RX Family

How to implement FreeRTOS OTA by using Amazon Web Services on RX65N

Introduction

Objectives
This document helps users to be familiar with the procedures to use OTA demo applications with FreeRTOS IoT libraries on RX65N

Operating Environment
Operation was confirmed in the following environments.

<table>
<thead>
<tr>
<th>IDE</th>
<th>e2 studio 7.8.0, e2 studio 2020-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toolchains</td>
<td>CCRX Compiler v3.0.1</td>
</tr>
<tr>
<td>Target board</td>
<td>RSKRX65N-2MB</td>
</tr>
<tr>
<td>Debuggers</td>
<td>E2, E2 Lite emulator</td>
</tr>
<tr>
<td>Software</td>
<td>Renesas Flash Programmer, Renesas Secure Flash Programmer.exe, Tera Term</td>
</tr>
</tbody>
</table>

Hardware:
1. Connect E2 Lite emulator and USB serial port to RX65N board and PC
2. Connect power source to RX65N

Reference: Renesas MCU Firmware Update Design Policy R01AN5548EJ0100
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1. **Set up AWS**

To run the FreeRTOS demos, user needs an AWS account, an IAM user with permission to access AWS IoT and FreeRTOS cloud services.

To set up AWS account and permission, please refer to [https://docs.aws.amazon.com/freertos/latest/userguide/freertos-account-and-permissions.html](https://docs.aws.amazon.com/freertos/latest/userguide/freertos-account-and-permissions.html).

Set up for the OTA update, please refer to [https://docs.aws.amazon.com/freertos/latest/userguide/ota-prereqs.html](https://docs.aws.amazon.com/freertos/latest/userguide/ota-prereqs.html).

Next, user needs to register the board with AWS IoT as described at [https://docs.aws.amazon.com/freertos/latest/userguide/get-started-freertos-thing.html](https://docs.aws.amazon.com/freertos/latest/userguide/get-started-freertos-thing.html).

To make the demo communicate with AWS, user needs to configure the source code as described at section 2.

1.1 **Sign in the console**

① Sign in the console on [https://aws.amazon.com/?nc2=h_lg](https://aws.amazon.com/?nc2=h_lg) and choose IoT Core.
② Go to Secure ➔ Policies to create policy

The AWS IoT policy grants device permissions to access AWS IoT resources. It is stored on the AWS Cloud.

![Policy creation interface]

③ Choose advance mode and copy the following code

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:Connect",
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": "iot:Publish",
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": "iot:Subscribe",
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": "iot:Receive",
      "Resource": "*"
    }
  ]
}```
Go to Manage ➔ Things to create Thing

A thing is a representation of a device or logical entity in AWS IoT. It can be a physical device or sensor (for example, a light bulb or a switch on a wall). It can also be a logical entity like an instance of an application or physical entity that does not connect to AWS IoT, but is related to devices that do (for example, a car that has engine sensors or a control panel). AWS IoT provides a thing registry that helps to manage your things.

- Choose Create a single thing
- Give a name for thing
- Click on Create certificate
- Download 3 files
- Attach policy

Download these files and save them in a safe place. Certificates can be retrieved at any time, but the private and public keys cannot be retrieved after you close this page.

In order to connect a device, you need to download the following:

<table>
<thead>
<tr>
<th>Certificate Type</th>
<th>Filename</th>
<th>Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>A certificate for this thing</td>
<td>9deb40d984.cert.pem</td>
<td>Download</td>
</tr>
<tr>
<td>A public key</td>
<td>9deb40d984.public.key</td>
<td>Download</td>
</tr>
<tr>
<td>A private key</td>
<td>9deb40d984.private.key</td>
<td>Download</td>
</tr>
</tbody>
</table>

You also need to download a root CA for AWS IoT:
A root CA for AWS IoT Download

Activate

Cancel

Done

Attach a policy
1.2 Create an Amazon S3 bucket

① Amazon Simple Storage Service (S3) AWS Service that enables to store files in the cloud that can be accessed by you or other services. OTA update files are stored in Amazon S3 buckets.

