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General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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

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

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

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

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

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

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

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

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

This document is user’s manual for the Renesas LPWA Studio V3.0.0.3 or later.

Renesas LPWA Studio is the GUI frontend program for the Radio Evaluation Program V3.01 or later.

Features:
- Supports both LoRa® modulation and GFSK modulation
- Continuous wave transmission mode supports both unmodulated transmission wave and modulated transmission wave.
- Packet transmission mode supports PN9 data packet for PER/BER, DevEUI data packet, and user defined data packet.
- Packet reception mode supports dual channel packet capture with built-in LoRaWAN® decoder and PER/BER testing.
- Spectrum mode supports real-time RSSI visualization (simple spectrum analyzer).
- Terminal mode supports all AT commands of the Radio Evaluation Program for the expert users.
- Supports packet forwarder for the Wireshark with LoRaTap over UDP protocol.
- Supports packet capture from the Semtech PicoCell Gateway with Packet Forwarder
- Supports packet in/out with JSON/UDP for external Apps (e.g. Renesas LPWA Studio, Python, Ruby, …)
2. Requirements

The minimum requirements to install and run this software as follows.

1. **Target Board**
   - RL78/G23-64p Fast Prototyping Board or RL78/G14 Fast Prototyping Board with Pmod USBUART
   - Semtech SX1261 Shield or Semtech SX1262 Shield
   - Renesas HS3001 Humidity and Temperature sensor Pmod Module (Optional)

   ![](RL78/G23-64p_Fast_Prototyping_Board.png) ![RL78/G14_Fast_Prototyping_Board.png]

   **IMPORTANT:**

   Before using the boards, you should read the Quick Start Guide because some board needs modification.

   (package top)/documents/QuickStartGuide/r11qs0033ej{VERSION}-lora.pdf

2. **PC** : Microsoft Windows 10 (64bit) with .NET Framework 4.8
3. **Radio Evaluation Program** : RadioEvalApp V3.01 or later
3. Getting Started

3.1 Setup the Radio Evaluation Program

Before using the Renesas LPWA Studio, you should install the Radio Evaluation Program on the RL78/G23-64p Fast Prototyping Board or RL78/G14 Fast Prototyping Board.

For more detail, please refer to the Quick Start Guide located in,

(package top)/documents/QuickStartGuide/r11qs0033ej{VERSION}/lor.pdf

NOTE:
You can find the pre-compiled Radio Evaluation Program located in

(package top)/samples/project/e2studio/RadioEvalApp/DefaultBuild/RadioEvalApp.mot

If you have the Renesas Flash Programmer (V3.08.02 or later), you can directly download the Radio Evaluation Program on your RL78/G23-64p Fast Prototyping Board or RL78/G14 Fast Prototyping Board.
### 3.2 Install and uninstall the Renesas LPWA Studio

**IMPORTANT:**
If an older version of this program is installed on your PC, please uninstall the older version before installing new version.

Install the Renesas LPWA Studio:

**Step1:** Double-Click following windows installer and Click “Install”

(package top)\samples\tools\RLPWAStudio\setup.exe

**NOTE:** If .NET Framework 4.8 is not installed on your PC, the installer will try to install it.

Step2: If the installation is completed, Renesas LPWA Studio will start automatically.

You can also start from the “Start Menu” > “Renesas Electronics” > “Renesas LPWA Studio”.

Uninstall the Renesas LPWA Studio:

Right click “Start Menu” > “Settings” > “Apps” > Select “Renesas LPWA Studio” > Click “Uninstall”.
4. Using Renesas LPWA Studio [ Basic ]

4.1 Connect and Disconnect the Radio Evaluation Program

Click Pulldown List and select COM Port associated with your target board.

Click “CONNECT”, if the connection is completed, the Button will change to “DISCONNECT”.

Click “DISCONNECT” to disconnect from the target board.
4.2 Select Modem, Frequency and Radio parameters.

