

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



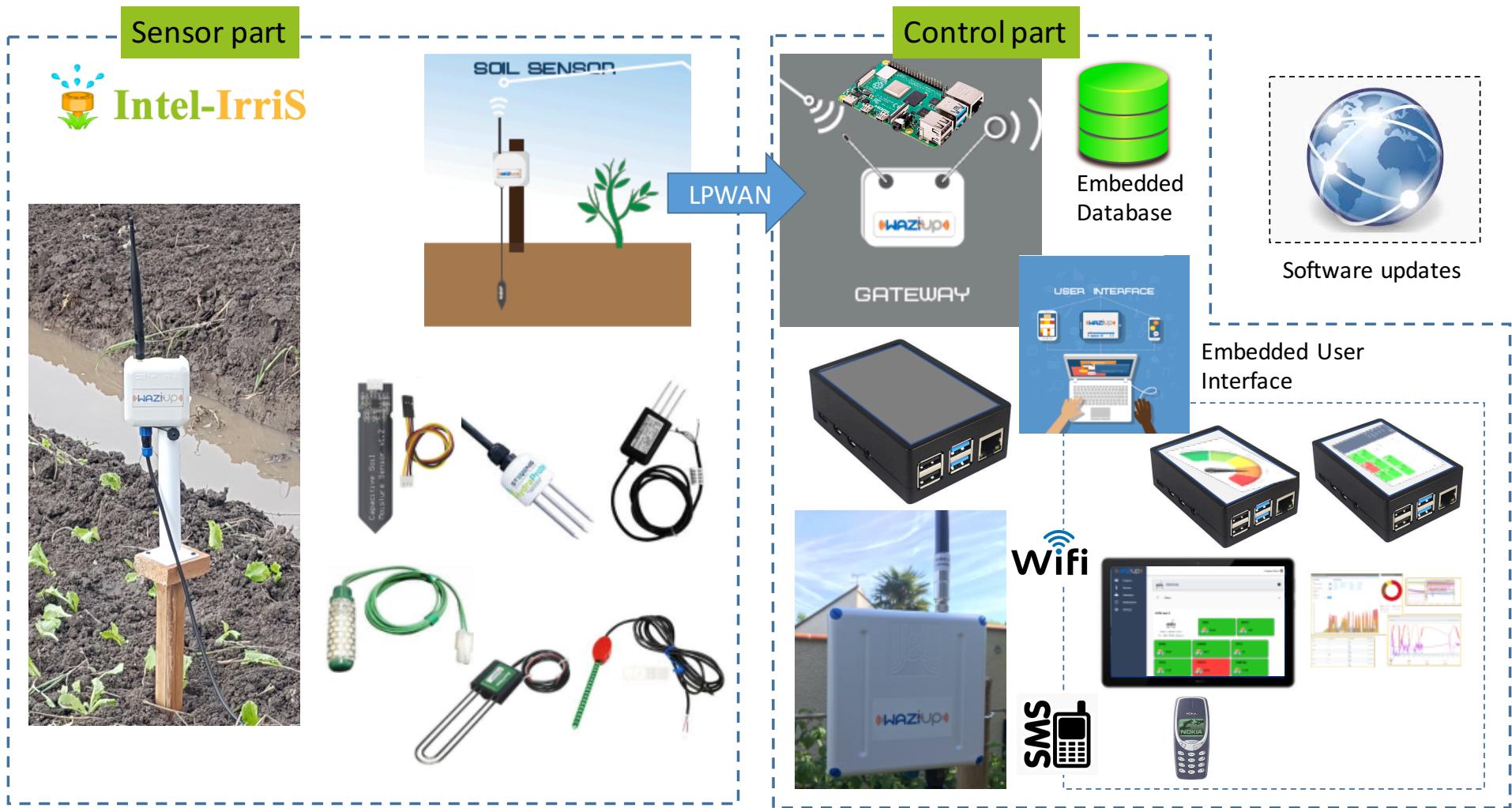
Building the Intel-IrriS IoT platform Part 1: soil sensor device



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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

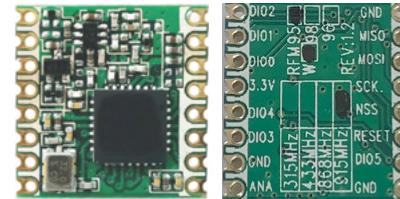
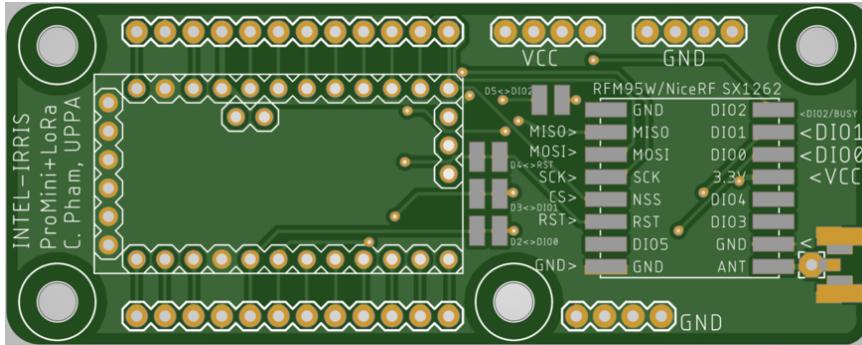


Review: Starter-kits

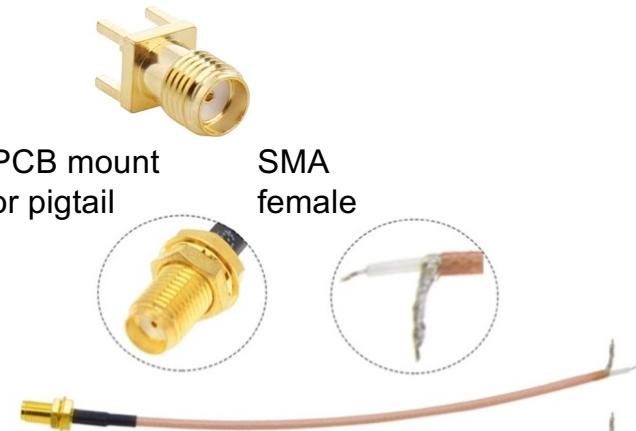
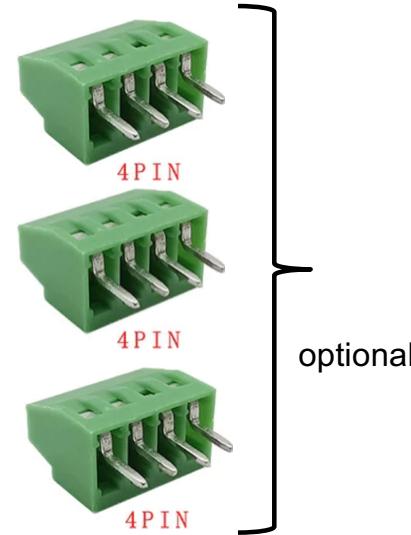
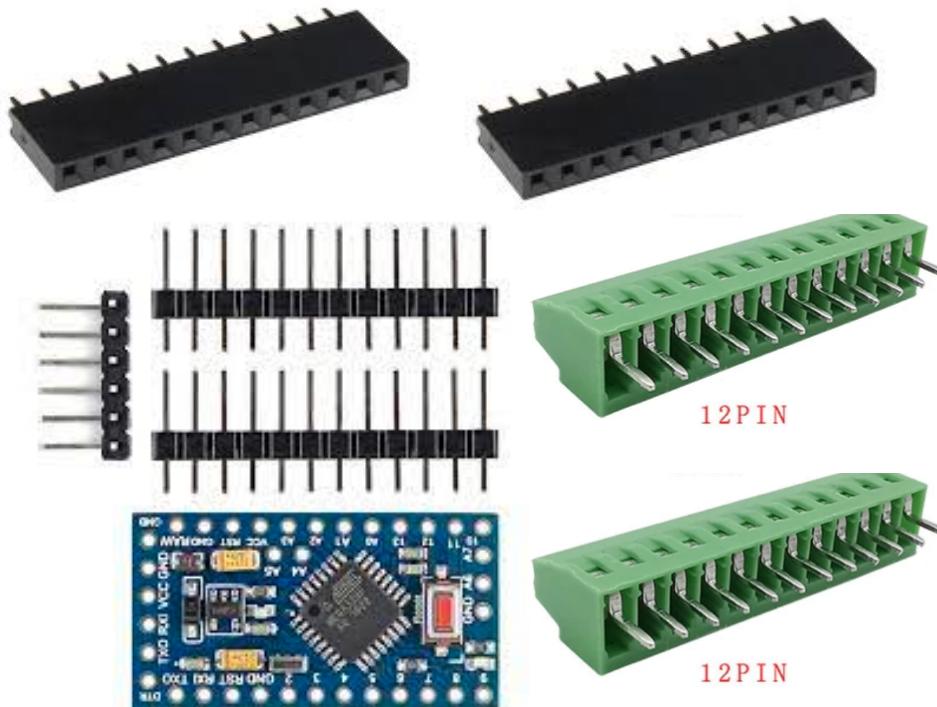
- "Intelligent Irrigation in-the-box", "plug-&-sense"
- At least 100 starter-kit will be distributed



