# EMB-LR1121-e

# Datasheet



**Rev. 1.4**

**Embit s.r.l.**

# *Document information*

## Versions & Revisions

| Revision | Date | Author | Comments |
|---|---|---|---|
| 1.0 | 2025-02-04 | Embit | Initial release |
| 1.1 | 2025-05-06 | Embit | Correction of Images and update |
| 1.2 | 2025-06-10 | Embit | Added support for EMB-LR1121-e/m |
| 1.3 | 2025-08-06 | Embit | Added Fuota Info |
| 1.4 | 2026-02-24 | Embit | Pinout correction |
| | | | |

# Index

# 1 Introduction

**EMB-LR1121-e** is the new ultra-low-power OEM module from Embit, designed for long-range wireless communication across both sub-GHz and 2.4 GHz ISM bands. At its core, it features Semtech®'s proprietary spread spectrum modulation, delivering outstanding range and robustness in harsh RF environments.

The **sub-GHz band** is especially suited for long-distance communication with minimal power consumption. Signals in this band exhibit **superior propagation characteristics**, such as better **penetration through walls, foliage, and urban infrastructure**, and **longer range** with lower attenuation compared to higher-frequency bands.

In parallel, the module also supports operation in the **2.4 GHz ISM band**, which, unlike regional sub-GHz allocations, is **globally license-free and not subject to duty-cycle restrictions**. This allows for higher transmission throughput and seamless deployment across different regulatory regions.

**EMB-LR1121-e** is based on Semtech®'s LR1121 multi-band LoRa and Long Range 2.4 GHz transceiver coupled with the STM32U0x MCU. The MCU is equipped with up to 256 KB Flash memory and up to 40 KB of RAM memory. The module integrates three crystals, two at 32 kHz and one at 32 MHz and a Crypto Unit to protect the communication between the module and external interfaces, enhancing data security.

**EMB-LR1121-e** can communicate with other devices through a wide range of serial interfaces: UART, I2C, USB, SPI, several digital and analog I/O ports useful for the management of external devices and interfaces. Moreover, the extremely reduced low power consumption provided by the STM32U0x MCU, makes the **EMB-LR1121-e** particularly suitable to implement long life battery powered devices.

## 1.1 Specifications

| EMB-LR1121 | -e | -e/mesh | -e/m |
|---|---|---|---|
| Operating Voltage: | 2.5 ÷ 3.6 V | | |
| MCU | Arm Cortex-M0+ 32-bit STM32U083 | | - |
| RAM | 40 KB | | - |
| FLASH size | 256 KB | | - |
| Transceiver | Semtech$^®$ LR1121 | | |
| RF output power | up to 20dBm @sub-GHz, up to 10.5 dBm @2.4GHz | | |
| RF sensitivity | down to -132 dBm at 595 bps | | |
| Modulation: | LoRa$^®$ Spread Spectrum, FLRC, (G)FSK | | |
| Operating Frequency: | 868 MHz, 915 MHz and 2.4 GHz | | |
| Frequency Range: | 150 MHz to 960MHz (sub-GHz), 2400 MHz to 2485 MHz | | |
| Interfaces: | UART/LPUART/I2C/SPI/ADC/GPIOs | | |
| Dimensions: | 15.5 x 20 x 2.3 mm | | |
| Temperature Range | -40°C to +85°C | | |
| U.FL Connector or ceramic antenna | | | |
| Crypto unit to protect communication (Optionally) | | | |

## 1.2 Applications

The device can be used in several applications where LoRa$^®$ gateway is needed, such as:

- Internet of Things (IoT)
- Automated Meter reading
- Smart cities
- Home Building Automation
- Wireless Alarm and Security System
- Machine to Machine (M2M)

- Industrial Monitoring and Control
- Smart lighting
- Long Range Irrigation System

