UM01811

RHF2S208 User Manual

V1.1

Document information

Info	Content
Keywords	*RisingHF, LoRa Gateway, Instruction, web-based utility*
Abstract	This document describes how to use RHF2S208, which includes content about configuration, development and so on.

Content

1 Preface

RHF2S208 is an IoT gateway/concentrator which integrates POE, LTE/4G/3G, GPS, WiFi and LoRa, designed and manufactured by RisingHF.

This document will describe how to use and configure RHF2S208, for end-user and developer usage. Covers:

- Quick start
  - Get to know about your gateway
  - Setup your gateway
  - Log into your gateway
  - Connecct a LoRaWAN server
- The device file system
- Detailed descriptions of the web-based utility of the gateway
- How to connect to LoRaWAN server?
  - General Packet Forwarder server
  - Loriot LoRaWAN server
  - TTN LoRaWAN server
  - Aisenz Loraflow server
  - LoRa server
- How to do scanning to check the noise floor before installation
- How to select a network for backhaul
  - LTE 4G
  - Wired 10/100m ethernet
- How to use the GPS information
- How to get remote support from risinghf with rssh service
- FAQs

2 Quick Start

This chapter introduces apperance of the gateway and show how to setup your gateway and connect it to a cloud LoRaWAN server.

2.1 Get to know about your gateway

RisingHF RHF2S208 LoRaWAN gateway integrates a high performance high reliabitliy ARM cortex A53, 1 or 2xSX1301 LoRa core processor, a 4G LTE module, a GPS module, a WiFi module, temperature monitor, RTC, and power management unit. The RHF2S208Bxx series would have a internal battery for backup which could support over 5 hr duration without external power. Rather than logging into the gateway and doing operation with command in the linux environment, a web-based utility is built in which help customer use the device much easier.

There are 4 antenna ports, a external power input port, a RJ45 port, and a USB debug port for the device.

ANT1 ANT3 ANT4 ANT5 :

The RHF2S208 gateway have 4 antenna ports. ANT1 is for LoRa antenna (ANT2 is not used at this moment). ANT3 is for GPS antenna. ANT4 is for WiFi Antenna. ANT5 is for LTE Antenna.

Power: External power supply input port, DC12 to 28V.

RJ45: RJ45 port, ethernet and PoE power injector.

USB: USB port for debug.

Figure 2-1 Apperance of RHF2S208

2.2 Set up your gateway

Please set up your gateway like Figure 2-2 shown below.

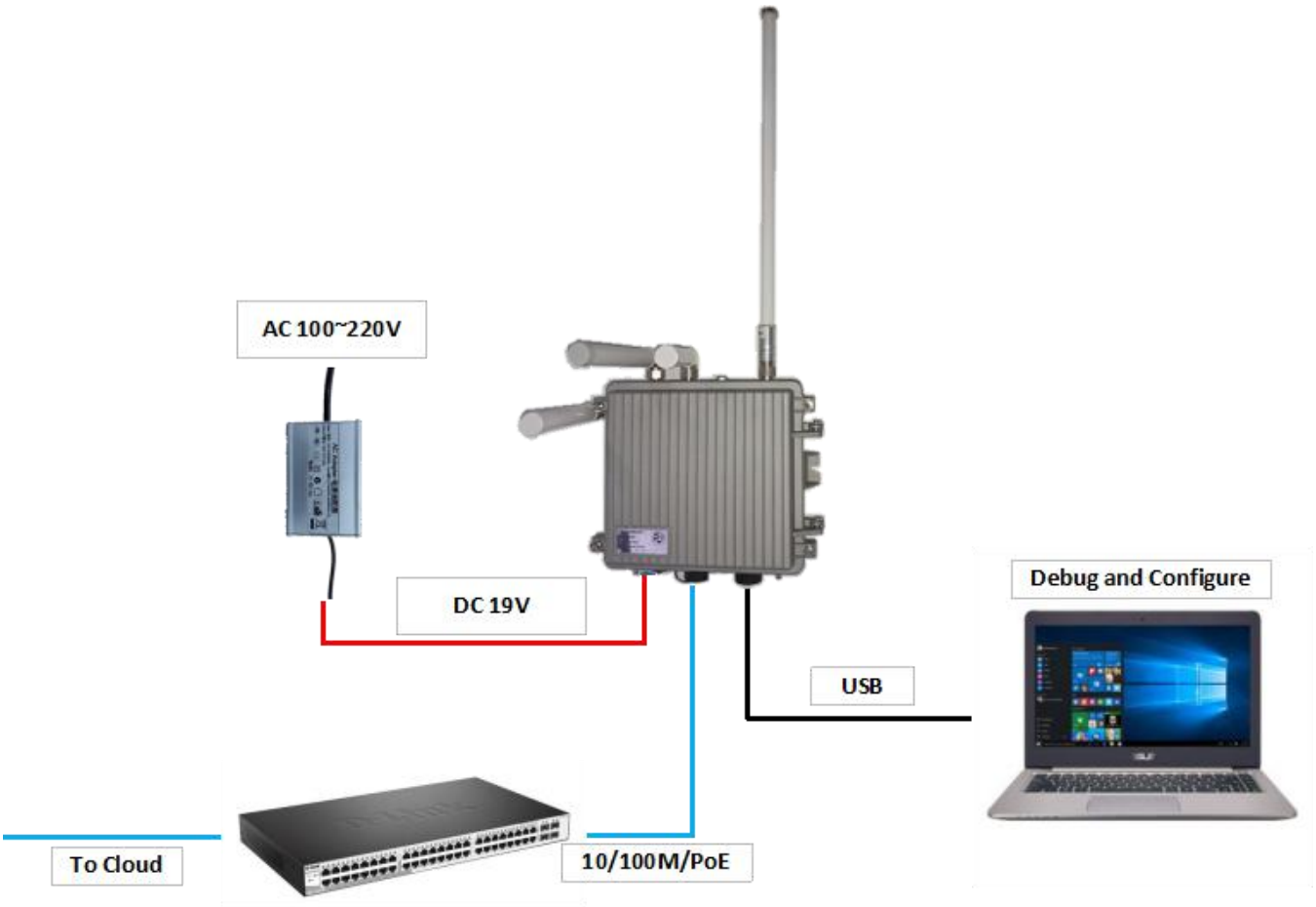


Figure 2-2 Set up your gateway

2.2.1 Power supply

RHF2S208 could be powered by both AC/DC adapter and PoE injector. An high reliability industrial IP67 AC to DC adapter is configured for each gateway when it comes out from the factory. Specially, a 3.2Ah LiFePo4 battery is integrated for RHF2S208Bxx. All the source could be injected into the gateway, which could be switched automatically based on the logic the AC/DC adapter > PoE injector > battery.

2.2.2 Networking

RHF2S208 support serveral kinds of way for networking backhaul. Please uncover the enclosure and install the sim card if you want to use the cellular network. Or a cable is needed to be connected to a router to use the 10/100m ethernet. And you can set the priority of the two selection on the web-based utility.

2.2.3 Debug and Configure

Several debug interface could be used:

1) Connect the gateway to your PC with USB to UART interface
2) DHCP in a LAN
3) Wireless access via WiFi

Please use **ExtraPutty** to access into your gateway and debug and configure it.

2.3 Log into your gateway

You can log into your gateway with UART, DHCP or WiFi.
Default account information :

```
User:       rxhf
Password:   risinghf
```

2.3.1 Login with COM port

Before connecting your gateway to the PC, please install FTDI USB to UART driver. Connect your gateway to PC with a type A female to type A female USB cable and you will find a COM port. Open the Etraputty and select “Serial” connection type with COM3 port for example and baudrate=115200.

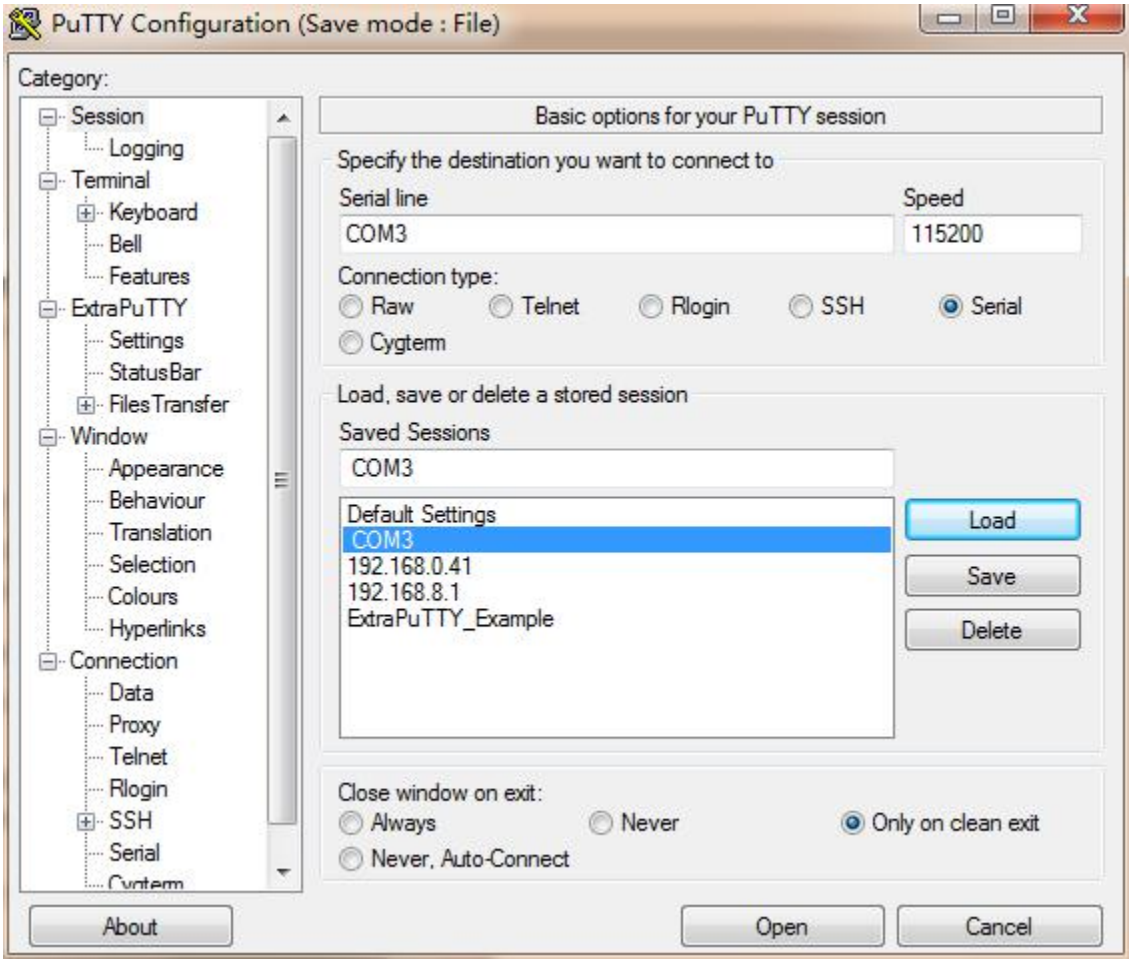


Figure 2-3 Login with COM port

Then input user name “rxhf” and password “risinghf” to log into the system.

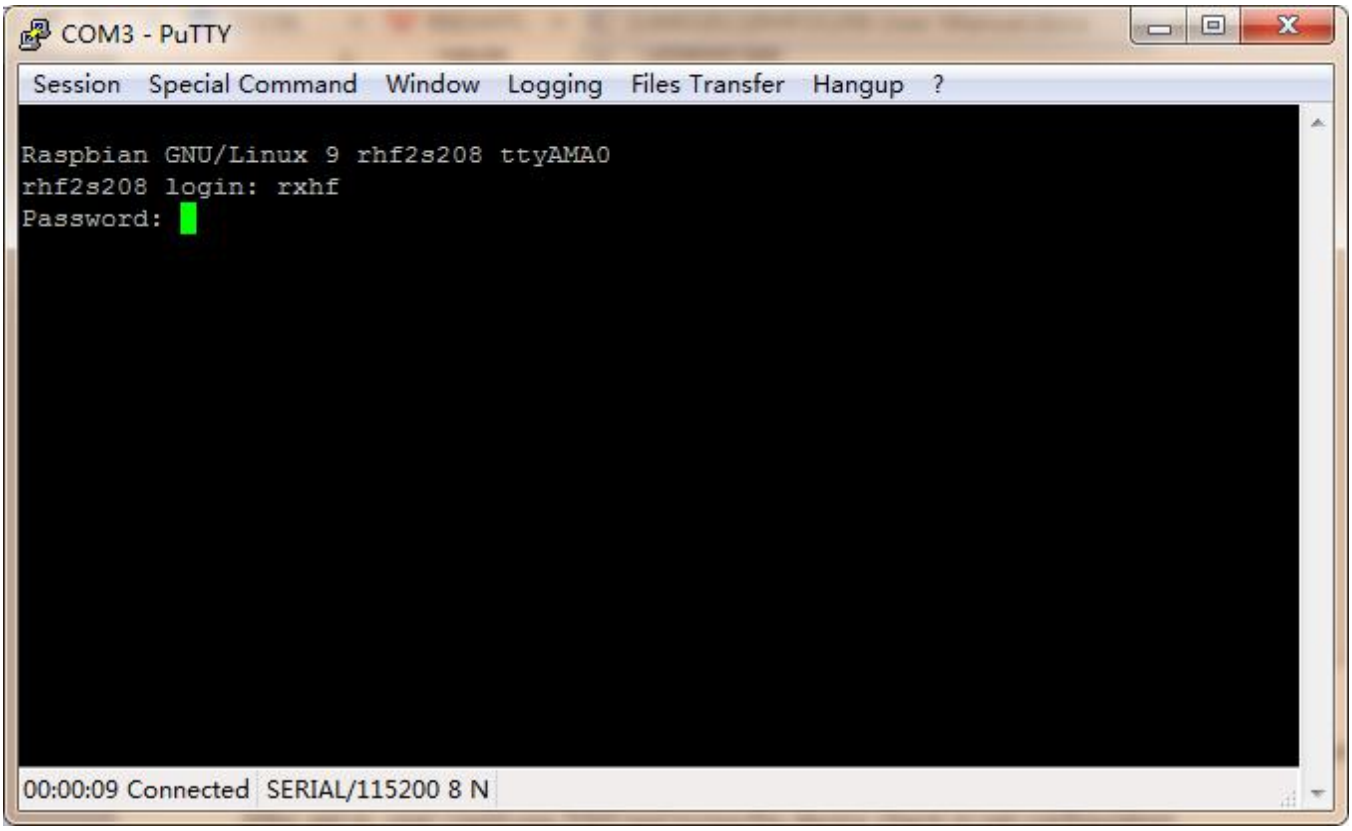


Figure 2-4 Login with user name and password

2.3.2 Login with DHCP

Connect your gateway with DHCP router, log in router or scan IP to get RHF2S208 ip. Hostname of your gateway is "RHF2S208".
After get ip, user could use SSH tool to log the device check or set configuration.
For example, use PuTTY under Windows and use ssh command under Linux. SSH port is 22.

