

INTEL-IRRIS

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



This project is part of the PRIMA
Programme supported by the
European Union



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



Building the INTEL-IRRIS LoRa IoT platform Part 1: soil sensor device (using the latest IRD PCB v4.1)



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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



INTEL-IRRIS's starter-kit

○ From idea to reality!



INTEL-IRRIS

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

CASING & PARTS

List of components for IRD PCB



**For 2xAA
alkaline
batteries**



For SOLAR



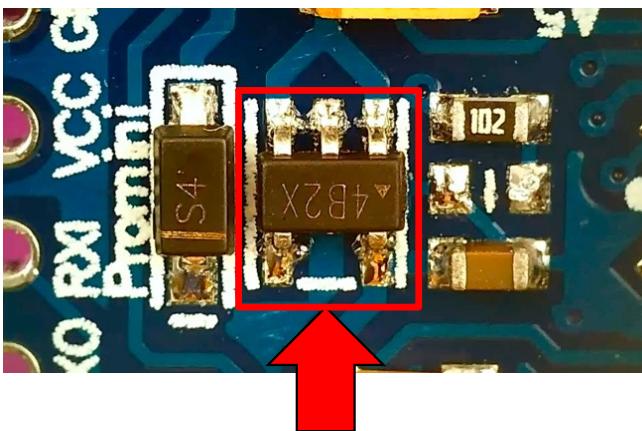
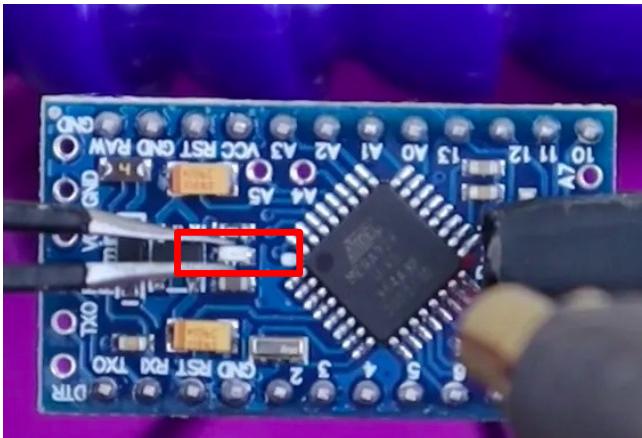
**For SOLAR
with NiMh
battery**



SMA
male

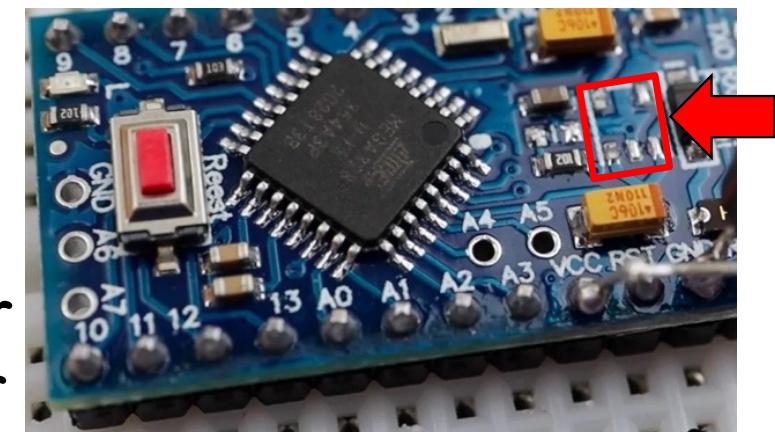


Reduce power consumption



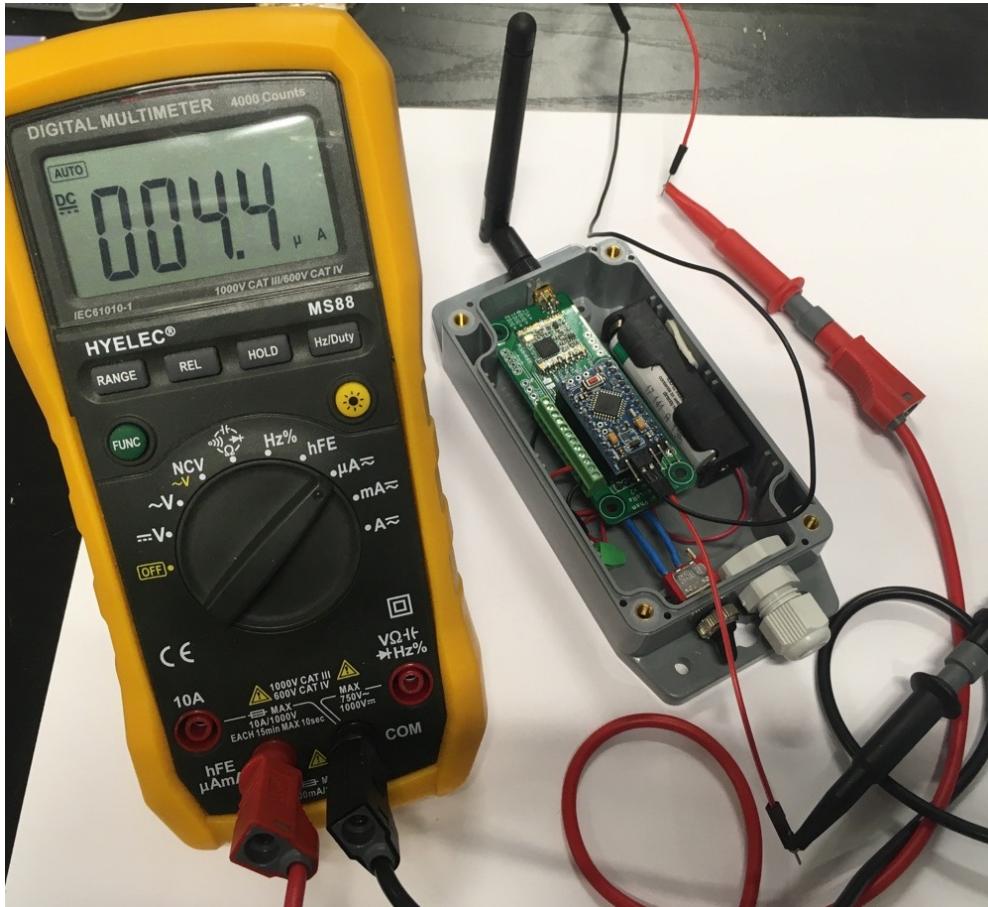
Do not forget to remove the power LED by just clipping it off with some wire cutters

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



Only inject up to 3.6V through the VCC pin

Power consumption in deep sleep



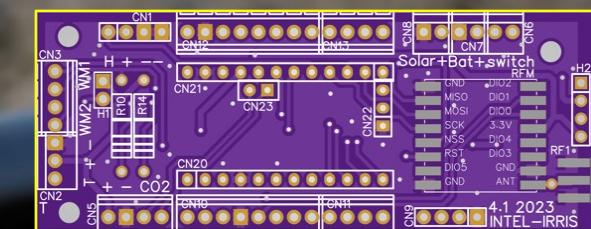
Measured below 5 μ A in deep sleep, between 2 active periods with transmissions

Expected autonomy with 1 transmission / hour is over 2 years with 2 AA batteries

INTEL-IRRIS

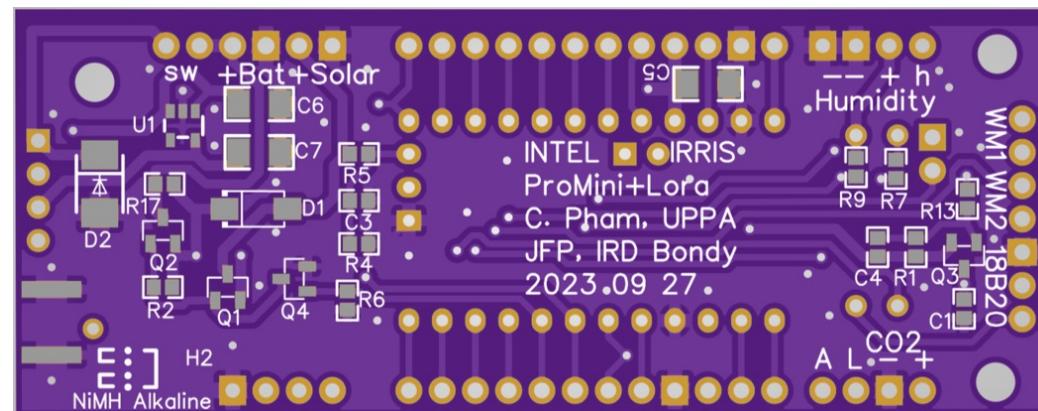
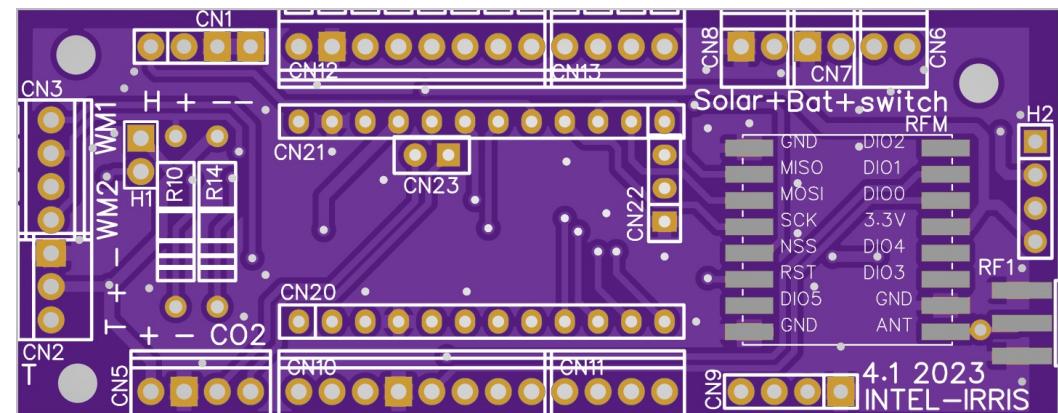
Intelligent Irrigation System for Low-cost Autonomous Water Control in Small-scale Agriculture

IRD PCB v4.1

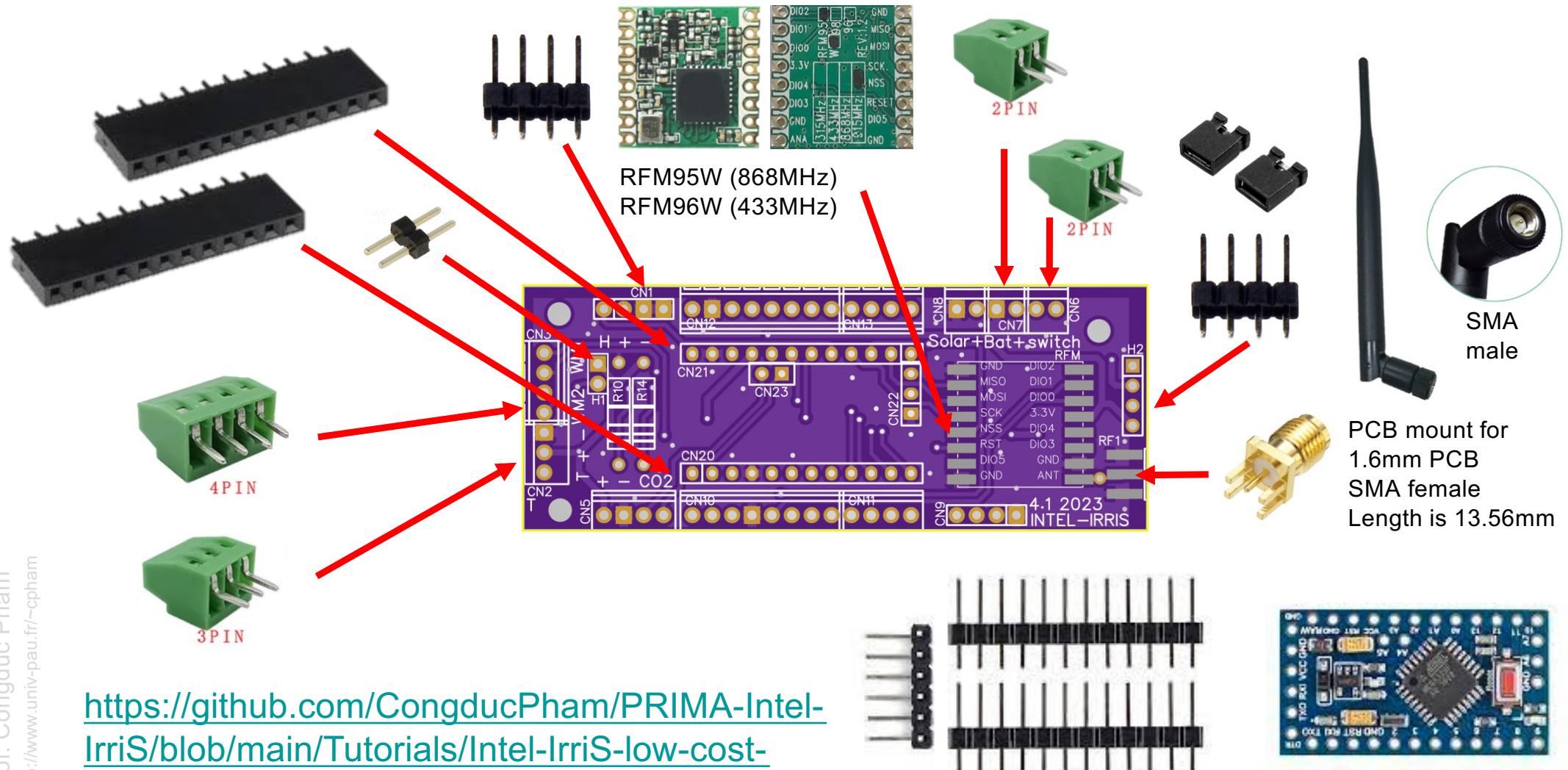


The IRD PCB v4.1 – raw version

- You can order the raw version of the IRD PCB, which means only the PCB, without any electronic components soldered by the manufacturer
- It is the so-called DIY approach
- The raw version is not intended to have solar charging capabilities



Electronic parts - starter-kit version



<https://github.com/CongducPham/PRIMA-Intel-Irris/blob/main/Tutorials/Intel-Irris-low-cost-sensor-hardware-parts.pdf>

Arduino ProMini 3.3V 8MHz

Tutorial video

- This dedicated video will show how to solder all the components
Video n°1: <https://youtu.be/3jdQ0Uo0phQ>
- The "old" version of the INTEL-IRRIS PCB is shown on the video but you can easily adapt for the new IRD PCB v4.1





Good soldering

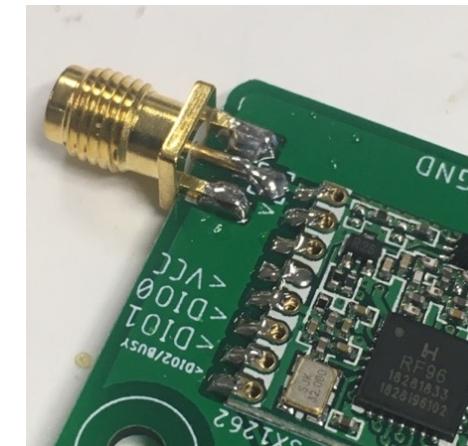
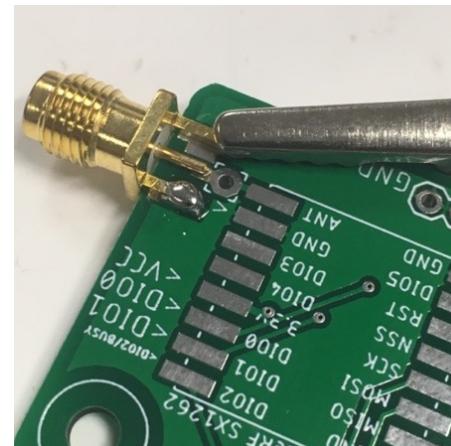
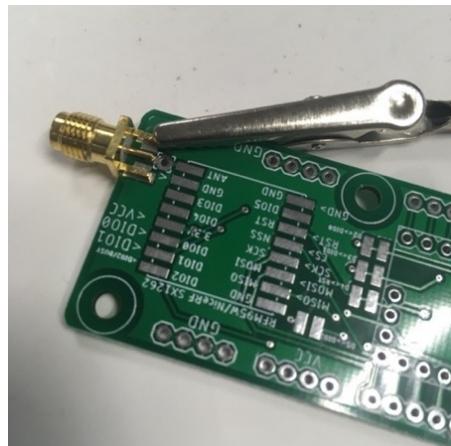
- It is important to have good soldering to avoid any issue when deploying the devices
- Check this great soldering tutorial from Collin's lab
 - <https://youtu.be/RB4P1HTmwLc>



