Renesas RA Family

RA Azure IoT Cloud Connectivity Solution

Introduction

The objective of this Application Project is to demonstrate the Renesas RA Azure IoT Cloud Connectivity solution by providing a fully working solution that sends sensor data to the Microsoft® Azure IoT Central cloud over Wi-Fi/Ethernet connection and using HAL drivers and middleware provided with Renesas Flexible Software Package (FSP).

You will start by setting up the project to read the necessary sensor data from the On-chip temperature sensor and then view that data within the debug context of e² studio IDE. Next, you will setup your Azure IoT Central software-as-a-service (SaaS) application to send and receive data to and from the evaluation kit. Lastly you will configure the necessary security credentials on your evaluation kit to securely connect to the Azure cloud.

This application project contains integrated Azure Embedded C SDK files which are designed to allow embedded (IoT) MCU devices like RA6M3 to communicate with Azure services such as Azure Device Provisioning Service (DPS) and Azure IoT Hub to demonstrate Azure cloud connectivity.

Hardware/Software Prerequisites:

Hardware:

• Renesas EK-RA6M3 kit with USB micro B cables (2) ([renesas.com/ra/ek-ra6m3](renesas.com/ra/ek-ra6m3))
• Silex SX-ULPGN Wi-Fi PMOD module (or) Ethernet cable.([renesas.com/wi-fi-pmod](renesas.com/wi-fi-pmod))
• PC running Windows® 10 with at least 2 USB ports

Software:

• Renesas Flexible Software Package platform installation, which includes:
  — e² studio 2.10.0 or later
  — FSP v 2.0.0 or greater
  — GCC Arm Embedded 9.2.1 (2019-q4-major)
• SEGGER J-Link USB driver
• Tera Term v4.0 or newer
• Web browser (Google Chrome, Mozilla Firefox or Microsoft Edge)

Prerequisites and Intended Audience

This application note assumes that the user has some experience with the Renesas e² studio IDE and Flexible Software Package (FSP). Before running this application, follow the procedure in the FSP User Manual to build and run the Blinky project. Doing so enables you to become familiar with the e² studio and the FSP and ensures proper functioning of debug connection to your board. In addition, this application note assumes the user have some knowledge of MQTT/TLS protocols.

The intended audience are users who want to develop Azure Cloud Connectivity applications using FSP MQTT/TLS modules on Renesas RA6M3 MCU series.
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1. RA MQTT/TLS Application Overview

This application project demonstrates the Renesas RA IoT Cloud Connectivity solution using the FSP MQTT/TLS modules and uses Microsoft® Azure as the cloud provider. Ethernet or Wi-Fi can be used as primary communication interface between the MQTT device and the Azure IoT Services.

The EK-RA6M3 kit acts as an MQTT node, connects to the Azure IoT service using MQTT/TLS protocol over Ethernet or Wi-Fi network interface. The application periodically reads the on-chip temperature sensor values and publishes this information to the Azure IoT Core. It also subscribes to a User LED state MQTT topic. You can turn the User LEDs ON/OFF by publishing the LED state remotely. This application reads the updated LED state and turns the Users LEDs ON/OFF.

![RA MQTT/TLS Application Overview](image)

This application project is a single user thread application and the main thread handles the following major functions:

1. Initialize network interface (Ethernet in case of Azure_EK_RA6M3_Eth project or Wi-Fi in case of Azure_EK_RA6M3_WiFi project).
2. Initialize sensors.
3. Initialize USB PCDC interface to print debug message over serial console.
4. Connect to Azure Cloud services.
5. Read sensor data periodically and publish the data on MQTT topics.
6. Toggle the user LED state based on the incoming MQTT message.
2. Powering Up the EK-RA6M3 Evaluation Kit

The following hardware components are needed for this application. Refer to EK-RA6M3 user’s manual (renesas.com/ra/ek-ra6m3) for the default jumper settings.

![Figure 2. EK-RA6M3 Board](image)

![Figure 3. Silex SX-ULPGN Wi-Fi PMOD Module](image)

Note: One micro USB cable is provided with the EK-RA6M3 kit. Users will need to supply one additional cable.

![Figure 4. Micro USB Cable](image)
1. In case of using Wi-Fi network interface, attach Silex SX-ULPGN Wi-Fi Pmod module to PMOD2 (J25, upper right). The Silex module and components should be facing up.

2. In case of using Ethernet network interface, attach an Ethernet cable to the EK_RA6M3 Ethernet LAN Port.

3. Connect the EK-RA6M3 kit to the PC using a USB micro-B cable connected to DEBUG (J10) on the board (right side of board above Ethernet jack).