To log in device of whose ip is 192.168.0.182.
Windows:

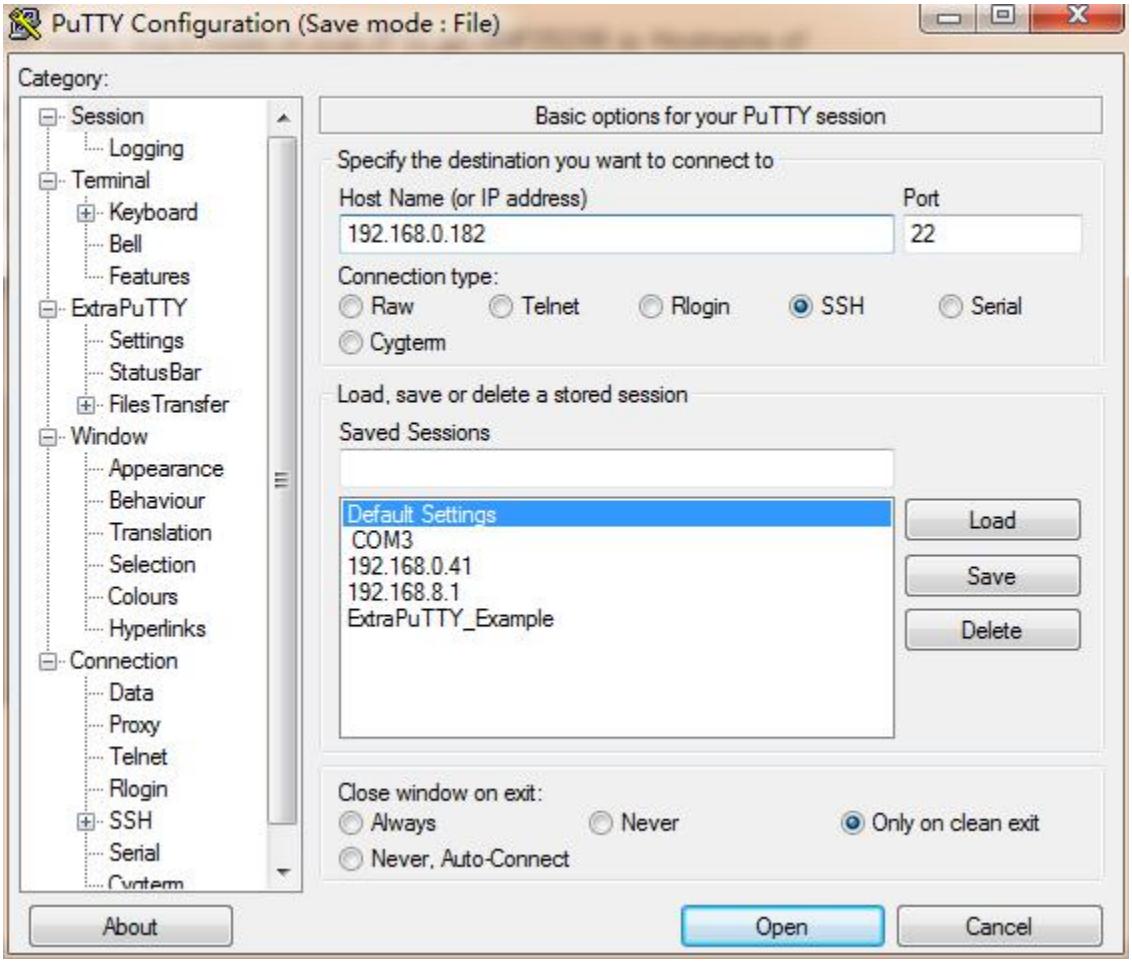


Figure 2-5 Login with DHCP

Linux

```
ssh rxhf@192.168.0.182
```

2.3.3 Login with WiFi

Scan the WiFi SSID with your PC and you will find your gateway whose SSID is RHF2S208_xxxxxx end with the last 3 bytes of the MAC address of the gateway. Connect your gateway to this WiFi. The default ip of the WiFi gateway is 192.168.8.1. Use putty to access into your device after your PC connected to WiFi successfully with ip 192.168.8.1 and ssh por 22.

Figure 2-6 SCAN and find the WiFi SSID of your gateway

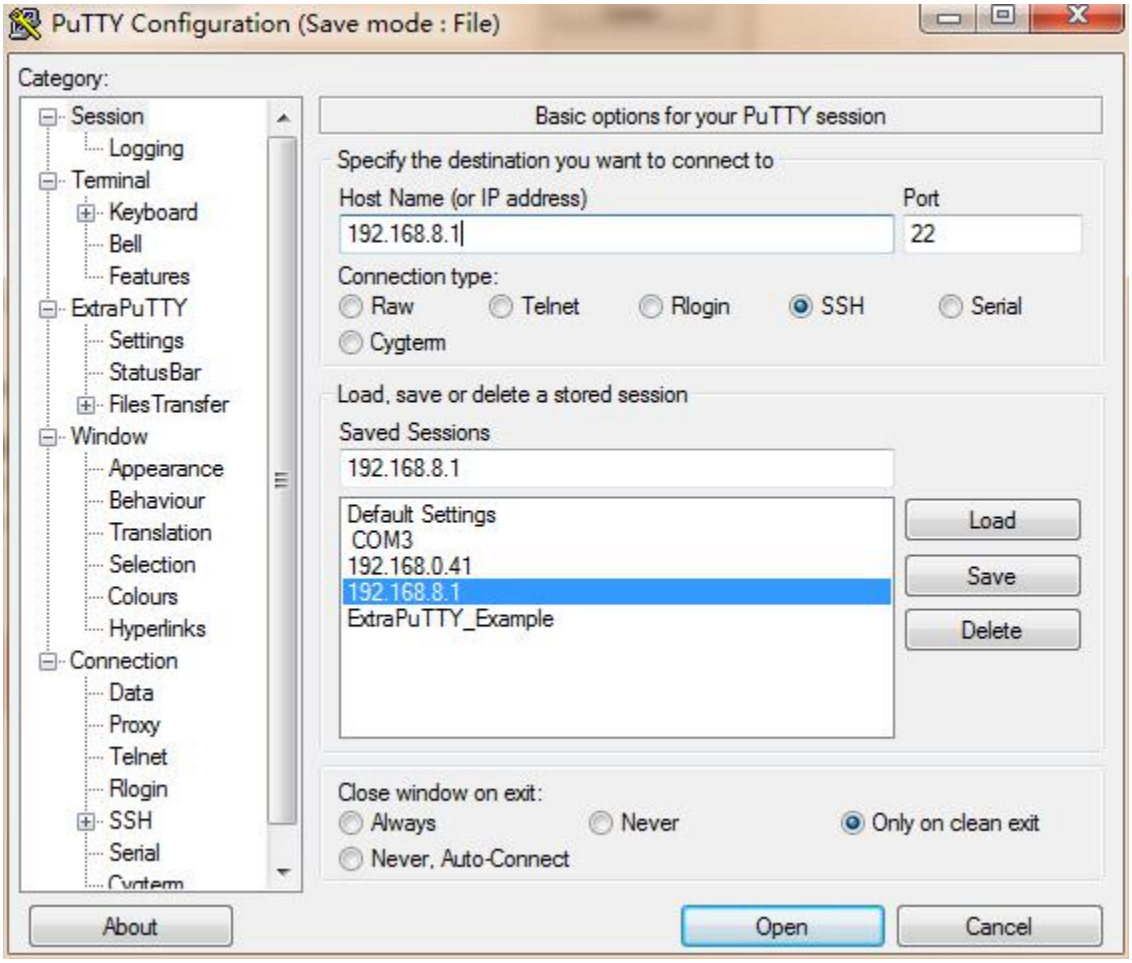


Figure 2-7 Login with WiFi

2.4 Connect to a LoRaWAN server

2.4.1 Connect to a standard packet forwarder server

Standard Semtech Packet forwarder service is support by RHF2S208 series gateway. You could connect the gateway to any target server support packet forwarder interface. Please follow step below to set your gateway to connect to the server:

1) Use the ip above to open the built-in web-based utility
   a. Use the DHCP ip (192.168.0.xxx for example) of the gateway if both your PC and gateway is in the same LAN
   b. Use the default ip 192.168.8.1 if you connect your PC to the WiFi of the gateway
2) Log into the gateway

   User name: rxhf

   Password: risinghf
3) Select LoRaWAN configuration on the Navigation panel

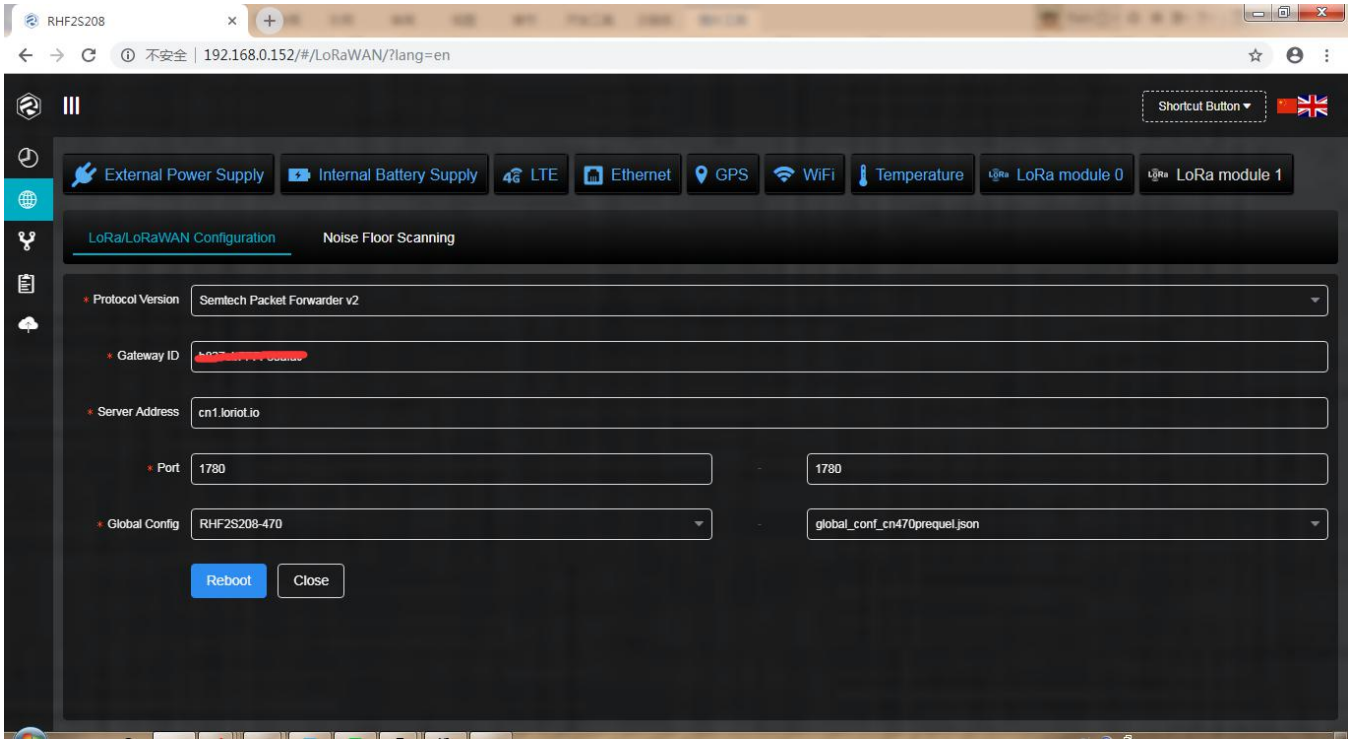


Figure 2-8 Connect to a LoRaWAN server with packet forwarder service

4) Select protocol version
5) Input gateway ID
6) Input Server address
7) Input uplink and downlink port
8) Select global configuration json file

Figure 2-9 Configure the gateway to connect to LoRaWAN with packet forwarder service step by step

9) Reboot

10) Check that if the gateway is on line or not.

2.4.2 Connect to cn1.loriot.io

Here will show how to use command to enable and start the Loriot service.

1) Use the ip above to open ExtraPutty ssh service; a COM port is also supported
   a. Use the DHCP ip (192.168.0.xxx for example) of the gateway if both your PC and gateway is in the same LAN
   b. Use the default ip 192.168.8.1 if you connect your PC to the WiFi of the gateway
   c. Connect the gateway to your PC USB interface and check the COM port on your PC, and open the ExtraPutty Serial service
      Serial line: COM3 (for example) Speed: 115200
2) Log into the gateway

```
User name: rxhf
Password: risinghf
```

3) Use command below to enable and start the loriot service

```
sudo systemctl enable loriot-gw.service
sudo systemctl start loriot-gw.service
```

4) Use command below to check if the gateway is online or not

```
sudo systemctl status loriot-gw.service
```

5) Use command to disable and stop loriot serivce

```
sudo systemctl stop loriot-gw.service
sudo systemctl disable loriot-gw.service
```

3 Device File System

RHF2S208 firmware use Systemd structure. User could use systemctl and journalctl to manage the integrated services and check log.

3.1 Log In

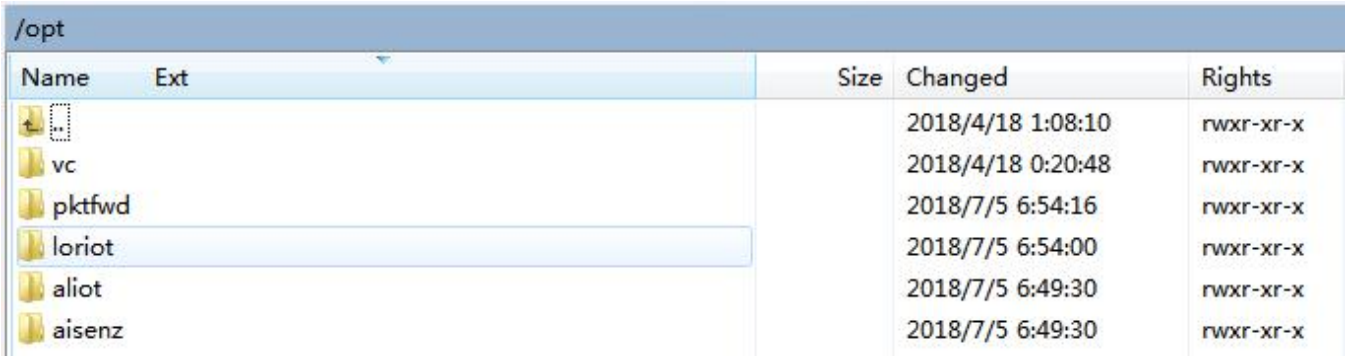
```
User name: rxhf
Password: risinghf
```

3.2 Device File System

/home/rxhf and /opt are very important directory for user.

