Introduction

This manual describes the device composition, software composition, procedure of checking operation, details of software processing and software sequence about the host sample.

The host sample works on the Renesas Starter Kit for RL78/G14, and controls the Renesas Bluetooth low energy microcontroller RL78/G1D device programmed with Bluetooth Low Energy protocol by serial communication.

Target Device

Renesas Starter Kit for RL78/G14

Related documents

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluetooth Low Energy Protocol Stack</td>
<td></td>
</tr>
<tr>
<td>User’s Manual</td>
<td>R01UW0095E</td>
</tr>
<tr>
<td>API Reference Manual: Basics</td>
<td>R01UW0088E</td>
</tr>
<tr>
<td>Application Note: Sample Program</td>
<td>R01AN1375E</td>
</tr>
<tr>
<td>Application Note: rBLE Command Specification</td>
<td>R01AN1376E</td>
</tr>
<tr>
<td>RL78/G1D</td>
<td></td>
</tr>
<tr>
<td>User’s Manual: Hardware</td>
<td>R01UH0515E</td>
</tr>
<tr>
<td>RL78/G1D Evaluation Board</td>
<td></td>
</tr>
<tr>
<td>User’s Manual</td>
<td>R30UZ0048E</td>
</tr>
<tr>
<td>RL78/G14</td>
<td></td>
</tr>
<tr>
<td>User’s Manual: Hardware</td>
<td>R01UH0186E</td>
</tr>
<tr>
<td>Renesas Starter Kit for RL78/G14</td>
<td></td>
</tr>
<tr>
<td>User’s Manual</td>
<td>R20UT0785E</td>
</tr>
<tr>
<td>Tutorial Manual</td>
<td>R20UT0786E</td>
</tr>
<tr>
<td>Quick Start Guide</td>
<td>R20UT0787E</td>
</tr>
<tr>
<td>CPU Board Schematics</td>
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1. Overview

This manual describes the device composition, software composition, procedure of checking operation, details of software processing and software sequence about the host sample.

The host sample works on the Renesas Starter Kit for RL78/G14 (RSK), and controls the Renesas Bluetooth low energy microcontroller RL78/G1D device programmed with Bluetooth Low Energy protocol by serial communication. Serial communication between the RSK and the RL78/G1D evaluation board supports the UART 2-wire connection\textsuperscript{NOTE1} and UART 2-wire with branch connection\textsuperscript{NOTE2}.

For details about the BLE protocol stack APIs, refer to Bluetooth Low Energy Protocol Stack API Reference Manual\textsuperscript{(R01UW0088)}.

Notes: 1. UART 2-wire connection is a communication method using TxD and RxD of the UART data signal line.
2. UART 2-wire with branch connection is expanding 2-wire UART. The TxD line is branched and connected to the WAKEUP of modules from Host MCU. About connection between Host MCU and BLE MCU, refer to "4.3.3 Example of Application Circuit".

1.1 Environment

The environment in which the host sample was build and checking operation is shown below.

- Hardware environment
  - Host
    - PC/AT\textsuperscript{TM} compatible computer
    - Processor : At least 1.6GHz
    - Main Memory : At least 1GB
    - Display : 1024 x 768 or higher resolution and 65,536 colors
    - Interface : USB2.0
  - Device
    - Renesas Starter Kit for RL78/G14
    - Renesas BLE Evaluation Board for RL78/G1D
    - Smart Phone (Android device or iOS device)

- Tools
  - Renesas on-chip debugging emulator E1

- Software environment
  - Windows7 Service Pack1
  - e\textsuperscript{2} studio V4.3.1.001 / RL78 Family C Compiler Package V1 V1.03.00
    or Renesas CS+ for CC V4.00.00 / RL78 Family C Compiler Package V1 V1.03.00
    or Renesas CS+ for CA, CX V3.02.00 / Renesas CA78K0R V1.72
  - Renesas Flash Programmer v3.02.00
2. Compositions

2.1 Device Composition

The device composition for checking operation the host sample is shown in Figure 2-1.

Local Device consists of RL78/G14 as a Host MCU and RL78/G1D as a BLE MCU which are connected by UART. Remote Device is a Smart Phone which is an Android device or iOS device.

Local Device behaves as a Slave and Remote Device behaves as a Master. RL78/G14 executes BLE communication with Smart Phone by controlling BLE protocol stack on RL78/G1D via interactive UART communication.

![Device Composition Diagram](image)

Figure 2-1 Device Composition

The overview of the host sample is shown below.

- It uses rBLE API and executes below operations.
  - After power up, it starts broadcasting and establishes a connection automatically.
  - After establishing a connection, it enables SCP (Sample Custom Profile).
  - It executes pairing and starting encryption if Remote Device requires.
  - It sends ADC result value every second if Remote Device permits the notification from Local Device.
- It is implemented a simple scheduler for management processing sequence.
- It changes the RL78/G14 state into the STOP mode if there is nothing to execute.
- It supposes that peer device is a smart phone (Android device or iOS device).
2.2 Software Composition

The software composition of RL78/G14 and RL78/G1D is shown in Figure 2-2.

![Software Composition Diagram](image)

Figure 2-2 Software Composition

The software of Host MCU consists of Low Level Peripheral drivers and Peripheral drivers which controls MCU peripheral hardware, RSCIP (Renesas Serial Communication Interface Protocol), rBLE_Host which provides rBLE APIs, Host Application which controls the system, and Sample Custom Profile using the GATT API.

Low Level Peripheral driver code is generated by the Code Generator. RSCIP and rBLE_Host are included in BLE protocol stack package and provided code. When developing software, it is necessary to use the latest code which is provided by BLE protocol stack package.

<table>
<thead>
<tr>
<th>Software</th>
<th>Functions</th>
<th>When developing software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host Application</td>
<td>Initializing rBLE</td>
<td>Need to be coded</td>
</tr>
<tr>
<td></td>
<td>Scheduling rBLE command execution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Registering rBLE event callbacks</td>
<td></td>
</tr>
<tr>
<td>Sample Custom Profile (SCP)</td>
<td>Custom Profile using GATT APIs</td>
<td>No need to be coded (provided by package)</td>
</tr>
<tr>
<td>rBLE_Host</td>
<td>Providing rBLE APIs</td>
<td>No need to be coded (provided by package)</td>
</tr>
<tr>
<td></td>
<td>Executing rBLE event callbacks</td>
<td></td>
</tr>
<tr>
<td>RSCIP</td>
<td>Controlling serial communication</td>
<td>No need to be coded (provided by package)</td>
</tr>
<tr>
<td>Peripheral Driver</td>
<td>Controlling Host MCU peripheral hardware</td>
<td>Need to be coded</td>
</tr>
<tr>
<td>Low Level Peripheral Driver</td>
<td>Controlling Host MCU peripheral hardware primitively</td>
<td>No need to be coded (generated by tool)</td>
</tr>
</tbody>
</table>

Notes: 1. Code files for software development are provided by BLE protocol stack package.
2. Code files for software development are generated by the Code Generator.
The software of BLE MCU consists of RF driver which controls RF/BB, Host/Controller stacks, Profiles, rBLE_Core, Serial Driver and RSCIP for communicating with Host MCU, RWKE (Renesas Wireless Kernel Extension) which manages the system and Modem application.

