WoMaster

LoRa Wan End-Node Device User Manual

LoRa Wan End-Node Device

LR140

LR144

User Manual: v2.0.3

LR140: v1.0.8

LR144: v1.0.3

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Disclaimer

WoMaster reserves the right to make changes to this user manual or to the product hardware at any time without notice. It is the user’ s responsibility to determine whether there have been any such updates or amendments herein.
Defects, malfunctions, or failures of the warranted Product(s) caused by damage resulting from unforeseeable incidents (such as lightings, floods, fire, etc.), environmental and atmospheric disturbances, other external forces such as power line disturbances and surge, host computer malfunction and virus, incorrect power input, or incorrect cabling, incorrect grounding and damages caused by misuse, abuse and unauthorized alteration or repair are not warranted.

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Content

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1. Overview

The LR140 and LR144 utilize the latest Low Power Wide Area (LPWA) technology to build Modbus/RTU communication, Analog Input, and Analog Output Control for long-distance, wide-coverage, and low-power consumption wireless IoT applications.

The LR140 supports Modbus function codes #01, #02, #03, #04 and Analog Input (0-10V, 4-20mA) and also utilizes LPWA technology to build one-way, long-distance communication coverage with LoRa WAN Cloud Gateway for filed RS-485 RTU slave device connect with IoT Cloud Service.

LR144 most of the features are the same as LR140 but support Analog Output Control for 0-10V, 4-20mA, 5V PWM, and 10V PWM Control Output. The following table shows the difference of LR140 and LR144 for your reference.

Features	LR140	LR144
LoRa Wan Protocol	1.0.2	1.0.2
Modbus Host	Yes	Yes
Modbus Function Code	#01, #02, #03, #04	#01, #02, #03, #04, #05, #06, #15, #16
Modbus Register Entry	20	20
Analog Input (4-20mA)	2	2
Analog Output (4-20mA)	Not Available (N/A)	1
Analog Input (0-10V)	2	2
Analog Output (0-10V)	Not Available (N/A)	1, Default O.C.
PWM 5V Output	Not Available (N/A)	1
PWM 10V O.C. Output	Not Available (N/A)	1
Connectivity	LoRaWAN Cloud Gateway/Router	LoRaWAN Cloud Gateway / Router
LoRa Spreading Factory	SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12	SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12

1.1 LR140 Specification

Wireless Specification	
Frequency	LR140-EU433: 433~434Mhz LR140-EU868: 863~870Mhz LR140-US915: 902~928Mhz LR140-AS923: 923~923.5Mhz LR140-KR920: 920~923Mhz LR140-CN470: 470~510MHz
Wireless Technology	Low Power Wide Area – LoRa WAN Technology 1.0.2
Radio TX Power	22dBm
Radio RX Sensitivity	- 148dBm, SF=12 @ 250bps
Spreading Factor	SF5/SF6/SF7/SF8/SF9/SF10/SF12, Default SF7
Demodulator SNR	LoRa Demodulator Signal to Noise Ratio: -2.5dB ~ -20dB
Operating Mode	LoRa Wan Class-C Mode, Auto Upload (Publish) Data. RTU 485: Modbus protocol over the Air (LoRa WAN Transmission) with configurable RTU Device / Register Address Analog Input: Auto measuring the Current Input Channel/ Voltage Input Channel
Forwarding Data Buffer	256Bytes FIFO Data Buffer for LoRa signal transmission
Data Encryption	Supports 128bits AES
Management	
System Management	1 x Micro USB 2.0 port for system configuration
Software Utility	Windows© Based Utility – LoRa WAN Utility , Installation Free Software
I/O Interface	
Antenna Connector	1x 50-ohm, Female SMA
Serial Interface	2-wires RS-485 Terminal Connector with 1kv isolation Connector Type: Removable Terminal Connector Supported Model: LR-140(Host)

Serial Parameters	Baud Rate: 1200bps,2400bps, 4800bps, 9600bps Data Bits: 8 Parity Check: None, Even, Odd Stop Bit: 1,2
Current Input	2 Channels Detection Range: 4-20mA Accuracy Level: 0.3%
Voltage Input	2 Channels Detection Range: 0~10 V Accuracy Level: 0.2%
Modbus RTU	
Function Code	Support RS-485 Modbus Host with Function Code: Code 01: Read Coil-Read, Output Control bit Code 02: Read Discreet-Read Input bit, Read Input bit Code 03: Read Holding Register, Read Output word Code 04: Read Input Registers, Read Input Word
System Indication	
LED	Power (On): System Power applied LoRa (Blinking): LoRa RF Signal on Communication
Power Requirement	
Input Rating	Typical DC 24V, Rating: 10~30V 3-Pins Removable Terminal Connector for V+ ,Com and Chassis Earth Ground
Reverse Protection	Yes
Power Consumption	LR-140: 3 Watts @ DC 24V power input
Mechanical	
Installation	DIN Rail Mount
Enclosure Material	UL94v0, ABS , Anti- U/V
Ingress Protection	IP 40
Dimension	26(D) x 102.5 (H) x 72 mm (W) / with wall mounting clip
Weight	115g
Environmental	

Operating Temperature	-40°C~75°C, 0% ~ 90%, non-condensing
Storage Temperature	-40°C~80°C, 0% ~ 90%, non-condensing
Reliability & Warranty	
MTBF	20000> Hours
Warranty	3 Years, No-Natural damaged
Standards	
EMC	Compliance with IEC / EN61000-6-2, IEC/ EN61000-6-4
EMI	Electromagnetic Immunity: CISPR 22, FCC part 15B Class A
EMS	Electromagnetic Suspension: IEC 61000-4-2 ESD IEC 61000-4-3 RS IEC 61000-4-4 EFT IEC 61000-4-5 Surge IEC 61000-4-6 CS IEC 61000-4-8 Pulse Magnetic Field

1.2 LR144 Specification

Wireless Specification	
Frequency	LR144-EU433 (Region Code): 433~434Mhz LR144-EU868 (Region Code): 863~870Mhz LR144-US915 (Region Code): 902~928Mhz LR144-AS923 (Region Code): 920~923.5Mhz, Group AS923-1 LR144-KR920 (Region Code): 920~923Mhz LR144-CN470 (Region Code): 470~510MHz
Wireless Technology	Low Power Wide Area – LoRa WAN Technology 1.0.2
Radio TX Power	22dBm
Radio RX Sensitivity	- 148dBm, SF=12 @ 250bps

Spreading Factor	SF5/SF6/SF7/SF8/SF9/SF10/SF11/SF12, Default SF7; the Class-C RX2 Spreading Factor regarding the LoRaWan standard, please refers to User Manual.
Demodulator SNR	LoRa Demodulator Signal to Noise Ratio: -2.5dB ~ -20dB
Operating Mode	System operating in LoRa WAN Class-C Mode, OTAA and ABP joint modes
Forwarding Data Buffer	256Bytes FIFO Data Buffer for LoRa signal transmission
Data Encryption	Supports 128bits AES
Management	
System Management	1 x Micro USB 2.0 port for system configuration
Software Utility	Windows© Based Utility – LoRa WAN Utility, Installation Free Software
Analog I/O Interface	
Antenna Connector	1x 50-ohm, Female SMA
Serial Interface	2-wires RS-485 Terminal Connector with 1kv isolation Connector Type: Removable Terminal Connector Supported Model: LR-144(Modbus Host)
Serial Parameters	Baud Rate: 1200bps,2400bps, 4800bps, 9600bps Data Bits: 8 Parity Check: None, Even, Odd Stop Bit: 1, 2
Current I/O	4~20mA Input: 2 Channels Accuracy Level: 0.3% 4~20mA Output: 1 Channel Accuracy Level: 0.3%
Voltage I/O	0~10V Input: 2 Channels Accuracy Level: 0.2% 0~10V Output (Open Drain): 1 Channel Accuracy: 0.2% 5V PWM Output: 1 Channel Voltage Accuracy: 0.2% Adjustable Duty Cycle, 100Hz ~1KHz 10V PWM Output (Open Drain): 1 Channel Voltage Accuracy: 0.2% Adjustable Duty Cycle, 100Hz ~1KHz

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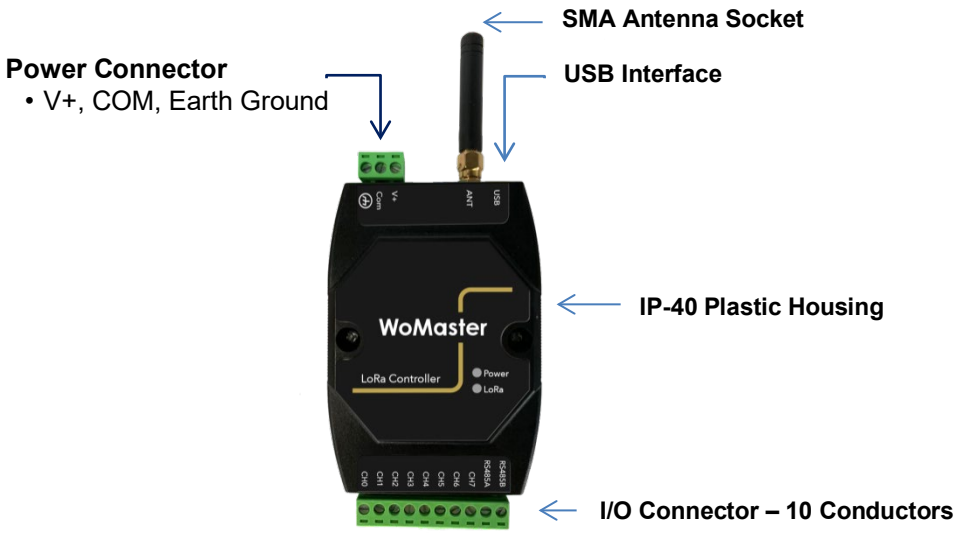
Modbus RTU	
Function Code	Support RS-485 Modbus Host with Function Code: Code 01: Read Coil - Read Output Control bit Code 02: Read Discreet - Read Input bit Code 03: Read Holding Register - Read Output word Code 04: Read Input Registers - Read Input Word Code 05: Write Single Coils – Write one bit output Code 06: Write Single Coils – Write one word output Code 15: Write Multiple Coils – Write a number of output bits Code 16: Write Multiple Registers - Write a number of output words
System Indication	
LED	Power (On): System Power applied LoRa (Blinking): LoRa RF Signal on Communication
Power Requirement	
Input Rating	Typical DC 24V, Rating: 10~30V 3-Pins Removable Terminal Connector for V+ ,Com and Chassis Earth Ground
Power Consumption	LR144: 3 Watts @ DC 24V power input
Reverse Protection	Yes
Mechanical	
Installation	DIN Rail Mount
Enclosure Material	UL94v0 level plastic, ABS, Anti- U/V
Ingress Protection	IP 40
Dimension	26(D) x 102.5 (H) x 72 mm (W) / with wall mounting clip
Weight	115g
Environmental	
Operating Temperature	-40°C~75°C, 0% ~ 90%, non-condensing
Storage Temperature	-40°C~80°C, 0% ~ 90%, non-condensing
Reliability & Warranty	
MTBF	> 20000Hours
Warranty	3 Years, No-Natural & Human damaged
Standards	

EMC	Compliance with IEC / EN61000-6-2, IEC/ EN61000-6-4
EMI	Electromagnetic Immunity: CISPR 22, FCC part 15B Class A
EMS	Electromagnetic Suspension: IEC 61000-4-2 ESD IEC 61000-4-3 RS IEC 61000-4-4 EFT IEC 61000-4-5 Surge IEC 61000-4-6 CS IEC 61000-4-8 Pulse Magnetic Field

2. System Appearance & Connector description

The WoMaster LoRaWan End-Node series devices feature a unified enclosure design with a 3-pin terminal connector for system power and earth grounding. Additionally, they are equipped with a 10-pin connector for I/O access. For more detailed information on the connector assignment please refer to Table 2-1 below:



I/O Channel #	LR140	LR144
0	V-in: 0~10V, Positive	V-in: 0~10V, Positive
1	I-in: 4~20mA, Positive	I-in: 4~20mA, Positive
2	V-in: 0~10V, Positive	V-in: 0~10V, Positive
3	I-in: 4~20mA, Positive	I-in: 4~20mA, Positive
4	Not Available	Output Current 4~20mA Positive
5	Not Available	Output Voltage (OC) 0~10V Positive
6	Not Available	Output PWM Voltage 0~5V Positive
7	Not Available	Output PWM(OC) 0~10V Positive
RS-485A	RTU Host mode	RTU Host mode
RS-485B	RTU Host mode	RTU Host mode

Table 2-1

Note: The analog input/ output Com (negative) is share with "Com".

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3.System Installation

3.1 DIN Rail Installation

To install the LR140/LR144 series, follow these steps:

1. Ensure you have a DIN Rail that complies with the DIN EN50022 standard.
2. Insert the upper end of the DIN-Rail clip into the back of the DIN-Rail track from its upper side.
3. Lightly push the bottom of the DIN-Rail clip into the track to secure it in place.

Using the correct DIN Rail is crucial for safe installation. Failure to use the proper DIN Rail may result in an unsafe installation.

3.2 Power Wiring

Power System Configuration:

- The system power input range supports DC 10~30V.
- Use an AC/DC Switching power supply with DC 24V/1.5A output as the main power source.

Wiring Instructions:

Refer to the Diagram 3.2-1 for guidance on how to wire the power system using the AC/DC Switching Power Supply.

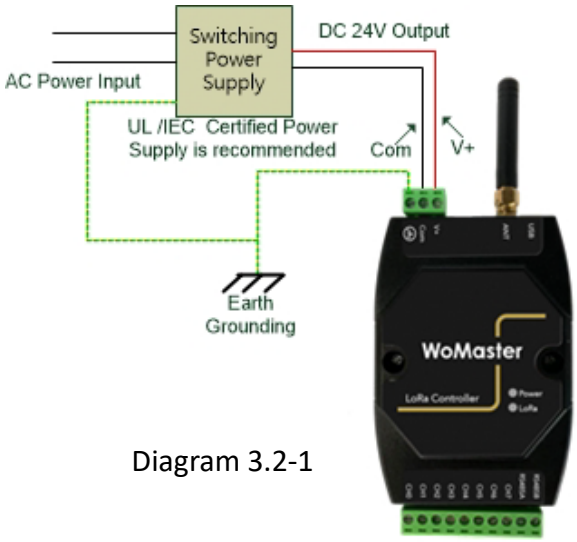


Diagram 3.2-1

Note: During the power wiring, please turn off the AC power input, and make sure the Earth Ground is well connected with the Switching Power Supply module, LoRa Device, and Earth Grounding System for noise immunity.

3.3 Analog Input Wiring (LR140, LR144)

Analog Input Support:

- LR140 and LR144 support two types of analog input: 4-20mA and 0-10V with 3‰ accuracy

Channel Type Definition:

- Refer to Table 2-1 in chapter 2 for the definition of channel type. A 12-bit A/D converter with 3‰ accuracy is adopted for industrial IoT field site application.

Analog Input Wiring:

- Diagram 3.3-1 illustrates the wiring for analog input

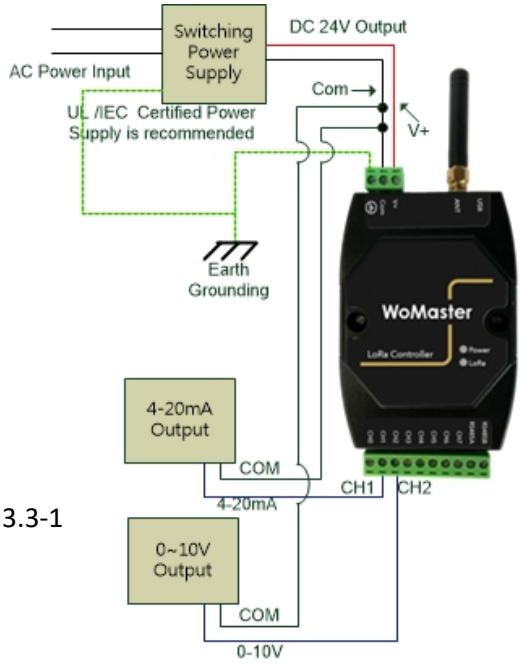


Diagram 3.3-1

3.4 Analog Voltage Output Wiring (LR144)

The **Analog output** provides:

- **0~10V voltage output** in open-collector (O.C.) driven mode
- **4~20mA current output**

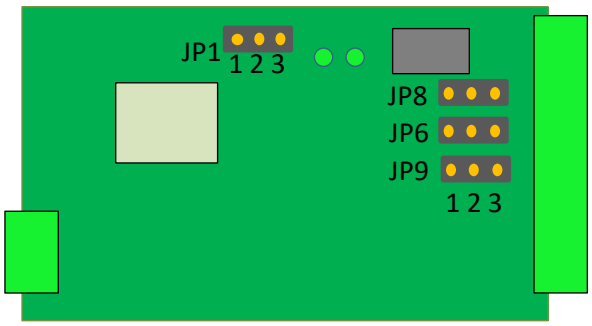
The analog voltage output supports a range from zero to 10 volts with **push-pull or external O.C. mode** for Far-End device internal pull-high applications.

- **Push-Pull mode**: Utilizes an internal pull high resistor connected to Power Input V+. The output current can reach up to 200mA
- **O.C. mode**: Involves external pull high by the far-end connected device, wherein the control input circuit adopts a resistor and connects to the internal power

There are 4 jumpers located at PCBA top side as following drawing.

Jumper	Channel #	Location	O.C. – Ext. Pull-High	Push-Pull, Internal Pull-High (No external Resistor required)
JP8	CH-7 (PWM 10V)	Nearby CH-7	1-2 Short (Default)	2-3 Short
JP6	CH-6 (PWM 5V)	Nearby CH-6	1-2 Short	2-3 Short (Default)/200mA
JP9	CH-5 (0-10V Out)	Nearby CH-5	1-2 Short (Default)	2-3 Short

Change the JP8, JP6 and JP9 for output mode change, and the JP1 is for firmware upgrade.



CH-5 Voltage Output (0~10V) – JP9

The Push-pull output current up to 200mA, and the O.C. mode depends on the connected device internal pull-high resistance. Change the position of JP9 for mode changes. In push-pull mode, the output voltage should lower than Power input voltage. Since, the internal circuit is connected with system power.

4~20mA Current Output: the current output control is commonly used at linear control system, like as electrical valve control applied for oil/liquid control system.

The I-out (CH4) wiring refers to Diagram 3.4-2.

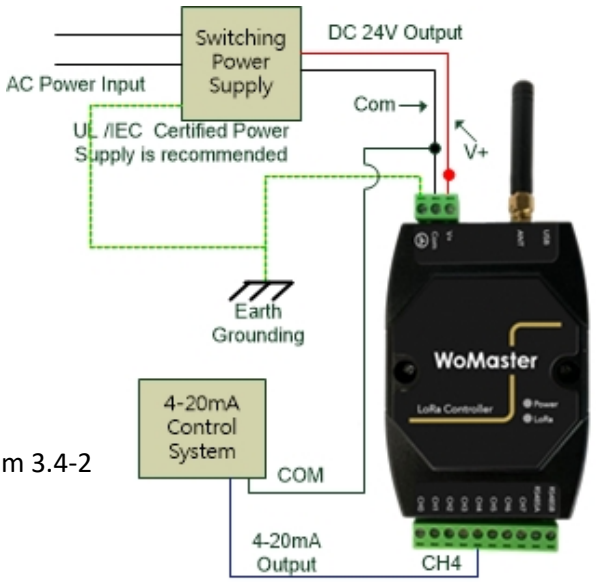


Diagram 3.4-2

3.5 PWM (Pulse Width Modulation) Output

CH-6 PWM 5V Output – JP6

The CH-6 default is PWM 5V output with certain duty-cycle and operating in push-pull mode. Once, the jumper changes to O.C. mode the output voltage will refer to the connected device internal voltage, the limited voltage is 30V.

CH-7 PWM 10V Output – JP8

The CH-7 default is PWM 10V output with certain duty-cycle and operating in push-pull mode. Once, the jumper changes to O.C. mode the output voltage will refer to the connected device internal voltage, the limited voltage is 30V.

Theory of PWM Duty-Cycle Control

The PWM control uses constant voltage as output, and adjusts the duty cycle to control the PWM dimmer output.

In the diagram 3.5-1, the output voltage is 10V, modulate the on/ Off duty cycle, and the end control device internal get voltage will be “Full-Volt x Duty Cycle %”.

Example: Full _Output = 10V

50% Duty Cycle, the End Control Device measured 5V, 75% get 7.5V and so on.

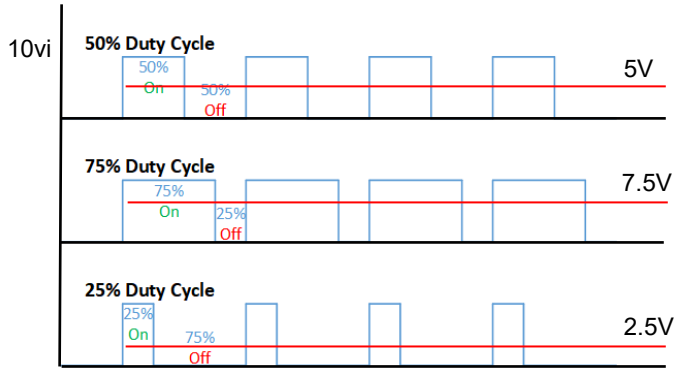


Diagram 3.5-1

3.6 RS-485 Wiring

The LM, LC, and LR series have equipped one isolated 2-wire RS-485 serial interface for long-distance communication. The baud rate supports 1200bps, 2400bps, 4800bps, and 9600bps, it is configured by LoRa WAN Utility which downloads from the WoMaster support Web site.

