

# RX65N Group

# Visualization of Sensor Data using RX65N Cloud Kit and Azure RTOS

# Introduction

This document offers sample code that the RX65N Cloud Kit from Renesas and the Wi-Fi module (SX-SDMAC (from Silex Technology)) included in the kit are used to communicate with the Azure cloud service (Azure IoT Hub) using Microsoft's Azure RTOS.In addition, This document is described how to visualize the temperature data uploaded to Azure IoT Hub via Wi-Fi using a web application.

Azure RTOS is a realtime operating system for connectivity, security, and over-the-air (OTA) updates. Azure RTOS provided by Microsoft includes demo applications for demonstrating the functionality of Azure RTOS. This demo application runs on the RX65N Cloud Kit.

In addition, the RX family is certified by Microsoft as Azure RTOS certified hardware. Therefore, it is available free of charge when using Azure RTOS on RX family MCUs.

Click here for details.<<u>https://github.com/azure-rtos/threadx/blob/master/LICENSED-HARDWARE.txt</u>>

e<sup>2</sup> 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).

# Target Device

RX65N Group (RX65N Cloud Kit)

• Visit the following webpage for information on boards, related programs and development environments needed for development work using RX cloud solutions. <u>https://www.renesas.com/rx-cloud</u>

• YouTube

The contents described in this application note explained with a video.

Azure RTOS Tutorial (1/3) RX65N Cloud Kit: ~ Development Environment Setup ~ -YouTube Azure RTOS Tutorial (2/3) RX65N Cloud Kit: ~ Set up the program ~ -YouTube Azure RTOS Tutorial (3/3) RX65N Cloud Kit: ~ Operate Azure Cloud ~ -YouTube

• Azure RTOS GitHub Sample Code Azure RTOS Embedded IDE samples

https://github.com/azure-rtos/samples

Azure RTOS Plug and Play sample code https://github.com/azure-rtos/samples/tree/PublicPreview/PnP

Azure RTOS ADU sample code <u>https://github.com/azure-rtos/samples/tree/PublicPreview/ADU</u>



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# 1. Overview

# 1.1 System Diagram

The system diagram below shows the steps from getting the sensor data of the RX65N Cloud Kit to visualization and the use of the Azure IoT Explorer service to control RX65N Cloud Kit.

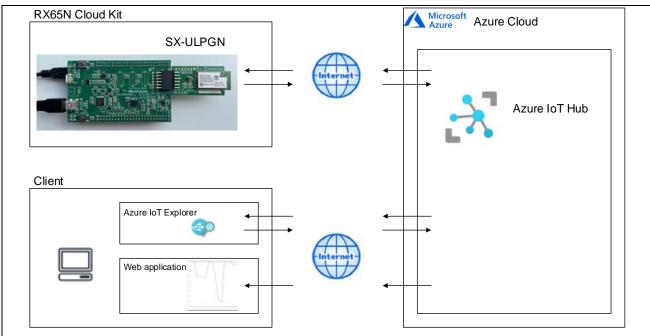


Figure 1.1System Diagram

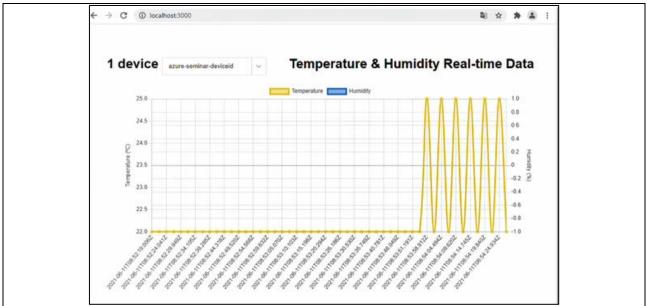


Figure 1.2 Visualization of sensor data



# 2. Preparation

# 2.1 Hardware Configuration

The hardware configuration of the system is listed in the table below.

|                              |                           |                        | -   |
|------------------------------|---------------------------|------------------------|---|
| Item                         | Content                   | Provider               | Description   |
| Board used<br>(packaged with | Target Board for<br>RX65N | Renesas<br>Electronics | Evaluation board mounted with RX65N MCU <sup>*1</sup>                             |
| RX65N Cloud Kit)             | RX Cloud Option<br>Board  | - Corporation          | Cloud communication evaluation board capable of connecting to Azure <sup>*1</sup> |
|                              | Silex Pmod<br>Module      |                        | Communication board mounted with wireless LAN module <sup>*1</sup>                |
| Wi-Fi                        | Wireless router           | -                      | Wireless LAN standard: IEEE 802.11b/g/n<br>(2.4 GHz)<br>Encryption method: AES    |
| PC                           | Windows 10                | -                      | Recommended OS  |
|                              | Google Chrome             | -                      | Web browser used  |
| Note: 1. The target          | board for RX65N, R        | X65N cloud option b    | board, and Silex Pmod module are included in                                      |
| RX65N Cl                     | oud Kit.                  |                        |   |

#### **Table 2.1 Hardware Configurations**

RX65N Cloud Kit Web:

https://www.renesas.com/products/microcontrollers-microprocessors/rx-32-bit-performance-efficiencymcus/rx65n-cloud-kit-renesas-rx65n-cloud-kit

# 2.2 About Azure and Azure RTOS

Azure is a cloud computing service provided by Microsoft.

Azure RTOS, which is a real-time operating system for microcomputers provided by Microsoft, has a library for connecting the microcomputer and Azure, and can manage and control IoT devices connected to the cloud.



# 2.3 Software Configuration

The software configuration of the system is listed in the table below.

| Item                               | Content                     | Version        |
|------------------------------------|-----------------------------|----------------|
| Integrated development environment | e <sup>2</sup> studio       | 2021-04        |
| Compiler                           | GCC for Renesas RX          | 8.3.0.202004   |
| Communication software             | Tera Term                   | Version4.105   |
| Tool for device interaction        | Azure IoT Explorer          | Version 0.14.3 |
| Tool for web application download  | Git                         | 2.31.1         |
| Tool for web application running   | node.js (npm)               | 14.17.0        |
| Emulator                           | E2 emulator Lite (on-board) | -              |

#### Table 2.2 Software Configurations

The software download sites used in this system are shown in the table below.

Note: Link destinations are subject to change.

#### Table 2.3 Tool download sites

| Content               | Link   |
|-----------------------|--|
| e <sup>2</sup> studio | https://www.renesas.com/kr/software-tool/e-studio    |
| GCC for Renesas RX    | https://llvm-gcc-renesas.com/rx-download-toolchains  |
| Tera Term             | https://osdn.net/projects/ttssh2/                    |
| Azure IoT Explorer    | https://github.com/Azure/azure-iot-explorer/releases |
| Git                   | https://www.git-scm.com/download                     |
| node.js (npm)         | http://nodejs.org                                    |



# 3. Connecting to Azure

The following preparation is necessary in order to connect RX65N Cloud Kit to Azure.

# 3.1 Azure Preparation

#### 3.1.1 Sign in to Azure

- 1. Sign in to Azure.
- Azure Sign-in page as follows.

#### https://azure.microsoft.com

If you do not have an Azure account, create one from the Free account on the screen.

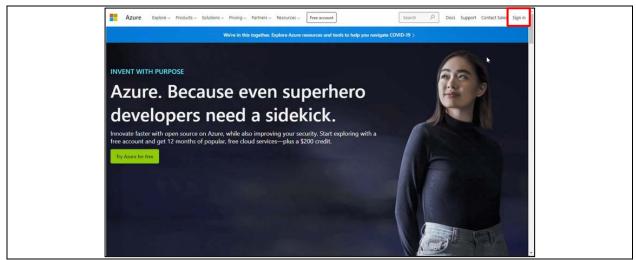


Figure 3.1 Sign-in screen

2. After signing in, go to the Azure portal page.

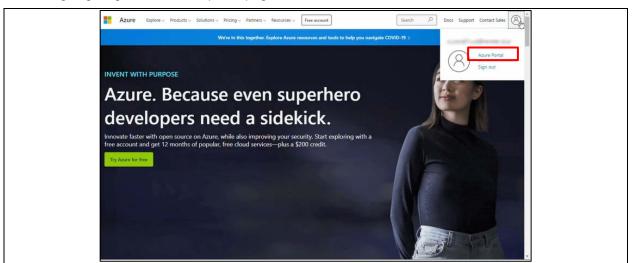


Figure 3.2 Azure Portal selection screen



### 3.1.2 Create an Azure IoT Hub

#### 1. Click **Create a resource**.

| = Micr | osoft Azure       | € P Search n | esources, services, and | d docs (G+/) |                    |                    | Σ          |
|--------|-------------------|--------------|-------------------------|--------------|--------------------|--------------------|------------|
| Az     | ure services      |              |                         |              |                    |                    |            |
| Г      | +                 | K.           | +                       | 8            | \$                 | 6                  | 32         |
|        | Create a resource | IoT Hub      | Subscriptions           | Users        | Cost<br>Management | Cost<br>Management | Event Hubs |

Figure 3.3 Create a resource

2. Enter "IoT Hub" and click IoT Hub from the displayed candidates.

| Home >                |  |  |
|-----------------------|--|--|
| Create a resource     | e  |  |
| Get started           | P IoT Hub  | X Getting Started? Try our Quickstart center |
| Recently created      | ioT Hub ្សាក្  |  |
| Categories            | IoT Hub Device Provisioning Service<br>Device Update for IoT Hub |  |
| AI + Machine Learning | Crosser IoT Connectivity & Streaming Analytics                   |  |
|                       | BOUND DE VELEVOTEIS  |  |

Figure 3.4 IoT Hub Search  $\rightarrow$  IoT Hub Selection

#### 3. Click Create.



# Figure 3.5 IoT Hub Create



**RX65N Cloud Kit and Azure RTOS** 

4. On the Basics tab, select the **Subscription** that suitable your environment then enter the **Resource** group, Region and IoT hub name\*  $\rightarrow$  Click Next: Networking >. Note: The IoT hub name must be unique across the Azure cloud.

