

LoRa Technology

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How LoRa Works

LoRa (Long Range) is a proprietary wireless modulation technique developed by Semtech Corporation. It is the physical radio layer that both MeshCore and Meshtastic use to transmit messages over long distances without any infrastructure.

The Physics: Chirp Spread Spectrum

LoRa uses a modulation method called **Chirp Spread Spectrum (CSS)**. Instead of transmitting a signal at a fixed frequency, LoRa encodes data in "chirps" - continuous sweeps across a range of frequencies. This has two major practical effects:

- **Noise resistance:** Chirps are extremely hard to destroy with narrowband interference. A signal can be decoded even when it is well below the noise floor - typically down to - 20 dB SNR (20 dB below noise).
- **Multipath resilience:** Reflected signals arrive slightly offset in time but still decode correctly, which is critical in urban environments.

Key Radio Parameters

LoRa performance is controlled by three main parameters that trade off between speed, range, and battery use:

Parameter	What It Controls	Trade-off
Spreading Factor (SF)	How long each symbol is spread in time; each symbol carries SF bits using 2 to the power of SF chirps (SF5 - SF12 on modern chips; presets typically use SF7 - SF12)	Higher SF = longer range & more noise resistance, but slower data rate and more airtime
Bandwidth (BW)	Width of the frequency channel (125, 250, or 500 kHz typical)	Wider BW = faster data rate, shorter range
Coding Rate (CR)	Forward error correction ratio (4/5, 4/6, 4/7, 4/8)	Higher CR = more redundancy and error correction, more overhead per packet

MeshCore and Meshtastic both define preset channel configurations that bundle these parameters together. Most users never need to change the raw parameters - picking the right preset is sufficient.

Frequency Bands

LoRa devices operate in the ISM (Industrial, Scientific, and Medical) bands, which are license-free for compliant devices:

- **915 MHz** - United States and Canada (902 - 928 MHz ISM band)
- **868 MHz** - Europe
- **433 MHz** - available in some regions; better building penetration per the physics, but tight power and duty-cycle limits often offset the range advantage

In the US, 915 MHz operation is governed by FCC Part 15 rules: maximum 1 W (30 dBm) conducted power, and maximum 4 W (36 dBm) EIRP (conducted power plus antenna gain). **No amateur radio license is required** to operate a LoRa mesh node under these rules.

Practical Range

Range depends heavily on environment, antenna height, and channel settings:

- **Urban, near ground level:** 1 - 5 km node to node
- **Rural, line-of-sight:** 5 - 20 km node to node
- **Elevated repeater (hilltop or tower):** 20 - 50+ km

Through a mesh network of repeater nodes, a single message can travel hundreds of miles, hopping from node to node across a region.

Power Consumption

LoRa radios use very little power, which is one of their key advantages:

- **RF output power:** typically 100 - 160 mW (20 - 22 dBm) at maximum on common nodes
- **Total power consumption:** roughly 50 - 150 mW for the radio while idle-listening, rising to 0.4 - 1 W or more for the whole node while transmitting, depending on the board
- **Sleep mode:** in deep sleep a node draws a fraction of a milliamp - weeks to months on a small LiPo - though mesh nodes are rarely fully asleep, since they must keep listening to relay
- **Typical client node:** 1 - 3 days on a 3000 mAh battery with moderate messaging activity

- **E-ink display devices** (T-Echo, Wireless Paper): 7 - 14 days on a charge

Repeater nodes that must always be listening should be placed on continuous power (solar or mains) for reliable operation.

Data Rate

LoRa is designed for low data rate, low power communication - not for streaming or large file transfers. Depending on settings:

- Data rate ranges from approximately 0.3 kbps (slowest, longest range) to about 22 kbps (fastest LoRa preset, such as ShortTurbo, shortest range)
- Typical mesh presets are optimized for the 1 - 5 kbps range, balancing range and throughput for text messaging
- Each LoRa packet payload is limited to 255 bytes maximum

This makes LoRa mesh ideal for text messages, GPS coordinates, and short sensor readings - and unsuitable for voice, images, or video.

LoRa vs LoRaWAN: What's the Difference?

This is one of the most common points of confusion for newcomers. LoRa and LoRaWAN are related but completely different things. MeshCore and Meshtastic use **LoRa** - not LoRaWAN. Understanding the distinction helps explain why mesh networking is fundamentally different from IoT sensor networks.

LoRa: The Physical Radio Layer

LoRa refers specifically to Semtech's Chirp Spread Spectrum modulation technology. It defines *how bits are encoded onto radio waves*. Any software protocol can use LoRa as its radio layer - LoRaWAN uses it, and so do MeshCore and Meshtastic.

Think of LoRa as the engine. Multiple different vehicles can use the same engine.

LoRaWAN: A Centralized IoT Network Protocol

LoRaWAN is a specific network architecture built on top of LoRa, designed by the LoRa Alliance for IoT (Internet of Things) deployments:

- **Topology:** Star - devices talk to gateways; no peer-to-peer relaying (an optional single-hop Relay extension exists but is rarely deployed)
- **Infrastructure required:** Gateways and backend servers (The Things Network, Chirpstack, etc.)
- **Internet dependency:** Gateways connect to the internet to reach the network server
- **Use cases:** Smart meters, asset tracking, environmental sensors, industrial monitoring
- **Encryption:** AES-128 with separate network and application session keys, managed via the network/join server
- **Messaging:** Sensors send data to servers - not person-to-person communication

If there is no gateway in range, a LoRaWAN device cannot communicate at all. It cannot mesh - at most an optional single-hop Relay extension exists, which is rarely deployed.

