Intel-IrriS

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION
IN THE MEDITERRANEAN AREA

Intelligent Irrigation System for Low-cost Autonomous Water Control in Small-scale Agriculture

Intel-IrriS

Building the Intel-IrriS LoRa IoT platform
Part 1: soil sensor device

PRIMA
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Prof. Congduc Pham
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UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR

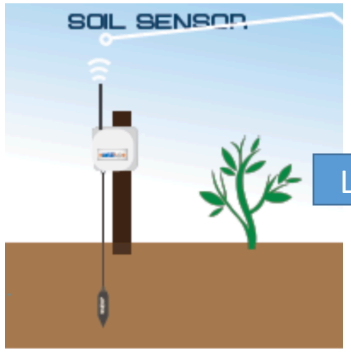
LIUPPA

WAZIup
IoT – from idea to reality
WAZIhub

Review: Technology components

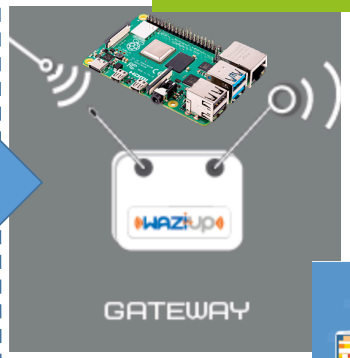
Sensor part

Intel-IrriS



LPWAN

Control part



Embedded Database

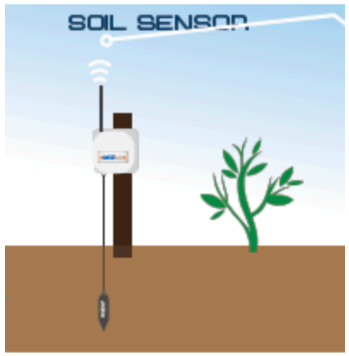
Software updates

Embedded User Interface

Review: Low-cost sensors

Sensor part

Intel-IrriS



- Build on low-cost, low-power IoT expertise
- Increase accuracy of low-cost sensors by automatic and remotely controlled procedures for advanced calibration
- Enable deployment of several complementary low-cost sensors
- Include agricultural models / knowledge with corrective & predictive analytics

Review: Smart embedded control

- Build on low-cost embedded & open IoT gateway expertise
- Implement the “Intelligent Irrigation in-the-box” with "plug-&-sense" approach
- Model complex water-soil-plant interaction
- Embed Decision Support System (DSS) and disruptive Artificial Intelligence (AI)
- Integration of various knowledge streams
- Fully autonomous

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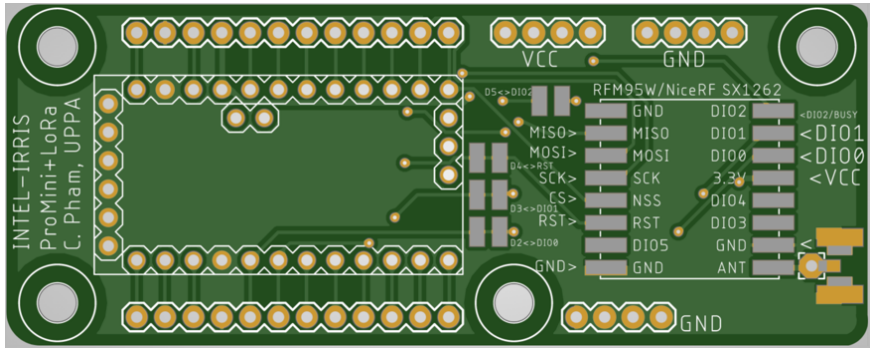
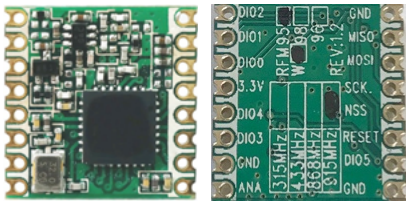
Review: Starter-kits

- "Intelligent Irrigation in-the-box", "plug-&-sense"
- At least 100 starter-kit will be distributed

Soil sensor: electronic parts

complete version

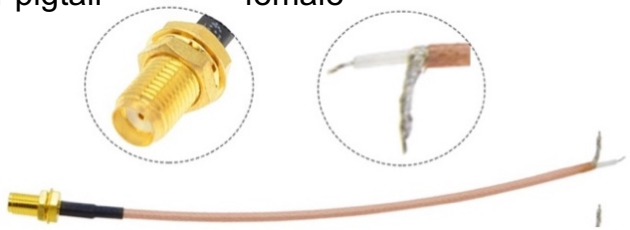


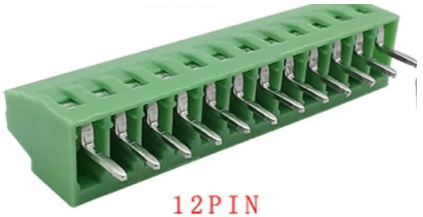


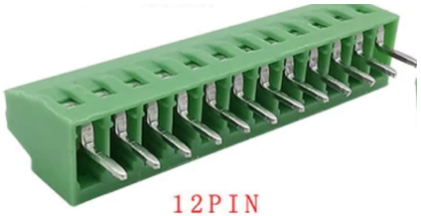
RFM95W (868MHz)
RFM96W (433MHz)
NiceRF SX1262 (868MHz)
NiceRF SX1268 (433MHz)
NiceRF SX1280 (2.4GHz)

PCB mount
or pigtail

SMA
female



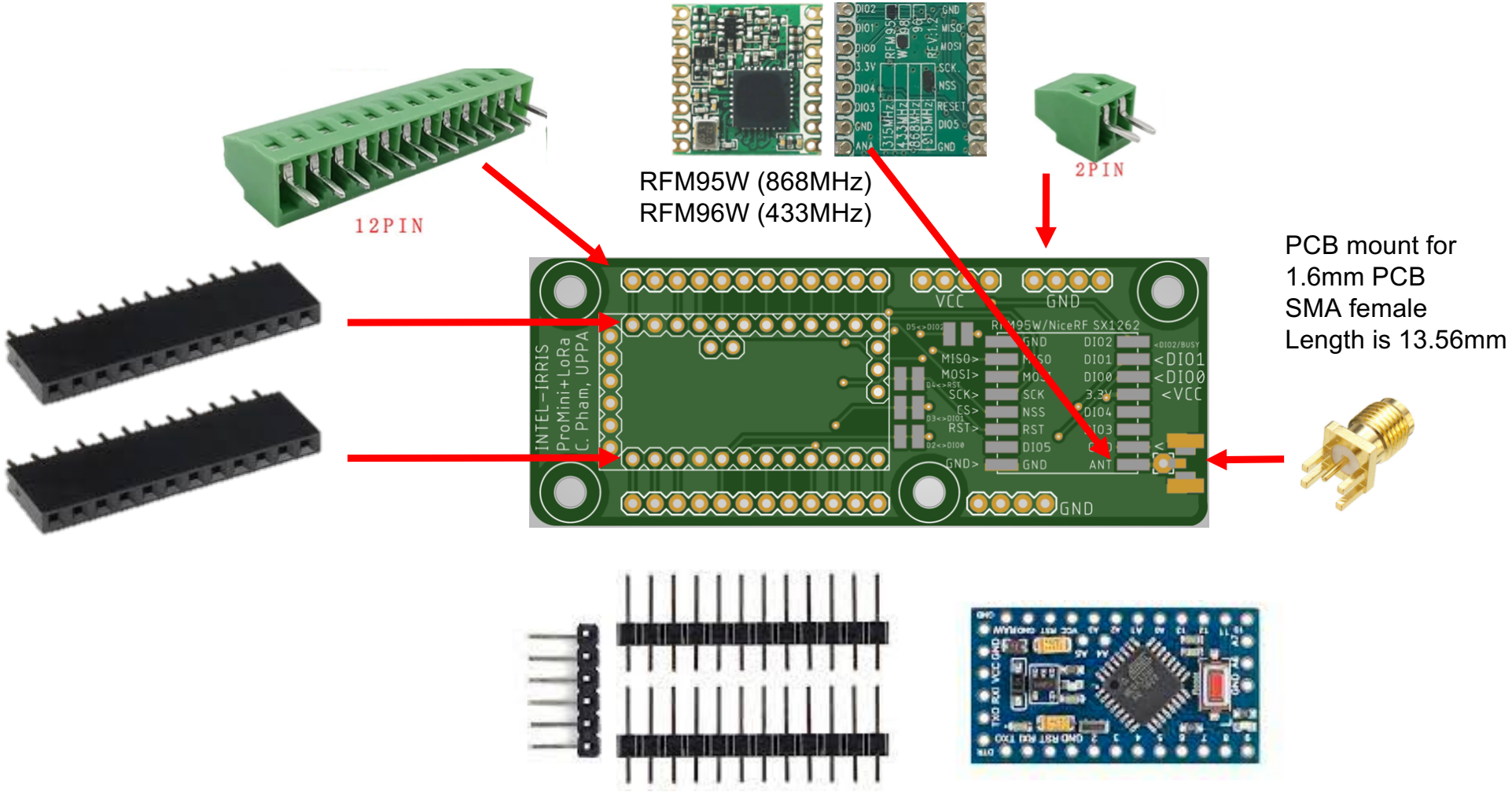




SMA
male

Soil sensor: electronic parts

starter-kit version

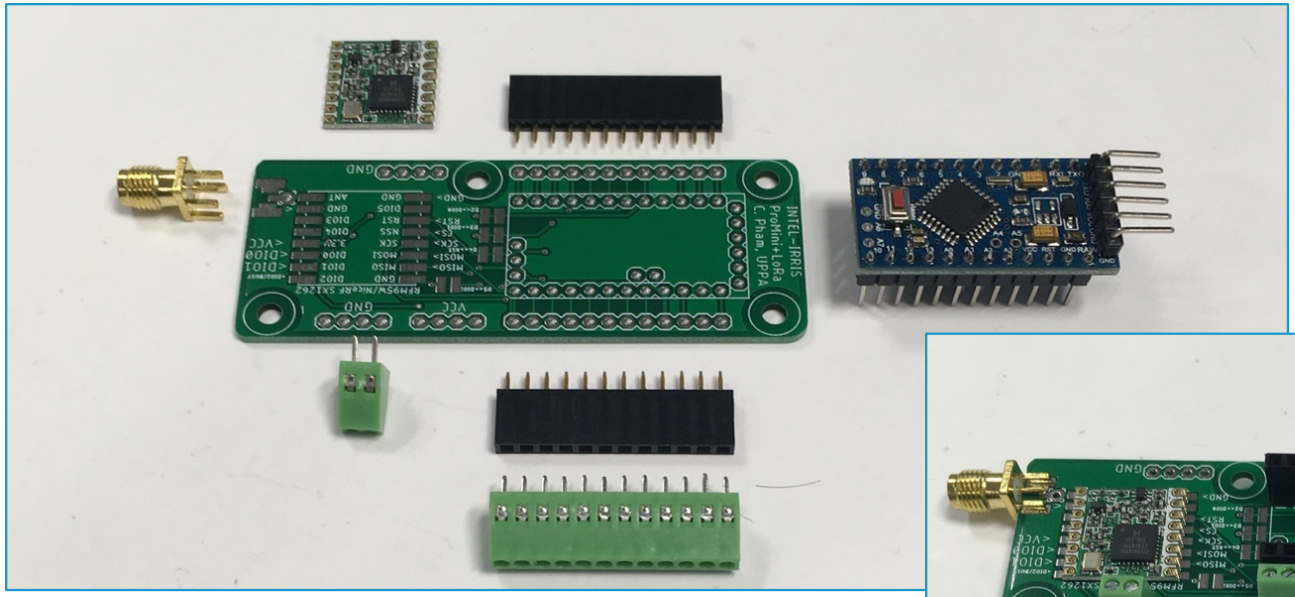


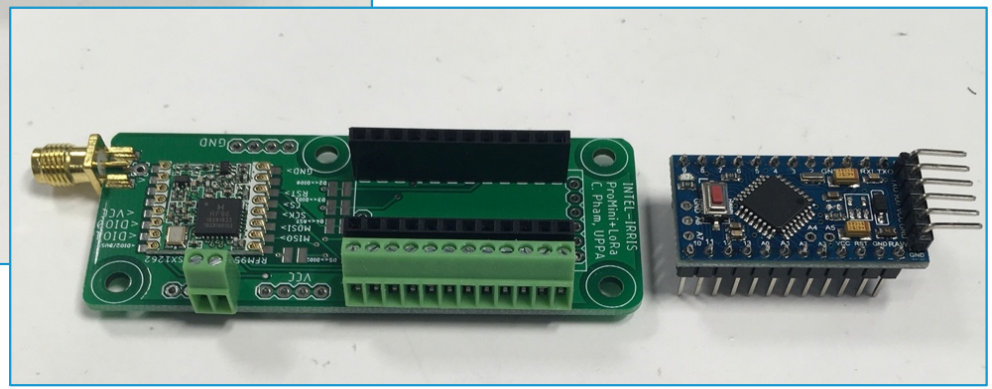
Arduino ProMini 3.3V 8MHz

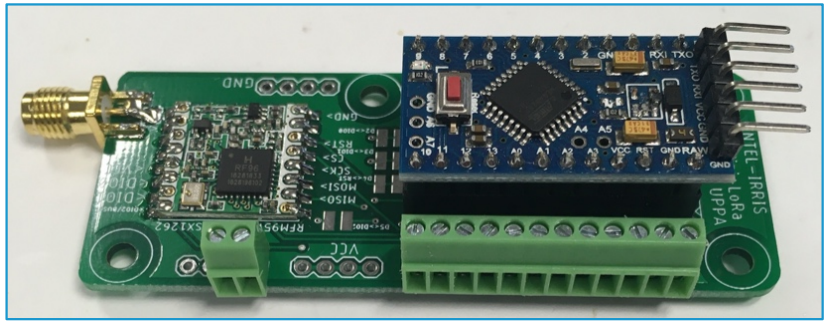
Soil sensor: enclosure & integration

proof-of-concept

Assembling the PCB board







This dedicated video will show how to solder all the components
Video n°1: https://youtu.be/3jdQ0Uo0phQ

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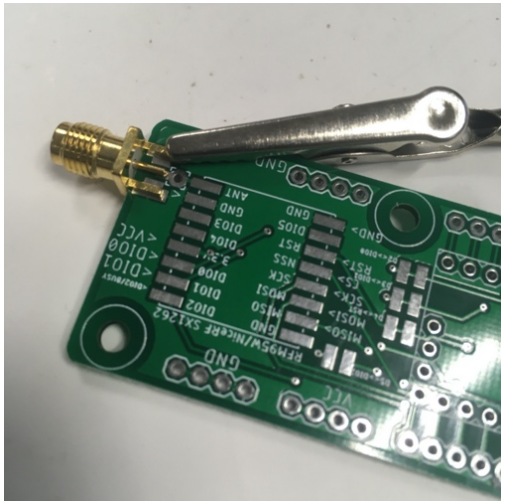
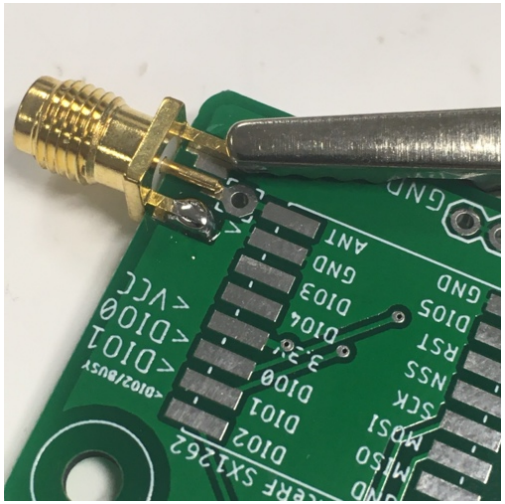
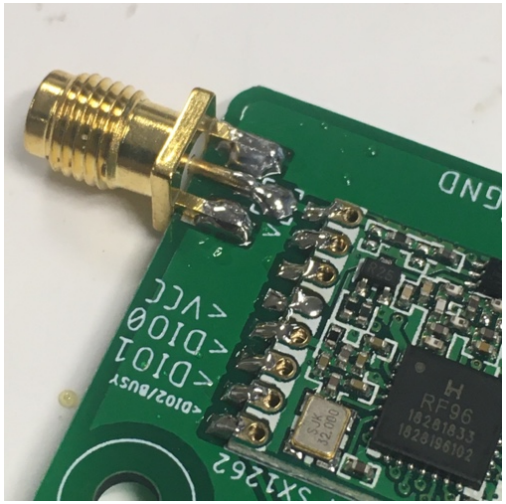
Updates