STEP1: Select Modem (LoRa or GFSK) from pulldown menu.
STEP2: Select Frequency and Radio parameters described as below.

For LoRa: Spread Factor (SF), Coding Rate (CR), Band Width (BW), IQ Polarity (IQ)

For GFSK: Data Rate (DR), Frequency Deviation (Fdev), Band Width (BW)

Tips: If you cannot find the DR/Fdev/BW field, please enlarge the window shown as above.
4.3 Configure Packet parameters (optional)

Click “Setup” Tab -> Click LoRa or GFSK Tab -> Change packet parameters described as below.

NOTE: For more detail of each parameter, please refer to the Semtech SX1261/2 Datasheet.

For LoRa:

For GFSK:
You can select Boosted Gain, enable the LBT (Listen Before Talk) and configure LBT parameters.

You can change the visualization settings on SNIFFER/SPECTRUM to improve performance. If you enable the Sensor Data Visualizer, the received sensor values (Humidity and Temperature) will be plotted in the SNIFFER view.

NOTE: You can reset all parameter and settings from “Menu” > “File” > “Reset All”.
4.4 Continuous Wave Transmission

[Operation]

Click “Transmit” Tab
> Select Continuous Wave Transmit and Select Unmodulated or Modulated
> Select Transmit Power > Click “START” > Click “STOP”

NOTE: The data pattern in Modulated Wave is an infinite sequence of alternating '0'.s and ‘1’.s in GFSK modulation and preamble symbol in LoRa.
4.5 Packet Transmission

[Operation]

Click “Transmit” Tab
> Select transmit packet data “PN9 Data for PER/BER”, “DevEUI” or “User Defined Data”.
> Select Transmission Power, Payload Length, Number of Packets and Transmission Interval.
> Click “START” > Click “STOP”

When you select PN9 Data for PER/BER, special payload data will be transmitted. In LoRa mode, the payload is “PER” + sequence number + PN9. In GFSK mode, the payload is all 0 with data whitening.

When you select DevEUI mode, Pseudo JOIN frame contains DevEUI will be transmitted.

If you select User Defined Data mode, you can input transmission data in HEX (bytes) format or TXT (single quoted strings s) format. You can Drag & Drop the data file (.txt or .dat). White space and carriage return are ignored. Transmission payload length is automatically calculated.

When you select Sensor mode, Sensor data (lowest byte of DevEUI + Humidity(2bytes, uint16_t, 0.1%) +Temperature (2bytes, int16_t, 0.1°C) will be transmitted.

By specifying the Rx Packet No and click “Copy” button, you can copy the transmission data from Received Packet list on SNIPPER (“Receive” Tab).

Time on Air will be calculated automatically using current payload length and radio parameters.
4.6 **SNIFFER (Packet Reception)**

[Operation]
Select “Receive” Tab > Select “SNIFFER” mode > Click “START” > Click “STOP”

You can change the column order by drag-and-drop the column title (e.g. “TIME”, “RSSI”, “DATA”), and you can sort the data by clicking the column title too. If you click the row, the packet payload data will be shown in the detail window in both HEX format and TXT format.

Click “Save” button, you can save the received packet in the packet log file with JSON format. Also, you can load the packet log file (.json) with Drag & Drop or “Load” button.

If you enable the RSSI visualization in “Setup” Tab, RSSI value will be plotted on the Chart window in Real-Time. However, this feature will cause performance issue with large number of the packets.

In GFSK, SNR is not supported by device, you should ignore the value on the SNR field.
Device number (“1” or “2”) and Interface number (“3” or “4”) are shown in DEV field.
Packet error is shown in ERR field, 0: No error (clear), 1: CRC error (red), 2: Timeout (brown).

On RSSI chart, you can use the mouse wheel to zoom in/out, and use the mouse hold and drag for panning.
If you enable the Sensor Data Visualization in “Setup” Tab, HS3001 Sensor values (Humidity and Temperature) will be plotted on the extra chart window in Real-Time.