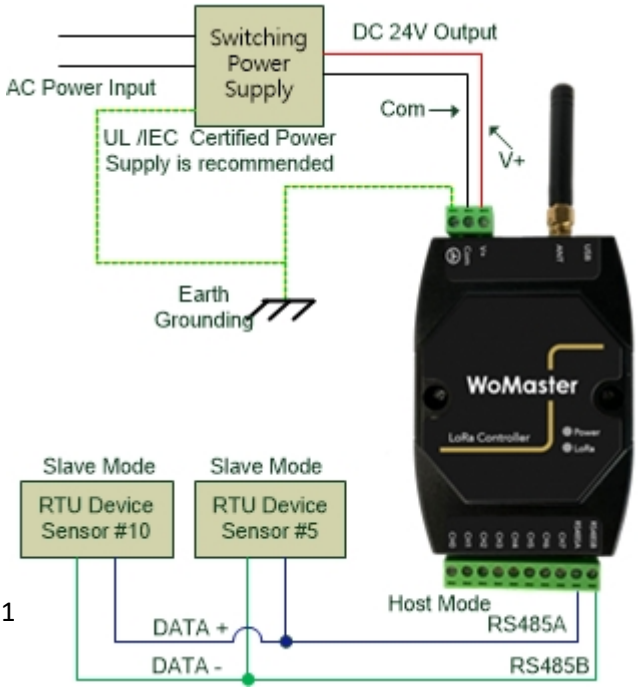


Diagram 3.6-1

The diagram 3.6-1 shows the LC100, LR140 and LR144 connect with the RTU Sensors Devices, device ID # 10 and device ID #5

Note: Device ID means the Modbus RTU Device Address.

4.LoRaWan Utility Configuration

The LoRaWan End- Node device is configured using the LoRaWan Utility via a USB interface. The LoRaWan Utility can be downloaded from the website: www.womaster.eu.
To configure the LoRaWan End-node device, connect it to your PC and perform a power on the End-node device, then the device will enter configuration mode when the status of USB port changes. Any new system setting applied during configuration mode will only take effect after the next power reset

4.1 Connects LoRaWan End Node device with LoRa WAN Utility

The LoRa WAN Utility is a software tool that does not require installation. Simply click on the “LoRa WAN Utility.exe” to launch the application, and the user interface will be displayed as follows.
The Utility main screw show as below diagram “ 4.1-1 Full Function TAB”

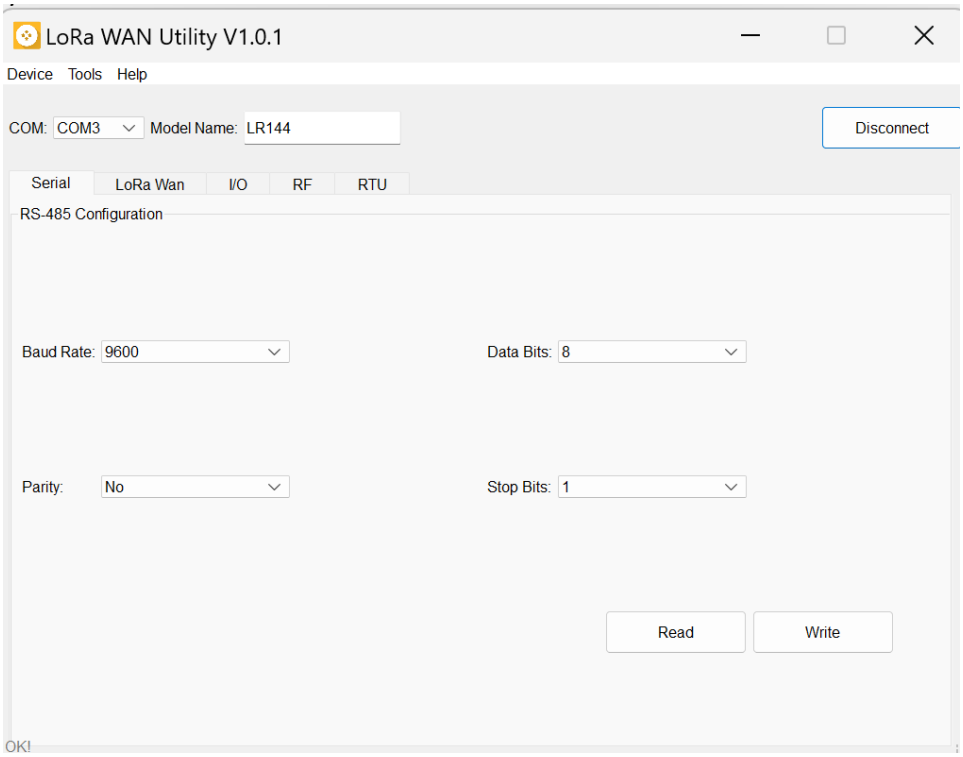


Diagram 4.1-1 Full Function TAB

TAB-Serial: RS485 Modbus RTU Serial Parameters Configure page
TAB-LoRa Wan: the LoRa Wan Network joint parameters setting page. 2 Joint modes, ABP and OTAA either one.
TAB-I/O: the Analog I/O setting page for your on-site monitoring and debugging.
TAB-RF: the LoRaWan Radio Signal monitoring page, includes RSSI (Radio Signal Strength Indication), SNR (Signal Noise Ratio).
TAB-RTU: Modbus RTU register entry table editing, RS485 Modbus Time-out setting and LoRaWan Data Upload interval time setting.

Click “COM” and select the USB mapping com port number. Diagram 4.1-2

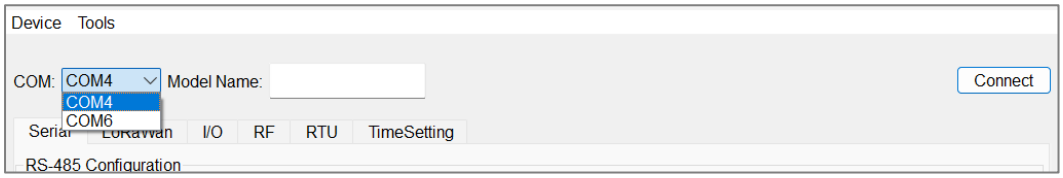


Diagram 4.1-2

Tools -- Options

Clicks the “Tools”, selects the “Options” for PC USB/Serial setting. The default parameter is Non parity check, 115200bps, 8 Data bits, 1 Stop bit (115200, N, 8, 1), the response time out is 1000ms, and retry number is 1. After new parameters setting, click “Apply” to apply the setting.

It is recommended does not modify these parameters. The LM100/ LM200/ LC100/ LR140/ LR144 supports USB COM port baud rate auto sensing.

Diagram 4.1-3, 4.1-4

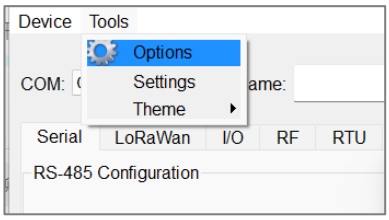


Diagram 4.1-3

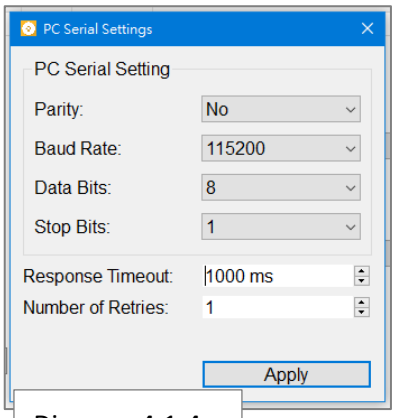


Diagram 4.1-4

Click the “Connect” icon, the login dialog will pop up for user name and password input. Diagram 4.1-5 LR140, LR144 communication mode just only select USB.

Default User Name and Password is “admin”

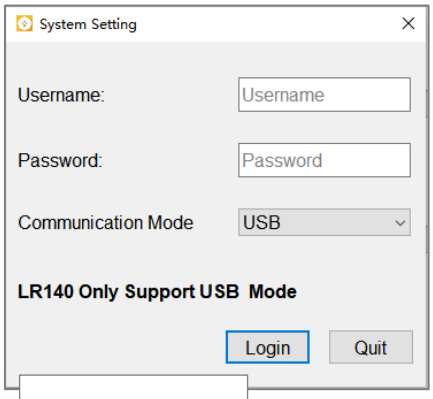


Diagram 4.1-5

Once login the End-Node system, the utility will show the connected device model name and the COM port information. Meanwhile, it will present available function TAB for different model. For the easy understanding, the function TAB listed in table as following Table 4.1-6 for different product series.

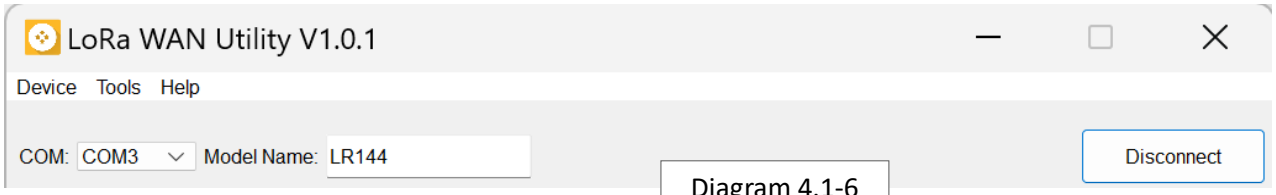


Diagram 4.1-6

Device – Connect: establish connection with end-node device with current USB/COM port.

Disconnect: disconnect with end-node device

Quit: Quite from the Utility

Tools – Setting- System Settings

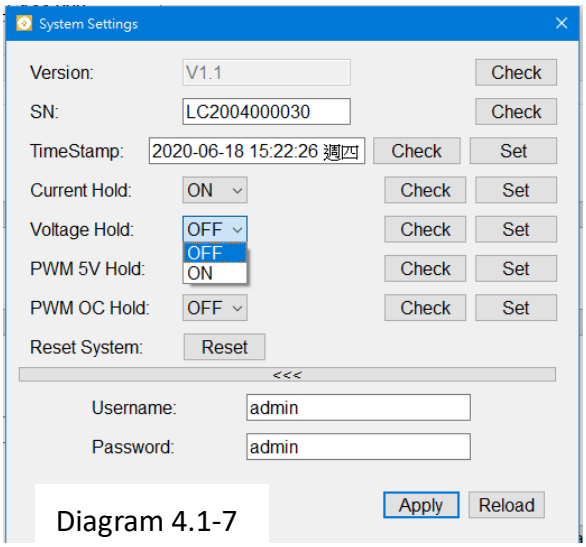


Diagram 4.1-7

The System Settings Dialog allows user to check device information, set TimeStamp, set Analog output value holding function and also provides login user name , password modification.

Those analog outputs **Hold On/Off** function support Holding Output function that keep previous value output after power reset.

That includes Current Output, Voltage Output, PWM-5V Output and PWM OC Output.

“**Check**”: retrieve current setting from device

“**Set**”: program new setting into device

Click “ >>> “ enable Username/Password modification.

Click “Apply” icon to apply the new setting, then warning dialog will pop up to make sure perform new setting. Click “Yes” to apply it.

Maximum Character Length for username and password is 16Bytes.

Tools – Theme Setting

The utility provides additional "**Dark**" mode theme for analog input, output calibration at "Adjust" TAB. Users can retrieve the default value and adjust it to increase or decrease accuracy. Click "Read" to retrieve current setting value, and click "Write" to program new value into system. In the Diagram 4.1-8 , the value is calibrated during factory production. It is not recommended to modify it.

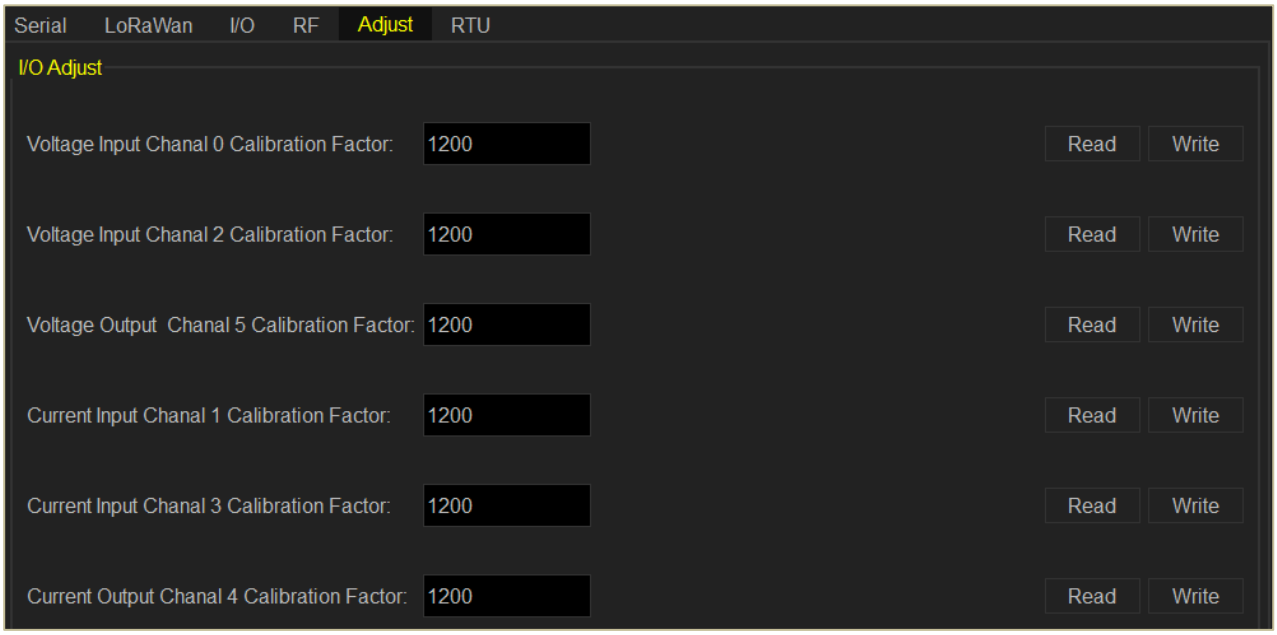


Diagram 4.1-8

4.2 Function Page

The LoRaWAN Utility includes 5 AB Pages for system configuration and 1 Help for assistance.
TAB-Serial: RS485 Modbus RTU Serial Parameters Configure page
TAB-LoRa Wan: the parameters setting page of the LoRa Wan Network includes options for ABP and OTAA Joint mode. Choose either one.
TAB-I/O: the Analog I/O setting page is designed for on-site monitoring and debugging.
TAB-RF: the LoRa Wan Radio Signal features RSSI (Radio Signal Strength Indication), SNR (Signal Noise Ratio).
TAB-RTU: Editing the Modbus RTU register entry table, setting the RS485 Modbus time-out, and adjusting the LoRa WAN data upload interval time.
TAB-Help: Brief User Menu for your quick reference.
On Each TAB function page, the icon" **Read**" is used to retrieve the current setting from the device, while the "**Write**" icon utilized for programming new parameters into the device.

4.2.1 TAB-Serial

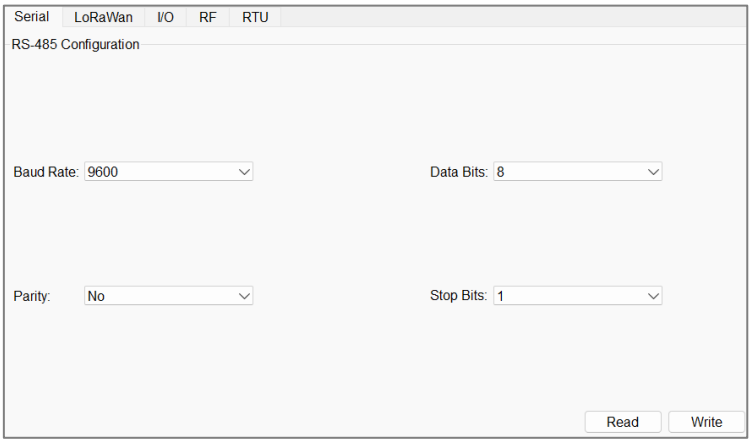
The LM100, LC100, LR140 and LR144 support a single RS-485 serial interface with various Modbus modes. Table 4.2.1-1 displays the Modbus mode for WoMaster LoRa MAC and LoRa WAN End-Node products. (LM100 & LC144 – LoRa MAC products, LR144 & LR140 LoRa WAN products)

Channel #	LM100	LC144	LR140/LR144
RS-485A	RTU Slave mode	RTU Host mode	RTU Host mode
RS-485B	RTU Slave mode	RTU Host mode	RTU Host mode

Table 4.2.1-1

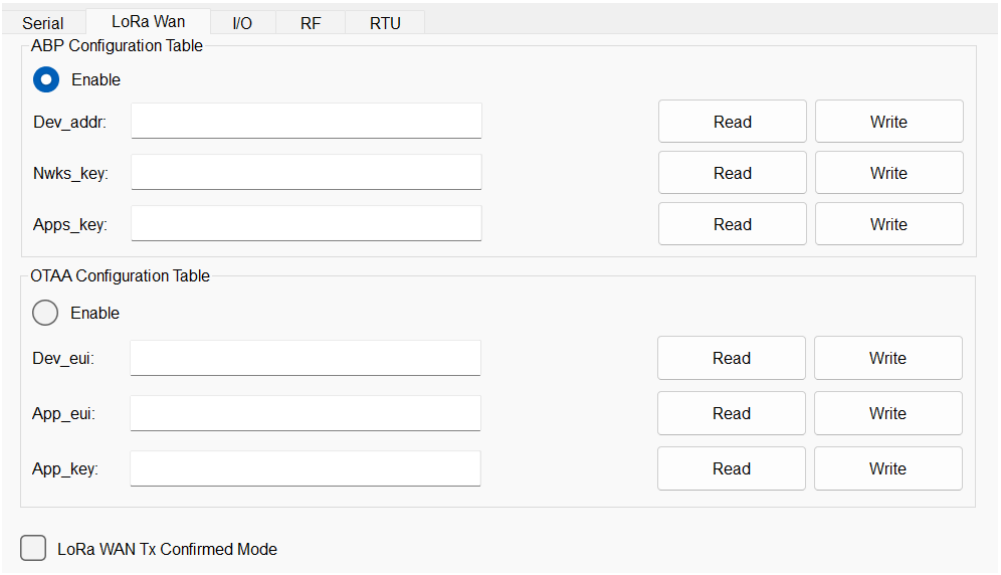
The Serial Page is for RS-485 Serial parameter setting.
Click "**Read** "to retrieve current setting, and click "**Write**" to set new parameters into device.
The following diagram illustrates the user interface for setting RS-485 parameters for LoRa Wan product – LR140/ LR144.

Baud Rate: 1200, 2400, 4800, 9600 bps
Data bit: 8 bits
Parity Check: No, Even, Odd
Stop bit: 1, 2bit
Default: 9600bps, N,8,1



4.2.2 TAB- LoRa Wan Configuration

The LoRa WAN Utility provides two way to active an end-node device. Either via Over-The-Air-Activation (OTAA) when an end-node device is deployed or reset, or via Activation By Personalization (ABP). The LR140 and LR144 support both ABP and OTAA. The default parameters for LR144 and LR140 are empty, and the network join parameters should be configured and generated from a LoRa WAN Router, such as the WR322-EC-LoRa WAN. Please refer to **Chapter 6**, "**WR322-EC-LoRa WAN Join End-Node Device**" for more information.



Dev_addr: Device Address of LoRaWan End-Node Device (8 Bytes, Hex Code)
Nwks_key: Network Security Key (32 Bytes, Hex code)
Apps_key: Application Session Key (32 Bytes, Hex code)
Dev_eui: Extended Unique Identifier of Network Device (16 Bytes, Hex code)
App_eui: Extended Unique Identifier of Application (8 Bytes, Hex Code)
App_key: the key of Application recognition (16 Bytes, Hex Code)
LoRa WAN Tx Confirmed Mode: request Gateway send acknowledge when received Tx from end-node device to ensure communication quality.

"**Read**": retrieve current setting from device; "**Write**": programming new setting into device
Those default parameters should be update with LoRa Wan Gateway which is going to joint with End-node device.

It is recommended to configure the LoRa WAN Gateway and LoRa WAN End Node together. During the setup process, some parameters need to be duplicated from the Gateway and programmed into the LoRa WAN End Node device. The table below shows a comparison of parameters for OTAA and ABP joint modes with WR322EC-LoRa.