- Here are some updates on Video n°1
- Clip the SMA connector to the PCB to correctly align the connector before soldering one of the GND pad
- Remove clip and finish soldering
- Make sure that the GND pads and the central pin are not touching each other, in doubt, do a continuity check







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Good soldering

- It is important to have good soldering to avoid any issue when deploying the devices
- Check this great soldering tutorial from Collin's lab
  - https://youtu.be/RB4P1HTmwLc

- Just put the required amount of lead, too much lead is not good!
- It is not a bad idea to train on soldering before making the device and not waste electronic components

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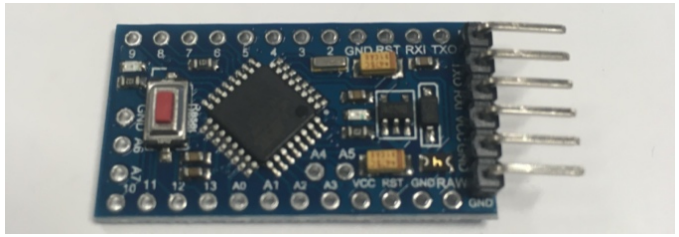
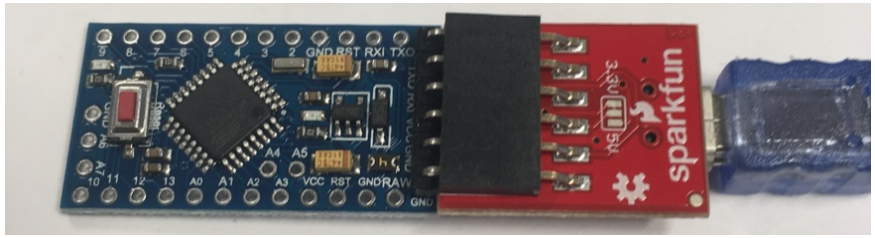
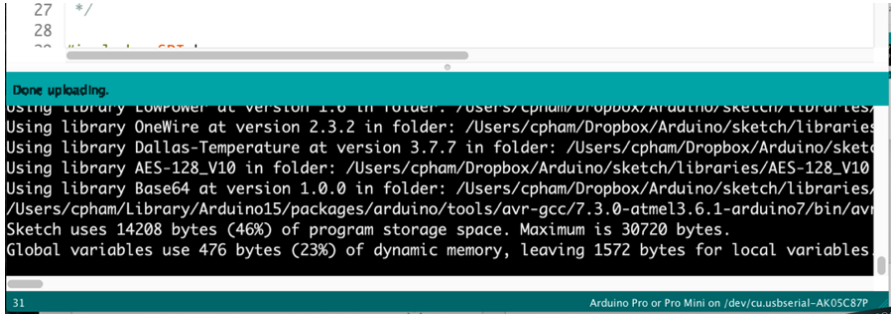
Check the Arduino

- First, just solder the programming header





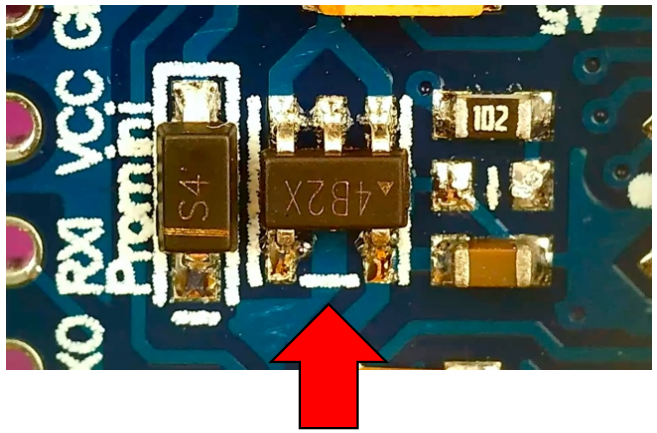
- To flash the Arduino board with the INTEL-IRRIS code
- See slides from "Getting the software: Arduino IDE" to "Uploading to your board"
- If uploading is successful, then you can continue with soldering the remaining header pins, otherwise, take another board as this one may have hardware issue



Never transmit without antenna

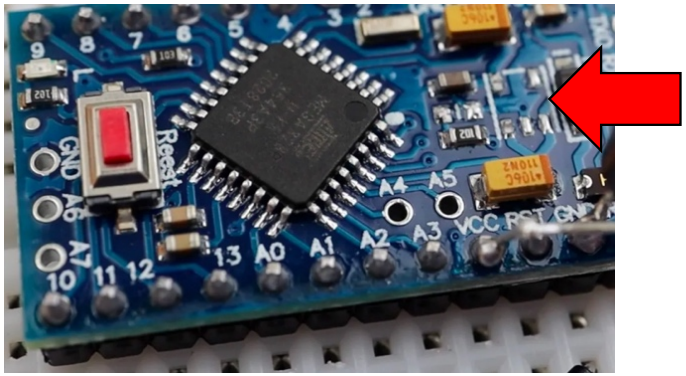
- NEVER, NEVER transmit without an antenna
- Doing so can damage the radio module
- If your board is already connected to the radio module and you need to flash the board, connect the antenna
- If you need to update the existing code and your device already run a code that transmit data, connect the antenna
- It is safer when programming the device to remove the Arduino board from the female header and program it disconnected from the radio module
- If you deploy a device, make sure that the antenna is correctly connected before powering on the device and realizing any transmission test

Reduce power consumption



Do not forget to remove the power LED by just clipping it off with some wire cutters

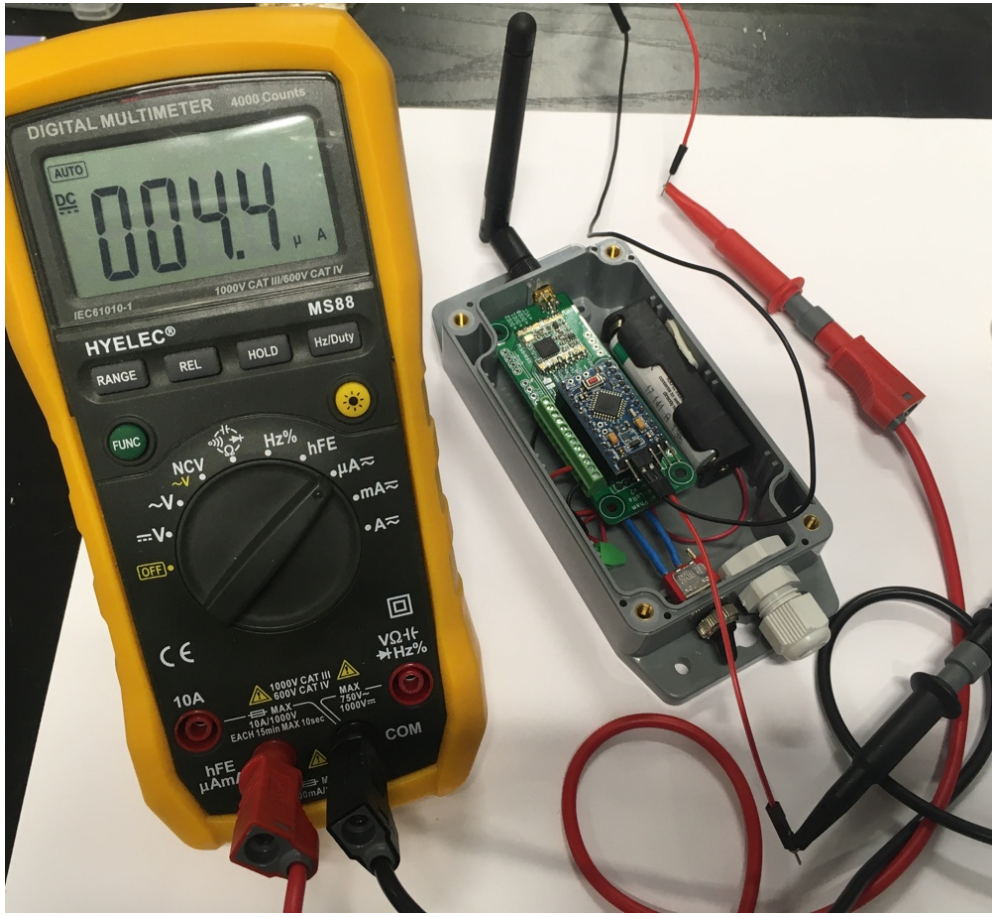
Do not forget to remove the voltage regulator with a small plier



Only inject up to 3.6V through the VCC pin

https://www.the-diy-life.com/making-an-ultra-low-power-arduino-pro/

Power consumption in deep sleep



Measured below 5uA in deep sleep, between 2 active periods with transmissions

Expected autonomy with 1 transmission / hour is over 2 years with either 2 AA batteries or 1 AA 3.6V Lithium battery

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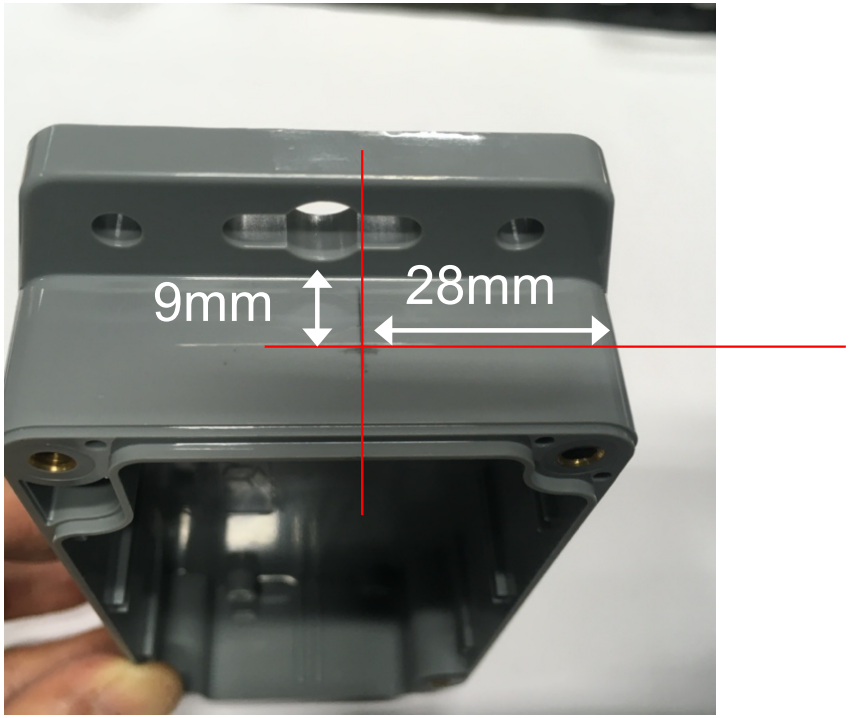
Get an enclosure for outdoor usage

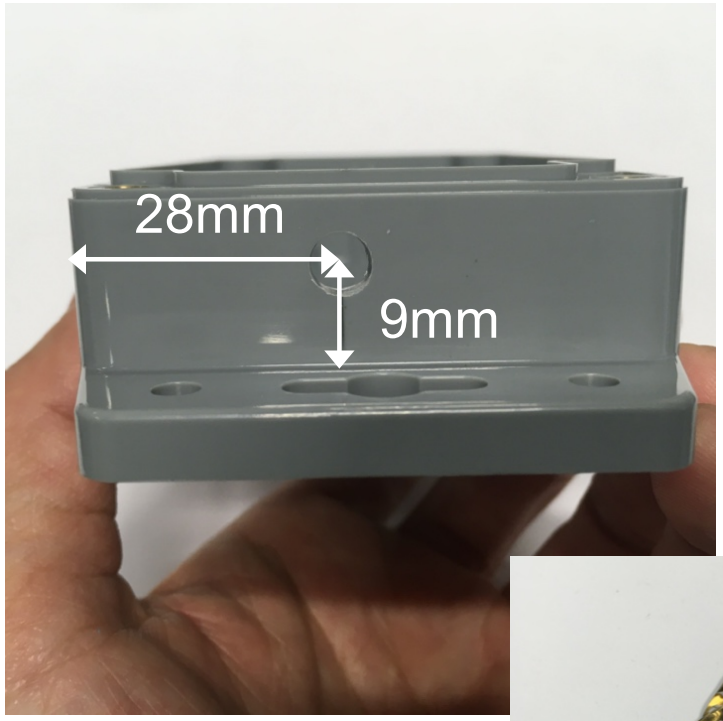
Here, it is an IP65 box which dimension is 115 x 65 x 40mm
https://www.gotronic.fr/art-boitier-abs-etanche-g304m-17977.htm

Drilling machine and drilling bits

At least a simple cordless drilling machine is necessary
If you have a (small) bench drilling machine it is of course better
Then you need an assortment of drilling bits for metal, not for wood nor concrete! Here, you will mainly need 7mm and 13mm bits
It is also interesting to have step drill bits

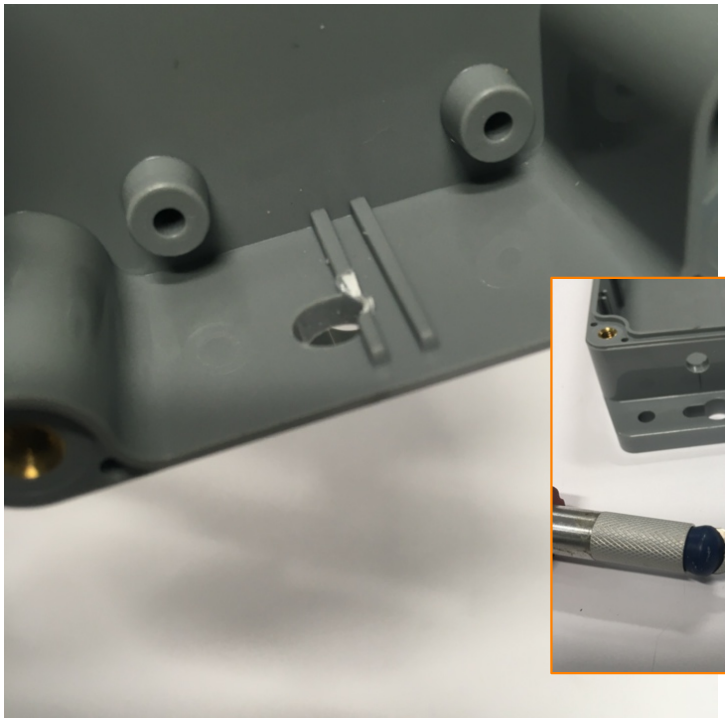
Drill a hole for the SMA connector

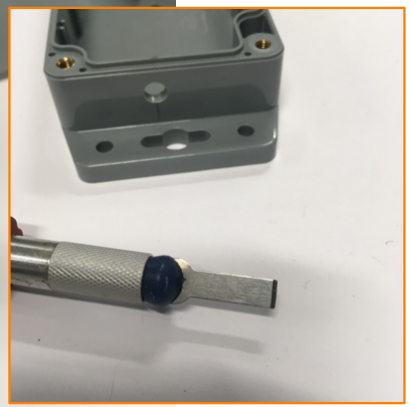




28mm for the right edge:
- measure from the flat side as the corner is round
9mm from the outside bottom
use a 7mm drill bit for metal, not for wood nor concrete!

