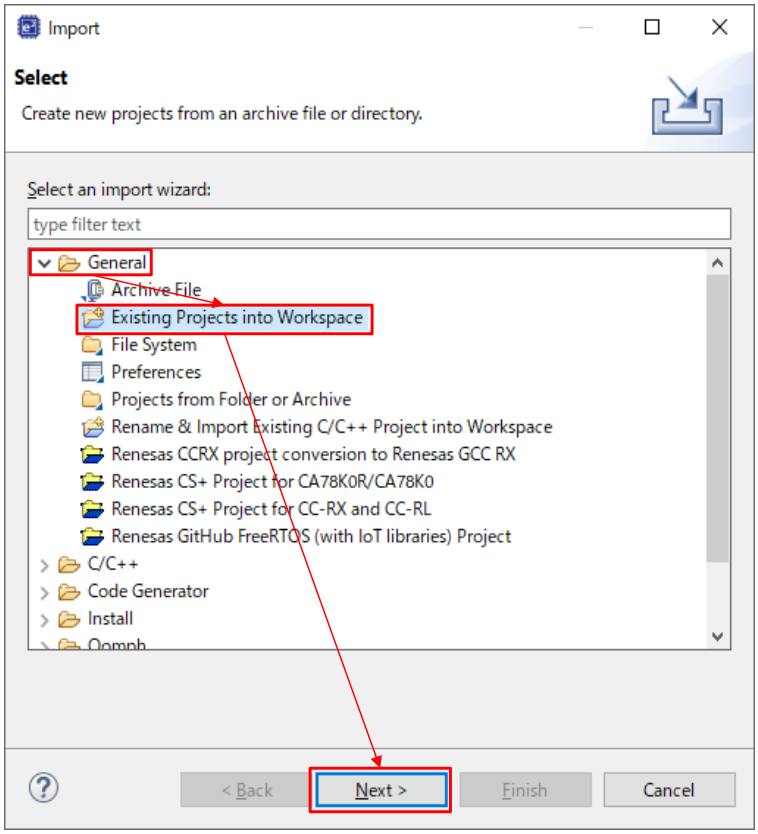

Figure 2.3 Select [Existing Projects into Workspace]

4. Click [Browse…], then specify the root directory as follows. Finally, click [Finish].
   projects -> renesas -> rl78g14-fpb-sx-ulpgn -> e2studio -> aws_demos

Note: Make sure [Copy projects into workspace] is unchecked.

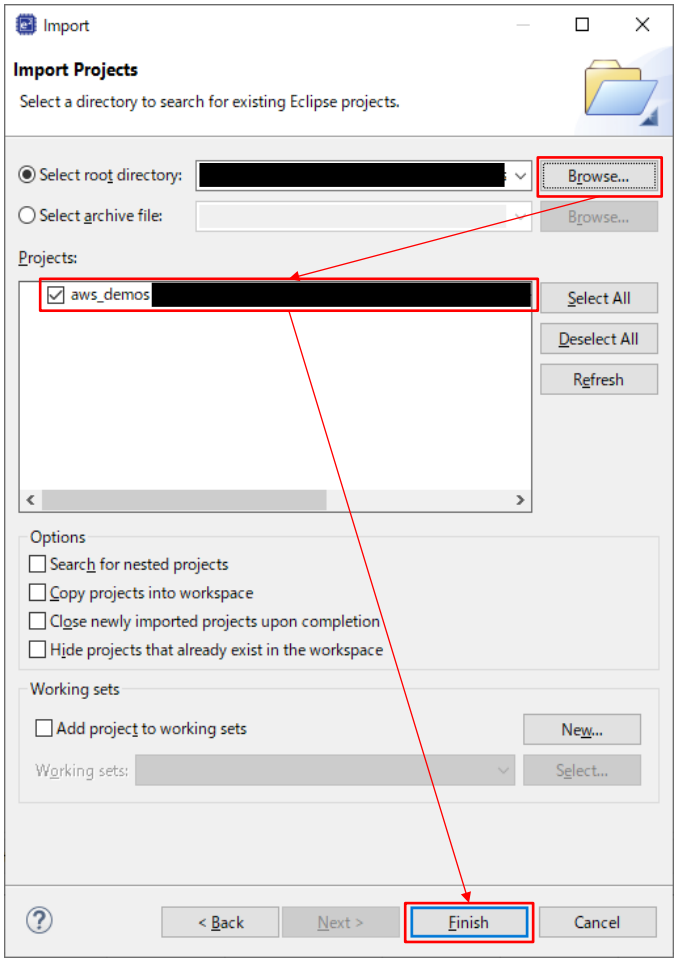

Figure 2.4 Import demo project

3. AWS Preparation

Some preparation on AWS is necessary before the demo can be run. Refer to the tutorial below and make the appropriate settings in AWS.

- Registering the device in AWS IoT.
  Register https://github.com/renesas/amazon-freertos/wiki/device in AWS IoT.

Also, make the following four macro settings in aws_demos -> demos -> include -> aws_clientcredential.h of the demo project.

- clientcredentialMQTT_BROKER_ENDPOINT -> endpoint name confirmed as described in “Registering the device in AWS IoT.”
- clientcredentialIOT_THING_NAME -> thing name registered as described in “Registering the device in AWS IoT.”
- clientcredentialWIFI_SSID (when using Wi-Fi) -> SSID for access point to connect to
- clientcredentialWIFI_PASSWORD (when using Wi-Fi) -> password for access point to connect to

```
 * 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 Macro Settings

4. Hardware Preparation

Some hardware preparation is necessary before the Amazon FreeROTS demo can be run.

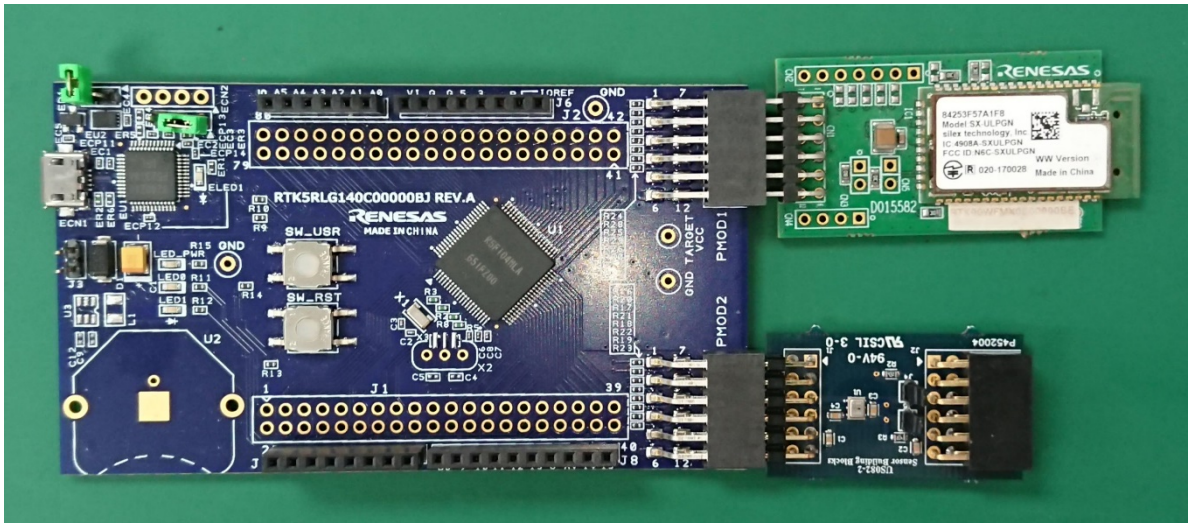

Figure 4.1 RL78/G14 Fast Prototyping Board and Wi-Fi Module (SX-ULPGN (Silex Technology))

4.1 RL78/G14 Fast Prototyping Board

The RL78/G14 Fast Prototyping Board is necessary to run the Amazon FreeRTOS demo for RL78/G14. Purchasing information is provided on the following webpage.

https://www.renesas.com/products/software-tools/boards-and-kits/eval-kits/rl78-g14-fast-prototyping-board.html

4.2 SX-ULPGN

A wireless LAN module that connects to the RL78/G14 Fast Prototyping Board is also necessary. Operation of the Amazon FreeRTOS demo for RL78/G14 has been confirmed when using the SX-ULPGN.

Purchasing information for the SX-ULPGN is provided on the following webpage.

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

4.3 US082-HS3001EVZ

A humidity and temperature sensor module that connects to the RL78/G14 Fast Prototyping Board is also necessary. Operation of the Amazon FreeRTOS demo for RL78/G14 has been confirmed when using the US082-HS3001EVZ.

Purchasing information for the US082-HS3001EVZ is provided on the following webpage.

https://www.renesas.com/us/en/products/sensor-products/humidity-sensors/us082-hs3001evz-relative-humidity-sensor-pmod-board-renesas-quick-connect-iot

4.4 Digilent Pmod USBUART

The Digilent Pmod USBUART is used to write certificates and CA lists to the SX-ULPGN and to receive debug logs when running the RL78/G14 demo.

Purchasing information for the Digilent Pmod USBUART is provided on the following webpage.

https://store.digilentinc.com/pmod-usbuart-usb-to-uart-interface/

4.5 Writing Certificates

Certificates and CA lists are written to the SX-ULPGN. Before writing them to the SX-ULPGN, certificate data needs to be converted to SharkSSLParseCert binary format and CA lists to SharkSSLPerseCAList binary format.

The procedure for writing a certificate to the SX-ULPGN using Tera Term is described below.

4.5.1 Downloading SharkSSL

You can use the following free software program to convert certificate data to the required format.

SharkSSL <https://realtimelogic.com/downloads/sharkssl/>

Choose [SharkSSL for Windows]. Download the software, and then follow the prompts to install it.

4.5.2 Obtaining Certificate Data

You will use the certificate and secret key obtained as described in 3, AWS Preparation.

4.5.3 Obtaining a CA List (Class 2 Root CA)

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

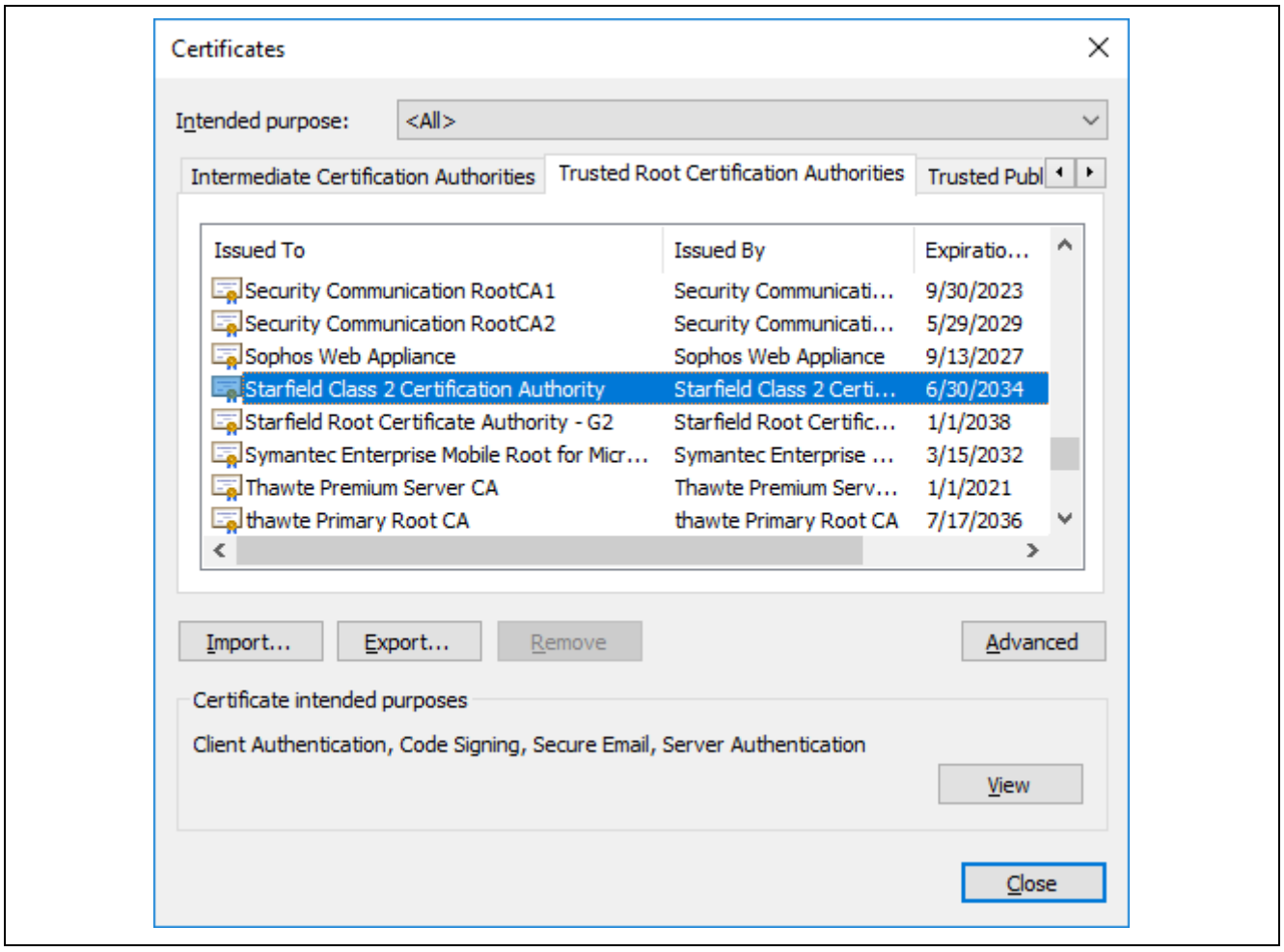

Figure 4.2 Obtaining a CA List

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

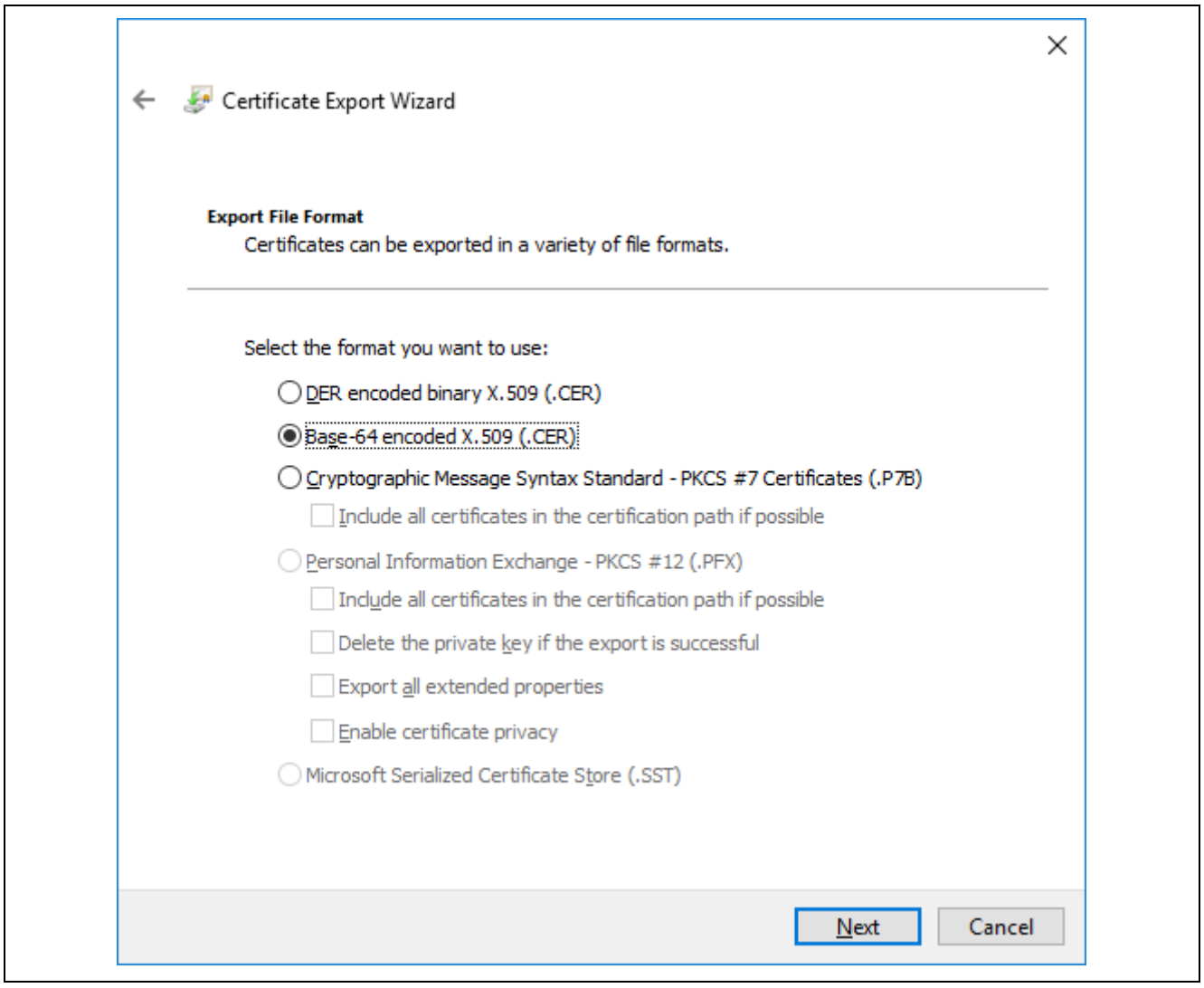

Figure 4.3 Selecting Base 64 encoded X.509 (.CER)

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

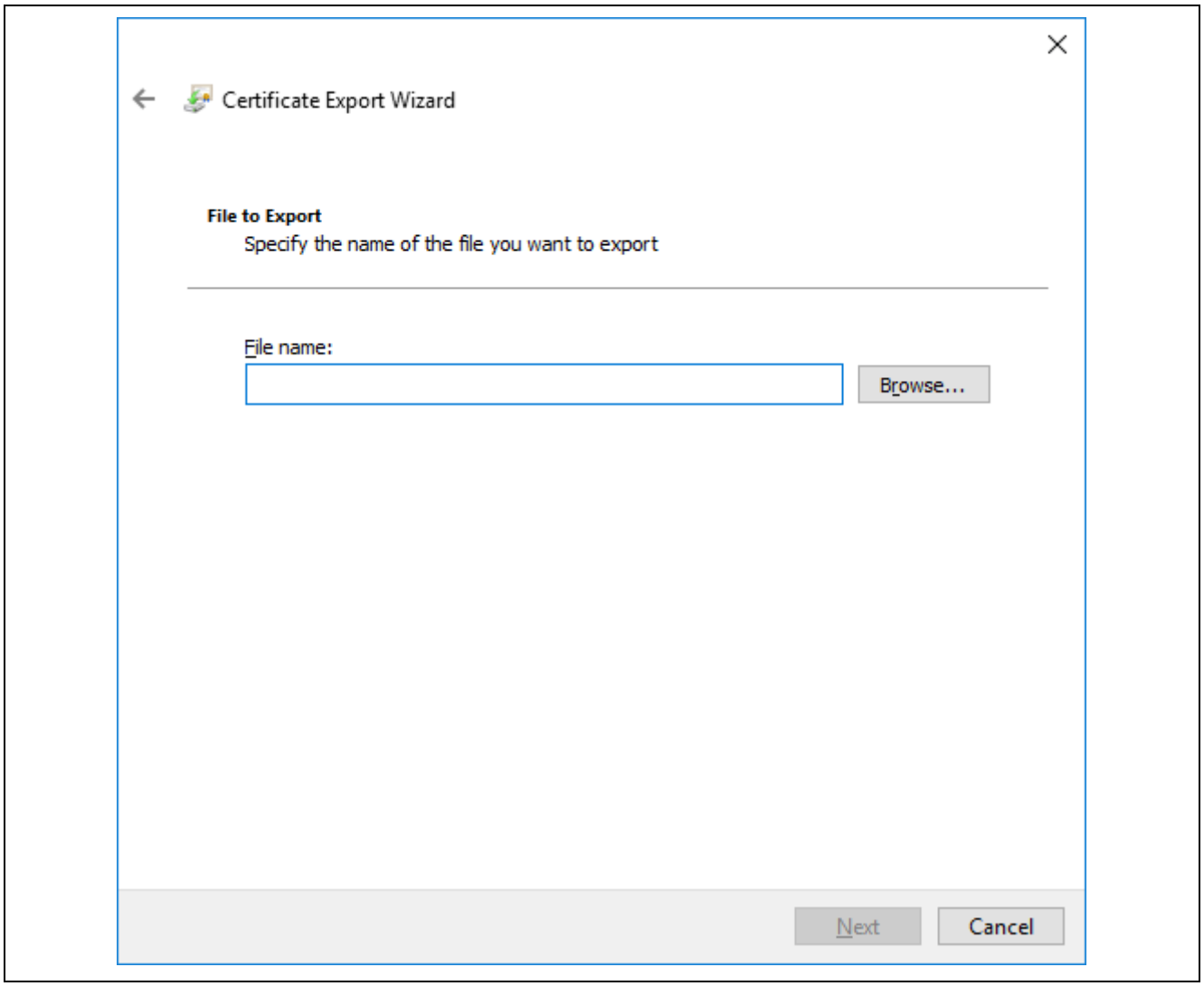

Figure 4.4 Exporting the Certificate

4.5.4 Converting the Certificate and Secret Key to SharkSSL Binary Format

Run the following command from the command prompt to convert the certificate and secret key to SharkSSL binary format.

