

LR2021

Wireless Transceiver Module

LoRa® Wireless Module – Powered by Semtech

DATASHEET



Multi-band Connectivity

Sub-GHz: 2.4 GHz ISM and
S-Band (1.5–2.5 GHz)



Long Range & High Performance

Up to 22 dBm TX Power
Link Budget up to 163.5 dB



High Data Rate

FLRC up to 2.6 Mbps



Ultra-Low Power

Deep sleep current as low as 470 nA



Multi-Protocol Support

LoRa/LoRaWAN, Amazon Sidewalk,
Sigfox, Wi-SUN, W-MBUS, Z-Wave,
BLE 5.0, 802.15.4 and more



Industrial Grade

-40 °C to +85 °C
FCC ID, CE Certified



1. Overview

1.1 Description

The LR2021 is a high-performance, multiband wireless transceiver module based on Semtech's fourth-generation LoRa® IP. The module incorporates the LR2021 RF transceiver chip and integrates RF front ends for Sub-GHz (150–960 MHz), the 2.4 GHz ISM band, and the licensed S-band (1.5–2.5 GHz). Its single-SKU design simultaneously supports terrestrial and satellite communications (SATCOM) networks, meeting the requirements of multiregional deployments worldwide.

The module is housed in an ultra-compact 10 mm × 10 mm × 2.5 mm surface-mount castellated package and integrates an industrial-grade 32 MHz TCXO clock source, SIMO/LDO power management, an SPI control interface, and dual antenna ports (ANT_LF and ANT_HF). Multiband switching requires no external RF switch, significantly reducing BOM cost and PCB footprint. The module is compatible with multiple protocols, including LoRa/LoRaWAN®, Amazon Sidewalk, Sigfox, Wi-SUN, W-MBUS, Z-Wave, BLE 5.0 PHY, and 802.15.4 (Thread/Zigbee), making it suitable for a wide range of applications such as smart metering, asset tracking, smart homes, industrial IoT, high-speed data transmission, and satellite IoT.

1.2 Key Features

- Integrated multiband RF: Supports Sub-GHz (150–960 MHz), 2.4 GHz ISM (2400–2483 MHz), and licensed S-band (1.5–2.5 GHz) satellite IoT frequencies; a single SKU provides worldwide multiregional coverage and supports both terrestrial and satellite networks.
- High-performance link: Sub-GHz receive sensitivity as low as –141.5 dBm (SF12/125 kHz), with maximum transmit power of +22 dBm; 2.4 GHz sensitivity of –103 dBm @250 kbps O-QPSK; FLRC data rates up to 2.6 Mbps; link budget up to 163.5 dB.
- Simplified RF design: Single-antenna-front-end multiband switching requires no external RF switch, saving PCB space and BOM cost.
- Ultra-low power consumption: Chip-level sleep current as low as 470 nA and typical Sub-GHz receive current of 5.7 mA.
- Ultra-compact size: Compact 10 mm × 10 mm × 2.5 mm package with a 20-pin SMT castellated design.
- Multiprotocol compatibility: Supports LoRa/LoRaWAN®, Amazon Sidewalk, Sigfox, Wi-SUN, W-MBUS, Z-Wave, BLE 5.0 PHY, 802.15.4 (Thread/Zigbee), 2-FSK/4-FSK, and more.
- Long-range communication: Typical Sub-GHz line-of-sight communication range exceeds 15 km, with ranges of up to 68 km achievable using a high-gain antenna in an open environment.
- Industrial-grade quality: Operating temperature of –40 °C to +85 °C; complies with FCC, CE, and RoHS certification requirements.