Remove unwanted plastic part

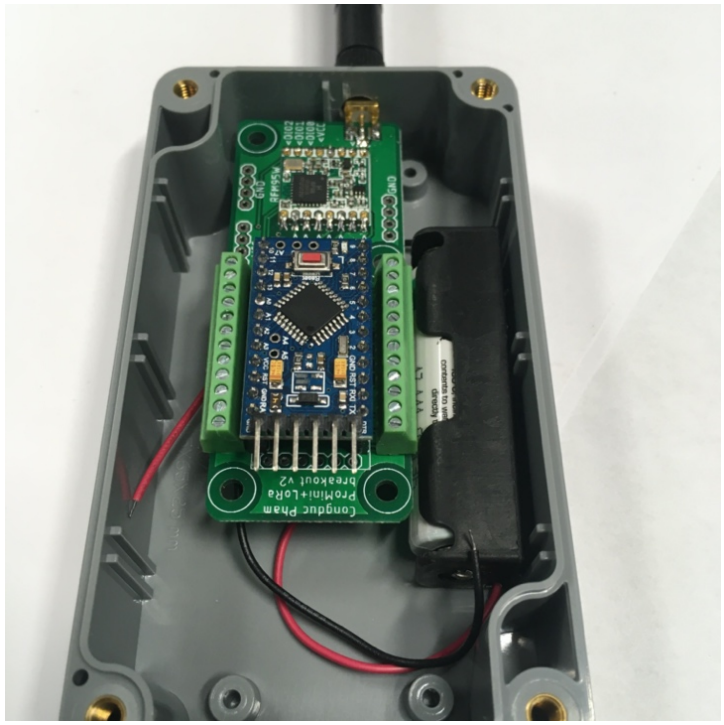




we need to remove the plastic reinforcement part for this particular enclosure

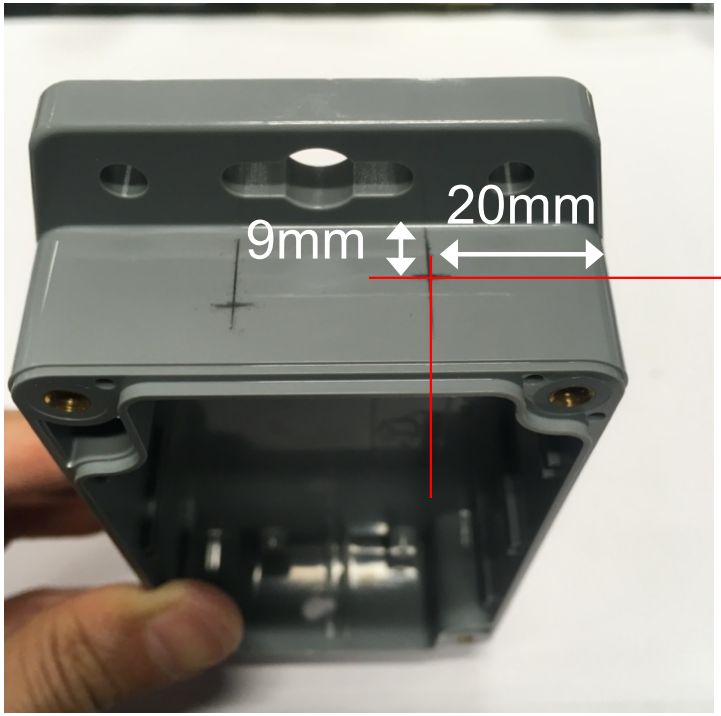
use a flat cutter for instance to remove and smooth the inside part (a small plier can be used first to remove most of the part)

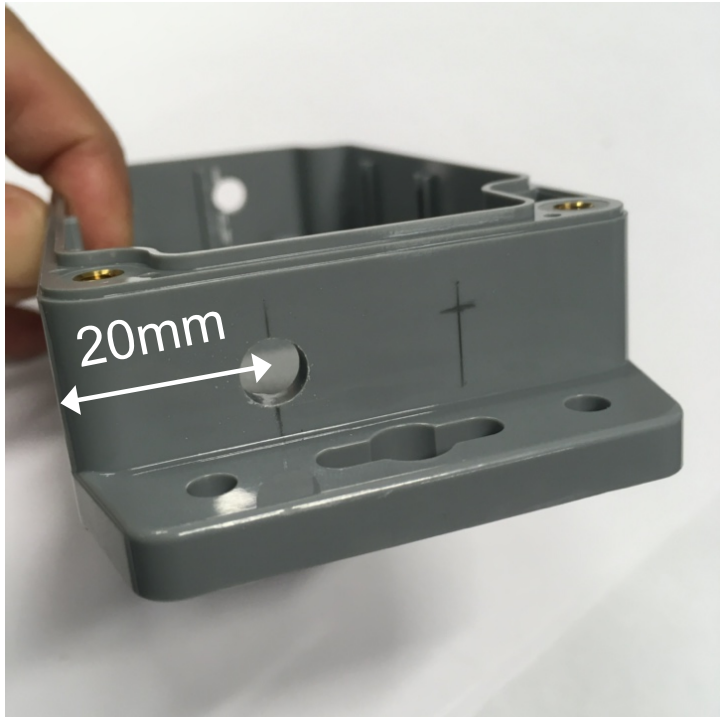
Placing the PCB board



- the PCB board can be placed, with the SMA connector going through the hole
- both 2-AA (left) and 1-AA (right) battery holder can be used

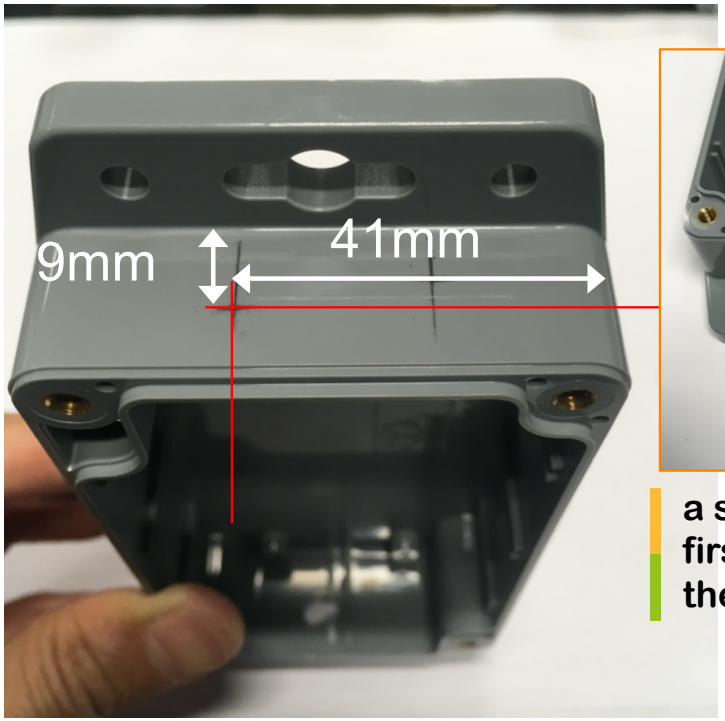
Drill a hole for the external switch



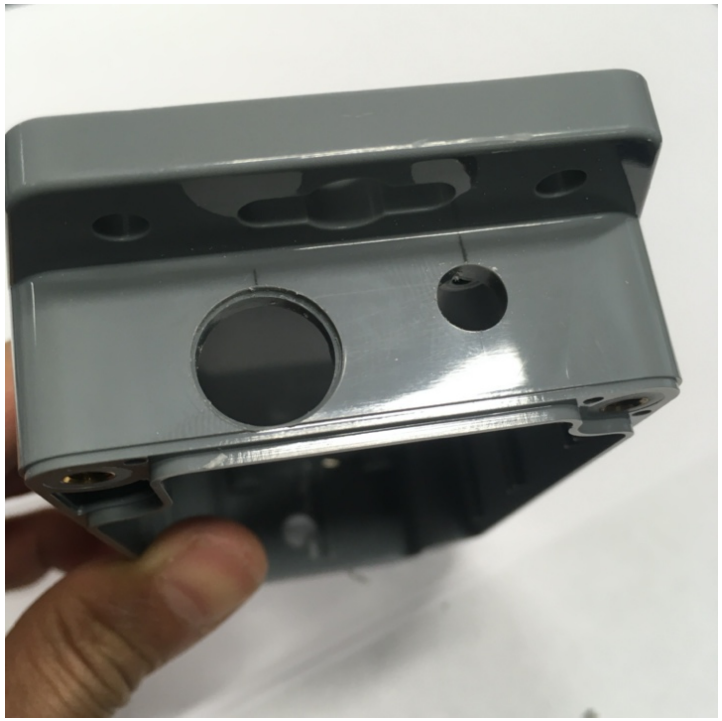


20mm for the right edge:
- measure from the flat side as the corner is round
9mm from the outside bottom
use a 7mm drill bit for metal

Drill a hole for the cable gland



a step drill bit can be used
first, drill to 12mm
then use a 13mm drill bit

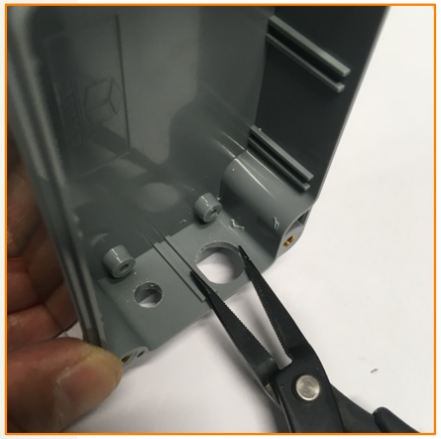


41mm for the right edge:
- measure from the flat side as the corner is round

9mm from the outside bottom

use a 13mm drill bit for metal

Remove unwanted plastic part



again, we need to remove the plastic reinforcement part for this particular enclosure

use a flat cutter for instance to remove and smooth the inside part (a small plier can be used first to remove most of the part)

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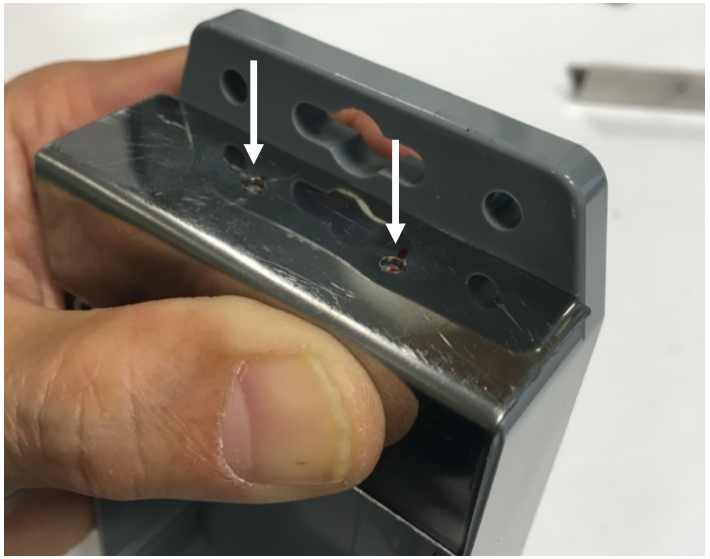
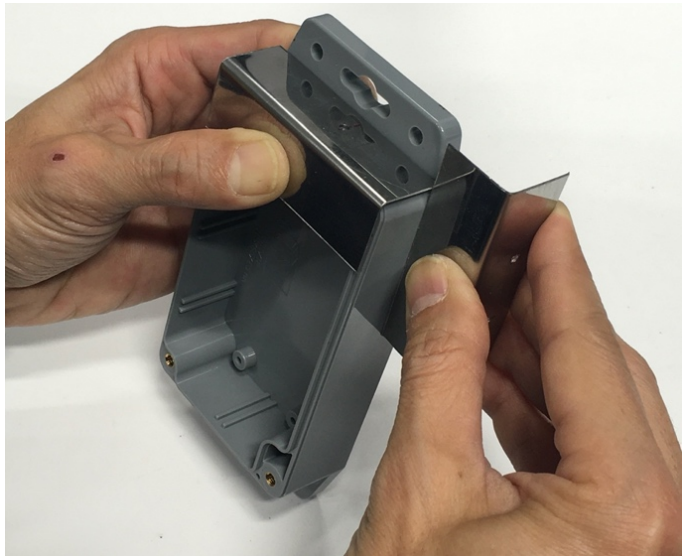
Going for larger production





If you need to prepare many enclosures, it may be faster to first make an assembly jig (here a piece of metal) for marking the holes

But be sure to precisely align the edge of the jig with the edge of the enclosure

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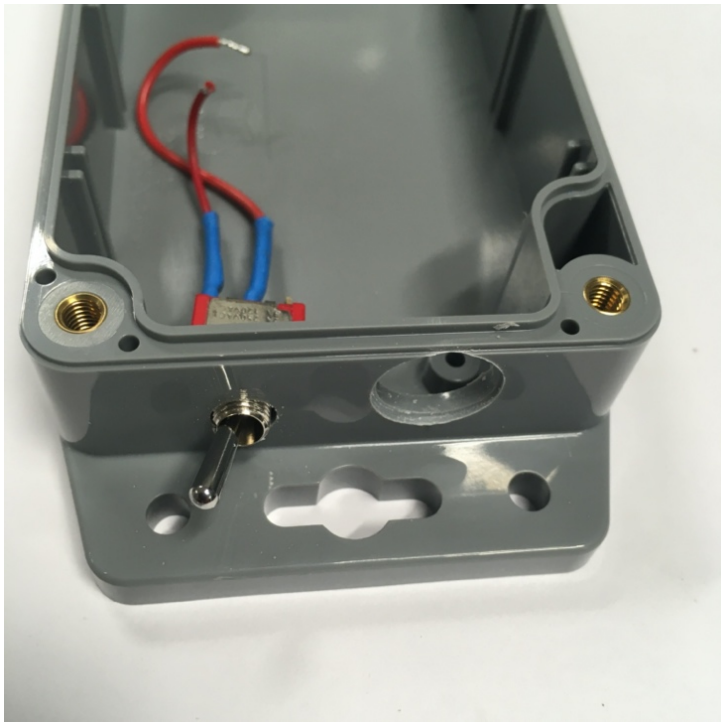
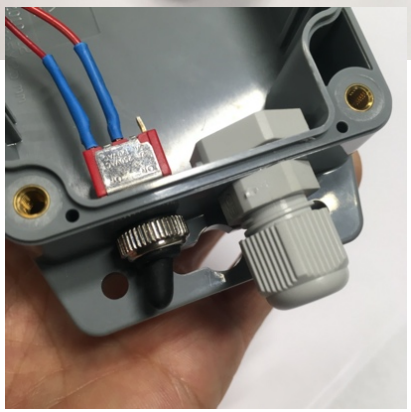
Placing switch and cable gland