3.2.1 /opt

/opt contains the working directory of most LoRaWAN serivices. And this will be updating when there is more services added.



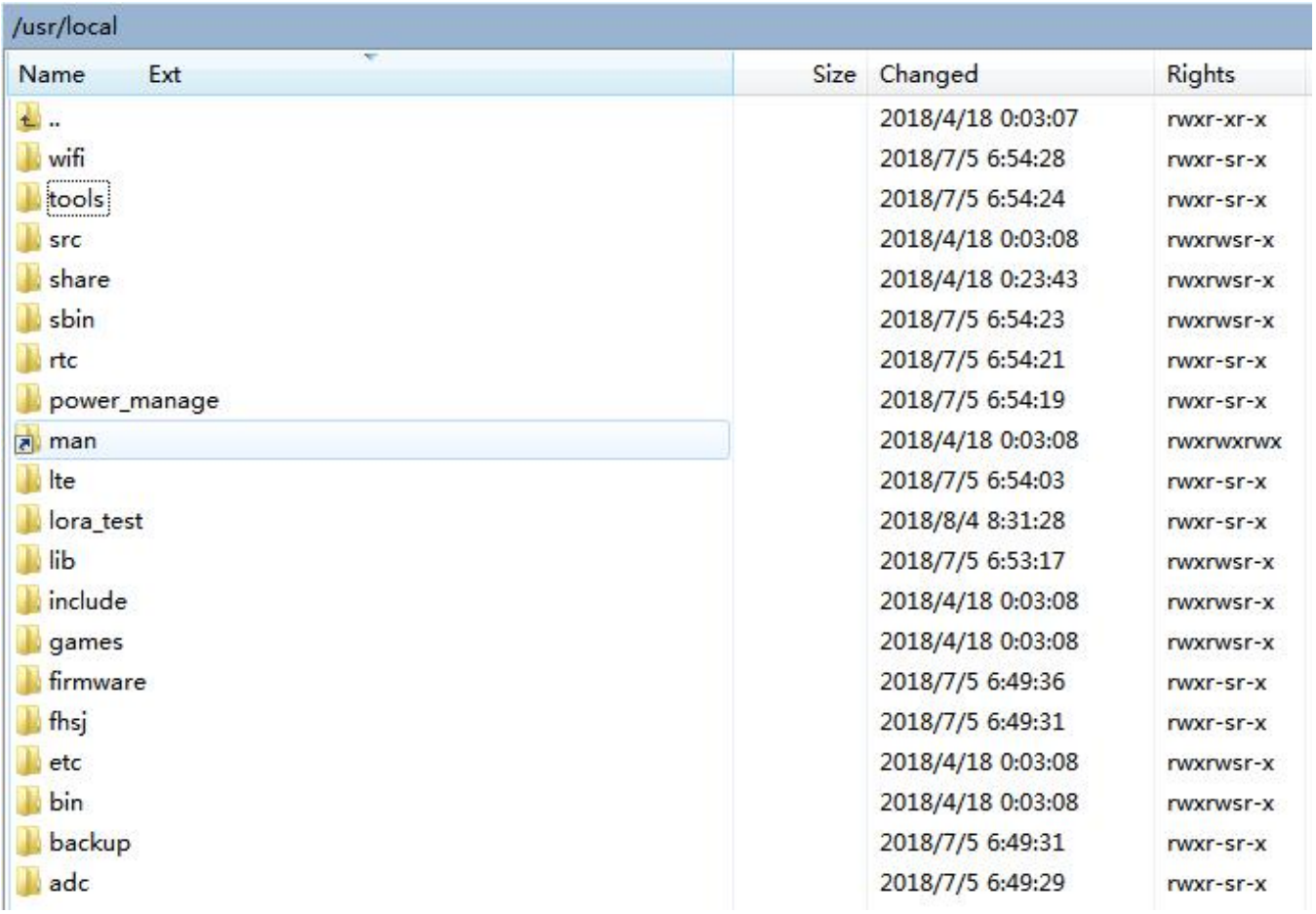
/opt

Name	Ext	Size	Changed	Rights
..			2018/4/18 1:08:10	rwxr-xr-x
vc			2018/4/18 0:20:48	rwxr-xr-x
pktfwd			2018/7/5 6:54:16	rwxr-xr-x
loriot			2018/7/5 6:54:00	rwxr-xr-x
aliot			2018/7/5 6:49:30	rwxr-xr-x
aisenz			2018/7/5 6:49:30	rwxr-xr-x

Figure 3-1 /opt file in gateway

3.2.2 /usr/local

/usr/local contains most of internal services of the gateway.



/usr/local

Name	Ext	Size	Changed	Rights
..			2018/4/18 0:03:07	rwxr-xr-x
wifi			2018/7/5 6:54:28	rwxr-sr-x
tools			2018/7/5 6:54:24	rwxr-sr-x
src			2018/4/18 0:03:08	rwxrwsr-x
share			2018/4/18 0:23:43	rwxrwsr-x
sbin			2018/7/5 6:54:23	rwxrwsr-x
rtc			2018/7/5 6:54:21	rwxr-sr-x
power_manage			2018/7/5 6:54:19	rwxr-sr-x
man			2018/4/18 0:03:08	rwxrwxrwx
lte			2018/7/5 6:54:03	rwxr-sr-x
lora_test			2018/8/4 8:31:28	rwxr-sr-x
lib			2018/7/5 6:53:17	rwxrwsr-x
include			2018/4/18 0:03:08	rwxrwsr-x
games			2018/4/18 0:03:08	rwxrwsr-x
firmware			2018/7/5 6:49:36	rwxr-sr-x
fhsj			2018/7/5 6:49:31	rwxr-sr-x
etc			2018/4/18 0:03:08	rwxrwsr-x
bin			2018/4/18 0:03:08	rwxrwsr-x
backup			2018/7/5 6:49:31	rwxr-sr-x
adc			2018/7/5 6:49:29	rwxr-sr-x

Figure 3-2 /usr/local file in gateway

4 Web-based utility

With the web-based utility, it is easily to configure and manage your gateway.
Default user name: rxhf
Default password: risinghf
There are two ways to open the built-in web of your gateway:
1) Connect your PC to the WiFi of your gateway and use 192.168.8.1 to open the built-in web with the web browser.

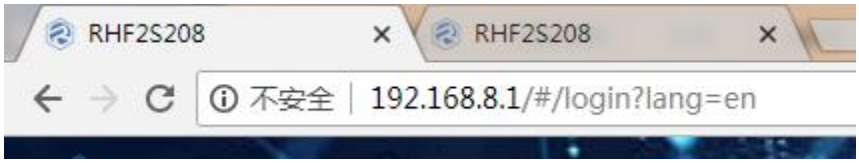


Figure 4-1 Open built-in web with 192.168.8.1 via WiFi

2) Connect both your gateway and PC to a same router, and get the ip of the gateway in the LAN. Use this ip to open the built-in web with the web browser. Here use 192.168.0.182 for example.

Figure 4-2 Open built-in web with gateweay ip in LAN

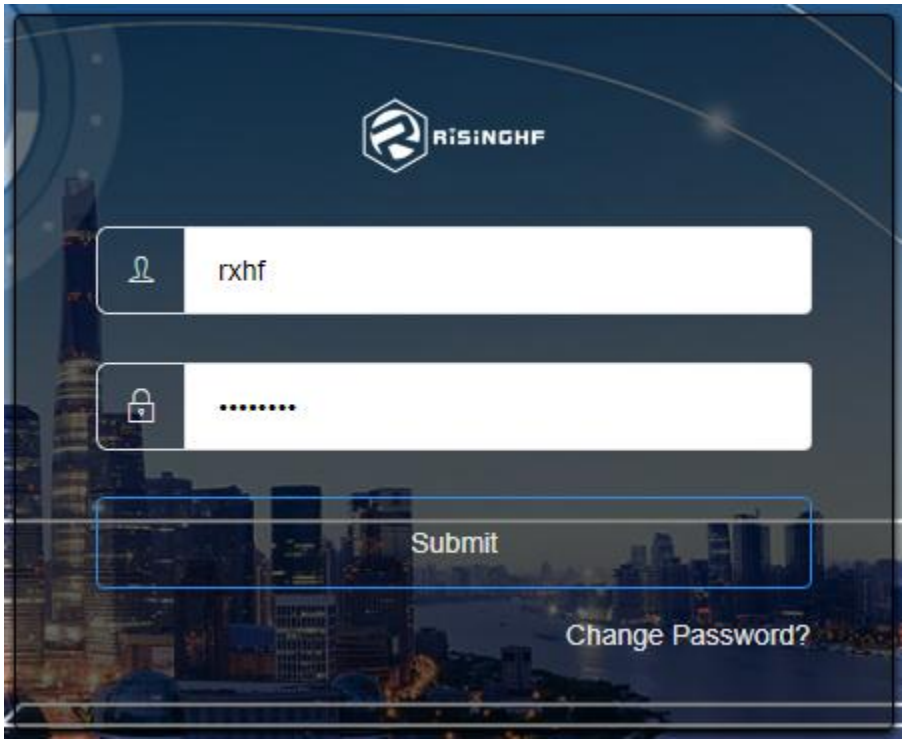


Figure 4-3 Login on the web

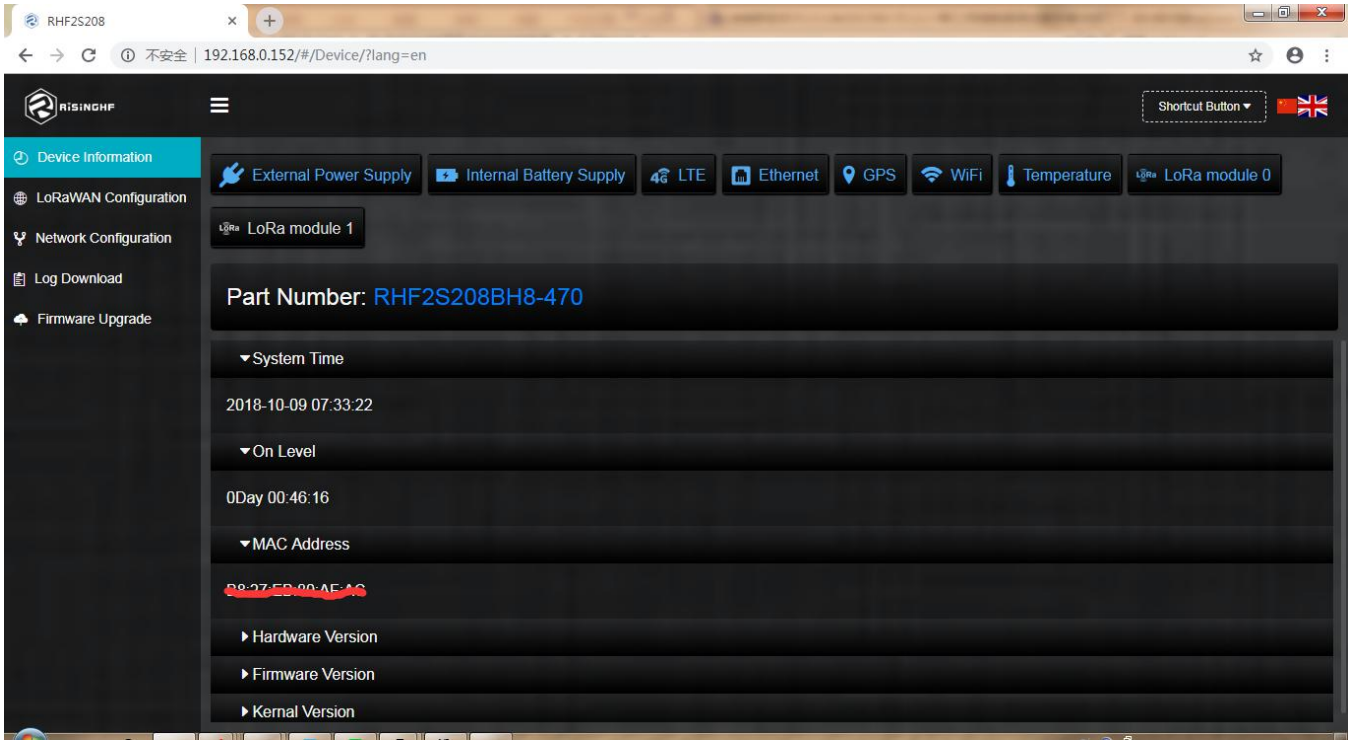


Figure 4-4 Built-in Web page after login

4.1 Status bar

A status bar show some key status of the hardware. Users could have a quick glimpse to check status of the hardware of your gateway. Each parameters on the status bar have 3 status with different color.

Green bar means OK;

Red bar means Error or Warning;

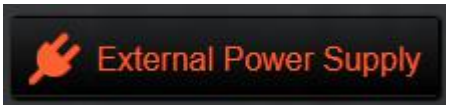
Grey bar means hardware is absent.

There are 9 parts total, which are External Power Supply, Internal Battery Supply, 4G LTE, Ethernet, GPS, WiFi, Temperature, LoRa module 0 and LoRa module 1.

Figure 4-5 Status bar

Below it is a example for “External Power Supply”:

means a external power supply (AC/DC adapter or PoE injector) is connected.



means a external power supply is removed or broken.

NOTE:

For series RHF2S20xExx which have no internal battery, the bar “Internal Battery Supply” is grey.
For series RHF2S208xxx which have just LoRa module 0 only support 8 channels, the bar “LoRa module 1” is grey.

4.2 Navigation bar

Navigation bar include most of the main configurations and management of the gateway:
Device Information: some basic information of the gateway
LoRaWAN Configuration: to connect to LoRaWAN server or do noise scanning
Network Configuration: configuration for WiFi of the gateway
Log Download: to download the working log of the gateway
Firmware Upgrades: to upgrade firmware.

