

INTELLIGENT IRRIGATION SYSTEM FOR LOW-COST AUTONOMOUS WATER CONTROL IN SMALL-SCALE AGRICULTURE



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



Prof. Congduc Pham
<http://www.univ-pau.fr/~cpham>
Université de Pau, France



Review: Technology components



Review: Low-cost sensors



- 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

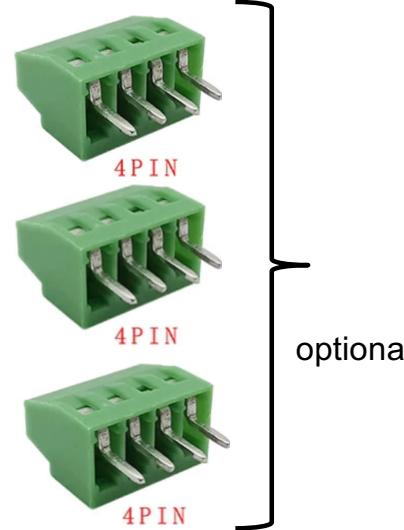
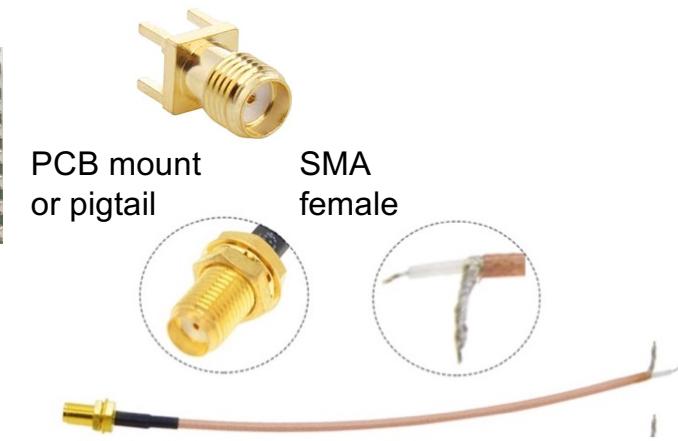
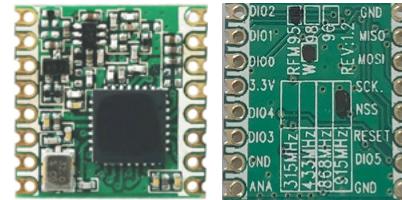
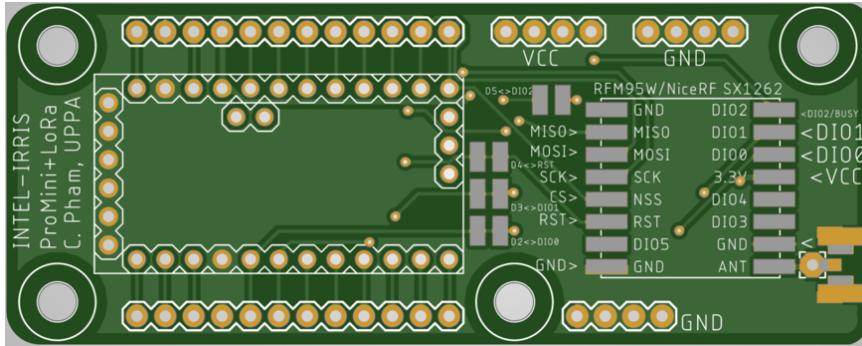


Review: Starter-kits

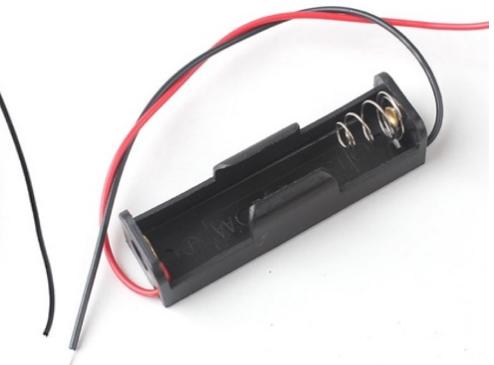
- "Intelligent Irrigation in-the-box", "plug-&-sense"
- At least 100 starter-kit will be distributed



Soil sensor: electronic parts

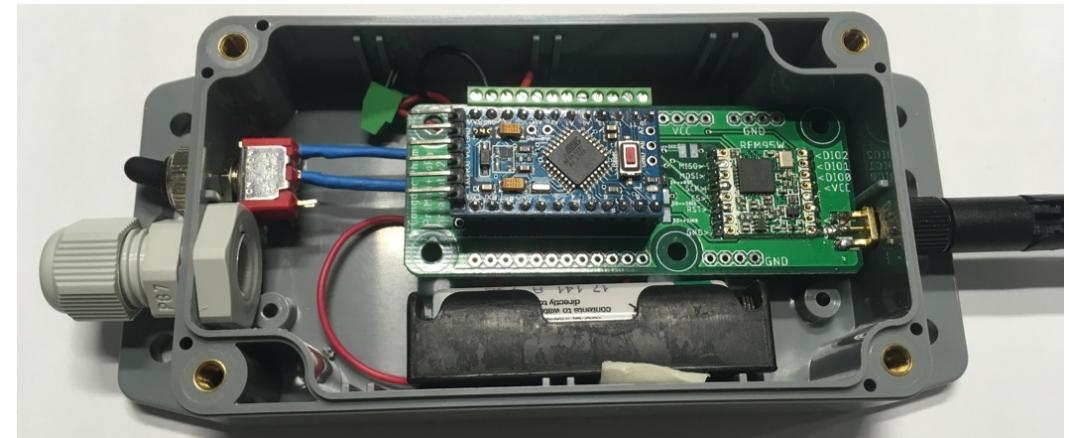


Soil sensor: casing parts & integration

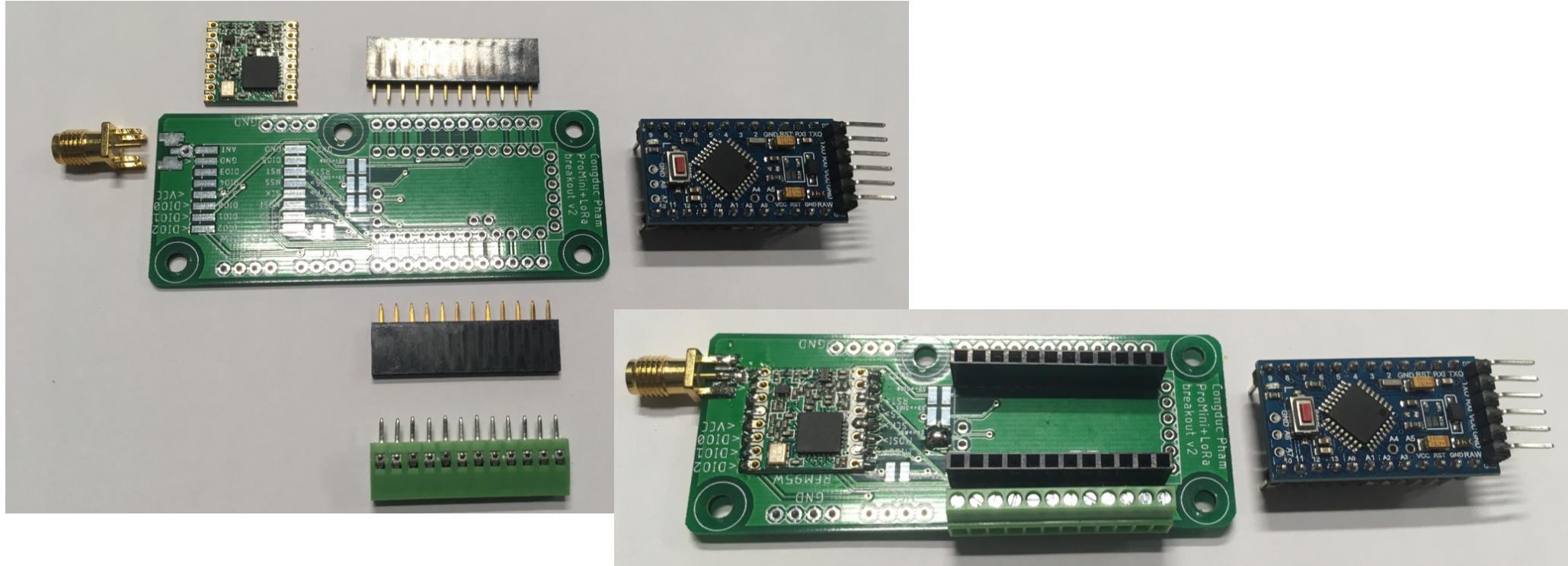


GLD
THROW AWAY
"DO NOT EAT"
DESICCANT
SILICA
GEL
THROW AWAY
"DO NOT EAT"