The build environment and tools and source code and libraries are provided by BLE protocol stack.

<table>
<thead>
<tr>
<th>Software</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modem Application</td>
<td>Controlling RSCIP and rBLE</td>
</tr>
<tr>
<td>RWKE</td>
<td>Managing the whole system schedule and memory resource.</td>
</tr>
<tr>
<td>RSCIP</td>
<td>Controlling serial communication</td>
</tr>
<tr>
<td>Peripheral Driver/Serial Driver</td>
<td>Controlling BLE MCU peripheral hardware</td>
</tr>
<tr>
<td>rBLE_Core</td>
<td>Providing rBLE APIs</td>
</tr>
<tr>
<td>Profile</td>
<td>Providing Profiles functions</td>
</tr>
<tr>
<td>Host Stack</td>
<td>Providing GAP, GATT, SM, L2CAP functions</td>
</tr>
<tr>
<td>SCP GATT Database</td>
<td>GATT Database of Sample Custom Profile</td>
</tr>
<tr>
<td>Controller Stack</td>
<td>Providing LL functions</td>
</tr>
</tbody>
</table>
2.3 Peripheral Hardware Composition

The peripheral hardware composition of RL78/G14 is shown in Figure 2-3.

The host sample uses the RL78/G14 peripherals of Serial Array Unit, 12bit Interval Timer A/D Converter, and uses the RSK peripheral hardware of Variable Resistor, LCD, LED, and SW. And at least it needs Serial Array Unit and 12bit Interval Timer for using rBLE.

![Figure 2-3 Peripheral Hardware Composition](image)

<table>
<thead>
<tr>
<th>Peripheral Hardware</th>
<th>Purpose</th>
<th>Necessity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Array Unit</td>
<td>Communicating with BLE MCU (UART2 or UART0 which can SNOOZE)</td>
<td>Mandatory</td>
</tr>
<tr>
<td>12bit Interval Timer</td>
<td>Monitoring UART timeout and Triggering for Profile Notification</td>
<td>Mandatory</td>
</tr>
<tr>
<td>A/D Converter</td>
<td>Generating for Notification data</td>
<td>Optional</td>
</tr>
<tr>
<td>Variable Resistor(RV1)</td>
<td>Generating for Notification data (connected ADC)</td>
<td>Optional</td>
</tr>
<tr>
<td>LCD(LCD)</td>
<td>Displaying BLE command, BLE event and PassKey in pairing</td>
<td>Optional</td>
</tr>
<tr>
<td>LED(LED0)</td>
<td>Displaying MCU status (light on: RUN mode, light off: STOP mode)</td>
<td>Optional</td>
</tr>
<tr>
<td>SW(SW3)</td>
<td>Triggering for Disconnection</td>
<td>Optional</td>
</tr>
</tbody>
</table>

Note: Peripheral hardware which Host MCU required to use the rBLE is classified “Mandatory”, other peripheral hardware is classified “Optional”.

Notable settings of Code Generator tool in CS+ is shown in Table 2-4.
### Table 2-4 Peripheral Hardware Configuration

<table>
<thead>
<tr>
<th>Peripheral Hardware</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock Generator</td>
<td>High-speed main mode 2.7(V) ≤ VDD ≤ 5.5(V)</td>
</tr>
<tr>
<td>-Clock</td>
<td></td>
</tr>
<tr>
<td>Main system clock (fMAIN)</td>
<td>High-speed on-chip oscillator (fIH)</td>
</tr>
<tr>
<td>Hi-speed on-chip oscillator</td>
<td>24(MHz)</td>
</tr>
<tr>
<td>Sub system clock (fSUB)</td>
<td>used XT1 oscillation (fXT) 32.768(kHz) low power consumption oscillation</td>
</tr>
<tr>
<td></td>
<td>permit to supply clock in STOP,HALT mode</td>
</tr>
<tr>
<td>RTC, interval timer clock</td>
<td>32.768(kHz)</td>
</tr>
<tr>
<td>CPU/peripheral hardware clock frequency (fCLK)</td>
<td>24000(kHz)</td>
</tr>
<tr>
<td>Interrupt functions</td>
<td></td>
</tr>
<tr>
<td>-External Interrupt</td>
<td></td>
</tr>
<tr>
<td>INT10</td>
<td>Use INTP10 detect falling edge low priority</td>
</tr>
<tr>
<td>Serial array unit</td>
<td></td>
</tr>
<tr>
<td>-SAU1</td>
<td></td>
</tr>
<tr>
<td>-Channel</td>
<td></td>
</tr>
<tr>
<td>Channel 0</td>
<td>UART2 transmitting/receiving</td>
</tr>
<tr>
<td>Serial array unit</td>
<td></td>
</tr>
<tr>
<td>-SAU1</td>
<td></td>
</tr>
<tr>
<td>-UART2</td>
<td></td>
</tr>
<tr>
<td>-Receiving</td>
<td></td>
</tr>
<tr>
<td>Data bit length</td>
<td>8 bit</td>
</tr>
<tr>
<td>Data Direction</td>
<td>LSB</td>
</tr>
<tr>
<td>Parity</td>
<td>no parity</td>
</tr>
<tr>
<td>Stop bit length</td>
<td>1 bit</td>
</tr>
<tr>
<td>Data Phase</td>
<td>standard</td>
</tr>
<tr>
<td>Baudrate</td>
<td>4800(bps)</td>
</tr>
<tr>
<td>Interrupt</td>
<td>reception transfer end interruption (INTSR2) high priority</td>
</tr>
<tr>
<td>Callback function</td>
<td>Received Error</td>
</tr>
<tr>
<td>Serial array unit</td>
<td></td>
</tr>
<tr>
<td>-SAU1</td>
<td></td>
</tr>
<tr>
<td>-UART2</td>
<td></td>
</tr>
<tr>
<td>-Transmitting</td>
<td></td>
</tr>
<tr>
<td>Transfer mode</td>
<td>single mode</td>
</tr>
<tr>
<td>Data bit length</td>
<td>8 bit</td>
</tr>
<tr>
<td>Data direction</td>
<td>LSB</td>
</tr>
<tr>
<td>Parity</td>
<td>no parity</td>
</tr>
<tr>
<td>Stop bit length</td>
<td>1 bit</td>
</tr>
<tr>
<td>Data phase</td>
<td>standard</td>
</tr>
<tr>
<td>Baudrate</td>
<td>4800(bps)</td>
</tr>
<tr>
<td>Interrupt</td>
<td>transmission end interruption (INTST2) low priority</td>
</tr>
<tr>
<td>Callback function</td>
<td>Transmitted</td>
</tr>
<tr>
<td>A/D converter</td>
<td></td>
</tr>
<tr>
<td>A/D converter</td>
<td>used</td>
</tr>
<tr>
<td>comparator</td>
<td>unused</td>
</tr>
<tr>
<td>Resolution</td>
<td>8 bit</td>
</tr>
<tr>
<td>Trigger mode</td>
<td>software trigger mode</td>
</tr>
<tr>
<td>Conversion mode</td>
<td>one shot select mode</td>
</tr>
<tr>
<td>Interrupt</td>
<td>conversion end interruption (INTAD) low priority</td>
</tr>
<tr>
<td>12-bit interval timer</td>
<td></td>
</tr>
<tr>
<td>Interval timer</td>
<td>used</td>
</tr>
<tr>
<td>Interval period</td>
<td>10(ms)</td>
</tr>
<tr>
<td>Interrupt</td>
<td>interval period expiration interruption (INTIT) low priority</td>
</tr>
</tbody>
</table>
2.4 File Composition

The file composition of the host sample is shown below.