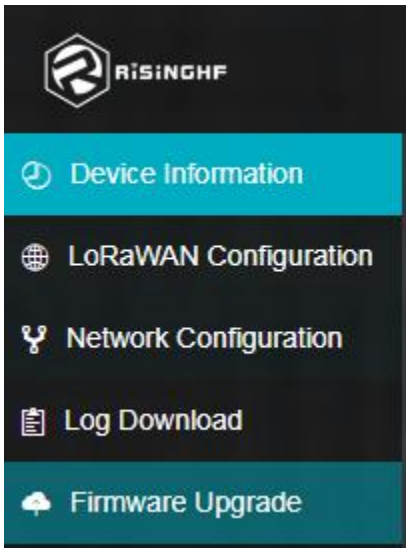


Figure 4-6 Navigation bar

4.2.1 Device information

Device information show the basic information of the gateway.

Figure 4-7 Device information of RHF2S208

4.2.2 LoRaWAN Configuration

With LoRaWAN Configuration you could do:

1) LoRaWAN Configuration (Connect to a LoRaWAN server)

Protocol version: select standard packet forwarder or other protocol to connect to a target server

Gateway ID: fill in the gateway ID. Please check with your operator for the gateway ID rule.

Server Address: fill in the target server address.

Port: fill in the uplinik port and downlink port.

Global Config: please select the right global config which your gateway support. Different Part Number support different band. You could find the detailed information that the band your gatway could support in datasheet “[DS01828]RHF2S208 Product Specification”.

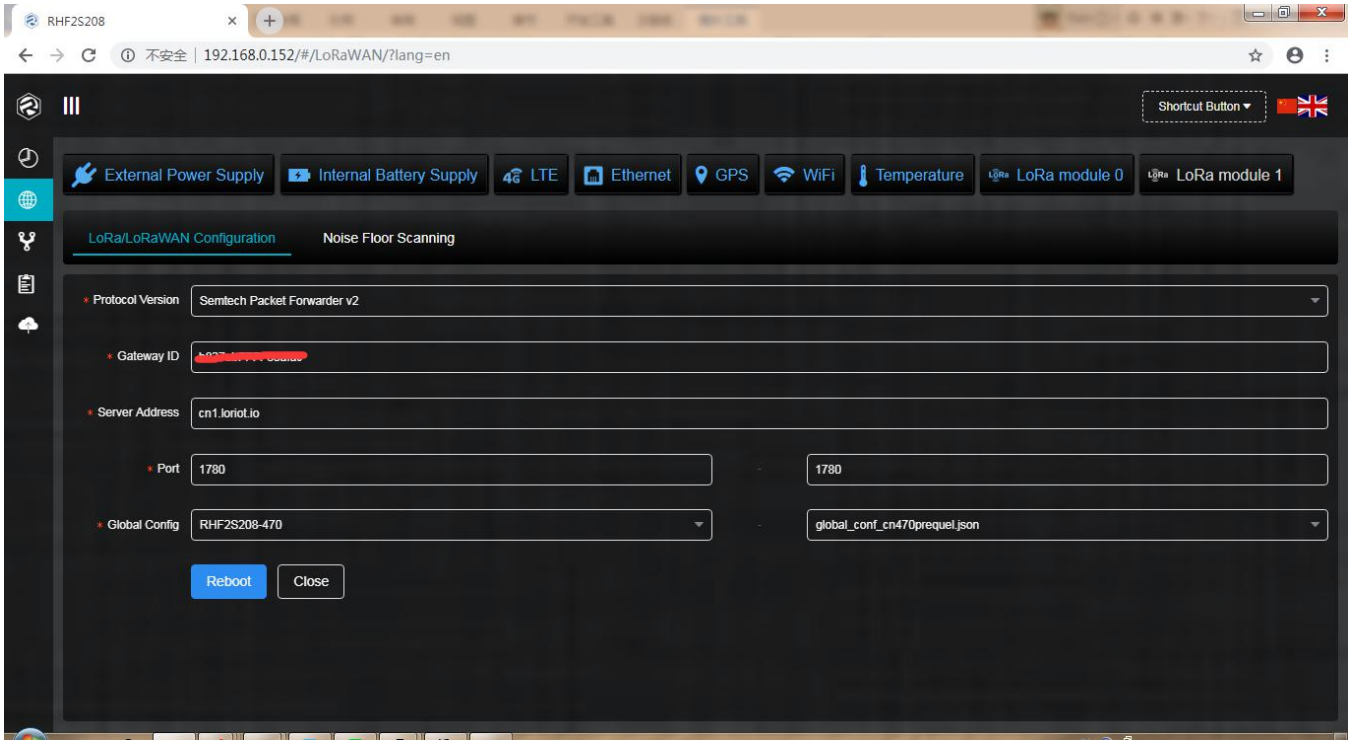


Figure 4-8 LoRaWAN configuration

2) Noise floor scanning

Noise floor scanning is a very useful tool when you want to check that there is some interfernce or noise in the band your gateway work.

Please fill in the Start Frequency and Stop Frequency and click Start Scanning to start noise scan. The default scanning band is 2MHz if you just input start frequency. Default step is 100kHz. The band you scan is bigger, the time is longer. Scanning band 2MHz or 5MHz which could cover the target operation band of your gateway is strongly suggested.

Figure 4-9 Noise floor scanning

After the gateway scanning finished, the noise floor will be shown in two mode: the transient noise distribution diagram and the average value diagram.

The transient noise distribution diagram show the transient noise or interference when scanning;

The average value diagram show the average value in the whole scanning.

Figure 4-10 Noise cannning example @470 to 472MHz

4.2.3 Network Configuration

The network configuration panel is for WiFi configuration. You could re-configure the ip address of the WiFi router from default 192.168.8.1 to any you want. SSID name and password also could be modified as you want.

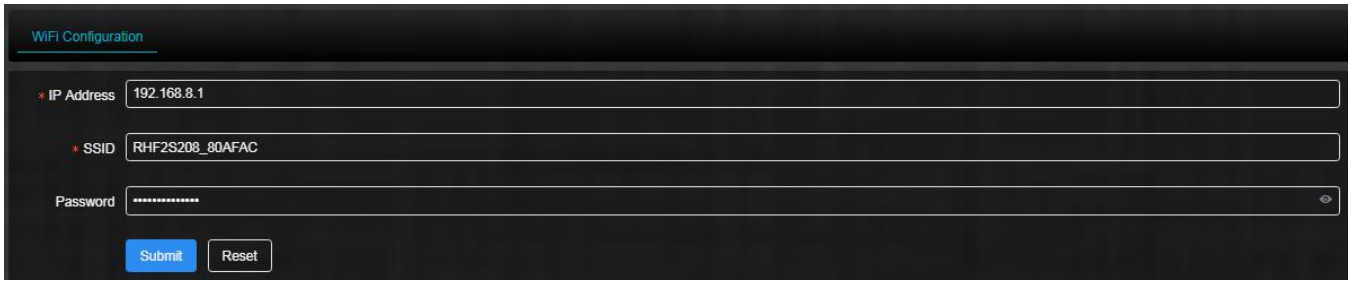


Figure 4-11 Network configuration

4.2.4 Log Download

In log download page, you could check kinds of log of the gateway.

1) System Analysis Log

System analysis log is the record of the system of the gateway, which could be used to analyse the of the platform.

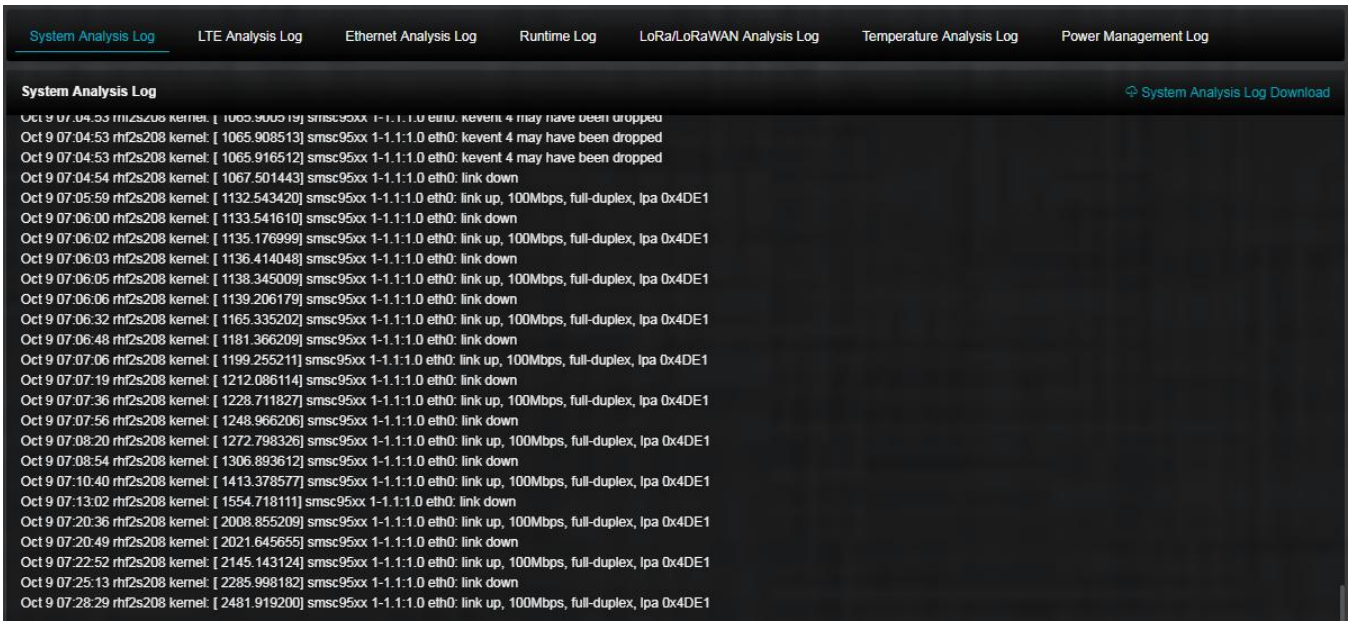


Figure 4-12 System Analysis Log

2) LTE analysis log

LTE analysis log could be used to check and analyse the offline issue, which include the dialing log.

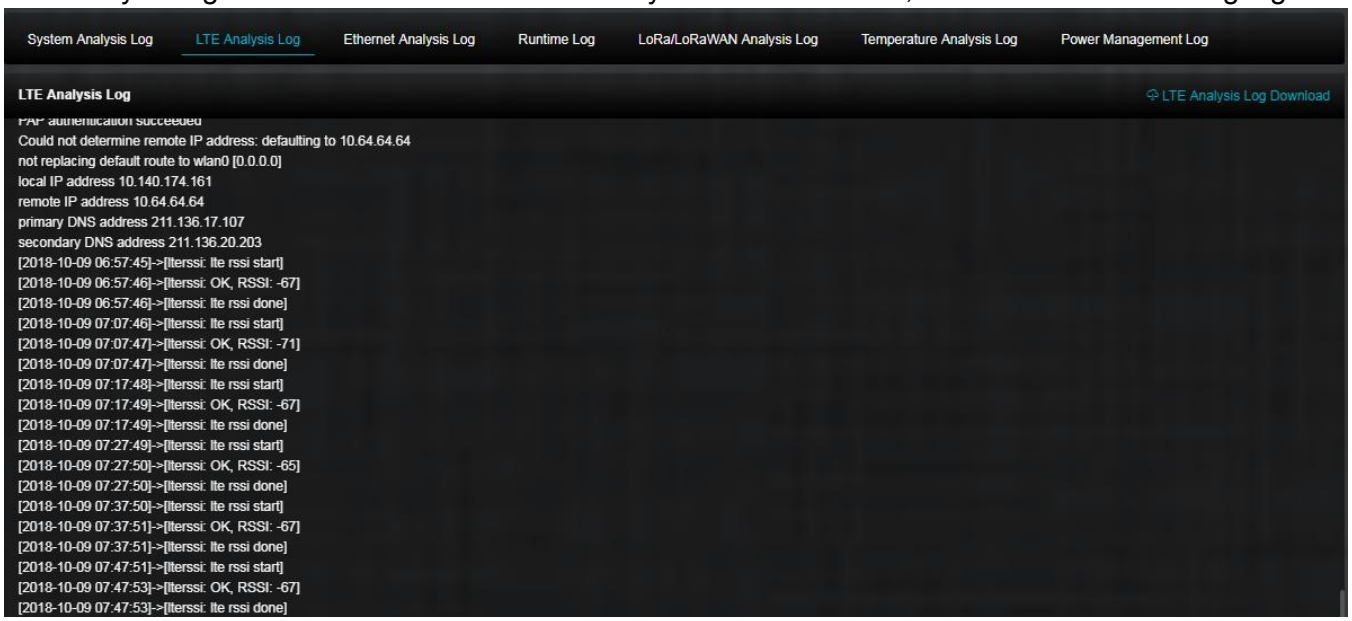


Figure 4-13 LTE Analysis Log

3) Ethernet Analysis Log

Ethernet analysis log record the connection and disconnection between the gateway and the ethernet.

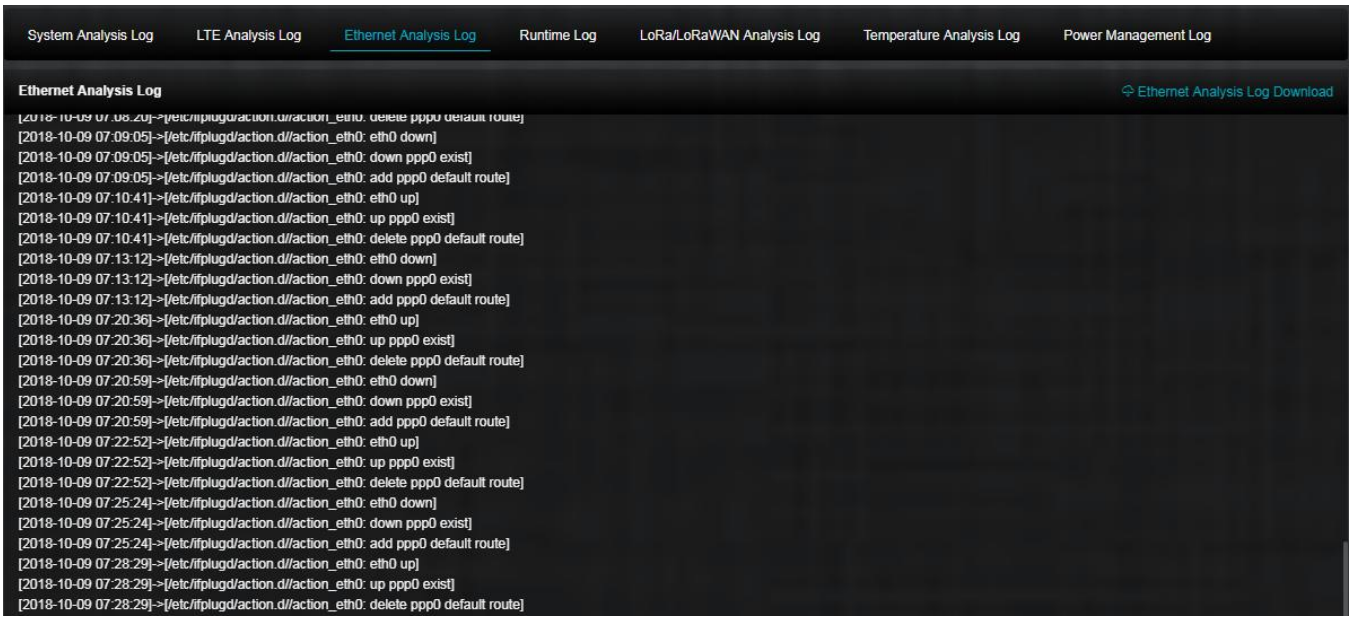


Figure 4-14 Ethernet Analysis Log

4) Runtime Log

Each time the gateway power on or reboot will trigger a log, which we call runtime log. With this log, we could know that when the gateway is reboot or powered on.