SharkSSLParseCert xxxxx-certificate.pem.crt xxxxx-private.pem.key –b cert1.bin

xxxxx is the private key obtained from AWS in "3. AWS Preparation", a hash value fragment such as "d666c26201" in the file name of the device certificate.

4.5.5 Converting 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 calist1.cer

4.5.6 Writing the Certificate to the SX-ULPGN

Write the converted certificate and CA list (binary files) to the SX-ULPGN. Connect the PC to the TX and RX pins of the Wi-Fi module via a USB-to-serial converter, and use AT commands to write the data. Use a baud rate of 115,200 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: 115,200 bps

Data: 8 bits

Parity: none

Stop: 1 bit

Flow control: none

[Terminal settings in Setup tab]

New line code

Receive: CR

Transmit: CR

Local echo: Unchecked

As an example, connections between the Digilent Pmod USBUART and SX-ULPGN are shown below. The connector on the SX-ULPGN has two rows. Connect wires from the Digilent Pmod USBUART to the top-row connectors on the SX-ULPGN.

On the Digilent Pmod USBUART, use a jumper to short VCC and SYS (power supply from Digilent Pmod USBUART to SX-ULPGN).

Connect pin 2 (RxD) on Digilent Pmod USBUART to pin 3 (TxD) on SX-ULPGN.

Connect pin 3 (TxD) on Digilent Pmod USBUART to pin 2 (RxD) on SX-ULPGN.

Connect pin 5 (GND) on Digilent Pmod USBUART to pin 5 (GND) on SX-ULPGN.

Connect pin 6 (VCC) on Digilent Pmod USBUART to pin 6 (VCC) on SX-ULPGN.

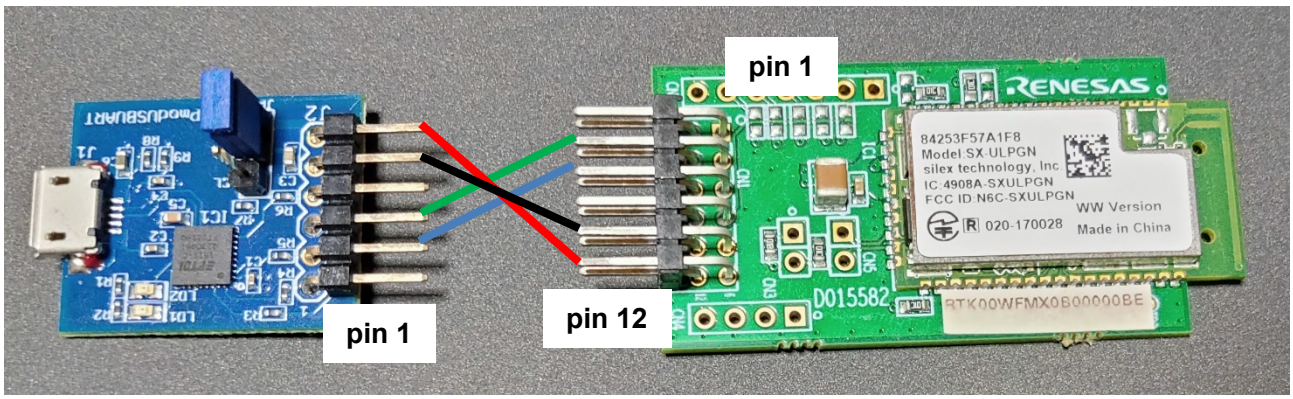

Figure 4.5 Connections between Digilent Pmod USBUART and SX-ULPGN

The procedure for registering a certificate using a terminal emulator (Tera Term) is described below.

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

2. Within 30 seconds, send the binary file converted as described in “Converting the Certificate and Secret Key to SharkSSL Binary Format” by file transfer [**Send file…**] from Tera Term.
   Note: Make sure that **Binary** is checked under **Option**.

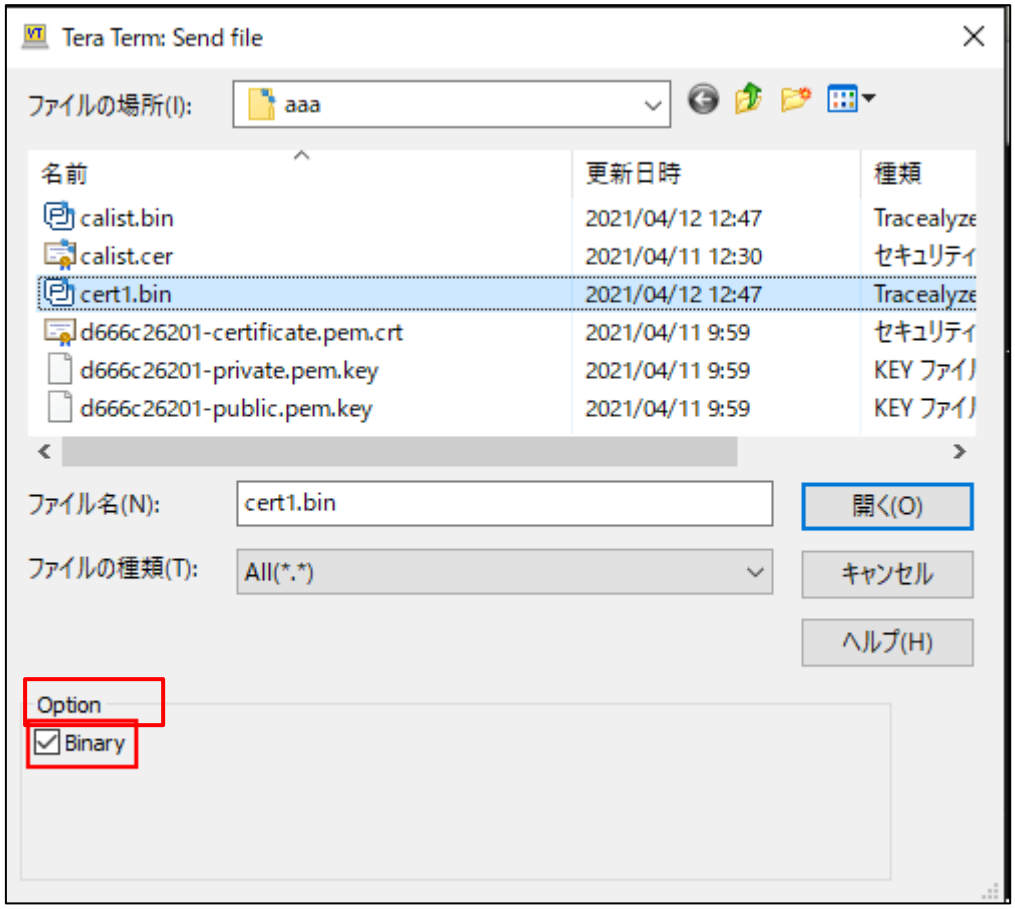

Figure 4.6 Registering a Certificate

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

4. 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**.

5. Run the ATNSSLCERT=? command, and confirm that the following lines are displayed.
   calist1.crt
   cert1.crt

Note: If you accidentally register the certificate, you can delete the registered certificate by executing the command "ATNSSLCERT = file name, 0".

4.5.7 Connecting the SX-ULPGN

Connect the SX-ULPGN to the RL78/G14 Fast Prototyping Board. The SX-ULPGN connects to PMOD1.

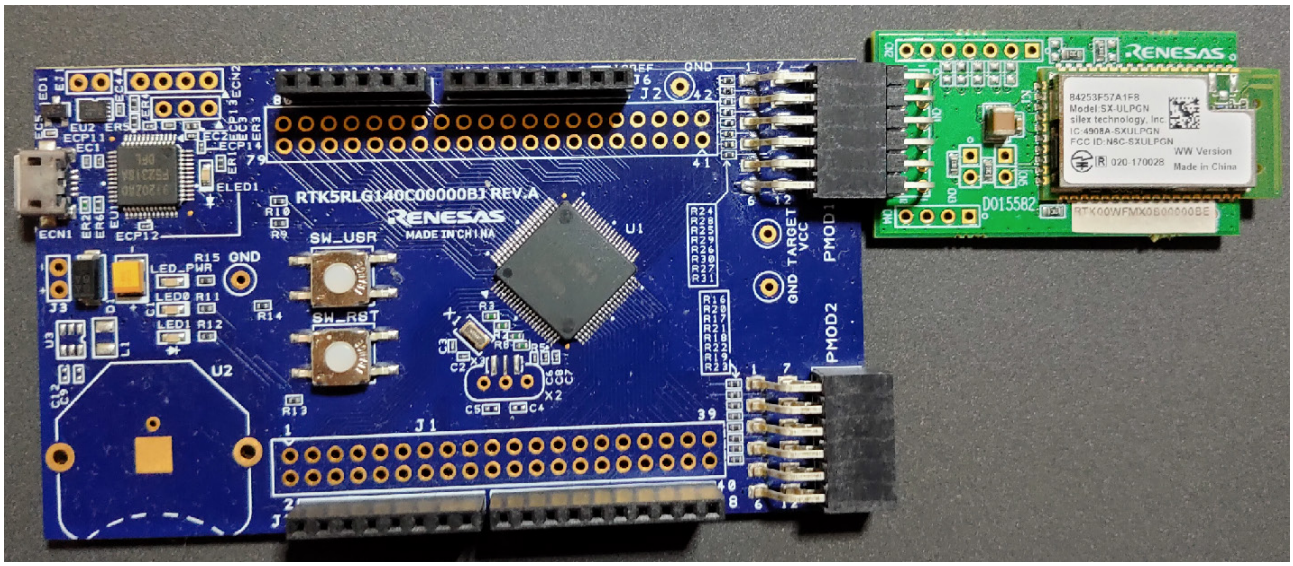

Figure 4.7 Connecting the SX-ULPGN to the RL78/G14 Fast Prototyping Board

4.6 Preparation to Receive Debug Logs

The demo outputs debug logs via the SCI port. To check the debug logs, use a terminal emulator (Tera Term, etc.) to connect to the serial port used by the SCI driver. As an example, connection of the Digilent Pmod USBUART and RL78/G14 Fast Prototyping Board is shown below.

Connect pin 2 (RxD) on Digilent Pmod USBUART to J7 pin 2 (TxD) on RL78/G14 Fast Prototyping Board. Connect pin 5 (GND) on Digilent Pmod USBUART to J6 pin 2 or 3 (GND) on RL78/G14 Fast Prototyping Board.

Power is supplied from the PC to the RL78/G14 Fast Prototyping Board via a USB cable, so there is no need to supply power from the Digilent Pmod USBUART. In addition, it is not necessary to send data from the Digilent Pmod USBUART because debug logs are only received, not sent.

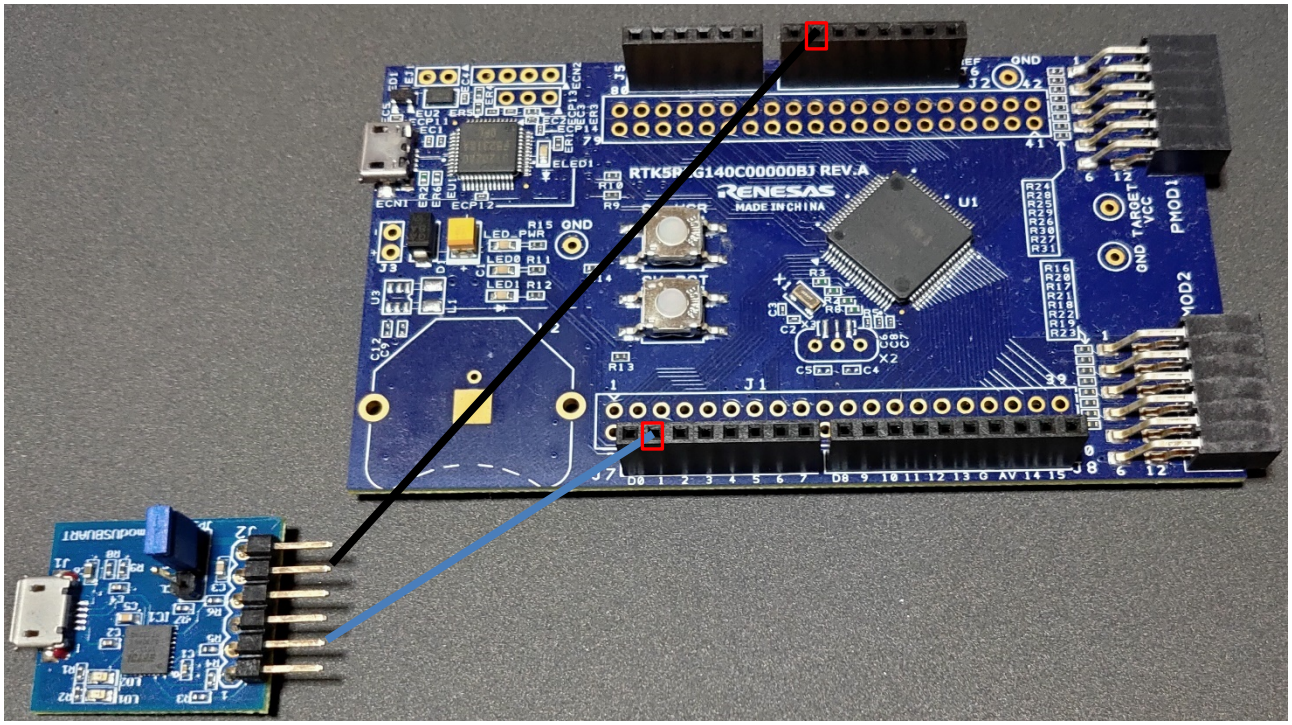

Figure 4.8 Connecting the Digilent Pmod USBUART to the RL78/G14 Fast Prototyping Board

When using Tera Term to receive debug logs, make sure to use version 4.105 or later. The Tera Term settings are given below.

[Serial port settings in Setup tab]

Baud rate: 115,200 bps

Data: 8 bits

Parity: none

Stop: 1 bit

Flow control: none

[Terminal settings in Setup tab]

New line code

Receive: CR

Transmit: CR

Local echo: Unchecked

5. Demo Project Preparation

Follow the steps below to build and run the demo.