(R)-mark which is set on the head of file name is shown that file is included in the BLE protocol stack package. When developing software, it is necessary to use the latest code which is provided by BLE protocol stack package.

HostSampleRL78G14

- Platform
  - driver
    - plf
      - plf.c
      - plf.h
    - serial
      -uart.c
      -uart.h
  - timer
      - timer.c
      - timer.h
  - lcd
      -lcd.c
      -lcd.h
- include
  - arch.h
  - compiler.h
  - ll.h
  - types.h
  - rscp_api.h
  - rskrl78g14def.h
  - iodefine.h
- rBLE
  - sample_app
    - app.c
  - sample_profile
    -scp
      -scps.c
  - host
    - rble_host.c
    - rble_if_api_ch.c
  - gap
    - rble_api_gap.c
  - gatt
    - rble_api_gatt.c
  - sm
    - rble_api_sm.c
  - vs
    - rble_api_vs.c
  - rscp
    - rscp.c
    - rscp.h
    - rscp_cntl.c
    - rscp_cntl.h
    - rscp_ext.h
    - rscp_uart.c
    - rscp_uart.h
- include
  - db_handle.h
  - prf_sel.h
  - rble.h
  - rble_api.h
  - rble_api_custom.h
  - rble_trans.h
  - rble.h
  - rble_macro.h
  - rble_api.h
  - rble_api_custom.h
  - rble_trans.h
  - scp
    -scps.c
  - host
    - rble_host.c
    - rble_if_api_ch.c
  - gap
    - rble_api_gap.c
  - gatt
    - rble_api_gatt.c
  - sm
    - rble_api_sm.c
  - vs
    - rble_api_vs.c
  - rscp
    - rscp.c
    - rscp.h
    - rscp_cntl.c
    - rscp_cntl.h
    - rscp_ext.h
    - rscp_uart.c
    - rscp_uart.h
  - include
    - db_handle.h
    - prf_sel.h
    - rble.h
    - rble_api.h
    - rble_api_custom.h
    - rble_trans.h
    -scp
      -scps.c
    - host
      - rble_host.c
      - rble_if_api_ch.c
    - gap
      - rble_api_gap.c
    - gatt
      - rble_api_gatt.c
    - sm
      - rble_api_sm.c
    - vs
      - rble_api_vs.c
    - rscp
      - rscp.c
      - rscp.h
      - rscp_cntl.c
      - rscp_cntl.h
      - rscp_ext.h
      - rscp_uart.c
      - rscp_uart.h
    - include
      - db_handle.h
      - prf_sel.h
      - rble.h
      - rble_api.h
      - rble_api_custom.h
      - rble_trans.h
      -scp
        -scps.c
      - host
        - rble_host.c
        - rble_if_api_ch.c
      - gap
        - rble_api_gap.c
      - gatt
        - rble_api_gatt.c
      - sm
        - rble_api_sm.c
      - vs
        - rble_api_vs.c
      - rscp
        - rscp.c
        - rscp.h
        - rscp_cntl.c
        - rscp_cntl.h
        - rscp_ext.h
        - rscp_uart.c
        - rscp_uart.h
      - include
        - db_handle.h
        - prf_sel.h
        - rble.h
        - rble_api.h
        - rble_api_custom.h
        - rble_trans.h

(R)-mark which is set on the head of file name is shown that file is included in the BLE protocol stack package. When developing software, it is necessary to use the latest code which is provided by BLE protocol stack package.
Each project directory include following low level peripheral drivers. Though the low level drivers for each project have different implementation such as interrupt handler declaration, the low level peripheral drivers have same behavior.
3. Procedure

3.1 Preparation

3.1.1 Host MCU

The procedure about preparing Host MCU of RL78/G14 is shown below. When changing the UART connection method, refer to 3.1.5.

Following shows the procedure to build the firmware for Host MCU. The procedure is different depends on the development environment.

(1) e²studio

1. Launch e² studio.
2. Right click on “Project Explorer” and select “Import…” from the dropdown menu.
3. “Import” window is popped up and select “Existing Projects into Workspace” and click “Next >>”.
4. Fill “Select root directory:” form with the project directory shown in Table 3-1.
5. Make sure that the project you selected is displayed in “Projects:” and click “Finish”. Then the windows is closed.
6. Right click on the project just imported on “Project Explorer” and Select “Build Project” from the dropdown menu.
7. Refer Table 3-1 for the Firmware file generate path.

(2) CS+

1. Double click the project file shown in Table 3-1.
2. Right click on “BLE_Emb” in “Project Tree” and select “Build BLE_Emb” from the dropdown menu.
3. Refer Table 3-1 for the Firmware file generate path.
Table 3-1  Host MCU Project Directory and Firmware Path

<table>
<thead>
<tr>
<th></th>
<th>e\textsuperscript{2}studio</th>
<th>CS+ for CC</th>
<th>CS+ for CA,CX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Directory</td>
<td>HostSampleRL78G14\project\e2studio\HostSample</td>
<td>HostSampleRL78G14\project\CS_CCRL\RSKRL78G14.mtpj</td>
<td>HostSampleRL78G14\project\CubeSuite\RSKRL78G14.mtpj</td>
</tr>
<tr>
<td>Firmware File</td>
<td>HostSampleRL78G14\project\e2studio\HostSample\DefaultBuild\HostSample.hex</td>
<td>HostSampleRL78G14\project\CS_CCRL\HostSample\DefaultBuild\HostSample.hex</td>
<td>HostSampleRL78G14\project\CubeSuite\HostSample\DefaultBuild\HostSample.hex</td>
</tr>
</tbody>
</table>

Next shows the procedure to boot the firmware on Host MCU.