- test that everything is OK
- the switch has a water-proof cap

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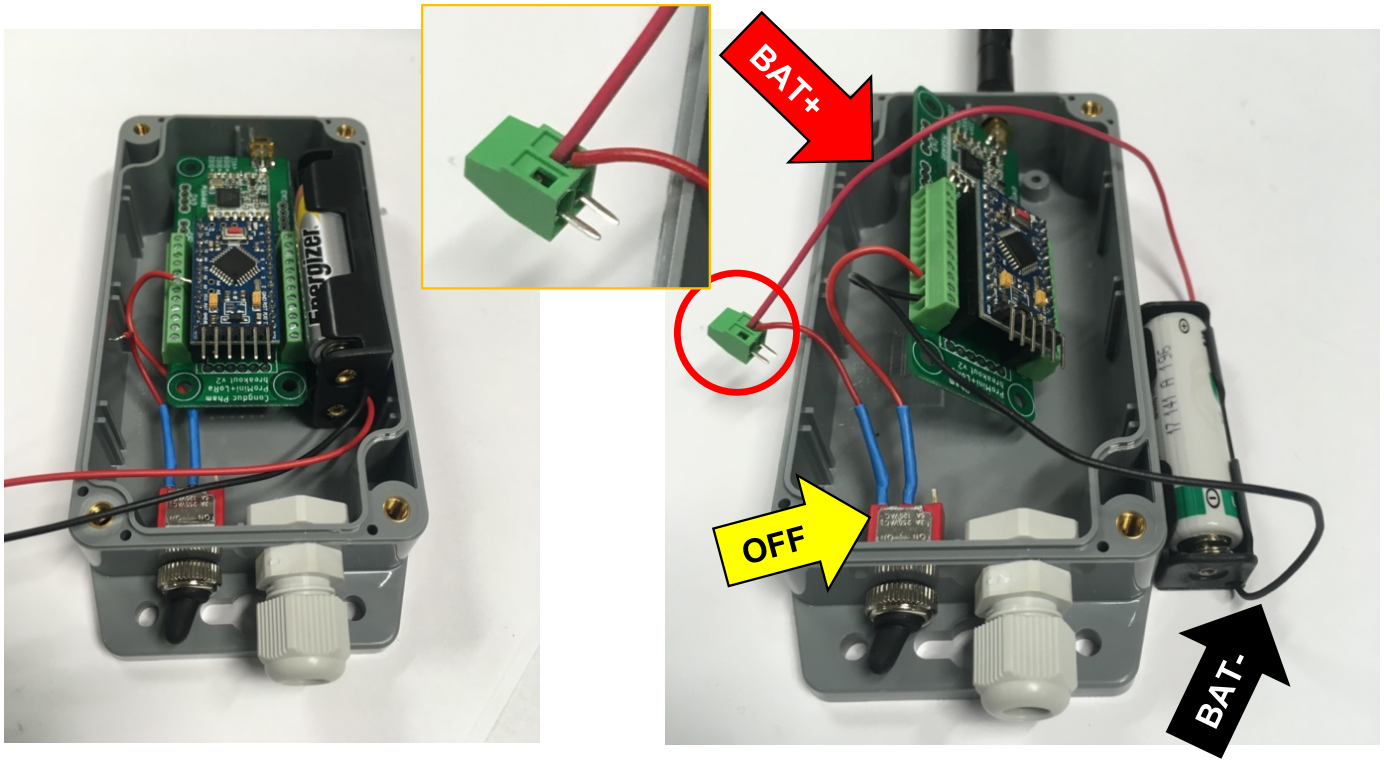
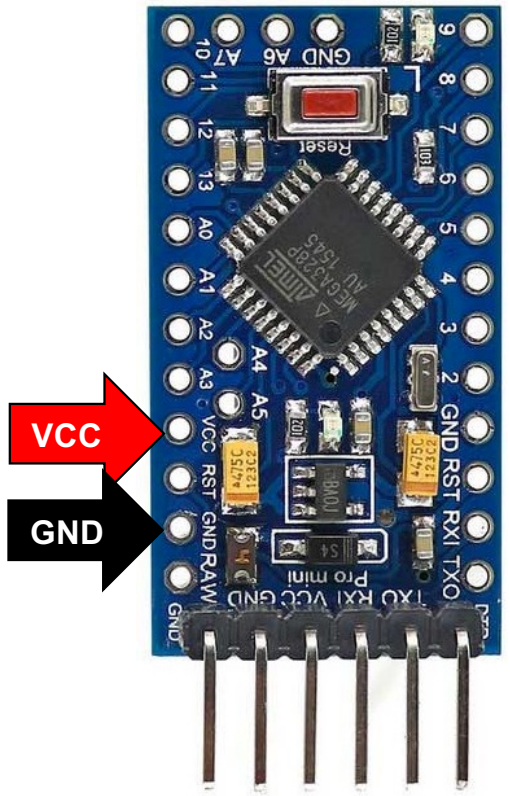
Connecting switch, battery & board





Connect <u>together</u> switch "off" pin (left) with BAT +
Connect directly switch "on" pin (middle) to board's VCC
Connect directly BAT – to board's GND
Toggling the switch to the right will then power the board

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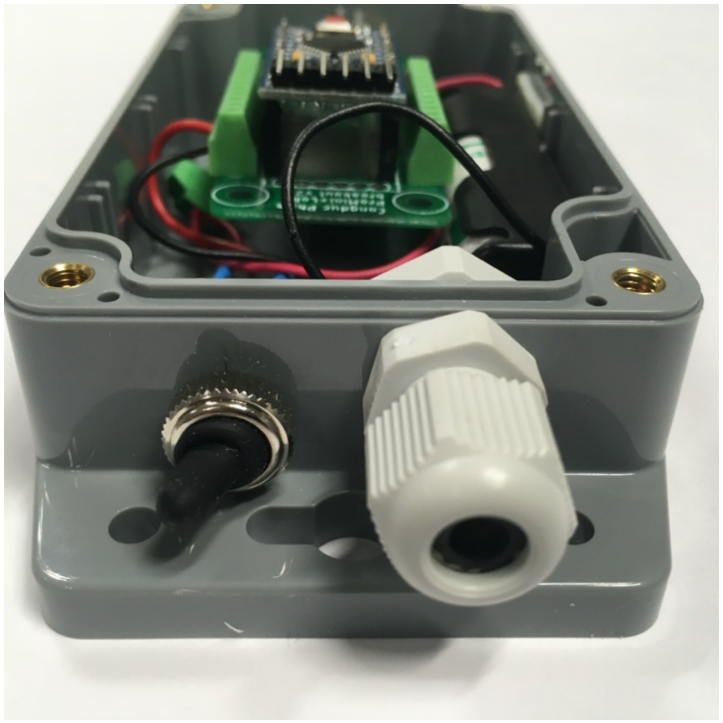
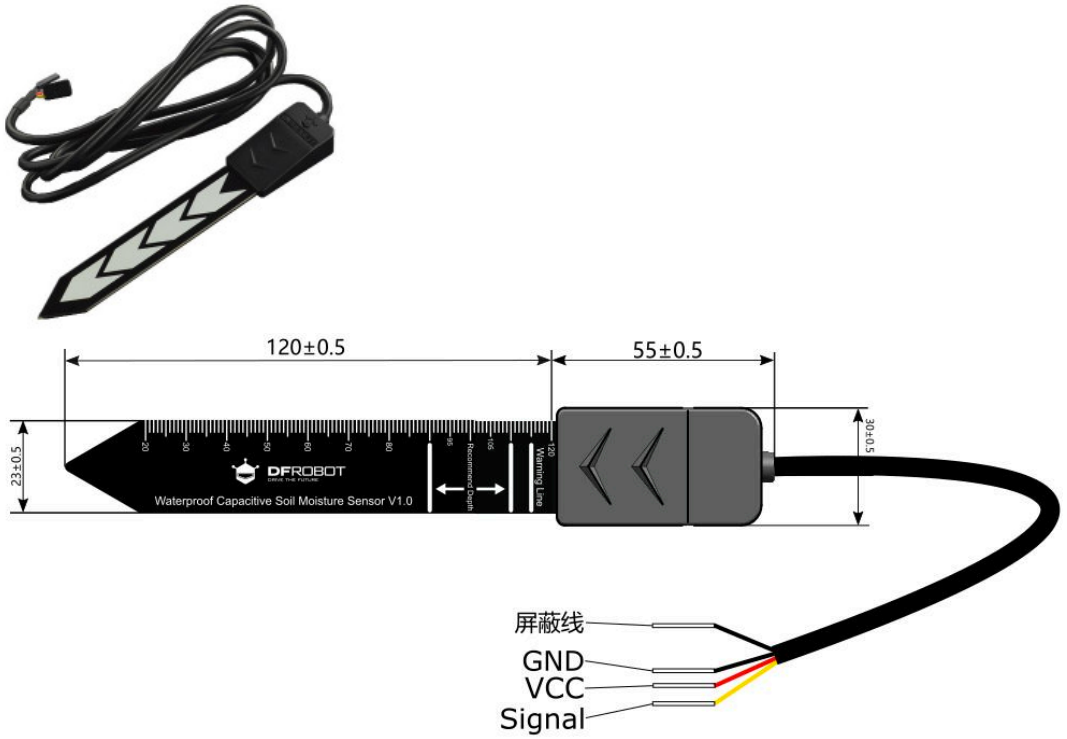
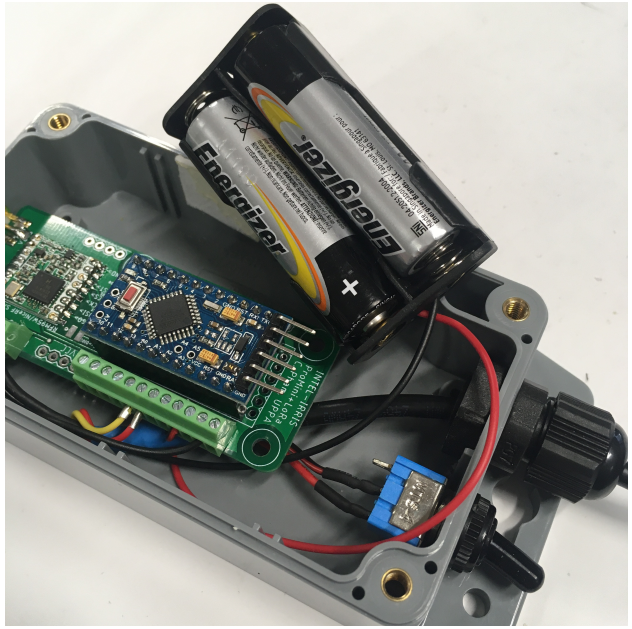
Wire the SEN0308 sensor

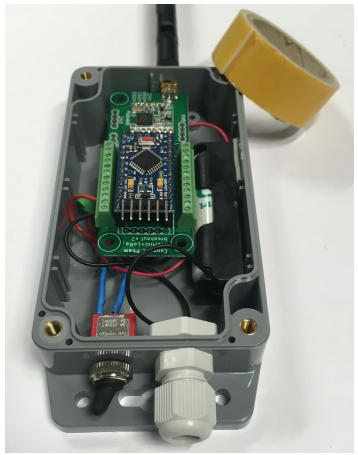




Insert sensor's wire through cable gland
Connect SEN0308's wires to board:
- **VCC to board's A1**
- **GND to board's GND (there are 2 GND wires)**
- **Signal to board's A0**

Putting it altogether





- You can fix the battery pack with double-side tape, e.g. those used to fix mirrors on wall
- You can also use a 3.6V lithium battery with a 1-AA battery holder
- This dedicated video will show how to build the outdoor soil device
  Video n°2: https://youtu.be/zcazzDbXvHk

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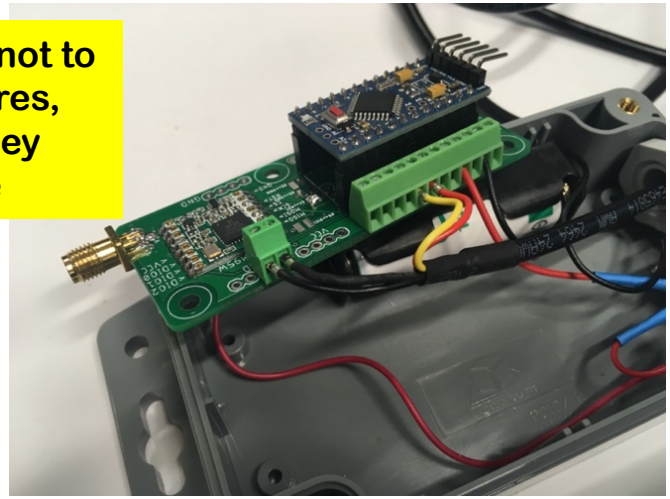
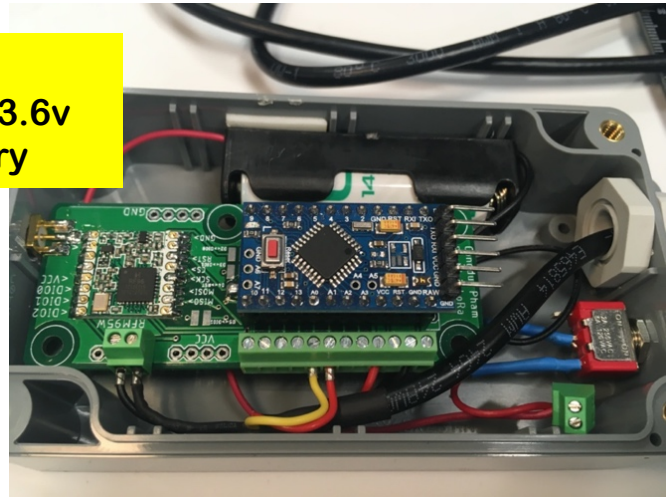
http://www.univ-pau.fr/~cpham