1. In Project Explorer, right-click the project and select **Build**.
2. From the menu, select [Run] -> [Debugging Configuration].
3. Expand Renesas GDB Hardware Debugging and select **aws_demos HardwareDebug**.

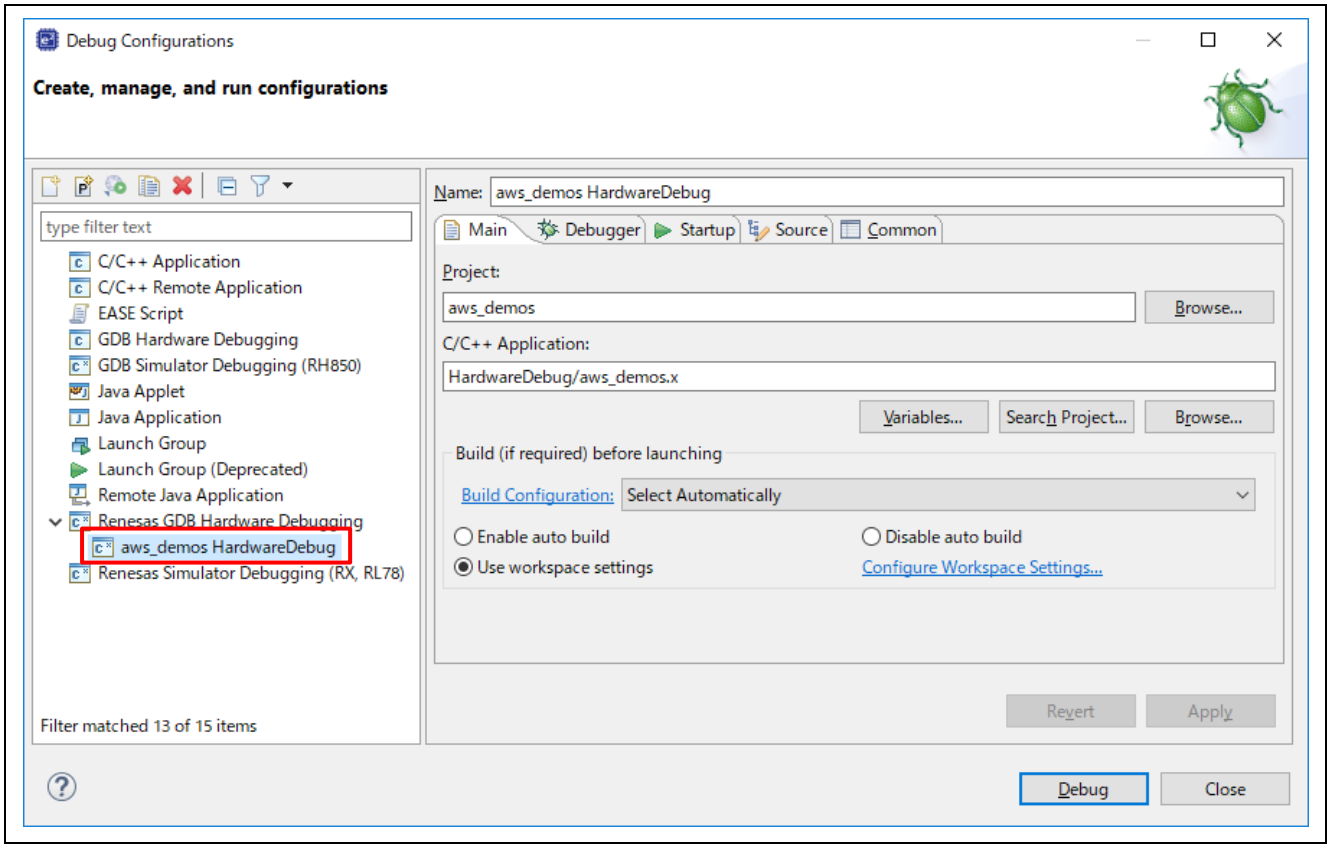

Figure 5.1 Selecting Startup Settings

4. Select the **Debugger** tab, then the **Connection Settings** tab. Check to make sure the connection settings are correct.

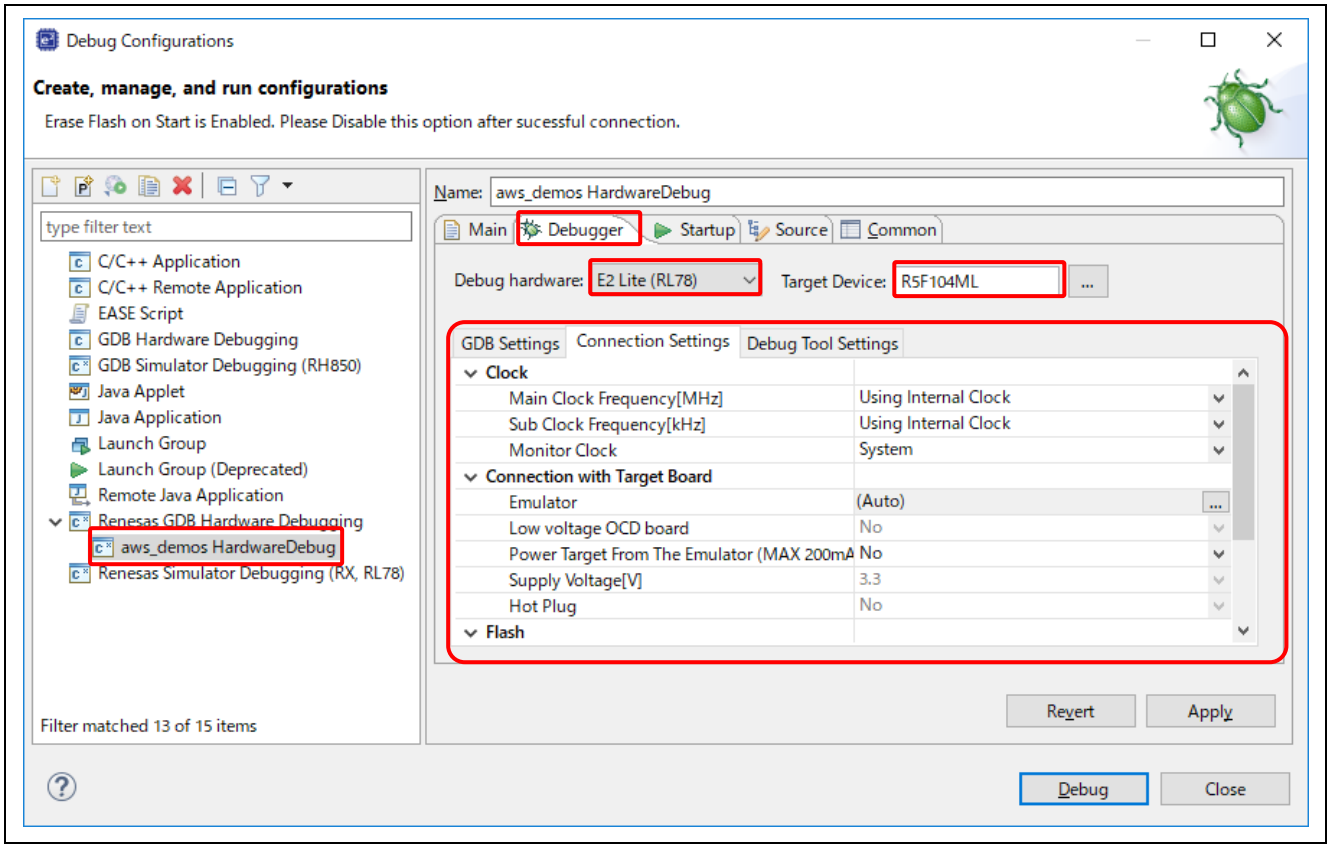

Figure 5.2 Hardware Debugging Settings

6. Elasticsearch Preparation

Elasticsearch can be used to visualize in AWS data obtained from a sensor module connected to the RL78/G14 Fast Prototyping Board.

Fees are incurred when using the Amazon Elasticsearch service. Make sure to delete your Elasticsearch domain after you finish using the demo program.

Follow the steps below to set up Elasticsearch. The latest setting items may differ from the images below. Items not shown should be set by default.

First, create a domain on the Amazon Elasticsearch Service. On the AWS Management Console, click **Elasticsearch Service** under **All services** -> **Analytics**.

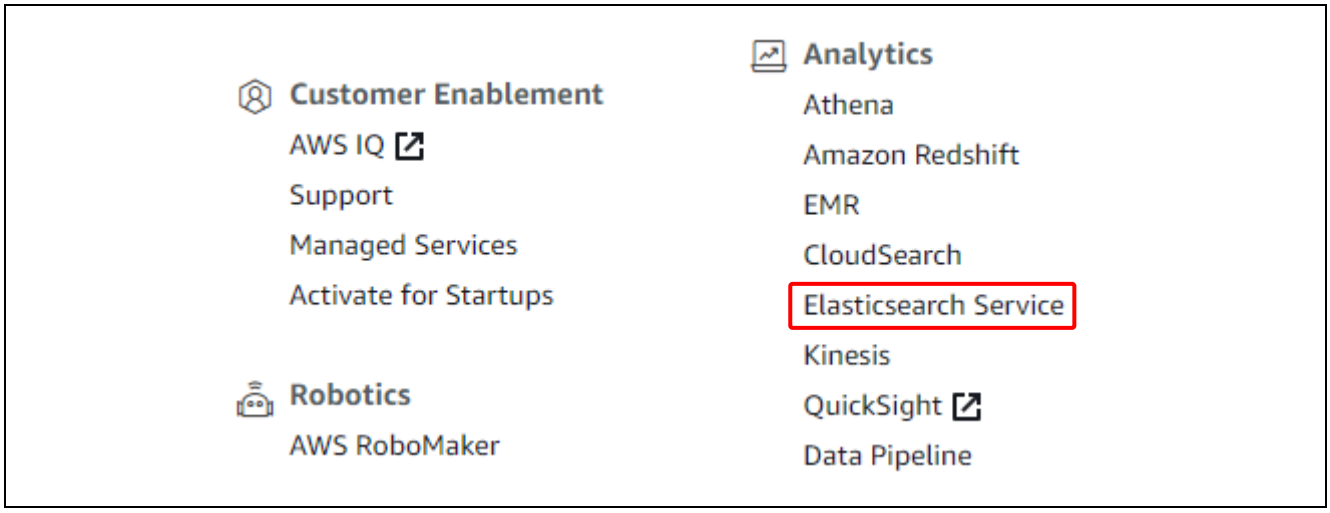

Figure 6.1 Selecting Elasticsearch Service

Click **Create a new domain**.

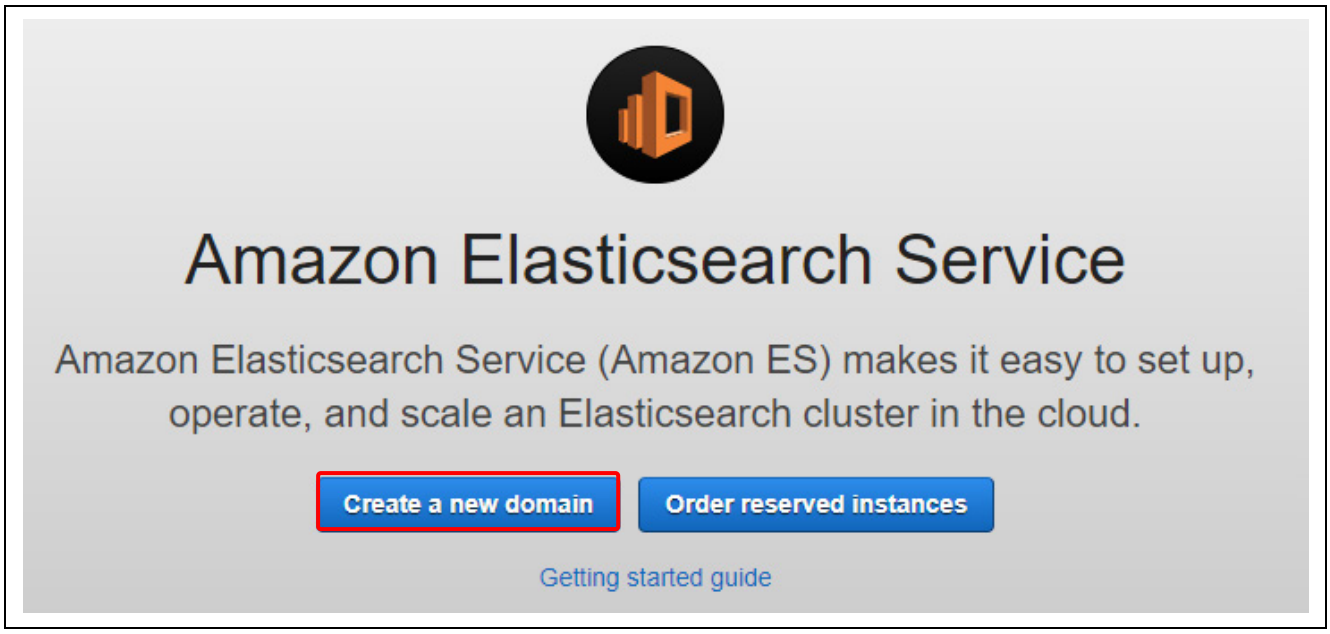

Figure 6.2 Create a new domain

Select the radio button next to **Development and testing** and set **Elasticsearch version** to **7.1**. Then click **Next**.

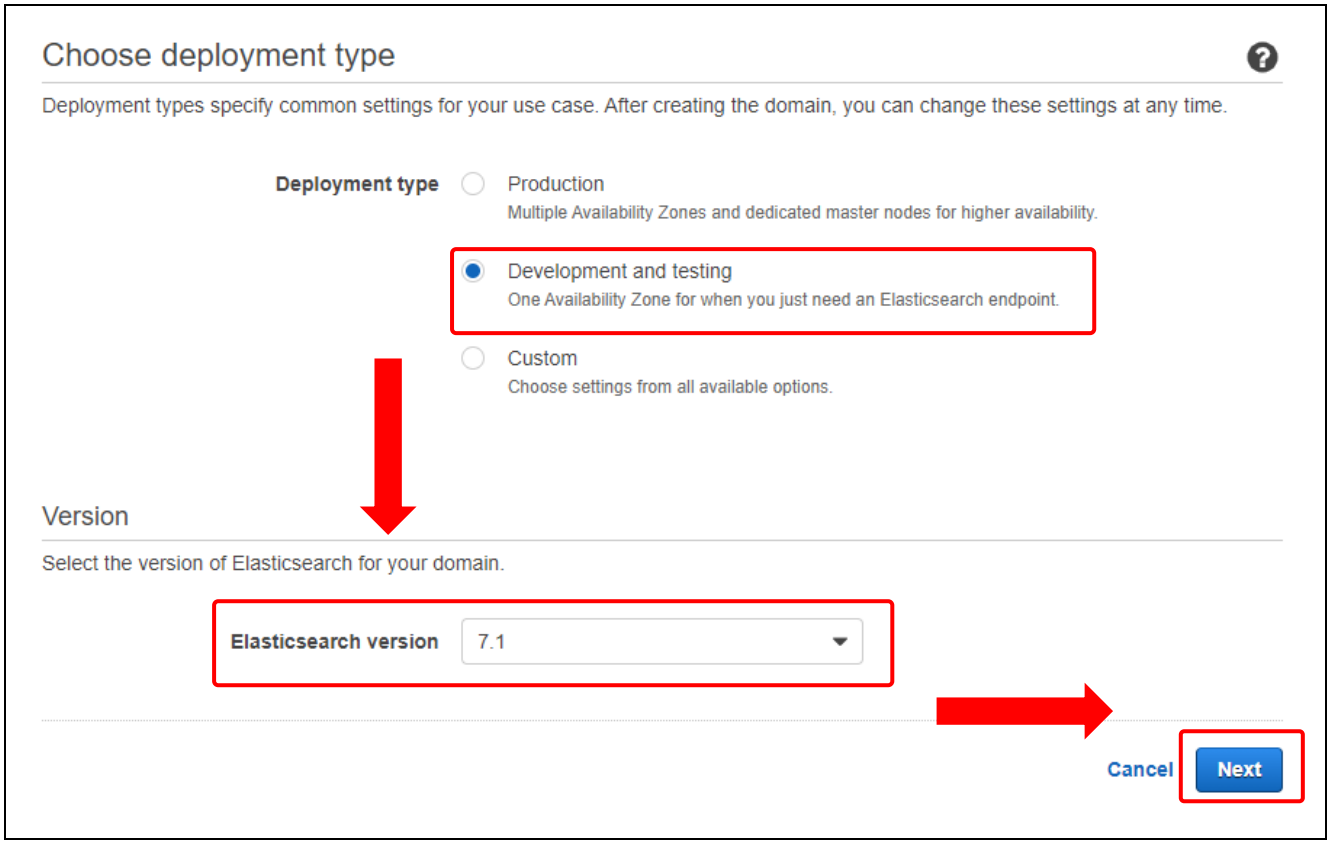

Figure 6.3 Choose deployment type

Enter an **Elasticsearch domain name** and change the **Instance type** selection to **t2.small.elasticsearch**, then scroll down.

