

# **RX Family**

## Provisioning Procedure for IoT Devices

## Introduction

IoT device provisioning is required in order to connect to AWS IoT, a cloud service provided as part of Amazon Web Services<sup>™</sup> (AWS). As used here, the term "provisioning" refers to the process of generating, utilizing, and managing authentication information such as things, private keys, and device certificates. Provisioning requires consideration of matters such as how to write authentication information to products as part of the manufacturing process (initial installation) and how to manage (protect) and update key data. These types of data are stored in the on-chip flash memory of RX Family MCUs. Since it is extremely difficult to modify the provisioning method for IoT devices afterward, the above-mentioned consideration must begin at the product development stage so that verification can be completed by the mass production phase.

Of the various provisioning methods provided by AWS, this document describes the "fleet provisioning method," which automates provisioning during the manufacturing process and when the device is initially used.

Deploying the fleet provisioning method eliminates the need to devote time and effort to cumbersome provisioning procedures while making the provisioning process more secure and convenient.

What you will learn in this application note

Overview of provisioning methods provided by AWS.

✓ How to realize fleet provisioning using demo and confirm operation. The steps to run the demo will be explained from "4 Running the Fleet Provisioning Demo".

The contents of this document are sufficient to implement provisioning, but if followed unmodified will result in important data saved as part of the provisioning processing, such as the private key and device certificate, being stored as "clear text" (unencrypted text) in the on-chip flash memory of the RX Family MCU. This means that if there is a security hole in a user program programmed to the RX Family MCU that allows arbitrary areas of memory to be read, the provisioning data in the flash memory could be accessed, possibly allowing an attacker to perform an unauthorized login to the user's AWS account.

Using the Trusted Secure IP (TSIP) module of the RX Family MCU enables the private key and device certificate to be stored in encrypted form, greatly reducing the danger of unauthorized access to the provisioning data. For details of the TSIP module, see the page linked to below.

https://www.renesas.com/software-tool/trusted-secure-ip-driver

We strongly encourage using the TSIP module to boost security.

It is possible to reduce the risk of unauthorized access to provisioning data by improving software quality, but this approach can never completely eliminate it. In particular, if there are defects in the software of IoT devices, which are vulnerable to threats posed by attackers, it is recommended that firmware update functionality be used to apply corrections in a timely manner. For more information on firmware updates, please refer to the application note Renesas MCU Firmware Update Design Policy (<u>R01AN5548</u>).



## **Operating Environment**

The operation described in this application note has been confirmed on the following environment.

Integrated development environment	e <sup>2</sup> studio 2023-10
Board	CK-RX65N
Toolchain	CC-RX Compiler v3.05.00
Emulator	E2OB (E2 Lite On Board) module of CK-RX65N

Before applying the contents of this application note to another MCU, a review of product-specific settings matching the specifications of the MCU should be made and adequate evaluation performed.

## **Related Application Notes**

Information on documents related to this application note is provided below. Refer to these documents as necessary.

- Renesas MCU Firmware Update Design Policy (R01AN5548)
- RX Family How to implement FreeRTOS OTA by using Amazon Web Services on RX65N (R01AN5549)
- Firmware Integration Technology User's Manual (R01AN1833)
- RX Family Adding Firmware Integration Technology Modules to Projects (R01AN1723)

Information about boards, related programs, and development tools needed to develop RX cloud solutions is summarized on the page linked to below.

#### https://www.renesas.com/rx-cloud

Also, the following information publicly released by AWS may be of use. (The first two items are only available in Japanese.)

- Provisioning authentication information to devices in AWS IoT Video: <u>https://youtu.be/gcJwNEQ2eLY</u> Document: <u>https://pages.awscloud.com/rs/112-TZM-766/images/EV\_iot-deepdive-aws2\_Sep-2020.pdf</u>
- Document on fleet provisioning templates
   <u>https://docs.aws.amazon.com/iot/latest/developerguide/provision-template.html</u>
- Document on AWS IoT Core policies
   https://docs.aws.amazon.com/iot/latest/developerguide/iot-policies.html
- AWS IoT API reference document: CreateCertificateFromCsr
   <u>https://docs.aws.amazon.com/iot/latest/apireference/API\_CreateCertificateFromCsr.html</u>
- Provisioning devices that don't have device certificates using fleet provisioning
   <u>https://docs.aws.amazon.com/iot/latest/developerguide/provision-wo-cert.html</u>
- How to automate onboarding of IoT devices to AWS IoT Core at scale with Fleet Provisioning
   <u>https://aws.amazon.com/blogs/iot/how-to-automate-onboarding-of-iot-devices-to-aws-iot-core-at-scale-with-fleet-provisioning/</u>



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• FreeRTOS<sup>™</sup> is a trademark of Amazon Web Services, Inc. (<u>https://freertos.org/copyright.html</u>)



## 1. Terminology

The following terms are used in this document.

#### Table 1.1 List of Terms

Term	Meaning
AWS	A suite of cloud computing services provided by Amazon Web Services, Inc.
FreeRTOS	An open-source real-time operating system for embedded systems.
Provisioning	Device provisioning. Certification of a device to enable communication with AWS IoT Core.
Fleet provisioning	Functionality that implements automated provisioning of IoT devices when they are turned on for the first time.

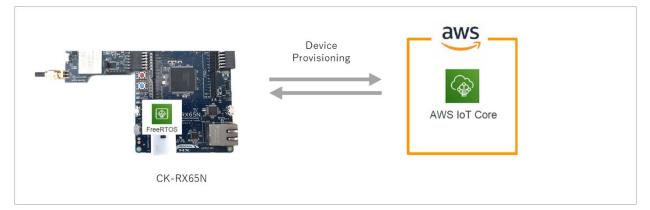


### 2. Device Provisioning

IoT device provisioning refers to the process of generating a unique ID (such as an X.509 certificate or private key) for a device, registering the unique ID with an AWS IoT endpoint, and linking the necessary access privileges (IoT policies, etc.) to enable the device to connect securely to AWS IoT and other cloud-based applications. (See Figure 2.2)

Device provisioning on AWS IoT makes use of AWS IoT Core functionality such as just-in-time-registration (JITR) and just-in-time-provisioning (JITP) to automate the process of registering the identity of each device in the AWS cloud and linking it with the necessary permissions, making it easy the perform provisioning for multiple devices. However, the process of securely generating a unique ID and writing it to each device is the responsibility of the user, and for OEM vendors manufacturing large numbers of devices, this process can involve manual operations and be quite time consuming.

Fleet provisioning, which is described in this document, is one way to deal with this issue.



#### Figure 2.1 Device Provisioning

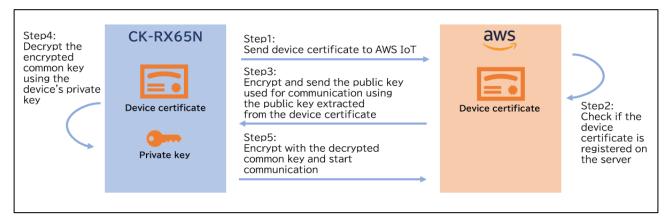


Figure 2.2 IoT Device Provisioning



## 2.1 Provisioning Methods of AWS IoT

AWS IoT allows the user to select from the provisioning methods listed below.

AWS allows the user to select the device provisioning method that best matches their application. Multiple provisioning methods are available to accommodate market demand and a variety of use cases. The following document describes now the various provisioning methods work as well as their advantages and disadvantages in order to assist users in making a selection. We recommend referencing this document when considering the different provisioning methods.

https://pages.awscloud.com/rs/112-TZM-766/images/EV\_iot-deepdive-aws2\_Sep-2020.pdf#page=115

[ Provisioning Methods of AWS IoT ]

- 1. Private key and certificate issuance and pre-registration by AWS IoT (registration at time of device kitting)
- 2. Certificate issuance and pre-registration by AWS IoT (registration at time of device kitting)
- 3. Fleet provisioning registration (Described in this document.)
- 4. Certificate issuance by your own certification authority and pre-registration on AWS IoT
- 5. Certificate issuance by your own certification authority and registration by JITR
- 6. Certificate issuance by your own certification authority and registration by JITP
- 7. Registration of a certificate from an unregistered certification authority (multi-account registration)

When confirming the operation of FreeRTOS at the preliminary stages when considering mass production, the simplest approach is "private key and certificate issuance and pre-registration by AWS IoT." In this case a private key certificate is issued and the source code is converted on AWS, and the resulting source code is embedded in the source code of FreeRTOS. However, it is difficult to embed individual certificates during manufacturing using this method. For this reason, this document focuses on fleet provisioning, which does not require use of a certification authority and imposes the lightest workload during mass production.

Note: A part of RX Family MCUs incorporate a Trusted Secure IP (TSIP) module. When the TSIP is used, an on-chip random number generator is used to generate an RSA or elliptic curve cryptosystem key pair, and the public key is extracted and sent to a user-specified certification authority, which appends and returns a certificate. This enables implementation of JITR or JITP. This method provides strong security while reducing the implementation cost, and it should be considered for practical use moving forward.



## 2.2 Fleet Provisioning Method

Fleet provisioning is a procedure in which provisioning takes place when each IoT device is started for the first time. Generally speaking, it can be implemented in either of the following two ways.