Soil sensor: electronic parts



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



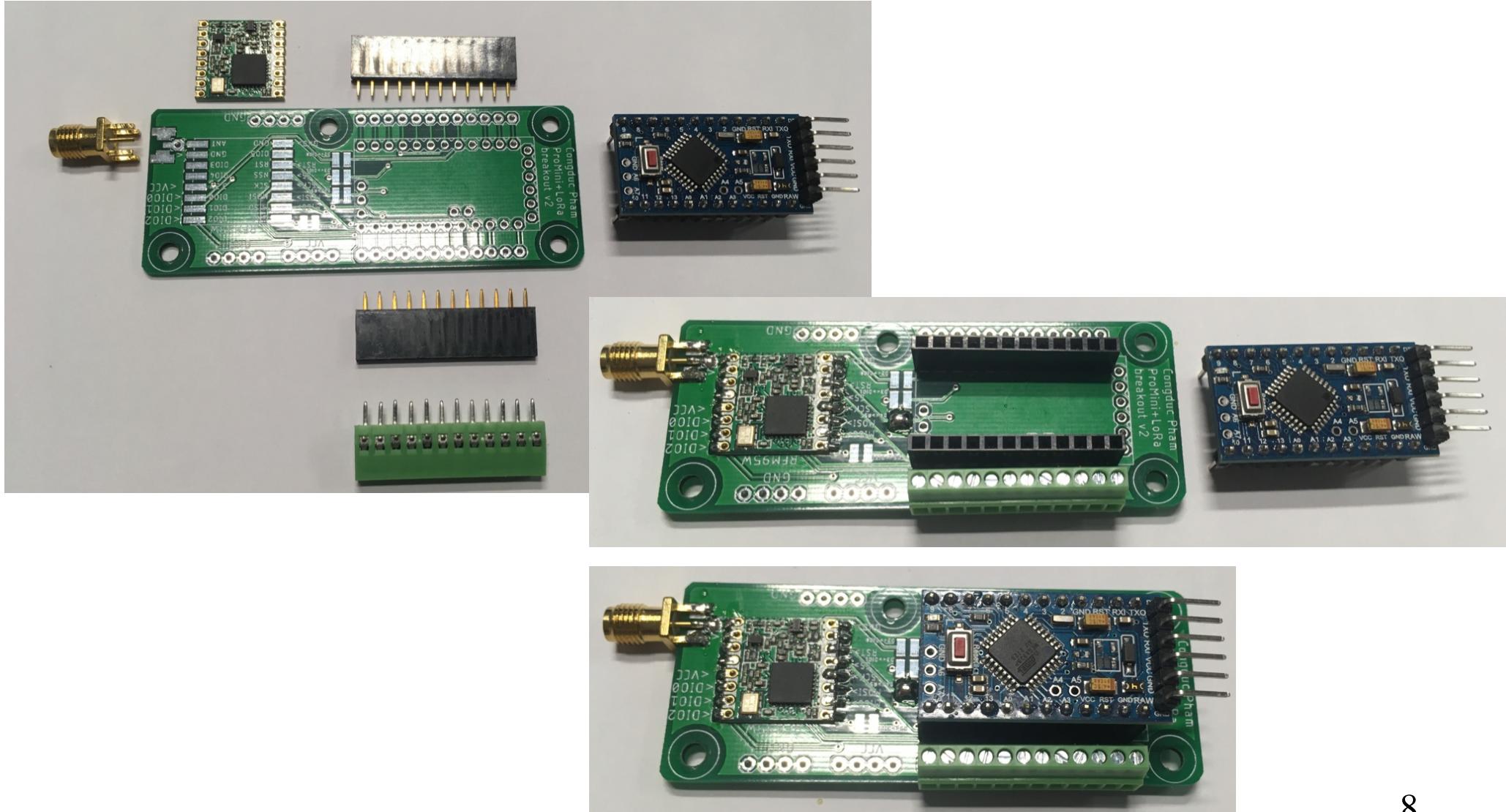
Soil sensor: casing parts & integration



proof-of-concept



Assembling PCB board



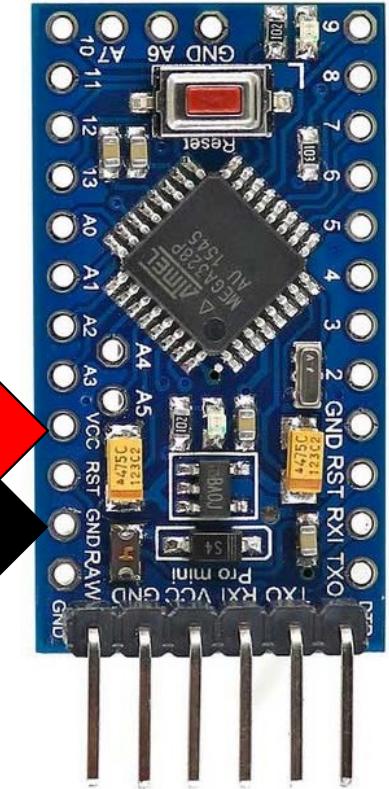
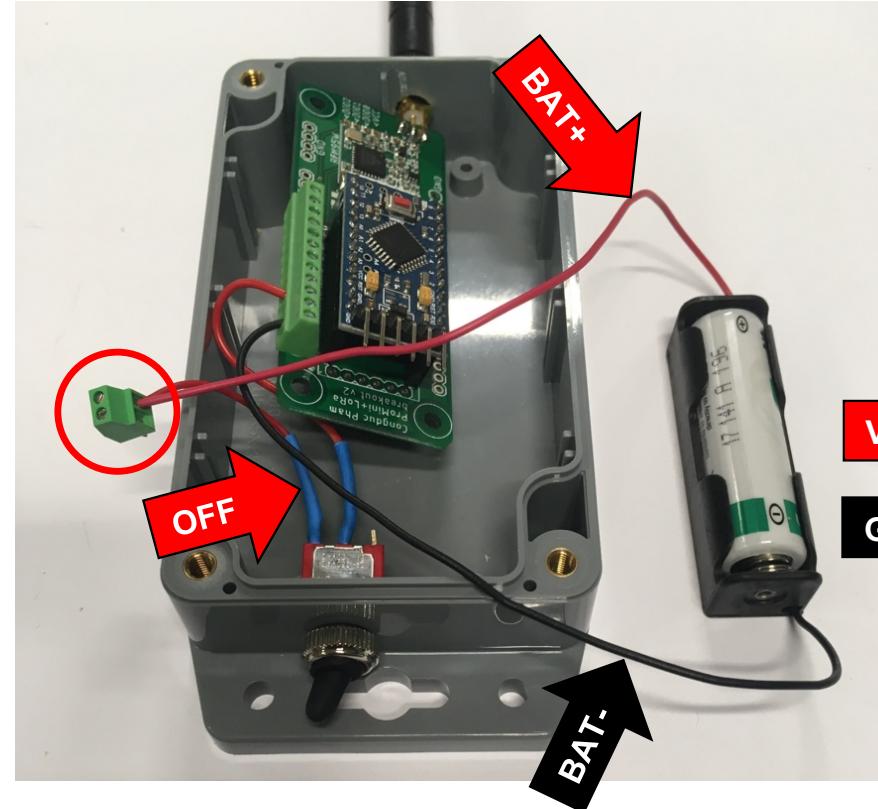
Get a case for outdoor usage