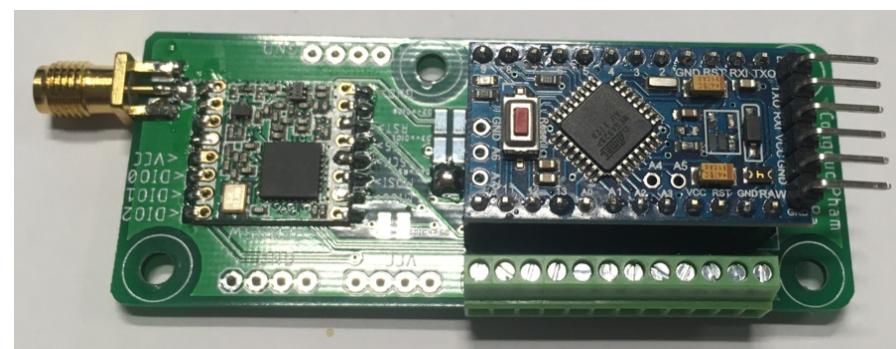
proof-of-concept



Assembling the PCB board



A dedicated video will show
how to solder the components



Get an enclosure for outdoor usage



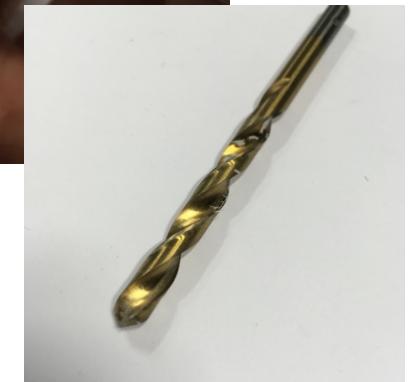
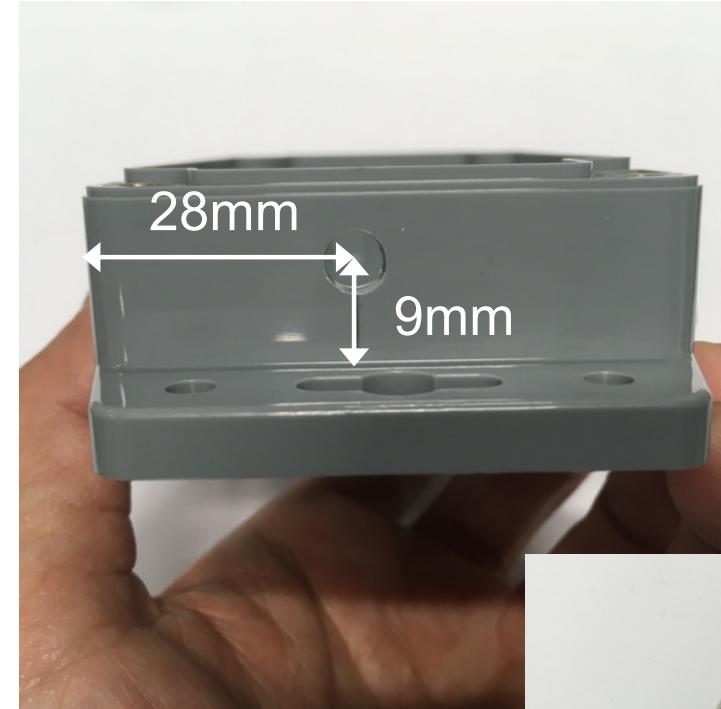
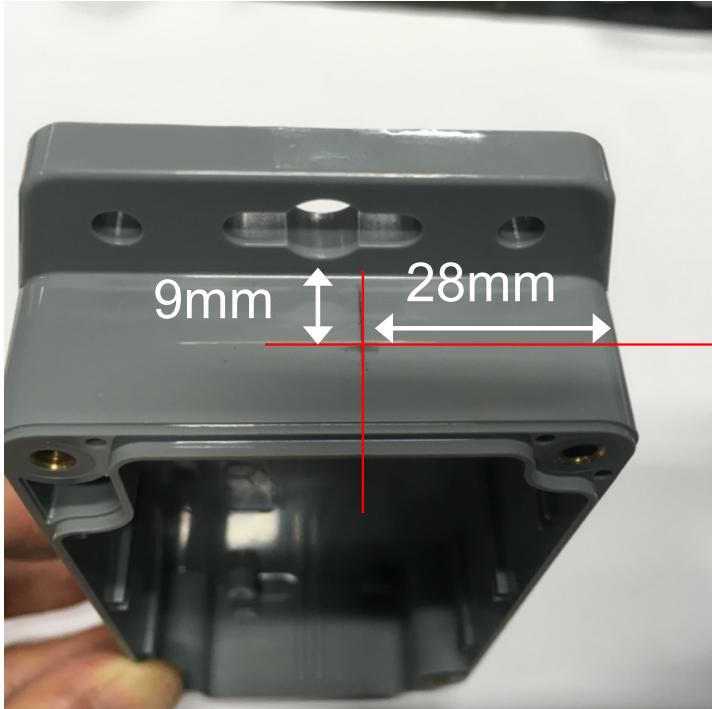
Here, it is an IP65 box which dimension is 115 x 65 x 40mm
<https://www.gotronic.fr/art-boitier-abs-etanche-g304m-17977.htm>

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)

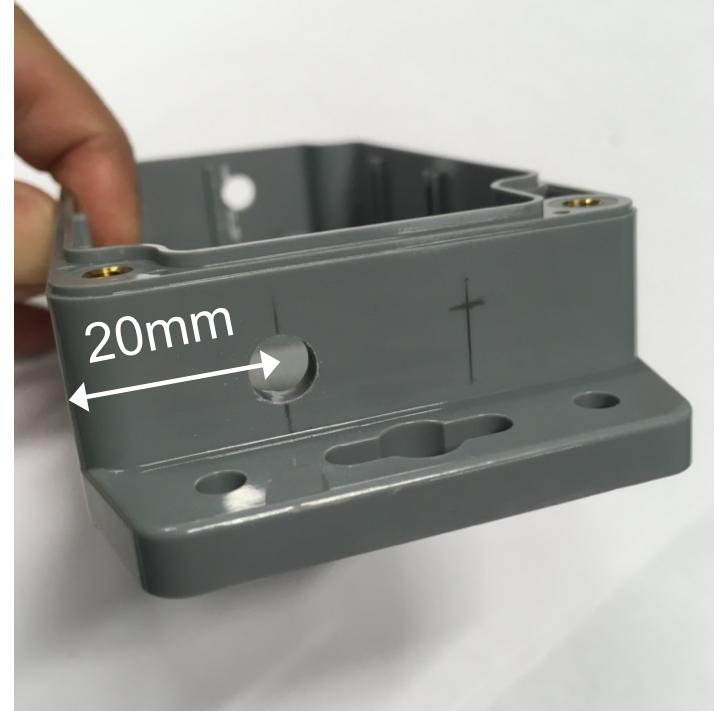
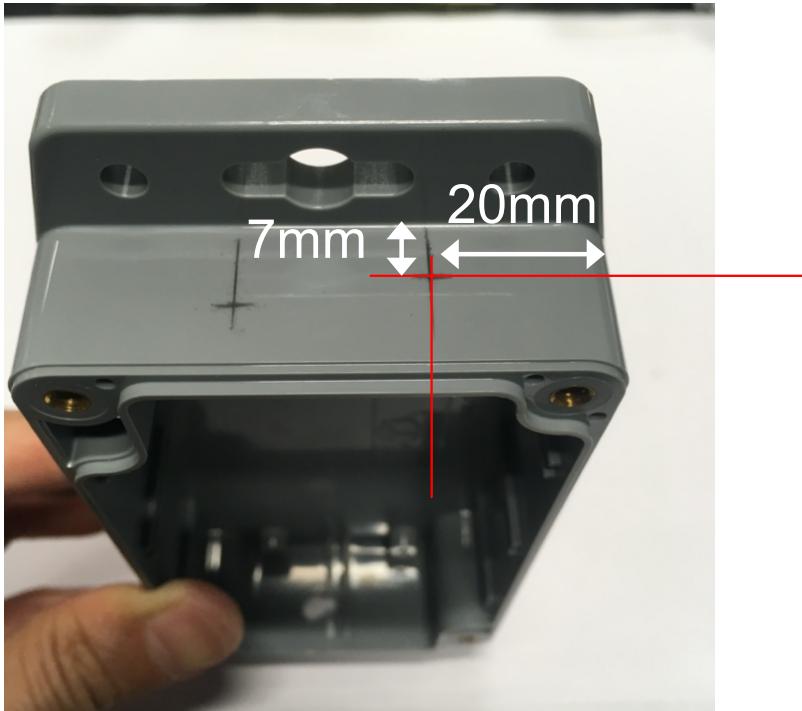
Placing the PCB board



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

7mm from the outside bottom

use a 7mm drill bit for metal

Drill a hole for the cable gland



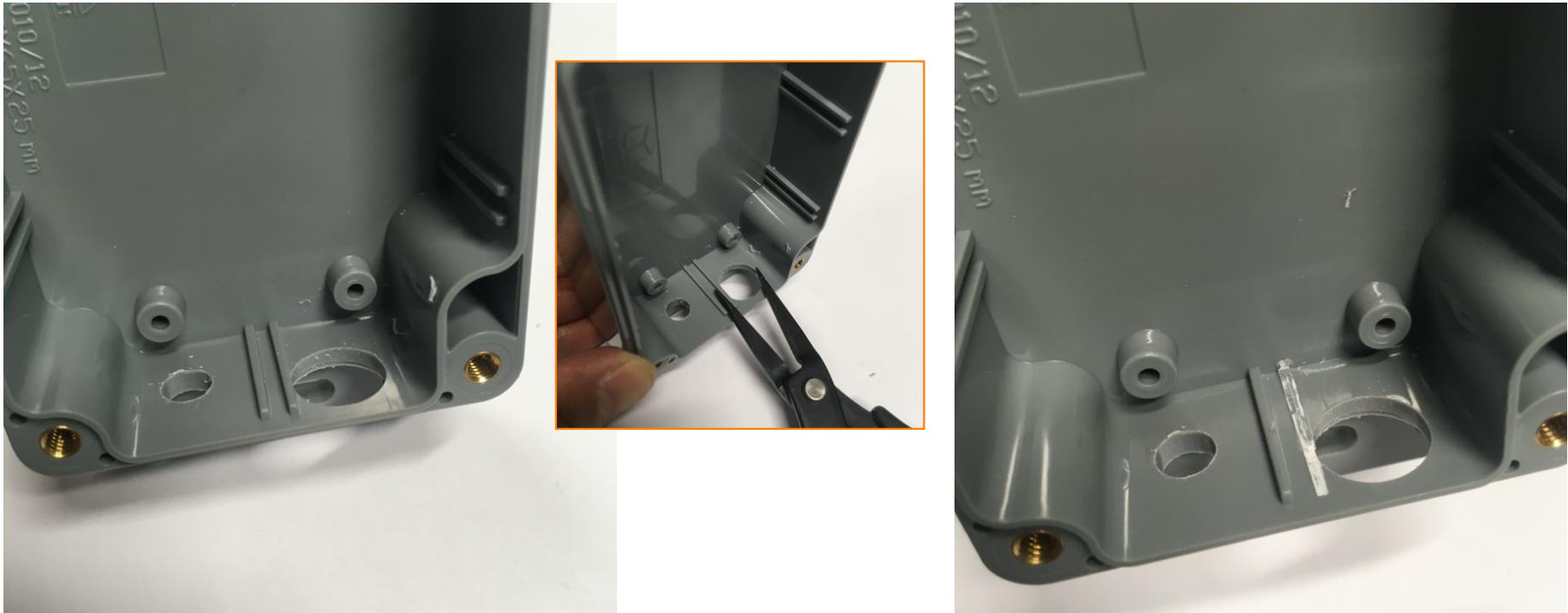
41mm for the right edge:

