EMB-Fem2GW-O-2G4

DOCUMENTATION

Rev 1.2

Embit s.r.l.

Document information

Versions & Revisions

Revision	Date	Author	Comments
1.0	2021-02-09	Embit-AM	Initial release
1.1	2021-06-17	Embit-DL	Added installation guide
1.2	2022-11-21	Embit	Aligned to the new Hardware release with POE

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1 Introduction

The **EMB-Fem2GW-2G4-O** uses LoRa® technology and complies with the Semtech® 2.4GHz protocol stack which aims to emulate LoRaWAN® behavior. It enables IoT (Internet of Things) implementations mandating worldwide interoperability and battery-powered end devices over long-distance connectivity. Thanks to the absence of duty cycle restriction on 2.4GHz ISM Band, it is perfectly suitable for applications which needs a continuous exchange of data, such as real time monitoring. The gateway is an IP67-grade outdoor product, with a plastic case.

This guide explains how to start using the **EMB-Fem2GW-2G4-O**. The **EMB-Fem2GW-2G4-O** gateway is a multi service up-gradable platform, designed to meet IoT (Internet of Things) and M2M (Machine-2-Machine) scenarios. It enables LoRa® 2.4 GHz connectivity, having the role of fully compliant Gateway. It provides the LoRa® 2.4 GHz packet forwarder functionality: it has 3 Semtech® SX1280 radio transceivers dedicated to the reception and 1 Semtech® SX1280, reserved for the transmission. The radio section is based on the EMBIT Mini PCI-express board, EMB-LR1280-mPCIe-4x. It starts to operate as a LoRa® 2.4GHz base station, receiving radio packets and forwarding them to a LoRa® 2.4GHz Network Server. It has a TCP/IP connection through Ethernet, or via 4G connection, available through SIM card and 4G Mini PCI express module. In the latter case, high latency could lead to the LoRa®

2.4 GHz network performance decrease. Its functionalities will be described in details in the following paragraphs. It includes GPS connectivity to locate the device.

Thanks to the Semtech® SX1280 performances and the efficient Embit RF design, the possible radio ranges are up to 7 km in the country side and up to 400 m in urban areas.

The OS system is Linux based, and the customer can configure it according to his needs, with a complete root access. The **EMB-Fem2GW-2G4-O** provides a web interface to manage and configure the connectivity with the different network protocols.

The gateway must be by POE (Power over Ethernet) IEEE 802.3at.

Figure 1 EMB-Fem2GW-2G4-O

2 Hardware Specification

- Processor: CPU ARM Cortex-A72 quad-core a 64 bit da 1,5 GHz
- RAM Memory: 2 GB, LPDDR2 SDRAM
- Flash Memory: 8/16/32 GB, EMMC Flash Memory
- LAN Connection: Ethernet RJ45 10/100/1000 Base-T
- LoRa® Connectivity: EMB-LR1280-mPCIe-4x, 3 LoRa® 2.4GHz Rx Channels, 1 LoRa® 2.4GHz Tx Channel
- Receiver Sensitivity: down to -129 dBm @ SF12 BW 812.5kHz

- Connectivity: GPS Module U-Blox NEO-M8-Q
- Cellular Connectivity: 4G LTE / 3G UMTS / 2G GPRS through Mini Size SIM embedded inside
- Cellular Module: Quectel EC21-E Mini PCIe
- Power Source: IEEE 802.11at Power Over Ethernet
- Ports: Ethernet 10/100/1000 RJ 45 / 1 N-Type Antenna Connector for 2.4 GHz / Air Port
- Power Consumption: 5 Watt (average)
- Operating System: Linux 9.8 Stretch
- Dimensions: L: 165 mm W: 165 mm H: 45 mm
- Weight: 1.0 kg

- Certifications: CE, RED

Absolute Maximum Ratings

The power consumption of the **EMB-Fem2GW-2G4-O** has been tested in two different conditions: outside the thermal chamber and inside the thermal chamber. The results are represented on the following tables:

Outside Thermal Chamber:

LTE Transmission	
Idle Condition in LTE Mode	**Connection in LTE Cell in LTE Mode**
405 mA peak	700 mA peak

Table 1 Outside Thermal Chamber-LTE Transmission

GSM Transmission	
Idle Condition in GSM Mode	**Connection in GSM Cell in GSM Mode**
405 mA peak	1110 mA peak

Table 2 Outside Thermal Chamber-GSM Transmission

Inside Thermal Chamber:

LTE Transmission	
Idle Condition in LTE Mode	**Connection in LTE Cell in LTE Mode**
400 mA peak	690 mA peak
Send LoRa® Packet in LTE Mode	**Switch from LTE to GSM Mode**
700 mA	1600 mA peak

Table 3 Inside Thermal Chamber-LTE Transmission

GSM Transmission	
Idle Condition in GSM Mode	**Connection in GSM Cell in GSM Mode**
400 mA peak	1200 mA peak
Send LoRa® Packet in LTE Mode	**Switch from LTE to GSM Mode**
1200 mA peak	1600 mA peak

Table 4 Inside Thermal Chamber-GSM Transmission

Note: the peak values are reached for a period of <1 ms and do not represent the continuous current consumption.

2.1 Thermal Tests

The **EMB-Fem2GW-2G4-O** has been tested by using the Embit Thermo Camera and for three different supply voltage values.

All the temperatures were read 1 hour after switching on with Wi-Fi, LTE, LoRa® and GPS ***turned on.***

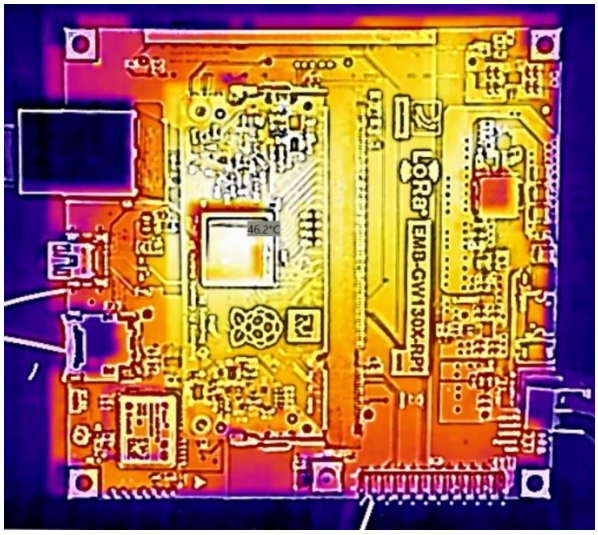

Figure 2 Thermal stress test

The maximum temperature registered has been 46.2 °C on the MCU Core and the maximum current measured is 0.377 A.

3 Gateway Installation Guide

3.1 Pole mounting

In this section, it is described how to mount the **EMB-Fem2GW-2G4-O** on a pole. It has to be in a position sufficiently high to guarantee a good communication range.

The **EMB-Fem2GW-2G4-O** must be installed vertically, with the cables exposed on the lower side of the gateway (see Figure 6). Otherwise, the correct functioning of the product is not guaranteed.

EMB-Fem2GW-2G4-O is provided with the mounting bracket, shown in the following picture.

Figure 5 Mounting Bracket with Gateway

The mounting bracket has to be attached to the back of the **EMB-Fem2GW-2G4-O** using screws and washer and attached on the pole as the image below.

Figure 6 EMB-Fem2GW-2G4-O on the pole

3.2 Ethernet connection

In order to exploit the Ethernet connection of the **EMB-Fem2GW-2G4-O**, you have to simply plug the proper cable (not provided) in the Ethernet port (see Figure 9).

Once the cable is fixed, you have to screw the outdoor IP68 socket adapter (Figure 7) to avoid water leaks.

Figure 7 Waterproof outdoor socket adapter

3.3 Power supply and connection

The gateway must be powered by POE following the standard IEEE 802.3at. We recommend to use certified Power injectors capable to provide at least 20 Watt.

3.4 Grounding and Cables Section

The **EMB-Fem2GW-2G4-O** does not require ground connection.

Note: The external power supply, of course, must be grounded since it provides the ground reference. Please check that your power supply is properly grounded.

