

# **Renesas LPWA Studio**

User's Manual

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Renesas Electronics

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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.

#### 2. Processing at power-on

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

3. Input of signal during power-off state

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

4. Handling of unused pins

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

5. Clock signals

6

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. Voltage application waveform at input pin

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

7. Prohibition of access to reserved addresses

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

8. Differences between products

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



# Renesas LPWA Studio

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## 1. Overview

This document is user's manual for the Renesas LPWA Studio V4.3.0.0. Renesas LPWA Studio is the GUI front-end program for the Radio Evaluation Program (V4.60 or later).

Features:

- Supports both LoRa<sup>®</sup> 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<sup>®</sup> 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** (for example, Renesas LPWA Studio, Python, Ruby, ...).



Figure 1. Renesas LPWA Studio System Overview

## 2. Requirements

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

- 1. Evaluation Board
  - FPB-RA2E1 (with Pmod USBUART) or EK-RA2L1 (with Pmod USBUART) or FPB-RA0E1 (with Pmod USBUART) or FPB-RA0E2 or RL78/G22 Fast Prototyping Board or RL78/G23-64p Fast Prototyping Board or



RL78/G23-128p 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 US082-HS3001EVZ (Optional)
- 2. PC : Microsoft Windows 10 (64-bit) with .NET Framework 4.8
- 3. Radio Evaluation Program: RadioEvalApp V4.60 or later

#### 3. Getting Started

#### 3.1 Setup the Radio Evaluation Program

Before using the Renesas LPWA Studio, install the Radio Evaluation Program on your evaluation board.

For more detail, please refer to the following Application Notes:

- For RL78: RL78/G23, RL78/G22, RL78/G14 LoRa®-based Wireless Software Package (R11AN0595)
- For RA: RA2E1, RA2L1, RA0E1, RA0E2 LoRa®-based Wireless Software Package (R11AN0596)

#### 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:

1. Double-click the following windows installer and click Install. (package install top folder)\samples\tools\RLPWAStudio\setup.exe

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

RLStudio Setup >	
For the following components:	
Microsoft .NET Framework 4.8 (x86 and x64)	
Please read the following license agreement. Press the page down key to see	Application Install - Security Warning
the rest of the agreement.	Do you want to install this application?
MICROSOFT SOFTWARE SUPPLEMENTAL LICENSE TERMS	100 No.
.NET FRAMEWORK AND ASSOCIATED LANGUAGE PACKS FOR MICROSOFT WINDOWS OPERATING SYSTEM	Name: Renesas LPWA Studio
Microsoft Corporation (or based on where you live, one of its affiliates) licenses this supplement to you. If you are licensed to use Microsoft Windows operating system software (the "software") was marked this automate the unsult of the software the s	From (Hover over the string below to see the full domain): C:\Userrightstrift@constangiv.5.0.1
View EULA for printing	Publisher: Renesas Electronics Corporation
Do you accept the terms of the pending License Agreement?	Install Don't Install
If you choose Don't Accept, install will close. To install you must accept this agreement.	
Accept Don't Accept	While applications can be useful, they can potentially harm your computer. If you do not trust a source, do not install this software. <u>More Information</u>

Figure 2. Renesas LPWA Studio Installation

 If the installation is completed, Renesas LPWA Studio will be started 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 the COM port associated with your target board.

×	Renesas	s LPWA S	Studio				_	×
File	View	Help						
1		~	CO	NNECT				
2	COM3		GOI	NNECT				
Se	COM4		Rece	eive Spectrum T	ermi	nal Information		
Bo	COM8		-	eneral LoRaWAN	UDI		36	545
	COM9				-		 	
B	COM1(			ce Information				
	I/F	FW Ver	rsion	DevEUI (8bytes,HE)		Functions		
1 2	COM Com			0123456789ABC	_	Transmitter, Sniffer, PER/BER , Spectrum Sniffer (mainly for the downlink)		
	UUM			0125450789ADC	DEF			
		IP Addr	ress	Port		Functions		
3	UDP	0.0.0		1700		Packet Concentrator (JSON)		
4	UDP	0.0.0	9.0	1700		Packet Concentrator (LoRaWAN G/W)		
				Selec	t a de	vice and connect		

Figure 3. Connecting Radio Installation Program

Click **CONNECT**. If the connection is completed, the button will change to **DISCONNECT**.