| IoT hub  |   |              |
|--|---|--------------|
| Microsoft  |   |              |
| Basics Networking Mana   | gement Tags Review + create                                       |              |
| Create an IoT hub to help you con                                    | nect, monitor, and manage billions of your IoT assets. Learn more |              |
| Project details  |   |              |
| Choose the subscription you'll use<br>organize and manage resources. | to manage deployments and costs. Use resource groups like folders | to help you  |
| Subscription * 🕡   | subscription1   | $\sim$       |
| Resource group * ①   | (New) azure-seminar-ResourceGroup1<br>Create new                  | $\checkmark$ |
| Region * ①   | East US   | $\sim$       |
| IoT hub name * 🛈   | azure-seminar-iothub-001  | $\checkmark$ |
|  |   |              |
|  |   |              |
|  |   |              |
|  |   |              |
|  |   |              |

Figure 3.6 IoT Hub Basics Information Settings  $\rightarrow$  Next: Networking >

5. On the Networking tab, select **Public endpoint**  $\rightarrow$  Click **Next: Management >**.

| ■ Microsoft Azure                                       | ervices, and docs (G+/)                            |
|---|--|
| Home > Create a resource > IoT Hub >                    |  |
| loT hub   |  |
| Microsoft   |  |
| Basics Networking Management Tags                       | Review + create                                    |
| Network connectivity                                    |  |
| Connect to your lot Hub using public or private endpoin | nts.   |
|   | endpoint (all networks)                            |
| 0   | endpoint<br>orks will have access to this IoT hub. |
|   | ore about connectivity methods.                    |
|   |  |
|   |  |
| Review + create < Previous: Basics                      | Next: Management >                                 |

Figure 3.7 Select Public endpoint  $\rightarrow$  Next: Management >



6. On the Management tab, select the **Pricing and scale tier** that suitable your environment  $\rightarrow$  Click **Next: Tags** >.

If you select a Pricing and scale tier other than the F1: Free tier, set the subsequent setting items as necessary.

|  | Hub >                                 |  |                                   |  |
|--|---------------------------------------|--|-----------------------------------|--|
| IoT hub …<br>Microsoft   |                                       |  |                                   |  |
| Basics Networking Manag  | <b>jement Tag</b> s R                 | eview + create   |                                   |  |
| Each IoT hub is provisioned with a c<br>maximum daily quota of messages                          |                                       | in a specific tier. The tier and number of<br>rn more                                  | units determine the               |  |
| Scale tier and units   |                                       |  |                                   |  |
| Pricing and scale tier * ①   | F1: Free tier                         |  | $\sim$                            |  |
|  |                                       | Learn how to choose the right IoT hul  | o tier for your solution          |  |
|  |                                       |  |                                   |  |
| Number of F1 IoT hub units ①   | 0                                     |  | 1                                 |  |
|  | termines how your IoT                 | hub can scale. You can change this later i   | f your needs increase.            |  |
| Defender for IoT   | off                                   |  |                                   |  |
| Defender for IoT   | off                                   | hub can scale. You can change this later i<br>protection to IcT Hub, IoT Edge, and you |                                   |  |
| Defender for IoT   | off                                   |  |                                   |  |
| Defender for IoT<br>T <mark>urn</mark> on Def <mark>end</mark> er fo <mark>r I</mark> oT and add | Off<br>an extra layer of threat       | protection to IcT Hub, IoT Edge, and you   | ur devices. Learn more            |  |
| Defender for IoT<br>Turn on Defender for IoT and add<br>Pricing and scale tier ①                 | Off<br>an extra layer of threat<br>F1 | protection to IcT Hub, IoT Edge, and you<br>Device-to-coud-messages ①                  | ur devices. Learn more<br>Enabled |  |

Figure 3.8 Select the Pricing and scale tier  $\rightarrow$  Next: Tags >

7. On the Tags tab, set tags as needed  $\rightarrow$  Click Next: Review + create >.

This document does not require any input, so do not enter anything and click Next: Review + create >.

| E Microsoft Azure                 | 𝒫 Search resources, services  | s, and docs (G+/)                  |  |
|-----------------------------------|---|------------------------------------|--|
| Home > Create a resource          | > IoT Hub >   |                                    |  |
| IoT hub …<br><sub>Microsoft</sub> |   |                                    |  |
| Tags are name/value pairs. T      | Management Tags Revie<br>categorize resources and conso<br>ill update automatically if you ch | lidate billing, apply the same tag |  |
| Name 🛈                            | Value ①   | Resource                           |  |
|                                   |   | IoT Hub                            |  |
|                                   |   |                                    |  |
| Review + create                   | < Previous: Management  | Next: Review + create >            |  |

Figure 3.9 Set tags  $\rightarrow$  Next: Review + create >



8. On the Review + create tab, review your selection  $\rightarrow$  Click **Create** if you are satisfied. Creating an IoT Hub takes a few minutes.

| 😑 🛛 Microsoft Azure 🛛 🔎        | Search resources, services, and docs (G+/) |  |
|--------------------------------|--|--|
| Home > Create a resource > IoT | Hub >                                      |  |
| IoT hub …<br>Microsoft         |  |  |
| Validation passed.             |  |  |
| Basics Networking Manag        | ement Tags Review + create                 |  |
| Basics                         |  |  |
| Subscription                   | subscription1                              |  |
| Resource group                 | azure-seminar-ResourceGroup1               |  |
| Region                         | East US                                    |  |
| IoT hub name                   | azure-seminar-iothub-001                   |  |
| Networking                     |  |  |
| Connectivity method            | Public endpoint (all networks)             |  |
| Private endpoint connections   | None                                       |  |
| Management                     |  |  |
| Pricing and scale tier         | F1   |  |
| Number of F1 IoT hub units     | 1  |  |
| Messages per day               | 8,000                                      |  |
| Device-to-cloud partitions     | 2  |  |
|                                | STOCK STOCK                                |  |

Figure 3.10 Review your selection  $\rightarrow$  Create

9. Once the IoT Hub is created, click **Go to resource**.

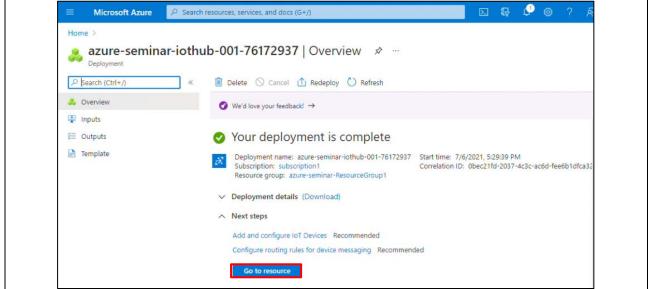


Figure 3.11 Go to resource



10. Make a note of the **Hostname** with a text editor. The Hostname information will be used later.

| Microsoft Azure  | arch resources, services, and docs (G+/)                | E 6 0 7  | R      |           |
|--|---|--|--------|-----------|
| Acome ><br>azure-seminar-ion<br>IoT Hub<br>P Bearch (Ctrl+/) | thub-001 & …<br>« → Move ∨ ■ Delete ♡ Refresh           |  |        | ×         |
| X Overview   | Senetials   |  |        | JSON View |
| Activity log   | Resource group (change)<br>azure-seminar-ResourceGroup1 | Hostname<br>azure-seminar-iothub-001.azure-devic | es.net |           |
| Access control (IAM) Tags                                    | Status<br>Active  | Pricing and scale tier<br>F1 - Free              |        |           |
| Diagnose and solve problems                                  | Current location<br>East US                             | Number of IoT Hub units<br>1                     |        |           |
| F Events   | Subscription (change)<br>subscription1                  | Minimum TLS Version                              |        |           |
| iettings   | Subscription ID   |  |        |           |

Figure 3.12 IoT Hub Hostname recording

# 3.1.3 Create an IoT Device

1. Click **IoT devices** on the left side of the screen  $\rightarrow$  Click **Add Device**.

| ■ Microsoft Azure        | 𝒫 Search resources, services, and docs (G+/)                                  | 🖂 🕼 🖓 🎯 ?          | ጽ |
|--------------------------|---|--------------------|---|
| Home > IoT Hub > azure-s | eminar-iothub-001   |                    |   |
| azure-semina             | ar-iothub-001   IoT devices 🛷 …   |                    |   |
|                          | <ul> <li>View, create, delete, and update devices in your IoT Hub.</li> </ul> |                    |   |
| O Pricing and scale      | Device name   |                    |   |
| Networking               | enter device ID   |                    |   |
| 🔎 Certificates           | Find devices  |                    |   |
| Built-in endpoints       | + Add Device 💍 Refresh 📋 Delete   |                    |   |
| - Sailover               |   |                    |   |
| 😂 Properties             | Device ID Status  | Last Status Update |   |
| 🔒 Locks                  |   |                    |   |
| Explorers                | There are no IoT devices to display.  |                    |   |
| Query explorer           |   |                    |   |
| IoT devices              |   |                    |   |
| $\odot$                  |   |                    |   |

Figure 3.13 IoT devices  $\rightarrow$  Add Device



2. In Create a Device, enter and select the following information  $\rightarrow$  Click **Save**.  $\rightarrow$  Enter arbitrary name

- Device ID

Authentication type

- → Symmetric key
- Auto-generate keys  $\rightarrow$  Put a check
- connect this device to an IoT hub  $\rightarrow$  Enable

|       | Microsoft Azure $P$ Search resources, services, and docs (G+/)              |
|-------|---|
| Hom   | $_{2}$ > azure-seminar-iothub-001-76172937 $>$ azure-seminar-iothub-001 $>$ |
| Æ     | Create a device   |
| C     | Find Certified for Azure IoT devices in the Device Catalog                  |
| Devic | e ID * (i)  |
| azu   | e-seminar-deviceid  |
|       | ntication type ①<br>metric key) X.509 Self-Signed X.509 CA Signed           |
| Prima | ry key 🕕  |
| Ente  | r your primary key  |
| Secor | dary key 🕕  |
| Ente  | r your secondary key  |
| Auto- | generate keys 🕕   |
|       | ect this device to an IoT hub ① ble Disable                                 |
| Paren | t device 🛈  |
|       | parent device<br>a parent device  |
|       |   |
| 2     | ave   |

Figure 3.14 Device ID information settings  $\rightarrow$  Save

3. Make a note of the **Device ID name** with a text editor and click the **Device ID**. The Device ID name information will be used later.

