

Meshtastic

An open source, off-grid, decentralized, mesh network built to
run on affordable, low-power devices

or

a license-free¹, open-source², encrypted³, off-grid , radio mesh
network on top of LoRa

Herb Lange

Updated on October 18th, 2025

Introduction

/^ESHT^ST/C

An open source, off-grid, decentralized, mesh network built to run on affordable, low-power devices

[Learn More](#)[Get Started](#)[Donate](#)

`https://meshtastic.org/`

Open-source



Free as in Freedom

By Free Software Foundation - gnu.org/graphics/license-logos.html, Public Domain,
<https://commons.wikimedia.org/w/index.php?curid=5393454>

Off-grid

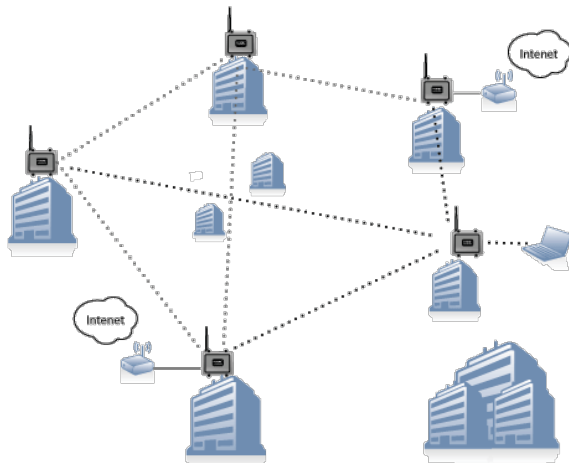


Here:

- ▶ low-energy, battery-powered $\Rightarrow$ does not require electricity grid
- ▶ decentralized mesh $\Rightarrow$ does not require internet or mobile network

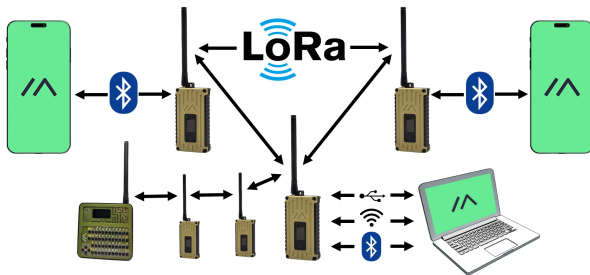
By File:Our Hut - Flickr - brewbooks.jpg: brewbooks from near Seattle, USA
derivative work: Georgfotoart - This file was derived from: Our Hut - Flickr - brewbooks.jpg:,
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Decentralized, Mesh Network



https://freifunk-ansbach.de/wp-content/uploads/2014/10/Mesh_network-e1403251545250.png

Decentralized, Mesh Network



<https://meshtastic.org/docs/introduction/>

Affordable

	Mfr. Part No. SX1262IMLTRT *****	Semtech *****	RF Transceiver LoRa, sub-GHz RF Transceiver 22dBm PA Learn More *****	Datasheet *****	1.609 In Stock	Cut Tape
	Mouser Part No 947-SX1262IMLTRT				3.000 Expected 02/16/2026	1 6,11 € **
						10 5,62 € ****
						25 5,06 € ****
						100 4,77 € *****
						250 View *****
						Reel
						3.000 4,02 € *****
						MouseReel Available *****

<https://www.mouser.se/c/?q=sx1262&sort=pricing>

Low-power

Compare

- ▶ QRP, up to 5W (or 10W SSB) e.g. CW, FT8, WSPR (33dBm, 2W)
- ▶ Wi-Fi, 20-23dBm (100-200mW)
- ▶ Bluetooth, -20 dBm-+20 dBm (0.01 mW-100 mW).
- ▶ Meshtastic/Lora, 22dBm (150mW)

License-free

ARTICLE 18

Licences

18.1 §1

1) No transmitting station may be established or operated by a private person or by any enterprise without a licence issued in an appropriate form and in conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station in question is subject (however, see Nos. 18.2, 18.8 and 18.11).