1.3 Applications

- Smart metering: Smart electricity, water, gas, and heat meters supporting LoRa/W-MBUS/Wi-SUN multimode communications.
- Asset tracking: A single-SKU solution for global logistics covering all Sub-GHz/2.4G/S-Band frequencies and enabling seamless tracking across land and sea.
- Smart homes: Compatible with Sidewalk/Z-Wave/Thread and suitable for use as a gateway or border router.
- Industrial IoT: Predictive equipment maintenance, voice intercom, and Mesh monitoring of factory environments.
- High-speed transmission: The FLRC 2.6 Mbps mode supports image backhaul, OTA upgrades, and edge AI result reporting.
- Satellite IoT: Direct S-Band connectivity to low-Earth-orbit satellites in areas without terrestrial network coverage, such as oceans and deserts, and during emergencies.
- Smart cities: Citywide low-power sensor networks for streetlights, waste bins, geomagnetic parking sensors, environmental sensing, and more.
- Consumer innovation: Mesh intercoms, drone video transmission, and remote synchronization for wearable devices.

2. System Block Diagram

The LR2021 module is built around the Semtech LR2021 RF transceiver and integrates an RF front-end matching network, a 32 MHz TCXO, and power-supply decoupling and management circuitry. It communicates with the host MCU through an SPI interface. The module includes a Sub-GHz low-frequency receive channel (RFI_LF/RFO_LF) and a 2.4 GHz/S-Band high-frequency receive channel (RFI_HF/RFO_HF), with separate low- and high-frequency antennas connected through the ANT_LF and ANT_HF antenna ports, respectively.

1. LR2021 Chip Description

The LR2021 is a highly capable half-duplex radio frequency (RF) transceiver, purpose-built to handle various constant envelope modulation schemes, including LoRa, (G)FSK, (G)MSK, FLRC, 4-FSK, O-QPSK and LR-FHSS (transmit only). Additionally, the chip supports OOK and low bit rate DBPSK (transmit only), providing a comprehensive set of modulation options to suit diverse wireless communication needs.

Designed to be fully compatible with the SX126x, SX127x, SX128x and LR11xx families, the LR2021 offers seamless integration and interoperability within existing systems using these families of ICs.

- Covering a broad frequency range from 150MHz to 2500MHz, the LR2021 enables communication across a wide spectrum of frequencies. Specifically, it excels in handling signals in the sub-GHz ISM bands, with continuous coverage from 150MHz to 960MHz facilitated by a dedicated Rx (Receiver) and Tx (Transmitter) low-frequency path.
- Furthermore, the LR2021 demonstrates its versatility by also supporting operation in the S band and the 2.4GHz ISM band using a dedicated Rx (Receiver) and Tx (Transmitter) high-frequency path. This allows the chip to handle communications in the 2.4GHz range, a frequency commonly utilized for various wireless applications.