# 2 Description

## 2.1    Block Diagram

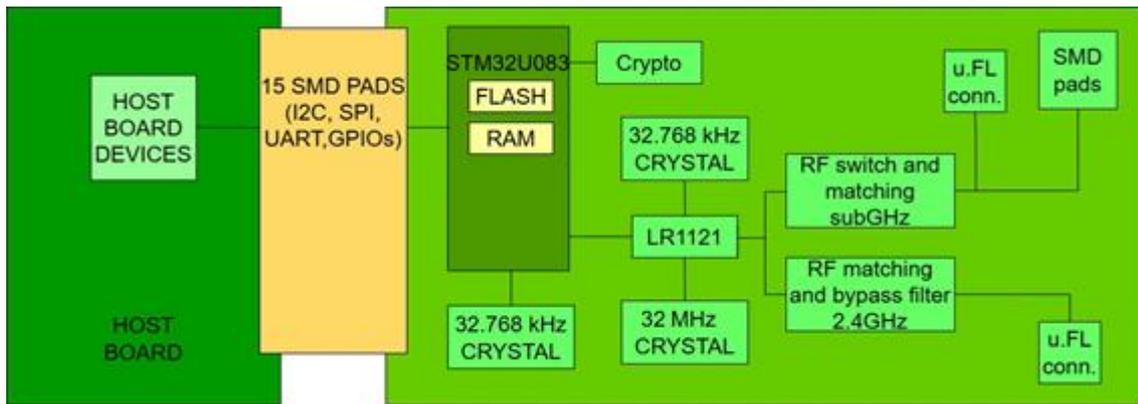The **EMB-LR1121-e** block diagram is shown below:



*Figure 1 EMB-LR1121-e schematics*

## 2.2    STM32U0x

The **EMB-LR1121-e** embeds an STM32U0x [1] MCU(*). It is an ultra-low-power, high-performance microcontroller based on an ARM Cortex M0+ 32-bit core operating at 32kHz. It is characterized by high-speed embedded memories (256 KBytes of data EEPROM, 40 KBytes of RAM for standard and /m version, instead 64 Kbytes of data EEPROM, 12 Kbytes of RAM for /b) and a Memory Protection Unit (**MPU**). The power management is highly effective and flexible thanks to the availability of 5 power modes, internal voltage adaptation and multiple internal/external clock sources. The MCU offers a wide range of standard and advanced interfaces such as I2C, SPI, USART and LPUART. Moreover, it embeds multiple analog and digital resources: 12-bit ADC with hardware oversampling, one RTC unit, multiple timers (with one low power timer), SysTick, programmable watchdog timer and multiple GPIOs.

*(*)Note: In **EMB-LR1121-e/m** version does not provide any STM MCU on board*

## 2.3    Transceiver

The Semtech® **LR1121**[2] is a half-duplex transceiver that provides ultra-long range communication, high interference immunity with minimized current consumption in the sub-GHz and 2.4 GHz band.

Other than LoRa®, the **LR1121** supports (G)FSK radio modulations. The maximum transmit power is 11.5 dBm at 2.4 GHz and 22 dBm at sub-GHz band with a receiver sensitivity of - 142 dBm @595 bps with LoRa® modulation @SF12 and 62.5KHz Bandwidth. The transceiver also offers a ranging engine with time-of-flight functionalities.

## 2.4    Antenna

The **EMB-LR1121-E** comes with two antenna options:

- 2 External antenna connectors: 50 Ω single-ended U.FL connector
- For subGHz provide Ground-signal-Ground pin

The connector positioned on the left side is intended for sub-1GHz applications, while the one on the right is used for 2.4 GHz.



*Figure 2 EMB-LR1121-e U.FL connectors*

## 2.5    Security Element (Optionally)

The **EMB-LR1121-E** features a crypto unit for protection, encryption and data security. This Security element is a high-security cryptographic device which combines world-class hardware-based key storage with hardware cryptographic accelerators to implement various authentication and encryption protocols.

