Getting started with the P-NUCLEO-LRWAN2 and P-NUCLEO-LRWAN3 starter packs

Introduction

This user manual describes how to get started with the P-NUCLEO-LRWAN2 and P-NUCLEO-LRWAN3 starter packs. Hardware and software setups are discussed in detail, together with the setup of supported network and application servers.

The P-NUCLEO-LRWAN2 starter pack supports the higher frequency bands (868 MHz and 915 MHz). It includes:

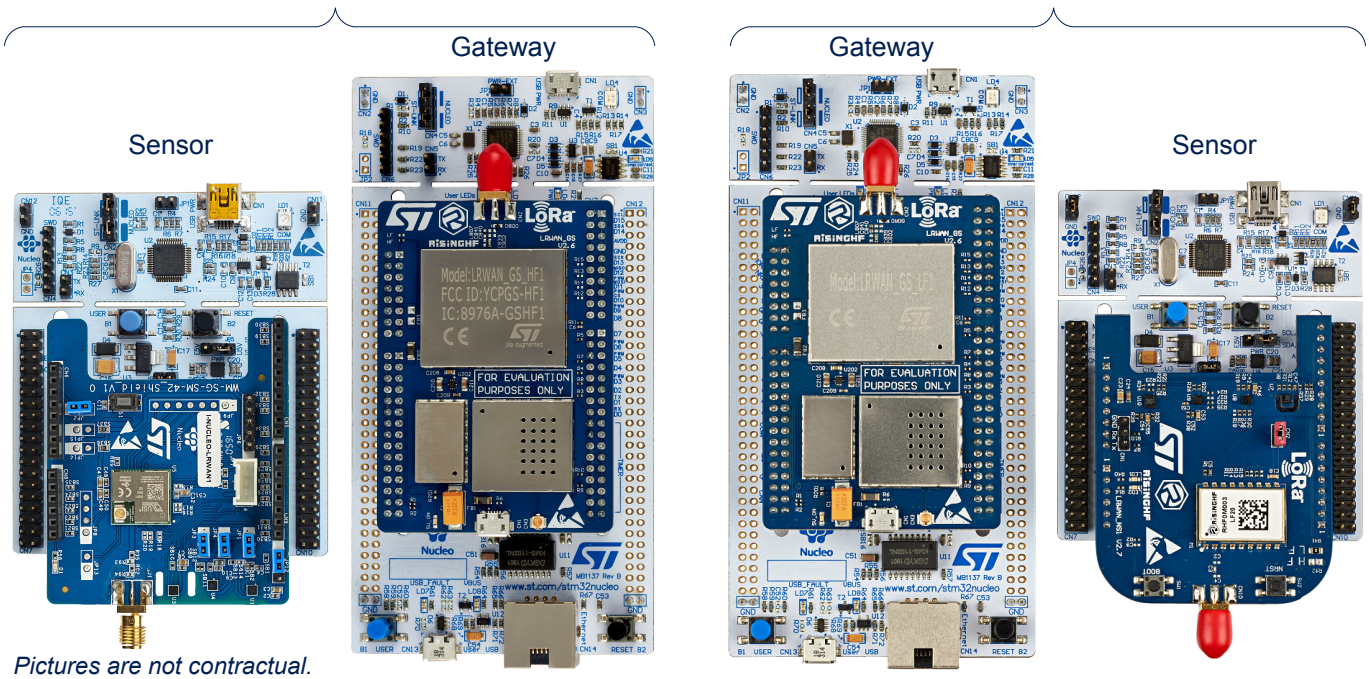
- A sensor node based on STMicroelectronics NUCLEO-L073RZ Nucleo board and USI® I-NUCLEO-LRWAN1 LoRa® expansion board with antenna
- A LoRaWAN® gateway based on STMicroelectronics NUCLEO-F746ZG Nucleo board and RisingHF LRWAN_GS_HF1 expansion board with antenna

The P-NUCLEO-LRWAN3 starter pack supports the lower frequency bands (433 MHz and 470 MHz). It includes:

- A sensor node based on STMicroelectronics NUCLEO-L073RZ Nucleo board and RisingHF LRWAN_NS1 LoRa® expansion board
- A LoRaWAN® gateway based on STMicroelectronics NUCLEO-F746ZG Nucleo board and RisingHF LRWAN_GS_LF1 expansion board
- Antennas

This user manual also describes the I-CUBE-LRWAN STM32Cube Expansion Package for the sensor node, and the gateway binary software.

Figure 1. P-NUCLEO-LRWAN2 and P-NUCLEO-LRWAN3 - LoRaWAN® sensors and gateways



Pictures are not contractual.

1 P-NUCLEO-LRWAN2 starter pack overview

Figure 2 shows an overview of the P-NUCLEO-LRWAN2 starter pack, which includes a LoRaWAN® sensor device and gateway as well as the antennas.

Instructions at the back of the insert card guide the users on how to power up and configure the sensor device and gateway and setup the network.

The starter pack is configured to use the EU868 frequency band with the sensor device in OTAA mode and the gateway forwarding the packets to Loriot EU1 server. The pack is user configurable by firmware and by AT commands.

Figure 2. STM32 Nucleo LoRaWAN® development kit (P-NUCLEO-LRWAN2 starter pack)

The antennas in this product are assembled and locked with the boards, which was not the case in earlier versions. They do not have to be removed by users to comply with FCC regulations. The current product packaging is adapted to this configuration. Visuals and illustrations in the related technical documents may differ from the current product version.

1.1 Sensor hardware overview

The P-NUCLEO-LRWAN2 LoRaWAN® sensor device has the following key features:

Main board

- NUCLEO-L073RZ development board (from STMicroelectronics)
  - STM32L073RZT6 Arm® Cortex®-M0+ ultra-low-power MCU at 32 MHz with 192-Kbyte Flash memory, 20-Kbyte SRAM and 6-Kbyte data EEPROM
  - 1 user LED
  - 1 user and 1 reset push-buttons
  - 32.768 kHz crystal oscillator
  - On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, Virtual COM port, and debug port
  - Board connectors
    - Mini-B USB connector for the ST-LINK
    - ARDUINO® Uno V3 expansion connector
    - ST morpho extension pin headers for full access to all STM32 I/Os

RF module and sensor expansion board

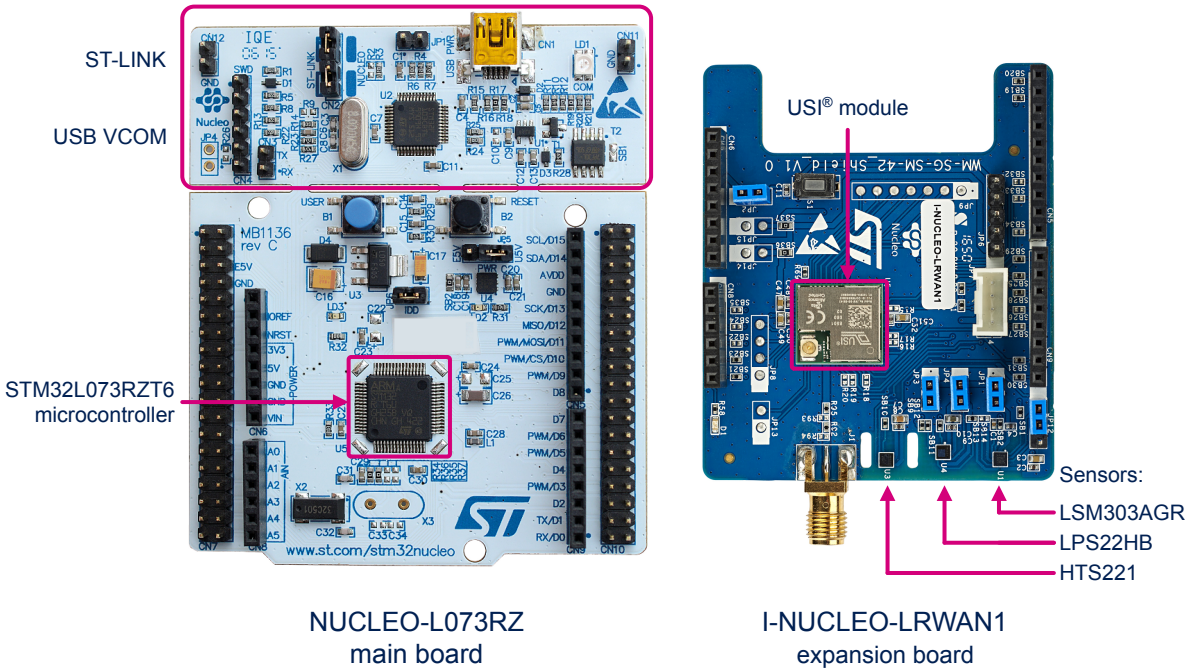
- I-NUCLEO-LRWAN1 LoRa® HF band (868/915/923 MHz) sensor expansion board (from USI®)
  - USI® WM-SG-SM-42 low-power long-range LoRaWAN® module, based on the STM32L052 MCU and Semtech SX1272 transceiver
  - STMicroelectronics HTS221 temperature and humidity sensor
  - STMicroelectronics LPS22HB pressure sensor
  - STMicroelectronics LSM303AGR accelerometer and gyroscope sensor

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.
All other trademarks are the property of their respective owners.

arm

Figure 3 shows the two boards in the P-NUCLEO-LRWAN2 LoRaWAN® sensor device.

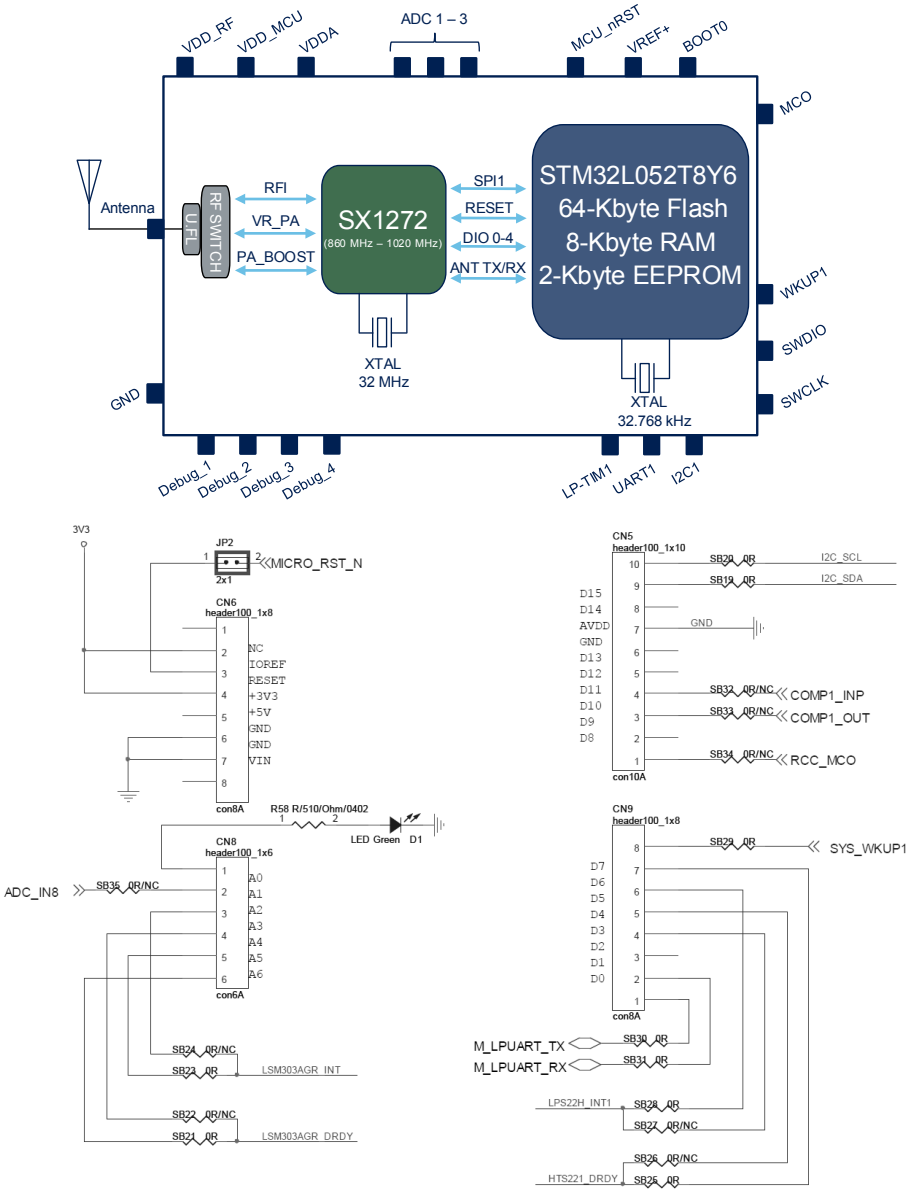
Figure 3. STM32 Nucleo LoRaWAN® sensor device (P-NUCLEO-LRWAN2)



1.1.1 I-NUCLEO-LRWAN1 LoRa® HF band and sensor expansion board

The I-NUCLEO-LRWAN1 is supplied by a third party (USI®). For complete and latest information, refer to the third party GitHub page https://github.com/USILoRaModule/USI_I-NUCLEO-LRWAN1.

Figure 4. I-NUCLEO-LRWAN1 block diagram and connectors



Note: The Nucleo board communicates with the expansion board via the STM32 UART (PA2, PA3). The following modifications are applied to the Nucleo board:

- *SB62 and SB63 are closed*
- *SB13 and SB14 are opened to disconnect the STM32 UART from ST-LINK*

1.2 Gateway hardware overview

The P-NUCLEO-LRWAN2 LoRaWAN® gateway shown in Section 1.2 has the following key features:

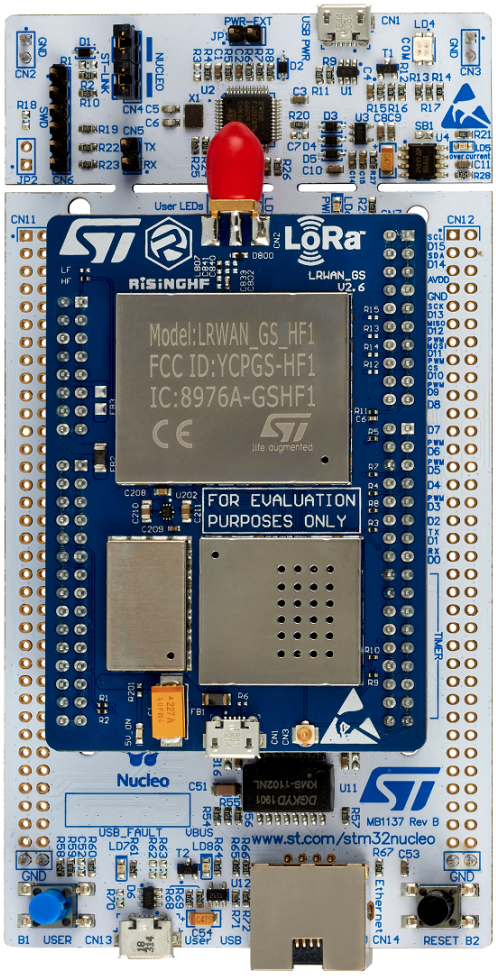
Gateway main board

- NUCLEO-F746ZG development board (from STMicroelectronics)
  - STM32F746ZGT6 Arm® Cortex®-M7 high-performance MCU at 216 MHz with 1-Mbyte Flash memory and 320-Kbyte SRAM
  - 3 user LEDs
  - 1 user and 1 reset push-buttons
  - Ethernet compliant with IEEE-802.3-2002
  - USB OTG Full Speed or device only
  - 32.768 kHz crystal oscillator
  - On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, Virtual COM port, and debug port
  - Board connectors
    - Micro-AB USB connector for the ST-LINK
    - ST Zio expansion connector including ARDUINO® Uno V3
    - ST morpho extension pin headers for full access to all STM32 I/Os
    - USB with Micro-AB
    - Ethernet RJ45

Gateway expansion board

- LRWAN_GS_HF1 LoRa® HF band (868/915/923 MHz) gateway expansion board (from RisingHF)
  - SX1301/SX1257 HF baseband data concentrator and transceiver
    - Automatically adaptive to spreading factor from SF12 to SF7 in each of 8 channels
    - High sensitivity down to -140 dBm at 300 bit/s
    - 6 dBm output power
    - Support LoRaWAN® protocol Class A and Class C
    - Support Semtech packet forwarder
    - Support DNS and NTP

Figure 5. **STM32 Nucleo LoRaWAN® gateway (P-NUCLEO-LRWAN2)**



Gateway additional features

- Programmable parallel demodulation paths
- LoRa® demodulators and 1 GFSK demodulator embedded
- Single +5 V supply
- AT command interface to re-configure the parameters of the gateway
  - change frequency plan
  - change IP of the gateway
  - change MAC address and ID of the gateway
  - change network server that supports Semtech packet forwarder
  - set to use public server or private server
  - change DNS address
  - change NTP server address

1.2.1 Gateway expansion board

The LRWAN_GS_HF1 gateway expansion board shown in Figure 6 is designed by RisingHF (www.risinghf.com). It includes a Semtech SX1301 digital baseband circuit integrating the LoRa® concentrator, Semtech SX1257 HF front-end transceiver module, and two SAW filters to achieve a wider bandwidth range (868 MHz to 915 MHz). The expansion board is controlled by the NUCLEO-F746ZG via the SPI interface.

The gateway expansion board includes also an external +5 V power supply circuitry, which powers both the gateway expansion board and NUCLEO-F746ZG development board. The NUCLEO-F746ZG is powered via pin VIN (Pin 15 of connector CN8 on the Nucleo board).

For more details, refer to [3].