Figure 1-1: LR2021 Block Diagram

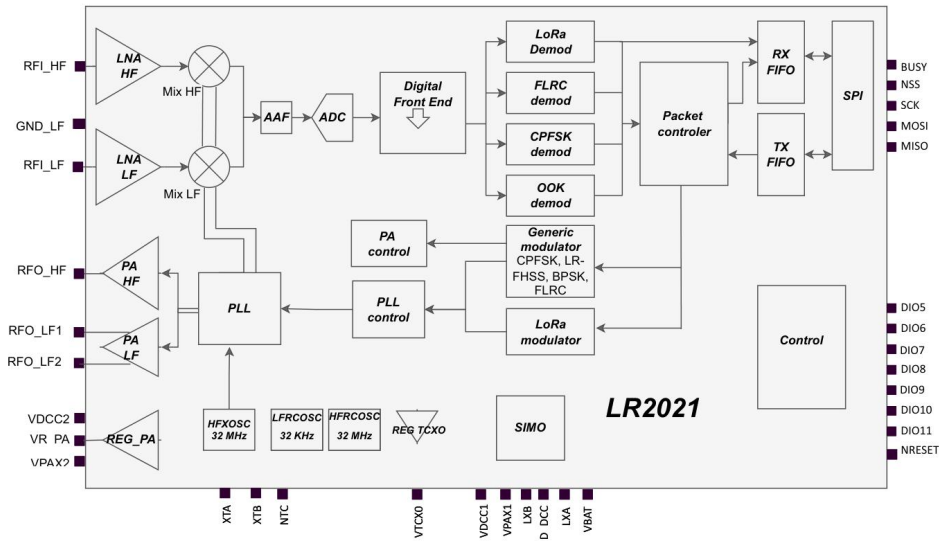


Figure 1 LR2021 Chip Internal System Block Diagram

3. Hardware Overview

3.1 Pin Layout

The LR2021 module uses a 20-pin SMT castellated package with a pin pitch of 1.27 mm and dimensions of 10 mm × 10 mm × 2.5 mm. The pin layout is shown in Figure 2. The module connects to the host through an SPI bus and provides signals such as general-purpose DIO digital I/O, BUSY status indication, NRESET reset control, and TX/RX_EN transmit/receive enable control.

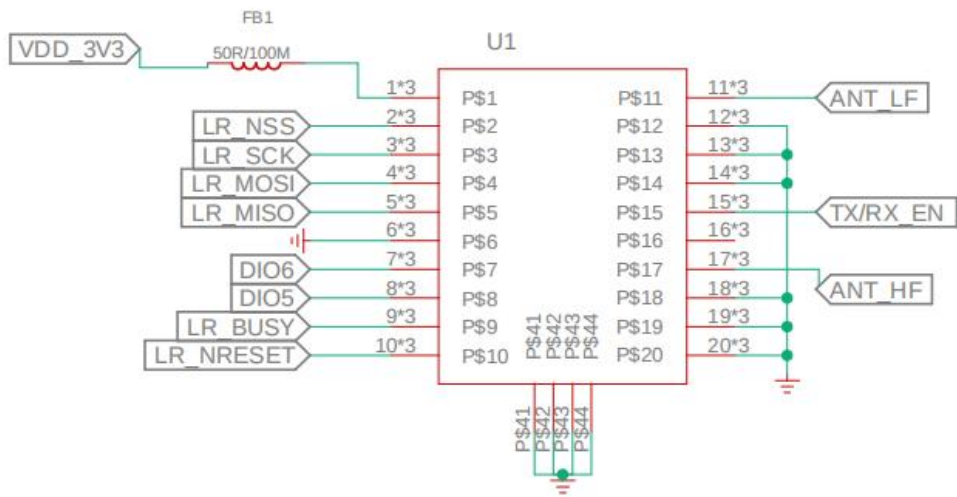
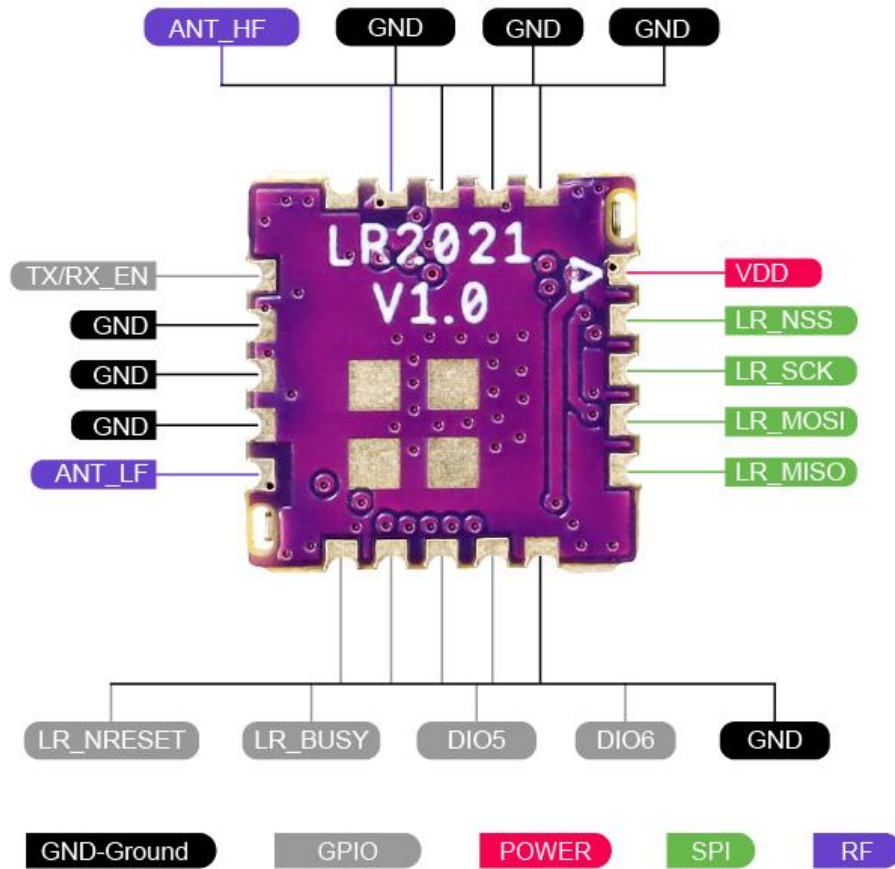


