ST Nucleo LoRa GW_US915 User Guide

V2.7

LRWAN_GS_HF1

Document information

Info	Content
Keywords	*RisingHF, ST, Loriot, LoRa, Gateway, Nucleo*
Abstract	This document describes how to use ST Nucleo F7 LoRa Gateway to connect to Loriot server or others similar server which support packet forwarder mode.

Content

1 Introduction

The ST Nucleo LoRa GW is a kit based on Nucleo-F746ZG Board and ST Nucleo LoRa GW Module which is designed by RisingHF (www.risinghf.com). The ST Nucleo LoRa GW Module includes the high performance LoRa baseband processor SX1301 from Semtech corporation. With Loriot (https://www.loriot.io/) LoRaWAN cloud server or others server with packet forward service, it provides support bidirectional communication with end devices in both Class A and Class C of LoRaWAN protocol, and complete compliant with the LoRaWAN™ specifications V1.0.2.
This document describes how to setup a LoRaWAN GW based on the ST Nucleo LoRa GW and Loriot Cloud server.
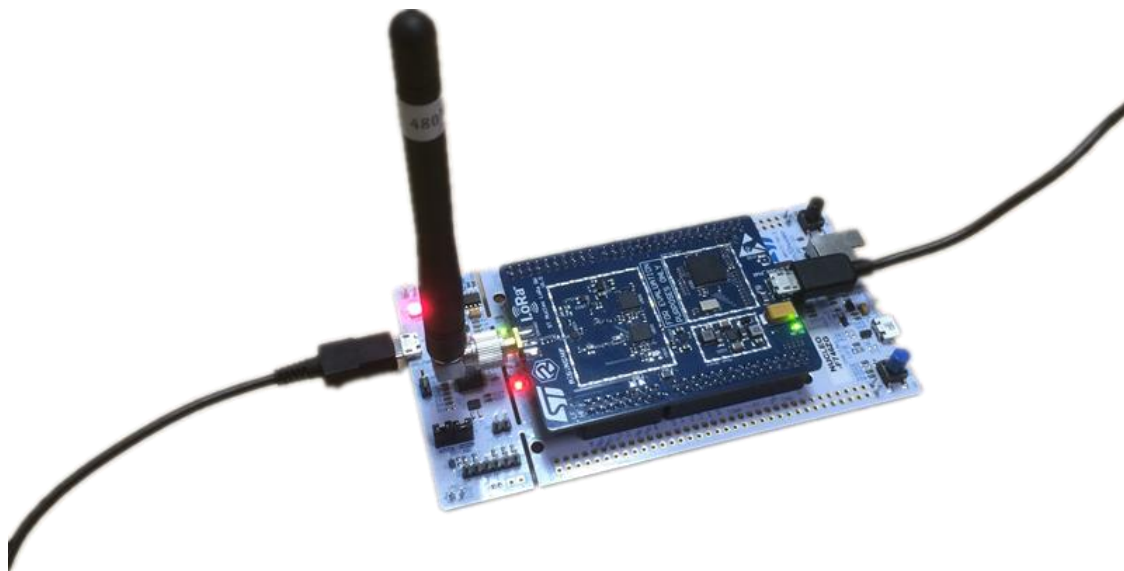
Figure 1-1 ST Nucleo LoRa GW

2 Features

ST Nucleo LoRa GW – HF: Cover 915MHz for US and Asia;
Programmable parallel demodulation paths;
LoRa demodulators and 1 GFSK demodulator embedded;
Automatic adaptive to spreading factor from SF12 to SF7 in each of 8 channels;
High performance:
-140dBm sensitivity @300bps ;
6dBm max output power without PA;
Single +5V supply;
Support LoRaWAN protocol, Class A and Class C;
Support Loriot Cloud Server;
Support Semtech Packet forwarder;
Support DNS;
Support NTP;
AT command interface to re-configure the parameters of the GW;
--change frequency plan;
--change IP of the GW;
--change MAC address of the GW;
--change Cloud server which support packet forwarder;
--to support public server or private server;
--change DNS address;
--change NTP server address;

3 System description

The ST Nucleo LoRa GW is composed of two boards:
- Nucleo-F746ZG Board
- ST Nucleo LoRa GW Module
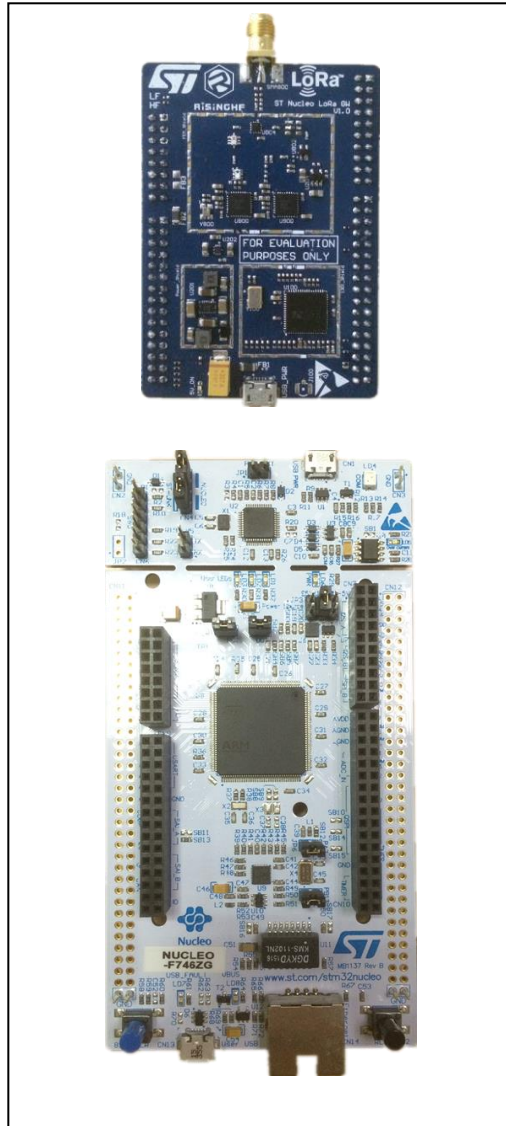
Figure 3-1 Nucleo F7 board and LoRa GW module

