Build tutorial on open-source hardware alternatives for SNR-based GPS/GNSS Reflectometry (GNSS-R)

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Portions and images reused from Adafruit tutorials, by Lady Ada and others.

Step 0: List of Materials

You can use this link to a bill of materials with all the necessary items:
https://www.adafruit.com/wishlists/469752

For convenience, we list below the items in the Adafruit shopping cart; other shops can be used for some of the items:

1x - 2.1mm female/male barrel jack extension cable - 1.5m / 5 ft
https://www.adafruit.com/product/327

1x - GPS Antenna - External Active Antenna - 3-5V 28dB 5 Meter SMA
https://www.adafruit.com/product/960

1x - CR1220 12mm Diameter - 3V Lithium Coin Cell Battery - CR1220
https://www.adafruit.com/product/380

1x - SMA to uFL/u.FL/IPX/IPEX RF Adapter Cable
https://www.adafruit.com/product/851

1x - Header Kit for Feather - 12-pin and 16-pin Female Header Set
https://www.adafruit.com/product/2886

1x - Adafruit Ultimate GPS FeatherWing
https://www.adafruit.com/product/3133

1x - Adafruit Feather 32u4 Adalogger
https://www.adafruit.com/product/2795

1x - Lithium Ion Battery Pack - 3.7V 4400mAh
https://www.adafruit.com/product/354

1x - 3.5 / 1.3mm or 3.8 / 1.1mm to 5.5 / 2.1mm DC Jack Adapter Cable
https://www.adafruit.com/product/2788

1x - Waterproof DC Power Cable Set - 5.5/2.1mm
https://www.adafruit.com/product/743

1x - 10K Precision Epoxy Thermistor - 3950 NTC
https://www.adafruit.com/product/372

1x - Cable Gland PG-9 size - 0.158" to 0.252" Cable Diameter - PG-9
https://www.adafruit.com/product/761

1x - USB / DC / Solar Lithium Ion/Polymer charger - v2

https://www.adafruit.com/product/390

1x - Huge 6V 6W Solar panel - 6.0 Watt
https://www.adafruit.com/product/1525

1x - Through-Hole Resistors - 2.2K ohm 5% 1/4W - Pack of 25
https://www.adafruit.com/product/2782

1x - Cable Gland PG-7 size - 0.118" to 0.169" Cable Diameter - PG-7
https://www.adafruit.com/product/762

1x - 2.1mm to 2.5mm DC Barrel Plug Adapter
https://www.adafruit.com/product/2897

1x - Large Plastic Project Enclosure - Weatherproof with Clear Top
https://www.adafruit.com/product/905

Step 1: Installing the software

You'll need:

- 1x - Adafruit Feather 32u4 Adalogger

1.1 - Download and install the Arduino IDE

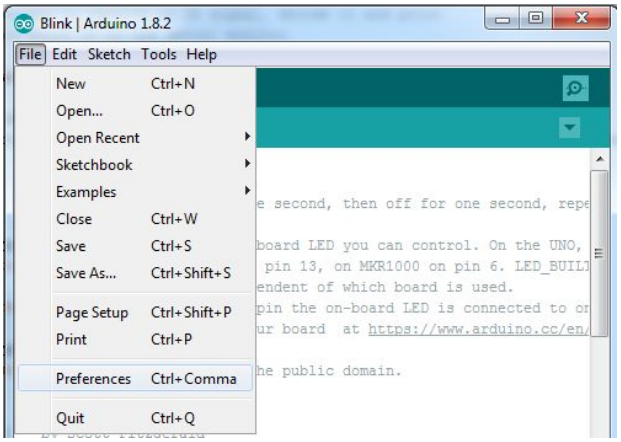
Available at: https://www.arduino.cc/en/Main/Software

1.2 - Install Adafruit drivers for the IDE

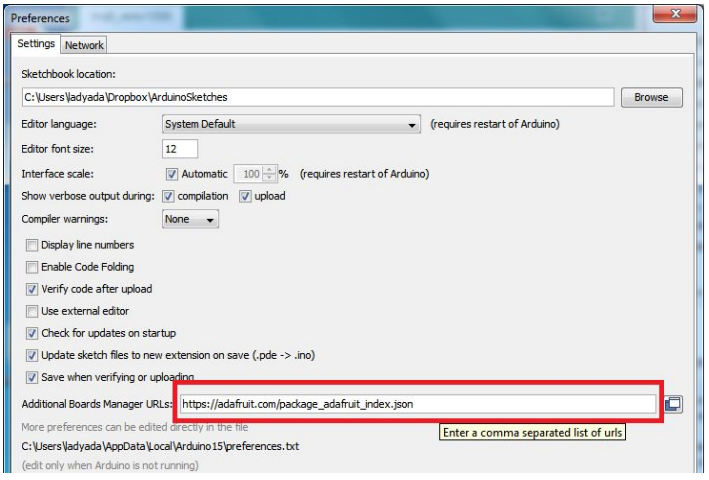
The steps are detailed in this link, but we'll shown a summary below.
https://learn.adafruit.com/adafruit-feather-32u4-basic-proto/arduino-ide-setup

Portion reused from Adafruit tutorial:

> "After you have downloaded and installed **the latest version of Arduino IDE**, you will need to start the IDE and navigate to the **Preferences** menu. You can access it from the **File** menu in *Windows* or *Linux*, or the **Arduino** menu on *OS X*.