ITU Radio Regulations 1 Articles Edition of 2024

BUNDESREPUBLIK DEUTSCHLAND



ZULASSUNG ZUR TEILNAHME
AM AMATEURFUNKDIENST

DOCUMENT FOR ADMISSION TO PARTICIPATION
IN THE AMATEUR RADIO SERVICE

DOCUMENT D'ADMISSION À LA PARTICIPATION
AU SERVICE DE RADIOAMATEUR

Diese Zulassung ist unbefristet gültig und berechtigt den Inhaber, Amateurfunkstellen auch in denjenigen Ländern, welche die ECC-Empfehlung (05/06) anwenden, unter den in der Empfehlung genannten Bedingungen und Auflagen zu benutzen.

This admission document is valid for an unlimited period of time and authorises its holder to use amateur stations also in those countries where ECC Recommendation (05/06) is applied, under the conditions and obligations specified in this Recommendation.

Ce document d'admission est valable pour une durée indéterminée et autorise le titulaire à utiliser des stations d'amateur également dans les pays qui appliquent la Recommandation ECC (05/06), conformément aux conditions et obligations figurant dans celle-ci.

BN 10.05/9 7 6 5 4 3 2 1

2×A6-620xy

Bundesnetzagentur F 3.065

Der Inhaber / The holder / Le titulaire

Vor- und Zuname / First name and surname / Prénom et nom

Geburtsdatum / Date of birth /
Date de naissance

Staatsangehörigkeit / Nationality /
Nationalité

deutsch

Straße Nr. / Street No. / Rue N°

PLZ Wohnort / Place of residence / Domicile

wird hiermit gemäß § 3 Abs. 1 des Gesetzes über den Amateurfunk vom 23. Juni 1967 (BGBl. I S. 1494) i.V.m. der Verordnung zum Gesetz über den Amateurfunk (AFuV) vom 15. Februar 2005 (BGBl. I S. 242) unter gleichzeitiger Zuteilung eines Rufzeichens zur Teilnahme am Amateurfunkdienst zugelassen.

is hereby admitted to, and at the same time assigned a call sign for, participation in the amateur service pursuant to section 3(1) of the Amateur Radio Act of 23 June 1967 (Federal Law Gazette Part I page 1494) in conjunction with the Ordinance concerning the Amateur Radio Act (AFuV) of 15 February 2005 (Federal Law Gazette Part I page 242).

est admise à participer au service d'amateur en vertu de l'article 3, paragraphe 1, de la Loi sur les radiocommunications d'amateur en date du 23 juin 1967 (Journal officiel de la République fédérale d'Allemagne, partie I, p. 1494), en liaison avec le Décret relatif à la loi sur les radiocommunications d'amateur en date du 15 février 2005 (Journal officiel de la République fédérale d'Allemagne, partie I, p. 242), un indicatif d'appel lui étant parallèlement assigné.

Rufzeichen / Call sign /
indicateur d'appel

DX

Nationale Zeugnisnummer /
National class / Classe nationale

K

Zuteilungsnummer / Assignment number /
Numéro d'attribution

Standort für eine ortsfeste Amateurfunkstelle / Location of a fixed amateur radio station / Emplacement pour une station fixe de radioamateur

Behörde/Autorität/Autorité
Bundesnetzagentur
Außenstelle Eschborn

Datum / Date
06.09.2007

Im Auftrag



MUSTER

Raum für weitere amtliche Eintragungen / Space for additional official entries / Espace pour d'autres inscriptions officielles
Widerrufsvorbehalt: Diese Zulassung kann widerrufen werden, wenn der Zulassungsinhaber die fälligen Beiträge gemäß der einschlägigen Rechtsverordnungen nicht entrichtet.



MUSTER

https://www.hamspirit.de/wp-content/uploads/2016/03/Zulassung_zur_Teilnahme_am_Amateurfunkdienst_Klasse_K.jpg

License-free



Tellyaddict at

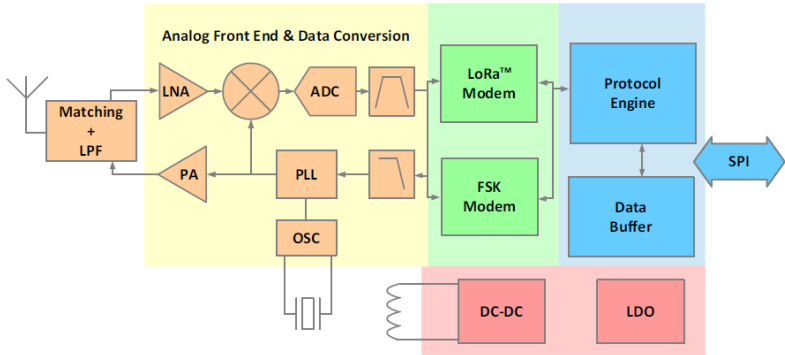
https://simple.wikipedia.org/wiki/File:Wikipedia_images_011.jpg