- 1. Provisioning by claim (approach using provisioning claim certificates)
- 2. Provisioning by trusted user (mobile or web app user, etc.)

In addition, either of the following two procedures can be used to obtain the individual certificates and private keys used for fleet provisioning.

- A) Having the AWS certification authority generate a new individual certificate and private key and send it to the device (CreateKeysAndCertificate).
- B) Generating a key pair on the device internally and sending a certificate signature request (CSR) to AWS to have them generate only an individual certificate and send it to the device (CreateCertificateFromCsr).

This document describes the implementation of a fleet provisioning demo that combines 1. and B). (See Figure 2.6.) The provisioning method presented in this document provides the following advantages.

#### Advantages:

- The device's private key never leaves the device.
- There is no need to establish a connection between the manufacturing plant and AWS loT.
- There is no need to put in place a structure for issuing individual certificates or registering devices.

On the other hand, it also has the following disadvantages. It is necessary to be aware of both the advantages and the disadvantages when using this provisioning method.

#### Disadvantages:

- It is necessary to take into account the possibility that the provisioning claim certificate could leak to an unauthorized party.
- It is necessary to implement functionality on the device to issue a provisioning request and receive a response.



## 2.3 Provisioning by Claim (Approach Using Provisioning Claim Certificates)

Each device can be manufactured with an embedded provisioning claim certificate and private key. If these credentials have been registered with AWS IoT, AWS IoT can exchange them for a unique device certificate that can then be used in the normal operation of the device. This process consists of the steps listed below.

The design of provisioning by claim assumes a scenario in which all the devices are manufactured using a common provisioning claim certificate. The provisioning claim certificate only allows each device to do the following.

- 1. Establish an initial connection to AWS IoT Core.
- 2. Verify identity.
- 3. Use data communication as described below to request an ID to which the necessary permissions have been assigned.

The provisioning claim certificate common to all the devices is written to each device, along with the initial software, at a site such as the manufacturing plant. If the device already contains an individual private key, it can send a provisioning claim certificate to be signed by AWS IoT Core and a certificate signature request (CSR). (See Figure 2.6.)

In addition to the provisioning claim certificate presented by each device, fleet provisioning can make use of Lambda-based provisioning hooks to verify the attributes of devices. Examples of device attributes include serial number, MAC ID, and device location. We recommend that you consider making use of Lambda functions in provisioning transactions as a way to automate acceptance or rejection of the provisioning status of individual devices based on the custom attributes sent during this process.

(The demo project described in this application note does not make use of Lambda functions.)

Refer to the page linked to below for information on using AWS Lambda for provisioning.

https://docs.aws.amazon.com/iot/latest/developerguide/provision-wo-cert.html

"Using pre-provisioning hooks with the AWS CLI"



#### 2.3.1 Overview of Provisioning by Claim (Using Provisioning Claim Certificate)

When the device is powered on and capable of establishing a network connection, one of the following workflows is executed.

Figure 2.5 and Figure 2.6 show the workflows for the CreateKeysAndCertificate method and CreateCertificateFromCsr method, respectively.

Also, you can confirm the details of the AWS IoT Fleet Provisioning Demo workflow (CreateCertificateFromCsr method), on which the fleet provisioning demo described in this document is based, by visiting the page linked to below.

https://aws.github.io/aws-iot-device-sdk-embedded-C/latest/docs/doxygen/output/html/fleet\_provisioning\_demo.html

- Using the claim certificate written to the device beforehand, the device connects to AWS IoT Core via a secure TLS 1.2 connection. If the device contains a CSR, this is presented along with the provisioning claim certificate.
- 2. The certificate is linked to an extremely restrictive policy that only provides access to IoT topics linked to the fleet provisioning process.
- 3. The fleet provisioning service returns a token providing "proof of ownership" to securely isolate the transaction and a valid certificate and private key payload. The token will be called later to activate the certificate. If a CSR was presented, it is used to generate the certificate.
- 4. The device sends a MQTT request to AWS IoT Core and presents the ownership token, the name of the fleet provisioning template created by the account owner, and (optionally) device attributes for provisioning validation. It is recommended that Lambda-based provisioning hooks be used to enable additional validation, such as checking the device's serial number or MAC ID against a pre-approved list.
- 5. The fleet provisioning template is acted upon, the provisioning transaction takes place, and the results are returned. Typically, these results may include verification by Lambda function of device attributes, certificate activation, production policy attachment, and thing or group creation (optional).
- 6. Based on the results of the provisioning transaction, the status of the new certificate is returned. If the transaction was successful, the provisioning claim certificate is deprecated or rotated for the "production" certificate. If the transaction is denied, an "access denied" error is returned to the device.



## **RX** Family

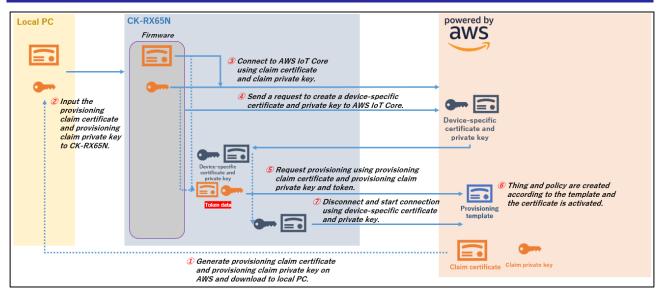


Figure 2.3 Workflow of Provisioning by Claim Using CreateKeysAndCertificate Method

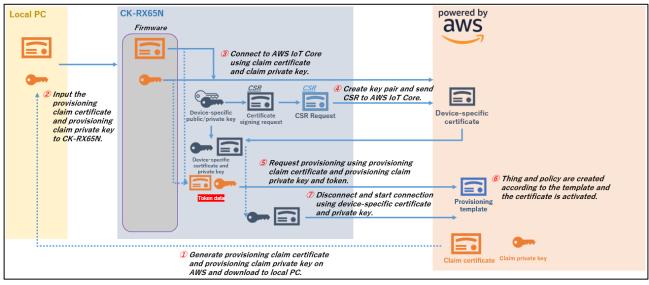


Figure 2.4 Workflow of Provisioning by Claim Using CreateCertificateFromCsr Method



#### **RX** Family

#### 2.3.2 Determining a Unique Thing Name

When sending a request to MQTT during fleet provisioning, the device's serial number can be included in the payload to ensure that each device has a unique thing name that does not duplicate an existing one.

Generally speaking, one of the following two methods is used to determine the serial number.

- 1. A random value generated by a random number generator or an ID value unique to the device is used as the serial number.
- 2. A Lambda-based provisioning hook and Amazon S3 or a user-specified database are used to change a temporarily assigned serial number to a unique serial number.

The example described in this document makes use of method 1. The unique ID assigned to each RX Family MCU is used to prevent duplication of thing names.



Figure 2.5 Using a Random Value or Unique ID to Determine the Thing Name

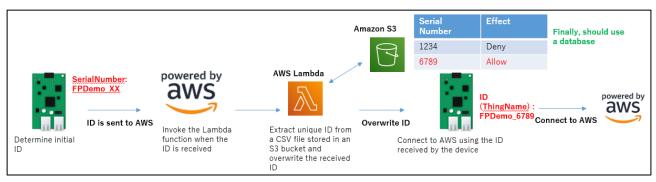


Figure 2.6 Using Amazon S3 or a Database to Determine the Thing Name



#### 3. Preparation

This section and those that follow describe the sequence of steps from importing the project accompanying this application note to running the fleet provisioning demo on the CK-RX65N board.

#### 3.1 Hardware Environment

The components of the hardware environment for the demo project are listed below.

#### Table 3.1 Hardware Components

ltem	Product Name	Provider	Description
Board	CK-RX65N	Renesas Electronics Corporation	RX65N Cloud Kit
PC	PC running Windows 10 (recommended)	—	Host PC for demo

#### 3.2 Software Environment

The components of the software environment for the demo project are listed below.

#### Table 3.2 Components

Item	Product Name	Version	Description
Integrated development environment	e <sup>2</sup> studio	2023-10	
Toolchain	CC-RX	v3.05.00	—
Communication software	Tera Term	Ver 4.106	For displaying logs
Emulator	E2OB (E2 Lite On Board) module of CK-RX65N	—	—

#### 3.3 Tera Term Settings

The demo uses Tera Term to display log output. Configure the settings in Tera Term as shown below.

Table 3.3	Tera Term	Settings
-----------	-----------	----------

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



#### 3.4 FreeRTOS Project

Figure 3.1 shows the software components of the demo project.

Renesas software / hardware FreeRTOS related software	Demo application described in this document
Fleet Provisioning	demo Application
AWS IoT Fleet Pro	ovisioning Library
Freel	RTOS
RX Drive	r Package
	65N

Figure 3.1 Components of Demo Project Accompanying This Application Note

The AWS IoT Fleet Provisioning Library for FreeRTOS is used to implement fleet provisioning functionality. RX Driver Package, FreeRTOS, AWS IoT Fleet Provisioning Library, and the demo application are available from the repository linked to below.

Demo application: <u>iot-reference-rx</u> : FreeRTOS reference repository



## 4. Running the Fleet Provisioning Demo

How to run the fleet provisioning demo application is described below.

#### 4.1 **Preparing the Running Environment**

First, prepare the environment on which the demo will run. Figure 4.1 shows an example using the CK-RX65N board. Either a wired (Ethernet) or wireless (cellular) communication interface can be used to connect to AWS.