Figure 2 LR2021 Module Pin Connection Diagram

LR2021-Pin Definition



3.2 Pin Definitions

The following table provides the pin definitions and functional descriptions for the LR2021 module.

No.	Name	Type	Connected Signal	Functional Description
P1	VDD	Power	VDD_3V3	3.3 V power input; parallel 47 μ F + 10 μ F + 100 nF decoupling capacitors are

				recommended
P2	LR_NSS	I	LR_NSS	SPI chip-select signal, active low
P3	LR_SCK	I	LR_SCK	SPI clock signal
P4	LR_MOSI	I	LR_MOSI	SPI data input (host→module)
P5	LR_MISO	O	LR_MISO	SPI data output (module→host)
P6	GND	—	—	System ground
P7	DIO6	I/O	DIO6	DIO6 multipurpose digital I/O: 0 IRQ (O); 1 RF_SWITCH (O); 2 GPIO output low/high (O); 3 HF_CLK_OUT (O); 4 TX_TRIGGER / RX_TRIGGER (I). The specific function is configured by the host.
P8	DIO5	I/O	DIO5	DIO5 multipurpose digital I/O: 0 IRQ (O); 1 RF_SWITCH (O); 2 GPIO output low/high (O); 3 HF_CLK_OUT (O); 4 TX_TRIGGER / RX_TRIGGER (I). Pulled up by default after reset; the specific function is configured by the host.
P9	LR_BUSY	O	LR_BUSY	Module busy status indicator; high indicates that the module is

				processing a command
P10	LR_NRESET	I	LR_NRESET	Reset signal, active low; low-level hold time $\geq 100\ \mu\text{s}$
P11	ANT_LF	RF I/O	—	Low-frequency antenna port covering the Sub-GHz band (150–960 MHz), $50\ \Omega$ impedance
P12	GND	—	—	System ground
P13	GND	—	—	System ground
P14	GND	—	—	System ground
P15	TX/RX_EN	I/O	—	Transmit/receive enable control; can drive an external RF switch or FEM, or be configured by the module as a general-purpose control signal.
P16	—	—	—	Not connected (NC)
P17	ANT_HF	RF I/O	—	High-frequency antenna port covering the 2.4 GHz ISM and S-Band (1.5–2.5 GHz), $50\ \Omega$ impedance.
P18	GND	—	—	System ground
P19	GND	—	—	System ground
P20	GND	—	—	System ground

4. Technical Specifications

Unless otherwise specified, the following parameters were measured at VDD = 3.3 V, a temperature of 25 °C, and a 32 MHz TCXO reference clock.