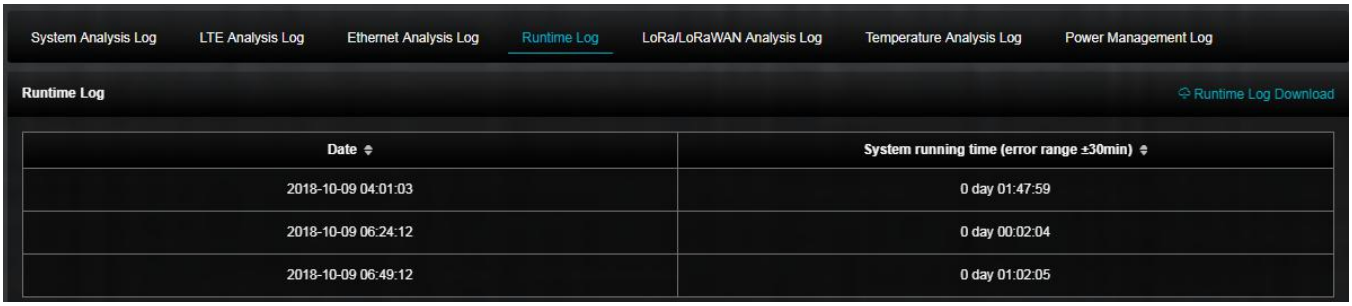


Figure 4-15 Runtime Log

5) LoRa/LoRaWAN Analysis Log

LoRa/LoRaWAN analysis log just record the abnormal event of the LoRaWAN progress. Nothing will be recorded if the LoRaWAN is OK.

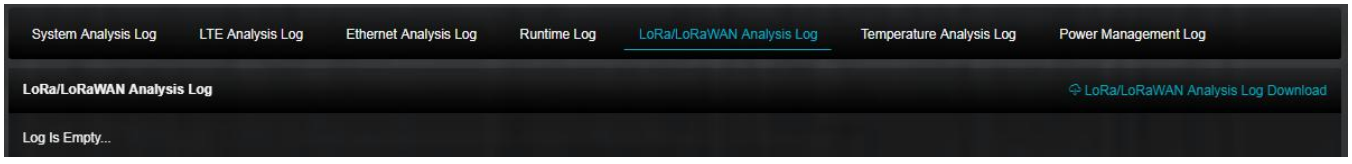


Figure 4-16 LoRa/LoRaWAN Analysis Log

6) Temperature Analysis Log

A temperature sensor is inside the gateway. The temperature analysis log is the temperature record inside the gateway recorded every minute.

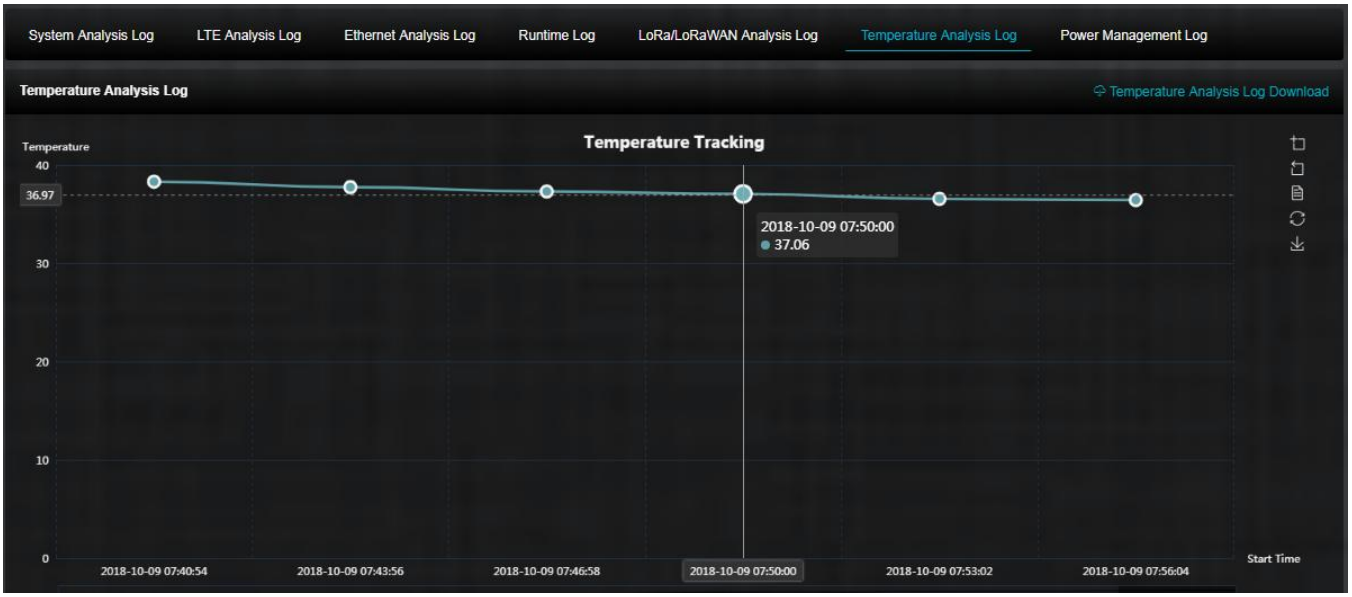


Figure 4-17 Temperature Analysis Log

7) Power Management Log

Power management log include the power on/off log and discarging log with battery supply. With this log, you could check it when the gateway is off or restart abnormaly.

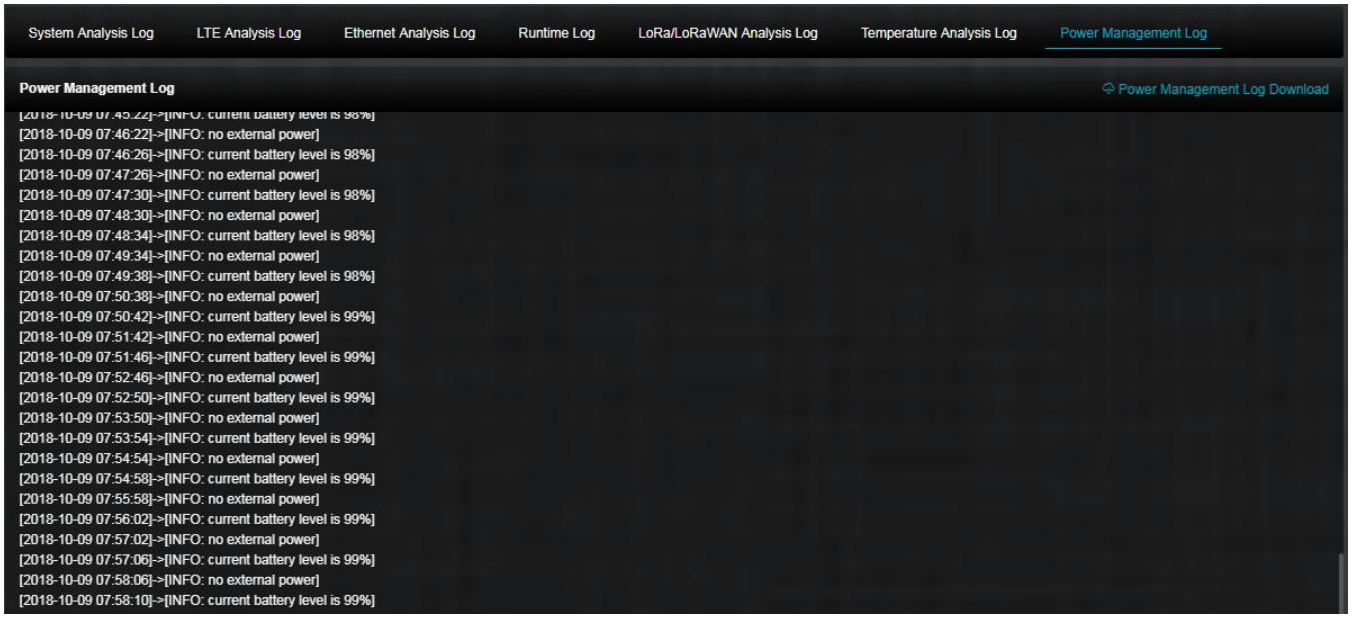


Figure 4-18 Power Management Log

4.2.5 Firmware Upgrade

Use application upgrades icon customer could upgrade the application of their gateway.

Figure 4-19 Firmware Upgrade

4.3 Shortcut button

There is a shortcut button list on the upper right corner of the web page. With this shortcut button list, you can do quick diagnosis, system reset, set priority of the backhaul networking and sign out.

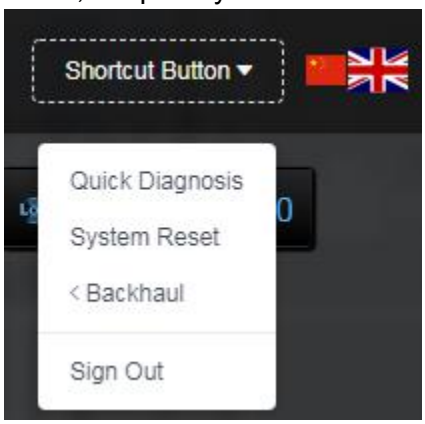


Figure 4-20 Shortcut button

4.3.1 Quick Diagnosis

With the Quick Diagnosis function, you can have a quick check for the hardware of the gateway. This function would be useful when the gateway is being installed in the field. The step below show the whole progress of the diagnosis:

1) Click quick diagnosis there will be a quick diagnosis window ask you : To Do Diagnosis?
2) A progress bar will be shown after you click OK on the diagnosis window.
3) The diagnosis results window will be shown when diagnosis is finished

The passed results are shown in green if all the self-test succeed. The failed parts are shown in red.

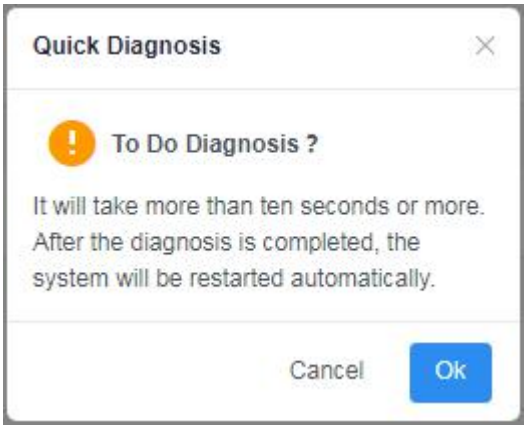


Figure 4-21 Quick Diagnosis

Figure 4-22 Quick Diagnosis ongoing

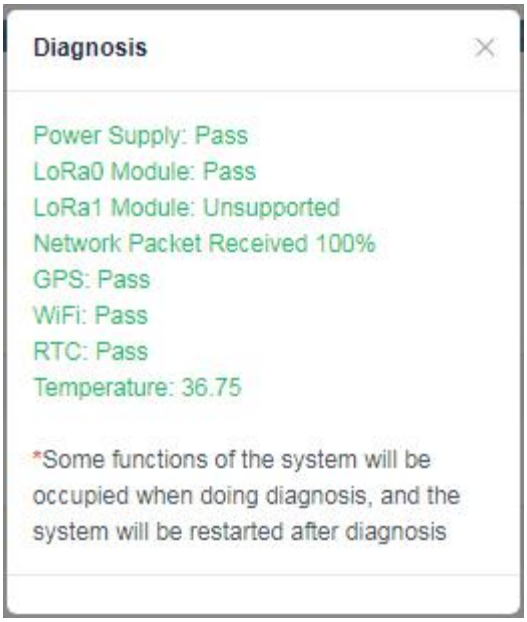


Figure 4-23 Quick Diagnosis complete

NOTE: The system will be reboot after quick diagnosis.

4.3.2 System Reset

System Reset is used to reset the system. When you click “system reset” bar on the shortcut button list, a “Whether To Restart The Gatway” question window will be shown. Click OK button the system will restart immediately and a progress bar will be shown. Please rejoin the WiFi network and access into the gateway again after you restart the system.

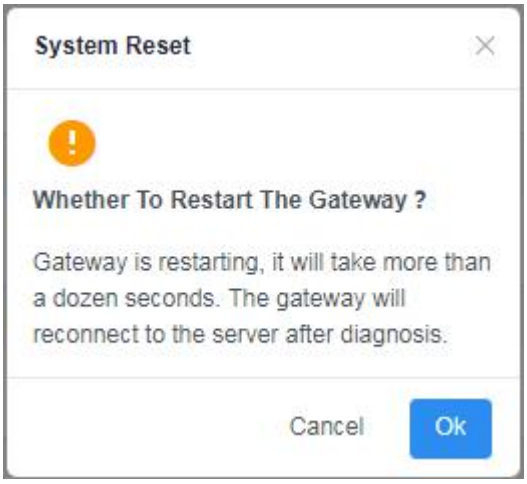


Figure 4-24 System Reset window

Figure 4-25 System Reset progress ongoing

4.3.3 Networking Backhaul

You could configure the priority of the networking. 4G LTE is the first choice in default. But the networking will be switched to wired 10/100m ethernet automatically if 4G LTE is off-line. And you could re-configure the priority. The system will be reboot by mandatory if you change the priority of the networking.