4. Connect the second USB micro-B cable to the PC and to the USB high speed (J6) port on the opposite edge of the board. Make sure Jumper J7 has pin 2-3 connected.

5. Once completed, the LEDs should be illuminated as described below.

<table>
<thead>
<tr>
<th>LED1, LED2, LED3 (below user buttons)</th>
<th>Flashing red, green and blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED4 (middle of board)</td>
<td>Illuminating white</td>
</tr>
<tr>
<td>LED5 (right side, near USB debug port)</td>
<td>Illuminating yellow</td>
</tr>
</tbody>
</table>

3. **Importing the FSP Application Project**

1. Launch e² studio. e² studio can be launched from the Windows start menu or directly from the FSP folder. If you have multiple versions of e² studio installed, please make sure to launch the version of e² studio that was called out in the prerequisites section on page 1 of this application project.

2. In the Eclipse Launcher window, specify the destination for the new workspace. It is recommended to keep the path simple and avoid using spaces.

![Eclipse Launcher](image)

**Figure 5. Eclipse Launcher Window**

3. Click **Launch** to start e² studio in the specified path. When prompted, press **Apply** to dismiss pop-up window asking for permission to log and report usage (it will remain disabled).
4. The welcome screen may show inside the new workspace. It can be dismissed by clicking on the **Workbench** button in the top-right corner.

![Figure 6. Workbench Button](image)

5. Go to **File > Import** option.

![Figure 7. Import Option](image)

6. In the import dialog box, select the **General** option, and then select **Existing Projects into Workspace** to import the project into the current workspace and click **Next**.

![Figure 8. Importing Existing Projects into Workspace](image)
7. Click **Select archive file** and Click **Browse**.

![Selecting Archive File](image)

**Figure 9. Selecting Archive File**

8. Browse to the folder where the zip file for the project you want to import is located. Select the file for import. In our case, it is `Azure_EK_RA6M3_WiFi.zip` or `Azure_EK_RA6M3_Eth.zip` file depending up on the network interface.

9. Click **Finish** to import the project. Now that the project has been successfully imported, you can start configuring the project for the hardware.

10. Open the RA Configuration, if not already open, by double-clicking the configuration.xml file in the project explorer window.

![Project Explorer Window](image)

**Figure 10. Project Explorer Window**

**Note:** At this point, the ra_cfg and ra folders have not been created. These two folders contain files generated by e² studio and the FSP. The next step generates these files.
11. Click the **Generate Project Content** button in the top-right corner of the Configurator window. When prompted to *Proceed with save and generate*, tick the box next to **Always save and generate without asking** and click **Proceed**.

![Generate Project Content](image)

**Figure 11. Generate Project Content**

12. The RA Configurator will extract all the necessary drivers and generate the code based on the configurations provided in the **Properties** tab.

### 4. Setting up Azure IoT Central Application

In this section the cloud-side of the application will be created using Microsoft’s Azure IoT Central services. A device template will be used to structure the devices that will connect to the cloud application. EK-RA6M3 kit will be created as an instance of this template and will be used for communication with IoT Central in the upcoming sections.

1. Open a web browser and go to [http://azureiotcentral.com](http://azureiotcentral.com). Use the link in the top-right corner to **Sign in**. If you have not signed up yet, you will have a chance to do so (sign up is free).

![Sign in](image)

**Figure 12. Signing In**

2. Once logged in select **Build a solution**.

![Build a solution](image)

**Figure 13. Selecting 'Build a solution'**
3. On the upper left, click on the hamburger icon to **Expand Side Navigation** and then click **My apps**. Click + **New application** in **My Apps**.

![Image](image1.png)

**Figure 14.** Clicking New Application

4. Create a custom application with the parameters listed below. Once completed, press **Create**.

![Image](image2.png)

**Figure 15.** Creating a Custom Application

<table>
<thead>
<tr>
<th>Pricing plan:</th>
<th>Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select an application template:</td>
<td>Custom application</td>
</tr>
<tr>
<td>Application name:</td>
<td>(use the generated default or specify a unique name)</td>
</tr>
<tr>
<td>Contact information:</td>
<td>(specify required details)</td>
</tr>
</tbody>
</table>
5. The application dashboard will be shown. Press the **Device Templates** icon on the left navigation menu and click **+ New** to create a device template.

![Figure 16. Creating a New Device Template](image)

6. Select **IoT device** to create a custom device template for an **IoT device** and click **Next: Customize** button at the bottom of the page.

![Figure 17. Customizing the Device Template](image)
7. On the next screen, we are not configuring a gateway device, so skip this step and click the **Next: Review** button at the bottom of the page.

