

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



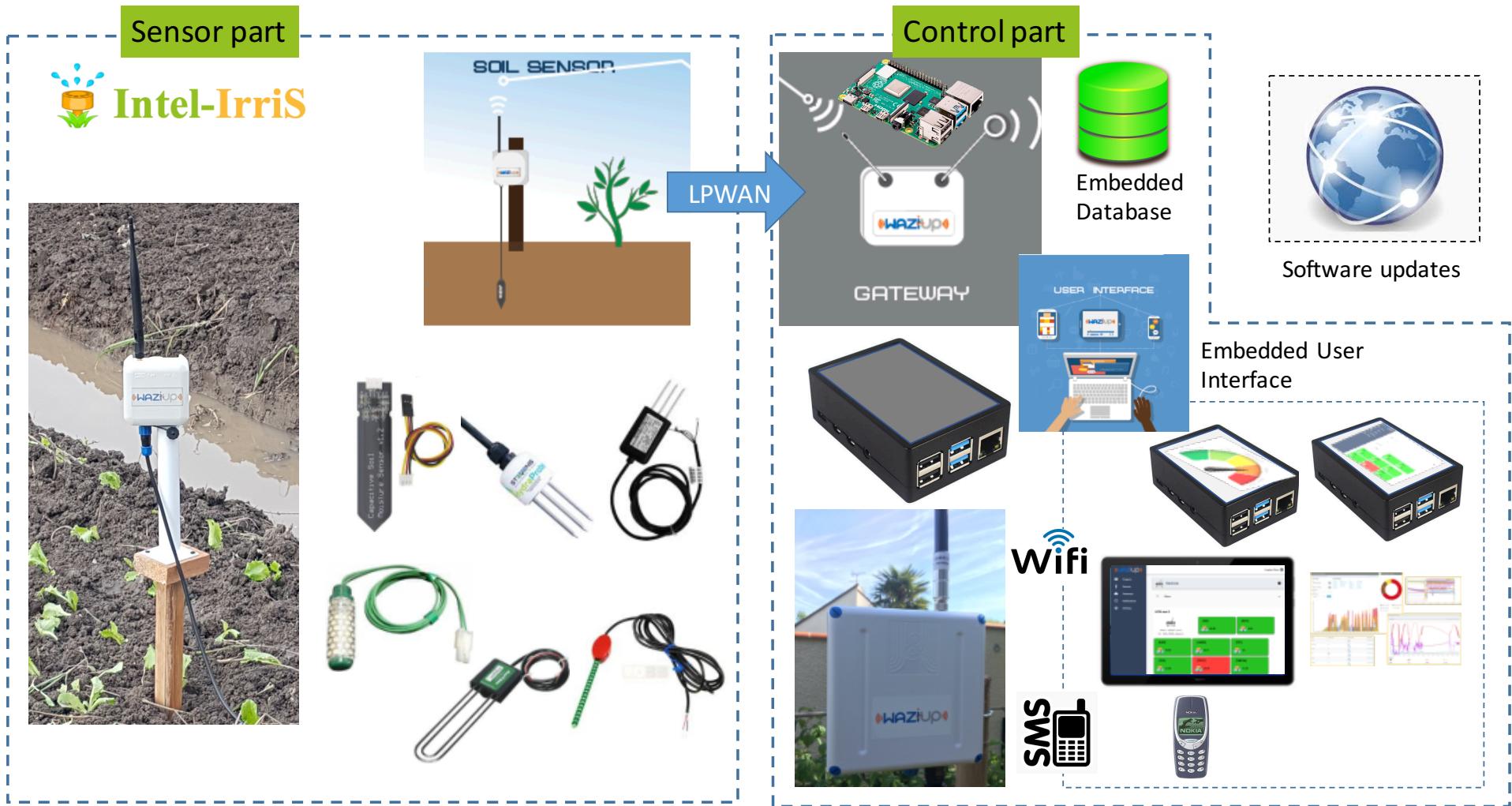
Building the Intel-IrriS IoT platform Part 1: soil sensor device



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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

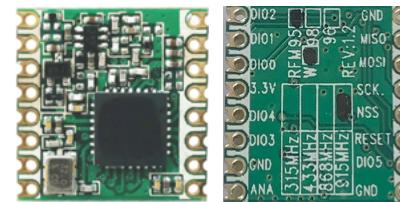
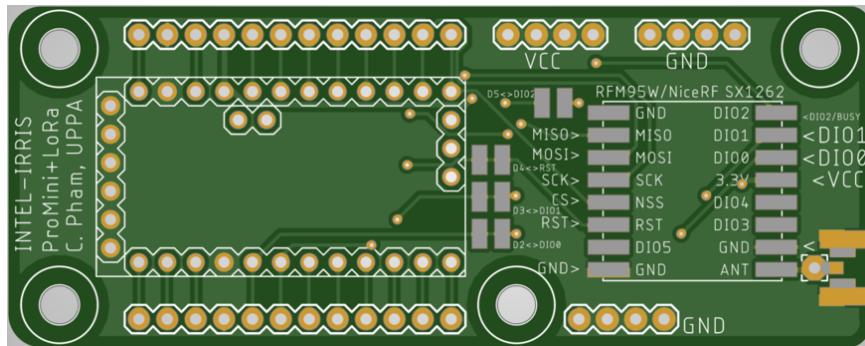


Review: Starter-kits

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



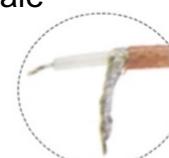
Soil sensor: electronic parts



RFM95W (868MHz)
RFM96W (433MHz)
NiceRF SX1262 (868MHz)
NiceRF SX1268 (433MHz)