Parameter Category	Parameter Name	Parameter Value
Chip and Hardware	Main Chip	Semtech LR2021 fourth-generation LoRa transceiver
Chip and Hardware	Operating Voltage	1.8 V ~ 3.7 V, typical 3.3 V
Chip and Hardware	Operating Temperature	–40 °C ~ +85 °C (industrial grade)
Chip and Hardware	Package Dimensions	10 mm × 10 mm × 2.5 mm, 20-pin SMT castellated package
Chip and Hardware	Reference Clock	Industrial-grade 32 MHz TCXO
Chip and Hardware	Antenna Ports	ANT_LF (Sub-GHz) + ANT_HF (2.4 GHz/S-Band), 50 Ω impedance
RF Transmit	Maximum Transmit Power (Sub-GHz)	+22 dBm (LF PA)
RF Transmit	Maximum Transmit Power (2.4 GHz)	+12 dBm (HF PA)
RF Transmit	Transmit Power Dynamic Range	32 dB, 0.5 dB steps
RF Receive	Sub-GHz Receive Sensitivity	–141.5 dBm @ LoRa SF12/BW=125 kHz
RF Receive	2.4 GHz Receive Sensitivity	–103 dBm @ O-QPSK 250 kbps DSSS
RF Receive	Link Budget	Typical 163.5 dB
Modulation	Supported Modulations	LoRa/(G)FSK/OOK/O-QPSK/LR-FHSS/FLRC/DBPSK/BLE 5.0 PHY
Modulation	Spreading Factor	SF5 ~ SF12
Data Rate	LoRa Data Rate	0.0458 ~ 125 kbps
Data Rate	FLRC Data Rate	Up to 2.6 Mbps
Supported Frequency Bands	Sub-GHz	150 ~ 960 MHz

Supported Frequency Bands	2.4 GHz ISM	2400 ~ 2483 MHz
Supported Frequency Bands	Licensed S-Band	1900 ~ 2200 MHz (satellite communications)
Interface	Control Interface	SPI (up to 16 MHz) + digital I/O
Interface	Data FIFO	Independent transmit/receive FIFOs

5. Electrical Characteristics

5.1 Absolute Maximum Ratings

Stresses exceeding the following absolute maximum ratings may cause permanent damage to the device. Prolonged exposure to absolute maximum rating conditions may affect device reliability and service life.

Symbol	Description	Minimum	Typical	Maximum	Unit
VDDmr	Supply voltage	−0.5	—	3.9	V
Tmr	Temperature	−55	—	125	°C
Pmr	Maximum RF port input power	—	—	+10	dBm

5.2 Normal Operating Conditions

Symbol	Description	Minimum	Typical	Maximum	Unit
VCC	Supply voltage	1.8	3.3	3.7	V
Top	Operating temperature	−40	—	+85	°C
Tmaxj	Maximum junction temperature	—	—	105	°C
Clop	Digital port load capacitance	—	—	20	pF

VSWR	Voltage standing wave ratio ensuring PA stability	—	—	10:1	—
------	---	---	---	------	---

5.3 Power Consumption Parameters

Mode	Condition	Minimum	Typical	Maximum	Unit
Sleep	No data retention, no RTC	—	0.47	—	μA
Sleep	Data retention, no RTC	—	0.57	—	μA
Sleep	Data retention, with RTC	—	1.4	—	μA
Standby RC	Internal 32 MHz RC oscillator enabled	—	1.21	—	mA
Standby XOSC	32 MHz crystal oscillator/TCXO enabled	—	1.79	—	mA
Frequency Synthesis	915 MHz	—	3	—	mA
Receive (Sub-GHz)	Non-boosted gain	—	5.7	—	mA
Transmit (Sub-GHz)	+22 dBm	—	105	—	mA
Transmit (Sub-GHz)	+17 dBm	—	43	—	mA
Transmit (Sub-GHz)	+14 dBm	—	27	—	mA
Transmit (Sub-GHz)	+10 dBm	—	17	—	mA
Transmit (2.4	+12 dBm	—	23	—	mA

GHz)					
------	--	--	--	--	--

6. Mechanical Characteristics

6.1 Module Dimensions

The LR2021 module outline dimensions and recommended PCB Layout are shown in Figure 3. The module uses a 10 mm × 10 mm square castellated package with a pin pitch of 1.27 mm and a typical module thickness of 2.5 mm. The PCB pad dimensions should match the module pins, and a ground pad should be provided beneath the module to ensure proper RF grounding and heat dissipation.

