Mounting, Grounding, and Lightning Protection

Mechanical installation, grounding systems, and lightning protection for outdoor antenna systems.

Antenna Mounting Best Practices

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Proper antenna mounting is the difference between a node that stays up through storms and one that fails or becomes a hazard. This page covers mechanical considerations, materials, and installation techniques for outdoor LoRa mesh antennas.

SAFETY WARNING - read before raising any mast. Aluminum and steel masts are electrical conductors, and contact with an overhead power line is frequently fatal. This is the leading cause of installer electrocution. Before raising any mast, confirm clearance of **at least the full mast length plus 10 ft (3 m) from every overhead power line** in the mast's entire fall radius - if the mast were to fall or swing in any direction, it must not be able to reach a line. Additionally: use fall protection for any work at height, keep people clear of the area below where a mast or antenna could fall, and never raise a mast alone. Tall or heavily loaded masts can swing unpredictably; have a second person steady the base.

Mast Types

The mast is the structural element that holds the antenna at height. Selection depends on application, available mounting surface, and antenna weight and wind load.

Mast Type	Material	Typical Height	Best Use	Notes
J-mount / pipe mount	Galvanized steel or aluminum	0 - 0.6 m above mount point	Eave and fascia mounting; residential rooftops	Low cost; widely available; adequate for small omni antennas

Mast Type	Material	Typical Height	Best Use	Notes
Telescoping push-up mast	Aluminum sections	3 - 12 m	Temporary deployment; emergency comms	Conductive - keep clear of power lines (see safety warning above). Push-up masts generally need guying once extended past a few metres (manufacturers commonly specify guying from roughly 4 m up); not rated for permanent installation without guying. Follow the specific mast's manual.
Schedule 40 galvanized pipe	Hot-dip galvanized steel	As designed	Permanent rooftop or ground-mounted nodes	1.5" or 2" diameter accommodates most commercial antenna clamps; excellent durability
Aluminum angle/tube	6061-T6 aluminum	Variable	Lightweight permanent installations	Good where weight matters; do not use raw aluminum near dissimilar metals (galvanic corrosion)
Non-conductive fiberglass mast	Fiberglass-reinforced polymer	Variable	When RF transparency is required; stealth installations	Higher cost; consider when metal mast would detune the antenna

Standoff Distance from Metal

Metal surfaces reflect and absorb RF energy at 915 MHz. Mounting an antenna too close to metal degrades performance, shifts resonant frequency, and distorts the radiation pattern. Pattern distortion does not vanish abruptly at any one distance - it decreases continuously as separation grows - so treat the figures below as a tiered rule of thumb (at 915 MHz, $\lambda \approx 33$ cm):

- **Absolute minimum standoff from any metal surface:** $\lambda/4 \approx 8$ cm. Below this, reactive near-field coupling to the metal significantly alters antenna behavior.
- **For little discernible pattern distortion:** $\lambda/2 \approx 16$ cm or greater (a rule of thumb - distortion lessens gradually, it does not stop at exactly $\lambda/2$).
- **Conservative target for high-performance fixed installs:** a full wavelength, ≈ 33 cm, where practical. This matches the "one wavelength from metal structures" rule given on the Base Station & Outdoor Antennas page.

- **For vertical collinear antennas mounted to a metal mast:** mount the antenna's feedpoint roughly one wavelength (about 33 cm at 915 MHz) above the top of the metal mast where practical, using a non-conductive standoff bracket or fiberglass spacer. Consult the antenna's installation manual for any mast-top clearance it specifies.
- **Metal roof surfaces:** mount the antenna well clear of the metal roof plane - on the order of a wavelength or more (roughly 0.3 - 0.6 m at 915 MHz) - to clear the roof's RF reflection zone.

Exception: if the metal IS the ground plane (e.g., a quarter-wave monopole mounted to a metal enclosure lid), close proximity is intended. A monopole needs a ground plane of at least about λ/4 radius (~8 cm radius / ~16 cm diameter at 915 MHz); the 30 cm (≈ one wavelength) diameter recommended here is a conservative target. Ensure the metal surface is electrically bonded to the antenna's ground reference.

J-Mount vs Direct Mount

The J-mount (also called a J-arm, chimney mount, or eave mount) is a bracket that attaches to an eave, chimney, or fence post and holds a vertical mast pipe. It is the standard residential antenna mounting solution. (Note: a "J-pole" is a type of *antenna* - an end-fed half-wave - not a mount. The bracket described here is a J-mount; don't confuse the two.)