PCB mount
or pigtail



SMA
female



SMA
male



| options



4P1

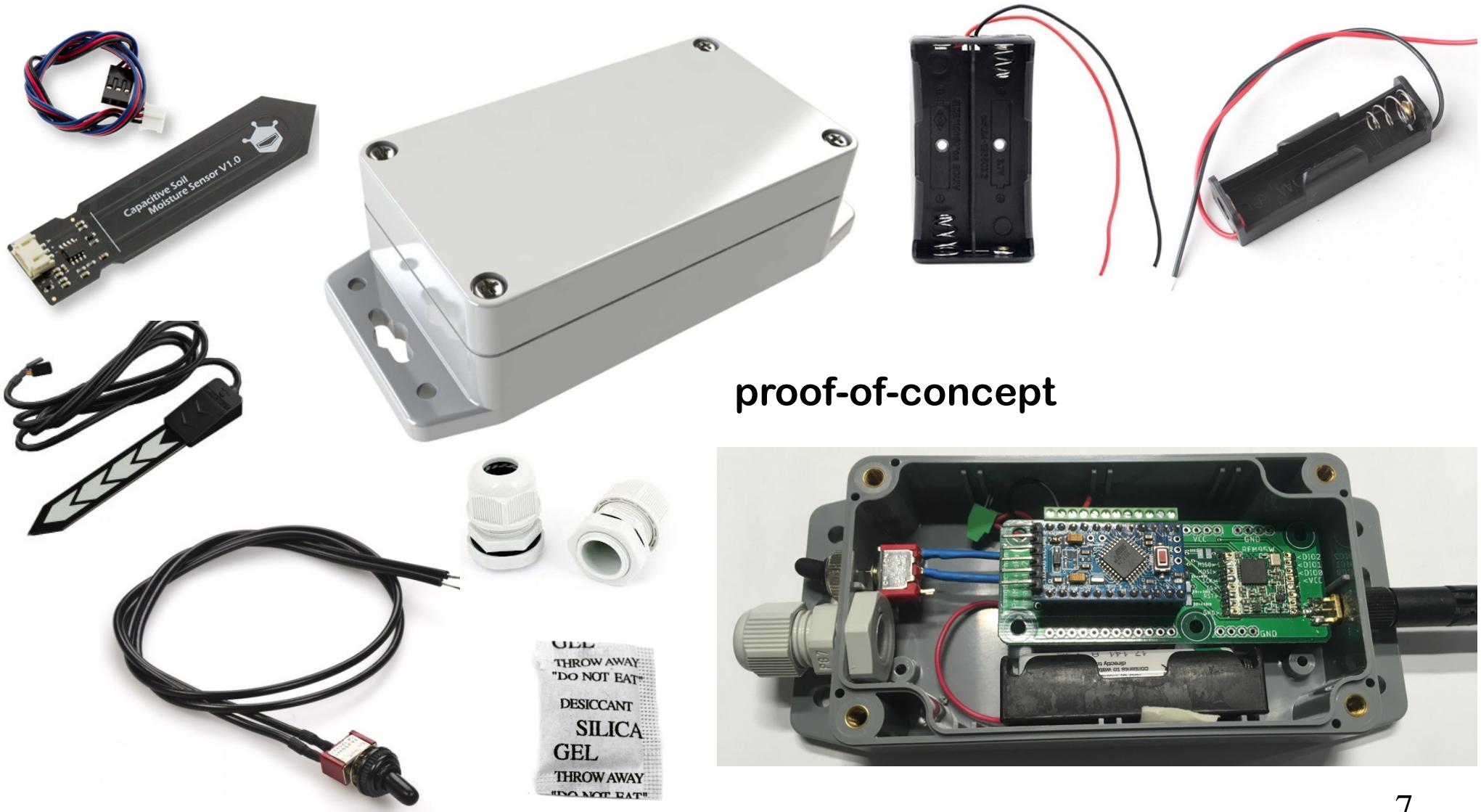


4P1

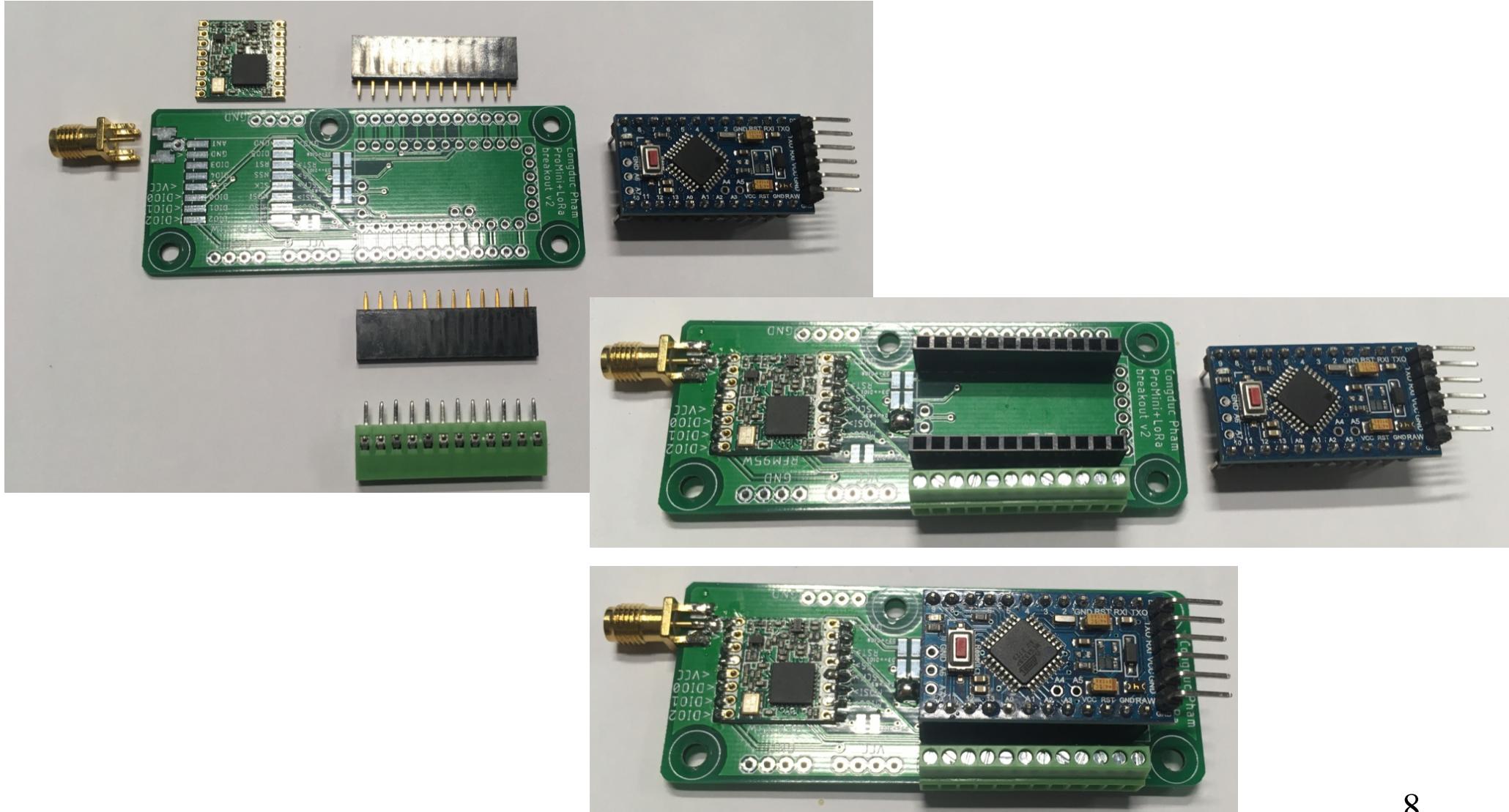


4 P I

Soil sensor: casing parts & integration



Assembling PCB board



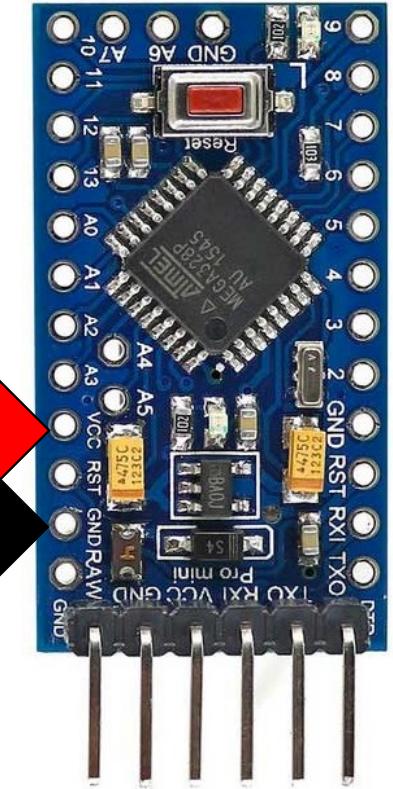
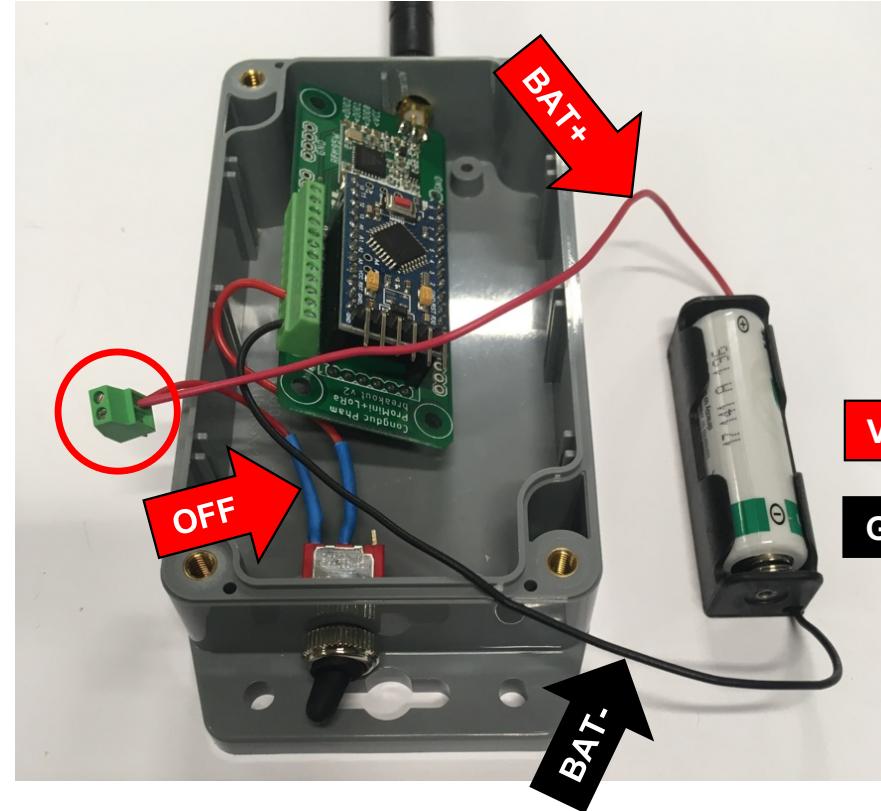
Get a case for outdoor usage