Mandatory Parameters of ABP and OTAA

Join Mode	Device Address	DeviceEUI	NetworkSessionKey	APP_EUI	ApplicationSessionKey	APP_Key
ABP	Mandatory	-	Mandatory	-	Mandatory	-
OTAA	-	Mandatory	-		-	Mandatory

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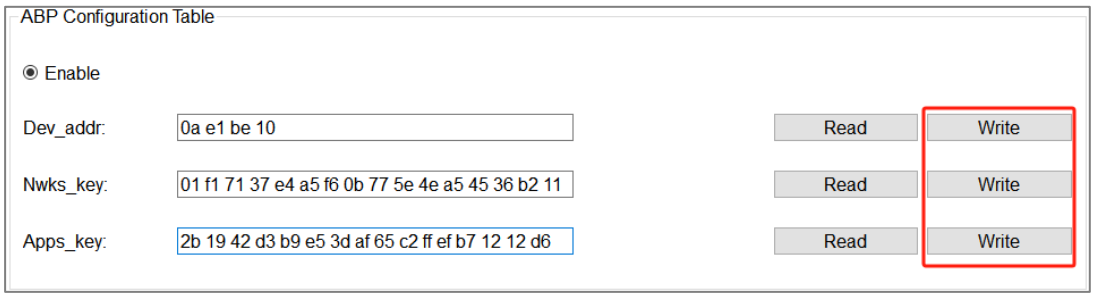
4.2.2-1 ABP Configuration

The following shows the configure user interface of LR140 in ABP mode:
Duplicate the **DeviceAddress**, **NetworkSessionkey** and **ApplicationSessionKey**, and then paste to the configure filed of end-node device.
The following diagram, the end-node device is joined to LoRa Wan Network in ABP mode.
In the other **chapter 6** "**WR322-EC-LoRaWan join End-Node Device**" will have detail introduction.

Mandatory Parameters of ABP

Join Mode	Device Address	DeviceEUI	NetworkSessionKey	APP_EUI	ApplicationSessionKey	APP_Key
ABP	Mandatory	-	Mandatory	-	Mandatory	-
OTAA	-	Mandatory	-		-	Mandatory

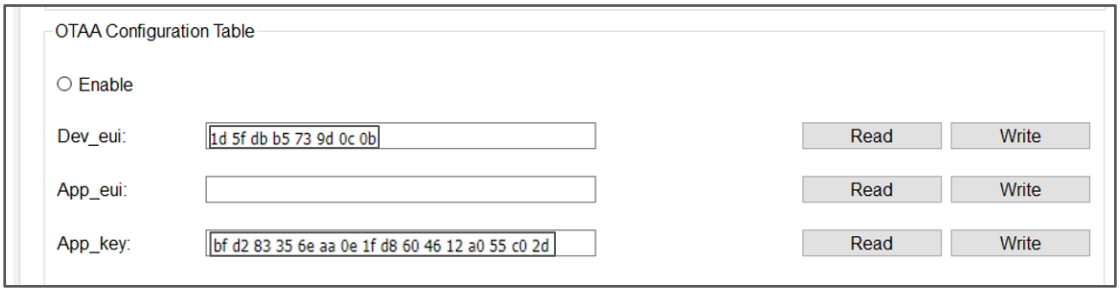


4.2.2-2 OTAA Configuration

The following shows the user interface of LR140/ LR144 in OTAA mode:
Duplicate the DeviceEUI, ApplicationSessionkey and then paste them to the configure field of the end-node device.
In the chapter 6 "**WR322-EC-LoRa Wan join End-Node Device**" will have detail introduction.

Mandatory Parameters of OTAA

Join Mode	Device Address	DeviceEUI	NetworkSessionKey	APP_EUI	ApplicationSessionKey	APP_Key
ABP	Mandatory	-	Mandatory	-	Mandatory	-
OTAA	-	Mandatory	-		-	Mandatory



For the OTAA mode LoRa WAN network joint, the App_eui is not necessary.

4.2.3 TAB-I/O

The I/O Page is only for the testing, diagnostic the status of analog I/O. All of parameters written data will not keep in the device internally once USB connection removed. Only the setting from the LoRa Wan cloud will be storage and keep.

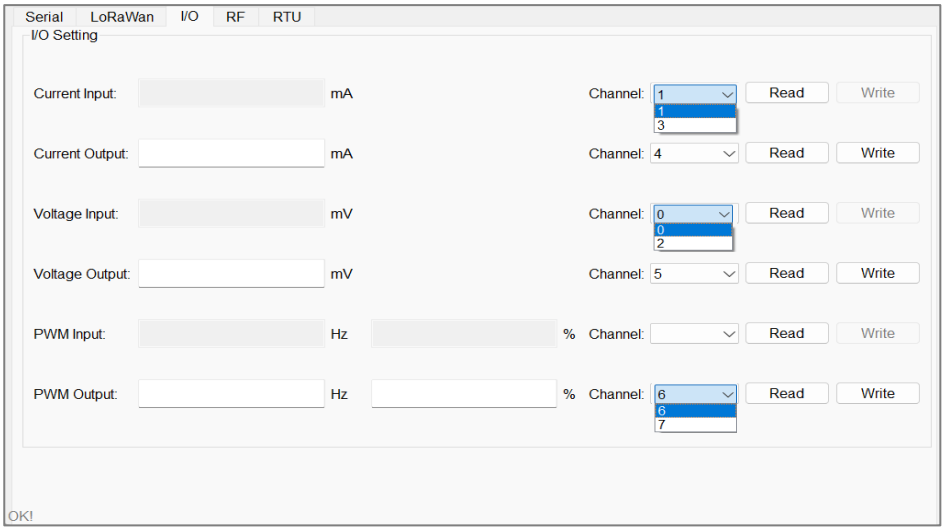


Diagram 4.2.3-1 I/O debug Page

The Analog I/O Pin definition as following Table 4.2.3-1

I/O Channel #	LR140	LR144
0	V-in: 0~10V, Positive	V-in: 0~10V, Positive
1	I-in: 4~20mA, Positive	I-in: 4~20mA, Positive
2	V-in: 0~10V, Positive	V-in: 0~10V, Positive
3	I-in: 4~20mA, Positive	I-in: 4~20mA, Positive
4	Not Available	Output Current 4~20mA Positive
5	Not Available	Output Voltage (OC) 0~10V Positive
6	Not Available	Output PWM Voltage 0~5V Positive
7	Not Available	Output PWM(OC) 0~10V Positive
RS-485A	RTU Host mode	RTU Host mode
RS-485B	RTU Host mode	RTU Host mode

Table 4.2.3-1

The I/O setting page includes Current Input/ Output, Voltage Input/Output, PWM Input/ Output information.

Select “Channel” and Click” Read” to import the parameter that read from the channel selected.

Each type of analog field will show with different color, white color is allowed to perform

"Read" and "Write", gray color is only for read function.

Some of model provides multiple channels in same type, and then select the target channel number that you want to monitor or testing.

4.2.4 TAB- RF (Radio Frequency Parameter)

The RF page is dedicated to monitoring radio signal quality. The RSSI stands for Radio Signal Strength Indication, while SNR represents Signal Noise Ratio. In cases where the RSSI is strong but the SNR is low, substantial interference is likely causing communication issues. If this occurs, consider relocating the equipment or adjusting the antenna position for better performance.

The Diagram 4.2.4-1 shows the RSSI, SNR page.

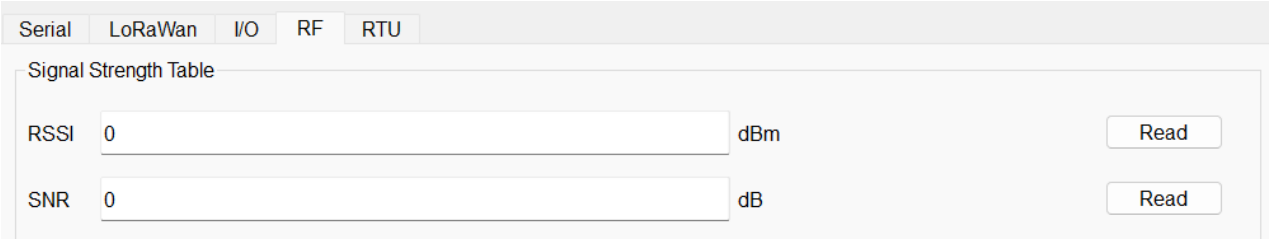


Diagram 4.2.4-1 RF- Radio Signal Strength Table

4.2.5 TAB-RTU

The LR140 and LR144 feature 1 RS485 interface and operate in Modbus RTU Host mode. This configuration allows the LR140 and LR144 devices to retrieve register values from Modbus RTU Slave devices via the RS485 bus and transmit this data to the LoRa WAN Cloud server. Users can access the "RTU" setting page to create and modify entries for pulling data from Modbus RTU slave devices. Additionally, the page includes settings for the LoRa WAN upload interval time. Diagram 4.2.5-1 illustrates the RTU and LoRa WAN upload settings. Diagram 4.2.5-1 shows the RTU and LoRaWan Upload setting.

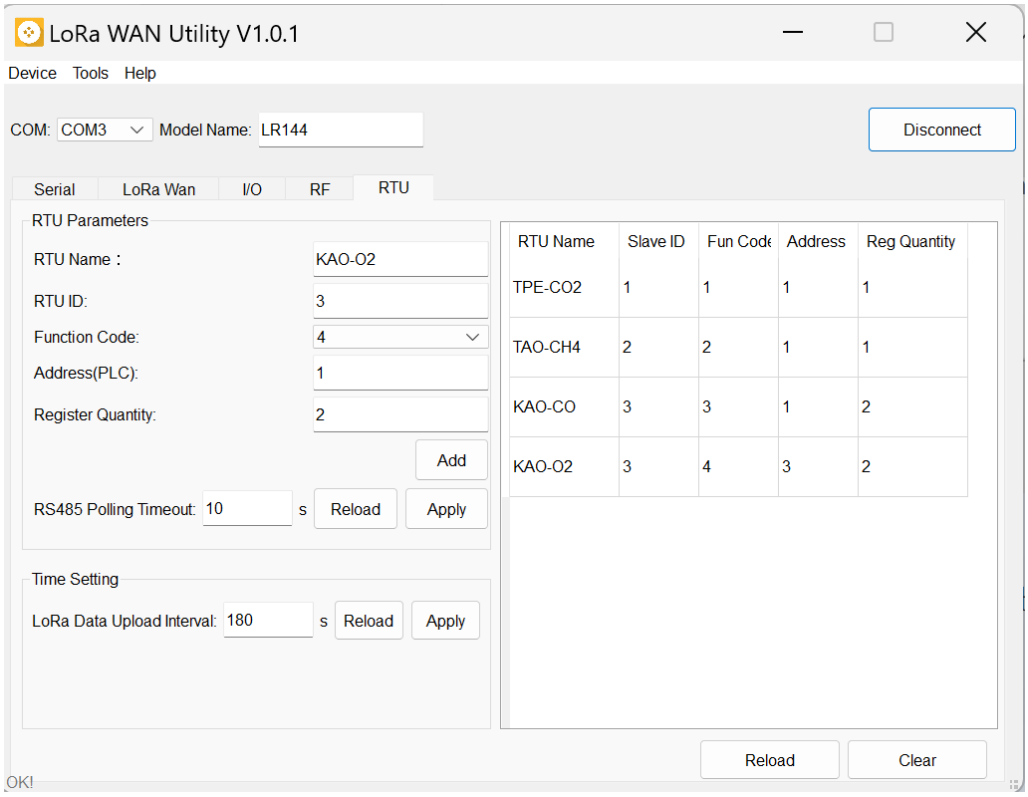


Diagram 4.2.5-1 RTU Table

RTU Name: Given a recognized name for the Modbus RTU register, the register's data will be uploaded to the cloud regularly.
RTU ID/ Slave ID/Device ID: Target Device Address of Modbus RTU device, or called Modbus Slave Device ID / Device ID (1~250)
Function Code: Supports reading function codes #1, #2, #3, #4
Address (PLC): PLC type Modbus RTU register address
Register Quantity: Register Reading Index number. Ex: Register Quantity =2, Address starts from 1, then the data polling will be from 1 to 2, the index number is 2.

The maximum register number of the Modbus RTU table is 20; 2 Bytes data width for each register, maximum 40 Bytes for the RTU table.

RS-485 Polling Timeout: the data polling time-out timer of Modbus RTU device. The maximum waiting time is 20 second, and the minimum is 1 second. The setting value should not exceed the LoRaWan Upload Timer.

LoRa Data Upload Interval: the interval timer of the LoRa Wan End-Node device publishes data to the LoRa Wan Router. The default setting is 180 second (minimum).

Note: The RS-485 Polling Timeout timer setting should not be lower than the LoRa Data Upload Interval timer. Generally, the response time of the RTU device is faster than 1 second.

Analog Input Polling Enable: the local analog input is active as RTU register and activate by established **VIN** or **AIN** RTU entry. The parameters of entries are listed in following table.

Note: About the analog output control will be introduced in the LoRaWan data parsing chapter.

The System internal analog input channel RTU name, the start register address and register quantity does not allow to modified, except Modbus Slave ID. Refers to the Table 4.2.5-1

I/O CH Analog Input	RTU Name **(Fixed)**	Modbus Slave ID (Changeable)	Address (PLC) **(Fixed)**	Register Quantity **(Fixed)**
CH 0 (0~10V)	**VIN0**	10	1017	1 (2 Bytes)
CH 1 (4~20mA)	**AIN1**	10	1002	1 (2 Bytes)
CH 2 (0~10V)	**VIN2**	10	1019	1 (2 Bytes)
CH 3 (4~20mA)	**AIN3**	10	1004	1 (2 Bytes)

Table 4.2.5-1 LR140/LR144 Internal Analog Input register address Table & RTU Name

The RTU Name is unchangeable, Modbus Slave ID assign any number between 1-250 , and the start address (PLC) is fixed for different type of analog input.

Channel 0- Voltage Input: RTU Name Set “VIN0

Channel 1 - Current Input: RTU Name Set “AIN1”

Channel 2- Voltage Input: RTU Name Set “VIN2”

Channel 3-Current Input: RTU Name Set “AIN3”

Slave ID: Any available ID (it is forbidden that applied same Modbus slave ID with analog Channel and external Modbus RTU device)

Function Code: Read function code 3 for all of analog input channel.

Address: register address, refers the table 4.2.5-1 above**.**

Slave ID: for the analog input, the Modbus slave ID number should be same for analog input channel.

Address: the pre-defined register address that existed in LoRaWan End-Node device which is going to read and forward the register data to Gateway.

Reg Quantity (Register Quantity): the depth of reading register. The fixed value is 1 (2Bytes data width).

Click "**Add**" to add new RTU entry, "**Reload**" to import current RTU device information and analog input entries enabled that existed in LoRaWan end node device

Edit & Delete exist RTU entry

Remove mouse cursor to the RTU entry which is going to edit or delete, then click the mouse right button, then the dialog will pop-up for edit or delete. Once done the new setting, click "Edit" to save into system. (Diagram 4.2.5-2)

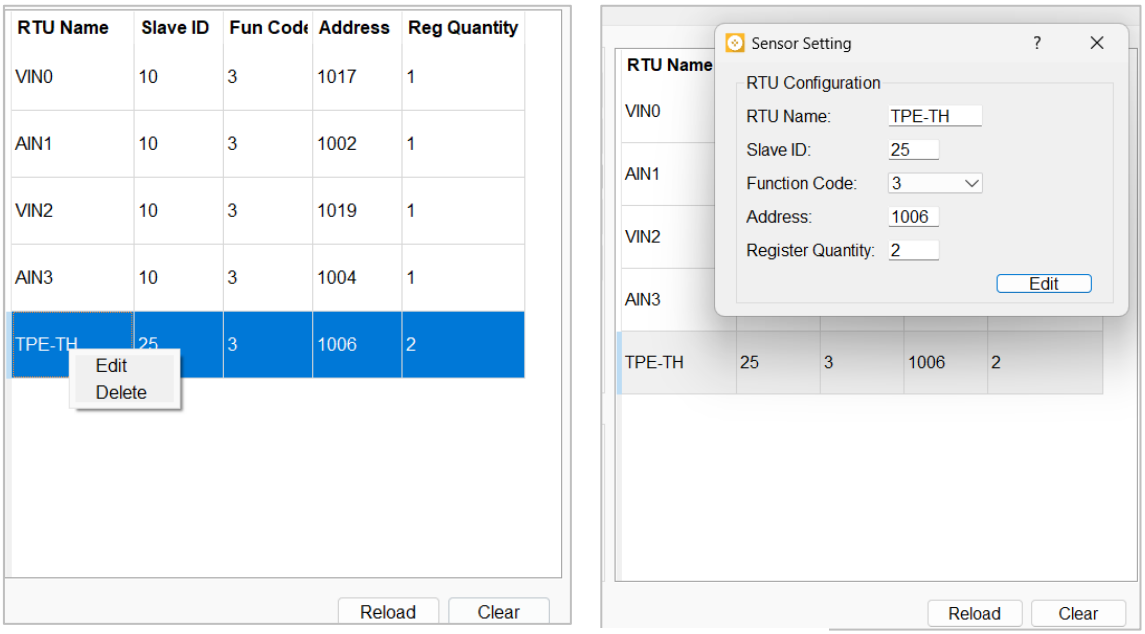


Diagram 4.2.5-2

After the RTU Table modification, Click the "Reload" to update the RTU Table. Click the "Clear" and click "reload" to refresh the RTU table.

5. LoRa Wan Data Packet Format

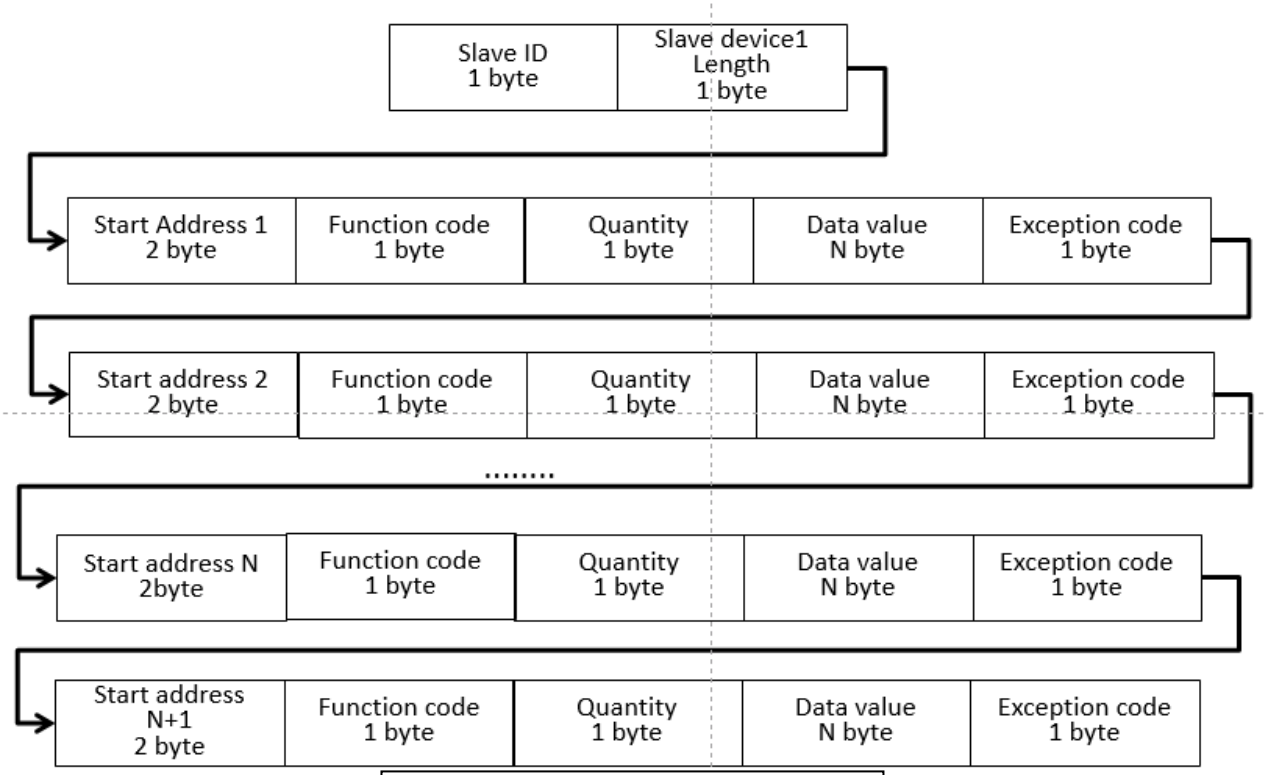
The LR140 and LR144 use different LoRaWan application communication service port numbers to distinguish applications. The following table describes the application types.

APP Service Port	Application Type for LR140/LR144	Supported Device
4	Regular Reporting (RS485/Voltage/Current/Heartbeat)	LR144, LR140
198	Modbus Far-End Read (Modbus Read Request from Gateway Router)	LR144
220	Modbus Far-End Write (Modbus Write Request from Gateway Router)	LR144
221	RTU Polling Timer setting, LoRaWan Data upload Timer setting	LR144
222	RTU Entry Configuration (Modbus RTU Entry modify Request from Gateway Router)	LR144
223	Remote Control (Voltage/Current/PWM) (Analog (Voltage, Current) Output, PWM Output Control from Gateway Router)	LR144

Note1 : LoRa WAN provides different applications based on different service port.
Note2 : The frame payload uses little-endian format.
Note3 : LR140 only has applications on service port 4, while LR144 includes all ports and applications.