Figure 6. Gateway expansion board (P-NUCLEO-LRWAN2)

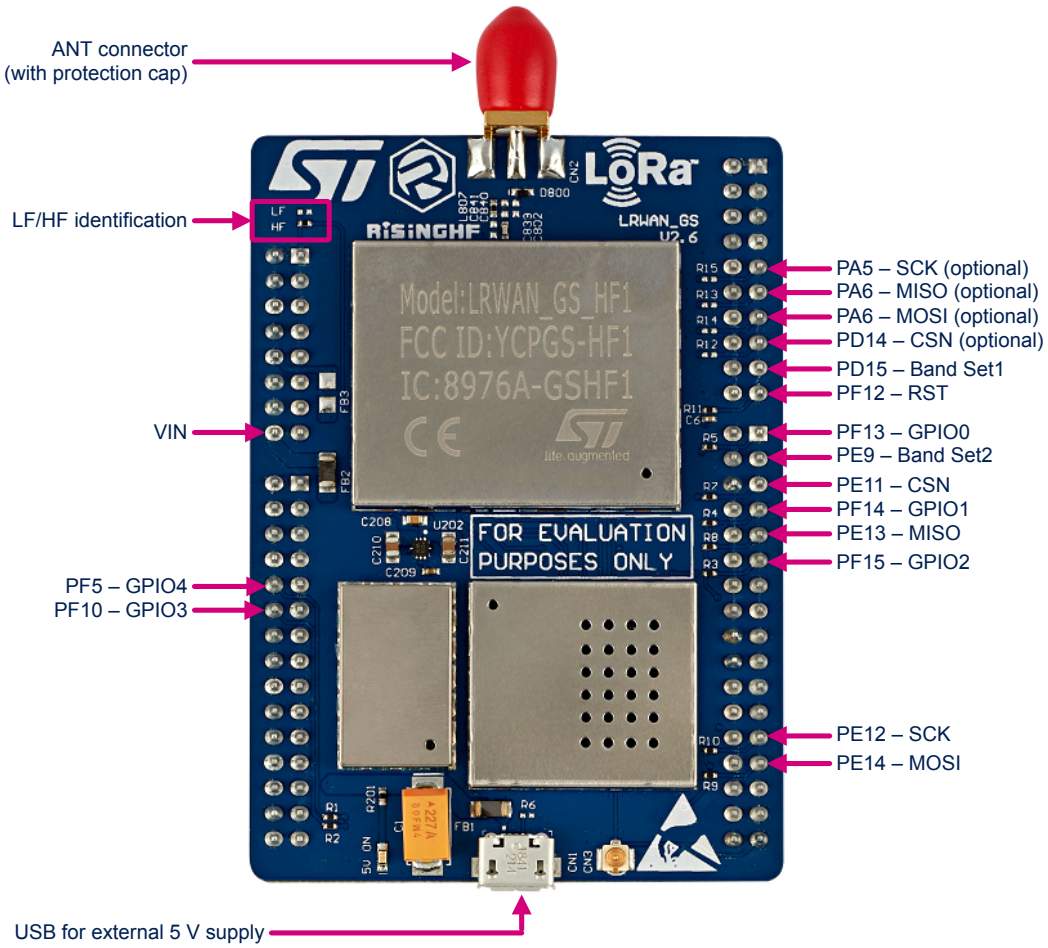


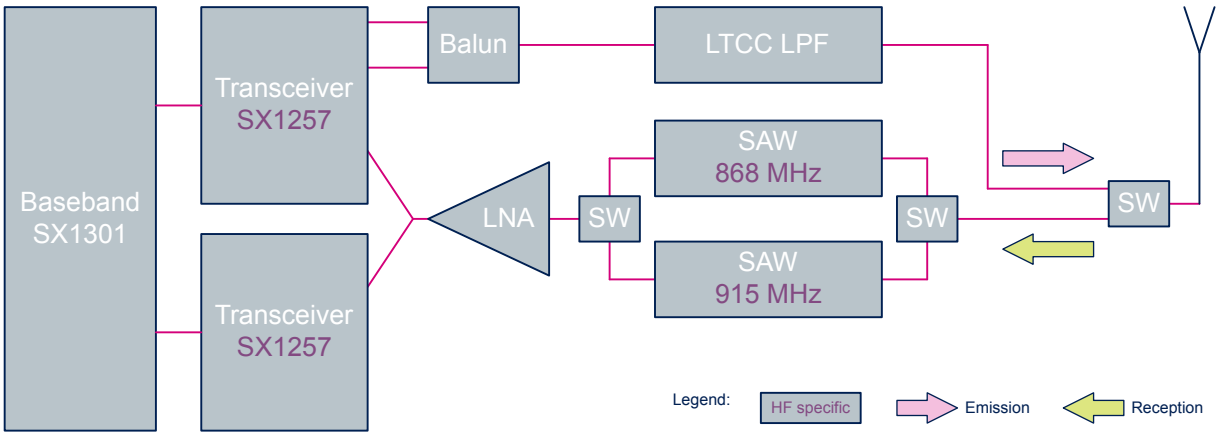
Table 1. P-NUCLEO-LRWAN2 gateway expansion board pins description

Pin name	Pin description
VIN	Power supply to NUCLEO-F746ZG from external 5 V
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

Pin name	Pin description
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 HF • PE9=0, PD15=1: Band EU868 • PE9=1, PD15=0: Band US915/AS915/AU915
PE9-Band Set2	
PA5-SCK (optional)	Backup SCK of SPI for SX1301 (no connection on board in default)
PA6-MISO (optional)	Backup MISO of SPI for SX1301 (no connection on board in default)
PA7/PB5-MOSI (optional)	Backup MOSI of SPI for SX1301 (no connection on board in default)
PD14-CSN (optional)	Backup CSN of SPI for SX1301 (no connection on board in default)

Figure 7 presents the architecture of the LRWAN_GS_HF1 gateway expansion board.

Figure 7. Hardware architectures of the P-NUCLEO-LRWAN2 gateway expansion board



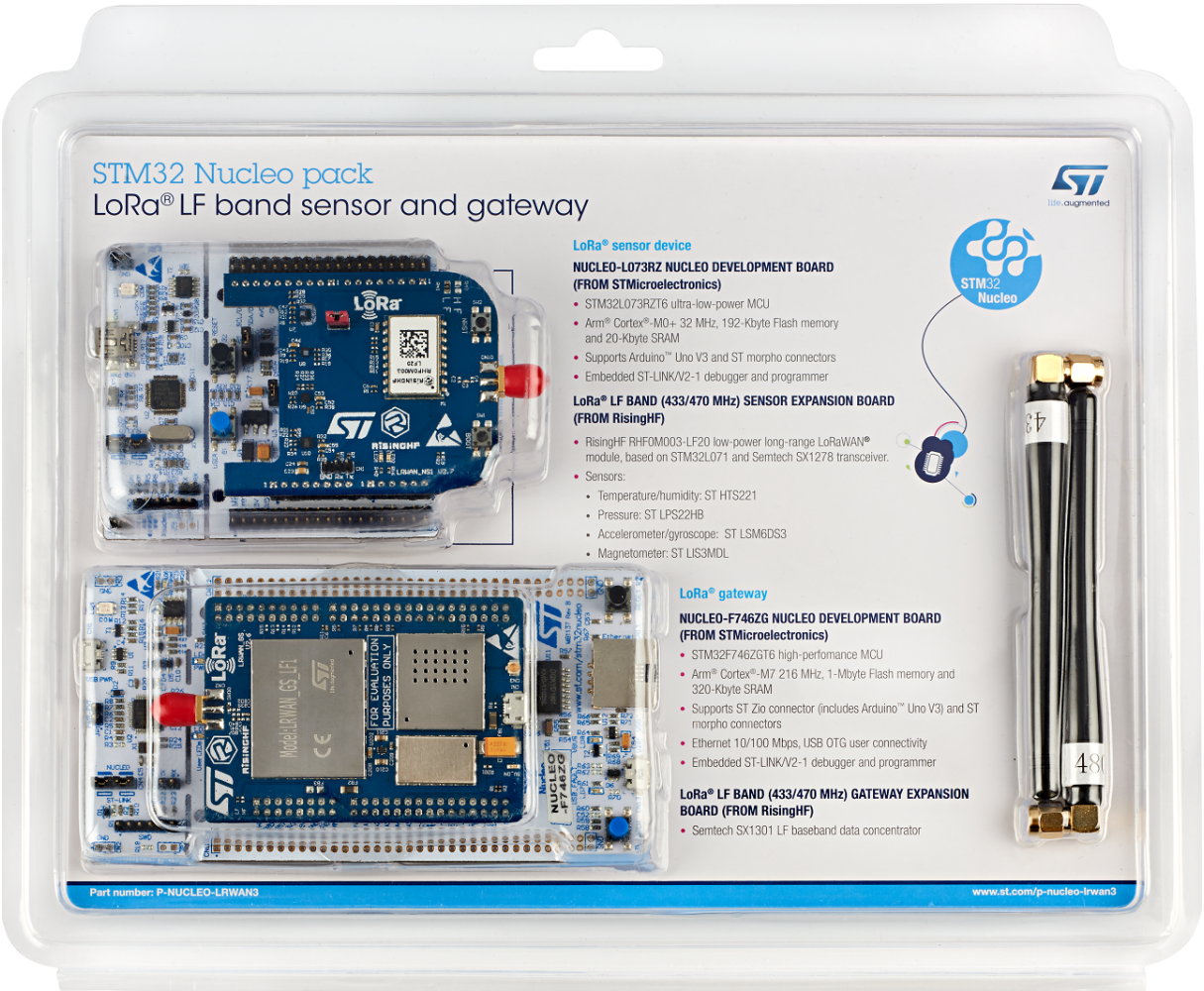
2 P-NUCLEO-LRWAN3 starter pack overview

Figure 8 shows an overview of the P-NUCLEO-LRWAN3 starter pack, which includes a LoRaWAN® sensor device and gateway as well as the antennas.

Instructions at the back of the insert card guide the users on how to power up and configure the sensor device and gateway and setup the network.

The starter pack is configured to use the CN470Prequel frequency band with the sensor device in OTAA mode and the gateway forwarding the packets to Loriot CN1 server. The pack is user configurable by firmware and by AT commands.

Figure 8. STM32 Nucleo LoRaWAN® development kit (P-NUCLEO-LRWAN3 starter pack)



2.1 P-NUCLEO-LRWAN3 starter pack known limitation

The serial number of the NUCLEO-L073RZ MB1136 reference board is indicated on a sticker under the MB1136.

If the number is within the range from A191400001 to A191402004, the board must be updated with a new firmware before use. Download the last firmware version available at www.st.com/en/product/i-cube-lrwan.

2.2 Sensor hardware overview

The P-NUCLEO-LRWAN3 LoRaWAN® sensor device has the following key features:

Main board

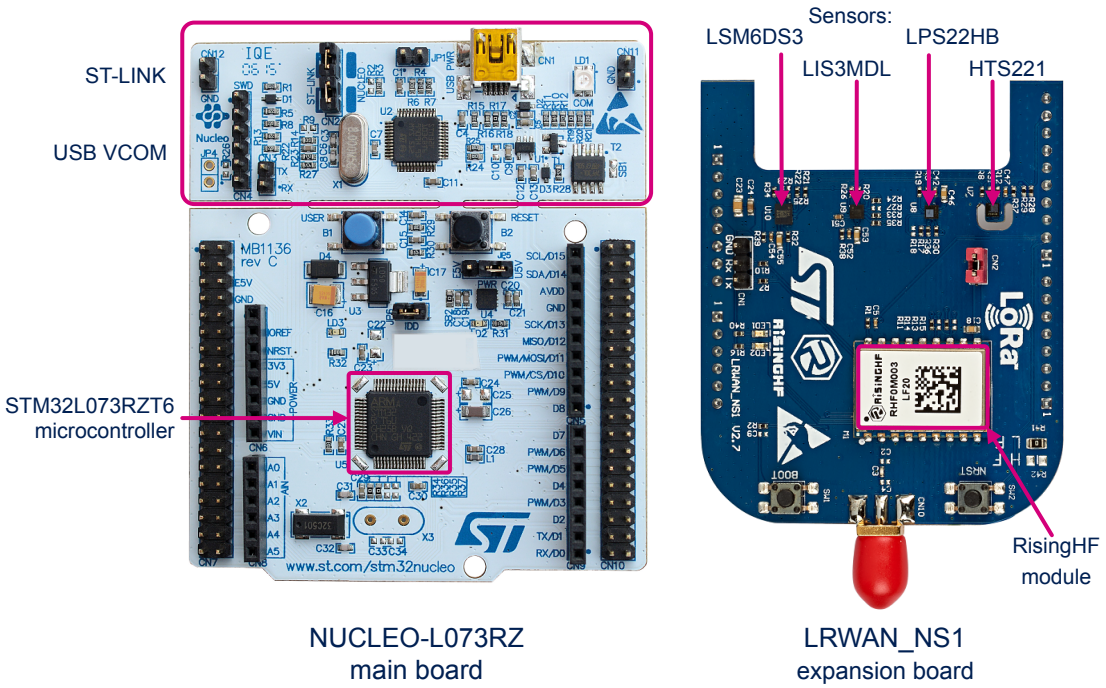
- NUCLEO-L073RZ development board (from STMicroelectronics)
  - STM32L073RZT6 Arm® Cortex®-M0+ ultra-low-power MCU at 32 MHz with 192-Kbyte Flash memory, 20-Kbyte SRAM and 6-Kbyte data EEPROM
  - 1 user LED
  - 1 user and 1 reset push-buttons
  - 32.768 kHz crystal oscillator
  - On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, Virtual COM port, and debug port
  - Board connectors
    - Mini-B USB connector for the ST-LINK
    - ARDUINO® Uno V3 expansion connector
    - ST morpho extension pin headers for full access to all STM32 I/Os

RF module and sensor expansion board

- LRWAN_NS1 LoRa® LF band (433/470 MHz) sensor expansion board (from RisingHF)
  - RisingHF RHF0M003-LF20 low-power long-range LoRaWAN® module, based on the STM32L071 MCU and Semtech SX1278 transceiver
    - High sensitivity down to -137 dBm
    - 14 dBm to 20 dBm output power
  - STMicroelectronics HTS221 temperature and humidity sensor
  - STMicroelectronics LPS22HB pressure sensor
  - STMicroelectronics LSM6DS3 accelerometer and gyroscope sensor
  - STMicroelectronics LIS3MDL magnetometer

Figure 9 shows the two boards in P-NUCLEO-LRWAN3 LoRaWAN® sensor device.

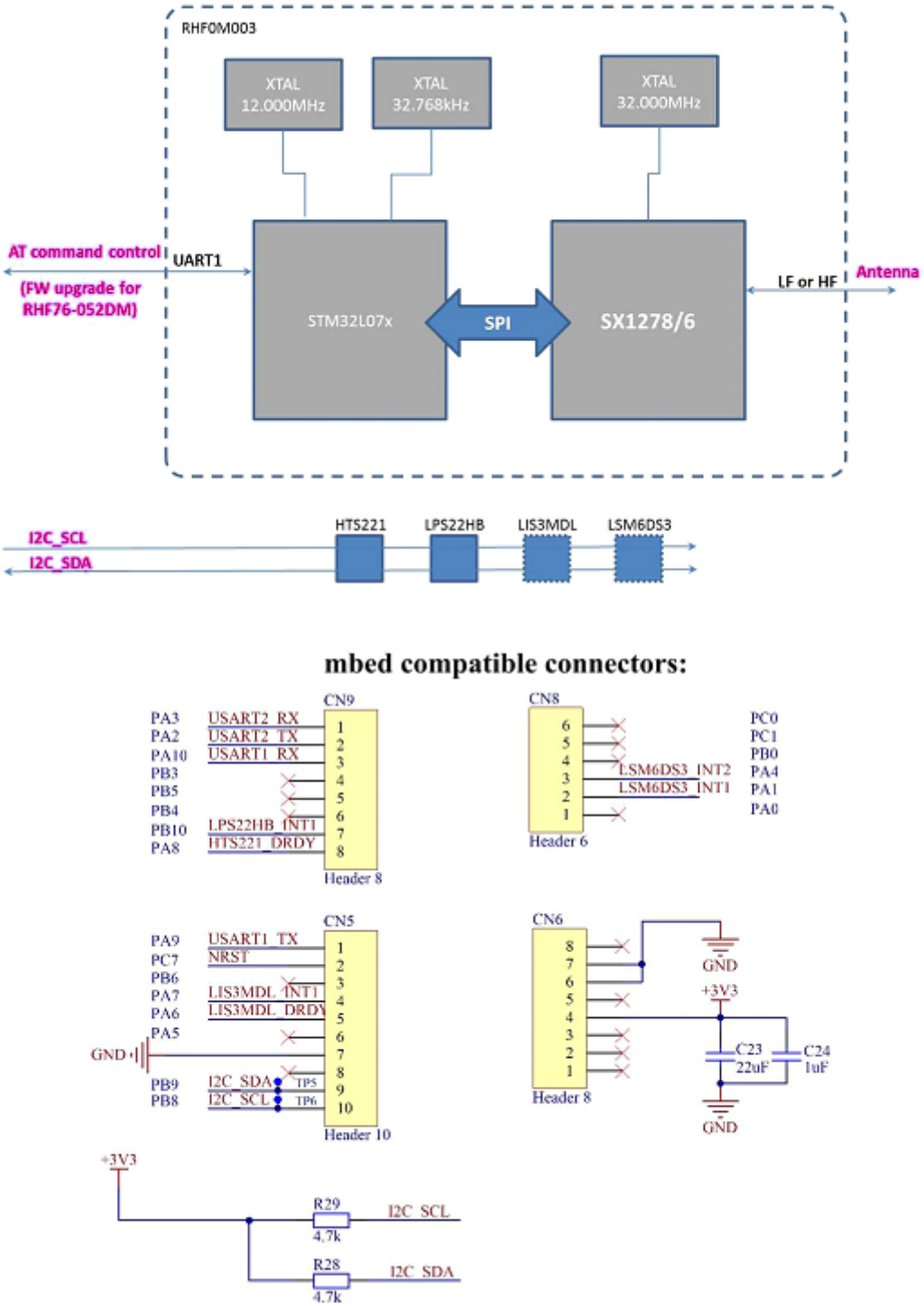
Figure 9. STM32 Nucleo LoRaWAN® sensor device (P-NUCLEO-LRWAN3)



2.2.1 LRWAN_NS1 LoRa® LF band and sensor expansion board

The LRWAN_NS1 is supplied by a third party (RisingHF). For complete and latest information, refer to LRWAN_NS1 reference manual [2].

Figure 10. LRWAN_NS1 block diagram and connectors



Note: By default, USART1 (PA9/PA10) is used in the NUCLEO-L073RZ board to control the RHF0M003-LF20 modem. Optionally, it is possible to use USART2 (PA2/PA3) via jumper resistor on the LRWAN_NS1. Refer to its user manual. If USART2 (PA2/PA3) is used to control the modem, the following solder bridge on the Nucleo board must be configured accordingly:

- *SB62 and SB63 are closed*
- *SB13 and SB14 are opened to disconnect the STM32 UART from ST-LINK*

Refer to [5] in the USART Communication section for more details.