3.1 Nucleo-F746ZG Board

Information about the STM32 Nucleo board is available on www.st.com .
The NUCLEO-F746ZG board embeds an STM32F746ZG MCU, ARM® 32-bit Cortex®-M7 CPU with FPU, adaptive real-time accelerator (ART Accelerator™) and L1-cache: 4KB data cache and 4KB instruction cache, allowing 0-wait state execution from embedded Flash memory and external memories, frequency up to 216 MHz, MPU, 462 DMIPS/2.14 DMIPS/MHz (Dhrystone 2.1), and DSP instructions.

3.2 ST Nucleo LoRa GW Module

3.2.1 Pin description
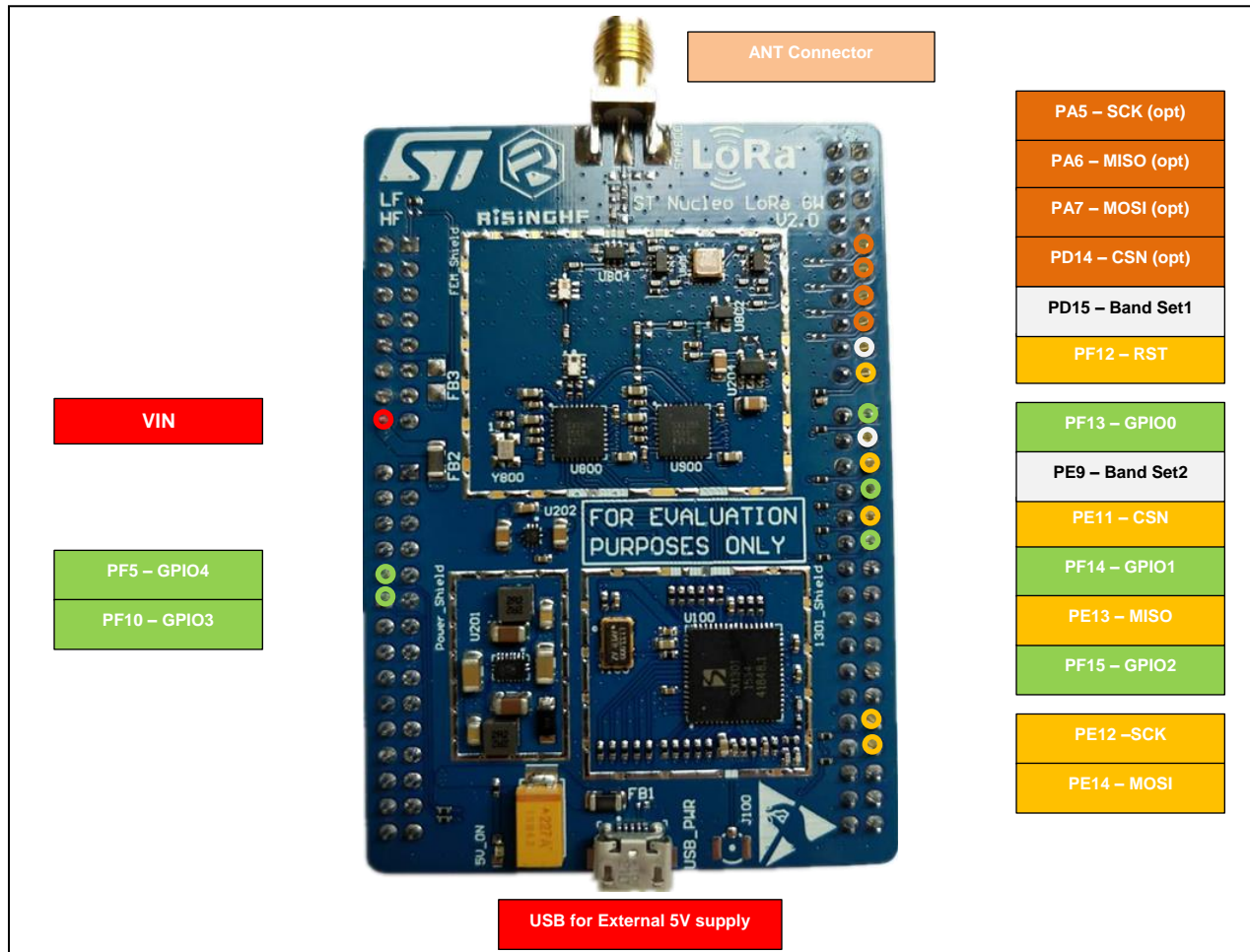
Figure 3-2 Pin description of ST Nucleo LoRa GW Module

Table 3-1 Pin description of ST Nucleo LoRa GW Module

PIN NAME	PIN Description
VIN	Power supply to Nucleo-F746ZG Board from External 5V
PF5/PD12/PC4/PB9 −GPIO4	GPIO4 from SX1301
PF10/PD13/PC5/PB8 −GPIO3	GPIO3 from SX1301
PF15−GPIO2	GPIO2 from SX1301
PF14−GPIO1	GPIO1 from SX1301
PF13−GPIO0	GPIO0 from SX1301
PE11−CSN	CSN of SPI for SX1301
PE13−MISO	MISO of SPI for SX1301
PE12−SCK	SCK of SPI for SX1301