- 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

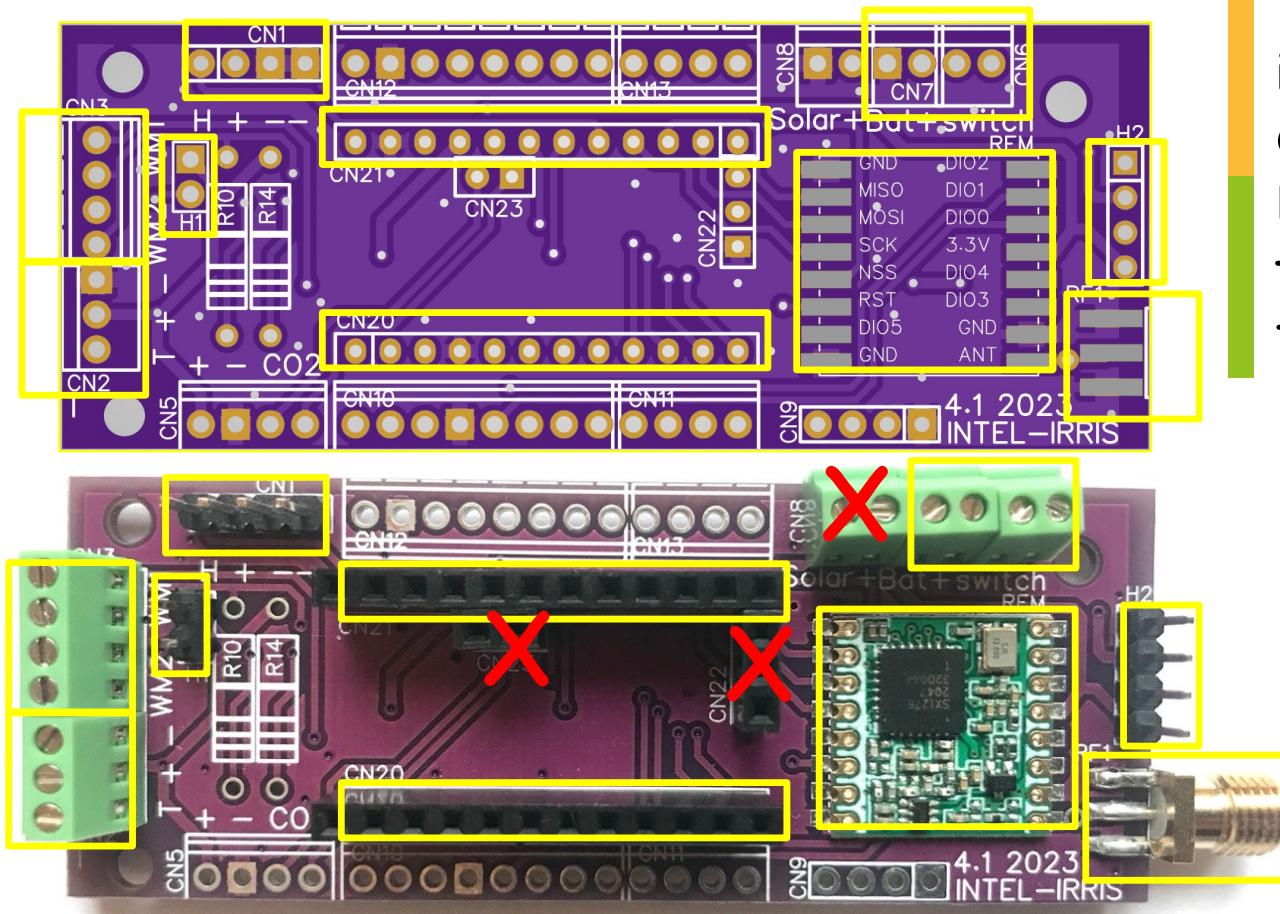
Updates on Video n°1

- Clip the SMA connector to the PCB to correctly align the connector before soldering one of the GND pad, then remove clip and finish soldering
- **Or**, gently press SMA connector pads so that insertion on PCB is harder and SMA connector will not move during soldering
- Make sure that the GND pads and the central pin are not touching each other, in doubt, do a continuity check



Wiring with IRD PCB v4.1 (raw version)

- First, solder the various components



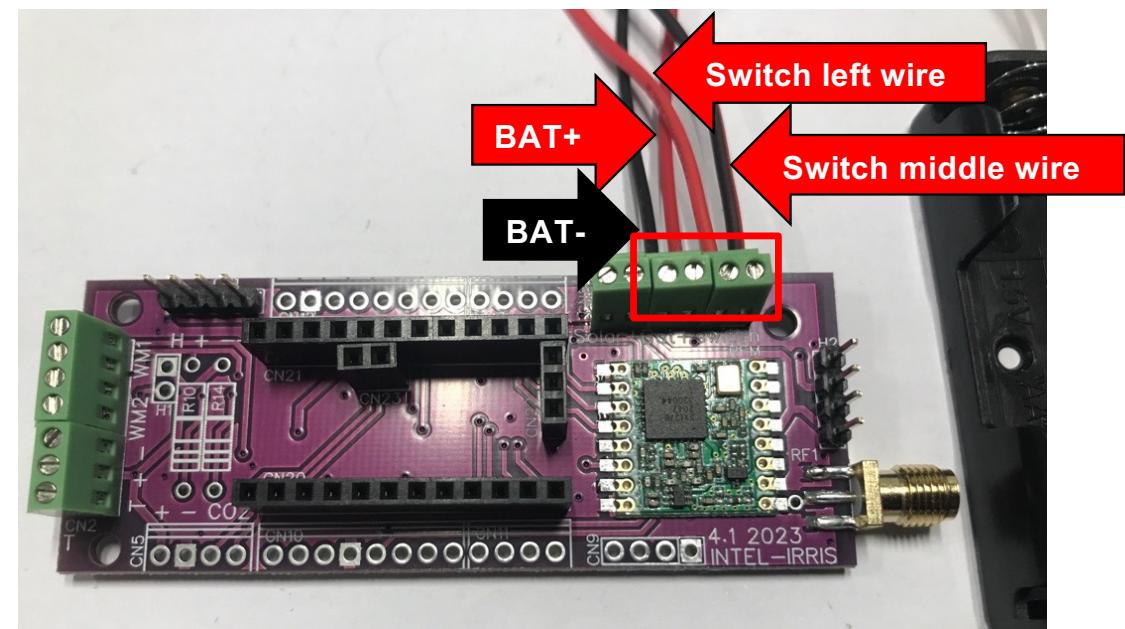
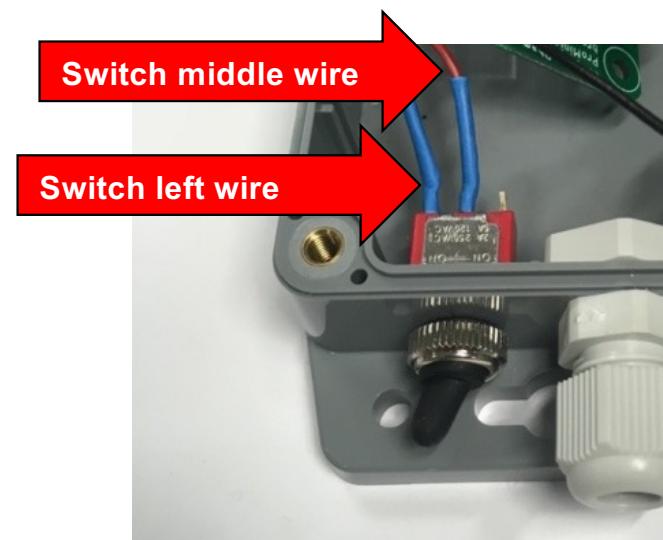
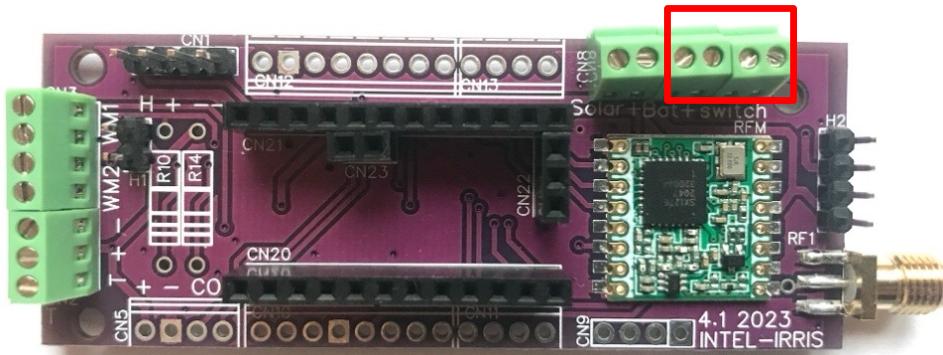
The raw version is not intended to have solar charging capabilities. For solar charging, the full version (see later) is the dedicated PCB

Not needed for the raw PCB which is not designed to have the solar circuit manually soldered

Wiring with IRD PCB v4.1 (raw version)

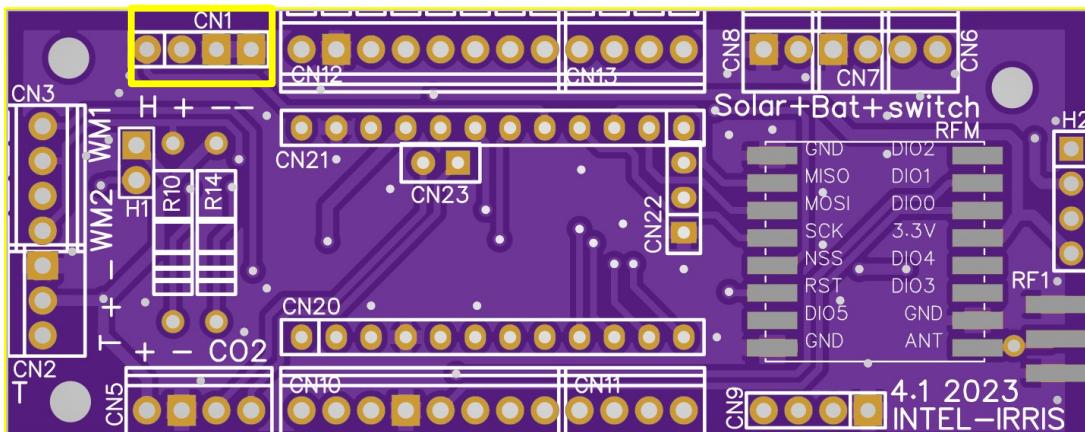


- Power wires (from AA alkaline battery)

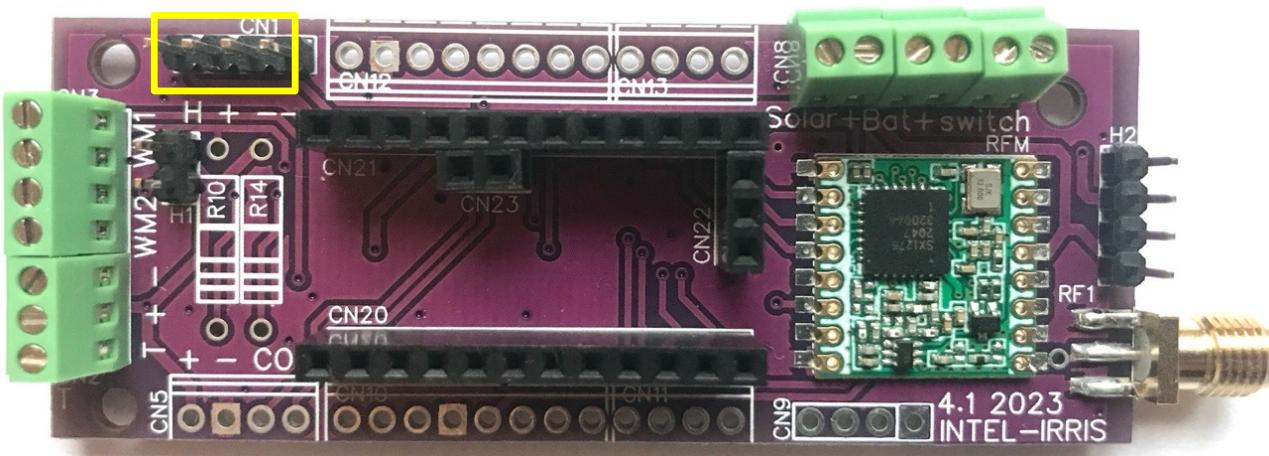


Wiring with IRD PCB v4.1 (raw version)

- SEN0308 capacitive

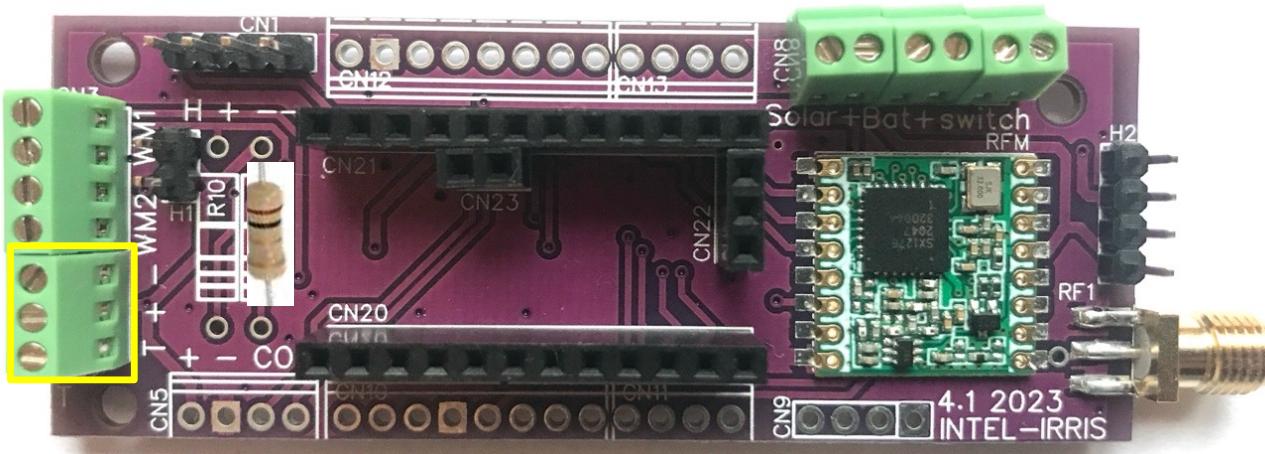
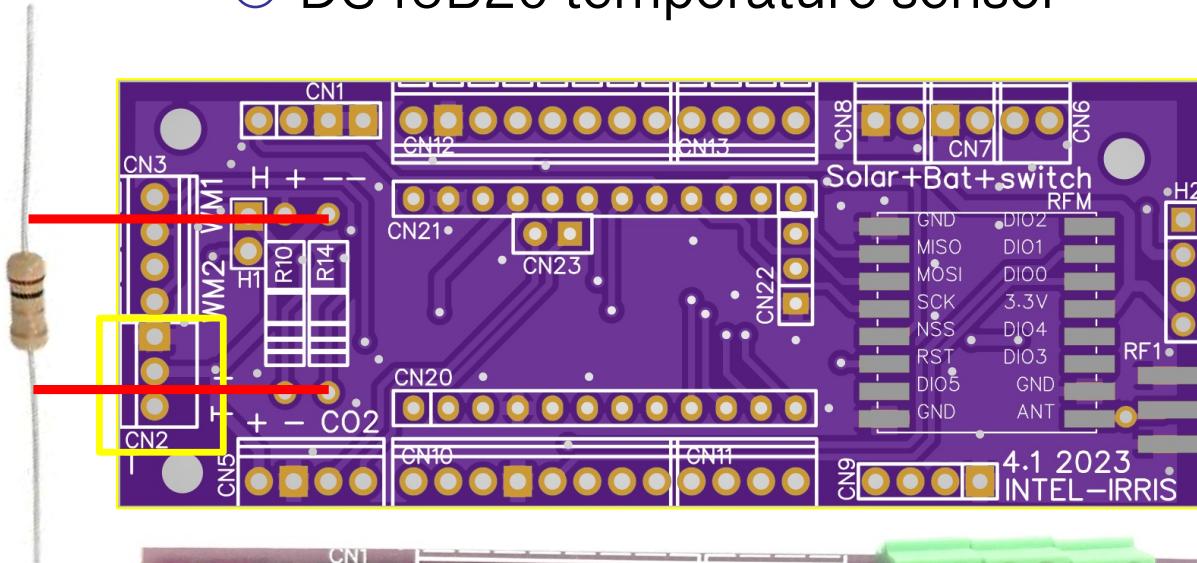


Just connect the sensor in the dedicated header
 -- are the 2 black wires
 + is red and H is yellow



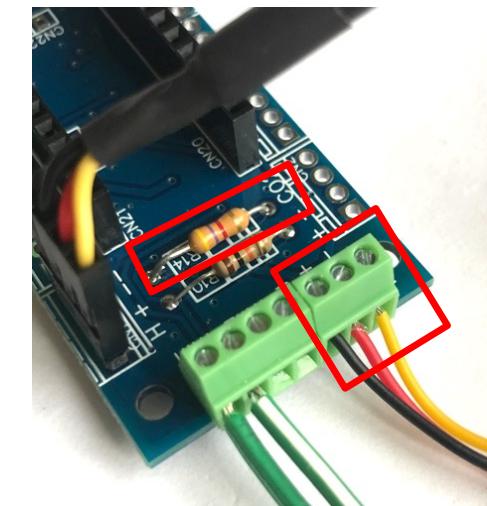
Wiring with IRD PCB v4.1 (raw version)

- DS18B20 temperature sensor



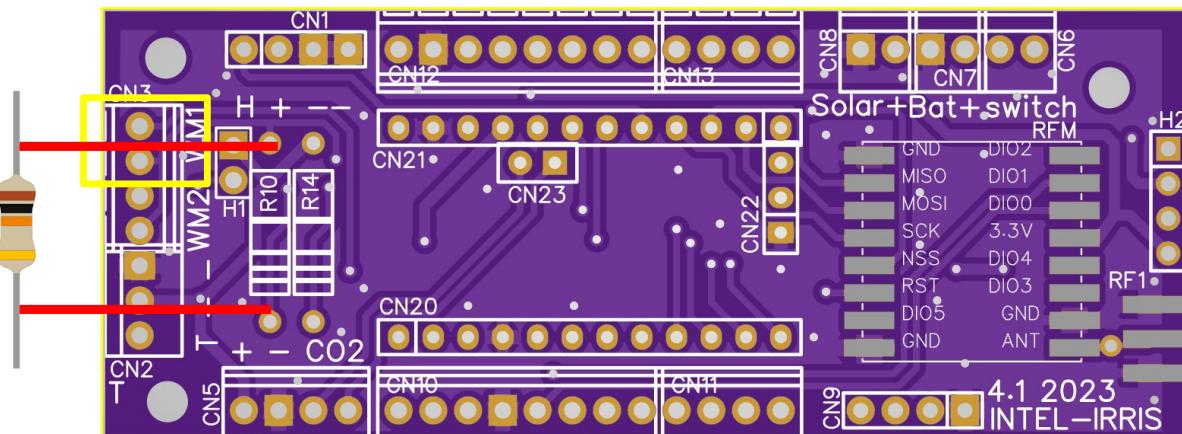
Solder a 4.7kOhms resistor
then wire in the dedicated
terminal block