Background

OSI Layer Model

Layer		Protocol data unit (PDU)	Function ^[26]
Host layers	7 Application	Data	High-level protocols such as for resource sharing or remote file access, e.g. HTTP .
	6 Presentation		Translation of data between a networking service and an application; including character encoding , data compression and encryption/decryption
	5 Session		Managing communication sessions , i.e., continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes
	4 Transport	Segment	Reliable transmission of data segments between points on a network, including segmentation , acknowledgement and multiplexing
Media layers	3 Network	Packet, Datagram ^[27]	Structuring and managing a multi-node network, including addressing , routing and traffic control
	2 Data link	Frame	Transmission of data frames between two nodes connected by a physical layer
	1 Physical	Bit, Symbol	Transmission and reception of raw bit streams over a physical medium

LoRa



https://www.semtech.com/uploads/products/SX126x_Block_Diagram_1.PNG

Decibel (dB), dBm and dBi

dB relative unit of measurement, expresses the ratio of two values of a power or root-power quantity on a logarithmic scale

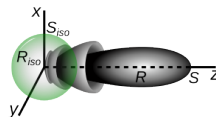
dBm unit of power level expressed using a logarithmic decibel (dB) scale respective to one milliwatt (mW)

dBd compares the received power to the power received by a lossless half-wave dipole antenna

dBi expressed with respect to an isotropic radiator
 $Gain(dBd) = Gain(dBi) - 2.15 \rightarrow$ a lossless dipole antenna has a gain of 2.15 dBi

Rule of thumb: $+3dB \approx$ double the amount

Antenna Gain

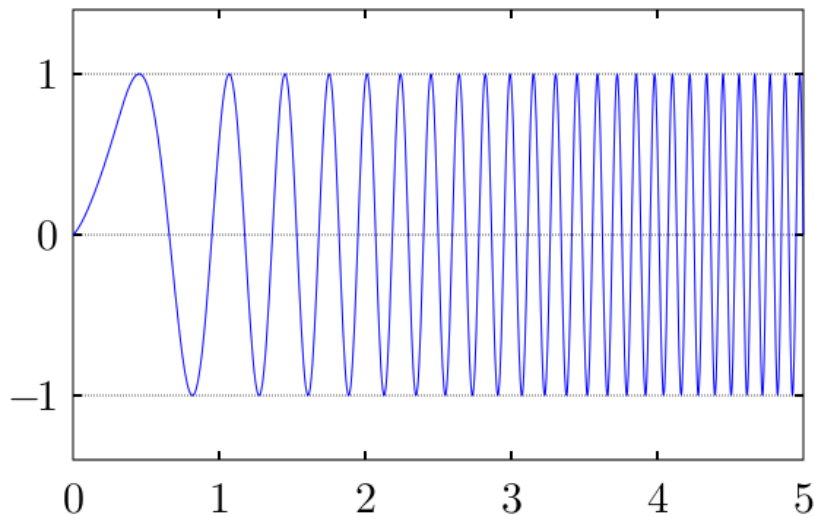


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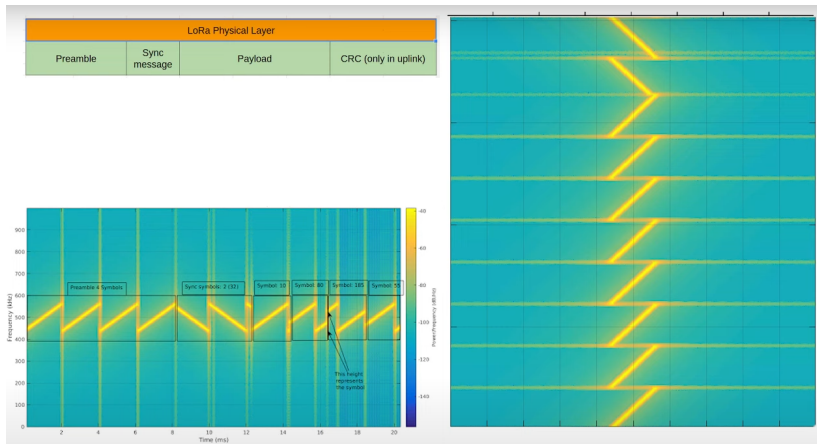
Chirp Spread Spectrum