It includes an EEPROM array which can be used for storage of up to 16 keys, certificates, miscellaneous read/write, secret data, and security configurations. Access to the various sections of memory can be restricted in a variety of ways and then the configuration can be locked to prevent changes.

It can be used as an Ecosystem control and Anti-Counterfeiting: it validates if a system or component is authentic and came from the OEM shown on the nameplate. The access to the device is made through a standard I2C interface at speeds of up to 1 Mb/s.

## 2.6    Crystals

The **EMB-LR1121-e** embeds two crystals:

- One 32MHz crystal required by the digital PLL of the transceiver to perform RF and baseband frequency conversion.
- One 32KHz crystal to be used as external clock source.
- Another 32KHz crystal connected to the MCU in standard and /b version. In /mesh version the 32KHz crystal is substituted with a TCXO

## 2.7    Firmware

### 2.7.1    EMB-LR1121-e

The **EMB-LR1121-e** comes with Semtech$^®$ LoRaWAN$^®$ Modem-E stack flash on the radio. On the MCU, EBI firmware is flash on it. You can write your custom firmware on the SDK that Embit provides.

### 2.7.2    EMB-LR1121-e/m

The **EMB-LR1121-e/m** comes with Semtech® LoRaWAN® Modem-E stack flash on the radio. To use the module, connect it to an external MCU and use the Semtech®'s API, to control the module, provided on github at this link:

[https://github.com/Lora-net/lr1121_modemE_driver/tree/main](https://github.com/Lora-net/lr1121_modemE_driver/tree/main)

The APIs are also described in the following file:

[Modem-E Reference Manual](Modem-E Reference Manual)

A usage example implementation of LoRaWAN® Application is provided by Semtech at this link:

[https://github.com/Lora-net/ModemE_application_examples](https://github.com/Lora-net/ModemE_application_examples)

To have lower power consumption and a better use of the **EMB-LR1121-e/m** module, please call the following function:

[lr1121_modem_system_set_dio_as_rf_switch](lr1121_modem_system_set_dio_as_rf_switch)

and modify the configuration with the following implementation:

```
lr1121_modem_system_rfswitch_cfg_t system_rf_switch_cfg =
{
.enable  =  LR1121_MODEM_SYSTEM_RFSW0_HIGH  |  LR1121_MODEM_SYSTEM_RFSW1_HIGH  |
LR1121_MODEM_SYSTEM_RFSW2_HIGH,
.standby = 0,
.rx = LR1121_MODEM_SYSTEM_RFSW0_HIGH | LR1121_MODEM_SYSTEM_RFSW2_HIGH,
.tx = LR1121_MODEM_SYSTEM_RFSW0_HIGH | LR1121_MODEM_SYSTEM_RFSW1_HIGH | LR1121_MO-
DEM_SYSTEM_RFSW2_HIGH,
.tx_hp = LR1121_MODEM_SYSTEM_RFSW1_HIGH | LR1121_MODEM_SYSTEM_RFSW2_HIGH,
.tx_hf = 0
};
```

And change the regulator from LDO to DCDC regulator using the following function:

```
lr1121_modem_system_set_reg_mode(radio_context,  LR1121_MODEM_SYSTEM_REG_MODE_DCDC
);
```

### 2.7.3    EMB-LR1121-e/mesh

For the **EMB-LR1121-e/mesh** please request its datasheet at Embit with all the information

## 2.8    Fuota (Not available yet)

To support future implementation of FUOTA (Firmware Update Over The Air), it is recommended that the system design includes provisions for an external memory connected directly to the EMB-LR1121-e module through I2C or SPI interface.

For further information regarding the Fuota feature, please contact our technical team.