4 Antenna Configuration

EMB-Fem2GW-2G4-O has 1 N-Type Antenna Connector. In the same side of the Ethernet connector, SMA connector is placed.

Antenna has to be screwed on the connector.

Note: You must be careful to place the antenna in an obstacle-free space as much as you can. Do not put it in an electromagnetic environment in order to not degrade the antenna performances.

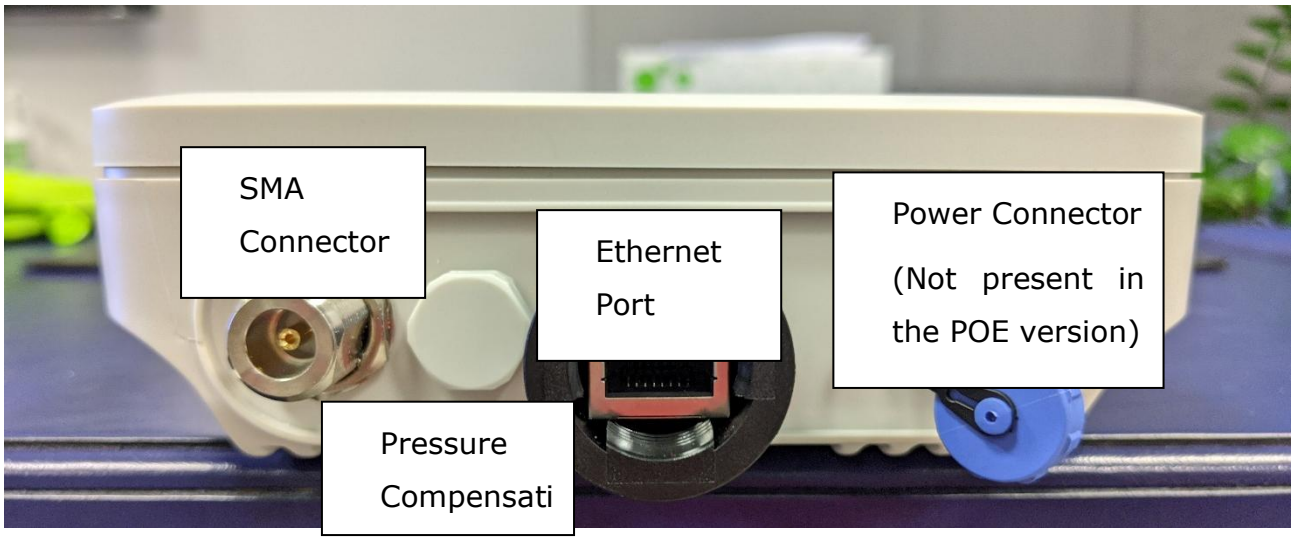

Figure 9 Side View of the EMB-Fem2GW-2G4-O

4.1 Antenna Radiation Pattern

The **EMB-Fem2GW-2G4-O** is provided with the antenna **EMB-AN24-SB**. It is an antenna ½ wave dipole at 2400-2500 MHz suitable for Wi-Fi, WLAN, LoRa®, Zigbee, Bluetooth and ISM applications.

The radiation pattern and the V.S.W.R. graph are represented in the following pictures.

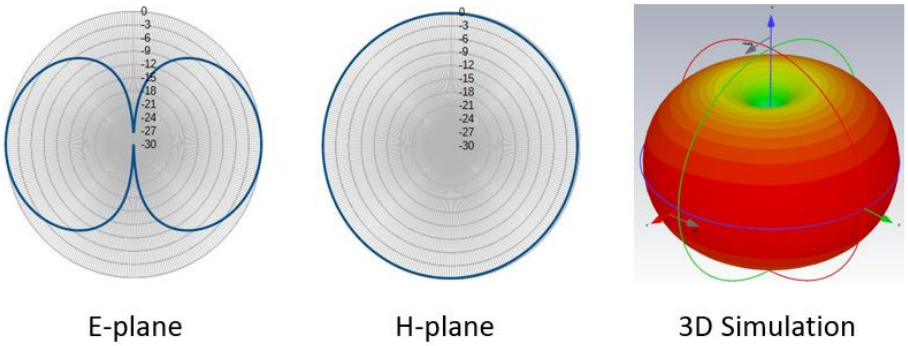

Figure 10 Antenna Radiation Pattern

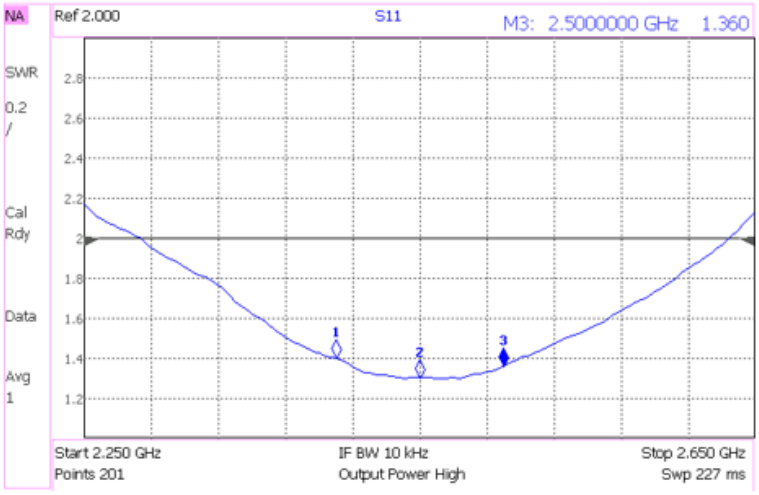

Figure 11 V.S.W.R. Graph

For further information, please check the Annex section.

5 Operating System

EMB-Fem2GW-2G4-O Operating System is Linux 9.8 Stretch.

It is allowed full SSH root access to the final user, using as username and password:

Username: user

Password: embit

The final user can install, uninstall, upgrade every single program.

Pay attention, each action may stop irretrievably the functionalities of the system.

6 LoRa® 2.4 GHz Feature

LoRa® 2.4 GHz is the physical layer utilized to create the communication link. It is based on Chirp Spread Spectrum (CSS) modulation, which combines low power characteristics and increases the communication range. It exploits 2.4 GHz RF properties to achieve higher data rate and deep indoor penetration. 2.4 GHz ISM Band is extremely crowded, but high interference immunity is guaranteed thanks to the LoRa® modulation.

LoRa® 2.4 GHz protocol stack emulates LoRaWAN® behavior, put on top the LoRa® physical layer. It is supported by an established ecosystem of LoRa® 2.4 GHz devices that are available from multiple vendors.

In this network Architecture, three main roles are defined:

- **End-Device**: endpoints with sensors embedded;
- **Gateways**: they provide LoRa® 2.4GHz wireless connectivity to the devices. They are the connection between the devices and the IP backhaul network to the Network Server;
- **Network Server**: the intelligence of the network. It is centralized radio controller, which performs radio management, the provisioning and authentication of devices, and the delivery of the data to one or multiple application servers through a set of Application Programming Interfaces (APIs).

Another role is the **Application Server**. It is managed by the final customer and it is put on top of the Network Server. Full Network Image follows.

