



The internet may not be there when you need it.

It's easy to take our communications infrastructure for granted, but the internet, phone, and electrical systems are more fragile than you may think. Hurricanes, tornadoes, and winter storms knock out power to huge regions on a regular basis, with large-scale repairs sometimes stretching to weeks. Even on a good day, these networks require constant monitoring and maintenance to keep working.

Sometimes there isn't enough bandwidth to go around. It's common to lose cell service when you're in a crowd because the network is overloaded. In a natural disaster, phone lines can get jammed as people check on loved ones. And many regions have no cell service at all.

Using the internet can also be risky. If you're trying to arrange an abortion in a fascist-run state, there's a real chance your online activity might be used against you. If you're attending a protest, simply connecting to the cell network creates metadata that confirms you were there.

It's good to have options, just in case.

Radio amateurs (a.k.a. hams) have been texting over the airwaves for decades, using [insert protocol details]. But getting a ham license requires taking a test, and encrypted communication is strictly forbidden on the ham bands.

LoRa (short for long range) is a radio modulation technique introduced in 2015 that makes it possible for low-power devices to send data over long distances, up to several miles. This project also demonstrates how much you can do with low-power electronic communications. It's apparent that we need to shift to renewable energy in the coming years, but we can't sustainably manufacture enough solar panels and wind turbines to support the level of energy consumption we're used to in the U.S. and Europe.

List of Parts

The following parts are included in your kit:















You'll provide these parts yourself:



You'll also need the following tools and supplies. We'll provide them for the workshop.



• Screw gun w/ hole saw	
• Duct tape	
 Packing tape 	The second se



What is LoRa?

LoRa is short for **Lo**ng **Ra**nge radio ideal for lowspeed data transmission from 250 bits/s to 27 kbits/s, like text chat and location beaconing. Typically, it reaches a range of 10km (~6 miles) in areas with a clear line of sight, sometimes more. In a city environment with many obstructions, your range is more likely to be 1–3 blocks.

LoRa implements chirp spread spectrum (CSS) modulation, meaning that it is robust to channel noise and resistant to multi-path fading, resulting in low interference.

What is Meshtastic?

For this workshop, your LoRa32 device is preconfigured with settings that will work well out of the box. Each device is set to the same channel, using an AES-256 encryption key. (We aren't using the default key.)

In the first part of the workshop we'll focus on mounting your LoRa device in a weatherproof enclosure.

What is a lithium-ion battery?

A lithium-ion battery is a lightweight, highefficiency battery. It tends to be on the pricer sider while offering a high depth of discharge, lifespan, charging rate.

What is a charge controller?

A charge controller regulates the voltage and current from the solar panel to the battery and the load by controlling the charging rate. Excess solar power from the panel could overcharge the battery. What is a voltage regulator circuit?

A voltage regulator circuit stabilizes fluctuating inputs to a fixed output to prevent even the slight chance of overcharging. The MCP1700 is a lowdropout positive (incoming) voltage regulator. It consumes a fraction (1.6 μ A) of what it can deliver (250 mA) leading to a longer battery life and is ideal for single lithium-ion batteries.



What is a decoupling capacitor?

A decoupling capacitor will help smooth out shortterm voltage spikes found in noise in the power supplies. For example, if the voltage suddenly drops, it'll have enough power to counter act this change. If the voltage suddenly increases, it'll be able to absorb that power.

□ Solder jump wires to battery clip

- 1. Find the parts you'll need:
- battery clip with stripped wires
- two port-to-stripped jump wires
- two lengths of heat

If any wires have loose bits of insulation on the stripped end, you can remove them now.

2. Slide a length of heat shrink tubing onto one of the wires connected to the battery clip.



3. Cross the stripped end of the wire with heat shrink tubing and the stripped end of a jump wire. Start with the two wires at a 90° angle like an X.

4. Twist the wires together tightly. When you're done, give them a slight tug to make sure the connection is secure.



When the wires are twisted together, they should look like this, a single spiraled wire:



5. Next you'll solder the wires together with a soldering iron. Start by applying some flux to the twisted wires (optional).

You can use a "helping hands" tool with alligator clips to hold the wires in place. Alternately, place the soldering iron on its stand to hold it stationary.