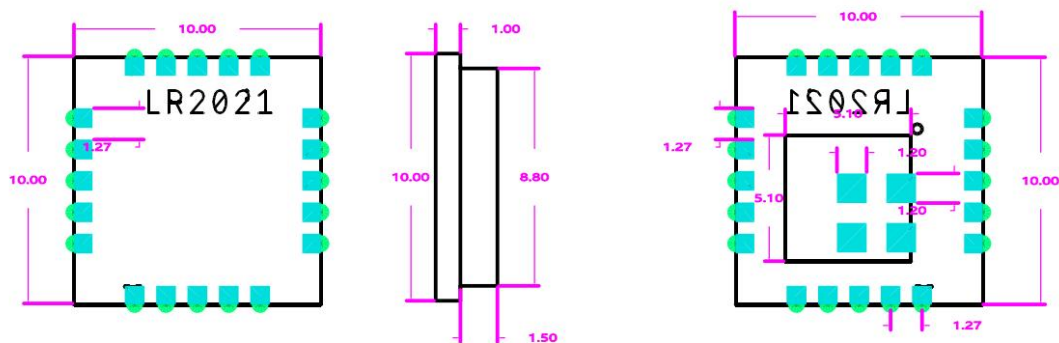


Figure 3 LR2021 Module Outline Dimensions (Unit: mm)

6.2 Layout Recommendations

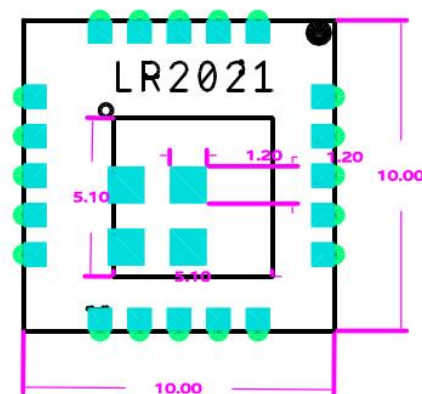


Figure 4 Recommended LR2021 PCB Layout (Unit: mm)

PCB layout considerations:

- Do not place copper pours or traces beneath the antenna area. Maintain a keepout area to reduce parasitic capacitance and impedance mismatch.
- ANT_LF and ANT_HF traces should be kept as short as possible and maintain a 50 Ω characteristic impedance.

- Power-supply decoupling capacitors should be placed close to the VDD pin to create the shortest possible return path.
- RF front-end matching-network components should be laid out according to the Semtech reference design, with the L and C components placed as close as possible to the chip's RF pins.
- The ground pad beneath the module should be connected to the main ground plane through multiple vias to ensure proper grounding and heat dissipation.

7. Reference Schematic

Figure 5 shows a typical application reference schematic for the LR2021 module. The reference design includes a 3.3 V power input, an SPI control interface, general-purpose DIO, antenna matching networks, and power-supply decoupling circuitry. Users may deploy either a single antenna (Sub-GHz or 2.4 GHz) or dual antennas simultaneously, depending on the application requirements.