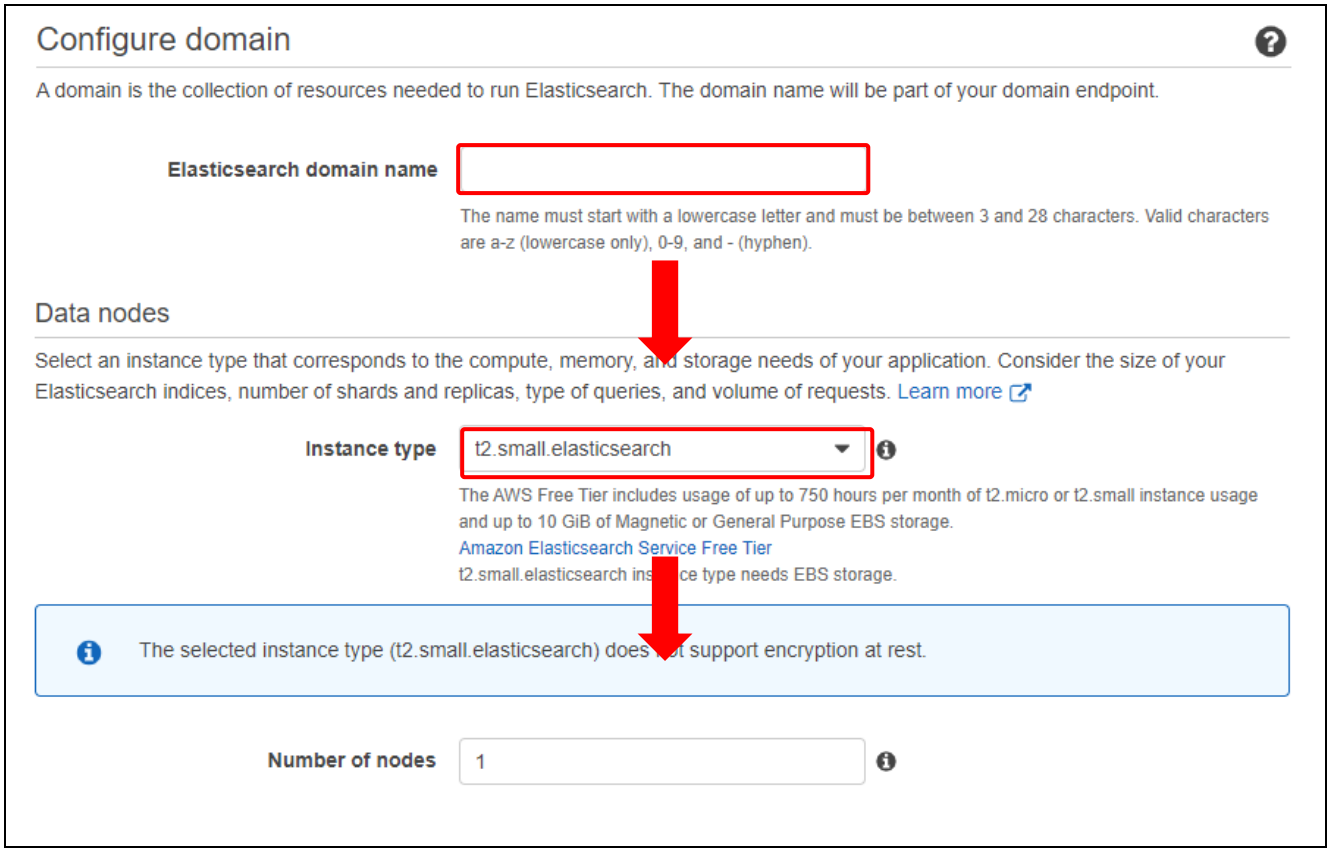

Figure 6.4 Configure domain

Click **Next**.

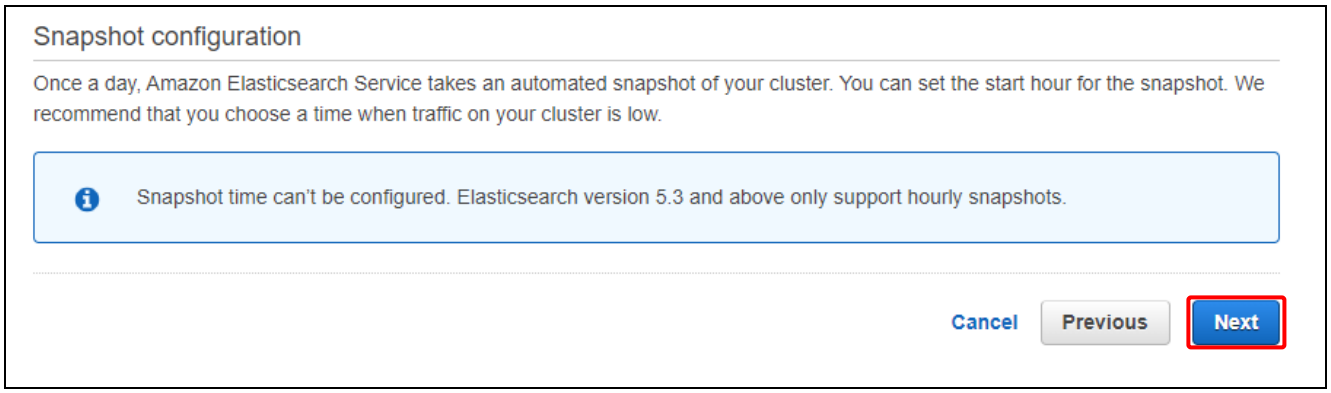

Figure 6.5 Configure domain, Next

Select **Public access**, then scroll down.

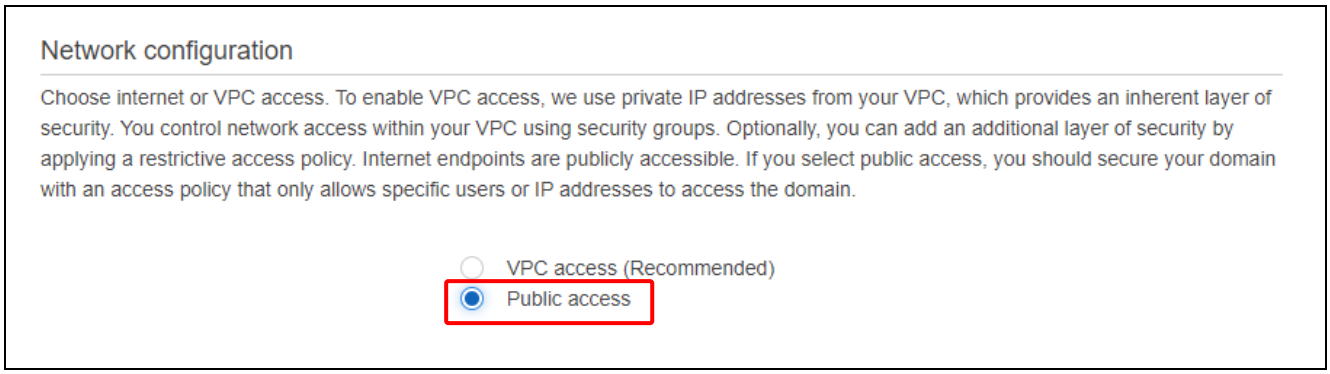

Figure 6.6 Network configuration

Set **Domain access policy** to **Custom access policy** and select **IPv4 address**. Enter the global IP address of RL78 Fast Prototyping Board and select **Allow**. To find out the global IP address of the RL78 Fast Prototyping Board, connect your PC to the same network as the RL78 Fast Prototyping Board, and search the Internet for "Global IP Address Confirmation Method" to confirm.

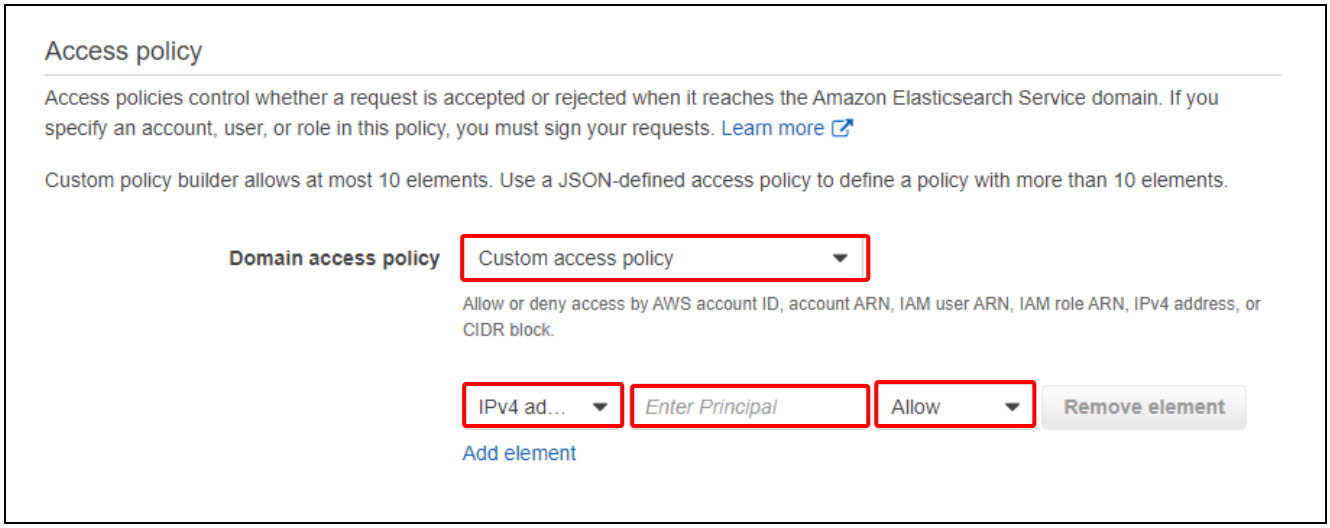

Figure 6.7 Access policy

Click **Next**.

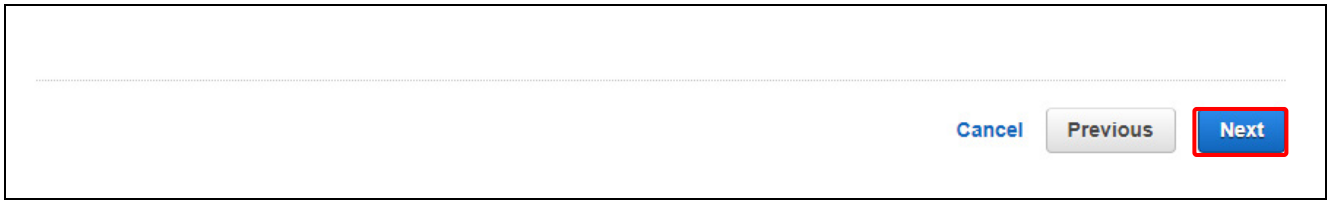

Figure 6.8 Access policy, Next

On the **Review** page, double-check your configuration and choose **Confirm**.

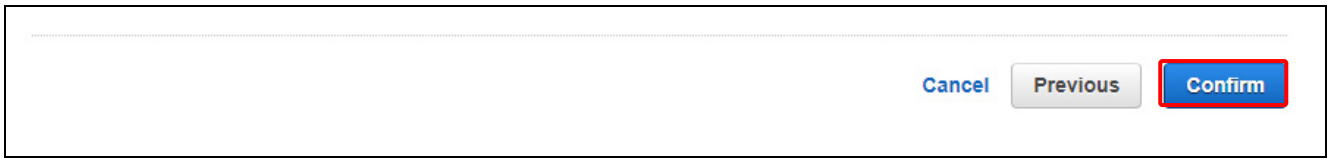

Figure 6.9 After Clicking Next, Confirm

Your Elasticsearch domain is created. Stand by until **Domain status** changes to **Active**.

Note: The screen says that it takes about 10 minutes to active the domain, but it may take longer.

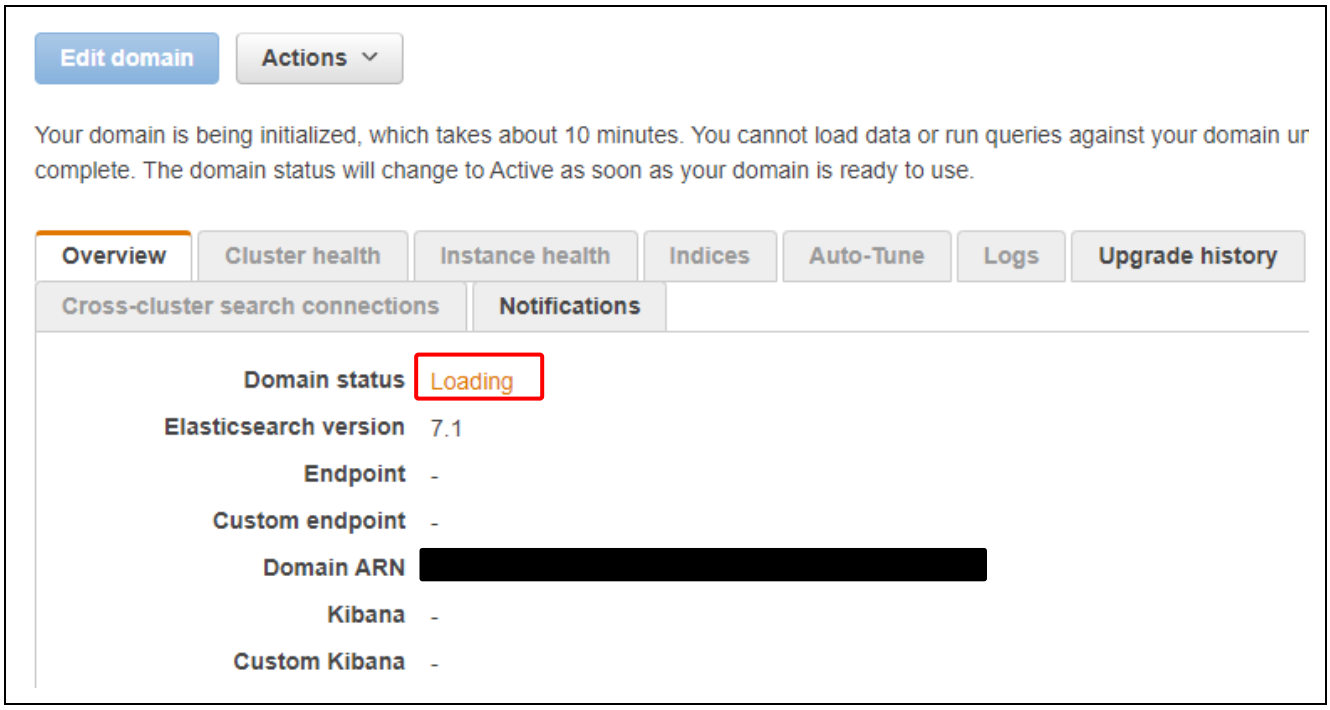

Figure 6.10 Stand by Until Domain status Changes to Active

Once **Domain status** changes to **Active**, access the **Kibana** URL.

Figure 6.11 Domain status: Active

7. Kibana Preparation

Click **Explore on my own**.

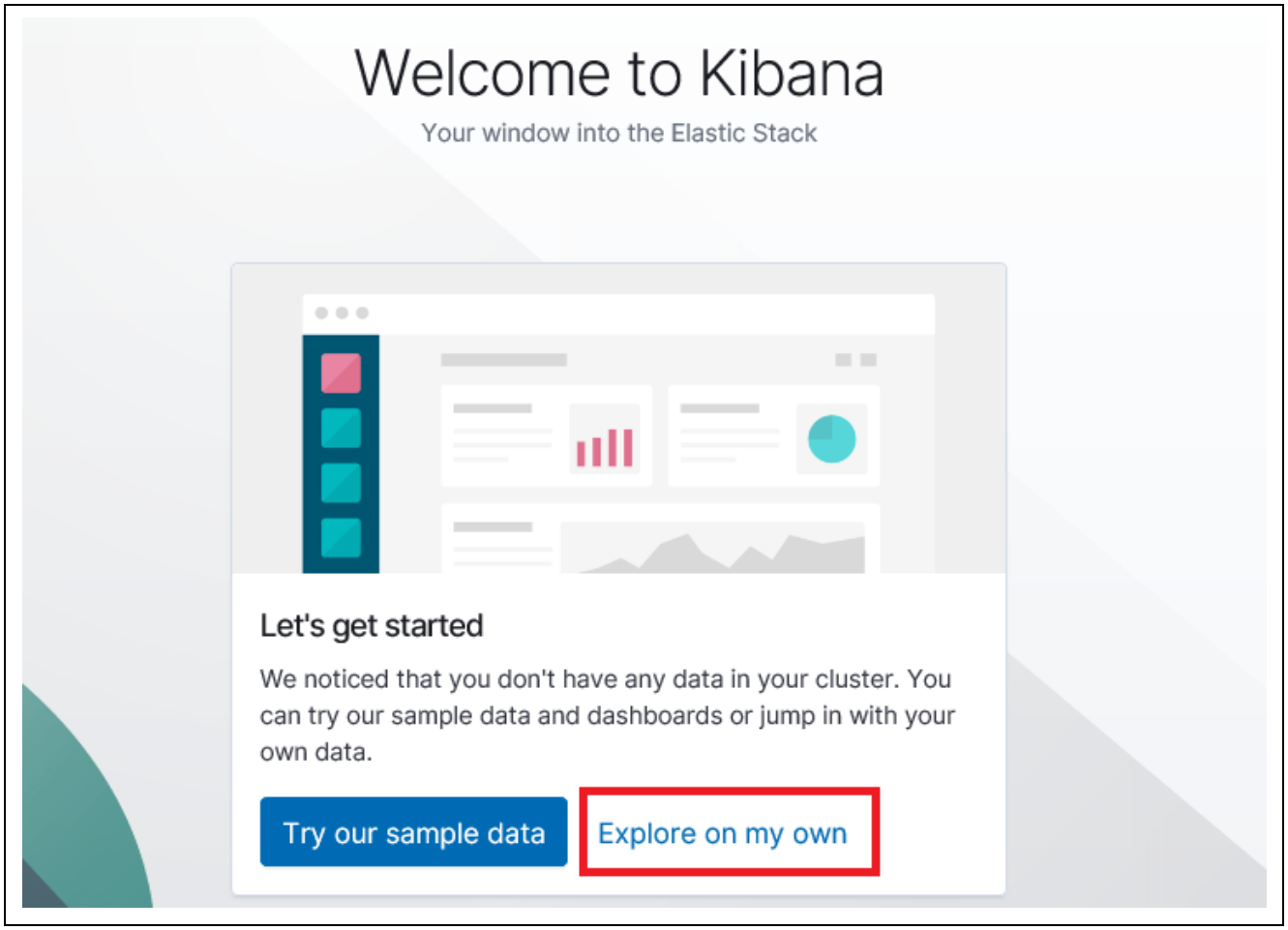

Figure 7.1 Explore on my own

On the menu bar on the left, click the **Dev Tools** icon.