2.3 Gateway hardware overview

The P-NUCLEO-LRWAN3 LoRaWAN® gateway shown in Figure 11 has the following key features:

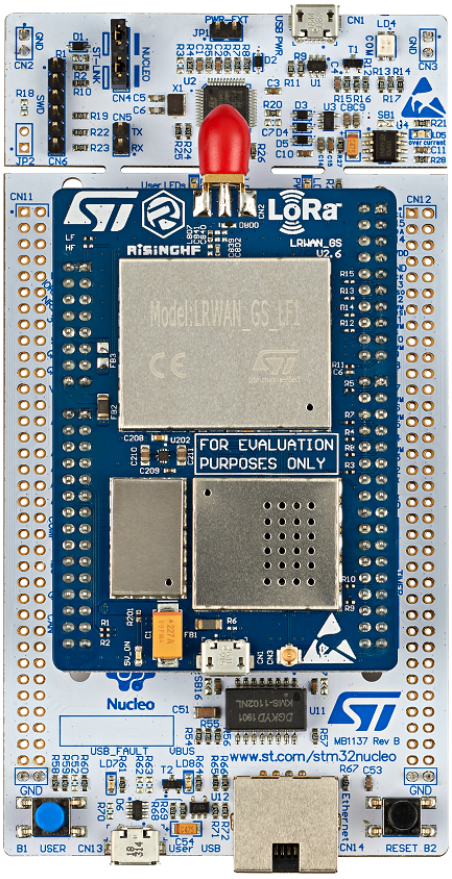
Gateway main board

- NUCLEO-F746ZG development board (from STMicroelectronics)
  - STM32F746ZGT6 Arm® Cortex®-M7 high-performance MCU at 216 MHz with 1-Mbyte Flash memory and 320-Kbyte SRAM
  - 3 user LEDs
  - 1 user and 1 reset push-buttons
  - Ethernet compliant with IEEE-802.3-2002
  - USB OTG Full Speed or device only
  - 32.768 kHz crystal oscillator
  - On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, Virtual COM port, and debug port
  - Board connectors
    - Micro-AB USB connector for the ST-LINK
    - ST Zio expansion connector including ARDUINO® Uno V3
    - ST morpho extension pin headers for full access to all STM32 I/Os
    - USB with Micro-AB
    - Ethernet RJ45

Gateway expansion board

- LRWAN_GS_LF1 LoRa® LF band (433/470 MHz) gateway expansion board (from RisingHF)
  - Semtech SX1301/SX1255 LF baseband data concentrator and transceiver
    - Automatically adaptive to spreading factor from SF12 to SF7 in each of 8 channels
    - High sensitivity down to -140 dBm at 300 bit/s
    - 6 dBm output power
    - Support LoRaWAN® protocol Class A and Class C
    - Support Semtech packet forwarder
    - Support DNS and NTP

Figure 11. **STM32 Nucleo LoRaWAN® gateway (P-NUCLEO-LRWAN3)**



Gateway additional features

- Programmable parallel demodulation paths
- LoRa® demodulators and 1 GFSK demodulator embedded
- Single +5 V supply
- AT command interface to re-configure the parameters of the gateway
  - change frequency plan
  - change IP of the gateway
  - change MAC address and ID of the gateway
  - change network server that supports Semtech packet forwarder
  - set to use public server or private server
  - change DNS address
  - change NTP server address

2.3.1 Gateway expansion board

The gateway expansion board shown in is designed by RisingHF (www.risinghf.com). It includes a Semtech SX1301 digital baseband circuit integrating the LoRa® concentrator, Semtech SX1255 LF front-end transceiver module, and two SAW filters to achieve a wider bandwidth range (434 MHz to 470 MHz). The expansion board is controlled by the NUCLEO-F746ZG via the SPI interface.

The gateway expansion board includes also an external +5 V power supply circuitry, which powers both the gateway expansion board and NUCLEO-F746ZG development board. The NUCLEO-F746ZG is powered via pin VIN (Pin 15 of connector CN8 on the Nucleo board).

For more details, refer to [3].

Figure 12. Gateway expansion board (P-NUCLEO-LRWAN3)

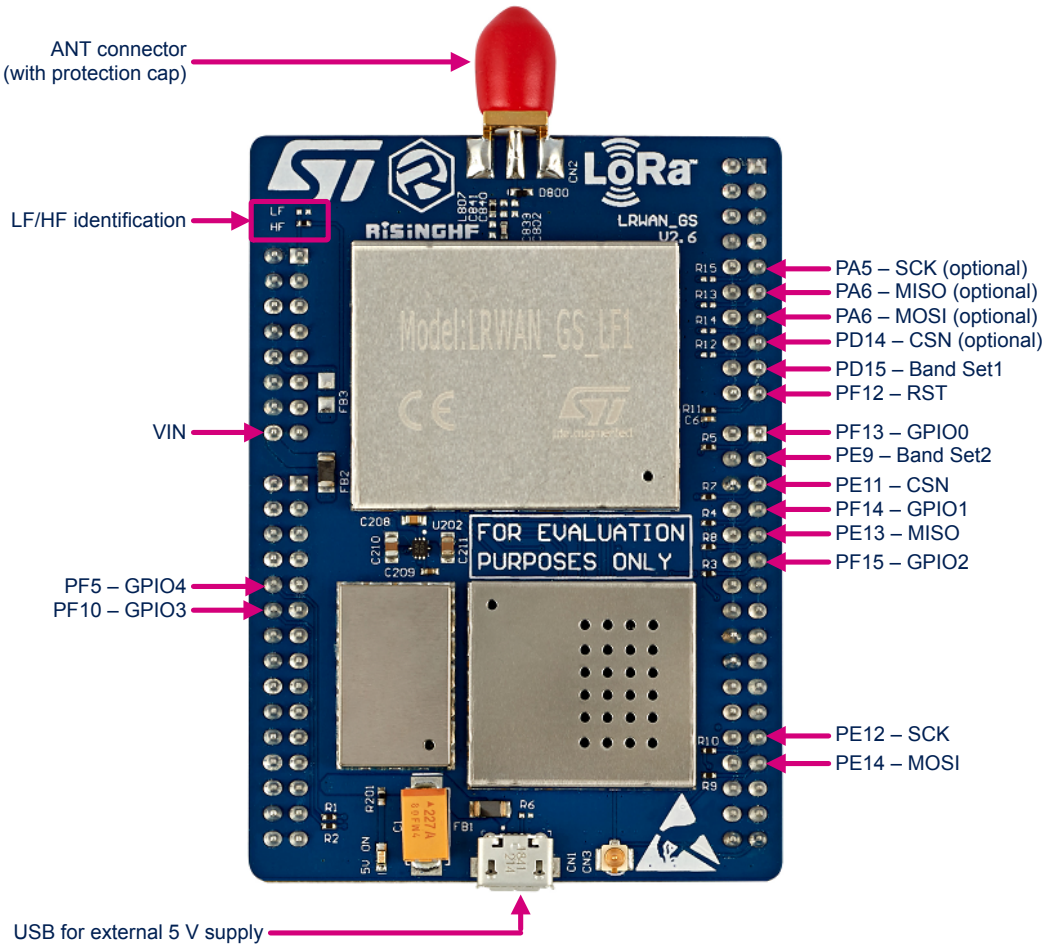


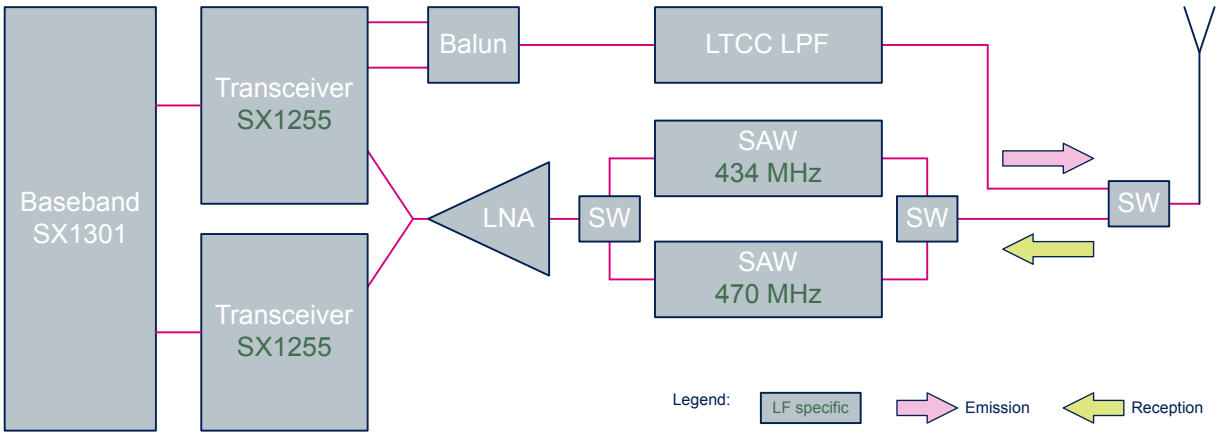
Table 2. P-NUCLEO-LRWAN3 gateway expansion board pins description

Pin name	Pin description
VIN	Power supply to NUCLEO-F746ZG from external 5 V
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

Pin name	Pin description
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	
PA5-SCK (optional)	Backup SCK of SPI for SX1301 (no connection on board in default)
PA6-MISO (optional)	Backup MISO of SPI for SX1301 (no connection on board in default)
PA7/PB5-MOSI (optional)	Backup MOSI of SPI for SX1301 (no connection on board in default)
PD14-CSN (optional)	Backup CSN of SPI for SX1301 (no connection on board in default)

Figure 13 presents the architecture of the LRWAN_GS_LF1 gateway expansion board.

Figure 13. Hardware architecture of the P-NUCLEO-LRWAN3 gateway expansion board



3 P-NUCLEO-LRWAN2 / P-NUCLEO-LRWAN3 firmware overview

The P-NUCLEO-LRWAN2 and P-NUCLEO-LRWAN3 starter packs include the following firmware:

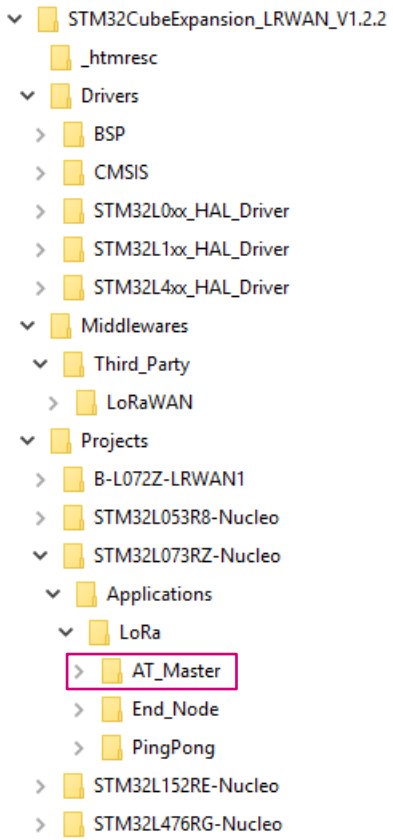
- I-CUBE-LRWAN LoRaWAN® STM32Cube Expansion Package for the microcontrollers in the STM32L0 Series, STM32L1 Series, STM32L4 Series, and STM32L4+ Series
- Binary for the STM32F746ZGT6 microcontroller of the LoRaWAN® gateway Nucleo board

3.1 I-CUBE-LRWAN LoRaWAN® STM32Cube Expansion Package

The I-CUBE-LRWAN Expansion Package consists of a set of libraries and application examples for STM32L0 Series, STM32L1 Series, STM32L4 Series, and STM32L4+ Series microcontrollers acting as end-devices. This firmware Expansion Package is downloadable from www.st.com/en/product/i-cube-lrwan.

A specific firmware project called *AT_Master* is an example code available only for the STM32L0 Series microcontroller interfacing either with the I-NUCLEO-LRWAN1 USI® LoRa® expansion board, or with the LRWAN_NS1 RisingHF LoRa® expansion board. The *AT_Master* sample project implements a host `AT_Master` application that controls the LoRa® modem via AT commands, establishes a link with the LoRaWAN® network, and sends sensor data.

Figure 14. `AT_Master` in LoRaWAN® STM32Cube Expansion Package



3.2 STM32F7 Nucleo LoRaWAN® gateway firmware

Firmware is based on the Semtech packet forwarder protocol ported over to the STM32F746ZGT6 device. The gateway parameters are fully reconfigurable by means of the AT command interface through the ST-LINK USB Virtual COM port. Refer to [3] for details.

User reconfigurable parameters by means of the AT command interface

- Frequency plan
- Network server settings
  - LoRaWAN® server address (public or private)
  - Uplink and downlink port
- Ethernet settings
  - MAC address (default based on STM32 unique ID)
  - Static or DHCP mode
  - IP address, DNS address, NTP server address
- Gateway ID
- Baud rate
- Enabling/disabling log messages

AT command list

Table 3. AT command list

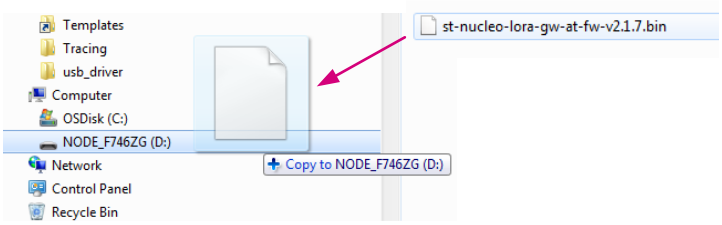
Command	Comment
AT	Returns +OK.
HELP	Prints help information.
FDEFAULT	Resets to factory default settings.
RESET	Software-reset gateway.
SYS	Checks all configurations.
VER	Gets version.
LOG	Turns on/off packet forwarder log.
ECHO	AT command echo on/off.
MAC	Sets/gets the gateway MAC address.
IP	DHCP/static IP control.
DNS	Sets/gets the DNS address.
NTP	Sets/gets the 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 settings.
CH	Packet forwarder channels.
Baudrate	AT command and logging UART interface baud rate.

The gateway firmware binary is available upon request directly from STMicroelectronics.

To reprogram the board, copy and paste, or drag and drop the binary file to the mbed storage device of the NUCLEO-F746ZG. The STM32 ST-LINK Utility (STSW-LINK004) programming software is another solution to program the board.

It is recommended to power the board first before connecting the board with the PC. Refer to Section 6 about how to power the board.

Figure 15. Programming the gateway using a binary file



At startup, firmware checks for frequency band setting compatibility versus RF hardware. It displays a warning if the setting is not compatible with the hardware.

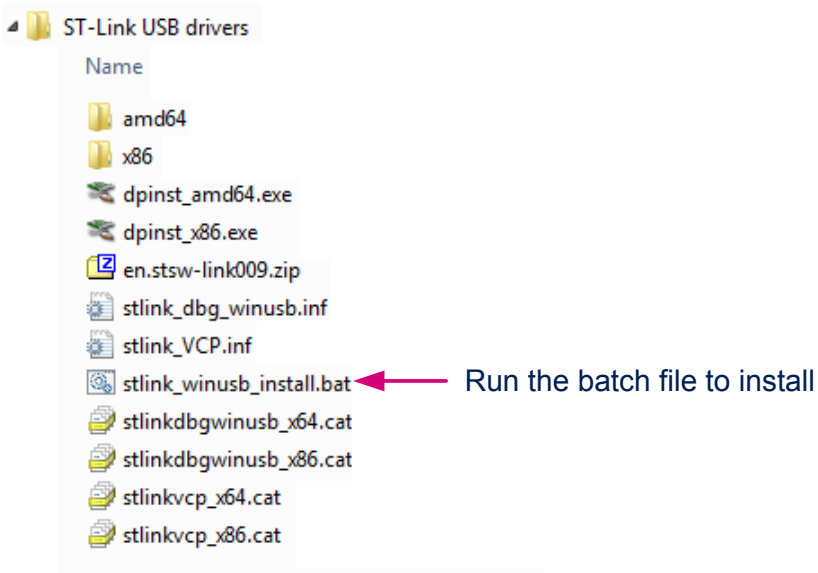
4 I-NUCLEO-LRWAN1 sensor device setup and reconfiguration

This section describes the steps to setup the I-NUCLEO-LRWAN1 sensor device and if necessary, reconfigure it to the desired frequency band. By default, the device is configured for the EU868 frequency band and in the OTAA mode.

4.1 Sensor device setup

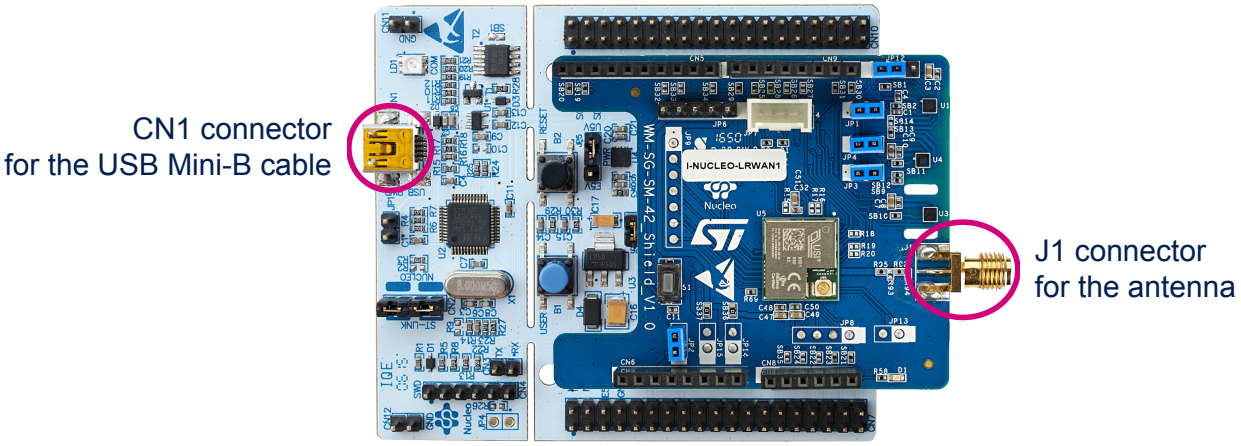
1. Make sure that the USB drivers are installed. Download ST-LINK USB driver (STSW-LINK009) from *www.st.com* if needed.