NOTE:
This function supports one sensor device only. When some sensor devices send the data, all received data will be plotted on the same chart unfortunately. If you need to display the sensor values on a sensor-by-sensor basis, some external tools (e.g. Python/influxDB/Grafana) are required. Renesas LPWA Studio can interface to these external tools with UDP packet forwarding function. For more detail, please refer to the Advanced Section.
4.7 PER/BER Test

[Preparation]
Before PER/BER testing, you should set the same parameters both transmitter side and receiver side. Parameters mean Modulation Parameters (e.g. Modulation, Frequency, Data Rate, Spread Factor, and so on) and Packet Format Parameter listed in the “Setup” Tab (e.g. Preamble Length, Payload CRC Type, Frame Header Type, Sync Word and so on). Recommend settings are below.

[Operation]:
Select PN9 Data for PER/BER on transmitter side and PER/BER mode on receiver side.
> Set the same settings (e.g. # of packets) are required on both transmitter side and receiver side.
> Start receiver side -> Start transmitter side -> Stop receiver side after transmission is completed.
After stopping the reception, the PER/BER and reception statistics are displayed automatically.
NOTE1: LoRa mode supports PER only, GFSK mode supports both PER and BER.
NOTE2: In GFSK, Expected Data Length field is displayed and SNR field is disabled.
4.8 Spectrum Scan

[Operation]
Click “Spectrum” Tab > Set BEGIN/END/STEP Frequency and Scan view > Click “START”
Once started, the spectrum scan will automatically stop when the scan reaches the “Max Scans”.
NOTE: GFSK mode is required for spectrum scanning. Before you start, select GFSK mode.

NOTE: To prevent performance issue, maximum number of the scan is limited as below.
(END–BEGIN) / STEP <= 200[plot/line], and (END–BEGIN)/STEP * scan lines <= 5000 [plot]
If you disable RSSI visualizer on “Setup” Tab, Data Grid will be displayed instead of the Heat Map.

NOTE: If the current rssi exceeds the Max Rssi parameter, all plotted data will be updated to redraw.
4.9 Information

Ultra-Low Power
LoRa®-based LPWA Solution

Smart Metering

Smart Monitoring

Smart Agriculture
5. Using Renesas LPWA Studio [Advanced]

5.1 Terminal

[Operation]
Click “Terminal” Tab > Input AT Commands (no need input prefix “AT+”).
For detail of Commands, please refer the Radio Evaluation Program Application Note.

NOTE: AT Command will cause parameter mismatch between GUI and CUI. After changing the parameters, you can initialize the parameter with GUI parameter by clicking “Resume”.
You can browse the command line history using up and down arrow keys.
Save Command log: Click “Save” to store all command log to the text file.
Load Command script: Click “Load” or Drag & Drop to run the command script file (.txt or .cmd).

```cpp
// Sample Script
AT+MODEM=1 // LoRa Modulation
AT+FREQ=923400000 // Frequency 923.4MHz
AT+TXPWR=10 // Transmission Power 10 dBm
AT+TXCP   // Start continuous modulated wave transmission
@wait 5000 // wait 5000 ms
AT+STOP   // Stop continuous modulated wave transmission
```
### 5.2 How to capture the LoRaWAN packets

Renesas LPWA Studio supports following four way to capture the LoRaWAN packets.

**CASE1**: Dual target board with USB serial (Single channel capture)

**CASE2**: Multiple Renesas LPWA Studio (Multi channel capture)

**CASE3**: Semtech PicoCell Gateway (max 8 channel capture)

**CASE4**: Combination of above case 1 to 3.
5.2.1 CASE1 Dual target board

In LoRaWAN with LoRa modulation, uplink and downlink are different IQ polarity. Uplink is Standard IQ (non-inverted) and Downlink is Inverted IQ. Therefore, you should open two devices.