![Figure 18. Clicking Next: Review Button](image)

8. On the next page (Review), Click on **Create** button. Enter a name for your device template and press **Enter**.

9. Next, create a capability model for our IoT device. Click on **Custom** button.

![Figure 19. Creating a Custom Capability Model](image)
10. Now you should create an interface for our capability model. Click + **Add interface** button.

![Figure 20. Creating an Interface for Capability Model](image)

11. Choose Custom interface as shown below.

![Figure 21. Choosing a Custom Interface](image)

12. Click the + **Add capability** button to create capabilities.

![Figure 22. Clicking Capability Button](image)
13. Start creating the capabilities for the temperature sensor data as shown below. Start with the temperature capability. Click + Add capability button to add new sensor data capabilities.

14. For this application project, use the following properties:

**Temperature Sensor:**

<table>
<thead>
<tr>
<th>Display Name:</th>
<th>“temperature”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability type:</td>
<td>“Telemetry”</td>
</tr>
<tr>
<td>Semantic type:</td>
<td>“Temperature”</td>
</tr>
<tr>
<td>Schema:</td>
<td>“Float”</td>
</tr>
<tr>
<td>Unit:</td>
<td>“°F”</td>
</tr>
</tbody>
</table>

**Manufacturer String:**

<table>
<thead>
<tr>
<th>Display Name:</th>
<th>“manufacturer”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability type:</td>
<td>“Property”</td>
</tr>
</tbody>
</table>

**Toggle LED:**

<table>
<thead>
<tr>
<th>Display Name:</th>
<th>“led_toggle”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability type:</td>
<td>“Command”</td>
</tr>
<tr>
<td>Command:</td>
<td>“synchronous”</td>
</tr>
</tbody>
</table>

15. Click the **Save button** to save the capabilities.

16. Click **Views** tab to Generate default views for the device to quickly begin displaying device information.

---

Figure 23. Selecting Capabilities for the Application Project

Figure 24. Generating Default Views for the Device
17. In the next window, click **Generate default dashboard view(s)** button as shown below.

![Generate default dashboard view(s)](image)

**Figure 25. Clicking ‘Generate default dashboard view(s)’ Button**

18. Publish the newly created device template. To publish, click the **Publish** button as highlighted below and then click **Publish** again in the pop-up window.

Note: Once the template is published it cannot be edited.

![Publish this device template to the application](image)

**Figure 26. Publishing the Newly Created Device Template**
At this stage, the device templates which include the capability model and corresponding interfaces are created and the corresponding view options are configured. Now we need to create Devices. To create devices, click Devices tab, followed by + New option as highlighted below.

19. A pop-up window appears, choose the Template type for the device template we just created. Leave the default value for the Device name and click the Create button.

20. Click on the newly created device and click Connect button as highlighted below.

A new pop-up window appears with Device Connection information. This information needs to match with the corresponding values in our e² studio project. Open user_cfg.h file in e² studio and copy the Scope ID.
to `AZURE_SCOPE` macro, `Device ID` to `AZURE_DEVICE_ID` macro. On the Azure side, it’s recommended to use the blue copy buttons to reduce the chance of errors in matching these values from Azure to the application project.

![Device Connection Information](image)

### Figure 30. Device Connection Information

5. Setting up X.509 Certificate based Authentication

To enable X.509 Certificate based authentication mechanism, follow the instructions mentioned in the following sub-sections to generate device credentials that will be used in this project.

#### 5.1 Setting up Environment

1. Download PowerShell script for creating test CA and leaf certificates. Go to the script file on CA tools page in Azure IoT SDK repository: [https://github.com/Azure/azure-iot-sdk-c/blob/master/tools/CACertificates/ca-certs.ps1](https://github.com/Azure/azure-iot-sdk-c/blob/master/tools/CACertificates/ca-certs.ps1). Right-click **Raw** and select **Save link as**… (in Google chrome) or equivalent (other browsers).

![Save Link as Option](image)

#### Figure 31. Save Link as Option

2. Save the file into designated work folder. This folder will later be used to output certificates for Azure IoT Central and the RA device.

3. If your machine already has OpenSSL installed, you can go directly to step 5.1.5. OpenSSL is typically installed with other commonly used utilities such as Git for Windows.

4. Download Win32 or Win64 OpenSSL from [https://slproweb.com/products/Win32OpenSSL.html](https://slproweb.com/products/Win32OpenSSL.html) and run the installer. Make note of the installation directory specified in the wizard.
5. Run Windows PowerShell as an administrator. Open Start Menu, type `powershell` and right-click `Windows PowerShell` to select Run as Administrator.

