FREE BUILD GUIDE

Hear a satellite from your balcony

Build a TinyGS ground station from about $20 in parts and log real packets from CubeSats in orbit.

- Parts list with sellers' prices
- Build and setup, field by field
- Three antenna options, including a DIY ground plane
- Your first packet, troubleshooting and next projects

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TinyGS satellite ground station build guide

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What you build

You build a receiving station that hears small satellites as they pass over your house, from about $20 in parts. A Heltec WiFi LoRa 32 V3 board listens on 433 MHz, a better antenna replaces the small one in the box, and the open TinyGS network collects what you hear and puts your station on a world map beside every other volunteer receiver.

The board does one job. When a CubeSat or a pico satellite flies within range, its LoRa beacon reaches your antenna, the board decodes the packet, and TinyGS logs it with your station's name. The radio only listens. Transmit stays off unless you hold an amateur license.

This station belongs on theconsciousness.ai because the project's aerospace pillar asks what it takes to run computation and sensing in orbit, the kind of hardware a machine that perceives its surroundings would one day carry. Before anyone flies a payload, they need to hear one. This station is a cheap way to receive real telemetry from real spacecraft, and a first step toward listening to a satellite of your own.

Budget one evening for the build and setup, then let it run while satellites come over.

> **How this guide was made.** Every step comes from the official TinyGS documentation and the tutorials listed at the end, written in our own words, with every source credited. We have not built this exact station ourselves. The guide is free, and every link in it is a plain link that earns nothing.

Parts list

The minimum station is the board plus a USB C cable, about $20 before shipping. The recommended station adds an outdoor 433 MHz antenna. Prices below were read on the sellers' pages on November 12, 2026. Prices change, so check them before you buy.

Part	Price	Where to buy	Needed?
Heltec WiFi LoRa 32 V3, **433 MHz band**	$17.90 to $19.90 plus shipping	Heltec's own store (plain link)	Yes
Same board, EU seller (listing includes an IPEX to SMA pigtail)	€39.90, in stock by backorder	Pileup Communications, Sweden (plain link)	Alternative for Europe
Same board, EU seller (listing includes an IPEX to SMA pigtail)	€22.75, out of stock (2 to 4 weeks)	TinyTronics, Netherlands (plain link)	Alternative for Europe

Part	Price	Where to buy	Needed?
IPEX (U.FL) to SMA female pigtail	a few dollars	Any electronics seller	Needed for an outdoor antenna if your box has none
USB C data cable	a few dollars, or one you own	Any	Yes (not in the box)
HYS 433 MHz omni antenna	check the listing	Linked from the TinyGS parts list (plain link)	Recommended
DIY quarter wave ground plane (1 m of 12 or 14 AWG copper wire, SO239 panel connector with PTFE insulation, four M3 bolts)	a few dollars in parts	Hardware store	Alternative to the HYS antenna
SMA to UHF (PL259) adapter cable, only for the DIY antenna or a Diamond X30A	check the listing	Linked from the TinyGS parts list (plain link)	Only with a UHF antenna

Heltec's own listing names the board, a LoRa antenna, a battery connector and two pin headers. It names no pigtail, while the two European sellers above list one. Check what your box holds before you plan the outdoor antenna.

Buy the 433 MHz version of the board, and confirm the listing you buy from says 433 MHz, because Heltec's own page is not consistent about the band options. TinyGS says more than 90% of active LoRa satellites on its network use the 437 and 400 MHz bands, and a board matched to 868 or 915 MHz will run the firmware but hear little from orbit. Source

TinyGS names the Heltec V3 as its recommended board, ahead of LilyGO boards, because its radio has a temperature compensated crystal (TCXO) that holds frequency. Its April 2026 newsletter says LilyGO T3 boards can have frequency stability issues, and reports one member whose daily packet count rose from about 400 to about 700 after swapping a LilyGO T3 v1.6 for a Heltec board on the same antenna. Newsletter

Heltec has since released a V4 board. We found no TinyGS note confirming V4 support as of November 12, 2026, so this guide sticks with the V3.

Tools

The board build needs no soldering. The pin headers in the box stay in the bag.