5.1 Regular LoRa Wan Upload Reporting Format

The regular reporting information includes: RS-485 Modbus RTU entry, Analog voltage input, Analog current input. The data payload format as the diagram 5.1-1 Report Payload.



5.1-1 Report Payload Format

First Group slave data

Address	Field Name	Data width	Description
0x0001	Slave ID	1	Modbus RTU Slave ID
0x0002	Length	1	Modbus RTU Slave total length (start addr to last Exception code) unit: byte
0x0003	Start addr	2	Start address (PLC Addresses Base 1)
0x0005	Function Code	1	Modbus RTU Slave function code
0x0006	Quantity	1	Number of Register/Coil/Discrete
0x0007	Data value	N	Data Value of Register/Coil/Discrete function code 3,4 : N = Quantity x 2 bytes function code 1,2 : N = (Quantity +7) / 8 bytes
0x0007+N	Exception code	1	Exception code 0x0: Success

			Other: Exception code, refer to exception code table
Second Group slave data ..Continue..			
0x0001+PGD	Slave ID	1	Modbus RTU Slave ID
0x0002+PGD	Length	1	Modbus RTU Slave total length(start addr to last Exception code) unit: byte
0x0003+PGD	Start address	2	Start address (PLC Addresses Base 1)
0x0005+PGD	Function Code	1	Modbus RTU Slave function code
0x0006+PGD	Quantity	1	Number of Register/Coil/Discrete
0x0007+PGD	Data value	M	Data Value of Register/Coil/Discrete function code 3,4 : M = Quantity x 2 bytes function code 1,2 : M = (Quantity +7) / 8 bytes
0x0007+M+PGD	Exception code	1	Exception code 0x0: Success Other: Exception code, refer to exception code table

Note:

1. The maximum data length of LoRa Wan data payload is 51 Bytes.

2. PGD: The length of the previous group data

3. G2L: Slave Data length of Second Group (7+M)

Third Group slave data ..Continue..			
Address	**Field Name**	**Data width**	**Description**
0x0001+PGD	Slave ID	1	Modbus RTU Slave ID
0x0002+PGD	Length	1	Modbus RTU Slave total length (start addr to last exception code), unit: byte
0x0003+PGD	Start addr	2	Start address (PLC Addresses Base 1)
0x0005+PGD	Function Code	1	Modbus RTU Slave function code
0x0006+PGD	Quantity	1	Number of Register/Coil/Discrete
0x0007+PGD	Data value	P	Data Value of Register/Coil/Discrete function code 3,4 : P = Quantity x 2 bytes function code 1,2 : P = (Quantity +7) / 8 bytes
0x0007+P+PGD	Exception code	1	Exception code 0x0: Success Other: Exception code, refer to exception code table
	.....		

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Note: (If we can put third group data, G3L+PGD<=51)
PGD: The length of the previous group data
G3L: third group slave data length(7+P)

Demonstration of LR144 RTU Table from the LoRa WAN Utility

RTU Name	Slave ID	Fun Code	Address	Reg Quantity
a	1	3	1	2
b	1	3	3	1
c	1	3	4	1
d	1	3	5	6
e	2	1	1	12
f	3	2	1	21
g	4	4	1	6

The end-node will upload LoRa data by same slave ID address and function code first.
The first Data upload will include entries from “a” to “e”, and the “f” and “g” will be packing and upload at 2nd times. Since, the maximum length of payload is less and equal to 51 Bytes.

The following is the payload #1 list in HEX:

Payload#1 list in HEX :
01 28 01 00 03 02 01 00 02 00 00 03 00 03 01 03 00 00 04 00 03 01 04
00 00 05 00 03 06 05 00 06 00 07 00 08 00 09 00 00 00 00 02 07 01 00
01 0c 55 0a 00

Analysis:
01 : slave ID
28 (HEX) : length of Bytes (start addr to last Exception code)

01 00 : Start address
03 : Function Code
02 : Quantity
01 00 02 00 : Value(1, 2)
00 : Exception code

03 00 : Start address
03 : Function Code
01 : Quantity
03 00 : Value(3)
00 : Exception code

04 00 : Start address
03 : Function Code
01 : Quantity
04 00 : Value(4)
00 : Exception code

05 00 : Start address
03 : Function Code
06 : Quantity
05 00 06 00 07 00 08 00 09 00 00 00 : Value(5,6,7,8,9,0)
00 : Exception code

02 : slave ID
07 : length(start addr to last Exception code)
01 00 : Start address
01 : Function Code
0c : Quantity
55 0a : Value
00 : Exception code

The following is the payload #2 list in HEX:

Payload #2:
03 08 01 00 02 15 aa aa 0a 00 04 11 01 00 04 06 01 00 02 00
03 00 04 00 05 00 06 00 00

Analysis:
03 : slave ID
08 : length(start addr to last Exception code)

01 00 : Start address
02 : Function Code
15 : Quantity
aa aa 0a : discrete value
00 : Exception code
04 : slave ID
11 : length(start addr to last Exception code)
01 00 : Start address
04 : Function Code
06 : Quantity
01 00 02 00 03 00 04 00 05 00 06 00 :
Value(1,2,3,4,5,6)
00 : Exception code

- **Analog Input (Voltage, Current) data definition**

Channel	Default RTU/Tag Name	Start Add. (PLC)	Quantity	Description
CH0	VIN0	1017	1	Channel 0 voltage input Resolution/Unit: Actual Voltage = Data x 0.001V
CH1	AIN1	1002	1	Channel 1 current input Resolution/Unit: Actual Current=Data x 0.001mA<
CH2	VIN2	1019	1	Channel 2 voltage input Resolution/Unit: Actual Voltage= Data x 0.001V
CH3	AIN3	1004	1	Channel 3current input Resolution/Unit: Actual Current=Data x 0.001mA

5.2 Modbus Far-End Reading

- **Down Link from Gateway/Router to End-Node Device**

The Modbus Far-End Read payload is forwarded from LoRaWan Gateway/ Router to LoRa Wan end node device and read specified Modbus RTU register . The payload architecture shows as Diagram 5.2-1. It includes Modbus RTU device ID (Slave ID), Function Code, Register Start Address and Quantity of Register.

APP Port: 198 (down link)

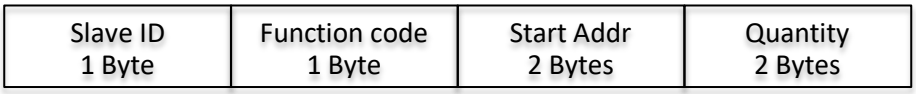

Diagram 5.2-1

The definition of payload as Table 5.2.1

Address	Field Name	Data width	Description
0x0001	Slave ID	1	Slave ID
0x0002	Function code	1	Modbus function code
0x0003	Start addr	2	start address(PLC)
0x0005	Quantity	2	Number of Register/Coil/Discrete

Table 5.2-1

- **Uplink, Ack from LoRa Wan End-Node**

  The payload of Uplink /Act from LoRa Wan End-Node to LoRa Wan Gateway/Router, the format as the diagram 5.2-2 and the definition as table 5.2-2.

APP port:198 (Ack, Upload)

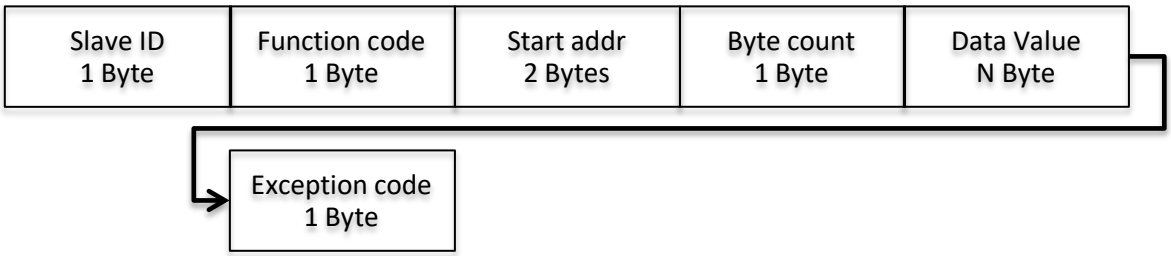

Diagram 5.2-2

Address	Field Name	Data width	Description
0x0001	Slave ID	1	Slave ID
0x0002	Function code	1	Modbus function code
0x0003	Start addr	2	start address(PLC Addresses Base 1)

0x0005	Byte count	1	Byte count of Register/Coil/Discrete value
0x0006	Data value	N	Data Value of Register/Coil/Discrete, little-endian format Register: N = Quantity x 2 bytes Coil/Discrete: N = (Quantity +7) / 8 bytes
0x0006+N	Exception code	1	0: Success Other: Exception code, refer to exception code table. Chapter 5.6

Note: Calculation of N
Register: N=Quantity x2
Coil/Discrete N=(Quantity +7)/8
Exception Code: Refers to Exception code table

Example: Remote command to read 2 holding-registers from address 2 on slave device ID 1

Downlink payload:
01 03 02 00 02 00 ;

Analysis:
01 : Slave ID is 1
03 : Function code is 3
02 00 : Start address is 2
02 00 : Quantity is 2

Uplink payload:
01 03 02 00 02 00 04 01 00 02 00 00;

Analysis:
01 : Slave ID is 1
03 : Function code is 3
02 00 : Start address is 2
04 : Byte count is 4
01 00 : The value of 1st register is 0x001
02 00 : The value of 2nd register is 0x002
00 : Exception code 0 (Success)

5.3 Modbus Far-End Writing

This charter will introduce the writing far-end Modbus RTU device's register through the APP service port #220 (downlink) includes down-link payload and uplink payload for Ack to LoRaWan Gateway/ Router.

- **Down Link from Gateway/Router to End-Node Device (write RTU Register/Coil/Discrete)**

the far-end writing payload's architecture as following Diagram 5.3-1 Writing Payload.

App service port : 220 (Downlink)

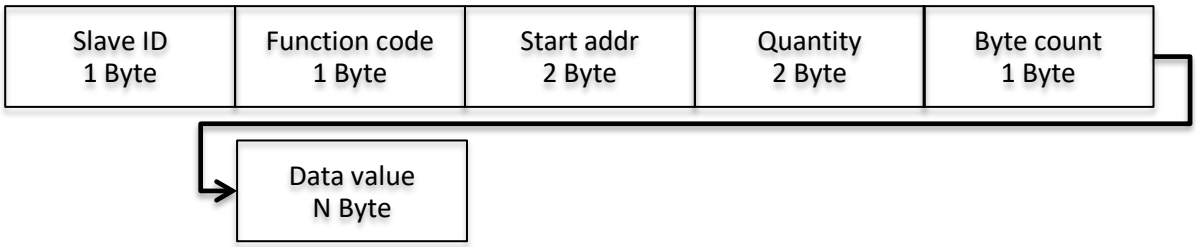

Diagram 5.3-1 Writing Payload

The definition of Far-End writing payload as following table 5.3-1

Address	Field Name	Data width	Description
0x0001	Slave ID	1	Slave ID
0x0002	Function code	1	Modbus function code
0x0003	Start addr	2	start address(PLC Addresses Base 1)
0x0005	Quantity	2	Number of Register/Coil/Discrete
0x0007	Byte count	1	Byte count of Register/Coil/Discrete value Default is zero. This field is only valid with Modbus function 0x0f(#15), 0x10(#16).
0x0008	Data value	N	Data Value of Register/Coil/Discrete, little-endian format Register: N = Quantity x 2 bytes Coil/Discrete: N = (Quantity +7) / 8 bytes

- **Uplink, Ack from LoRa Wan End-Node to LoRa Wan Gateway/Router**

The architecture of acknowledge payload from LoRaWan End-Node device to LoRaWan Gateway/Router shows as the diagram 5.3-2 and the definition as table 5.3-2.

App service port : 220 (ACK, Uplink)

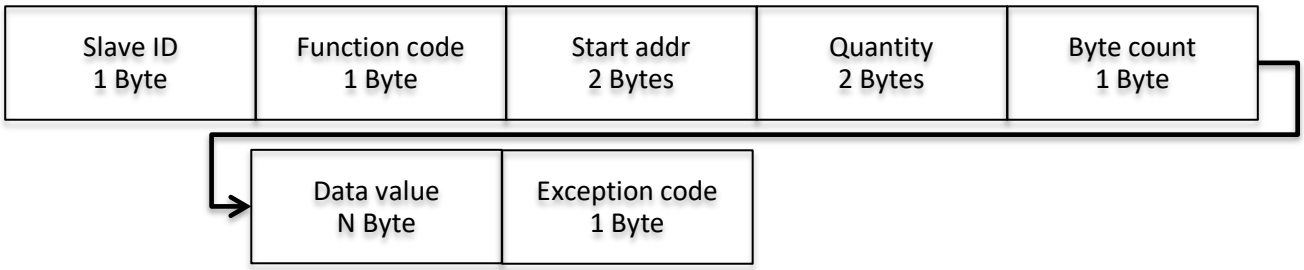

Diagram 5.3-2 ACK Payload after Far-End Writing

Address	Field Name	Data width	Description
0x0001	Slave ID	1	Slave ID
0x0002	Function code	1	Modbus function code
0x0003	Start addr	2	start address(PLC Addresses Base 1)
0x0005	Quantity	2	Number of Register/Coil/Discrete
0x0007	Byte count	1	Byte count of Register/Coil/Discrete value Default is zero. This field is only valid with function 0x0f, 0x10.
0x0008	Data value	N	Data Value of Register/Coil/Discrete, little-endian format Register: N = Quantity x 2 bytes Coil/Discrete: N = (Quantity +7) / 8 bytes
0x0008+N	Exception code	1	0: Success Other: Exception code, refer to exception code table- Chapter 5.7

Table 5.3-2 Definition of ACK

Example: Remote command to read 2 holding-registers with value 1000 and 2000 from address 2 on slave device ID 1

Downlink payload:
01 06 02 00 02 00 00 e8 03 d0 07;
Analysis:
01 : Slave ID is 1
06 : Function code is 6
02 00 : Start address is 2
02 00 : Quantity is 2
00 : byte count is 0
e8 03 : The 1st write value is 1000
d0 07 : The 2nd write value is 2000

Uplink payload:
01 06 02 00 02 00 00 e8 03 d0 07 00;
Analysis:
01 : Slave ID is 1
06 : Function code is 6
02 00 : Start address is 2
02 00 : Quantity is 2
00 : byte count is 0
e8 03 : The 1st write value is 1000
d0 07 : The 2nd write value is 2000
00 : Exception code 0 (Success)

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5.4 Modbus RTU Time-Out & Polling Interval

The session is about the register polling time-out timer setting and the regular polling timer setting. The LoRa Wan regular upload timer also follows the polling timer. About the payload format and the definition refers to diagram 5.4-1 and the table 5.4-1. The APP service port applied number 221, uses these downlink control to change the Modbus RTU polling timeout timer and LoRa Wan uplink interval timer. Once the downlink control successful, the LR140/LR144 will uplink ACK payload to LoRa Wan Gateway/ Router, the payload and definition as diagram 5.4-2 and Table 5.4-2.

Downlink Control payload & Definition – interval timer, Modbus timeout timer

App service port : 221 (downlink)

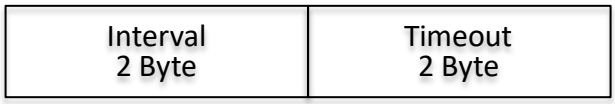

Diagram 5.4-1 Modbus timeout & Interval timer setting payload

Address	Field Name	Data width	Description
0x0001	Interval	2	LoraWAN report interval Unit: second
0x0003	Timeout	2	RTU polling Timeout Unit: second

Table 5.4-1 Modbus timeout & Interval timer setting payload definition

Uplink Control payload & Definition – interval timer, Modbus timeout timer

App service port : 221 (Ack, Uplink)

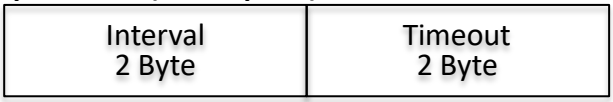

Diagram 5.4-2 ACK new setting

Address	Field Name	Data width	Description
0x0001	Interval	2	Polling interval Unit: second
0x0003	Timeout	2	Timeout Unit: second

Table 5.4-2 Modbus timeout & Interval timer setting payload definition

Example: Modify the report interval 10 min, polling timeout 2 sec.

Downlink payload:

0a 00 02 00 ;

Analysis:

0a 00 : Interval is 10 min

02 00 : Timeout is 2 second

Uplink payload:

0a 00 02 00 ;

Analysis:

0a 00 : Interval is 10 min

02 00 : Timeout is 2 second

5.5 Modbus RTU Entry Configuration

The remote modification of the far-end Modbus RTU register entry that connects to the RS-485 interface of either LR140 or LR144 is allowed. The payload and definition are shown in diagram 5.5-1 and table 5.5-1. The APP service port number used is 222 for downlink and Ack uplink

Diagram 5.5-1 Downlink payload

Address	Field Name	Data width	Description
0x0001	Index	2	Index of RTU item, start from zero
0x0003	RTU/Tag name	8	RTU/Tag name Max length is 8 characters. If not enough, padding 0x0
0x000b	Slave ID	1	RTU slave ID
0x000c	Function code	1	Modbus function code
0x000d	Start addr	2	start address(PLC Addresses Base 1)
0x000f	Quantity	2	Number of Register/Coil/Discrete

Table 5.5-1 Downlink payload

The acknowledged payload will be uploaded to the LoRaWan Gateway /Router with the latest RTU entry information. The payload format and definition of acknowledged are same as the downlink.

Example: Remote modification of parameters for RTU table index 1, named "SW104", with slide ID 5, function code 3, starting address 34, quantity 10

Downlink payload:

01 00 53 57 31 30 34 00 00 00 05 03 22 00 0a 00;

Analysis:

01 00 : Index is 1

53 57 31 30 34 00 00 00 : RTU/Tag name is “SW104”

05 : Slave ID is 5

03 : Function code is 3

22 00 : Start addr is 34

0a 00 : Quantity is 10

Uplink payload:

01 00 53 57 31 30 34 00 00 00 05 03 22 00 0a 00;

Analysis :

01 00 : Index is 1

53 57 31 30 34 00 00 00 : RTU/Tag name is “SW104”

05 : Slave ID is 5

03 : Function code is 3

22 00 : Start addr is 34

0a 00 : Quantity is 10

5.6 Remote Control (Voltage/Current/PWM)

The remote voltage, current, and PWM output control are only for the LR144. The remote control applied APP service port number 223 for the application recognition. Diagram 5.6-1 and Table 5.6-1 shows the payload format and definition.

APP port 223 (downlink)

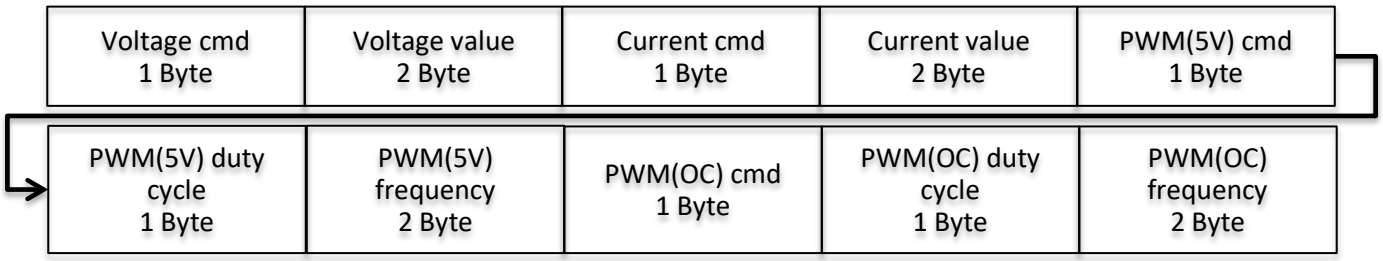

Diagram 5.6-1

Address	Field Name	Data width	Description
0x0001	Voltage cmd	1	[0-1] (0: invalid 1: valid)
0x0002	Voltage value	2	[0-10000] unit: 0.001V
0x0004	Current cmd	1	[0-1] (0: invalid 1: valid)
0x0005	Current value	2	[4000-20000] unit: 0.001mA
0x0007	PWM(5V) cmd	1	[0-1] (0: invalid 1: valid)
0x0008	PWM(5V) duty cycle	1	[0-100]
0x0009	PWM(5V) frequency	2	[100-1000] unit: Hz
0x000B	PWM(OC) cmd	1	[0-1] (0: invalid 1: valid)
0x000C	PWM(OC) duty cycle	1	[0-100]
0x000D	PWM(OC) frequency	2	[100-1000] unit: Hz

Table 5.6-1

The LR144 will uplink the acknowledged payload that embeds the latest parameters to LoRaWan Gateway/Router once those settings are successful. Diagram 5.6-2 and Table 5.6-2 shows the payload and definition of acknowledge.