![Running Windows PowerShell as an Administrator](image1.png)

Figure 32. Running Windows PowerShell as an Administrator

6. In the PowerShell window, type `openssl` and hit Enter. If red error message is shown, OpenSSL path is not present in the system PATH variable. If no error is shown and OpenSSL shell starts executing, write q, press Enter and skip to step 8.

7. Add OpenSSL directory to temporary PATH variable in current PowerShell session. Execute command shown below, where text inside quotation marks after the semicolon is replaced with path to bin directory inside OpenSSL installation directory (specified in step 4):

![Path to Bin Directory Inside OpenSSL](image2.png)

Figure 33. Path to Bin Directory Inside OpenSSL

8. Change active PowerShell directory to work folder used in step 2. Use `cd` command followed by directory path and press Enter. Include quotation marks at the start and end of the path if the path includes any whitespaces.

![Changing Active PowerShell Directory to Work Folder](image3.png)

Figure 34. Changing Active PowerShell Directory to Work Folder


10. If output from step 9 is other than Unrestricted, execute command below to set ExecutionPolicy. Original setting can be restored after CA and leaf certificates are generated (in section 4.3). Using Unrestricted execution policy will let PowerShell execute script used in this application project.

![Get-ExecutionPolicy Command](image4.png)

Figure 35. Get-ExecutionPolicy Command
11. Confirm changes to execution policy by typing y and pressing Enter.

12. Execute the script with ..\ca-certs.ps1 (notice the first two dot characters before backward-slash). This will introduce several new functions into the current PowerShell session. When prompted to confirm script execution, press r and hit Enter.

![Figure 36. Executing Script with '..\ca-certs.ps1']

13. Run Test-CACertsPrerequisites command. First two tests should return ok. Final test will return an error associated with missing OPENSSL_CONF definition. Since OpenSSL will use built-in defaults under such circumstances, this error message can be ignored.

![Figure 37. Running 'Test-CACertsPrerequisites' Command]

5.2 Creating and Verifying a Certificate Chain

1. Create root certificate, type New-CACertsCertChain rsa into PowerShell and confirm with Enter. Verify that the function outputs Success, as shown below. The output certificates will be added to the Windows Certificate store automatically and can be removed at the end of this application project.

![Figure 38. Creating the Root Certificate]
2. Go to the IoT Central application in the web browser and select Administration from the menu on the left side. Once in the Administration view, select Device Connection.

![Figure 39. Selecting the Device Connection](image)

3. Click ‘+ Create enrollment group’ under Device Connection.

![Figure 40. Creating the Enrollment Group](image)
4. Enter the **Name** for the new enrollment group, **Group type** as **IoT devices**, choose the Attestation type as **Certificate (X.509)** option and **Save** button.

![Figure 41. Selecting the Options for the New Enrollment Group](image)

5. Open the **enrollment group** just created as shown below.

![Figure 42. Opening the Enrollment Group Created](image)
6. Click **Manage primary** option as shown below.

![Figure 43. Clicking the ‘+Manage primary’ Option](image)

7. Click on **Upload** button for Primary certificate.

![Figure 44. Clicking ‘Upload’ Button for the Primary Certificate](image)

8. File upload prompt will now open. Navigate to the work folder used in step 1 and select *RootCA.pem* file.

9. Azure will parse the root certificate and will report that it needs to be verified. Click on the **Gear icon** to bring up Primary Certificate pop-up.

![Figure 45. Primary Certificate Pop-up](image)
10. In the **Certificate Verification** section of the window, press **Refresh** button to generate **Verification Code** against the root certificate.

![Certificate Verification](image)

**Figure 46. Generating Verification Code**

11. Copy the generated **Verification Code** into the clipboard. Use **Copy button** to avoid mistakes.

![Certificate Verification](image)

**Figure 47. Certificate Verification Window**

12. Keep **Primary Certificate** pop-up open in the browser and go back to the **PowerShell window**. Type `New-CACertsVerificationCert` followed by space and the verification code copied to the clipboard in previous step. Right-clicking inside **PowerShell** window will paste content from the clipboard automatically. Confirm command execution by hitting **Enter**.

![PowerShell Window](image)

**Figure 48. Verifying Certification**
13. Go back to the web browser where Primary Certificate pop-up should still be left open. Press Verify button at the bottom of the window.

Figure 49. Pressing Verify Button

14. Another file upload prompt will open. Select verifyCert4.cer file and confirm choice. Azure will parse the uploaded file and will produce notification that the primary certificate is now verified. Click Close to go back to IoT Central application.