- A computer running Linux, Windows or macOS with Google Chrome or Microsoft Edge (the TinyGS web installer needs one of these browsers)
- A USB C cable that carries data, since many charging cables do not
- A phone or laptop with WiFi, to reach the station's setup page
- Your station's latitude and longitude (any map app shows them)

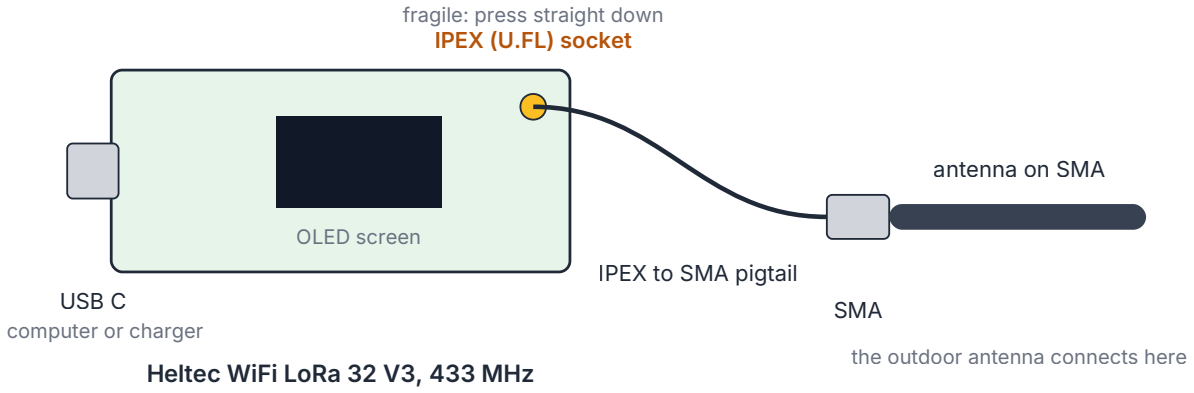
- Soldering iron and solder, wire cutters, pliers, a ruler, epoxy or hot glue, and self amalgamating or mastic tape for the outdoor joint (DIY antenna only)
- A NanoVNA to trim the DIY antenna to frequency (optional)

Build the station

The board's LoRa antenna socket is a tiny IPEX (U.FL) snap connector, and it is the one fragile part of the build.

1. Check the box against the listing. Confirm the label or listing says 433 MHz before you go further.
2. For a first test, connect the small LoRa antenna from the box to the board's LoRa socket. Line the IPEX connector up square and press straight down with a fingertip until it clicks. Never pull it off by the cable; lift it with a fingernail under the connector.
3. For an outdoor antenna, snap an IPEX to SMA pigtail onto the same socket instead, and screw the antenna's cable onto the pigtail's SMA end.
4. Fix the pigtail so it cannot tug on the socket. A dab of hot glue or a cable tie to a small board or case does it.
5. Plug the USB C cable into the board and your computer. The small OLED screen may stay blank until the firmware is on.
6. Keep the board indoors; only the antenna and its coax go outside.

Once setup is done, the station runs from USB power around the clock.



The board, an IPEX to SMA pigtail and the antenna connection

Flash TinyGS and set up the station

Three pieces have to line up, a TinyGS account, firmware on the board and the station's settings. Do them in that order.

1. Get a TinyGS account and your station credentials

Since TinyGS's Christmas 2025 release, it accepts sign ups by email invite, with no Telegram needed. Ask an active member for an invite, or (schools and workshops) write to the address on the join tutorial. The Telegram route still works. Join the TinyGS group, open a private chat with @tinygs_personal_bot, and send `/mqtt` for the MQTT user and password your station needs. Send `/weblogin` to the same bot for a login link to the web console.

2. Flash the firmware

1. Open installer.tinygs.com in Chrome or Edge with the board plugged in.
2. Click install and pick the board's serial port when the browser asks. The installer reads the chip and chooses the matching firmware.
3. Wait for it to finish and the board to restart.

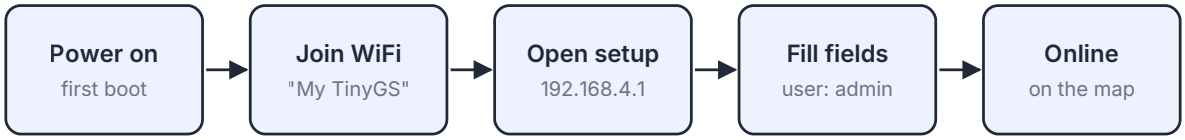
TinyGS calls the installer experimental. If it fails, the fallback is PlatformIO, covered on the TinyGS wiki.