Here, it is an IP65 box which dimension is $115 \times 65 \times 40\text{mm}$.

First, drill a 7mm hole for the SMA female connector.

Installing the PCB board



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

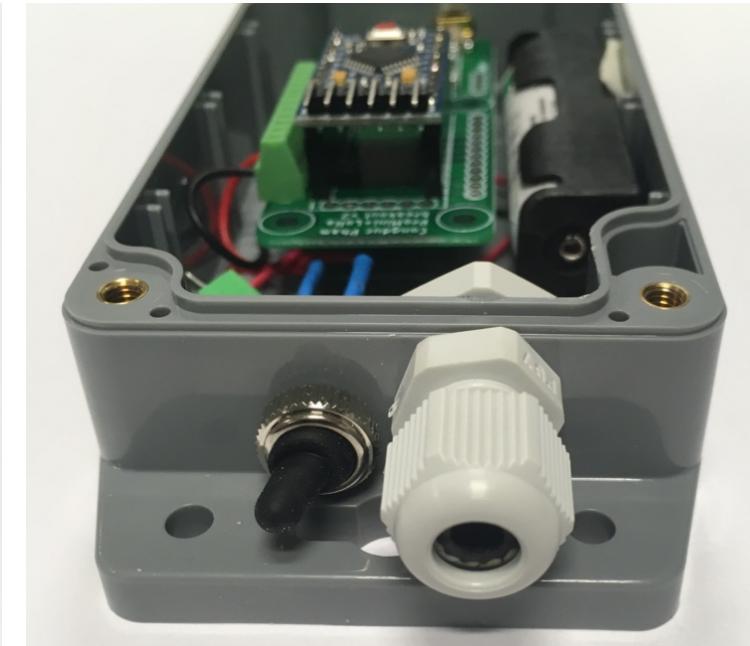
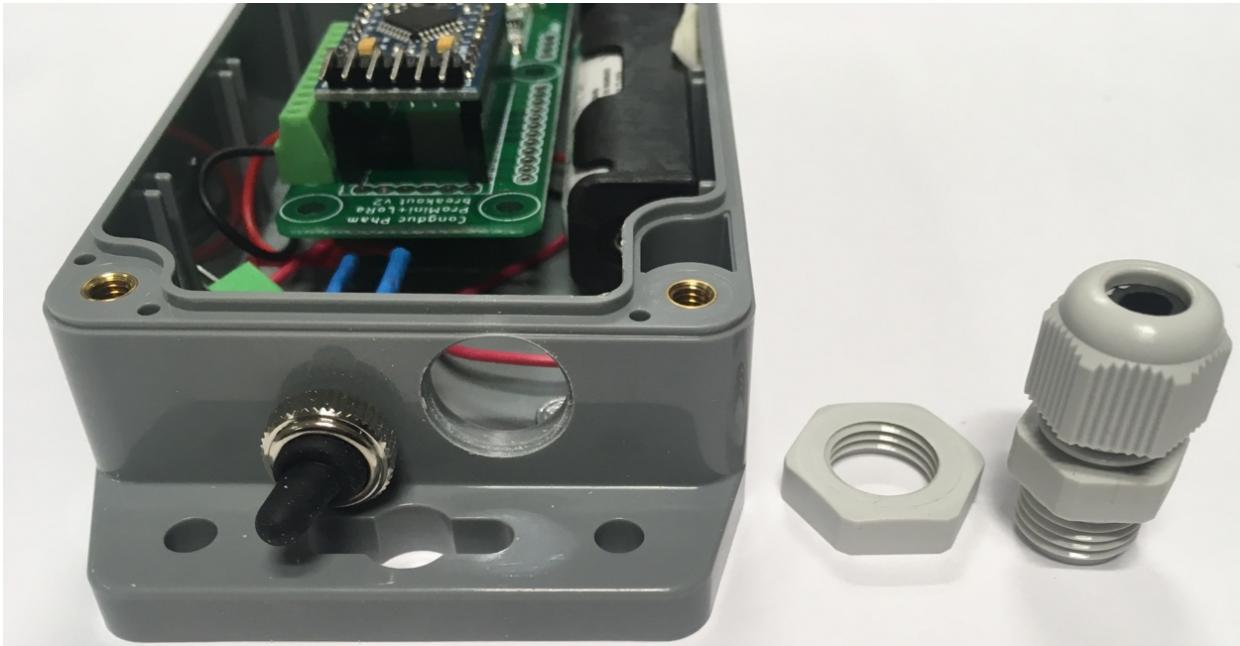
Putting it altogether