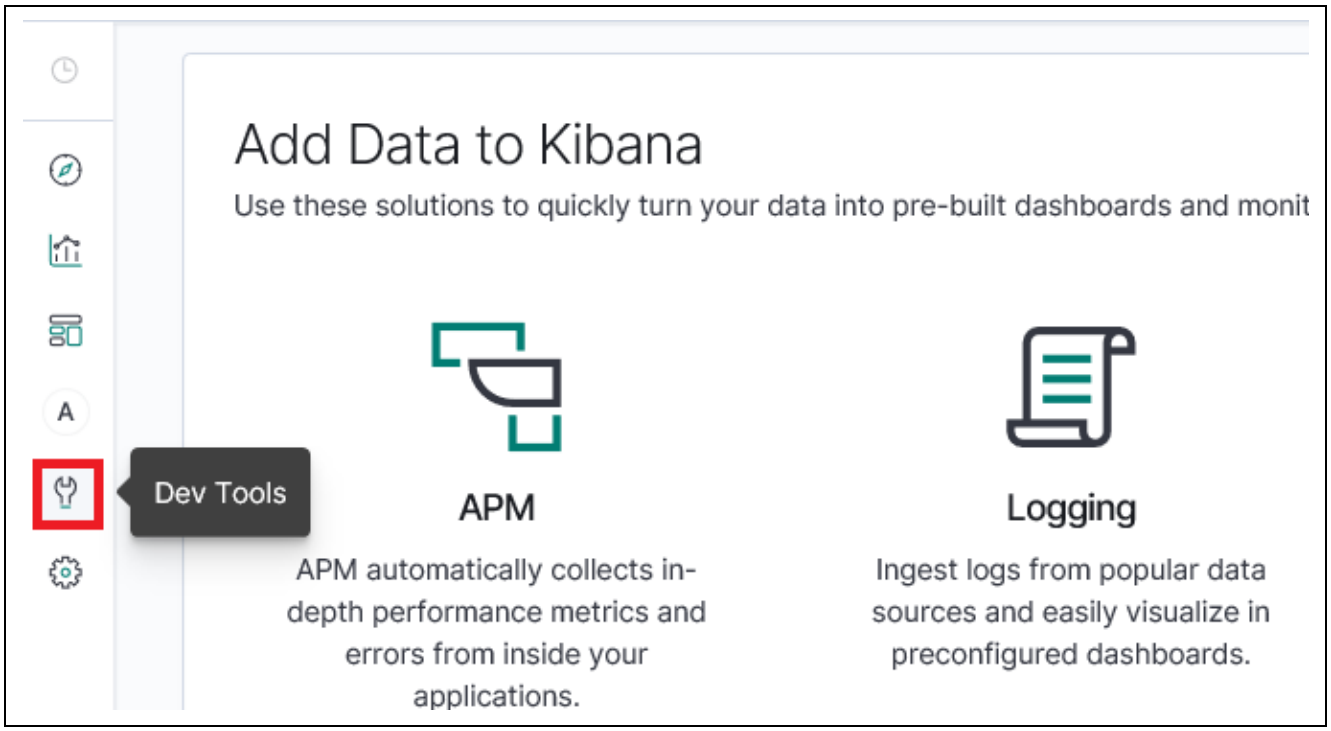

Figure 7.2 Dev Tools

Click **Get to work**.

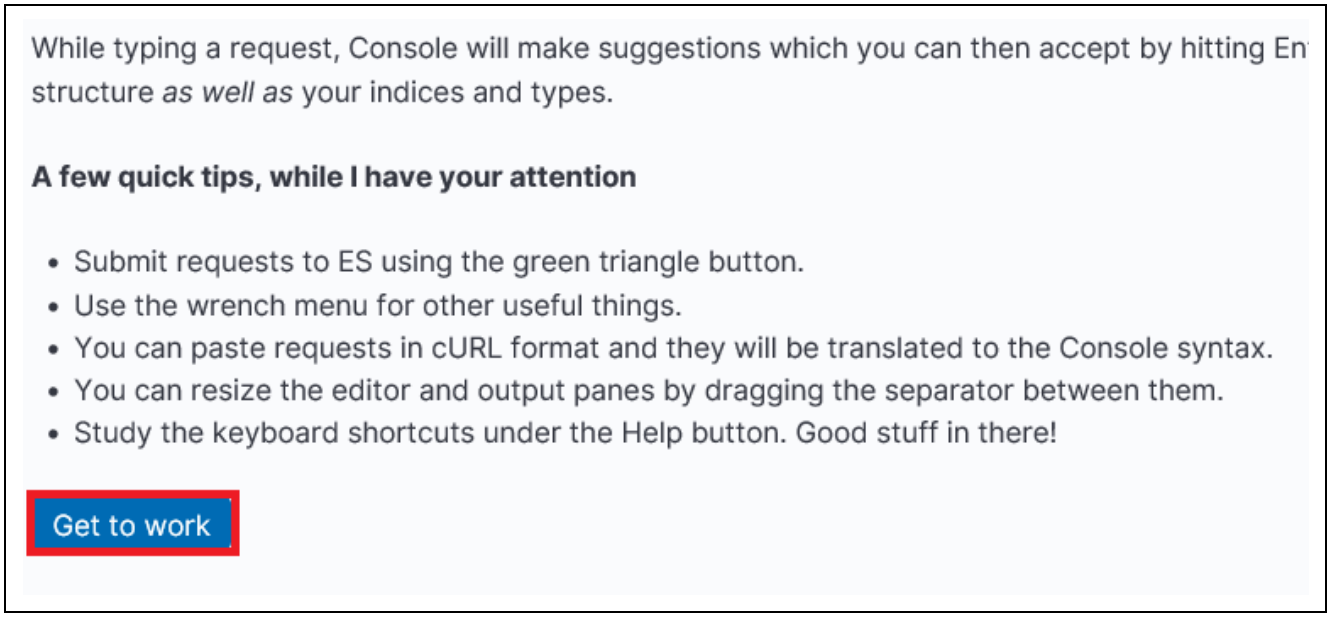

Figure 7.3 Get to work

In the console window on the left, enter the following code.

```
PUT /sensor?include_type_name=true
{
  "mappings": {
    "sensor": {
      "properties": {
        "timestamp": {
          "type": "long",
          "copy_to": "datetime"
        },
        "datetime": {
          "type": "date",
          "store": true
        },
        "temperature": {
          "type": "long"
        },
        "humidity": {
          "type": "long"
        }
      }
    }
  }
}
```

Figure 7.4 Code Entered in Console Window

Click the **click to send request** icon in the upper right corner of the console.

Figure 7.5 click to send request

Confirm that the following response is returned.

```
{
  "acknowledged" : true,
  "shards_acknowledged" : true,
  "index" : "sensor"
}
```

Figure 7.6 Confirming Response

8. IoT Rule Preparation

Create a rule by AWS IoT.

Go to the IoT Core control panel, select **Act** -> **Rules**, and click **Create a rule**.

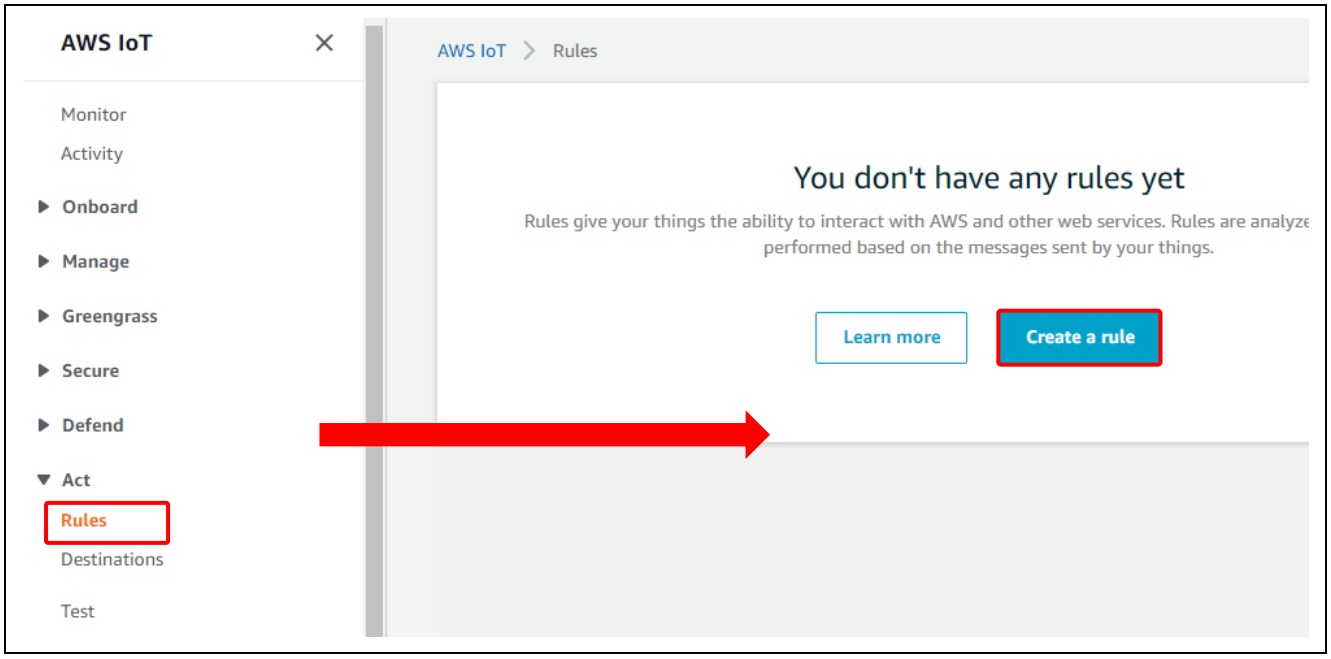

Figure 8.1 Create a rule

Enter a name for the rule, then enter the following code under **Rule query statement**.

SELECT *, timestamp() as timestamp FROM 'iotdemo/topic/sensor'

Note: After entering the rule query statement make sure to enter a line break.

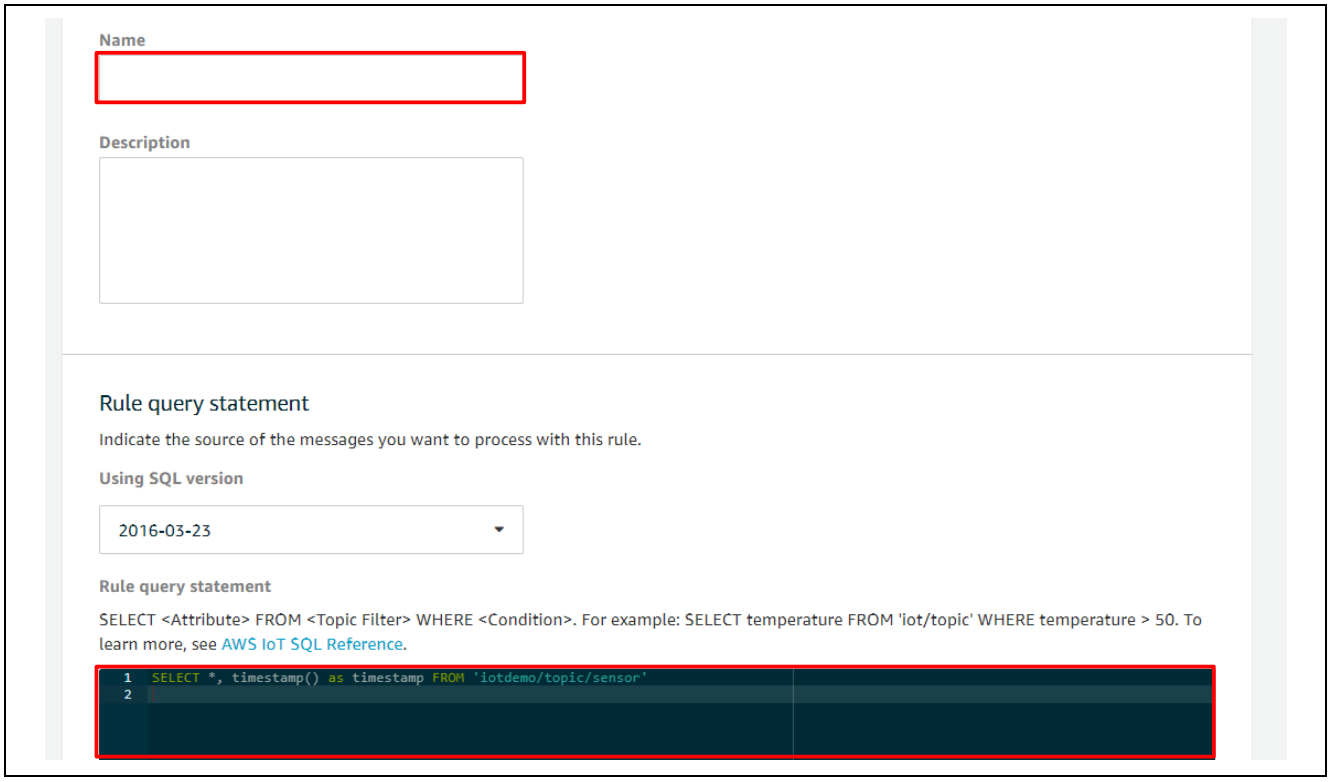

Figure 8.2 Entering Code

Click **Add action**.

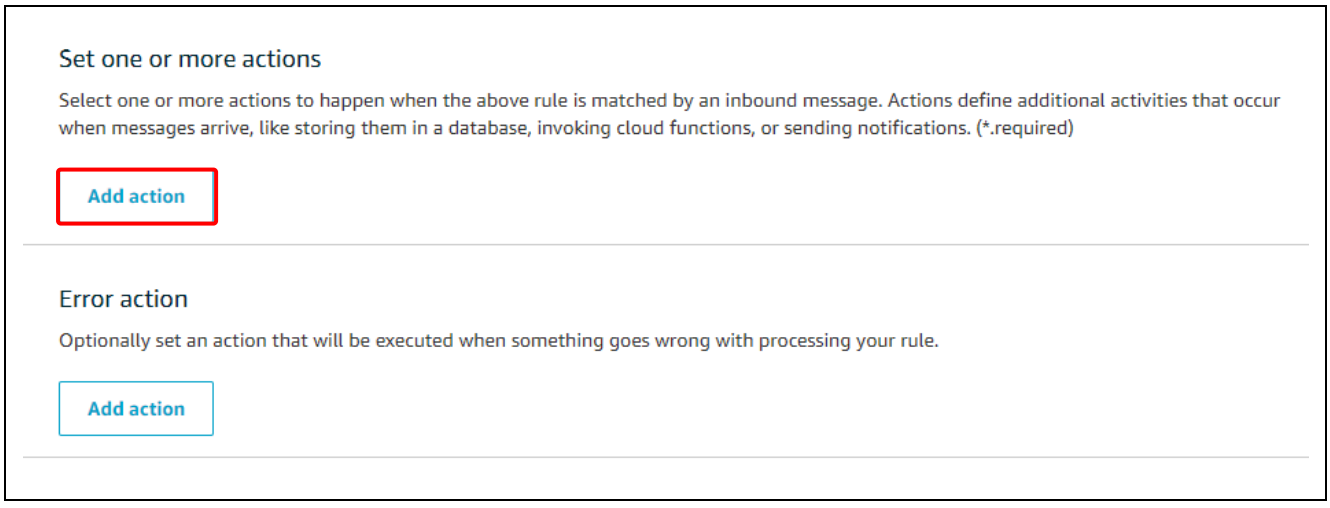

Figure 8.3 Add action

Select **Send messages to the Amazon Elasticsearch Service** and click **Configure action**.