- measure from the flat side as the corner is round

10mm from the outside bottom

use a 13mm drill bit for metal

Remove unwanted plastic part



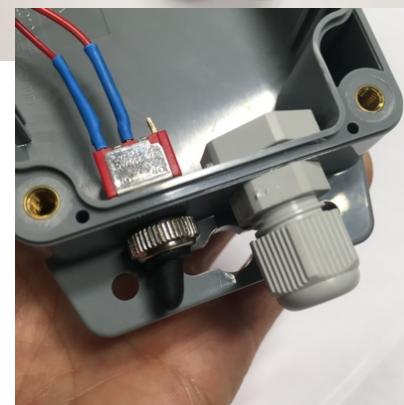
again, we need to remove the plastic reinforcement part for this particular enclosure
use a flat cutter for instance to remove and smooth the inside part
(a small plier can be used first to remove most of the part)

Placing switch and cable gland

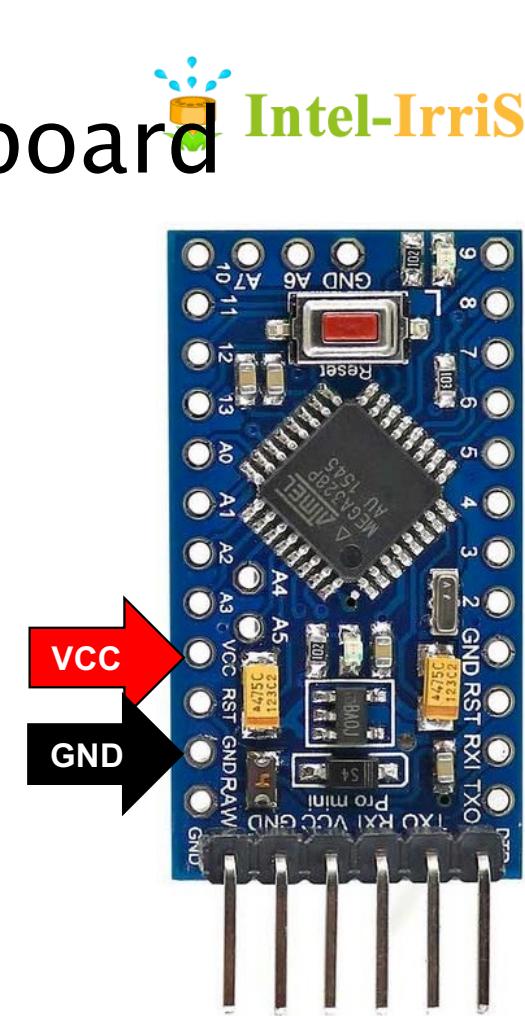
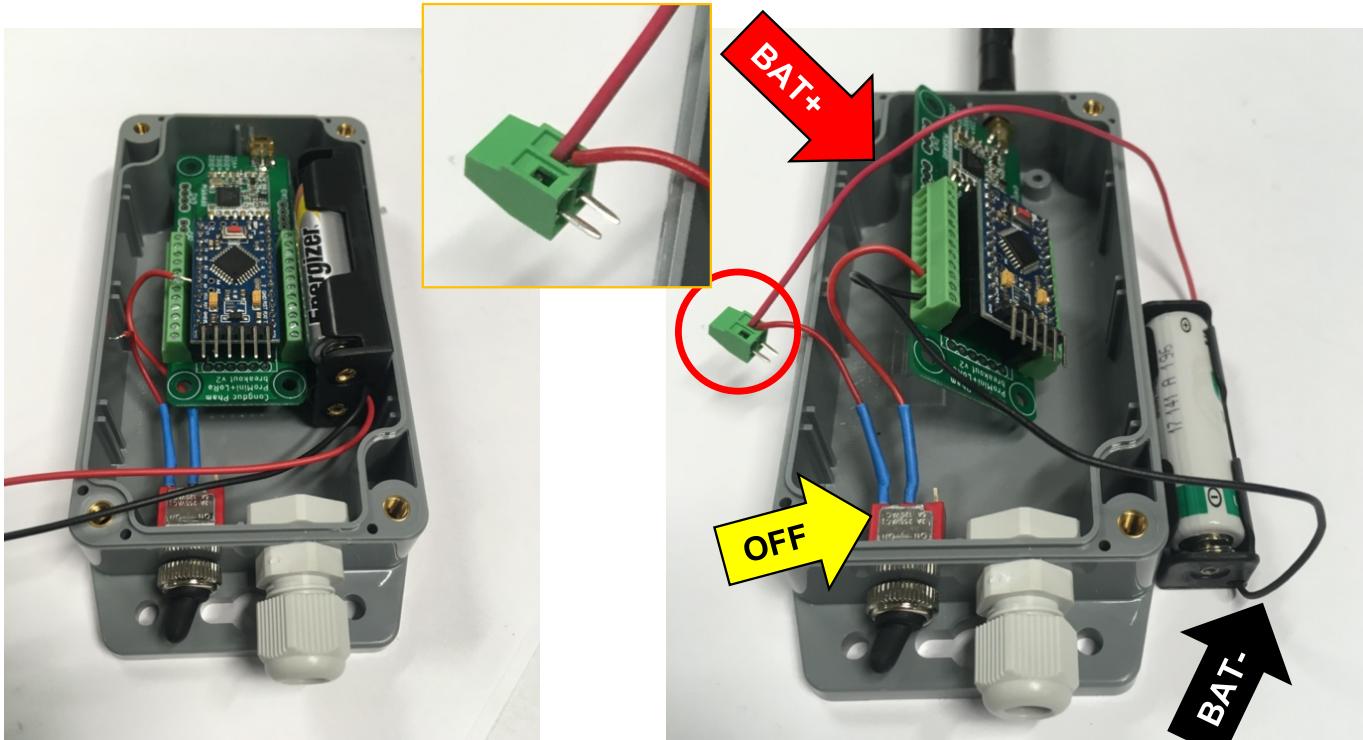


test that everything is OK

the switch has a water-proof cap

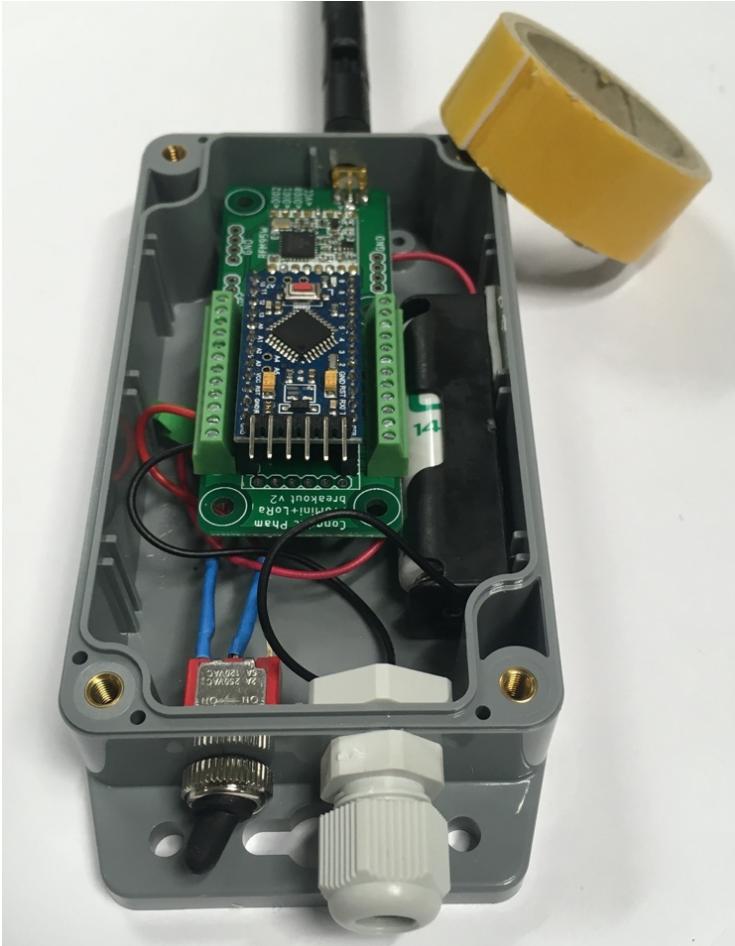


Connecting switch, battery & board



Connect together 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 right will then power the board