3. Configure the station

On first boot the board opens a WiFi network named "My TinyGS". Join it from your phone or laptop; the setup page should open by itself, and if it does not, browse to 192.168.4.1. The user name is always admin.

Field	What to enter
Groundstation name	A unique name; it shows on the world map
Groundstation password	Your own password for this panel; write it down
SSID and password	Your home WiFi
Time zone	Yours
Latitude and longitude	Your station's position
MQTT server and port	Leave the defaults
MQTT user and pass	The pair from your account or the bot
Board type	Usually detected; set Heltec V3 by hand only if the radio does not start
OLED bright	Below 100, to make the screen last
Enable TX	Leave off unless you hold an amateur license
Automatic tuning	On, so the station follows the next satellite (TinyGS marks it experimental)
Test mode	Off for real reception
Automatic firmware update	On, as TinyGS recommends

Save. The board joins your WiFi, connects to the TinyGS server and starts listening. Source



Setup in five steps

Antenna options

The antenna decides how many packets you catch. The TinyGS wiki says the small antenna in the box "most likely will not give any result" for satellites, though its FAQ notes such antennas have caught distant packets in good conditions. Treat it as a bench test and move to one of these.

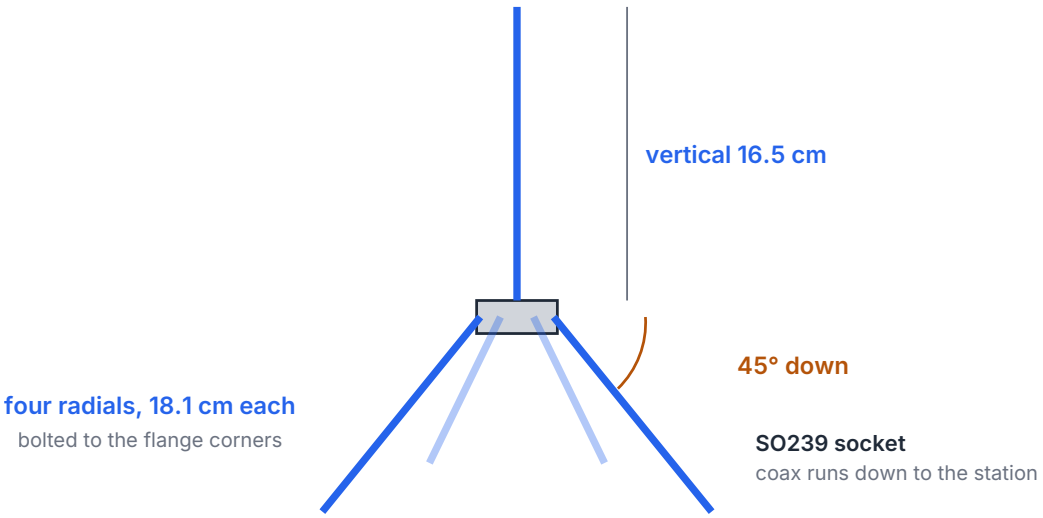
Antenna	Cost	Effort	Connector	Notes
Small antenna from the box	Included	None	Check your box	Bench test only
HYS 433 MHz omni	Check the listing	Mount and route cable	Check the listing	Recommended start; TinyGS calls it a strong price to performance balance and pairs it with an SMA extension cable
DIY quarter wave ground plane	A few dollars	One hour with a soldering iron	SO239	Best learning project; needs an SMA to UHF cable
Diamond X30A	Higher budget	Mast mount	UHF	TinyGS says it gives better horizon coverage; needs an SMA to UHF cable

Build the DIY ground plane (433.5 MHz)

1. Cut one vertical wire and four radials from 12 or 14 AWG solid copper, each 10 to 20% longer than the target.
2. Thread the SO239 onto a spare cable or male connector before you solder; the extra metal acts as a heat sink. Then solder the vertical wire into the center pin.
3. Bolt one radial to each corner hole of the connector flange with M3 bolts.
4. Bend the four radials down to about 45 degrees. That angle brings the antenna close to 50 ohms.

5. Trim the vertical to about 16.5 cm from the connector base to the tip, and the radials to about 18.1 cm from the bolt holes. With a NanoVNA, trim a little at a time; cutting is easy, adding wire back is not.
6. Seal the base of the vertical wire with epoxy or hot glue.