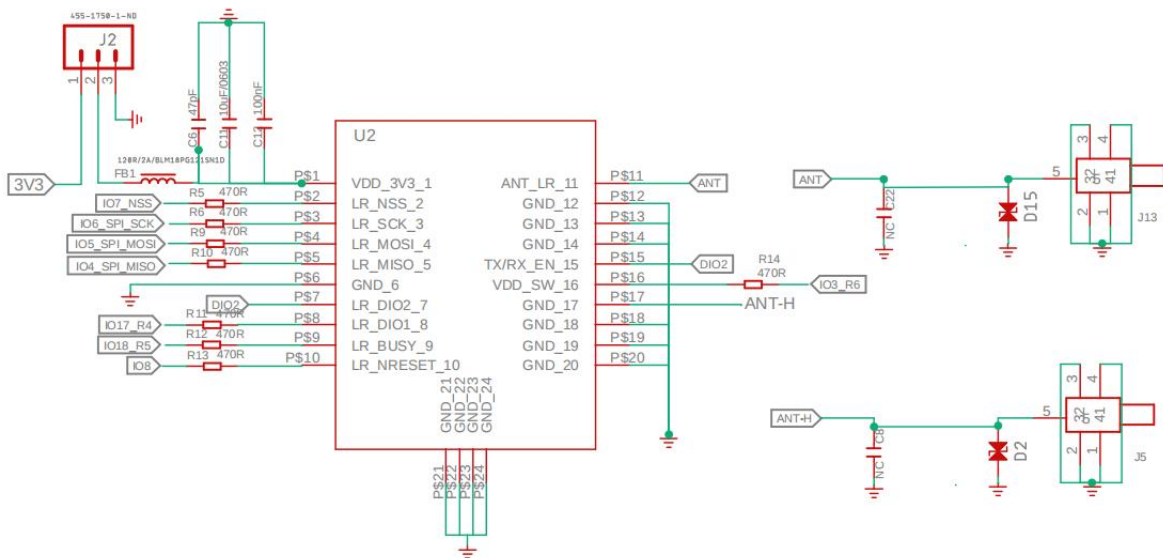


Figure 5 LR2021 Module Reference Schematic

Key schematic design considerations:

- The VDD_3V3 input should be equipped with $47\ \mu\text{F} + 10\ \mu\text{F} + 100\ \text{nF}$ multistage decoupling capacitors to suppress power-supply ripple.
- The SPI bus (NSS/SCK/MOSI/MISO) should include series $470\ \Omega$ resistors to reduce signal reflections and EMI.
- LR_NRESET should be connected to VDD through a $100\ \text{k}\Omega$ pull-up resistor to ensure reset-pin stability.
- TX/RX_EN can be used to drive an external RF switch; when a Direct-Tie antenna connection is used, it can be configured as a general-purpose DIO.

- Separate 50 Ω matching networks should be designed for the low-frequency antenna (ANT_LF) and high-frequency antenna (ANT_HF) based on their target frequency bands.
- ESD protection devices, such as TVS diodes, should be added at the RF ports to improve the system's electrostatic-discharge protection.

8. Certifications

The LR2021 module complies with the following international and regional certification requirements. Users may integrate the module into their products and apply for end-product certification.



Figure 6 Certification Marks

- FCC Part 15.247 / 15.249: Applicable to the 2.4 GHz ISM and license-free Sub-GHz bands.
- CE / ETSI EN 300 220-1: Applicable to European Sub-GHz bands.
- RoHS: Complies with the Restriction of Hazardous Substances Directive and environmental protection requirements.
- LoRaWAN®: Supports all LoRaWAN regional parameters worldwide.

9. Related Documents and Resources

- Semtech LR2021 Datasheet, Rev. 1.1
- LR2021 Module Schematic Reference Design (LR2021_V0.2)
- LR2021 Module Reference PCB Layout
- LoRaWAN® Regional Parameters v1.0.3
- AN1200.102: LR2021 TCXO Temperature Compensation Application Note

10. Revision History

Date	Version	Release Notes
2026/07/10	V1.0	Initial release, compiled from the complete Semtech LR2021

		chip datasheet.
--	--	-----------------

Disclaimer: The contents of this specification are provided for reference only. Shenzhen Yikenuo Technology Development Co., Ltd. reserves the right to modify product specifications at any time without prior notice. Actual parameters are subject to the latest datasheet and test reports.