Please refer https://docs.aws.amazon.com/freertos/latest/userguide/dg-ota-bucket.html

② Choose Create bucket, type name and choose Next

![Create bucket](image-url)
③ Select **Versioning to keep all versions in the same bucket**, and then choose **Next**

④ Choose **Next** to accept the default permissions.
Choose **Create bucket**.
1.3 Create service role for OTA update

Identity Access Management (IAM) helps you securely control access to AWS resources.

Please refer to https://docs.aws.amazon.com/freertos/latest/userguide/create-service-role.html
1.4 Create an OTA user policy and attach the OTA user policy to your IAM user

① Create an OTA user policy and attach the OTA user policy to your IAM user

Please refer https://docs.aws.amazon.com/freertos/latest/userguide/create-ota-user-policy.html

② Attach the OTA user policy to your IAM user
1.5 Register a code-signing certificate on AWS

Register a code-signing certificate on AWS

- Please refer Renesas MCU Firmware Update Design Policy section 7.3 Generating ECDSA-SHA256 Key Pairs with OpenSSL to create keys and certification.
- Go to IoT Core → Manage → Jobs → Create → Create Update Job → Select Devices to Update under Select a job → choose Select under Sign New Firmware Image and choose any thing create before → Next → Choose Create under Code Signing Profile

✓ Profile Name: Anything is OK
✓ Device Hardware Platform: Windows Simulator
✓ Code-signing certificate:
  ✓ Select Certificate: Specify secp256r1.crt
  ✓ Select certificate private key: specify secp256r1.key
  ✓ Select Certificate Chain (Optional): ca.crt
✓ Device code-signing certificate pathname: Anything is OK

Create a code signing profile

Profile name

e.g. profile_for_platform

Device hardware platform

No code signing platform selected

Select

Code signing certificate

AWS Certificate Manager (ACM) handles the complexity of creating and managing or importing SSL/TLS certificates. You use ACM to create an ACM Certificate or import a third-party certificate that you use for signing. You must have a certificate to sign code.

No certificate selected

Import

Select

Pathname of code signing certificate on device

This is the platform-specific location and name of the certificate used by the FreeRTOS device firmware to perform OTA image signature verification.

e.g. /certificates/authcert.pem
1.6 Grant access to code signing for AWS IoT

Grant access to code signing for AWS IoT

Please refer [https://docs.aws.amazon.com/freertos/latest/userguide/code-sign-policy.html](https://docs.aws.amazon.com/freertos/latest/userguide/code-sign-policy.html)
2 FreeRTOS OTA environment construction
At the beginning, user would be able to choose the version of Amazon FreeRTOS package, and the selected version will be downloaded from GitHub and imported automatically into the project. This makes it easier for the user, so that the user can focus only on Amazon FreeRTOS configuration and writing application code.

Note: If you want to start over from the beginning due to an operation error in 2.2 and 2.3, execute "⑥ Erase RX65N-RSK" in 2.2 and then start over.

2.1 Import, configure head file and build aws_demos and boot_loader
The figure below shows how to import Amazon FreeRTOS project:
① Launch e² studio
② Select [File] → [Import…]
③ Select “Renesas GitHub FreeRTOS (with IoT libraries) Project”
④ Select “Check for more version…” to show the download dialog

⑤ Choose the lastest package
⑥ Agree the end user license agreement.

⑦ Wait for downloading completed.
Select the project to import. Choose aws_demos and bootloader project.
Open project [project] → [properties] → C/C++ Build → Tool Chain Editor for both projects, select toolchain and builder, then specify toolchain version.
⑩ Check output hex file.
⑪ **Input public key**

In bootloader project, open `projects\renesas\rx65n-rskle2studio\boot_loader\src\key\code_signer_public_key.h` and input public key.

Please refer “How to implement FreeRTOS OTA by using Amazon Web Services on RX65N” section “7.3 Generating ECDSA-SHA256 Key Pairs with OpenSSL” to create public key.