## 2.9    *Development tools*

To work with **EMB-LR1121-e** the following tools are suggested:

- **STM32CUBEIDE**
- **j-Link** debugger and programmer

Embit also provides ready-to-use firmware that allows the module to act as a simple modem over UART. (*)

This AT-like protocol is named **"EBI" (Embit Binary Interface)**. By exploiting a set of binary commands, it is possible to configure the module, send/receive data over the air and develop complex applications without the need of writing complex custom firmware.

*(*)Note: The **EBI** protocol is available only for **-e** version of **EMB-LR1121-e**, not for **/mesh** or **/m** version*

**Note:** For the **EMB-LR1121-e/mesh** please request its datasheet at Embit with all the information

# 3 Size and footprint

## 3.1 Size

The mechanical dimensions of **EMB-LR1121-e** are 15.5 x 20 mm with a thickness of 3.2 mm (considering the shield).

The module has a total of 31 pins (10 on each side edge, 8 on bottom side and 3 at the top left) with 1.27 mm pitch and 1.02 x 0.81 as dimensions. Positioning is shown in the following image (Figure 2).
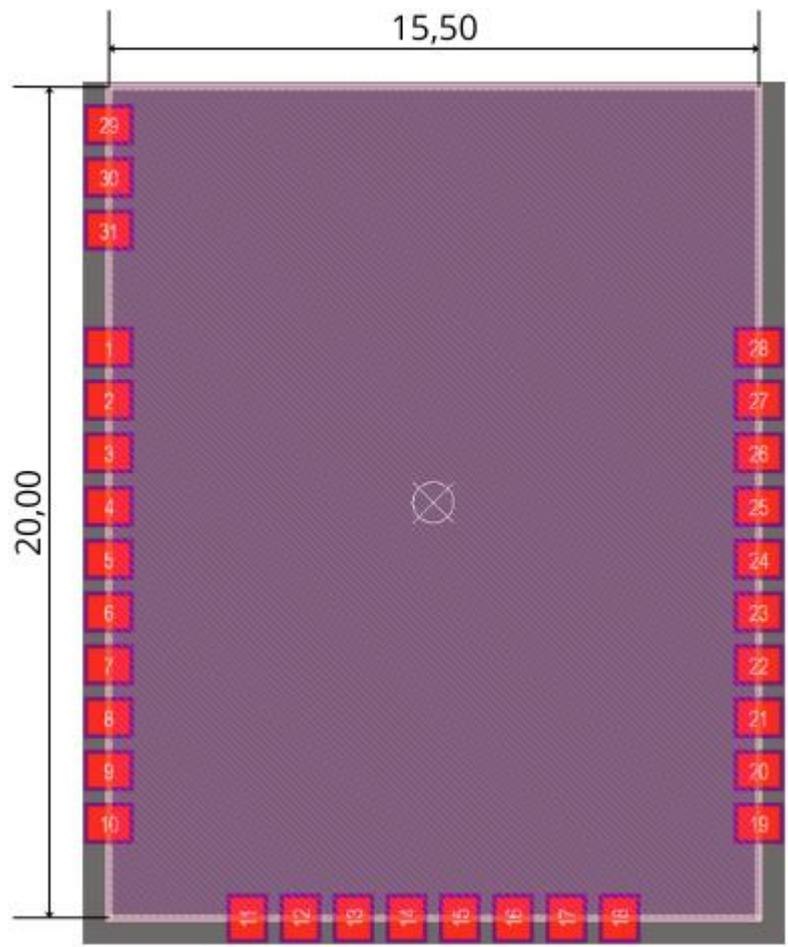