- **J-mount advantages:** No roof penetration required; easy to install and remove; good for HOA-restricted or rental properties
- **J-mount disadvantages:** The mast end hangs below the mounting surface, limiting usable height gain; can deform in high winds if not sized correctly
- **Direct mount (U-bolt to mast):** Preferred for rooftop penetrations or wall-through installations where a base plate is attached directly to a structural surface. More permanent and secure but requires sealing any penetration against water intrusion.

Pole Diameters and Clamp Compatibility

Commercial antenna base clamps are typically designed for specific pole outside diameters. The most common:

Nominal Pipe Size	Actual OD	Compatible Clamps
3/4" Schedule 40 pipe	26.7 mm (1.05")	Clamps rated for 1" - 1.25" poles
1" Schedule 40 pipe	33.4 mm (1.32")	Clamps rated for 1.25" - 1.5" poles
1.5" Schedule 40 pipe	48.3 mm (1.9")	Clamps rated for 1.5" - 2" poles; most commercial clamps
2" Schedule 40 pipe	60.3 mm (2.375")	Heavy-duty commercial clamps

Always verify clamp OD range before ordering. Antenna manufacturers typically specify the accepted pole diameter range in the product data sheet.

UV-Rated Materials

At 915 MHz, antenna elements and enclosures are routinely exposed to direct sunlight for years. UV degradation is a real concern:

- **Antenna radomes:** Quality outdoor antennas use UV-stabilized fiberglass or ABS. Cheap antennas often use standard PVC or thin ABS that chalks and cracks within 2 - 3 years in direct sun.
- **Cable jacket:** Use UV-resistant (black polyethylene or LLDPE jacket) cable for any outdoor run. LMR-400 standard uses a black UV-resistant jacket. White or gray jacketed cables require conduit or UV protection coating if exposed.
- **Mounting hardware:** Use stainless steel (316 preferred for coastal; 304 acceptable inland) or hot-dip galvanized hardware. Zinc-plated (electroplated) hardware will rust within 2 - 5 years outdoors.
- **Cable ties:** Use UV-rated black nylon cable ties, not natural (white) ties which degrade in 6 - 18 months of sun exposure. Stainless steel cable ties are best for permanent high-UV installations.
- **Enclosures:** NEMA 4X (IP66) ABS or polycarbonate enclosures with UV stabilization are appropriate for electronics housing. Fiberglass NEMA 4X enclosures offer superior UV resistance for long-term outdoor use.

Wind Load Considerations

Antenna wind loading is a frequently overlooked mechanical consideration. A 5 dBi fiberglass omni in a 60 mph wind generates more force than most people expect:

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Approximate wind load (lbs) = 0.00256 × V² × A × Cd

Where:
 V = wind velocity (mph)
 A = projected area (ft²) = diameter × length
 Cd = drag coefficient (~1.2 for cylinders)

Example: 1" diameter × 3 ft antenna at 70 mph wind:
Area = (1/12) × 3 = 0.25 ft²
Load = 0.00256 × 70² × 0.25 × 1.2 ≈ 3.8 lbs bending force

Same method for a 5 dBi fiberglass omni (~1.25" × 4 ft, area ≈ 0.42 ft²) at 60 mph:
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Load = 0.00256 × 60² × 0.42 × 1.2 ≈ 4.6 lbs - acting at the top of the mast.
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These forces seem small but they act at the top of the mast, creating a significant bending moment (force × height) at the mounting point - that moment, not the raw force, is what overloads a mount. This is a simplified flat-plate estimate: real structural design per ASCE 7 adds height (K_z), topographic (K_{zt}), and gust factors that can raise the effective load roughly 1.5 - 3×, so tall masts see considerably more than this simple figure suggests.

To size a mast, compare the bending moment (force × mounting height) against the mast and mount manufacturer's published moment or load rating, and apply a generous safety margin (a 3× rule of thumb is a reasonable starting point, but it is not a substitute for the manufacturer's rating). For tall or multi-antenna installations, account for the cumulative load of every antenna on the mast, and have the design reviewed by someone with structural experience.

Installer safety reminder: rooftop and at-height work carries fall and dropped-object hazards independent of the structure's wind rating. Use fall protection, secure tools and hardware so nothing drops onto people below, keep the area beneath the work clear, and re-check the power-line clearance warning at the top of this page before raising anything.

Grounding and Lightning Protection

Grounding and Lightning Protection

A properly grounded and surge-protected antenna installation helps mitigate the destructive effects of direct lightning strikes and the more common (but still damaging) induced transients from nearby strikes, protecting people, equipment, and buildings. No grounding or surge-protection system can fully protect against a direct strike, but a correct installation greatly reduces the risk. This page covers the components and procedures for a compliant, effective 915 MHz LoRa antenna grounding installation.