5.2.2 CASE2 Multiple Renesas LPWA Studio

Renesas LPWA Studio can forward and concentrate the received packets via the UDP port. The same UDP port settings are required both forwarder side and concentrator side described as below.

IMPORTANT: Enable the concentrator first, then enable the forwarder. Once you have enabled the concentrator, you cannot disable it until you exit the program.
5.2.3 CASE3 Semtech PicoCell Gateway

Semtech PicoCell Gateway is 8ch LoRaWAN gateway. Semtech PicoCell gateway can forward the received packet to the UDP port with PUSH_DATA packet format. For more detail, please refer to https://github.com/Lora-net/picoGW_packet_forwarder/blob/master/PROTOCOL.TXT

Renesas LPWA Studio can capture the PUSH_DATA packets and display on the SNIFFER view. The same UDP port settings are required both forwarder side (Semtech PicoCell gateway GUI) and concentrator side (Renesas LPWA Studio) described as below.

IMPORTANT: Enable the concentrator (Renesas LPWA Studio) first, then start the forwarder (GW). Once you have enabled the concentrator, you cannot disable it until you exit the program.
5.3 Built-in LoRaWAN decoder

Built-in LoRaWAN decoder can decode and decrypt the LoRaWAN(v1.0.3) Class A/B/C frames.

NOTE: This function is experimental and supports only AS923/EU868/US915.

[Operation]
To enable the built-in LoRaWAN decoder, Set LoRa SyncWord to “Public (LoRaWAN)”.

If following security keys are set, LoRaWAN decoder will try to decrypt a LoRaWAN MAC payload. AppKey is required for OTAA (Over-The-Air-Activation), both NwkSKey and AppSKey are required for ABP (Activation-By-Personalization).

NOTE: NwkSKey and AppSKey will be updated by clicking the valid JOIN Request Packet and corresponding valid JOIN Acknowledge Packet on the SNIFFER.
Click Receive Tab > Select SNIFFER mode > Start Capture > Select received LoRaWAN packet. Then, the decoded and decrypted LoRaWAN packet will be displayed as shown below.

For more detail, please refer to the LoRaWAN Specification v1.0.2 or v1.0.3.
https://lora-alliance.org/resource-hub/lorawanr-specification-v102
https://lora-alliance.org/resource-hub/lorawanr-specification-v103
5.4 Packet Forwarder

Renesas LPWA Studio supports two ways to forward the received packets to the external programs.

CASE1: Wireshark

CASE2: External Applications
5.4.1 CASE1: Wireshark

[Preparation on Wireshark]
Download and install latest builds of Wireshark V3.x.x (64bit) or later from following download site.
https://www.wireshark.org/#download

Copy loratap_over_udp.lua script to following Wireshark plugin directory.
C:\Program Files\Wireshark\plugins\3.x\epan\You can find loratap_over_udp.lua in the release package (samples\tools\RLPWAStudio)

[Preparation on Renesas LPWA Studio]
Click Setup Tab > Click UDP Tab > Configure UDP Packet Forwarder as follows.

![UDP Packet I/O Configuration](image)

Note: Default IP address “127.0.0.1” is loopback IP address. Wireshark V3.0 or later can capture loopback interface. if you change port number “54321” to another port number, you should edit loratap_over_udp.lua script and replace port number “54321” to new port you specified.

[Operation]
Renesas LPWA Studio: Click Receive Tab > Select SNIFTER > Click Start
Wireshark: Set “udp port 54321” as capture filter
> Select Adapter for loopback traffic capture. > Start capture.
5.4.2 CASE2: External Programs

[Preparation on Renesas LPWA Studio]
Click Setup Tab > Click UDP Tab > Configure UDP Packet Forwarder as follows.

[Preparation on External Program]
External Program bind the socket on the same address/port specified on the Renesas LPWA Studio.