Figure 4. Connection and Disconnection Buttons

Click **DISCONNECT** to disconnect from the target board.



#### 4.2 Select Modem, Frequency and Radio Parameters

- 1. Select Modem (LoRa or GFSK) from pulldown menu.
- 2. Select Frequency and Radio parameters described as below.

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



Figure 5. LoRa Parameters

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

📡 Renesas LPWA Studio		_	
File View Help			
1 COM10 V DISCONNECT GFS	K × FREQ 923000000 Hz DR 50000 Bps Fdev 25000	Hz BW	58600 × H
2 CONNECT GFS			
Setup Transmit Receive Spe <sup>LOR</sup>	minal Information		
Board LoRa GFSK General LoRa	VAN UDP	RE	NESAS
<b>Board and Interface Informat</b>	ion		
I/F FW Version	DevEUI (8bytes,HEX) Functions		
1 COM 2.0 20200327 SX1261/XTAL	0123456789ABCDEF Transmitter, Sniffer, PER/BER , Spectrum		
2 COM	0123456789ABCDEF Sniffer (mainly for the downlink)		

Figure 6. GFSK Parameters

Note: 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:

📡 Renesas LPWA Studio		_	
File View Help			
1 COM10 V DISCONNE	CT LORA × FREQ 923000000 Hz SF 7 × CR 4/5 × 1	BW <b>125</b>	Y IQ STD Y
2 CONNEC			
Setup Transmit Receive	Spectrum Terminal Information		
Board LoRa GFSK Gener	al LoRaWAN UDP	R	ENESAS
LoRa Configuration			
Preamble Length (symbols)	8		
Sync Word	Private ~		
Payload CRC Type	CRC ON ~		
Frame Header Type	Explicit header (Variable length packet) \vee		

Figure 7. LoRa Packet Parameters Configuration

For GFSK:

📡 Renesas LPWA Studio		—		×
File     View     Help       1     COM10     V       2     V     CONNECT		Hz BW	58600	¥ Hz
Setup Transmit Receive Board LoRa GFSK Gene	Spectrum Terminal Information	Re	NES	<u> </u>
<b>GFSK Configuration</b>				
Preamble Length (bytes) Packet Type CRC Type	5 Variable length payload ~ CRC ON ~			

Figure 8. GFSK Packet Parameters Configuration



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

	×
	~
' IQ S	TD ~
	542

#### Figure 9. RX Boosted Gain and LBT Parameters Configuration

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.

📡 Renesas LPWA Studio						_		×
File View Help								
1 COM10 V DISCONNECT	LoRa × FREQ	923000000	Hz SF 7	* CR 4/5	× B	w 125	Y 10 ST	id ~
2 CONNECT								
Setup Transmit Receive Sp	ectrum Terminal	Information						
Board LoRa GFSK General	LoRaWAN UDP					R	ENES	5AS
<b>General Configuration</b>								
Rx Boosted Gain	ENABLE							
LBT (Listen before Talk)	ENABLE							
LBT Threshold (dBm)	-80							
LBT Duration [ms]	5							
LBT Bandwidth [Hz]	Use GFSK BW 👻							
RSSI Visualizer	🗹 ENABLE							
Spectrum Scan Interval Imsi	0							
Spectrum Max Scans	200							
Spectrum Max RssildBm1	-30							
Sensor Data Visualizer	🗹 ENABLE							

Figure 10. Sensor Data Visualizer

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

🔀 Renesas LPWA Studio	- 0	×
File View Help		
1 COM10 V DISCONNECT LORA V FREQ 923000000 Hz SF 7 V CR 4/5 V BW	125 ~ [(	STD ~
Setup Transmit Receive Spectrum Terminal Information	_	
START STOP POWER 10 V dBm	REN	ESAS
Continuous Wave Transmit     O Unmodulated     Modulated		
		M
Packet Transmit           PN9 ( PER / BER)         DevEUI         Iser Defined Data         Sensor		
12 34 'Hello' ABcd '{"x":1,"y":2}'		
Rx Packet No. 0	Co	py Clear
Trasnsmit Payload Length (bytes)22Number of Transmit Packets1Trasnsmit Interval [ms]1000	.98	
Info: Payload length is updated by user defined data.		