DANGER — Overhead power lines and fall hazards: Never erect, raise, lower, or position a mast or antenna where it could contact or fall into an overhead power line. Maintain a horizontal and vertical clearance of at least the mast's full length plus 10 ft from any power line. Power-line contact can be instantly fatal, and grounding does **NOT** make it safe to touch an energized structure — a mast that contacts a live line can remain lethally energized regardless of how well it is grounded. Antenna/mast contact with power lines is a leading cause of installer electrocution. Working at height also carries a serious fall hazard: use proper fall protection, never work alone, and do not raise masts in wet or windy conditions.

Why Ground Your Antenna Installation?

The goal of antenna grounding is threefold:

1. **Lightning protection:** Provide a low-impedance path to earth for direct strike energy, bypassing protected equipment.
2. **Static dissipation:** Continuously bleed off static charge that accumulates on isolated metal structures, preventing equipment damage from static discharge.
3. **Safety:** Bonding the structure to ground reduces shock hazard from fault currents and helps clear faults. Note, however, that grounding does **not** make a structure safe to touch if it contacts an energized overhead power line — see the power-line warning above. Maintaining clearance from power lines, not grounding, is what prevents power-line

electrocution.

Note: Grounding does not prevent lightning from striking. It controls where the energy goes when a strike occurs - to ground, not through your radio.

Ground Rods

The earth electrode (ground rod) is the interface between the grounding system and earth. NEC (National Electrical Code) Article 810 (for antenna systems) and Article 250 (general grounding) specify requirements:

- **Minimum rod specifications (NEC 250.52):** 5/8" diameter, 8-foot length, copper or copper-clad steel. Where a single driven rod does not have a resistance to earth of 25 ohms or less, NEC 250.53(A)(2) requires it to be supplemented by a second electrode. In practice many installers cannot measure ground resistance, so the simpler code-compliant path is to drive two rods spaced at least 6 ft apart.
- **Preferred rod (recommended upgrade, not code-required):** 3/4" diameter, 10-foot copper-clad steel lowers contact resistance in dry soils.
- **Installation:** Drive rod vertically into soil. Where rock prevents full depth, rod may be installed at a 45° angle or in a horizontal trench per NEC 250.53.
- **Connection:** Use a listed ground rod clamp (not a hose clamp). Connect the antenna grounding/bonding conductor with minimum #10 AWG copper (or #17 AWG copper-clad steel) per NEC 810.21. Heavier conductor — #6 AWG copper — is recommended for better surge handling.
- **Bonding to building ground:** The antenna ground rod must be bonded to the building's primary grounding electrode system. The conductor that bonds the antenna ground rod to the building grounding electrode system must be a minimum of #6 AWG copper (NEC 250 / intersystem bonding). Do not create an isolated "antenna ground" disconnected from the main service ground - this creates dangerous voltage differences between grounded objects during a strike.

Bonding Conductors

The bonding conductor (ground wire) connects the antenna mast, cable shield, and equipment ground to the earth electrode. Per NEC 810.21, the antenna grounding/bonding conductor must not be smaller than #10 AWG copper (or #17 AWG copper-clad steel or bronze). The #6 AWG figure below applies to the conductor that bonds the antenna ground rod to the building grounding electrode system — a different, larger requirement. The "Recommended" column reflects engineering best practice for surge handling, not a code minimum:

Component	Minimum Wire Size (NEC 810.21)	Recommended (best practice)	Notes

Antenna mast to ground rod	#10 AWG copper	#6 AWG solid copper	#10 AWG is the NEC 810.21 minimum; #6 AWG is a recommended upgrade for better surge handling. Must be mechanically protected if exposed to physical damage (810.21).
Coax shield ground at entry	#10 AWG copper (or #17 AWG copper-clad steel)	#10 AWG copper	Ground coax shield at the building entry point (NEC 810.21). Do not use #17 AWG copper — the #17 AWG figure applies only to copper-clad steel/bronze.
Bonding antenna ground rod to building electrode	#6 AWG copper	#6 AWG solid copper	Connects antenna ground rod to the building grounding electrode system (NEC 250 / intersystem bonding termination).

Run bonding conductors in as straight a path as possible. Every bend in the conductor adds inductance, which increases impedance to fast-rise lightning transients. A ground wire with many bends is far less effective than a straight run, even if the same gauge.

Lightning Arrestors at 915 MHz

A lightning arrestor (also called a surge protector, coaxial surge protector, or gas discharge tube protector) is installed inline in the coaxial feedline, typically at the building entry point where the cable enters a weatherproof enclosure. It provides a low-impedance path to ground for surge energy while remaining essentially transparent to normal 915 MHz signals.