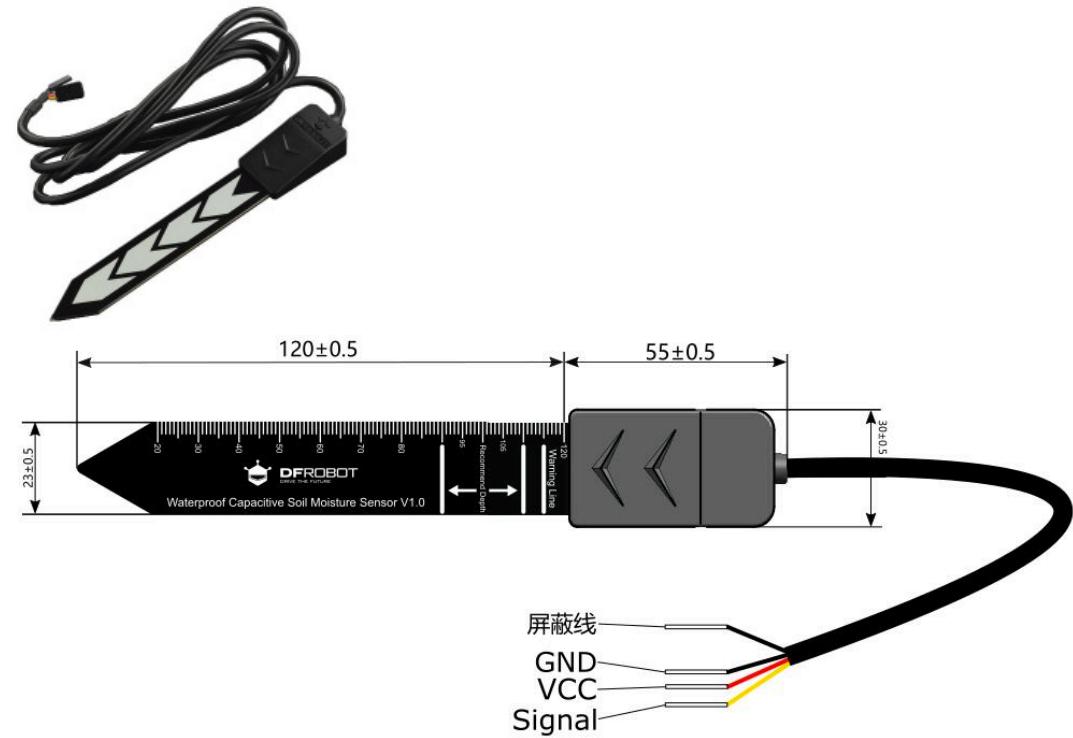
Putting it altogether



Here we use a 1-AA battery pack
Fix the battery pack with double-side tape
e.g. those used to fix mirrors on wall
Then we use a 3.6V Lithium battery



Last step: connect the SEN0308

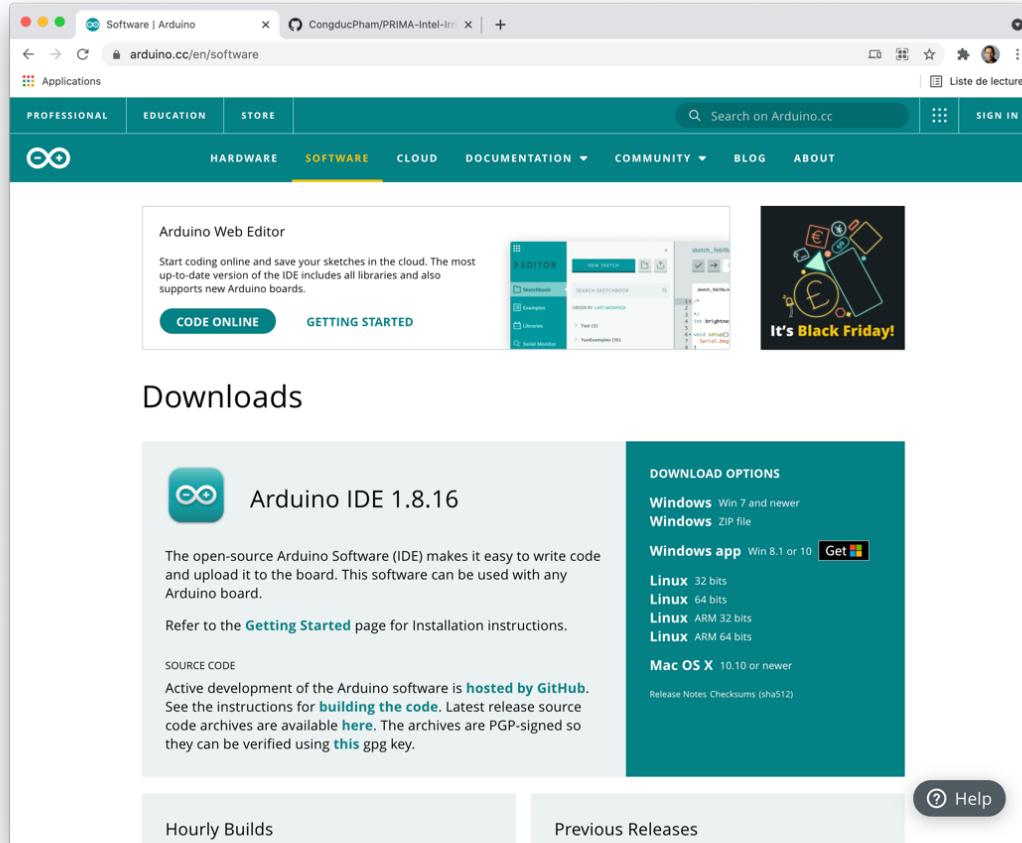


Insert sensor's wire through cable gland

Connect SEN0308's wires to board:

- VCC to board's A1
- GND to board's GND
- Signal to board's A0

Getting the software: Arduino IDE

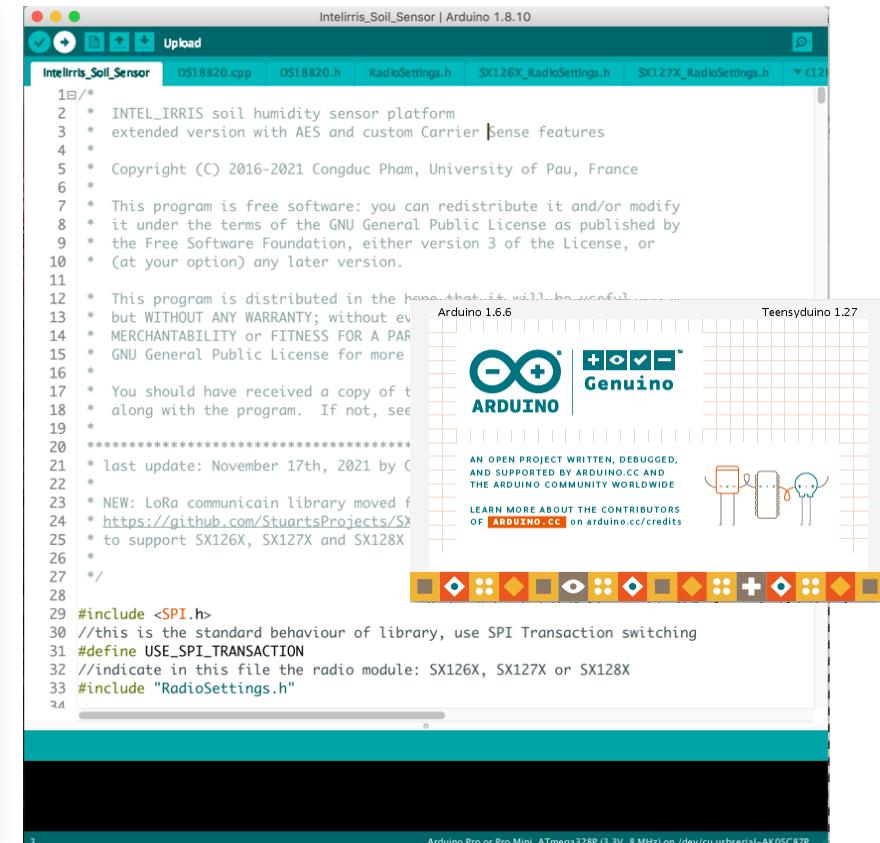


The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

Refer to the [Getting Started](#) page for Installation instructions.

SOURCE CODE
 Active development of the Arduino software is [hosted by GitHub](#). See the instructions for [building the code](#). Latest release source code archives are available [here](#). The archives are PGP-signed so they can be verified using [this gpg key](#).