1. Refer to Table 3-2 and set jumpers on the RSK board.
2. Connect E1 emulator to RSK and connect E1 emulator to PC.
3. Connect AC power adapter to RSK and supply power from AC power adapter to RSK.
4. Start RFP (Renesas Flash Programmer) and create workspace by selecting [File] \rightarrow [Create New Project], select [RL78] as [Microcontroller] and push [Connect] button.
5. Select “HostSample.hex” on [Operation] tab \rightarrow [Program File].
7. Remove AC power adapter and E1 emulator from RSK board.

Table 3-2  Jumper Setting

<table>
<thead>
<tr>
<th>JumperJ5 setting</th>
<th>JumperJ6 setting</th>
<th>Power source</th>
<th>Input voltage</th>
<th>Regulator supply voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin2-3 shorted</td>
<td>open</td>
<td>PWR connector</td>
<td>5V</td>
<td>3.3V</td>
</tr>
</tbody>
</table>
3.1.2 BLE MCU

The procedure about preparing BLE MCU of RL78/G1D is shown below. When changing the UART connection method, refer to 3.1.5.

Note: The source of supplying power is selectable from AC power adapter or USB port.

Note: It is possible to use “RL78_G1D_CM(SCP).hex” firmware included in the package of BLE protocol stack. If use this firmware, start below procedure from the step 8. But pairing sequence with iOS device is not executed, because this firmware is made without the step2.

First prepare the source code.

1. Download the EEPROM Emulation Library and Code Flash Library from the Renesas web site, and copy the library to following directories. The copy directory is different depends on the compiler.
   - EEPROM Emulation Library
     - CC-RL
       RL78_G1D\Project_Source\renesas\src\driver\dataflash\cc_rl
     - CA78K0R
       RL78_G1D\Project_Source\renesas\src\driver\dataflash\cs
   - Code Flash Library
     - CC-RL
       RL78_G1D\Project_Source\renesas\src\driver\codeflash\cc_rl
     - CA78K0R
       RL78_G1D\Project_Source\renesas\src\driver\codeflash\cs

2. To execute pairing with Remote Device, perform the following procedures. But this alteration is not essential. Open “prf_config.c” file and find “Sample Custom Notify Cfg Value” words. In near the location where found words, change the Attribute Permission configuration from (RBLE_GATT_PERM_RD | RBLE_GATT_PERM_WR) to (RBLE_GATT_PERM_RD | RBLE_GATT_PERM_WR_UNAUTH). This alteration changes Notification configuration of Sample Custom Profile to Write Permission (Unauthentication Required). This configuration will be needed for secure communication with Remote Device.

Then build the source code. The procedure is different depends on the development environment.

1. Launch e2 studio.
2. Right click on “Project Explorer” and select “Import...” from the dropdown menu.
3. “Import” window is popped up and select “Existing Projects into Workspace” and click “Next >”.
4. Fill “Select root directory:” form with the project directory shown in Table 3-3.
5. Make sure that the project you selected is displayed in “Projects:” and click “Finish”. Then the windows is closed.
6. Right click on the project just imported on “Project Explorer” and select “Renesas Tool Settings” → “Tool Settings” → “Compiler” → “Source” → “Macro definition” and add “USE_SAMPLE_PROFILE” macro (If “noUSE_SAMPLE_PROFILE” macro is defined, delete “no” word.).
7. Right click on the project on “Project Explorer” and select “Build Project” from the dropdown menu.
8. Refer Table 3-3 for the Firmware file generate path.
1. Double click the project file shown in Table 3-3.
2. Select [Property] in the right clicked menu of Build Tool in “rBLE_emb” subproject in the project tree.
3. Define “USE_SAMPLE_PROFILE” macro in the location of [Preprocess] \(\rightarrow\) [Defined Macros] in the Compile Option of the dialog displayed. (If “noUSE_SAMPLE_PROFILE” macro is defined, delete “no” word.)
4. Right click on “BLE_Emb” in “Project Tree” and select “Build BLE_Emb” from the dropdown menu.
5. Refer Table 3-3 for the Firmware file generate path.

Finally write the firmware onto BLE MCU.

1. Connect E1 emulator to BLE Evaluation Board and connect E1 emulator to PC.
2. Connect the power source to BLE Evaluation Board and supply power to BLE Evaluation Board.
3. Start RFP (Renesas Flash Programmer) and create workspace by selecting [File] \(\rightarrow\) [Create New Project]. And then select [RL78] as [Microcontroller] and push [Connect] button.
4. Uncheck Erase and P.V checkbox on the [Block Setting] tab \(\rightarrow\) [Code Flash 1] \(\rightarrow\) [Block255] and all blocks of [Data Flash 1].
5. Select the generated firmware by the menu [User/Data Area] and select [Write after Delete] command.
7. Remove the power source and E1 emulator from BLE Evaluation Board.
### Table 3-4  Switch Setting

<table>
<thead>
<tr>
<th>Switch</th>
<th>Setting</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW7</td>
<td>2-3 connected (right) &lt;Default&gt;</td>
<td>Power supplied from AC adapter or USB via regulator</td>
</tr>
<tr>
<td>SW8</td>
<td>1-2 connected (left) &lt;Default&gt;</td>
<td>Power supplied from AC adapter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: if power supplied from USB, connect 2-3 (Right)</td>
</tr>
<tr>
<td>SW9</td>
<td>1-2 connected (left)</td>
<td>Connected to an external extension interface.</td>
</tr>
<tr>
<td>SW10</td>
<td>1-2 connected (left)</td>
<td>Power supplied to the module.</td>
</tr>
<tr>
<td>SW11</td>
<td>2-3 connected (right)</td>
<td>Power supplied from a source other than the E1 debugger.</td>
</tr>
<tr>
<td>SW12</td>
<td>2-3 connected (right)</td>
<td>(fixed default)</td>
</tr>
<tr>
<td>SW13</td>
<td>1-2 connected (left)</td>
<td>Connected to USB interface.</td>
</tr>
</tbody>
</table>

### 3.1.3 Host MCU - BLE MCU Connection

The procedure about wired connection between Host MCU and BLE MCU is shown below.

Note: About connection of UART 2-wire with branch connection, refer to "4.3.3 Example of Application Circuit".

1. Refer to Table 3-5 and connect pins RSK board and BLE Evaluation Board by wires.
2. Start supplying power to BLE Evaluation Board.
3. Start supplying power to RSK board.

### Table 3-5  pin connection

<table>
<thead>
<tr>
<th>RL78/G14 ports (RSK pins)</th>
<th>RL78/G1D ports (board pins)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>TXD2 (J3-Pin16)</td>
<td>RxD0 (CN4-Pin16)</td>
<td>UART (Host MCU→BLE MCU)</td>
</tr>
<tr>
<td>RXD2 (J3-Pin15)</td>
<td>TxD0 (CN4-Pin14)</td>
<td>UART (BLE MCU→Host MCU)</td>
</tr>
<tr>
<td>Vss (GND1)</td>
<td>Vss (CN4-Pin26)</td>
<td>Ground</td>
</tr>
</tbody>
</table>

### 3.1.4 Smart Phone

The procedure about preparation Smart Phone is shown below.