By Georg-Johann - Own work, CC BY-SA 3.0,

<https://commons.wikimedia.org/w/index.php?curid=11330709>

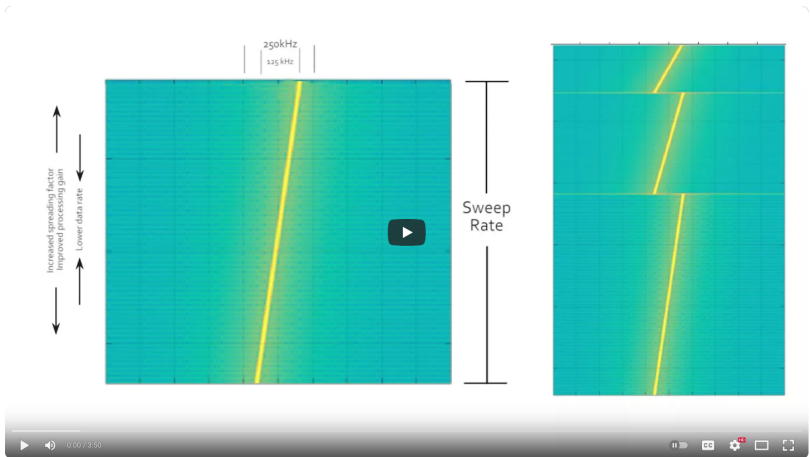
Chirp Spread Spectrum



<https://hamradio.my/2025/03/>

[lora-and-chirp-spread-spectrum-css-modulation-how-it-works/](#)

Chirp Spread Spectrum



LoRa CHIRP



Richard Wenner
15.2K subscribers

Subscribe

2.3K



Share

Clip



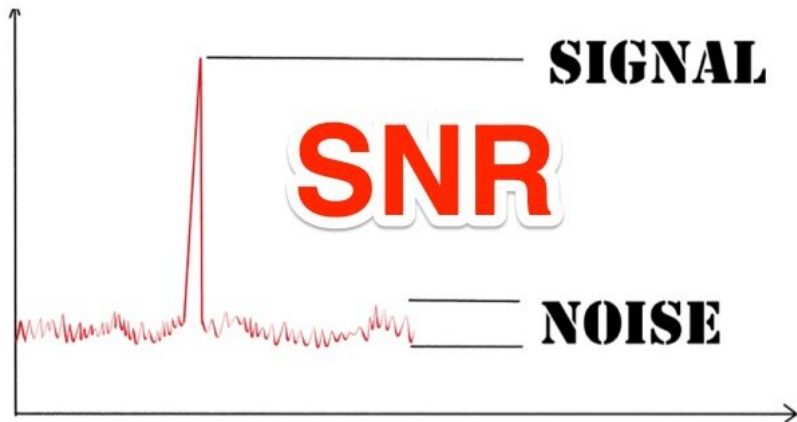
<https://www.youtube.com/watch?v=dxYY097QNs0>

<https://www.sigidwiki.com/wiki/LoRa>

Spread Factor (SF)

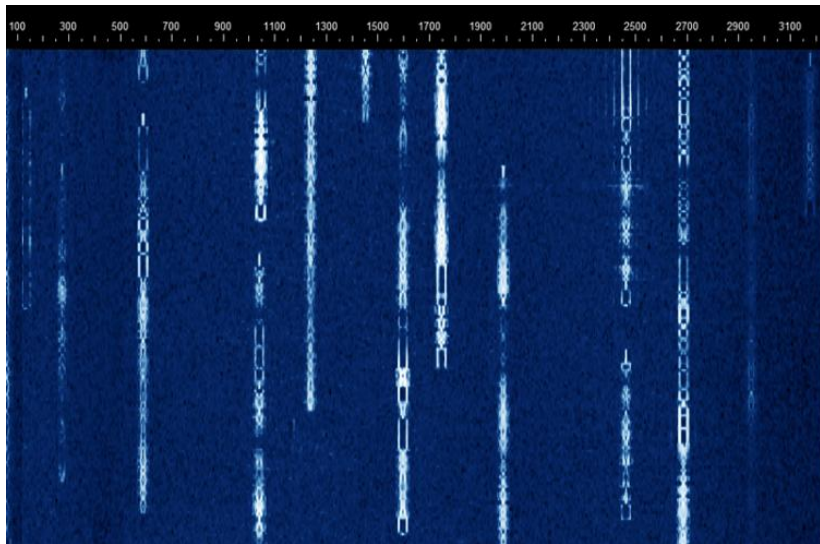
- ▶ SF determines the length of the chirp and the amount of spreading applied to the signal
- ▶ each chirp corresponds to a different symbol (chip)
- ▶ the number of possible symbols (chips) depends on SF
- ▶ Meshtastic supports SF7 to SF12, where higher SF values provide better sensitivity but lower data rates
- ▶ $DataRate = (SF \times Bandwidth) / 2^{SF}$