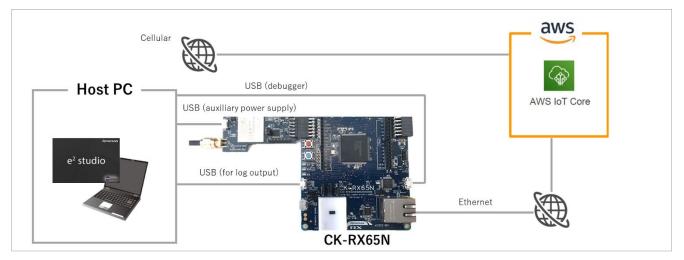


Figure 4.1 Demo Running Environment



#### 4.2 AWS Preparation

An AWS account is required to run the fleet provisioning demo application. If you do not have an account, start by creating an account and logging in to the console. Note that the screenshots of the AWS console appearing in this application note are current as of September 2023.

AWS top page (<u>https://aws.amazon.com/</u>)

#### (1) Select Sign In to the Console $\rightarrow$ Get Started for Free to create a new account.

	Contact Us Support - English - My Account - Sign In to the Console
AWS Marketplace Customer Enablement Events Expl	ore More Q
2 Click Sign In to the Console an	d sign in.
	Contact Us Support + English + My Account + Sign In to the Console
AWS Marketplace Customer Enablement Events Expl	ore More Q
2 Soloot Somuicos Internet of T	<b>Things</b> $\rightarrow$ <b>IoT Core</b> to open the AWS IoT console.
Services Q Search	[Alt+S]
Application Integration	FreeRTOS
🛗 AWS Cost Management	FreeRTOS is an IoT Operating System for Microcontrollers
888 Blockchain	
Lusiness Applications	IoT 1-Click Trigger AWS Lambda functions from simple devices
Compute	
🖮 Containers	IoT Analytics
Cuttomer Enablement	Collect, preprocess, store, analyze and visualize data of IoT devices
Database	IoT Core
X Devuloper Tools	Connect Devices to the Cloud
End User Computing	IoT Device Defender
	Secure your fleet of connected IoT devices
Frontend Web & Mobile	
🕅 Game Development	IoT Device Management Securely Manage Fleets as Small as One Device, or as Broad as Millions of Devices
Internet of Things	
Machine Learning	IoT Events
Management &	Detect and respond to events from IoT sensors and Industrial IoT equipment
Governance	





### 4.3 AWS Settings for Fleet Provisioning

It is necessary to configure AWS settings in order to run the fleet provisioning demo.

- 1. Policy settings
- 2. Generating a claim certificate and claim key pair
- 3. Creating a fleet provisioning template

#### 4.3.1 Policy Settings

Follow the steps below to create AWS IoT Core policies. The first policy you create will be used when fleet provisioning is run.

AWS IoT X	AWS IOT > Security > Policies
Monitor	AWS IoT policies (1) Info AWS IoT policies allow you to control access to the AWS IoT Core data plane operations. AWS IoT policies are separate and different from IAM policies.
Connect Connect one device Connect many devices	C     Delete     Create policy       Q     Find policies       Delete     Policy name
Test	ck rx65n der/o policy
<ul> <li>Device Advisor</li> <li>MQTT test client</li> <li>Device Location New</li> </ul>	
Manage	
All devices	
<ul> <li>Greengrass devices</li> <li>LPWAN devices</li> </ul>	
Software packages New	
<ul> <li>Remote actions</li> </ul>	
Message routing	
Retained messages  Retained messages  Security  Intro Certificates  Certificate authorities	

Select **Security**  $\rightarrow$  **Policies** and then click the **Create policy** button.

Figure 4.3 Creating an AWS IoT Policy (1)



In the **Policy name** field, enter a policy name of your choice.

Click the **JSON** button to display the policy document input field, then copy and paste the policy document shown in Figure 4.5 into the input field. When copying and pasting the policy document in Figure 4.5, make the following changes:

• Change "ap-northeast-1" to match the region used.

• Change <account id> to your own account ID (account ID is the 12-digit number after @ that is displayed by clicking on the account name in the upper right corner, excluding the hyphen)

Click the **Create** button to create the policy.

Policy propertie The dree supports named publics to that many identities can reference the same publicy documents.	Create policy Info AWS IoT Core policies allow you to manage access to the AWS IoT Core data plane operations.	
Peddy/Marrel         A policy statements         Palicy statements         Policy document info         An MDS information once or more policy statements. Each policy statements contain action, resource, and an effect that grants or drains the actions by the resource.         Policy document         * MDS information         * MDS information         * MDS information         * Source		
L palar same is an algebraument, string that can also contribupering {} underscore {} being logit regard sign (?), and at sign (g)) characters, but on spaces. Tags - optional Policy statements Policy contains one more policy statement. Each policy statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statements {} being regard statements. Each policy statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statements {} contains contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statements {} contains contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statements {} contains contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statement {} for statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statement {} for statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statement {} for statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statement {} for statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statement {} for statement {} for statement contains actions, resources, and an effect that grants or denies the actions by the resource. Policy Statement {} for statemen	Policy name	
Tags - optiond          Noticy statements       Policy examples                 Policy document info             And but policy contains one or more policy attements. Each policy attement contains actions, resources, and an effect that youts or denies the actions by the resource.                  Policy document               Subject to fifty and the policy document actions actions, resources, and an effect that youts or denies the actions by the resource.               Subject to fifty actions                 Policy document               Subject to fifty actions               Subject to fifty actions               Subject to fifty actions               Subject to fifty actions                 Solver and passite the text of the policy document heree.                 Solver 10: Copy and passte the text of the policy document heree.                 Solver 10: Copy and passte the text of the policy document heree.                 Solver 10: Course 1             Out actions                 Solver 10: Course 1             Out actions                 Solver 10: Course 1             Out actions	PolicyName	
Policy statement Policy scattements. Each policy statement contains actions, resources, and an effect that grants or denies the actions by the resource.   Policy document   Policy document     ************************************	A policy name is an alphanumeric string that can also contain period (.), comma (.), hyphen(-), underscore (_), plus sign (+), equal sign (-), and at sign (@) characters, but no spaces.	
Policy document ind       During:	► Tags - optional	
An AWS for policy contains one or more policy statements. Each policy statement contains actions, resources, and an effect that grants or denies the actions by the resource.	Policy statements Policy examples	
Image: Statement *: [         ************************************		Builder J50N
Cancel Create	<pre>1 Version": "2012-10-17", 2 "Version": "2012-10-17", 4 ( 5 "Effect": "Allow",</pre>	
		Cancel

Figure 4.4 Creating an AWS IoT Policy (2)



```
{
 "Version": "2012-10-17",
 "Statement": [
   {
     "Effect": "Allow",
     "Action": "iot:Connect",
     "Resource": "*"
   },
   {
     "Effect": "Allow",
      "Action": [
       "iot:Publish",
       "iot:Receive",
       "iot:RetainPublish"
     ],
     "Resource": [
       "arn:aws:iot:ap-northeast-1:<account id>:topic/$aws/certificates/create-from-csr/*",
       "arn:aws:iot:ap-northeast-1:<account id>:*"
     ]
   },
   {
     "Effect": "Allow",
     "Action": "iot:Subscribe",
      "Resource": [
       "arn:aws:iot:ap-northeast-1:<account id>:topicfilter/$aws/certificates/create-from-csr/*",
       "arn:aws:iot:ap-northeast-1:<account id>:*"
      ]
   }
 ]
}
```

Figure 4.5 Policy Document



Next, create a policy that will be attached to things created after fleet provisioning is run.

Select **Security**  $\rightarrow$  **Policies** and then click the **Create policy** button.

AWS IoT ×	AWS IOT > Security > Policies
Monitor	AWS IOT policies (1) Info AWS IOT policies allow you to control access to the AWS IoT Core data plane operations. AWS IoT policies are separate and different from IAM policies.
Connect Connect one device Connect many devices	C     Delete     Create policy       Q. Find policies
Test	ck.rx65n.demo.policy.
Device Advisor	
MQTT test client	
Device Location New	
Manage	
All devices	
<ul> <li>Greengrass devices</li> <li>LPWAN devices</li> </ul>	
Software packages New	
<ul> <li>Remote actions</li> </ul>	
Message routing	
Retained messages	
Security     Intro     Certificates     Policies	
Certificate authorities	



In the **Policy name** field, enter a policy name of your choice.

For **Policy action** under **Policy document**, select **Allow** for **iot:Connect**, **iot:Publish**, **iot:Subscribe**, and **iot:Receive**. For **Policy resource** enter the wildcard character (\*) to allow all resources. By default you can configure one statement. Click the **Add new statement** button to add additional statements as needed.

