Connectors & Regulatory Reference

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RF Connector Types Guide

Choosing the wrong connector is one of the most common causes of installation failure and wasted money. LoRa devices and antennas use several different RF connector types, and they are not all interchangeable.

The critical SMA vs. RP-SMA distinction

SMA and RP-SMA (Reverse Polarity SMA) look nearly identical but are incompatible. The difference is which part has the center pin. The canonical identification rubric uses both the center contact and the thread location: **SMA male = center pin + external (outside) thread; SMA female = center socket + internal thread.** RP-SMA reverses the center contact only (the threads stay the same):

Connector type	Center contact & thread	Typical use
SMA male	Center pin + external thread (on the plug)	Antenna end; cable end that plugs into a device
SMA female	Center socket + internal thread (device/bulkhead)	Panel mount on enclosures; device ports
RP-SMA male	Center socket + external thread (center is hollow)	Wi-Fi router antennas; also legitimately used on some LoRa boards
RP-SMA female	Center pin + internal thread	Wi-Fi devices; some LoRa enclosures (e.g. certain RAK WisBlock revisions)

For LoRa 915 MHz devices: standard SMA is the more common convention, but RP-SMA is not an error — it originated in the Wi-Fi industry as a way to satisfy FCC § 15.203 (which requires a unique antenna coupling so users can't easily fit a non-compliant antenna). It is not FCC-mandated, and some LoRa products legitimately use RP-SMA. Because boards vary by revision, always verify which connector your specific device has — against the manufacturer's product page — before ordering antennas and pigtails.

How to tell them apart visually: look at the center of the connector. If the plug (male) has a visible pin sticking out, it's standard SMA male. If the male plug has a hole in the center (no pin), it's RP-SMA male.

Common connector types in LoRa deployments

Connector	Where you'll see it	Max frequency	Notes
SMA	Most LoRa devices; most antennas	18 GHz	Standard for LoRa. Verify SMA vs RP-SMA.
u.FL / IPEX	Board-level connector on many LoRa modules (RAK4631, Heltec boards)	6 GHz	Tiny, fragile. Use pigtail adapter to reach external SMA.
N-type	Outdoor antennas; cable-to-antenna junction	~11 GHz (precision versions to 18 GHz)	Weatherproof, preferred for outdoor permanent installs over SMA.
BNC	Some test equipment	4 GHz	Rarely used for LoRa; easy to connect/disconnect.
MCX / MMCX	Some compact boards	6 GHz	Smaller than SMA; uncommon in LoRa community.

Pigtail adapters

A pigtail is a short cable that adapts between two connector types, e.g., u.FL to SMA bulkhead. Used to bring a board's internal u.FL port out to an external SMA connector through an enclosure wall.

Key rules for pigtails:

- Keep them as short as possible - 10 - 15 cm is ideal. Even "low-loss" pigtails add measurable loss at 915 MHz.
- Use RG316 or LMR-100A for short pigtails. Avoid thin RG178 (high loss) or cheap no-name coax.
- Handle u.FL connectors carefully - they're rated for ~30 insertion cycles. Don't repeatedly attach and detach.

Coaxial cable selection

The figures below are at 915 MHz, expressed both per 100 ft (the standard datasheet reference length) and per 10 ft. They are reconciled with the rest of this book's coax tables and with the

Times Microwave / manufacturer datasheets.

Cable type	Loss at 915 MHz (per 100 ft)	Per 10 ft	Use case
LMR-100A	~3.9 dB	~0.4 dB	Pigtails only (under 1 m); too lossy for longer runs
LMR-200	~9.9 dB	~1.0 dB	Short runs (1 - 5 m); rooftop pigtails; default outdoor choice
LMR-400	~3.9 dB	~0.39 dB	Longer runs (5 - 20 m); tower installations; weatherproof
RG58	~10.6 dB	~1.1 dB	Avoid - too lossy for outdoor 915 MHz runs
RG8X	~4.4 dB	~0.44 dB	Acceptable for short outdoor runs; more flexible than LMR-400

Cable loss adds directly to your system's signal attenuation. At 915 MHz a 10-foot LMR-400 run costs about 0.4 dB; the same run in RG58 costs about 1.1 dB - a difference of roughly 0.4-0.7 dB over 10 ft. The gap is small at this length but widens with longer runs, which is where cable quality really matters: a 50-foot RG58 run loses ~5.3 dB versus ~2 dB for LMR-400.

Weatherproofing connections

All outdoor connector joints must be weatherproofed to prevent water intrusion and oxidation:

- **Self-amalgamating (self-fusing) tape:** Wrap from connector body up the cable. Stretch to 50% its width as you wrap - it fuses to itself and creates a waterproof seal. Best for most outdoor installations.
- **Weatherproof connector boots:** Slip-on rubber boots for N-type and SMA connectors. Less reliable than self-amalgamating tape but reusable.
- **Coax seal putty:** Moldable putty for irregular shapes and added protection under tape.