Install below application either Android device or iOS device which is used as Remote Device.

- (for Android device) “BLE Scanner: Read, Write, Notify” - Pixel’s Perception  
- (for iOS device) “GATTBrowser” – Renesas Electronics  
3.1.5 UART Connection Method Setting

It shows the source files change point for setting the UART connection method.

(1) Host MCU

UART connection method of the host sample is selected by the following macro of uart.h.

Table 3-6 Setting of uart.h

<table>
<thead>
<tr>
<th>Macro</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERIAL_U_DIV_2WIRE</td>
<td>0 : UART 2-wire connection &lt;default setting&gt;</td>
</tr>
<tr>
<td></td>
<td>1 : UART 2-wire with branch connection</td>
</tr>
</tbody>
</table>

(2) BLE MCU

BLE UART connection method of the MCU firmware will be selected in the following macro of serial.h and wakeup.c, which is included in the BLE protocol stack.

Table 3-7 Setting of serial.h

<table>
<thead>
<tr>
<th>Macro</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERIAL_U_2WIRE</td>
<td>(1) UART 2-wire connection : &lt;default setting&gt; Set (1) to SERIAL_U_2WIRE. Set (0) to other macros.</td>
</tr>
<tr>
<td>SERIAL_U_DIV_2WIRE</td>
<td>(0) UART 2-wire with branch connection : Set (1) to SERIAL_U_DIV_2WIRE. Set (0) to other macros.</td>
</tr>
</tbody>
</table>

Table 3-8 Setting of wakeup.c

<table>
<thead>
<tr>
<th>Macro</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE_WAKEUP_SIGNAL_PORT</td>
<td>(0) /* Modem Setting */ 0 : UART 2-wire connection &lt;default setting&gt;</td>
</tr>
<tr>
<td></td>
<td>1 : UART 2-wire with branch connection</td>
</tr>
</tbody>
</table>
3.2 Verification

3.2.1 Android Device

The procedure about verifying host sample with Android device is shown below.

1. Start “GATTBrowser” application.
2. Select a device named “Renesas-BLE” from the nearby devices list to connect with the device. (Figure A1 Arrow-1)
3. Select the Characteristic the UUID is 02000000-0000-0000-0000-000000000080. (Figure A2 Arrow-1)
4. Select [Notification Off]. (Figure A3 Arrow-1)
5. Enter passkey (six digits) to the passkey dialog. Note1 Note2 (Figure A4 Arrow-1). When USEPAIRING_JUSTWORKS macro is set, the passkey input is not requested. Though GUI indication of BLE Scanner looks like Notification has been enabled, Notification is still disabled. To enable Notification actually, re-selects N button (N button’s color turns to blue) and once again selects N button (N button’s color turns to green).
6. If the passkey entered is correct, notification is started. Bit16:31 of the notification data is incremented in every second. (Figure A5 Arrow-1)
7. Bit0:7 of the notification data is changed depending on the potentiometer’s position on the RSK. (Figure A5 Arrow-1)
8. Select [Notification On]. (Figure A5 Arrow-2)
9. Select [↩] to disconnect the connection. (Figure A5 Arrow-3) (Figure A6 Arrow-1)
10. Repeat 2~4 and make sure that notification is re-started without passkey request. Note3
11. Repeat 8~9 to disconnect the connection.

Notes: 1. Sometimes the passkey dialog is not displayed on the foreground. That time you will see the message “Pairing request” in the information pane and click it to open the dialog.
2. To run the pairing again, select [Settings]→[Bluetooth]. In the [Paired devices] list, you will see the device named “Renesas-BLE” and select the device →[FORGET] to delete pairing information.
3. Android 6.0/6.0.1 always fail to connect with bonded devices. To reconnect with bonded devices, use Android 5 series, or follow [Note2] to delete pairing information and re-connect.

3.2.2 iOS Device

The procedure about verifying host sample with iOS device is shown below.

1. Start “GATTBrowser” application.
2. Select a device named “Renesas-BLE” from the nearby devices list to connect with the device. (Figure i1 Arrow-1)
3. Select the characteristic [UUID: 0x02000000-0000-0000-0000-000000000080]. (Figure i2 Arrow-1)
4. Select [Enable Notification] to enable notification. (Figure i3 Arrow-1)
5. Enter passkey (six digits) to the dialog. Note1 (Figure i4 Arrow-1). When USE JUSTWORKS_PAIRING macro is set, the dialog showing the receipt of pairing request is pop up. Select “Pair” to accept the request.
6. If the passkey entered is correct, notification is started. Bit16:31 of the notification data is incremented in every second. Note2 (Figure i5 Arrow-1)
7. Bit0:7 of the notification data is changed depending on the potentiometer’s position on the RSK. (Figure i5-1)
8. Select [Disable Notification] to disable notification. (Figure i5 Arrow-2)
9. Select [< Services] → [< Back] to disconnect the connection. (Figure i5 Arrow-3) (Figure i6 Arrow-1)
10. Re-do 2~4 to make sure that notification is re-started without passkey request.
11. Re-do 8~9 to disconnect the connection.

Notes: 1. To re-run the pairing, select [Settings] → [General] → [Bluetooth] → [Device] and select [Forget this Device] to delete pairing information.
Notes: 2. Sometimes notification is not started automatically after entering passkey. In such case, select [Enable Notification] once again.
3.3 Configuration

3.3.1 Configuration Macro Settings

The procedure about changing the behavior of host sample is shown below. The behavior of host sample is able to be changed by changing definition the behavior configuration macros in compile option. The procedure of changing macros is selecting [Property] in the right clicked menu of “HostSample” subproject in the project tree and defined or undefined macros in [preprocess]→[definition macros] on compile option tab in the dialog displayed.

<table>
<thead>
<tr>
<th>Macro</th>
<th>when defined</th>
<th>when undefined</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE_PAIRING_JUSTWORKS</td>
<td>execute pairing with JustWorks method</td>
<td>&lt;default setting&gt; execute pairing with PassKeyEntry method</td>
</tr>
<tr>
<td>USE_RSK_LCD</td>
<td>&lt;default setting&gt; use LCD on RSK</td>
<td>no use LCD on RSK Note: select JustWorks method in pairing because impossible to display PassKey</td>
</tr>
<tr>
<td>USE_RSK_LED</td>
<td>&lt;default setting&gt; use LED on RSK</td>
<td>no use LED on RSK</td>
</tr>
<tr>
<td>USE_RSK_SW</td>
<td>&lt;default setting&gt; use SW on RSK</td>
<td>no use SW on RSK Note: impossible to request disconnection from host sample when this setting</td>
</tr>
<tr>
<td>USE_RSK_ADC</td>
<td>&lt;default setting&gt; use A/D converter on RSK</td>
<td>no use A/D converter on RSK Note: set A/D converter configuration on Code Generator to [no use A/D converter] when this setting</td>
</tr>
</tbody>
</table>

3.3.2 Low Level Peripheral Driver Update By Code Generation Tool

You can update the low level peripheral drivers by using Code Generation Tool. Following file is updated in this project to avoid the type declaration confliction. You shall not overwrite the file when you use Code Generation Tool.