PE14-MOSI	MOSI of SPI for SX1301
PE15-RST	Reset for SX1301
PD15-Band Set1	**ST Nucleo LoRa GW LF** PE9=0, PD15=1: Band EU433 PE9=1, PD15=0: Band CN470
PE9-Band Set2	**ST Nucleo LoRa GW HF** PE9=0, PD15=1: Band EU868 PE9=1, PD15=0: Band US915/AS915/AU915
PA5-SCK (opt)	Backup SCK of SPI for SX1301 (NO connection on board in default)
PA6-MISO (opt)	Backup MISO of SPI for SX1301 (NO connection on board in default)
PA7/PB5-MOSI (opt)	Backup MOSI of SPI for SX1301 (NO connection on board in default)
PD14-CSN(opt)	Backup CSN of SPI for SX1301 (NO connection on board in default)

3.2.2 HW architecture of ST Nucleo LoRa GW Module

The Module is composed of one pcs of SX1301 and two pcs of SX125x FEM. The SX1301 will be controlled and configured by ST Nucleo-F746ZG board via SPI. In this module, the external PA is removed refer to Semtech's reference design. The maximum output power will decrease to be about 6dBm for downlink. To get a wider operation bandwidth for evaluation, two parallel SAWs will be used instead of the single band SAW. Two RF switches are used to select the target band which would be used in the application. And the band selection is done automatically by software with frequency channel identification. Users no need to set it by manual.

4 System setup

4.1 Hardware connection

✧ Use a 5V 1A adapter to connect to the ST Nucleo LoRa GW Module on the top to power the system
✧ Connect the micro USB connector CN1 of the Nucleo board on the bottom to PC with a USB cable. This USB port could be used as FW download port or as Virtual COM port for message monitor or log checking.
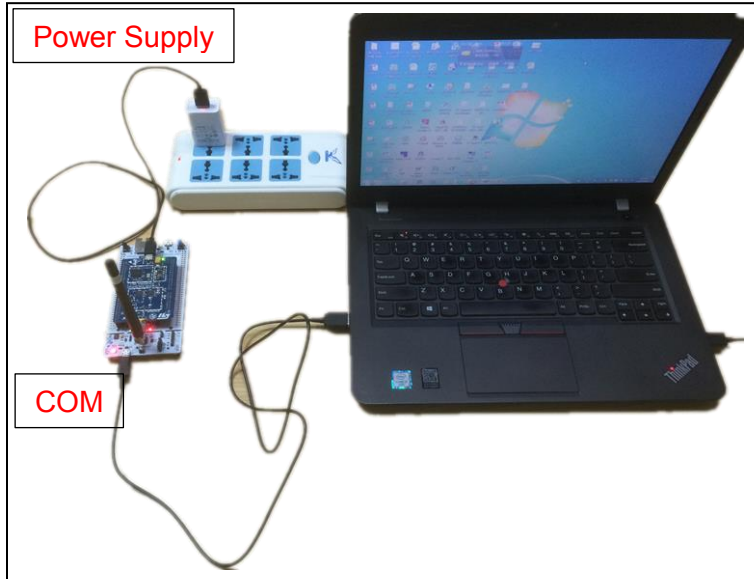
Figure 4-1 System setup

4.2 FW download

Below firmware is included in this package. You could download them in www.st.com.

■ st-nucleo-lora-gw-at-fw-v2.0.2.bin   //*EU868 by default* //

For the first time you get the kit, there will be a default configuration like below:
///
Restarting...
Ethernet started

```
 _/_/_/   _/_/_/   _/_/_/ _/_/_/  _/    _/  _/_/_/  _/   _/ _/_/_/
  _/   _/  _/   _/       _/  _/_/  _/ _/      _/   _/ _/
 _/_/_/    _/    _/_/    _/   _/ _/ _/ _/ _/_/ _/_/_/ _/_/_/
 _/   _/  _/       _/   _/   _/  _/_/ _/   _/ _/   _/ _/
_/    _/ _/_/_/ _/_/_/  _/_/_/ _/     _/  _/_/_/ _/   _/ _/
```

Powered by RisingHF & STMicroelectronics

```
          VERSION: 2.0.2, Dec  6 2016
             LOG: OFF
          AT ECHO: ON
         BAUDRATE: 115200bps
          MACADDR: 08:00:27:0A:48:3B
         ETHERNET: DHCP
             DNS1: 114.114.114.114
             DNS2: 8.8.8.8
       NTP SERVER: 1.ubuntu.pool.ntp.org
      EUI PADDING: {3, FF}, {4, FF}
       GATEWAY ID: 080027FFFF0A483B
          LORAWAN: Public
   LORAWAN SERVER: ap1.loriot.io
  UPLINK UDP PORT: 1780
 DOWNLINK UDP PORT: 1780
--------------------------------------------------------------------------
Concentrator starting...
Concentrator Radio A type SX1257
Concentrator Radio B type SX1257
Concentrator started (2926ms)
Ethernet starting...
Ethernet started
DHCP IP: 192.168.0.118
Downlink UDP Connected
Uplink UDP Connected
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
```

If you want to upgrade to a new firmware, please follow step below:
1) Connect ST Nucleo F746ZG to PC, then a mass storage device could be recognized.
2) Drag the target bin file and drop to the "NODE_F746ZG" device. When it is done, the firmware is programmed successfully.