Then **build** to create `boot_loader.mot`.

⑫ **Open AWS IoT console**

- Browse to the AWS IoT console.
- Choose **Setting**. Make a note of Endpoint. *“Your AWS IoT endpoint”*
Choose Manager→Things. Make a note of AWS IoT thing name. "The AWS IoT thing name of your board"

Open aws_demos project

- Open /demos/include/aws_clientcredential.h, specify values below

```c
#define clientcredentialMQTT_BROKER_ENDPOINT = "Your AWS IoT endpoint"
#define clientcredentialIOT_THING_NAME "The AWS IoT thing name of your board"
```
Open Certificate Configuration Tool
- Move to the FreeRTOS path downloaded in 2.1 step ⑤
- Open tools → certificate_configuration → CertificateConfigurator.html
- Import certificate PEM file and Private Key PEM file which were downloaded on 1.1 step ④
- Generate aws_clientcredential_keys.h

![Certificate Configuration Tool](image)

Save the generated header file to the demos/commons/include folder of the demo project.

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Open aws_demos project

- Replace the aws_clientcredential_keys.h generated in ⑮ with the file in /demos/include/

- Open /demos/include/ aws_ota_codesigner_certificate.h, specify values below

  `signingcredentialSIGNING_CERTIFICATE_PEM [] = "xxxx";`

  “xxxx” is value from `secp256r1.crt`. Remember the “\” after each line of certification

  For creating `secp256r1.crt` please refer

  “How to implement FreeRTOS OTA by using Amazon Web Services on RX65N” section “7.3
  Generating ECDSA-SHA256 Key Pairs with OpenSSL”.

```c
/* FreeRTOS V202002 release */

#define __AWS_CODESIGNER_KEYS_H__
#define __AWS_CODESIGNER_KEYS__

/**** PEM-encoded code signer certificate ****

/* Next include the PEM header and footer: */
"-----BEGIN CERTIFICATE-----\n"-----\n"-----END CERTIFICATE-----\n"

/****

static const char signingcredentialSIGNING_CERTIFICATE_PEM[] =

"-----BEGIN CERTIFICATE-----\n"-----\n"-----END CERTIFICATE-----\n";
@endif
```
2.2 Install the initial version of firmware

1. Open amazon-freertos/vendors/renesas/boards/board/aws_demos/config_files/aws_demo_config.h, comment out #define CONFIG_MQTT_DEMO_ENABLED, and define CONFIG_OTA_UPDATE_DEMO_ENABLED.

2. Open amazon-freertos/demos/include/aws_application_version.h, set initial version of firmware to 0.9.2

```c
#include "iot_appversion32.h"

extern const AppVersion32_t xAppFirmwareVersion;
#define APP_VERSION_MAJOR 0
#define APP_VERSION_MINOR 9
#define APP_VERSION_BUILD 2

#define _AWS_APPLICATION_VERSION_H_
#endif
```
Open Section Viewer by selecting [Project]-> [Properties]-> C / C ++ Build-> Settings-> [Tool Settings] tab-> Linker-> Section-> […] and change section of aws_demos as following picture:

④ Build を押して aws_demos.mot ファイルを作成する
5. Create userprog.mot from Renesas Secure Flash Programmer

userprog.mot is a combination of aws_demos.mot and boot_loader.mot. Users can flash this file to RX65N-RSK to install initial firmware.

- Choose Initial Firm tab and then set parameters as following picture.
  