|       | Microsoft Azure        | ₽ Search    | n resources, services, and docs (G+/)   |                     | Ŗ    | 2         |      | ? A? |
|-------|------------------------|-------------|---|---------------------|------|-----------|------|------|
| Hom   | e > IoT Hub > azure-se | eminar-ioth | ub-001                                  |                     |      |           |      |      |
|       | azure-semina           | ar-ioth     | ub-001   IoT devices                    | \$ <sup>2</sup> ··· |      |           |      |      |
| 100   | IoT Hub                |             |   |                     |      |           |      |      |
| ₽ s   | Search (Ctrl+/)        | *           | View, create, delete, and update device | es in your IoT Hub. |      |           |      |      |
| 0 p   | Pricing and scale      | -           | Device name                             |                     |      |           |      |      |
| <-> N | Vetworking             |             | enter device ID                         |                     |      |           |      |      |
| 🔎 с   | Certificates           |             | Find devices                            |                     |      |           |      |      |
|       | Built-in endpoints     | - 1         | + Add Device 🖒 Refresh 🗐                | Delete              |      |           |      |      |
| - 1 F | ailover                | - 1         |   |                     |      |           |      |      |
| P P   | Properties             | - 1         | Device ID                               | Status              | Last | Status Up | date |      |
| Αu    | .ocks                  | - 1         |   |                     | 2001 | status op |      |      |
| Explo | orers                  |             | azure-seminar-deviceid                  | Enabled             |      |           |      |      |

Figure 3.15 Click Device ID



4. Make a note of the **Primary Key** with a text editor. The Primary Key information will be used later.

| 😑 🛛 Microsoft Azure 🛛 🖉       | Search resources, services, and docs (G+/) 🛛 💀 🤌 🛞 🦓 🧖                        | MY DIRECTOR | ev 🐇  |
|-------------------------------|---|-------------|-------|
| Home > azure-seminar-iothub-0 | 001-76172937 > azure-seminar-iothub-001 >                                     |             |       |
| azure-seminar-dev             | iceid &   |             | Х     |
| azure-seminar-iothub-001      |   |             | 15.52 |
| Save 🖾 Message to Device      | 🗡 Direct Method 🕂 Add Module Identity 🔲 Device twin 🔍 Manage keys 🗠 🖒 Refresh |             |       |
| an sone in strage to before   | / Discrimented   Hod module dentity = Dence thin - Q manage wys - O terreat   | -           |       |
| Device ID                     | azure-seminar-deviceid  |             | 0     |
| Primary Key 🜒                 |   | 0           | 0     |
| Secondary Key 🌘               |   | ۲           | 0     |
| rimary Connection String 🕚    |   | ۵           | 0     |
|                               | [   | 0           | 0     |
| Secondary Connection String 👩 |   |             |       |
| Secondary Connection String 🕚 |   |             |       |

Figure 3.16 Device ID Primary Key recording



# 3.2 Software Preparation

Follow the steps below to prepare the software for the demo program.

#### 1. Download the sample project.

Download the Azure RTOS project for the RX65N Cloud Kit and GCC compiler combination from the Azure RTOS sample page on GitHub.

• GitHub sample page as follows.

#### https://github.com/azure-rtos/samples

#### Figure 3.17 GitHub sample page

2. Extract the project files from the archive and copy them to a suitable location. (In the description below, the root folder containing the project files is designated as \${base\_folder}.)

Note: After extracting the project files from the archive, 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.



#### 3. Launch e<sup>2</sup> studio and specify a workspace directory.

| 📴 e <sup>z</sup> studio Launcher  | ×                          |
|---|----------------------------|
| Select a directory as workspace   |                            |
| e <sup>2</sup> studio uses the workspace directory to store its preferences | and development artifacts. |
|   |                            |
| Workspace: C:\e2workspace_azure   | ✓ Browse                   |
|   |                            |
|   |                            |
| Use this as the default and do not ask again                                |                            |
|   |                            |
|   | Launch Cancel              |

Figure 3.18 Workspace selection screen

| eworkspace_azure - e <sup>2</sup> studio   File   Edit   New   Alt+Shift+N >   Open File   Open Projects from File System   Recent Files   Close All Editors   Ctrl+Shift+S   Save All   Ctrl+Shift+S   Revert   Move   Rename   File   Refresh   Convert Line Delimiters To   Print   Ctrl+P   Print   Chrypties   Alt+Enter  | 4. Select <b>File</b> → <b>Import</b> . |   |                                       |  |
|--|---|---|---------------------------------------|--|
| New       Alt+Shift+N >       h Configurations         Open File       Open Projects from File System       File - C*         Recent Files       >         diose Editor       Ctrl+W         Cbee All Editors       Ctrl+Shift+W         Save       Ctrl+Shift+W         Save All       Ctrl+Shift+W         Move       Revert         Move       F2         Rename       F5         Convert Line Delimiters To       >         Print       Ctrl+P         Import       Ctrl+N |   | e2workspace_azure - e <sup>2</sup> stu  | dio                                   |  |
| Open File   Open Projects from File System   Recent Files   Close Editor   Ctrl+ Shift+ W   Save   Copen All Editors   Ctrl+ Shift+ W   Save As   Save As   Save As   Revert   Move   Refresh   Convert Lirle Delimiters To   Print   Ctrl+ P   Import   Export  |   | File Edit Source Refactor               | Navigate Search Project Renesas Views |  |
| Close All Editors       Ctrl+Shift+W         Save       Ctrl+S         SaveAs       SaveAs         SaveAs       Evert         Move       F2         Rename       F5         Convert Line Delimiters To       >         Print       Ctrl+P         Import       Ctrl+P  |   | Open File<br>Open Projects from File Sy | /stem                                 |  |
| Save As<br>Save All Ctrl+Shift+S<br>Revert<br>Move<br>Rename F2<br>Refresh F5<br>Convert Line Delimiters To ><br>Print Ctrl+P<br>Move  |   |   |                                       |  |
| Revert   Move   Rename   F2   Refresh   Convert Line Delimiters To   Print   Ctrl+P  |   |   | Ctrl+S                                |  |
| Rename     F2       Refresh     F5       Convert Line Delimiters To     >       Print     Ctrl+P       Import     Ctrl+P       Export     F  |   |   | Ctrl+Shift+S                          |  |
| Convert Line Delimiters To ><br>Print Ctrl+P<br>Import<br>Export   |   | Rename.                                 |                                       |  |
| import<br><u> <u> </u> <u> </u> <u> </u> <u> </u> Export </u>  |   |   |                                       |  |
| Export   |   | _                                       | Ctrl+P                                |  |
| Properties Alt+Enter   |   |   |                                       |  |
| Switch Workspace >   |   |   |                                       |  |
| Switch Workspace > Restart Exit  |   | Restart                                 | ,                                     |  |

Figure 3.19 Select File  $\rightarrow$  Import...



| 5. | Click | General | $\rightarrow$ Existing | Projects | into | Worksp | ace $\rightarrow$ N | ext > |
|----|-------|---------|------------------------|----------|------|--------|---------------------|-------|
| ۰. | 0.000 | ••••••  |                        |          |      |        |                     |       |

| Import -  |        |  |
|---|--------|--|
| Select<br>Choose import wizard.   | Ľ      |  |
| Select an import wizard:<br>type filter text<br>Select an import wizard:<br>type filter text<br>Constant of the selection of the system<br>File System<br>File System<br>Preferences<br>Preferences<br>Preferences<br>Renawa & Import Existing C/C++ Project into Workspace<br>Renewas CCRX project conversion to Renewas GCC RX<br>Renewas CCRX project for CA78K0R/CA78K0<br>Renewas CS+ Project for CA78K0R/CA78K0<br>Renewas CS+ Project for CC-RX and CC-RL<br>Renewas CS+ Project for CC-RX and CC-RL<br>C/C++<br>C/C++<br>Code Generator<br>C/C++<br>Comph | Cancel |  |

Figure 3.20 General  $\rightarrow$  Existing Projects into Workspace  $\rightarrow$  Next >

6. Click **Browse...**, specify  $\delta = \frac{1}{rx65n-cloud-kit folder}$  select all of the sample project extracted  $\rightarrow Click$  **Finish**.

| S Import  | – 🗆 X                     |
|---|---------------------------|
| Import Projects<br>Select a directory to search for existing Eclipse projects.  |                           |
| Select root directory:     C:\azure_rtos\rx65n-cloud-kit     Select archive file:     Projects:     filex (C:\azure_rtos\rx65n-cloud-kit\e2studio_gnurx\filex)     netxduo_addons (C:\azure_rtos\rx65n-cloud-kit\e2studio_gnurx\ntextudio | u Deselect All<br>Refresh |
| sample_filex_ramdisk (C:\azure_tos\rx65n-cloud-kit\e2studio,     sample_netxduo_ping (C:\azure_tos\rx65n-cloud-kit\e2studio     sample_pnp_temperature_controller (C:\azure_tos\rx65n-cloud-kit\e2studio     sample_pnp_temperature_controller (C:\azure_tos\rx65n-cloud-kit\e2studio     sample_pnp_temperature_controller (C:\azure_tos\rx65n-cloud-kit\e2studio     sample_nop_temperature_controller (C:\azure_tos\rx65n-cloud-kit\e2studio     cloud-kit\e2studio     cloud-kit\e2stud | -<br>d                    |
| Working sets Add project to working sets Working sets:  | New<br>> Select           |
| ? < Back Next > Finish  | Cancel                    |

Figure 3.21 Project import screen



#### 7. Define the following two macros in

{\$base\_folder}/rx65n-cloud-kit/e2studio\_gnurx/sample\_pnp\_temperature\_controller/src/main.c.

- WIFI\_SSID  $\rightarrow$  The SSID of the access point to connect to.

- WIFI\_PASSWORD  $\rightarrow$  The password of the access point to connect to.

#### (Makes sure to enclose the above macro definitions in quotes (" ") as shown in the figure below.

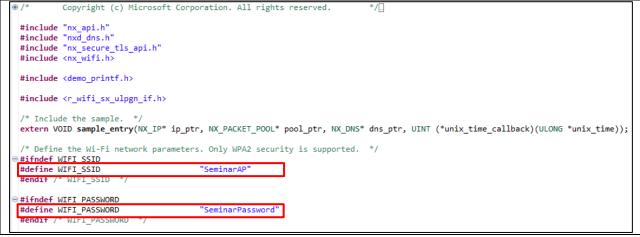


Figure 3.22 main.c

#### 8. Define the following three macros in

 $\{\text{base_folder}/\text{rx65n-cloud-kit/e2studio_gnurx/sample_pnp_temperature_controller/src/sample_config.h.} - HOST_NAME \rightarrow The hostname confirmed as described in 3.1, Azure Preparation.}$ 

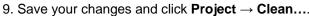
- DEVICE\_ID  $\rightarrow$  The Device ID created as described in 3.1, Azure Preparation.