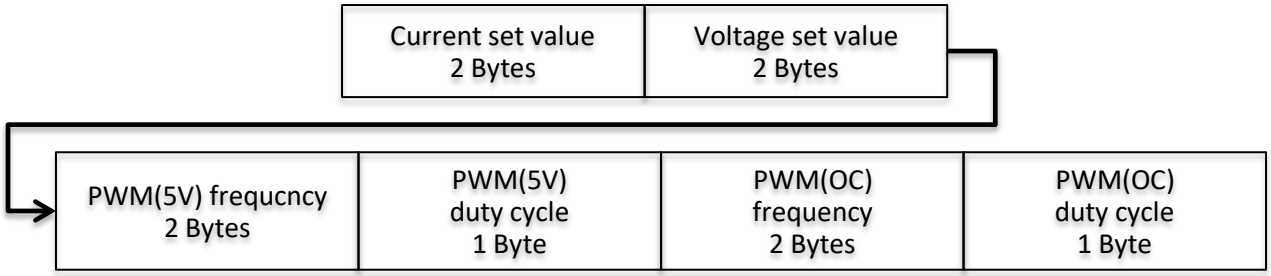

Diagram 5.6-2

Address	Field Name	Data width	Description
0x0001	Current set value	2	[0-10000] unit: 0.001V
0x0003	Voltage set value	2	[4000-20000] unit: 0.001mA
0x0005	PWM(5V) frequency	2	[100-1000] unit: Hz
0x0007	PWM(5V) duty cycle	2	[0-100]
0x0009	PWM(OC) frequency	2	[100-1000] unit: Hz
0x000B	PWM(OC) duty cycle	2	[0-100]

Table 5.6-2

Example: Remote control voltage output 10V, current output 20mA, PWM (5V) output duty cycle 40%, frequency 500Hz, PWM (OC) output duty cycle 50%, frequency 1000Hz

Downlink payload:

01 10 27 01 20 4e 01 28 f4 01 01 3c e8 03;

Analysis:

01 : Enable voltage output

10 27 : 10000 mV

01 : Enable current output

20 4e : 20000 uA

01 : Enable PWM(5V)

28 : 40%

f4 01 : 500Hz

01 : Enable PWM(OC)

3c : 50%

e8 03 : 1000Hz

Uplink payload :

20 4e 10 27 f4 01 28 e8 03 3c;

Analysis :

20 4e : current set 20000 uA

10 27 : voltage set 10000 mV

f4 01 : PWM(5V) frequency 500Hz

28 : PWM(5V) duty cycle 40%

e8 03 : PWM(OC) frequency 1000Hz

3c : PWM(OC) duty cycle 50%

5.7 Modbus Exception Code Table & Little-Endian, Big-Endian

Here is the customer error code for Modbus communication.

Exception code	Description
0x00	Success
0xE0	Invalid slave ID : The requested Slave ID is not equal to the Slave ID in received payload
0xE1	Invalid function code: The requested function code is not equal to the function code in received payload
0xE2	Response timeout
0xE3	Invalid CRC

Modbus Exception codes for your reference

MODBUS Exception Codes		
Code	**Name**	**Meaning**
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the server. This may be because the function code is only applicable to newer devices, and was not implemented in the unit selected. It could also indicate that the server is in the wrong state to process a request of this type, for example because it is unconfigured and is being asked to return register values.
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the server. More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, the PDU addresses the first register as 0, and the last one as 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 4, then this request will successfully operate (address-wise at least) on registers 96, 97, 98, 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 5, then this request will fail with Exception Code 0x02 “Illegal Data Address” since it attempts to operate on registers 96, 97, 98, 99 and 100, and there is no register with address 100.
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for server. This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does NOT mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the MODBUS protocol is unaware of the significance of any particular value of any particular register.

04	SERVER DEVICE FAILURE	An unrecoverable error occurred while the server was attempting to perform the requested action.
05	ACKNOWLEDGE	Specialized use in conjunction with programming commands. The server has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the client. The client can next issue a Poll Program Complete message to determine if processing is completed.
06	SERVER DEVICE BUSY	Specialized use in conjunction with programming commands. The server is engaged in processing a long–duration program command. The client should retransmit the message later when the server is free.
08	MEMORY PARITY ERROR	Specialized use in conjunction with function codes 20 and 21 and reference type 6, to indicate that the extended file area failed to pass a consistency check. The server attempted to read record file, but detected a parity error in the memory. The client can retry the request, but service may be required
0A	GATEWAY PATH UNAVAILABLE	Specialized use in conjunction with gateways, indicates that the gateway was unable to allocate an internal communication path from the input port to the output port for processing the request. Usually means that the gateway is misconfigured or overloaded.
0B	GATEWAY TARGET DEVICE FAILED TO RESPOND	Specialized use in conjunction with gateways, indicates that no response was obtained from the target device. Usually means that the device is not present on the network.

Little-Endian & Big-Endian

Little Endian and Big Endian are two different byte order representation methods that have wide applications in computer storage and communication. Here are specific examples of them：

Little-Endian :

Taking the 16 bit wide number 0x1234 as an example, the storage method in Little Endian mode CPU memory is to store the low byte at a low address and the high byte at a high address. Assuming storage starts from address 0x4000, memory address 0x4000 stores 0x34, while memory address 0x4001 stores 0x12.

For the 32-bit wide number 0x12345678, the rule of storing low byte addresses is also followed. Starting from address 0x4000, memory address 0x4000 stores 0x78, 0x4001 stores 0x56, 0x4002 stores 0x34, and 0x4003 stores 0x12.

Big-Endian :

Taking the same 16 bit wide number 0x1234 as an example, the storage method in the Big Endian mode CPU memory is to store the high byte at a low address and the low byte at a high address. Assuming storage starts from address 0x4000, memory address 0x4000 stores 0x12, while memory address 0x4001 stores 0x34.

For a 32-bit wide number 0x12345678, starting from address 0x4000, memory address 0x4000 stores 0x12, 0x4001 stores 0x34, 0x4002 stores 0x56, and 0x4003 stores 0x78.

Simply put, the small end format stores low byte addresses, while the large end format stores high byte addresses. These two formats have their own limitations in different systems and applications

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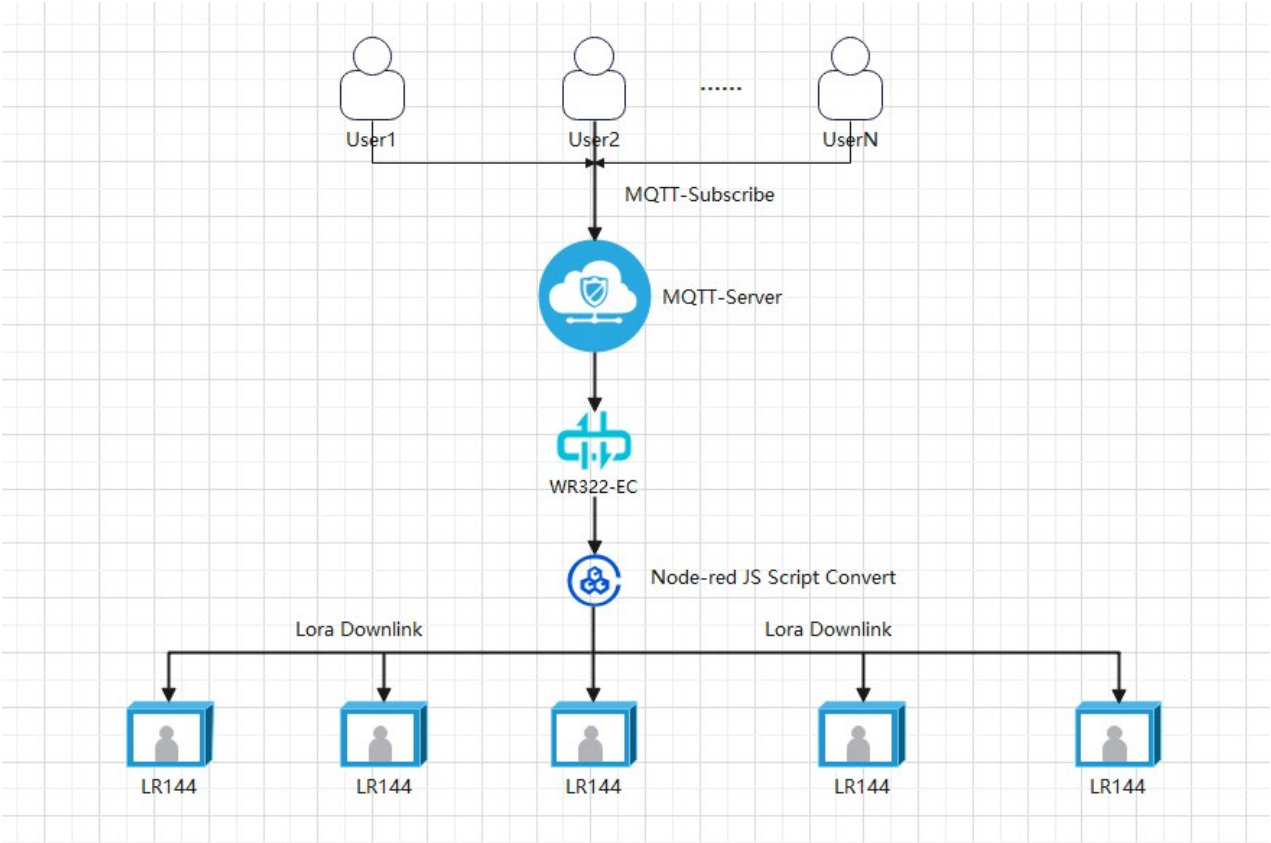
6. WR322 & LR140/144 Join LoRa Wan Network

The following flow-chart describes the system configuration procedure between WR322GR-EC-LoRa Wan Gateway and LoRa Wan end-node device (ex. LR140/144).

Due to the LoRa Wan Gateway router -WR322GR-EC-LoRa Wan has embedded a Network Server and an Application server in one hardware platform. Therefore, users need to perform different function settings through different User operating interfaces that are supported by different TCP service port number and co-configure with end-node devices (ex. LR140/144).

After the device parameter configuration is successful, users can use MQTT to issue instructions to WR322 to control the LR144 related parameters, making it convenient for users to manage and set the end node device.

*Only LR144 supports downlink control, LR140 does not support it.



1. System Hardware Interface – Ethernet Port (LAN, WAN) Configuration, Monitoring

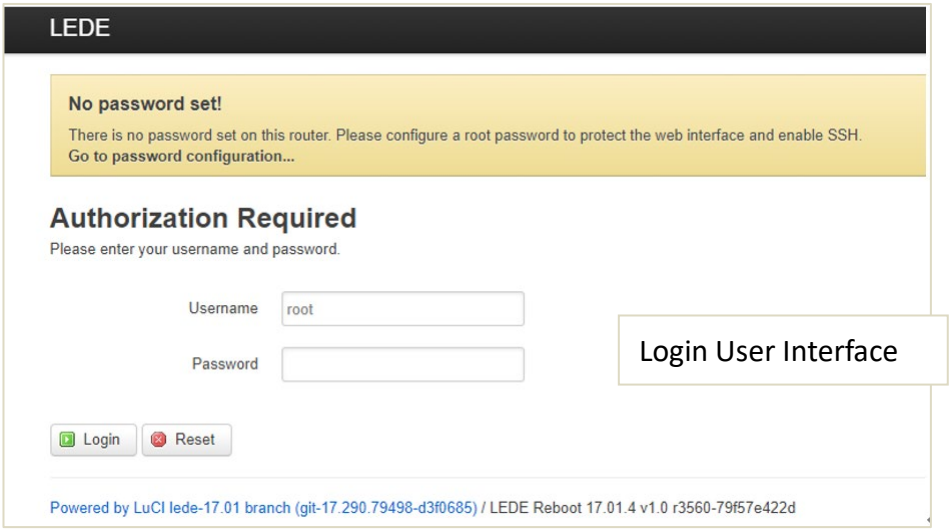
WAN Port: RJ-45 Port #1 – Local Management

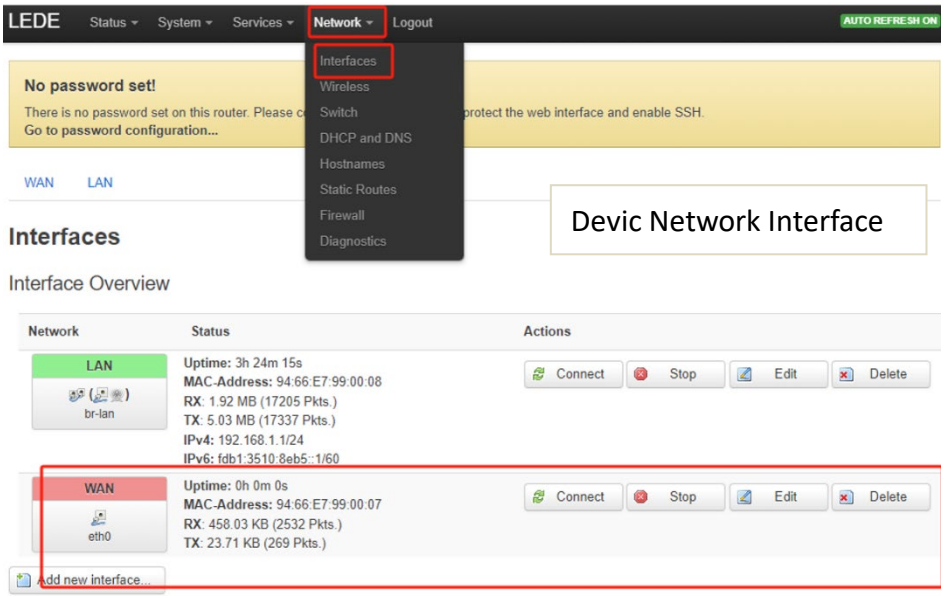
LAN Port: RJ-45 Port #2

System Device Default IP Address: **192.168.1.1**

Login User Name: **root**

Login Password: null (default without password)





2. LoRaWan Gateway & Network Server Configure

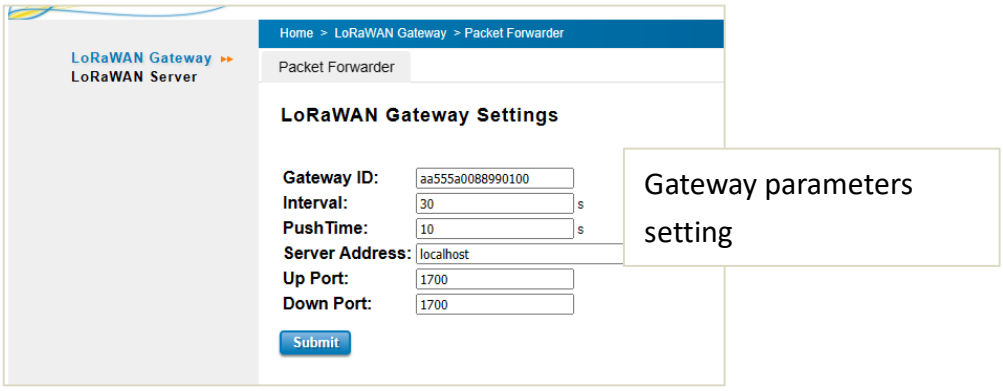
Establish a LoRaWan Network System.

The system embedded LoRaWan Gateway module when shipping. It has adopted suitable LoRaWan module that compliance your country region with properly frequency.

The Hyper-Link IP address and TCP service port number of Gateway & Network Server is **192.168.1.1:8088.** The Web UI show as following 2.1 “Gateway Parameters Setting”

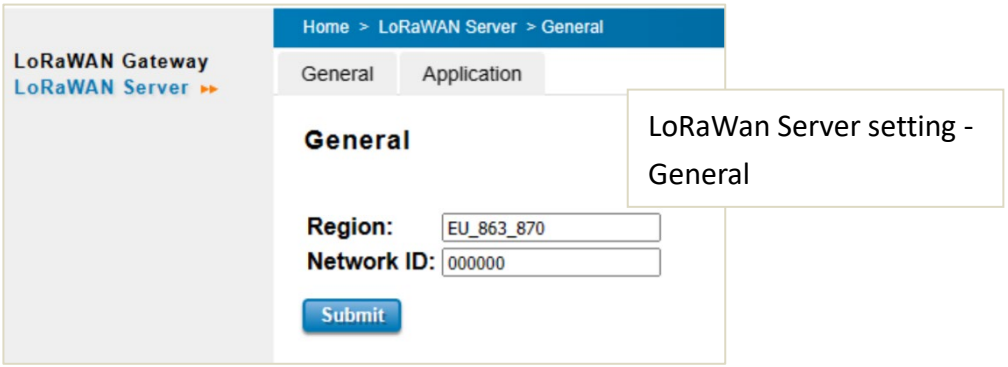
2.1 Gateway Setting

All of the parameters are default setting, any new configure should be saved into system by click the “Submit” button.



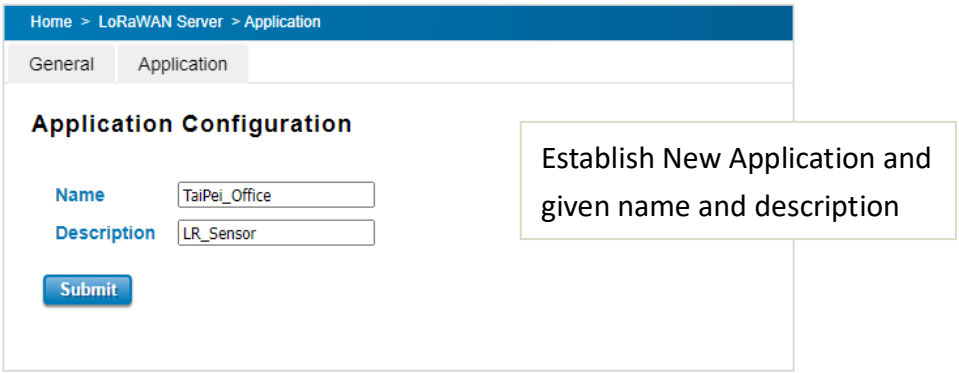
2.2 Server Setting - General

The following shows the LoRaWan Network Server Setting, it shows the current LoRaWan module compliance with LoRa Wan channel plan “EU863~870”, and the current Network I.D. is “0000000”. Users may need to change different Network I.D. for the LoRaWan signal distinguish to avoid communication congestion and collision when installing several LoRaWan Gateway Devices.



2.2.1 Server Setting – Add a new Application

After the Network Server is configured, the user needs to establish the application. The following show the application Name and Description for easy recognition.

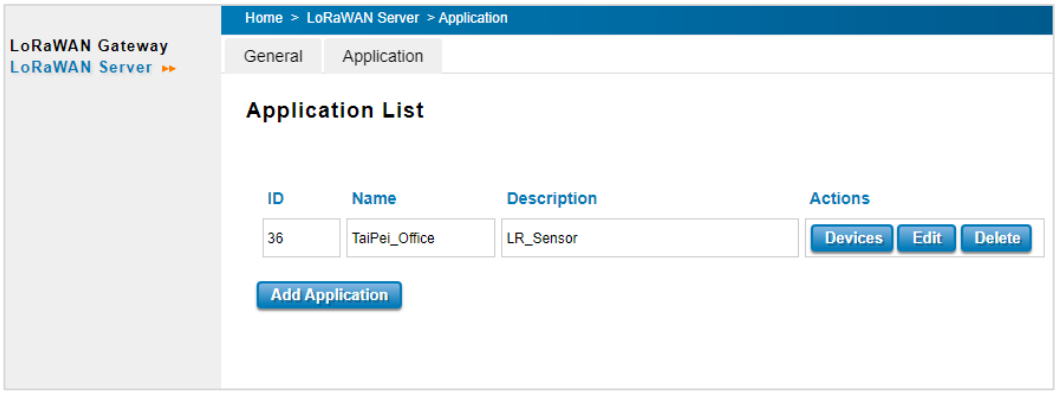


Name: the application name – TaiPei_Office

Description: detail information about this application which going to add. – LR_ Sensor

After configuring both of Name and Description, click the “Submit” icon to apply the new application.

The following show the application listing after submits new application.



Ther are 3 Action icons to edit each application rule for the LoRaWan End-Node device.

ID: random number system given for Application

Devices: Configure the Remote LoRaWan End-Node device parameters of current application.

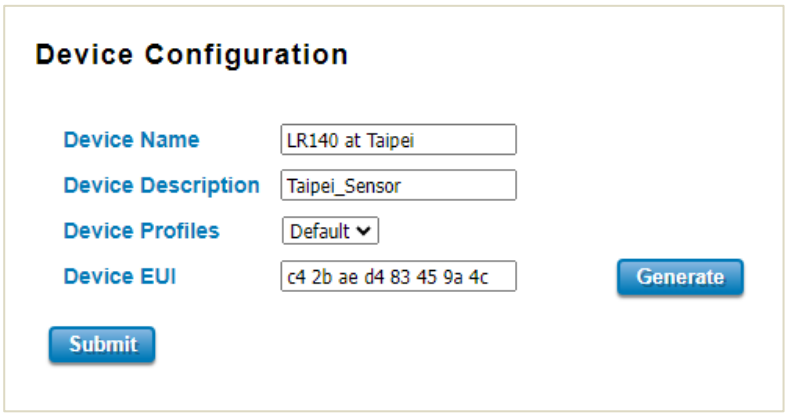
Edit: Edit Current configuration.

Delete: Delete current application.

Add Application: Add a new application.

