

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.

Revision #3

Created 2026-05-03 03:02:13 UTC by Mesh America Admin

Updated 2026-06-08 19:54:40 UTC by Mesh America Admin