T+ - : Yellow, Red, Black wires

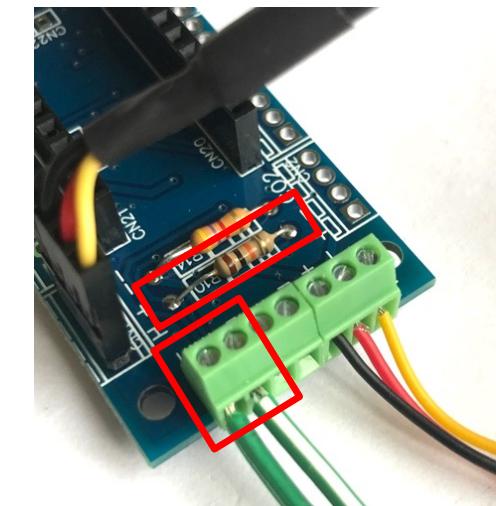
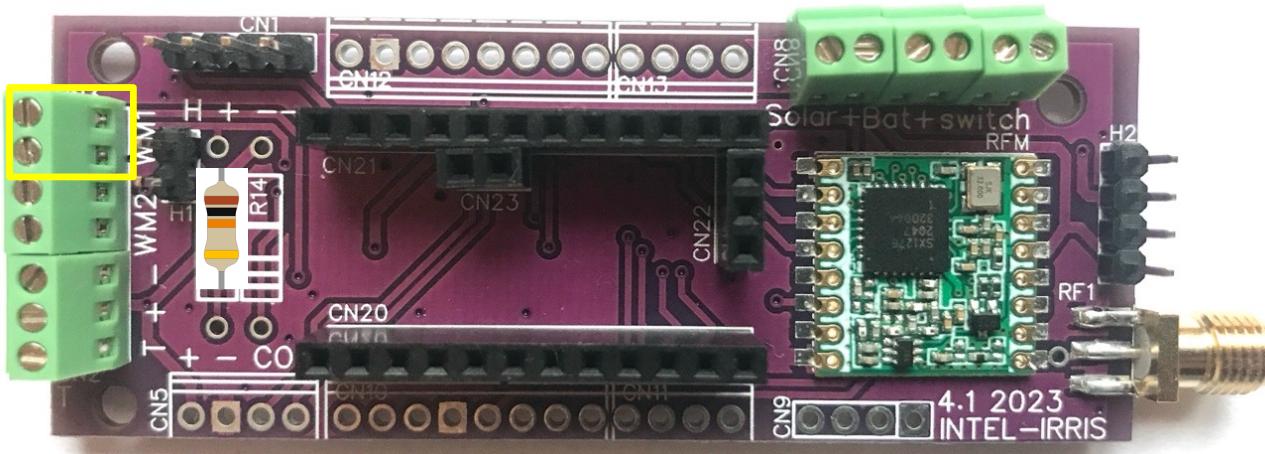


Wiring with IRD PCB v4.1 (raw version)

○ First Watermark

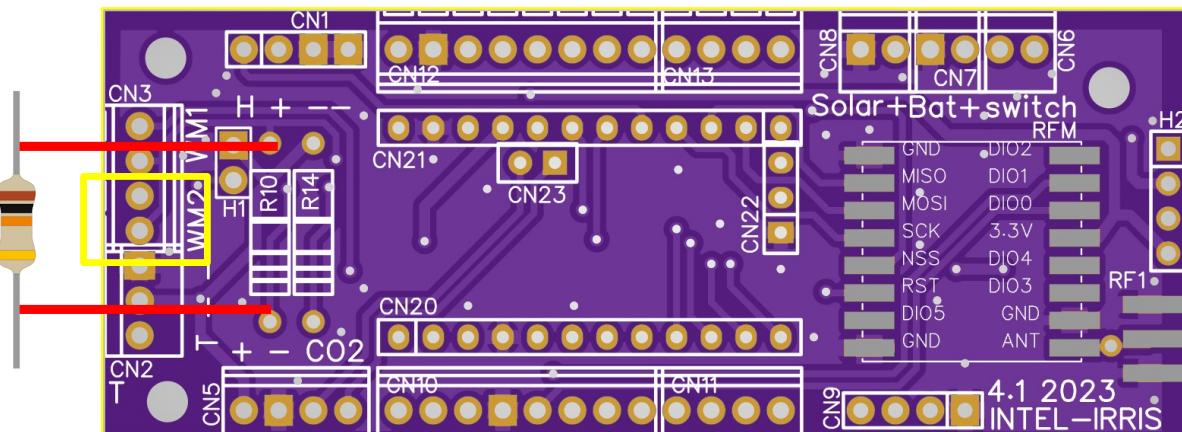


Solder a 10kOhms resistor
then wire in the dedicated
WM1 terminal block

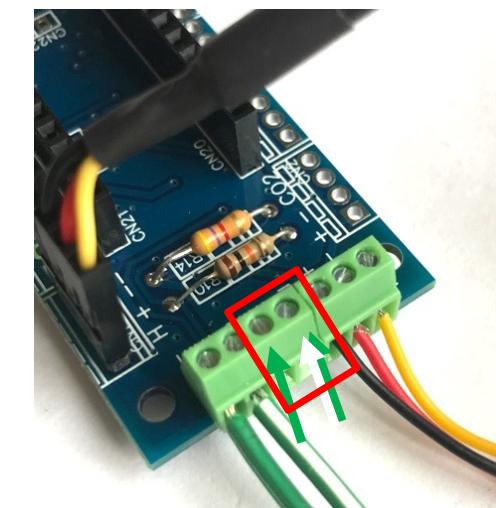
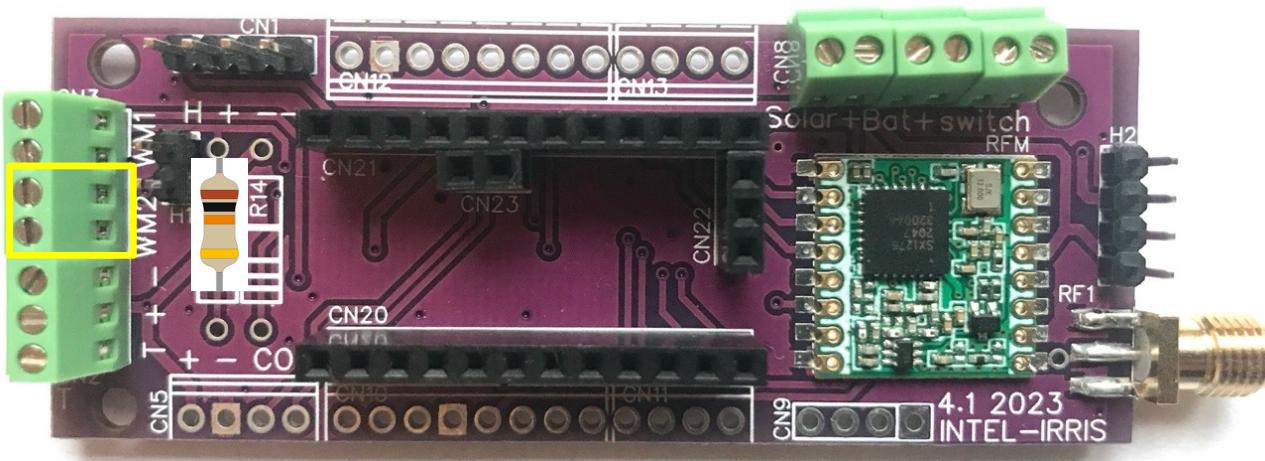
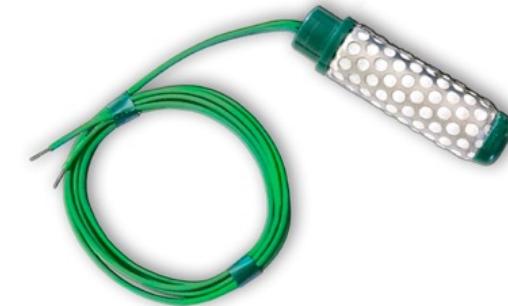


Wiring with IRD PCB v4.1 (raw version)

○ Second Watermark

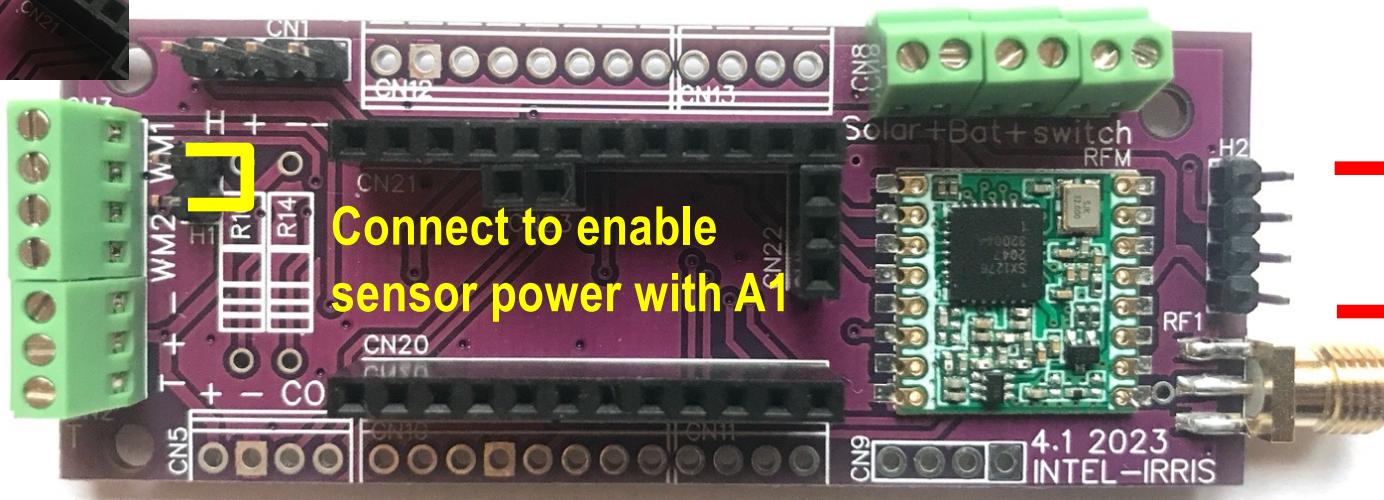
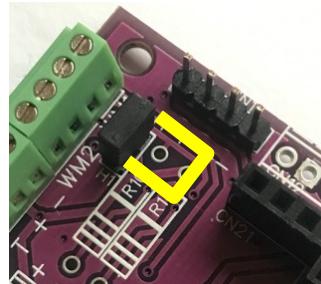


No additional resistor needed
just wire in the dedicated
WM2 terminal block



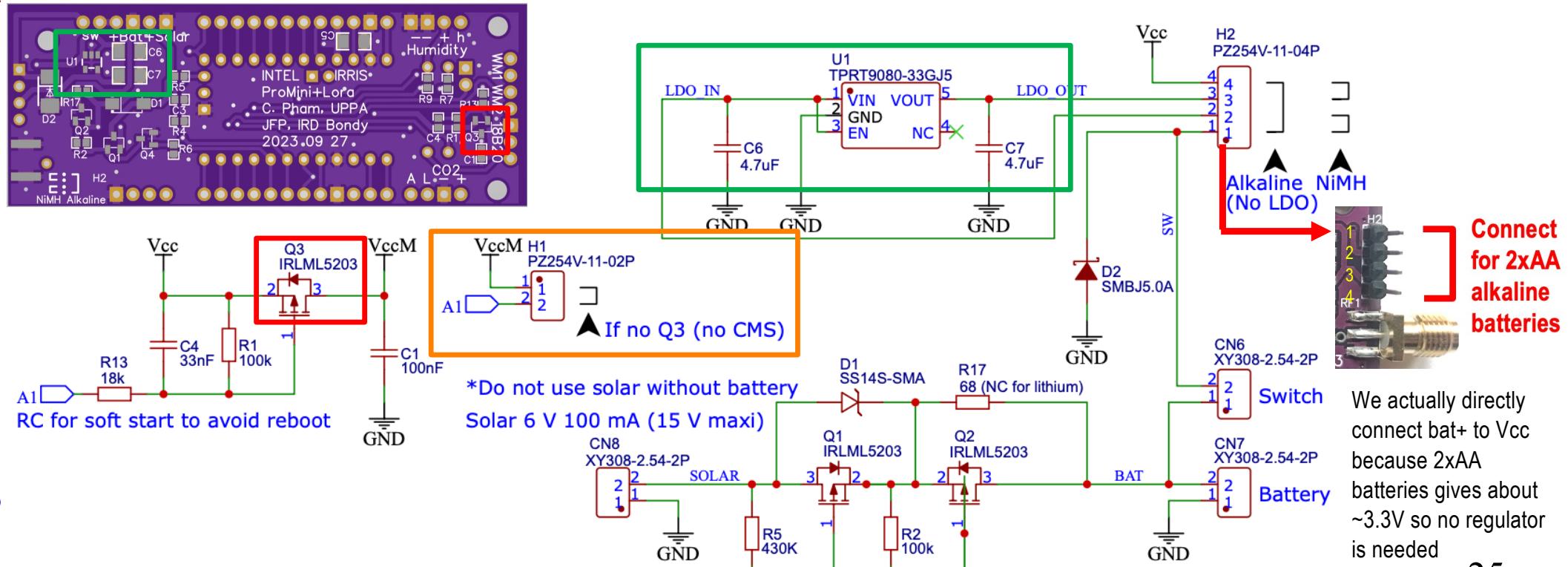
Wiring with IRD PCB v4.1 (raw version)

- The raw version is not intended to have the solar circuit soldered manually on the back side
 - 2 alkaline AA 1.5V batteries providing ~3.2V (when new) will be used similar to the simple PCB v2
 - It is necessary to short the 2 external pins of H2 connector and the 2 pins of H1 connector



Explanation of previous slide

- As can be seen, the raw PCB does not have Q3 to connect Vcc to VccM, the power line for all physical sensors controlled by A1 pin
- Therefore H1 needs to be shorted to directly connect A1 to VccM



Alternatives for batteries

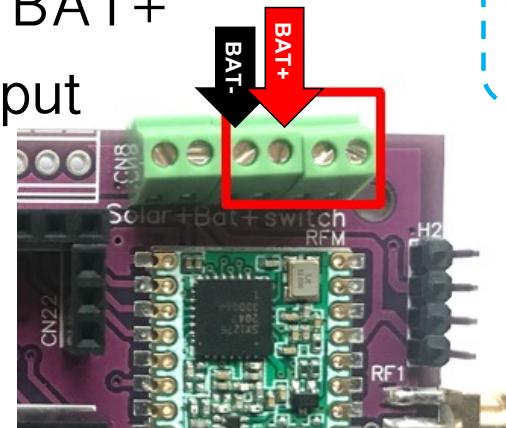
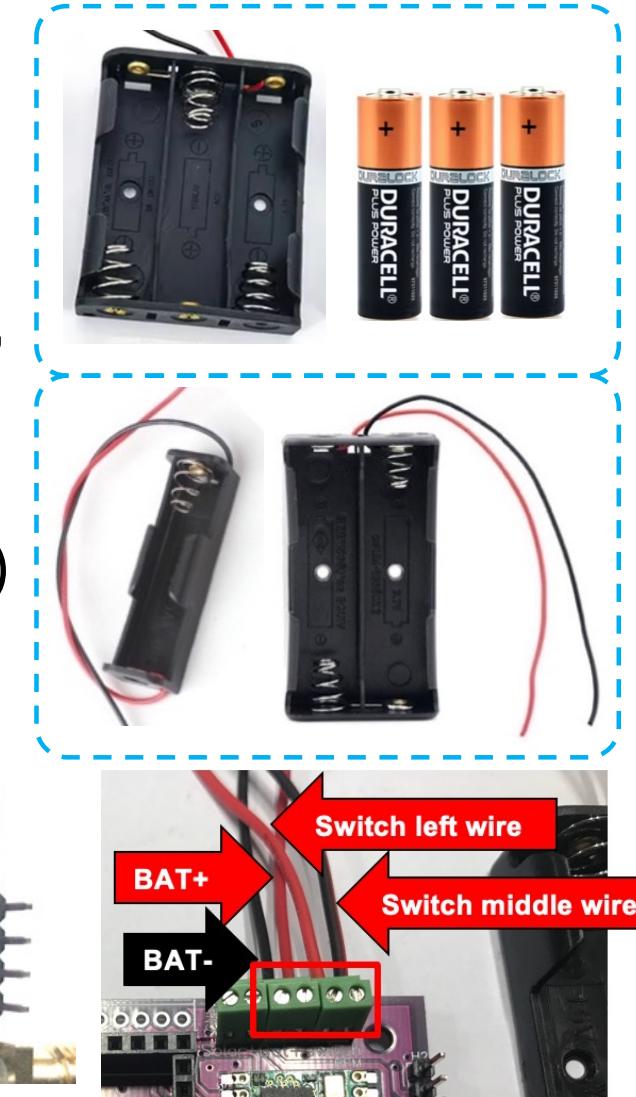
- Simple 2xAA 1.5V batteries delivering ~3.2V when new can be too low for some settings where the connected sensors needs a stable voltable close to 3.3V, especially when the highest quality for alkaline/lithium AA 1.5V batteries are not easily found
- There are other alternatives as illustrated below