PolicyName					
policy name is an alphanumeric st	tring that can also contain perio	od (.), comma (.), hyphen(-), underscore (_), plus sign (+), equal	sign (=), and at sign (@) characters, but no space	5.	
• Tags - optional					
olicy statements Polic	y examples	<b>\</b>			
olicy document Info					the second se
n AWS IoT policy contains one or r		olicy statement contains actions, resources, and an effect that			Builder JSON
		Policy action	grants or denies the actions by the resources. Policy resource	Remove	Builder JSON
AWS IoT policy contains one or r plicy effect Allow		Policy action lot:Connect	Policy resource	Remove	Builder JSON
n AWS IoT policy contains one or r olicy effect Allow	•	Policy action lot:Connect	Policy resource		Builder JSON
AWS IoT policy contains one or r	•	Policy.action lot:Connect lot:Publish lot:Subscribe	Policy resource	Remove	Builder JSON



#### 4.3.2 Generating a Claim Certificate and Claim Key Pair

Generate a provisioning claim certificate and provisioning claim key pair for use in fleet provisioning.

#### Select Security $\rightarrow$ Certificates and then click Add certificate $\rightarrow$ Create certificate.

Device Location New	AWS IoT > Security > Certificates	
Manage All devices Greengrass devices LPWAN devices	Certificates Info X.509 certificates authenticate device and client connections. Certificates must be registered with AWS IoT and activated before a device or client can communicate with AWS IoT. Certificates Certificates you've transferred Certificates	
Software packages New <ul> <li>Remote actions</li> <li>Message routing</li> </ul>		Add certificate 🔺
Retained messages  Security		Register certificates
Intro	O         June 26, 2023, 16:35:26 (UTC+09:00)	
Policies	□	
Certificate authorities	□ Ø Active May 18, 2023, 10:36:39 (UTC+09:00)	
Role aliases Authorizers	□ Ø Active May 17, 2023, 17:04:26 (UTC+09:00)	

Figure 4.6 Creating a Certificate



#### Click Auto-generate new certificate (recommended) $\rightarrow$ Create.

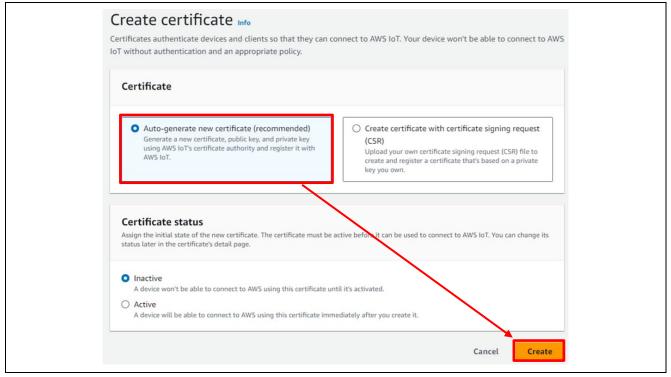


Figure 4.7 Creating a Certificate Automatically

Download the newly created certificate (1) and key pair (2)(3), then click the **Continue** button.

Download certificates and keys
Download certificates and keys Download and install the certificate and key files to your device so that it can connect securely to AWS IoT. You can download the certificate now, or later, but the key files can only be downloaded now.
Device certificate          Device certificate         Image: Certificate downloaded
Key files The key files are unique to this certificate and can't be downloaded after you leave this page. Download them now and save them in a secure place.
This is the only time you can download the key files for this certificate.
Public key file
Private key file 3 Download S Key downloaded
Root CA certificates Download the root CA certificate file that corresponds to the type of data endpoint and cipher suite you're using. You can also download the root CA certificates later.
Amazon trust services endpoint RSA 2048 bit key: Amazon Root CA 1
Amazon trust services endpoint ECC 256 bit key: Amazon Root CA 3
If you don't see the root CA certificate that you need here, AWS IoT supports additional root CA certificates. These root CA certificates and others are available from our developer guides.
Continue

Figure 4.8 Downloading the Certificate and Key Pair



#### RX Family

On the AWS console, select **Security**  $\rightarrow$  **Certificates** and select the newly generated certificate ID.

Connect Connect one device Connect many devices	AWS IOT > Security > Certificates Certificates Info X.509 certificates authenticate device and client connections. Certificate	es must be registered with AWS IoT and activat	ed before a device or client can communicate with A
Test	Certificates Certificates you've transferred		
Device Advisor			
MQTT test client	Certificates (15)		
Device Location New	Q. Find certificates		
Manage			1
<ul> <li>All devices</li> </ul>	Certificate ID	⊽ Status ⊽	Created
Greengrass devices		⊖ Inactive	September 07, 2023, 18:50:57 (UTC+09:00)
LPWAN devices		⊘ Active	June 26, 2023, 16:35:26 (UTC+09:00)
Software packages New		⊘ Active	May 18, 2023, 10:49:25 (UTC+09:00)
<ul> <li>Remote actions</li> <li>Message routing</li> </ul>		⊘ Active	May 18, 2023, 10:36:39 (UTC+09:00)
Retained messages		⊘ Active	May 17, 2023, 17:04:26 (UTC+09:00)
▼ Security		⊘ Active	May 17, 2023, 17:04:24 (UTC+09:00)
Intro		⊘ Active	May 17, 2023, 17:00:16 (UTC+09:00)
Policies		⊘ Active	May 17, 2023, 16:54:23 (UTC+09:00)
Certificate authorities		⊘ Active	May 17, 2023, 16:53:37 (UTC+09:00)

Figure 4.9 Certificate Settings



Click Actions  $\rightarrow$  Activate to activate the certificate. Also click the Attach policies button.

	Info	Actions
		Activate
etails artificate ID artificate ARN ubject v=AWS IoT Certificate suer U=Amazon Web Services O=Amazon.com Inc. L=Seattle ST=Washington C=US	Status → Inactive Created September 07, 2023, 18:50:57 (UTC+09:00) Valid September 07, 2023, 18:48:57 (UTC+09:00) Expires January 01, 2050, 08:59:59 (UTC+09:00)	Deactivele Revoke Accept transfer Reject transfer Start transfer Attach policy Attach to things Downlo d Delete
olicies (0) Info VS IOT policies allow you to control access to the AWS IOT Core data plane operations.	C	Detach policies Attach policies
Name		
	No policies	

Figure 4.10 Certificate Settings: Attach Policies (1)

Clicking the Attach policies button opens the dialog box shown in Figure 4.11.

Select the policy to be used when fleet provisioning is run, created in 4.3.1, Policy Settings, and then click the **Attach policies** button to attach it to the certificate.

This completes the settings related to generation of the claim certificate and claim key pair.

Attach policies to the certifi	
Policies Choose policies to attach to this certificate.	. The certificate can have up to 10 policies attached to it.
Choose AWS IoT policy	▲ C
Q	
- 1	
✓ fp_demo_policy	

Figure 4.11 Certificate Settings: Attach Policies (2)



#### 4.3.3 Creating a Fleet Provisioning Template

Select Connect many devices  $\rightarrow$  Connect many devices, then click the Create provisioning template button.

AWS IoT ×	AWSIOT > Connect > Connect many devices		
Monitor	▼ How it works		
Connect Connect one device ▼ Connect many devices Buik registration		Image: Constraint of the constraint	
Test Device Advisor MQTT test client Device Location New	Step 1. Determine providioning scenario Devices need a unique certificate to come to <u>avys</u> IoT. You can install this certificate during the device's manufacture. You day device is provisioned by an authenticated user, or by installing a class certificate that's exchanged for a unique device certificate the first time the device connects to AVS IoT. Learn more	Step 2. Define device management structure Connected devices are represented in AWS IoT by thing resources, which help you organize, manage, and maintain your devices. Thing secures, thing groups, thing types, searchable attributes, and billing groups also the user manage your devices and can also be created when the device is provisible.	Step 3. Create a provisioning template A provisioning template is a JSON document that describes the resources, policies, and permissions to create for the device when it's provisioned. Learn more
Manage  All devices  Greengrass devices  LPWAN devices	Connect many devices (0) info To connect many devices, the provisioning template automates the provisioning regul	red to connect new devices.	Deactivate Delete Create provisioning template
Software packages <u>New</u> Remote actions Message routing	Name A Template type	▼ Created date ▼ State	
Retained messages     Security     Fleet Hub		No provisioning templates You don't have any provisioning templates in us-east-1. Create provisioning template	

Figure 4.12 Creating a Provisioning Template (1)

Select Provisioning devices with claim certificates, then click the Next button.

#### Create provisioning template

Provisioning scenario Choose the provisioning scenario that fits your device manufacturing and installation pr	ocesses the best. Learn more 🖸	
<ul> <li>Provisioning devices with unique certificates (JITP) - recommended</li> <li>Your IoT devices will be installed with unique device certificates already on the device. This scenario is also known as just-in-time provisioning (JITP).</li> </ul>	Provisioning devices by authorized users Your IoT devices don't have unique certificates when they are installed. Authorized installers or end users use an app to provision the devices before they are connected to AWS IoT. In this scamator, you provide the installation app to configure the device during installation and the device's firmware must support this provisioning process. This is also known as fleet provisioning with user.	Provisioning devices with claim certificates Choose this option if your IoT devices are delivered with claim certificates that are shared with other devices. The devices use their claim certificate is replaced with unique device certificate after provisioning. This option is also known as flee provisioning with certificate.
To provision devices with claim certificates Learn more → → → → → → → → → →	OOO     Set provisioning actions  A Set provisioning actions  Configure how AWS IoT should provision your IoT device when it uses the claim certificate to connect to AWS IoT. You describe the AWS IoT resources and permissions that AWS will create for your device in a provisioning template that provisions your device when it uses the claim certificate to connect.	Connect devices      S. Connect devices      When your lof devices use the claim certificate to connect to AWS lo     the device is provisioning template. Dur     the provisioning process, a unique device certificate is created and     installed on your loT device for all subsequent connections to AWS lo

Figure 4.13 Creating a Provisioning Template (2)



On the template creation screen, specify the provisioning template status, template name, and provisioning role. For **Provisioning template status** select **Active**, and enter the name of the provisioning template. Then click the **Create new role** button and enter the role name.