2.2.2 Configure the LoRa End-Node Device of the Application

Once click the “Edit”icon, the Device Configuration UI will show as following:



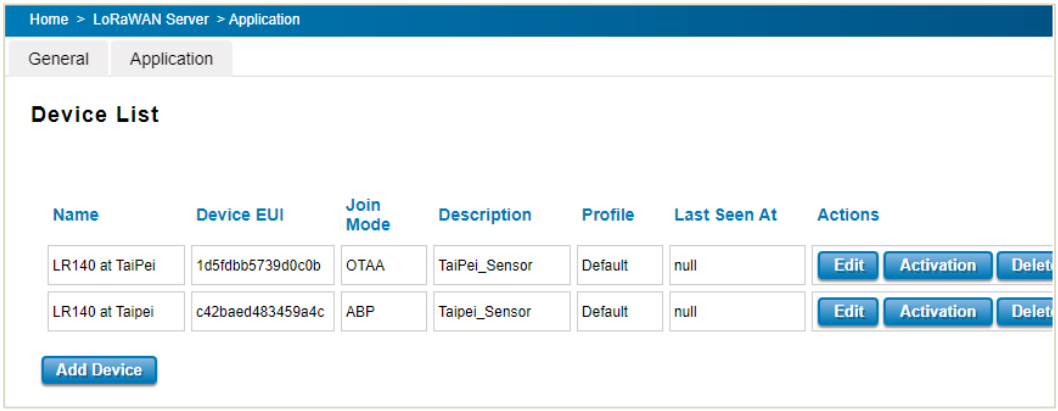
Device Name: the name of remote LoRaWan End-Node device. (LR140 at Taipei)

Device Description: detail information of the device. (Taipei_Sensor)

Device EUI: 64 bit unique identifier address for LoRaWan End-Node device. The Device EUI address will belong to the LoRaWan end-node device of the current application. It will apply to End-node device for network recognition. The Device EUI should be generate by LoRaWan Gateway/Router and copy to the end-node device for identify.

Click “ **Generate**” to generate a new Device EUI for End-node device joint network.

After click the “Submit”, the UI will be update and show the device list as following:



In the UI, it shows the configuration of each device. Also, 3 function icons for detail configure, user can modify the join-mode, description and show last time of seen on the LoRaWan network.

Join Mode: Activation of an end-device can be achieved in two ways, either via Over-The-Air Activation (**OTAA**) or via Activation by Personalization (**ABP**)

Device EUI (DevEUI): The Device EUI is a global end-device ID in IEEE EUI64 address space that uniquely identifies the end-device. DevEUI is the recommended unique device identifier by Network Server(s), whatever activation procedure is used, to identify a device roaming across networks.

For OTAA devices, the DevEUI MUST be stored in the end-device before the Join procedure is executed. ABP devices do not need the DevEUI to be stored in the device itself, but it is recommended to do so.

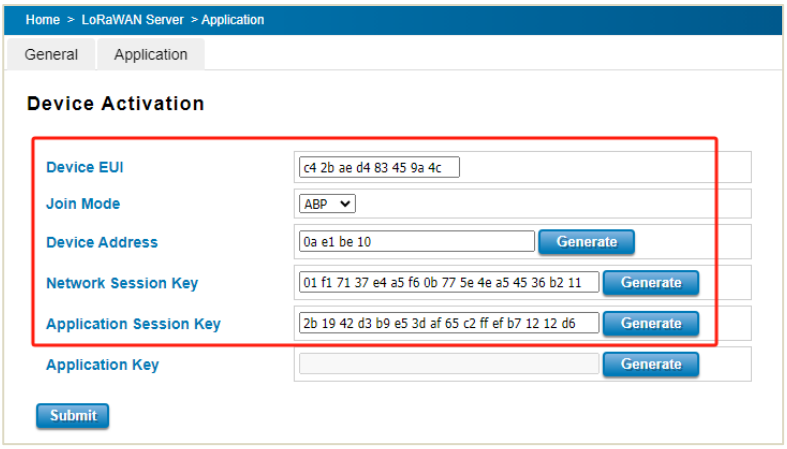
Click “**Activation”** icon of the Device list, the UI will get into Device Activation mode, and support 4 generate icons for **Device Address**, **Network Session Key** and **Application Session Key** for network joint and should be applied on the End-Node devices.

The Join Mode of LoRaWan Gateway Setting parameters:

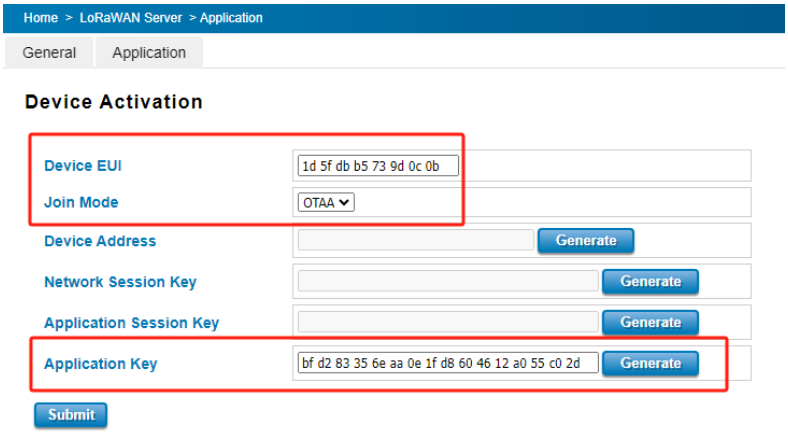
Join Mode	DeviceEUI	Device Address	NetworkSessionKey	APP_EUI	ApplicationSessionKey	APP_Key
ABP	-	Mandatory	Mandatory	-	Mandatory	-
OTAA	Mandatory	-	-		-	Mandatory

There two Join-Modes, ABP and OTAA. Both of Users Interfaces captured as following.

(1) **ABP Mode**: the **Device Address, NetworkSessionKey**, **Application Session Key** are mandatory. The Application key is not mandatory for end-node device when ABP join mode.



(2) **OTAA Mode**: In OTAA join mode, there are 2 parameters are mandatory, **Device EUI, Application Key** for end-node device join in OTAA mode.



2.2.3 Activate the LoRaWan End-Node Device – LR140/144

In a LoRaWn network, each end-device has to be personalized and activated.

Activation of an end-device can be achieved in two ways, either via **OTAA** (Over-The-Air Activation) or via **ABP** (Activation by Personalization).

It is recommend configure the LoRaWan Gateway and LoRaWan End node together. During the setting, some parameters need duplicate from Gateway and paste to LoRaWan End node setting.

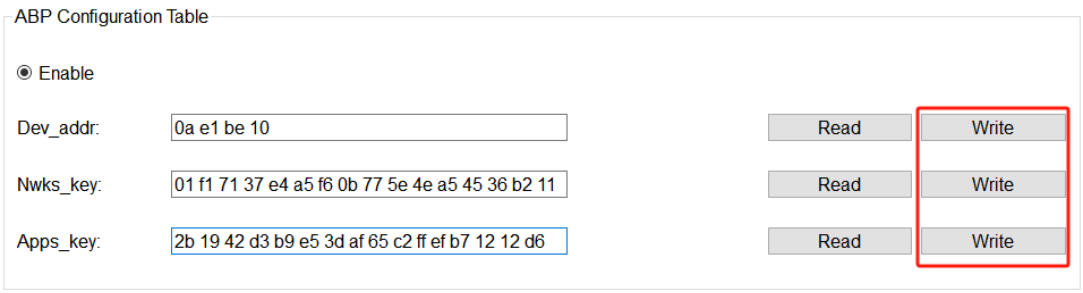
Join Mode	DeviceEUI	Device Address	NetworkSessionKey	APP_EUI	ApplicationSessionKey	APP_Key
ABP	-	Mandatory	Mandatory	-	Mandatory	-
OTAA	Mandatory	-	-		-	Mandatory

End-Node Device (LR140/144) Join LoRaWan Gateway in ABP Mode

The following shows the configure user interface of LR140/144 in ABP mode:

Duplicate the **DeviceAddress**, **NetworkSessionkey** and **Application Session Key**, and then paste to the configure user interface of end-node device.

The following diagram, the end-node device is joined to LoRaWan Network in ABP mode.

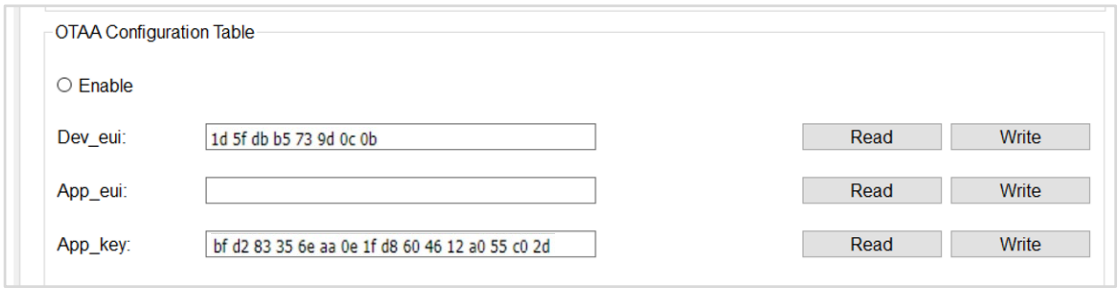


End-Node Device (LR140/144) Join in OTAA Mode

The following diagram, the end-node device is joined to LoRaWan Network in OTAA mode.

Join Mode	DeviceEUI	Device Address	NetworkSessionKey	APP_EUI	ApplicationSessionKey	APP_Key
ABP	-	Mandatory	Mandatory	-	Mandatory	-
OTAA	Mandatory	-	-		-	Mandatory

Duplicated the **Device EUI (Dev_eui)** and **Application Key (App_key)** from the User Interface of WR322EC-LoRa and paste to the configure user interface of end-node device, then click “Write” to programming new update information into End-node system.



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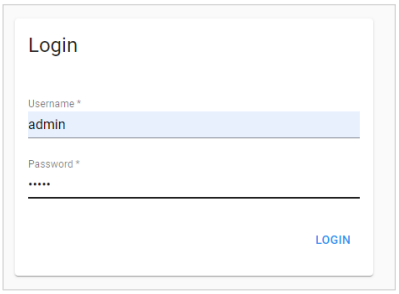
1. ChripStack Network Server Check

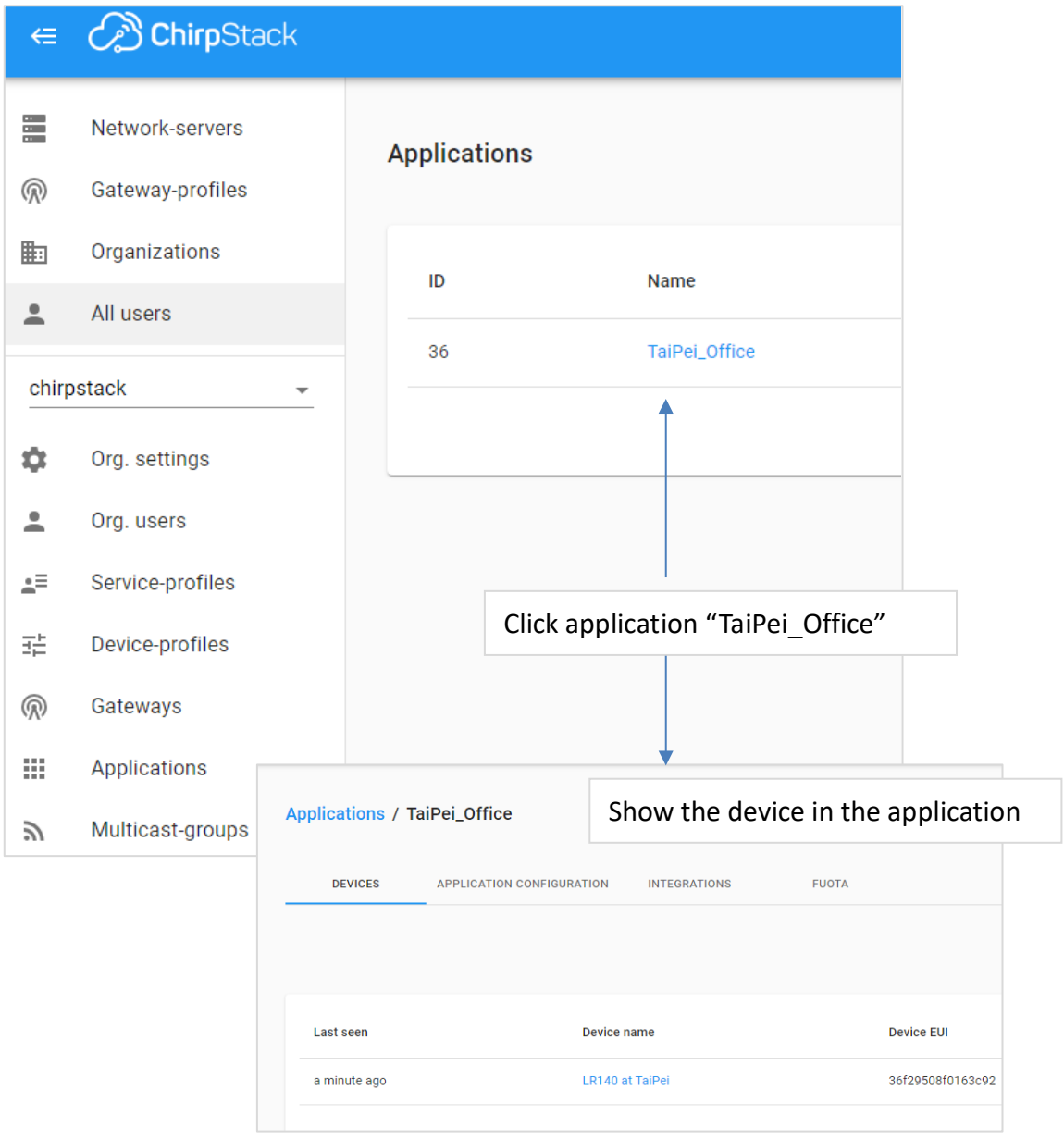
(Suggest operating by software engineer for debug)

The WR322EC-LoRa Gateway embedded network server- ChripStack, user can browsing the default Ip address with 8080 service port to login ChripStack server for LoRaWan Network connection debugging.

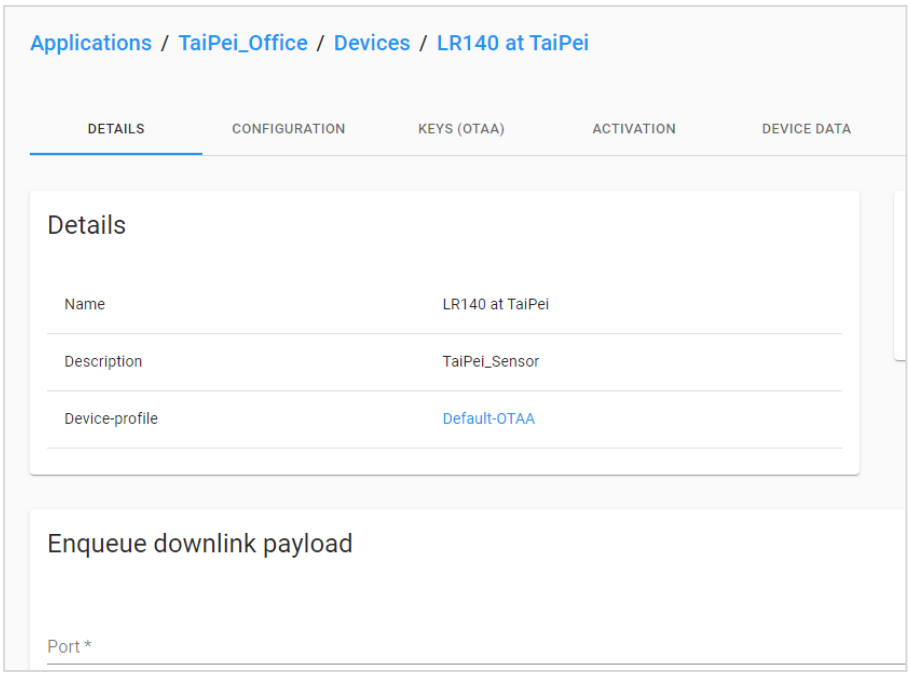


Login IP: 192.168.1.1:8080
User Name: admin
Password: admin

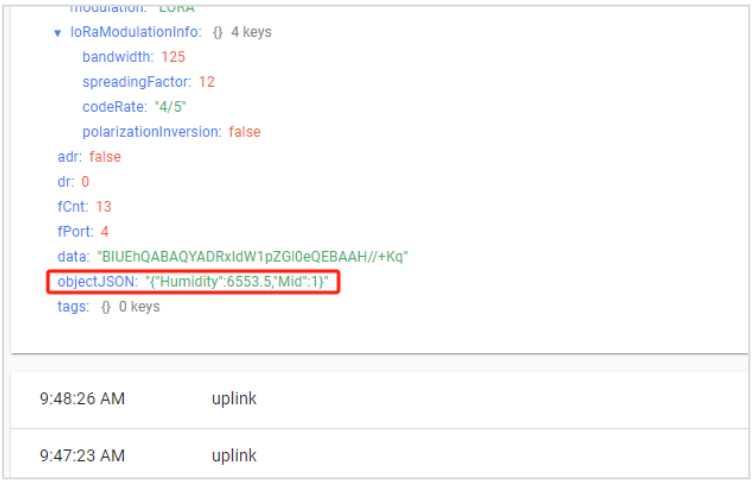
Click the “Application “icon on the left menu to show the application list, and click application Name, it will show all device under the application “TaiPei_Office”



Choose a device set in the http://192.168.1.1:8080/index.asp,here click device name“LR140 at TaiPei” .it will display all device under”TaiPei_Office” application.



Choose top menu bar “Device Data”, wait a moment, it will show a newest message.it will show a humidity value :65535,it represents humidity value is null and mid value is 1 means rtu id is 1.



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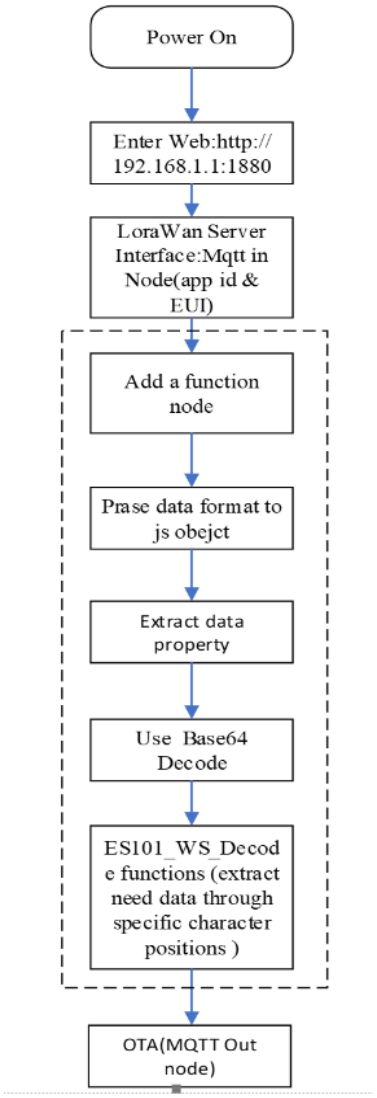
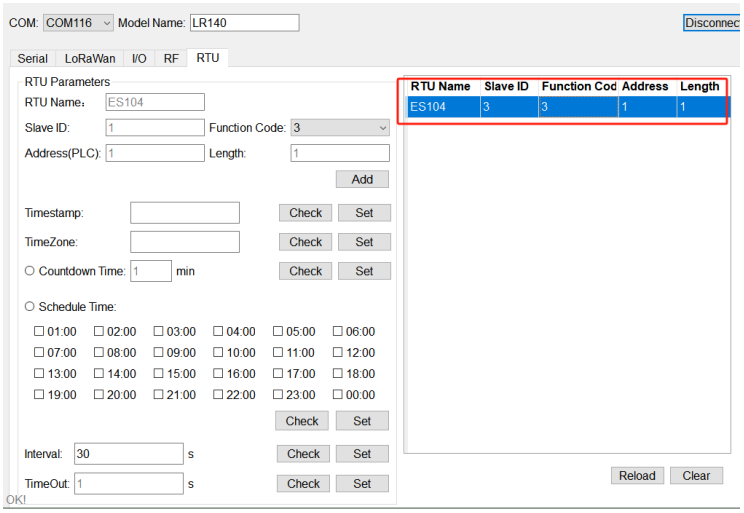
2.Node-Red server (data edge computer and ota)

After finish ChripStack setting, then you need enable Node-Red server for edge computing and perform more logical process. The default IP address of Node-Red: **192.168.1.1:1880** without Login name and password.

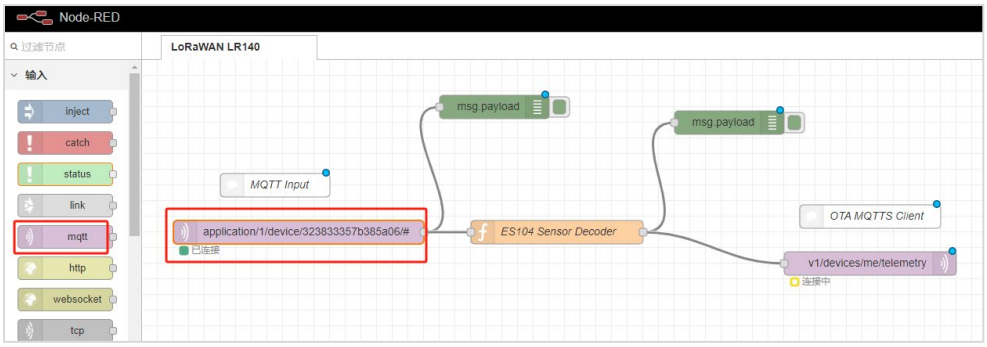
This chapter will explain the Node-Red with LoRa End-node device LR140/144 and environment sensor – ES104 for demonstration.