Here we use a 1xAA 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



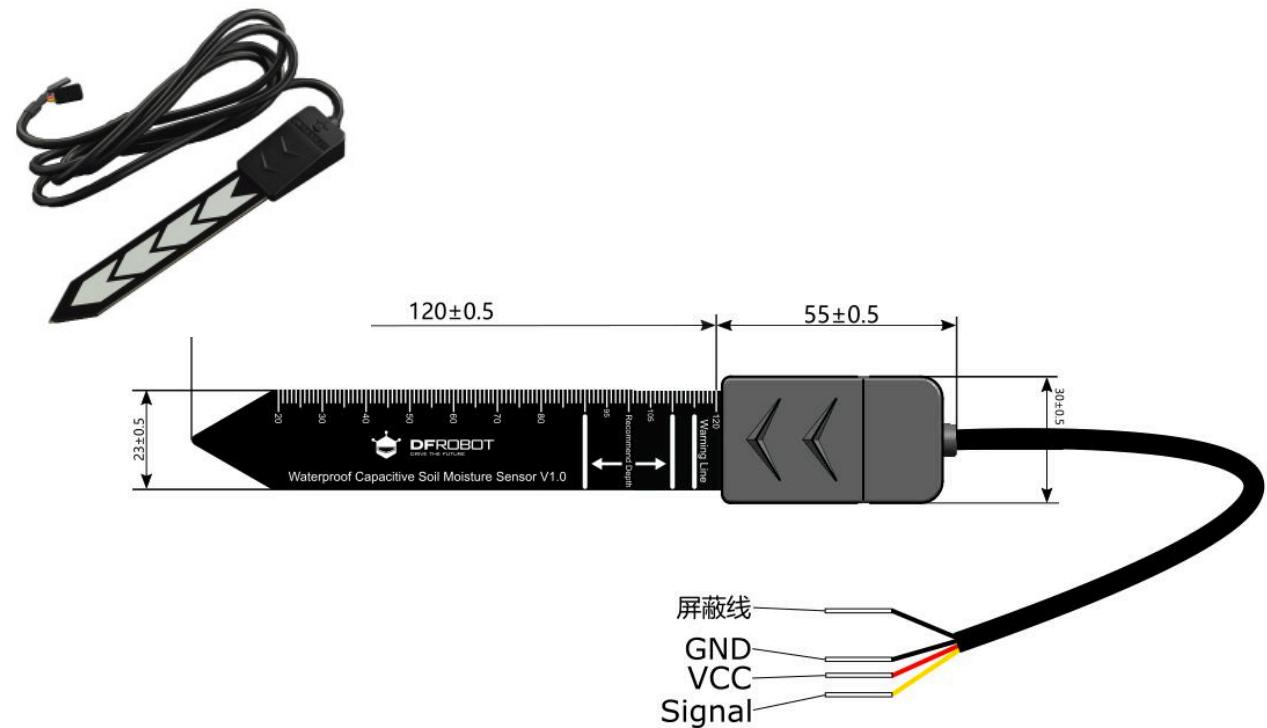
Installing your own cable gland



Drill a hole depending on the gland diameter

Here PG7, 12mm, so a hole of 13mm

Last step: connect the SEN0308

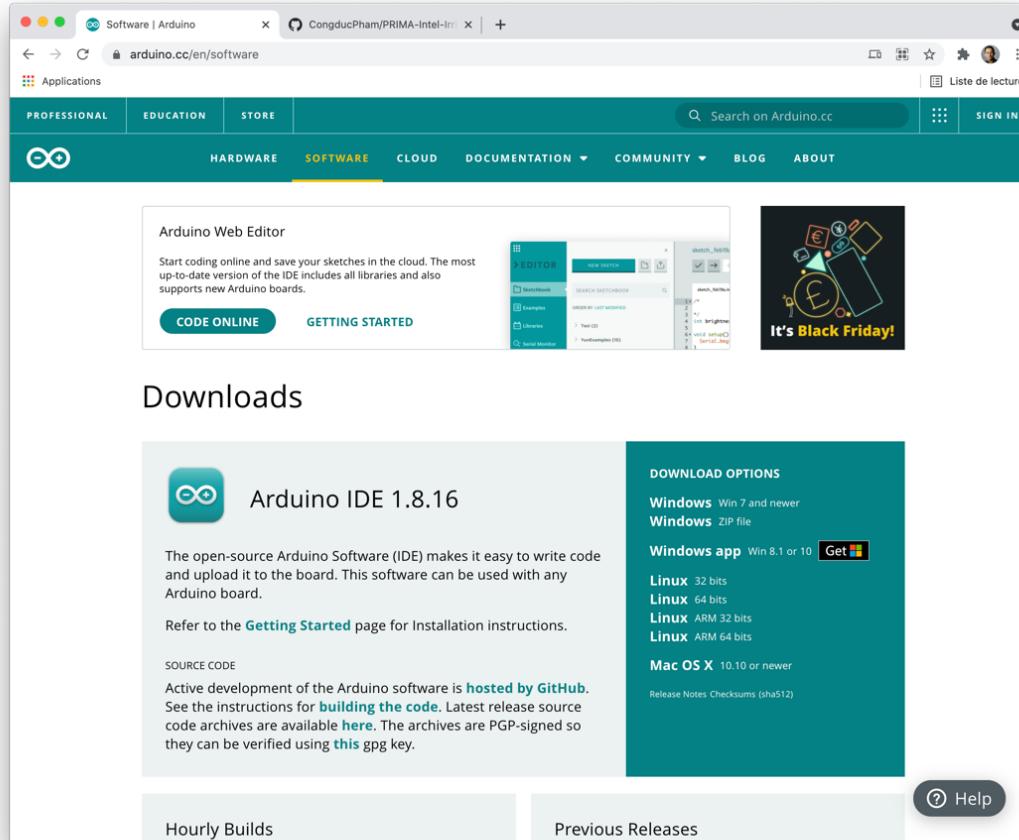


Insert sensor's wire through cable gland

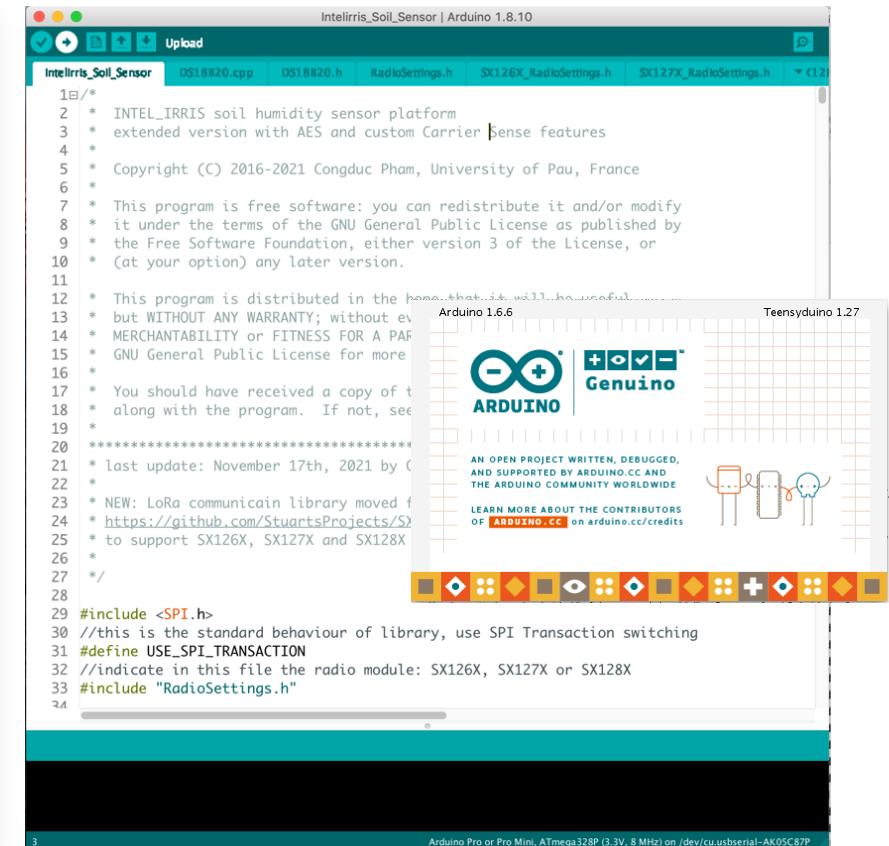
Connect SEN0308 wires to board:

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

Getting the software: Arduino IDE



The screenshot shows the Arduino website's download section for the Arduino IDE. It features a large image of the IDE interface with a "It's Black Friday!" promotion overlay. Below the image, there are two main download options: "CODE ONLINE" and "GETTING STARTED". The "GETTING STARTED" option leads to the installation instructions. To the right, there is a "Downloads" section for the Arduino IDE 1.8.16 version. It includes a download icon, the version number, and a brief description: "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." It also provides links for "SOURCE CODE" (hosted on GitHub) and "DOWNLOAD OPTIONS" for Windows, Linux, and Mac OS X.