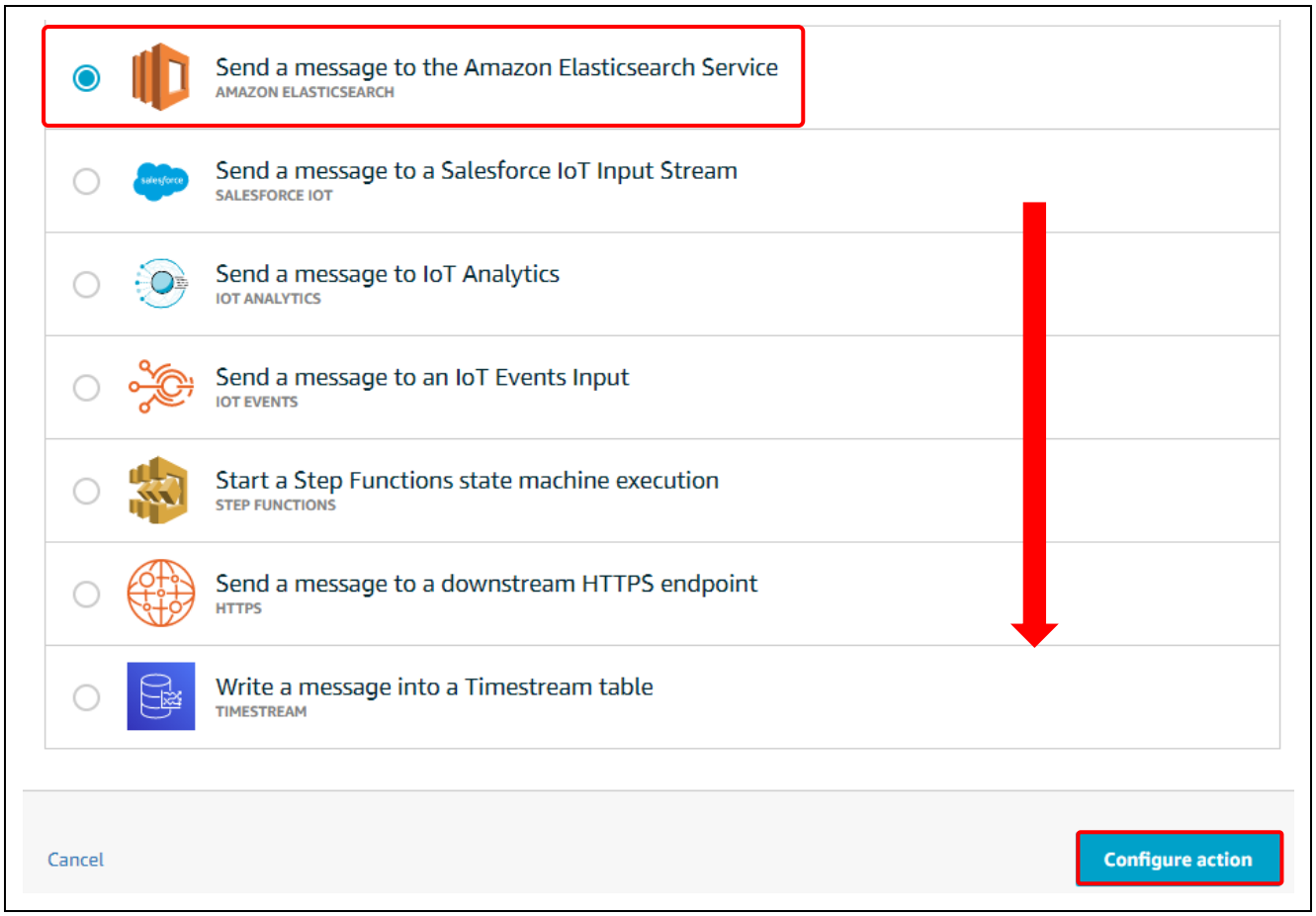

Figure 8.4 Configure action

For **Domain name** enter the domain name created on the Amazon Elasticsearch Service, for **ID** enter **${newuuid()}**, for **Index** enter **sensor**, and for **Type** enter **sensor**.

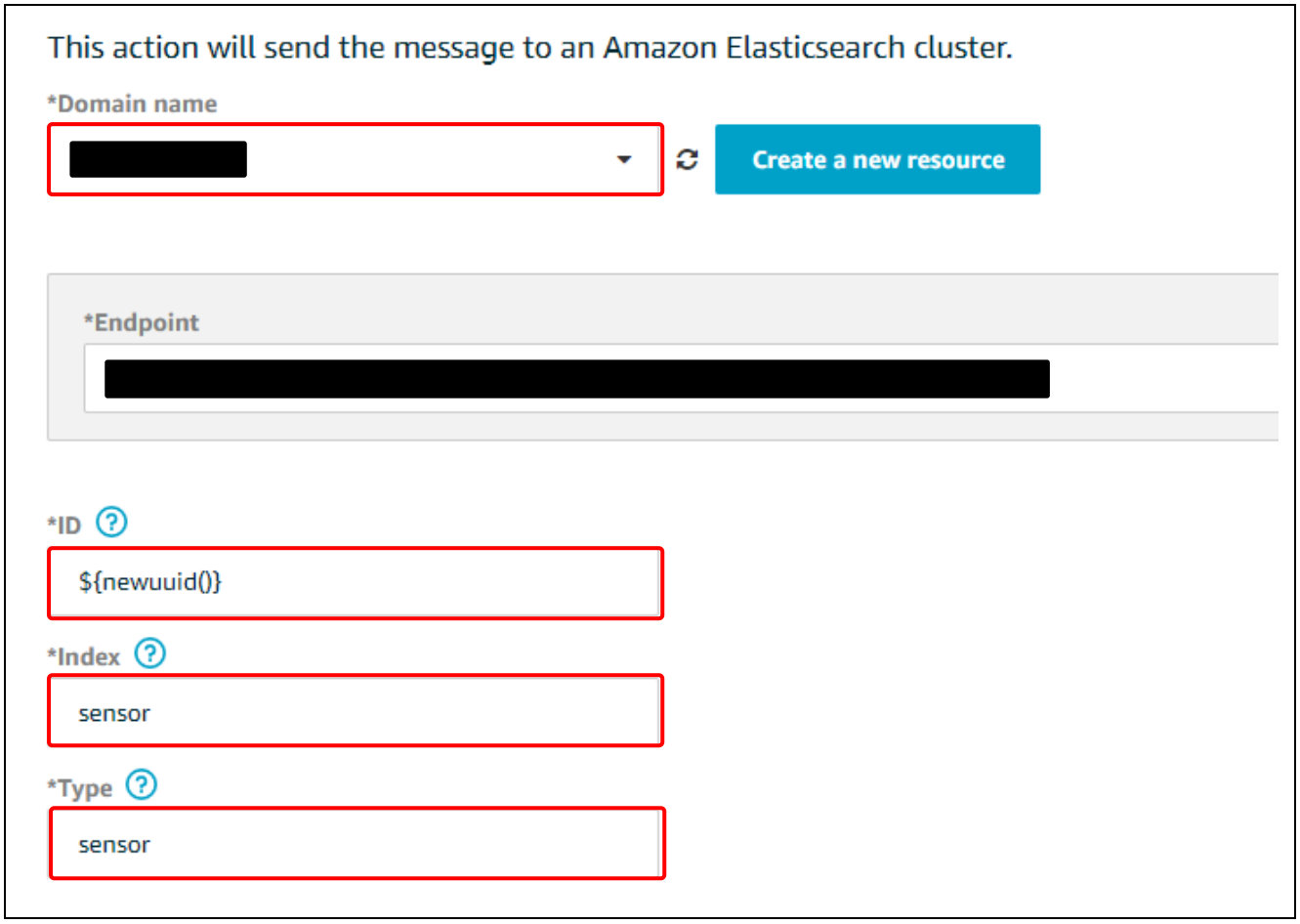

Figure 8.5 Domain name, ID, Index, and Type Settings

Click **Create a new role**, then enter the name of the role and click **Create role**.

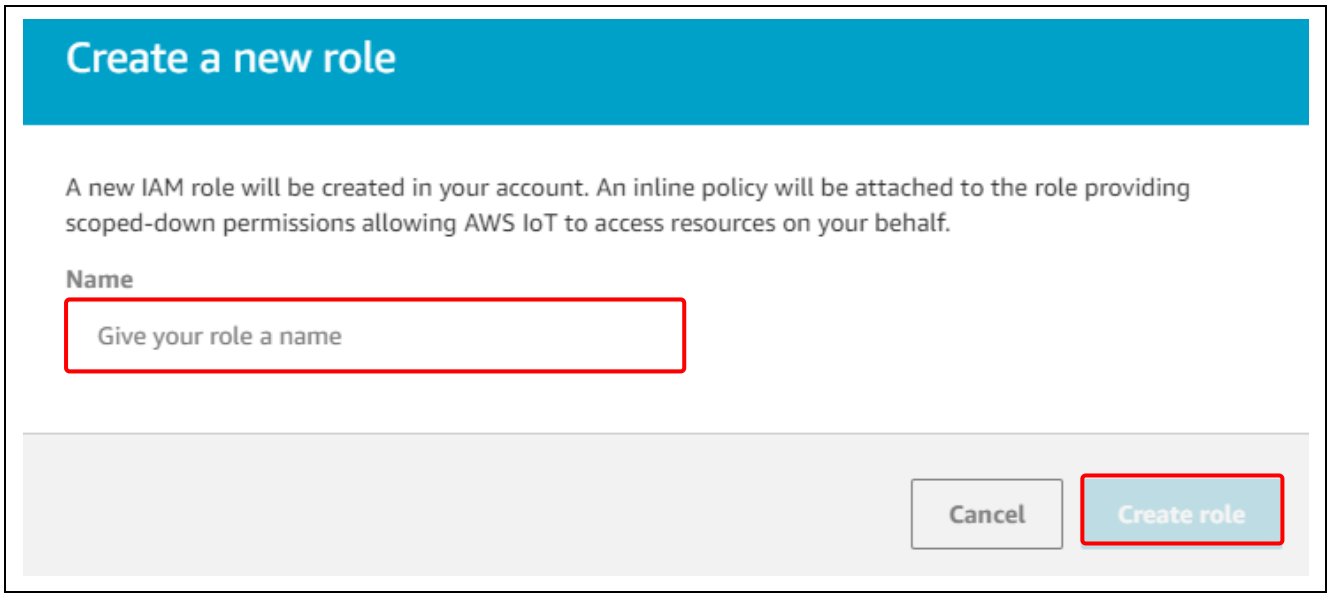

Figure 8.6 Create role

Confirm that the role you created is selected, then click **Add action**.

Figure 8.7 Add action

Confirm that the action was added, then click **Create rule**.

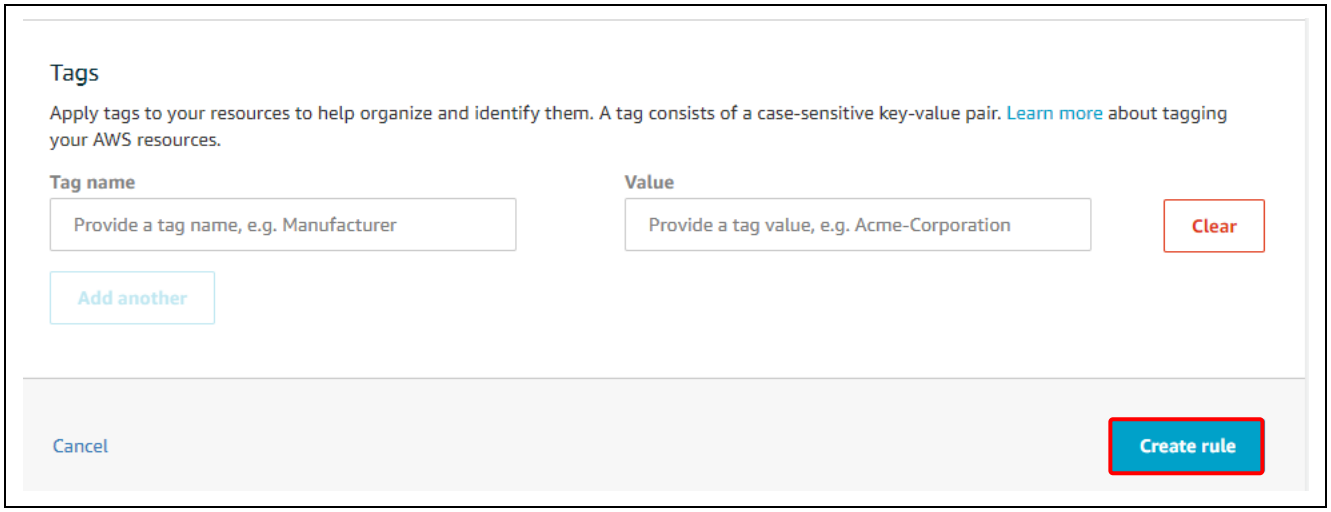

Figure 8.8 Create rule

9. Running the Demo Program

Now you can run the demo program in the project prepared as described in 5, Demo Project Preparation.

Click the **Debug** button to connect to the RL78/G14 Fast Prototyping Board.

Figure 9.1 Debug

When you click the **Start** button, execution pauses at the main function. Click the **Start** button again to run the demo program.

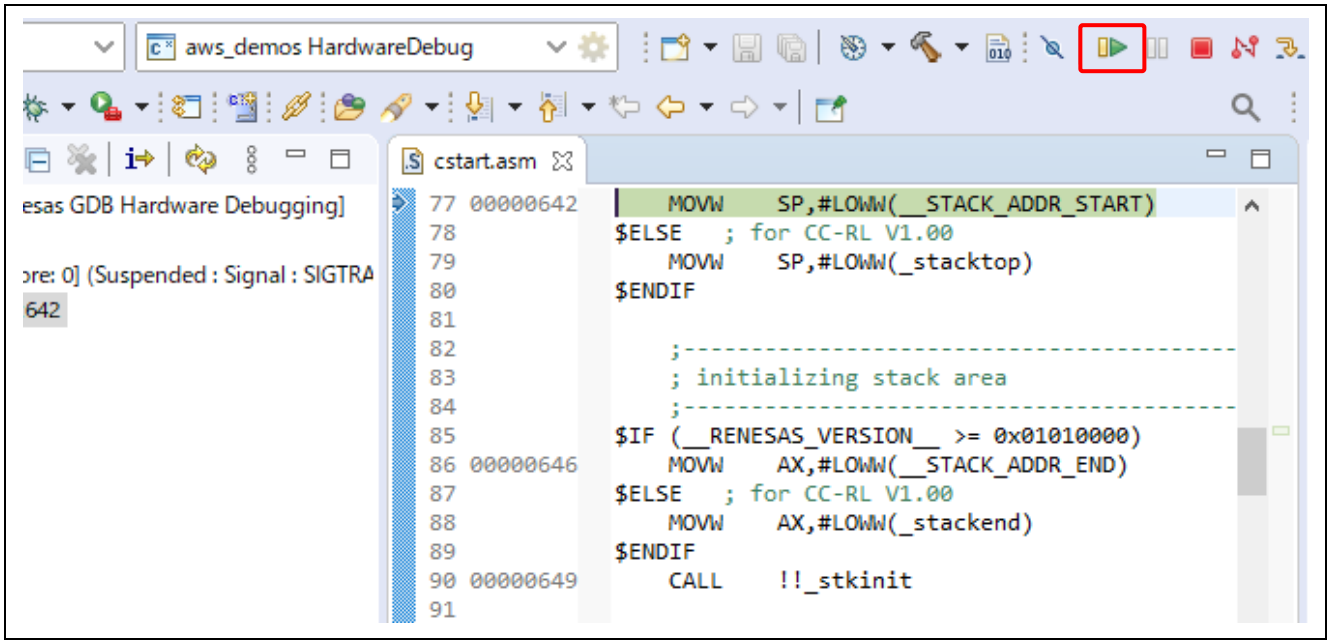

Figure 9.2 Running the Demo Program

10. Visualizing Sensor Information with Kibana

Go to Kibana, and click the **Management** icon in the menu at left.

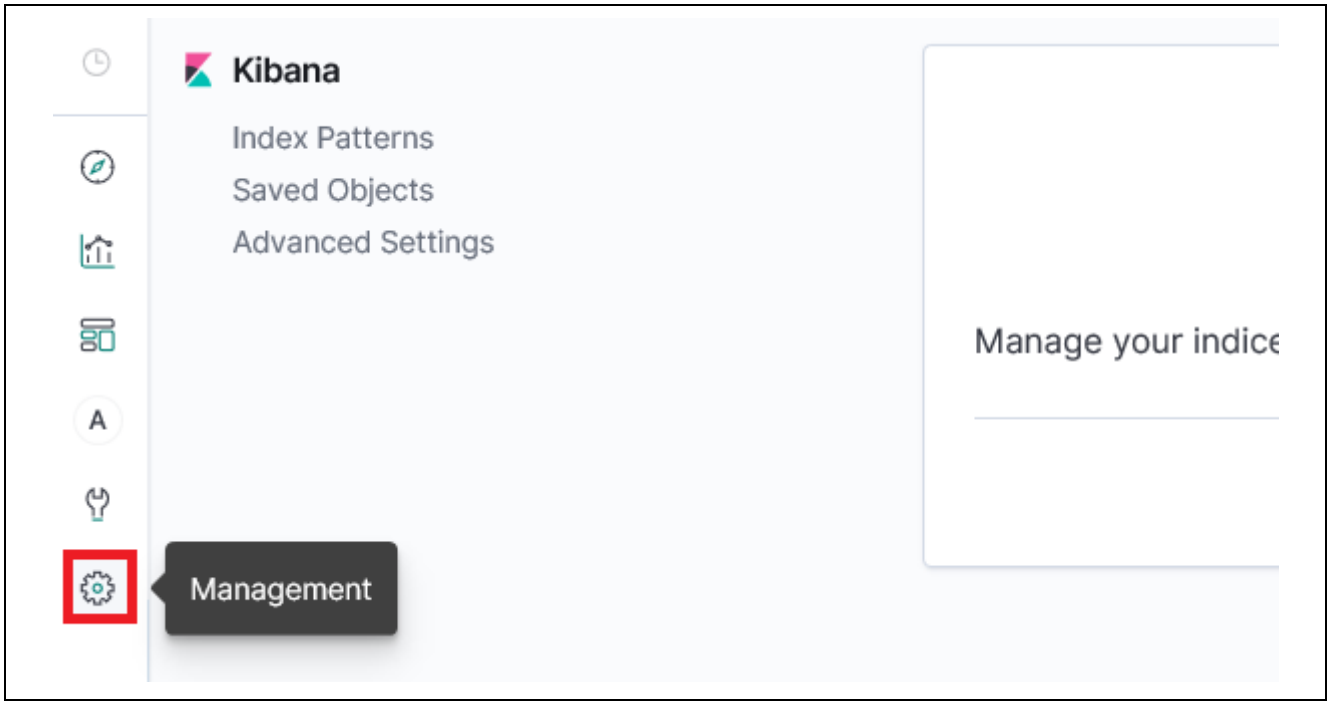

Figure 10.1 Kibana Setup

Click **Index Patterns** and for **Index pattern** enter **sensor**, then click **> Next step**.