[Hourly Builds](#) [Previous Releases](#)



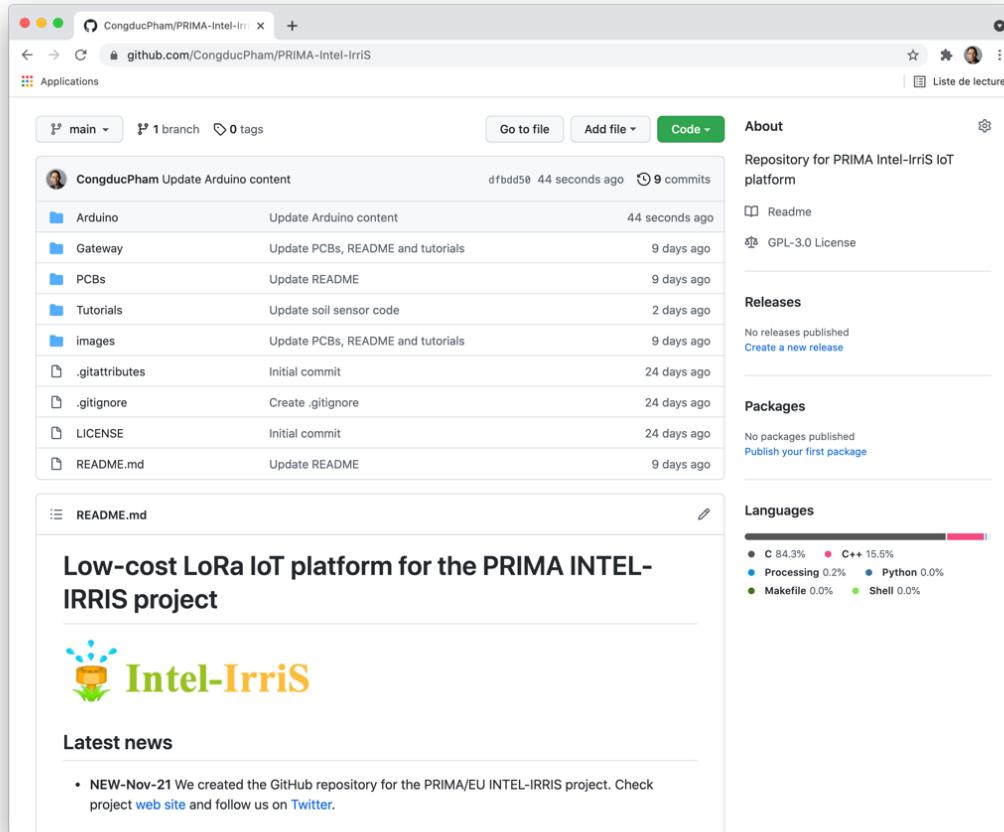
```

1/*
2 * INTEL_IRRIS soil humidity sensor platform
3 * extended version with AES and custom CarrierSense features
4 *
5 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France
6 *
7 * This program is free software: you can redistribute it and/or modify
8 * it under the terms of the GNU General Public License as published by
9 * the Free Software Foundation, either version 3 of the License, or
10 * (at your option) any later version.
11 *
12 * This program is distributed in the hope that it will be useful,
13 * but WITHOUT ANY WARRANTY; without even
14 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
15 * GNU General Public License for more details.
16 *
17 * You should have received a copy of the
18 * along with the program. If not, see
19 *
20 ****
21 * last update: November 17th, 2021 by C
22 *
23 * NEW: LoRa communication library moved from
24 * https://github.com/StuartsProjects/SX
25 * to support SX126X, SX127X and SX128X
26 *
27 */
28
29 #include <SPI.h>
30 //this is the standard behaviour of library, use SPI Transaction switching
31 #define USE_SPI_TRANSACTION
32 //indicate in this file the radio module: SX126X, SX127X or SX128X
33 #include "RadioSettings.h"
34

```

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

Getting the software: Intel-IrriS code



The screenshot shows the GitHub repository page for CongducPham/PRIMA-Intel-IrriS. The repository has 1 branch and 0 tags. The main commit is by CongducPham, updating Arduino content. The repository includes sections for Arduino, Gateway, PCBs, Tutorials, Images, .gitattributes, .gitignore, LICENSE, and README.md. The README.md file describes the Low-cost LoRa IoT platform for the PRIMA INTEL-IrriS project. The repository also features an Intel-IrriS logo and a "Latest news" section with a recent update about the creation of the GitHub repository.

On your computer, create a sketch folder

Then download the whole repository as ZIP file

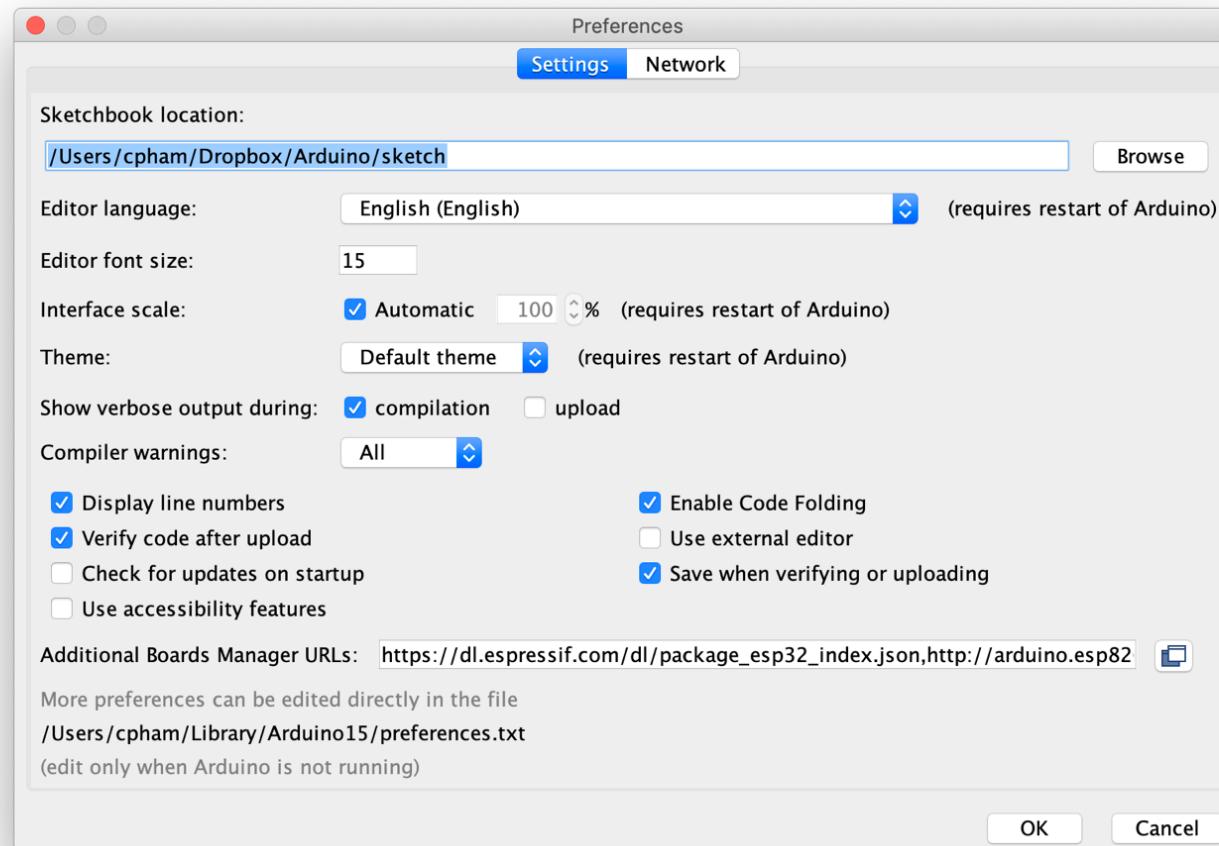
Unzip the file and copy the whole Arduino folder into your sketch folder