The screenshot shows the Arduino IDE interface with a project titled "Intelirris_Soil_Sensor" loaded. The code editor displays the following header file content:

```

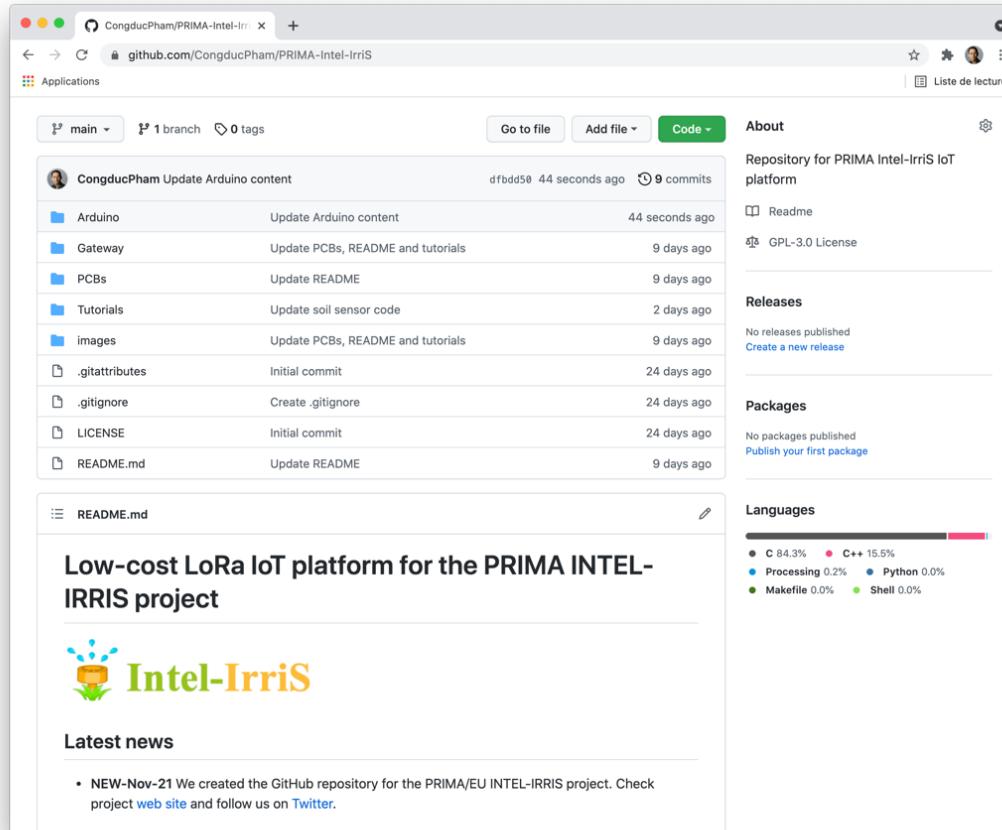
1 //*
2 * INTEL_IRRIS soil humidity sensor platform
3 * extended version with AES and custom CarrierSense features
4 *
5 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France
6 *
7 * This program is free software: you can redistribute it and/or modify
8 * it under the terms of the GNU General 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 * See the GNU General Public License for more details.
16 *
17 * You should have received a copy of the
18 * GNU General Public License along with this program. If not, see
19 *
20 * last update: November 17th, 2021 by C
21 *
22 * NEW: LoRa communication library moved f
23 * https://github.com/StuartsProjects/S
24 * to support SX126X, SX127X and SX128X
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

```

The interface includes toolbars for file operations like Open, Save, and Print, and a status bar at the bottom indicating "Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz) on /dev/cu.usbserial-AK05C87P". The Arduino and Genuino logos are visible in the bottom right corner.

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. There are 9 commits in the main branch. The commits are:

- CongducPham Update Arduino content (dfbdd58, 44 seconds ago)
- Arduino Update Arduino content (44 seconds ago)
- Gateway Update PCBs, README and tutorials (9 days ago)
- PCBs Update README (9 days ago)
- Tutorials Update soil sensor code (2 days ago)
- images Update PCBs, README and tutorials (9 days ago)
- .gitattributes Initial commit (24 days ago)
- .gitignore Create .gitignore (24 days ago)
- LICENSE Initial commit (24 days ago)
- README.md Update README (9 days ago)

The repository has a README.md file which contains the following text:

```
Low-cost LoRa IoT platform for the PRIMA INTEL-IRRIS project
```

The repository also includes an Intel-IrriS logo and a "Latest news" section.

On your computer, create a sketch folder

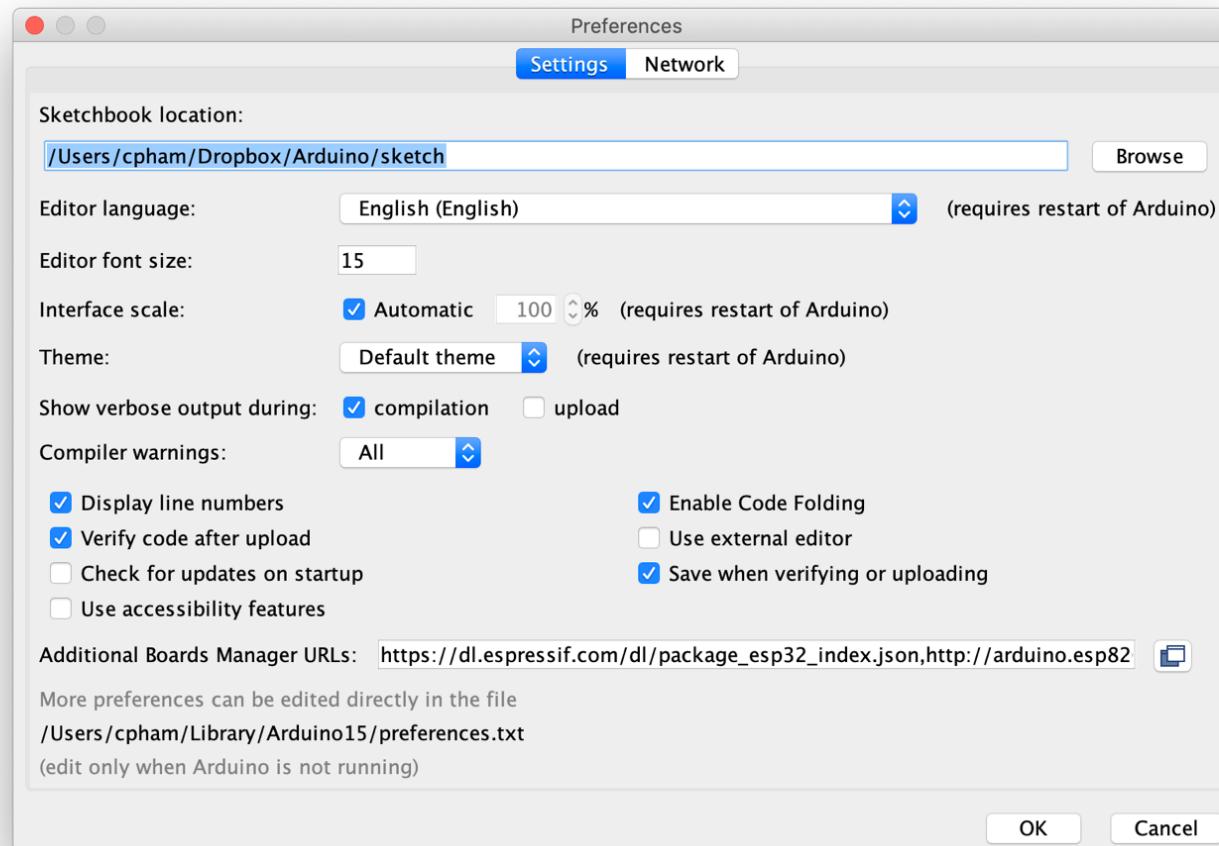
Then download the whole repository as ZIP file