Touch the tip of the iron to the twisted wires and gently apply solder. Your finished connection should look like the photo on the right.





6. Slide the heat shrink tubing over the solderedtogether wires. Cover the solder connection completely.

7. Use a heat gun (or hair dryer) on the heat shrink tubing until it makes a tight seal.



Note: In a pinch, you can use a lighter instead. Hold the tip of the flame under the heat shrink tubing, 1" away. Run it parallel to the tubing while twisting the wire around. Ventilate please, and don't touch hot plastic. 8. <u>Repeat steps 2–7 above with the battery clip's</u> other wire.

Here's what the part will look like when you're finished:



□ Solder SH1.25 connector to DuPont jump wire

- 1. Find the parts you'll need:
 - two plug-to-stripped jump wires
 - an SH1.25 connector with stripped wires
 - two lengths of heat shrink tubing
- 2. Put heat shrink tube on one of the SH1.25 connector's stripped wires.



3. Cross the stripped end of the wire with the heat shrink tubing and the stripped end of one of the jump wires. The ends of the wires should be crossed at a 90° angle. (Make sure you're using a jump wire with a <u>plug</u> connector for this step.)

4. Twist the wires together tightly. When you're done, give them a slight tug to make sure the connection is secure.



5. Apply some flux to the twisted wires (optional) and solder them together.

6. Again, slide the heat shrink over the solder wires, covering the completely.

7. Use a heat gun (or hair dryer) on the heat shrink tubing until it makes a tight seal.



7. <u>Repeat steps 2–6 above with the SH1.25</u> <u>connector's other wire.</u>

Here's what the part will look like when you're finished:



□ Solder pins to TP4056 board

If you're assembling a kit from Iffy Books, you don't need to do this step. You can skip forward to the step titled "<u>Attach antenna to Lora32</u>."

1. Insert two pairs of header pins near the edge of a breadboard, separated by two rows.

2. Align the pin holes on the TP4056 board on the pins.



- 3. Solder the first pin.
- 4. Solder the remaining pins.



5. Carefully remove the finished TP4056 from the breadboard. It should look like this:



□ Solder wires to LoRa32

If you're assembling a kit from Iffy Books, you don't need to do this step.

1. To power your LoRa32 at 3.3V (instead of 5V via the USB-C port), you'll need to solder wires to the pin holes labeled **3V3** and **GND**. Connect the red wire on an SH1.25 connector to 3V3 and the black wire to GND.



When you're done, your LoRa32 will look like this:



Attach antenna to LoRa32

1. Find your antenna and the small cable with a matching SMA connector. Screw them together.





2. Line up the antenna cable's IPEX-1 connector with the corresponding plug on the LoRa32 board (to the right of the OLED screen). Press it on with your thumb.



The finished connection will look like this:



□ Install the Meshtastic app on your phone

iOS: Search for "Meshtastic" in the App Store and install it.

Android: Go to the Google Play Store or the Amazon Appstore and search for "Meshtastic." Install the app.

Or download the .apk from GitHub and sideload it: <u>https://github.com/meshtastic/Meshtastic-Android/</u> or <u>https://iffybooks.net/link/5a11</u>

Pair with your LoRa radio (Android)

Open the Meshtastic app and tap the **plus sign** (+) in the bottom right corner to start scanning for LoRa devices.


Find your device using its four-character ID. Tap the radio button next to it to start pairing.

Type the six-digit number from your LoRa device's screen and tap **OK**.



Pair with your LoRa radio (iOS)

1. Tap the **Bluetooth** icon at the bottom of the screen. Find your LoRa device under **Available Radios** and tap it.

2. A six-digit code will appear on your LoRa32's screen. Enter the code and tap **Pair**.



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□ Set your region (Android)

Tap **Region** at the top right of the screen and select your region from the dropdown menu.

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You must s	set a region!		

When you're done, you'll see your region code next to the name of your LoRa device.