Provisioning template properties Info   Provisioning template status The provisioning template status determines whether the template can be used to provision a new device. Only active templates can provision devices.    Inactive templates can't provision any devices that are configured to use it. You can create an inactive template to prevent devices from being provisioned until you're ready.    Active   An active template can provision the devices that are configured to use it.   Provisioning template name   Enter_template_name   The name can have up to 36 characters and must not contine spaces. Valid characters: A-Z, a-z, 0-9, and _ (underscore) and - (hyphen).   Description - optional   A description of the provisioning template you're creating.   500 character remaining   Provisioning role   The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalte.   Choose an IAM role	escribe provisioning template Info	
Provisioning template status The provisioning template status determines whether the template can be used to provision a new device. Only active templates can provision devices.  Inactive templates can't provision any devices that are configured to use it. You can create an inactive template can provision the devices from being provisioned until you're ready.  An active template can provision the devices that are configured to use it. Provisioning template name Enter_template_name The name can have up to 36 characters and must not control spaces. Valid characters: A-Z, a-Z, 0-9, and _ (underscore) and - (hyphen). Description - optional A description of the provisioning template you're creating.  Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts. Choose an IAM role Attach managed policy to IAM role	e details on this page describe the general aspects of the provisioning template that you're creating.	
The provisioning template status determines whether the template can be used to provision a new device. Only active templates can provision devices.  Inactive Inactive templates can't provision any devices that are configured to use it. You can create an inactive template to prevent devices from being provisioned until you're ready.  Active An active template can provision the devices that are configured to use it.  Provisioning template name Enter_template_name The name can have up to 36 characters and must not contXin spaces. Valid characters: A-Z, a-z, 0-9, and _ (underscore) and - (hyphen).  Description - optional A description of the provisioning template you're creating.  So0 character remaining Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts  Choose an IAM role Attach managed policy to IAM role	Provisioning template properties Info	
An active template can provision the devices that are configured to use it.  Provisioning template name Enter_template_name The name can have up to 36 characters and must not contain spaces. Valid characters: A-Z, a-z, 0-9, and _ (underscore) and - (hyphen). Description - optional A description of the provisioning template you're creating. 500 character remaining Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalte Choose an IAM role Attach managed policy to IAM role	<ul> <li>provision devices.</li> <li>Inactive</li> <li>Inactive templates can't provision any devices that are configured to use it. You can create an</li> </ul>	1
Provisioning template name Enter_template_name The name can have up to 36 characters and must not contain spaces. Valid characters: A-Z, a-z, 0-9, and _ (underscore) and - (hyphen). Description - optional A description of the provisioning template you're creating. 500 character remaining Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts Choose an IAM role Attach managed policy to IAM role	<ul> <li>Active</li> <li>An active template can provision the devices that are configured to use it.</li> </ul>	
Enter_template_name   The name can have up to 36 characters and must not contain spaces. Valid characters: A-Z, a-z, 0-9, and _ (underscore) and - (hyphen). Description - optional   A description of the provisioning template you're creating.   500 character remaining   Provisioning role   The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalty.   Choose an IAM role   View   Attach managed policy to IAM role		
Description - optional A description of the provisioning template you're creating. 500 character remaining Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts Choose an IAM role  Create new role Attach managed policy to IAM role	Enter_template_name	
A description of the provisioning template you're creating. 500 character remaining Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts Choose an IAM role Create new role Attach managed policy to IAM role	The name can have up to 36 characters and must not contain spaces. Valid characters: A-Z, a-z, 0-9, and _ (underscore) and - (hypher	n).
500 character remaining Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts Choose an IAM role  ✓ View C Create new role ✓ Attach managed policy to IAM role	Description - optional	
Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts Choose an IAM role  Choose an IAM role  Attach managed policy to IAM role	A description of the provisioning template you're creating.	
The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts.  Choose an IAM role  ✓ C View C Create new role  ✓ Attach managed policy to IAM role	500 character remaining	
Attach managed policy to IAM role	Provisioning role The provisioning role uses an IAM role that authorizes AWS IoT to access resources on your behalts	
	Choose an IAM role   Choose an IAM role  Create new role	
Tags - optional	Attach managed policy to IAM role	
Tags - optional		
	Tags - optional	

Figure 4.14 Creating a Provisioning Template (3)



#### **RX** Family

For **Claim certificate policy**, select the policy to be used when fleet provisioning is run, created in 4.3.1, for **Claim certificate**, select the certificate created in 4.3.2, and click the **Next** button.

he claim certificate requires a po loesn't apply to the device certific							
Claim certificate provisioning choose the AWS IoT policy that an ertificates you choose in the next	thorizes the claim ce	ertificate to co	nnect and	l provision the lo	T device. Th	is policy is attache	d to the claim
fp_demo_policy		<b>A</b>	C	View 🖸	C	reate IoT policy	
Q							
fp_demo_policy		~					
ck_rx65n_demo_policy							
ck_rx65n_demo_policy	a use monopre en	fica	tes to pr	ovision your d	evice fleet	. Using each clai	im certificate
me recomment that ye							im certificate
							im certificate
me recomment that ye							im certificate
me recomment that ye							im certificate
in a limited number of	IoT devices limits	your exposi					im certificate
in a limited number of	IoT devices limits	your exposu	ure in cas	e a claim certi	ficate is co	ompromised.	
in a limited number of Claim certificates - op Choose the claim certificates to at	IoT devices limits	your exposu	ure in cas	se a claim certi	ficate is co	ompromised.	
in a limited number of	IoT devices limits	your exposu	ure in cas	se a claim certi	ficate is co	ompromised.	
in a limited number of Claim certificates - op thoose the claim certificates to at laim certificates must be active a	IoT devices limits	your exposu	ure in cas	se a claim certi	ficate is co	ompromised.	
in a limited number of <b>Claim certificates -</b> <i>op</i> Choose the claim certificates to at Claim certificates must be active a	IoT devices limits	your exposu	ure in cas	be a claim certing the providence of the provide	ficate is co	ompromised.	
in a limited number of <b>Claim certificates -</b> <i>op</i> choose the claim certificates to at claim certificates must be active a <b>C</b> Activate	IoT devices limits	your exposu	ure in cas	be a claim certing the providence of the provide	ficate is co	emplate's provisior	ning initiator.
in a limited number of Claim certificates - op Choose the claim certificates to at Claim certificates must be active a	IoT devices limits	your exposu	ure in cas	be a claim certing the providence of the provide	ficate is co	ompromised.	ning initiator.
in a limited number of <b>Claim certificates -</b> <i>op</i> choose the claim certificates to at claim certificates must be active a <b>C</b> Activate	IoT devices limits	your exposu	ure in cas	be a claim certing the providence of the provide	ficate is co	emplate's provisior	ning initiator.
in a limited number of <b>Claim certificates -</b> <i>op</i> choose the claim certificates to at claim certificates must be active a <b>C</b> Activate	IoT devices limits	your exposu	ure in cas	be a claim certing the providence of the provide	ficate is co	emplate's provisior	ning initiator.
in a limited number of Claim certificates - op thoose the claim certificates to at Claim certificates must be active a CALC	IoT devices limits	your exposu	ure in cas	be a claim certing the providence of the provide	ficate is co	emplate's provision	ning initiator.

Figure 4.15 Creating a Provisioning Template (4)



For **Pre-provisioning actions**, select **Don't use a pre-provisioning action**. Also, under **Automatic thing creation**, turn on **Automatically create a thing resource when provisioning a device**, and if necessary enter a character string of your choice as the thing name prefix. The thing name registered with AWS will be generated from this character string and the serial number set by the program. After entering the prefix, click the **Next** button.