Here, it is an IP65 box which dimension is 115 x 65 x 40mm.

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

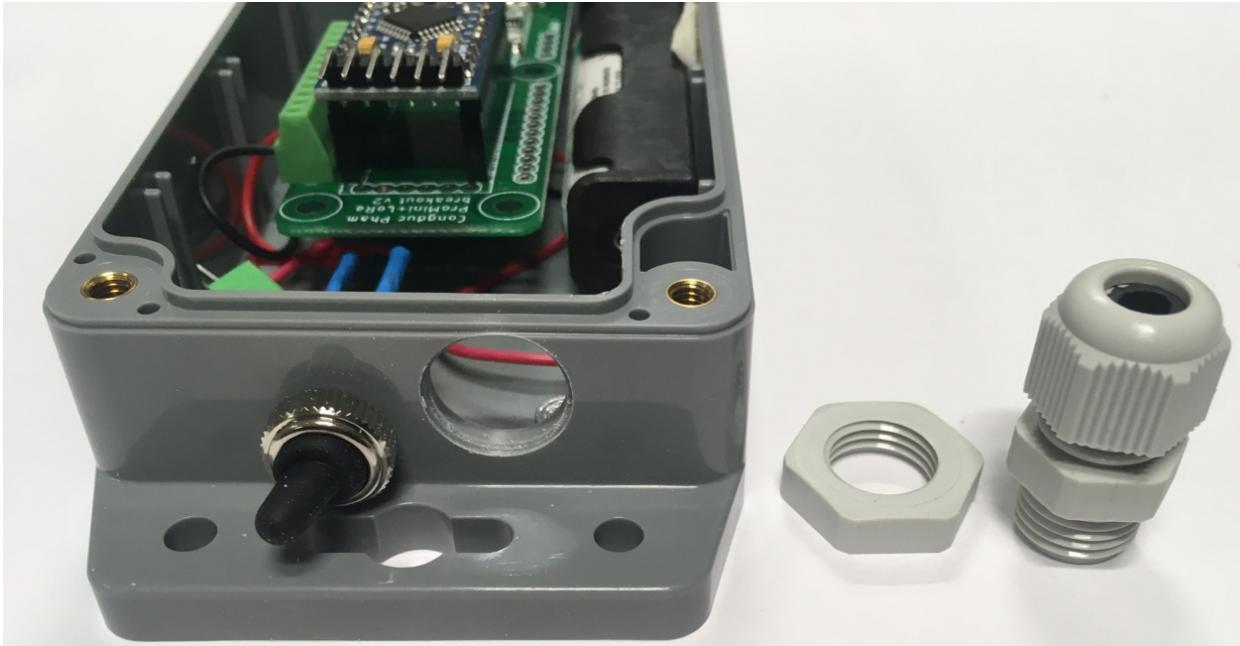
Putting it altogether



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



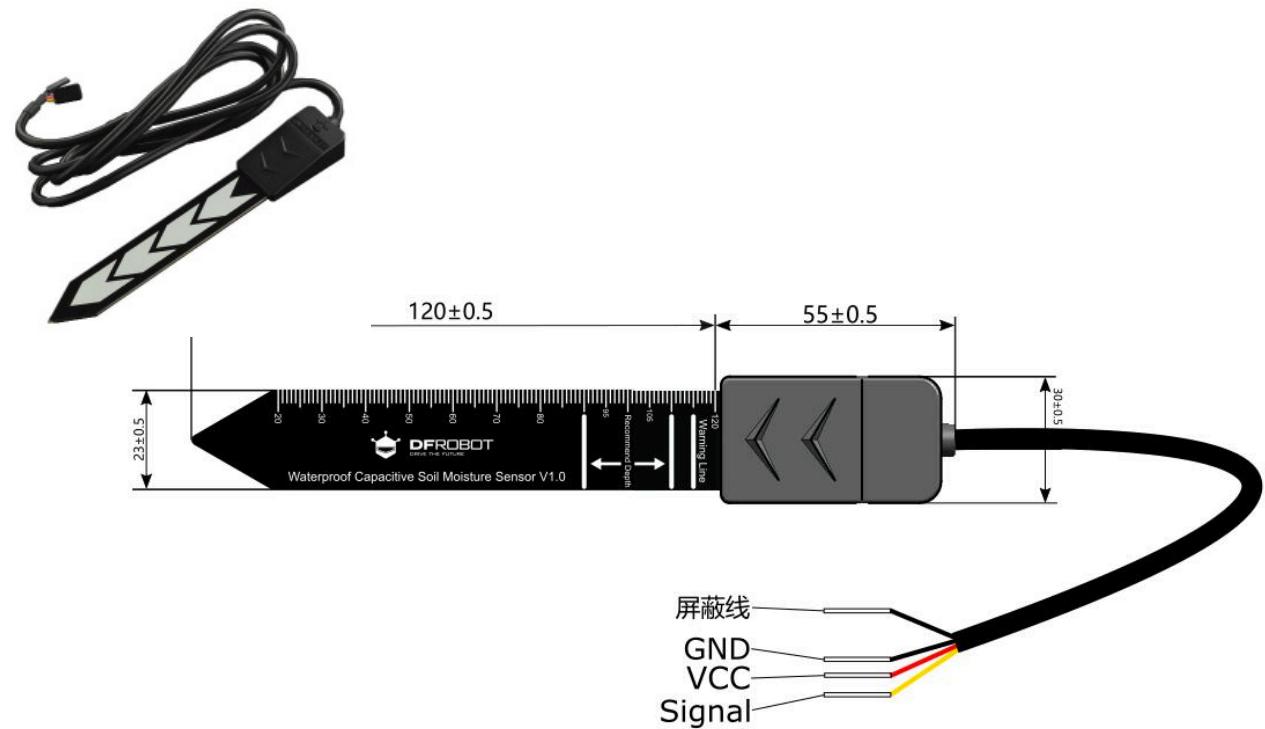
Installing your own cable gland



Drill a hole depending on the gland diameter

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

Last step: connect the SEN0308

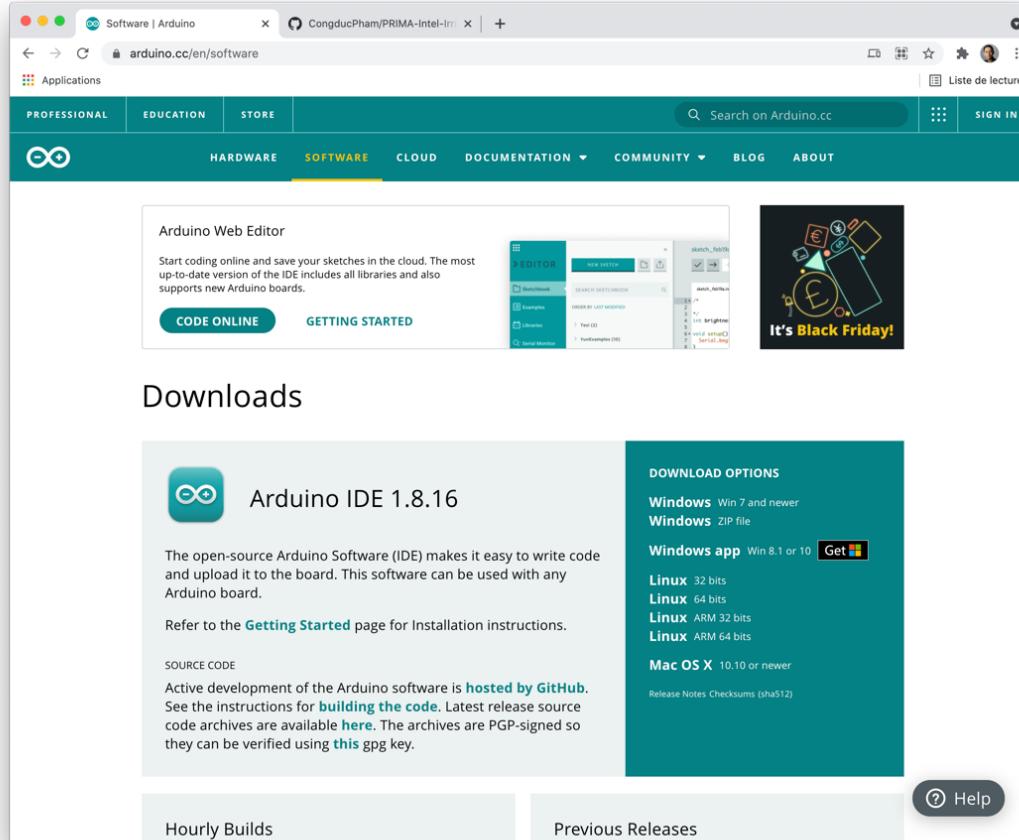


Insert sensor's wire through cable gland

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. It features a large image of the Arduino IDE interface with a '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 download page for Arduino IDE 1.8.16. This page includes a brief description of the IDE, a 'SOURCE CODE' link to GitHub, and a 'DOWNLOAD OPTIONS' section with links for Windows, Windows ZIP file, Windows app, Linux, Mac OS X, and Release Notes Checksums.



The screenshot shows the Arduino IDE interface with an open project titled 'IntelIrris_Soil_Sensor'. The code editor displays the following header comments:

```