— DEVICE\_SYMMETRIC\_KEY → The Primary Key confirmed as described in 3.1, Azure Preparation.

| <pre>/* Required when DPS is not used. */ /* These values can be picked from device</pre> | connection string which is of format : HostName= <host1>;DeviceId=<device1>;SharedAcce</device1></host1>        | essKev=4 |
|---|---|----------|
| HOST NAME can be set to <host1>,</host1>  | connection set ing mach as of format i november mestar perfaction contect                                       | , some y |
| DEVICE ID can be set to <device1>,</device1>  |   |          |
| DEVICE_SYMMETRIC_KEY can be set to <key< th=""><th>1&gt;. */</th><th></th></key<>         | 1>. */  |          |
| #ifndef HOST_NAME   |   |          |
| #define HOST_NAME   | "azure-seminar-iothub-001.azure-devices.net"  |          |
| Wendit / HOST_NAME /  |   |          |
| #ifndef DEVICE ID   |   |          |
| #define DEVICE ID   | "azure-seminar-deviceid"  |          |
| <pre>#endif /* DEVICE_ID */</pre>   |   |          |
| <pre>#else /* IENABLE_DPS_SAMPLE */</pre>   |   |          |
| /* Required when DPS is used. */  |   |          |
| #ifndef ENDPOINT  |   |          |
| #define ENDPOINT  |   |          |
| <pre>#endif /* ENDPOINT */</pre>  |   |          |
| #ifndef ID SCOPE  |   |          |
| #define ID SCOPE  | **  |          |
| <pre>#endif /* ID_SCOPE */</pre>  |   |          |
| #ifndef REGISTRATION ID   |   |          |
| #define REGISTRATION ID   | **  |          |
| <pre>#endif /* REGISTRATION_ID */</pre>   |   |          |
| <pre>#endif /* ENABLE_DPS_SAMPLE */</pre>   |   |          |
| /* Optional SYMMETRIC KEY. */   |   |          |
| #ifndef DEVICE_SYMMETRIC_KEY  |   |          |
| #define DEVICE_SYMMETRIC_KEY  | the second se |          |

Figure 3.23 sample\_config.h





| e2workspace_azure - sample_pnp_temperature_                                | contre         | oller/src/sample_config.h - e <sup>2</sup> | studio      |
|--|----------------|--|-------------|
| File Edit Source Refactor Navigate Search                                  | Pro            | ject Renesas Views Run                     | Window Help |
| 🍝 🔯 🔳 🎄 Debug 🗸  |                | Open Project                               |             |
| 😕 🛷 👻 🗾 🗊 🖷 😫 🗸 🤸 🏷 😅  |                | Close Project                              | 0.1.4% 0    |
| 🎦 Project Explorer 💥 🛛 🖨 🕏 🖓 🖇 🖵   | 010            | Build All<br>Build Configurations          | Ctrl+Alt+B  |
| > 😂 filex<br>> 😂 netxduo   |                | Build Project                              | Ctrl+B      |
| > 📂 netxduo_addons   | _              | Build Working Set                          | >           |
| > 📂 sample_azure_iot_embedded_sdk<br>> 🞏 sample_azure_iot_embedded_sdk_pnp |                | Clean                                      |             |
| > 😰 sample_azore_ior_embedded_sdk_prip                                     |                | Build Automatically                        |             |
| > 📂 sample_netxduo_ping  |                | Build Targets                              | >           |
| ✓ Sample_pnp_temperature_controller [Hard<br>> S Includes                  | ^              | C/C++ Index                                | >           |
| ✓ <sup>™</sup> src   | e <sup>2</sup> | Update All Dependencies                    | Alt+D       |
| > 🧽 r_wifi_sx_ulpgn  |                | Change Device                              |             |
| > 🧀 smc_gen<br>> 🔀 compat.c  | <b>\$</b>      | C/C++ Project Settings                     | Ctrl+Alt+P  |
| > 🖻 demo_printf.c  |                | Properties                                 |             |

Figure 3.24 Project  $\rightarrow$  Clean...

10. Uncheck **Clean all projects**, check only **sample\_pnp\_temperature\_controller**, click **Clean**, and confirm that **0 errors** are reported.

| Clean   | - 0               | ×   |   |   |
|---|-------------------|-----|---|---|
| Clean discards all build results and states. The next time a build projects will be rebuilt from scratch. | occurs the select | ed  |   |   |
| Clean all projects  |                   |     |   |   |
| type filter text  |                   |     |   |   |
| 🗆 😂 filex   |                   |     |   |   |
| 🔲 🗁 netiduo   |                   |     |   |   |
| 🗌 😂 netx duo_addons   |                   |     |   |   |
| <sup>C</sup> sample_azure_iot_embedded_sdk  |                   |     |   |   |
| Sample_azure_iot_embedded_sdk_pnp Sample_filex_ramdisk  |                   |     |   |   |
| Sample Tilex_ramoisk  |                   |     |   |   |
| Sample_pnp_temperature_controller   |                   |     | - |   |
| □ 🗁 sample_threadx  |                   |     |   |   |
| □ 😂 threadx   |                   |     |   |   |
|   |                   |     |   |   |
| Start a build immediately   |                   |     |   |   |
| Build the entire workspace  |                   |     |   |   |
| O Build only the selected projects  |                   |     |   |   |
| Clean   | Can               | cel |   | _ |

Figure 3.25 Clean setting screen

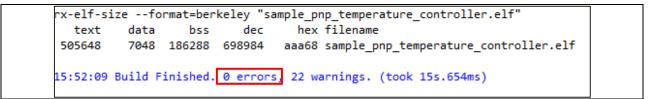


Figure 3.26 Clean completion screen



# 3.3 Running the Demo Program Preparation

Prepare to run the demo program.

#### 3.3.1 Hardware Preparation

- 1. Remove the jumper from the EJ2 pins on the target board (bottom board).
- 2. Connect the ECN1 connector on the target board (bottom board) to the PC via a USB cable.
- 3. Connect the CN18 connector on the cloud option board (top board) to the PC via a USB cable.

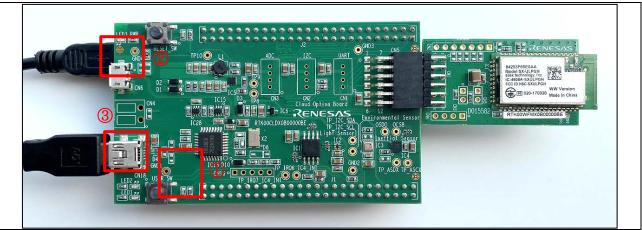


Figure 3.27 RX65N Cloud Kit (Top)

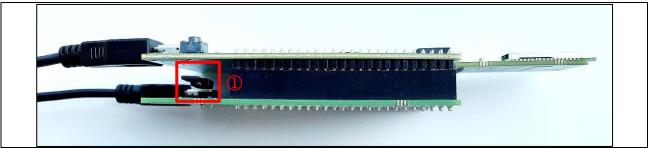


Figure 3.28 RX65N Cloud Kit (Bottom)



**3.3.2 Tera Term Preparation** Launch Tera Term and set as shown in the table below.

#### **Table 3.1 Tera Term Settings**

| Item         | Setting |
|--------------|---------|
| Baud rate    | 115,200 |
| Data length  | 8bit    |
| Parity       | none    |
| Stop bits    | 1bit    |
| Flow control | none    |



# 3.4 Running the Demo Program

Follow the steps below to run the demo program.

1. Click **sample\_pnp\_temperature\_controller HardwareDebug** from the drop-down list in the upper left of the e<sup>2</sup> studio window.

| e2workspace_azure - sample_pnp_temperature_   | controller/src/sample_config.h - e² studio         |
|---|--|
| File Edit Source Refactor Navigate Search   | Project Renesas Views Run Window Help              |
| 🍕 🎋 🔳 🔻 Debug 🗸   | 💽 sample_threadx HardwareDebug 🔨 🔅 🗂 🕶 🔚 🌚         |
| (四) 세····································   | sample_threadx HardwareDebug                       |
| Image: Project Explorer     ⋈     Image: Project Explorer     ⋈       > ﷺ filex                                 | sample_pnp_temperature_controller HardwareDebug    |
| > 👺 netxduo   | 🔄 sample_netxduo_ping HardwareDebug                |
| > 6 sample_azure_iot_embedded_sdk<br>> 6 sample_azure_iot_embedded_sdk<br>> 6 sample_azure_iot_embedded_sdk_pnp | sample_azure_iot_embedded_sdk HardwareDebug        |
| > 😰 sample_filex_ramdisk  | cs sample_azure_iot_embedded_sdk_pnp HardwareDebug |
| <ul> <li>&gt; Sample_netxduo_ping</li> <li>&gt; Sample_pnp_temperature_controller [Hardy</li> </ul>             | sample_filex_ramdisk HardwareDebug                 |
| > 🔆 Binaries  | 💽 sample_netxduo_ping HardwareDebug 🗸 🗸            |
| > 🔊 includes<br>🗸 🥵 src   | New Launch Configuration                           |
| N 🧰 r wifi sy ulgan   |  |

Figure 3.29 Hardware Debug selection

| 2. Click the D | Debug icon.   |  |
|----------------|---|--|
|                | 🔨 🐞 🔳 🔅 Debug 🗸 💽 sample_pnp_temperature_controll 🗸 🄅 |  |
|                | Figure 3.30 Debug                                     |  |

3. A message appears asking you to confirm that you wish to switch to the Debug perspective; click the **Switch** button.