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>

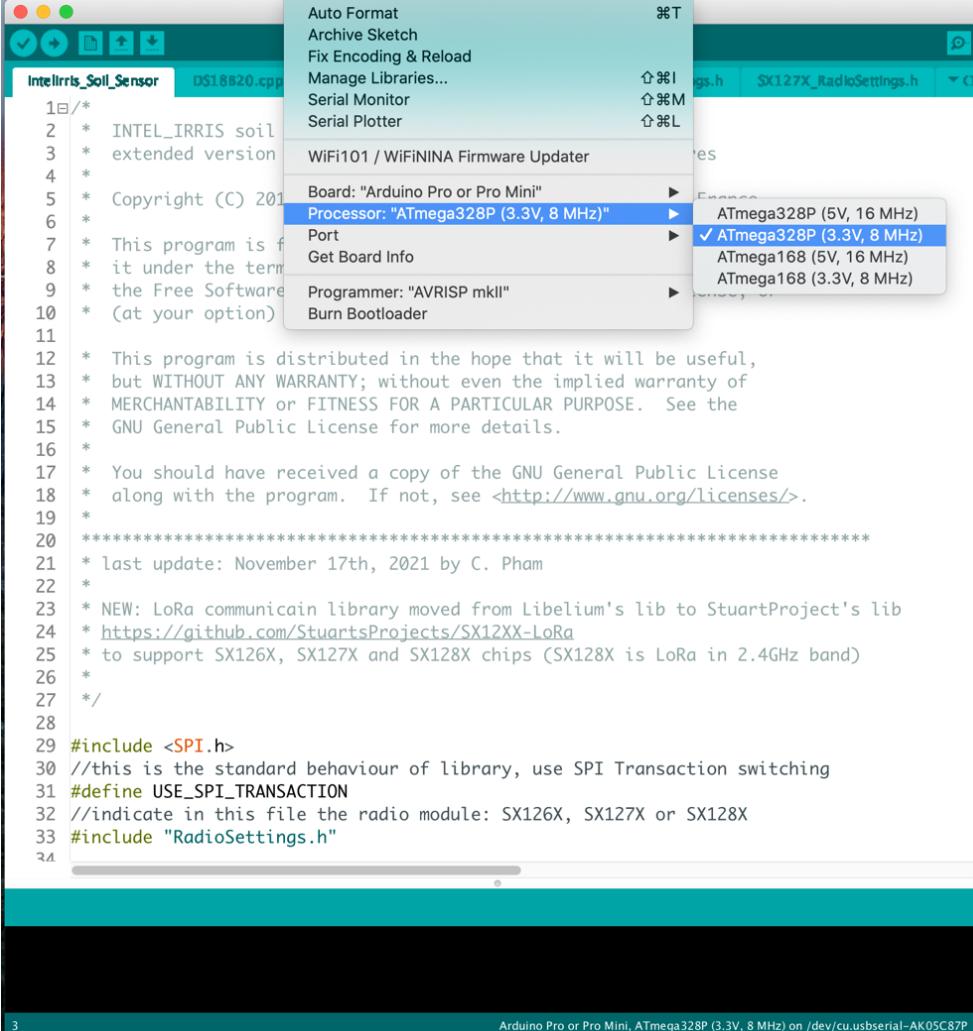


Setting your Arduino IDE



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

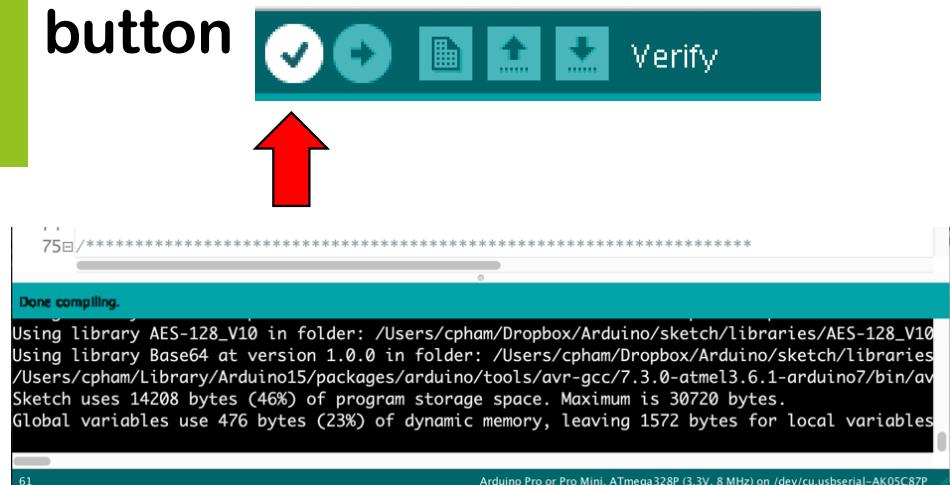
```

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**

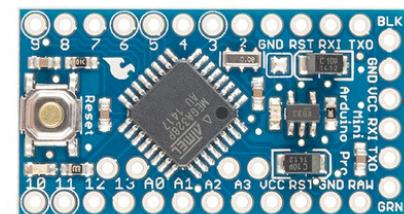
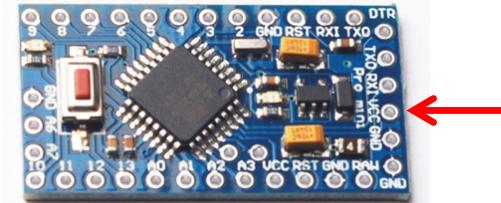
**Then click on the "verify"
button**



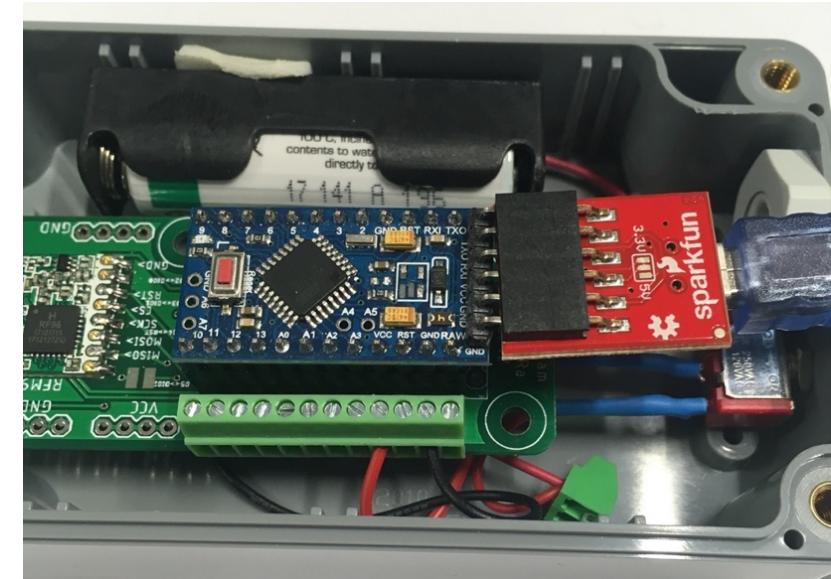
Connecting with an FTDI cable



Some clone version, check the VCC pin



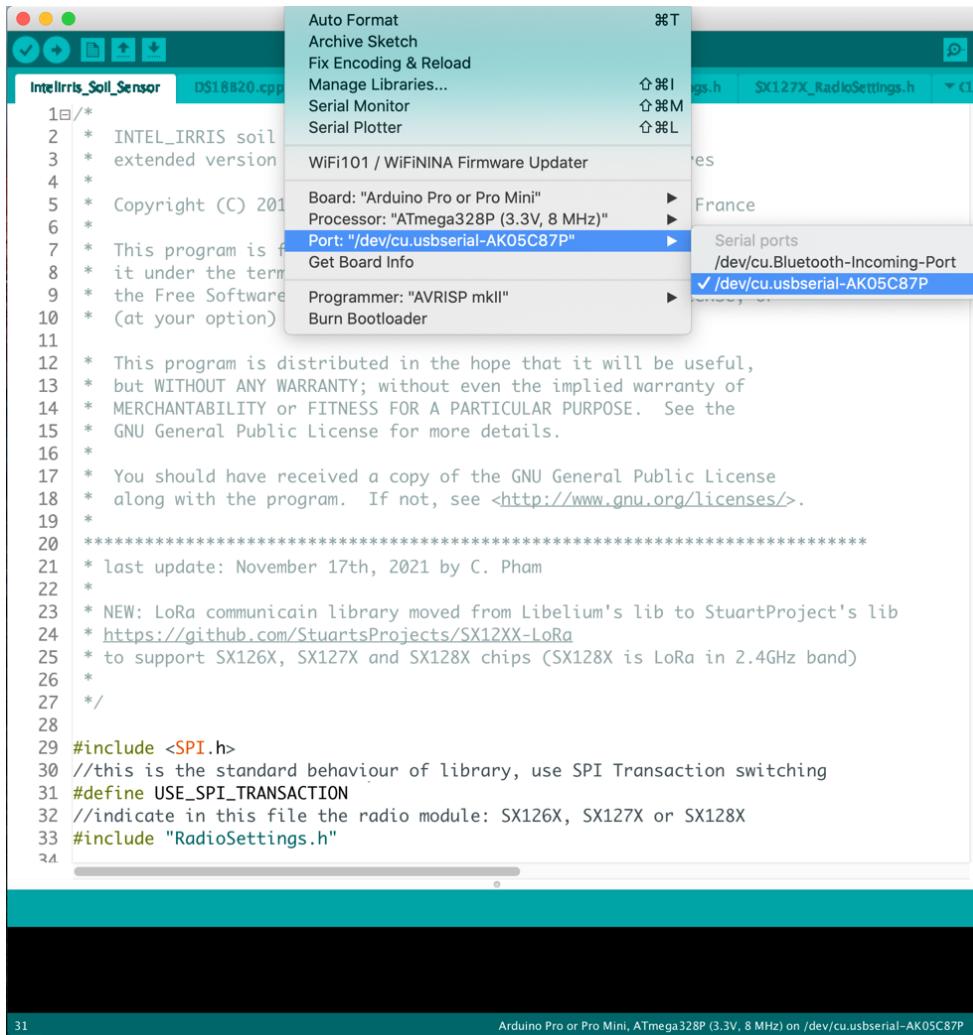
Original Sparkfun
version



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>

Uploading to your board

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_IRRIS 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 *  
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32 //indicate in this file the radio module: SX126X, SX127X or SX128X  
33 #include "RadioSettings.h"  
34
```