Never use standard electrical tape for weatherproofing RF connectors - it dries out, shrinks, and allows water to track along the adhesive.

FCC Regulations and EIRP Reference

Operating LoRa mesh equipment in the United States requires compliance with FCC Part 15 rules. This page summarizes the relevant regulations and explains how to calculate whether your installation is within limits.

> **Disclaimer:** This page is a general reference for community operators. It is not legal advice. For installations with high-gain antennas or unusual configurations, consult the FCC rules directly (47 CFR § 15.247, eCFR) or a licensed RF engineer.
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> Rules summarized as of June 2026.

The 915 MHz ISM band

LoRa mesh in North America operates in the 902–928 MHz band, designated as an ISM (Industrial, Scientific, and Medical) band. This band is available for unlicensed operation under FCC Part 15, Subpart C (Intentional Radiators).

Key rule: FCC § 15.247 governs spread-spectrum and digitally modulated operation in the 902–928 MHz band.

Power limits

Limit type	Value	Notes
Conducted output power (the primary FCC limit)	1 W (30 dBm)	Maximum power at the antenna port, valid for antennas up to 6 dBi gain; above 6 dBi the conducted power must be reduced (see below)

Limit type	Value	Notes
EIRP (Effective Isotropic Radiated Power)	≈ 36 dBm (4 W) — **a derived ceiling, not an independent limit**	This is simply 30 dBm conducted + 6 dBi (the maximum gain allowed before power reduction kicks in). § 15.247 does **not** grant a standalone 4 W EIRP allowance; you cannot reach it by pairing higher gain with full power
Antenna gain above 6 dBi	Reduce conducted power dB-for-dB above 6 dBi	EIRP stays capped at ~36 dBm — § 15.247(b)(4)

There is no extra EIRP allowance at 902–928 MHz — not even for fixed point-to-point links. If your antenna gain exceeds 6 dBi (common with directional antennas), FCC rules require you to reduce conducted transmit power by the full amount the gain exceeds 6 dBi (47 CFR § 15.247(b)(4)), which keeps maximum EIRP at 36 dBm (4 W) in every configuration. Example: a 9 dBi Yagi limits you to 27 dBm conducted; a 12 dBi antenna to 24 dBm.

You may have read about point-to-point gain allowances in § 15.247 — those provisions (§ 15.247(c)(1)) apply **only to the 2.4 GHz and 5.8 GHz bands**, not to 902–928 MHz. At 2.4 GHz a fixed point-to-point link may reduce conducted power only 1 dB for every 3 dB of gain above 6 dBi (§ 15.247(c)(1)(i)); 5.8 GHz allows extra gain with no reduction (§ 15.247(c)(1)(ii)). **Neither relief exists at 902–928 MHz** — there the full dB-for-dB reduction of § 15.247(b)(4) always applies. Canada's RSS-247 works the same way: its point-to-point exception also excludes 902–928 MHz.

Conditions behind the 1 W figure

The 1 W ceiling applies to qualifying system types: digitally modulated systems with at least 500 kHz of 6 dB bandwidth (§ 15.247(a)(2)), or frequency-hopping systems with at least 50 hopping channels (§ 15.247(b)(2); systems with 25–49 channels — permitted only when the hopping channel's 20 dB bandwidth is 250 kHz or greater, § 15.247(a)(1)(i) — are limited to 0.25 W). Digitally modulated systems are additionally limited to 8 dBm of power spectral density in any 3 kHz band (§ 15.247(e)). Common LoRa mesh presets use 125–250 kHz bandwidth, so **your device's FCC certification grant — not the rule's 1 W ceiling — defines what it is authorized to transmit.** Operating a certified device in its stock configuration is the safe harbor.

EIRP calculation

EIRP (dBm) = TX Power (dBm) + Antenna Gain (dBi) − Cable Loss (dB)

Example 1: Stock node with a small upgrade antenna (within limits)

Parameter	Value
TX power	22 dBm (stock SX1262-class board)
Cable loss (3 m LMR-200)	1.0 dB
Antenna gain	+5 dBi
EIRP	**22 + 5 − 1.0 = 26.0 dBm** (below 36 dBm limit ✓)

Example 2: PA-equipped rooftop repeater (within limits)

Parameter	Value
TX power	27 dBm (500 mW — PA-equipped/base-station class)
Cable loss (3 m LMR-200)	1.0 dB
Antenna gain	+5 dBi
EIRP	**27 + 5 − 1.0 = 31.0 dBm** (below 36 dBm limit ✓)

Note: 3 m of LMR-200 loses about 1.0 dB at 900 MHz (Times Microwave datasheet: ~32.6 dB/100 m). Thinner cables lose more; budget for your actual cable type and length.