LoRa Mesh (MeshCore & Meshtastic): Decentralized Peer-to-Peer

MeshCore and Meshtastic use LoRa radio but implement their own peer-to-peer mesh networking protocols on top of it:

- **Topology:** Mesh - every node can relay for other nodes
- **Infrastructure required:** None - no gateways, no servers, no internet
- **Works completely off-grid:** Yes, by design
- **Use cases:** Off-grid messaging, emergency communications, outdoor recreation, community networks
- **Encryption:** Group channels use pre-shared keys (Meshtastic); direct messages use per-node public-key encryption (Meshtastic v2.5+, MeshCore)
- **Messaging:** Person-to-person text messages, group channels, GPS position sharing

Side-by-Side Comparison

Feature	LoRaWAN	LoRa Mesh (MeshCore/Meshtastic)
Network topology	Star (hub-and-spoke)	Mesh (peer-to-peer)
Requires internet	Yes (at gateway)	No
Requires servers	Yes	No
Works off-grid	No	Yes
Node-to-node relay	No (an optional single-hop Relay extension exists, rarely deployed)	Yes
Primary use case	IoT sensors	Off-grid communication
Message type	Sensor data to server	Person-to-person text/GPS
Managed by	LoRa Alliance	Open-source communities
License required?	No (ISM band)	No (ISM band)

What This Wiki Covers

This wiki covers **LoRa mesh networking** using MeshCore and Meshtastic. LoRaWAN is a separate topic entirely and is not covered here. If you are reading about "The Things Network," "Chirpstack," or "LoRa gateways," you are reading about LoRaWAN - a different technology from what this wiki describes.

When someone says they have a "LoRa device" that works with MeshCore or Meshtastic, they mean a device that uses LoRa radio with peer-to-peer mesh firmware - not a LoRaWAN end node.

LoRa Range: Realistic Expectations

Range is the most common question new users have, and the most complex to answer accurately. LoRa range depends on antenna height, terrain, preset configuration, and environmental conditions. Here's how to set realistic expectations for your deployment.

The Honest Range Summary

The figures below are community-reported estimates, not measured specifications. Real-world range varies widely with antenna height, terrain, preset, and line of sight, and the longer brackets assume clear line of sight between elevated antennas. Treat them as rough planning aids and confirm with an on-site range test.

Environment	Typical Range (stock antenna)	Typical Range (good external antenna)
Open flat terrain, low antennas	2-5 km	8-20 km
Suburban (houses, trees)	0.5-2 km	2-6 km
Dense urban (buildings)	200m - 1 km	1-3 km
One node elevated (hilltop/tower), line of sight	5-15 km	15-50 km
Both nodes elevated (mountain ridge), clear line of sight	20-80 km	50-200+ km

The largest factor in real-world range is antenna elevation. Raising an antenna from ground level to 30 feet (10m) often improves range dramatically - largely by clearing local rooftops, trees, and other clutter so more of the path has line of sight. Getting up to 100 feet (30m) can extend useful range much further still. The exact gain depends entirely on the surrounding terrain and the height of the far end, so treat any multiplier as a rough rule of thumb rather than a fixed figure. This is why community networks invest in hilltop and water tower installations.

Modem Preset vs. Range

Meshtastic's modem presets trade speed for range. Slower presets = longer range (throughput figures below are from the official Meshtastic radio-settings table):

Preset	Relative Range	Message Throughput	Best For
ShortTurbo	Shortest	~21 kbps	Dense urban, close range
ShortFast	Short	~10 kbps	Indoor/urban
MediumFast	Medium	~3.5 kbps	Suburban networks
LongFast	Long (default)	~1.1 kbps	Community networks (best balance)
LongModerate	Very long	~0.34 kbps	Rural sparse networks
LongSlow (deprecated)	Very long	~0.18 kbps	Deprecated - prefer Long Moderate for sparse rural meshes
VeryLongSlow (not recommended)	Maximum (in theory)	very low	The Meshtastic project recommends against this preset - it does not form meshes well and is unreliable; avoid it

Range Factors You Can Control

- **Antenna height:** The single biggest lever. Even a few extra meters of height can improve range substantially by clearing local obstructions; the exact improvement depends on the surrounding terrain.
- **Antenna quality:** A quality external fiberglass antenna can add several dB over the stock rubber-duck whip - often the single cheapest range upgrade. (Stock whips are typically ~0-2 dBi and consumer fiberglass antennas ~3-8 dBi; be skeptical of inflated gain claims from sellers. A decent external antenna ran about \$30 as of 2026-06-07.)
- **Modem preset:** Switching from LongFast to a slower long-range preset can extend range at the cost of message throughput.
- **TX power:** In the US the legal limit is 1 W (30 dBm) conducted with up to 6 dBi antenna gain. Meshtastic already defaults to the maximum power your hardware and region allow (`tx_power 0` means "use default max"), so for range you should simply leave it at the default - the setting exists mainly to *reduce* power. Manually setting 30 usually does *not* extend range vs. the default, and most boards (e.g. SX1262-based) top out around +22 dBm regardless.

Range Factors You Can't Control

- **Terrain:** Hills, buildings, and forests attenuate signal significantly. Even a single building in the path can cut range drastically - sometimes by half or more, sometimes blocking the link entirely - depending on the construction and geometry.
- **Weather:** Rain has negligible direct effect at 915 MHz (well under 1 dB even in heavy rain - meaningful rain attenuation only begins above roughly 5-10 GHz). The real wet-weather losses come from wet foliage and water sitting on antennas and connectors, not the rain in the path itself.
- **Interference:** Other 900 MHz ISM devices sharing the band can raise the noise floor and reduce effective range.
- **Multipath fading:** In urban environments, reflections from buildings create constructive and destructive interference that causes range to vary significantly over short distances.