  **Private Key Path**: location to secp256r1.privatekey
  
  **Boot Loader File Path**: location to boot_loader.mot
  
  `(projects\renesas\rx65n-rsk\e2studio\boot_loader\HardwareDebug)`
  
  **Bank 0 User Program File Path**: location to aws_demos.mot
  
  `(projects\renesas\rx65n-rsk\e2studio\aws_demos\HardwareDebug)`
  
- Create a folder named `init_firmware`, generate `userprog.mot`, and save to `init_firmware` folder and check `generate succeeded`
Erase RX65N-RSK

- Open vendors/renesas/rx_mcu_boards/boards/rx65n-rsk/aws_demos/flash_project/erase_from_bank/erase.rpj to erase data on bank
- Hit **Start** to erase flash ROM
Flash initial firmware on RX65N-RSK

- Create a new project with a Renesas Flash Programmer. (Ex: flash_project.rpj)
- Start flashing userprog.mot which was saved in `init_firmware` folder.
- Browse to `init_firmware` folder, select userprog.mot and hit **Start**

![Renesas Flash Programmer](image)
Open Tera Term to see something like the following on initial firmware.

If don’t have Tera Term on PC, please download from https://tssh2.osdn.jp/index.html.en and set up as following picture. Make sure that plugin USB Serial port to PC.

Version 0.9.2 (initial version) was install to RX65N-RSK. The RX65N-RSK board is now listening for OTA updates.

RX65N secure boot program
Checking flash ROM status.
bank 0 status = 0xff [LIFECYCLE_STATE_BLANK]
bank 1 status = 0xfc [LIFECYCLE_STATE_INSTALLING]
bank info = 1. (start bank = 0)
start installing user program.
copy secure boot (part1) from bank0 to bank1...OK
copy secure boot (part2) from bank0 to bank1...OK
update LIFECYCLE_STATE from [LIFECYCLE_STATE_INSTALLING] to [LIFECYCLE_STATE_VALID]
swap bank...