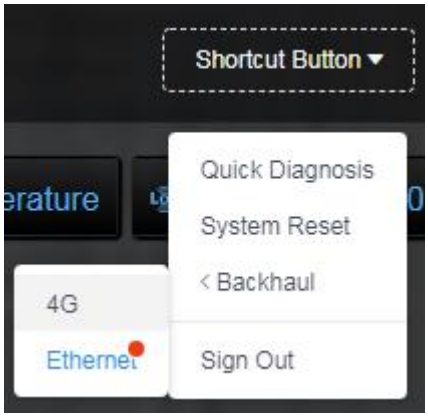


Figure 4-26 Set priority of the networking

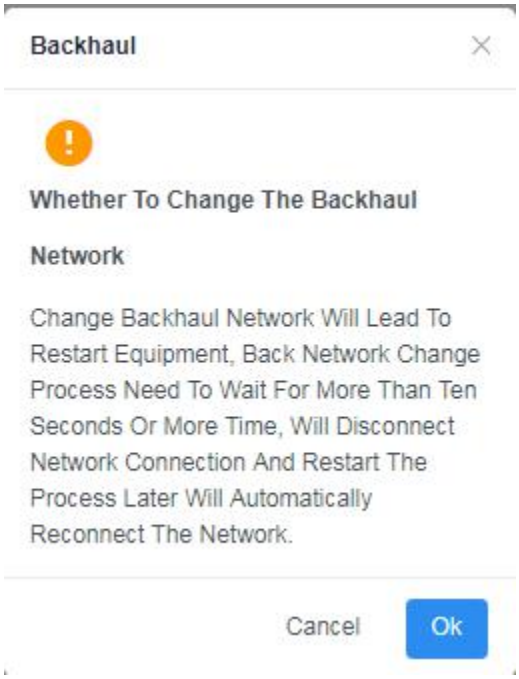


Figure 4-27 To change the priority of the backhaul network

Figure 4-28 Progress bar of changing the priority of the backhaul network

NOTE: The system will be reboot if priority of the backhaul network is changing.

4.3.4 Sign Out

Sign out button will make it return to the login web page.

5 LoRaWAN Server Solutions

According to the different request, user could choose which server to connect to. RHF2S208 integrates several third party manufacture's server like Loriot.io and Loraflow.io, and also preinstall the packet forwarder program for customer's convenience.

NOTE: At the same time, a gateway can only connect to only one server. When user needs to switch between servers, it must be sure that service which is not used is not ruuning.

5.1 Packet Forwarder

Packet Forwarder is a bridge program for lora gateway and server which is provided by Semtech, supplies basic LoRa packet forwarding feature for simple LoRaWAN network. Packet Forwarder itself doesn't handle LoRaWAN frame analysis. RHF2S208 integrates the latest version of packet forwarder protocol lora_pkt_fwd (v4.0.1).

TIPS: PROTOCOL.TXT is accessible at GitHub https://github.com/Lora-net/packet_forwarder , checkout different commit to check the specified version.
Preinstalled Packet Forwarder locates at /opt/pktfwd directory.

*.json files under pkt service working directory are gps_pkt_fwd / lora_pkt_fwd configuration files. Among the json files, global_conf.json and local_conf.json are files which are used by Packet Forwarder, when using it user could use symbol link to point global_conf.json and local_conf.json to specified json files to choose different frequency plan and server.

global_conf.json and local_conf.json are in the same format. local_conf.json has higher priority than global_conf.json, Packet Forwarder will use configurations contained by local_conf.json overwrite the global_conf.json ones.

You could find all the configuration json file in /opt/pktfwd/cfg for different bands, i.e. 434MHz, 470MHz, 780MHz, 868MHz, 915MHz.

/opt/pktfwd

```
================================================================================
        rxhf@rhf2s208:/opt/pktfwd$ ls -l
        total 188
        drwxr-xr-x 7 root root   4096 Jun 21 11:16 cfg
        lrwxrwxrwx 1 root root     50 Jul 30 11:40 global_conf.json ->
/opt/pktfwd/cfg/470/global_conf_cn470_ch88_95.json
        -rw-r--r-- 1 root root    215 Jul 18 08:33 local_conf.json
        -rwxr-xr-x 1 root root 166240 Jul  5 06:54 lora_pkt_fwd
        -rw-r--r-- 1 root root     52 Jul 18 08:33 pktfwd.conf
        -rwxr-xr-x 1 root root    401 Jul  5 06:54 start.sh
        -rwxr-xr-x 1 root root   1089 Jul  5 06:54 update_gwid.sh
        -rw-r--r-- 1 root root      6 Jul  5 06:54 VERSION
```

/opt/pktfwd/cfg

```
================================================================================
        rxhf@rhf2s208:/opt/pktfwd/cfg$ ls -l
        total 20
        drwxr-xr-x 2 root root 4096 Jun 21 11:16 434
        drwxr-xr-x 2 root root 4096 Jun 21 11:16 470
        drwxr-xr-x 2 root root 4096 Jun 21 11:16 780
        drwxr-xr-x 2 root root 4096 Jun 21 11:16 868
        drwxr-xr-x 2 root root 4096 Jun 21 11:16 915
```

json configuration file example: (868MHz)

```
{
    "SX1301_conf": {
        "lorawan_public": true,
        "clksrc": 1,
        "antenna_gain": 0,
        "radio_0": {
            "enable": true,
            "type": "SX1257",
            "freq": 867500000,
            "rssi_offset": -166.0,
            "tx_enable": true,
            "tx_freq_min": 863000000,
            "tx_freq_max": 870000000
        },
        "radio_1": {
            "enable": true,
            "type": "SX1257",
            "freq": 868500000,
            "rssi_offset": -166.0,
            "tx_enable": false
        },

        // SX1301 MultiSF, standard LoRa and FSK channels
        "chan_multiSF_0": { "enable": true, "radio": 1, "if": -400000 },
        "chan_multiSF_1": { "enable": true, "radio": 1, "if": -200000 },
        "chan_multiSF_2": { "enable": true, "radio": 1, "if": 0 },
        "chan_multiSF_3": { "enable": true, "radio": 0, "if": -400000 },
        "chan_multiSF_4": { "enable": true, "radio": 0, "if": -200000 },
        "chan_multiSF_5": { "enable": true, "radio": 0, "if": 0 },
        "chan_multiSF_6": { "enable": true, "radio": 0, "if": 200000 },
        "chan_multiSF_7": { "enable": true, "radio": 0, "if": 400000 },
        "chan_Lora_std":  { "enable": true, "radio": 1, "if": -200000, "bandwidth": 250000, "spread_factor": 7 },
        "chan_FSK":       { "enable": true, "radio": 1, "if": 300000, "bandwidth": 125000, "datarate": 50000 },

        // RHF0M301-868
```

```
        "tx_lut_0":  { "rf_power": -1, "dig_gain": 0, "mix_gain": 8,  "pa_gain": 1 },
        "tx_lut_1":  { "rf_power": 2,  "dig_gain": 0, "mix_gain": 10, "pa_gain": 1 },
        "tx_lut_2":  { "rf_power": 5,  "dig_gain": 0, "mix_gain": 12, "pa_gain": 1 },
        "tx_lut_3":  { "rf_power": 6,  "dig_gain": 0, "mix_gain": 8,  "pa_gain": 2 },
        "tx_lut_4":  { "rf_power": 8,  "dig_gain": 0, "mix_gain": 9,  "pa_gain": 2 },
        "tx_lut_5":  { "rf_power": 9,  "dig_gain": 0, "mix_gain": 10, "pa_gain": 2 },
        "tx_lut_6":  { "rf_power": 11, "dig_gain": 0, "mix_gain": 11, "pa_gain": 2 },
        "tx_lut_7":  { "rf_power": 12, "dig_gain": 0, "mix_gain": 12, "pa_gain": 2 },
        "tx_lut_8":  { "rf_power": 14, "dig_gain": 0, "mix_gain": 13, "pa_gain": 2 },
        "tx_lut_9":  { "rf_power": 15, "dig_gain": 0, "mix_gain": 8,  "pa_gain": 3 },
        "tx_lut_10": { "rf_power": 17, "dig_gain": 0, "mix_gain": 9,  "pa_gain": 3 },
        "tx_lut_11": { "rf_power": 18, "dig_gain": 0, "mix_gain": 10, "pa_gain": 3 },
        "tx_lut_12": { "rf_power": 20, "dig_gain": 0, "mix_gain": 11, "pa_gain": 3 },
        "tx_lut_13": { "rf_power": 22, "dig_gain": 0, "mix_gain": 12, "pa_gain": 3 },
        "tx_lut_14": { "rf_power": 23, "dig_gain": 0, "mix_gain": 13, "pa_gain": 3 },
        "tx_lut_15": { "rf_power": 25, "dig_gain": 0, "mix_gain": 15, "pa_gain": 3 }

    },

    "gateway_conf": {
        "gateway_ID": "AA555A0000000000",

        /* change with default server address/ports, or overwrite in local_conf.json */
        "server_address": "localhost",
        "serv_port_up": 1680,
        "serv_port_down": 1680,

        /* adjust the following parameters for your network */
        "keepalive_interval": 10,
        "stat_interval": 3600,
        "push_timeout_ms": 100,
        "autoquit_threshold": 5,

        /* forward only valid packets */
        "forward_crc_valid": true,
        "forward_crc_error": false,
        "forward_crc_disabled": false,

        /* GPS reference coordinates */
        "ref_latitude": 0.0,
        "ref_longitude": 0.0,
        "ref_altitude": 0,

        /* Beaconing parameters */
        //"gps_tty_path": "/dev/ttyAMA0",
        "beacon_period": 128,
        "beacon_freq_hz": 869525000
    }
}
```

Packet Forwarder configuration itself is a json object (enclosed by "{" and "}"), the root object contains 2 sub-objects `SX1301_conf` and `gateway_conf`. `SX1301_conf` object is for LoRa radio configuration, `gateway_conf` is for network communication configuration (server address, gateway id etc).

Because global_conf.json file already contains all configurations of Packet Forwarder, local_conf.json is mostly used for items which need to be changed frequently (Eg. `gateway_ID`), like below:

local_conf.json example:

```
{
    "gateway_conf": {
        "gateway_ID": "AA555A0000000000",

        /* change with default server address/ports, or overwrite in local_conf.json */
        "server_address": "localhost",
        "serv_port_up": 1680,
        "serv_port_down": 1680
    }
}
```

In combination with description above, SX1301 has below features:

1. One SX1301 supports 2 Radios. SX1255 or SX1257 can be used .
2. One SX1301 could support maximum 10 channels, of which 8 Multi-SF channels, 1 standard channel and 1 FSK channel.
3. One single SX125x chip has below limitations.

Lower Side Channel Bandwidth	Upper Side Channel Bandwidth	SX125x Bandwidth
125KHz	**125KHz**	925KHz
250KHz	**250KHz**	1MHz
500KHz	**500KHz**	1.1MHz
125KHz	**250KHz**	962.5KHz
250KHz	**125KHz**	962.5KHz
500KHz	**250KHz**	1.05MHz
250KHz	**500KHz**	1.05MHz
500KHz	**125KHz**	1.0125MHz
125KHz	**500KHz**	1.0125MHz

LoRa Module hardware structures:

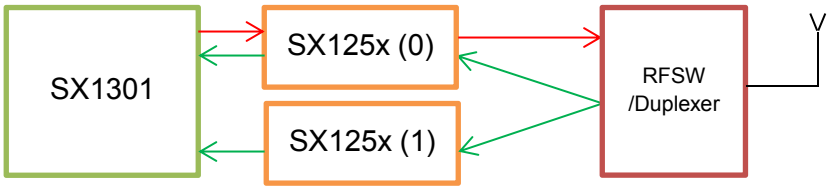


Figure 5-1 LoRa Module hardware structures

5.1.1 Customized channels

User could follow below principles to customize different frequency channel.

1. Split defined channels to two group for radio_0(radio_a) and radio_1(radio_b), calculate central frequency. Set `SX1301_conf.radio_0.freq` and `SX1301_conf.radio_1.freq` the new value.
2. Choose `SX1301_conf.radio_0.type` and `SX1301_conf.radio_1.type` depends on the new radio frequency. If it is higher than 520MHz set radio type `SX1257`, if it is less than 520MHz set radio type `SX1255`. (Note: real products have a narrow band support, please follow specified specification for the details)
3. Refer to the RHF-DS01603 document to get device configuration parameters, include RSSI offset and radio frequency TX power. Set `SX1301_conf.radio_0.rssi_offset` and `SX1301_conf.radio_1.rssi_offset` and `tx_lut_xxx` value
4. Calculate IF channel offset value. Modify `SX1301_conf.chan_multiSF_xxx`, `SX1301_conf.chan_Lora_std` 和 `SX1301_conf.chan_FSK` object. Channel configuration follows below rules.
   a) Each IF channel can be associated with either radio0 or radio1 freely.
   b) Each IF channel offset can't be out of range the SX125x bandwidth limitation, or the IF channel setting will be invalid.
   c) Each IF channel can be enable or disable independently .
5. So the example json file contains below channels:
   d) CH0 868.1MHz Multi-SF
   e) CH1 868.3MHz Multi-SF
   f) CH2 868.5MHz Multi-SF

g) CH3 867.1MHz Multi-SF
h) CH4 867.3MHz Multi-SF
i) CH5 867.5MHz Multi-SF
j) CH6 867.7MHz Multi-SF
k) CH7 867.9MHz Multi-SF
l) CH8 868.3MHz LoRa Standard SF7/250KHz
m) CH9 868.8MHz FSK 50Kbps

5.1.2 Configure server address

Edit local_conf.json file. Modify `server_address` object to configure server address, modify `serv_port_up` object to configure uplink port, modify `serv_port_down` object to configure downlink port.