Note: The demo does not use pre-provisioning actions. Refer to the page linked to below for information on using pre-provisioning actions.

https://docs.aws.amazon.com/iot/latest/developerguide/provision-wo-cert.html "Using pre-provisioning hooks with the AWS CLI"

Pre-provisioni	g actions (recommended) Info	
	ovisioned, you can run a Lambda function to verify the device should be provisioned. We recommend use th s to your AWS account.	is
Pre-provisioning ac	n	
Perform actions pr	ning action (recommended) r to provisioning the device. For example, to check the device against a known revent unauthorized devices from connecting to your account.	
<ul> <li>Don't use a pre- No actions will be AWS account.</li> </ul>	ovisioning action rformed prior to provisioning the device and the device is given access to your	
/:\	end that you use a pre-provisioning action	3
We recom	end that you use a pre-provisioning action when using a claim	
contificate	a provision way advises. This action performs additional validation of	
	o provision your devices. This action performs additional validation of one they are provisioned in your AWS account	
devices be	pre they are provisioned in your AWS account.	
devices be Automatic thir		nt
devices be Automatic thir Greate a thing resource features such as thing	ore they are provisioned in your AWS account. <b>creation -</b> <i>optional</i> o represent the device in AWS IoT. Your devices will need thing resources to use AWS IoT device management	nt
devices be Automatic thin Create a thing resource features such as thing Automatically Thing name prefix	ore they are provisioned in your AWS account. I creation - optional o represent the device in AWS IoT. Your devices will need thing resources to use AWS IoT device management pups, billing groups, and Device Shadows.	ıt
devices be Automatic thir Create a thing resource features such as thing Automatically Thing name prefix	ore they are provisioned in your AWS account. I creation - optional o represent the device in AWS IoT. Your devices will need thing resources to use AWS IoT device management pups, billing groups, and Device Shadows. eate a thing resource when provisioning a device	nt
devices be Automatic thir Create a thing resource features such as thing Automatically Thing name prefix The thing name prefix Enter_thing_prefix	ore they are provisioned in your AWS account. I creation - optional o represent the device in AWS IoT. Your devices will need thing resources to use AWS IoT device management pups, billing groups, and Device Shadows. eate a thing resource when provisioning a device	nt
devices be Automatic thin Create a thing resource features such as thing Automatically Thing name prefix The thing name prefix Enter_thing_prefix The name can't contain	ore they are provisioned in your AWS account. I creation - optional o represent the device in AWS IoT. Your devices will need thing resources to use AWS IoT device management pups, billing groups, and Device Shadows. reate a thing resource when provisioning a device rms the beginning of each thing resource related by this provisioning template.	ıt

Figure 4.16 Creating a Provisioning Template (5)



For **Set device permissions**, check the box next to the policy attached to newly created things, which was created in 4.3.1, then click the **Next** button.

# Set device permissions Info

AWS IoT policies authorize devices to access AWS IoT resources such as other thing resources, MQTT topics, and Device Shadows.

y 🖸	Create policy	C	.ate.	ies (1/2) Info up to 10 policies to attach to this cert	
0	< 1 >			ind policies	Q FI
~			ARN	Policy name	
Î			ð	fp demo policy	
			Ø	<u>sk cx65n demo policy</u>	2
	Previous	Cancel	đ	<u>ek ex65n demo policy</u>	2

Figure 4.17 Creating a Provisioning Template (6)

Click the **Create template** button to complete the process of creating a fleet provisioning template.

Policies		
Policy name	Policy action	Policy effect
k_rx65n_demo_policy 🖸	iot:Connect	Allow
	iot:Publish	Allow
	iot:Subscribe	Allow
	iot:Receive	Allow

Figure 4.18 Creating a Provisioning Template (7)



#### 4.4 Deploying the Demo Project

Clone the GitHub repository linked to below to a Git client of your choice and then import it into e<sup>2</sup> studio. Clone iot-reference-rx to a folder of your choice.

Demo application: iot-reference-rx : FreeRTOS reference repository

Note: Due to a limitation affecting e<sup>2</sup> studio, the path name of the "folder of your choice" (including the folder name) must be no more than 35 characters long. If you specify a path name of 36 or more characters, an error will result when you attempt to build the project.

From the top left of the menu bar of  $e^2$  studio, select File  $\rightarrow$  Import  $\rightarrow$  General  $\rightarrow$  Existing Projects into Workspace, then use the browse button next to the Select root directory to navigate to and select Projects\aws\_ryz014a\_ck\_rx65n\e2studio\_ccrx. Figure 4.19 shows an example in which the CK-RX65N board (Cellular version) is used. Substitute different values as appropriate for "ck\_rx65n" or "ryz014a" if you are using a different board or a different communication interface.

Select Folder					×
← → • ↑ 📜 «	> iot-reference-rx > F	Projects > aws_ryz014a	_ck_rx65n >	ٽ ×	, ○ Search aws_ryz014a_ck_rx65n
Organize • New folder					· ?
Name	Date modified	Туре	Size		
👼 e2studio_ccrx	9/5/2023 3:33 PM	File folder			
Folder:					
				S	elect Folder Cancel

Figure 4.19 Demo Project



## 4.5 FreeRTOS Settings

You will need to make a modification to the program in order to run the demo.

#### 4.5.1 Modifying the Configuration File

From the **Project Explorer** panel in e<sup>2</sup> studio, open aws\_ryz014a\_ck\_rx65n/src/frtos\_config/demo\_config.h and change the value of **ENABLE\_FLEET\_PROVISIONING\_DEMO** to **1**.

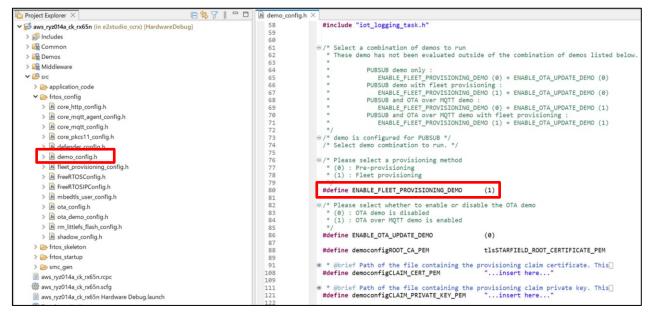


Figure 4.20 Location of Modification in demo\_config.h



#### 4.5.2 Cellular information settings

From the **Project Explorer** panel in e2 studio, open aws\_ryz014a\_ck\_rx65n/aws\_ryz014a\_ck\_rx65n.scfg and launch the Smart Configurator. (Figure 4.21)

Select the **Components** tab in the Smart Configurator and select **Middleware**  $\rightarrow$  **Generic**  $\rightarrow$  **r\_cellular** from the Components. Set each item of **Access point name**, **Access point login ID**, **Access point password** and **SIM card PIN code** according to the SIM card you are using. If there is no content to enter, leave it blank. (Figure 4.22)

After entering the Cellular information, click the **Generate Code** button to apply the settings to the program.

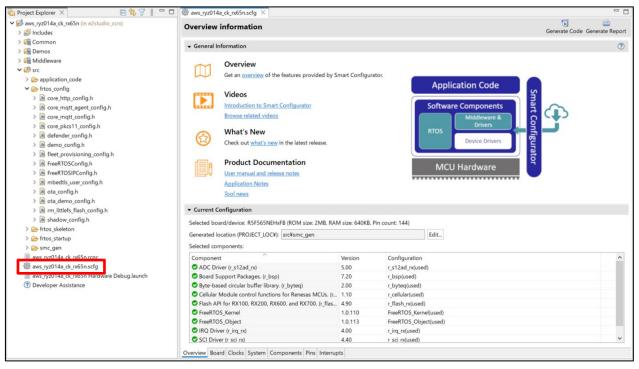


Figure 4.21 Launch the Smart Configurator



🍋 Project Explorer 🗡 🛛 🖹 🖻 🖞	□ 💮 aws_ryz014a_ck_rx65n.scfg ×			- 0
✓	Software component configur	ation		6
> 🔊 Includes	Software component comgan		Gene	rate Code Generate Report
> 🔀 Common	Components 🚵 🛃 📲 🖪 🖶 🏇 🕶	Configure		(1)
> 🔀 Demos		Configure		U
> 🚱 Middleware	6.5	Property	Value	0
✓ 25 src	type filter text	✓ @ Configurations	value	
> 🧁 application_code		# Access point name	ibasis.iot	
✓ ➢ frtos_config	V 🗁 Startup	# Access point login ID	100515.101	
> 🖻 core_http_config.h	✓ 🧁 Generic	# Access point password		
> h core mgtt agent config.h	the second seco	# SIM card PIN code		
> Core_mgtt_config.h	Comparison      Comparison	# Authentication protocol type.	2	
> Core_pkcs11_config.h	• Conterrupt • r_irq_rx		2	
> A defender config.h	A/D Converter	# Connection retry limit	600	
> 🖻 demo_config.h	r_s12ad_rx	# TCP connection timeout	0	
> h fleet_provisioning_config.h	✓ ➢ Memory	# SCI interrupt priority	4	
> FreeRTOSConfig.h	r_flash_rx	# Maximum semaphore acquisition latency(msec)	15000	
> FreeRTOSIPConfig.h	✓ (⇒ Security	# Reception guard time before the module transitions to PSM	ions to PSM 100	
> mbedtls_user_config.h	₩ r_tsip_rx	# Maximum allowable wake-up delay from PSM	5000	
> in ota_config.h	✓ Communications	# RING line active duration	1000	
> in ota_config.h	© r_sci_rx ✓ ➢ Middleware ✓ ➢ Generic ③ r_scellular	# Maximum FW update latency	60	
> m ota_demo_config.h			Disable	
		# User URC charget function name	my_sw_urc_charget_function	
> 🗈 shadow_config.h		# Debug log output level.	4	
> 🗁 frtos_skeleton		# Reset signal logic.		
> 🗁 frtos_startup	V 🗁 RTOS	# SCI Channel	6	
> 🗁 smc_gen	✓ → RTOS Kernel		CTS(Hardware), RTS(Software)	
aws_ryz014a_ck_rx65n.rcpc	FreeRTOS_Kernel			
aws_ryz014a_ck_rx65n.scfg				
aws_ryz014a_ck_rx65n Hardware Debug.launch	FreeRTOS_Object	# KTS pin function set value	0x080	
⑦ Developer Assistance				<u></u>
	Overview Board Clocks System Compon	ents Pins Interrupts		

Figure 4.22 Entering Cellular information



#### 4.6 Building and Running the Program

Build the project, program it to the device, and run the demo.