Source

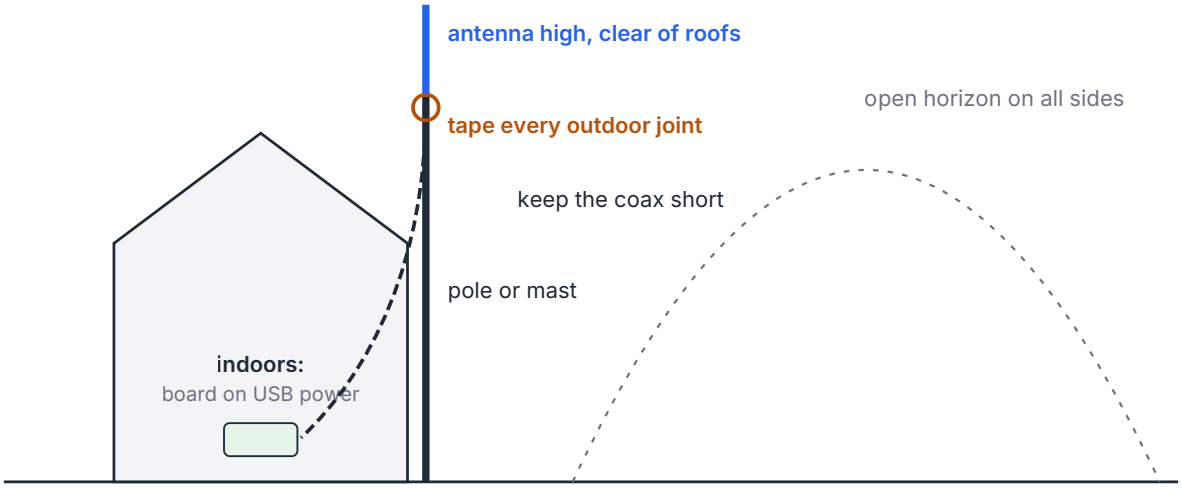


Trim a little at a time. Seal the base of the vertical with epoxy.

The DIY ground plane, seen from the side

Mount it

Put the antenna high and clear, with as much open horizon as you can get, on a pole, mast or balcony rail. Keep the coax run short, and wrap every outdoor connector joint tightly in mastic or self amalgamating tape.

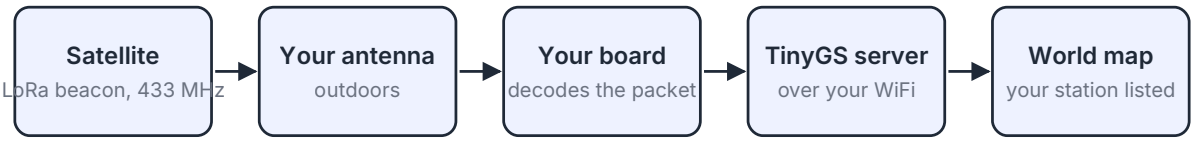


Antenna high and clear, cable short, joints taped

Later, an LNA (low noise amplifier) can lift weak signals. One contributor's tests on the TinyGS wiki found that a filter is a must alongside it, that a 60 dB amplifier gave no advantage, and that an LNA powered by a bias tee killed a LoRa chip over weeks, so add a DC blocker. Get the plain station working first. Source

Your first satellite

Your first packet arrives when a LoRa satellite passes within range and your antenna can see it. Low orbit passes are short, so the station has to be listening at the right minutes; leave it running.



How a packet travels from orbit to the map

1. Log in to your station console on tinygs.com with the link from `/weblogin` or your email account. Find your station by name and check it shows as online.
2. Watch the OLED. Out of the box the station listens for Norby, the network's default target. With automatic tuning on, it retunes to the nearest compatible satellite about 5 to 10 minutes before that satellite rises, and if none is overhead it waits.
3. When a packet lands, it appears under your station in the console. The packets page on tinygs.com shows packets from the whole network in real time, so you can see other stations hearing the same satellites.

4. Read what came down. TinyGS decodes packets from the satellites it supports, and the console shows what it decoded.

Two things look like failures and are not. A CRC error means a packet arrived with damaged bytes; it still shows the station is hearing something. Packets marked Unknown are usually ground LoRa traffic that shares the band, not satellites. Source

Write down the date, the satellite and your antenna for the first packet. Change one thing at a time after that (antenna height, cable, position) and compare packet counts over a week. That is the first real experiment this station gives you.