// local_conf.json file example:

```
{
    "gateway_conf": {
        "gateway_ID": "AA555A0000000000",
        "server_address": "localhost",
        "serv_port_up": 1680,
        "serv_port_down": 1680
    }
}
```

Some known packet forwarder serer address list:

Address	Uplink Port	Downlink Port	Packet Forward Version	Supplier	Band
Iot.semtech.com	1680	1680	V1/V2	Semtech	EU868
us01-iot.semtech.com	1780	1780	V1/V2	Semtech	US915
cn1.loriot.io	1780	1780	V1/V2	Loriot	All
ap1.loriot.io	1780	1780	V1/V2	Loriot	All
au1.loriot.io	1780	1780	V1/V2	Loriot	All
eu1.loriot.io	1780	1780	V1/V2	Loriot	All
sa1.loriot.io	1780	1780	V1/V2	Loriot	All
us1.loriot.io	1780	1780	V1/V2	Loriot	All
router.eu.thethings.network	1700	1700	V1	TTN	EU433 EU868
router.us.thethings.network	1700	1700	V1	TTN	US915
router.cn.thethings.network	1700	1700	V1	TTN	CN470 CN780
router.au.thethings.network	1700	1700	V1	TTN	AU915

5.1.3 Choose preinstalled frequency plan

Use ln command to make global_conf.json file points to other json file to choose preinstalled frequency plan. User can also create their own json file depends on the previous defined json file.

```
sudo ln -sf global_conf_xxx.json global_conf.json
```

NOTE:

1. **Replace global_conf_xxx.json with the real file name**
2. **Use `ls -l /opt/risinghf/pktfwd` command to check which frequency plan is contained in /opt/risinghf/pktfwd**
3. **Physical frequency which is supported by RHF2S208 is decided by the hardware. For example RHF2S208xxx-470 only support 470MHz frequency band, doesn't support 433MHz, 868MHz etc...**
4. **Other undocumented channels plans, user could calculate each channel frequency according to the previous description.**

CH	eu868	us915	eu433	cn780	as920	cn470
0	867.1	902.3	433.175	779.5	923.2	470.3
1	867.3	902.5	433.375	779.7	923.4	470.5
2	867.5	902.7	433.575	779.9	923.6	470.7
3	867.7	902.9	433.775	780.1	923.8	470.9
4	867.9	903.1	433.975	780.3	924.0	471.1
5	868.1	903.3	434.175	780.5	924.2	471.3
6	868.3	903.5	434.375	780.7	924.4	471.5
7	868.5	903.7	434.575	780.9	924.6	471.7
8	868.3 BW250 SF7	903.0 BW500 SF8	OFF	OFF	OFF	OFF
9	868.8 FSK 50Kbps	OFF	OFF	OFF	OFF	OFF

5.1.4 Start Packet Forwarder service

Execute commands below to start pktfwd service:

```
sudo systemctl enable pktfwd
sudo systemctl restart pktfwd
```

5.1.5 Stop Packet Forwarder service

Execute commands below to stop pktfwd service:

```
sudo systemctl disable pktfwd
sudo systemctl stop pktfwd
```

5.2 Loriot Server(loriot.io)

Loriot is a LoRaWAN server supplier based at Switzerland, Loriot server supply free test account for user. Main site http://www.loriot.io. Please note, free account has some limitation like active downlink, OTAA etc.

Please read online documentation before get started. (Subdomain name will be different if you use other region servers)

https://cn1.loriot.io/home/documentation.html

5.2.1 Register RHF2S208 Gateway

1) Get MAC address, which is in format xx:xx:xx:xx:xx:xx. MAC address is sticky on the side of the RHF2S208 device. You could also use command ifconfig to get the MAC address or find it on the web-based utility.

```
rxhf@rhf2s208:~$ ifconfig
================================================================================
    eth0: flags=4099<UP,BROADCAST,MULTICAST>  mtu 1500
            ether b8:27:eb:80:af:ac  txqueuelen 1000  (Ethernet)
            RX packets 0  bytes 0 (0.0 B)
            RX errors 0  dropped 0  overruns 0  frame 0
            TX packets 0  bytes 0 (0.0 B)
            TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

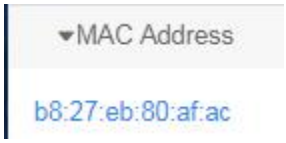


Figure 5-2 Mac addr shown on web-based utility

2) Access http://cn1.loriot.io register account, log in directly if you have already gotten one.
3) Click Dashboard -> Gateways -> Add Gateway, choose RHF2S208
4) Radio front-end configuration. Match the device type. Available options:
   a) 868/915 MHz (SX1257)
   b) 434/470/780 MHz (SX1255)
   c) Note: RHF2S208-780MHz gateway need choose "868/915 MHz (SX1257)"
5) Scroll down, fill in MAC address, and set gateway location information.
6) Click "Register RisingHF RHF2S208 Gateway" finish register
7) Click "Go to the gateway detail page" or click "gateway xx:xx:xx:xx:xx:xx" from plane at the left to enter gateway configuration page.
8) According to the gateway frequency band to choose a band. Contact support@risinghf.com if you need help.
9) Register gateway finish.
10) Connect Ethernet cable, power up RHF2S208.
11) Log in to the gateway and start Loriot service and start test.

5.2.2 Start Loriot Service

Set auto start:

```
sudo systemctl enable loriot-gw
```

Start:

```
sudo systemctl start loriot-gw
```

Stop:

```
sudo systemctl stop loriot-gw
```

Disable auto start:

```
sudo systemctl disable loriot-gw
```

NOTE: Once you set to auto start the service, please make sure disable the auto start of loriot-gw service. In case of the gateway service collision.

5.2.3 Configure Gateway Frequency

Set gateway frequency, open loriot console find gateway page. Choose frequency plan. Check online documentation for more details.
https://cn1.loriot.io/home/documentation.html#docu/frequency-plan

5.2.4 Loriot Firmware Upgrade

Please download loriot-risinghf-RHF2S208-xxxxxx-SPI-0-latest.bin file, and replace /opt/loriot/bin/loriot-gw

```
sudo su
cd /opt/loriot/bin
wget URL -O loriot-gw
```

Please get the actual URL from the gateway page.

5.3 Aisenz Server (loraflow.io)

Loraflow.io is a Chinese LoRaWAN server. Official website http://loraflow.io.

Check loraflow online document first before get started,.
https://loraflow.io/static/docs/zh/index.html

5.3.1 Register RHF2S208 Gateway

1) Get MAC address, which is in format xx:xx:xx:xx:xx:xx. MAC address is sticky on the side of the RHF2S208 device.
2) Access https://loraflow.io register account, log in directly if you have already gotten one.
3) Click gateway management page, click add button to register a new gateway.
4) Gateway type RHF2S008/RHF2S208
5) Gateway name, set a customized one
6) MAC Address, fill in the address read from the device
7) (Optional) Fill in gateway location
8) Click gateway to configure

5.3.2 Start lorabridge and lrgateway service

```
sudo systemctl enable  lorabridge
sudo systemctl enable  lrgateway
sudo systemctl restart  lrgateway
sudo systemctl restart  lorabridge
```

5.3.3 Start/Stop loraflow SDK

Start:

```
sudo systemctl start lorabridge
sudo systemctl start lrgateway
```

Stop

```
sudo systemctl stop lorabridge
sudo systemctl stop lrgateway
```

Disable auto start:

```
sudo systemctl disable lorabridge
sudo systemctl disable lrgateway
```

Enable auto start:

```
sudo systemctl enable lorabridge
sudo systemctl enable lrgateway
```

5.3.4 Configure Gateway Frequency

loraflow.io default working directory /home/rxhf/aisenz/pktfwd.

```
cd /opt/pktfwd
```

/home/rxhf/aisenz/pktfwd contains different frequency plans. Among them Loraflow.io SDK reuse Semtech packet forwarder to control gateway, check 2.3.1 Packet Forwarder about the detailed configuration.

5.3.5 loraflow SDK upgrade

Download lorasdk.zip. Refer to loraflow online document to upgrade SDK
https://loraflow.io/static/docs/zh/gateway/SDKInstall.html

6 Advanced Usage

6.1 Networking Backhaul

6.1.1 Cellular Network (LTE/4G/3G)

RHF2S208 device embedded service for wireless networking backhaul which is named lte, and is an auto start service. Use below command to check log of lte service:

```
sudo journalctl -f -n 200 -u lte
```

Feature:

- ✓ **Auto generate APN information according to the SIM card**
- ✓ **SIM card hot plug**
- ✓ **Not support roaming**

With command below you could do more analysis on LTE cellular networking:

- ifconfig ppp0

After dial-up success, system will generate ppp0 device.

```
rxhf@RHF2S208:~$ ifconfig ppp0
ppp0      Link encap:Point-to-Point Protocol
          inet addr:10.65.6.136  P-t-P:10.64.64.64  Mask:255.255.255.255
          UP POINTOPOINT RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:5 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:3
          RX bytes:56 (56.0 B)  TX bytes:80 (80.0 B)
```

- Sudo ltesim

With command “sudo ltesim”, you could check if the sim card is inserted or not. The log would be printed on the web-based utility >log download >LTE analysis Log.

```
[2018-08-03 01:31:22]->[ltesim: lte sim start]
[2018-08-03 01:31:23]->[ltesim: OK, SIM inserted]
[2018-08-03 01:31:23]->[ltesim: lte sim done]
```

- Sudo lterssi

When connected, lterssi command could be used to check the signal quality. The log of rssi would be printed on the web-based utility >log download >LTE analysis Log.

```
sudo lterssi
[2018-08-03 01:22:14]->[lterssi: lte rssi start]
[2018-08-03 01:22:15]->[lterssi: OK, RSSI: -75]
[2018-08-03 01:22:15]->[lterssi: lte rssi done]
// -75 is the signal strength
```

If not connected, it shows:

```
ERROR: Celluar network disconnected
```

- Sudo lteimei

With this command, you could get lteimei of the gateway. The IMEI of the device would be printed on the web-based utility >log download >LTE analysis Log.

```
[2018-08-03 02:21:02]->[lteimei: lte imei start]
[2018-08-03 02:21:03]->[lteimei: OK, 867012030909920]
[2018-08-03 02:21:03]->[lteimei: lte imei done]
```

- Sudo ltediagnosis

If you want to do diagnosis for the LTE networking, please use “sudo ltediagnosis” command. The log of diagnosis would be printed on the web-based utility >log download >LTE analysis Log.

```
[2018-08-03 02:14:36]->[ltediagnosis: lte diagnosis start]
[2018-08-03 02:14:37]->[ltediagnosis: OK, usb bus normal]
[2018-08-03 02:14:37]->[ltediagnosis: OK, lte modem normal]
[2018-08-03 02:14:38]->[ltediagnosis: OK, SIM inserted]
[2018-08-03 02:14:38]->[ltediagnosis: OK, RSSI: -75]
[2018-08-03 02:14:38]->[carrier: 中国移动 (China Mobile) IoT]
```

[2018-08-03 02:14:38]->[ltediagnosis: OK, 460042462508255]
[2018-08-03 02:14:38]->[ltediagnosis: lte diagnosis done]

- APN configuration

Normally, the APN configuration for most of the operators is included. But users could re-configure the APN if needed. Please use the comand “addapn” to add a new APN configuration. Use “addapn -h” to get help.

```
rxhf@rhf2s208:~ $ addapn -h
Usage: addapn [options]

Options:
  --help                  Show this help
  --carrier <CARRIER>     Set carrier name
  --mcc <MCC>             Set carrier mcc
  --mnc <MNC>             Set carrier mnc
  --apn <APN>             Set carrier apn
  --user <USER>           Set apn user
  --pwd <PWD>             Set apn pwd

Examples:
  addapn --carrier CARRIER --mcc MCC --mnc MNC --apn APN --user USER --pwd PWD
  addapn --carrier CARRIER --mcc MCC --mnc MNC --apn APN
```

6.1.2 10/100m Ethernet

When you connect the gateway to the ethernet with wired cable, a eth0 interface is found. The gateway will get an ip in the lan. Please use ifconfig to check the ip. You could also use ping command to check the connection quality.

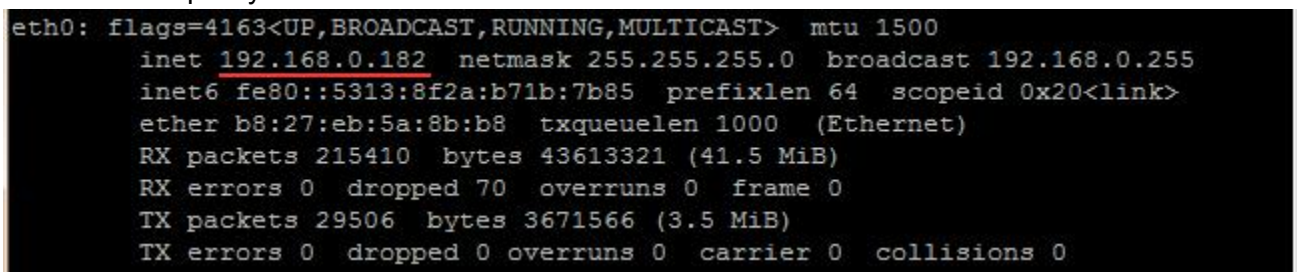


Figure 6-1 Eth0 interface

6.1.3 Networking priority choice

RHF2S208 could connect to the cloud server with wireless 4G LTE networking or wired 10/100m ethernet networking. And you could set the priority of the two modes on the web-based utility. The system would be reboot after you reconfigure the priority of the networking for backhaul, then you could use command route to check if the priority is changed or not.