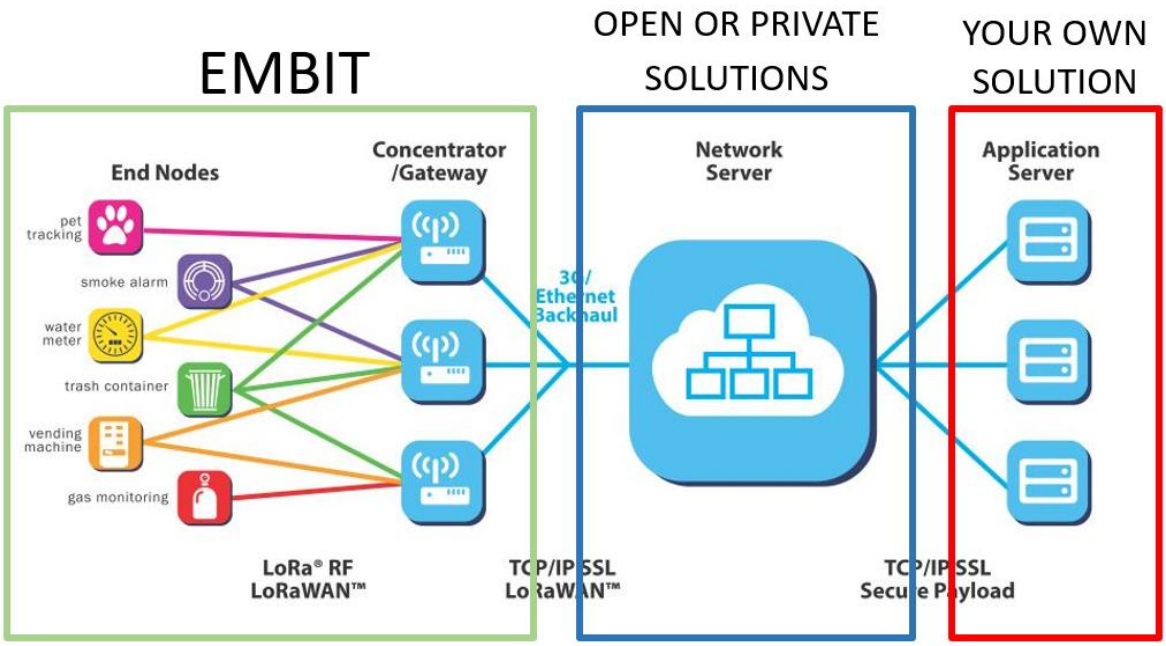

Figure 12 LoRa® Network Architecture

Each communication is fully encrypted with three keys, each one with a length of 128 bits. The algorithm used for it is AES-128. These algorithms have been analysed by the cryptographic community for many years, are NIST approved and widely adopted as a best security practice for constrained nodes and networks.

EMB-Fem2GW-2G4-O provides LoRa® 2.4 GHz connectivity up to 2-3 km in urban area and up to 15 km in rural environment. It adds SF5 and SF6 to the well-known list of Spreading Factor. The Bit Rate varies from 1.2 kbps to 63 kbps.

The RF path is fully compliant to Semtech® specifications and it is able to achieve a Receiver Sensitivity up to -129 dBm.

7 LoRa® 2.4 GHz Gateway Configuration Web Interface

EMB-Fem2GW-2G4-O provides a web interface, which allows to select and configure the desired LoRa® 2.4 GHz packet forwarder.

It is reachable at *https://[gateway_IP_address]:10000*. The default data access is:

username: user

password:embit

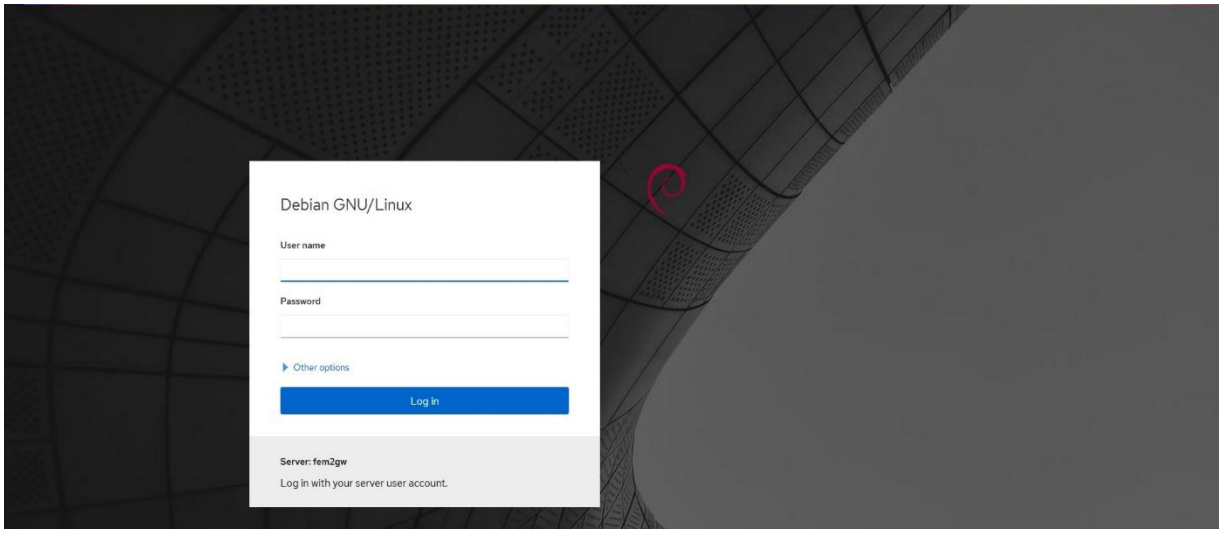

Figure 13 Log In Page

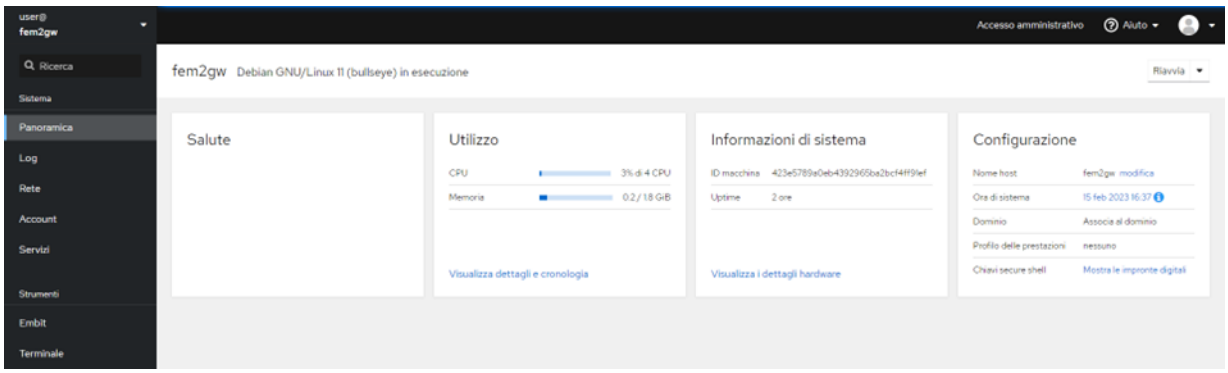

Figure 14 Main Page

Clicking "services" you can reach the "*Packet Forwarder*" page, the system state information is reported. In this page is possible to manage and monitor the LoRa® packet forwarder status.

It is recommended to turn off the packet forwarder before configuring new parameters, and turn it back on afterwards.

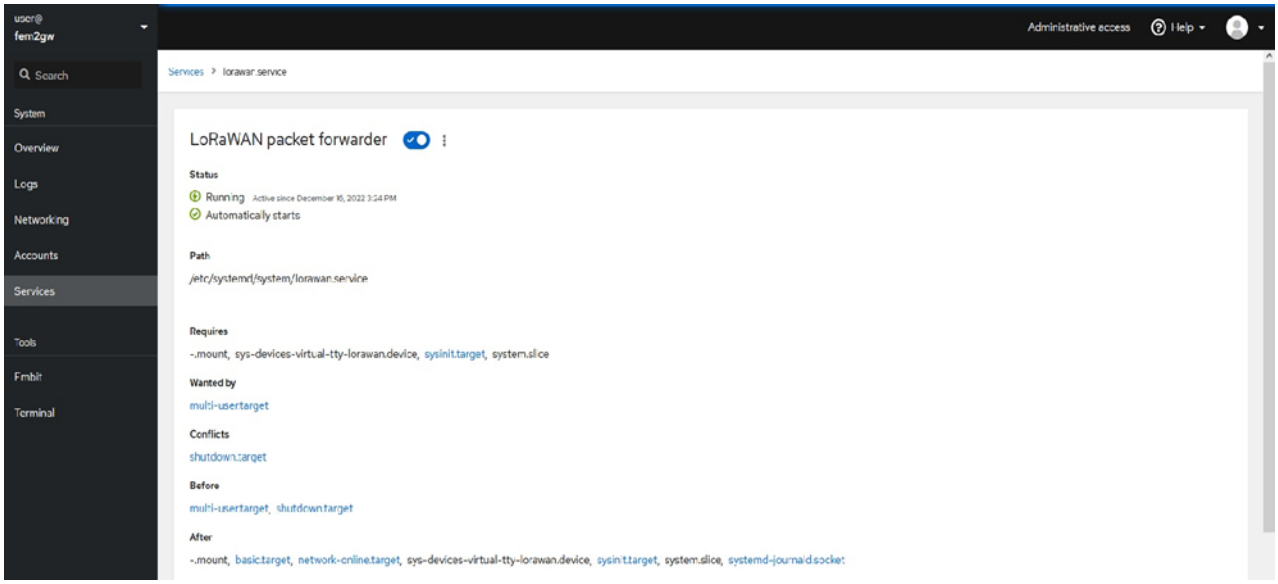

Figure 15 LoRaWAN packet forwarder Tab

"*Embit Gateway Configuration"* is located in the left menu, in the category Tools.