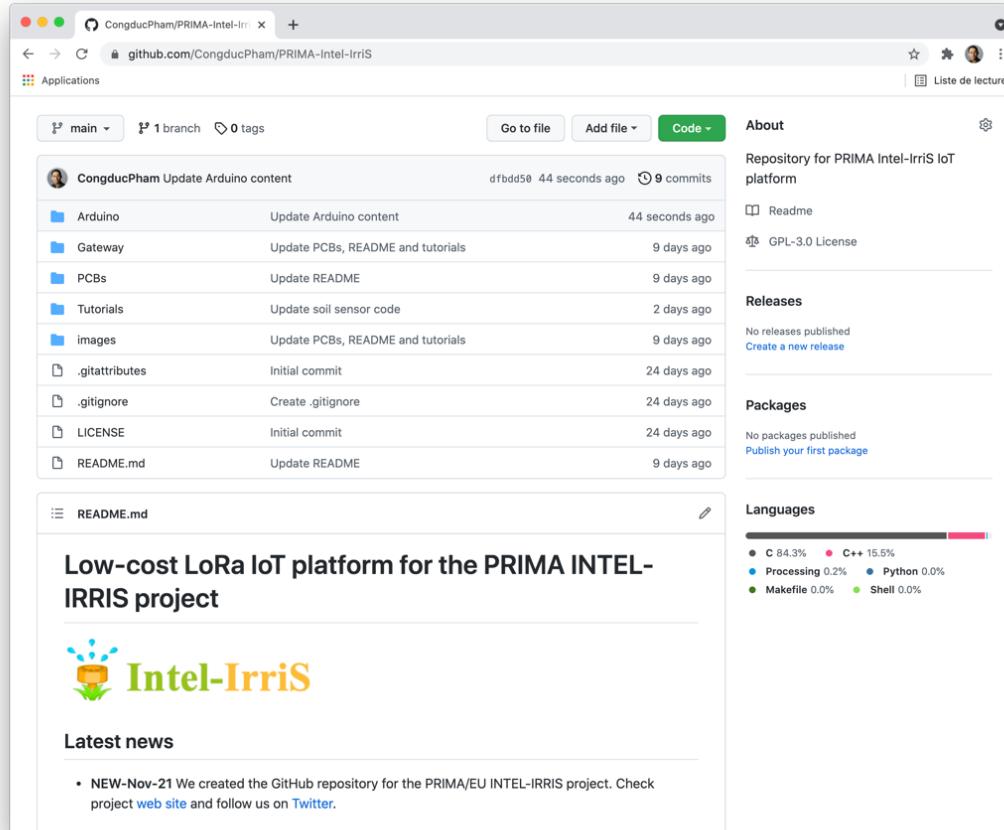
1 //*
2 * INTEL_IRRIS soil humidity sensor platform
3 * extended version with AES and custom CarrierSense features
4 *
5 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France
6 *
7 * This program is free software: you can redistribute it and/or modify
8 * it under the terms of the GNU General 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/SX128X
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

```

The interface also shows the Arduino 1.6.6 logo and the Teensyduino 1.2.7 logo. The bottom status bar indicates the board is an 'Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz)' connected to '/dev/cu.usbserial-AK05C87P'.

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 for PRIMA Intel-IrriS. It includes a list of files and commits, a detailed description of the project in the README, and a languages usage chart.

Commits:

- 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)

README.md:

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

Languages:

Language	Percentage
C	84.3%
C++	15.5%
Processing	0.2%
Python	0.0%
Makefile	0.0%
Shell	0.0%