Figure 11. Continuous Wave Transmit Selection

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 (PER/BER)**, **DevEUI**, or **User Defined Data**.
  - > Select Transmission Power, Payload Length, Number of Packets and Transmission Interval.
  - ---- > Click START > click STOP

🔀 Renesas LPWA Studio	– 🗆 X
File View Help <b>1 COM10 · DISCONNECT LoRa · FREQ 923000000 Hz</b>	SF <mark>7 × CR</mark> 4/5 × BW 125 × IQ <b>STD ×</b>
Setup Transmit Receive Spectrum Terminal Information	RENESAS
<ul> <li>Continuous Wave Transmit</li> <li>Unmodulated</li> <li>Modulated</li> <li>Modulated</li> <li>Packet Transmit</li> </ul>	
○ PN9 ( PER / BER) ○ DevEUI	ISOF
Trasnsmit Payload Length (bytes) 22	Rx Packet No. 0 Copy Clear
Number of Transmit Packets1Trasnsmit Interval [ms]1000	Time On Air Ims] 30.98
Info: Payload length is updated by a	user defined data.

#### Figure 12. Packet Transmission Parameters

When you select **PN9 Data (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 containing 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) 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. The transmission interval is the time from the end of the previous packet to the beginning of the next packet. In sensor mode, it should be at least 4 seconds.

By specifying the **Rx Packet No.** and clicking the **Copy** button, you can copy the transmission data from Received Packet list on SNIFFER (**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**.

×	Renesas LPW/	A Studio	D									_		×
File														
1	COM10 ~	DISC	ONNE	ET LoRa ~	FREQ	923400000 H	2 SF 1	2 ~ (	R 4/5	× I	6W <b>125 ×</b> IQ	STD ×		
Sei	up Transmi	Rec	eive	Spectrum T	ermina	I Information								
	START 📕 ST	OP	MOE	IE SNIFFER ~								Re	INES	<b>AS</b>
No	.   TIME		DEV	FREQ	INFO		ERR	RSSI	SNR	LEN	DATA			
0	17:44:15	.333	1			SF7BW125 4/5	0	-32	14	10	50455200000	0001FF	83DF	
1	17:45:43	.517	1	923400000	LoRa	SF8BW250 4/6	2	-32	13	10	50455200000	0001FF	83DF	
2	17:46:39	.091	1	923600000	LoRa	SF9BW500 4/7	0	-31	11	10	50455200000	0001FF	83DF	
3	17:47:48	.074	1	923800000	GFSK	50000BW58600	1	-30	-35	0				
4	17:49:26	.828	1	923800000	GFSK	50000BW58600	0	-35	-35	10	FF83DF17326	994ED1	E7CD	
5	17:50:43	.069	1	923800000	GFSK	50000BW78200	0	-34	-33	10	FF83DF17326	994ED1	E7CD	
6	17:52:28	.333	1	923400000	LoRa	SF12BW125 4/5	0	-31	6	17	12345648656	5C6C6F	20576F	726C6
											7			
<											5			>
Гн	x1.1234564	18656	6666	20576F7260	64448	RCC								
	(T]:.4VHell										<b>-</b>			
											r	Clear	Load	Save
												ucai	LUAU	Jave
-28										-	5			-
			_			0	-				O RSSI -34			
-33												-		
(	)				2					4				6
				Recep	otion sto	opped.								

Figure 13. SNIFFER Mode

You can change the column order by dragging-and-dropping the column title (for example, "TIME", "RSSI","DATA"), and you can also sort the data by clicking the column title. 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, the RSSI value will be plotted on the chart window in realtime. However, this feature will cause performance issues with large number of packets.

In GFSK, SNR is not supported by device, and so you should ignore the value on the SNR field.

Device number ("1" or "2") and Interface number ("3" or "4") are shown in the **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 zoon 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.

File \	/iew Help											
	DM10 -	DISCONN	ici LoRa v	FREQ	923000000	lz SF	<b>7</b> ~	GR <b>4</b> /	5 ~	BW 125 ~		D ~
Setup	Transmit	Receive	Spectrum 1	Terminal	Information							
ST	ART <b>E STO</b>	P MO	DE SNIFFER	v						Re		545
No.	TIME		/ FREQ	INFO		FRR	RSSI	SNR	I EN	DATA		
	15:37:19.				SF7BW125 4/5		-23	12	5	EF022006	9E8	-
	15:37:20.				SF7BW125 4/5		-23	12	5	EF021B06		
	15:37:21.				SF7BW125 4/5		-23	12	5	EF021806	9E7	
3	15:37:22.	830 1			SE78W125 4/5		-23	12	5	FF021506	AF7	×
25 24.5					eg 6	ممر						- 75 - 70
		5 O TEMP					d					65
24						1	× .					
24 23.5 23 (		нин () •••••••	az.a			٥٩	0000	000	9085	****	****	<b>10</b> <sup>55</sup>
	200000	0 HUM	az.a	<b>***</b> *		°°4	2000 2000	00 <b>0</b> 4	<del>, 68</del> 5		8888	55 50 45