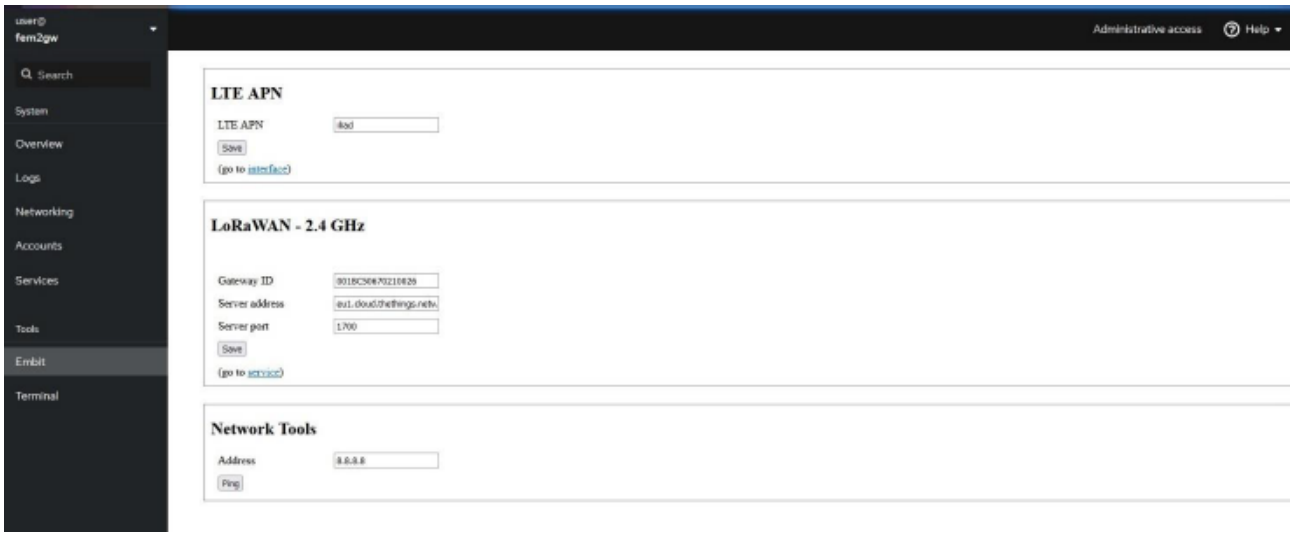

Figure 16 Embit Gateway Configuration Main Tab

In the configuration tab, it is possible to customize the network parameter of the LoRa® 2.4 GHz packet forwarder.

The following figure shows the TTN (The Thing Network) LoRa 2.4 GHz configuration:

Figure 17 Embit Gateway Configuration Main Tab

8 LoRa® 2.4 GHz Gateway EUI

EMB-Fem2GW-2G4-O connects to the LoRa® 2.4 GHz network with a Gateway EUI (Extended Unique Identifier) written in the label. Gateway EUI can be changed using the LoRa® 2.4 GHz Gateway Configuration Web Interface.

forwarders.

Step 1: Take your Unique Gateway EUI

The Unique Gateway EUI is a number which allows the Network Server to identify your gateway. This parameter is written in the label of the **EMB-Fem2GW-2G4-O** Gateway. It can be changed, according to your preferences, through Embit Gateway Configuration Web Interface, under the "Configuration Tab".

9 Example: The Things Network LoRa® 2.4 GHz Network Server

This section provides a brief explanation to register a new gateway in a LoRaWAN® Network Server.

The LoRaWAN® Network Server taken into account for this example is "The Things Network" network server.

The references to all the complete procedure to be carried out can be found on The Thing Industries website in the "Registering Gateways" tab, at the link: [The Things Industries]

Step 1: Sign up with your Account or register a new one

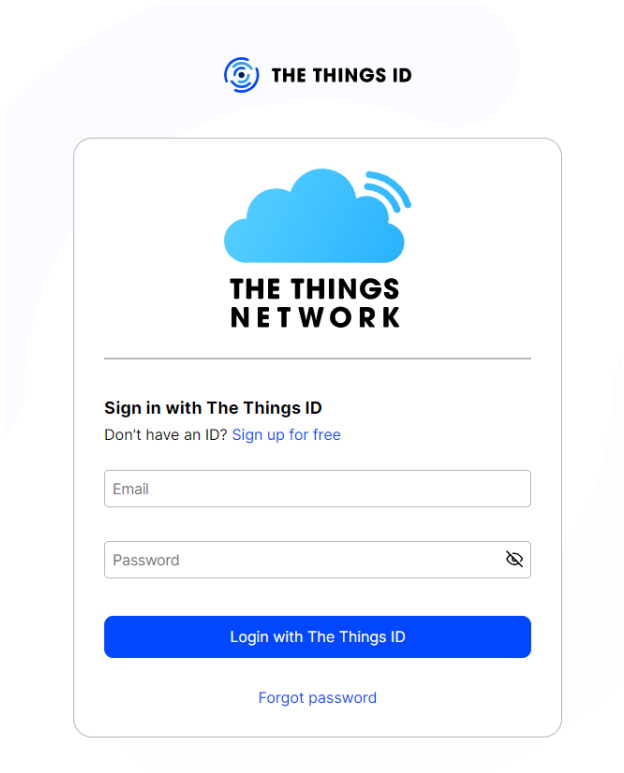

Figure 18 TTN Login Page

Step 2: Add a new gateway

Once you are logged in, click on your profile name, go to "Console" and select your cluster (Example: Europe).

In the next page, click on "Go to gateways" (Figure 19) and then click on "Register gateway" (Figure 20).

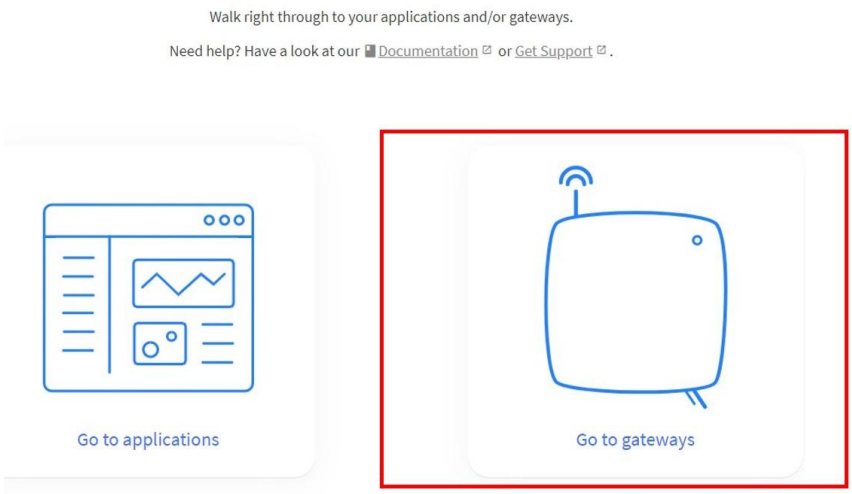

Figure19 Gateway selection

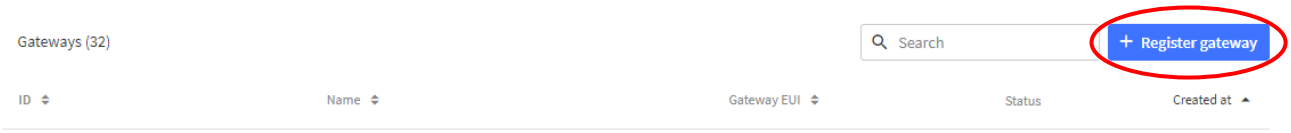

Figure 20 Register gateway button

In the next window, you have to compile all the fields required (Figure 21). The Gateway EUI is the hexadecimal EUI written on the label "Gateway EUI" in the Embit Gateway Configuration Tab from the Gateway Web Interface.