Signal-to-Noise Ratio



<https://www.k0nr.com/wordpress/wp-content/uploads/2025/03/signal-to-noise-ratio-snr-e1742580379678.jpg>

Signal-to-Noise Ratio



<https://www.arrl.org/news/10-tips-for-the-psk31-digital-mode>

Signal-to-Noise Ratio

$$SNR_{dB} = P_{signal,dB} - P_{noise,dB} = 10 * \log_{10}\left(\frac{P_{signal}}{P_{noise}}\right)$$

	PA3FWM	N6MW	KB9II	KF6HI	KØLB-KK4SNO	Aggregated (KØNR)
SSB	10	10	6	6	10	6
RTTY	-5		-9	-9		-9
PSK31	-10		-12	-9		-9
CW	-12	-12	-15	-5	-15	-12
FT4		-17.4				-17
FT8		-20.8		-20	-21	-21
JT65	-24			-24	-25	-24
WSPR	-27			-32	-31	-28

<https://www.k0nr.com/wordpress/wp-content/uploads/2025/03/SNR-Table.png>

Signal-to-Noise Ratio

Table 6-1: Range of Spreading Factors (SF)

Spreading Factor (SF) ¹	5	6	7	8	9	10	11	12
2^{SF} (Chips / Symbol)	32	64	128	256	512	1024	2048	4096
Typical LoRa Demodulator SNR [dB]	-2.5	-5	-7.5	-10	-12.5	-15	-17.5	-20

SX1262 datasheet [https:](https://www.semtech.com/products/wireless-rf/lora-connect/sx1262#resources)

[//www.semtech.com/products/wireless-rf/lora-connect/sx1262#resources](https://www.semtech.com/products/wireless-rf/lora-connect/sx1262#resources)

Link Budget

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX}$$

with

P_{RX} received power (dBm)

P_{TX} transmitted power (dBm)

G_{TX} transmitter antenna gain (dBi)

L_{TX} transmitter losses (coax, connectors...) (dB)

L_{FS} path loss (dB)

L_M miscellaneous losses (fading margin, body loss, polarization mismatch, other losses, ...) (dB)

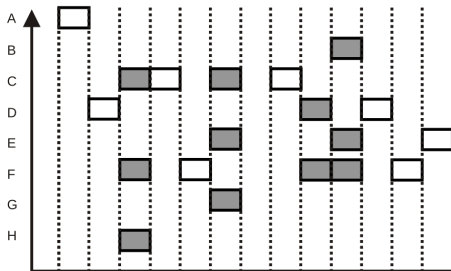
G_{RX} receiver antenna gain (dBi)

L_{RX} receiver losses (coax, connectors, ...) (dB)

https://en.wikipedia.org/wiki/Link_budget#In_radio_systems

ALOHA

- ▶ pioneering computer networking system developed at the University of
- ▶ became operational in June 1971
- ▶ first public demonstration of a wireless packet data network

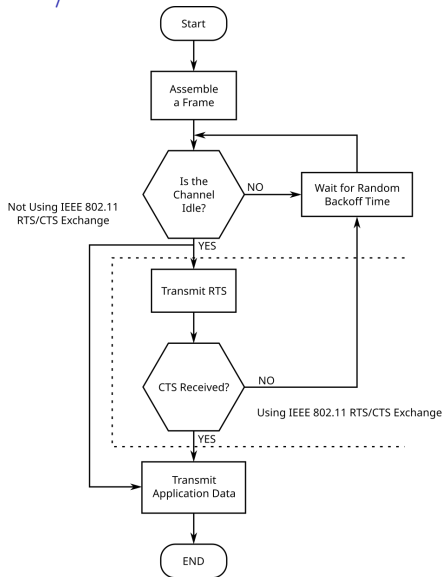


Slotted ALOHA protocol (shaded slots indicate collision)