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

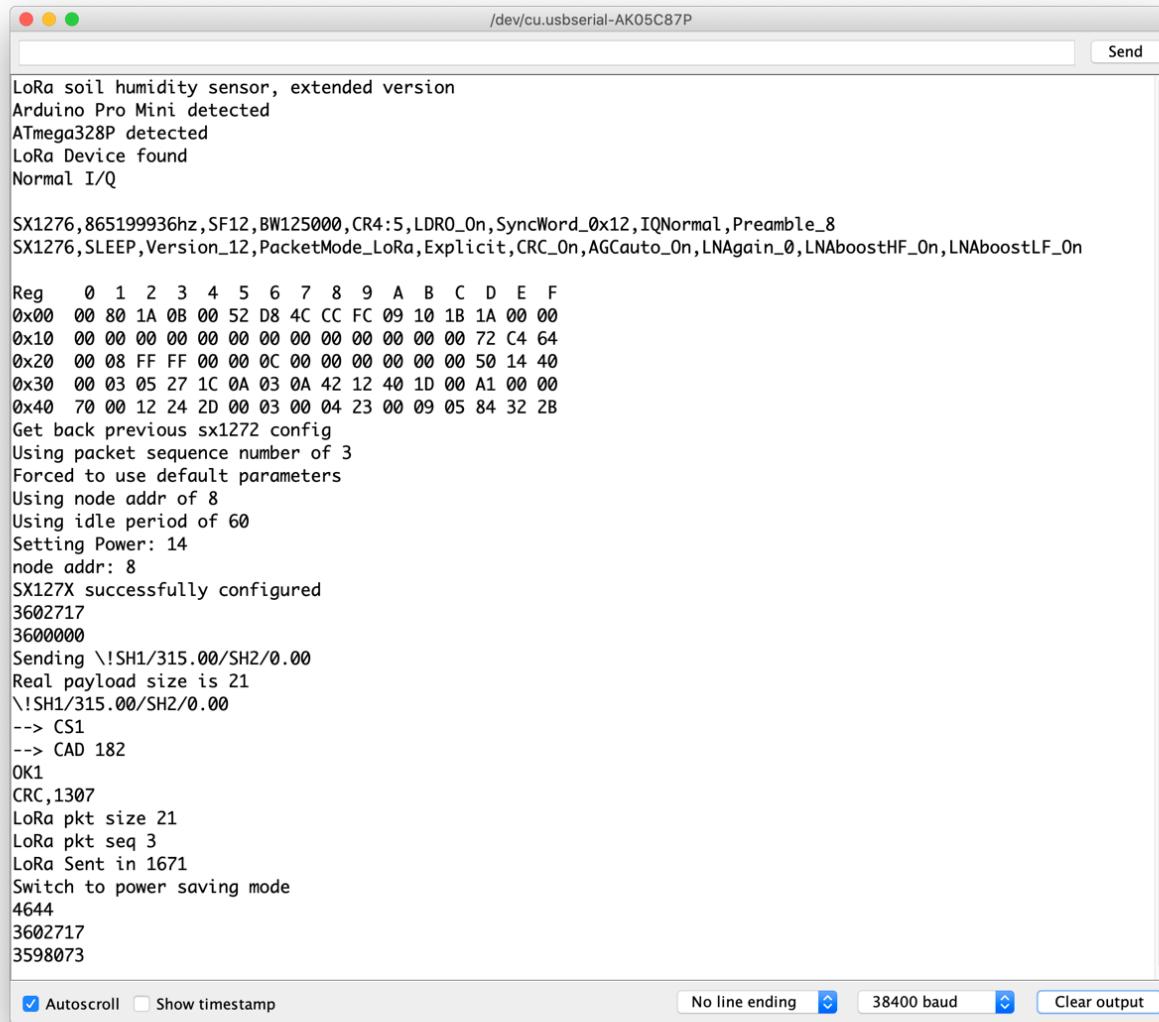
Click on the "upload" button



And wait until upload is completed

```
27 */
28
29
30
31 Done uploading.
Using library LowPower 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/libraries
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 soil humidity sensor. The output includes:

- LoRa soil humidity sensor, extended version
- Arduino Pro Mini detected
- ATmega328P detected
- LoRa Device found
- Normal I/Q
- SX1276, 865199936hz, SF12, BW125000, CR4:5, LDR0_On, SyncWord_0x12, IQNormal, Preamble_8
- SX1276, SLEEP, Version_12, PacketMode_LoRa, Explicit, CRC_On, AGCAuto_On, LNAGain_0, LNABoostHF_0n, LNABoostLF_0n
- 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 08 FF FF 00 00 0C 00 00 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