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



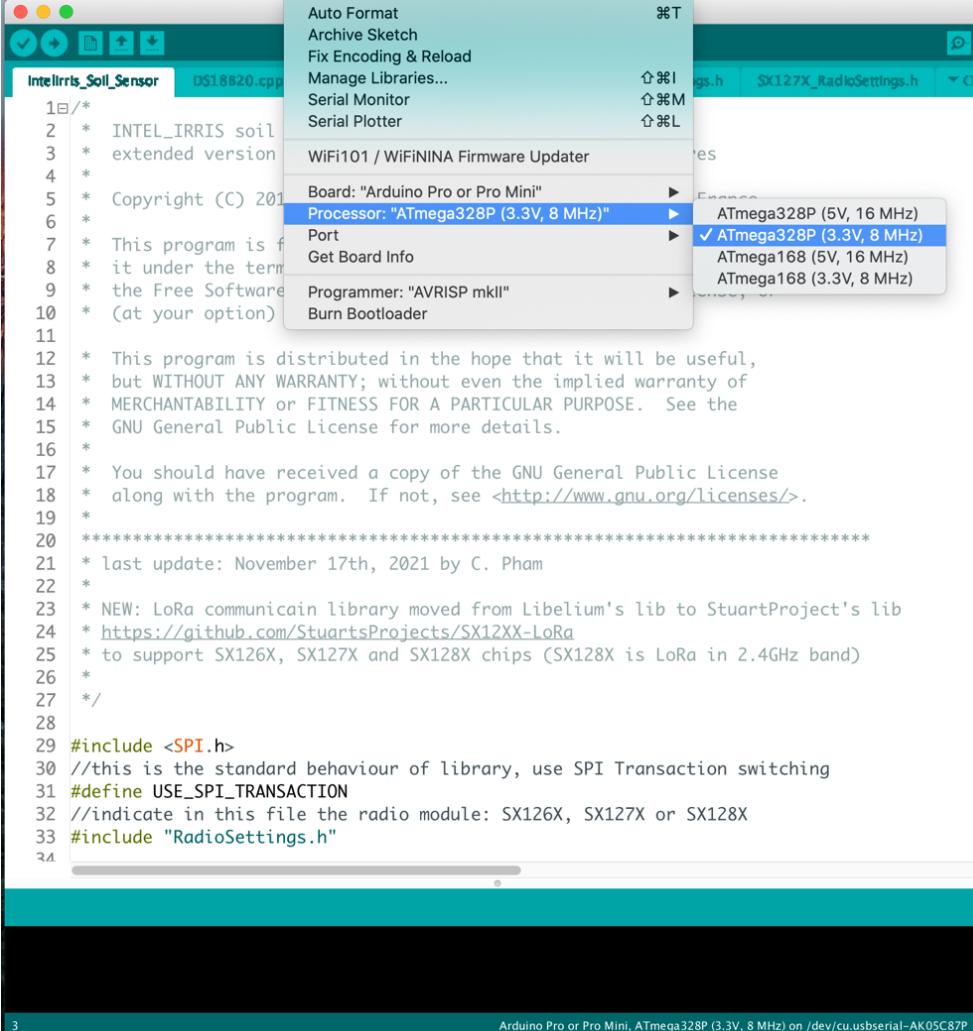
GitHub

Setting your Arduino IDE



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

Compiling the soil sensor code



```

1/* INTEL_IRRIS soil
2 * extended version
3 *
4 * Copyright (C) 201
5 * This program is f
6 * it under the term
7 * the Free Software
8 * (at your option)
9 *
10 * This program is distributed in the hope that it will be useful,
11 * but WITHOUT ANY WARRANTY; without even the implied warranty of
12 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
13 * GNU General Public License for more details.
14 *
15 * You should have received a copy of the GNU General Public License
16 * along with the program. If not, see <http://www.gnu.org/licenses/>.
17 *
18 ****
19 * last update: November 17th, 2021 by C. Pham
20 *
21 * NEW: LoRa communicain library moved from Libelium's lib to StuartProject's lib
22 * https://github.com/StuartsProjects/SX1XX-LoRa
23 * to support SX126X, SX127X and SX128X chips (SX128X is LoRa in 2.4GHz band)
24 *
25 */
26
27 */
28
29 #include <SPI.h>
30 //this is the standard behaviour of library, use SPI Transaction switching
31 #define USE_SPI_TRANSACTION
32 //indicate in this file the radio module: SX126X, SX127X or SX128X
33 #include "RadioSettings.h"
34

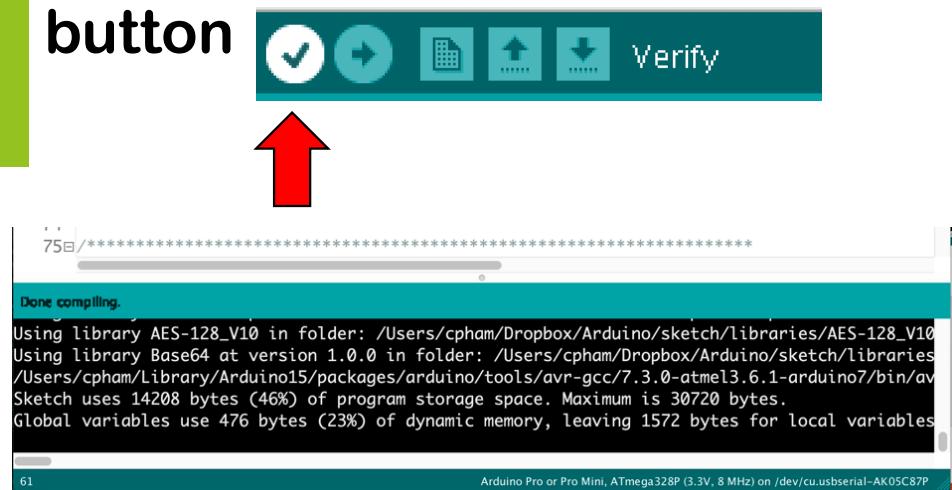
```

Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz) on /dev/cu.usbserial-AK05C87P

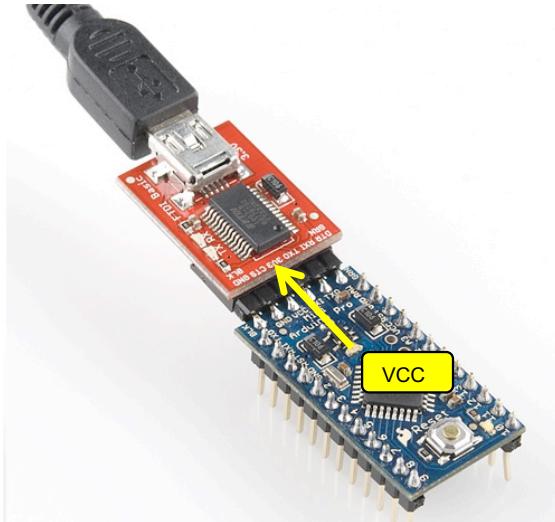
Open the Intelirris_Soil_Sensor sketch

**Select the ProMini board,
3.3V and 8MHz version**

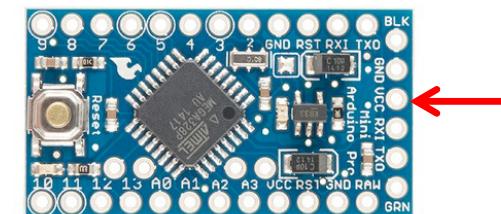
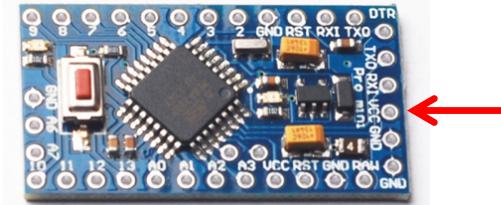
**Then click on the "verify"
button**



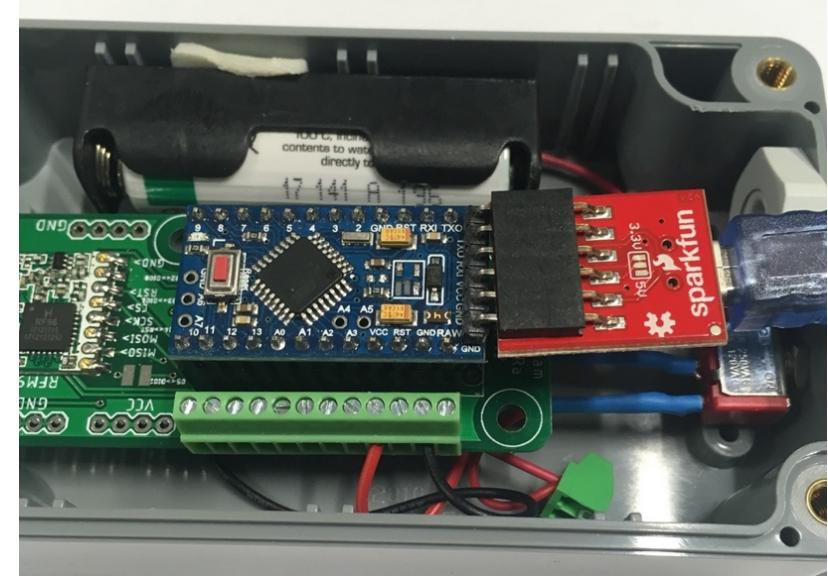
Connecting with an FTDI cable



Some clone version, check the VCC pin



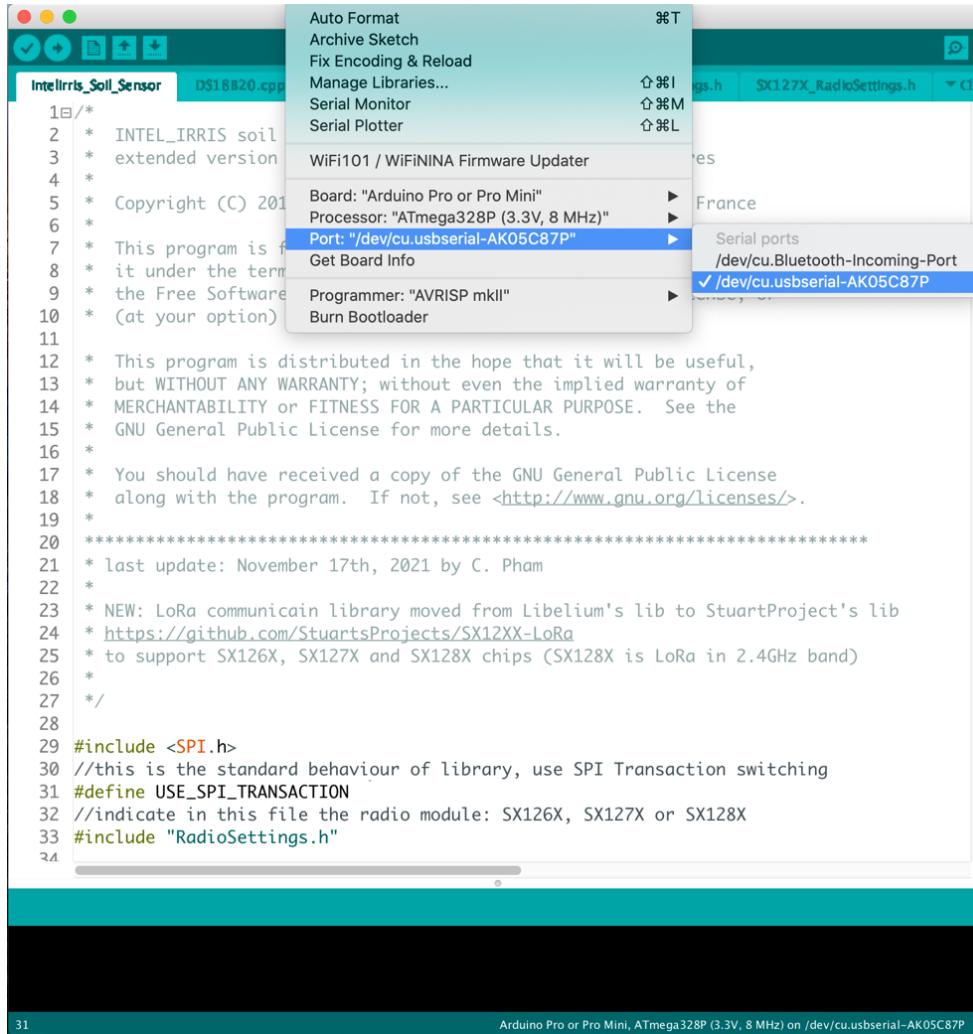
Original Sparkfun
version



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>

Intelirris_Soil_Sensor | Arduino 1.8.10

```
Intelirris_Soil_Sensor DS18B20.cpp DS18B20.h RadioSettings.h SX126X_RadioSettings.h SX127X_RadioSettings.h C1
```