By helix84 - Own work, CC BY 2.5,

<https://commons.wikimedia.org/w/index.php?curid=1374526>

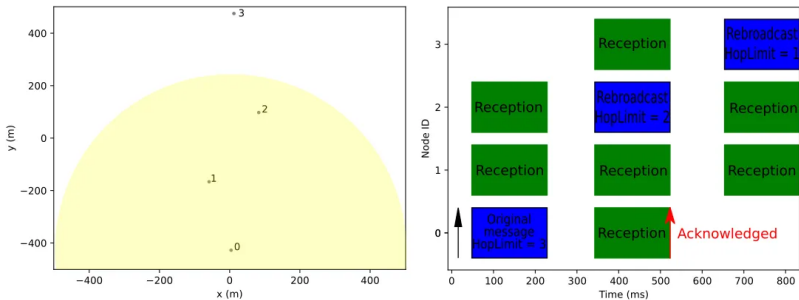
CSMA/CA



By jjgarcia.tsc - File:Csmaca_algorithm.png, Attribution,

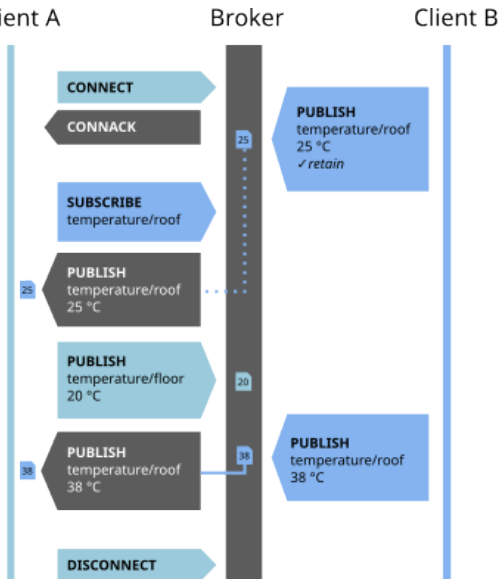
<https://commons.wikimedia.org/w/index.php?curid=12661157>

Managed Flooding



<https://meshtastic.org/docs/overview/mesh-algo/>

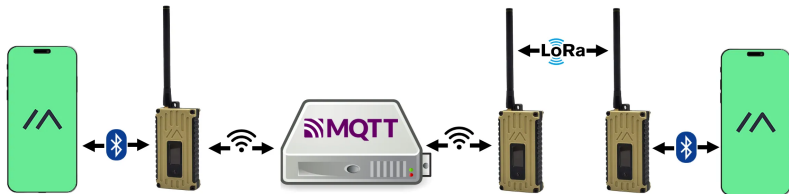
MQTT



By Simon A. Eugster - Own work, CC BY-SA 4.0,

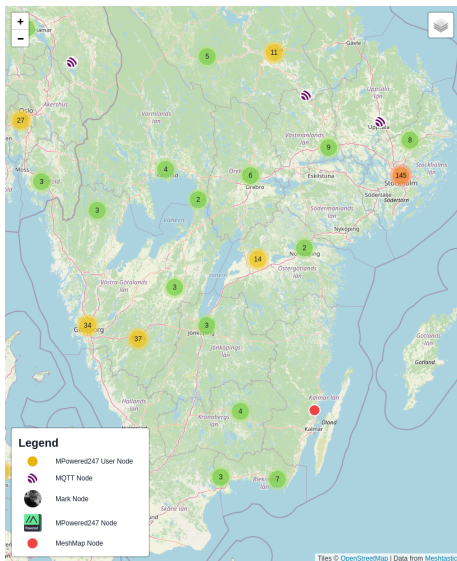
<https://commons.wikimedia.org/w/index.php?curid=70622928>