Figure 14. Sensor Data Visualization

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 (for example, 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 in both transmitter side and receiver side.

Parameter means Modulation Parameter (for example, Modulation, Frequency, Data Rate, Spread Factor, and so on) and Packet Format Parameter listed in the **Setup** tab (for example, **Preamble Length**, **Sync Word**, **Payload CRC Type**, **Frame Header Type**, and so on). Recommended settings are shown below.

📡 Renesas LPWA Studio		📡 Renesas LPWA Studio							
File     View     Help       1     COM10     ✓     DISCONNE       2     ✓     CONNECT		File     View     Help       1     COM10     DISCONNECT     LoRa     FREQ       2     ~     CONNECT	23						
Setup Transmit Receive Board LoRa GFSK Gener LoRa Configuration	Spectrum Terminal Information	Setup Transmit Receive Spectrum Terminal Board LoRa GFSK General LoRaWAN UDP	Ini						
Preamble Length (symbols) Sync Word	8 Private	GFSK Configuration Preamble Length Ibytes1 5							
Payload CRC Type Frame Header Type	CRC ON · · · · · · · · · · · · · · · · · ·	Packet Type Fixed length payload CRC Type CRC OFF	v V						

Figure 15. Setting LoRa and GFSK Configuration Parameters for PER/BER Testing

#### [Operation]:

Select PN9 Data for PER/BER on transmitter side and PER/BER mode on receiver side.

- Set the same settings (for example, number of packets) 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.





Figure 16. Transmitter and Receiver Side Settings

## 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 issues, maximum number of the scan is limited as shown below: (END-BEGIN) / STEP <= 200[plot/line], and (END-BEGIN)/STEP \* scan lines <= 5000 [plot]

If you disable RSSI visualizer on the **Setup** tab, the Data Grid will be displayed instead of the Heat Map.

Setup Transmit Receive Sp	ectrum Terminal Info	mation	
Board LoRa GFSK General	LoRaWAN UDP		RENESAS
<b>General Configuration</b>			
Rx Boosted Gain LBT (Listen before Talk) LBT Threshold (dBm) LBT Duration Ims)	ENABLE ENABLE -80 5		
LBT Bandwidth [Hz] RSSI Visualizer	USE GFSK BW ~ Second Letter Statement of the second secon		
Spectrum Scan Interval (ms)			
Spectrum Max Scans Spectrum Max RssildBm]	200 -30		

#### Figure 18. Spectrum Scan Data

Note: If the current Rssi exceeds the Max Rssi parameter, all plotted data will be updated to redraw.



## 4.9 Information

The following screen capture shows the LoRa-based solution information that can be accessed from the Renesas LPWA Studio window.



Figure 19. LoRa-based LPWA Solution Information



## 5. Using Renesas LPWA Studio [Advanced]

#### 5.1 Terminal

[Operation]

Click **Terminal** tab > Input AT Commands (no need input prefix "AT+").

For details on the commands, please see the Radio Evaluation Program Application Note.

File View Help <b>1 COM13 · DISCONNECT LoRa · FREQ 92</b>	3000000 Hz sf 7 × cr 4/5 × bw 125 × 10 STD ×
Setup Transmit Receive Spectrum Terminal I	
ICAUTIONI	RENESA
AT Command Input for device 1	Resume Glear Load Sav
FREQ?	
OK AT+TXPWR=0	
OK	
AT+RXGAIN=0	
ок	
AT+LBT=0,-80,5,0	
ОК	
AT+TXT0=65535	
ОК	
AT+FREQ?	
+FREQ:923000000	

Figure 20. Terminal View

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).