Figure 50. Primary Certificate Verification

5.3 Creating a Device Certificate

1. To create leaf certificate, type `New-CACertsDevice` followed by space and the device name into the PowerShell console. Use name (Device ID) provided on IoT Central in earlier sections (as specified in section 4, step 20). Function will prompt for user password twice – any text can be provided here however it must be the same on both occasions. Script will output certificate files to the work folder.

Figure 51. Creating Leaf Certificate
2. Open the device certificate <device_id>-public.pem file using Notepad++ or similar utility. Copy the contents and convert them into strings. Open azure.h file in src directory, copy the converted string to DEVICE_X509_TRUST_PEM_FILE macro. Refer to example shown in the following image.

Note: By default, the application project contains a sample device certificate. Refer to the existing format and replace it with newly generated device certificate.

3. Open the device private key <device_id>-private.pem file using Notepad++ or similar utility. Copy the contents and convert them into strings. Open azure.h file in src directory, copy the converted string to DEVICE_PRIVATE_KEY_FILE macro. Refer to example shown in the following image.

Note: By default, the application project contains a sample device private key. Refer to the existing format and replace it with newly generated device private key.

---BEGIN RSA PRIVATE KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAvrO7l-1J2Lw52Bb2+eUYH9RkJK3H2FzDz/VYyc3uB5yL5eVe
I1unxfPK32m3/Zk3fKsFb8v9597rQdccccm96296wEw6v6vTqyCkx6uw1x0wCTCxEE6188
Bu1S5NnQ8W9szSU9lEcuHS8dN3e9Fh3f9QKXOGxq1x79P9kSte8Xs7T3033aw
Pn/hr9PC4n9NnVq7z6F66HDQe7vTFvLc5Hn6R55nB6Ykj5yS7/g7b6m5HhHTvLdL
KC7t4s1t3Jh/k36n4w62031793AdC7t2F/sC9kCv4w2767/1089BC8Lr5Q5565tAy6
1X9t87Y95V7e5v9H92h3k1d9J9bFvB1qt9Q9DQABQAgEBCA45kJ8j1fNgYqQ65g
p7tj/0674t7zJmYd27hXvUov699nK3/Fou6vVim6V5cCpq3V25D9O10G8bW42t
fe037d2x62FE9zF7sU/bUyJ49mNgC522P12RBFbJdCgabC5SDBCWbF9/0f998
jvdP5Q561c063xG76STXtX68/04q7e2w3UfF0yV02G8lZSG7Q98g9G9DEZC5F35p4C
/sCoA69n8j7T1o4U4B99C9e2w3UfF0Y02G8lQ98g9G9DEZC5F35p4C/shdP5Q561c063
2X1m50KrWq69P0m9at27chEt7PQfV5xvaQ9p30+8fvrjyhjxmn8M3eFrRa8n578
Eka2k1lVq/5BxYuVivlV7x8303d1m1RdFp7t0wHjxk3x+s/s2qX0Kyp02H7bEjtvkut6
EzUye3XkGyRZla1sV9zVla9b6Sn6YnF785j9g5c7hu1sVc6M0HcU
O17W139wK0G3h62v9a8iLb369Nqi/s7d64w0Yi37z41r3J3UyS0Mv06C6r413jUvGj9yCA
wy319yV5/35cCjx/jqek6s27ITnF15sCv7r7/PaOl7oD8vE1SqqUPMyYqYqYqSEAYQ0YU6
wIq5QbQ+eacv1jkm0Q5rs2u6snasV9Y17l7F1TvBVmYv9n9eI1m4xuAfQJm8hUk
9sLkFlEy003c3l21m5NlJ9s7F8/g21k6D7Tt0z312JyEv63f8z6B9m9O727XG
6kqY0q6vD72v3y0a2bM5LkN1s87Fp3D6Xn7cZTw6w3Pz97z72S968YG
29/zsP3s/321G97oI5z402s79U7i7Tz/06J9k3n9PqDjay399kO7Y
b/6GFvYv/229sL75/nK6v/LyJnKf3oU5Kr6fRe9mF2x0F7FLHz6CQ7Zg52I9NoV6G
G8F3VbJXOa8fI8Y7ww8xvKf7cyseAAM5hLrL4855z/a234jQgKuwW10U3ZEGFJv8d
LjCVs5tLsAK4k29bJ7T5X98/088/CS9v6S7P0Y83V9n6d7eovqaz23Q8UN
nRf5GcD9bVrYN6Lh32wY/v44x6MxWbEwJ7zLwDwVpQ6/FKX5Gq5jMe31JyU5BG1C