Troubleshooting

Symptom	Likely cause	Fix
Installer finds no board	Charging only USB cable, or a browser other than Chrome or Edge	Swap the cable; use Chrome or Edge
Installer fails partway	The installer is experimental	Retry, then flash with PlatformIO from the TinyGS wiki
No "My TinyGS" network	Firmware not running yet, or the board already joined your WiFi	Reflash; or find the board's address on your router and open it there
Setup page does not open	Phone did not trigger the captive page	Browse to 192.168.4.1 while joined to "My TinyGS"
Lost the panel password		Hold the PRG button for 8 seconds for rescue mode (an open setup network named after your station), or send the letter e over serial at 115200 baud to reset to defaults
Console shows MQTT "failed, rc=-2"	A firewall or ad blocker (Pi hole, for example) blocks the TinyGS server	Add an exception for it
Radio does not start	Board type not detected	Set the board type by hand in the panel
Station stays on Norby	No compatible satellite overhead yet	Wait; check automatic tuning settings in the console
Online for days, no packets	Small antenna from the box, indoor position, or a board for the wrong band	Fit an outdoor antenna; confirm the board is the 433 MHz version
OLED flips between light and dark	Intended, to slow screen wear	Leave it

Sources: TinyGS FAQ, Quick Start. For anything else, the TinyGS Telegram group is where the volunteers who run the network answer.

Next projects

1. Plot your own data. TinyGS documents a programmatic API, still in development, that lets a script control the station and read its data. Chart reception against antenna changes, and send the result to info@theconsciousness.ai if you want it shared as a reader experiment.
2. Add a wideband receiver. Our free RTL-SDR satellite receiver guide pairs an RTL-SDR Blog V4L with a dipole antenna kit and the open SatDump and SatNOGS software to hear weather satellites and the ISS, and to join the SatNOGS network. It covers far more of the spectrum than LoRa; this station teaches the habits it needs.
3. Put a satellite on your desk. AMSAT's open CubeSatSim is a working 1U model with solar panels, sensors and a radio beacon. Your ground station experience carries straight over, since you will be the operator listening to your own spacecraft. See the kits page for where to get it.

Credits and license

TinyGS is a non profit organization run entirely by volunteers. It started on November 28, 2019 as the ESP32 OLED Fossa GroundStation and took the TinyGS name when tinyGS.com launched on February 14, 2021. Its station software is licensed under GPL 3.0. This guide contains none of that code; it sends you to TinyGS's own installer and wiki. If the network helps you, you can support it through the donation page on tinygs.com.

This guide is independent and written by theconsciousness.ai. It is not made, endorsed or reviewed by TinyGS or Heltec Automation.

The guide is free, and every link in it is a plain link that earns nothing.

Tutorials we built on

Source	Date	License	What we used
TinyGS wiki	Ongoing	None stated for text; software is GPL-3.0	Flashing, configuration fields, LNA tests, rescue mode
TinyGS parts list tutorial	May 31, 2026	None stated	Parts, antennas and cables
TinyGS join tutorial	June 3, 2026	None stated	Email invite signup and the Telegram bot
TinyGS ground plane tutorial	Undated	None stated	Ground plane dimensions
TinyGS newsletter	Apr 19, 2026	None stated	Heltec V3 as the recommended board, LilyGO frequency stability

Source	Date	License	What we used
TinyGS FAQ	Ongoing	None stated	Troubleshooting
TinyGS repository on GitHub	Ongoing	GPL-3.0	Board support list, project history
Heltec, Pileup and TinyTronics listings	Nov 12, 2026	Not applicable	Prices and box contents

All wording above is ours; no TinyGS text is copied. Video tutorials were not reviewed for this guide.

Where sources disagree, or only one source exists

1. The wiki and the FAQ differ on whether the small antenna that ships with the board is enough to start. The guide treats it as a test antenna and recommends an upgrade.
2. The wiki's board list names only older Heltec and TTGO boards. The repository's README adds the Heltec V3, and the parts list and the newsletter recommend it. The guide follows the parts list.
3. Heltec's listing names no pigtail in the box; the two European sellers list one. The guide treats it as a part you may need to buy.
4. The ground plane dimensions come from one tutorial. They match the quarter wave formula for 433 MHz, which is why the guide keeps them.
5. Email invite signup is described in one source, the join tutorial from June 2026.
6. Holding PRG for 8 seconds to reset is described in one source.

Images

Every diagram in this guide was drawn for it by theconsciousness.ai. The guide uses no photos or screenshots from TinyGS, Heltec or any other site.