

Antenna Installation and Measurement

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Mast and Pole Mounting

Safety first

Erecting and climbing masts is hazardous. Before any mast work:

- **Overhead power lines:** Keep the mast's full fall radius clear of power lines - allow a clearance of at least the mast length plus 10 ft in every direction. A falling or tipping mast that contacts an overhead line can be fatal; power-line contact is the leading cause of installer electrocution.
- **Never raise a mast alone.** Use a spotter, and never raise or work on a mast in wind or near power lines without help.
- **Fall protection:** Use fall protection for any rooftop or elevated work, and do not climb push-up or telescoping masts - they are not rated to support a person.

Mast options

- **J-pipe mounts:** Common TV antenna hardware. Good for moderate antennas on walls or chimneys.
- **Galvanized conduit:** 1-1.5" Schedule 40 steel conduit. Strong, affordable, easy to work with. Suitable for short unguyed masts (commonly cited around 4-5 meters), but the safe free-standing height depends heavily on wind load and antenna weight - for taller masts or heavier antennas, guy the mast or consult a structural/EIA-222 or manufacturer guideline rather than relying on a flat height figure.
- **Telescoping push-up masts:** Aluminum sections. Easy to deploy. Common for temporary or semi-permanent installs.
- **Non-penetrating roof base:** A weighted base holds a mast on a flat roof without drilling. Ballast requirements scale with mast height and antenna wind load - 50 lb of paving blocks is a minimum for short masts only. Calculate the overturning moment for your wind zone; tall masts may need several hundred pounds of ballast or guying. An inadequately ballasted mast can blow over, becoming a falling hazard or striking power lines.

Guy wires

Masts more than about 3-4 meters free-standing (and any telescoping push-up mast above roughly 4 m) need guy wires. Use three guys at 120 degree intervals (a triangular arrangement). Use stainless cable or UV-resistant rope. Guy at 2/3 height and near the top. The exact threshold depends on mast type, antenna wind load, and exposure - guy sooner for heavier antennas or windy sites.

Grounding and lightning protection

Ground the mast and antenna with a bonding/down conductor not smaller than #10 AWG copper (NEC 810.21); #8 AWG or larger exceeds this minimum and is fine. If you drive a separate ground rod for the antenna, it **must** be bonded to the building's main grounding electrode system with at least a #6 AWG copper conductor (NEC 810/250) - grounding the mast to its own isolated rod without bonding to building ground creates a dangerous ground-potential difference and is a code violation. Install a coaxial lightning arrestor rated for 915 MHz at the building entry point and bond it to building ground. See the dedicated [grounding and lightning protection](#) page for full detail.

Key rules

- Mount antenna as high as practical, clear of obstructions
- Keep the coax run short by mounting the radio enclosure close to the antenna
- Use stainless steel hardware outdoors to prevent galvanic corrosion
- **Never power on the radio without an antenna connected** - transmitting into an open or shorted port can damage the power amplifier. LoRa transceivers (SX126x/SX127x) often survive brief keying into an open port, but sustained transmission without a proper load can cause permanent damage, so always connect the antenna (or a 50-ohm dummy load) before transmitting. This caution applies most during bench testing - see the getting-started and testing material.

SWR and Antenna Analyzers

SWR (Standing Wave Ratio) measures how well your antenna is matched to the 50-ohm feedline impedance. A well-matched antenna transfers all power to the air; a mismatched antenna reflects some power back.

SWR values

SWR	Reflected Power	Assessment
1.0:1	0%	Perfect (theoretical)
1.5:1	4%	Excellent
2.0:1	11%	Acceptable
3.0:1	25%	Poor - investigate

Common causes of high SWR

- Connector not fully tightened (most common)
- Water ingress into connector or cable
- Damaged or kinked coax
- Wrong-band antenna (e.g. 868 MHz antenna on a 915 MHz system)

NanoVNA for measurement

The common low-cost NanoVNA-H covers roughly 50 kHz to 1.5 GHz (the original NanoVNA / NanoVNA-H tops out near 1.5 GHz via harmonics, with best accuracy below ~900 MHz). Only some variants such as the NanoVNA-F V2 / V2 series reach 3 GHz. Any of these easily covers the 915 MHz band and is ideal for checking LoRa antenna systems. Check your specific model's published spec before buying. Connect to the antenna feedpoint, sweep 850-950 MHz, and look for the SWR minimum. A good 915 MHz antenna shows SWR below 1.5:1 across the 902-928 MHz band.