- r_cg_macrodriver.h
4. Behavior

The software behavior of Host Application (hereafter called APP) and rBLE is shown in this chapter.

4.1 Command and Event

The behavior of command and event which is used by APP and rBLE is shown in Figure 4-1.

1. APP issues the command by calling rBLE API.
2. rBLE executes the command issued by APP.
3. After finishing executing the command, rBLE informs the event by calling the callback function registered by APP.
4. APP decides whether to issue the next command or not in the callback function. (And go back to step1.)

![Figure 4-1 Command and Event](image)

4.2 Main Loop

The main loop behavior of the host sample is shown in Figure 4-2.

The main loop of the host sample executes the APP Scheduler, rBLE Scheduler and the MCU Mode Manager repeatedly. The APP Scheduler issues the command. The rBLE Scheduler calls the callback function. The MCU Mode Manager changes the MCU mode to STOP state for reducing power consumption.

![Figure 4-2 Main Loop](image)

The APP Scheduler has the command request queue. If there is a command request in the queue, the scheduler calls rBLE API.

The rBLE Scheduler has the event queue. If there is an event in the queue, the scheduler calls callback function which is registered by APP.

The MCU Mode Manager checks if the command request queue and the event queue is set. If both of the queue is empty, the manager changes the MCU mode to STOP state. After changing to STOP state, MCU is awoke by occurring interruption.
4.3 UART 2-wire with Branch Connection

This section describes the UART driver communication method in the UART 2-wire branch connection.

4.3.1 Transmission Process

A handshake is performed to send the packet to a module from Host MCU. A handshake is performed by send the REQ byte (0xC0) from the Host MCU and send the ACK byte (0x88) or the RSCIP packet from the module. In addition, when performing a handshake performs monitoring by the timer, the timeout occurs and restart the handshake. Host MCU of UART driver for performing a handshake, it has a 5 state by the transmission status.

<table>
<thead>
<tr>
<th>STATE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_IDLE</td>
<td>Initialize UART driver. RSCIP packet transmission completion.</td>
</tr>
<tr>
<td>T_REQUESTING</td>
<td>During REQ byte transmission.</td>
</tr>
<tr>
<td>T_RCV_BF_REQUESTED</td>
<td>Receive RSCIP packet from the module instead of ACK bytes.</td>
</tr>
<tr>
<td>T_REQUESTED</td>
<td>REQ byte transmission completion. (Wait for the ACK byte from the module)</td>
</tr>
<tr>
<td>T_ACTIVE</td>
<td>During RSCIP packet transmission.</td>
</tr>
</tbody>
</table>

Transmission from the Host MCU to the module, always start with REQ byte. After sending the REQ byte, Host MCU branches to one of the following operations by the receiving state.

(a) Host MCU has not received RSCIP packet from the module (Figure 4-3)

(b) Host MCU is receiving RSCIP packet from the module (Figure 4-4)

(c) ACK byte reception time-out (Figure 4-5)

(a) Host MCU has not received RSCIP packet from the module

This state is RSCIP packet has not been transmitted from the module, after sending the REQ byte from Host the MCU, the Host MCU is waiting to receive an ACK byte. Module sends an ACK byte receive the REQ byte. Host MCU which received ACK byte sends a RSCIP packet to a module.

Figure 4-3 Host MCU has not received RSCIP packet from the module
(b) Host MCU is receiving RSCIP packet from the module

This state module has to send RSCIP packet, Host MCU is receiving RSCIP packet. Even if a module receives REQ, ACK byte isn't returned. The RSCIP packet which is being sent is made a substitute of ACK byte. A host regards a RSCIP packet from a module as a substitute of ACK byte. And a RSCIP packet is sent to a module.

![Figure 4-4 Host MCU is receiving RSCIP packet from the module](image)

(c) ACK byte reception time-out

After sending REQ byte, Host MCU starts a timeout timer. If it can not be received ACK bytes for a certain period, and then resend the REQ byte.

![Figure 4-5 ACK byte reception time-out](image)

4.3.2 Reception Process

There is no state transition of a UART driver at the reception. In order to receive the data from the module, it listens for RSCIP packet from the module in the specified number of bytes from rBLE_Host.
4.3.3 Example of Application Circuit

UART 2-wire with branch connection example of Host MCU and BLE MCU are shown below.

![UART 2-wire with branch connection example](image)

**Figure 4-6 UART 2-wire with branch connection example**

**Notes:**
1. Pin number is CN4 external extension interface connector pin number of RL78/G1D evaluation board.
2. /RESET pin are pulled-up/pulled-down with a resistor in accordance with the system requirement (see RL78/G1D User’s Manual: Hardware) (R01UH0515).
3. VBUS detection of USB is assigned to P30/INTP3/RCT1HZ (WAKEUP) of the RL78/G1D evaluation board. If it supplies a power to an evaluation board from USB, do not connect TXD line of RSK which diverged to INTP3 of the RL78/G1D evaluation board.
5. Sequence chart

The sequence chart of Local Device and Remote Device is shown in this chapter. Each sequence is consisted of the devices which contains Host MCU, BLE MCU, Smart Phone and the software which contains APP and rBLE.

5.1 Main sequence chart

In the Main Sequence Chart, the processing blocks of 10 steps are shown. The detail of each processing block is shown in following sections.

![Figure 5-1 main sequence chart](image-url)
5.2 Step1. rBLE Initialize sequence

APP calls “RBLE_Init” function to initialize rBLE (rBLE_Host and rBLE_Core). After initializing rBLE and establishing communication to BLE MCU, rBLE informs “RBLE_MODE_ACTIVE” event.

![Figure 5-2  rBLE Initialize sequence chart](image)

5.3 Step2. GAP Initialize sequence

APP calls “RBLE_GAP_Reset” function to reset GAP. After resetting rBLE, rBLE informs “RBLE_GAP_EVENT_RESET_RESULT” event.

APP calls “RBLE_GAP_Set_Bonding_Mode” function to permit the bonding with remote device. After setting the permission, rBLE informs “RBLE_GAP_EVENT_SET_BONDING_MODE_COMP” event.

APP calls “RBLE_GAP_Set_Security_Request” function to set security level. After setting security level, rBLE informs “RBLE_GAP_EVENT_SET_SECURITY_REQUEST_COMP” event.

![Figure 5-3  GAP Initialize sequence chart](image)
5.4 Step 3. Broadcast sequence

Local Device starts broadcasting to establish connection as a slave.

APP calls “RBLE_GAP_Broadcast_Enable” function to start broadcasting. After starting the broadcast, rBLE informs “RBLE_GAP_EVENT_BROADCAST_ENABLE_COMP” event.

![Broadcast sequence chart](image)

5.5 Step 4. Connection sequence

Remote Device receives the broadcast and requests to establish connection with Local Device.