First, on the **Project Explorer** panel, right-click aws\_ryz014a\_ck\_rx65n and select **Build Project** to build the project.

Next, select **Run**  $\rightarrow$  **Debug Configurations...** from the e<sup>2</sup> studio menu to open the Debug Configurations window. In the list at the left of the Debug Configurations window, select **Renesas GDB Hardware Debugging**  $\rightarrow$  **aws\_ryz014a\_ck\_rx65n Hardware Debug**. Then select the **Debugger** tab followed by the **Connection Settings** tab (indicated by arrows in Figure 4.23).

Check to make sure that the settings of the items enclosed by red frames in Figure 4.21 match those shown, then click the **Debug** button to download to the device the executable data produced by building the project.

			19
	Name: aws_ryz014a_ck_rx65n Hardware Debug		
pe filter text	Main 🗱 Debugger 🕨 Startup 🦞 Source 🔲 Common		
E C/C++ Application E C/C++ Remote Application E EASE Script E GDB Hardware Debugging	Debug hardware: E2 Lite (RX) Target Device: R5F565NE	DUAL	
GDB Simulator Debugging (RH850)	✓ Clock		
🖏 Launch Group	Main Clock Source	EXTAL	~
Renesas GDB Hardware Debugging	Extal Frequency[MHz]	24	
🔄 aws_ryz014a_ck_rx65n Hardware Debug	Operating Frequency [MHz]	120.000	
Renesas Simulator Debugging (RX, RL78)	Permit Clock Source Change On Writing Internal Flash Memory	Yes	~
	✓ Connection with Target Board		
	Emulator	(Auto)	
	Connection Type	Fine	~
	JTag Clock Frequency[MHz]	6.00	~
	Fine Baud Rate[Mbps]	1.50	~
	Hot Plug	No	~
	✓ Power		
	Power Target From The Emulator (MAX 200mA)	No	~
	Supply Voltage (V)	3.3	~
	✓ CPU Operating Mode		
	Register Setting	Single Chip	~
	Mode pin	Single-chip mode	~
	Change startup bank	No	~
ter matched 9 of 11 items			App

Figure 4.23 Debug Configurations



Launch Tera Term in order to enter the claim certificate, claim private key, endpoint, and provisioning template name.

After Tera Term starts, select **Serial** and **USB Serial Device**, then click the **OK** button.

○ TCP/IP	Host:	myhost.examp	ole.com		~
	Service:	History Telnet	TCP port#	22	
		SSH	SSH version:	SSH2	
		Other	IP version:	AUTO	
Serial	Port:	COM12: USB S	Serial Device (COM	12)	~

Figure 4.24 Initial Window when Tera Term Starts

Select **Setup**  $\rightarrow$  **Serial port...** from the menu, configure the serial port setting items enclosed by red frames as shown, and then click the **New setting** button.

ra Term: Serial port	setup and co	nnection	×
Port:	COM12	~	New setting
Speed:	115200	~	
Data:	8 bit	~	Cancel
Parity:	none	~	
Stop bits:	1 bit	~	Help
Flow control:	none	~	
Transn 0	nit delay msec/cha	r O	msec/line
Device Friendly N Device Instance II Device Manufact Provider Name: N Driver Date: 6-21- Driver Version: 10	D: USB¥VID_0 urer: Microso Aicrosoft •2006	45B&PID ft	e (COM12) ^ _8111¥000000000001
			~
<			>

Figure 4.25 Serial Port Setup



Select Setup  $\rightarrow$  Terminal... from the menu, set Receive: to AUTO and Transmit: to CR+LF as shown in the red frames, and then click the OK button.

Tera Term: Terminal setup		×
Terminal size 80 X 24 Term size = win size	New-line Receive: AUTO ~ Transmit: CR+LF ~	OK Cancel
Auto window resize Terminal ID: VT100  Answerback:	Local echo	Help •TEK)

Figure 4.26 Terminal Setup

From the AWS IoT console, select **MQTT test client**, enter **#** under **Topic filter**, and click the **Subscribe** button.

Test Device Advisor MQTT test client	Subscribe to a topic Publish to a to	opic	
Device Location New	Topic filter Info The topic filter describes the topic(s) to which you want to subscribe	The tools filter can include MOTT without characters.	
Manage	#		
All devices	Addition configuration		
Greengrass devices	Addition		
LPWAN devices	Subscribe		
Software packages New	1		
Remote actions			
Message routing	Subscriptions #		Pause Clear Export Edit
Retained messages	# 🗢 X		
▶ Security		ublish messages to a wildcard topic.	
Fleet Hub		a different topic to publish messages to.	
Device software			
Billing groups	No messages have been	sent to this subscription yet. Please send a message to this subscription to see messages here.	
Settings			

Figure 4.27 MQTT Test Client Settings



In e<sup>2</sup> studio, press **Resume** (F8) to display the text output shown below in Tera Term. Within 10 seconds, type **CLI** in Tera Term and press the Enter key.

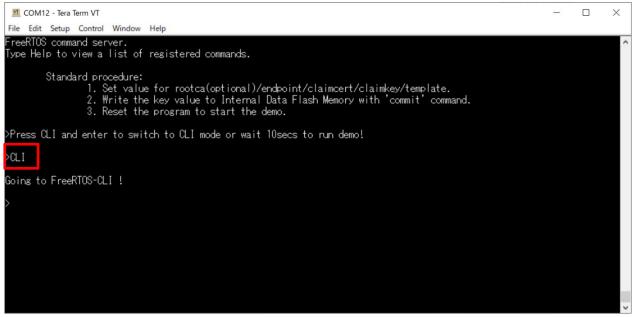


Figure 4.28 Entering Information Using CLI (1)

It is possible that information may have been stored already if the demo was run previously, so type **format** in Tera Term and press the Enter key.

This causes all stored information to be erased.



Figure 4.29 Entering Information Using CLI (2)



To enter the endpoint, type **conf set endpoint <endpoint>** in Tera Term and press the Enter key.

For **<endpoint>**, enter the value in the format **xxxxxxx.amazonaws.com** that is displayed for **Endpoint** when you select **Settings**  $\rightarrow$  **Device data endpoint** on the AWS IoT console.

Device data endpoint Info Your devices can use your account's device data endpoint to connect to AWS.		
Each of your things has a REST API available at this endpoint. MQTT clients and AWS IoT Device SDKs 🖸 also use this endpoint.		
Endpoint		
Io Casonine you residence to relations and apported opine sares, choose a security policy.		 •
Compare security policies 🖸		
COM12 - Tera Term VT     File Edit Setup Control Window telp	-	×
FreeRTOS command server. Type Help to view a list of registered commands. Standard procedure: 1. Set value for rootca(optional)/endpoint/claimcert/claimkey/template. 2. Write the key value to Internal Data Flash Memory with 'commit' command. 3. Reset the program to start the demo. >Press CLI and enter to switch to CLI mode or wait 10secs to run demo! >CLI		<
Going to FreeRTOS-CLI !		
>format		
Format OK !		
>conf set endpoint		
0K.		
		~

Figure 4.30 Entering Information Using CLI (3)



To enter the provisioning template name, type **conf set template <template\_name>** in Tera Term and press the Enter key.

For **<template\_name>**, enter the name of the provisioning template created in 4.3.3.

I COM12 - Tera Term VT	—	$\times$
File Edit Setup Control Window Help		
Standard procedure: 1. Set value for rootca(optional)/endpoint/claimcert/claimkey/template. 2. Write the key value to Internal Data Flash Memory with 'commit' command. 3. Reset the program to start the demo.		^
>Press CLI and enter to switch to CLI mode or wait 10secs to run demo!		
>CL1		
Going to FreeRTOS-CLI !		
>format		
Format OK !		
>conf set endpoint		
ОК.		
>conf set template fp_demo_template		
ОК.		
$\rightarrow$		~

Figure 4.31 Entering Information Using CLI (4)



To enter the provisioning claim certificate, type **conf set claimcert** in Tera Term. Next, drag and drop the provisioning claim certificate file (**xxxx-certificate.pem.crt**) created in 4.3.2 onto the Tera Term window (**Send File**). Finally, press the Enter key in Tera Term.

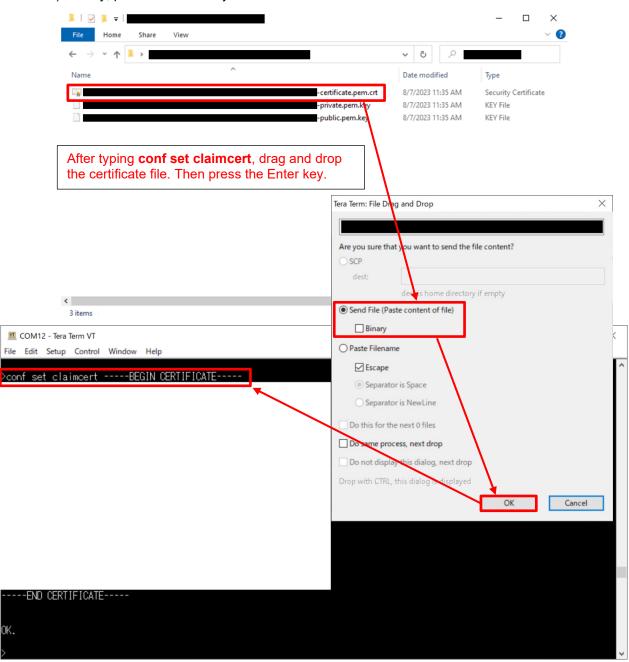


Figure 4.32 Entering Information Using CLI (5)



To enter the provisioning claim private key, type **conf set claimkey** in Tera Term. Next, drag and drop the provisioning claim private key file (**xxxx-private.pem.key**) created in 4.3.2 onto the Tera Term window (**Send File**). Finally, press the Enter key in Tera Term.