RX65N secure boot program
Checking flash ROM status.
bank 0 status = 0xf8 [LIFECYCLE_STATE_VALID]
bank 1 status = 0xff [LIFECYCLE_STATE_BLANK]
bank info = 0. (start bank = 1)
integrity check scheme = sig-sha256-ecdsa
bank0(execute area) on code flash integrity check...OK
jump to user program
0 1 [ETHER_RECEI] Deferred Interrupt Handler Task started
1 1 [ETHER_RECEI] Network buffers: 3 lowest 3
2 1 [ETHER_RECEI] Heap: current 234192 lowest 234192
3 1 [ETHER_RECEI] Queue space: lowest 8
4 1 [IP-task] InitializeNetwork returns OK
5 1 [IP-task] xNetworkInterfaceInitialise returns 0
6 101 [ETHER_RECEI] Heap: current 234592 lowest 233392
7 2102 [ETHER_RECEI] prvEMACHandlerTask: PHY LS now 1
8 3001 [IP-task] xNetworkInterfaceInitialise returns 1
9 3092 [ETHER_RECEI] Network buffers: 2 lowest 2
10 3092 [ETHER_RECEI] Queue space: lowest 7
11 3092 [ETHER_RECEI] Heap: current 233320 lowest 233320
12 3193 [ETHER_RECEI] Heap: current 233816 lowest 233120
13 3593 [IP-task] vDHCPProcess: offer c0a80a09ip
14 3597 [ETHER_RECEI] Heap: current 233200 lowest 233000
15 3597 [IP-task] vDHCPProcess: offer c0a80a09ip
16 3597 [IP-task] IP Address: 192.168.10.9
17 3597 [IP-task] Subnet Mask: 255.255.255.0
18 3597 [IP-task] Gateway Address: 192.168.10.1
19 3597 [IP-task] DNS Server Address: 192.168.10.1
20 3600 [Tmr Svc] The network is up and running
21 3622 [Tmr Svc] Write certificate...
22 3697 [ETHER_RECEI] Heap: current 232320 lowest 230904
23 4497 [ETHER_RECEI] Heap: current 226344 lowest 225944
24 5317 [iot_thread] [INFO] [DEMO][5317] ---------STARTING DEMO---------
25 5317 [iot_thread] [INFO] [INIT][5317] SDK successfully initialized.
26 5317 [iot_thread] [INFO] [DEMO][5317] Successfully initialized the demo. Network type for the demo: 4
27 5317 [iot_thread] [INFO] [MQTT][5317] MQTT library successfully initialized.
28 5317 [iot_thread] [INFO] [DEMO][5317] OTA demo version 0.9.2
29 5317 [iot_thread] [INFO] [DEMO][5317] Connecting to broker...
30 5317 [iot_thread] [INFO] [DEMO][5317] MQTT demo client identifier is rx65n-gr-rose (length 13).
31 5325 [ETHER_RECEI] Heap: current 206844 lowest 206504
32 5325 [ETHER_RECEI] Heap: current 206440 lowest 206440
33 5325 [ETHER_RECEI] Heap: current 206240 lowest 206240
34 5330 [ETHER_RECEI] Heap: current 2190288 lowest 190288
35 5334 [ETHER_RECEI] Heap: current 199088 lowest 199088
36 5334 [ETHER_RECEI] Heap: current 199088 lowest 199088
37 5361 [ETHER_RECEI] Heap: current 158512 lowest 158168
38 5363 [ETHER_RECEI] Heap: current 158032 lowest 158032
39 5364 [ETHER_RECEI] Network buffers: 1 lowest 1
40 5364 [ETHER_RECEI] Heap: current 156856 lowest 156856
41 5364 [ETHER_RECEI] Heap: current 156656 lowest 156656
42 5364 [ETHER_RECEI] Heap: current 156656 lowest 156656
43 5374 [ETHER_RECEI] Heap: current 153016 lowest 152040
44 5492 [ETHER_RECEI] Heap: current 141464 lowest 139016
45 5751 [ETHER_RECEI] Heap: current 140160 lowest 138660
46 5917 [ETHER_RECEI] Heap: current 138280 lowest 138168
59 7361 [iot_thread] [INFO] [MQTT][7361] Establishing new MQTT connection.
60 7428 [iot_thread] [INFO] [MQTT][7428] (MQTT connection 81cf08, CONNECT operation 81d0e8) Wait complete with result SUCCESS.
61 7428 [iot_thread] [INFO] [MQTT][7428] New MQTT connection 81cf08 established.
64 7430 [iot_thread] [OTA_AgentT][7430] OTA Task is Ready.
66 7431 [OTA_AgentT][7431] [MQTT][7431] (MQTT connection 81cf08) SUBSCRIBE operation scheduled.
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67 7431 [OTA Agent T] [INFO [MQTT] [7431] (MQTT connection 81cf8, SUBSCRIBE operation 818c8) Waiting for operation completion.

68 7436 [ETHER_RECEI] Heap: current 128248 lowest 127992

69 7480 [OTA Agent T] [INFO [MQTT] [7480] (MQTT connection 81cf8, SUBSCRIBE operation 818c8) Wait complete with result SUCCESS.

70 7481 [OTA Agent T] [prvSubscribeToJobNotificationTopics] OK: $aws/things/rx65n-gr-rose/jobs/$next/get/accepted

71 7481 [OTA Agent T] [INFO [MQTT] [7481] (MQTT connection 81cf8) SUBSCRIBE operation scheduled.

72 7481 [OTA Agent T] [INFO [MQTT] [7481] (MQTT connection 81cf8, SUBSCRIBE operation 818c8) Waiting for operation completion.

73 7530 [OTA Agent T] [INFO [MQTT] [7530] (MQTT connection 81cf8, SUBSCRIBE operation 818c8) Wait complete with result SUCCESS.

74 7530 [OTA Agent T] [prvSubscribeToJobNotificationTopics] OK: $aws/things/rx65n-gr-rose/jobs/notify-next

75 7530 [OTA Agent T] [INFO [MQTT] [7530] (MQTT connection 81cfc8) SUBSCRIBE operation scheduled.

76 7530 [OTA Agent T] [INFO [MQTT] [7530] (MQTT connection 81cfc8, SUBSCRIBE operation 818c48) Waiting for operation completion.

77 7530 [OTA Agent T] [INFO [MQTT] [7530] (MQTT connection 81cfc8) SUBSCRIBE operation queued.