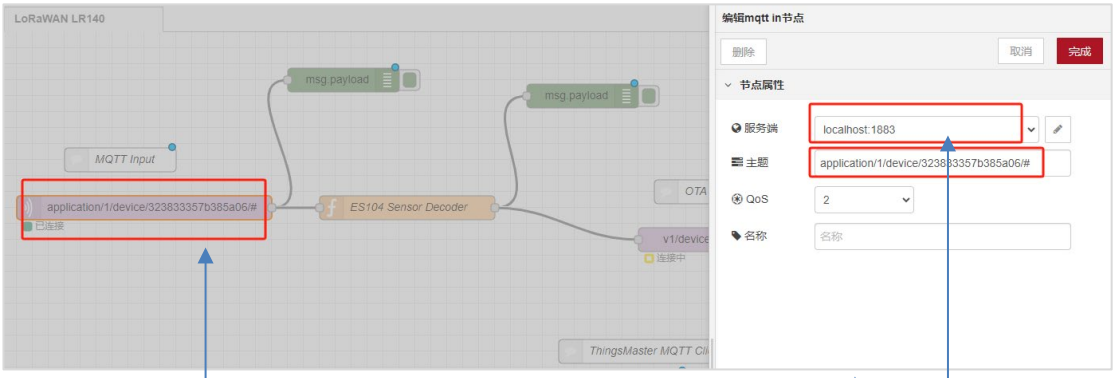
Step1: Using Lora Utility setting ES104 device RTU reading humidity, set RTU slave ID=3, function code=3, register address =1, register length =1. (Ex: the LR140 integrated with a T/H sensor)



Step 2: Browser:http://192.168.1.1:1880,enter LoraWan edge computer and data ota configuration page. It embedded a default data OTA example.

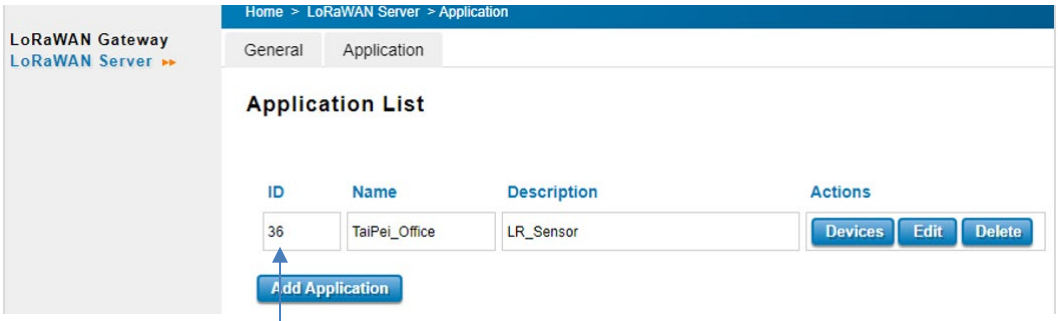


Step 3: the Node-Red application Server offer a local mqtt input interface, click the icon “application/1/device/323833357b385a06/#”to pull choice the local host 1883, and modify the Topic, the format as:“application/xx(application id)/device/xxxxxxxxxxxxx(device eui)/#. The Application-id and device-eui should be same as the setting – 2.2.1 Server Setting –Application id and 2.2.1 Device list – Device EUI. The following captured show the configuration.



double click the "application icon" then system will pop up modify dialog

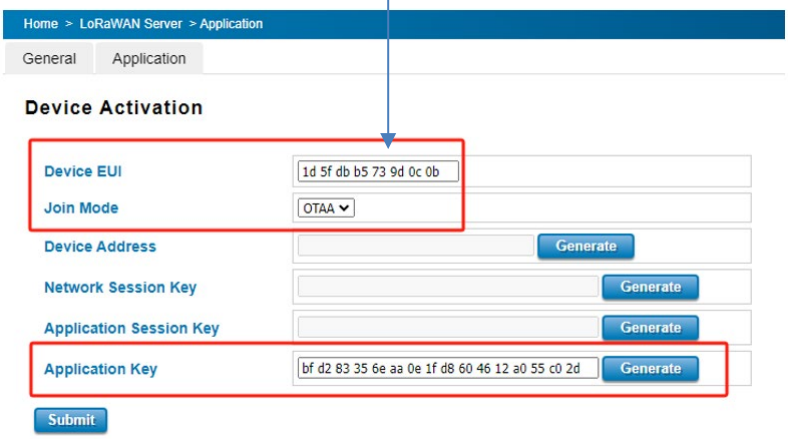
Localhost:1883



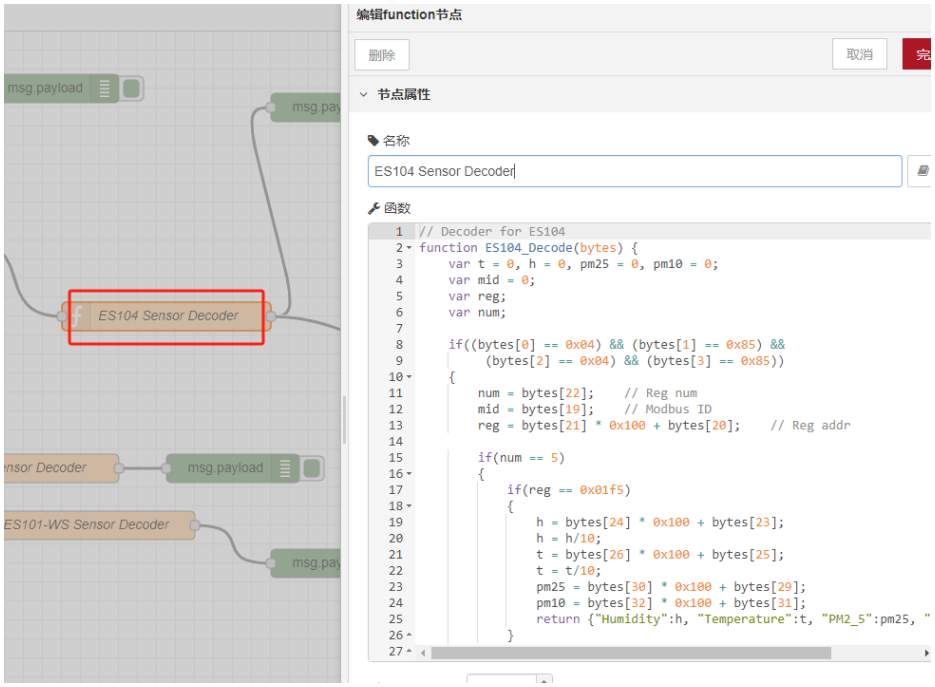
Application ID

Topic: "application/36/device/1d5fdbb5739d0c0b/#"

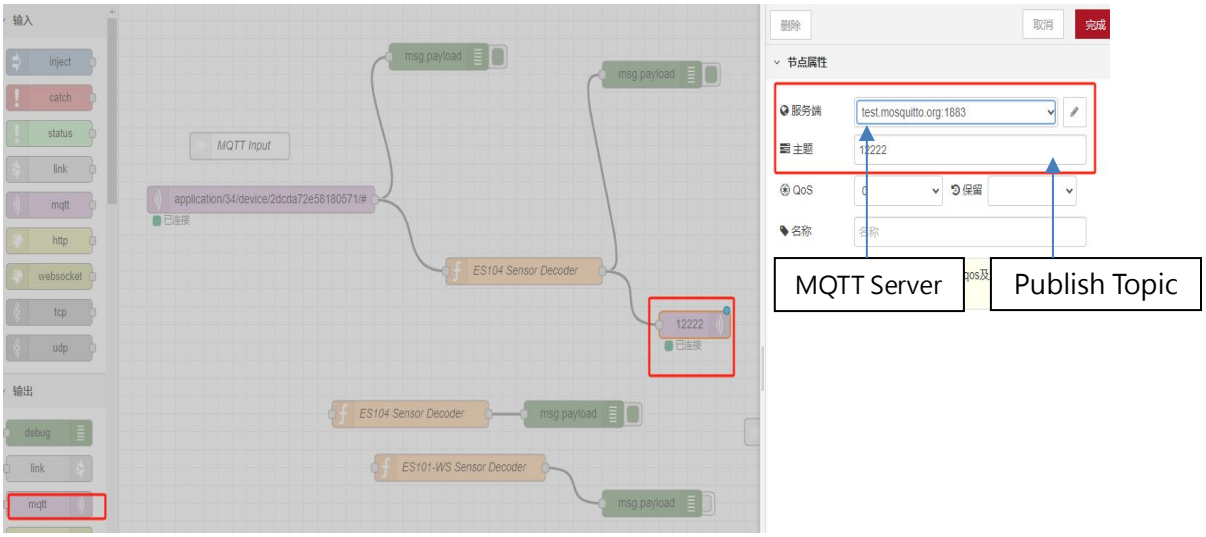
Device EUI



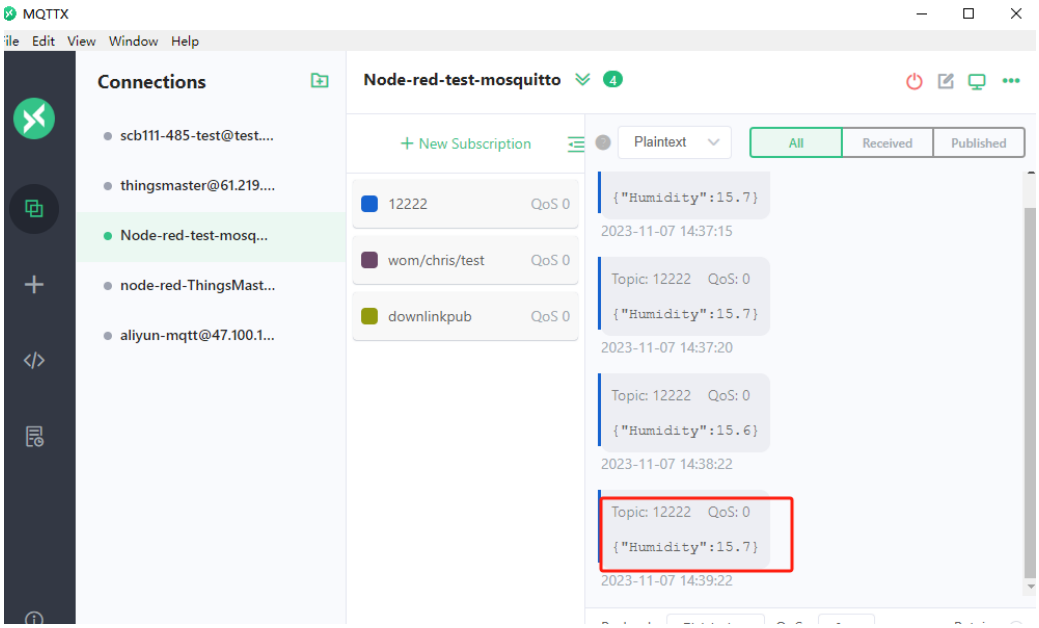
Step 4: after setting mqtt in node, the data enter ‘ES104 Sensor Decoder’ node prased,the purpose of this function node is to decode and output the values of the RTU register set on the Utility in JSON format. Double click the “ES104 Sensor Decoder”, then pop-up dialog for modify the naming, and also explore the data in JSON format.



Step 5: After parsing, the data will send OTA platform, in this case, add a mqtt out node , type-in mqtt server address and topic of publish.

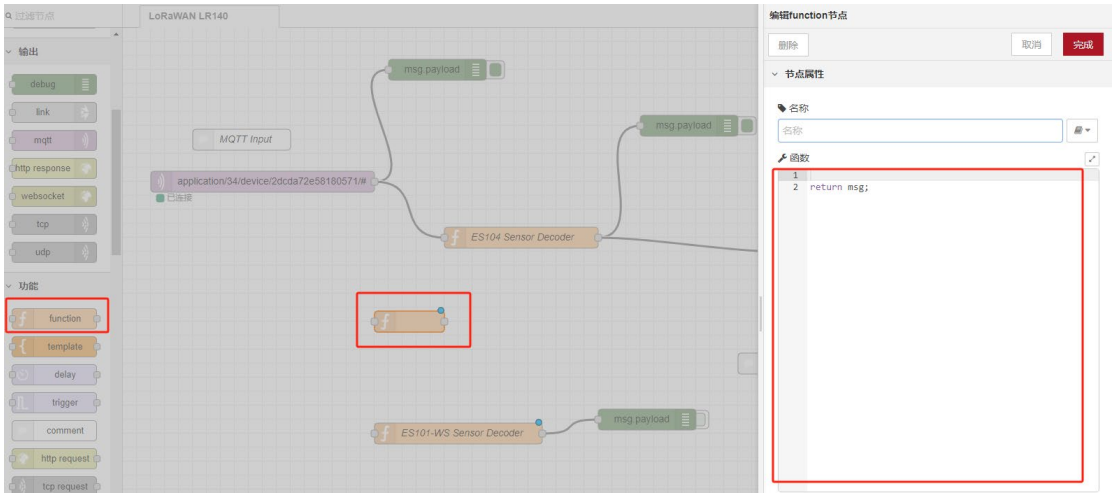


Open mqtt.x client, add a mqtt subscribe , the mqtt server and topic correspond with node-red mqtt out node. (Establish MQTTx connection for client)
the following shows the LoRa End-Node device polling data and send to WR322-LoRaWan and publish to MQTTx server in JSON format.



How to create a new function node?

If user need add a new series of function node which contains edge computer and prase LoraWan data,user can add a function node from left bar menu, following picture shows.



For example, user end-node device connects a ES101 which is a wind speed sensor, the function node script copied from external text which offered by Womaster.

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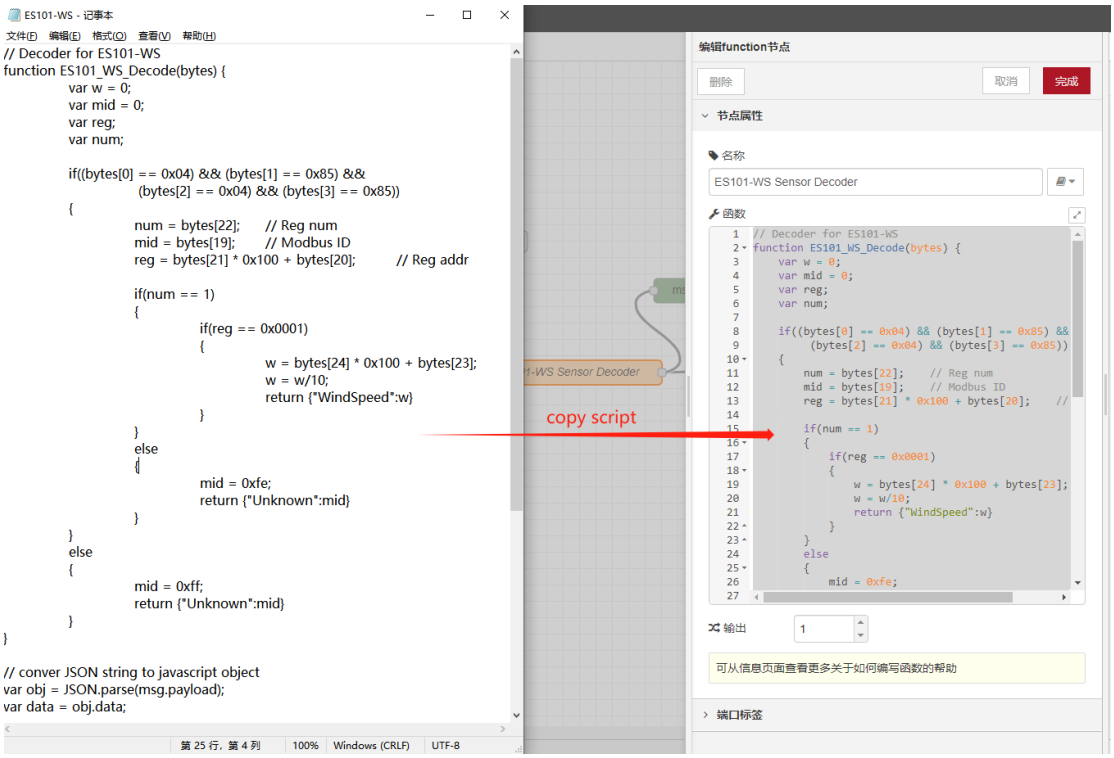
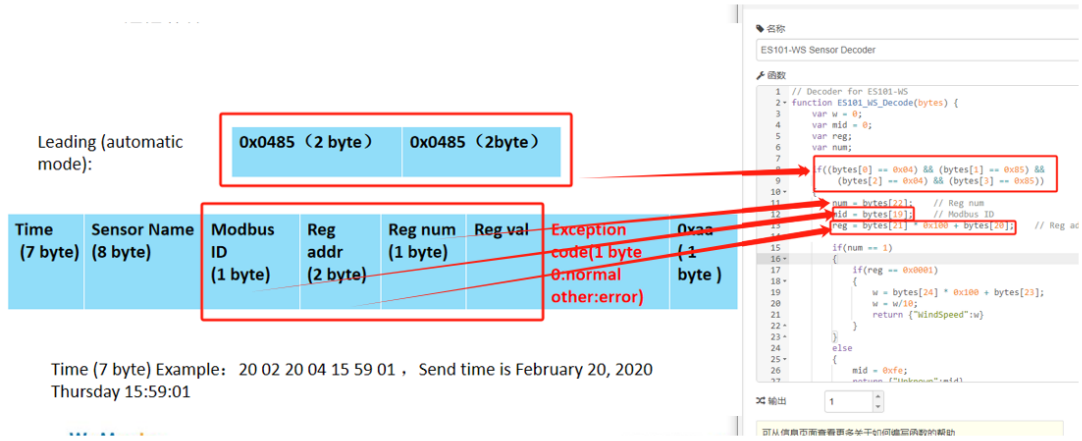


In this script, there are several main steps:

1. Parse the received JSON string into a JavaScript object,
2. Assign the result to obj,
3. Extract the attribute value named data from the obj object.
4. Decode the data string into binary data using Base64, and assign the result to buf.
5. Use a custom function to extract the data in buf through specific character positions.
6. Assign the decoded value to msg,Payload and return value.

It's most important above step is 5 which is custom function, in this function,womaster use a fixed format to tansfer Modbus RTU data.the follow pictures shows.



Each uplink message includes the following formats: **a leading character of 4 bytes 0x485, 0x485, a time of 7 bytes (Example: 0x231108105601, means: November 8, 2023 , 10:56:01), a Modbus ID of 1 byte, a Modbus register addr of 2 bytes, a register number of 1 byte, a register value (the length dependency on reading register number), an Exception code of 1 byte (1 byte 0: normal other: error), 1 byte terminator (0xaa).**

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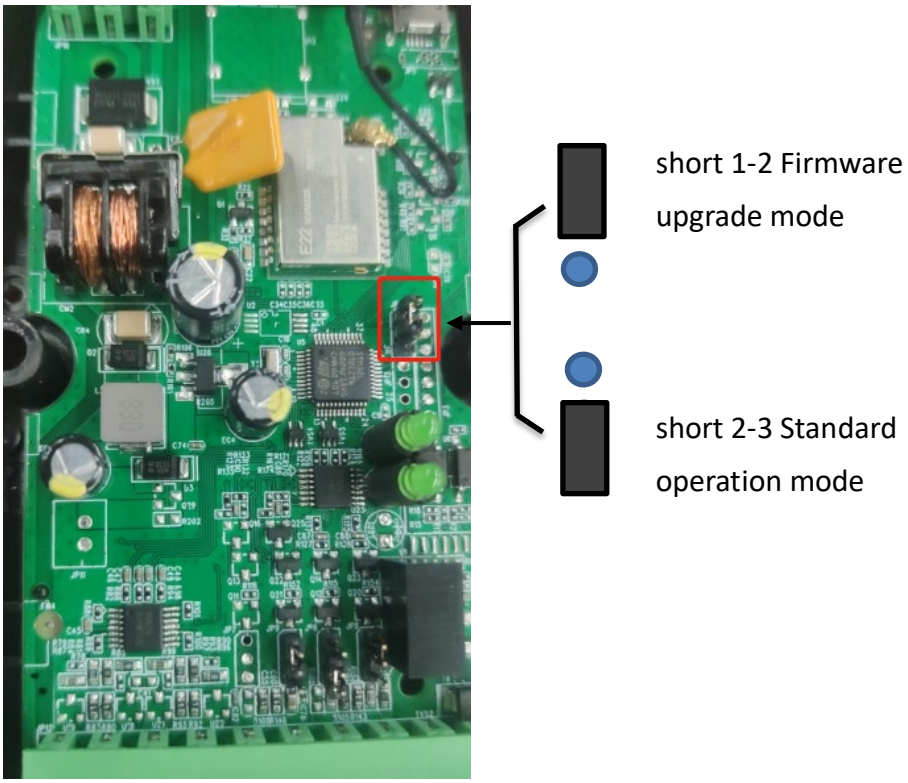
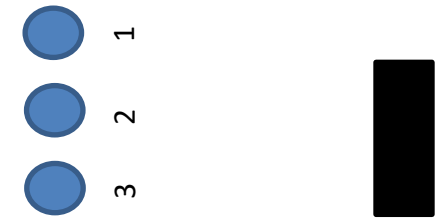
7. System Firmware Upgrade

The device supports the firmware upgrade function. The default setting is 2-3 short for normal operation, and short 1-2 pin will get into firmware upgrade mode. Programming new firmware via the USB and STM32 software tool which performs by Windows.