// Sample Script	
AT+MODEM=1	// LoRa Modulation
AT+FREQ=923400000	// Frequency 923.4MHz
AT+TXPWR=10	// Transmission Power 10 dBm
AT+TXCP	<pre>// Start continuous modulated wave transmission</pre>
@wait 5000	// wait 5000 ms





## 5.2 Capturing the LoRaWAN Packets

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



Case 1: Dual target board with USB serial (Single channel capture)

Figure 22. Two Target Boards with Serial USB (Single Channel Capture)





Figure 23. Multiple Target Boards (Multi Channel Capture)

**Case 3**: Semtech Packet Forwarder (max 8 channel capture)



Figure 24. Semtech Packet Forwarder (Maximum of 8 Channels Capture)

**Case 4**: Combination of above cases 1 to 3.



#### 5.2.1 Case 1 Dual Target Board

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

File Vi	iew Help														
1 00	M10 ·	DISCONNECT	LoRa	• FREQ	923000000	Hz SF	· ·	CR	4/5	×	ew 12	25 ~	10	STD	*
2 CO	M13 ·	DISCONNECT	LoRa	* FREQ	923000000	Hz SF	· ·	CR	4/5	~	SW 12	25 ~	10	INV	~
Setup	Transmit	Receive S	pectrum	Terminal	Informatio	n					01				
Board	LoRa G	SK General	LoRaWA	N UDP								R	EN	ES/	15
Bear	d and Int	erface Info	ormatio	n											
PART AND A	-	sion		levEUI (8b	ytes,HEX)	Functions	s								
I/I	F FW Vei				the state has a set of the ball of the set o	and the second second second						-			
1/1		200327 SX 126	1/XTAL	0123456	789ABCDEF	Transmit	ter, S	nitter,	PER/	BER,	, Spec	trum			

Figure 25. Two Target Boards Case 1

#### 5.2.2 Case 2 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 on 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.

	Forwarder Side Ra - FREQ <mark>923000000 H</mark> z SF 7 -	
	✓ ENABLE 127.0.0.1 50001	A Studio Concentrator Side
UDP Packet Concentrator UDP Rx Address UDP Rx Port Number	ENABLE (at once) 0.0.0.0 1700 UDP Packet Co UDP Rx Addres	varder Same Dorr ENABLE 127.0.0.1 ber Jorr JSON - bencentrator ENABLE (at once)
	UDP Rx Port Nu	umber 50001

Figure 26. Multiple Target Boards Case 2



#### 5.2.3 Case 3 Semtech Packet Forwarder

Renesas LPWA Studio can capture the PUSH\_DATA packets sent by Semtech Packet Forwarder and display on the SNIFFER view. The same UDP port settings are required both forwarder side (Semtech Packet Forwarder. For example, Semtech PicoCell Gateway) and concentrator side (Renesas LPWA Studio) described as below.

NOTE: For more detail of the Semtech Packet Forwarder's PUSH\_DATA packet format, Please refer to <a href="https://github.com/Lora-net/picoGW\_packet\_forwarder/blob/master/PROTOCOL.TXT">https://github.com/Lora-net/picoGW\_packet\_forwarder/blob/master/PROTOCOL.TXT</a>

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.

Properties_UI			Forwarder	Side	(For	exam	ple	e, Semt	ech Pi	coCell	Gateway)		
Cloud network Server Address n	s.eu.iot.semt	ech.cloud	~	F	ort 20	000	*	Us	e a cloud	network [			
Gateway properties	Conc	entrat	or's IP			nesas LPV		udio		Со	ncentrato	r Side	
ID 3834	38341D0067	00	Use custor	ı gatev		/iew He D <b>M4</b>		DISCONNE	CT LoRa	FREQ	923000000	Hz SF <mark>7</mark>	~
Server address	127.0.0.1		Keepalive ir	nterval	2	_	~	CONNECT					
Port up	50001	÷,	Stat interv	al	Setup Board	Transı LoRa			Spectrum al LoRaW		l Informatio	n	
Port down	50002	-	Push time	out	UDP			Config					
-SX1301 Properties						cket For Address		ler			E)	ABLE 107.0.0	
LoRaWAN Public Network	true	<b>*</b>	Clksrc	1	UDP Tx	Port Nui Format	-		Same p			127.0.0 5432 JSON	21
Radio	Radio_0	$\sim$	Chan	Cha					- p	ort		7001	
		-			UDP Rx	cket Co Addres Port Nu	5	trator				ABLE (at onc) 0.0.0 5000	.0

Figure 27. Semtech Packer Forwarder Case 3



## 5.3 Built-in LoRaWAN Decoder

Built-in LoRaWAN decoder can decode and decrypt the LoRaWAN (v1.0.3/v1.0.4) class A/B/C frames.