- The 3xAA is the simplest and the cheapest alternative

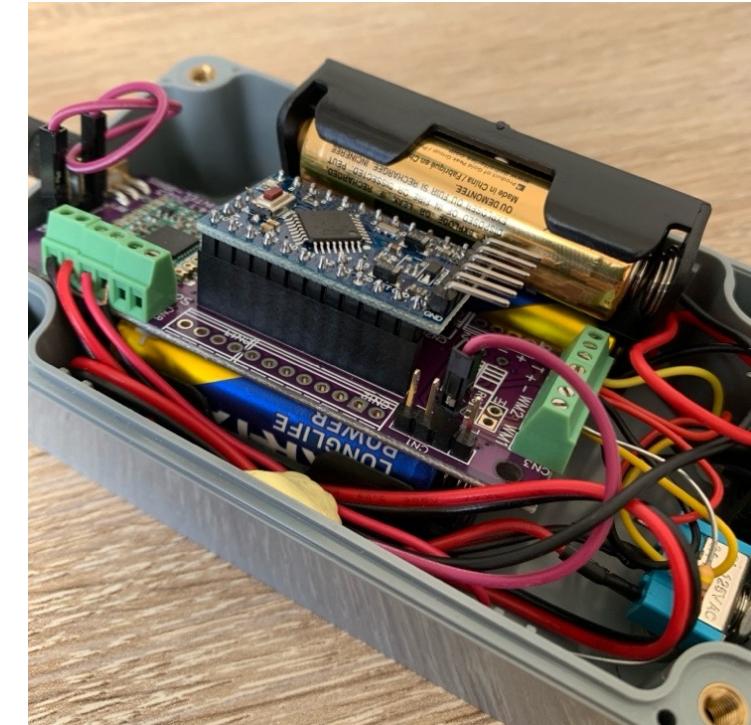
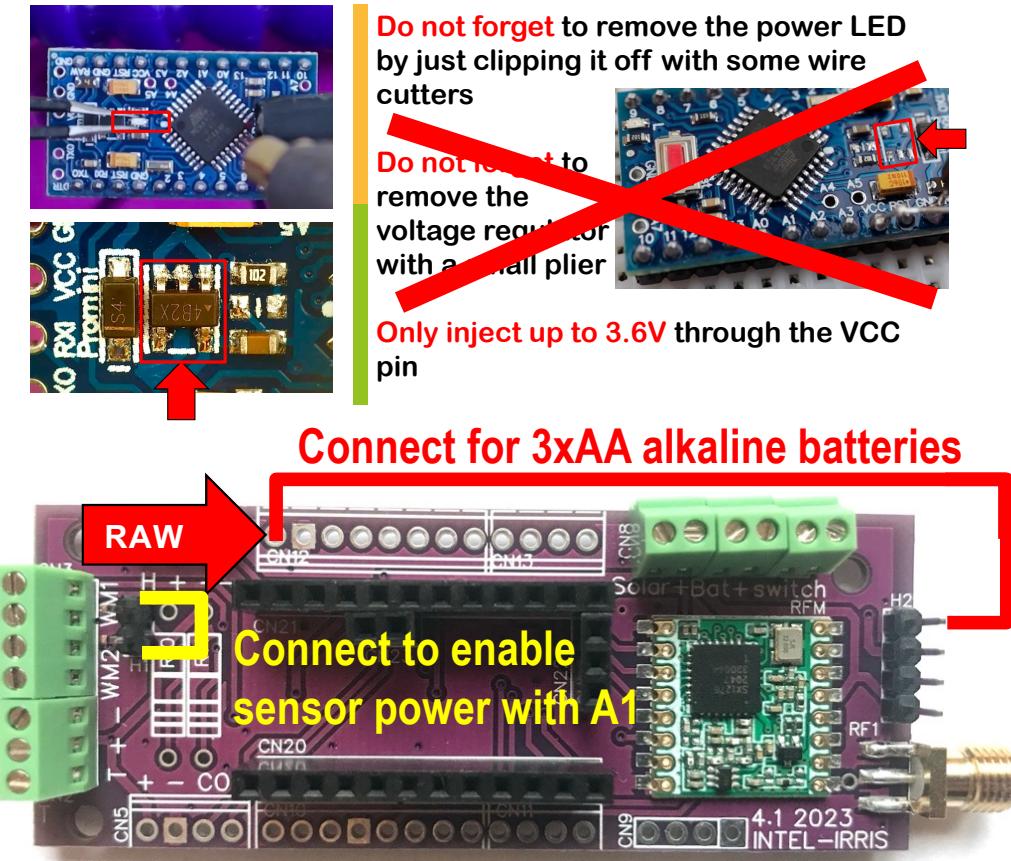
Using 3xAA alkaline batteries

- The 3xAA battery holder is too big for the selected case. If we keep the same case, here is a possible solution
- In addition to the already 2xAA battery holder, add a 1xAA battery holder
- Connect 2xAA bat- (black) to BAT-
- Connect 2xAA bat+ (red) to 1xAA bat- (black)
- Connect 1xAA bat+ (red) to BAT+
- Both battery holders can be put in the case , see next slide



Using 3xAA, keep Pro Mini regulator

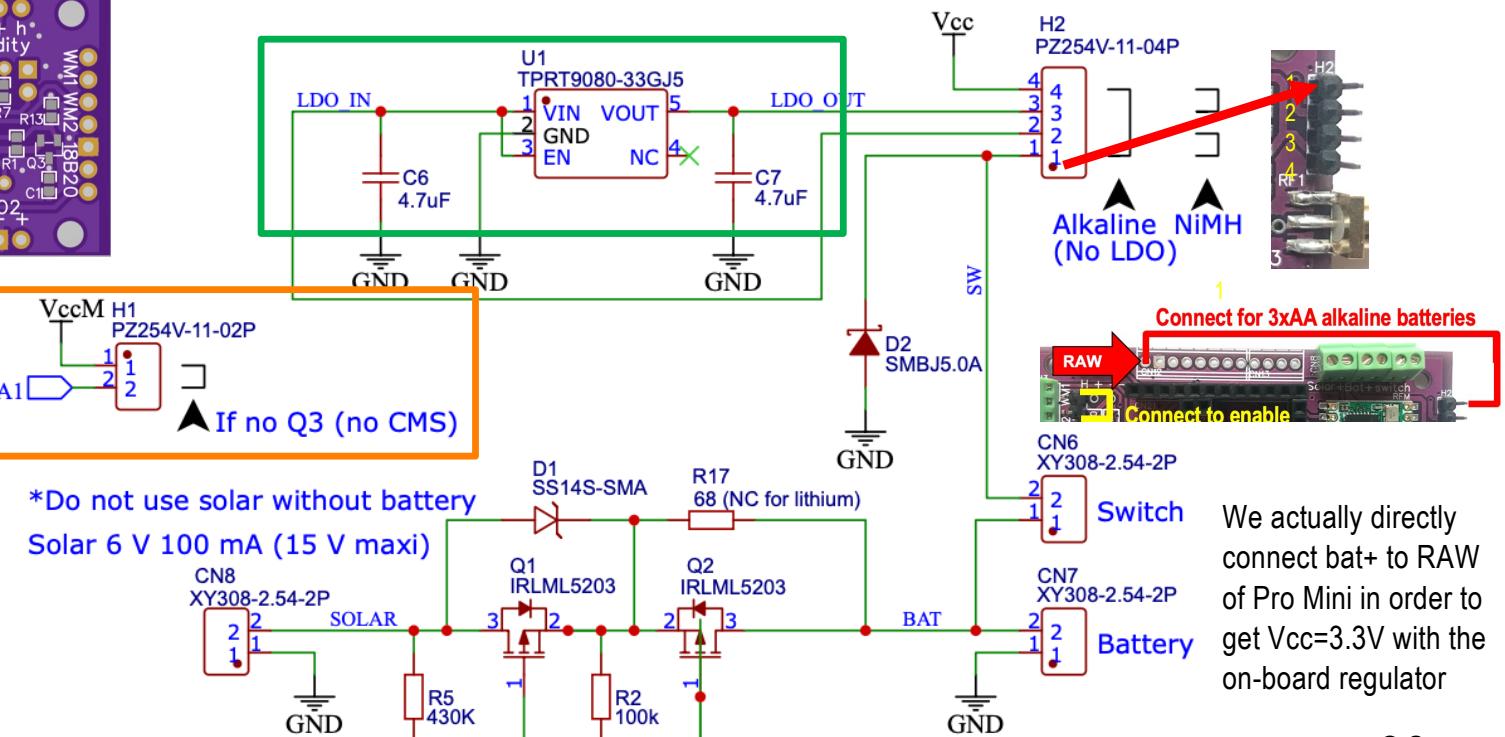
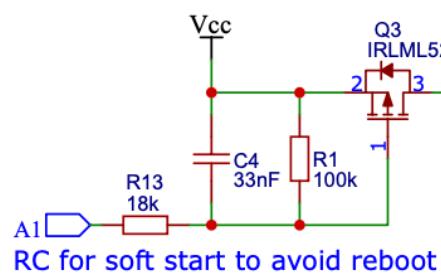
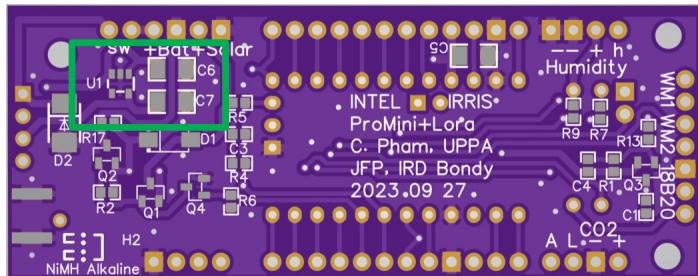
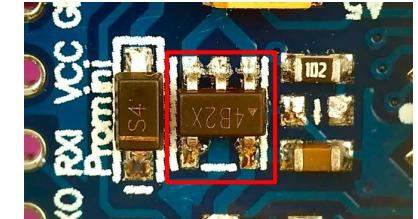
- With 3xAA providing ~ 4.8V, we MUST keep the Arduino Pro Mini on-board voltage regulator!



Both battery holders can be put in the case

Explanation of previous slide

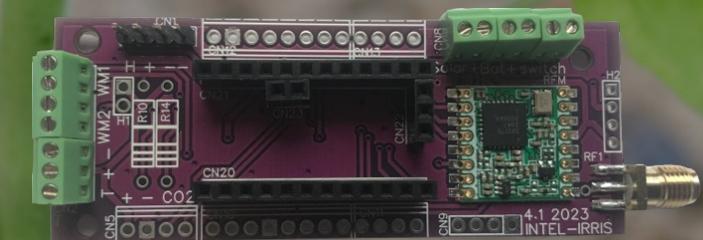
- With 3xAA batteries providing 4.8V, we need a voltage regulator to get down to 3.3V. As the raw PCB does not have a regulator (U1) we will use the regulator of the Pro Mini that we keep for this 3xAA batteries version
- Therefore we connect bat+ to RAW of Pro Mini to use its regulator which will deliver 3.3V to Vcc – consumption will be about 45uA in deep sleep
- H1 still needs to be shorted to directly connect A1 to VccM



INTEL-IRRIS

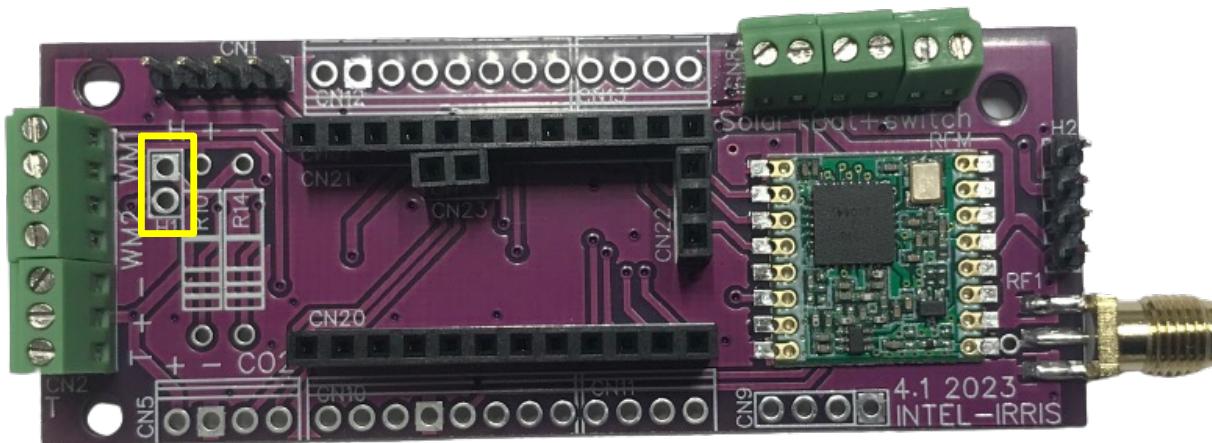
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in Small-scale Agriculture

THE IRD PCBA v4.1



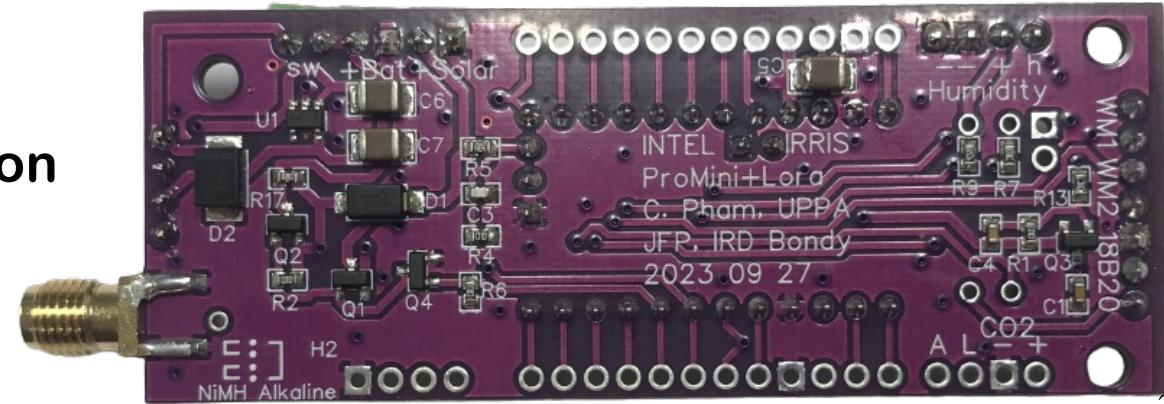
Wiring with IRD PCB v4.1 (PCBA)

- The PCBA is already fully assembled, including the resistors for the temperature and watermark sensors (on the back side)



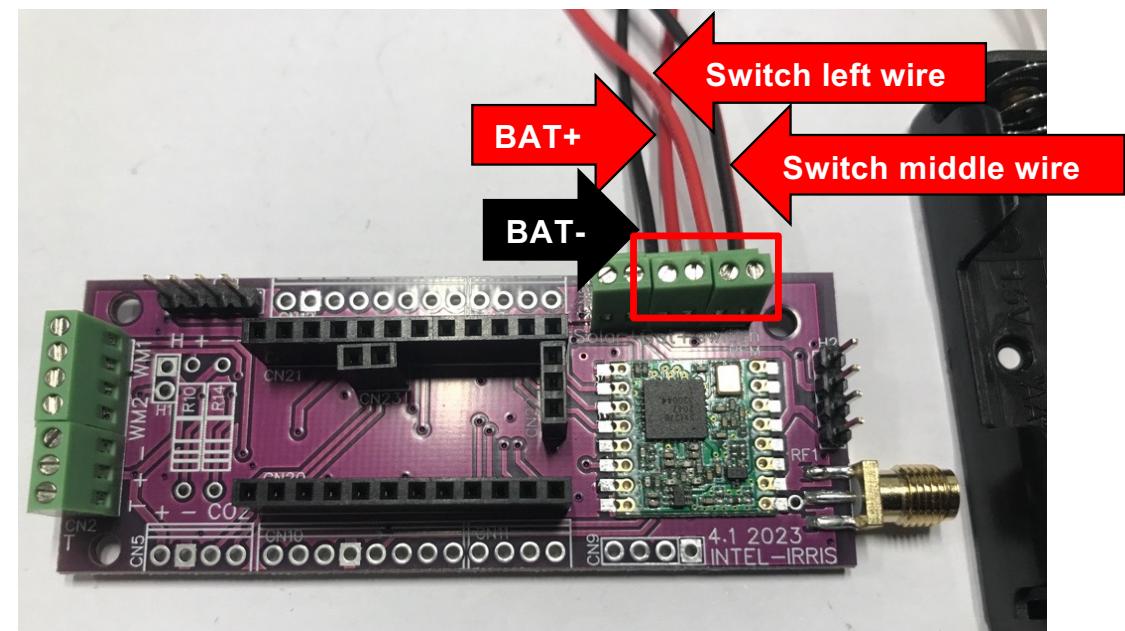
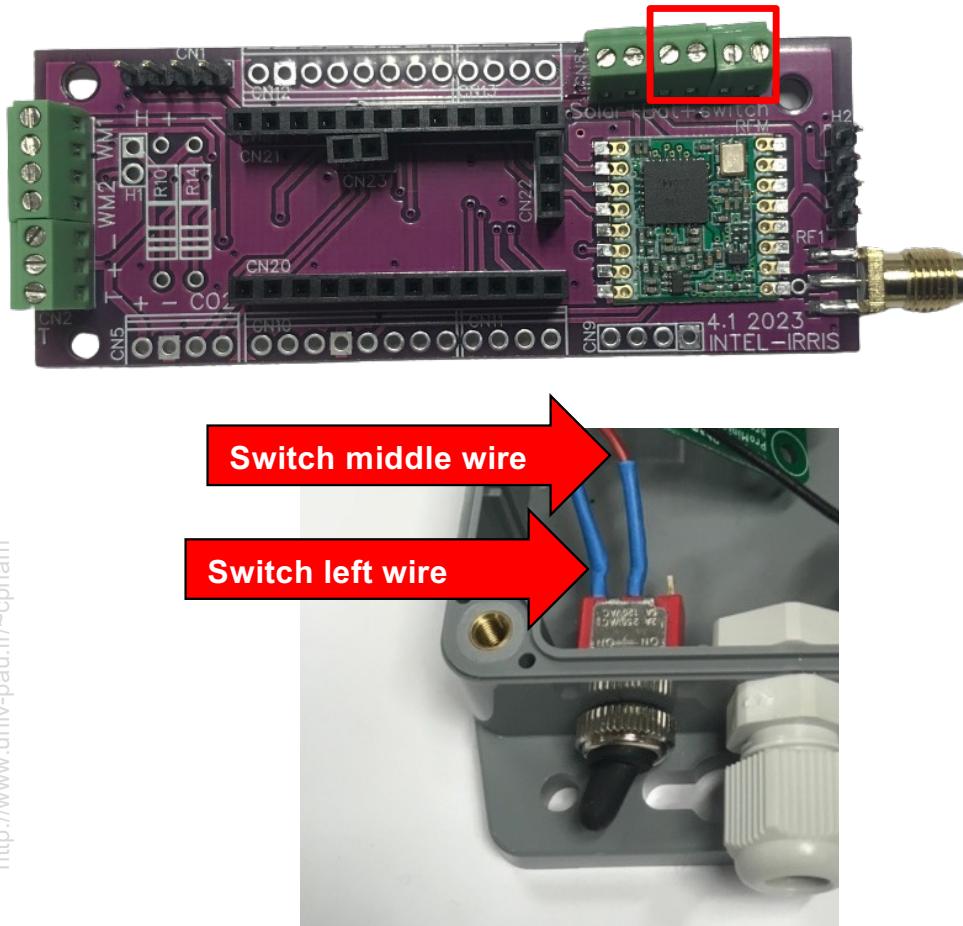
The full version
does not need to
have header for H1