4. Click the **Restart** icon. After a short time execution pauses at the main function; click the **Resume** icon.

| ature_controll 🗸 🔅 | - 🖻 - | 🔊 <b>-</b> 🐔 | - | a 💵 |   | 5 24 | <br>i+ 👼 | <br>* | <b>Q</b> . | ÷ 0 <sub>00</sub> • | *** | 000 100 1 | 2 | 3 |
|--------------------|-------|--------------|---|-----|---|------|----------|-------|------------|---------------------|-----|-----------|---|---|
|                    |       | <br>         |   |     | _ |      |          |       |            |                     |     |           | _ |   |

Figure 3.31 Demo program execution

5. Confirm that the execution log is output on the Tera Term screen.

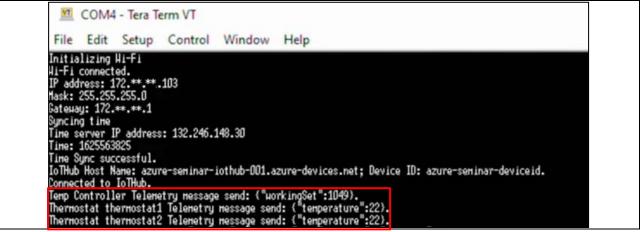


Figure 3.32 Demo program execution log



# 3.5 Communication confirmation by Azure IoT Explorer

Confirm the uploaded data is sent to the Azure cloud.

1. Access the created IoT Hub page on the Azure portal and the Shared access policies  $\rightarrow$  iothubowner  $\rightarrow$  Get Primary connection string.

| ome > IoT Hub > azure-seminar-iothu<br>azure-seminar-iothu<br>IoT Hub | <b>ıb-001</b>   Shared access poli  | cies \$          | iothubowner<br>azure-seminar-iothub-001<br>Regenerate primary key | ×        |
|---|---|------------------|---|----------|
| O Search (Ctrl+/) «   | 2   |                  |   |          |
| Overview  | Shared access policies are used to generate sec<br>+ Add shared access policy O Refresh | Delete           | Primary key   | <b>)</b> |
| Activity log  | 1 Add shared access pointy O remean   | E peiere         | Secondary key   |          |
| A Access control (IAM)  | Policy Name   | Permissions      |   | ▶ []     |
| Tags  |   |                  | Primary connection string   |          |
| Diagnose and solve problems   | ✓ iothubowner   | Registry Read, F |   |          |
| Events  | service   | Service Connect  | Secondary connection string                                       |          |
| ettings   | device  | Device Connect   |   | ∞ [      |
| Shared access policies  | registryRead  | Registry Read    | Permissions   |          |
| Identity  |   |                  | Registry Read   |          |
| Pricing and scale   | registryReadWrite   | Registry Read, F | Registry Write  |          |
| Networking  |   |                  | Service Connect   |          |
| Certificates  |   |                  | V Device Connect  |          |
| Built-in endpoints  |   |                  |   |          |
| Failover  |   |                  |   |          |
| Properties  |   |                  |   |          |

#### Figure 3.33 shared access policies $\rightarrow$ iothubowner $\rightarrow$ Primary connection string

#### 2. Launch Azure IoT Explorer and click **Add connection**.

| Azure IoT Explorer (preview)     Azure IoT Explorer (preview)     Ottifications  |
|--|
| Home > IoT hubs         IoT hubs         IoT hubs         IoT Plug and Play         IoT Notification Center         Notification Center         Volume         Value         Volume         Volume |

Figure 3.34 Azure IoT Explorer



#### 3. Enter the got **Primary connection string** in **Connection string** $\rightarrow$ Click **Save**.

| <ul> <li>Azure IoT Explorer (preview)</li> <li>File Edit View Window Hel</li> </ul> |  | – 🗆 X  |
|---|--|--|
| Azure IoT Explorer (p   | oreview)   | Notifications Settings   |
| Home > IoT hubs   |  | Add connection string $	imes$  |
| =   | + Add confin   | Connection string *  |
| සි loT hubs<br>ග් loT Plug and Play<br>O Notification Center                        | No conne<br>You will nee<br>storage and<br>Help:<br>Where do L | enter a connection string<br>Where do I get an IoT hub connection string?<br>Please do not save your hub connection string to any unsafe locations |
|   |  | Save   |

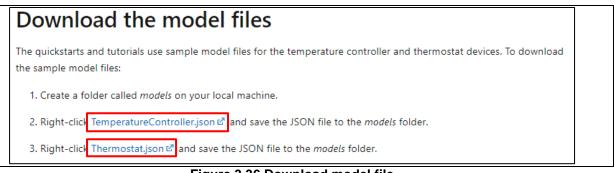
Figure 3.35 Enter the primary connection string in Azure IoT Explorer  $\rightarrow$  Save

4. Create a folder named models in your local folder.

5. Go to the IoT Plug and Play quickstarts web page and download the two model files into the models folder.

· IoT Plug and Play quickstarts web page as follows.

https://docs.microsoft.com/azure/iot-develop/set-up-environment



#### Figure 3.36 Download model file



6. Click **IoT Plug and Play components** in Azure IoT Explorer  $\rightarrow$  **Add**  $\rightarrow$  Click **Local folder** in the pull-down.

| Azure IoT Explorer (preview) File Edit View Window Hell | lp  | -  |            |
|---|---|--|------------|
| Azure IoT Explorer (p                                   | preview)  | Notifications  | 🌀 Settings |
| Home > IoT Plug a                                       | No mo<br>Model repository<br>definitio<br>by returned a construction of the second secon | Help<br>to <b>display</b><br>re the application looks to find IoT Plug and Play mode<br>ication storage and can be edited or removed at any ti |            |

Figure 3.37 IoT Plug and Play components  $\rightarrow$  Add  $\rightarrow$  Local folder

7. Pick a folder  $\rightarrow$  Select the models folder where you saved the model file  $\rightarrow$  Click Save.

| Azure IoT Explorer (p   | preview)  | Notifications              | 🍘 Settings |
|---|---|----------------------------|------------|
| Home > IoT Plug   | and Play components   |                            |            |
| <ul> <li>■</li> <li>♣ IoT hubs</li> <li> <sup>g</sup> IoT Plug and Pla</li> <li> <sup>Q</sup> Notification Center     </li> </ul> | Image: Savg + Add ∨ ? Revert ? Help         We'll Rok for your model definition in the for         Click 'Aot' to enable more ways to can resol         Before enabling us to retrieve model definiti         Statement         1         Local Folder *         Selected folder         C/models | ve your model definitions. |            |

Figure 3.38 Pick a folder  $\rightarrow$  Select the models folder where you saved the model file  $\rightarrow$  Save

8. Click **IoT hubs** on the left side of the screen  $\rightarrow$  **Created IoT Hub**.

| Azure IoT Explorer (preview) File Edit View Window He |  | - 0 ×                    |
|---|--|--------------------------|
| Azure IoT Explorer (                                  | preview)                                   | Notifications 💿 Settings |
| Home > IoT hubs                                       |  |                          |
| =   | + Add connection                           |                          |
| 品 IoT hubs ,  |  |                          |
| 5 <sup>g</sup> IoT Plug and Play                      | azure-seminar-iothub-001                   | 1 🗊                      |
| Q Notification Center                                 | azure-seminar-iothub-001.azure-devices.net | D                        |
|   | Shared access policy name                  |                          |
|   | iothubowner                                | D                        |

Figure 3.39 IoT Hub selection



#### 9. Click the **Device ID name**.

| P Azure IoT Explorer (preview)<br>File Edit View Window Help |                  |             |                |                                 | - 🗆 X       |
|--|------------------|-------------|----------------|---------------------------------|-------------|
| Azure IoT Explorer (preview)                                 |                  |             | 9              | Notifications                   | Settings    |
| Home > azure-seminar-io                                      | othub-001 > Devi | ces         |                |                                 |             |
| New Nefresh Delete   |                  | y parameter | Last status up | loT Plug and                    | Edge device |
| azure-seminar-<br>deviceid Enabled                           | Disconnected     | Sas         |                | dtmi:com:exam<br>ple:Temperatur | Euge device |
| 4  |                  |             |                | ple:Temperatur<br>eController;1 |             |

Figure 3.40 Device ID selection

#### 10. Click the **IoT Plug and Play components**.

| Azure IoT Explorer (preview<br>File Edit View Window H |  |          |
|--|--|----------|
| Azure IoT Explorer (                                   | preview) 🚨 Notifications   | Settings |
| Home > azure-se  | eminar-iothub-001 > <u>Devices</u> > azure-seminar-deviceid > Device ide | ntity    |
| =  | 🗟 Save 🔍 Manage keys 🗸   |          |
| Device identity  |  |          |
| 🔁 Device twin  | Device identity  |          |
| C Telemetry  | Device ID ①  | ^<br>_   |
| > Direct method  | azure-seminar-deviceid   | Đ        |
| S. Direct method                                       | Primary key 💿  |          |
| Cloud-to-device  | •••••  | D        |
| 🛠 Module identities                                    | Secondary key 💿  |          |
| og IoT Plug and Play                                   | •••••  | D        |
| Dr lot ridy and ridy                                   | Primary connection string ①  |          |

Figure 3.41 Device ID selection



11. Scroll down the page and click thermostat1 from Components.

| Azure IoT Explorer (preview File Edit View Window H Azure IoT Explorer      | Help                         |  | × |
|---|------------------------------|--|---|
|   |                              | e-seminar-deviceid > IoT Plug and Pla        |   |
| =   | 🕐 Refresh                    |  |   |
| <ul> <li>Device identity</li> <li>Device twin</li> <li>Telemetry</li> </ul> | LoT Plug and Play components | )<br>Model ID                                | • |
| Direct method Cloud-to-device   | Default component            | dtmi:com:example:Temperatur<br>eController;1 |   |
| 🛠 Module identities<br>🖉 loT Plug and Pla                                   | thermostat1                  | dtmi:com:example:Thermostat;<br>1            |   |
|   | thermostat2                  | dtmi:com:example:Thermostat:                 |   |

Figure 3.42 thermostat1 selection

#### 12. Click the **Telemetry**.

| Azure IoT Explorer (previe<br>File Edit View Window |  | -                 |          |
|---|--|-------------------|----------|
| Azure IoT Explorer                                  | (preview)  | Notifications     | Settings |
| <u>Home</u> > azure-s<br><u>components</u> > t<br>≡ |  | ommands Telemetry | _        |
| Device identity                                     | C) Refresh   | 0                 | 🕑 Back   |
| 🔁 Device twin                                       | You model definition has been resolved from: Local Folder 🛞 Config | gure              |          |
| C Telemetry   | Interface Id   |                   |          |
| S Direct method                                     | dtmi:com:example:Thermostat:1                                      |                   | D        |