When the device operates in different modes, the jumper cap position is set as shown in the figure below.



Pin numbers of row pins are shown in the figure below:



Pin Header

Jumper cap

The firmware programming tool is downloaded from the hyperlink - https://www.st.com/en/development-tools/stm32cubeprog.html

All of the copyrights belong to ST Semiconductor. It needs to perform online registration.

Select the software version which depends on your programming platform.

The following procedure based on Windows 64 bits O.S.

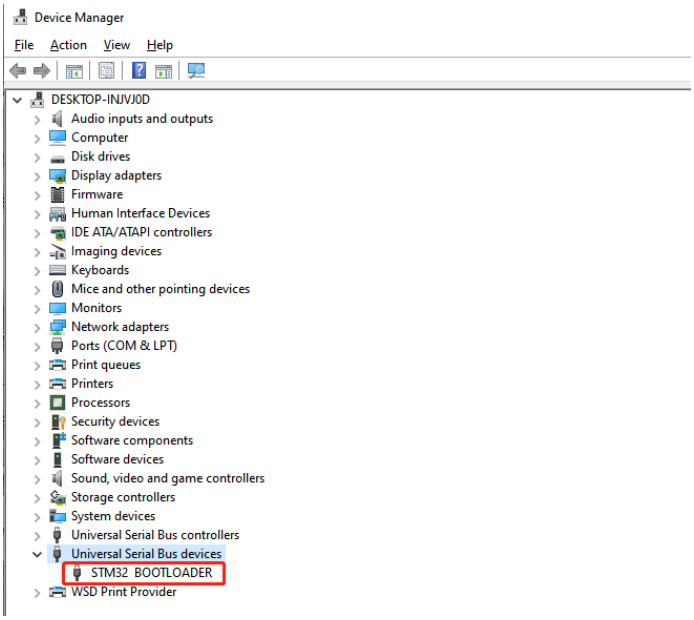
Get Software

	Part Number	Download	Previous versions
+	STM32CubePrg-Lin	Get Software	Select version
+	STM32CubePrg-Mac	Get Software	Select version
+	STM32CubePrg-W32	Get Software	Select version
+	STM32CubePrg-W64	Get Software	Select version

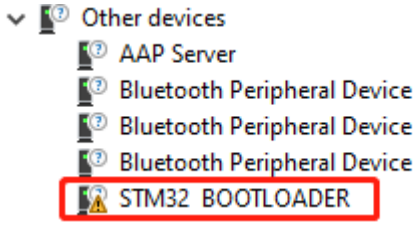
7.1 Update STM32

After the software installation is completed, it is necessary to confirm whether the STM32 driver is available before upgrading.

Disconnect the power supply of device and change the position of the jumper cap to upgrade mode. Connect your device to your PC using USB. Open the PC Device Manager and “STM32 BOOTLOADER” will be displayed in the Universal Serial Bus devices subdirectory. The installation success status is shown in the following figure.



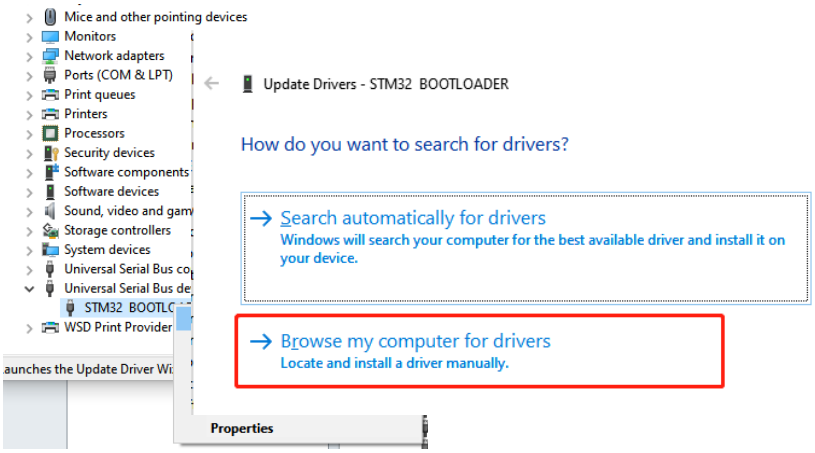
If the drive is shown as follows: A yellow exclamation mark appears, the drive is not installed properly. You need to reinstall the driver at this time.

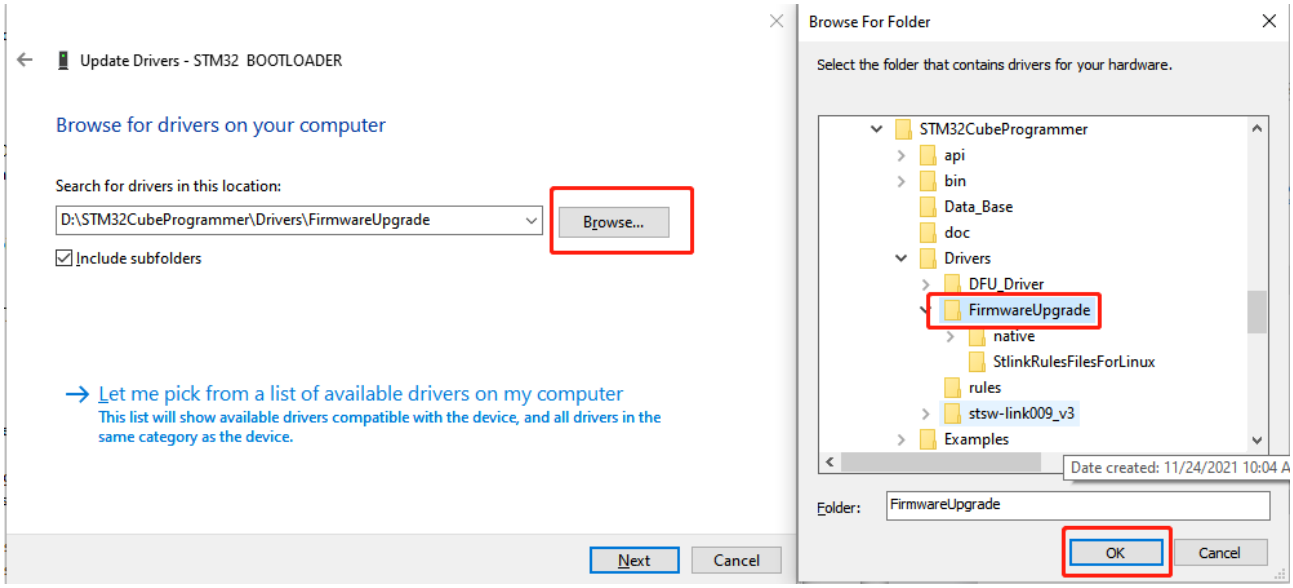


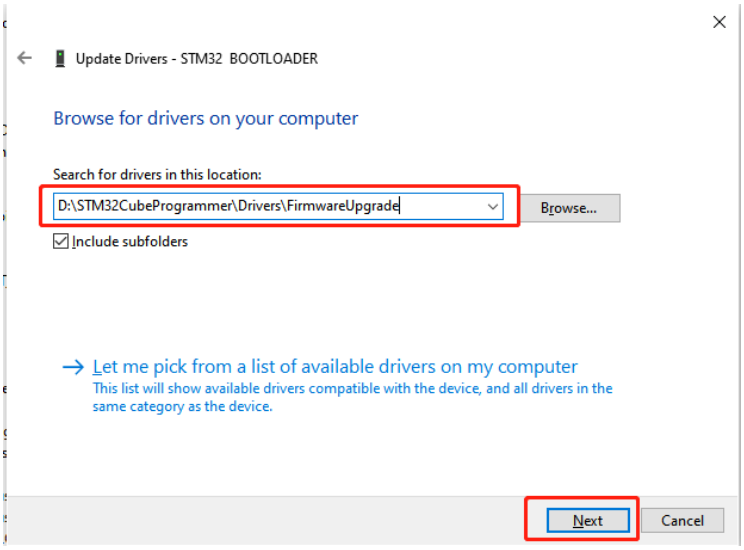
Update driver steps:

Right-click ”STM BOOTLOADER”=>Update driver=>Browse my computer for drivers=> Browse=> STM32CubeProgrammer\ Drivers\ FirmwareUpgrade=> OK=> Next

After completing the above steps, the yellow exclamation mark on the drive disappears, indicating that the drive has been successfully installed.

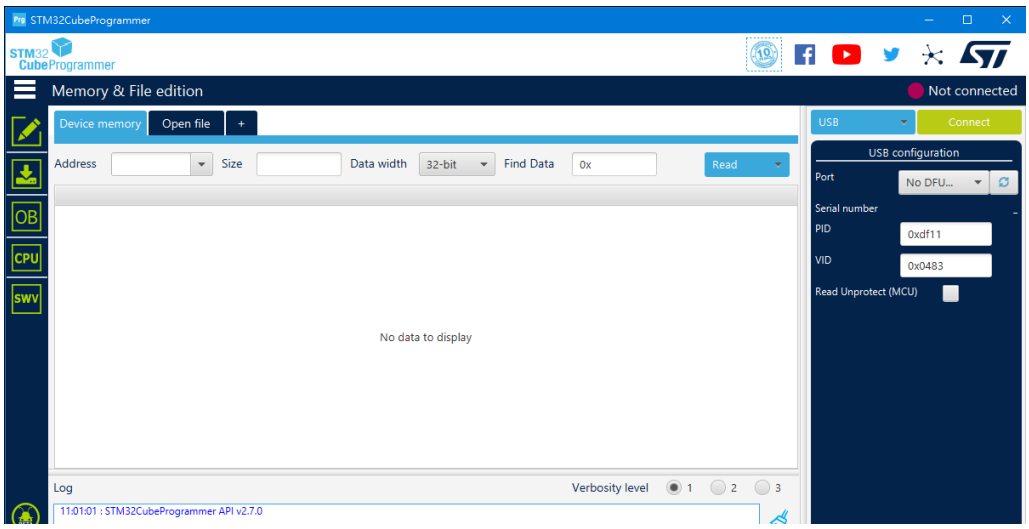




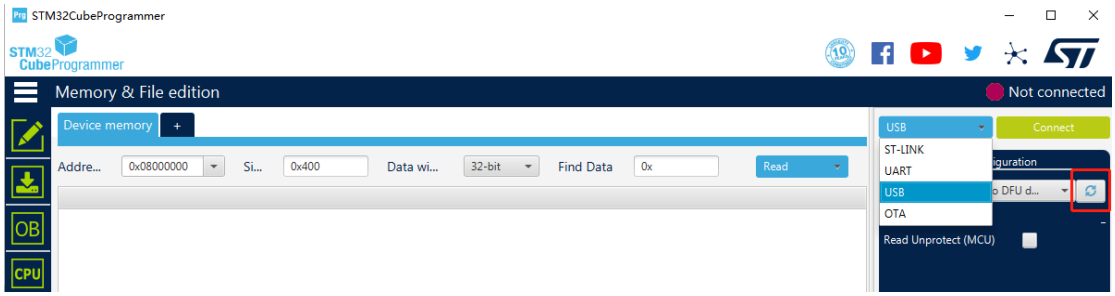

Update Drivers - STM32 BOOTLOADER
Browse for drivers on your computer
Search for drivers in this location:
D:\STM32CubeProgrammer\Drivers\FirmwareUpgrade
Browse...
Include subfolders
Let me pick from a list of available drivers on my computer
This list will show available drivers compatible with the device, and all drivers in the same category as the device.
Next
Cancel

7.2 Start STM32 Cube Programmer

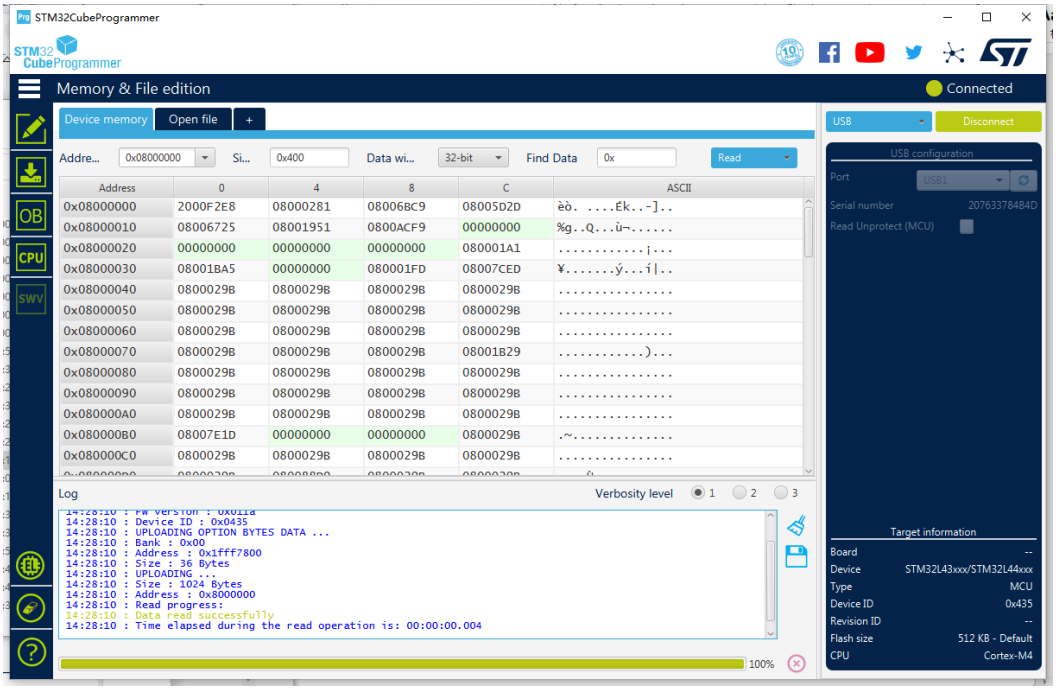
Step-1. Run the software “STM32 Cube Programmer”, the User Interface is like as below:



Step-2. Select the Interface –USB, and refresh the Port located at USB Configuration, then it will show the “USB X(Port)”.

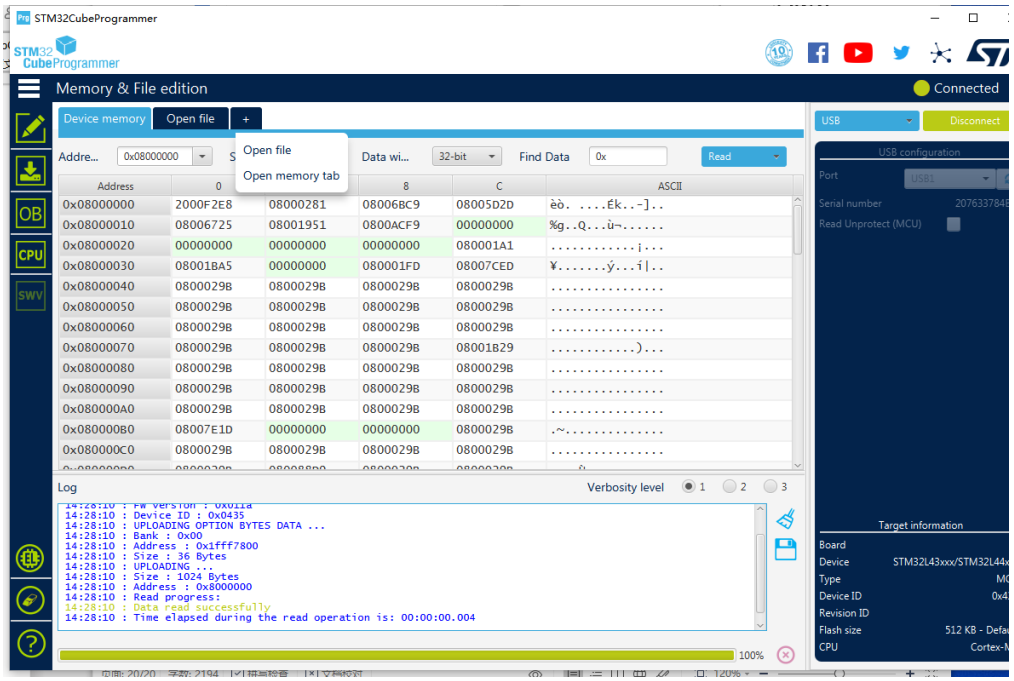


Click the “Connect”, then the tool will download the current HEX from the system. The UI will like as below:

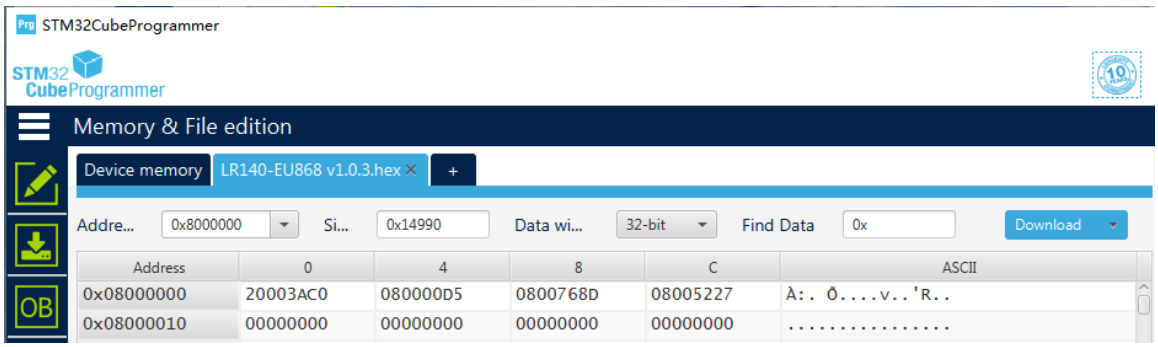


Now, the programming tool is successfully connected to the system.

Step-3: Download new firmware for the programmer. Click “Open file” and select target firmware – LR/LC/LM xxx. hex.

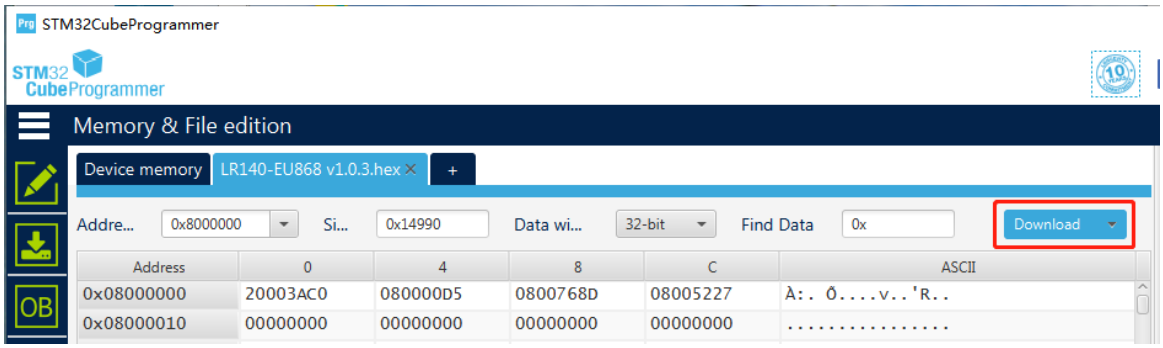


Once select target new firmware, the programmer will read and create a new TAB “LR140-EU868 xxx. hex”.



Step-4: Start Programming into the system

Click the “Download” icon to start programming into the system. After completed programming, it will pop up dialogue to remind process done.



Step-5 Finish Firmware Upgrade process

Disconnect the power supply, close the programming tool, and change the jumper to 2-3 short. Then power on the system and use the "LoRa Utility" to check the firmware version.

Click the Tools –Setting, and perform a version Check.

It shows the version you upgraded. Congratulations, the firmware upgrade was successful. Don’t forget to check the setting again, ensure the setting is not changed due to the firmware upgrade.

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Release Note

Release Note - LM100 / LC100/ LR100 User's Manual			
Version	Description	By	Date
V2.0.0	Modify from LC/LM/ LR140/LR144 User manual Apply to New LoRaWan Utility for LR140/LR144 only Updated: 1. Erase LM/LC product information. 2. Integrate LR144/LR140 Hardware description, specification 3. Utility UI new update 4. LoRaWan Data Payload WR322 join with LR140/LR144		
V2.0.1	LoRaWan change to LoRa Wan Update UI diagram – New Utility		2024/04/30
V2.0.2	More description about the Holding Output function		2024/6/6
V2.0.3	Update LoRaWan regular RTU entry Upload payload format. Chapter 5.1		2024/8/15