Types used at 915 MHz:

- **Gas discharge tube (GDT) type:** Contains a sealed gap filled with an ionizable gas. Remains open (no conduction) at normal voltages; ionizes and conducts to ground when voltage spike exceeds breakdown voltage (typically 90 - 200 V). Returns to non-conducting state after transient passes. Excellent RF transparency; virtually no insertion loss.
- **Solid-state (transient voltage suppressor) type:** Uses TVS diodes to clamp voltage. Faster response than GDT but higher capacitance. At 915 MHz, higher capacitance can cause reflections; look for units specified for 900 - 1000 MHz with insertion loss under 0.5 dB.
- **Hybrid GDT + TVS:** Best of both; GDT handles bulk energy, TVS handles fast rising edge. More expensive but preferred for high-value installations.

Recommended Arrestors for 900 MHz LoRa

Verify the current part number, connector configuration, and insertion-loss spec against the manufacturer's datasheet before purchasing — surge arrestors are a safety component and model numbers change. The models below are representative N-female gas-tube coax arrestors that cover the 900 MHz band:

Model	Type	Connectors	Insertion Loss @ 1 GHz	Notes
Polyphaser IS-50NX-C2	GDT	N-female both ends	<0.1 dB	Industry standard; bulkhead mount; requires grounding lug
Proxicast 0-6 GHz N-Female coaxial lightning arrester (e.g., ANT-211-001)	GDT	N-female both ends	<0.2 dB	Lower-cost alternative to Polyphaser; confirm current SKU on the datasheet
Citel P8AX-900	GDT	N-female both ends	<0.3 dB	DC-blocked version available for bias-T applications
Times Microwave Times-Protect N-female gas-tube arrestor	GDT	N-female both ends	<0.1 dB	2-stage gas tube; good energy handling. Confirm the exact Times-Protect SKU on the datasheet.

Installation Procedure

1. **Install the ground rod** at or near the building entry point. Drive to full depth. Connect the ground lug from the ground rod to the building's main grounding electrode system with #6 AWG copper (NEC 810.21).
2. **Mount the arrestor** at the building entry point - the location where the outdoor coaxial cable transitions from outside to inside the building. Mount it on a grounding panel or use a bulkhead mount penetration.
3. **Bond the arrestor ground lug** directly to the ground rod with the shortest possible #6 AWG (or heavier) copper conductor. #10 AWG copper is the absolute NEC 810.21 minimum, but #6 AWG is strongly preferred for strike-energy bonding. Every inch of extra length adds inductance and reduces protection effectiveness.
4. **Ground the mast** separately. Run a #6 AWG conductor from the mast base directly to the ground rod. Bond at a second lug on the ground rod or a listed bonding clamp. Ensure

the mast ground and arrestor ground tie to the same electrode, then bond to the building grounding electrode system — avoid isolated grounds.

5. **Connect outdoor cable** from antenna to the antenna (outdoor) port of the arrestor.
6. **Connect indoor cable** from the equipment (indoor) port of the arrestor to the LoRa radio or gateway.
7. **Verify continuity:** With an ohmmeter, verify that the mast, cable shield, and arrestor ground lug all measure under 1 ohm to the ground rod. This <1 ohm value is a bonding-continuity workmanship target, not the 25-ohm earth-resistance figure (which is a different measurement of the rod-to-earth resistance).

NEC Requirements Summary

Key NEC articles applicable to antenna grounding (2023 NEC). Verify every article number and conductor size against the current National Electrical Code, as interpreted by a licensed electrician, before relying on it for an inspection:

- **Article 810.21:** Grounding of outside antenna systems - grounding/bonding conductors (minimum #10 AWG copper or #17 AWG copper-clad steel), electrode requirements, bonding to the building grounding electrode system.
- **Article 810.20:** Surge protector installation location and specifications for receiving antenna systems.
- **Article 250.52/250.53:** Grounding electrode and installation requirements.
- **Article 250.94:** Intersystem bonding termination - provides a means to bond communications/antenna grounds to the building grounding electrode system. (Note: bonding of separately derived systems is a separate provision, NEC 250.30.)

Disclaimer: This page provides a general overview for reference. Always consult the current edition of the NEC and any applicable local amendments. Installation may require a licensed electrician and/or a permit depending on local code adoption and the requirements of the authority having jurisdiction (AHJ). Radio amateur and commercial operations may have additional FAA (Part 77) and FCC antenna-structure-registration (47 CFR Part 17) requirements beyond NEC scope.