If the connection between Remote Device and Local Device is established by receiving Connection Request from Remote Device, rBLE informs “RBLE_GAP_EVENT_CONNECTION_COMP” event.

![Connection sequence chart](image)
5.6 Step5. Profile Enable sequence

Local Device enables SCP (Sample Custom Profile) to send data.

APP calls “RBLE_SCP_Server_Enable” function to enable SCP. After enabling SCP, rBLE informs “RBLE_SCP_EVENT_SERVER_ENABLE_COMP” event.

![Diagram of Profile Enable sequence chart]

5.7 Step6. Remote Device Check sequence

Local Device confirms security information about Remote Device.

If the device address of Remote Device is public address or if it is random address except resolvable private address, rBLE informs “RBLE_SM_CHK_BD_ADDR_REQ” event to acquire security information about Remote Device. APP calls “RBLE_SM_Chk_Bd_Addr_Req_Resp” function to inform security information.

If the device address of Remote Device is resolvable private address, rBLE informs “RBLE_SM_IRK_REQ_IND” event to acquire IRK (Identify Resolving Key) which is used for resolving address. APP calls “RBLE_SM_Irk_Req_Resp” function to informs whether to have IRK or not and informs IRK. If resolving address is success, rBLE informs “RBLE_GAP_EVENT_RPA_RESOLVED” event. If resolving address is failed, rBLE informs “RBLE_SM_IRK_REQ_IND” event repeatedly until it is successful or until all of IRK which APP possess is checked.

![Diagram of Remote Device Check sequence chart]
5.8 Step7. Pairing sequence

If the connection with the Remote Device is first time or if pairing is not executed in previous connection, Local Device starts pairing sequence by request from Remote Device. Pairing sequence is consisted of PHASE1, PHASE2, starting encryption and PHASE3.

PHASE1 is for exchanging the pairing features between Local Device and Remote Device.
If Local Device receives Pairing Request from Remote Device, rBLE informs “RBLE_GAP_EVENT_BONDING_REQ_IND” event. APP calls “RBLE_GAP_Bonding_Response” function to send Pairing Response.

PHASE2 is for generating STK (Short Term Key).
rBLE informs “RBLE_SM_TK_REQ_IND” event to acquire TK (Temporary Key). APP calls “RBLE_SM_Tk_Req_Resp” function to inform TK. After generating STK by BLE_MCU, Local Device and Remote Device start encrypting the contents of communication.

PHASE3 is for distributing encryption keys of Local Device and Remote Device.
rBLE informs “RBLE_SM_LTK_REQ_IND” event to acquire LTK (Long Term Key). APP calls “RBLE_SM_Ltk_Req_Resp” function to inform LTK and send Encryption Information (LTK).
By receiving Encryption Information (LTK) from Remote Device, rBLE informs “RBLE_SM_KEY_IND” event.
By receiving Identity Information (IRK) from Remote Device, rBLE informs “RBLE_SM_KEY_IND” event.
If pairing sequence is success, rBLE informs “RBLE_GAP_EVENT_BONDING_COMP” event.
**Figure 5-8  Pairing sequence chart**

- **PHASE 1: PAIRING FEATURE EXCHANGE**
  - Pairing Request
  - Pairing Response

- **PHASE 2: SHORT TERM KEY (STK) GENERATION**
  - Pairing Confirm (Mconfirm)
  - Pairing Confirm (Sconfirm)
  - Pairing Random (Mrand)
  - Pairing Random (Srlist)

- **PHASE 3: TRANSPORT SPECIFIC KEY DISTRIBUTION**
  - Encryption Request
  - Encryption Response
  - Start Encryption Request
  - Start Encryption Response
  - Start Encryption Response

- Establishment of encrypted connection with STK
  - Encryption Information (LTK)
  - Master Identification (EDIV, Rand)
  - Identity Information (IRK)
  - Identity Address Information

- Peer Device (Smart Phone)
  - Remote Device as a Master
  - Local Device as a Slave

- Host MCU (RL78/G14)
  - rBLE (Host)
  - BLE MCU (RL78/G1D)
  - rBLE (Core)
5.9 Step8. Start Encryption sequence

If pairing is success in previous connection, Local Device starts encryption sequence with LTK (Long Term Key) by request from Remote Device.

By receiving Encryption Request from Remote Device, rBLE informs “RBLE_SM_LTK_REQ_FOR_ENC_IND” event. APP calls “RBLE_SM_Ltk_Req_Resp” function to inform LTK and send Encryption Response.

By receiving Start Encryption Request, BLE MCU of Local Device sends Start Encryption Response.

If start encryption sequence is success, rBLE informs “RBLE_SM_ENC_START_IND” event.

![Start Encryption sequence chart](image-url)

Figure 5-9 Start Encryption sequence chart
5.10 Step9. Profile Communication sequence

Local Device starts sending data to Remote Device with SCP (Sample Custom Profile).

By receiving Write Client Characteristic Configuration for permitting Notification, rBLE informs “RBLE_SCP_EVENT_SERVER_CHG_INDNTF_IND” event.

APP activates interval timer, and the timer generates INTIT interruption periodically. By receiving INTIT interruption, APP activates A/D converter. The converter generates INTAD interruption when finished converting. By receiving INTAD, APP calls “RBLE_SCP_Server_Send_Notify” function to send result value of converting by Notification.

By receiving Write Client Characteristic Configuration for inhibiting Notification, rBLE informs “RBLE_SCP_EVENT_SERVER_CHG_INDNTF_IND” event. APP inactivates interval timer to stop sending data.

![Profile Communication sequence chart](image)
5.11 Step10. Disconnection sequence

Remote Device and Local Device are able to request disconnection.

By receiving Disconnect from Remote Device, rBLE disconnects connection and informs “RBLE_GAP_EVENT_DISCONNECT_COMP” event.

If INTP10 interruption occurs, APP calls “RBLE_GAP_Disconnect” function to send Disconnect to Remote Device. After disconnecting, rBLE informs “RBLE_GAP_EVENT_DISCONNECT_COMP” event.

Figure 5-11 Disconnection sequence chart
6. Appendix

6.1 ROM size, RAM size

The ROM size and the RAM size which is used by host sample is shown in Table 6-1.