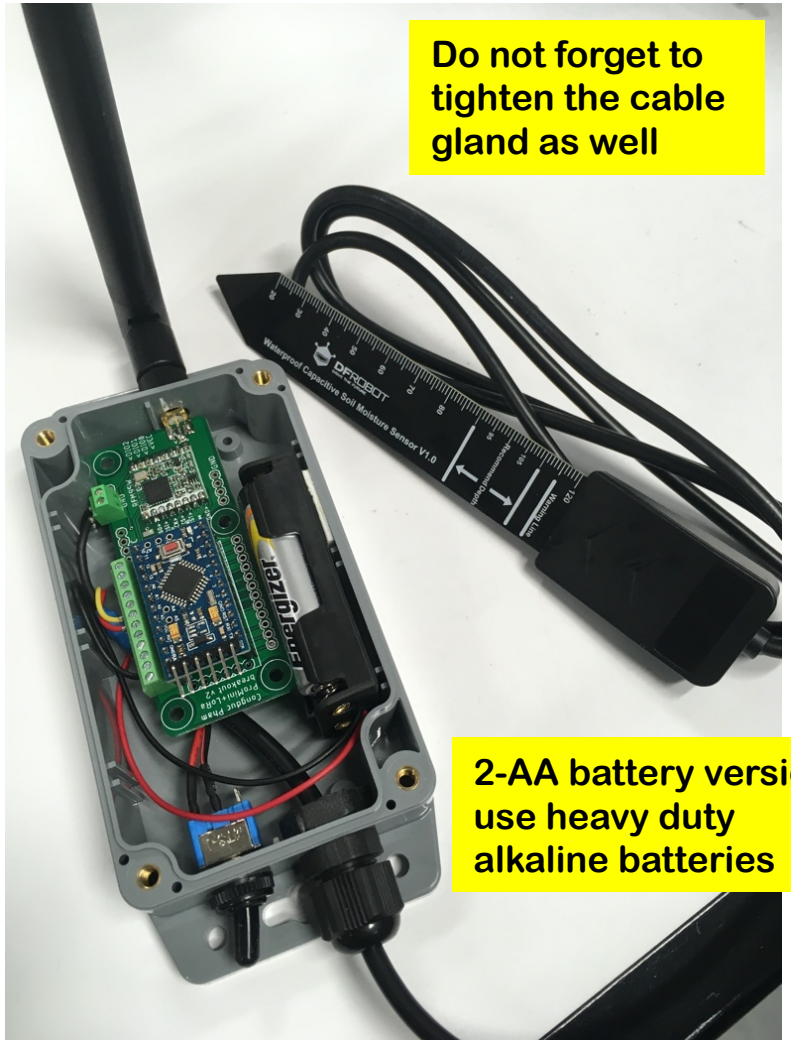
The complete soil sensor device

Tighten (but not to much!) all wires, check that they are not loose



1-AA battery version, use 3.6v lithium battery

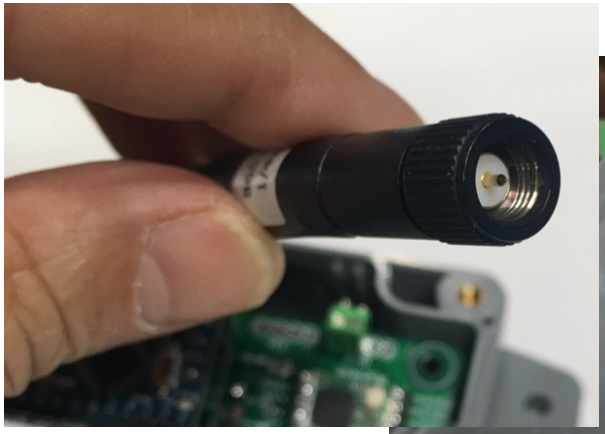


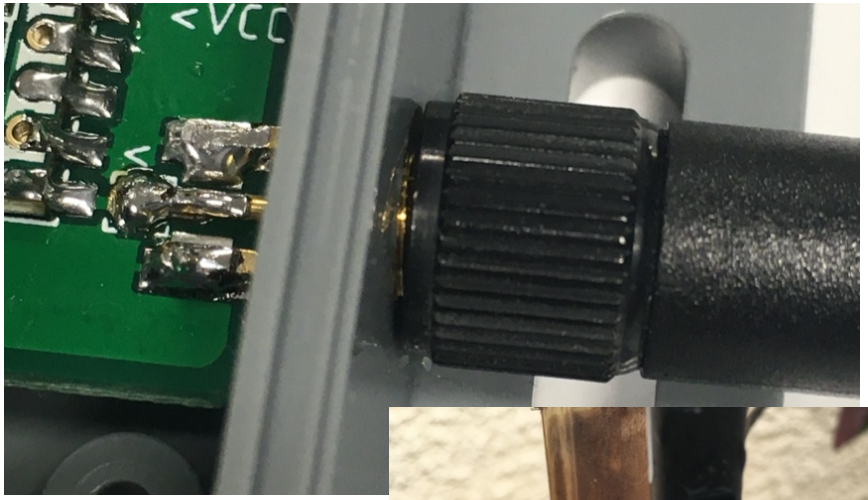


Do not forget to tighten the cable gland as well

2-AA battery version, use heavy duty alkaline batteries

Connecting antenna

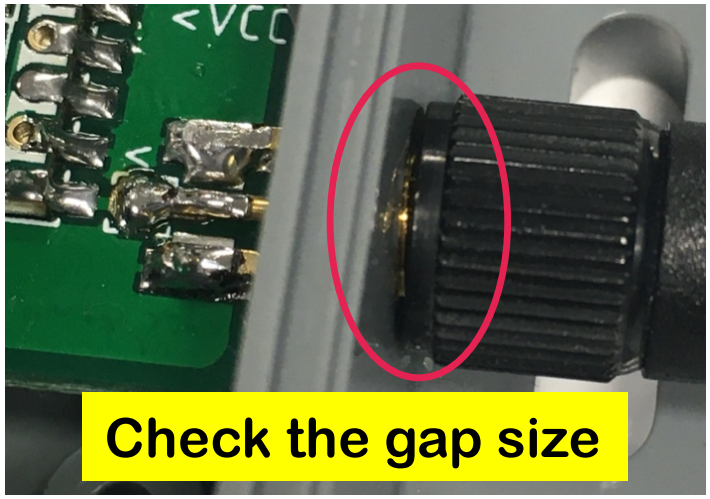


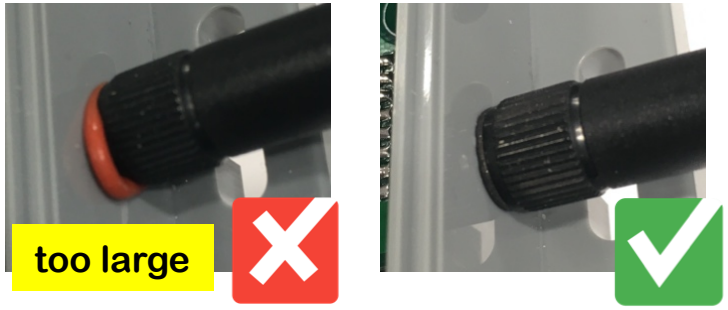


Be sure to connect the matching antenna
Here, SMA female with SMA male antenna
Need to screw the antenna in <u>all the way</u>

The antenna junction is critical because this is where rain water can come in

Waterproofing the antenna junction





Even when the antenna is screwed in all the way, there might still be a gap

Even with no apparent gap, it is necessary to waterproof the junction

Take an o-ring for that purpose, but do not take it too thick or too large!

Too thick: the antenna will not be screwed in all the way!

There are o-ring for SMA connector but the gap size is an indication

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http://www.univ-pau.fr/~cpham

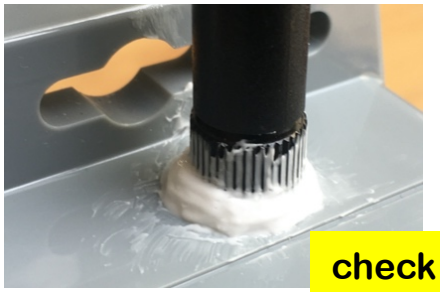
Do not have or can not use o-ring?

Maybe the gap is too big? Use silicon joint sealant

First, screw in the antenna <u>all the way</u>

Put small amount of silicon around the antenna junction (use a flat screw driver or other flat tool)

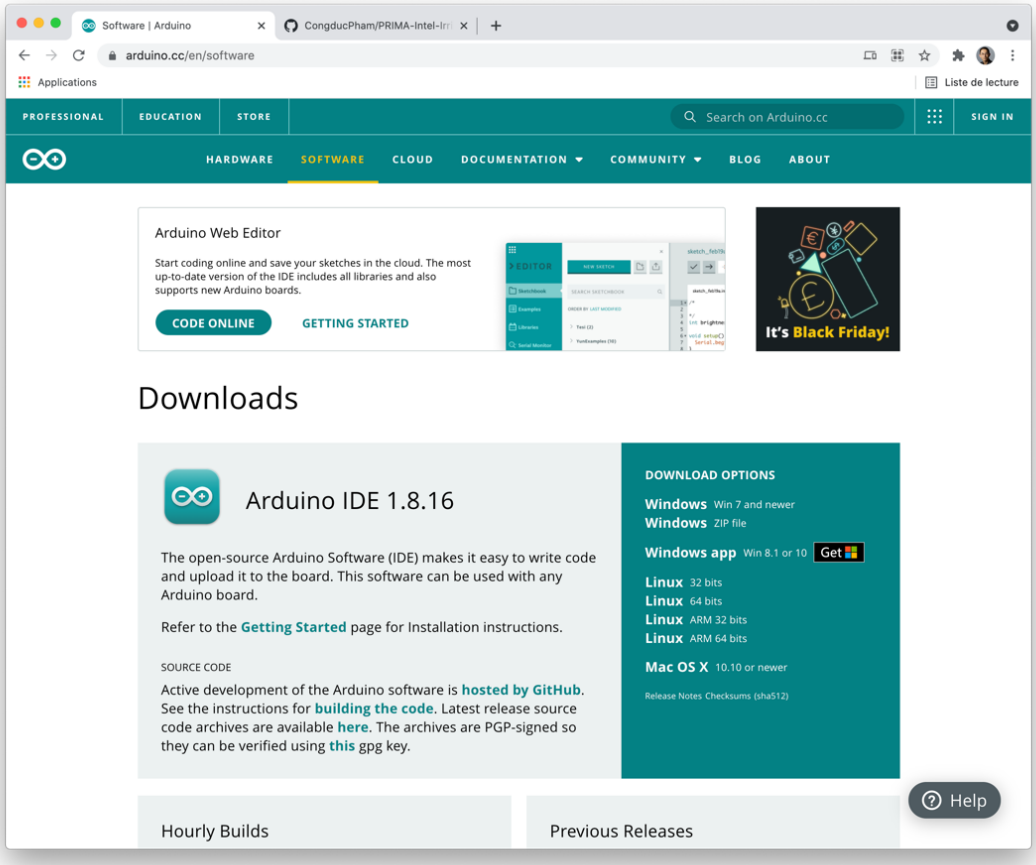
Use a <u>wet</u> toothpick to finish and clean the silicon all around the antenna junction

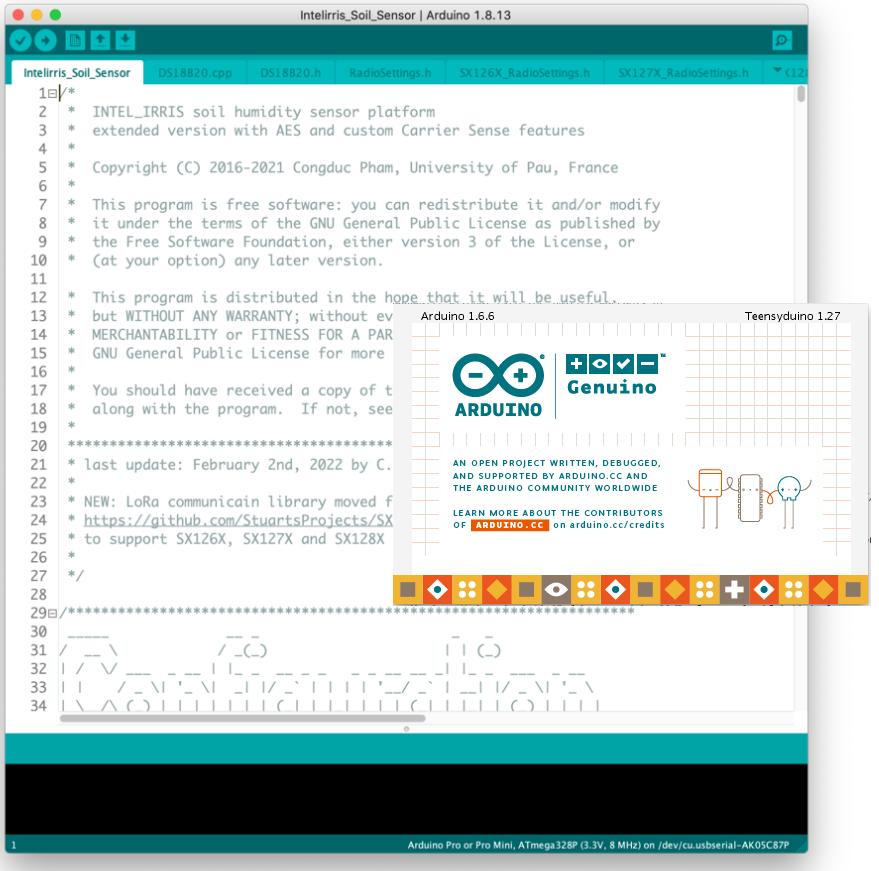


check especially the back side

Even with o-ring, it is good to add silicon!

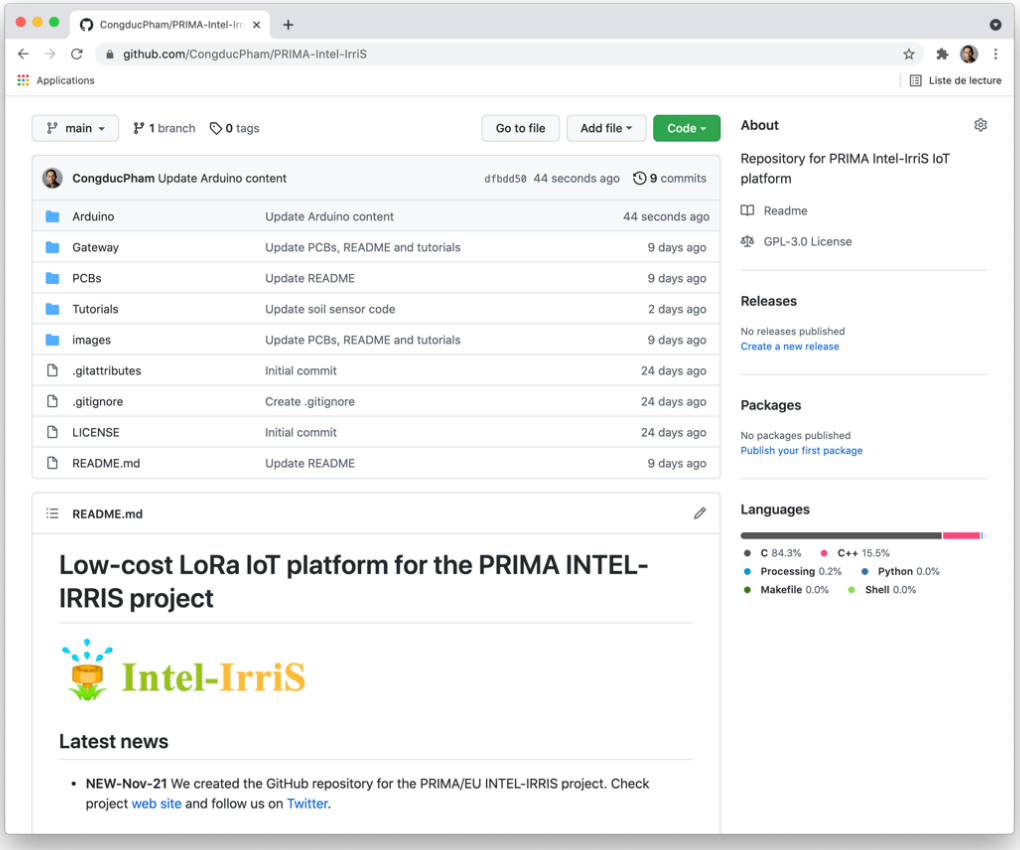
Getting the software: Arduino IDE





Install latest version of Arduino IDE from
https://www.arduino.cc/en/software

Getting the software: Intel-IrriS code



On your computer, create a `sketch` folder

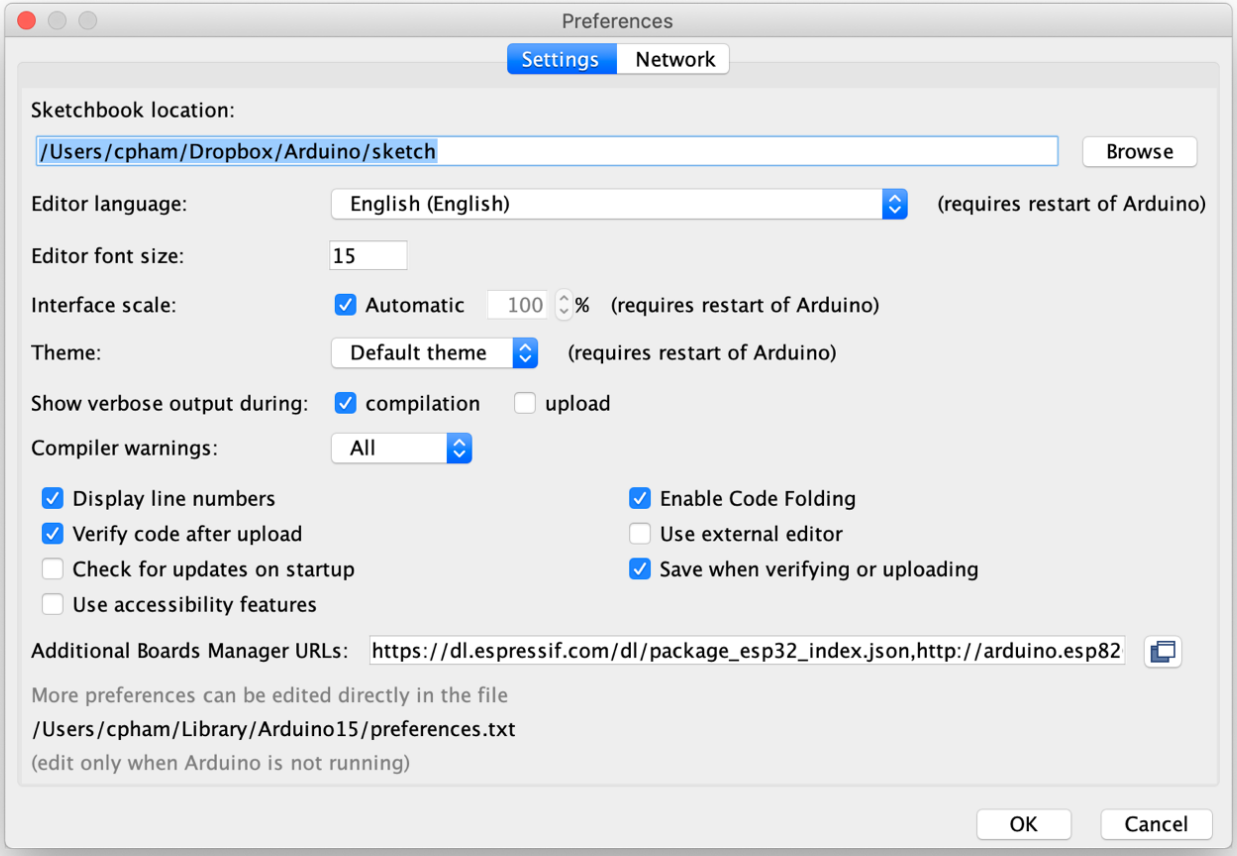
Then download the whole repository as ZIP file