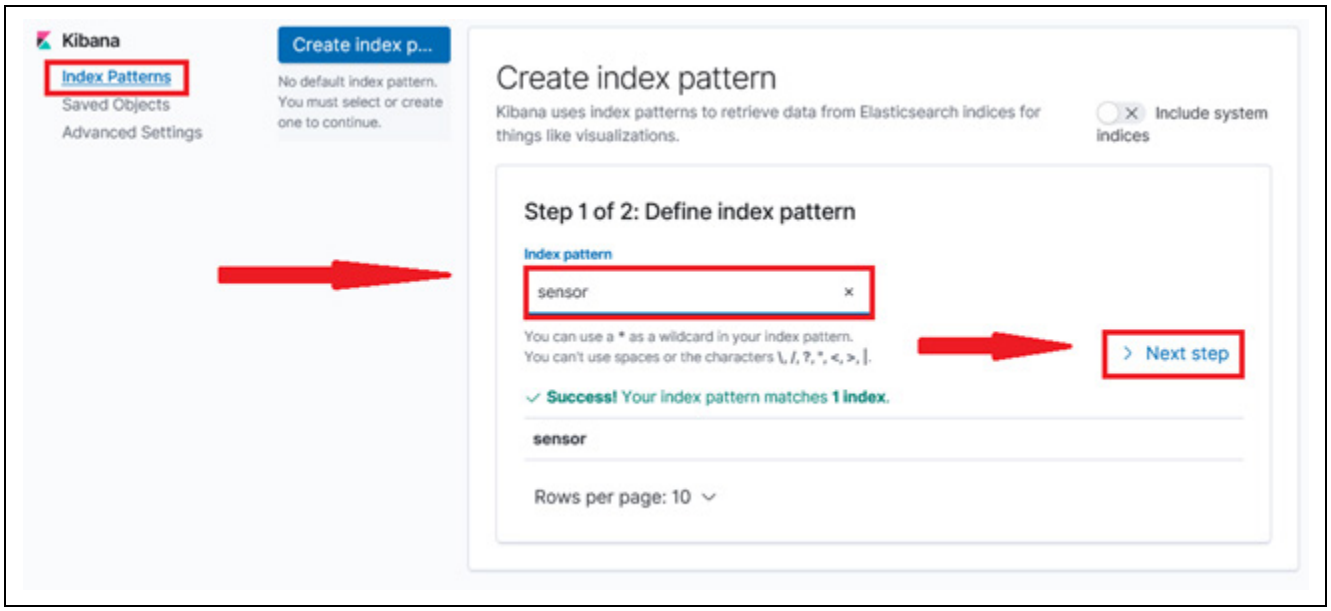

Figure 10.2 Define index pattern

For **Time Filter field name** select **datetime**, then click **Create index pattern**.

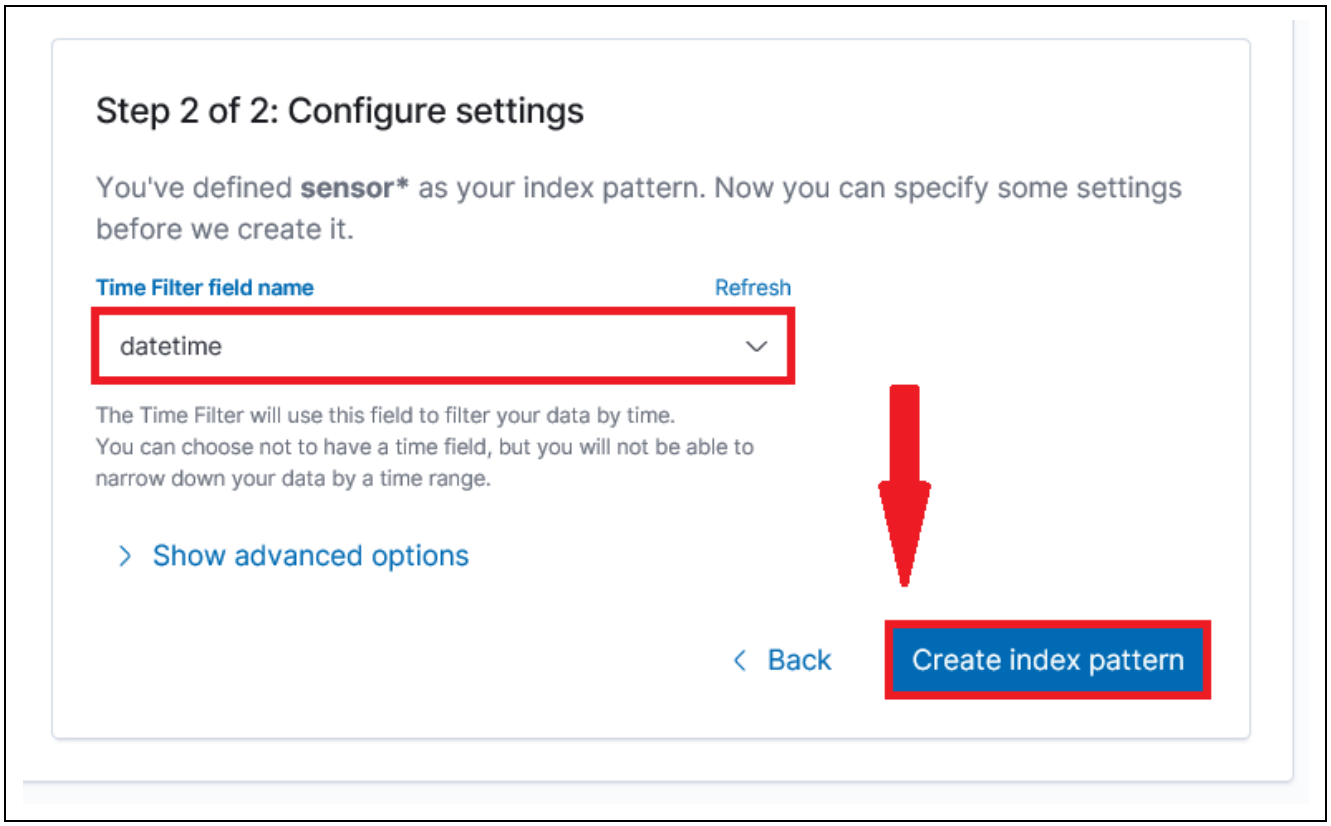

Figure 10.3 Configure settings

Click the **Visualize** icon in the menu at left.

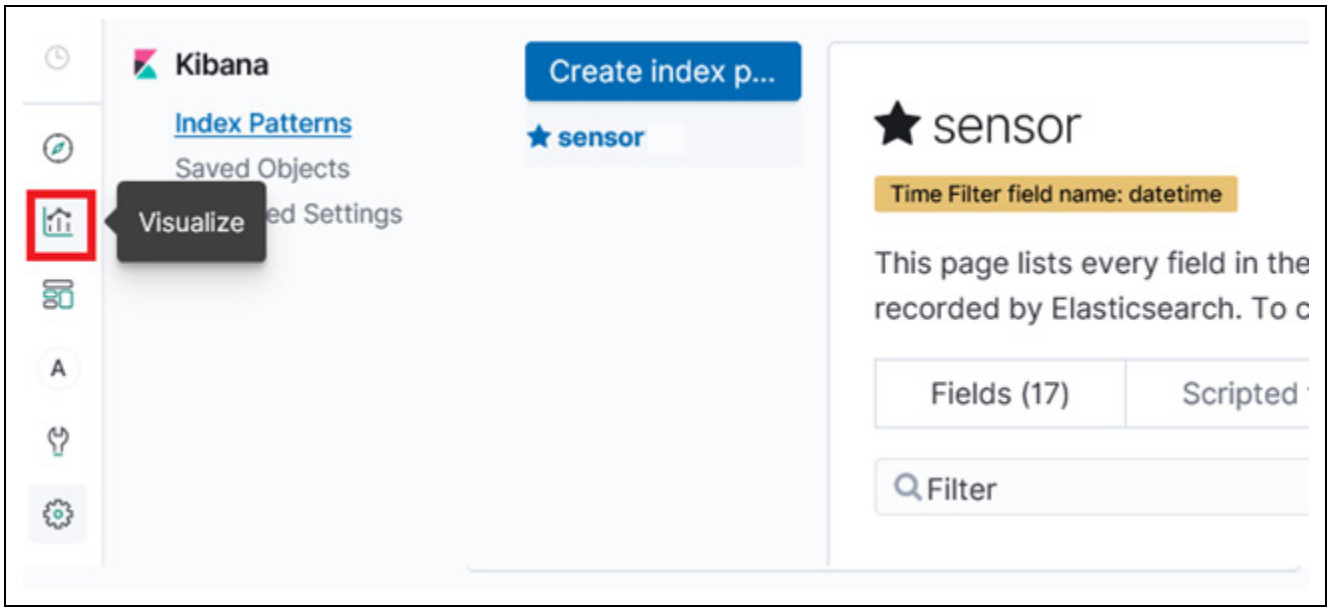

Figure 10.4 Visualize

Click **Create a visualization**.

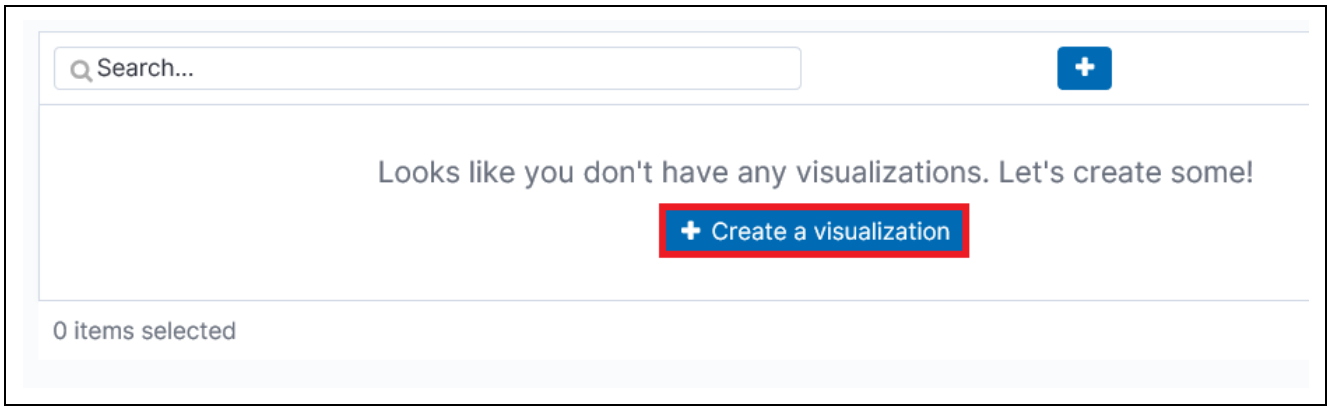

Figure 10.5 Create a visualization

Click the **Line** icon.

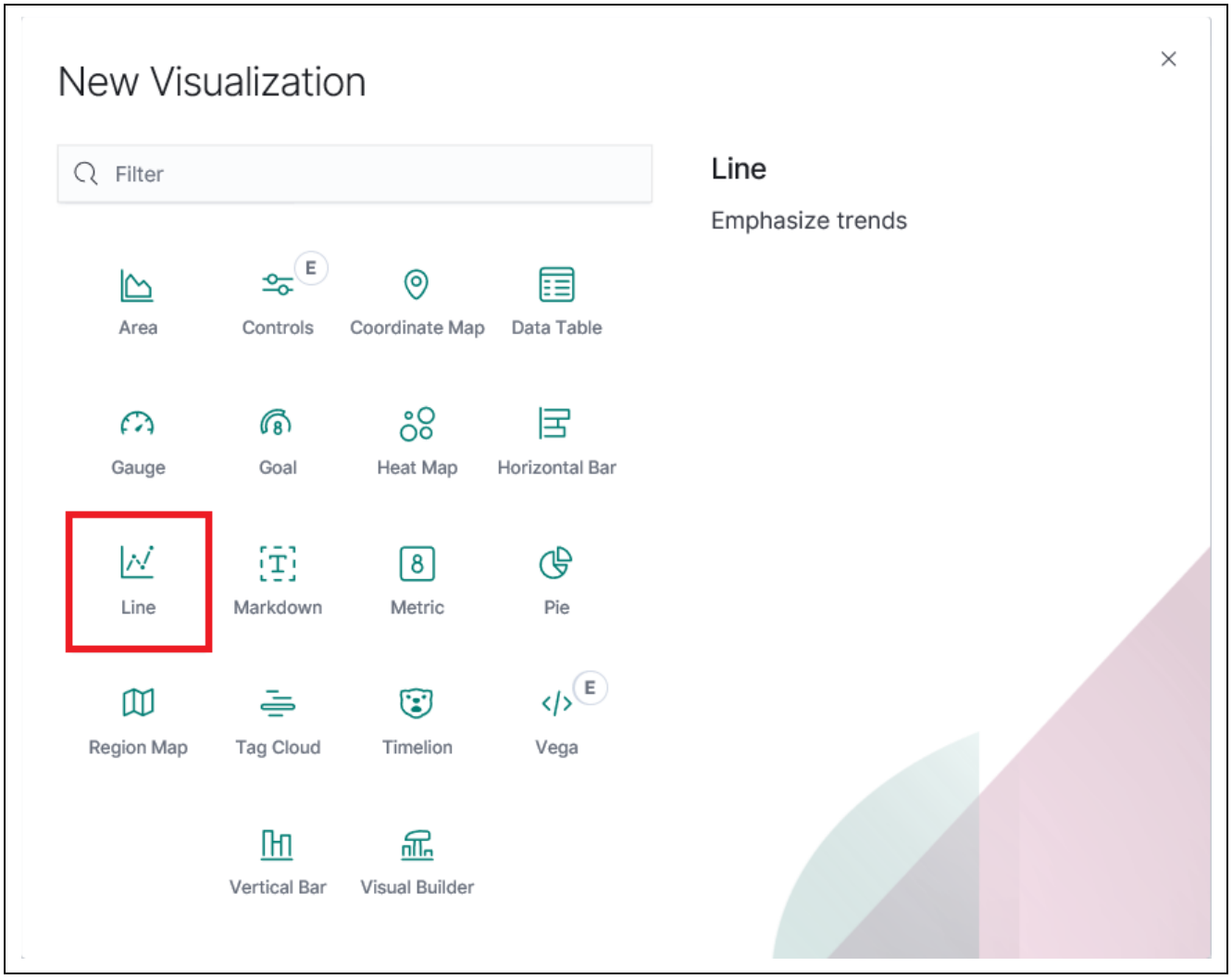

Figure 10.6 Line

Click **sensor**.

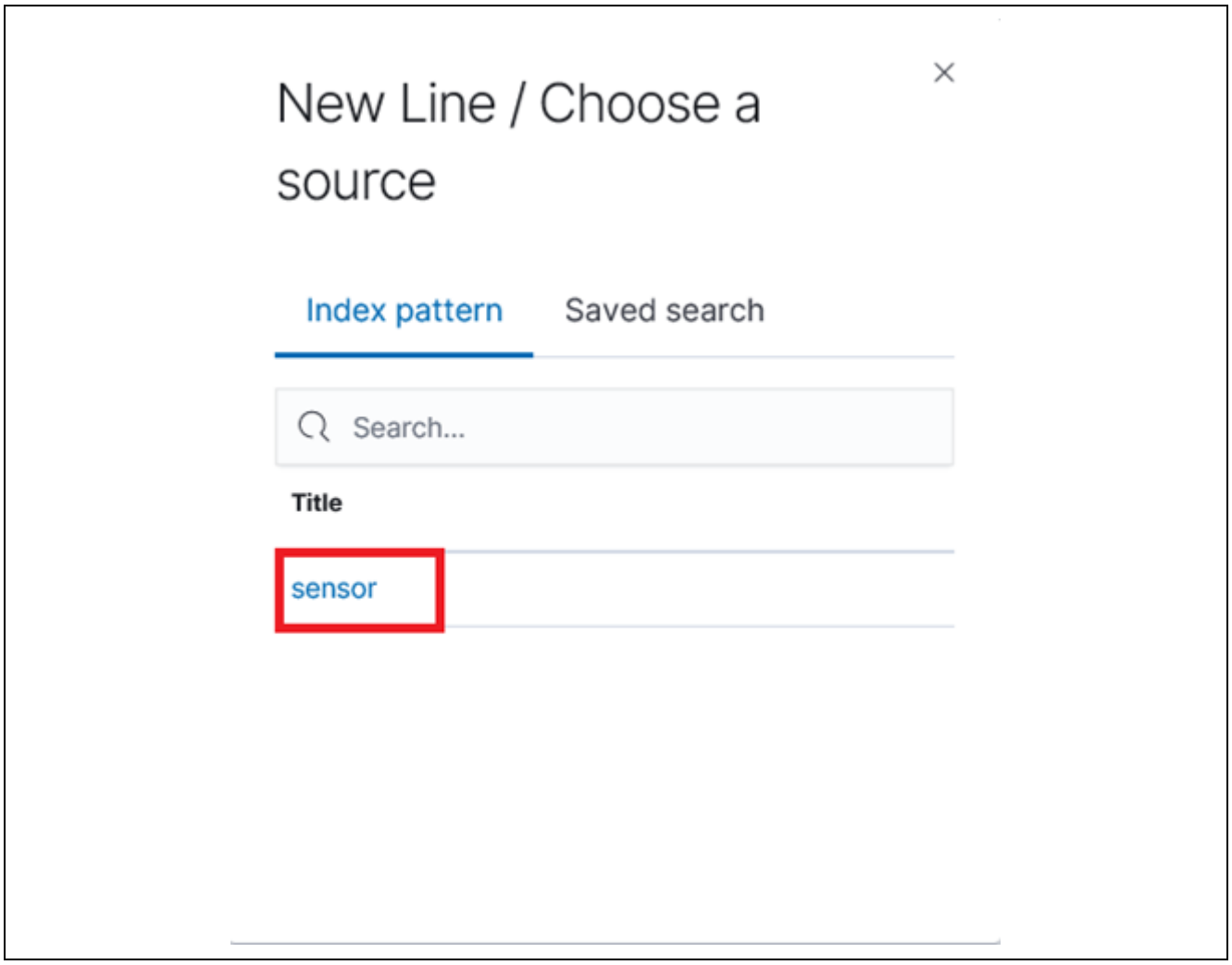

Figure 10.7 New Line / Choose a source

Click the calendar icon at the upper right, set **Refresh every** to **5 seconds**, and click **Start**.