The solar circuit is on
the back side



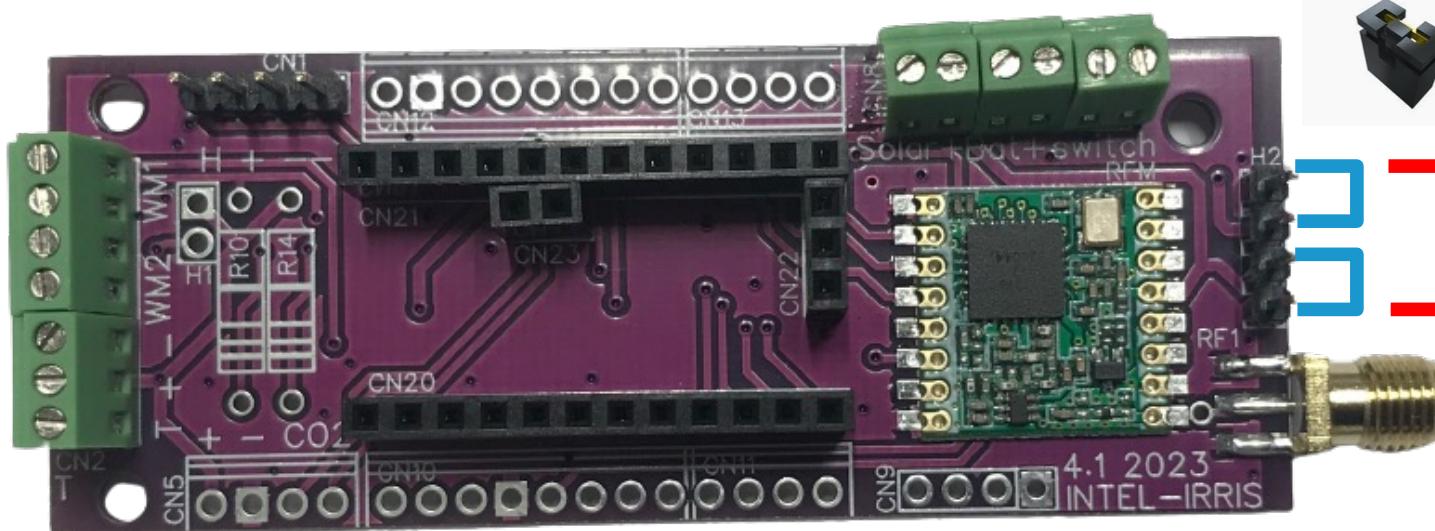
Wiring with IRD PCB v4.1 (PCBA)

- Power wires (from NiMh batteries or AA alkaline batteries)

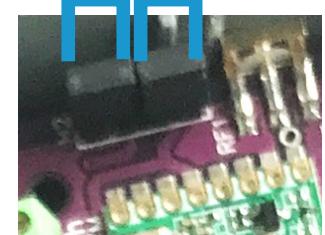


Wiring with IRD PCB v4.1 (PCBA)

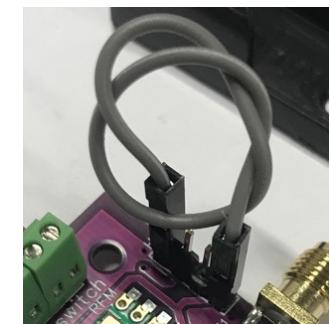
- The full version (PCBA) comes with the solar charging circuit
- **BUT** you can still power it with 2 alkaline AA batteries without using a solar panel to avoid external fragile parts
- You can select between **solar charging with NiMh batteries** or **no solar charging with 2xAA alkaline batteries**



Connect
for SOLAR
with NiMh



Connect
for 2xAA
alkaline
batteries



Alternatives for batteries

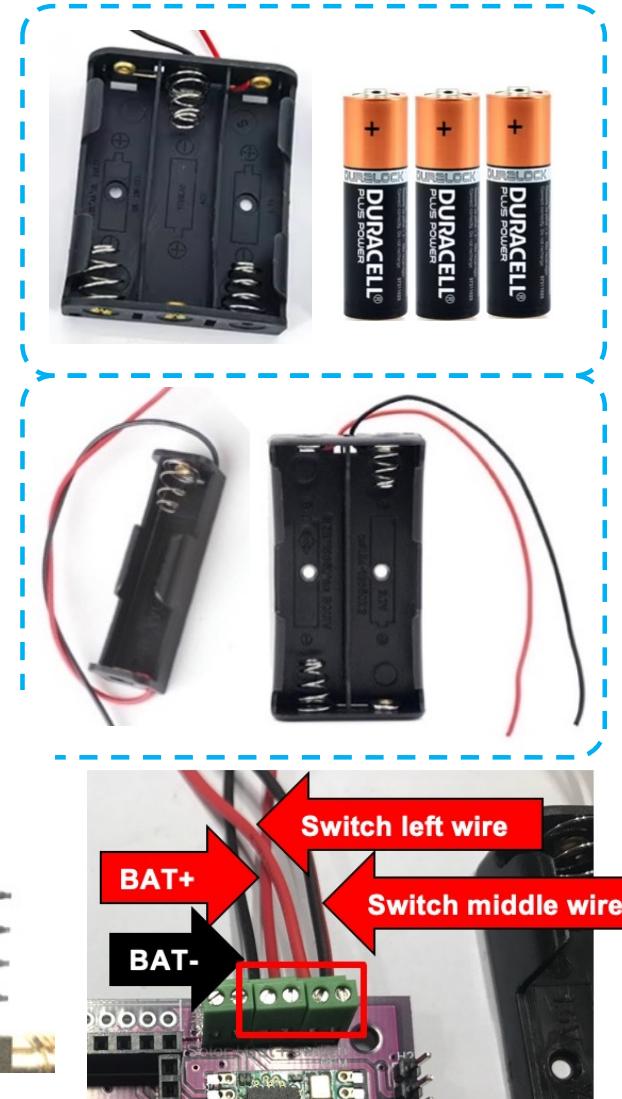
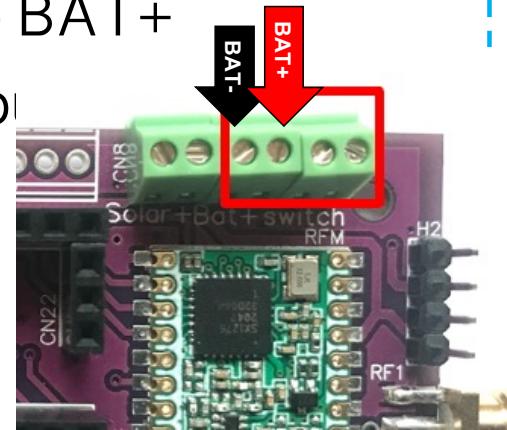
- Simple 2xAA 1.5V batteries delivering ~3.2V when new can be too low for some settings where the connected sensors needs a stable voltable close to 3.3V, especially when the highest quality for alkaline/lithium AA 1.5V batteries are not easily found
- There are other alternatives as illustrated below



- The 3xAA is the simplest and the cheapest alternative

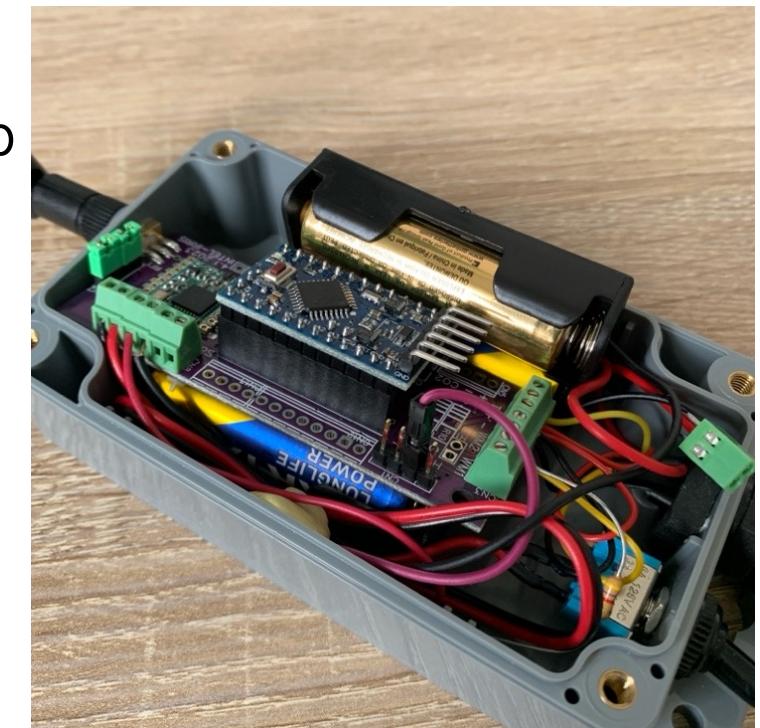
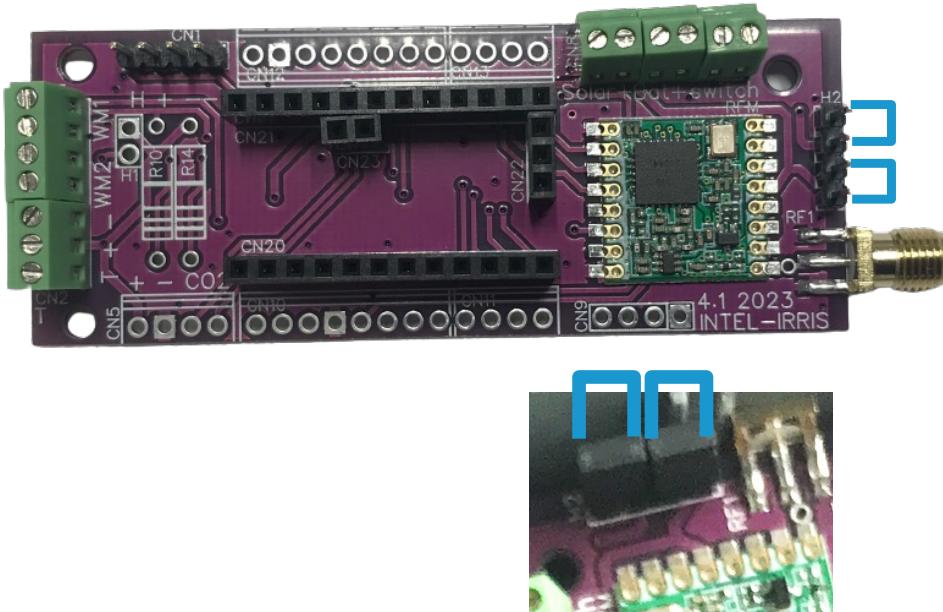
Using 3xAA alkaline batteries

- The 3xAA battery holder is too big for the selected case. If we keep the same case, here is a possible solution
- In addition to the already 2xAA battery holder, add a 1xAA battery holder
- Connect 2xAA bat- (black) to BAT-
- Connect 2xAA bat+ (red) to 1xAA bat- (black)
- Connect 1xAA bat+ (red) to BAT+
- Both battery holder can be placed in the case , see next slide



Using 3xAA, use voltage regulator

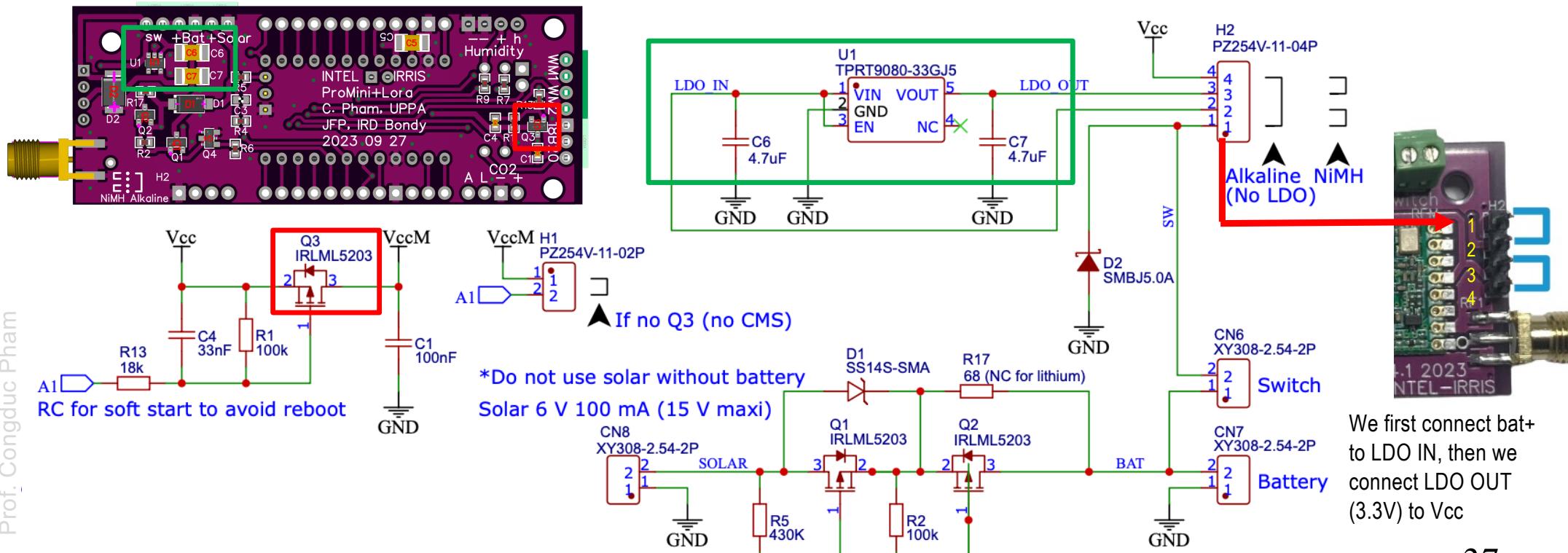
- With 3xAA providing ~ 4.8V, we can use the PCBAv4.1 on-board voltage regulator (assuming the regulator on the Pro Mini was removed)
- Consumption will be about 55uA in deep sleep



Both battery holders can be put in the case

Explanation of previous slide

- With PCBAv4.1, all components are present: Q3 allows to inject Vcc into VccM when A1 is HIGH; regulator U1 can be used to get down from 4.8V to 3.3V

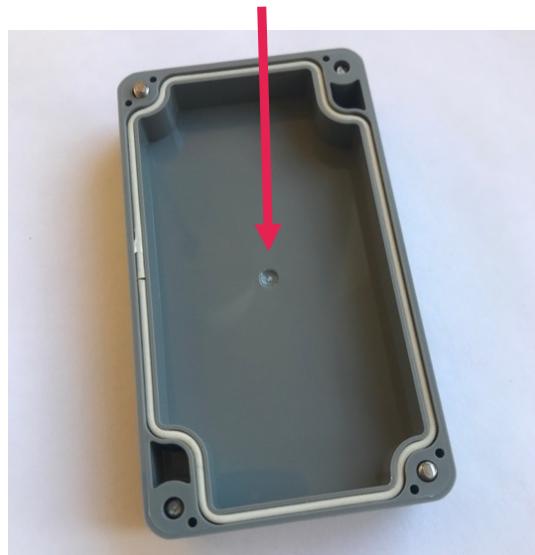


PCBA: Installing solar panel (1)

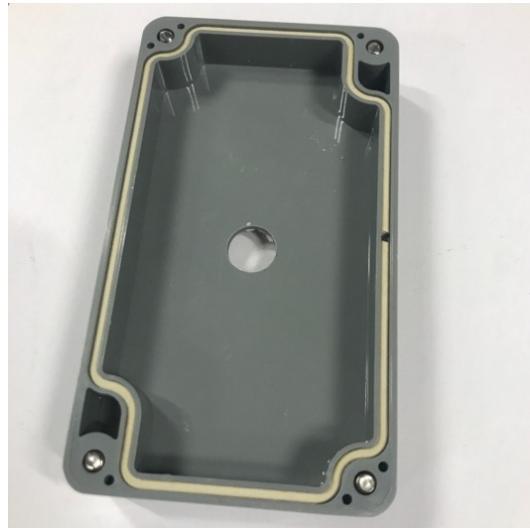
① Mini solar panel

6 V 0.6 W 100 mA 60x90mm

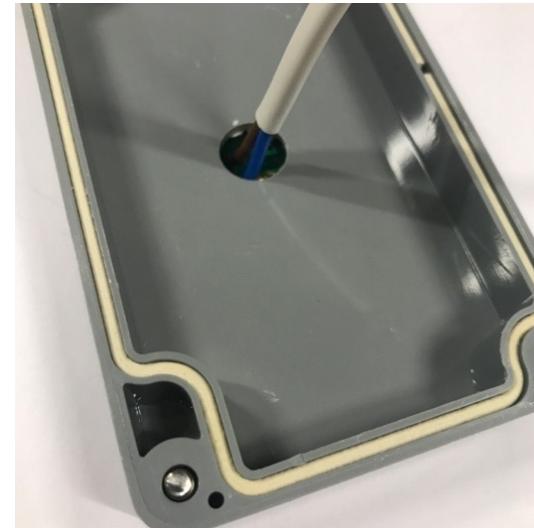
The case cover has
a mark indicating the
center



Drill a hole with a
10mm to 12mm
drill bit for metal

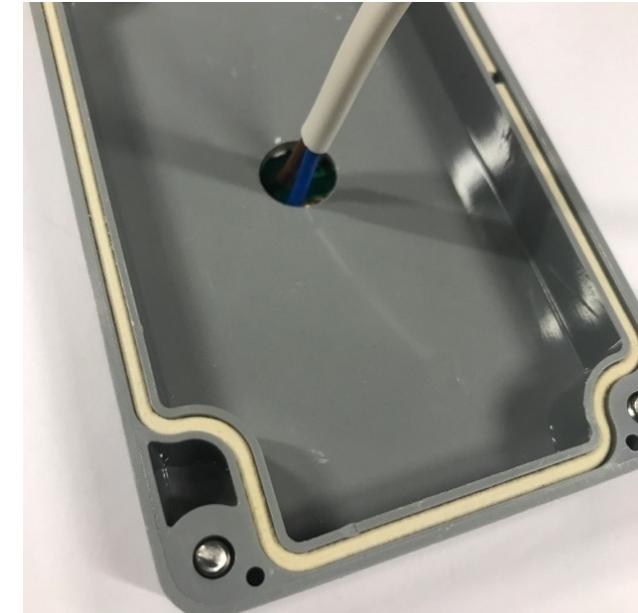
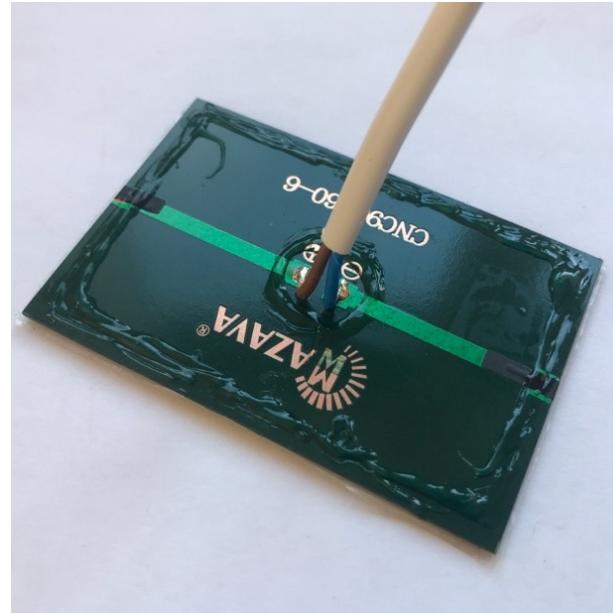
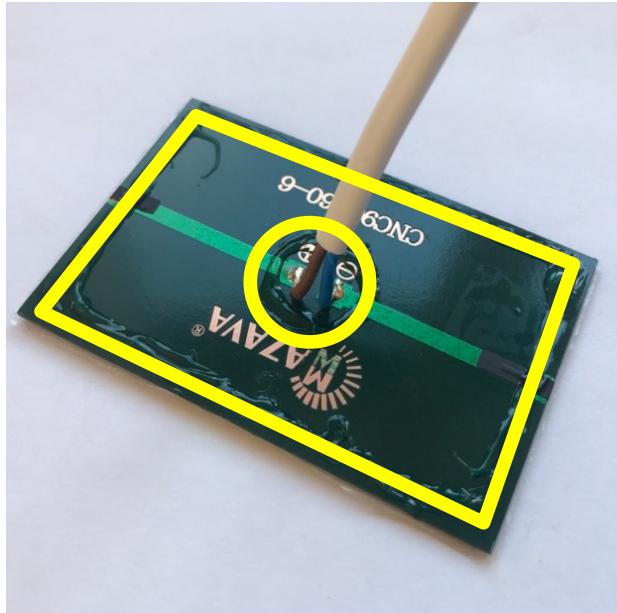