MQTT



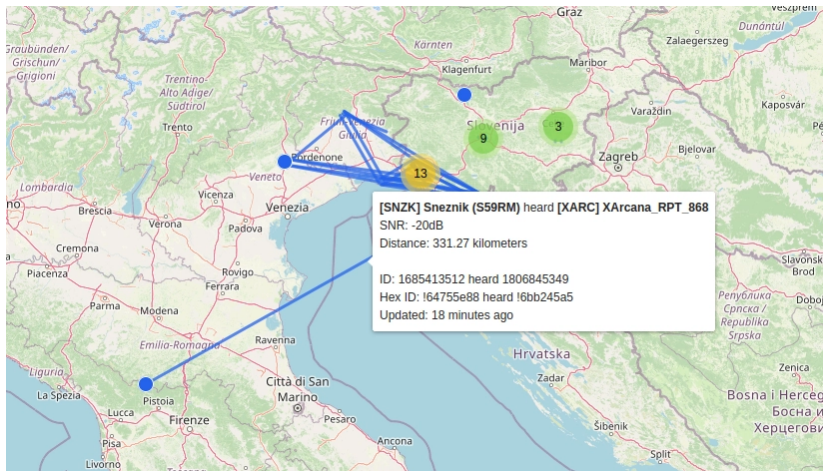
<https://meshtastic.org/docs/software/integrations/mqtt/>

Mesh Maps



- ▶ <https://meshmap.net/>
uses the official MQTT server
- ▶ <https://meshtastic.liamcottle.net/>
has its own MQTT server
- ▶ <https://meshtastic-map.friendlydev.com/>
merges several sources

Range Record



Default Very Long Slow. Frequency: 868MHz, Bandwidth: 62.5,
Spread Factor: 12, Coding Rate: 4/8

<https://meshtastic.org/docs/overview/range-tests/>

Own Experience

First Contact



First Setup

0. Attach antenna
1. Download app
2. Power on device
3. Connect via Bluetooth
4. Setup, or curse if Bluetooth fails

Radio Settings

Region

Sets the region for your node. Default is `unset`. As long as this is not set, the node screen will display message and not transmit any packets.

Region Code	Description	Frequency Range (MHz)	Duty Cycle (%)	Power Limit (dBm)
<code>UNSET</code>	Unset	N/A	N/A	N/A
<code>US</code>	United States	902.0 - 928.0	100	30
<code>EU_433</code>	European Union 433MHz	433.0 - 434.0	10	12
<code>EU_868</code>	European Union 868MHz	869.4 - 869.65	10	27

<https://meshtastic.org/docs/configuration/radio/lora/>

Radio Settings

Radio Preset	Alt Preset Name	Data-Rate	SF / Symbols	Coding Rate	Bandwidth	Link Budget
Short Range / Turbo	Short Turbo	21.88 kbps	7 / 128	4/5	500 kHz ¹	140dB
Short Range / Fast	Short Fast	10.94 kbps	7 / 128	4/5	250 kHz	143dB
Short Range / Slow	Short Slow	6.25 kbps	8 / 256	4/5	250 kHz	145.5dB
Medium Range / Fast	Medium Fast	3.52 kbps	9 / 512	4/5	250 kHz	148dB
Medium Range / Slow	Medium Slow	1.95 kbps	10 / 1024	4/5	250 kHz	150.5dB
Long Range / Fast	Long Fast	1.07 kbps	11 / 2048	4/5	250 kHz	153dB
Long Range / Moderate	Long Moderate	0.34 kbps	11 / 2048	4/8	125 kHz	156dB
Long Range / Slow	Long Slow	0.18 kbps	12 / 4096	4/8	125 kHz	158.5dB

<https://meshtastic.org/docs/overview/radio-settings/>

Radio Settings

Roles

Device Role	Description	Best Uses
CLIENT	App connected or stand alone messaging device. Rebroadcasts packets when no other node has done so.	General use for individuals needing to communicate over the Meshtastic network with support for client applications.
CLIENT_MUTE	Device that does not forward packets from other devices.	Situations where a device needs to participate in the network without assisting in packet routing, reducing network load.
CLIENT_HIDDEN	Device that only broadcasts as needed for stealth or power savings.	Use in stealth/hidden deployments or to reduce airtime/power consumption while still participating in the network.
REPEATER	Infrastructure node for extending network coverage by always rebroadcasting packets once with minimal overhead. Not visible in Nodes list.	Best positioned in strategic locations to maximize the network's overall coverage. Device is not shown in topology.
ROUTER	Infrastructure node for extending network coverage by always rebroadcasting packets once. Visible in Nodes list.	Best positioned in strategic locations to maximize the network's overall coverage. Device is shown in topology.