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Connected			

□ Set your region (iOS)

1. Tap the **Bluetooth** icon.



2. Tap Set LoRa region.



3. Select your region from the dropdown menu.

4. Tap **Save** at the bottom of the screen to save and reboot your LoRa device.

□ Turn off GPS location sharing (Android)

1. Tap the **three dots** at the top right corner of the screen, then select **Device settings**.



2. Scroll down to **Position Config** and deselect **GPS enabled**. Tap **Send** to save and reboot your device.

<u>Turn off GPS location sharing (iOS)</u>

1. Open Settings.



2. Under **Configure** in the Settings window, make sure your LoRa device is selected. If it isn't, select it from the dropdown menu.

 About Meshtastic App Settings 	
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3. Tap **App Settings**. If the option **Provide location to mesh** is selected, deselect it.



4. You can also disable location sharing at the OS level. Go to **Settings** in iOS, scroll down, and tap **Meshtastic**. Then make sure **Location** sharing is set to **Never**.



5. While you're here, tap on **Siri & Search**. To avoid leaking data needlessly, deselect **Learn from this App** and **Show Content in Search**.



🗌 Name your LoRa Radio (Android)

1. Go to Settings.

2. Enter a short name and long name for your LoRa device (optional). Note that these names will be visible to everyone else on the network.

3. Tap **Send** to save and reboot.

🗌 Name your LoRa Radio (iOS)

Go to the Meshtastic settings, then tap **User**. Enter a short and long name for your LoRa device. Tap **Save** to save and reboot.

You can read more about Meshtastic's configuration options at the following URL:

https://meshtastic.org/docs/settings/config



Tap the Messages icon.



Then tap the icon for channel 0, which will take you to the primary channel (a.k.a. the group chat).



Type a message and tap the **Send** button.

In the Android app, if your message is received you'll see a check mark appear in the cloud icon under your message. In the iOS app, you'll see the word "Acknowledged" under your message instead.

Send a direct message

Once you've connected with someone in the primary channel, you can send a direct message (DM).

Tap the Messages icon. Under Direct Messages, tap the device you want to DM.



Type a message and tap **Send**.



You're now chatting without the internet or cell network. Pretty cool!

It's important to note that Meshtastic DMs are encrypted using the same shared key as the group chat. That means anyone else on the channel can (in theory) read your messages.

If you want to chat privately with a friend, create a new shared encryption key and don't reveal it to anyone else.

□ Choose a weatherproof enclosure for your solar-powered Meshtastic node

An opaque, light-colored material is best to keep the temperature down. Avoid metal containers, which may block radio communication. At the workshop we'll show you how to cut a hole in the bottom of your enclosure to pass a power cable through.

Here are some items that would make good enclosures:

- a plastic ammo box from Harbor Freight
- a waterproof container for boating, such as an Otter Box
- an empty Gatorade bottle painted white
- a food storage container with a good seal
- a plastic bucket with lid

□ Cut a hole in the bottom of the enclosure

You'll need a hole in the bottom of your enclosure so you can connect power to your LoRa32 without letting in rain.

1. Attach a hole saw to your power drill. You'll need to make a hole large enough for your USB extension cable to pass through.

2. Choose a spot on the bottom of your enclosure and line up your drill.

3. Pierce the enclosure with the drill, then use the hole saw to cut a hole.





Pass USB extension cable through hole and tape shut

1. Pass your USB extension through hole at the bottom of your enclosure with the plug side sticking out. You'll connect this to the USB port on your solar panel.

2. Seal the hole completely with duct tape.



3. Apply an extra layer of packing tape (optional).

4. Cover the inside of the hole with tape (optional).

Cut notches in LoRa32 case

In your LoRa32 case, the only openings for wires to pass through are on the back. But you're going to glue the back of the LoRa32 case to your enclosure, so you'll need to cut openings for the power and antenna wires.

1. Put your LoRa32 in the case and use a marker to make dots where you're planning to cut notches.

2. Cut two notches with a rotary tool or hobby saw.



Connect LDO regulator to breadboard

1. Find the low-dropout (LDO) regulator in your kit, which has three leads sticking out of it. Gently spread the leads apart so they can fit into adjacent rows in your breadboard.