```
rxhf@rhf2s208:~$ route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
default         0.0.0.0         0.0.0.0         U     0      0        0 ppp0
default         RT-AC5300-6BC0  0.0.0.0         UG    203    0        0 eth0
10.64.64.64     0.0.0.0         255.255.255.255 UH    0      0        0 ppp0
link-local      0.0.0.0         255.255.0.0     U     302    0        0 wlan0
192.168.0.0     0.0.0.0         255.255.255.0   U     203    0        0 eth0
192.168.8.0     0.0.0.0         255.255.255.0   U     0      0        0 wlan0
rxhf@rhf2s208:~$
```

Figure 6-2 Default route priority

```
rxhf@rhf2s208:~$ route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
default         RT-AC5300-6BC0  0.0.0.0         UG    203    0        0 eth0
10.64.64.64     0.0.0.0         255.255.255.255 UH    0      0        0 ppp0
link-local      0.0.0.0         255.255.0.0     U     302    0        0 wlan0
192.168.0.0     0.0.0.0         255.255.255.0   U     203    0        0 eth0
192.168.8.0     0.0.0.0         255.255.255.0   U     0      0        0 wlan0
```

Figure 6-3 Route priority changed

6.2 WiFi accessing

Please use your PC to scan the SSID RHF2S208_xxxxxx and connect to this WiFi device. The password is risinghfxxxxxx. The last 6 characters are same for both SSID and the password, which are the last 3 bytes of the MAC address. Then you can use 192.168.8.1 to access into the gateway on the web-based utility.

Figure 6-4 Scan WiFi SSID of RHF2S208

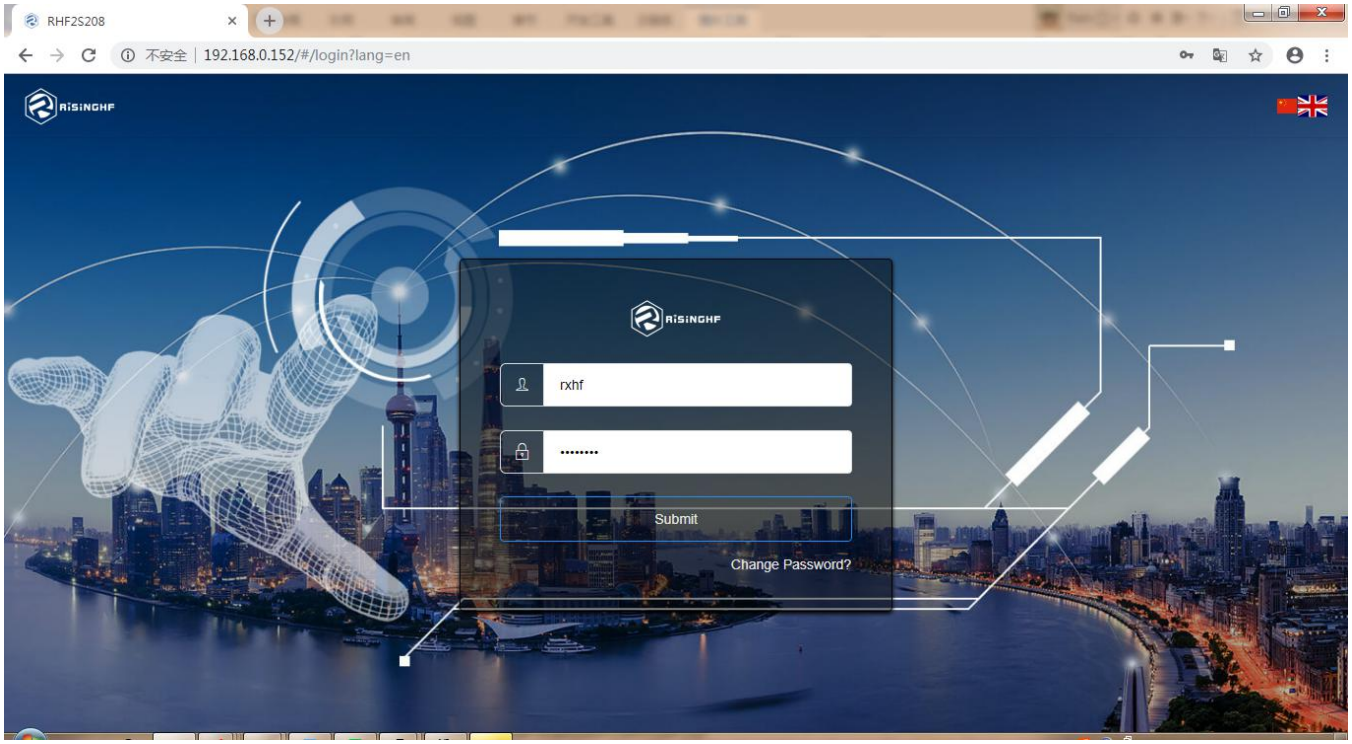


Figure 6-5 login page with wifi

You could also use command ifconfig to check the interface Wlan0.

```
wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.8.1  netmask 255.255.255.0  broadcast 192.168.8.255
        inet6 fe80::51f3:489a:17cf:184c  prefixlen 64  scopeid 0x20<link>
        ether 10:a4:be:d2:70:77  txqueuelen 1000  (Ethernet)
        RX packets 1668  bytes 231937 (226.5 KiB)
        RX errors 0  dropped 1  overruns 0  frame 0
        TX packets 1241  bytes 491420 (479.9 KiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

rxhf@rhf2s208:~$
```

Figure 6-6 Use command to check interface Wlan0

6.3 Use GPS module

RHF2S208 embedded on board GPS module (MAX-7Q), which is necessary for LoRaWAN Class B network.

Access gps module through **`/dev/serial1 device`**, default baud rate 9600.

Simply test GPS module by executing below commands:

```
sudo stty -F /dev/serial1 9600 -raw
cat /dev/serial1
```

It returns below messages:

```
$GPRMC,095521.00,V,,,,,,,100417,,,N*74
```

```
$GPVTG,,,,,,,,N*30

$GPGGA,095521.00,,,,,0,00,99.99,,,,,,*6C

$GPGSA,A,1,,,,,,,,,,,,,99.99,99.99,99.99*30

$GPGSV,4,1,13,01,70,146,,03,09,158,,07,75,257,,08,36,031,*77

$GPGSV,4,2,13,09,15,217,,11,80,034,,16,06,101,,17,14,253,*7D

$GPGSV,4,3,13,22,17,134,,23,05,183,,27,06,051,,28,20,314,*7B

$GPGSV,4,4,13,30,41,313,*4C

$GPGLL,,,,,095521.00,V,N*40
```

6.4 Temperature monitor

A temperature monitor is integrated inside your gateway. You could use both command sudo get_temp to get the temperature or download the tempmerature log with the web-based utility.

```
sudo get_temp
40.25 // value return ℃
```

The temperture will be refreshed every minutes and shown on the web-based utility. And you could also download the log which help you do some analysis when needed.

Figure 6-7 Temperture shown on the web

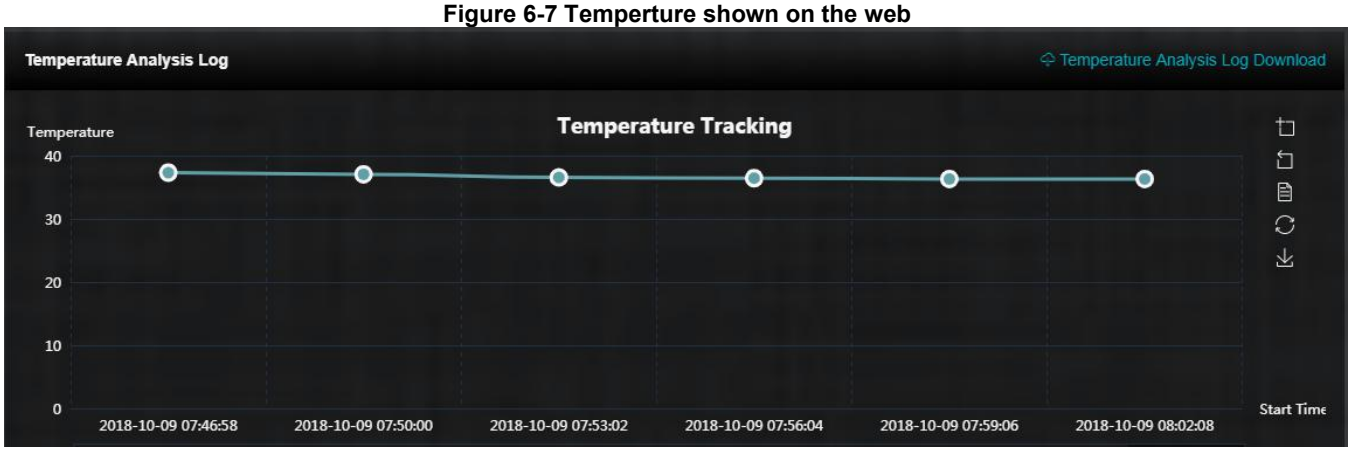


Figure 6-8 Temperature Log

6.5 RTC

The system time would be synchronized to UTC time with inside RTC. You can use command below to check the synchronized time.

```
sudo hwclock -r
2018-08-04 08:18:33.770069+0000 // synchronized time
```

6.6 Noise floor scanning

RHF2S208 integrate a noise analysis engine which could help noise pre-scan when operator want to do network optimization. Please access into the gateway on web-based utility when you want to do noise scanning. Please refer to 4.2.2.

Noise floor is a very important parameters you should know when you install your gateway in the field. To get a best coverage we want to have as low as possible noise. But actually there are lots of inteference or noise signal in the environment. Target average noise floor is about -110dBm±5dB, but less than -100dB is also acceptable.When the average noise floor is higher than -95dBm or more, changing operation band is suggested.

6.7 Remote Support with rssh service

RHF2S208 integrates a rssh service, which could enable RisingHF to access your RHF2S208 device remotely. It is closed by default. (Note: this function can be only used by RisingHF to support customer when necessary)

One time start rssh service (Invalid after restarting)

```
sudo systemctl restart rssh
```

Check log to get port number, execute below command and wait after a while:

```
sudo journalctl -f -n 50 -u rssh
```

Then it shows log like below, include "Allocated port …" message

When asking remote support, please send your screenshot to support@risinghf.com, and explain your trouble, RisingHF technical support will help you diagnose.

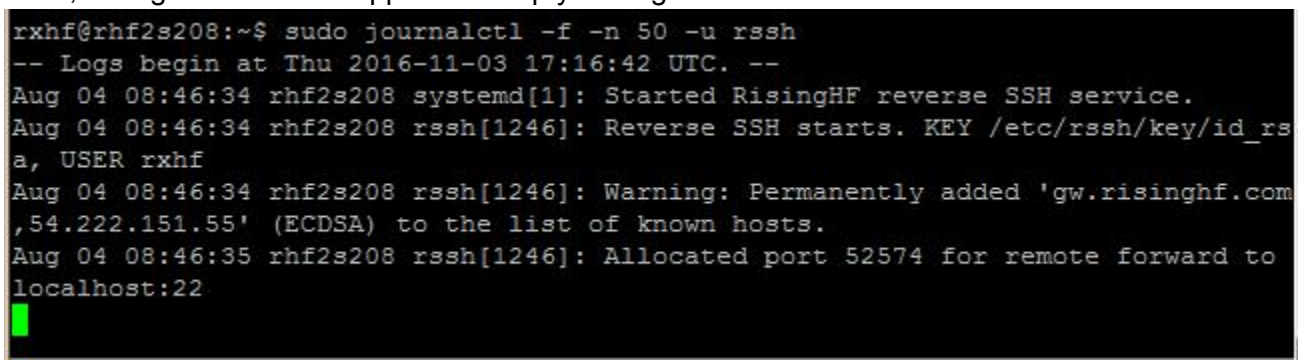


Figure 6-9 To get allocated port with rssh service

7 Factory Default Restore

7.1 Download image

Contact support@risinghf.com to get image address.

7.2 Bootloader Mode

Set RHF2S208 to entern Bootloader mode

1) Cut off RHF2S208 power
2) Connect Micro USB cable let RHF2S208 to connect with PC
3) Restart RHF2S208
4) Bootloader mode enabled

7.3 Program

Check online document to burn RHF2S208 firmware. Link

8 FAQ

Q1: Customized global_conf.json file can't be recognized by packet forwarder?
A1: Check below rule. Every object must end with comma, except the last member of a object or array. (// and /* */ are special comment format, no need consider it)

Q2: One gateway receives 2 same packets at almost the same time
A2: If the main channel receive packets at a high signal strength, in such case SX1301 chip is possible to receive mirror packet, server should compare the packets to filter the fake packet.
Semtech official explain: https://github.com/Lora-net/lora_gateway/issues/48

Q3: Gateway TX packet is received back
A3: SX1301+SX125x is full duplex chips with half duplex design. When gateway switch to TX mode the receiver is not closed, only switch is controlled, it is possible to receive such packet.

Q4: Can't dial in cellular network.
A4: Make sure below items OK.
1) lte service is enabled
2) SIM card is inserted correctly (Be careful about the SIM card direction, SIM direction mark outside)
3) SIM card is OK
4) APN configuration
If it is still an issue, please contact support@risinghf.com to get help. Remember to attach the log.

Q5: ADR issue when connecting with Loriot server
A5: Loriot server assumes that device enables 8 channels, if device has less channels it is possible to lead to the problem.

Q6: Fail to connect to a LoRaWAN server
A6: If you have succeded in connecting the gateway to a LoRaWAN server but you fail to connect to another server, please check if you have stopped previous service. Two competion service will make your gateway fail to connect to the target server.
If this is the first time to connect to the server, please make sure you have select the right operation band which should be compatible with the part number of your gateway.

Q7: Fail to connect to Loriot server
A7: Please check if you have selected the right radio front-end for your gateway when you register the gateway. Please select 434/470MHz (SX1255) for RHF2S208xxx-434 and RHF2S208xxx-470, and select 868/915MHz (SX1257) for RHF2S208xxx-868 and RHF2S208xxx-915.

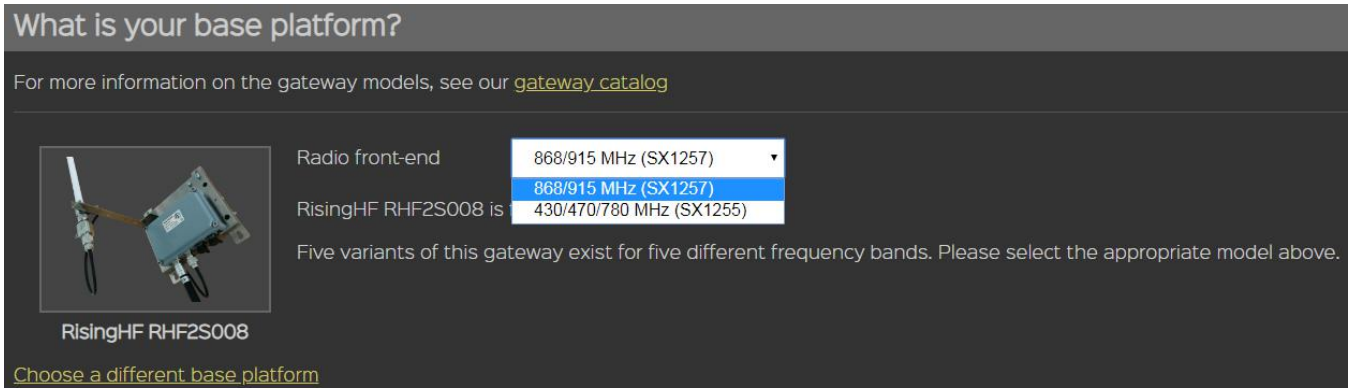


Figure 8-1 select the right radio front-end for your gateway when registered in Loriot server

Q8: Forget the WiFi password

A8: Please contact with support@risinghf.com to get help.

Q9: Can I use WiFi for networking backhaul

A9: No. WiFi is just for configuration and debugging at the moment.

Q10: PER is very bad

A10: Please check points below:

1) Make sure you havn't run two or more LoRaWAN service
2) Make sure you have configure the same channels for both gateway and nodes
3) Make sure there is no strong inteference or signal

Revision

V1.1 2018 -10-9

+update WiFi accessing password

+add APN configuration description

+update web-based utility

V1.0 2018 -07-28

+ Initial creation

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changes or modifications not expressly approved by the party responsible for compliance could void the user’ s authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

– Reorient or relocate the receiving antenna.

– Increase the separation between the equipment and receiver.

– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

– Consult the dealer or an experienced radio/TV technician for help.

FCC 20cm Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator & your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.