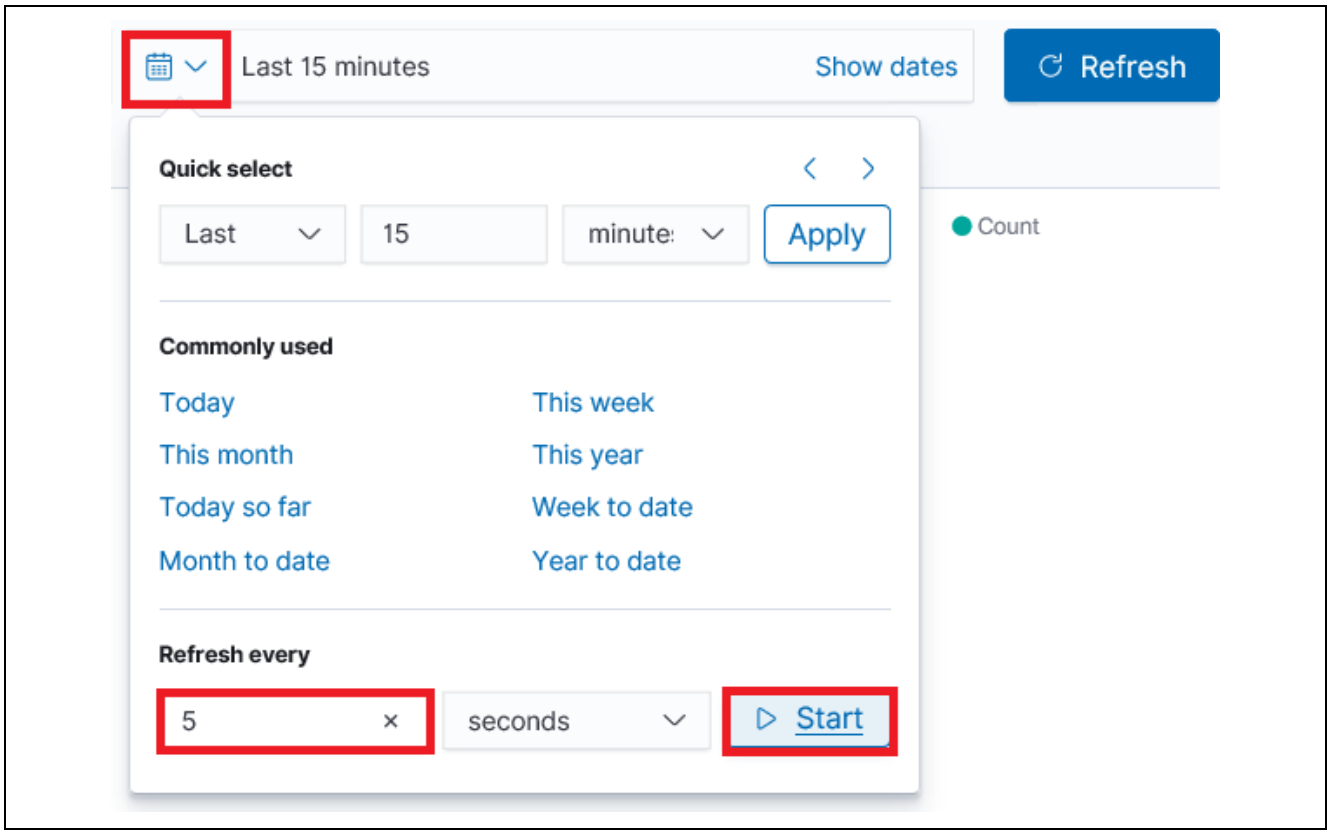

Figure 10.8 Refresh every Setting

For **Metrics**, under **Y-Axis** set **Aggregation** to **Average** and **Field** to **temperature** or **humidity**.

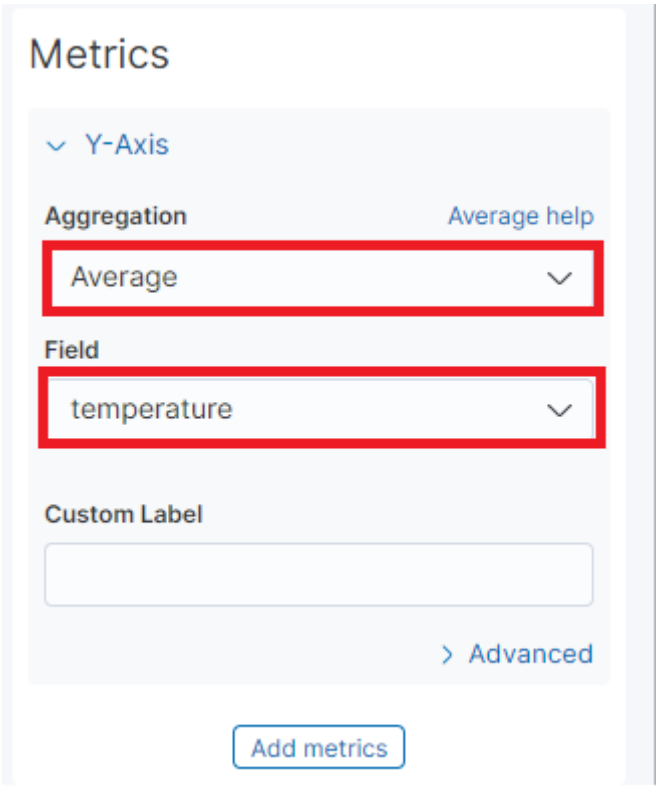

Figure 10.9 Metrics Settings

For **Buckets**, under **X-Axis** set **Aggregation** to **Date Histogram**, **Field** to **datetime**, and **Interval** to **Second**.

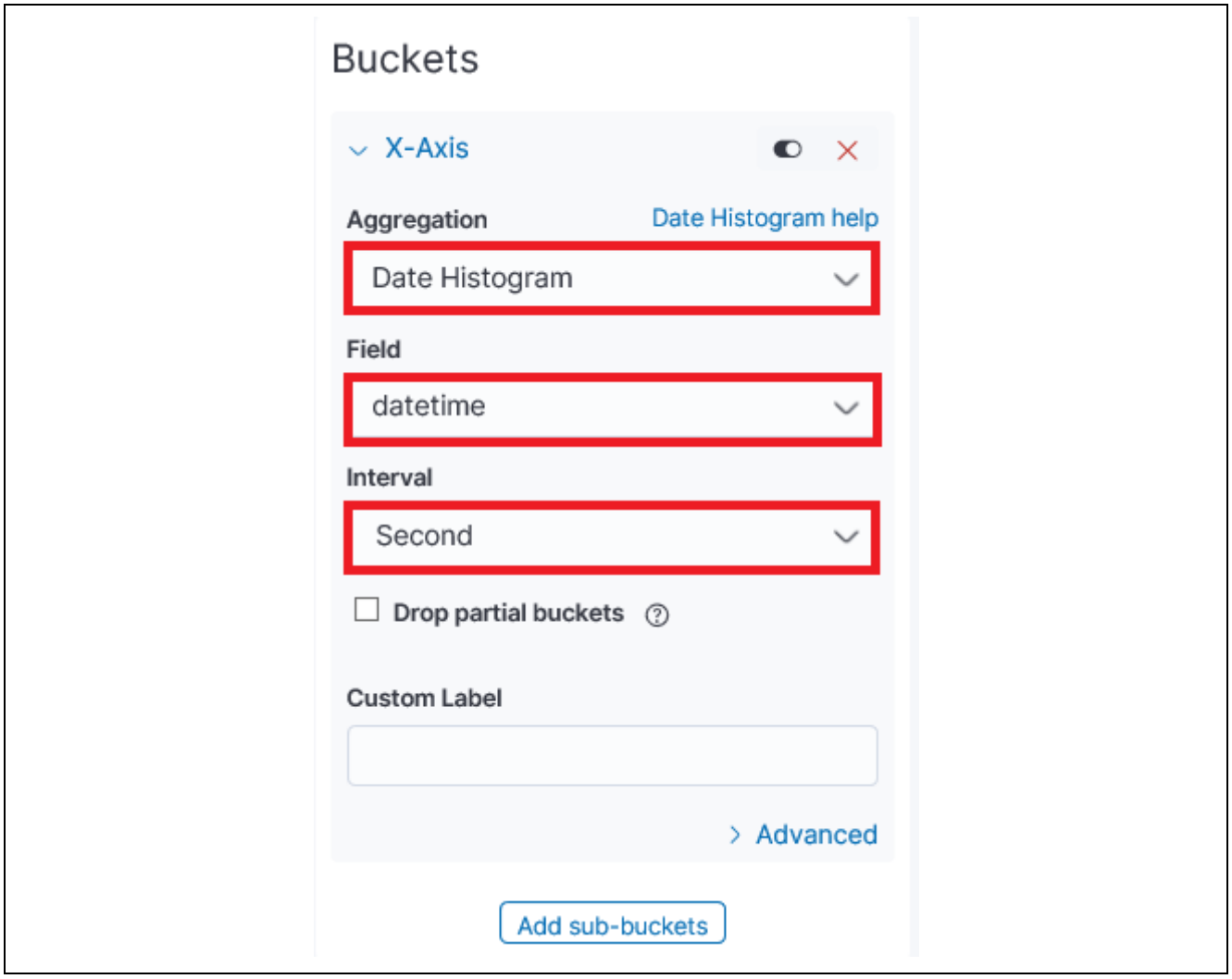

Figure 10.10 X-Axis Settings

Click the **Apply changes** icon.

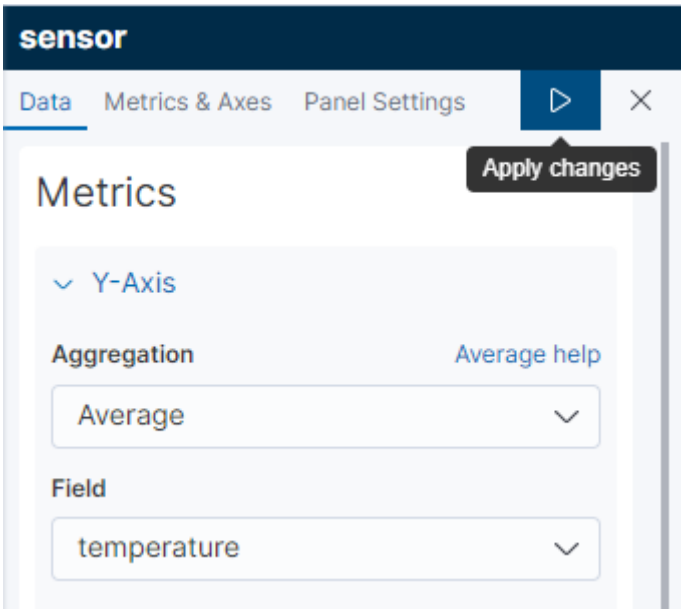

Figure 10.11 Apply changes

Confirm that a graph showing sensor data is displayed. Confirm that the values change when you switch between temperature and humidity. A visualization of temperature sensor information is shown below.

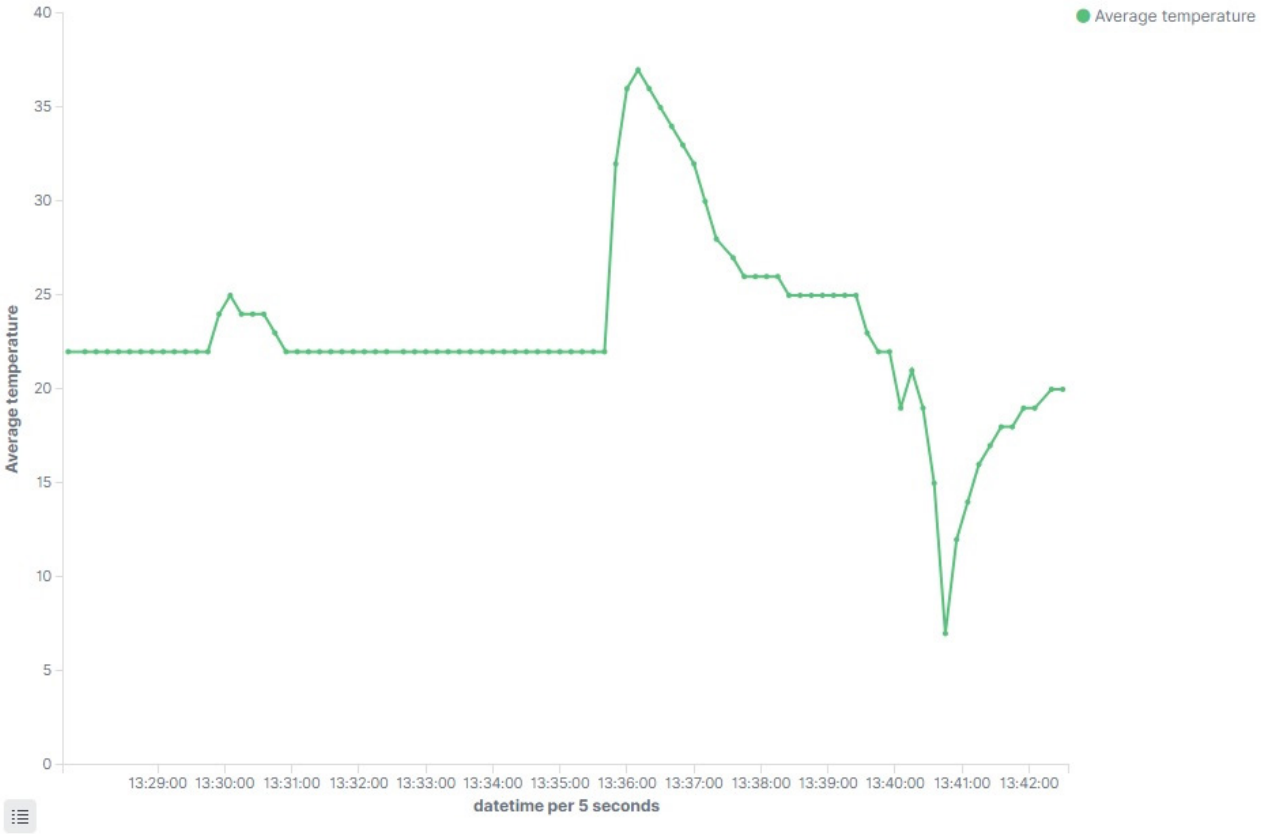

Figure 10.12 Visualization of Temperature Sensor Information

11. Important Note after Running Demo Program

Fees are incurred when are using the Amazon Elasticsearch Service.

Make sure to delete your Elasticsearch domain after you finish using the demo program.

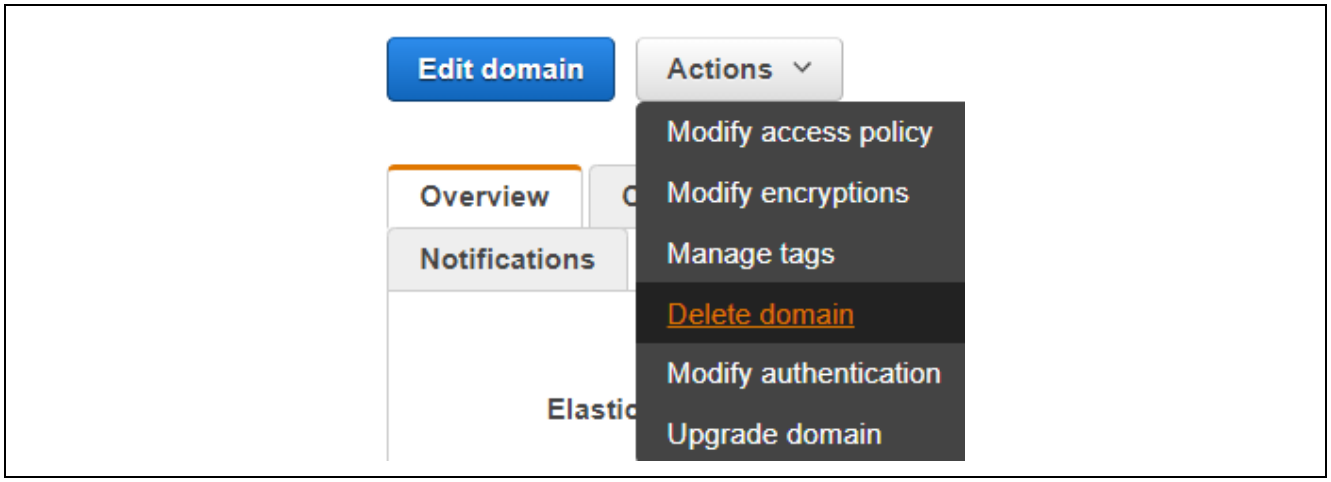

Figure 11.1 Don't Forget to Delete Your Elasticsearch Domain!

12. Websites 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	Feb.12.2021	—	First edition issued
1.01	Apr.12.2021	12	Corrected the description of exporting file names
		13	Fixed conversion method to binary format
		14	Fixed board wiring color
		15	Fixed how to register a certificate using a terminal emulator (Tera Term)
		16	Added a deletion method when a certificate is registered by mistake
		24	Corrected the description of global IP address
1.02	Jul.30.2021	1	Fixed humidity and temperature sensor to US082-HS3001EVZ.
		1	Updated operating environment.
		4	Changed the board photo in Figure 1-1 to use US082-HS3001EVZ.
		5	Updated a tag name to check out.
		10	Changed the board photo in Figure 4-1 to use US082-HS3001EVZ.
		10	Changed the sensor description in Chapter 4.3 to the US082-HS3001EVZ description.
		19	Fixed the pin number for GND of Digilent Pmod USBUART.

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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