2. Position your breadboard so the column labels ("1 2 3") are facing you. Each column is connected by

3. With the flat side of the LDO facing you, you'll

insert its three leads in the middle row of the breadboard. The first lead (GND) goes in column 1, the second one (V_{IN}) goes in column 2, and the third lead (V_{OUT}) goes in column 3.



Here's a side view:



□ Connect a 100 uF electrolytic capacitor to your breadboard

You'll add two decoupling capacitors to your voltage regulator circuit. The capacitors we're using are polarized, which means they need to be oriented in a specific direction. The long lead is the positive (+) side, and the short lead is negative (–). Many polarized capacitors also have a white stripe running along the negative side.



Place the capacitor in front of the curved side of the LDO. Connect the capacitor's positive (long) lead in column 3 on the bread board. Then connect the negative lead to column 1 on the breadboard.





We're still working on cleaning up the steps from here with more details. Keep an eye on for updated versions of this and feel free to keep skimming through to get an overview of what happens next.

□ Connect 100 nF ceramic capacitor to breadboard

The ceramic capacitor is not polarized, so it doesn't matter which direction it's facing.



Place the ceramic capacitor on the other side of the decoupling capacitor, opposite of the end of the breadboard.





Connect battery clip to TP4056



TP4056 has two, two-pin headers on one end. Orient it so USB-C port end is facing you. Take the positive end of your battery clip, the red cable, and clip it onto the inner pin on the left set of headers next to the B+ label. Take the negative end of the battery clip, the black cable, and clip it onto the inner pin on the right set of headers, next to the Bcable.





Connect jump wires to TP4056

two plug-to-port DuPont wires



Place each port end of the wires on the outer headers on the TP4056.



Connect TP4056 to voltage regulator

Point your breadboard with the numbers facing you. Take the plug end of the DuPont wire from the outer-right side, next to the B- label, of the TP4056 and plug it into column 1.



Take the plug end of the DuPont wire from the outer-left side, next to the B+ label, of the TP4056

and plug it into column 2. Column 3 should still be empty at this point.



Connect SH1.25 connector to voltage regulator

- Connect negative wire to column 1
- Connect positive wire to column 3







Connect LoRa32 to voltage regulator (SH1.25 connection)




Place brick in enclosure (optional)



□ Decide how to arrange components in the



enclosure

□ Glue battery clip to enclosure







Glue LoRa32 case to enclosure







□ Glue voltage regulator to enclosure





Glue TP4056 to enclosure



🗆 Insert LoRa32 into case





Put cover on LoRa32 case



□ Mount antenna with tape



□ Tape down wires as needed



🗌 Insert 18650 battery into clip

1. Orient battery.



2. Snap battery into place.



Connect USB-C cable to TP4056



Connect USB-C cable to USB extension



□ Connect solar panel to USB extension



🗆 Test in the sun



□ Seal the enclosure



□ Find a place for your LoRa node

- ideally south facing
- if stationary, angle of lattitude usually works well
- it should be in a place that's okay to leave it alone all the time to run consistently
- ideally as high as you can get without obstructions

Advanced software options

You can update your device's preferences (some of them, anyway) using the iOS/Android app.

Enable/disable GPS location sharing

Switch to Router mode to save power

- We're currently using Client Router mode

Routing options

- You can choose whether to route any message your device receives, or just messages from your friends.

Create a preset pin number for connecting via Bluetooth

Adjust the number of hops

- If you're using your solar LoRa station as a repeater (e.g., on your roof) and you're having trouble with lost messages, you can increase the number of hops from 3 to 4.

Adjust the transmission speed

To access more preferences, connect your LoRa32 to a computer - We'll use client.meshtastic.org (with Chrome) because it's the same for every OS.

Create a new shared encryption key

Switch to low-power mode

Only rebroadcast the messages on your channel

Troubleshooting

Make sure you and your friends are using the same version of the Meshtastic firmware. When you reset your LoRa32, you'll see the version number at the top right corner of the screen.

[photo of startup screen with version number]

Acknowledgments

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Tips (Find a place to put these.)

If your port jump wires aren't attached to the TP4056 pins securely, you can disconnect the wire, apply superglue at the base of the pin, and reconnect.

You can extend your range with a larger antenna. Try searching for '5dBi antenna LoRa antenna' and you'll find lots of options.

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