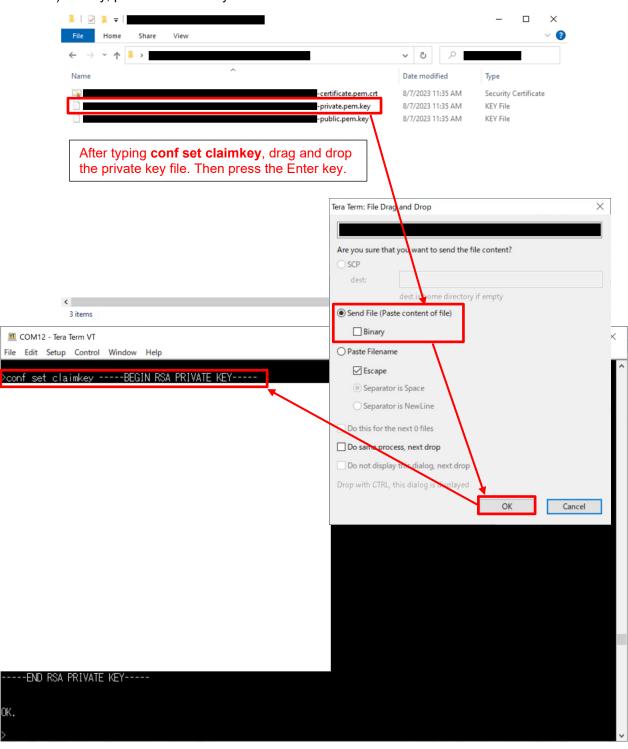


Figure 4.33 Entering Information Using CLI (6)



To store the information entered up to this point in the data flash memory, type **conf commit** in Tera Term and press the Enter key.

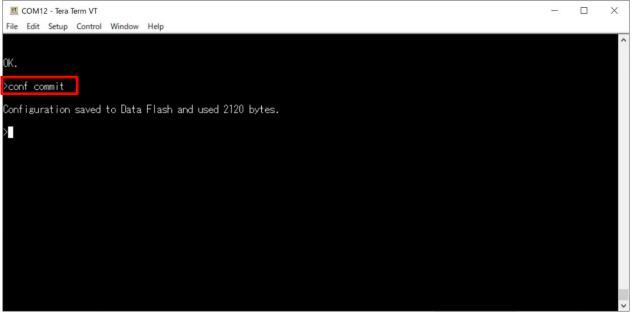


Figure 4.34 Entering Information Using CLI (7)

To start the demo, type **reset** in Tera Term and press the Enter key. If nothing is entered in Tera Term for 10 seconds after the reset, the demo starts.



Figure 4.35 Entering Information Using CLI (8)



# 4.7 Confirming the Results of Running the Demo

Figure 4.36 shows a log file produced by running the fleet provisioning demo.

(The log is displayed in Tera Term.)

If the text string "Demo completed successfully." appears at the end of the log, the fleet provisioning demo completed successfully. Successful completion of the demo means that a new thing has been registered on AWS IoT Core and an individual device certificate assigned to it.

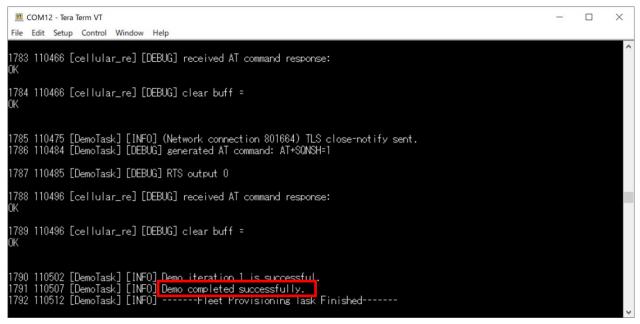


Figure 4.36 Log Produced when Fleet Provisioning Demo Completes Successfully



After running the fleet provisioning demo, you can use the individual device certificate and private key obtained from AWS to run the PubSub demo. Check to confirm that the text string "Successfully sent QoS 0 publish to topic:" appears in the log as shown in Figure 4.37.



Figure 4.37 Log Produced when PubSub Demo Completes Successfully

You can also check MQTT messages sent to AWS from CK-RX65N by selecting **MQTT test client** from the AWS IoT console.

AWS IoT ×	Subscribe to a topic Publish to a topic
Monitor	
Connect Connect one device	Topic filter       Info         The topic filter describes the topic(s) to which you want to subscribe. The topic filter can include MQTT wildcard characters.         #
<ul> <li>Connect one device</li> <li>Connect many devices</li> </ul>	Additional configuration
Test	Subscribe
<ul> <li>Device Advisor</li> <li>MQTT test client</li> </ul>	Subscriptions #
Device Location New	# ♥ ×
Manage	You cannot publish messages to a wildcard topic. Please select a different topic to publish messages to.
All devices	
<ul> <li>Greengrass devices</li> <li>LPWAN devices</li> <li>Software packages New</li> </ul>	pubsub_demo/dummy/task_1
Remote actions      Message routing	Message cannot be displayed in specified format.
Retained messages	
Security	
Fleet Hub	Task 1 publishing message 9
Device software	Properties

Figure 4.38 MQTT Test Client after Successful Completion of PubSub Demo



You can check on the thing registered by the fleet provisioning demo from the AWS IoT console.

Under **All devices**, select **Things**. The thing (shown as

aws Services	<b>Q</b> Search	[Alt+S]
AWS IoT	×	AWS IoT > Manage > Things
Monitor		Things (96) Info An IoT thing is a representation and record of your physical device in the cloud. A physical device needs a thing record in order to work with AWS IoT.
Connect Connect one device		Q Filter things by: name, type, group, billing, or searchable attribute.
Connect many device	ces	Name     FPDemolD
Test		
<ul> <li>Device Advisor</li> <li>MQTT test client</li> </ul>		
Device Location Ne	w /	
Manage		
<ul> <li>All devices</li> </ul>	4	
Things Thing groups		
Thing types		

Figure 4.39 Confirming the Results of Running the Demo (1)



## **RX** Family

By checking the registered things, you can confirm that the individual device certificate generated and assigned by fleet provisioning (**Certificate ID** in Figure 4.40) has been attached and activated.

COM1	2 - Tera Term VT	-		$\times$
	Setup Control Window Help			_
824 6703 >	4 [cellular_re] [DEBUG] clear buff =			1
825 6704 OK	4 [cellular_re] [DEBUG] received AT command response:			
826 6704 OK	4 [cellular_re] [DEBUG] clear buff =			ŀ
827 6705	4 [DemoTask] [INFO] Received certificate with Id:			כ
828 6706 829 6710	5 [DemoTask] [INF0] Writing certificate into label 7Device Cert". 14 [DemoTask] [DEBUG] generated AT command: AT+SONSS <mark>END</mark> EXT=1,33			
830 6710	14 [DemoTask] [DEBUG] RTS output 0			
831 6711	4 [cellular_re] [DEBUG] received AT command response:			
, 832 6711 >	4 [cellular_re] [DEBUG] clear buff =			
833 6712 NK	4 [cellular_re] [DEBUG] received AT command response:			
	FPDemoID			
	Thing details			
	Name Type FPDemoID			
	ARN Billing group			
	Confirm that the certificate ID matches that she the debug log.	iown	in	
	Attributes Certificates Thing groups Device Shadows Activity Packages and versions Jobs	Alarn	ns	
	Certificates (1) Info The device certificates attached to this thing resource.			
	Q Find certificates			
	Certificate ID Status			
	□ O Active			

Figure 4.40 Confirming the Results of Running the Demo (2)



# 5. Conclusion

As mentioned earlier, there are multiple provisioning methods, and there are also various ways to enhance security. Nowadays, it is essential to select and deploy an appropriate provisioning method that matches the actual application in the target market, the scale of the system (number of devices), and the required level of security.

However, it is not a simple matter to maintain, manage, and operate a secure manufacturing facility in-house in order to implement provisioning functionality. This is why the fleet provisioning method had gained so much attention as an approach to the device provisioning process, and this is probably why market demand for this method is growing rapidly.

The provisioning method described in this document is only one example, so it will not satisfy the requirements of all users. Nevertheless, we think the information presented here will help deepen the reader's understanding of the advantages and disadvantages of deployment. It is our hope that this document will help users build convenient and practical production lines.

# 6. Websites and Support Information

AWS re:Post : https://repost.aws

Renesas FreeRTOS GitHub : https://github.com/renesas/iot-reference-rx



# **Revision History**

		Description		
Rev.	Date	Page	Summary	
1.00	Sep. 30, 2023	—	First edition issued	
			Below, intentionally left blank.	



# 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

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 systemevaluation test for the given product.

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# **Corporate Headquarters**

TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

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