Here your ID name will appear

Configured Gateway EUI

Gateway ID – Auto generated (can be modified)

Gateway name

Select LoRa 2.4 GHz

Figure 21 Add gateway settings

Once that all the settings are completed, click on "Register gateway" button.

Step 3: Check your connection

After that the adding procedure is completed, a general overview will appear (Figure 22)

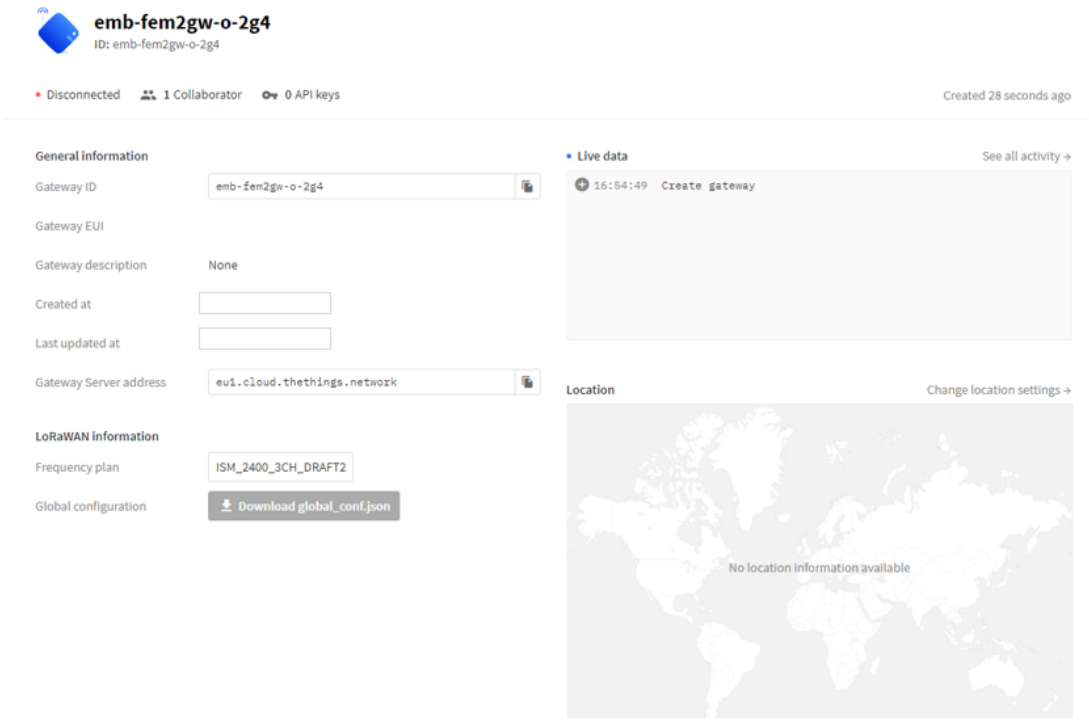

Figure 22 General overview of the added gateway

When your Gateway is connected, a green dot is showed in the upper side of the info. Near the connection status, you can also find the list of the collaborators of the new gateway and, by clicking "Collaborator" you can add a new member.

10 IP Backhaul Connection

EMB-Fem2GW-2G4-O supports two kinds of backhaul IP connection:

- Ethernet IP connectivity;
- Cellular connectivity.

The system is connected to the Ethernet Network through Ethernet Cable. IP address is assigned through DHCP.

Cellular connectivity is achieved using Quectel LTE Module. **EMB-Fem2GW-2G4-O** supports mini SIM Size, with a Push-Push connector. It automatically guarantees LTE connectivity, and without it switches to 3G/UMTS or to GPRS connection according to the cellular coverage.

11 LTE Connection

In this section is described how **EMB-Fem2GW-2G4-O** manages the LTE peripheral.

How to set up an LTE Network is explained. In Linux OS, LTE interface is called ppp0. We setup the OS to start the LTE module at boot time, according to the lte configuration file stored in `/etc/ppp/peers`.

This file is composed as follows:

```
#connect is the command to manage the script to launch LTE connection. The last name, in this case tre.it, is the APN server name.
connect "/usr/sbin/chat -v -f /etc/chatscripts/gprs -T tre.it"
#serial port adopted by the LTE Module
/dev/ttyUSB3
#With this option, the peer will have to supply the local IP address during IPCP negotiation (unless it specified explicitly on the command line or in an options file)
Noipdefault
#Add a default route to the system routing tables, using the peer as the gateway, when IPCP negotiation is successfully completed
defaultroute
replacedefaultroute
#Do not require the peer to authenticate itself
Noauth
# Do not exit after a connection is terminated; instead try to reopen the connection
persist
```

```
# Ask the peer for up to 2 DNS server addresses. The addresses supplied
by the peer (if any) are passed to the /etc/ppp/ip-up script in the
environment variables DNS1 and DNS2, and the environment variable
USEPEERDNS will be set to 1. In addition, pppd will create an
/etc/ppp/resolv.conf file containing one or two nameserver lines with
the address(es) supplied by the peer.
```

```
Usepeerdns
```

Steps to modify this file follows:

1. Enter through SSH Connection in the Gateway using as username root and password raspberry
2. Move to the proper folder using the command `cd /etc/ppp/peers`

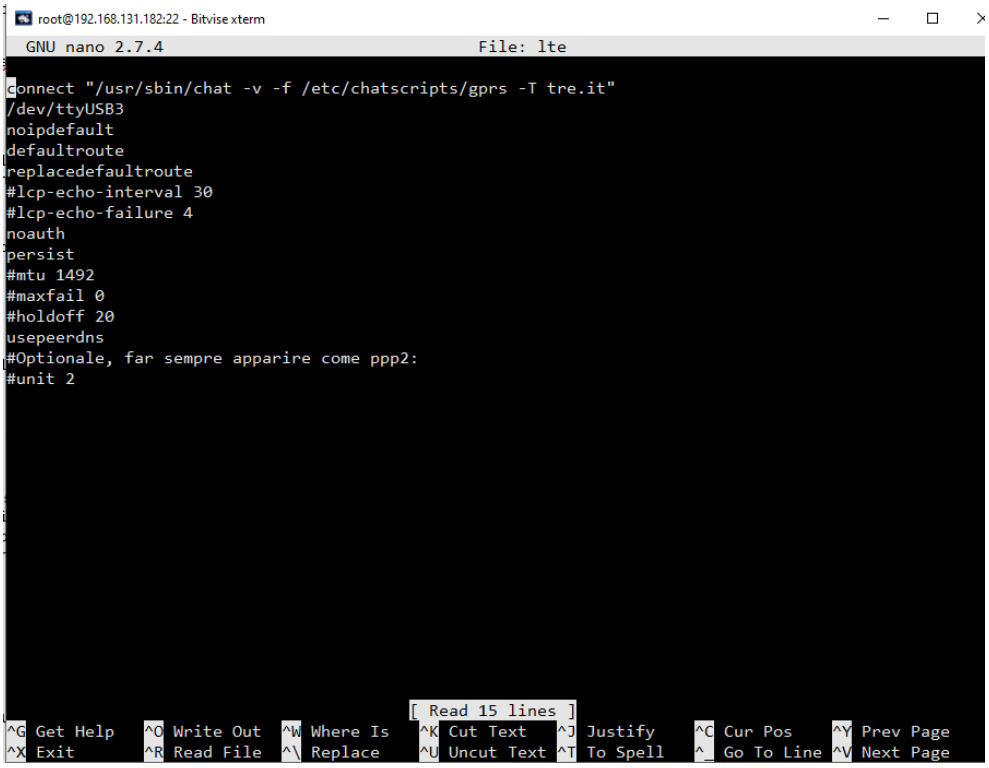

Figure 23 /etc/lte file view

3. Open a Linux File editor to modify the file using the command `nano lte`

   The following screen appears
4. Change tre.it with your APN address
5. Press Ctrl+O to save, confirming the name of the file pressing ENTER

6. Restart the LTE network using the commands

```
ifdown lte
ifup lte
```

12 Annex

12.1 Antenna Datasheet

In this section you can find some additional information about the **EMB-AN24-SB** antenna.