#### Figure 3.43 Telemetry selection

#### 13. Click the Start.

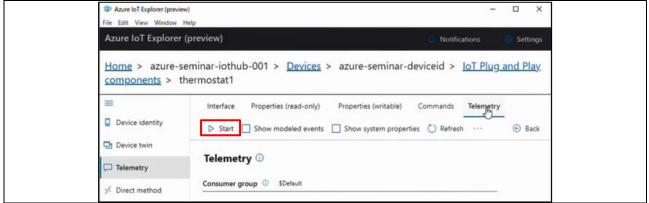


Figure 3.44 Telemetry started



14. Confirm that the uploaded data is displayed in the **Receiving events** field  $\rightarrow$  Click **Stop**.

| Azure IoT Explorer (pre                               | view) Q Notifications   | 💮 Settings |
|---|---|------------|
| <u>Home</u> > azure-semi<br><u>components</u> > therr | nar-iothub-001 > <u>Devices</u> > azure-seminar-deviceid > <u>IoT Plug and Play</u><br>nostat1                                  |            |
| =   | Interface Properties (read-only) Properties (writable) Commands Telemetry   |            |
| Device identity                                       | Stop  | 🕝 Back     |
| 🔁 Device twin   |   |            |
| Telemetry   | Telemetry 🛈   |            |
| ✓ Direct method                                       | Consumer group ① \$Default  |            |
| 🗹 Cloud-to-device me                                  | Specify enqueue 🕕   |            |
| Module identities                                     | No No   |            |
| o <sup>⊄</sup> IoT Plug and Play co                   | Use built-in event hub Yes  |            |
|   | ① Receiving events 〇  |            |
|   | Thu Jul 08 2021 11:20:02 GMT+0900 (Japan Standard Time):  | Í          |
|   | {     "body": {         "temperature": 22     },     "enqueuedTime": "Thu Jul 08 2021 11:20:02 GMT+0900 (Japan Standard Time)", |            |
|   | "properties": {} }  |            |
|   | Thu Jul 08 2021 11:19:57 GMT+0900 (Japan Standard Time):  |            |
|   | {     "body": {         "temperature": 22         }   |            |
|   | },<br>"enqueuedTime": "Thu Jul 08 2021 11:19:57 GMT+0900 (Japan Standard Time)",  |            |

15. Click the **Stop** icon on the  $e^2$  studio screen.



Figure 3.46 Demo program stop



# 4. LED ON/OFF operation by Azure IoT Explorer

Follow the steps below to turning on/off LED1 on the RX65N Cloud Kit from the Azure cloud.

To operate LED1, you need to make changes to the sample project downloaded from the Azure RTOS sample page on GitHub in 3.2 Software Preparation.Please refer to 8. Appendices for the changes.

1. Click the **device ID** created in Azure IoT Explorer  $\rightarrow$  Click **Device twin**.

| File Edit View Window He |  |            |          |
|--------------------------|--|------------|----------|
| Azure IoT Explorer (p    | preview)   | fications  | Settings |
| Home > azure-se          | minar-iothub-001 > <u>Devices</u> > azure-seminar-deviceid >   | Device twi | in       |
| =                        | 💍 Refresh 📙 Save   |            |          |
| Device identity          |  |            |          |
| 🔁 Device twin            | Device twin ①  |            |          |
| Telemetry                | <pre>1* { 2 "deviceId": "azure-seminar-deviceid", 3 "etag": "AAAAAAAAB8",</pre>  |            | 1        |
| ✓ Direct method          | <pre>4 "deviceEtag": "NTEwNzkSODU4",<br/>5 "status": "enabled",<br/>6 "statusUpdateTime": "0001-01-01T00:00:00Z",<br/>7 "connectionState": "Connected".</pre>        |            | - 1      |
| Cloud-to-device          | <pre>7 "connectionState": "Connected", 8 "lastActivityTime": "2021-06-11707:09:16.31689472", 9 "cloudToDeviceMessageCount": 0, 10 "authenticationType": "sas",</pre> |            | - 1      |
| Module identities        | 10 addmentedition/per ses,<br>11 - "x509Thumbprint": (<br>12 "primaryThumbprint": null,<br>13 "secondaryThumbprint": null  |            |          |
| S loT Plug and Play      | <pre>14 },<br/>15 "modelId": "dtmi:com:example:TemperatureController;1",</pre>   |            |          |

Figure 4.1 Device twin screen

2. Add the following lines of code into **desired properties**  $\rightarrow$  Click **Save**.

"LED": { "LED1": 1 }, Figure 4.2 Message payload to turn on LED1



| <ul> <li>Device identity</li> <li>Device twin</li> <li>Device twin</li> <li>Telemetry</li> <li>Direct method</li> <li>Cloud-to-device</li> <li>Module identities</li> </ul> | r-iothub-001 > <u>Devices</u> > azure-seminar-deviceid > Device twin  | tings |
|---|---|-------|
| <ul> <li>Device identity</li> <li>Device twin</li> <li>Telemetry</li> <li>Direct method</li> <li>Cloud-to-device</li> <li>Module identities</li> </ul>                      | r-iothub-001 > <u>Devices</u> > azure-seminar-deviceid > Device twin  |       |
| Device identity  Device twin  Telemetry  Direct method  Cloud-to-device  Module identities  |   |       |
| Device identity  Device twin  Telemetry  Direct method  Cloud-to-device  Module identities  |   |       |
| Device twin  Telemetry  Direct method  Cloud-to-device  Module identities   | ) Refresh 🗟 Save  |       |
|   |   |       |
| Direct method     Cloud-to-device     Module identities   | evice twin 🛈  |       |
| Cloud-to-device   | <pre>1 - { 2 "deviceId": "azure-seminar-deviceid",</pre>  | -     |
| X Module identities   | <pre>3 "etag": "AAAAAAAAB0=",<br/>4 "deviceEtag": "NTEwNik5OOU4",<br/>5 "status": "enabled",</pre>  | I     |
| S Module identities   | <pre>6 "statusUpdateTime": "0001-01-01700:00:002",<br/>7 "connectionState": "Connected",<br/>8 "lastActivityTime": "2021-06-11T07:09:16.3168947Z",<br/>9 "cloudToOviceNessageCount": 0.</pre> |       |
|   | <pre>9 "cloudToDeviceMessageCount": 0,<br/>10 "authenticationType": "sas",<br/>11+ "x509Thumbprint": {<br/>2</pre>  |       |
|   | 13 "secondaryThumbprint": null<br>14 },   |       |
| p for high and hops.  | <pre>15 "modelId": "dtmi:com:example:TemperatureController;1",<br/>16 "version": 212,</pre>   |       |
|   | 17 - "properties": {<br>18 - "desired": {   |       |
|   | 19- "thermostat1": (<br>20 "t": "C, t": "(<br>21 "targetTemperature": 22  |       |
|   | 22 },<br>23 - "LED": {  |       |
|   | 24 "LED1": 1<br>25 }.   |       |
|   | 26 - "Smetacata": (   |       |
|   | 27 "\$lastUpdated": "2021-06-10T02:45:36.25003772",<br>28 "\$lastUpdatedVersion": 29,   |       |
|   | 29 * "thermostat1": {<br>30 "\$lastUpdated": "2021-06-10702:45:36.25083772",  |       |
|   | 31 "\$lastUpdatedVersion": 29,  |       |
|   | 32 + "t": (<br>33 "\$lastUpdated": "2021-06-10T02:45:36.25083772",  |       |
|   | 34 "\$lastUpdatedVersion": 29   |       |
|   | 35         },           36 -         "targetTemperature": {           37         "\$lastUpdated": "2021-06-10702:45:36.25083772",   |       |

Figure 4.3 Device twin setting state

3. Confirm that RX65N Cloud Kit LED1 turn on.

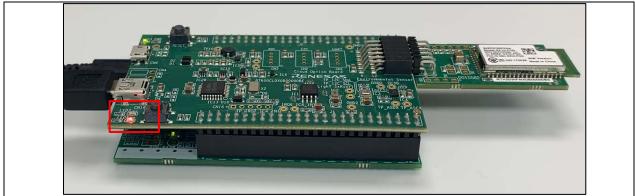


Figure 4.4 LED1 turn on



4. Add the following lines of code into **desired properties**  $\rightarrow$  Click **Save**.

"LED": { "LED1": 0 },

Figure 4.5 Message payload to turn off LED1

5. Confirm that RX65N Cloud Kit LED1 turn off.

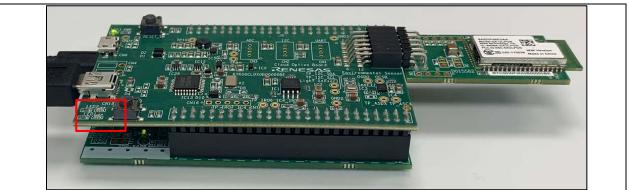


Figure 4.6 LED1 turn off



### 5. Visualization of Sensor Data

Follow the steps below to visualizing the sensor data\* uploaded from the RX65N Cloud Kit to the Azure cloud using a web application.

Note: The demo program in this document uploads fixed values as sensor data.

### 5.1 Software Preparation

1. Go to the IoT Hub page you created on the Azure portal **Built-in endpoints**  $\rightarrow$  Enter arbitrary name to **Create new consumer group**  $\rightarrow$  Click **Save**.

| 😑 Microsoft Azure 🔎 s  | earch resources, services, and docs (G+/) 🛛 🕼 🛛 🕼 🖓 🖓 🛞 🥍 MY DIRECTORY 🜷  |
|--|---|
| Home > azure-seminar-iothub-001                              |   |
| e azure-seminar-io   | thub-001   Built-in endpoints 🖈 … 🛛 🗙   |
| P Search (Ctrl+/)  | « 🗟 Save り Undo   |
| X Overview   | 1   |
| Activity log   | Bach IoT hub comes with built-in system endpoints to handle system and device messages. When you create new endpoints and routes, messages stop flowing |
| R Access control (IAM)                                       | to the built-in endpoint unless you create a separate route and direct them there. Learn more   |
| Tags   | Event Hub Details   |
| Diagnose and solve problems                                  |   |
| 🗲 Events   | Partitions D  |
| Settings   |   |
| Shared access policies                                       | Event Hub-compatible name ① iothub-ehublazure-semi-13259798-53385e18b7 ①  |
| <ul> <li>Shared access policies</li> <li>Identity</li> </ul> |   |
|  | Retain for ①  |
| O Pricing and scale  | Days  |
| Networking   | Consumer Groups ①   |
| 🔎 Certificates   | Consumer Groups   |
| Built-in endpoints   | SDefault  |
| -* Failover  | Create new consumer group   |
| Se Properties  |   |

Figure 5.1 Consumer group creation

2. Make a note of the **consumer group name** with a text editor.

The consumer group name information will be used later.