A dialog will pop up just like the one shown beside.

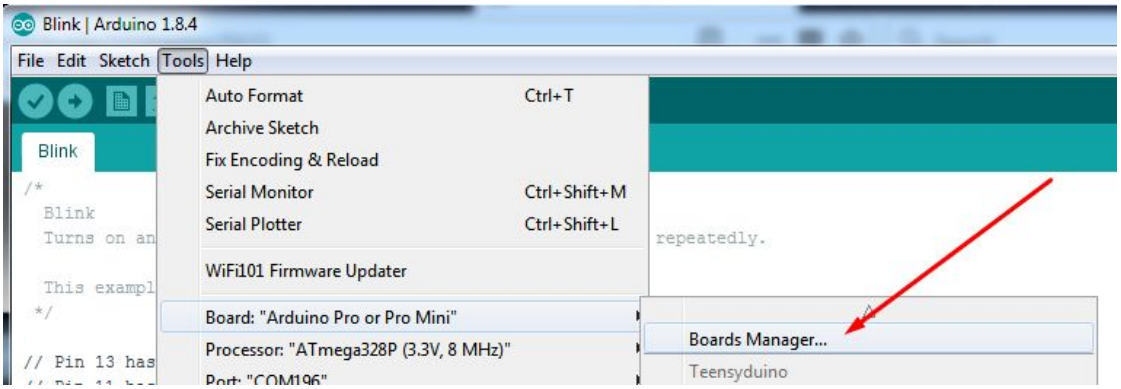


We will be adding a URL to the new **Additional Boards Manager URLs** option. The list of URLs is comma separated, and *you will only have to add each URL once.* New Adafruit boards and updates to existing boards will automatically be picked up by the Board Manager each time it is opened. The URLs point to index files that the Board Manager

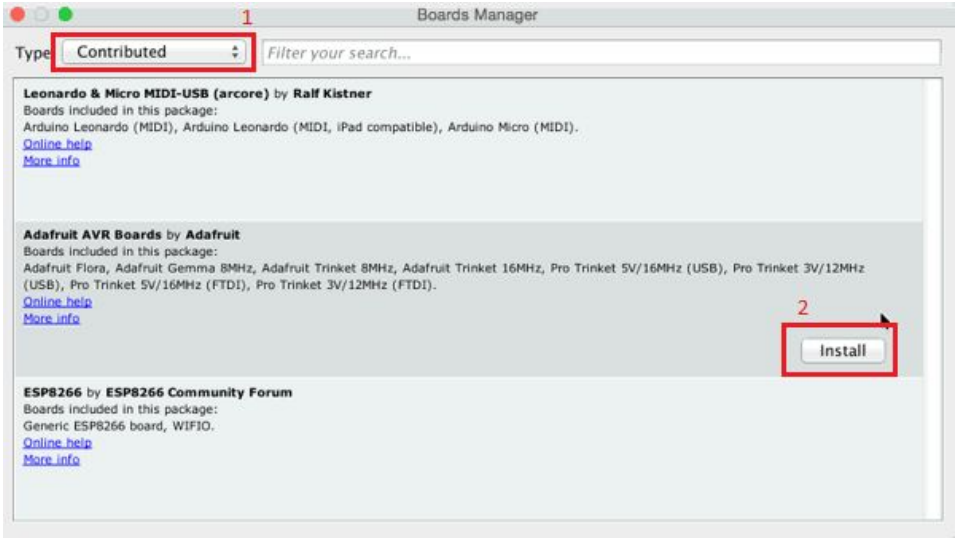
uses to build the list of available & installed boards.

Insert this link in the Arduino IDE preferences:
https://adafruit.github.io/arduino-board-index/package_adafruit_index.json

Now that you have added the appropriate URLs to the Arduino IDE preferences, you can open the **Boards Manager** by navigating to the **Tools->Board** menu.



Once the Board Manager opens, click on the category drop down menu on the top left hand side of the window and select **Contributed**. You will then be able to select and install the boards supplied by the URLs added to the preferences. In the example below, we are installing support for ***Adafruit AVR Boards***, but the same applies to all boards installed with the Board Manager.



Next, **quit and reopen the Arduino IDE** to ensure that all of the boards are properly installed. You should now be able to select and upload to the new boards listed in the **Tools->Board** menu."