Radio Settings

Role Comparison

This table shows the **default** values after selecting a preset. As always, individual settings can be adjusted after choosing a preset.

Device Role	BLE/WiFi/ Serial	Screen Enabled	Power Consumption	Retransmit	Prioritized Routing	Visible in Nodes List
CLIENT	Yes	Yes	Regular	Yes	No	Yes
CLIENT_MUTE	Yes	Yes	Lowest	No	No	Yes
CLIENT_HIDDEN	Yes	Yes	Lowest	Local Only	No	No
CLIENT_BASE	Yes	Yes	Regular	Yes	Favorites Only ¹	Yes

ROUTER	No ³	No	High	Yes	Yes	Yes
--------	-----------------	----	------	-----	-----	-----

<https://meshtastic.org/docs/configuration/radio/device/>

Going Further



Lilygo T3-S3 epaper



Lilygo T-Deck

Summary

- ▶ It's easy to lock yourself out
- ▶ Bluetooth can be problematic
- ▶ It really isn't fast
- ▶ There are too few nodes for a proper mesh in my area
- ▶ But: It's a nice rabbit hole and great for first radio experiments

Summary

- ▶ It's easy to lock yourself out
- ▶ Bluetooth can be problematic
- ▶ It really isn't fast
- ▶ There are too few nodes for a proper mesh in my area
- ▶ But: It's a nice rabbit hole and great for first radio experiments

RTFM!?!

Controversies

Proprietary Technology

- ▶ The code is F/OSS but the technology is proprietary (compare e.f. DMR)
- ▶ Semtech controls the supply and/or gets license fees for every LoRa chip

Security and Privacy Issues



nullagent
@nullagent

🌐 Aug 10_*

Which brings me to part two, MeshMarauder.

An open source tool demonstrating proof-of-concept exploits against the DEFCON 33 Meshtastic firmware.

MeshMarauder will demonstrate:

- Tracking user activity on any mesh regardless of encryption usage
- Hijack all meshtastic user profile metadata
- Change any users public key
- Send messages as any user in channel chats that appear authentic
- MITM direct messages

meshmarauder.net



#defcon

#meshtastic

#meshmarauder

...and 1 more



1



<https://partyon.xyz/@nullagent/115005279479795061>

Telemetry and GDPR Non-Compliance



Jouni OH3CUF

@OH3CUF@mastodon.radio

Oct 6

Meshtastic iOS app breaks EU law with sending lots of telemetry (logs, usage) to DataDog in US without user consent and without any kind of notification of the app doing so.

I reported this as issue and it got immediately closed without any explanation:

[github.com/meshtastic/Meshtastic...](https://github.com/meshtastic/Meshtastic-Apple/issues/1449)

meshtastic/Meshtastic-Apple

#1449  **[Bug]: DataDog telemetry collection lacks GDPR...**



9 comments

 j0uni opened on October 6, 2025



GitHub

 **[Bug]: DataDog telemetry collection lacks GDPR-compliant consent mechanism at app startup · Issue #1449 · ...**

By j0uni

#meshtastic

#gdpr

#datadog

20

212

145

...

<https://mastodon.radio/@OH3CUF/115326190113198755>

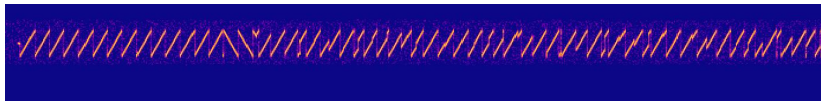
Telemetry and GDPR Non-Compliance



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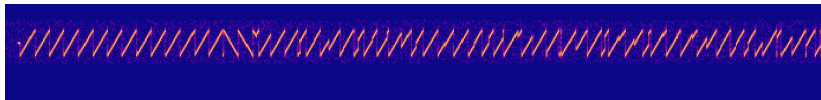
<https://github.com/meshtastic/Meshtastic-Apple/issues/1449>

Enjoy the Spectrum



Some more info

- ▶ <https://hackaday.com/2020/01/28/rf-modulation-crash-course-for-hackers/>
- ▶ <https://magazine.raspberrypi.com/hackspace/issues/80>



<https://www.sigidwiki.com/wiki/LoRa>