Note : LoRaWAN v1.0.3 Class B Beacon frame format is region specific. Built-in LoRaWAN decoder supports only AS923/EU868/KR920/US915.

#### [Operation]

To enable the built-in LoRaWAN decoder, click **Setup** tab > click **LoRaWAN** tab > **Enable LoRaWAN Packet Decoder**.

If the following security keys are set, LoRaWAN decoder will try to decrypt a LoRaWAN MAC payload.

AppKey is required for OTAA (Over-The-Air-Activation), and both **NwkSKey** and **AppSKey** are required for ABP (Activation-By-Personalization). **GenAppKey** are required to decrypt a Multicast LoRaWAN frame.

LoRaWAN decoder supports Application Layer Clock Synchronization Protocol, Remote Multicast Setup Protocol and Fragmented Data Block Transport Protocol to decode FUOTA V1.0.0 / V2.0.0 transaction.

📡 Renesas LPWA Studio		- 🗆 X
File View Help		
1 COM8 · DISCONNECT LORa · FREQ 9	23000000 Hz SF 7 👻 CR 4/5 🐃 BW 125 👻	IQ STD 🗡
2 COM4 · DISCONNECT LORa · FREQ 9	23000000 Hz sf 7 × gr 4/5 × bw 125 ×	IQ INV 👻
Setup Transmit Receive Spectrum Terminal	Information	
Board LoRa GFSK General LoRaWAN UDP		RENESAS
LoRaWAN Configuration		
_		
LoRaWAN Packet Decoder	✓ ENABLE	
AppKey (16bytes, HEX)	55555555555555555AAAAAAAAAAAAAAAAAA	
NwkSKey (16bytes, HEX)	745E887328A4BB5868EFEDBE553AED47	
AppSKey (16bytes, HEX)	D9AA63941792F31674DC629622F35CDF	
GenAppKey (16bytes, HEX)	000000000000000000000000000000000000000	
Application Layer Clock Synchronization (FPort:202)	Version 1.0.0 ×	
Remote Multicast Setup (FPort 200)	Version 1.0.0 🗸	
Fragmented Data Block Transport (FPort 201)	Version 1.0.0 🗸	

Figure 28. Enabling Built-in LoRaWAN Decoder

- Note1: **NwkSKey** and **AppSKey** will be updated by clicking the valid JOIN Request Packet and corresponding valid JOIN Acknowledge Packet on the SNIFFER.
- Note2: Multicast Groups, Address and Session Keys (McAppSKey and McNwkSKey) will be updated by clicking the valid Remote Multicast Setup Packet (McGroupSetupReq) on the SNIFFER.



Setup Transmit Receive	Spectrum Terminal Information	
Board LoRa GFSK Gener	al LoRaWAN UDP	RENESAS
LoRa Configuration		
Preamble Length (symbols)	8	
Sync Word	Public (LoRaWAN) 🛛 🗸	
Payload CRC Type	CRC ON Y	
Frame Header Type	Explicit header (Variable length packet) 🗸	

Figure 29. Setting LoRa Sync Word to Public

If you want to capture LoRaWAN compliant packets, you must set the LoRa Sync Word to Public.

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.

If you want to save the decoded single frame to the file (JSON format), Click Clip button.

K	Renesas LPWA	Studio	)									_		×
File	View Help													
1	COM8 ~	DISC	ONNEC	T LoRa 🗎	FRE	923000000	Hz	SF 7	¥ B	4/5	* BW 1	25 × [	Q STD	~
2	COM4 ~	DISC	ONNEC	T LoRa 🖻	FRE	923000000	Hz	SF 7	× B	4/5	* BW 1	25 ~	Q INV	~
Seti	up Transmit	Rec	eive 🛛	pectrum 1	<b>Fermina</b>	I Informatio	n							
•	START 🔳 STO	P	MOD	E SNIFFER	~							1	<b>REN</b> E	ESAS
No.	TIME			FREQ	INFO			RSSI	SNR	LEN	DATA			
0	09:42:38	901				SF10BW125		0	0	23	0067452	301674	523014	460C0( ^
1	09:42:44	362	1	923400000	LoRa	SF10BW125	0	-2	8	33	20F22AE	8A3820	7D949I	DF63F6
2	09:42:57	873	1	923200000	LoRa	SF10BW125	0	0	0	19	406EE83	501800	100CAI	D53C9I
<	00 10 50	000					Î		^		COCEEDO		0000 <del>-</del>	> `
⊿ I	MHDR : 00										Clear	Load	Save	Clip
	000			= Join R	eques <sup>.</sup>	t								
				- = LoRaWA	N R1									
4	Join Reques					0C00FEFF50	9074	230016	A290	7F				
				123456701										
	DevEUI			49050FFFE	000C4	5								
	Device N													
N	MIC : 7F90	9A210	5 (OK	: calcula	ated 7	F90A216)								