4.3 Get Started

1. Set up the system and connect the hardware like Figure 4-1.
2. Program the GW with the right binary file with right frequency plan and right cloud server. Skip this step if the default configuration is acceptable for you.
3. Check Log with extraputty or some similar tools. Power up the system and reset the Nucleo board. The log with some useful information will be shown on window of the extraputty. Configuration is "115200, 8, n, 1".

Figure 4-2 log shown after reset Nucleo board

Some useful information needs to be known from this log, MAC Address, predefined channels and server address. All these configurations are configurable by user through AT command.

4. Register the GW to Loriot server with right MAC address. You need register an account first on the server before adding the GW. Please refer to step below for the details.

For example, the MAC address is "08:00:27:xx:xx:xx". Use below procedure to register gateway:

    (1) Log in to http://ap1.loriot.io server. If you want to connect to other server of Loriot, please change the server address.

    (2) Dashboard -> Gateway -> Add Gateway

    (3) Choose "Semtech Packet Forwarder"

    (4) Fill in the MAC address "08:00:27:xx:xx:xx"

    (5) Fill in the gateway location

    (6) Finish registration

5. Reset the GW. The ST Nucleo LoRa GW would connect to the server now.

4.4 Register Sensor Mote

Due to this document date, Loriot packet forwarder mode could support all the function, like uplink and downlink, ABP and OTAA mode, Class A and Class C LoRaWAN and so on.

Step below is an example to show how to register a device in ABP mode.

1. Dashboard -> Application -> SampleApp -> Manage devices.
2. Import Existing ABP
3. Fill in all necessary information includes DEVADDR, DEVEUI, APPSKEY, NWKSKEY, FCntUp, FCntDown.

Note: If you don't want that your device follow the strict sequence number checking rule, you could choose relaxed one to neglect it.
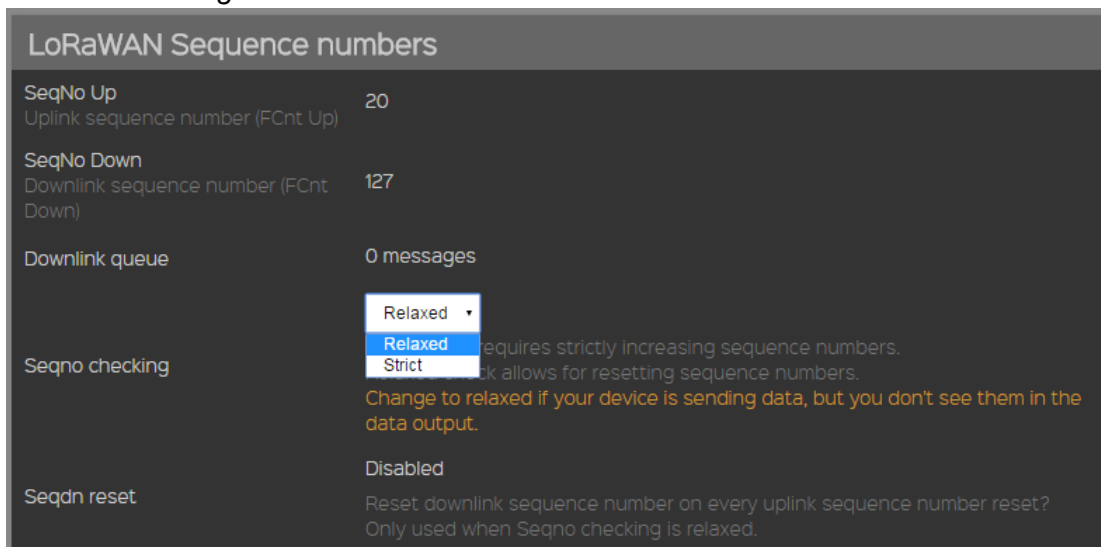
Figure 4-3 Change seqno checking to be relaxed if need