On your computer, create a sketch folder

Then download the whole repository as ZIP file

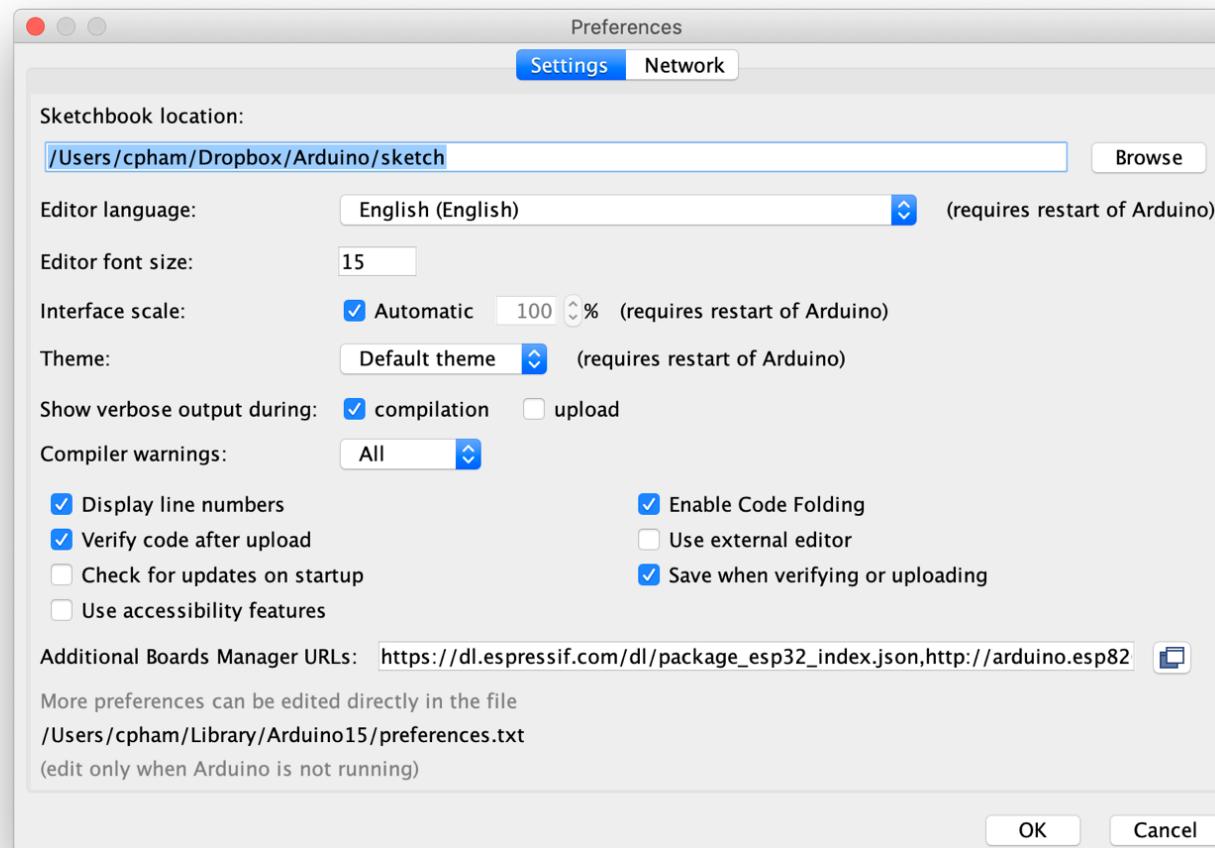
Unzip the file and copy the whole Arduino folder into your sketch folder

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



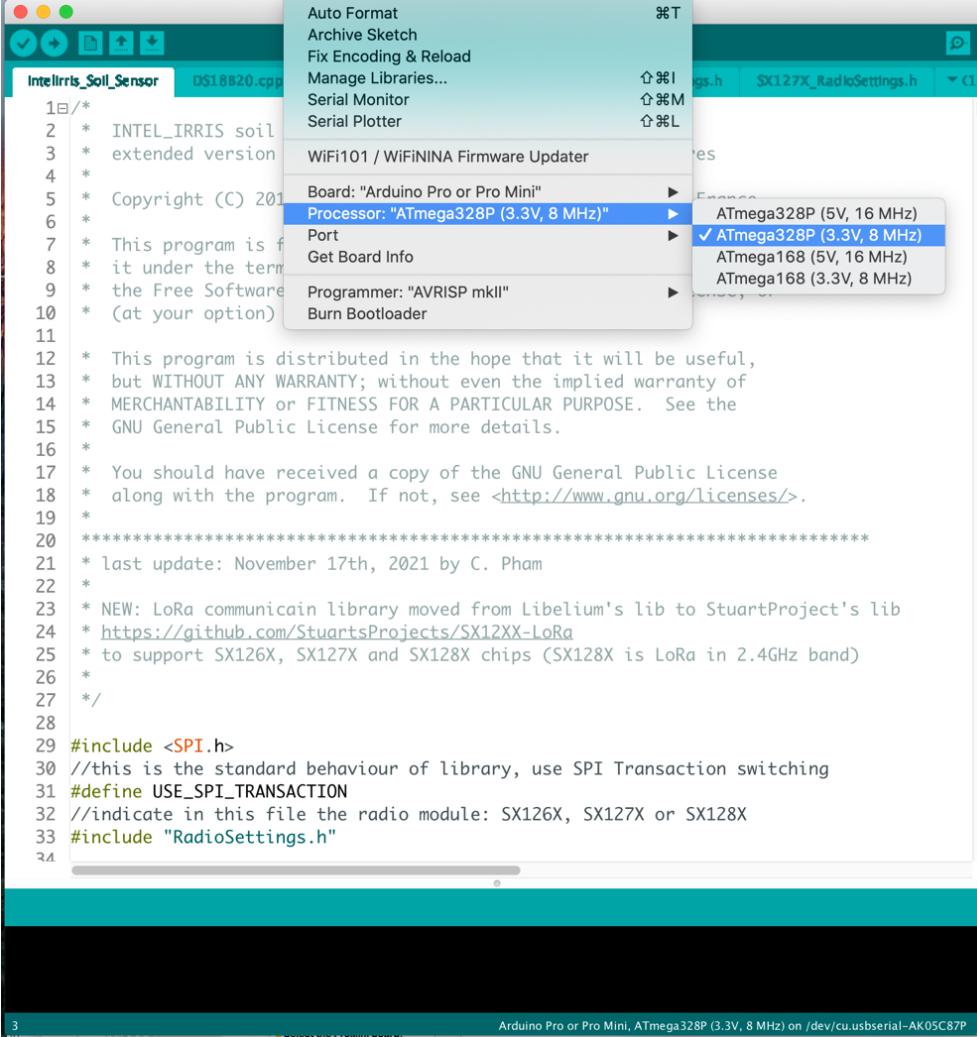
GitHub

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 */
30 */
31 */
32 */
33 */

#include <SPI.h>
//this is the standard behaviour of library, use SPI Transaction switching
#define USE_SPI_TRANSACTION
//indicate in this file the radio module: SX126X, SX127X or SX128X
#include "RadioSettings.h"