Unzip the file and copy the content of `Arduino` folder into your `sketch` folder

The entire Intel-IrriS GitHub repository is hosted here
https://github.com/CongducPham/PRIMA-Intel-IrriS

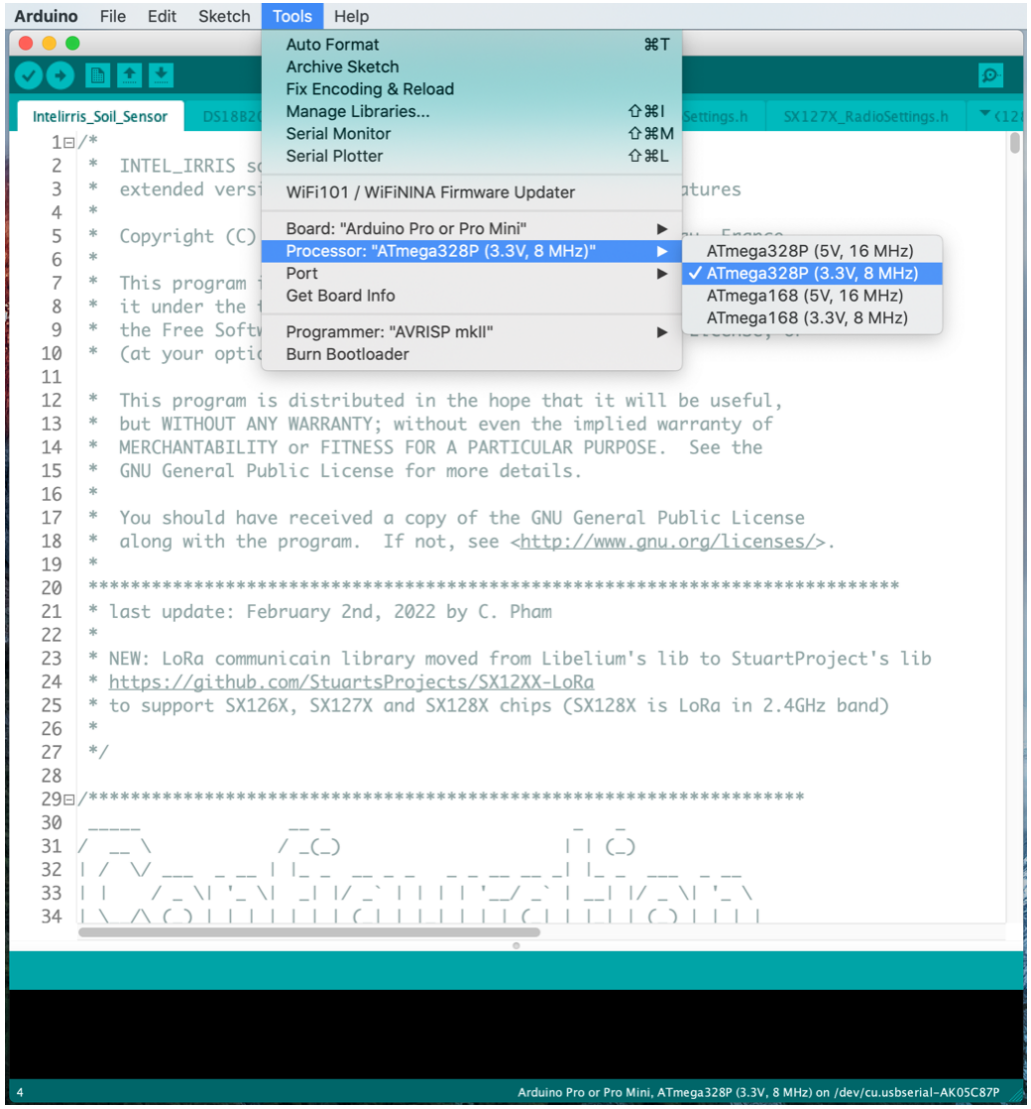
GitHub

Setting your Arduino IDE



Run Arduino IDE, open Preferences
Indicate your `sketch` folder in Sketchbook location

Compiling the soil sensor code



Open Intelirris_Soil_Sensor sketch – no change required

Select the ProMini board, 3.3V and 8MHz version

Then click on the "verify" button

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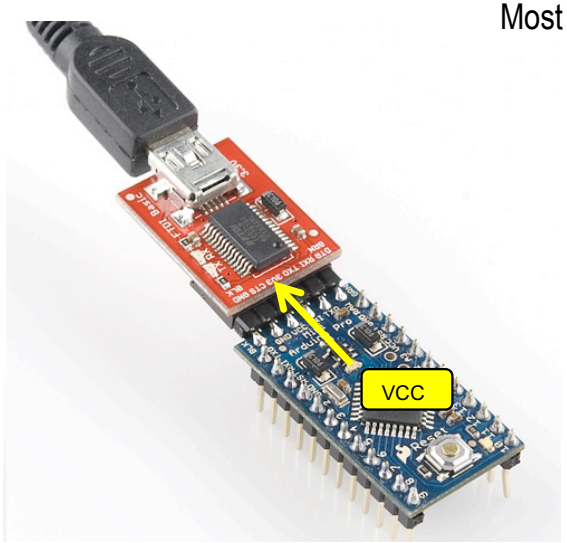
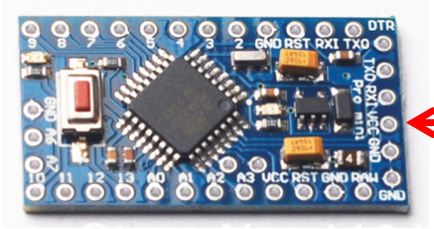
Never transmit without antenna

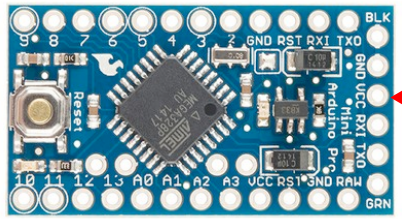
- NEVER, NEVER transmit without an antenna
- Doing so can damage the radio module
- If your board is already connected to the radio module and you need to flash the board, connect the antenna
- If you need to update the existing code and your device already run a code that transmit data, connect the antenna
- It is safer when programming the device to remove the Arduino board from the female header and program it disconnected from the radio module
- If you deploy a device, make sure that the antenna is correctly connected before powering on the device and realizing any transmission test

Connecting with an FTDI cable

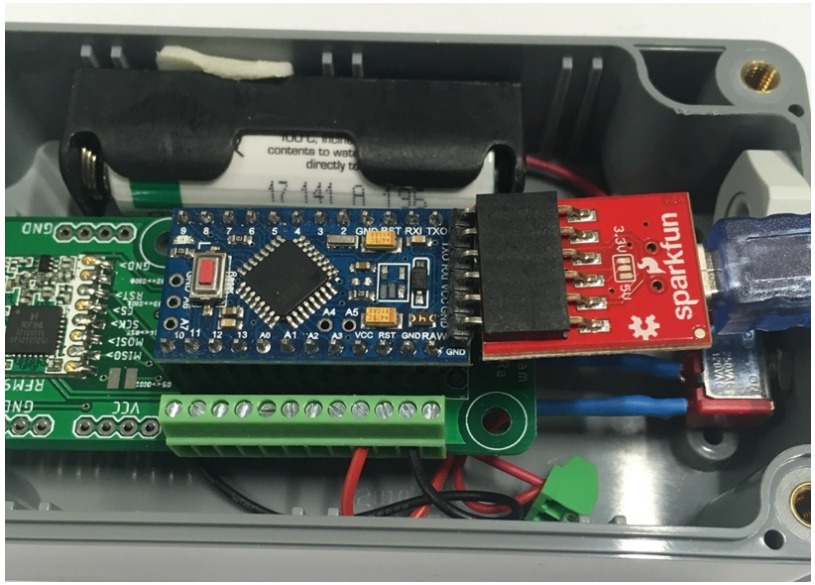


Most Chinese clone version, check the VCC pin





Original Sparkfun version



For the ProMini, you need to have an FTDI breakout cable working at 3.3v

Check the VCC pin position and make it to correspond to the VCC pin of the FTDI breakout.

Select serial port for uploading

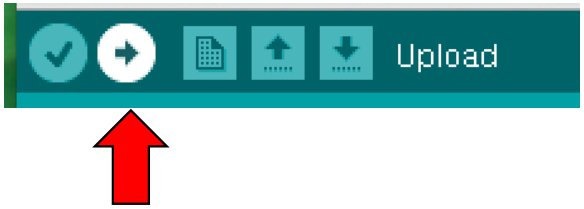
After connecting the cable to your computer/laptop USB port, try to find the serial port

If you don't find it, you may need to install specific drivers

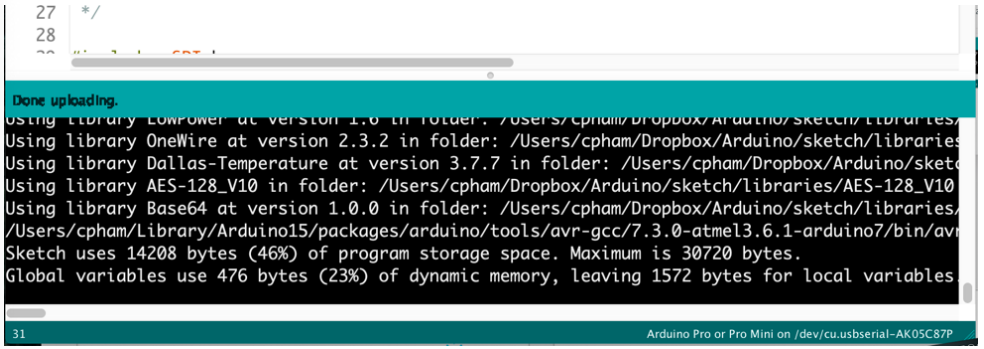
https://learn.sparkfun.com/tutorials/how-to-install-ch340-drivers/all

Uploading to your board

Click on the "upload" button



And wait until upload is completed



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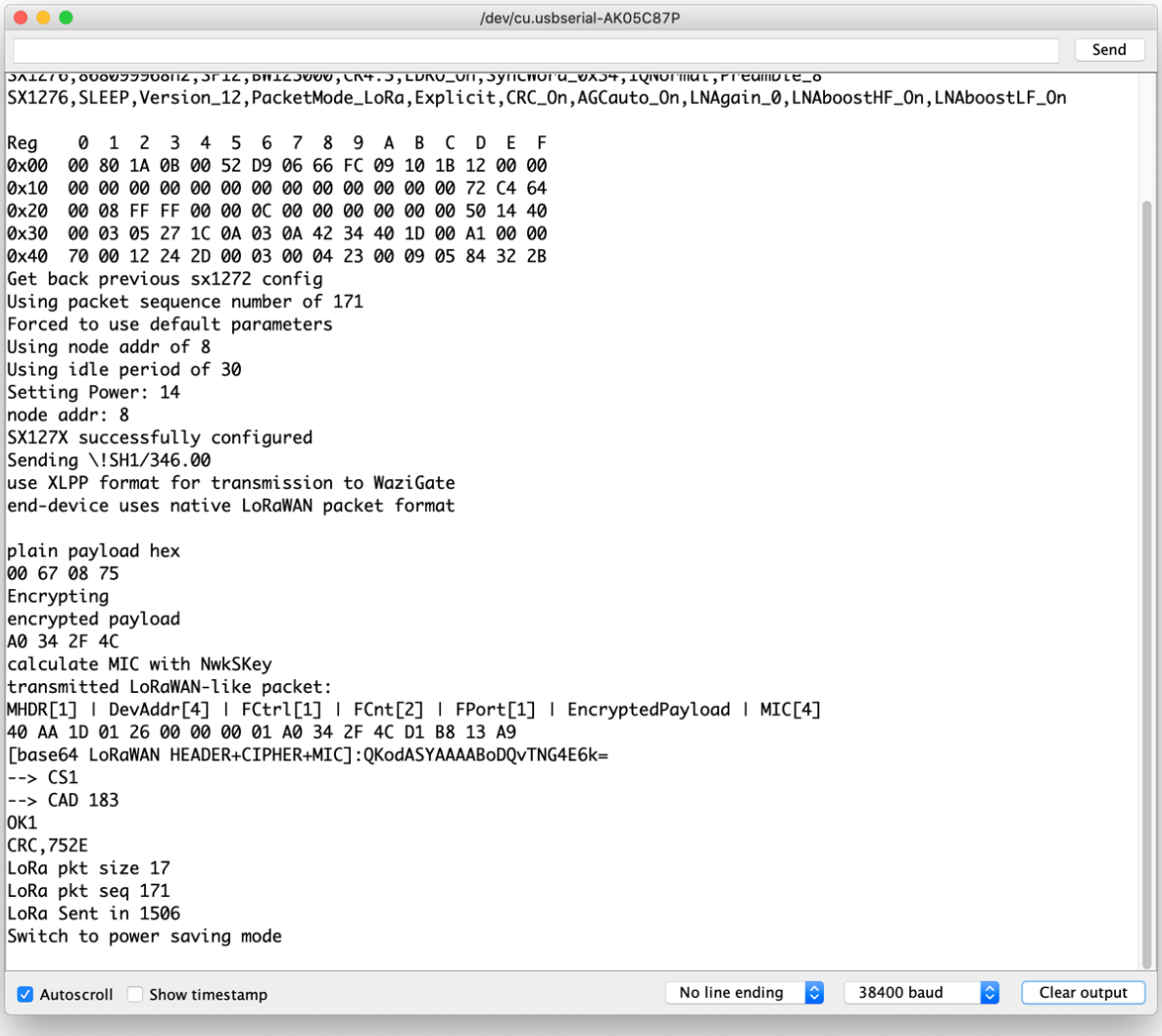
Checking that device is operational

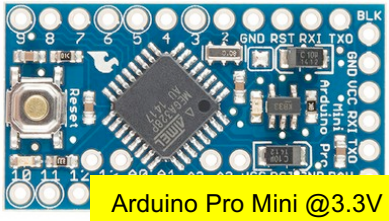


- Open serial monitor
- Set baud rate to 38400
- See output from board
- Check that transmission is OK

Generic & cyclic behavior

SEN0308
capacitive soil humidity
A0 (signal), A1 (power)