---END RSA PRIVATE KEY-----

Figure 52. Device Private Key Generation Example
6. Building the Application

1. In case of running Azure_EK_RA6M3_WiFi project, open user_cfg.h insert your Wi-Fi network name (SSID) and password in the designated defines between the quotation marks.

```c
#define WIFI_SSID "" 
#define WIFI_PWD ""
```

**Figure 53. Entering Wi-Fi Network Name and Password**

2. The project is now ready to compile. Press the “hammer” icon to start building the project.

**Figure 54. Starting to Build the Project**

3. The toolchain will report compilation and build status to the console pane in the lower-right corner of e² studio. When the build has completed, it should confirm that there are zero errors and four warnings. All warnings come from the third-party code.

**Figure 55. Compilation and Build Status Report**
7. Connecting to Azure IoT Cloud Server

This section covers establishing connectivity with the Azure Device Provisioning Service (DPS) server. Establishing a connection with DPS will be necessary to detect additional connection details such as the assigned hub – these will be needed in subsequent sections when using MQTT.

Using the connection string from DPS, the RA device will establish connection to the corresponding Azure IoT Hub. Upon, connection, the RA device will be able to periodically upload the sensor telemetry data to the Microsoft Azure hub. Microsoft’s server-side backend will manage the information so that it will later be displayed inside an IoT Central application.

1. The application is now ready to be programmed and run on the EK-RA6M3 board. Press the “bug” icon to begin the debug session.

![Figure 56. Starting the Debug Session](image)

2. You may be prompted to update the J-Link debugger firmware. You can click Yes to update. It should not take long to complete.

![Figure 57. J-Link Debugger Firmware Update Prompt](image)

3. Windows could also prompt you to allow the GBD server through your firewall. Click the checkbox to allow it through private networks, then Allow access.

![Figure 58. Allowing Access to the GBD Server](image)
4. e2 studio will perform flash programming routines and prompt to switch to Debug perspective. Select the check box by Remember my decision and click Yes. LED5 near the debug USB port will blink while programming.

5. The debug session is now started, and the application is paused at its entry function (Reset_Handler). At this point, you can set up additional debug features such as variable and expressions views before the program is executed. Select the Expressions tab on the top right pane of the e2 studio window:

![Figure 59. Selecting Expressions Tab on the Top Right Pane](image)

6. Click Add new expression and type “temp” for the symbol. Confirm the symbol name by pressing Enter on the keyboard. This variable holds temperature readings from the On-chip temperature sensor.

![Figure 60. Adding New Expression of Type ‘temp’](image)

7. Right-click the temp table entry and select Real-time Refresh. R symbol to the left of temp shows that real-time refresh has been enabled.

![Figure 61. Selecting Real-time Refresh](image)
8. Click the **Resume** button or press **F8** on the keyboard to start the application.

![Figure 62. Starting the Application](image)

9. The Program will stop again, this time at the start of the `main` function. Low-level initialization routines are now completed, and the temp and hum values reported on the Expressions pane should be 0. Press Resume or F8 again to resume the application and begin executing user code.

10. As the program is executing the **Expressions** view will report changing value for the `temp` and `hum` variables.

![Figure 63. Expressions View](image)
11. Open the serial console such as Tera Term to check the serial debug messages from the EK-RA6M3 kit. The RA device establishes connection with the Azure DPS to obtain the connection string. The RA device establishes connection with the Azure IoT Hub using the connection string obtained from Azure DPS and periodically publishes sensor data.

![COM3 - Tera Term VT](image)

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Image: COM3 - Tera Term VT

File Edit Setup Control Window Help

IP Address: 192.168.1.22
Subnet Mask: 255.255.255.0
Gateway IP: 192.168.1.1
Host Name: r0000BES63\registrations/2fyyw\tnmgc\api-version:2019-03-31
Connected to global.azure.devices.provisioning.net.

All demo topic filter subscriptions accepted.
Subscribed to $iot畋Registrations/cm/#
Sending register post message to DPS...
NOT PUBLISH successfully sent.