*Figure 3 Connector positions*

## 3.2    Suggested footprint

The **EMB-LR1121-e** suggested footprint consists in 31 LGA pads positioned as following (Figure 3 and Figure 4, all sizes are in mm).
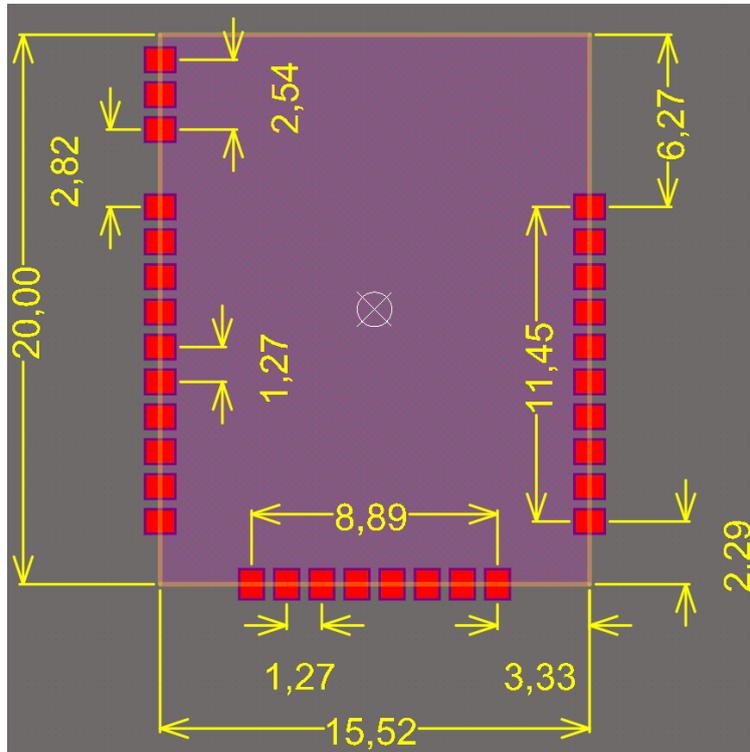
*Figure 4 EMB-LR1121-e suggested footprint*
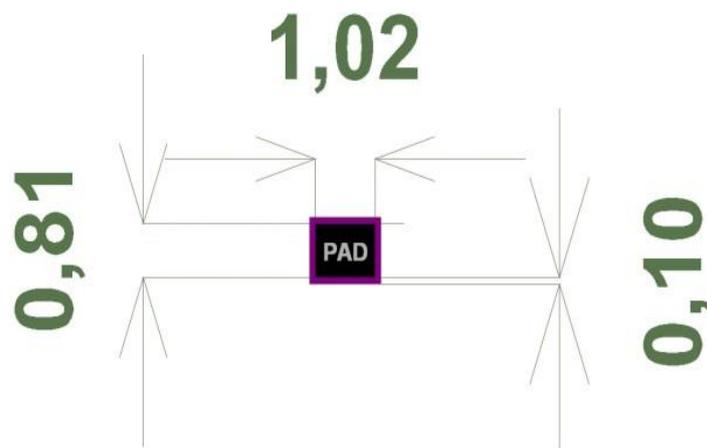
*Figure 5 Pad*

## 3.3    Notes

- The area underneath the module must be kept free of components (both top and bottom layers) and must be covered with solder resist.
- The PCB top layer underneath the module must be free of nets, power planes and vias.
- The module power supply must be as clean as possible. It must be decoupled placing a ceramic capacitor as near as possible to the Vcc pins. Additional filtering made by a ferrite bead is recommended.
- Noisy electronic components (such as switching power supply) must be placed as far as possible and adequately decoupled.
- The ground pins of the module shall be connected to a solid ground plane.

*Note:* Taking no account of these recommendations may affect the radio performances.