Figure 16. ST-LINK driver installation



2. On the LoRa® expansion board, connect the antenna to connector J1 (for P-NUCLEO-LRWAN3).

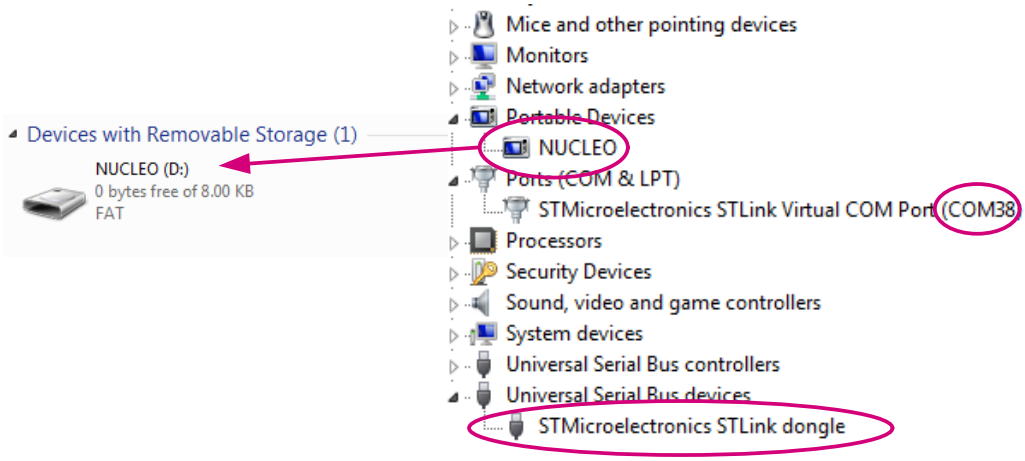
Figure 17. Antenna and personal computer connection



3. Connect the Nucleo board to a personal computer with a USB Type-A or USB Type-C® to Mini-B cable through USB connector CN1 to the power the board. Then red LED LD3 (PWR) and LD1 (COM) light up.

4. Allow the personal computer to enumerate and install the USB drivers.
   Take note of the Virtual COM port number assigned to the board.
   Note: the Nucleo board is also enumerated as an mbed removable storage device.

Figure 18. USB enumerated instances



4.2 Extracting DevEUI and AppEUI from the LoRa® module

Device enrollment to the network server requires activation parameters stored in the LoRa® module. Depending on the join mode used (OTAA/ABP), the pieces of information presented in Table 4 need to be extracted from the LoRa® module (default) or changed.

Table 4. Device activation and parameters (P-NUCLEO-LRWAN2)

Parameters	Description	End-device activation
`DevEUI`	64-bit global unique ID that uniquely identifies the end-device (IEEE EUI64 address).	OTAA
`AppEUI`	64-bit application ID that uniquely identifies the application provider (owner) of the end-device (IEEE EUI64 address).	
`AppKey`	AES-128 application key, specific to the end-device, assigned by the application provider, that is used to derive the session keys, `NwkSKey` and `AppSKey` specific to that end-device to encrypt and verify network communication and application data.	
`NwkSKey`	Network session key, specific to the end-device. Used by the network server and end-device to calculate and verify the MIC (message integrity code) and further encrypt and decrypt the payload field of MAC-only data messages.	ABP
`AppSKey`	Application session key, specific to the end-device. Used by both the network server and the end-device to encrypt and decrypt the payload field of 30 application-specific data messages.	
`DevAddr`	32-bit address that identifies the end-device within the current network.	

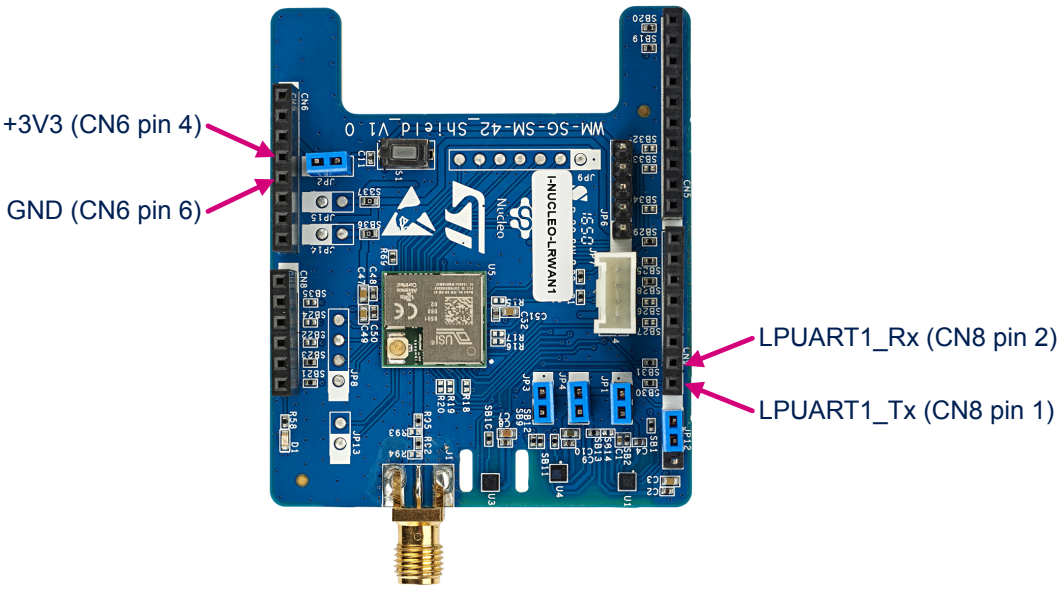
Send a *get* AT command to extract the default parameters of the USI® WM-SG-SM-42 LoRa® module through its serial port. Refer to [1] for details.

- Get Device EUI (`AT+EUI`)
- Get Application EUI (`AT+APPEUI`)
- Get Application Key (`AT+AK`)

The I-NUCLEO-LRWAN1 expansion board uses the serial interface (CN8 pin 1 (Tx) and pin 2 (Rx)) shown in Figure 19 for the AT command console. The default serial configuration is:

- Baud rate: 115200
- Data: 8 bit
- Parity: none
- Stop: 1 bit

Figure 19. I-NUCLEO-LRWAN1 expansion board serial port



Alternatively, since preloaded firmware reads the `DevEUI` and `AppEUI` parameters of the module and saves them to the internal data memory of the STM32L073RZT6 (Data Memory Bank 1 of the NUCLEO-L073RZ Nucleo board), the user can extract both parameters by reading the data memory using the STM32 ST-LINK Utility (STSW-LINK004) or the STM32CubeProgrammer (STM32CubeProg).

Follow these steps to extract `DevEUI` and `AppEUI` using the STM32 ST-LINK Utility:

1. Download STM32 ST-LINK Utility (STSW-LINK004) from STMicroelectronics web site and install it
2. Connect the NUCLEO-L073RZ Nucleo board with the personal computer by means of the USB
3. Open a Windows® *Command* prompt and set the path for the STM32 ST-LINK Utility:

   ```
   SET PATH=%PATH%;C:\Program Files (x86)\STMicroelectronics\STM32 ST-LINK Utility\ST-LINK Utility
   ```

4. Read `DEvUI` and `AppEui` using STM32 ST-LINK Utility CLI command:
   - For `DevEUI`: `ST-LINK_CLI.exe -c swd ur -r8 0x08080000 0x08`
   - For `AppEUI`: `ST-LINK_CLI.exe -c swd ur -r8 0x08080008 0x08`

   The addresses in the CLI commands are for Data Memory Bank 1 of the NUCLEO-L073RZ Nucleo board.

Note: The STM32 ST-LINK Utility (STSW-LINK004) GUI can also be used to read the data memory of the NUCLEO-L073RZ.

A similar process is possible using the STM32CubeProgrammer (STM32CubeProg). Refer to STM32CubeProgrammer documentation on www.st.com.

4.3 Reconfiguring the sensor device using the *AT_Master* project

Edit firmware to change join mode, frequency band, device IDs, and keys. More parameters are reconfigurable. The following examples show functions used to set these parameters in user firmware.

In file `main.c`:

```
#define JOIN_MODE OTAA_JOIN_MODE /*ABP_JOIN_MODE*/ /*LoRaWan join method*/
```

In file `lora_driver.c`:

- `Lora_SetDeviceBand(uint8_t DeviceBand)` → Sets the band plan
- `LoRa_SetDeviceID(uint8_t *PtrDeviceID)` → Sets the device ID (DevEUI)
- `LoRa_SetAppID(uint8_t *PtrAppID)` → Sets the application identifier (AppEUI)
- `LoRa_SetDeviceAddress(uint32_t DeviceAddr)` → Sets the device address (DevAddr)
- `LoRa_SetKey(ATCmd_t KeyType, uint8_t *PtrKey)` → Sets the key configuration (APPKEY, NWKSKE, APPSKEY)
- `Lora_UpdateConfigTable()` → Updates the DCT content table with new values

The corresponding *Get* functions are also available.

Alternatively, it is possible to reconfigure the WM-SG-SM-42 module directly via its serial port by sending AT commands from the PC. Refer to [1] for details.

Set additional options in the `hw_conf.h` file in folder `AT_Master`:

- Low-power mode: enables/disables the low-power mode
- Sensor-enable switch: enables reading the data from the sensors in the I-NUCLEO-LRWAN1 expansion board

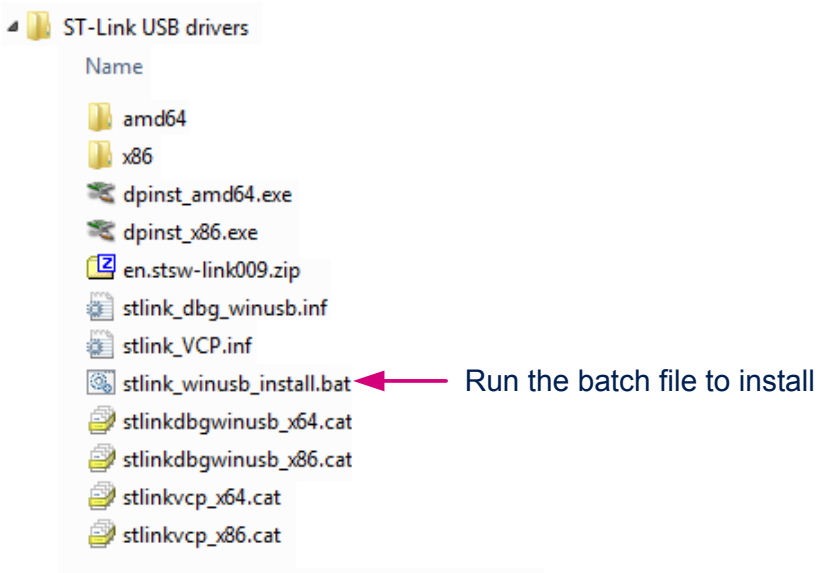
5 LRWAN_NS1 sensor device setup and reconfiguration

This section describes the steps to setup the LRWAN_NS1 sensor device and if necessary, reconfigure it to the desired frequency band. By default, the device is configured for the CN470Prequel frequency band and in the OTAA mode.

5.1 Sensor device setup

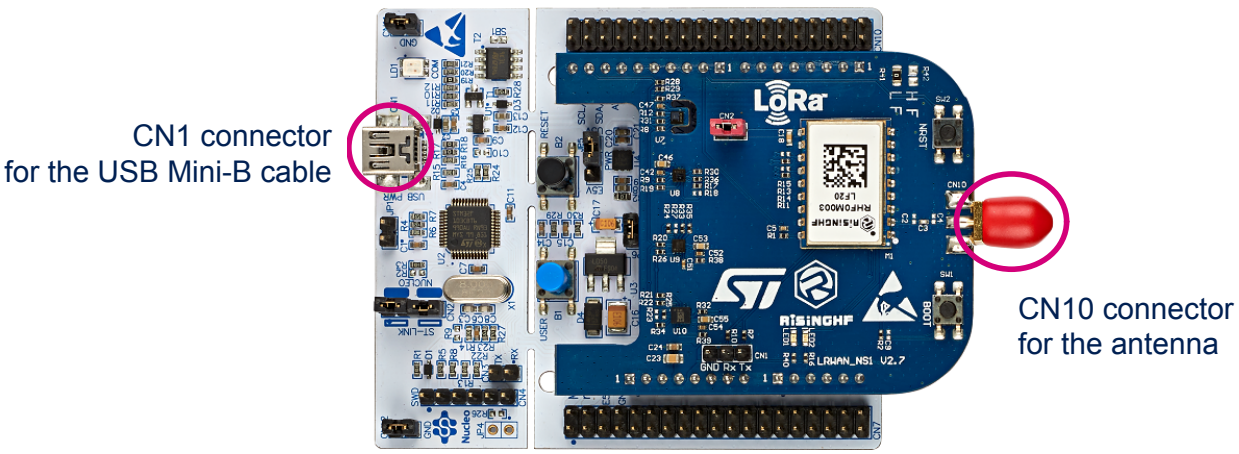
1. Make sure that the USB drivers are installed. Download ST-LINK USB driver (STSW-LINK009) from *www.st.com* if needed.

Figure 20. ST-LINK driver installation



2. On the LoRa® expansion board, connect the antenna to connector CN10 (for P-NUCLEO-LRWAN3).

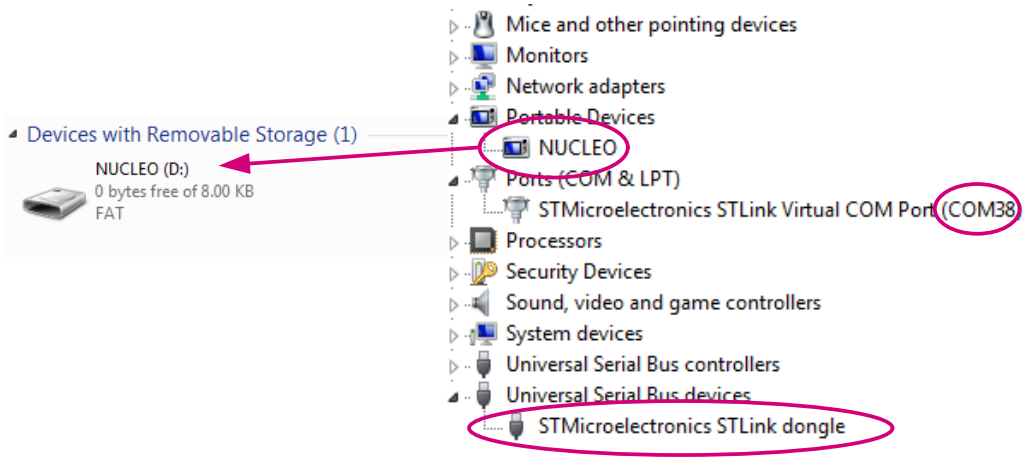
Figure 21. Antenna and personal computer connection



3. Connect the Nucleo board to a personal computer with a USB Type-A or USB Type-C® to Mini-B cable through USB connector CN1 to the power the board. Then red LED LD3 (PWR) and LD1 (COM) light up.

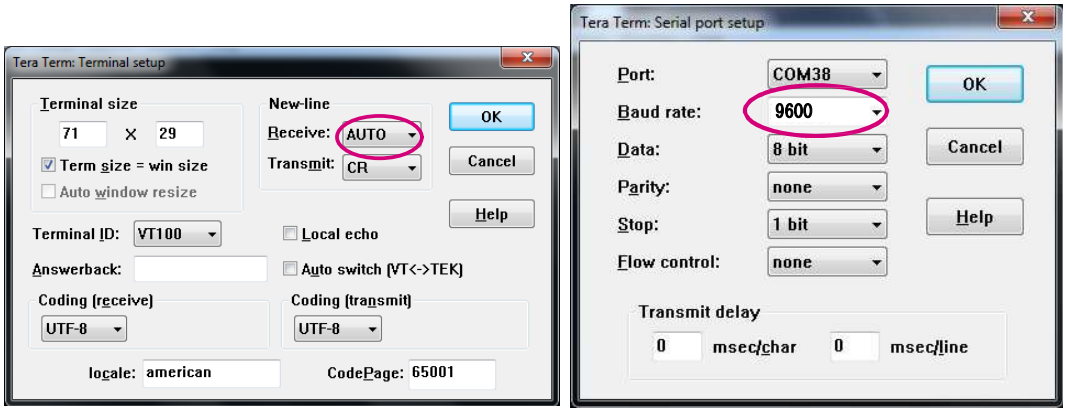
4. Allow the personal computer to enumerate and install the USB drivers.
   Take note of the Virtual COM port number assigned to the board.
   Note: the Nucleo board is also enumerated as an mbed removable storage device.

Figure 22. USB enumerated instances



5. [Optional: to display debug printf messages] Open a terminal emulation software such as Tera Term and configure it with the following settings for further viewing of the LoRa® device parameters:
   – Port: (Virtual COM port number assigned to the board from step 4)
   – Baud rate: 9600
   – Data: 8 bit
   – Parity: none
   – Stop: 1 bit

Figure 23. Terminal emulation software settings



5.2 Extracting DevEUI and AppEUI from the LoRa® module

Device enrollment to the network server requires activation parameters stored in the LoRa® module. Depending on the join mode used (OTAA/ABP), the pieces of information presented in Table 5 need to be extracted from the LoRa® module (default) or changed.

Table 5. Device activation and parameters (P-NUCLEO-LRWAN3)

Parameters	Description	End-device activation
DevEUI	64-bit global unique ID that uniquely identifies the end-device (IEEE EUI64 address).	OTAA
AppEUI	64-bit application ID that uniquely identifies the application provider (owner) of the end-device (IEEE EUI64 address).	
AppKey	AES-128 application key, specific to the end-device, assigned by the application provider, that is used to derive the session keys, NwkSKey and AppSKey specific to that end-device to encrypt and verify network communication and application data.	
NwkSKey	Network session key, specific to the end-device. Used by the network server and end-device to calculate and verify the MIC (message integrity code) and further encrypt and decrypt the payload field of MAC-only data messages.	ABP
AppSKey	Application session key, specific to the end-device. Used by both the network server and the end-device to encrypt and decrypt the payload field of 30 application-specific data messages.	
DevAddr	32-bit address that identifies the end-device within the current network.	

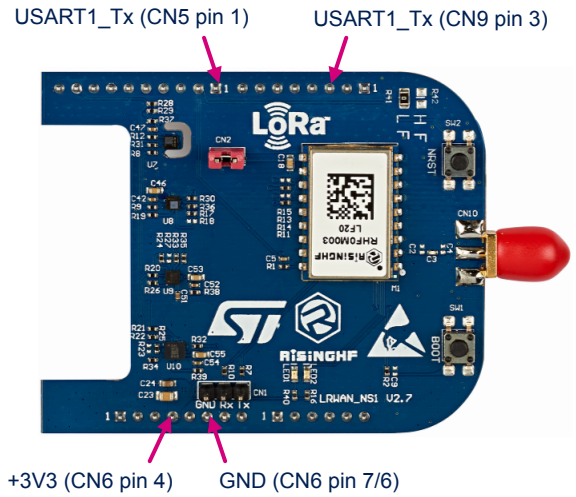
Send a *get* AT command to extract the default parameters of the RisingHF RHF0M003-LF20 LoRa® module through its serial port. Refer to [2] for details.