---------------------------

Incoming message:

Subscription topic filter: $ps\registrations/cm/#
Publish topic name: $ps\registrations/cm/#
Publish retain flag: 0
Publish qos: 1
Publish payload: "{"operationId":"4.0b3d5effe758b7b.58fc1e9-c72e-4f07-a46a-c6ac3f1f401","status":"assigning"}

---------------------------

Incoming message:

Subscription topic filter: $ps\registrations/cm/#
Publish topic name: $ps\registrations/cm/#
Publish retain flag: 0
Publish qos: 1
Publish payload: "{"operationId":"4.0b3d5effe758b7b.58fc1e9-c72e-4f07-a46a-c6ac3f1f401","status":"assigning"}

---------------------------

SUCCESS - Device provisioned:
Azure Hub Hostname: iotc-3d6d907fe-19e8-4a23-9a38-36bd7a104911.azure-devices.net
Device Id: 2fyyw\tnmgc

***** Attached from DPS *****
Connecting to Azure IoT Hub...
mqtt_client_id: 2fyyw\tnmgc
mqtt_username: iotc-3d6d907fe-19e8-4a23-9a38-36bd7a104911.azure-devices.net/2fyyw\tnmgc/api-version:2018-06-30/DeviceClientType:cx2F1.8.0-preview.2
Connected to iotc-3d6d907fe-19e8-4a23-9a38-36bd7a104911.azure-devices.net.
All demo topic filter subscriptions accepted.
Subscribed to $iot畋methds/POST/
Payload: "{"manufacturer":"Renesas Electronics America"}
Successfully connected to Azure IoT Hub
"temperature": "89.83"
NOT PUBLISH successfully sent.
NOT PUBLISH successfully sent.
"temperature": "90.19"
NOT PUBLISH successfully sent.

Figure 64. Serial Log Message for X.509 Based Authentication using Ethernet Interface
Connecting to WiFi...
Success!!!

IP Addr: 192.168.1.24

dps_username: OneMQ085653 registrations/2fyru?tmac?api-version=2019-03-31
Connected to global.azure-devices-provisioning.net.

All demo topic filter subscriptions accepted.
Subscribed to dps/registrations/tes/
Receiving pub message to DPS...
MQII PUBLISH successfully sent.

--------------------------------------------------
Incoming message:
Subscription topic filter: dps/registrations/tes/
Publish topic name: dps/registrations/tes/200/?grid=1&retry-after=3
Publish retain flag: 0
Publish qos: 1
Publish payload: ("operationId":4.0bd3d5f0e7507b9.618eb7d6-ac5d-417d-976+a-1333
086f8a0f", "status": "assigning")

--------------------------------------------------
Publishing after 2 seconds...
MQII PUBLISH successfully sent.

--------------------------------------------------
Incoming message:
Subscription topic filter: dps/registrations/tes/
Publish topic name: dps/registrations/tes/200/?grid=1
Publish retain flag: 0
Publish qos: 1
Publish payload: ("operationId":4.0bd3d5f0e7507b9.618eb7d6-ac5d-417d-976+a-1333
086f8a0f", "status": "assigned", "registrationState": "$25B9$": "enrollmentGroupID":
71729e-4945-4042-9a86-e4158553be3b", "registrationId": "2fyru?tmac?"; "coreId":
"0228-87-8705-12-43.235081.792", "assignedHub": "iotc-30907fe-19c8-4a23-9a38-35b7a104911.azure-devices.net", "deviceld": "2fyru?tmac?", "status": "assigning"
subscriptionId": "nnub", "subscriptionAssignment": "nnub", "publish_message": "nnub", "deviceMetadata": "nnub", "deviceMetadata": "nnub", "deviceMetadata": "nnub", "deviceMetadata": "nnub"}

SUCCESS - Device provisioned:
Azure Hub Hostname: iotc-30907fe-19c8-4a23-9a38-36bd7a104911.azure-devices.net
Device Id: 2fyru?tmac

Detached from DPS

Connecting to Azure IoT Hub...

mqtt_client_id: 2fyru?tmac
mqtt_username: iotc-30907fe-19c8-4a23-9a38-36bd7a104911.azure-devices.net/2fyru?
tmac?/api-version=2018-06-30.DeviceClientType=x2F1.0.0-preview.2

Connected to iotc-30907fe-19c8-4a23-9a38-36bd7a104911.azure-devices.net.

All demo topic filter subscriptions accepted.
Subscribed to $iotHub/methods/PPOST/#
Payload: ("manufacturer": "Renesas Electronics America")

Successfully connected to Azure IoT Hub

"temperature": "99.83"
MQII PUBLISH successfully sent.
MQII PUBLISH successfully sent.

"temperature": "91.96"
MQII PUBLISH successfully sent.
MQII PUBLISH successfully sent.

Figure 65. Serial Log Message for X.509 Based Authentication using Wi-Fi Interface
12. The RA device also publishes the read-only device property (manufacturer) string “Renesas Electronics America” only once after connecting to Azure IoT Central application. Go back to the web browser with the Azure IoT Central application open. Select the Devices tab and click on the device name. If the About window is not displayed, then select About tab to see this property update.