78 7532 [OTA Agent T] [INFO [MQTT] [7532] (MQTT connection 81cf8) PUBLISH operation queued.

79 7532 [OTA Agent T] [INFO [MQTT] [7532] (MQTT connection 81cf8) PUBLISH operation scheduled.

80 7532 [OTA Agent T] [INFO [MQTT] [7532] (MQTT connection 81cf8) PUBLISH operation queued.

81 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

82 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation queued.

83 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

84 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation queued.

85 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

86 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation queued.

87 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

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91 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

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96 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation queued.

97 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

98 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation queued.

99 7552 [OTA Agent T] [INFO [MQTT] [7552] (MQTT connection 81cf8) PUBLISH operation scheduled.

100 8430 [iot_thread] [INFO [DEMO] [8430] State: Ready  Received: 1  Queued: 0  Processed: 0  Dropped: 0

101 9430 [iot_thread] [INFO [DEMO] [9430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0

102 10430 [iot_thread] [INFO [DEMO] [10430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0

103 11430 [iot_thread] [INFO [DEMO] [11430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0

104 12430 [iot_thread] [INFO [DEMO] [12430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0

105 13430 [iot_thread] [INFO [DEMO] [13430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0

106 14430 [iot_thread] [INFO [DEMO] [14430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0

107 15430 [iot_thread] [INFO [DEMO] [15430] State: WaitingForJob  Received: 1  Queued: 0  Processed: 0  Dropped: 0
2.3 Update the version of your firmware

① Open demos/include/aws_application_version.h and increment the APP_VERSION_BUILD token value (increase to 0.9.3)

② Rebuild the project

③ Create userprog.rsu from Renesas Secure Flash Programmer for Update the version of your firmware

   - Open Amazon-FreeRTOS-Tools\Renesas Secure Flash Programmer.exe
   - Choose Update Firm tab and then set parameters as following picture.
     - File Path: location to aws_demos.mot
       (projects\renesas\rx65n-rsk\e2studio\aws_demos\HardwareDebug)
     - Create a folder named update_firmware, generate userprog.rsu and save to update_firmware folder and check generate succeeded
Upload firmware update into the Amazon S3 bucket as described in 1.2 Create an Amazon S3 bucket to store update

Upload **userprog.rsu** to Amazon S3 bucket
Create Job to update firmware on RX65N-RSK

AWS IoT Jobs is a service that notifies one or more connected devices of a pending “Job”. A Job can be used to manage fleet of devices, update firmware and security certificates on devices, or perform administrative tasks such as restarting devices and performing diagnostics.

- Go to AWS IoT → Manage → Jobs → Create → Create OTA Update job → Choose thing name → Next
- Create a FreeRTOS OTA update job as below:
  - Select Code signing profile created in previous section
  - Select firmware image from S3
  - Choose IAM role created in previous section
- Click Next
6. Give ID and hit Create

- Enter ID: demu_test
- Description (optional): Give your job a helpful description

Job type
- Your job will complete after deploying to the selected devices/groups (snapshot)
- Your job will continue deploying to any devices added to the selected groups (continuous)

Tags
- Provide a tag name, e.g. Manufacturer: Provide a tag value, e.g. Acme-Corporation

Add another
Clear

Cancel  Back  Create
⑦ Reopen Tera Term to see update firmware

OTA demo version is 0.9.3 was updated successfully.

⑧ Check Job status to be “Succeeded” or not.
### Revision History

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<td>1.00</td>
<td>Aug. 31, 2020</td>
<td>—</td>
<td>—</td>
<td>First release.</td>
</tr>
<tr>
<td>1.01</td>
<td>Oct. 30, 2020</td>
<td>—</td>
<td>—</td>
<td>Chapter division</td>
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General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between \( V_{IL} \) (Max.) and \( V_{IH} \) (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between \( V_{IL} \) (Max.) and \( V_{IH} \) (Min.).

7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.
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