[Operation]
Renesas LPWA Studio: Click Receive Tab > Select SNIFFER > Click Start
External Program: Listen the socket to receive UDP packet forwarded by Renesas LPWA Studio.

[Simple example script to dump UDP packets]
[Example: Sensor Data Visualization Demo with UDP packet forwarding function]

Sensor Data -> LPWA Studio -> UDP/JSON -> Python(sensor_demo.py) -> influxDB/Grafana

[Preparation on External Programs]
- Install InfluxDB 1.8.x / Grafana 7.1.x and run (If Docker is available, Docker container is convenient).
- Install Python3 and InfluxDB library (pip install influxdb)
- Create database named “home” on the influxDB (influx[RET] create databases home [RET] quit [RET])
- Configure data source on the Grafana (URL=http://localhost 8086, Database=home, method=GET)
- Run sensor_demo.py in the command prompt (sensor_demo.py is included in the release package)
  The sensor_demo.py will receive UDP packets, and parse JSON, and write sensor data to the influxDB named “home” located on localhost:8086. If you use Docker container, you should modify influxdb server address in the sensor_demo.py from localhost:8086 to influxdb docker container name:8086.

[Operation]
Start LPWA Studio as UDP Packet forwarder (start Rx with forwarding to 127.0.0.1:54321, JSON)
Start another LPWA Studio as sensor node (start Tx with sensor payload type)
Start query on the Grafana with following settings.

FROM sensor_demo WHERE deveui = lowest byte of the DevEUI
SELECT temperature or humidity
## Revision History

<table>
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<td>1.00</td>
<td>Jan. 29, 2018</td>
<td>ALL</td>
<td>First official release</td>
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<tr>
<td>1.10</td>
<td>Aug. 30, 2019</td>
<td>5-7</td>
<td>Change firmware directory path. Add information regarding .NET framework.</td>
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<tr>
<td></td>
<td></td>
<td>16</td>
<td>Add some recommended settings for PER/BER testing.</td>
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<td>21</td>
<td>Add LoRaWAN V1.0.3 (Class A/B/C) decode function.</td>
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<td></td>
<td></td>
<td>24-25</td>
<td>Update Wireshark version. Support local loopback interface.</td>
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<td>1.11</td>
<td>Sep. 26, 2019</td>
<td>ALL</td>
<td>Change program name and LoRaWAN trademarks</td>
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<tr>
<td>1.20</td>
<td>Nov. 18, 2019</td>
<td>4</td>
<td>Change target board, Firmware Version. Delete flash programming tools.</td>
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<td>5</td>
<td>Change setup procedure regarding Radio Evaluation Program.</td>
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<td>Change installation and uninstallation procedure.</td>
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<tr>
<td>2.10</td>
<td>July 3, 2020</td>
<td>ALL</td>
<td>First release based on the Radio Evaluation Program (RadioEvalApp) V2.1</td>
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<tr>
<td>2.20</td>
<td>Sep. 16, 2020</td>
<td>3,4,10,12,14,27</td>
<td>Add new function regarding Tx/Rx sensor data (Humidity and Temperature)</td>
</tr>
<tr>
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<td>Add new sensor demo as the example of the UDP packet forward function.</td>
</tr>
<tr>
<td>3.00</td>
<td>Mar. 2, 2021</td>
<td>3,4,5,6,12,14,ALL</td>
<td>Support RadioEvalApp V3.0 and RL78G23-64p Fast Prototyping Board.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Fixed a resolution issue in the sensor data visualization window.</td>
</tr>
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<td></td>
<td>No functional changes from V2.20.</td>
</tr>
<tr>
<td>3.01</td>
<td>June 7, 2021</td>
<td>6</td>
<td>Delete notification regarding the security alert during installation because Renesas LPWA Studio V3.0.0.3 or later supports the trusted code signing certification.</td>
</tr>
</tbody>
</table>