4.5 Cautions

For US915 frequency band, only US1 server of Loriot can support, for customers who need use US915 frequency band, please switch to us1.loriot.io. us1.loriot.io -915.bin firmware enables US915 Hybrid mode, CH0~7 are selected as the communication channels. Once your gateway is registered, please switch frequency plan to US915_CH0_7.
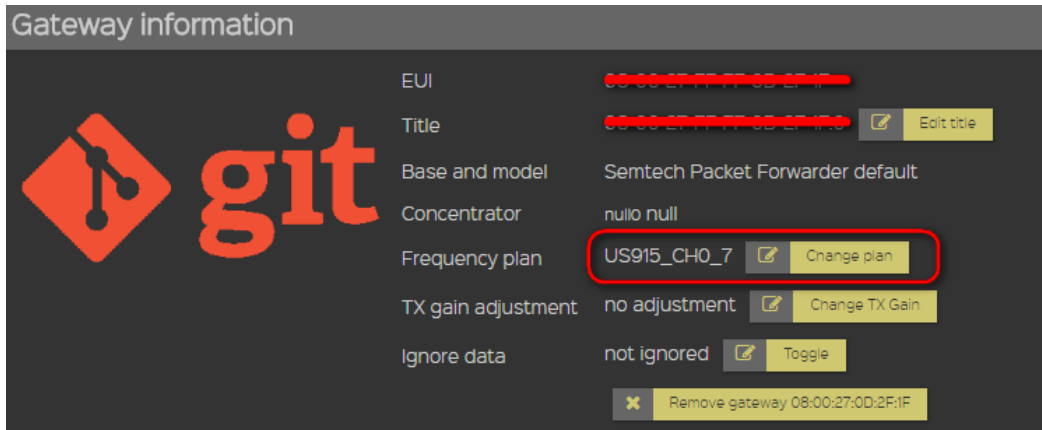
Figure 4-4 Frequency plan for US915 selection on Loriot server

5 AT Command

5.1 Rules

- **New configuration will be effected after restart**;
- All commands are case insensitive;
- All commands have response;
- Command length never exceeds total 528 characters;
- One valid AT Command must end with '\n' or '\r'
- <LF> means the newline character. <CR> means carriage return;
- UART configuration "115200, 8, n 1" (8 bits data, no parity, 1 stop bit);

5.2 Symbols

- =   --> Set value for command
- ?   --> Query
- :   --> Start a list input parameter
- +   --> Prefix of command
- ,   --> Separator of parameters
- Space --> Empty character, could be used to format command

NOTE: Use quote sign < " > to force input parameter with space

5.3 Format

All commands in this document are end with <CR><LF>. In order to facilitate the description, all <CR><LF> is intentionally omitted in this document.

5.3.1 Query

Use query command to check LoRaWAN modem configuration, such as channel configuration, ADR status, TX power, etc.

```
AT+COMMAND
AT+COMMAND?
AT+COMMAND=?
```

NOTE: Query format is available with every LoRaWAN supported command

5.3.2 Configure / Control

Uses configure/control command to set new configuration or control transaction.

```
AT+COMMAND=PARA0,PARA1,...,PARAx
```

5.3.3 Return

Return data is in format like "+CMD: DATA"

```
+COMMAND: DATA
```

5.4 Commands List

Table 5-1 Command List

Command	Comment
AT	Return "+OK"
HELP	Print help information
FDEFAULT	Reset to factory default settings
RESET	Software reset gateway
SYS	Check all configurations
VER	Get version
LOG	Turn on/off packet forwarder log
ECHO	AT command echo on/off
MAC	Set/Get gateway MAC Address
IP	DHCP/STATIC IP control
DNS	Set/Get DNS address
NTP	Set/Get NTP server address
EUI	MAC Address (EUI48) to Gateway ID (EUI64) padding
LORAWAN	LoRaWAN network selection (public / private)
PKTFWD	Packet forwarder server address and port setttings
CH	Packet forwarder channels
Baudrate	AT command and logging UART interface baud rate

5.5 Error Code

Table 5-2 Error code description for AT command

ERROR	Description
-1	Command format unknown, must be one of below formats: AT+CMD AT+CMD? AT+CMD=? AT+CMD=para0,para1,para2
-2	Unknown command, the command is not supported
-3	The number of parameters is not expected
-4	Invalid parameter
-5	Illegal character received
-6	Command is too long

5.6 Commands

5.6.1 AT

Use to test if connection of module is OK. This is a dummy command is just like other common "AT modules"

Format:

```
AT
```

Return:

```
+AT: OK
```

5.6.2 HELP

Return brief help information.

Format:

```
AT+HELP
```

Return:

```
+HELP: OK

        AT -- AT Ping

      HELP -- Print command list
                -> AT+HELP

  FDEFAULT -- Restore factory default
                -> AT+FDEFAULT

     RESET -- Reset gateway
                -> AT+RESET

       SYS -- Check device configuration
                -> AT+SYS

       VER -- Version
                -> AT+VER

       LOG -- Logging
                -> AT+LOG
                -> AT+LOG=ON
                -> AT+LOG=OFF

      ECHO -- AT echo on/ff
                -> AT+ECHO
                -> AT+ECHO=ON
                -> AT+ECHO=OFF

       MAC -- MAC address
                -> AT+MAC
                -> AT+MAC=mac_address

        IP -- Gateway DHCP/STATIC ip
                -> AT+IP
```

```
                        -> AT+IP=DHCP
                        -> AT+IP=STATIC,ip,netmask,gateway


            DNS -- DNS record
                        -> AT+DNS
                        -> AT+DNS=dns1,dns2


            NTP -- NTP server address
                        -> AT+NTP
                        -> AT+NTP=ntp_server_address


            EUI -- MACADDRESS (EUI48) to EUI64 padding
                        -> AT+EUI
                        -> AT+EUI=pos0,val0_hex,pos1,val1_hex


        LORAWAN -- LORAWAN Public/Private
                        -> AT+LORAWAN
                        -> AT+LORAWAN=PUBLIC
                        -> AT+LORAWAN=PRIVATE


         PKTFWD -- Packet forwarder server address and port
                        -> AT+PKTFWD
                        -> AT+PKTFWD=address,port_up,[port_down]


             CH -- Packet forwarder channels
                        -> AT+CH
                        -> AT+CH=0~7,freq,radio                 // Set multi SF LoRa channel
                        -> AT+CH=8,freq,radio,sf,bw             // Set standard LoRa channel
                        -> AT+CH=9,freq,radio                   // Set FSK channel
                        -> AT+CH=0~9,0                          // Turn off a channel
                        -> AT+CH=0~9,OFF                        // Turn off a channel
                        -> AT+CH=EU868|US915|EU433|CN780|AU915|AS923|KR920|CN470|IN866|CN470PREQUEL


       BAUDRATE -- UART baudrate
                        -> AT+BAUDRATE
                        -> AT+BAUDRATE=new_br                           // MAX 4000000bps
```