# 4  Connections

## 4.1    Module pinout

| | EMB-LR1121-e | | |
|---|---|---|---|
| **Number** | **Pin Name** | **Type** | **Description** |
| 1 | GND1 | GND | Ground |
| 2 | GND2 | GND | Ground |
| 3 | BOOT0 | BOOT0 Input | BOOT0 pin* |
| 4 | VCC | Power Input | Supply voltage |
| 5 | PA4 | Digital I/O | I/O |
| 6 | PA3 | Digital I/O | I/O |
| 7 | DEBUG_CLK | JTAG | SWD Debug port clock |
| 8 | DEBUG_DATA | JTAG | SWD Debug port data |
| 9 | VCC | Power Input | Supply voltage |
| 10 | GND3 | GND | Ground |
| 11 | PB6_I2C_SCL | Digital I/O | I2C1 SCL |
| 12 | PB7_I2C_SDA | Digital I/O | I2C1 SDA |
| 13 | PA12_SPI_MOSI | Digital I/O | SPI MOSI |
| 14 | PA11_SPI_MISO | Digital I/O | SPI MISO |
| 15 | PA1_SPI_SCK | Digital I/O | SPI SCK, LPUART RX |
| 16 | PA10_SPI_NSS | Digital I/O | SPI NSS |
| 17 | LR_IRQ | IRQ Out | Radio IRQ** |
| 18 | PB0 | Digital I/O | I/O |
| 19 | GND4 | GND | Ground |
| 20 | VCC | Power Input | Supply voltage |
| 21 | PB1_UART_CTS | Digital I/O | UART CTS |
| 22 | PA6_UART_RTS | Digital I/O | UART RTS |
| 23 | PA5_UART_TX | Digital I/O | UART TX |
| 24 | PA7_UART_RX | Digital I/O | UART RX |
| 25 | VCC | Power Input | Supply voltage |
| 26 | PA0_ADC | Analog/Digital I/O | ADC_IN0 |
| 27 | NRESET | Reset input | System reset input (active low) |
| 28 | GND5 | GND | Ground |
| 29 | GND6 | GND | Ground |
| 30 | RF_SIG | RF | RF sub-GHz input/output |
| 31 | GND7 | GND | Ground |

*Table 1 EMB-LR1121-e Interface Pin Out, valid for standard and /mesh*

| Number | EMB-LR1121-e/m | | |
|---|---|---|---|
| | **Pin Name** | **Type** | **Description** |
| 1 | GND1 | GND | Ground |
| 2 | GND2 | GND | Ground |
| 3 | - | - | NC |
| 4 | VCC | Power Input | Supply voltage |
| 5 | - | - | NC |
| 6 | - | - | NC |
| 7 | - | - | NC |
| 8 | - | - | NC |
| 9 | VCC | Power Input | Supply voltage |
| 10 | GND3 | GND | Ground |
| 11 | - | - | NC |
| 12 | - | - | NC |
| 13 | SPI_MOSI | Digital I/O | Radio SPI MOSI |
| 14 | SPI_MISO | Digital I/O | Radio SPI MISO |
| 15 | SPI_SCK | Digital I/O | Radio SPI SCK |
| 16 | SPI_NSS | Digital I/O | Radio SPI NSS |
| 17 | LR_IRQ | IRQ Out | Radio IRQ |
| 18 | PB0 | Digital I/O | I/O |
| 19 | GND4 | GND | Ground |
| 20 | VCC | Power Input | Supply voltage |
| 21 | BUSY | Digital I/O | Digital I/O |
| 22 | - | - | NC |
| 23 | - | - | NC |
| 24 | - | - | NC |
| 25 | VCC | Power Input | Supply voltage |
| 26 | - | - | NC |
| 27 | LR_NRESET | Reset input | Radio System reset input |
| 28 | GND5 | GND | Ground |
| 29 | GND6 | GND | Ground |
| 30 | RF_SIG | RF I/O | RF sub-GHz input/output |
| 31 | GND7 | GND | Ground |

*Table 1 EMB-LR1121-e Interface Pinout  1 version /m*

**Note:** All Digital I/O support the MCU interrupt request.

For the **EMB-LR1121-e/mesh** please request its datasheet at Embit

*: After device initialization, the BOOT0 pin (PF3) can also be configured as a General Purpose I/O (GPIO). On all versions of the EMB-LR1121-e module, this pin is internally pulled down by default. Check the STM32 documentation

**: IRQ pin of the radio. It is recommended not to connect anything to that pin in non /m version.

## 4.2　　Typical application circuit

The external supply shall include protection from spikes, short circuits and it requires adequate decoupling.