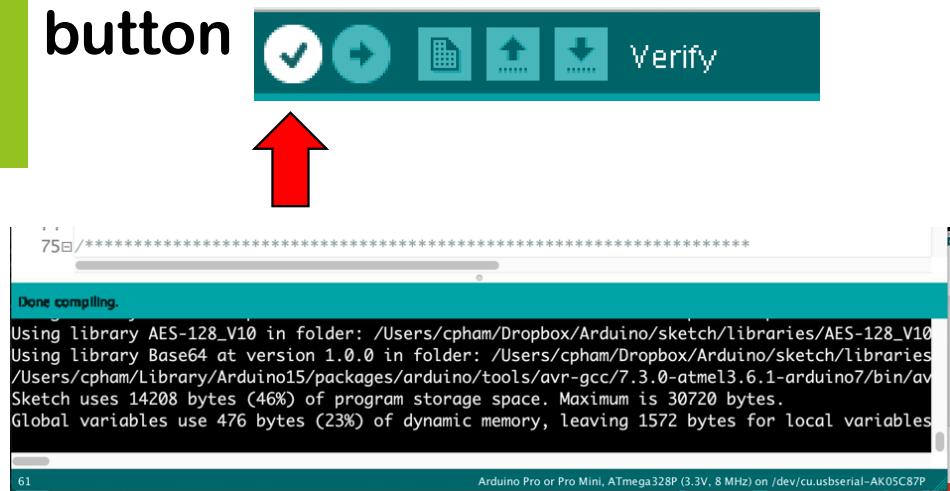
```

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**

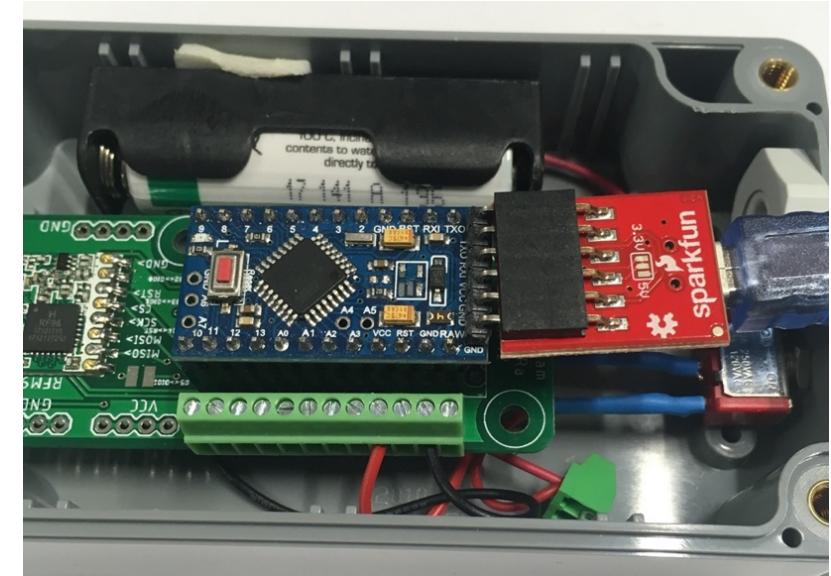
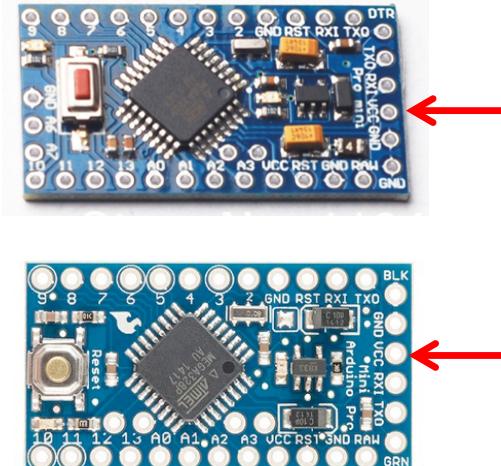
**Then click on the "verify"
button**



Connecting with an FTDI cable



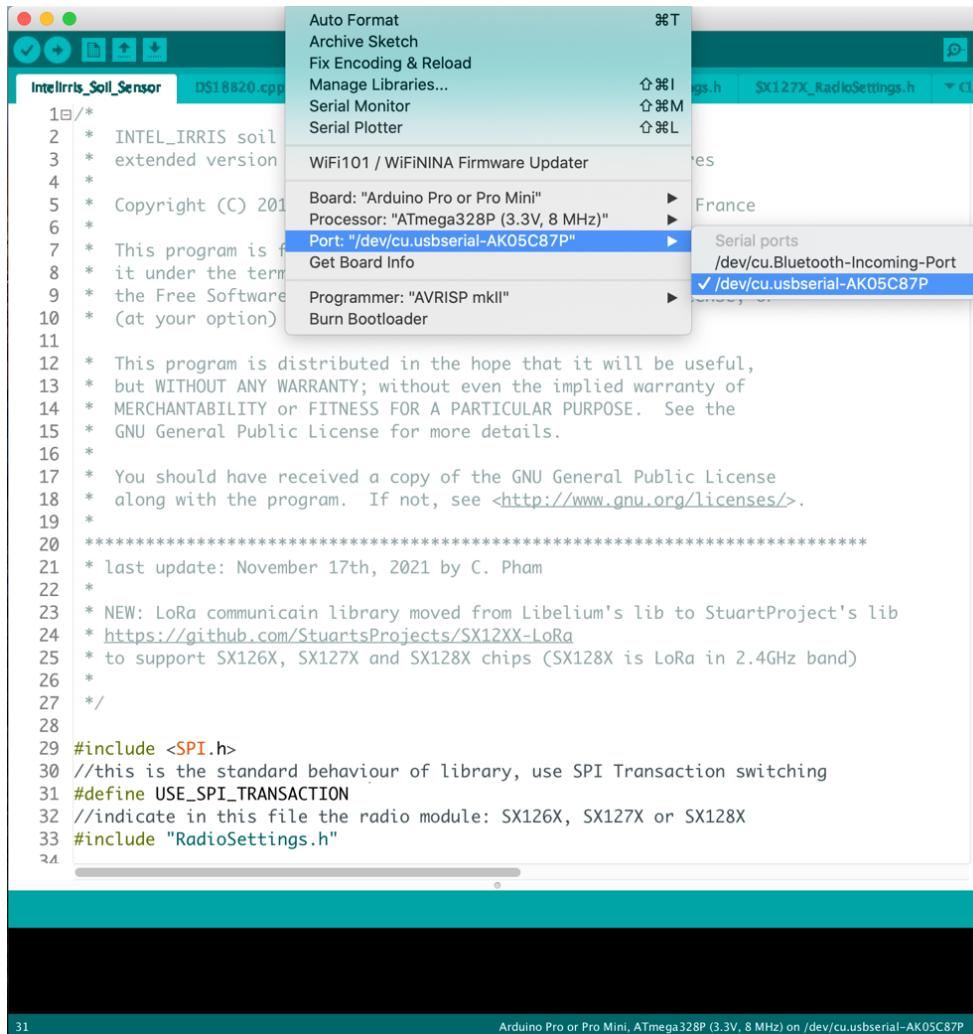
Some clone version, check the VCC pin



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

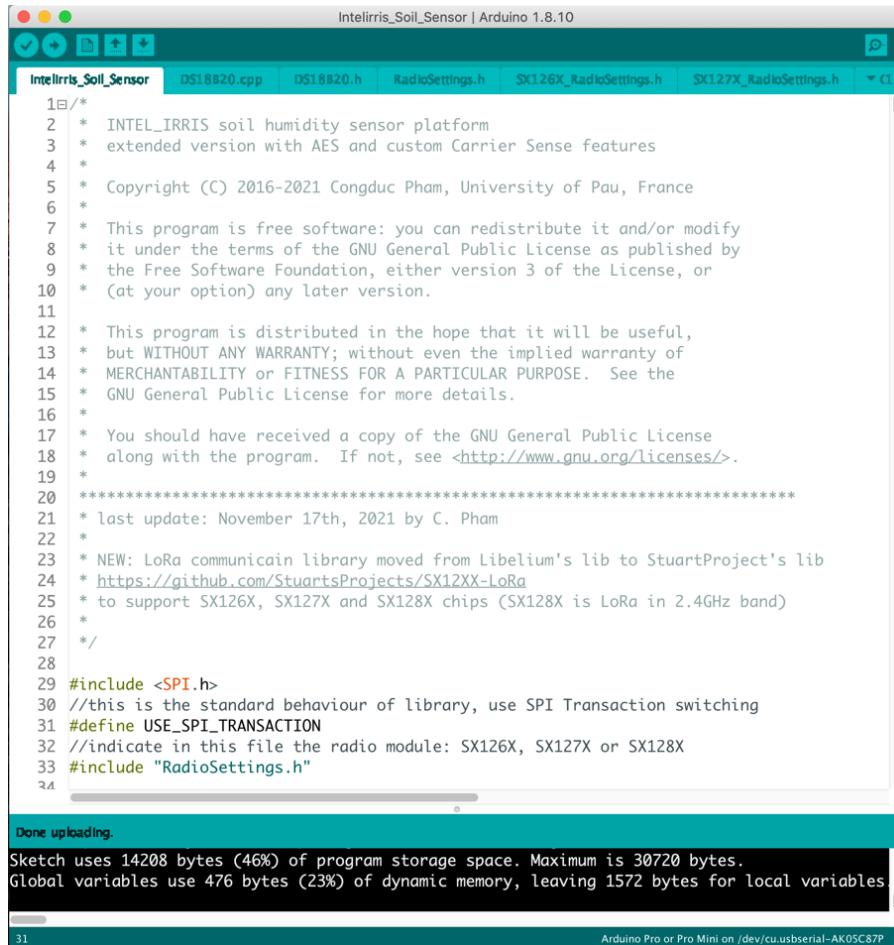


After connecting the cable to your computer/laptop USB port, try to find the serial port

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

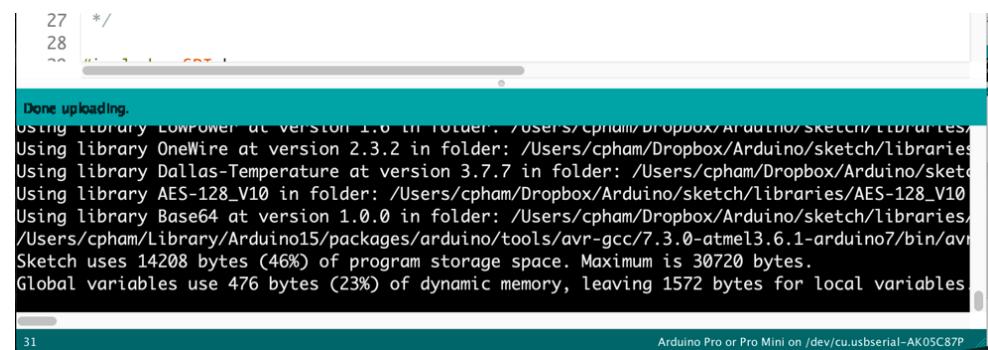


The screenshot shows the Arduino IDE interface with the sketch `Intelirris_Soil_Sensor`. The code is a C++ program for a soil humidity sensor platform using the DS18B20 and SX12XX chips. It includes comments about the GNU General Public License and the LoRa library moved from Libelium's lib to StuartProject's