5.6.3 FDEFAULT

Reset LoRaWAN AT modem to factory default configuration. This command will trigger the gateway restart. Execute "AT+SYS" command to read configuration back.

Format:

```
AT+FDEFAULT
```

Return:

```
+FDEFAULT: OK
```

5.6.4 RESET

Use to reset the module. If module returns error, then reset function is invalid.

Format:

```
AT+RESET
```

Return:

```
+RESET: OK
```

5.6.5 SYS

Check all configurations.

Format:

```
AT+SYS
```

Return:

```
+SYS: OK
--------------------------------------------------------------------------------
            VERSION: 2.0.0, Nov 27 2016
                LOG: OFF
            AT ECHO: ON
           BAUDRATE: 115200bps
            MACADDR: 08:00:27:0D:2F:1F
           ETHERNET: DHCP
               DNS1: 114.114.114.114
               DNS2: 8.8.8.8
         NTP SERVER: 1.ubuntu.pool.ntp.org
        EUI PADDING: {3, FF}, {4, FF}
         GATEWAY ID: 080027FFFF0D2F1F
            LORAWAN: Public
     LORAWAN SERVER: 54.222.151.55
   UPLINK UDP PORT: 1680
 DOWNLINK UDP PORT: 1680
--------------------------------------------------------------------------------
```

5.6.6 VER

Get firmware version

Format:

```
AT+VER
```

Return:

```
+VER: 2.0.0, Nov 27 2016
```

5.6.7 LOG

Packet forwarder log control.

Format:

```
AT+LOG
AT+LOG=ON
AT+LOG=OFF
```

Return:

```
+LOG: ON
+LOG: OFF
```

5.6.8 ECHO

AT command echo control.

Format:

```
AT+ECHO
AT+ECHO=ON
AT+ECHO=OFF
```

Return:

```
+ECHO: ON
+ECHO: OFF
```

5.6.9 MAC

Set and get gateway MAC address
Format:

```
AT+MAC
AT+MAC=001122334455
```

Return:

```
+MAC: 08:00:27:0D:2F:1F
```

5.6.10 IP

DHCP and static IP settings
Format:

```
AT+IP
AT+IP=DHCP
AT+IP=STATIC,IP,NETMASK,GATEWAY
```

Return:

```
+IP: DHCP
+IP: STATIC, 192.168.15.200, 255.255.255.0, 192.168.15.1
```

Static IP setting example:

```
AT+IP=STATIC, 192.168.15.200, 255.255.255.0, 192.168.15.1
+IP: STATIC, 192.168.15.200, 255.255.255.0, 192.168.15.1
```

5.6.11 DNS

Set DNS record
Format:

```
AT+DNS
AT+DNS=dns1,dns2
```

Return:

```
+DNS: dns1,dns2
```

Example:

```
AT+DNS=8.8.8.8,8.8.4.4
+DNS: 114.114.114.114, 8.8.8.8
```

Free DNS server list:

Table 5-3 DNS server list

Provider	Primary DNS Server	Secondary DNS Server
Google	8.8.8.8	8.8.4.4
DNS.WATCH	84.200.69.80	84.200.70.40
Comodo Secure DNS	8.26.56.26	8.20.247.20
OpenDNS Home5	208.67.222.222	208.67.220.220
114DNS	114.114.114.114	114.114.115.115
Alibaba DNS	223.5.5.5	223.6.6.6
Norton DNS	198.153.192.1	198.153.194.1

Refer below link for latest information:

https://www.lifewire.com/free-and-public-dns-servers-2626062

5.6.12 NTP

Set NTP server address
Format:

```
AT+NTP
AT+NTP=ntp_server_address
```

ntp_server_address must be less than 40 bytes

Return:

```
+NTP: "1.ubuntu.pool.ntp.org"
```

5.6.13 EUI

EUI48 to EUI64 padding.
Format:

```
AT+EUI
AT+EUI=pos0,val0_hex,pos1,val1_hex                // pos 0~7, val 00~FF
```

Return:

```
+EUI=pos0,val0_hex,pos1,val1_hex,gw_id
```

Example 1:

```
AT+MAC
+MAC: 00:11:22:33:44:55
AT+EUI=0,FF,1,FE
+EUI: 0, FF, 1, FE, FFFE001122334455
```

Example 2:

```
AT+MAC
+MAC: 00:11:22:33:44:55
AT+EUI=0,AA,7,99
+EUI: 0, AA, 7, 99, AA00112233445599
```

5.6.14 LORAWAN

Choose LORAWAN network type (public or private), this will influence LoRa syncword. Public to set sync word 0x34, private to set sync word to 0x12. Try this command only when you know exactly what this is.
Format:

```
AT+LORAWAN
AT+LORAWAN=PRIVATE
AT+LORAWAN=PUBLIC
```

Return:

```
+LORAWAN: PUBLIC
+LORAWAN: PRIVATE
```

5.6.15 PKTFWD

Set packet forwarder server address and port (up and down).