The **EMB-AN24-SB** is a ½ wave dipole antenna at 2400-2500 MHz, suitable for Wi-Fi, WLAN, LoRa®, Zigbee, Bluetooth and ISM applications.

Figure 24 The EMB-AN24-SB Antenna

Electrical data:

Parameter	Value
Frequency Range (with V.S.W.R. < 2: 1)	2400-2500 MHz
Impedance	50 Ω
V.S.W.R.	< 1,5:1
Max Power	15 W
Polarization	Linear

Radiation	Omnidirectional
Gain	2,1 dBi
Beam Angle (-3dB E-plane)	77°
Beam Angle (-3dB H-plane)	360°

Mechanical data:

Parameter	**Value**
Dimensions (approximately)	Ø19x150 mm
Connection	N-male
Cable	Available on request
Operating temperature range	-30° / +80°C
Weight (approximately)	0,065 kg
Radome material	Black POM pipe
Radiating element material	Copper
Optional mounting accessories	Brackets of mounting on pole/wall stainless steel band

Radiation pattern and V.S.W.R:

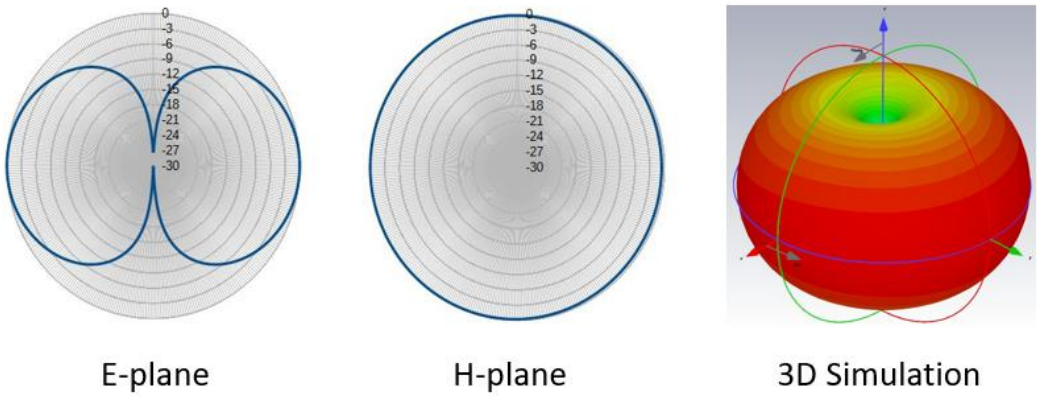

Figure 25 Antenna Radiation Pattern

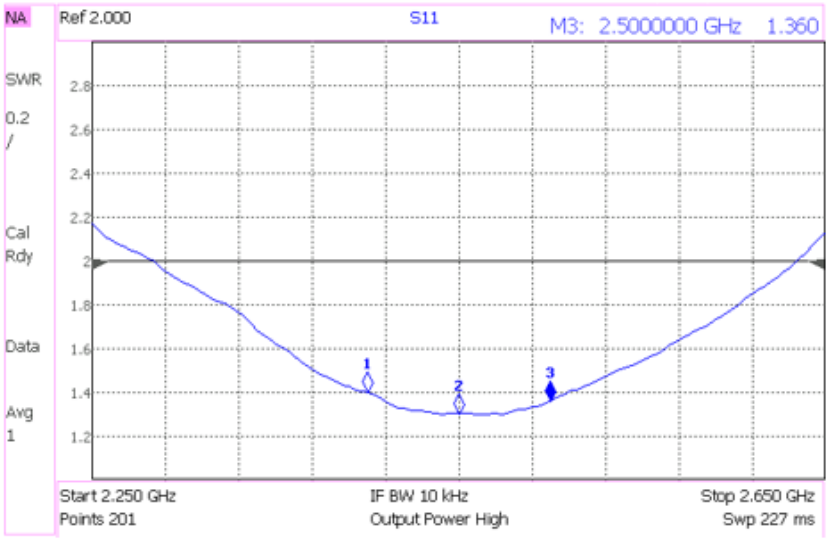

Figure 26 Antenna V.S.W.R.

The antenna is designed to be able to withstand the worst climatic conditions; in this way, the oxidation of its parts is prevented. The plastic parts are made of raw materials resistant to external environmental agents.

The **EMB-AN24-SB** antenna is RoHS Directive compliant.

13 End Device configuration on Network Server

In case you want to build a complete network consisting of a gateway and end devices (only with end devices "Embit Development Kit"), the additional configurations to be made on the Network Server are as follows:

13.1 Create New Application

Once you have configured your gateway, click on your profile name and then go to "Console". In this page, click on "Go to applications" (Figure 27) and in the next page click on "Create application" (Figure 28).

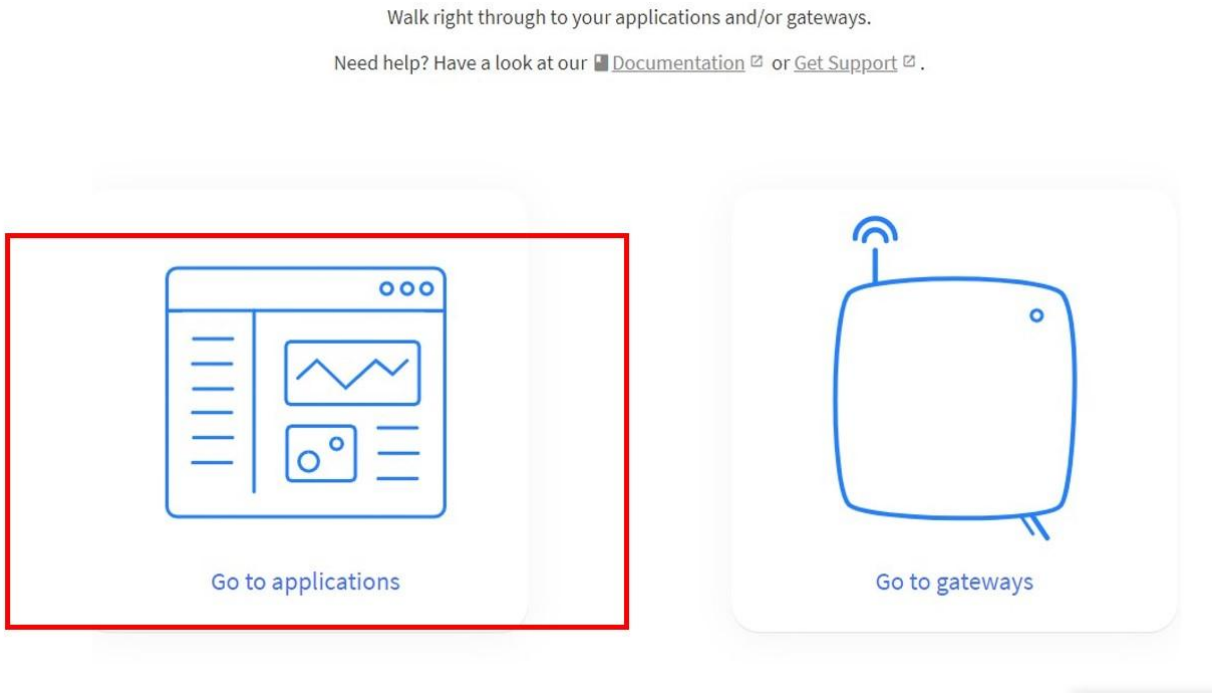

Figure 27 TTN Console view

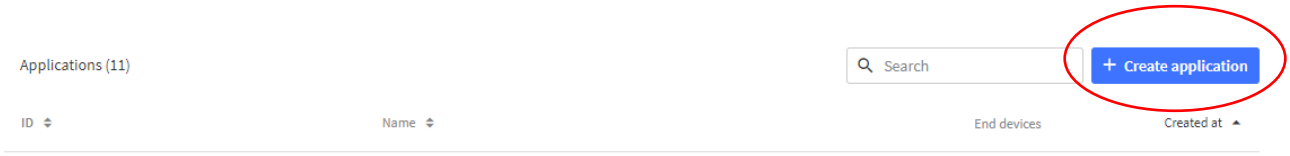

Figure 28 Add application button

A window like the one in Figure 29 will be opened.