- Get Device EUI (AT+EUI)
- Get Application EUI (AT+APPEUI)
- Get Application Key (AT+AK)

The LRWAN_NS1 LoRa® expansion board uses the serial interface (CN8 pin 1 (Tx) and pin 2 (Rx)) shown in Figure 24 for the AT command console. The default serial configuration is:

- Baud rate: 9600
- Data: 8 bit
- Parity: none
- Stop: 1 bit

Figure 24. LRWAN_NS1 expansion board serial port



Alternatively, since preloaded firmware reads the `DevEUI` and `AppEUI` parameters of the module and saves them to the internal data memory of the STM32L073RZT6 (Data Memory Bank 1 of the NUCLEO-L073RZ Nucleo board), the user can extract both parameters by reading the data memory using the STM32 ST-LINK Utility (STSW-LINK004) or the STM32CubeProgrammer (STM32CubeProg).

Follow these steps to extract `DevEUI` and `AppEUI` using the STM32 ST-LINK Utility:

1. Download STM32 ST-LINK Utility (STSW-LINK004) from STMicroelectronics web site and install it
2. Connect the NUCLEO-L073RZ Nucleo board with the personal computer by means of the USB
3. Open a Windows® *Command* prompt and set the path for the STM32 ST-LINK Utility:
   ```
   SET PATH=%PATH%;C:\Program Files (x86)\STMicroelectronics\STM32 ST-LINK Utility\ST-LINK Utility
   ```
4. Read `DEvUI` and `AppEui` using STM32 ST-LINK Utility CLI command:
   - For `DevEUI`: `ST-LINK_CLI.exe -c swd ur -r8 0x08080000 0x08`
   - For `AppEUI`: `ST-LINK_CLI.exe -c swd ur -r8 0x08080008 0x08`

   The addresses in the CLI commands are for Data Memory Bank 1 of the NUCLEO-L073RZ Nucleo board.

Note: The STM32 ST-LINK Utility (STSW-LINK004) GUI can also be used to read the data memory of the NUCLEO-L073RZ.

A similar process is possible using the STM32CubeProgrammer (STM32CubeProg). Refer to STM32CubeProgrammer documentation on www.st.com.

5.3 Reconfiguring the sensor device using the *AT_Master* project

Edit firmware to change join mode, frequency band, device IDs, and keys. More parameters are reconfigurable. The following examples show functions used to set these parameters in user firmware.

In file `main.c`:

```
#define JOIN_MODE OTAA_JOIN_MODE /*ABP_JOIN_MODE*/ /*LoRaWan join method*/
```

In file `lora_driver.c`:

- `Lora_SetDeviceBand(uint8_t DeviceBand)` → Sets the band plan
- `LoRa_SetDeviceID(uint8_t *PtrDeviceID)` → Sets the device ID (DevEUI)
- `LoRa_SetAppID(uint8_t *PtrAppID)` → Sets the application identifier (AppEUI)
- `LoRa_SetDeviceAddress(uint32_t DeviceAddr)` → Sets the device address (DevAddr)
- `LoRa_SetKey(ATCmd_t KeyType, uint8_t *PtrKey)` → Sets the key configuration (APPKEY, NWKSKE, APPSKEY)
- `Lora_SetWDT(0)` → triggers a module reset so that the new settings will take effect

The corresponding *Get* functions are also available.

Alternatively, it is possible to reconfigure the RHF0M003-LF20 module directly via its serial port by sending AT commands from the PC. Refer to [2] for details.

Set additional options in the `hw_conf.h` file in folder `AT_Master`:

- Low-power mode: enables/disables the low-power mode
- Sensor-enable switch: enables reading the data from the sensors in the LRWAN_NS1 expansion board

AT command debug printf messages can be sent via ST-LINK Virtual COM port by:

- enabling the definition of CMD_DEBUG in the toolchain preprocessor symbols settings,
- or adding the line

```
#define CMD_DEBUG
```

in the user file (e.g. main.c).

6 Gateway setup and configuration

The gateway is a simple packet forwarder based on the Semtech packet forwarder protocol. It needs to be configured to the desired frequency band and LoRaWAN® network server among other parameters that are reconfigurable. This can be done by sending AT commands using the Virtual COM port of the Nucleo board.

This section describes the steps to setup the gateway and reconfigure it to the desired frequency band and network server that supports the Semtech packet forwarder protocol.

6.1 Gateway setup

1. On the NUCLEO-F746ZG board, verify the jumper settings:
   - JP1 (PWR-EXT) OFF
   - JP3 (power source) on VIN-5V
   - JP5 (IDD) ON
2. Connect the NUCLEO-F746ZG board to a network router with an Ethernet cable through Ethernet connector CN14.

   Make sure that the router has DHCP service and Internet access (no password).
3. Connect the antenna to the antenna connector (CN2) (for P-NUCLEO-LRWAN3).
4. On the LoRa® gateway expansion board, connect an external 5 V supply through its USB Micro-B connector (CN1) to power the whole board.

   Important: power supply must be connected to the gateway shield USB port and not with the Nucleo USB port.

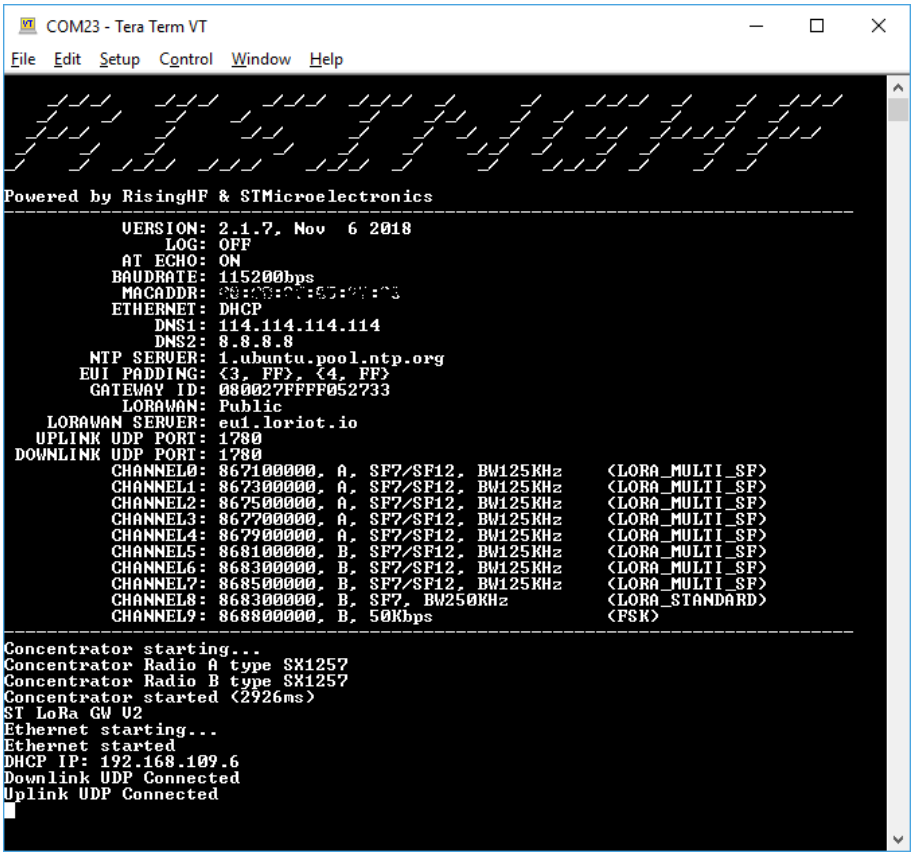
   On the Nucleo board, green LED LD6 (PWR) and LD4 (COM) light up. On the gateway shield, the green LED lights up.

   Note: a USB wall adapter/charger is required to power the gateway.
5. To view the gateway MAC address, channel frequency and status, connect the NUCLEO-F746ZG board with a personal computer by means of a USB Type-A or USB Type-C® to Micro-B cable through USB connector CN1. View the parameters using a terminal emulation software such as Tera Term.
6. Allow the personal computer to enumerate and install the USB drivers.

   Take note of the Virtual COM port number assigned to the board.
7. Open a terminal emulation software such as Tera Term and configure it with the following settings:
   - Port: (Virtual COM port number assigned to the board from step 6)
   - Baud rate: 115200
   - Data: 8 bit
   - Parity: none
   - Stop: 1 bit

8. Press the reset button B2 (black button) to view the gateway MAC address, channel frequency and status. These parameters are further used to register the gateway to the network server (refer to Section 7 Network server setup). The USB cable (Virtual COM) can then be removed when the gateway is registered.

Figure 25. Gateway parameter settings



P-NUCLEO-LRWAN2

The default setting of the LRWAN_GS_HF1 gateway is set to the EU868 frequency band and Loriot EU1 server.

P-NUCLEO-LRWAN3

The default setting of the LRWAN_GS_LF1 gateway is set to the CN470Prequel frequency band and Loriot CN1 server.

6.2 Configuring the gateway to use a different frequency band

The *ST Nucleo LoRa GW* user guide from RisingHF ([3]) details the reconfiguration of the gateway using AT commands.

To change the frequency channels, use the `AT+CH` command. Reset the board for the new settings to take effect. At startup, firmware checks for the compatibility of the frequency band setting versus RF hardware. It displays a warning if the setting is not compatible with the hardware.

Set the packet forwarder channels as follows:

- 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)
```

Refer to [3] for more details.

Predefined channels are available for quick setting of the frequency plan. Use the `AT+CH=band` command to use the predefined channels. The available bands are EU868, US915, EU433, CN780, AU915, AS923, KR920, CN470, CN470 prequel, and IN865. Table 6 shows the corresponding frequencies in MHz.

Table 6. Predefined frequency channel plans

CH	EU868	US915	EU433	CN780	AU915	AS923	KR920	CN470	CN470 Prequel	IN865
0	867.1	902.3	433.175	779.5	915.2	923.2	922.1	470.3	471.5	865.0625
1	867.3	902.5	433.375	779.7	915.4	923.4	922.3	470.5	471.7	865.2625
2	867.5	902.7	433.575	779.9	915.6	923.6	922.5	470.7	471.9	865.4625
3	867.7	902.9	433.775	780.1	915.8	923.8	922.7	470.9	472.1	865.6625
4	867.9	903.1	433.975	780.3	916.0	924.0	922.9	471.1	472.3	865.985
5	868.1	903.3	434.175	780.5	916.2	924.2	923.1	471.3	472.5	866.185
6	868.3	903.5	434.375	780.7	916.4	924.4	923.3	471.5	472.7	866.385
7	868.5	903.7	434.575	780.9	916.6	924.6	923.5	471.7	472.9	866.585
8	868.3 BW250 SF7	903.0 BW500 SF8	OFF	OFF	915.9 BW500 SF8	OFF	OFF	OFF	OFF	OFF
9	868.8 FSK 50 Kbps	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

For instance, to set the EU868 band plan, send AT command `AT+CH=EU868`.

```
AT+CH=EU868
  AT+CH=0,867.1,A
  AT+CH=1,867.3,A
  AT+CH=2,867.5,A
  AT+CH=3,867.7,A
  AT+CH=4,867.9,B
  AT+CH=5,868.1,B
  AT+CH=6,868.3,B
  AT+CH=7,868.5,B
  AT+CH=8,868.3,B,7,250
  AT+CH=9,868.8
```

For instance, to set the CN470Prequel band plan, send AT command `AT+CH=CN470PREQUEL`.

```
AT+CH=CN470PREQUEL
  AT+CH=0,471.5,A
  AT+CH=1,471.7,A
  AT+CH=2,472.9,A
  AT+CH=3,472.1,A
  AT+CH=4,472.3,B
  AT+CH=5,472.5,B
  AT+CH=6,472.7,B
  AT+CH=7,472.9,B
  AT+CH=8,OFF
  AT+CH=9,OFF
```

Reset the board for the new setting to take effect or use the `AT+RESET` command. The new frequency channels are displayed after reset. Use `AT+SYS` to view the configuration again.

Display for the P-NUCLEO-LRWAN2:

```
         VERSION: 2.1.7, Nov 6 2018
             LOG: OFF
         AT ECHO: ON
        BAUDRATE: 115200bps
         MACADDR: 08:00:27:0C:23:38
        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: 080027FFFF0C2338
         LORAWAN: Public
   LORAWAN SERVER: eu1.loriot.io
  UPLINK UDP PORT: 1780
DOWNLINK UDP PORT: 1780
        CHANNEL0: 867100000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL1: 867300000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL2: 867500000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL3: 867700000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL4: 867900000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL5: 868100000, B, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL6: 868300000, B, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL7: 868500000, B, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
        CHANNEL8: 868300000, B, SF7, BW250KHz        (LORA_STANDARD)
        CHANNEL9: 868800000, B, 50Kbps               (FSK)
```

Display for the P-NUCLEO-LRWAN3:

```
          VERSION: 2.1.7, Nov 6 2018
              LOG: OFF
          AT ECHO: ON
         BAUDRATE: 115200bps
          MACADDR: xx:xx:xx:xx:xx:xx
         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: XXXXXXXXXXXXXXXX
          LORAWAN: Public
   LORAWAN SERVER: cn1.loriot.io
  UPLINK UDP PORT: 1780
DOWNLINK UDP PORT: 1780
         CHANNEL0: 471500000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL1: 471700000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL2: 471900000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL3: 472100000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL4: 472300000, A, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL5: 472500000, B, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL6: 472700000, B, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL7: 472900000, B, SF7/SF12, BW125KHz   (LORA_MULTI_SF)
         CHANNEL8: OFF                                (LORA_STANDARD)
         CHANNEL9: OFF                                (FSK)
```

6.3 Changing the LoRaWAN® server, MAC address, and gateway EUI

By default, the gateway is configured to forward packets to Loriot network server. It is possible to use other servers that support the Semtech packet forwarder protocol. Use the following commands to change the settings:

- `AT+PKTFWD`

  Changes the packet forwarder server address and port. Refer to [3] for some of the available server addresses and uplink/downlink ports.

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

  – Example for Loriot AP1 server – Singapore:

  ```
  AT+PKTFWD=ap1.loriot.io,1780,1780
    +PKTFWD: ap1.loriot.io, 1780, 1780
  ```

- `AT+MAC`

  Changes the MAC address if needed.

  `AT+MAC=mac_address`

  – Example:

  ```
  AT+MAC=001122334455
    +MAC: 00:11:22:33:44:55
  ```

- `AT+MEUI`

  Sets the gateway EUI by adding paddings at specific positions of the Ethernet MAC address.

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

  – Example:

  ```
  AT+MAC
    +MAC: 00:11:22:33:44:55
  AT+EUI=3,FF,4,FF
    +EUI: 0, FF, 1, FE, 001122FFFF334455
  AT+RESET
  ```

  The gateway ID becomes 001122FFFF334455.

7 Network server setup

This section describes how to register the sensor device and gateway to the network server. The following network server providers are supported:

- Loriot
- The Things Network

7.1 Loriot network server setup

Go to the Loriot website at www.loriot.io/ and create an account on the preferred Loriot server, such as *EU1 – Frankfurt, Germany*, or *AP1 – Singapore*. Whichever Loriot server is used, the gateway needs to be configured to forward packets to the correct server address. Refer to Section 6.3 Changing the LoRaWAN server, MAC address, and gateway EUI on how to change the server address. The Loriot free account allows the registration of a limited number of devices and gateway with limited features for evaluation purpose. Refer to the Loriot website for more details about their offer.

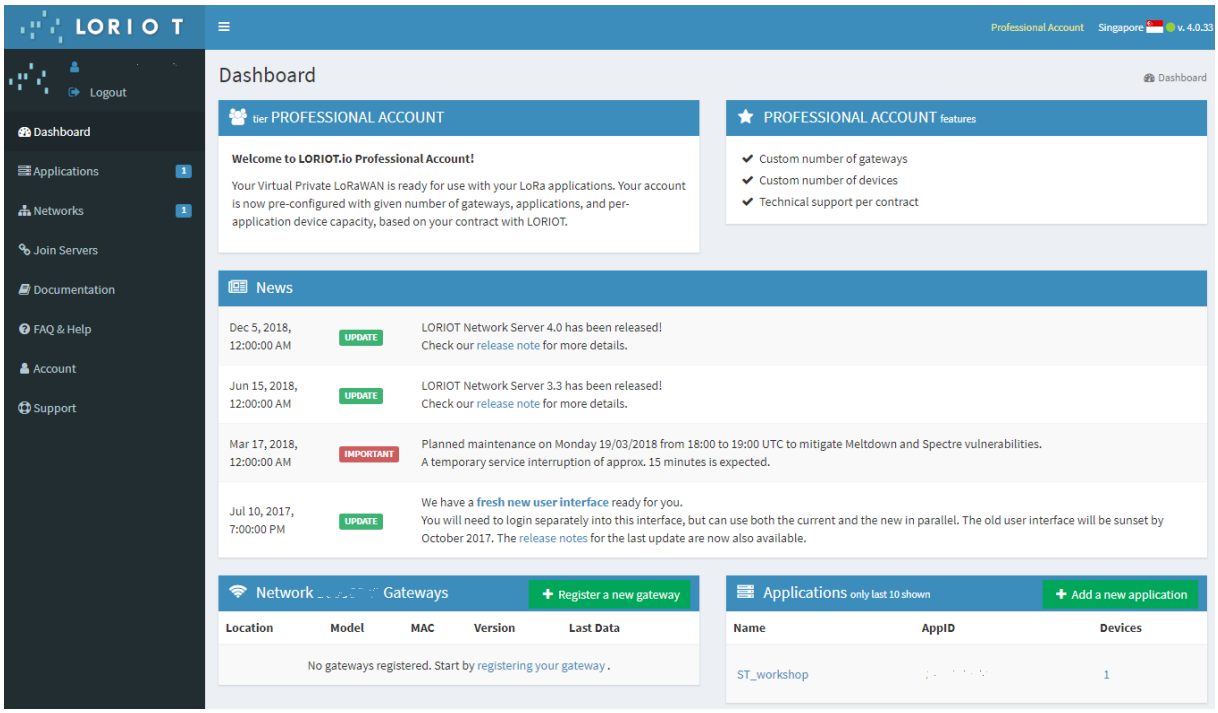
The default network server setting for the P-NUCLEO-LRWAN2 gateway is: *eu1.loriot.io*. The corresponding Loriot network server that the user needs to create an account from must be *EU1 – Frankfurt, Germany*.

The default network server setting for the P-NUCLEO-LRWAN3 gateway is: *cn1.loriot.io*. The corresponding Loriot network server that the user needs to create an account from must be *CN1 – Shenzhen, China*.

If the nearest server is desired, the gateway LoRaWAN® server setting need to be changed accordingly to the new server address and port.

Both the LoRa® sensor device and gateway need to be registered to the Loriot network server. Log in to start registering the sensor device and gateway.

Figure 26. Loriot dashboard



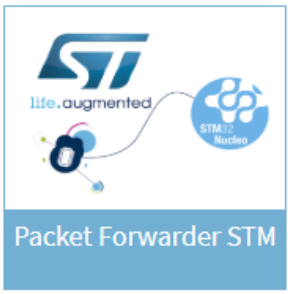
7.1.1 Gateway registration to the Loriot network server

Follow the procedure below to register the gateway to the Loriot server:

1. Click on [**Register new gateway**]

2. Choose the base platform [**Packet Forwarder STM**]

Figure 27. ST gateway platform



3. Fill in the MAC address of the gateway. Refer to Figure 25 for this information
4. Fill in the gateway location
5. Click [**Register Packet Forwarder STM gateway**]
6. From the Loriot dashboard, select the added gateway to view its detailed information
7. Edit the channel plan parameter and select the desired region frequency. The P-NUCLEO-LRWAN2 gateway default region frequency is *EU868_Semtech*. The P-NUCLEO-LRWAN3 gateway default region frequency is *CN470*
8. The gateway status is updated after a few seconds

7.1.2 Device registration to Loriot network server

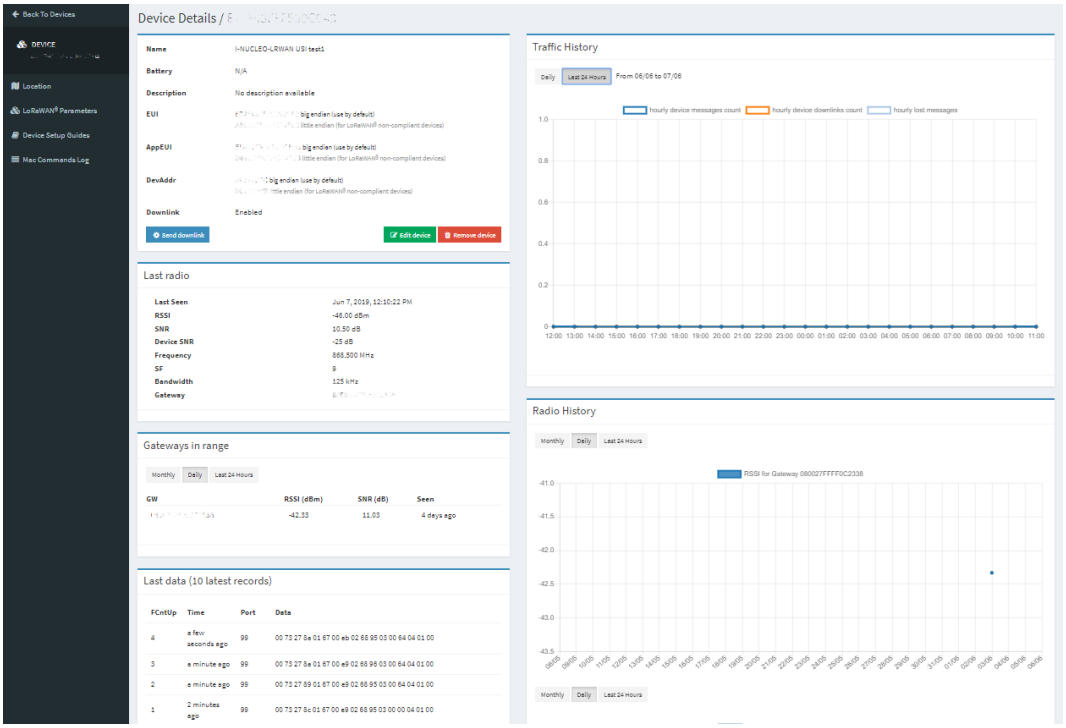
The device parameters are needed to enroll the device, depending on the join-mode setting of the device.

Follow the procedure below to enroll the sensor device:

1. Go to [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]>[**Enroll Device**]
2. Select the correct enrollment process of the device. The default enrollment is *OTAA*.
3. Fill in all necessary information. Refer to the credentials on the device sticker: *DevEUI*, *AppEUI* and *AppKey*
4. Click [**Enroll**]
5. Once enrolled, the device is visible in the device list in menu [**Devices**]
6. Reset the device to allow the device to join the network especially for OTAA devices.

7. Go to the device details by clicking on the link corresponding to the recently-enrolled device. If the device has successfully joined the network, the *Last data (10 latest records)* sent by the device is visible. Note that the page may need to be refreshed to display the latest message entries.

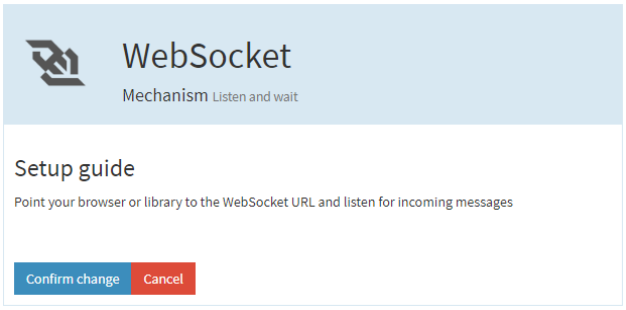
Figure 28. Loriot registered device details



7.1.3 Loriot default application output

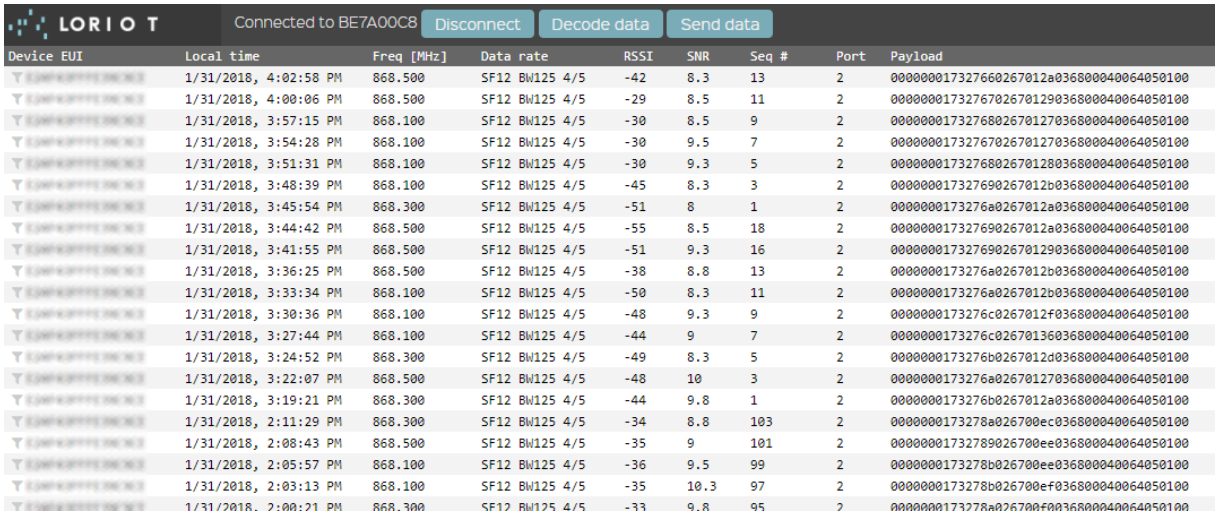
A number of application APIs are available in [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]>[**Output**]. Click on [**Add new output**] and select [**Websocket (by Loriot)**].

Figure 29. `WebSocket` API from Loriot



To view the packets received by the network, go to [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]>[**Websockets Applications**] and click on the [**WebSocket sample by LORIOT**] sample application.

Figure 30. `WebSocket` sample by LORIOT



Device EUI	Local time	Freq [MHz]	Data rate	RSSI	SNR	Seq #	Port	Payload
[redacted]	1/31/2018, 4:02:58 PM	868.500	SF12 BW125 4/5	-42	8.3	13	2	00000001732766026701 2a036800040064050100
[redacted]	1/31/2018, 4:00:06 PM	868.500	SF12 BW125 4/5	-29	8.5	11	2	00000001732767026701290368000400 64050100
[redacted]	1/31/2018, 3:57:15 PM	868.100	SF12 BW125 4/5	-30	8.5	9	2	00000001732768026701270368000400 64050100
[redacted]	1/31/2018, 3:54:28 PM	868.100	SF12 BW125 4/5	-30	9.5	7	2	00000001732767026701270368000400 64050100
[redacted]	1/31/2018, 3:51:31 PM	868.100	SF12 BW125 4/5	-30	9.3	5	2	00000001732768026701280368000400 64050100
[redacted]	1/31/2018, 3:48:39 PM	868.100	SF12 BW125 4/5	-45	8.3	3	2	00000001732769026701 2b036800040064050100
[redacted]	1/31/2018, 3:45:54 PM	868.300	SF12 BW125 4/5	-51	8	1	2	0000000173276a026701 2a036800040064050100
[redacted]	1/31/2018, 3:44:42 PM	868.500	SF12 BW125 4/5	-55	8.5	18	2	00000001732769026701 2a036800040064050100
[redacted]	1/31/2018, 3:41:55 PM	868.500	SF12 BW125 4/5	-51	9.3	16	2	00000001732769026701290368000400 64050100
[redacted]	1/31/2018, 3:36:25 PM	868.500	SF12 BW125 4/5	-38	8.8	13	2	0000000173276a026701 2b036800040064050100
[redacted]	1/31/2018, 3:33:34 PM	868.100	SF12 BW125 4/5	-50	8.3	11	2	0000000173276a026701 2b036800040064050100
[redacted]	1/31/2018, 3:30:36 PM	868.100	SF12 BW125 4/5	-48	9.3	9	2	0000000173276c026701 2f036800040064050100
[redacted]	1/31/2018, 3:27:44 PM	868.100	SF12 BW125 4/5	-44	9	7	2	00000001732760267013603680004006 4050100
[redacted]	1/31/2018, 3:24:52 PM	868.300	SF12 BW125 4/5	-49	8.3	5	2	0000000173276b026701 2d036800040064050100
[redacted]	1/31/2018, 3:22:07 PM	868.500	SF12 BW125 4/5	-48	10	3	2	0000000173276a026701270368000400 64050100
[redacted]	1/31/2018, 3:19:21 PM	868.300	SF12 BW125 4/5	-44	9.8	1	2	0000000173276b026701 2a036800040064050100