Format:

```
AT+PKTFWD
AT+PKTFWD=address,port_up,[port_down]
```

Return:

```
AT+PKTFWD=address, port_up, port_down
```

Example:

```
AT+PKTFWD=iot.semtech.com,1680,1680
+PKTFWD: iot.semtech.com, 1680, 1680
```

5.6.15.1 Available Servers

Table 5-4 Available Cloud servers list

Address	Uplink Port	Downlink Port	Supplier
Iot.semtech.com	1680	1680	Semtech
us01-iot.semtech.com	1780	1780	Semtech
cn1.loriot.io	1780	1780	Loriot
ap1.loriot.io	1780	1780	Loriot
au1.loriot.io	1780	1780	Loriot
eu1.loriot.io	1780	1780	Loriot
sa1.loriot.io	1780	1780	Loriot
us1.loriot.io	1780	1780	Loriot

5.6.16 CH
Set packet forwarder channels.
Format:

```
AT+CH=0~7,freq,radio          // Set multi SF LoRa channel
AT+CH=8,freq,radio,sf,bw      // Set standard LoRa channel
AT+CH=9,freq,radio            // Set FSK channel
AT+CH=0~9,0                   // Turn off a channel
AT+CH=0~9,OFF                 // Turn off a channel
AT+CH=band                    // Set to predefined channel plan
```

Return:

```
+CH: 0~7, freq, radio, SF7/SF12, BW125KHz (LORA_MULTI_SF)
+CH: 8, freq, radio, SFx, BWxxxKHz      (LORA_STANDARD)
+CH: 9, freq, radio, 50Kbps             (FSK)
```

5.6.16.1 Details about SX1301 Channels
The ST Nucleo LoRa GW supports maximum 10 channels, all of the channels are configurable. Channel 0 to 7 are Multiple Spread Factor channels, bandwidth of which are fixed 125KHz, channel 8 is standard LoRa channels which could supports 125KHz, 250KHz and 500KHz bandwidth, channel 9 is FSK channel 50Kbps (RXBW 125KHz).

Channel	Radio	Type	Bandwidth	Data Rate
0-10	A/B	LoRa Standard	500KHz	SF7 ~ SF12 (optional)

The ST Nucleo LoRa GW integrates two radio frequency front end. Which is identified as radio A and B, the all 10 channels could be freely configured to use either of the two radios (A/B).

Each of the Radio could cover maximum 1.1MHz (500KHz) analyze bandwidth, so when set new channels, please arrange the channels to radio carefully, so that bandwidth of radio is less than 1.1MHz. According to lora_gateway library v4.1.1, SX125x bandwidth limitation is described as below table:

5.6.16.2 Predefined Channel Plan
Use "AT+CH=band" command to set predefined channel. Available bands are EU868, US915, EU433, CN780, AU915, AS923, KR920, CN470, CN470Prequel and IN866.
The frequency unit is MHz.

CH	US915
0	902.5
1	905
2	907.5
3	910
4	912.5
5	915
6	917.5
7	920
8	922.5
9	925

10	927.5

5.6.17 Baudrate

Set and get UART baudrate
Format:

```
AT+BAUDRATE
AT+BAUDRATE=new_br                    // Maximum: 4Mbps
```

Return:

```
+BAUDRATE: 115200
```

5.7 Button

ST Nucleo LoRa GW blue button can be used to restore to factory default in case of UART baudrate is lost. Function:

Table 5-5 Button function description

Blue Button	Function
Click	Click button to print the system configuration (same as AT+SYS)
Long press	Press and hold the button (about 6s) until 3 LEDs (RED, BLUE, GREEN) start blinking will restore the configuration to factory default. (same as AT+FDEFAULT)

6 Demo Page

When you succeed in setting up both the Nucleo LoRa GW and Sensor mote, you could check link below for special application DEMO for STM device. Please use your own socket id instead of the part which is marked in red below.

https://ap1.loriot.io/apps/stm/index.html?id=BE7A0089&token=LCTGG3rg8oczTGmw1aYHtg
https://cn1.loriot.io/apps/stm/index.html?id=BE7A0089&token=LCTGG3rg8oczTGmw1aYHtg