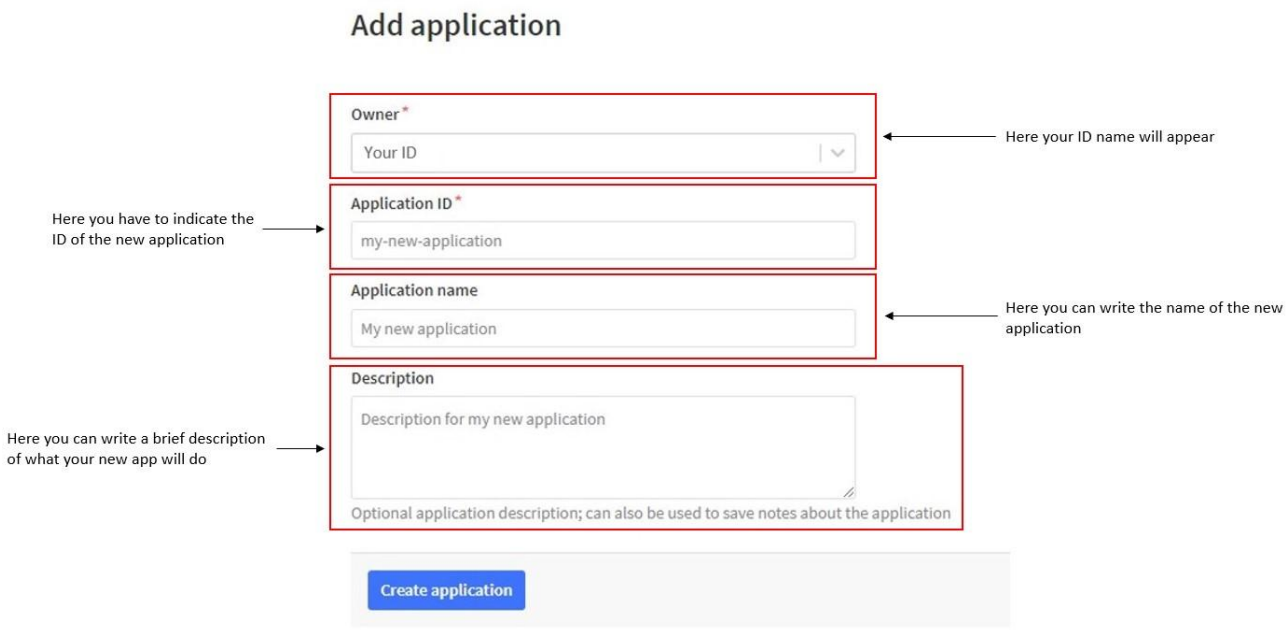

Figure 29 Add new application procedure

"Application ID" and "Description" are human-readable string. Fill all the fields with your personal information and then press "Create application" button.

13.2 Add New Device

Once that your application is created, in the relative box you can find all the information related to the selected application and add a new device, by clicking on the "Register end device" button (Figure 30).

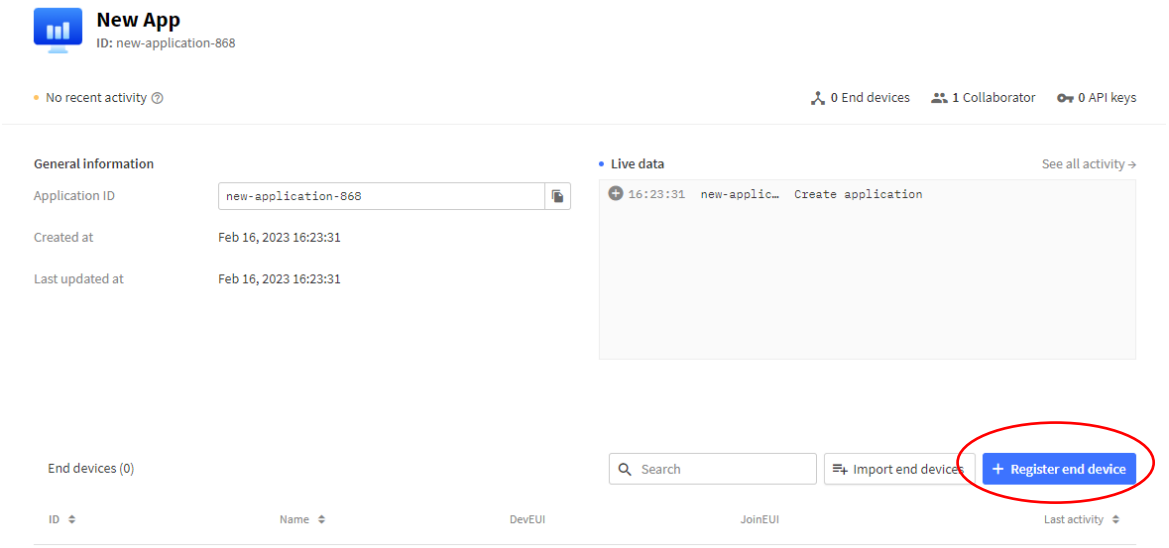

Figure 30 Add a new end device

In the next window, select "Enter end device specifics manually" (Figure 31)

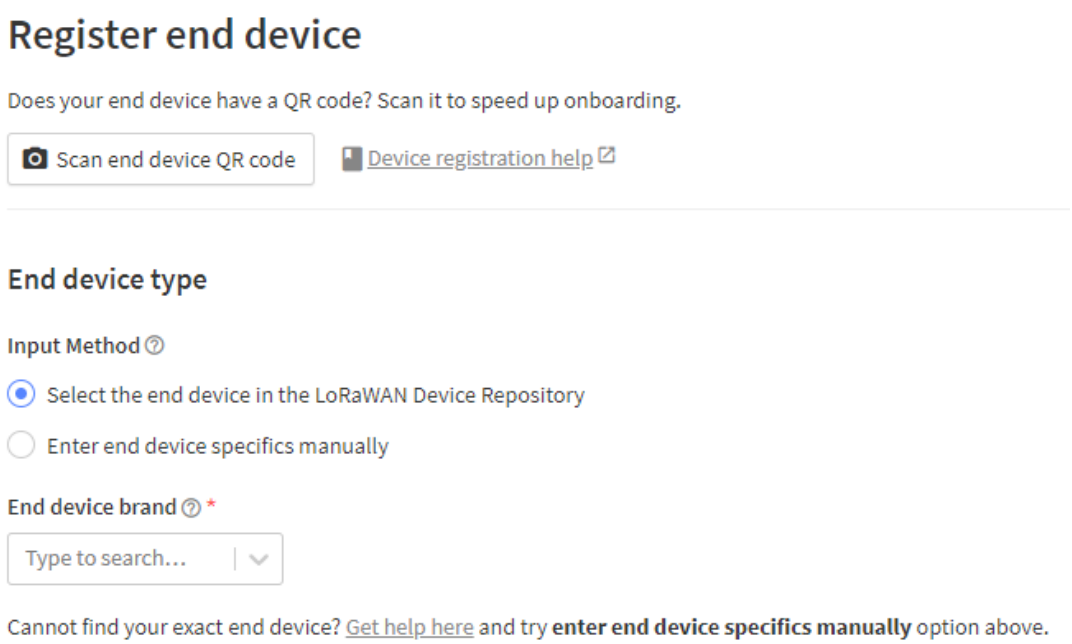

Figure 31 Register end device window

Now further settings will be proposed. Select a proper "frequency plan" and 1.0.3 LoRaWAN version. If the correct parameters have been selected, the ability to add advanced settings for configuration will be displayed (Figure 32)