Important: A NanoVNA is a measurement instrument, not a transmitter port. Never key up your radio into the analyzer, and never transmit without an antenna connected - doing either can damage the analyzer or the radio's final stage.

Most commercial LoRa antennas are pre-tuned and work fine out of the box. Measure when troubleshooting performance problems, building DIY antennas, or verifying a new cable run.

Feedline Loss Reference

At 915 MHz, cable loss is significant. A long run of cheap coax can negate the benefit of a quality antenna upgrade. This is the canonical loss table for the book; all values are at 915 MHz, sourced from manufacturer datasheets (Times Microwave for LMR types) and expressed per 100 ft of cable.

Loss at 915 MHz per 100 ft

Cable Type	Loss per 100 ft	Notes
RG-58	~20 dB	Avoid for any outdoor run over about 6 ft (2 m)
RG-8X	~12.6 dB	Acceptable for short indoor runs
LMR-200	~9.9 dB	Good for runs up to about 30 ft (10 m)
LMR-400	~3.9 dB	Use for runs over about 30 ft (10 m)
LMR-600	~2.5 dB	Very long runs; stiff and expensive

Loss scales linearly with length: divide the per-100 ft figure by 10 for a per-10 ft estimate, or multiply by 0.0328 for a per-metre estimate (for example, LMR-400 at ~3.9 dB/100 ft is ~1.28 dB per 10 m).

Practical guidance

- Rooftop install with a 10-15 ft (3-5 m) run: LMR-200 is ideal
- Runs over about 30 ft (10 m): LMR-400 minimum
- Never use RG-58 for permanent outdoor installs
- Each connector adds loss - a quality N connector adds ~0.1-0.3 dB, while cheaper or worn SMA can reach 0.5-1 dB. Either way, minimize adapters.

The proximity advantage: The best way to minimize cable loss is to mount the radio enclosure close to the antenna. A 0.5 m cable run with any cable type adds negligible loss.

Ground Planes for Monopole Antennas

A monopole antenna (vertical rod) radiates efficiently only when paired with a ground plane - a conducting surface that acts as the electrical other half of the antenna.

What counts as a ground plane

- **Vehicle roof:** Excellent. A metal roof is an ideal ground plane for NMO-mount antennas.
- **Metal enclosure:** A metal equipment housing near the feedpoint serves as a ground plane.
- **PCB ground plane:** The copper ground layers on a dev board act as a ground plane for the stock whip / helical ("rubber duck") antenna supplied with dev boards. Note that this is a *marginal* ground plane: the PCB is electrically small at 915 MHz, so performance from the stock antenna is often poor. Where range matters, mount the antenna on a proper ground plane or use a self-contained antenna rather than relying on the dev board.
- **Radials:** For antennas on non-conductive masts, attach 3-4 quarter-wave radials (8.2 cm at 915 MHz) at the base, angled 45 degrees downward.

Do commercial LoRa antennas need a ground plane?

Most commercial 915 MHz verticals designed for LoRa use a self-contained design - a balanced dipole structure, a collinear, or built-in radials - and so do not require an external ground plane. The caveat is common-mode current on the coax shield: even a "self-contained" antenna can effectively turn the feedline into part of the antenna unless it is decoupled (a choke or the antenna's own decoupling section). Check the manufacturer mounting instructions.

How to tell whether your antenna needs a ground plane: a bare whip with no visible radials and a single feed point is a monopole and needs a ground plane. An antenna labeled as a dipole, or one with a wider base section or its own radials, is self-contained. When you are unsure, check the product page, or measure SWR with and without a ground plane - a monopole that needs one will show a clear difference.

A poorly grounded monopole can have its radiation pattern tilted upward rather than horizontal, reducing effective range. This matters mainly for DIY wire antennas and bare whips, not for self-contained commercial products.