- 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
- 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
- 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' (set to 'None') and '38400 baud' (set to '38400'). There is also a 'Clear output' button.

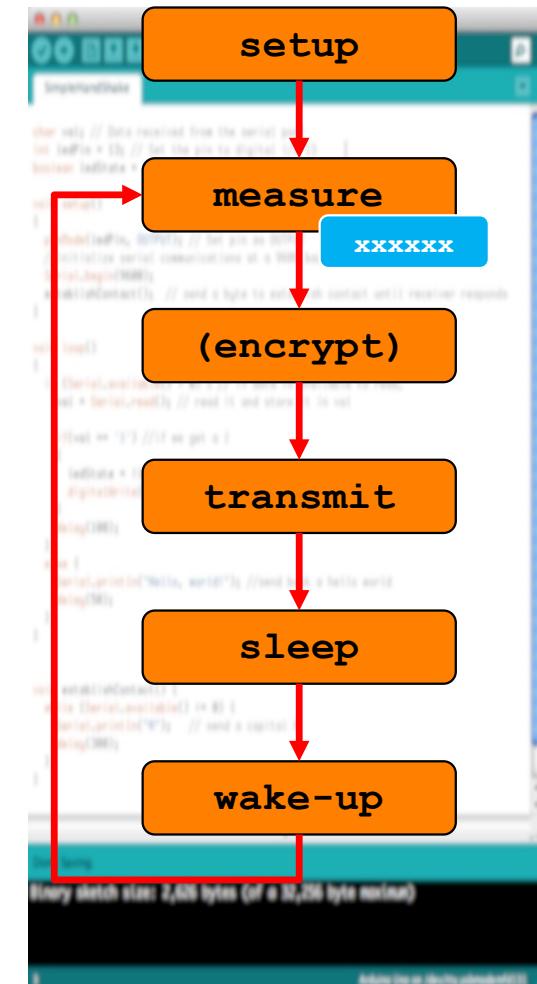
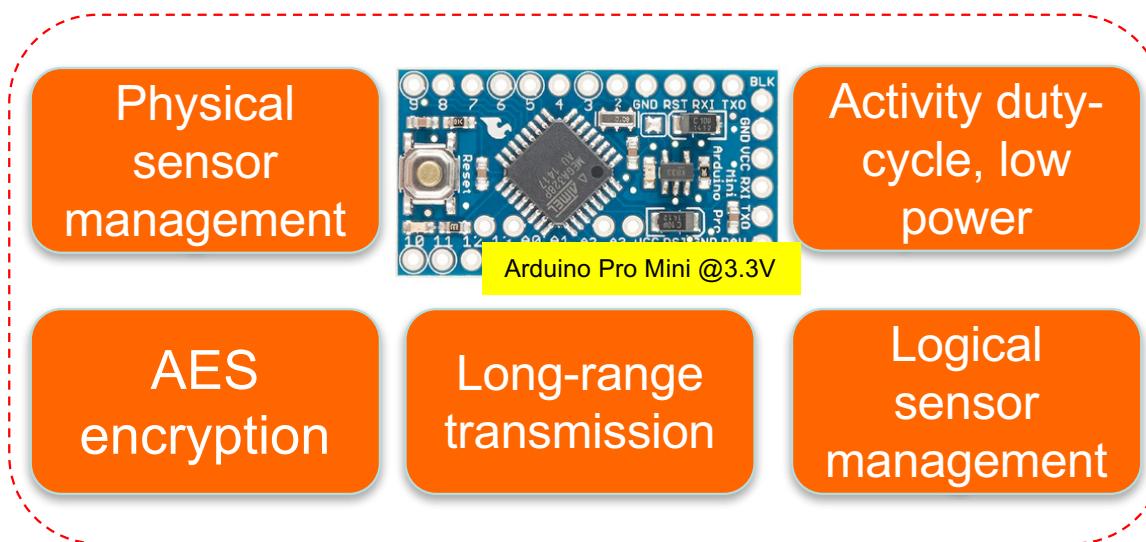
Open serial monitor

Set baud rate to 38400

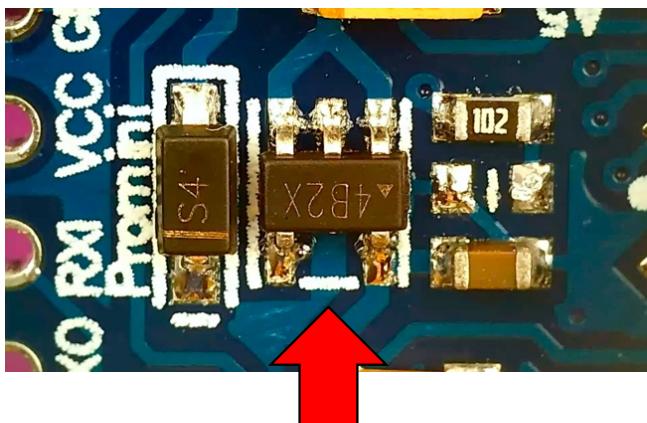
See output from board

**Check that
transmission is OK**

2 soil
sensors can
be attached



Reducing power consumption

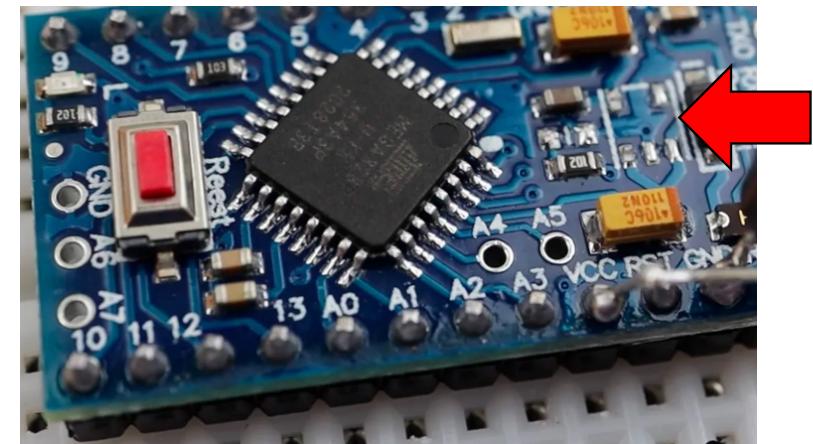


Remove the power LED by just clipping it off with some wire cutters

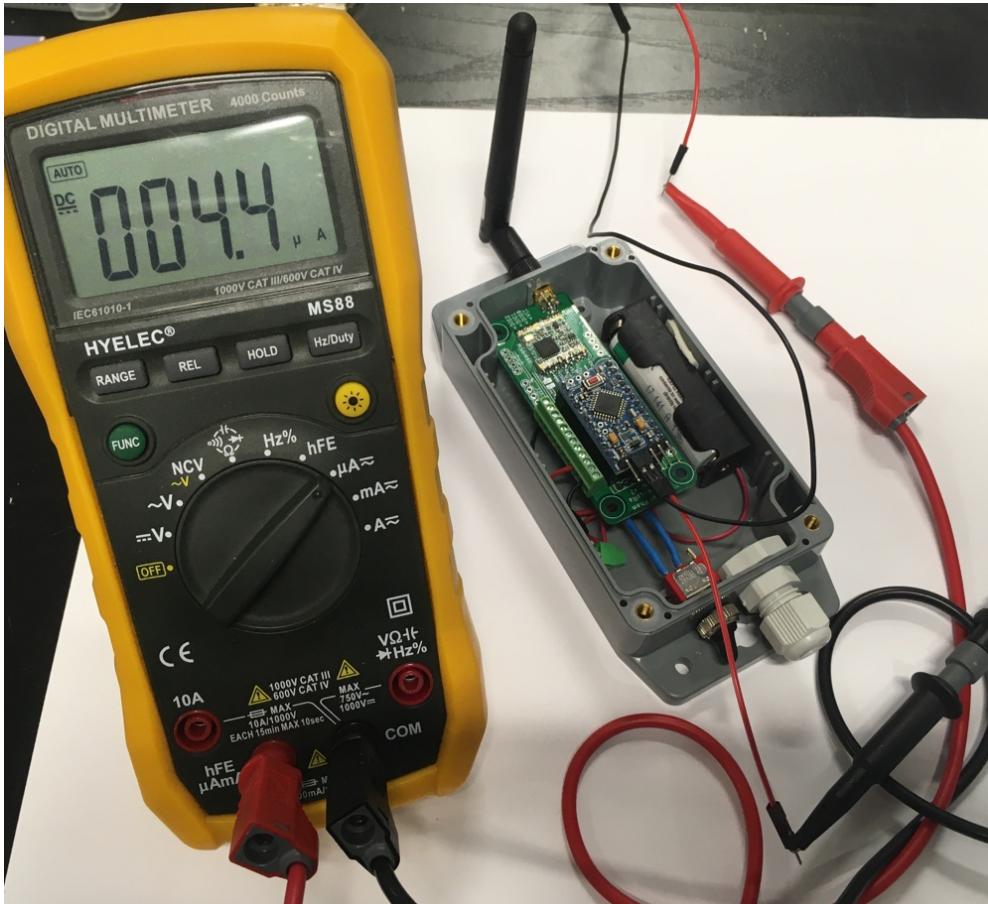
Remove the voltage regulator with a small plier

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