1 /*
2 * INTEL_INRRIS soil humidity sensor platform
3 * extended version with AES and custom Carrier Sense features
4 *
5 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France
6 *
7 * This program is free software: you can redistribute it and/or modify
8 * it under the terms of the GNU General Public License as published by
9 * the Free Software Foundation, either version 3 of the License, or
10 * (at your option) any later version.
11 *
12 * This program is distributed in the hope that it will be useful,
13 * but WITHOUT ANY WARRANTY; without even the implied warranty of
14 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
15 * GNU General Public License for more details.
16 *
17 * You should have received a copy of the GNU General Public License
18 * along with the program. If not, see <<http://www.gnu.org/licenses/>>.
19 *
20 ****
21 * last update: November 17th, 2021 by C. Pham
22 *
23 * NEW: LoRa communication library moved from Libelium's lib to StuartProject's lib
24 * <https://github.com/StuartProjects/SX12XX-LoRa>
25 * to support SX126X, SX127X and SX128X chips (SX128X is LoRa in 2.4GHz band)
26 *
27 */
28 *
29 #include <SPI.h>
30 //this is the standard behaviour of library, use SPI Transaction switching
31 #define USE_SPI_TRANSACTION
32 //indicate in this file the radio module: SX126X, SX127X or SX128X
33 #include "RadioSettings.h"

Done uploading.

Sketch uses 14208 bytes (46%) of program storage space. Maximum is 30720 bytes.
Global variables use 476 bytes (23%) of dynamic memory, leaving 1572 bytes for local variables

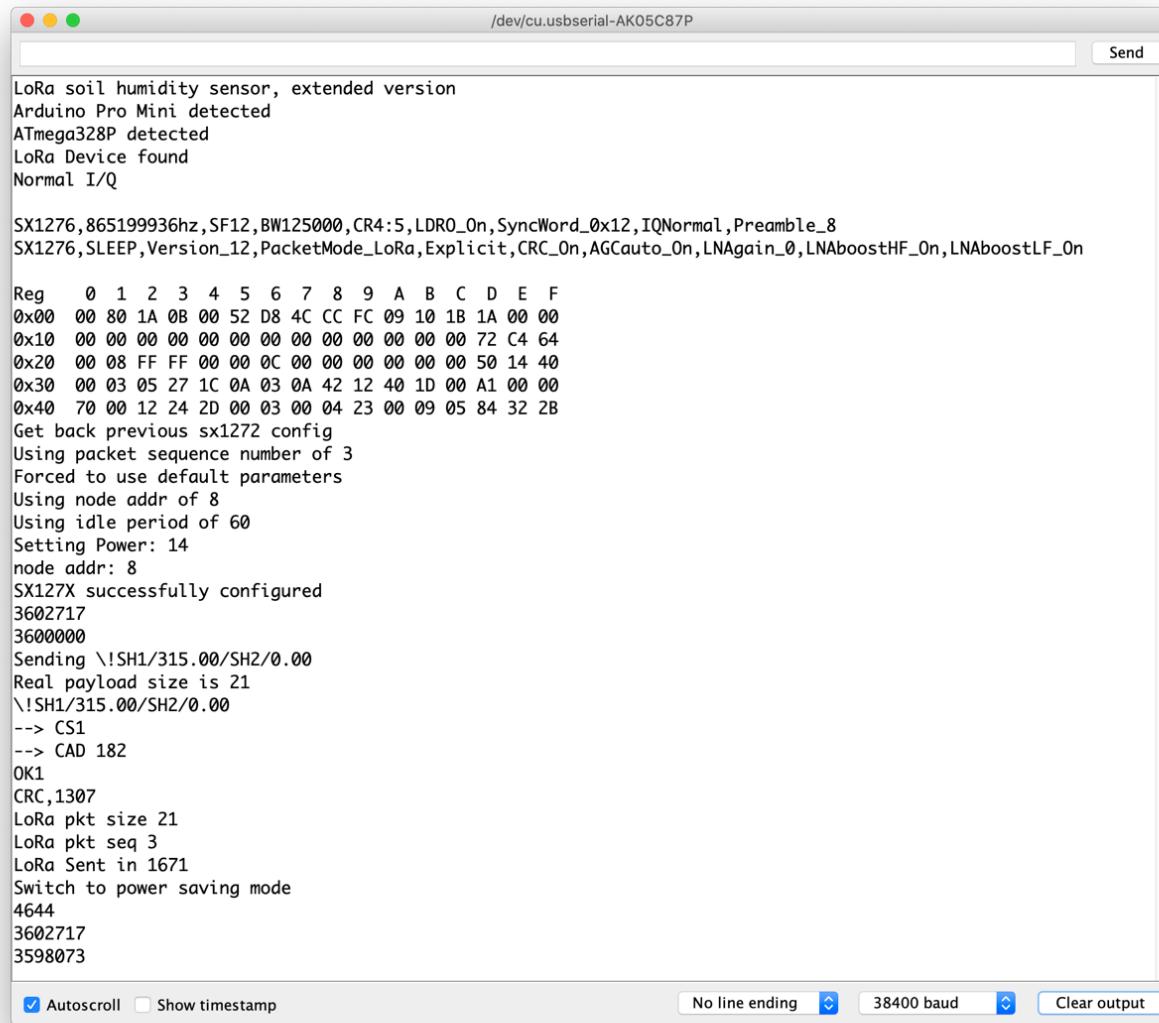
Click on the "upload" button



And wait until upload is completed

```
27 */  
28  
29 Done uploading.  
Using library Lowercase at version 1.0 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/  
Using library OneWire at version 2.3.2 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/  
Using library Dallas-Temperature at version 3.7.7 in folder: /Users/cpham/Dropbox/Arduino/sketch/  
Using library AES-128_V10 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/AES-128_V10  
Using library Base64 at version 1.0.0 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/  
/Users/cpham/Library/Arduino15/packages/arduino/tools/avr-gcc/7.3.0-atmel3.6.1-arduino7/bin/avr  
Sketch uses 14208 bytes (46%) of program storage space. Maximum is 30720 bytes.  
Global variables use 476 bytes (23%) of dynamic memory, leaving 1572 bytes for local variables
```

Checking that device is operational



The screenshot shows a terminal window titled '/dev/cu.usbserial-AK05C87P' displaying the output of a LoRa device. The output includes:

- Device identification: LoRa soil humidity sensor, extended version; Arduino Pro Mini detected; ATmega328P detected; LoRa Device found; Normal I/Q.
- Radio parameters: SX1276, 865199936hz, SF12, BW125000, CR4:5, LDR0_On, SyncWord_0x12, IQNormal, Preamble_8.
- Configuration details: SX1276, SLEEP, Version_12, PacketMode_LoRa, Explicit, CRC_On, AGCAuto_On, LNAGain_0, LNABoostHF_0n, LNABoostLF_0n.
- Registers dump (Reg A B C D E F):

Reg	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0x00	00	80	1A	0B	00	52	D8	4C	CC	FC	09	10	1B	1A	00	00
0x10	00	00	00	00	00	00	00	00	00	00	00	00	00	72	C4	64
0x20	00	00	08	FF	FF	00	00	0C	00	00	00	00	00	50	14	40
0x30	00	03	05	27	1C	0A	03	0A	42	12	40	1D	00	A1	00	00
0x40	70	00	12	24	2D	00	03	00	04	23	00	09	05	84	32	2B

- Configuration steps: Get back previous sx1272 config, Using packet sequence number of 3, Forced to use default parameters, Using node addr of 8, Using idle period of 60, Setting Power: 14, node addr: 8.
- Transmission details: SX127X successfully configured, 3602717, 3600000, Sending \!SH1/315.00/SH2/0.00, Real payload size is 21, \!SH1/315.00/SH2/0.00, --> CS1, --> CAD 182, OK1, CRC,1307.
- Final status: LoRa pkt size 21, LoRa pkt seq 3, LoRa Sent in 1671, Switch to power saving mode, 4644, 3602717, 3598073.

At the bottom of the window, there are checkboxes for 'Autoscroll' and 'Show timestamp', and dropdown menus for 'No line ending' and '38400 baud' along with a 'Clear output' button.