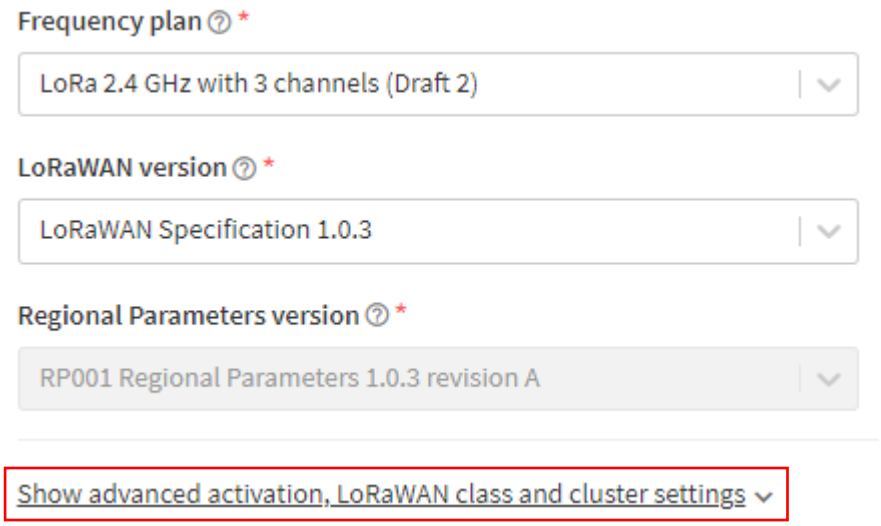

Figure 32 New device initial settings

Using the "advanced settings" section, you will be able to select OTAA (Over-The-Air-Activation), and the end-device LoRaWAN Class. (Figure 33)

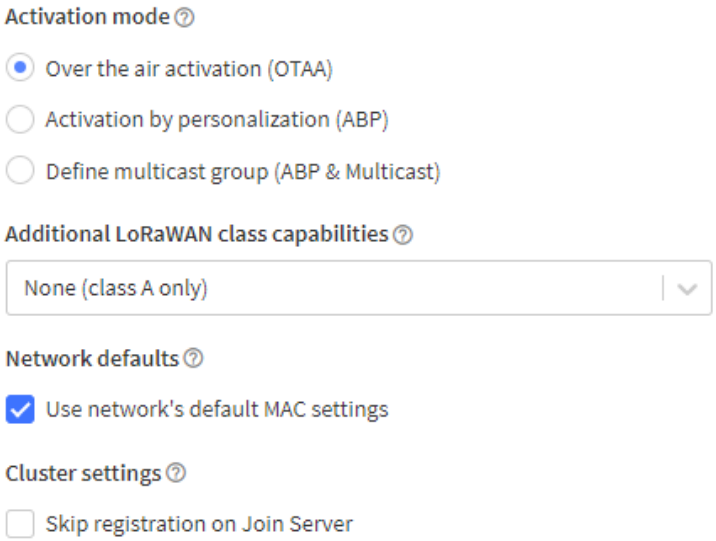

Figure 33 New device advanced settings

In the "Provisioning Information" section below the advanced settings you have to configure the device specific parameters and addresses (Figure 33):

- "JoinEUI" (formerly "App EUI") is an 8-bytes (hex) value used by the server for the join procedure. It is related to your application (it can be the same for every device registered for the application) and, if it is not provided by the manufacturer, it can be generated through to the appropriate button.
- "Dev EUI" is a unique 8-bytes (hex) value given by the manufacturer.
- "AppKey" is a 16-bytes (hex) key used by the network server for encrypt operation. It can be generated or directly created by the user and can be the same for every device registered for the application).

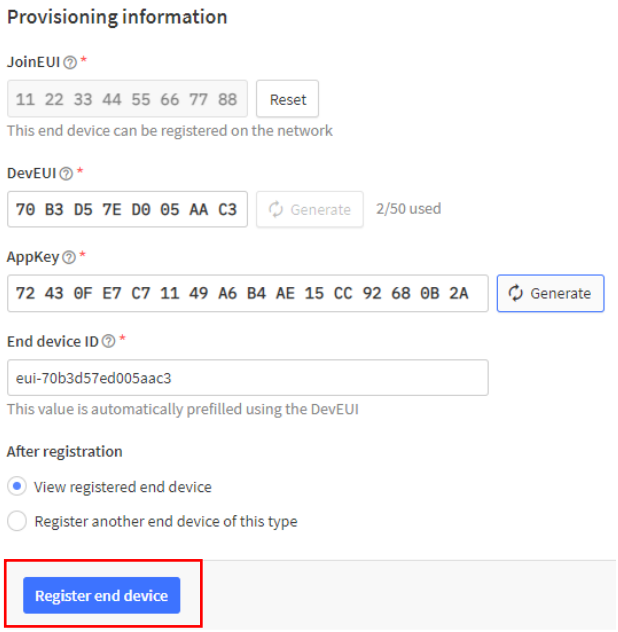

Figure 34 Provisioning Information Setting

The "End device ID" is automatically generate from the "Dev EUI" but it can be modified using any name.

Once all parameters have ben set, you can complete the registration clicking on "Register end device" (Figure 34).

Now an overview page will open. Please, check if all the parameters are correctly set (Figure 35).

After that the configuration is finished, in "Live data" section is possible to see all the packets which we are sending/receiving to/from the network server.

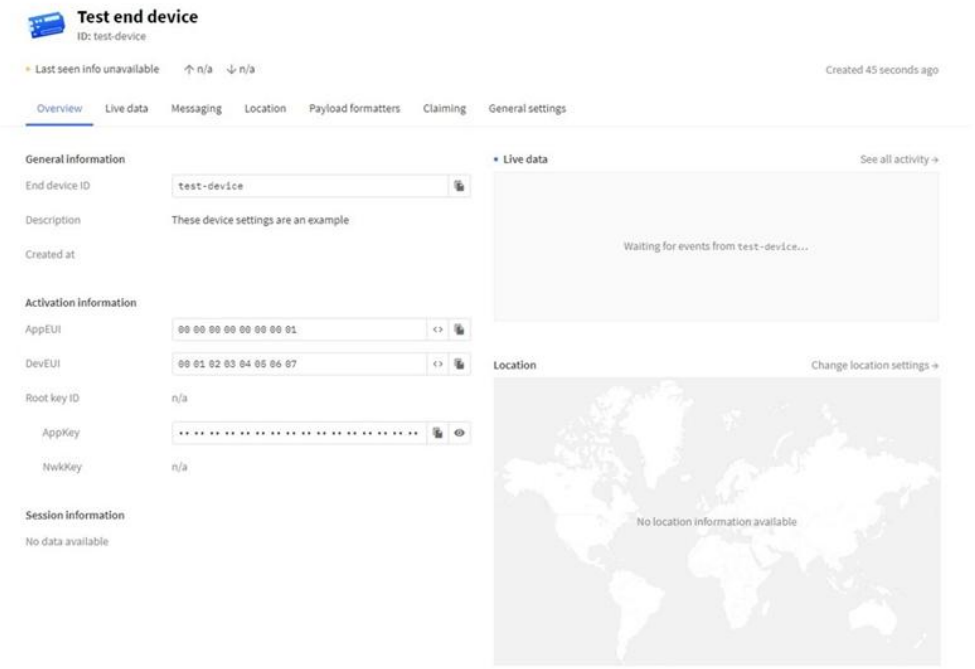

Figure 35 End device overview

14 Disclaimer of liability

The information provided in this and other documents associated to the product might contain technical inaccuracies as well as typing errors. Regulations might also vary in

time. Updates to these documents are performed periodically and the information provided in these manuals might change without notice. The user is required to ensure that the documentation is updated and the information contained is valid. Embit reserves the right to change any of the technical/functional specifications as well as to discontinue manufacture or support of any of its products without any written announcement.

14.1 Disclaimer of liability

The user must read carefully all the documentation available before using the product. In particular, care must be taken in order to comply with the regulations (e.g., power limits, duty cycle limits, etc.).

14.2 Handling Precautions

This product is an ESD sensitive device. Handling precautions should be carefully observed.

14.3 Limitations

Every operation involving a modification on the internal components of the module will void the warranty.

14.4 Trademarks

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