lib. The sketch defines constants for SPI transaction switching and includes the `RadioSettings.h` header. At the bottom, it provides memory usage statistics: 14208 bytes (46%) of program storage space used, with a maximum of 30720 bytes, and 476 bytes (23%) of dynamic memory used, leaving 1572 bytes for local variables.

Click on the "upload" button

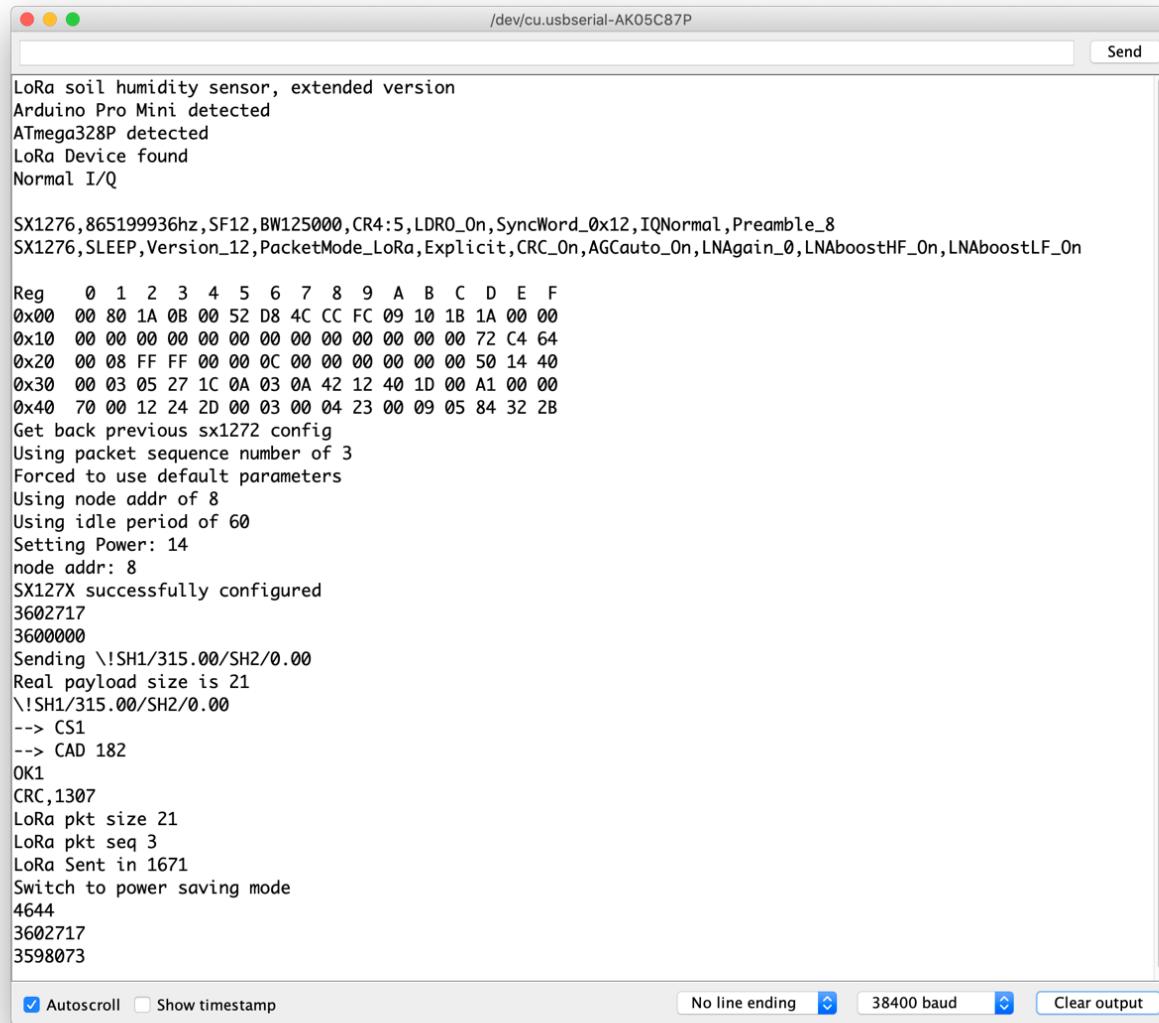


And wait until upload is completed



The screenshot shows the Arduino IDE serial monitor window during the upload process. The text "Done uploading." is displayed at the top. Below it, the IDE lists the libraries being used and their versions, followed by a summary of memory usage. The memory usage statistics are identical to those shown in the code editor: 14208 bytes (46%) of program storage space used, with a maximum of 30720 bytes, and 476 bytes (23%) of dynamic memory used, 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:

- Device detection: 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.
- Registers (hex dump): Reg 0 1 2 3 4 5 6 7 8 9 A B C D E F, followed by values for each register.
- 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, SX127X successfully configured.
- Transmission details: 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 details: 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

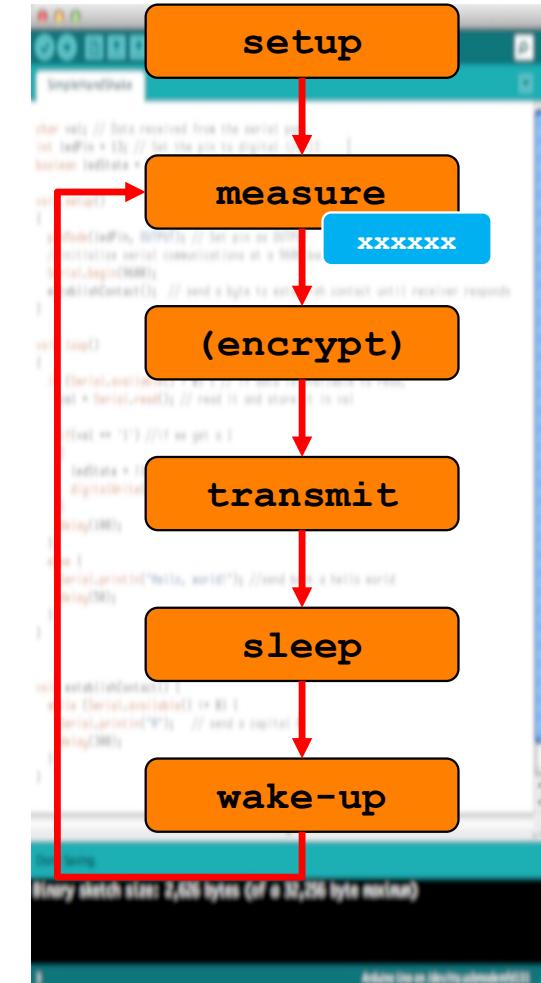
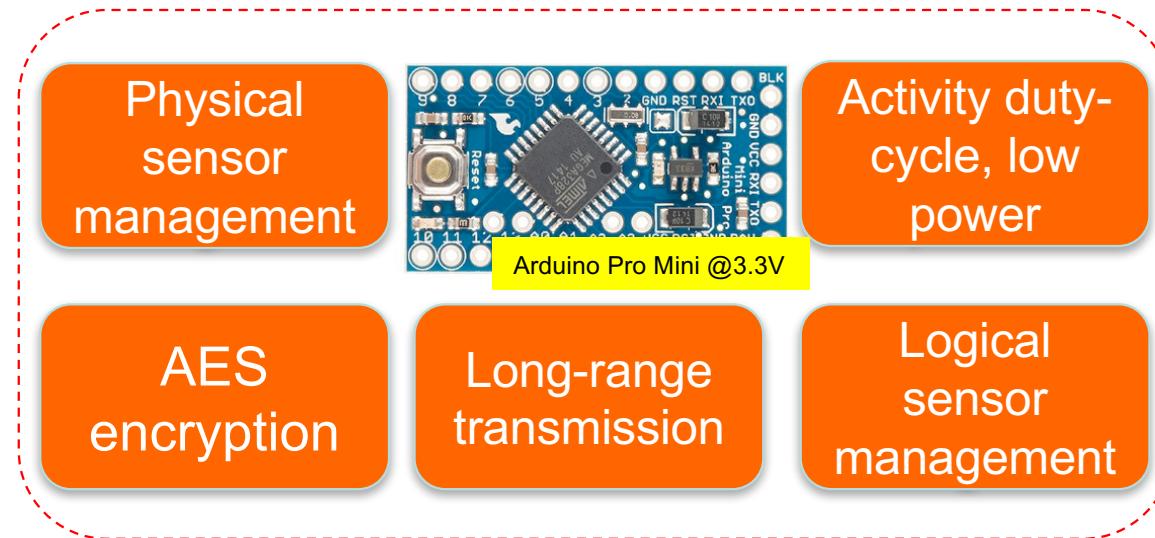
Set baud rate to 38400

See output from board

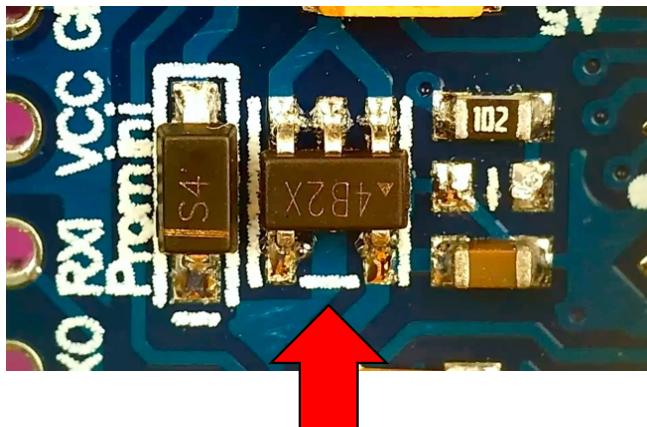
Check that transmission is OK

Generic & cyclic behavior

2 soil
sensors can
be attached



Reducing power consumption

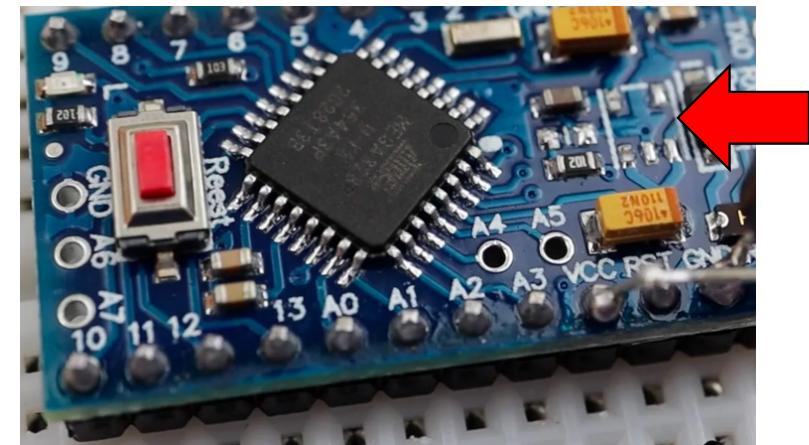


Remove the power LED by just clipping it off with some wire cutters

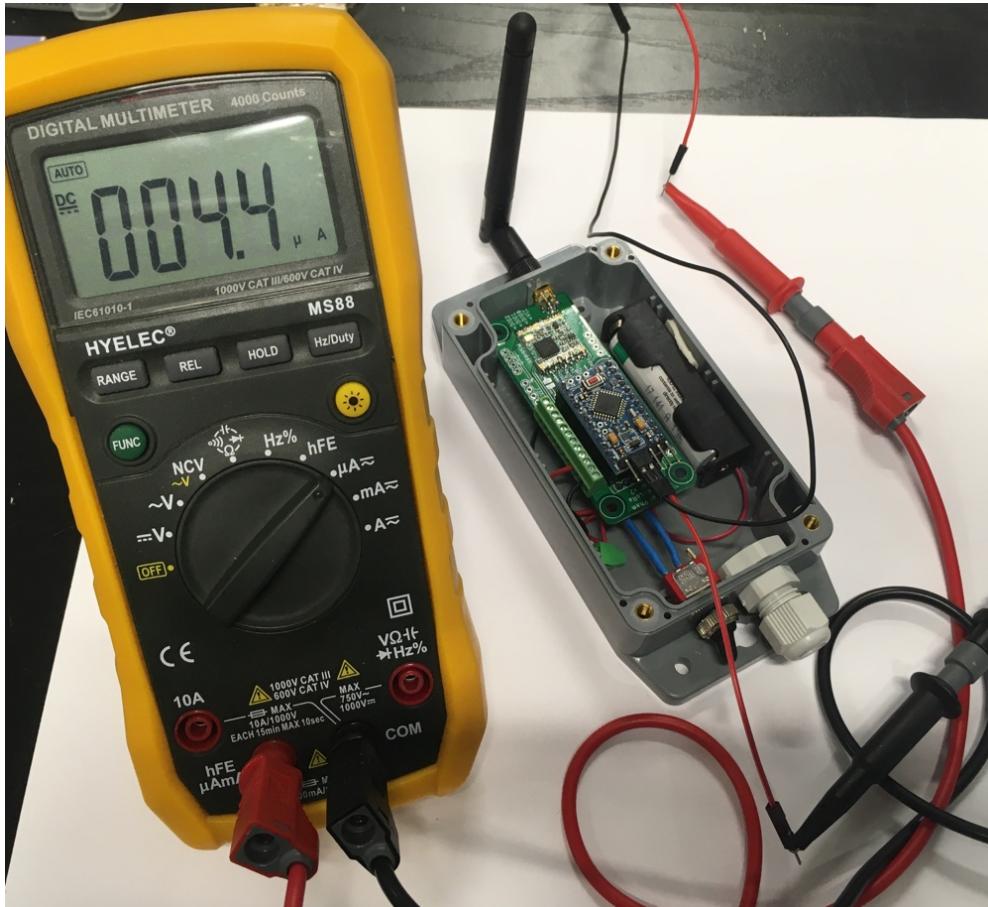
Remove the voltage regulator with a small plier

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