Example 3: High-gain antenna requiring power reduction

Parameter	Value
TX power (attempted)	30 dBm (1 W)
Antenna gain	+9 dBi
Required reduction	Antenna gain exceeds 6 dBi by 3 dB → reduce conducted power by 3 dB
Maximum legal TX power	**27 dBm** (47 CFR § 15.247(b)(4))
Resulting EIRP	27 + 9 − 0.5 (cable) = 35.5 dBm (within 36 dBm ✓)

The reduction is computed from antenna gain alone — cable loss does **not** offset it. In Meshtastic, set `LoRa config → Transmit Power` to 27 (integer dBm; always round **down**).

Standard device compliance

Many mainstream LoRa boards (LILYGO T-Beam — FCC ID 2ASYE-T-BEAM, RAK4631 — see RAK's certification page, Heltec, etc.) carry FCC certification covering their shipped configuration. **Check that your specific board has an FCC ID — uncertified clones are common.** If you use a certified device as shipped with the included antenna, or with a replacement antenna **of the same type and equal or lower gain** (47 CFR § 15.204(c)(4)), you are within the certification. A different antenna type or higher gain — even a "comparable" one — is not covered, and compliance responsibility shifts to you.

Custom installations — especially with high-gain external antennas or increased TX power settings — require you to verify EIRP compliance independently.

What happens if you exceed the limits?

Exceeding the limits is a violation of federal rules regardless of how likely enforcement is. The operator (or, for professionally installed equipment, the installer) is responsible for ensuring the system stays in compliance. The FCC can and does act on interference complaints, issuing warnings and monetary forfeitures, and any Part 15 operator must stop transmitting if notified that they are causing harmful interference (47 CFR § 15.5). The rules also exist for good reason: excessive EIRP interferes with other users of the band, including industrial IoT systems, 900 MHz ISM devices, and licensed services.

More practically: running higher power than necessary increases interference with nearby mesh nodes and doesn't improve range as much as better antenna placement would. For most installations, stock TX power with a 3–6 dBi antenna at a better location is the right operating point.

Beyond power limits, fixed transmitters must also comply with the FCC's RF human-exposure (MPE) limits under 47 CFR § 1.1310 (evaluated per § 15.247(i)/OET Bulletin 65). At 915 MHz the general-population power-density limit is roughly 0.6 mW/cm². High-gain or co-located antennas near occupied areas may require an exposure evaluation and a minimum separation distance — keep antennas out of arm's reach of people while transmitting.

Canada (ISED) rules

Innovation, Science and Economic Development Canada (ISED, formerly Industry Canada) rules for 902–928 MHz operation are similar to FCC § 15.247. The relevant standard is RSS-247 (with RSS-Gen general requirements). The conducted power limit is also 1 W, but ISED's antenna-gain and e.i.r.p. provisions are written separately and are not guaranteed identical to FCC § 15.247 — verify against RSS-247 directly rather than assuming they align. RSS-247's point-to-point exception likewise does not cover 902–928 MHz. Certified devices sold in both markets carry both FCC and IC certification numbers.

Frequency coordination

The 902–928 MHz band is shared with many other services and devices, including:

- **Federal radiolocation systems (primary users)** — high-EIRP government radars; you must accept their interference
- **Part 18 ISM equipment** — Part 15 devices are secondary to it
- **Amateur radio (33 cm band)** — licensed hams may also run mesh hardware at higher power under Part 97 (47 CFR § 97.313(j))
- Other LoRa/LoRaWAN deployments
- 900 MHz Wi-Fi (802.11ah/HaLow)
- Legacy 900 MHz consumer devices (older 900 MHz analog/digital cordless phones — now largely obsolete; note that DECT 6.0 cordless phones operate at 1.9 GHz, not 900 MHz — and some baby monitors)

Part 15 operation is unprotected: you must accept interference from these services and must not cause harmful interference to them (47 CFR § 15.5).

Meshtastic and MeshCore each transmit on a single configurable channel frequency — they do **not** automatically frequency-hop. As used in mesh, these are digitally modulated (non-hopping) systems under § 15.247(a)(2), not frequency-hopping systems. If you experience interference, manually select a different frequency slot (Meshtastic: `LoRa config → Frequency Slot`; MeshCore: `set freq` via the serial CLI on repeaters/room servers, or the app's radio settings on client nodes). Coordinate with other operators in your area to avoid overlapping on the same exact frequency.