3. Make a note of the Shared access policies  $\rightarrow$  service  $\rightarrow$  Primary connection string with a text editor.

The Primary connection string information will be used later.

| Home > azure-seminar-iothub-001 | ub-001   Shared access pol   | icies 🖈          | service<br>azure-seminar-iothub-001<br>③ Regenerate primary key ③ Regenerate secondary key 11 Swap keys |   |
|---------------------------------|--|------------------|---|---|
| P Search (Ctrl+/) «             | #b   |                  | Primary key   |   |
| X Overview                      | Shared access policies are used to generate se<br>+ Add shared access policy O Refresh | 20<br>           | enmary key  | > |
| Activity log                    | T Add shared access policy O Remesh  | D Delete         | Secondary key   |   |
| R Access control (IAM)          | Policy Name  | Permissions      |   |   |
| Tags                            | a national sector and the sector of the  |                  | Primary connection string   |   |
| Diagnose and solve problems     | iothubowner  | Registry Read, F |   | Þ |
| 🗲 Events                        | service  | Service Connect  | Secondary connection string   |   |
| Settings                        | device   | Device Connect   | <   | > |
| Shared access policies          | registryRead   | Registry Read    | Permissions   |   |
| 🐒 Identity                      |  |                  | Registry Read   |   |
| Pricing and scale               | registryReadWrite  | Registry Read, F | Registry Write  |   |
| 6 Networking                    |  |                  | Service Connect   |   |
|                                 |  |                  | Device Connect  |   |

Figure 5.2 Shared access policies  $\rightarrow$  service  $\rightarrow$  Primary connection string



### 5.2 Running the web application

1. Start the command prompt and run the commands in the following order.

(1) Download the sample code of the web application for visualization from GitHub.

git clone https://github.com/Azure-Samples/web-apps-node-iot-hub-data-visualization.git

#### Figure 5.3 Web application sample code download

(2) Move the folder to the storage location of the sample code.

cd web-apps-node-iot-hub-data-visualization

#### Figure 5.4 Move sample code folder

(3) Set environment variables.

set lotHubConnectionString=[5.1 Software Preparation 3. Primary connection string]

set EventHubConsumerGroup=[5.1 Software Preparation 2. consumer group name]

### Figure 5.5 Environment variable settings

(4) Launch website.

Enter Ctrl-C to exit the website.

npm install

npm start

#### Figure 5.6 Launch website

| command Prompt  | -             |        | ×    |
|---|---------------|--------|------|
| licrosoft Windows [Version 10.0.19041.867]<br>c) 2020 Microsoft Corporation. All rights reserved.   |               |        | ^    |
| :\myfolder>git clone https://github.com/Azure-Samples/web-apps-node-iot-hub-data-visualization.gi<br>loning into 'web-apps-node-iot-hub-data-visualization'<br>emote: Enumerating objects: 193, done.<br>emote: Counting objects: 100% (13/13), done.<br>emote: Compressing objects: 100% (13/13), done.<br>emote: Total 193 (delta 6), reused 0 (delta 0), pack-reused 180<br>eceiving objects: 100% (13/193).es & KiB   1.69 MiB/s, done.<br>esolving deltas: 100% (79/79), done. | t             |        |      |
| :\myfolder>cd web-apps-node-iot-hub-data-visualization  |               |        |      |
| :\myfolder\web-apps-node-iot-hub-data-visualization>set IotHubConnectionString=HostName=azure-sem<br>levices.net;SharedAccessKeyName=service;SharedAccessKey=   | inar-iothub-0 | 901.az | ure- |
| :\myfolder\web-apps-node-iot-hub-data-visualization>set EventHubConsumerGroup=azure_consumer_grou   | p_test        |        |      |
| :\myfolder\web-apps-node-iot-hub-data-visualization>npm install<br>dded 349 packages from 306 contributors and audited 352 packages in 10.488s  |               |        |      |
| packages are looking for funding<br>run `npm fund` for details  |               |        |      |
|   |               |        |      |
| ound 6 vulnerabilities (3 moderate, 3 high)<br>run `npm audit fix` to fix them, or `npm audit` for details  |               |        |      |

Figure 5.7 Command prompt screen

2. Run the demo program according to the procedure in 3.4 Running the demo program.



#### 3. Start your browser and go to http://localhost:3000 to see the temperature data graph.

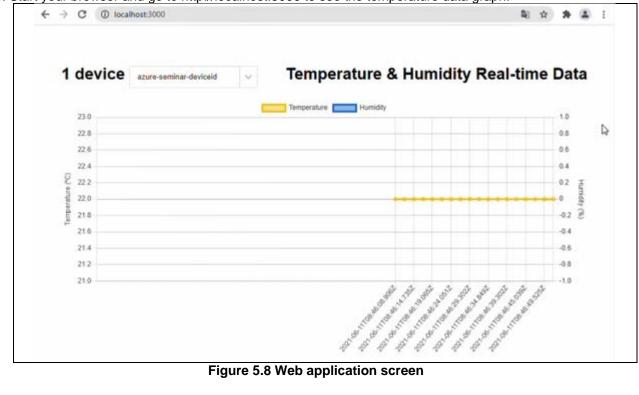


Figure 5.8 Web application screen



# 5.3 Display of graph changes

The sample program allows you to change the value of the sensor data to be uploaded. The changed data can be confirmed in the graph.

1. Go to the **Device ID** you created on the Azure portal  $\rightarrow$  **IoT Plug and Play components**  $\rightarrow$  Scroll down and click **thermostat1** from Component.

| Azure IoT Explorer (preview<br>File Edit View Window H                      |  | - 🗆 X  |
|---|--|--|
| Azure IoT Explorer (  | preview)                                   | 📮 Notifications 🛛 🎯 Settings                 |
| <u>Home</u> > azure-se<br>components  | eminar-iothub-001 > <u>Devices</u> > azure | -seminar-deviceid > IoT Plug and Play        |
| =   | 🕐 Refresh                                  |  |
| <ul> <li>Device identity</li> <li>Device twin</li> <li>Telemetry</li> </ul> | LoT Plug and Play components               |  |
| ✓ Direct method   | Component                                  | Model ID                                     |
| 🖾 Cloud-to-device   | Default component                          | dtmi:com:example:Temperatur<br>eController;1 |
| Module identities 6 <sup>3</sup> IoT Plug and Pla                           | thermostat1                                | dtmi:com:example:Thermostat;<br>1            |
|   | thermostat2                                | dtmi:com:example:Thermostat:                 |

Figure 5.9 Components screen

#### 2. Click Properties (writable).

| Azure IoT Explorer (previe<br>File Edit View Window |  | -                    |          |
|---|--|----------------------|----------|
| Azure IoT Explorer                                  | (preview)  | Notifications        | Settings |
| <u>Home</u> > azure-s<br>components > t             | eminar-iothub-001 > <u>Devices</u> > azure-seminar-devicei<br>hermostat1 | id > <u>loT Plug</u> | and Play |
| Device identity                                     | Interface Properties (read-only) Properties (writable) Comm              | nands Telemetry      | 🕣 Back   |
| Device twin   | You model definition has been resolved from: Local Folder 🛞 Configure    | 2                    |          |
| > Direct method                                     | dtmi:com:example:Thermostat;1  |                      | D        |

Figure 5.10 Properties (writable) selection



3. Enter the temperature data in target Temperature  $\rightarrow$  Click Update desired value.

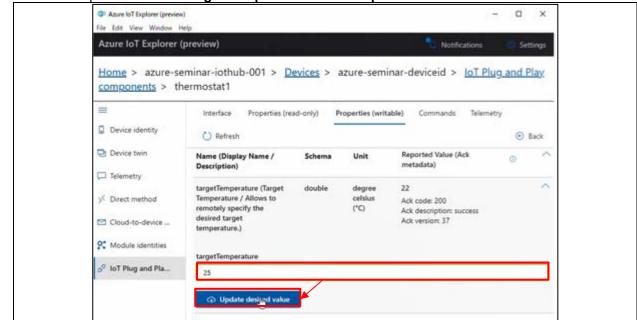


Figure 5.11 Enter the temperature data  $\rightarrow$  Update desired value

4. Go to http://localhost:3000 and check that the graph is changing.

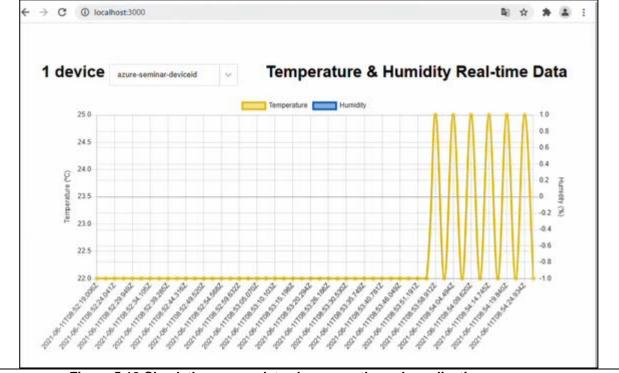


Figure 5.12 Check the sensor data change on the web application screen

5. Click the **Stop** icon on the  $e^2$  studio screen to end the demo run.



# 6. Important Note after Running Demo Program

Fees are incurred when are using the Azure Service. Make sure to delete your account if you will no longer be using it.

# 7. Websites and Support

Azure RTOS: <u>https://azure.microsoft.com/support/community/</u>

Azure RTOS GitHub: https://github.com/azure-rtos

# 8. Appendices

The changes required for the sample program to perform 4. LED ON/OFF operation by Azure IoT Explorer are shown below.