- Voltage glitches on VCC supply may cause reset or malfunctioning of the microcontroller.
- Slow voltage ramp on VCC or NRESET may cause malfunctioning of the microcontroller[1].
- Do not reset or turn off the power of the module while writing to the flash; otherwise, memory corruption may occur.

# 5 Electrical characteristic

## 5.1 Absolute Maximum Ratings

| Parameter | Value | Unit |
|---|---|---|
| Power Supply Voltage | +3.6 | V |
| Voltage on any pin | +3.6 | V |
| Rf input power ($P_{max}$) | 0 | dBm |
| Storage Temp. Range | -40 ~ +85 | ºC |

*Table 2 Absolute Maximum Ratings*

## 5.2 Operating Conditions

| Parameter | Min | Max | Unit |
|---|---|---|---|
| Power Supply Voltage (Vcc) | +2.5 | +3.3 | V |
| Operating Temperature range | -40 | +85 | °C |
| Logic Input Low Voltage | Vss | 0.3*Vcc | V |
| Logic Input High Voltage | 0.7*Vcc | Vcc | V |
| Logic Output Low Level | Vss | Vss + 0.45 | V |
| Logic Output High Level | Vcc-0.45 | Vcc | V |

*Table 3 Operating Conditions*

## 5.3 Power Consumption

| Mode | Typ. value | Unit |
|---|---|---|
| Transmit @+11.5 dBm (2.4 GHz) | 23 | mA |
| Transmit @+14 dBm (868 MHz) | 27 | mA |
| Transmit @+22 dBm (915 MHz) | 124 | mA |
| Receive (2.4 GHz) | 7 | mA |
| Receive (868 MHz) | 6 | mA |
| Receive (915 MHz) | 6 | mA |
| Sleep | 3 | µA |

*Table 4 Power Consumption*

## 5.4    RF characteristics

| Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| RF Frequency range (sub-GHz) | 150 | | 928 | MHz |
| Frequency tolerance | | ±10 | | ppm |
| Programmable Output Power Range (LPA) | -17 | | +13 | dBm |
| Programmable Output Power Range (HPA) | -9 | | +20 | dBm |
| RF Data Rate LoRa® | 0.292 | | 101.5 | kbps |
| RX sensitivity SF7; BW=125 KHz | | -118 | | dBm |
| RX sensitivity SF12; BW=125 KHz | | -132.5 | | dBm |
| RX sensitivity SF7; BW=250 KHz | | -116 | | dBm |
| RX sensitivity SF12; BW=250 KHz | | -130 | | dBm |
| RX sensitivity SF7; BW=500 KHz | | -112 | | dBm |
| RX sensitivity SF12; BW=500 KHz | | -124.5 | | dBm |

*Table 5 RF characteristics sub-Ghz*

| Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| RF Frequency range (2.4 GHz) | 2400 | | 2485 | MHz |
| Frequency tolerance | | ±10 | | ppm |
| Programmable Output Power Range (PA HF) | -17 | | +10.5 | dBm |
| RF Data Rate LoRa® | 0.292 | | 101.5 | kbps |
| Rx sensitivity SF5; BW=406 KHz | | -111 | | dBm |
| RX sensitivity SF7; BW=406 KHz | | -129 | | dBm |
| RX sensitivity SF5; BW=812 KHz | | -108 | | dBm |
| RX sensitivity SF7; BW=812 KHz | | -112 | | dBm |

*Table 6 RF characteristics 2.4 GHz*

# 6 References

[1] STM, STM32U083KC Datasheet from www.st.com //

[2] Semtech, LR1121 Datasheet from www.semtech.com //

# 7 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.

## 7.1 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.).

## 7.2 Handling Precautions

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

## 7.3 Limitations

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

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