Physical sensor management



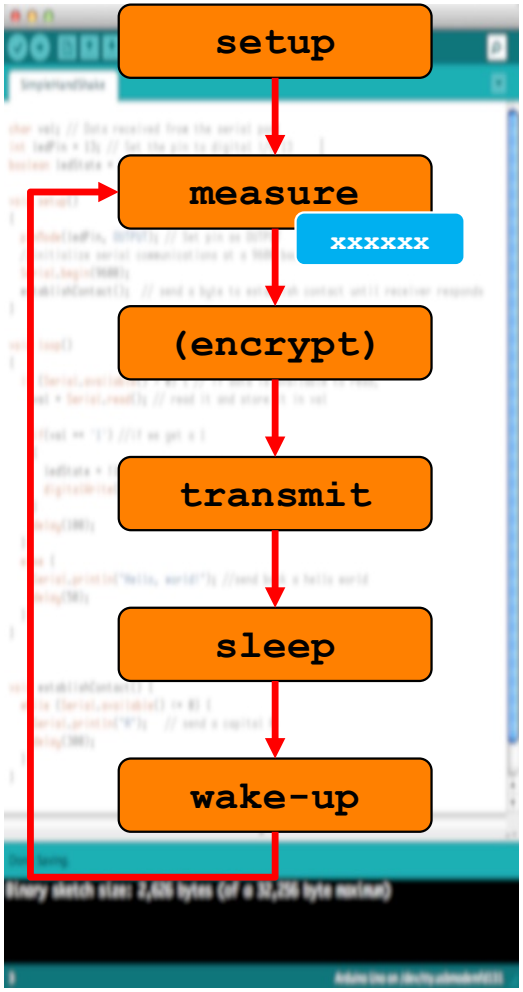
Arduino Pro Mini @3.3V

Activity duty-cycle, low power

AES encryption

Long-range transmission

Logical sensor management



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Transmission to WaziGate

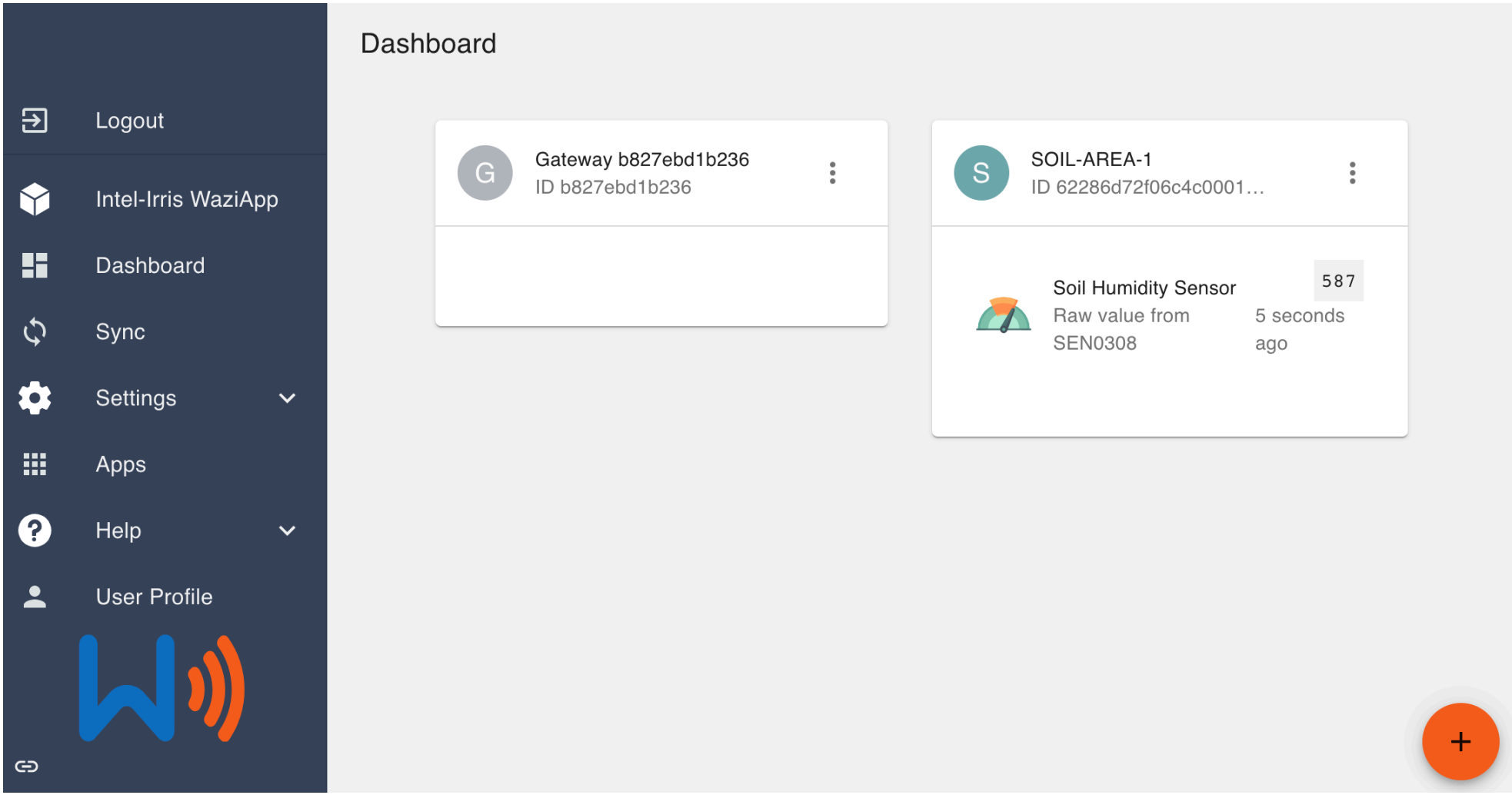
Parameters for
INTEL-IRRIS WaziGate

LoRaWAN

SF12BW125
868.1MHz | 433.175MHz
Node id is 26011DAA
1 msg/60mins
1 sensor
XLPP data

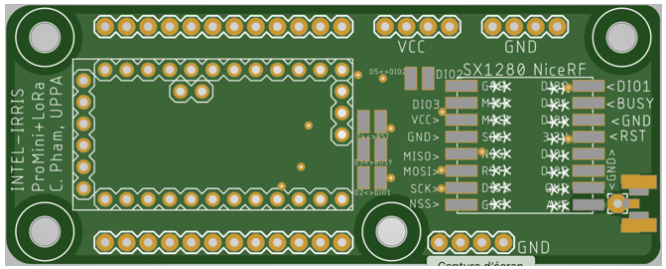
This dedicated video will show all these steps, from connecting the SEN0308 to testing transmission to the WaziGate
Video n°4: https://youtu.be/j-1Nk0tv0xM

See it on the dashboard



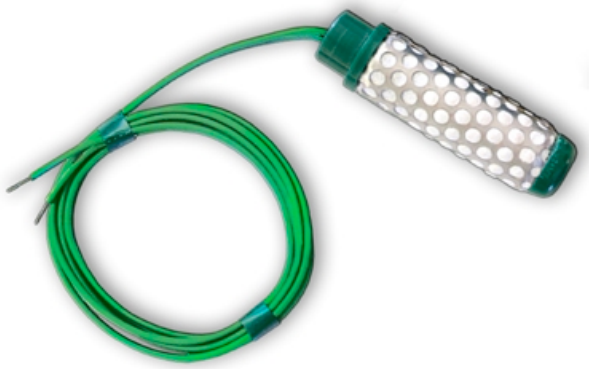
Advanced options

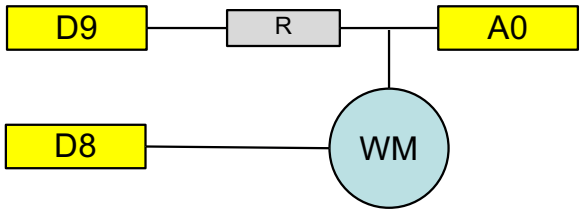
- The Intelirris_Soil_Sensor sketch can
  - Drive SX127X, SX126X and SX128X LoRa chips
    - SX128X requires a dedicated PCB for NiceRF SX1280

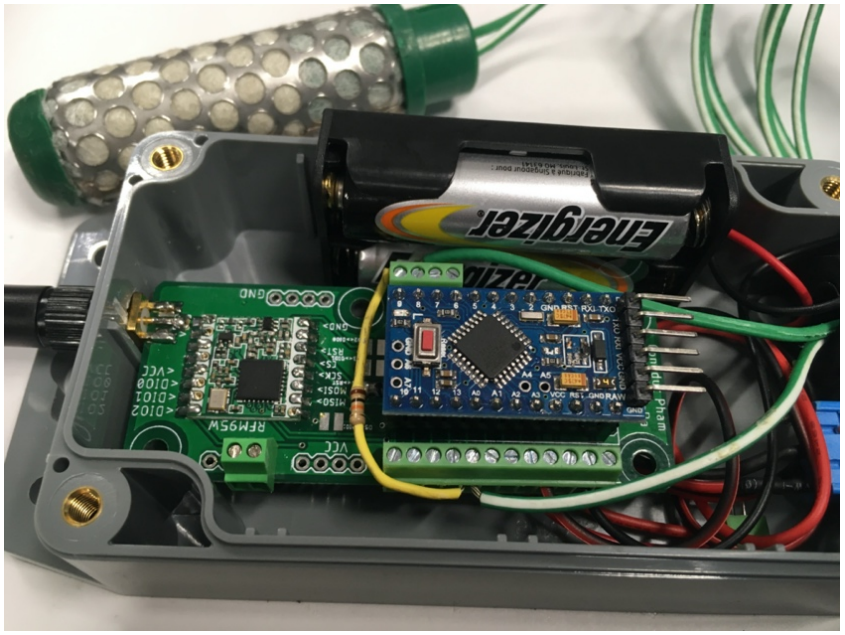


  - Send AES 128-bit encrypted packet
  - Send uplink LoRaWAN packet (encrypted)
  - Receive downlink LoRaWAN packet
  - Can read from a Watermark water tension sensor
  - Can read additionally from a DS18B20 soil temperature sensor
  - Support WaziSense and WaziDev boards specific features

With a Watermark sensor







- with a Watermark sensor, the "pseudo-AC Short Pulse" method will be used – see https://www.irrometer.com/200ss.html
- D9 and D8 will be used to alternating power the sensor
- A0 will be used to read signal from sensor
- R is a resistor from 7kOhms to 14kOhms

Software configuration for WM

- Default resistor value is 10kOhms
- Change in `watermark.h` file the `WM_RESISTOR` value to match the one you are using

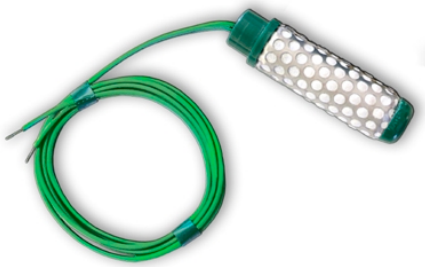
```
11 #define WATERMARKANALOG_SCALE _BOARD_MVOLT_SCALE
12 //put here the resistor value, in Ohms
13 #define WM_RESISTOR 10000
14 //we defined WM_MAX_RESISTOR=32760 because the transmitted value would be 32760/10=3276
15 //and currently a bug in WaziGate XLPP decoding code will limit the maximum value to 3276
16 #define WM_MAX_RESISTOR 32760
17
```

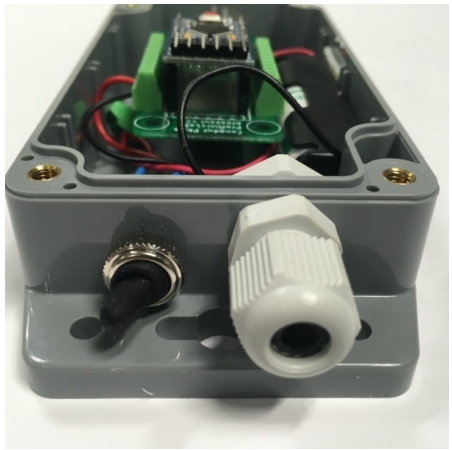
- Uncomment in main program `WITH_WATERMARK`

```
//////////////////////////////////////////////////////////////////////
// uncomment to have a soil tensiometer watermark sensor
#define WITH_WATERMARK
#define WM_REF_TEMPERATURE 28.0
//////////////////////////////////////////////////////////////////////
// uncomment to force the watermark to have default device address for WaziGate
//#define WM_AS_PRIMARY_SENSOR
```

Transmission with the WM sensor

- Devices with a WM sensor will have a different default address
  - 26011DB1 instead of 26011DAA for capacitive
- 2 values are transmitted
  - Centibars converted from resistance value
  - Raw resistance value measured for WM sensor, but scaled down by a factor of 10 → 300 = 3000 Ohms



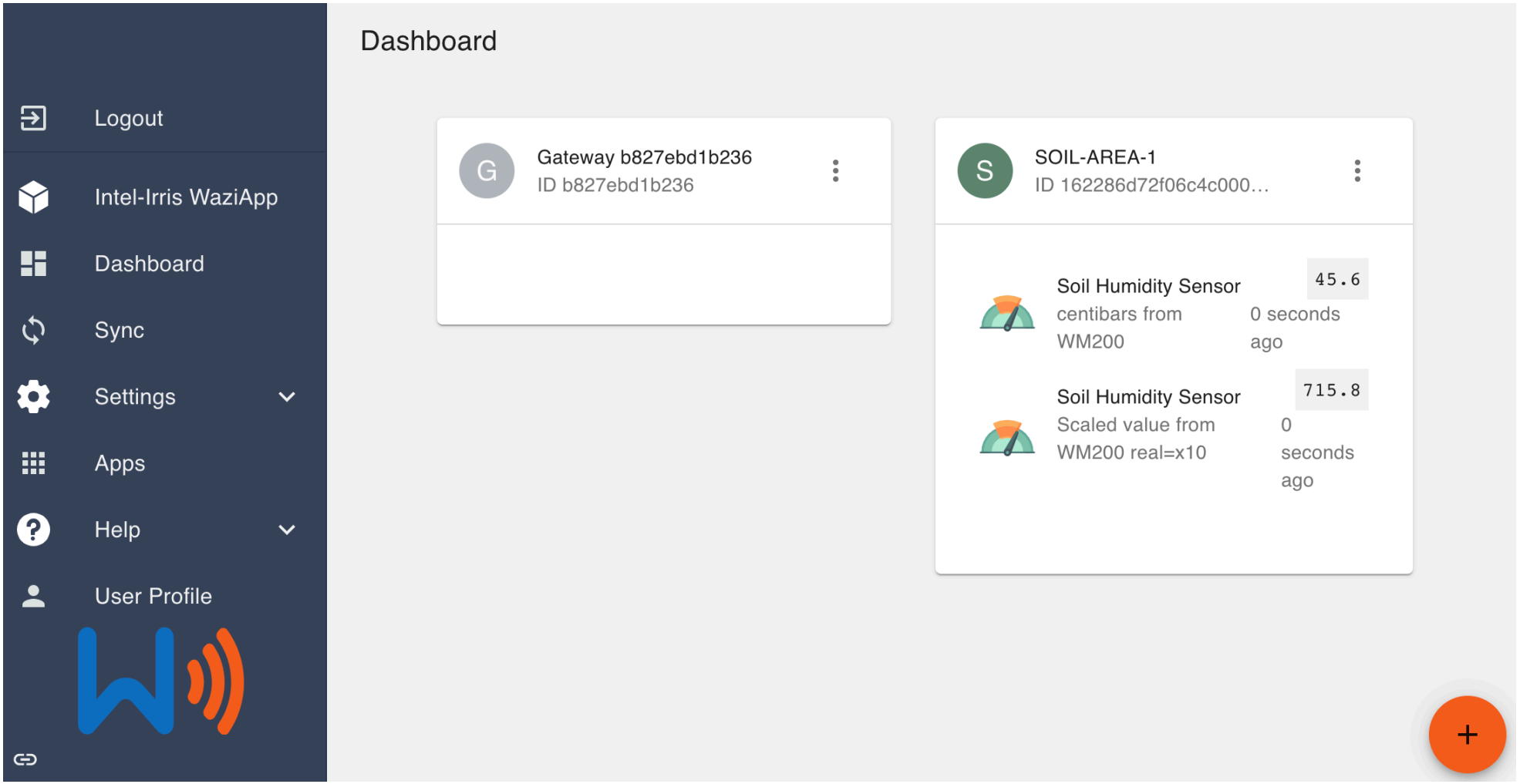


Parameters for
INTEL-IRRIS WaziGate

LoRaWAN™

SF12BW125
868.1MHz | 433.175MHz
Node id is 26011DB1
1 msg/60mins
1 sensor
XLPP data

See it on the dashboard



2 versions of the soil device

SEN0308 capacitive sensor
Default address is 26011DAA

Watermark WM200
Water tension sensor
Default address is 26011DB1

Soil temperature with WM sensor (1)

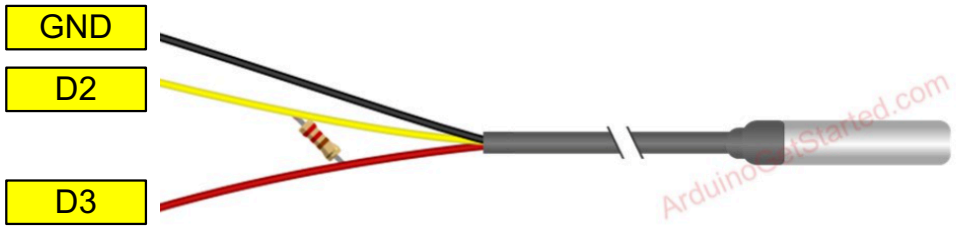
- Without a real temperature sensor, the Arduino code uses a default soil temperature set to 28°C to convert the resistance value into centibars (see https://www.irrometer.com/200ss.html)

```
////////////////////////////////////////////////////////////////////
// uncomment to have a soil tensiometer watermark sensor
#define WITH_WATERMARK
#define WM_REF_TEMPERATURE 28.0
////////////////////////////////////////////////////////////////////
// uncomment to force the watermark to have default device address for WaziGate
//#define WM_AS_PRIMARY_SENSOR
```