Figure 6-1 STM Application on Loriot Server

7 Others information for reference

7.1 Power supply and consumption

7.1.1 Power supply

The power supply +5V will be injected into the system via micro USB connector of the Nucleo shield (blue board) from an external adapter. The max rated current of this adapter is suggested to be more than 1A. The Nucleo board (white board) should be powered by the supply from the shield board. So the Nucleo board (white board) would be power supplied by VIN (Pin15 of CN8 on the Nucleo F7 board).
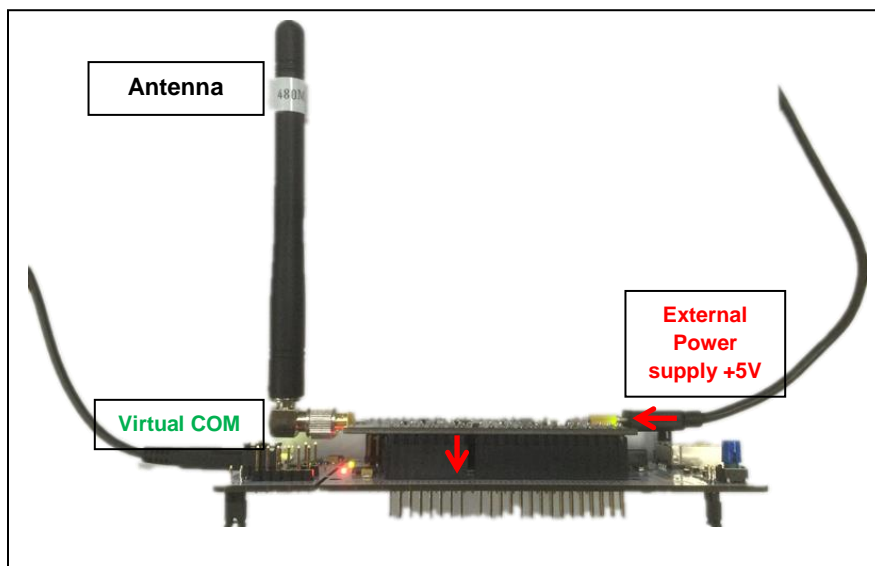

Figure 7-1 Side View of the Nucleo LoRa GW Demo

When STM32 Nucleo-144 board is power supplied by VIN, the jumper configuration must be the following:
- Jumper JP3 on pin 5 and pin 6 for VIN
- Jumper JP1 OFF

7.1.2 Power consumption

Table 7-1 below shows the current consumption of the Nucleo shield module in different mode. The maximum current would be almost 360mA when both uplink and downlink are on.

Table 7-1 Power consumption of ST LoRa Nucleo GW Module

Band	Standby consumption	Current @TX max OP	Consumption @8 CH RX Only	RX/TX ON Max Current
HF	39mA	175mA	330mA	364mA

For the consumption of the Nucleo F746ZG board, please refer to the manual from ST. The max current of this board would be more than 200mA depend on the source code and peripheral interface used.

7.2 LED status

On the GW shield (Blue board), there is only one LED to show power supply.

- ➢ 5V_ON (Green): When there is external power supply +5V to the system from adapter, this LED will be ON.

On the Nucleo F746ZG board (White board), there will be 3 LEDs will be used in the demo:

- ➢ LD3 (Red): ON -> ST LoRa GW board is detected, OFF -> ST LoRa GW board is removed
- ➢ LD2 (Blue): Blink when Packet is received
- ➢ LD1 (Green): Reserved

For others LEDs used on the Nucleo F746ZG board, please refer to the manual of the Nucleo board from ST.

7.3 RF performance measurement

Table 7-2 below shows the RF performance in conductive test. Please note that, there is no external PA refer to Semtech's reference design, so the RF power is output from SX125x FEM directly. The maximum output power normally would be 6-7dBm type in different band.

Table 7-2 RF performance

Band	Frequency	TX op max/dBm	Harmonic/dBm	Sensitivity/dBm	
HF	915MHz	6dBm type	Below -56dBm	SF12 125kHz	-140dBm
				SF11 125kHz	-137dBm
				SF10 125kHz	-134dBm
				SF9 125kHz	-131dBm
				SF8 125kHz	-128dBm
				SF7 125kHz	-124dBm

8 Reference documents

a) UM1974-User manual, STM32 Nucleo-144 board; STMicroelectronics
b) LoRaWAN™ Specification 1.0.2; LoRa Alliance
c) Data sheet of STM32F745xx/STM32F746xx, ARM®-based Cortex®-M7 32b MCU+FPU, 462DMIPS, up to 1MB Flash/320+16+ 4KB RAM, USB OTG HS/FS, ethernet, 18 TIMs, 3 ADCs, 25 com itf, cam & LCD, Datasheet - production data; STMicroelectronics
d) Data sheet of SX1301; Semtech

Revision

V1.0 2016-06-22
        + First version

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.
(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
NOTE: The manufacturer is not responsible for any radio or TV interference caused by unauthorized
modifications to this equipment. Such modifications could void the user's authority to operate the equipment.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

*This radio transmitter [8976A-GSHF1] has been approved by Innovation, Science and Economic
Development Canada to operate with the antenna types listed below, with the maximum permissible gain
indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated
for any type listed are strictly prohibited for use with this device.*
 Dipole antenna, Antenna gain: -2dBi, Impedance: 50 Ω

This device complies with RSS-247 of Industry Canada.
Operation is subject to the following two conditions:
this device may not cause harmful interference, and
this device must accept any interference received, including interference that may cause undesired
operation.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de
licence. L'exploitation est autorisée aux deux conditions suivantes :
(1) l'appareil ne doit pas produire de brouillage, et
(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est
susceptible d'en compromettre le fonctionnement.

Cet équipement est conforme aux limites d'exposition aux rayonnements de la IC établies pour unenvironnement non contrôé. Cet équipement doit être installé et fonctionner à au moins 5mm de distance d'un radiateur ou de votre corps.

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