Solder 2 wires on + and -



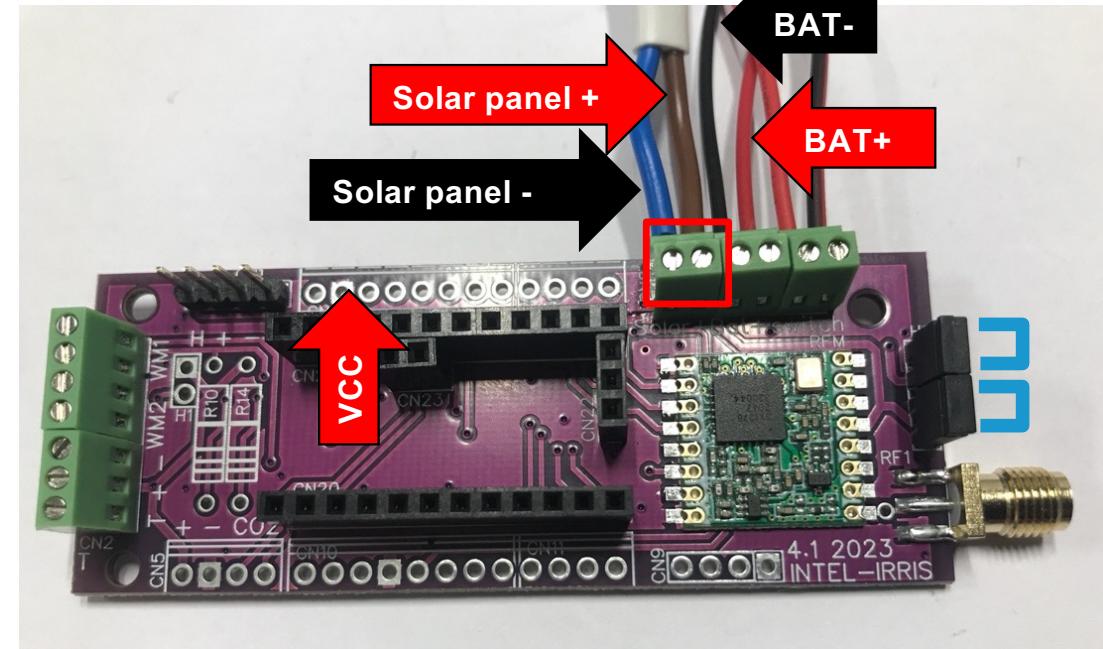
PCBA: Installing solar panel (2)

- Use silicon or glue to assemble the solar panel on the case cover
- Make sure there is no discontinuity of glue, also add glue around the centered hole surrounding the wires



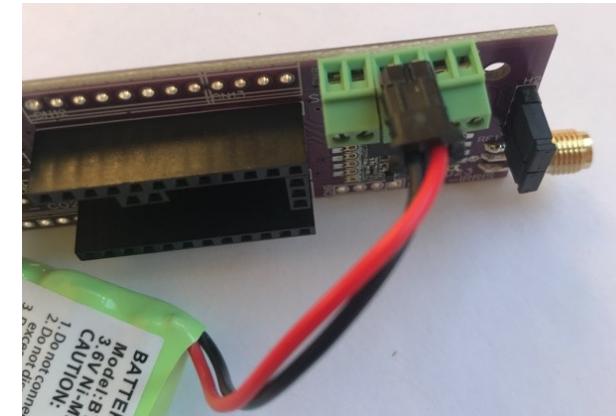
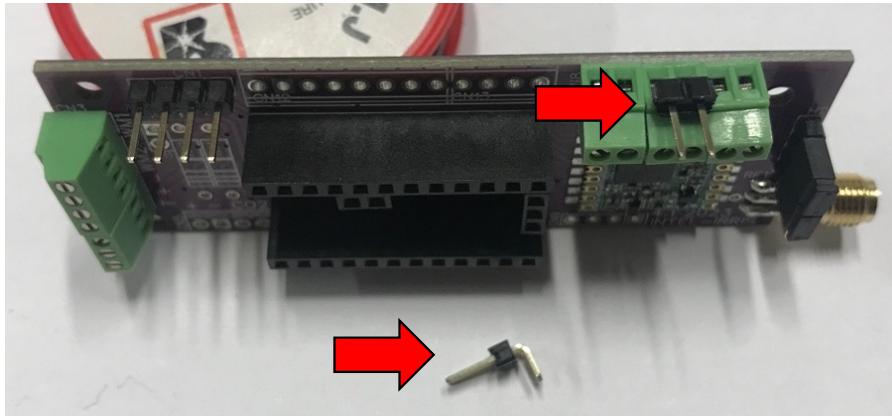
Wiring with IRD PCB v4.1 (PCBA)

➊ Solar panel wires



Wiring with IRD PCB v4.1 (PCBA)

- Connect NiMh batterie packs with a 2-pin female connector
- You can screw in a 2-pin male 90° header

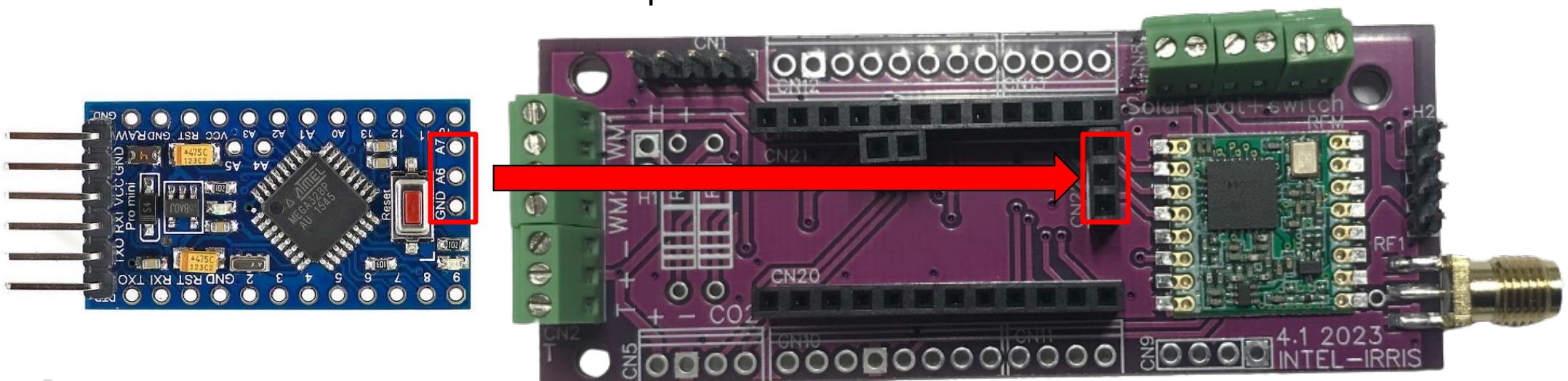


You can buy NiMh
battery packs with
a 2 pin connector
that can be used
for fast connection

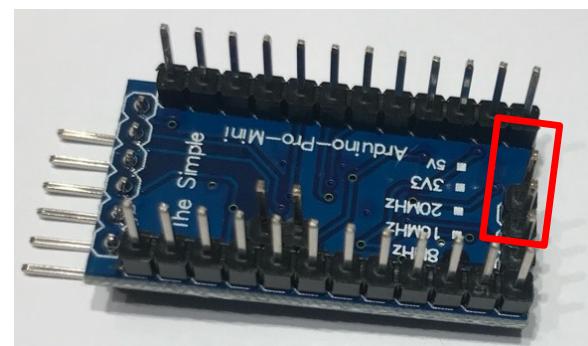


IMPORTANT: Arduino ProMini

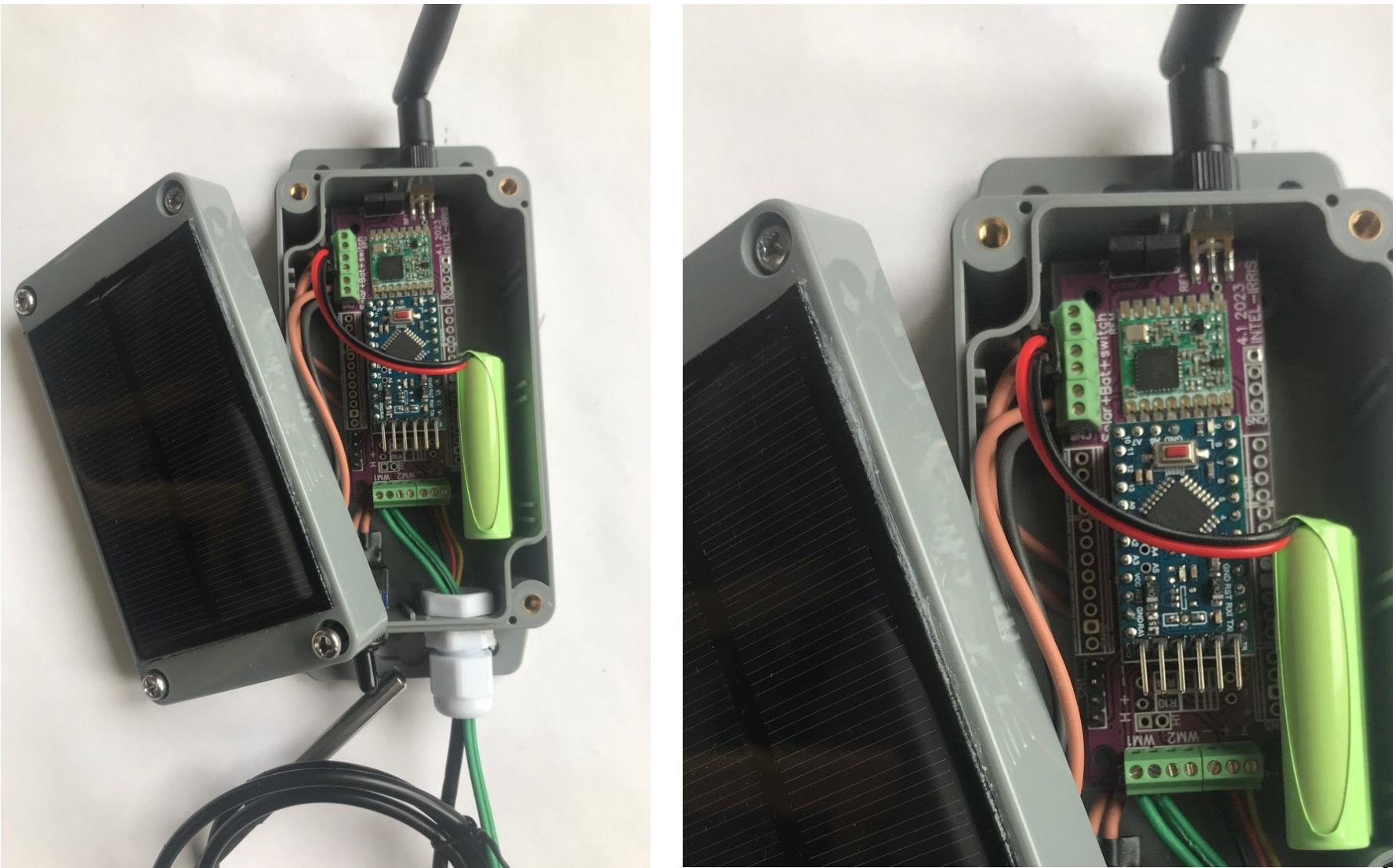
- For solar charging, using the IRD PCBA v4.1, the Arduino ProMini **MUST** have pin A7 connected!



- So, it is **MANDATORY** to solder a 3-pin header for GND, A6 & A7 on the Arduino ProMini board

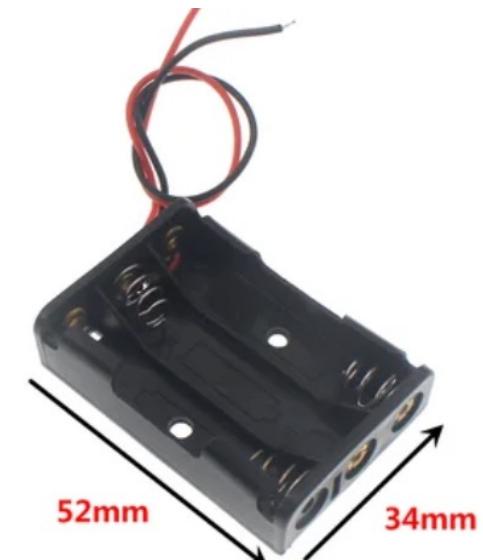


Soil device with PCBA v4.1, final result



Using 3xAAA batteries

- You can alternatively use 3xAAA NiMh rechargeable batteries with a battery holder
- This would allow you to slip the 3xAAA battery holder under the PCBA board



INTEL-IRRIS

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

INTEGRATION & CASING

Get an enclosure for outdoor usage



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

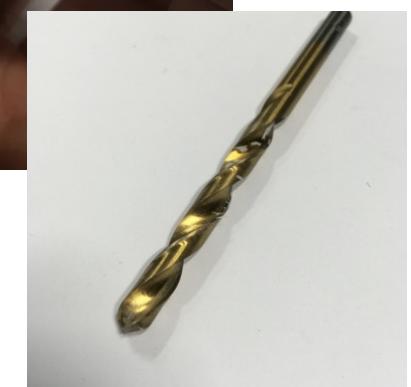
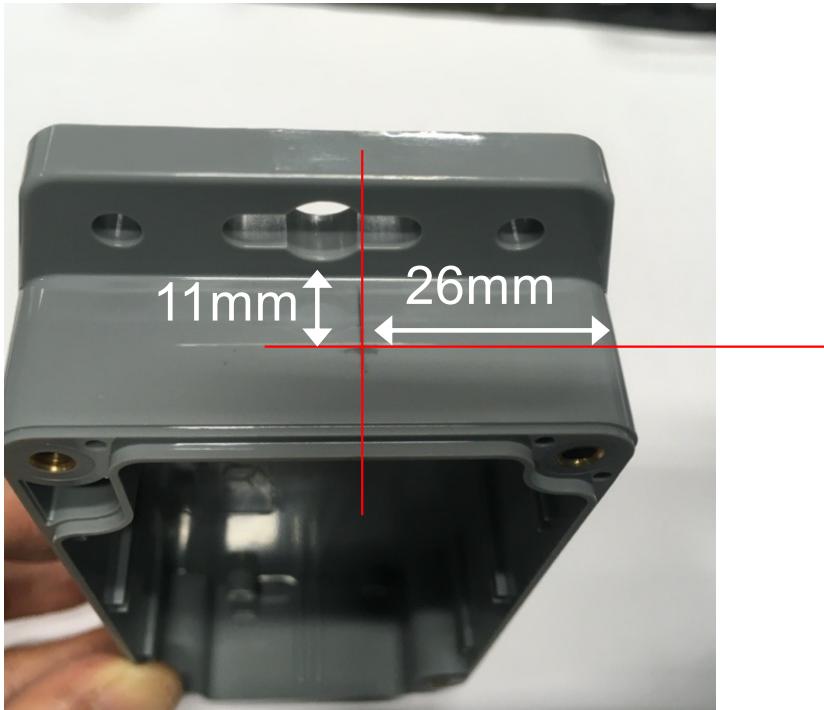
<https://www.gotronic.fr/art-boitier-abs-etanche-g304m-17977.htm>

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



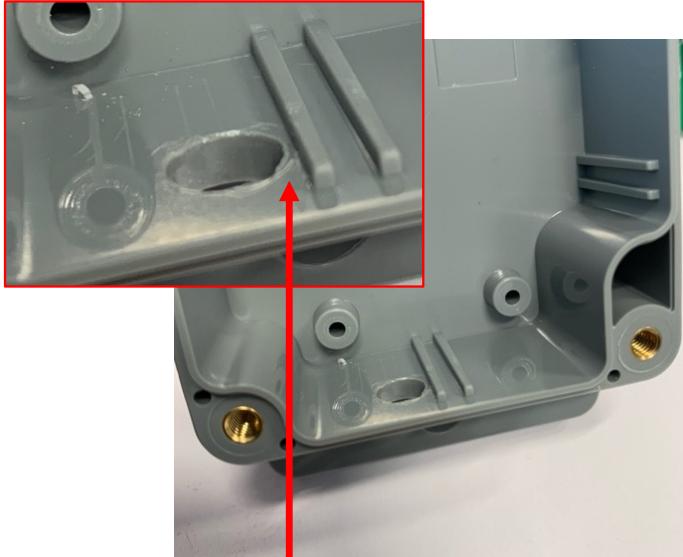
26mm for the right edge:

- measure from the flat side as the corner is round

11mm from the outside bottom

use a 7mm drill bit for metal, not for wood nor concrete!