- You can change this setting in the code for testing purposes
- The final objective is to use a real temperature sensor to dynamically get the soil temperature

Soil temperature with WM sensor (2)

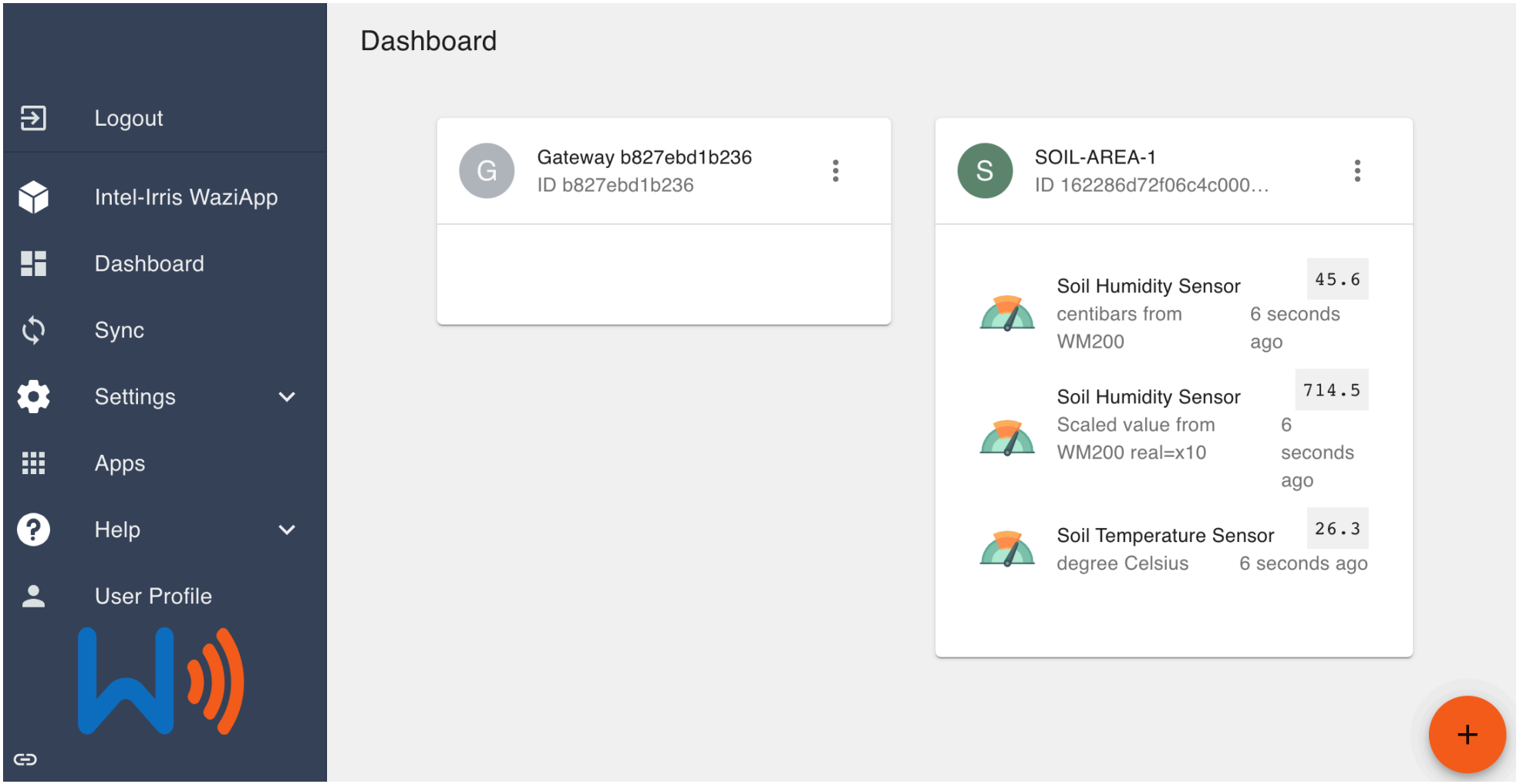
- A DS18B20 temperature sensor can be connected to the device. A 4.7kOhms must be added as illustrated, connecting D2 and D3



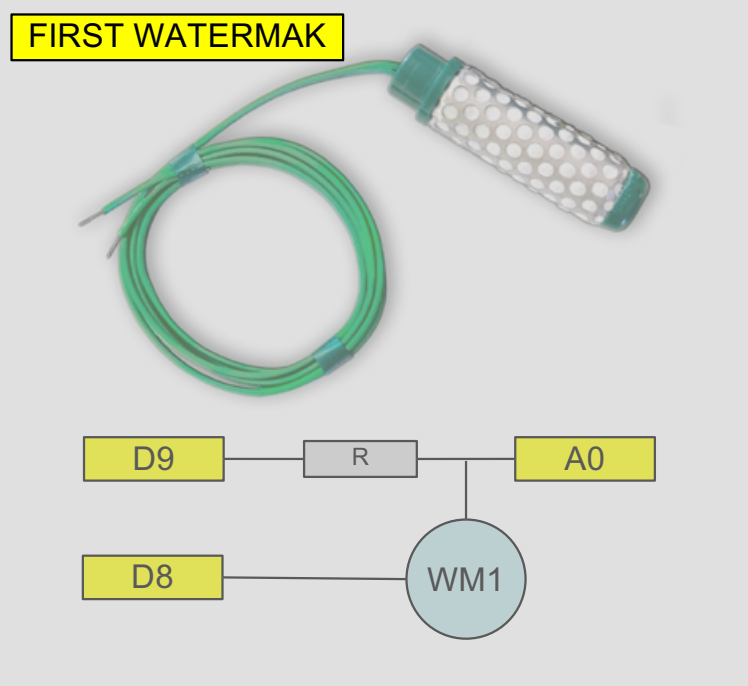
```
//////////////////////////////////////////////////////////////////////
// uncomment to have 1 soil temperature sensor ST
// using a one-wire DS18B20 sensor
#define SOIL_TEMP_SENSOR
#define LINK_SOIL_TEMP_TO_CENTIBAR
```

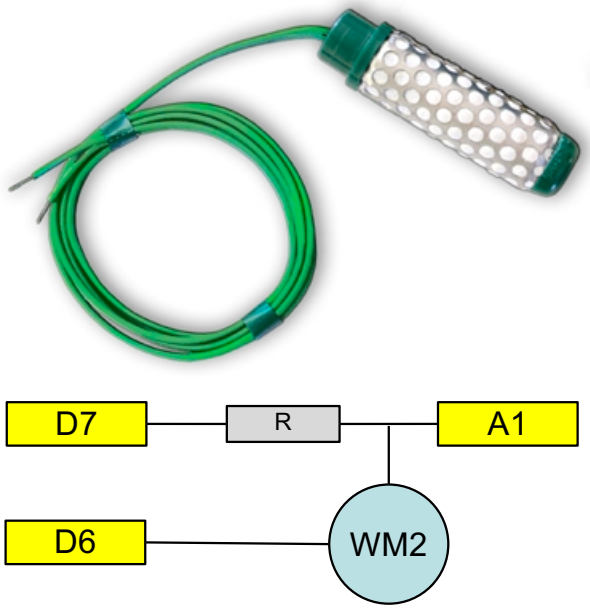
- In this case, the soil temperature will also be sent to the gateway
- It is also possible to link the measured soil temperature to the centibar calculation performed by the device itself

See it on the dashboard



Add a second Watermark sensors





- a second Watermark sensor can be connected: the purpose is to determine the water movement in the soil
- D7 and D6 will be used to alternating power the sensor
- A1 will be used to read signal from sensor
- R should be identical for both Watermark

Software configuration for 2 WM

- Uncomment in main program `TWO_WATERMARK`

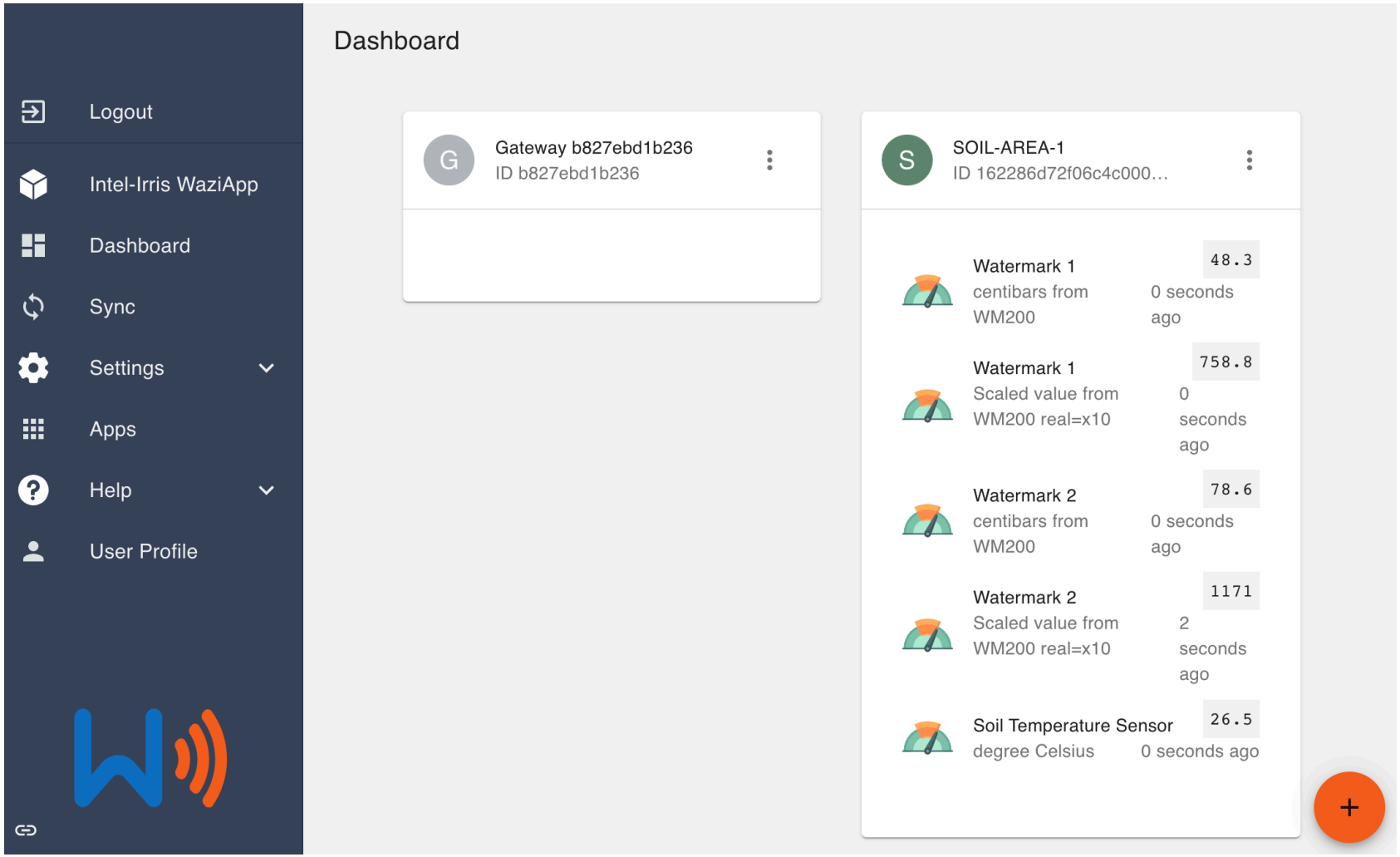
```
////////////////////////////////////////////////////////////////////
// uncomment to have a soil tensiometer watermark sensor
#define WITH_WATERMARK
#define WM_REF_TEMPERATURE 28.0

////////////////////////////////////////////////////////////////////
// uncomment to force the watermark to have default device address for WaziGate
//#define WM_AS_PRIMARY_SENSOR

////////////////////////////////////////////////////////////////////
// uncomment to have 2 tensiometer watermark sensor on the same device
#define TWO_WATERMARK
```

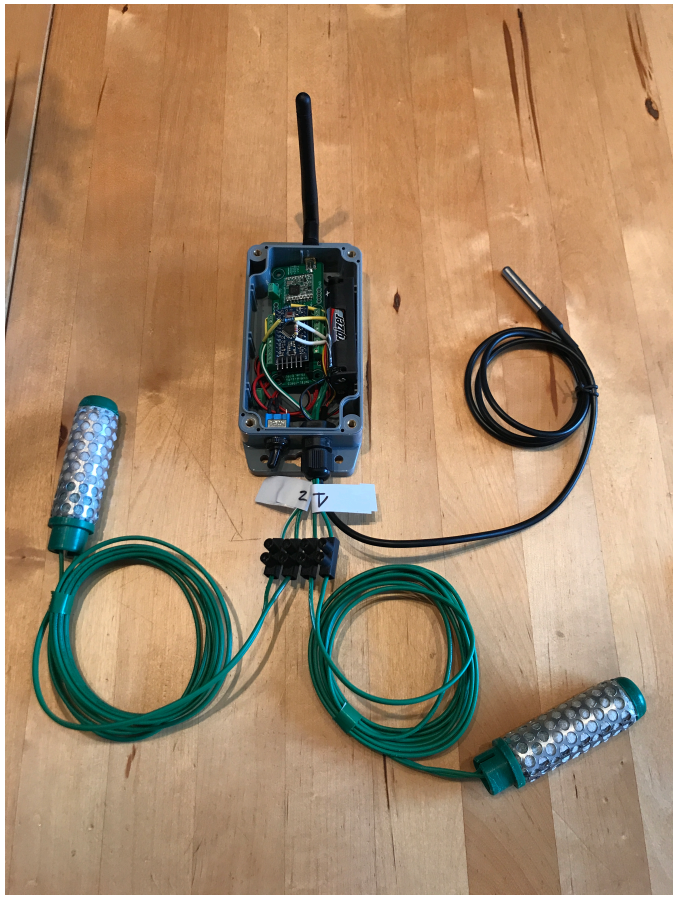
- You can still add a soil temperature sensor

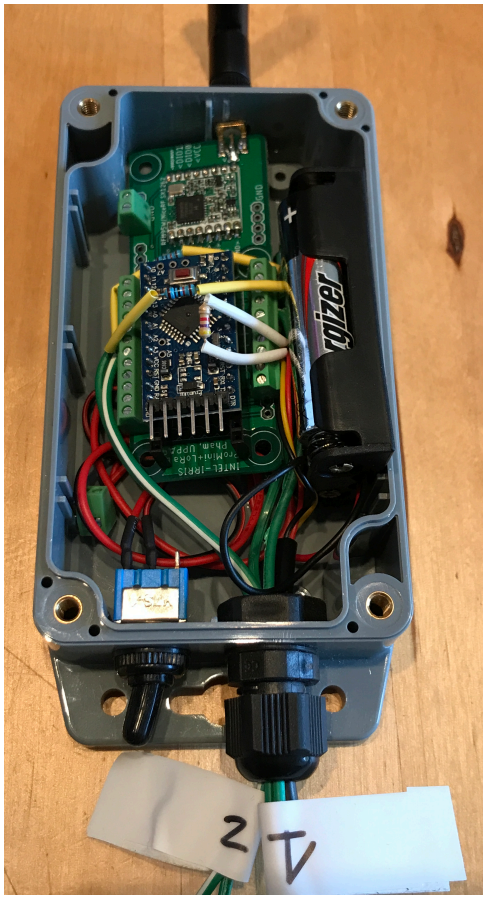
See it on the dashboard



Experimental INTEL-IRRIS soil device

- 2 Watermark sensors and 1 soil temperature sensor





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PARTNERSHIP FOR RESEARCH AND INNOVATION
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