[redacted]	1/31/2018, 2:11:29 PM	868.300	SF12 BW125 4/5	-34	8.8	103	2	00000001732780267 00ec036800040064050100
[redacted]	1/31/2018, 2:08:43 PM	868.500	SF12 BW125 4/5	-35	9	101	2	00000001732789026700ee036800040064050100
[redacted]	1/31/2018, 2:05:57 PM	868.100	SF12 BW125 4/5	-36	9.5	99	2	0000000173278b026700ee036800040064050100
[redacted]	1/31/2018, 2:03:13 PM	868.100	SF12 BW125 4/5	-35	10.3	97	2	0000000173278b026700ef036800040064050100
[redacted]	1/31/2018, 2:00:21 PM	868.300	SF12 BW125 4/5	-33	9.8	95	2	0000000173278a026700f0036800040064050100

7.1.4 Setup the Cayenne data output in Loriot

The network server can also be configured to forward the data to a third-party application server like myDevices Cayenne:

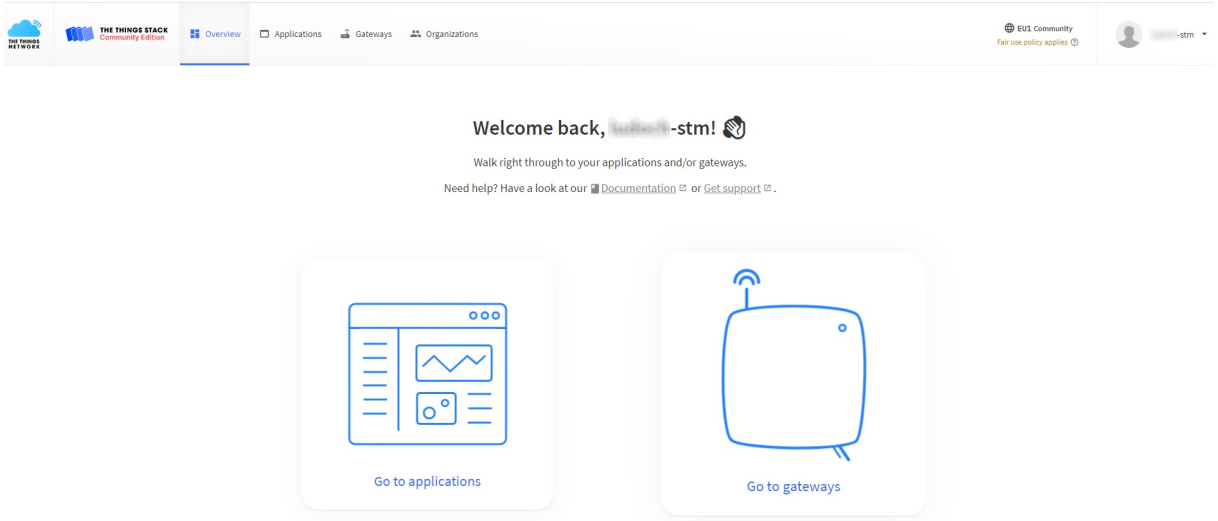
1. In [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]>[**Output**], click on [**Add new output**]
2. Select [**myDevices Cayenne**] from the list of supported data output types
3. Click [**Confirm change**]

Refer to Section 8 to setup the myDevices Cayenne dashboard.

7.2 The Things Network (TTN) v3 server setup

Go to The Things Network website at www.thethingsnetwork.org and create an account. Log in to The Things Network and go to the [**Console**].

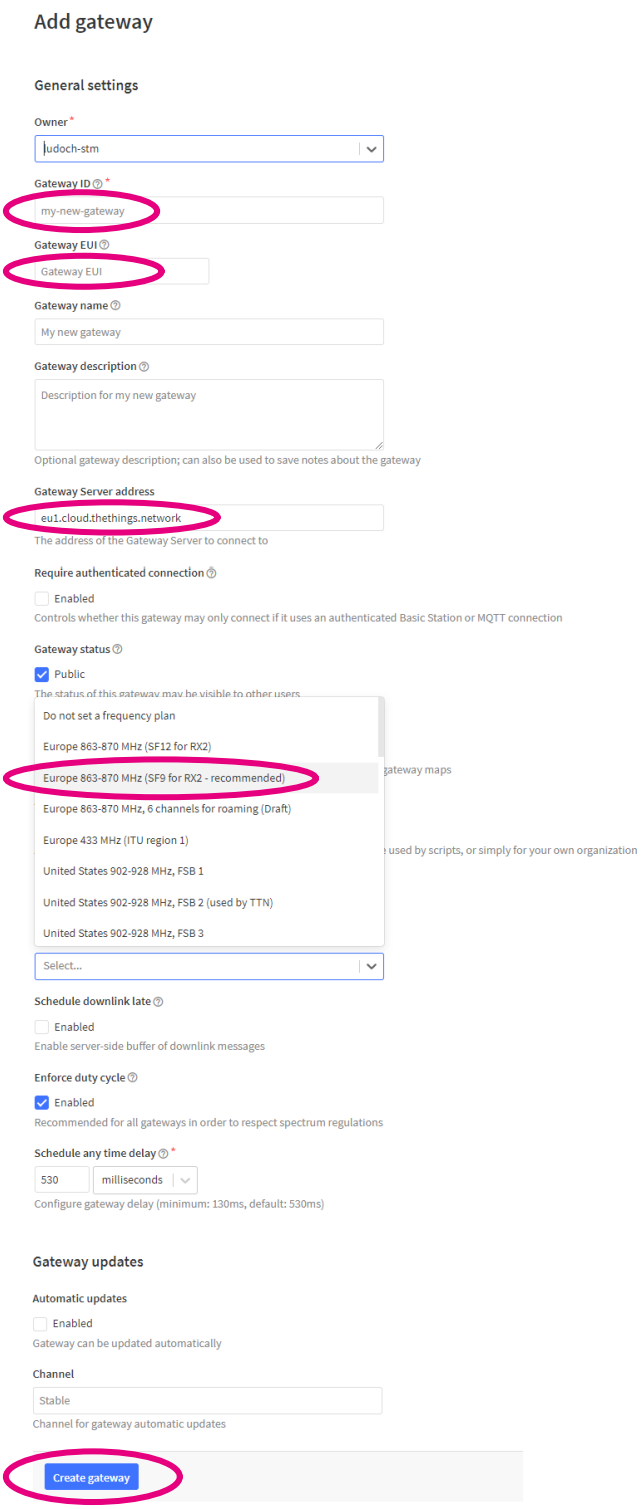
Figure 31. The Things Network Console



7.2.1 Gateway registration to The Things Network v3 server

Follow the procedure below to register the gateway to The Things Network server:

Figure 32. The Things Network gateway registration



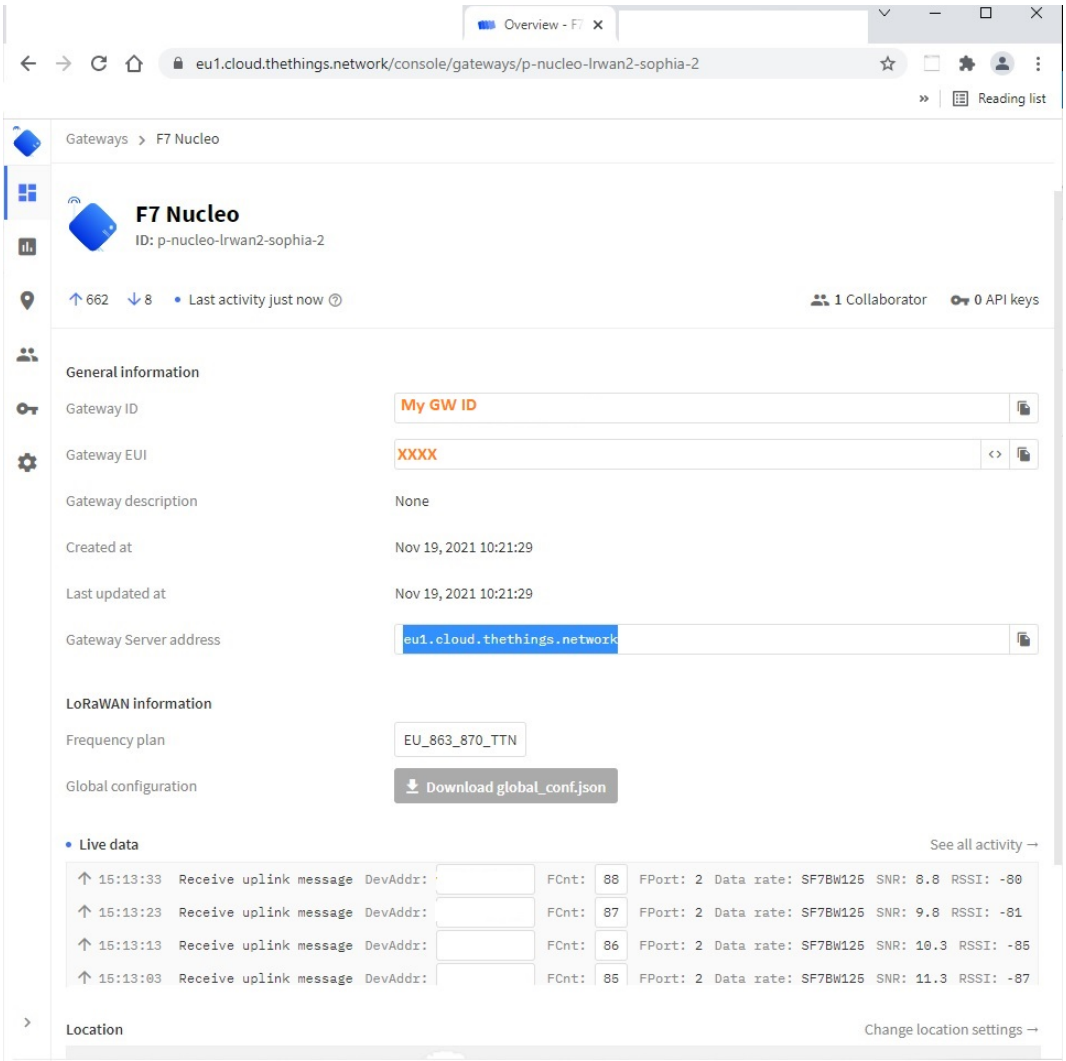
1. Configure the gateway to send data to the closest router address. The list of routers is available from The Things Network website at www.thethingsnetwork.org/docs/gateways/packet-forwarder/semtech-udp.html.

   A gateway configuration example is: `eu1.cloud.thethings.network`.

   Use the following AT command to configure the gateway packet forwarder to connect to The Things Network on UDP port 1700:

   `AT+PKTFWD=eu1.cloud.thethings.network,1700,1700`
2. In [**The Things Network Console Console**], click on [**Gateways**]>[**Add Gateway**].
3. Provide the necessary gateway information:
   - Gateway EUI: (taken from the gateway ID information. Refer to Section 6)
   - [**Description**]
   - [**Frequency plan**]: *Europe 863-870 MHz (SF9 for RX2 -recommended)*
   - [**Gateway Server address**]: `eu1.cloud.thethings.network`
4. Click on [**Create gateway**]

Figure 33. The Things Network registered gateway overview



Other regions

Two other regions are available: US (United States of America) and AU (Australia). Users choosing one of these regions must use the following server addresses:

- For the US region: `nam1.cloud.thethings.network`
- For the AU region: `au1.cloud.thethings.network`

For a US configuration with P-NUCLEO-LRWAN2 or P-NUCLEO-LRWAN3, the user can set the preferred frequency sub band (FSB) as described in Table 7.

Table 7. US FSB hybrid channels setting by AT commands

US frequency hybrid channel	AT command
FSB1	AT+CH=0, 902.3, 0 AT+CH=1, 902.5, 0 AT+CH=2, 902.7, 0 AT+CH=3, 902.9, 0 AT+CH=4, 903.1, 1 AT+CH=5, 903.3, 1 AT+CH=6, 903.5, 1 AT+CH=7, 903.7, 1 AT+CH=8, 903.0, 0, 8, 500
FSB2	AT+CH=0, 903.9, 0 AT+CH=1, 904.1, 0 AT+CH=2, 904.3, 0 AT+CH=3, 904.5, 0 AT+CH=4, 904.7, 1 AT+CH=5, 904.9, 1 AT+CH=6, 905.1, 1 AT+CH=7, 905.3, 1 AT+CH=8, 904.6, 0, 8, 500
FSB3	AT+CH=0, 905.5, 0 AT+CH=1, 905.7, 0 AT+CH=2, 905.9, 0 AT+CH=3, 906.1, 0 AT+CH=4, 906.3, 1 AT+CH=5, 906.5, 1 AT+CH=6, 906.7, 1 AT+CH=7, 906.9, 1 AT+CH=8, 906.2, 0, 8, 500
FSB4	AT+CH=0, 907.1, 0 AT+CH=1, 907.3, 0 AT+CH=2, 907.5 0 AT+CH=3, 907.7, 0 AT+CH=4, 907.9, 1 AT+CH=5, 908.1, 1 AT+CH=6, 908.3, 1 AT+CH=7, 908.5, 1 AT+CH=8, 907.8, 0, 8, 500
FSB5	AT+CH=0, 908.7, 0 AT+CH=1, 908.9, 0 AT+CH=2, 909.1 0 AT+CH=3, 909.3, 0 AT+CH=4, 909.5, 1 AT+CH=5, 909.7, 1 AT+CH=6, 909.9, 1 AT+CH=7, 910.1, 1 AT+CH=8, 909.4, 0, 8, 500
FSB6	AT+CH=0, 910.3, 0 AT+CH=1, 910.5, 0 AT+CH=2, 910.7 0 AT+CH=3, 910.9, 0 AT+CH=4, 911.1, 1 AT+CH=5, 911.3, 1 AT+CH=6, 911.5, 1 AT+CH=7, 911.7, 1 AT+CH=8, 911.0, 0, 8, 500
FSB7	AT+CH=0, 911.9, 0 AT+CH=1, 912.1, 0 AT+CH=2, 912.3 0 AT+CH=3, 912.5, 0 AT+CH=4, 912.7, 1 AT+CH=5, 912.9, 1 AT+CH=6, 913.1, 1 AT+CH=7, 913.3, 1 AT+CH=8, 912.6, 0, 8, 500
FSB8	AT+CH=0, 913.5, 0 AT+CH=1, 913.7, 0 AT+CH=2, 913.9 0 AT+CH=3, 914.1, 0 AT+CH=4, 914.3, 1 AT+CH=5, 914.5, 1 AT+CH=6, 914.7, 1 AT+CH=7, 914.9, 1 AT+CH=8, 914.2, 0, 8, 500

Then, the user must apply the same FSB in the field [**Frequency plan**] during the TTNv3 gateway registration. The same procedure must be applied for other regions proposing FSB channels, like AU (Australia) and CN (China).

Note: TTN gateways use the FSB2 channel by default.
For CN (China), only FSB11 is available for gateway registration on TTNv3.

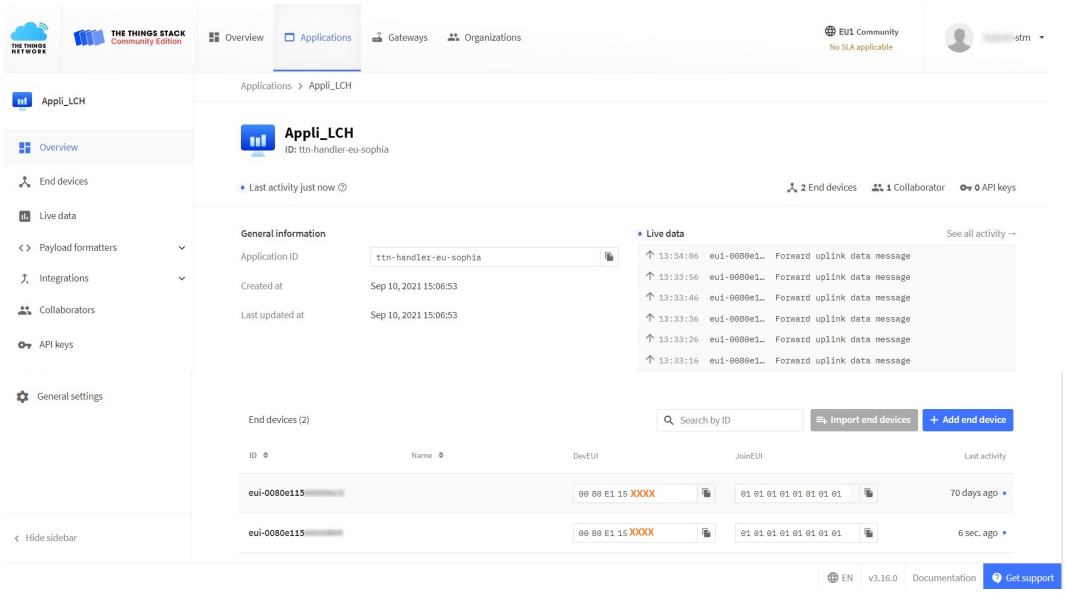
7.2.2 Device registration to The Things Network v3 server

Follow the procedure below to enroll the sensor device:

1. From the [**Console**], click on [**Applications**] and [**add application**] to create a device application for device registration.

2. Provide the necessary information:
   – Application ID: choose a unique ID or name made of lower-case, alphanumeric characters and nonconsecutive “-”, for example `ttn-handler-eu`
   – Application
   – Description
3. Click on [**Add application**].

Figure 34. The Things Network application overview

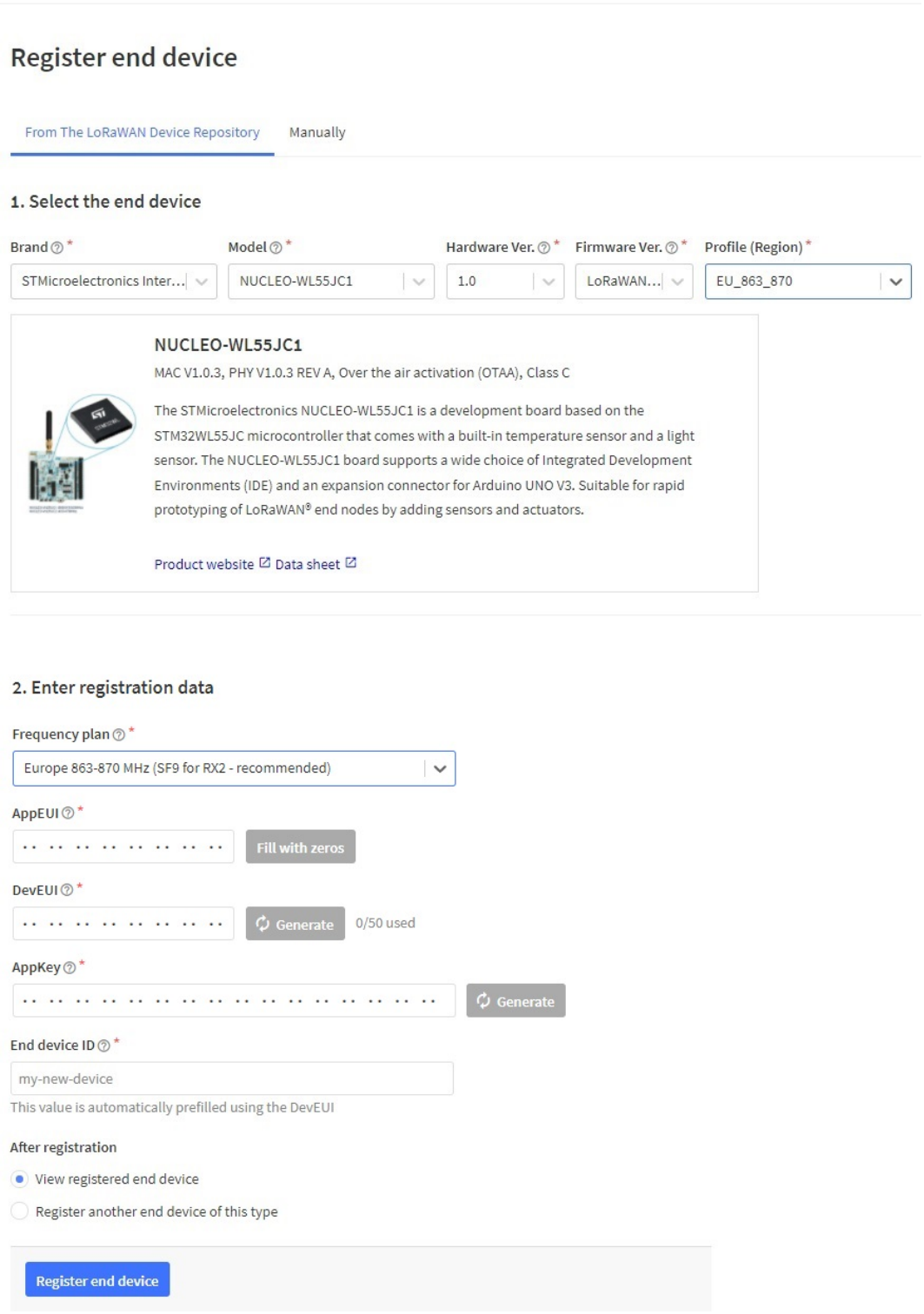


4. Click on [**Add end device**].
5. Select the end device type. For example, when using an STM32WL-based device such as the NUCLEO-WL55JC1, choose:
   – [**Brand**]: STMicroelectronics
   – [**Model**]: NUCLEO-WL55JC1
   – [**Profile (Region)**]: EU_868_870
6. In the section *Enter registration data*, provide the necessary information:
   – [**Frequency plan**]: select *Europe 863-870 MHz (SF9 for RX2 - recommended)*
   – [**AppEUI**]: select the app EUI of the device
   – [**DevEUI**]: enter the device EUI of the device (refer to the device credentials sticker)
   – [**AppKey**]: enter the app key of the device (refer to the device credentials sticker)
   – [**End device ID**]: choose a unique ID or name