Figure 30. Displaying the Received LoRaWAN Packet

For more details, please refer to the LoRaWAN Specification at the following link:

Technical Specifications (lora-alliance.org)



## 5.4 Packet Forwarder

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





Figure 31. Forwarding the Received LoRaWAN Packets (Wireshark)



Figure 32. Forwarding the Received LoRaWAN Packets (External Applications)



## 5.4.1 Case 1: Wireshark

[Preparation on Wireshark]

Download and install latest builds of Wireshark V3.x.x (64-bit) 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.

File V	/iew Help									
1 00	DM10 ×	DISCONNE		* FREQ	923000000	Hz SF <mark>10</mark>	* CR 4/5	× BW 125	<b>~</b> IQ	STD ~
2	Ý	CONNEC	T							
Setup	Transmit	Receive	Spectrum	Terminal	Information					
Board	LoRa GF	SK Gene	ral LoRaW	AN UDP				2	ENE	SVZ
UDP	Packet I/	0 Config	uration				_			
UDP Pa	cket Forwa	rder			🗹 ENABLE		ר			
UDP Tx	Address					<b>127.0.0</b> .1				
IIND TV	Port Numbe	er				5432				

#### Figure 33. Configuring the UDP Packet Forwarder for Wireshark

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 SNIFFER > click Start

Wireshark: Set **udp port 54321** as capture filter > Select **Adapter for loopback traffic capture** > Start capture.

File       Edit       View       Go       Capture       Analyze       Statistics       Telephony       Wireless       Tools       Help         Image: Statistic Statis Statis Statistic Statistic Statistic Statistic Stati	Wireshark -		×
Apply a display filter ··· < Ctrl-/> Welcome to Wreshark Capture			
Welcome to Wireshark Capture	◢ ■ ∅ ◎   _ □ ⊠ X ◘   9 ↔ ☆ ? ♪ 및 = 0.9 9 9 표		
Capture	Apply a display filter … <ctrl-></ctrl->		<b>•</b> +
		,	
	Adapter for loopback traffic capture	•	





#### 5.4.2 Case 2: External Programs

[Preparation on Renesas LPWA Studio]

Click **Setup** tab > Click **UDP** tab > Configure **UDP Packet Forwarder** as follows.

🔀 Renesas LPWA Studio	– 🗆 🗙				
File View Help					
1 COM10 · DISCONNECT LORa · FREQ 923000000 Hz sf 10 · Cr 4/5 · Bi	W 125 ~ 10 STD ~				
2 CONNECT					
Setup Transmit Receive Spectrum Terminal Information					
Board LoRa GFSK General LoRaWAN UDP	RENESAS				
UDP Packet I/O Configuration					
UDP Packet Forwarder 🗹 ENABLE					
UDP Tx Address 127.0.0.1					
UDP Tx Port Number 54321					
UDP Tx Format JSON 🗸					

Figure 35. Configuring the UDP Packet Forwarder for External Programs

[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 Programs: Listen to the socket to receive UDP packet forwarded by Renesas LPWA Studio.