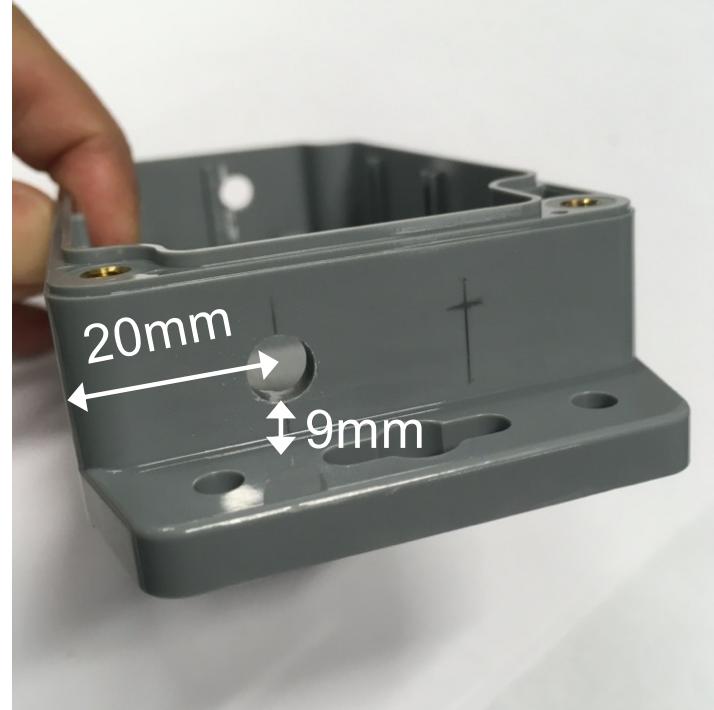
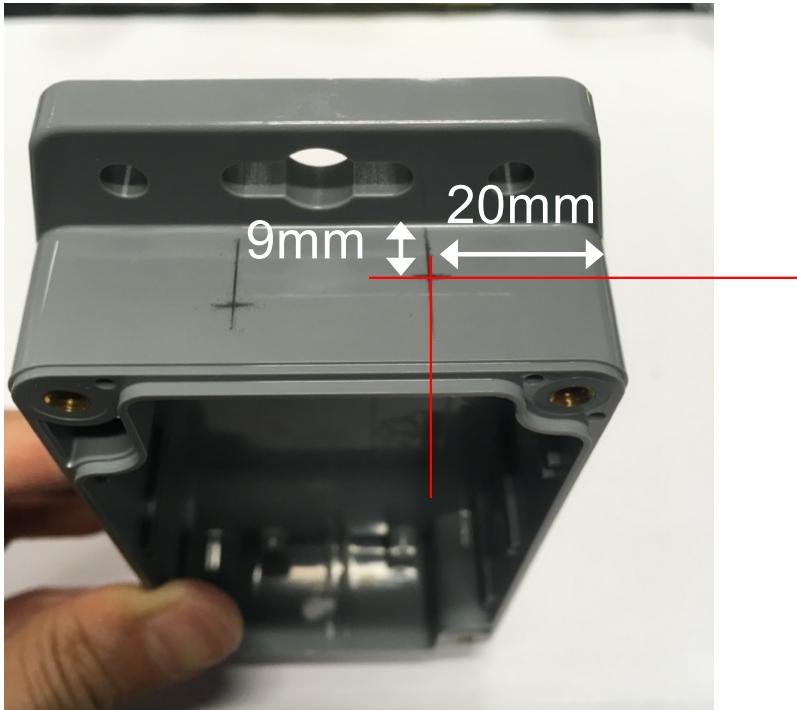
Placing the PCB board



With this particular enclosure case, it is better to have the hole about **1mm** next to the plastic reinforcement part

The board can be placed with the SMA connector going through the hole. The 2-AA battery holder is put next to the PCB

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



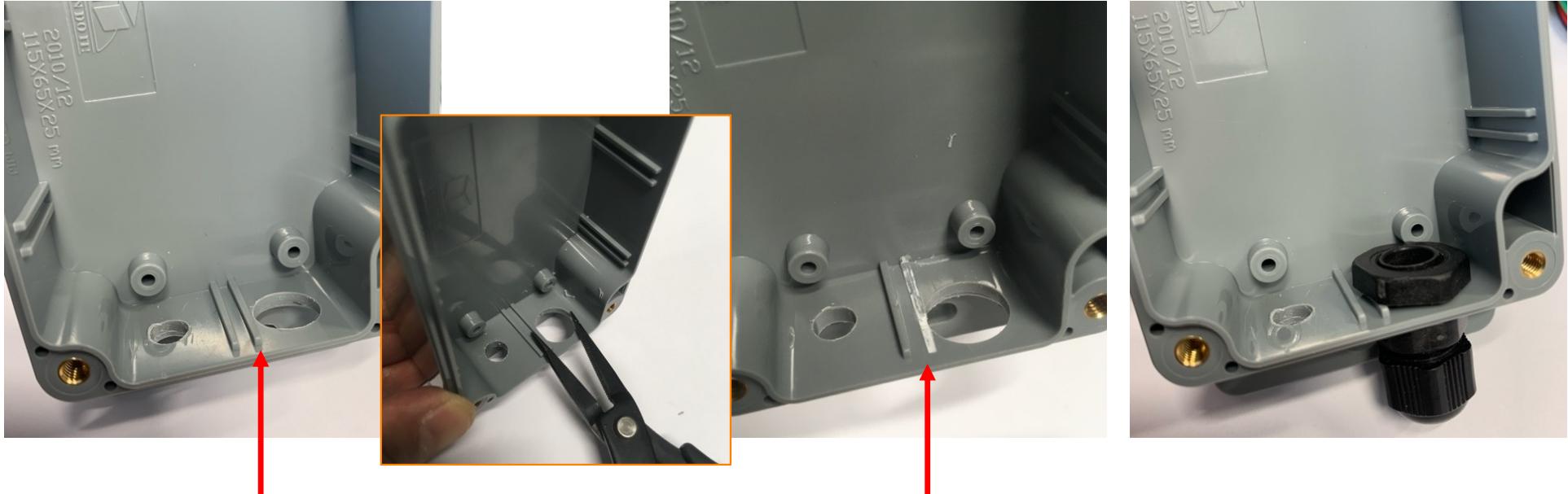
41mm for the right edge:

- measure from the flat side as the corner is round

9mm from the outside bottom

use a 13mm or 12mm drill bit for metal. If 13mm, it is recommended to use a step drill bit to first get a 12mm hole before

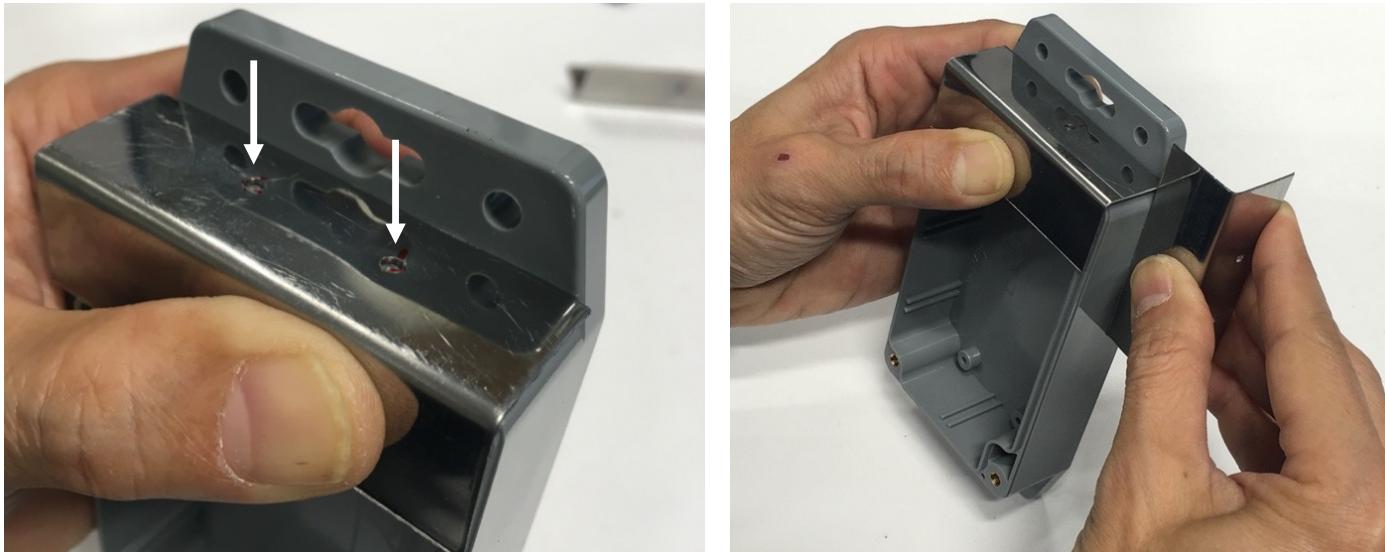
Remove unwanted plastic part



It may be needed 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)

But that may be not necessary if you can securely screw in the cable gland (right-most photo)

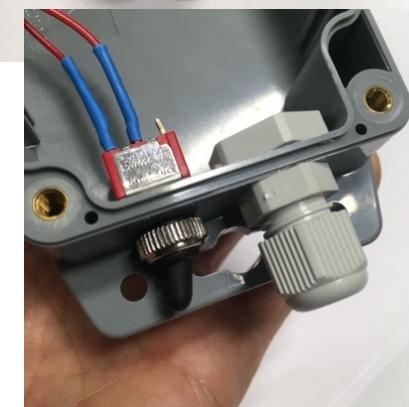
Going for larger production



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

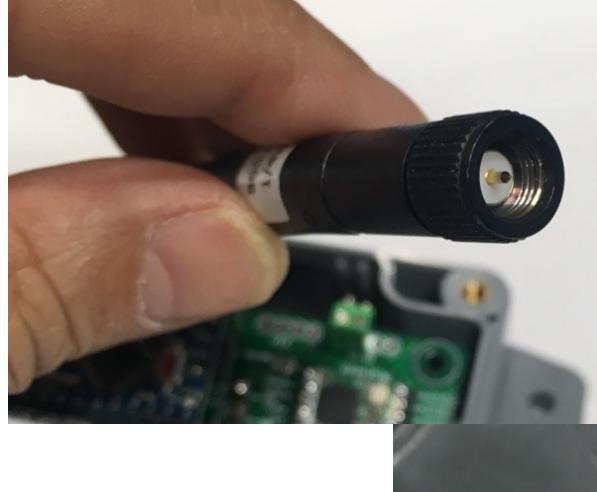
Placing switch and cable gland



test that everything is OK

the switch has a water-proof rubber cap which should be carefully tighten

Connecting antenna

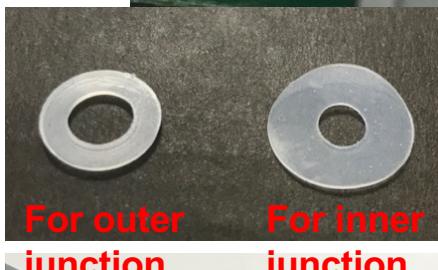


Be sure to connect the matching antenna
Here, SMA female with SMA male antenna
Need to screw the antenna in all the way

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

Waterproofing the antenna junction

Check the gap size



See example in
the list of part



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 flat silicon seals for that
purpose, but do not take it too
thick or too large!

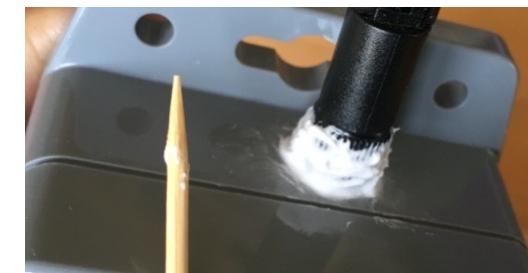
Too thick: the antenna will not be
screwed in all the way!

Do not have or can not use flat seal?

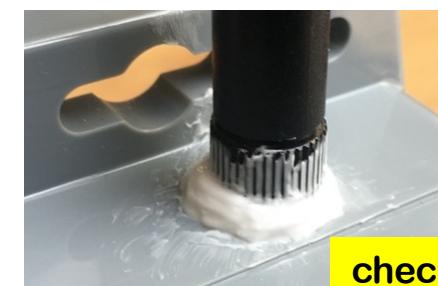
Maybe the gap is too big? Use silicon joint sealant



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



Use a wet toothpick to finish and clean the silicon all around the antenna junction



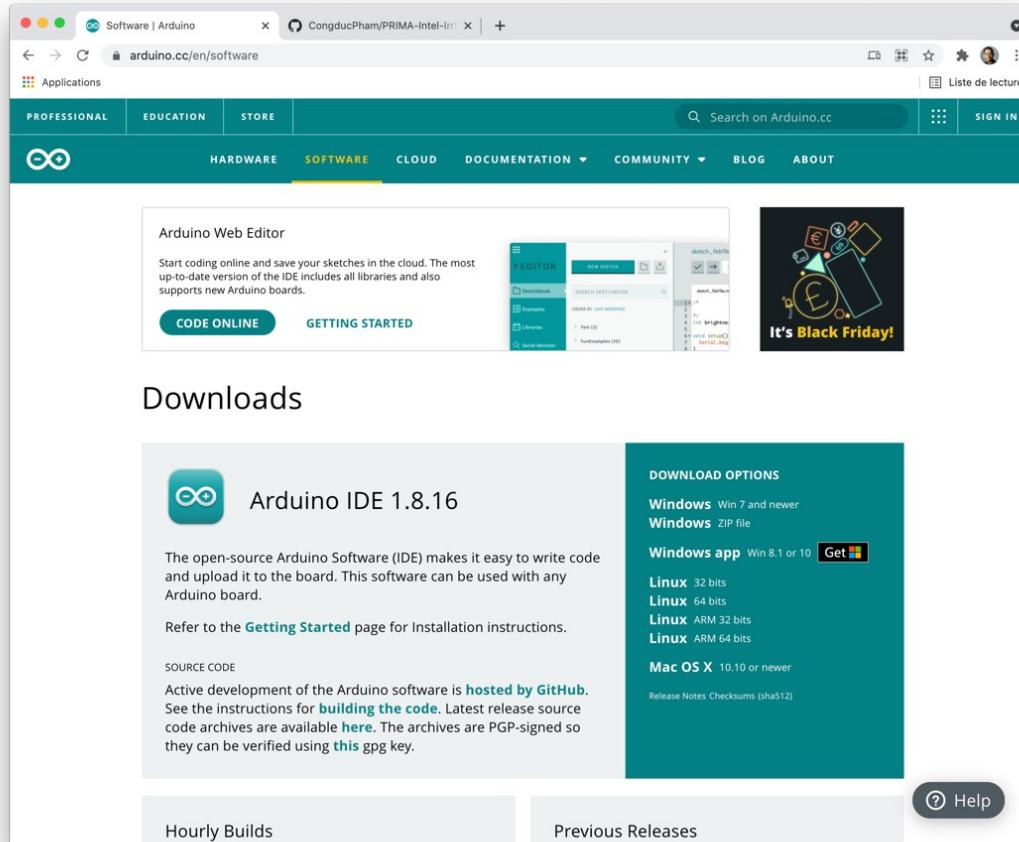
check especially
the back side

INTEL-IRRIS

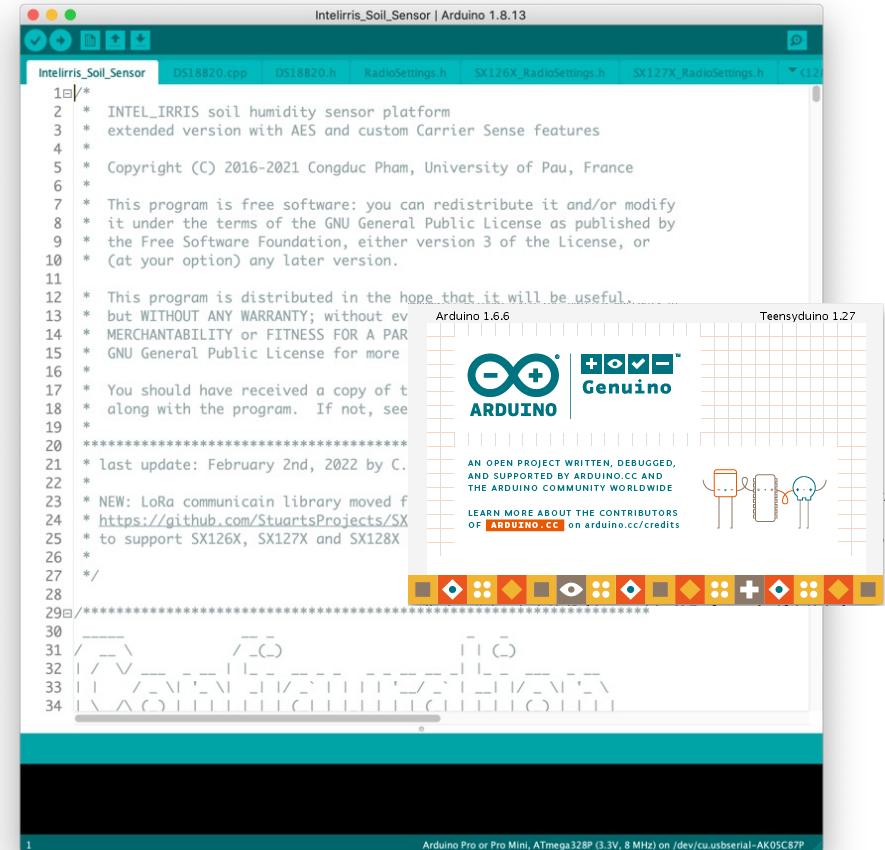
Intelligent Irrigation System for Low-cost Autonomous Water Control
in Small-scale Agriculture

PROGRAM THE ARDUINO

Getting the software: Arduino IDE



The screenshot shows the Arduino website's software page. It features a header with tabs for PROFESSIONAL, EDUCATION, STORE, HARDWARE, SOFTWARE, CLOUD, DOCUMENTATION, COMMUNITY, BLOG, and ABOUT. Below the header, there's a section for the Arduino Web Editor and a "Downloads" section. In the "Downloads" section, there's a large button for "Arduino IDE 1.8.16". To the right of this button is a "DOWNLOAD OPTIONS" panel listing download links for Windows (Win 7 and newer, ZIP file), Windows app (Get Microsoft Store), Linux (32 bits, 64 bits, ARM 32 bits, ARM 64 bits), and Mac OS X (10.10 or newer). Below these are links for "SOURCE CODE" and "Release Notes Checksums (sha512)". At the bottom of the "Downloads" section are links for "Hourly Builds" and "Previous Releases". A "Help" button is located at the bottom right.