Open serial monitor

Set baud rate to 38400

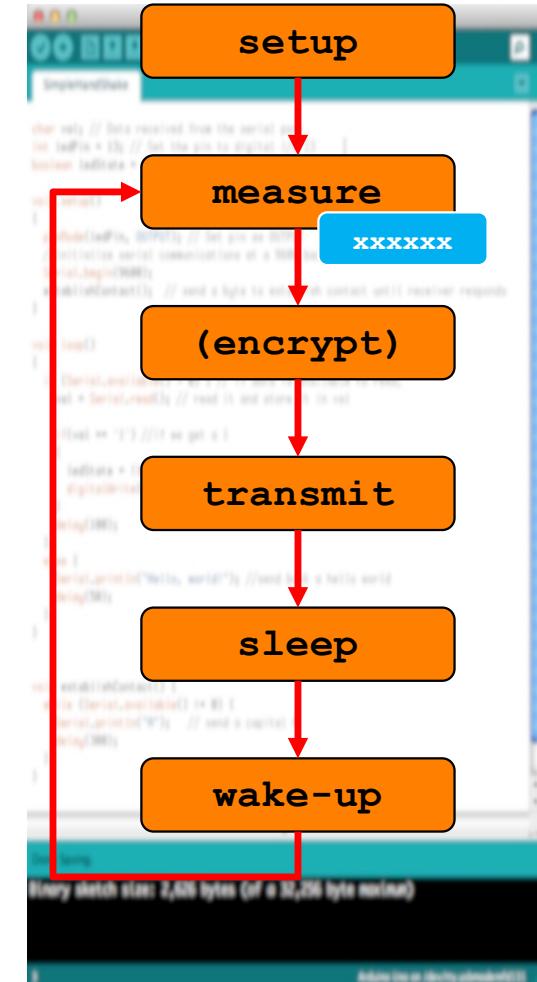
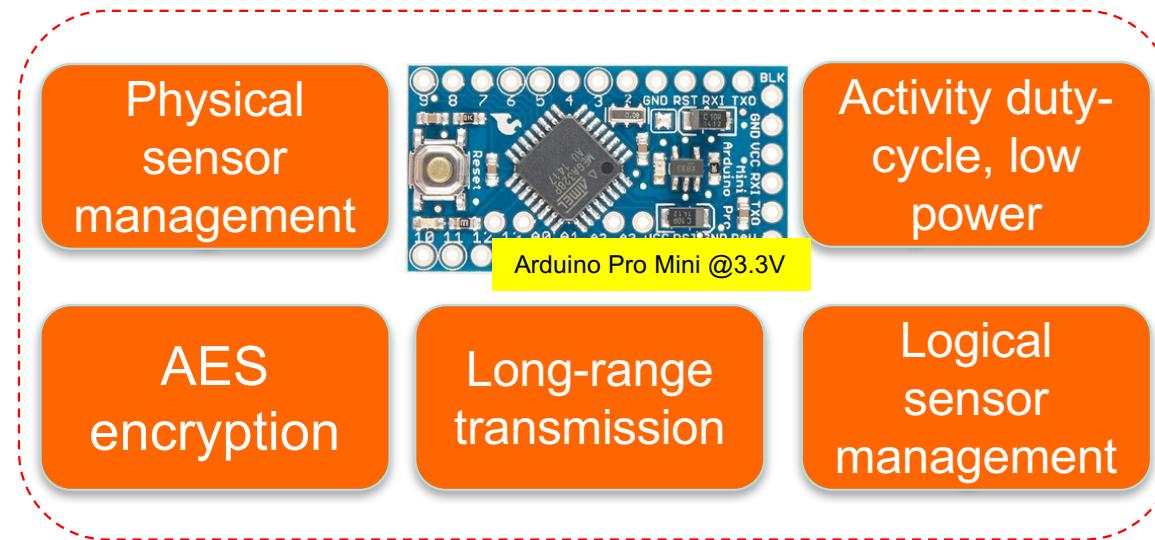
See output from board

Check that transmission is OK

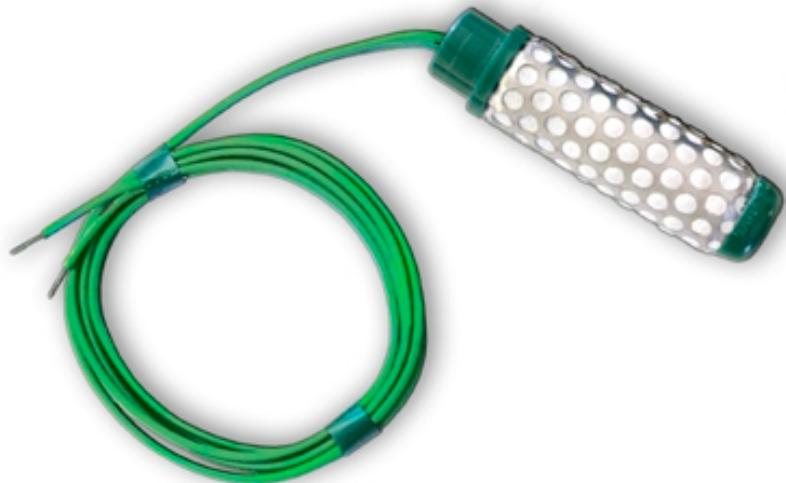
Generic & cyclic behavior

2 soil sensors can be attached

A0 (signal), A1 (pwr)
 &
 A2 (signal), A3 (pwr)

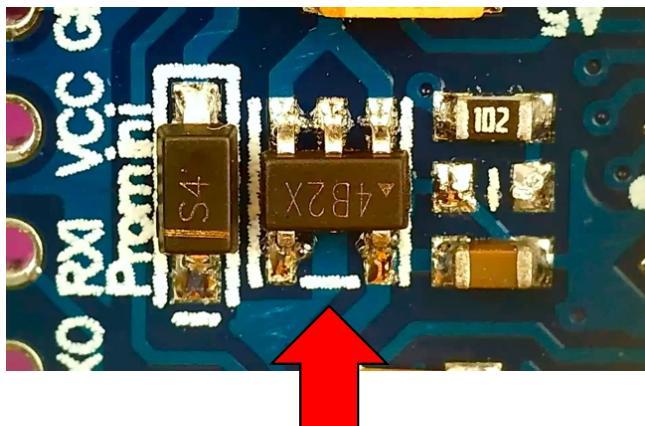


With a Watermark sensor



with a Watermark sensor, the "pseudo-AC Short Pulse" method will be used – see <https://www.irrometer.com/200ss.html>
D6 and D7 will be used to alternating power the sensor
A0 and A1 will be used to read signal from sensor

Reducing power consumption

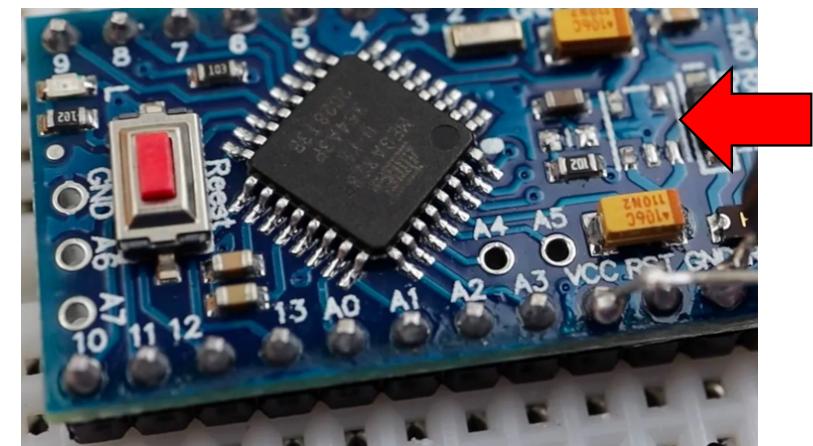


Remove the power LED by just clipping it off with some wire cutters

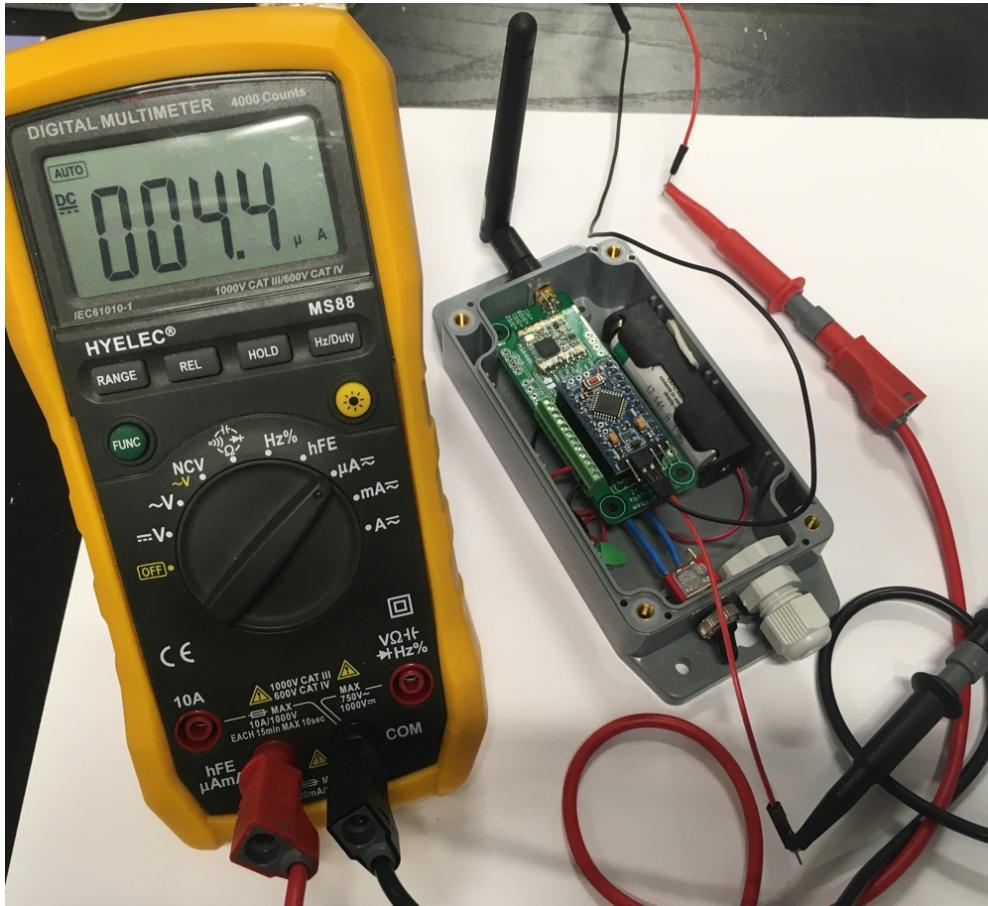
Remove the voltage regulator with a small plier

Only inject up to 3.6V through the VCC pin

5uA in deep sleep mode



Power consumption deep sleep



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

Expected autonomy with 1 transmission / hour:

over 2 years with either 2 AA batteries or 1 AA 3.6V Lithium battery