<table>
<thead>
<tr>
<th>Setting for build</th>
<th>Default setting of host sample released</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>➢ Define below macros</td>
</tr>
<tr>
<td></td>
<td> USE_RSK_LCD</td>
</tr>
<tr>
<td></td>
<td> USE_RSK_LED</td>
</tr>
<tr>
<td></td>
<td> USE_RSK_SW</td>
</tr>
<tr>
<td></td>
<td> USE_RSK_ADC</td>
</tr>
<tr>
<td></td>
<td>➢ Use Passkey as pairing method</td>
</tr>
<tr>
<td></td>
<td>➢ Use UART 2-wire</td>
</tr>
</tbody>
</table>

Table 6-1  ROM size, RAM size

<table>
<thead>
<tr>
<th>Compiler</th>
<th>ROM (bytes)</th>
<th>RAM (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC-RL</td>
<td>20,702</td>
<td>4,524</td>
</tr>
<tr>
<td>CA78K0R</td>
<td>29,625</td>
<td>4,736</td>
</tr>
</tbody>
</table>

6.2 References

1. Bluetooth Core Specification v4.2, Bluetooth SIG
### 6.3 Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>A service is provided from a GATT server to a GATT client. The GATT server exposes some characteristics as the interface. The service prescribes how to access the exposed characteristics.</td>
</tr>
<tr>
<td>Profile</td>
<td>A profile enables implementation of a use case by using one or more services. The services used are defined in the specifications of each profile.</td>
</tr>
<tr>
<td>Characteristic</td>
<td>A characteristic is a value used to identify services. The characteristics to be exposed and their formats are defined by each service.</td>
</tr>
<tr>
<td>Role</td>
<td>Each device takes the role prescribed by the profile or service in order to implement the specified use case.</td>
</tr>
<tr>
<td>Client Characteristic Configuration</td>
<td>A descriptor is used to control notifications or indications of characteristic values that include the client characteristic configuration descriptor sent from the GATT server.</td>
</tr>
<tr>
<td>Descriptor</td>
<td></td>
</tr>
<tr>
<td>Connection Handle</td>
<td>This is the handle determined by the controller stack and is used to identify connection with a remote device. The valid handle range is between 0x0000 and 0x0EFF.</td>
</tr>
<tr>
<td>Universally Unique Identifier (UUID)</td>
<td>This is an identifier for uniquely identifying an item. In the BLE standard, a 16-bit UUID is defined for identifying services and their characteristics.</td>
</tr>
<tr>
<td>Bluetooth Device Address (BD Address)</td>
<td>This is a 48-bit address for identifying a Bluetooth device. The BLE standard defines both public and random addresses, and at least one or the other must be supported.</td>
</tr>
<tr>
<td>Public Address</td>
<td>This is an address that includes an allocated 24-bit OUI (Organizationally Unique Identifier) registered with the IEEE.</td>
</tr>
<tr>
<td>Random Address</td>
<td>This is an address that contains a random number and belongs to one of the following three categories: Static Address, Non-Resolvable Private Address, Resolvable Private Address.</td>
</tr>
<tr>
<td>Static Address</td>
<td>This is an address whose 2 most significant bits are both 1, and whose remaining 46 bits form a random number other than all 1’s or all 0’s. This static address cannot be changed until the power is switched off.</td>
</tr>
<tr>
<td>Non-Resolvable Private Address</td>
<td>This is an address whose 2 most significant bits are both 0, and whose remaining 46 bits form a random number other than all 1’s or all 0’s. Static addresses and public addresses must not be equal. This type of address is used to make tracking by an attacker difficult by changing the address frequently.</td>
</tr>
<tr>
<td>Resolvable Private Address</td>
<td>This is an address generated from an IRK and a 24-bit random number. Its 2 most significant bits are 0 and 1, and the remaining higher 22 bits form a random number other than all 1’s or all 0’s. The lower 24 bits are calculated based on an IRK and the higher random number. This type of address is used to make tracking by an attacker difficult by changing the address frequently. By allocating an IRK to the peer device, the peer device can identify the communicating device by using that IRK.</td>
</tr>
<tr>
<td>Broadcaster</td>
<td>This is one of the roles of GAP. It is used to transmit advertising data.</td>
</tr>
<tr>
<td>Observer</td>
<td>This is one of the roles of GAP. It is used to receive advertising data.</td>
</tr>
<tr>
<td>Central</td>
<td>This is one of the roles of GAP. It is used to establish a physical link. In the link layer, it is called Master.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Peripheral</td>
<td>This is one of the roles of GAP. It is used to accept the establishment of a physical link. In the link layer, it is called Slave.</td>
</tr>
<tr>
<td>Advertising</td>
<td>Advertising is used to transmit data on a specific channel for the purpose of establishing a connection or performing data transmission.</td>
</tr>
<tr>
<td>Scan</td>
<td>Scans are used to receive advertising data. There are two types of scans: Passive scan, in which data is simply received, and active scan, in which additional information is requested by sending SCAN_REQ.</td>
</tr>
<tr>
<td>White List</td>
<td>By registering known devices that are connected or bonded to a White List, it is possible to filter devices that can accept advertising data or connection requests.</td>
</tr>
<tr>
<td>Device Name</td>
<td>This is a user-friendly name freely assigned to a Bluetooth device to identify it. In the BLE standard, the device name is exposed to the peer device by the GATT server as a GAP characteristic.</td>
</tr>
<tr>
<td>Reconnection Address</td>
<td>If a non-resolvable private address is used and the address is changed frequently, not only attackers but also the peer device will have difficulty identifying the device. Therefore, the address to be used at reconnection is reported by setting a new reconnection address as the exposed reconnection address characteristic.</td>
</tr>
<tr>
<td>Connection Interval</td>
<td>This is the interval for transmitting and receiving data periodically following connection establishment.</td>
</tr>
<tr>
<td>Connection Event</td>
<td>This is the period of time during which data is transmitted and received at the connection interval.</td>
</tr>
<tr>
<td>Supervision Timeout</td>
<td>This is the timeout interval after which the link is considered to have been lost when no response is received from the peer device.</td>
</tr>
<tr>
<td>Passkey Entry</td>
<td>This is a pairing method whereby a six-digit number is input by each device to the other, or a six-digit number is displayed by one of the devices and that number is input to the other device.</td>
</tr>
<tr>
<td>Just Works</td>
<td>This is a pairing method that does not require user action.</td>
</tr>
<tr>
<td>OOB</td>
<td>This is a pairing method whereby pairing is performed by using data obtained by a communication method other than Bluetooth.</td>
</tr>
<tr>
<td>Identity Resolving Key (IRK)</td>
<td>This is a 128-bit key used to generate and resolve resolvable private addresses.</td>
</tr>
<tr>
<td>Connection Signature Resolving Key (CSRK)</td>
<td>This is a 128-bit key used to create data signatures and verify the signature of incoming data.</td>
</tr>
<tr>
<td>Long Term Key (LTK)</td>
<td>This is a 128-bit key used for encryption. The key size to be used is the size agreed on during pairing.</td>
</tr>
<tr>
<td>Short Term Key (STK)</td>
<td>This is a 128-bit key used for encryption during key exchange. It is generated using TK.</td>
</tr>
<tr>
<td>Temporary Key (TK)</td>
<td>This is a 128-bit key required for STK generation. In the case of Just Works, the TK value is 0. In the case of Passkey Entry, it is the 6-digit number that was input, and in the case of OOB, it is the OOB data.</td>
</tr>
</tbody>
</table>
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## Revision Record

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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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on
   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   - The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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.
   Moreover, 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.

5. Differences between Products
   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.
   - The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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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