1.3 - Install Adafruit drivers for Windows

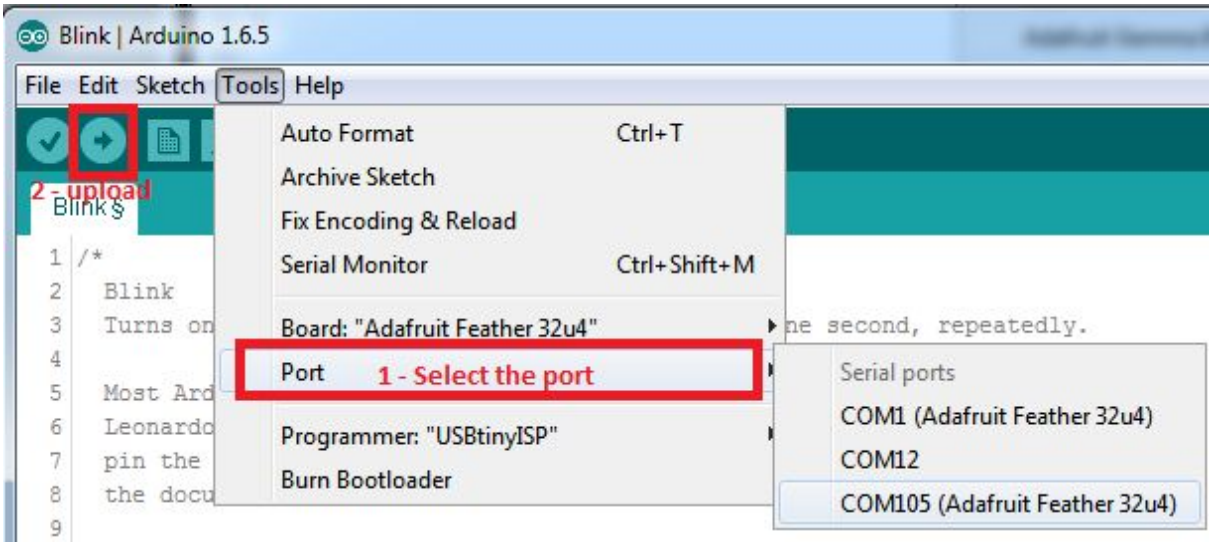
Download and run the installer:

https://github.com/adafruit/Adafruit_Windows_Drivers/releases/tag/2.3.4

1.4 - Upload the Arduino sketch

0) Download the source code on this link and open it on the IDE:
https://raw.githubusercontent.com/fgnievinski/mphw/master/code/ardu/ardu.ino

1) Plug in the Feather 32u4 to the computer using an USB cable. Wait for it to be recognized by the operating system (just takes a few seconds). It will create a serial/COM port, you can now select it from the dropdown menu, it'll even be 'indicated' as Feather 32u4!



2) Finally, we need to upload the software, that makes the system run. Simply click on the Upload button (arrow icon) and wait (it may take a while to finish).

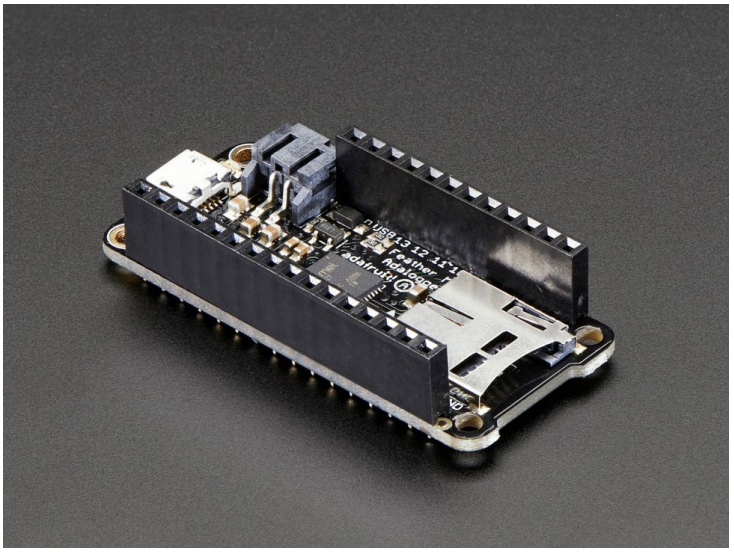
Step 2: Connecting the electronics

2.1 - Connecting the Arduino and its shield

You'll need:

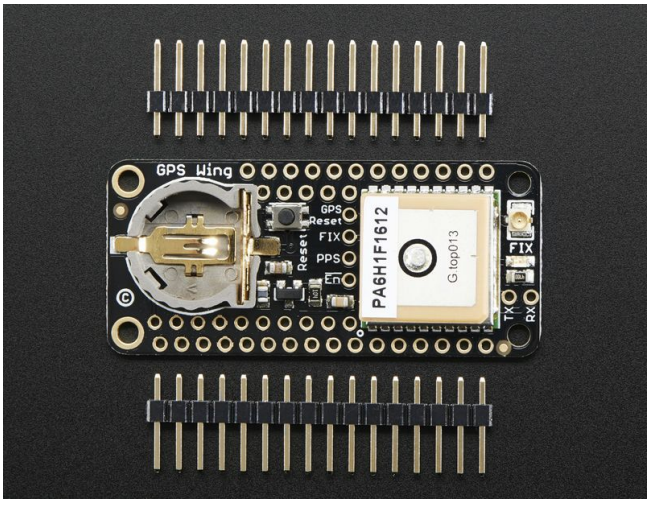
- 1x - Adafruit Feather 32u4 Adalogger
- 1x - Header Kit for Feather - 12-pin and 16-pin Female Header Set
- 1x - Adafruit Ultimate GPS FeatherWing

Solder the "Header Kit for Feather - 12-pin and 16-pin Female Header Set" on the Feather as below.

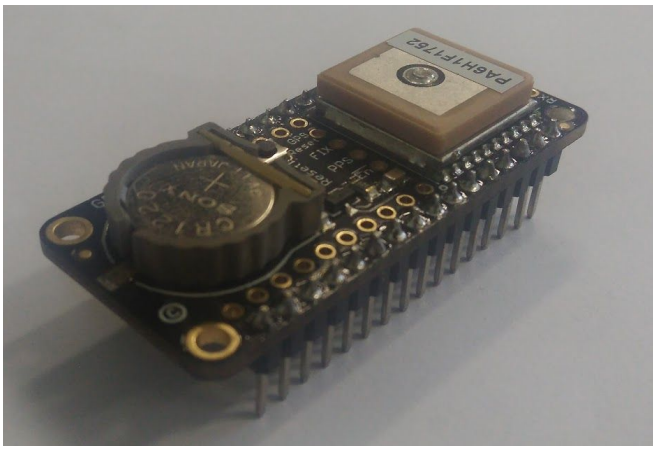


Check "Soldering on Female Header" at this link for detailed instructions:
https://cdn-learn.adafruit.com/downloads/pdf/adafruit-feather-32u4-adalogger.pdf?timestamp=1557404503#__WKANCHOR_q

Prepare the GPS module to attach on the Adafruit Feather soldering the male headers:

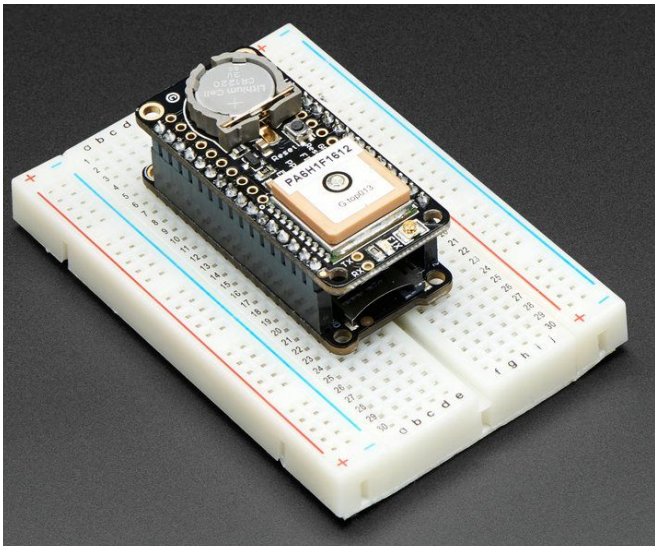


Make sure to solder the pins with the longer part facing down



Check “Adafruit Ultimate GPS featherwing” for details:
https://learn.adafruit.com/adafruit-ultimate-gps-featherwing?view=all

Finally, we can connect the boards pressing down (note: the protoboard is not necessary):



2.2 - Building the solar power supply system

You’ll need:

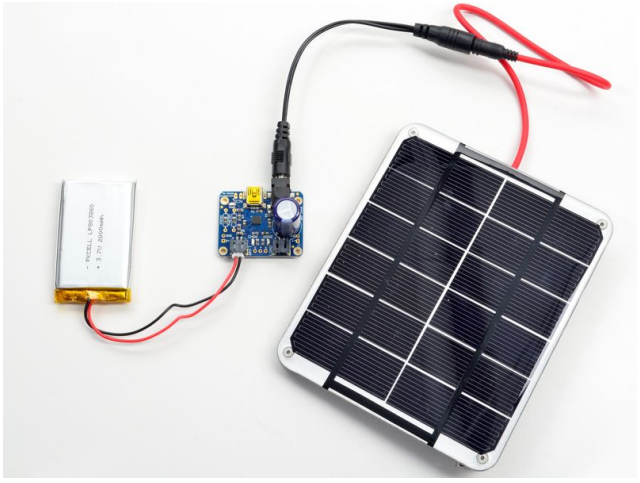
- USB / DC / Solar Lithium Ion/Polymer charger - v2
- Huge 6V 6W Solar panel - 6.0 Watt
- Lithium Ion Battery Pack - 3.7V 4400mAh
- 10K Precision Epoxy Thermistor - 3950 NTC

2.2.1 - Capacitor installation

The first thing to do before starting to charge with a solar panel, is to install the large capacitor on the USB / DC / Solar Lithium Ion/Polymer charger. Watch out to check the polarity of the capacitor, make sure the positive lead of the capacitor goes into the pad marked with a plus sign, **+** !