*Note: For the US915, AU915, or CN470 configuration, when registering a device, the user must set in the field [**Frequency plan**] the same frequency sub band (FSB) as entered during the gateway registration (refer to Other regions in Section 7.2.1 Gateway registration to The Things Network v3 server).*

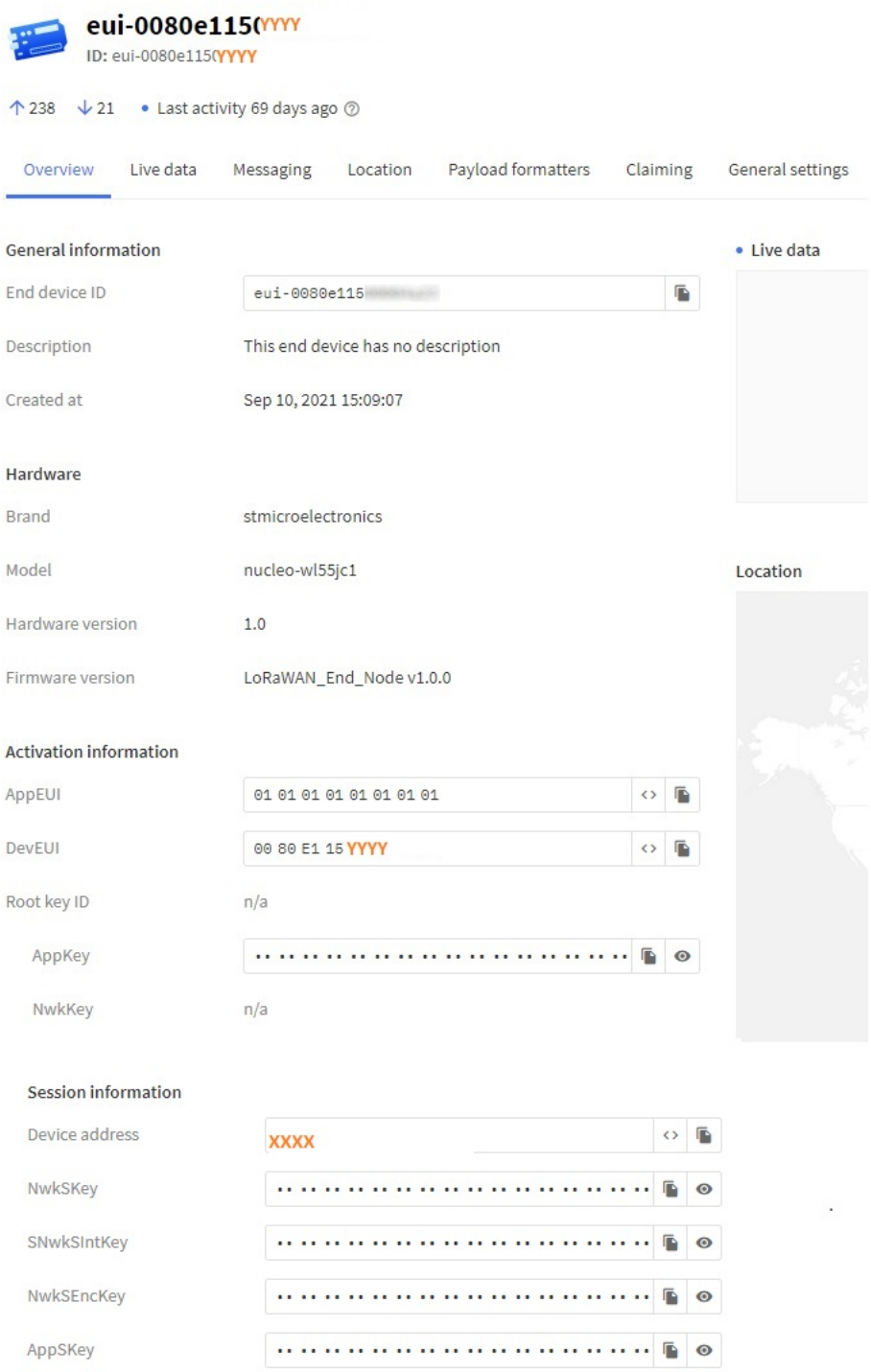
7. Click on [**Register end device**] to complete the registration.

Figure 35. The Things Network end device registration



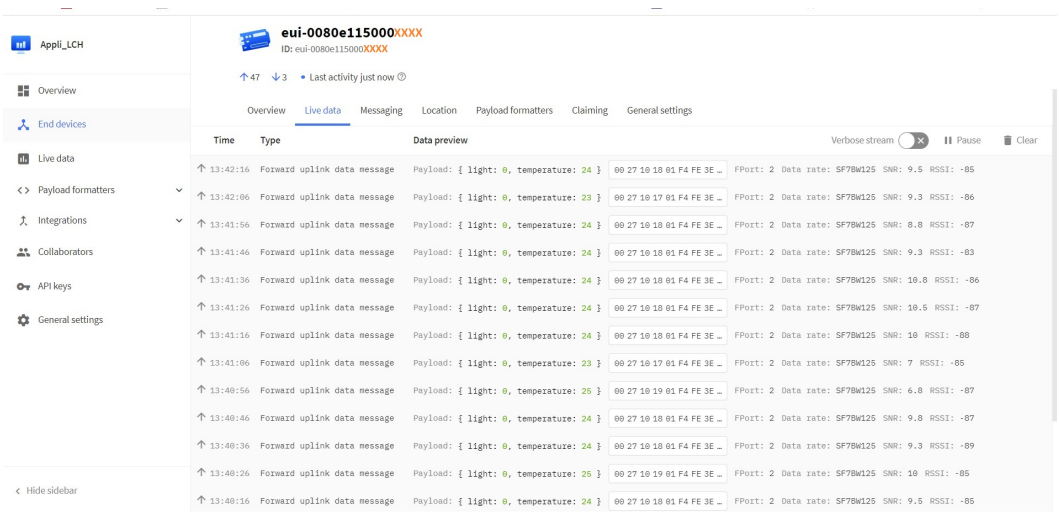
8. The device overview shows the credentials and status of the last packets received from the device.

Figure 36. The Things Network registered device overview



9. Select the *Live data* tab to view the packets received. The data can also be viewed from the *Applications overview* panel where it displays the data received from all registered devices in the application.

Figure 37. The Things Network received data



7.2.3 Setup the myDevices Cayenne integration in The Things Network v3

The network server can also be configured to forward the data to a third-party application server like myDevices Cayenne (refer to Figure 38 and Figure 39):

1. In the *Application* view, click on [**Integrations**] and then [**Webhooks**]
2. Choose the Cayenne webhook template
3. In template settings, fill the fields:
   – Webhook ID (mandatory)
   – Client ID (optional)
4. Click on the [**Create cayenne webhook**] button

Figure 38. **Cayenne webhook template selection**

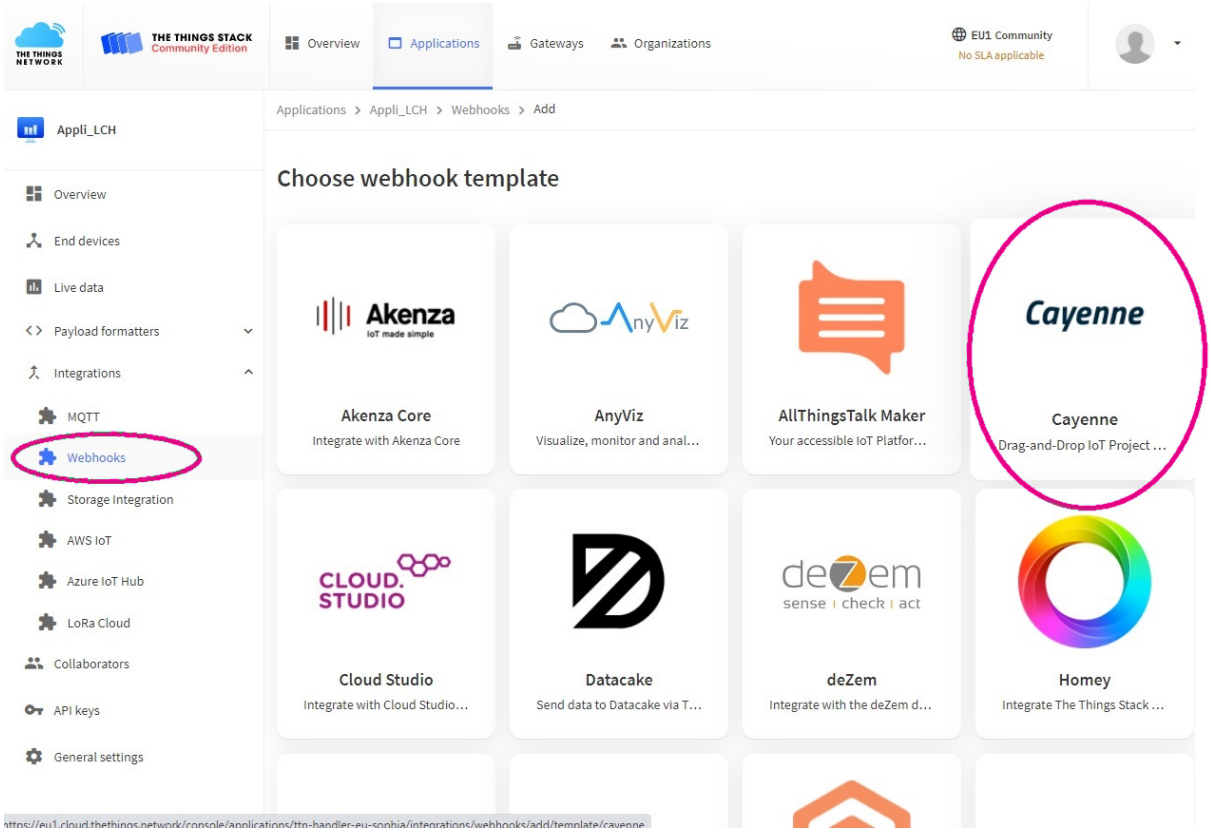
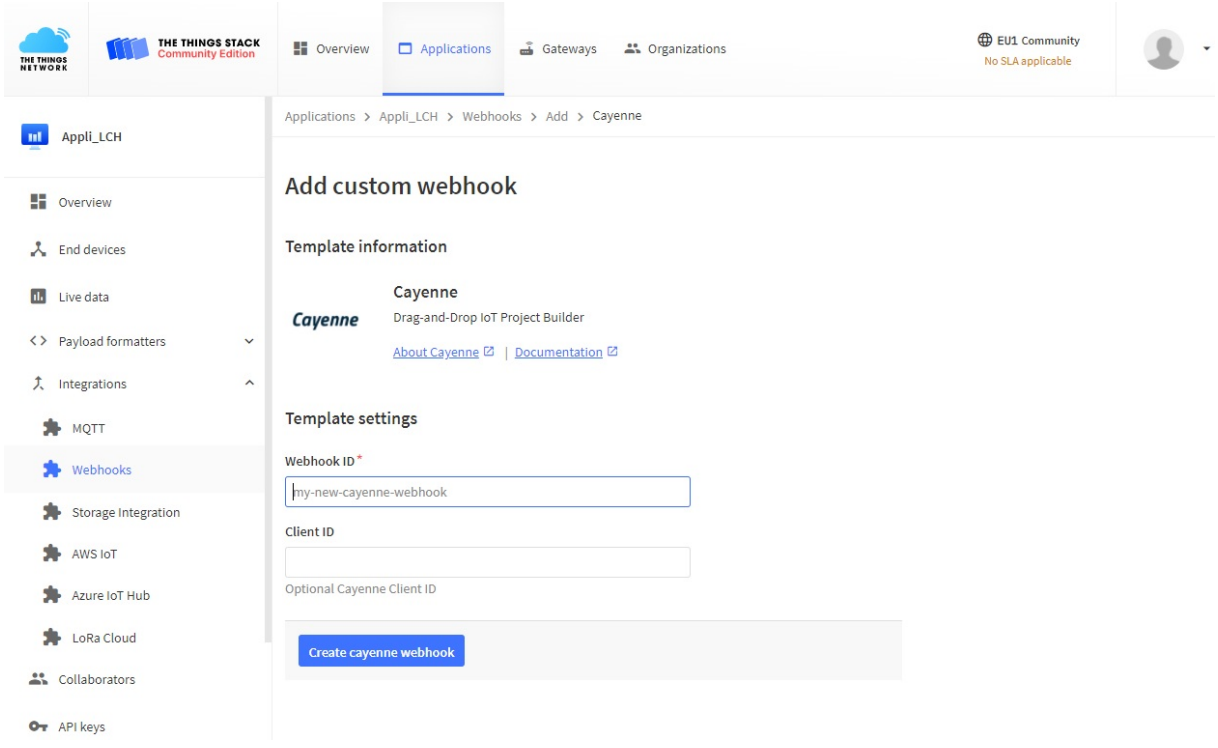


Figure 39. **Cayenne webhook settings**



Refer to Section 8 to setup the myDevices Cayenne dashboard.

8 Application server setup

This section describes how to register the sensor device to a LoRa® application server. The following application server providers are supported:

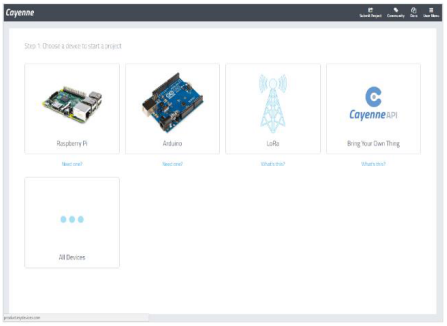
- myDevices Cayenne

8.1 myDevices Cayenne application setup

Go to myDevices web site at https://mydevices.com/ and create a free myDevices Cayenne account. The free account allows users to register LoRa® sensor devices connected to different LoRaWAN® network servers and view the sensor data on the dashboard. The widgets are customizable and trigger alerts can be set.

More details about the myDevices Cayenne dashboard is available from the https://mydevices.com/cayenne/docs web page.

Figure 40. Cayenne IoT project

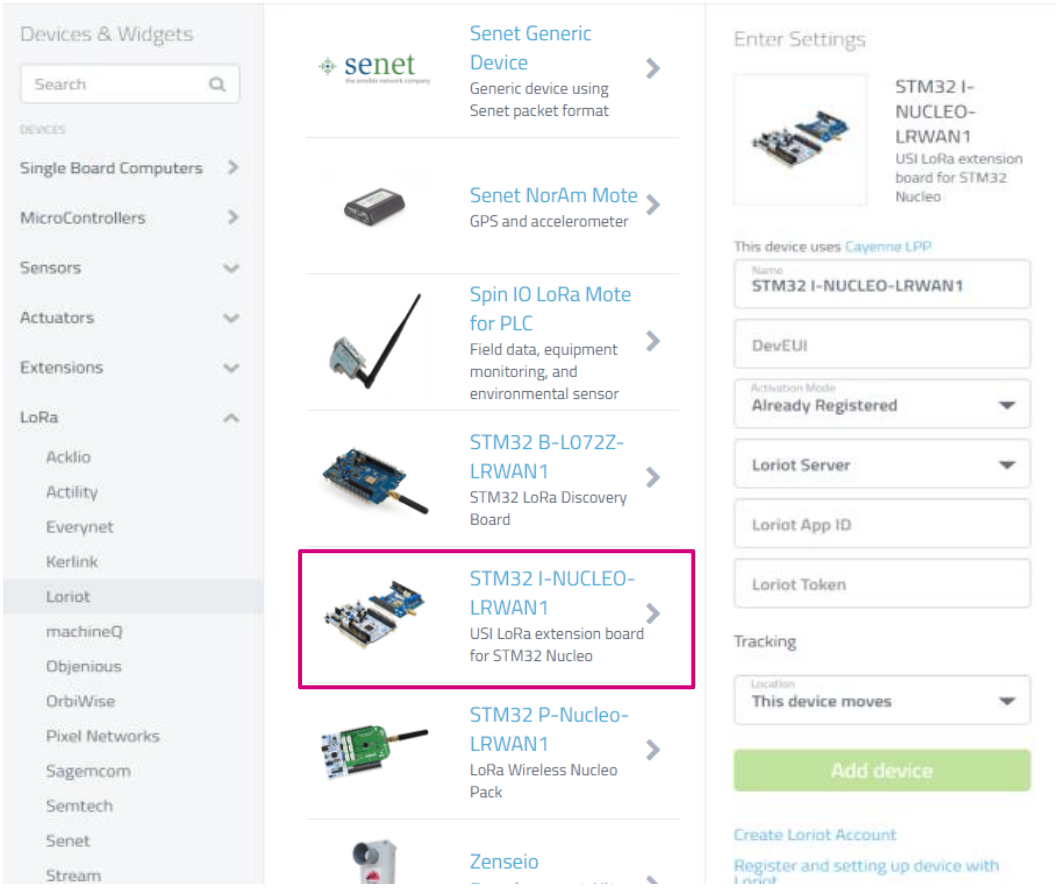


8.1.1 Add a LoRa® device

1. Choose LoRa® from the list of IoT projects
2. From the LoRa® category, choose the network server used from the list of supported LoRaWAN® network servers, such as Loriot, The Things Network, or Actility ThingPark

3. Select STM32 P-NUCLEO-LRWAN2 from the list of supported LoRa® devices

Figure 41. Selecting a LoRa® device



4. Enter the device settings, then add the device

   For Loriot:

   a. Name
   b. DevEUI
      (refer to [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]>[**Devices**]. Remove *"-"* or *":"*)
   c. Loriot server
      (the server used at Loriot account creation: *eu1.loriot.io*)
   d. Loriot AppID
      (refer to [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]: *Application ID*)
   e. Loriot security token
      (refer to [**Loriot Dashboard**]>[**Application**]>[**SampleApp**]>[**Access Token**]: *Authentication Tokens*)
   f. Tracking
      i. This device moves (if the device sends packets with GPS coordinates)
      ii. This device does not move (input fixed address)

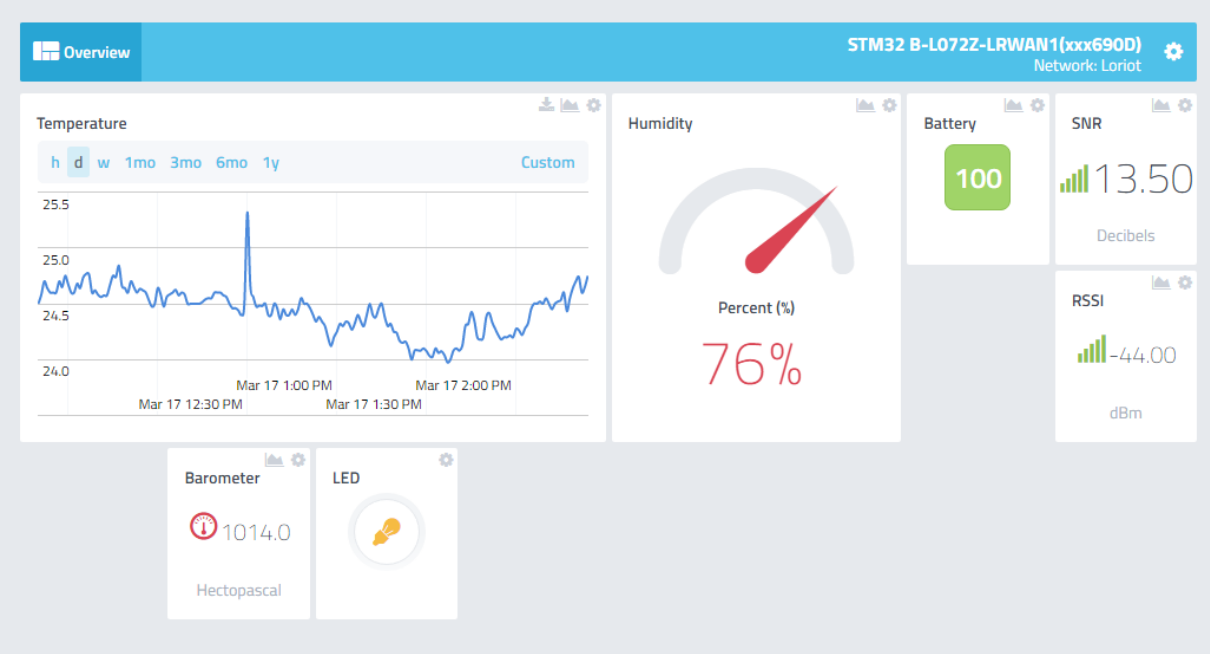
   For The Things Network (TTN):

   a. Name
   b. DevEUI
      (refer to [**TTN Dashboard**]>[**Application**]>[**appname**]>[**Devices**])
   c. Tracking
      i. This device moves (if the device sends packets with GPS coordinates)
      ii. This device does not move (input fixed address)

8.1.2 Cayenne dashboard

The pockets sent by the device are using the Cayenne low-power payload (LPP) format by default in the firmware code. As soon as pockets are received in Cayenne, the widgets automatically appear in the dashboard depending on the data types used in the data payload. Widgets can be customized as per preference.

Figure 42. myDevices Cayenne dashboard



9 References

Table 8 lists the complementary references for using P-NUCLEO-LRWAN2 and P-NUCLEO-LRWAN3.

Table 8. References

ID	Description
[1]	Reference manual: *USI WM-SG-SM-42 AT Command*. Refer to Universal Scientific Industrial (USI®) web site at www.usiglobal.com(1).
[2]	Reference manual: *[RHF-PS01709] LoRaWAN Class ABC AT Command Specification*. Refer to RisingHF web site at www.risinghf.com(1).
[3]	User guide: *ST Nucleo LoRa GW* (RHF-UM01622). Refer to RisingHF web site at www.risinghf.com(1).
[4]	User manual: *STM32 Nucleo-144 boards (MB1137)* (UM1974). Refer to STMicroelectronics web site at *www.st.com*.
[5]	User manual: *STM32 Nucleo-64 boards (MB1136)* (UM1724). Refer to STMicroelectronics web site at *www.st.com*.
[6]	User manual: *STM32 LoRa® Expansion Package for STM32Cube* (UM2073). Refer to STMicroelectronics web site at *www.st.com*.
[7]	User manual: *STM32 ST-LINK Utility software description* (UM0892). Refer to STMicroelectronics web site at *www.st.com*.
[8]	User manual: *STM32CubeProgrammer software description* (UM2237). Refer to STMicroelectronics web site at *www.st.com*.

1. *This URL belongs to a third party. It is active at document publication, however STMicroelectronics shall not be liable for any change, move or inactivation of the URL or the referenced material.*

Revision history

Table 9. **Document revision history**

Date	Revision	Changes
25-Sep-2019	1	Initial release.
21-Apr-2021	2	P-NUCLEO-LRWAN2 boards delivered with mounted antennas: updated *Introduction*, *Section 1 P-NUCLEO-LRWAN2 starter pack overview*, *Section 4.1 Sensor device setup*, *Section 5.1 Sensor device setup*, and *Section 6.1 Gateway setup*.
14-Dec-2021	3	Updated the registration procedure and configuration parameters in Section 7.2 The Things Network (TTN) v3 server setup after the server evolution. Updated the reference of the Indian frequency plan in Configuring the gateway to use a different frequency band. Removed the references to Arm® Mbed™.

Contents

List of tables

List of figures