![Figure 66. Read only Device Property in About Tab](image)

13. Go back to the web browser with the Azure IoT Central application open. Select the Devices tab and click on the device name. If the Overview window is not displayed, then select Overview to see the temperature sensor readings received from the device.

![Figure 67. Viewing Temperature Sensor Readings in Overview Window](image)
14. Note that the RA device is only sending the value every few seconds to conserve network bandwidth and the IoT Central application is performing averaging over fixed periods of time, so it may take some time (15-20 seconds) before the first value is shown on the graph or for subsequent values to be posted to IoT Central.

![Temperature Sensor Readings](image)

**Figure 68. Temperature Sensor Readings**

15. Click the *About* tab to check the device property reported from EK-RA6M3 kit.

![Checking Device Property in About Tab](image)

**Figure 69. Checking Device Property in About Tab**

16. Click the *Terminate* button or press **Ctrl + F2** on the keyboard to stop the application and terminate the debug session.

![Stopping the Application and Terminating the Debug Session](image)

**Figure 70. Stopping the Application and Terminating the Debug Session**

8. **Receiving Messages from the IoT Central Application**

   The previous sections showed how we can send MQTT data from our device up to the cloud. We can also receive information and commands from the cloud and act on them. We already configured a `led_toggle` command in IoT Central previously and we will now hook that up to toggle LEDs on the dev kit.

   1. Build the project and start the debug session once the project is compiled and error-free.
   2. Click the *Resume* button twice and switch to the *Tera Term* window. Go to *Edit* and select *Clear Buffer*.
   3. The RA device establishes connection with the Azure IoT Hub using the connection string obtained from Azure DPS and periodically publish sensor data.
4. In the Azure IoT Central application, click on the **Devices** tab and select the device we created for this application project. In the device window, go to **command** tab and click the **Run** button as highlighted below.

![Figure 71. Clicking Run Button on the Command Tab](image)

5. **IoT Central** will report that the message was sent, and the **Tera Term** console will display its contents. The three LEDs under the user buttons on the EK-RA6M3 kit will toggle on and off for each press of the **Run** button.

![Figure 72. Tera Term Console Display](image)

Congratulations! You've reached the end of this application project. Your RA application is now complete. You can use it as a starting point for your own Azure cloud applications by utilizing other components of the Flexible Software Package and Azure IoT Central.

9. **Cleaning up PowerShell and Windows Certificate Store**

1. Go back to the **PowerShell window** and type `Set-ExecutionPolicy -ExecutionPolicy` followed by space and the execution policy name retrieved in section 5, step 9. Usually this setting is **Restricted**. Press **Enter** to execute the command. When prompted, write **y** and press **Enter** again.

![Figure 73. Setting the Execution Policy](image)
2. The **PowerShell window** can now be closed.

3. Open start menu and type *manage computer certificates* and select the *best match* suggestion pointing to *Control Panel* widget.

![Figure 74. Managing Computer Certificates](image)

4. **Certificate Manager (certlm)** will now open. From the menu on the left side, expand Personal and select *Certificates*.

5. Select and delete (that is, by pressing **Delete** on the keyboard) every certificate issued by entity starting with *Azure IoT CA TestOnly*.

![Figure 75. Deleting Certificates Issued by Entities Starting with ‘Azure IoT Test CA TestOnly’](image)

6. Expand **Trusted Root Certification Authorities** on the left side and select *Certificates*. Repeat the process from step 5 – this category should only have one certificate issued by Azure IoT CA TestOnly Root CA.

7. Close Certificate Manager.

**10. Next Steps and References**

- Refer to the following GitHub repository for various FSP modules example projects and application projects ([https://github.com/renesas/ra-fsp-examples/](https://github.com/renesas/ra-fsp-examples/))
- Refer to Establishing and Protecting Device Identity using SCE7 and Security MPU (R11AN0449) on renesas.com
- Refer to Securing Data at Rest utilizing the RA Security MPU (R11AN0416) on renesas.com
- Refer to Azure GitHub link for more details on Azure SDK for Embedded C ([https://github.com/Azure/azure-sdk-for-c](https://github.com/Azure/azure-sdk-for-c))
Website and Support

Visit the following vanity URLs to learn about key elements of the RA family, download components and related documentation, and get support.

- RA Product Information: renesas.com/ra
- RA Product Support Forum: renesas.com/ra/forum
- RA Flexible Software Package: renesas.com/FSP
- Renesas Support: renesas.com/support
## Revision History

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<tr>
<td>1.00</td>
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<td>—</td>
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<td>First release document</td>
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