Follow these steps to prepare the capacitor of the solar charger
https://learn.adafruit.com/usb-dc-and-solar-lipoly-charger/solar-charger-preparation

Then connect the cables; once you've done that, you have something like this:

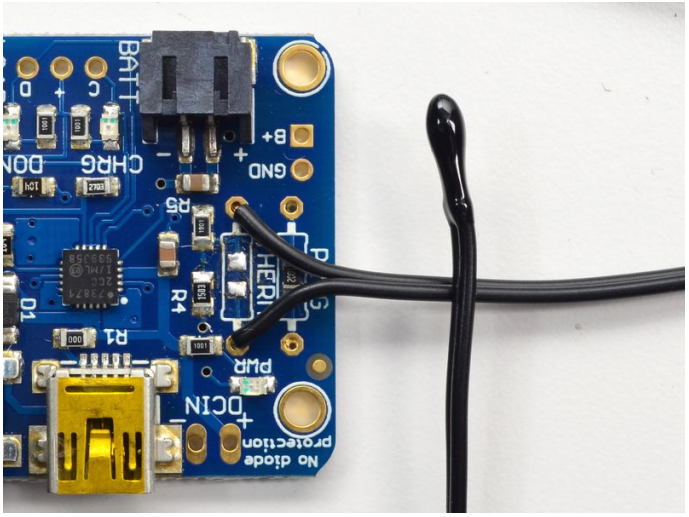


2.2.2 - Adding temperature sensing

Portion reused from Adafruit tutorial:

> "Remove the 10K surface mount resistor from the **THERM** pads (or cut the trace going to it) and solder in a 10K NTC thermistor. Test out the system by trying to charge while you place the thermistor in a freezer or against some ice, as well as in a cup of > 50°C hot water. The charger should stop charging the battery. Once you are

sure it is working, attach the sensing element (the epoxy bulb in this case) so it is resting against the battery."

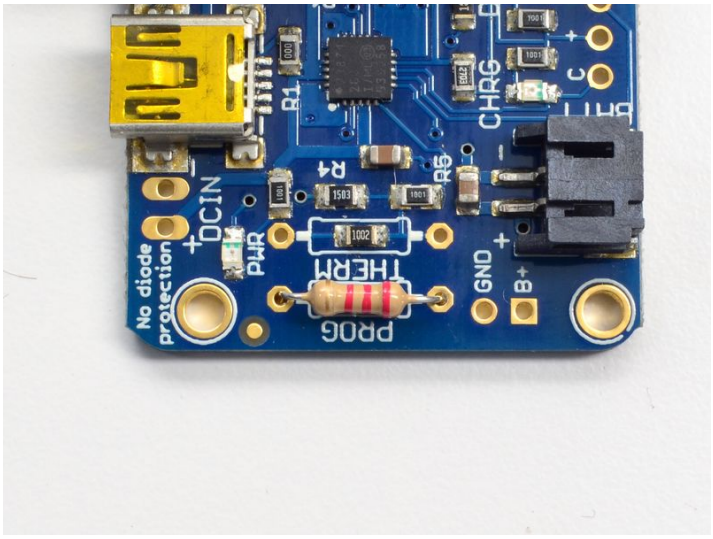


2.2.3 - Adjusting the maximum charging current

Portion reused from Adafruit tutorial:

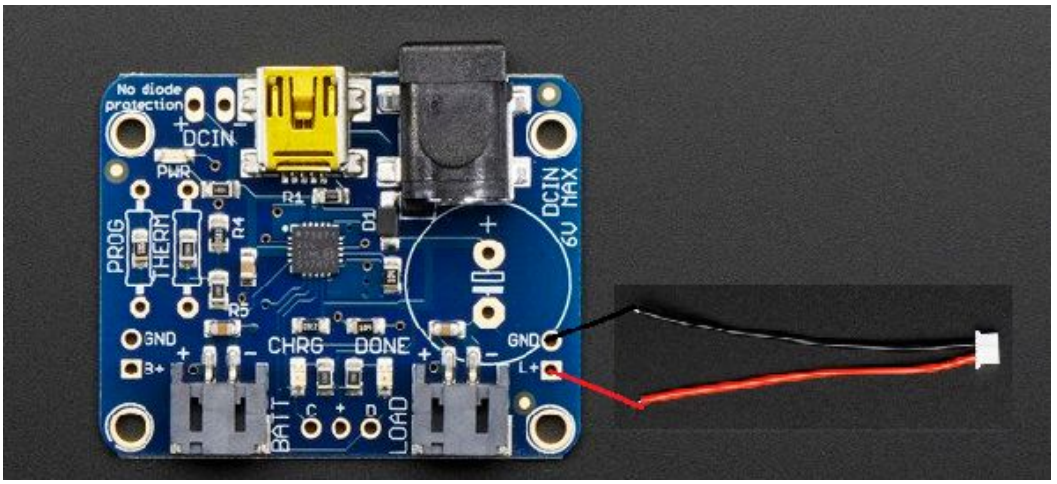
> "**CAUTION**: This modification is indicated only for batteries bigger than 2000mAh! The USB/Solar charger comes with a preset rate of 500mA which will work for USB ports, USB wall adapters and solar panels up to 3 Watts. If you have a project that uses a larger panel, or perhaps some other sort of setup, you can easily adjust the current by soldering a resistor into the **PROG** pads."

Check this link to details:
https://learn.adafruit.com/usb-dc-and-solar-lipoly-charger?view=all#adjusting-the-max-charge-current-5-20

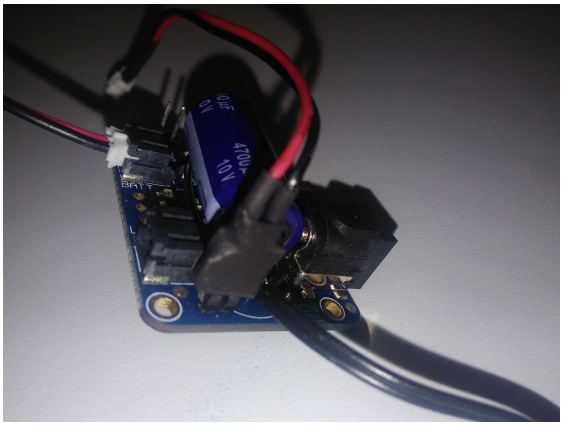


2.2.4 - Connecting the Arduino to power supply

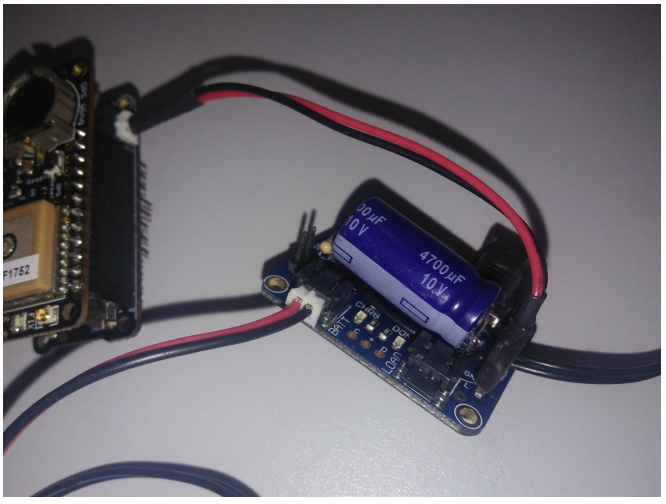
You can solder the black and the red wires here to connect the Feather:
we recommend applying some silicone glue to avoid breaking the wires



Alternatively (optionally), we've soldered male pins and the wire on that, and used a heat-shrink tubing for isolation:



Then connect the power supply on the Arduino and the on battery:

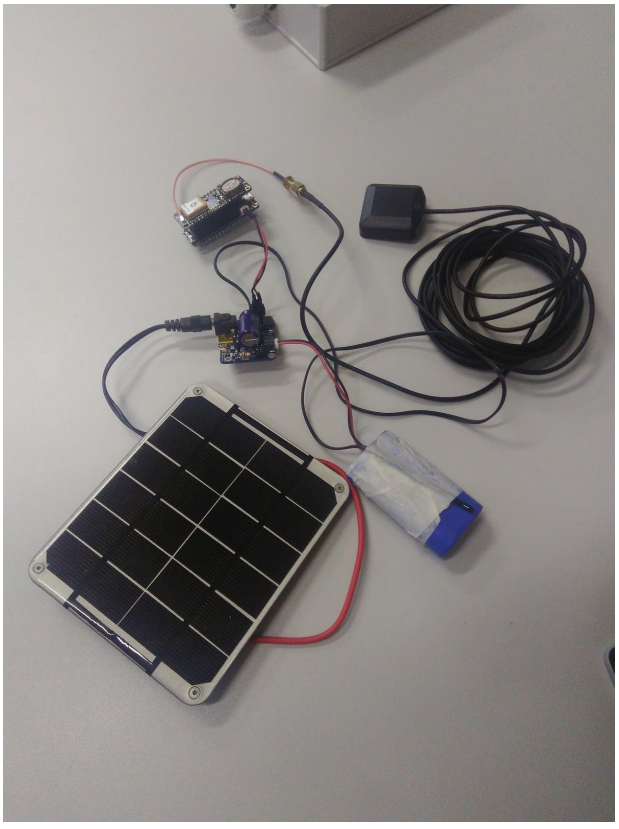


2.3 - Putting it all together

You'll need:

all items before

Now connect the antenna and battery.
This is a look of our system outside the box:

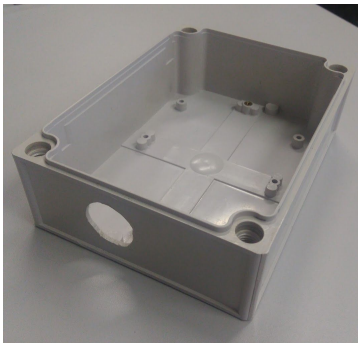


Step 3: Preparing the enclosure

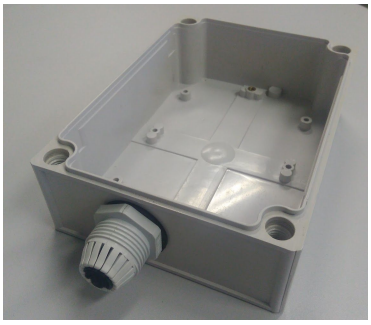
You'll need:

1 x Cable Gland PG-7 size - 0.118" to 0.169" Cable Diameter - PG-7
1x - Small Plastic Project Enclosure - Weatherproof with Clear Top

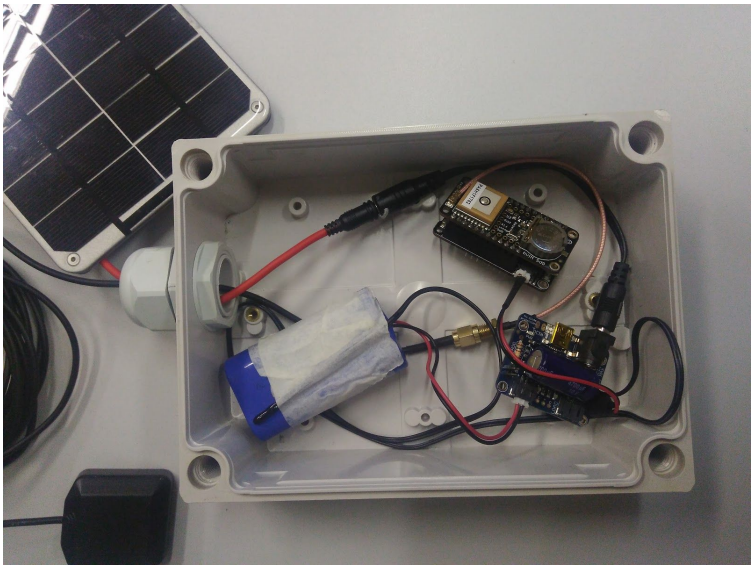
First of all you need to make a hole on the bottom side of the weatherproof box to pass the wiring through. You can use a drill or something alike to do this.