[Simple example script to dump UDP packets]



Figure 36. Example Scripts to Receive 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, 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



	calhost:3000/d/0rdZT5vGz/new-dashboard-copy?editPanel=2&orgId=1&refresh=5s		☆ 🔒 🗄
← New dashboar	d Copy / Edit Panel	Ø Discard	Save Apply
	Fill     Fit     Exact     Ø     Last 5 minutes     Q     S     S	Panel Field	Overrides
	temperature	Graph	Stat
33			12.4
32 31			
	$\mathbf{T}$		
30		Gauge	Bar gauge
30 29 19:51:30 19:52:00	19:52:30 19:53:00 19:53:30 19:54:00 19:54:30 19:55:00 19:55:30 19:56:00	Gauge	Bar gauge
29 -	19:52:30 19:53:00 19:53:30 19:54:00 19:54:30 19:55:00 19:55:30 19:56:00	Gauge	Bar gauge
29	19:52:30 19:53:00 19:54:00 19:54:30 19:55:00 19:55:30 19:56:00 Transform 0 ♀ Alert 0	(79)	
29 19:51:30 19:52:00 - sensor_demo.mean		Gauge (79) Table	Bar gauge
29		(79)	
29 19:51:30 19:52:00 - sensor_demo.mean	Transform         0         Query         Alert         0           V         O         Query         MD = auto =         Interval =         Query inspector	(79)	Text
29 19:51:30 19:52:00 - sensor_demo.mean	Transform         0         Query         Alert         0           V         O         Query         MD = auto =         Interval =         Query inspector	Table Heatmap	
29 19:51:30 19:52:00 — sensor_demo.mean В Query 1 €	Transform       0 <b>A</b> Alert       0         ✓       O       Query options       MD = auto = Interval = 500ms       Query inspector         Ø       ↓       C       ↓       C       ↓       ↓       ©       ∅ </td <td>Table</td> <td>Text</td>	Table	Text

Figure 37. Sensor Data Visualization Demo with UDP Packet Forwarding Function



## **Revision History**

		Description		
Rev.	Date	Page	Summary	
1.00	Jan.29.18	All	First official release	
1.10 Aug	Aug.30.19	5-7	Change firmware directory path. Add information regarding .NET framework.	
		16	Add some recommended settings for PER/BER testing.	
		21	Add LoRaWAN V1.0.3 (Class A/B/C) decode function.	
		24-25	Update Wireshark version. Support local loopback interface.	
1.11	Sep.26.19	All	Change program name and LoRaWAN trademarks	
1.20 Nov	Nov.18.19	4	Change target board, Firmware Version. Delete flash programming tools.	
		5	Change setup procedure regarding Radio Evaluation Program.	
		6	Change installation and uninstallation procedure.	
2.10	Jul.03.20	All	First release based on the Radio Evaluation Program (RadioEvalApp) V2.1	
2.20 Sep.16.20	Sep.16.20	3,4,10,12, 14,27	Add new function regarding Tx/Rx sensor data (Humidity and Temperature)	
			Add new sensor demo as the example of the UDP packet forward function.	
3.00 Mar.02.21	Mar.02.21	3,4,5	Support RadioEvalApp V3.00 and RL78/G23-64p Fast Prototyping Board.	
		6	Add notification regarding the security alert during installation.	
		12,14	Fixed a resolution issue in the sensor data visualization window.	
		All	No functional changes from V2.20.	
3.01	Jun.07.21	6	Delete notification regarding the security alert during installation because Renesas LPWA Studio V3.0.0.3 or later supports the trusted code signing certification.	
3.10 Sep.20	Sep.20.21	3,4,5	Support RadioEvalApp V3.10 and RL78/G23-128p Fast Prototyping Board.	
		12	Add notification regarding the sensor mode with RadioEvalApp V3.10 or later.	
		22	Add notification regarding LoRaWAN V1.0.4.	
4.00	Aug.29.22	3,4,5	Support RadioEvalApp V4.00 for RA2 and FPB-RA2E1 board.	
		22	Add check box to enable/disable the built-in LoRaWAN Packet Decoder.	
4.10	Nov.29.22	2,3	Change RadioEvalApp version from 3.10 to 4.10.	
4.20	Mar.31.23	2,3	Support EK-RA2L1 and RadioEvalApp 4.20.	
		19	Support Semtech Packet Forwarder.	
		20	Support LoRaWAN v1.0.4 and FUOTA v1.0.0/v2.0.0.	
		21	Add Clip button to save the decoded frame to the file.	
4.30	Apr.21.23	2,3	Support RL78/G22FPB and RadioEvalApp 4.30	
4.50	May.24.24	2,3	Support RA0E1 FPB and RadioEvalApp 4.50	
4.70	Apr.18.25	2,3	Support RA0E2 FPB.	
ч. <i>1</i> О	Αμι. 10.20	2,3		
			Support 4.60 or later version of RadioEvalApp.	



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