Note: The line numbers in the description indicate the number of lines in the sample program at the time of download.

1. Make the following changes to "{\$base\_folder}/rx65n-cloud-

kit/e2studio\_gnurx/sample\_pnp\_temperature\_controller/src/sample\_pnp\_temperature\_controller.c".

(1) Add the following variable declarations.

| l.143 | <pre>static const CHAR sample_device_info_component[] = "deviceInformation";</pre> |     |  |
|-------|--|-----|--|
|       | static SAMPLE_PNP_THERMOSTAT_COMPONENT sample_led;                                 | 7   |  |
|       | <pre>static const CHAR sample_led_component[] = "LED";</pre>                       | Add |  |
|       | static double sample_led_last_device_reported;                                     |     |  |

#### Figure 8.1 Changed sample\_pnp\_temperature\_controller.c (1)

(2) Add elements for LEDs to the sample\_components array.

| l.146 | static const CHAR *sample_components[] = { sample_thermostat_1_component, |
|-------|---|
| l.147 | sample_thermostat_2_component,  |
|       | sample_led_component, Add   |
| l.148 | <pre>sample_device_info_component };</pre>                                |

Figure 8.2 Changed sample\_pnp\_temperature\_controller.c (2)



|  | 0  |
|--|--|
| if (component_name_ptr == NULL    component_name_len == 0)   |  |
|  |  |
| (昭各)   |  |
| }  |  |
| else if (sample_pnp_led_process_property_update(&sample_led, |  |
| (NX_AZURE_IOT_HUB_CLIENT *)userContextCallback,              |  |
| component_name_ptr, component_name_len,                      |  |
| property_name_ptr, property_name_len,                        |  |
| &property_value_reader, version) == NX_AZURE_IOT_SUCCESS)    |  |
|  |  |
| printf("property updated of led1¥r¥n");                      |  |
|  |  |
| else   | Add  |
| {  | Auu  |
|  |  |
| }  |  |
|  | {<br>(略)<br>else if (sample_pnp_led_process_property_update(&sample_led,<br>(NX_AZURE_IOT_HUB_CLIENT *)userContextCallback,<br>component_name_ptr, component_name_len,<br>property_name_ptr, property_name_len,<br>&property_value_reader, version) == NX_AZURE_IOT_SUCCESS)<br>printf("property updated of led1¥r¥n");<br>else<br>{ |

(3) Add a conditional expression to the following if statement of the sample\_desired\_property\_callback() function



(4) Add conditional expression to the following if statement of sample\_components\_init() function.

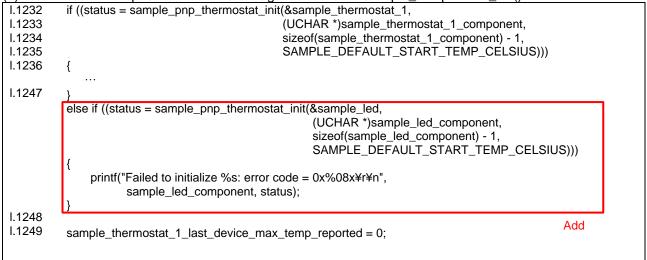


Figure 8.4 Changed sample\_pnp\_temperature\_controller.c (4)



| <ol> <li>Make the following changes to "{\$base_folder}/rx65n-cloud-<br/>kit/e2studio_gnurx/sample_pnp_temperature_controller/src/sample_pnp_thermostat_component.c".</li> </ol>   |  |  |  |  |  |
|--|--|--|--|--|--|
| 1) Add include settings in platform.h file.  |  |  |  |  |  |
| #include "sample_pnp_thermostat_component.h"   |  |  |  |  |  |
| #include "platform.h" Add  |  |  |  |  |  |
| Figure 8.5 Changed sample_pnp_thermostat_component.c (1)   |  |  |  |  |  |
| 2) Add a constant for the data key name <b>LED1</b> that communicates with Azure.  |  |  |  |  |  |
| I.36 static const CHAR temp_response_description_failed[] = "failed";  |  |  |  |  |  |
| <pre>static const CHAR led_property_name[] = "LED1"; Add</pre>   |  |  |  |  |  |
| Figure 8.6 Changed sample_pnp_thermostat_component.c (2)   |  |  |  |  |  |
| 3) Add 2 functions used for Device twin operation.   |  |  |  |  |  |
| Last static VOID sample_send_led_report(SAMPLE_PNP_THERMOSTAT_COMPONENT *handle,<br>line NX_AZURE_IOT_HUB_CLIENT *iothub_client_ptr, double temp,<br>INT status_code, UINT version, const CHAR *description)   |  |  |  |  |  |
| {     UINT bytes_copied;     UINT response_status;     UINT request_id;     NX_AZURE_IOT_JSON_WRITER json_writer;     ULONG reported_property_version;     /* Build telemetry JSON payload */     if (nx_azure_iot_json_writer_with_buffer_init(&json_writer, scratch_buffer, sizeof(scratch_buffer))) |  |  |  |  |  |
| <pre>{     printf("Failed to create json writer¥r¥n");     return; }</pre>   |  |  |  |  |  |
| if (nx_azure_iot_pnp_helper_build_reported_property_with_status(   |  |  |  |  |  |
| <pre>printf("Failed to create reported response¥r¥n"); } else {     bytes_copied = nx_azure_iot_json_writer_get_bytes_used(&amp;json_writer);     if (nx_azure_iot_hub_client_device_twin_reported_properties_send(iothub_client_ptr,</pre>  |  |  |  |  |  |
| &request_id, &response_status,<br>&reported_property_version,<br>(5 * NX_IP_PERIODIC_RATE)))<br>{<br>printf("Failed to send reported response¥r¥n");   |  |  |  |  |  |
| }  |  |  |  |  |  |
| }<br>nx_azure_iot_json_writer_deinit(&json_writer);<br>}   |  |  |  |  |  |

Figure 8.7 Changed sample\_pnp\_thermostat\_component.c (3)-1



# Visualization of Sensor Data using

#### **RX65N Cloud Kit and Azure RTOS**

```
UINT sample_pnp_led_process_property_update(SAMPLE_PNP_THERMOSTAT_COMPONENT *handle,
NX_AZURE_IOT_HUB_CLIENT *iothub_client_ptr,
Last
line
                                               CHAR *component_name_ptr, UINT component_name_length,
                                               UCHAR *property_name_ptr, UINT property_name_length,
                                              NX_AZURE_IOT_JSON_READER *property_value_reader_ptr, UINT version)
           {
               double parsed_value = 0;
               INT status code;
               const CHAR *description;
               if (handle == NX_NULL)
               {
                   return(NX_NOT_SUCCESSFUL);
               }
               if (handle -> component_name_length != component_name_length ||
                 strncmp((CHAR *)handle -> component_name_ptr,
                         (CHAR *)component_name_ptr, component_name_length) != 0)
               {
                   return(NX_NOT_SUCCESSFUL);
               }
               if (property_name_length != (sizeof(led_property_name) - 1) ||
                   strncmp((CHAR *)property_name_ptr, (CHAR *)led_property_name, property_name_length) != 0)
               {
                   printf("PnP property=%.*s is not supported on thermostat component¥r¥n",
                          property_name_length, property_name_ptr);
                   status_code = 404;
                   description = temp_response_description_failed;
               }
               else if (nx_azure_iot_json_reader_token_double_get(property_value_reader_ptr, &parsed_value))
               {
                   status_code = 401;
                   description = temp_response_description_failed;
               }
               else
               {
                   status_code = 200;
                   description = temp_response_description_success;
                   if (parsed_value == 1) // LED ON
                   {
                       PORTB.PDR.BIT.B0 = 1;
                       PORTB.PODR.BIT.B0 = 0;
                   }
                   else
                           // LED OFF
                   {
                       PORTB.PDR.BIT.B0 = 1:
                       PORTB.PODR.BIT.B0 = 1;
                   }
               }
               sample_send_led_report(handle, iothub_client_ptr, parsed_value,
                                       status_code, version, description);
               return(NX_AZURE_IOT_SUCCESS);
                    Figure 8.8 Changed sample_pnp_thermostat_component.c (3)-2
```



# Visualization of Sensor Data using RX65N Cloud Kit and Azure RTOS

3. Make the following changes to "{\$base\_folder}/rx65n-cloud-

|              | 0             | 0    | · · —       | ,                          |                           |
|--------------|---------------|------|-------------|----------------------------|---------------------------|
| kit/a2atudia | anury/aampla  | nnn  | tomporatura | controllar/ara/compla ppp  | _thermostat_component.h". |
| KII/ezstualo | griuix/sample | prip | lemperature | controller/src/sample prip |                           |
|              |               |      |             |                            |                           |

| (1) Add t | he declaration of the sample_pnp_led_process_property_update() function.                    |
|-----------|---|
| 1.65      | UINT sample_pnp_thermostat_process_property_update(SAMPLE_PNP_THERMOSTAT_COMPONENT *handle, |
| I.66      | NX_AZURE_IOT_HUB_CLIENT *iothub_client_ptr,   |
| l.67      | UCHAR *component_name_ptr, UINT component_name_length,                                      |
| 1.68      | UCHAR *property_name_ptr, UINT property_name_length,  |
| I.69      | NX_AZURE_IOT_JSON_READER *property_value_reader_ptr, UINT version);                         |
|           |   |
|           | UINT sample_pnp_led_process_property_update(SAMPLE_PNP_THERMOSTAT_COMPONENT *handle,        |
|           | NX_AZURE_IOT_HUB_CLIENT *iothub_client_ptr,   |
|           | UCHAR *component_name_ptr, UINT component_name_length,                                      |
|           |   |

UCHAR \*property\_name\_ptr, UINT property\_name\_length,

NX\_AZURE\_IOT\_JSON\_READER \*property\_value\_reader\_ptr, UINT version);

Add

Figure 8.9 Changed sample\_pnp\_thermostat\_component.h (1)



# **Revision History**

|      |          | Description |               |  |  |
|------|----------|-------------|---------------|--|--|
| Rev. | Date     | Page        | Summary       |  |  |
| 1.00 | XX.XX.21 | -           | First edition |  |  |
|      |          |             |               |  |  |



# 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 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

6

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. 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.).

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(Rev.5.0-1 October 2020)

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