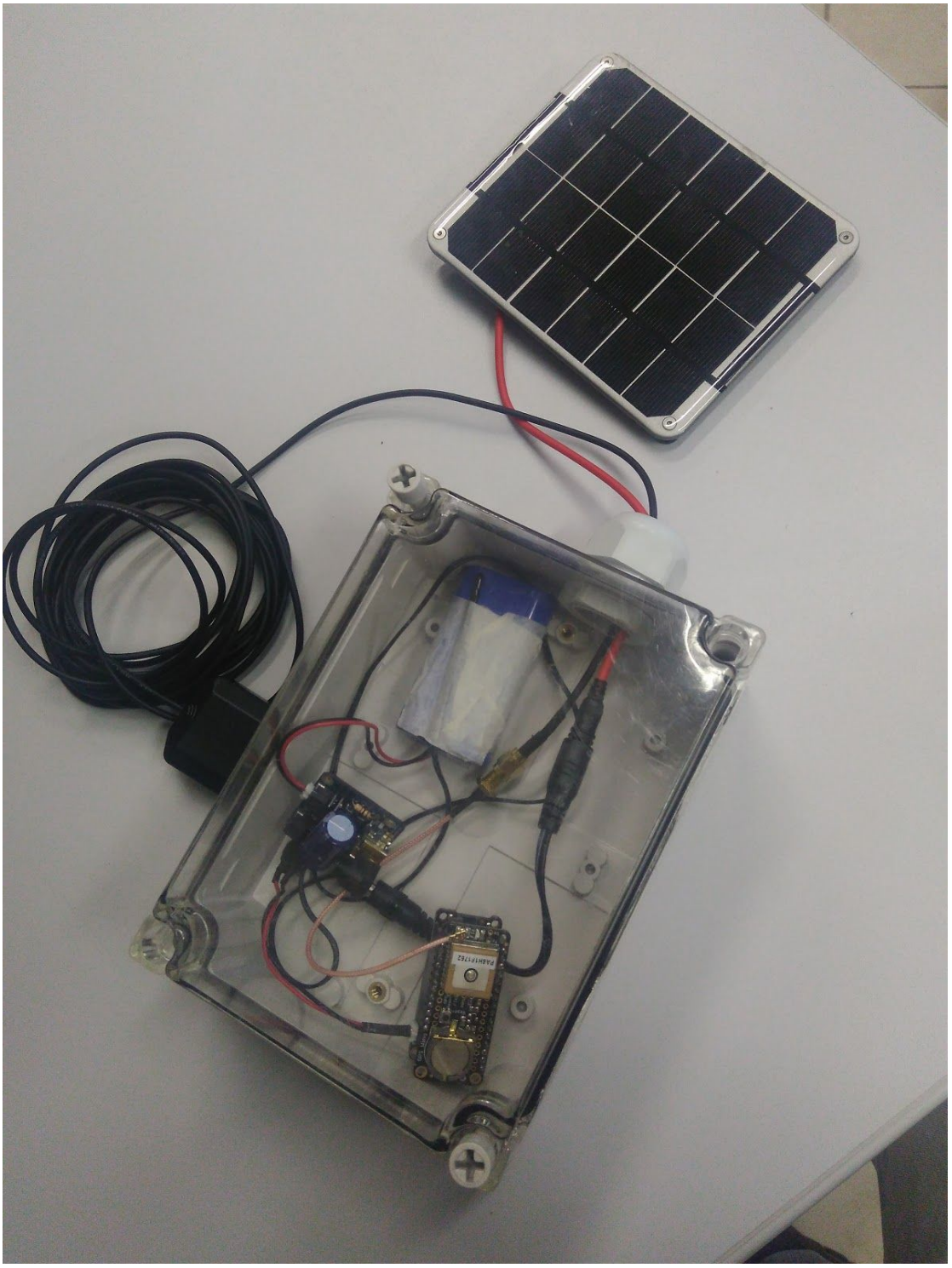


Then you install the cable gland:



Now you have to put all this inside the box, using the cable gland to pass the cables.



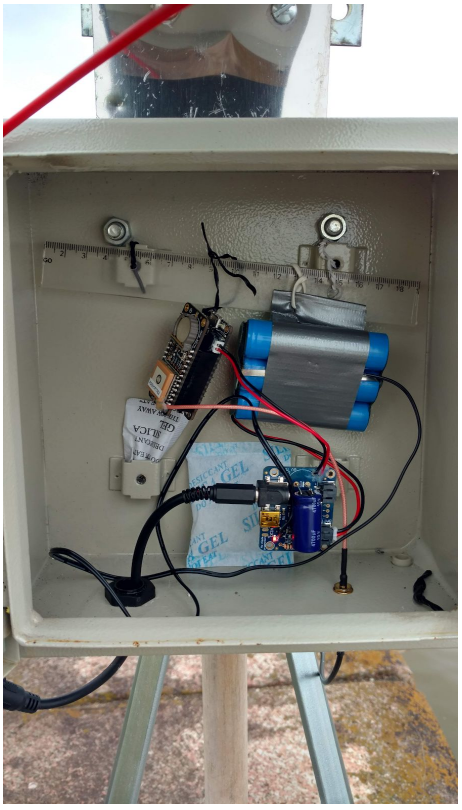


Step 6: Mounting it outdoors

You'll need:
1x - https://www.voltaicsystems.com/small-bracket
1x - stick or mast
1x - silver tape
1x - U support
1x - base (bi-pod, quadri-pod)

6.1 Basic precautions

When it is installed outdoors, there are the risk of rain and humidity. So you need to put the elements to work in suspending. Like this:



As you can see, even if the water enters it does not affect the system working. (This picture is of another enclosure version of our system, but use the same idea to implements in yours)

For a more professional setup, our suggestion is to use stand-off pins:
https://www.adafruit.com/product/3658

6.2 Preparing the mast and base

Fix the antenna on the top of a mast. Make sure to have some slack on the antenna cable -- coaxial cables should not be bent!

Set the bases

6.3 Adjusting the solar panel orientation

Once the solar incidence varies according the coordinates in the globe, you need to check the most useful position of the solar panel.

Adjusting Tilt:
Check this link to ensure the correct angle https://www.solarpaneltilt.com/

Adjusting Azimuth
Face the equator, opposite from the nearest geographical pole (for example, face north in the southern hemisphere).

You’re all done -- congratulations! :)