The screenshot shows the Arduino IDE 1.8.16 interface with an open sketch titled "Intelirris_Soil_Sensor". The code is as follows:

```

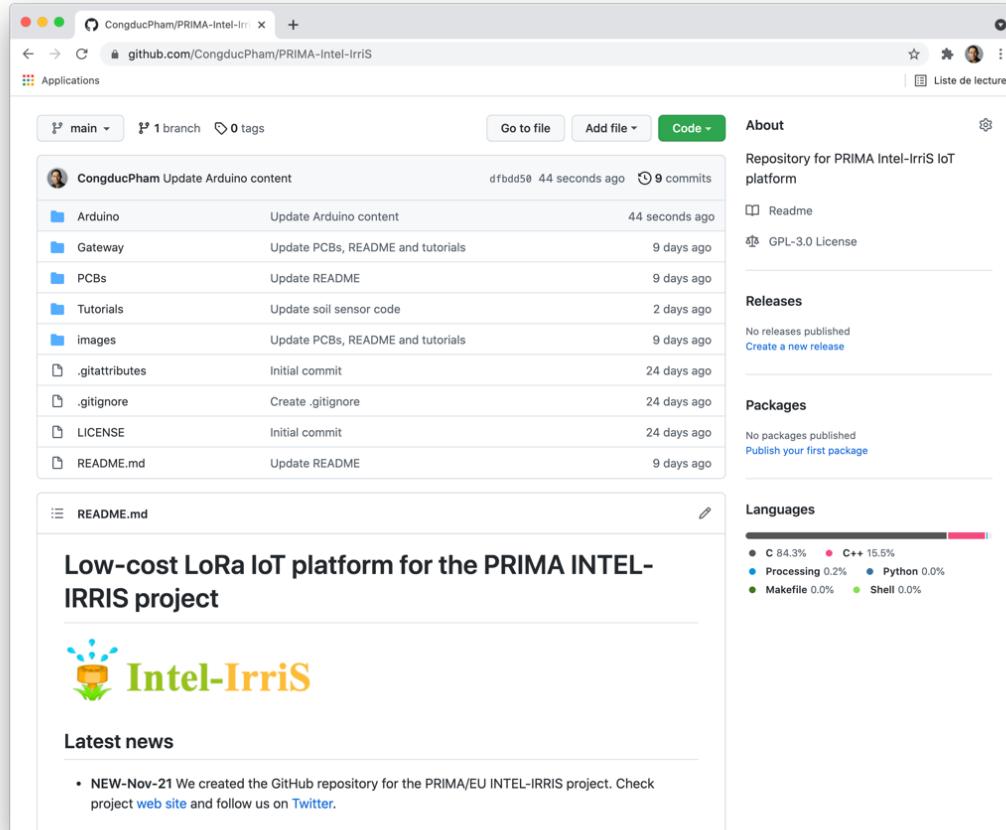
1 ///*
2 * INTEL_IRRIS soil humidity sensor platform
3 * extended version with AES and custom Carrier Sense features
4 *
5 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France
6 *
7 * This program is free software: you can redistribute it and/or modify
8 * it under the terms of the GNU General 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
14 * MERCHANTABILITY or FITNESS FOR A PARTICULAR
15 * GNU General Public License for more
16 *
17 * You should have received a copy of the
18 * along with the program. If not, see
19 *
20 ****
21 * last update: February 2nd, 2022 by C.
22 *
23 * NEW: LoRa communication library moved to
24 * https://github.com/StuartsProjects/SX
25 * to support SX126X, SX127X and SX128X
26 *
27 */
28
29 ****
30
31 /--\ /--\
32 | / \ | / \
33 | | / \ | / \
34 | \| / \ | / \

```

The interface includes toolbars for Arduino 1.6.6 and Teensyduino 1.2.7, and a status bar at the bottom indicating "Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz) on /dev/cu.usbserial-AK05C87P".

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

Getting the 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 from CongducPham, all made 44 seconds ago. The commits are:

- Update Arduino content
- Update Arduino content
- Update PCBs, README and tutorials
- Update README
- Update soil sensor code
- Update PCBs, README and tutorials
- Initial commit
- Create .gitignore
- Initial commit

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

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



Latest news:

- NEW-Nov-21 We created the GitHub repository for the PRIMA/EU INTEL-IRRIS project. Check project [web site](#) and follow us on [Twitter](#).

Code

About

Repository for PRIMA Intel-Irris IoT platform

Readme

GPL-3.0 License

Releases

No releases published [Create a new release](#)

Packages

No packages published [Publish your first package](#)

Languages

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

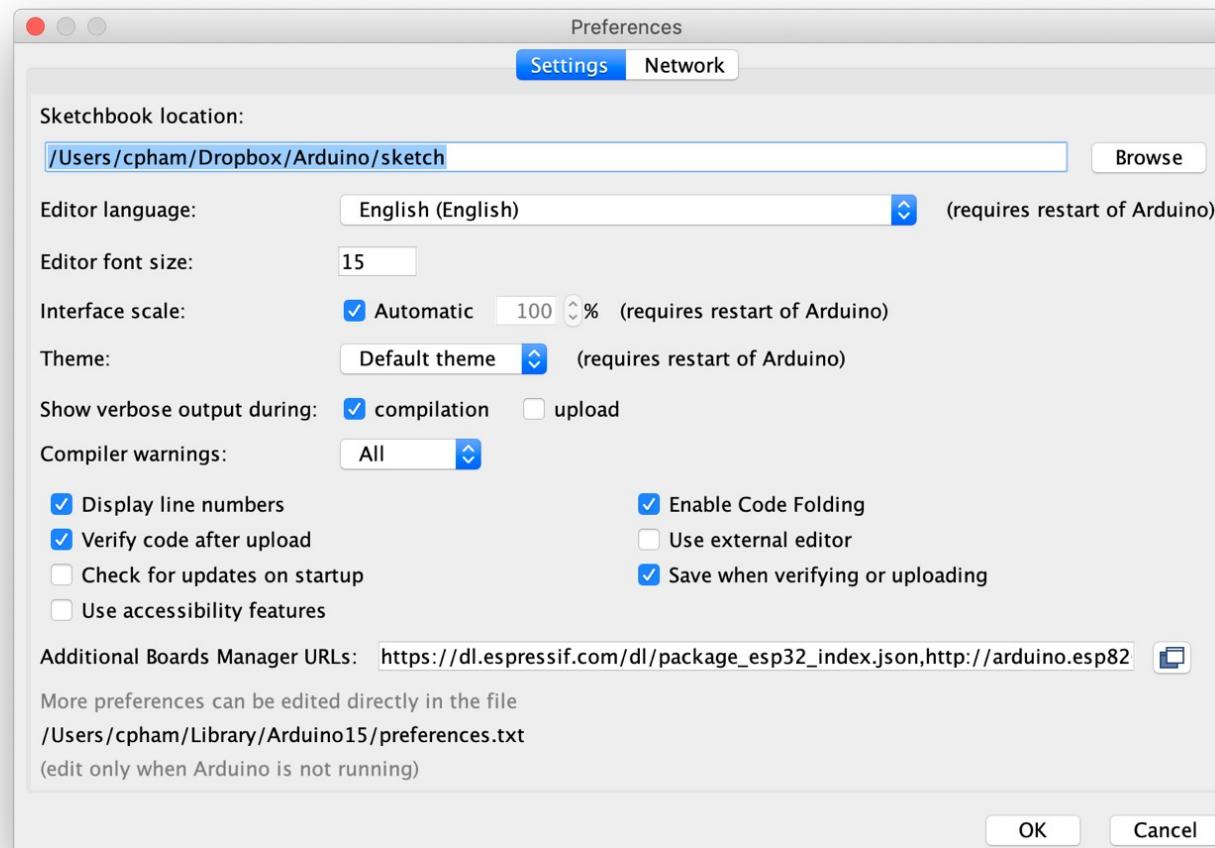
Unzip the file and copy the content of Arduino folder into your sketch folder

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

Config for IRD PCB v4.1

- For raw version, uncomment IRD_PCB in BoardSettings.h

```
//uncomment for WAZISENSE v2 board
//#define WAZISENSE
```

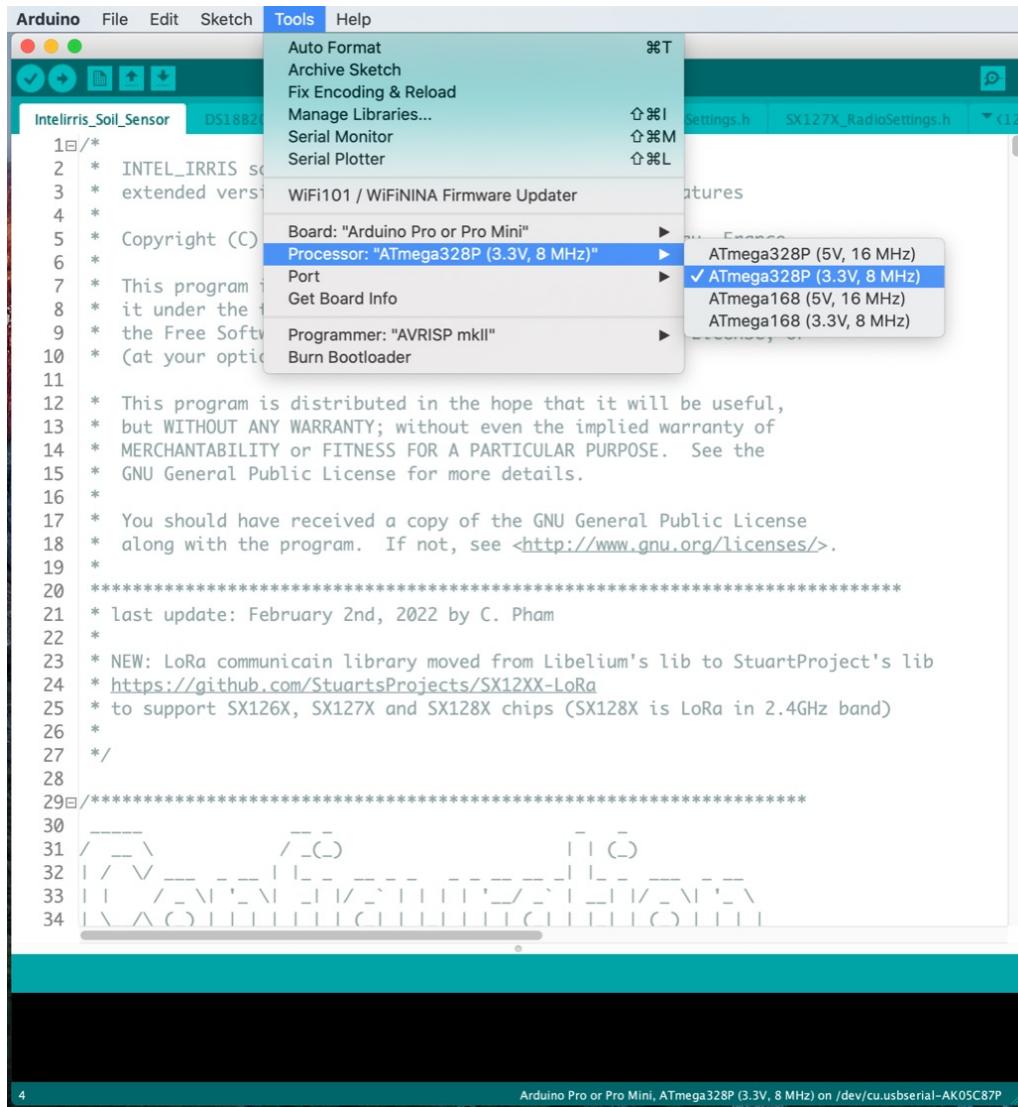
- For PCBA version, also uncomment IRD_PCBA

```
///////////////////////////////
//uncomment for IRD PCB board
#define IRD_PCB
//also uncomment for IRD PCB board fully assembled by manufacturer
//with all components, including solar circuit
#define IRD_PCBA
```

- ONLY for solar version, uncomment SOLAR_BAT

```
///////////////////////////////
// uncomment only if the IRD PCB is running on solar panel
// MUST be commented if running on alkaline battery
// code for SOLAR_BAT has been written by Jean-François Printanier from IRD
#define SOLAR_BAT
// do not change if you are not knowing what you are doing
#define NIMH
```

Compiling the soil sensor code



The screenshot shows the Arduino IDE interface. The file 'Intelirris_Soil_Sensor' is open. The 'Tools' menu is open, showing various options like Auto Format, Archive Sketch, and Board selection. Under Board selection, 'Processor: ATmega328P (3.3V, 8 MHz)' is selected. The code editor displays the source code for the soil sensor sketch, which includes comments about the Intel-Irris soil sensor and its compatibility with the DS18B20 temperature sensor.

```

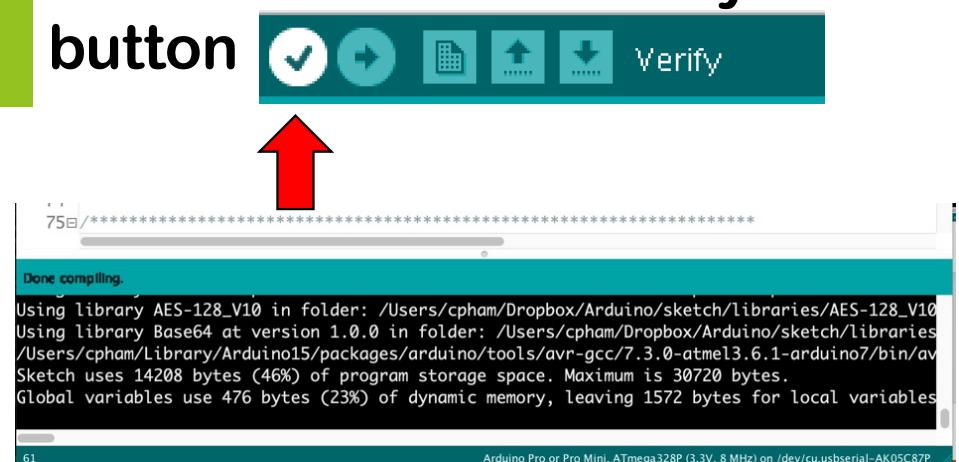
1/*
2 * INTEL_IRRIS soil sensor
3 * extended version
4 *
5 * Copyright (C)
6 * This program is free software; you can redistribute it and/or
7 * modify it under the terms of the GNU General Public License
8 * as published by the Free Software Foundation; either version 2
9 * of the License, or (at your option) any later version.
10 *
11 * This program is distributed in the hope that it will be useful,
12 * but WITHOUT ANY WARRANTY; without even the implied warranty of
13 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
14 * GNU General Public License for more details.
15 *
16 * You should have received a copy of the GNU General Public License
17 * along with the program. If not, see <http://www.gnu.org/licenses/>.
18 *
19 ****
20 * last update: February 2nd, 2022 by C. Pham
21 *
22 * NEW: LoRa communication library moved from Libelium's lib to StuartProject's lib
23 * https://github.com/StuartsProjects/SX12XX-LoRa
24 * to support SX126X, SX127X and SX128X chips (SX128X is LoRa in 2.4GHz band)
25 *
26 */
27
28 ****
29 */
30
31
32
33
34

```

Open Intelirris_Soil_Sensor sketch – no change required for default capacitive sensor

Select the ProMini board, 3.3V and 8MHz version

Then click on the "verify" button

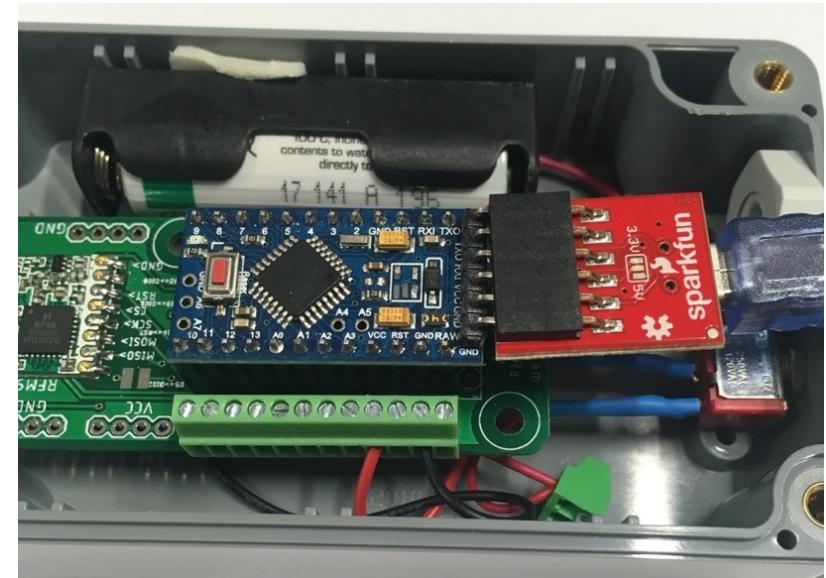
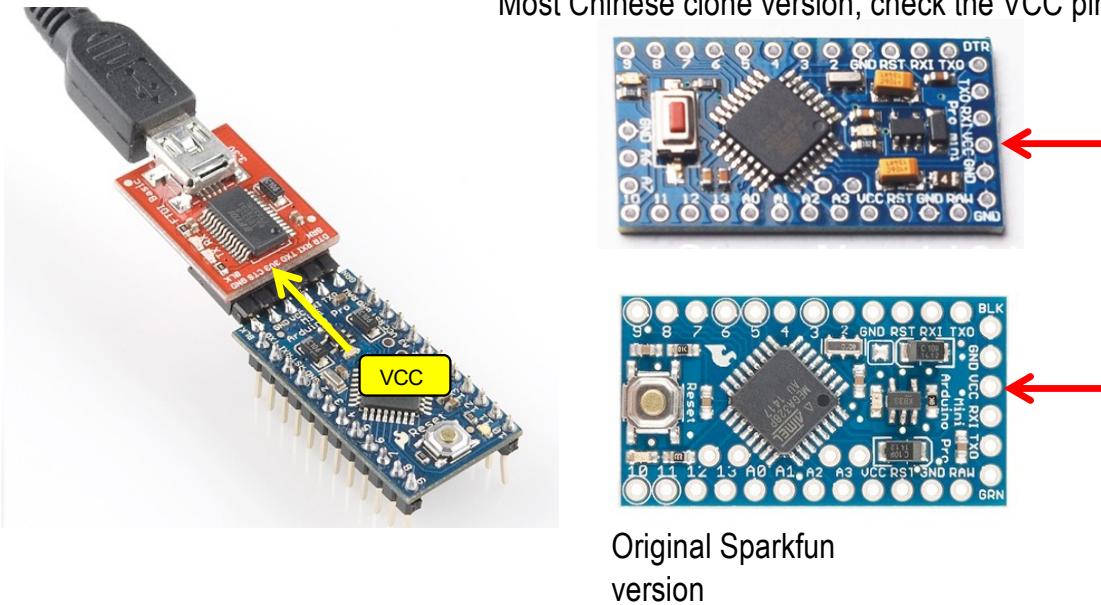




Never transmit without antenna

- 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, then 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



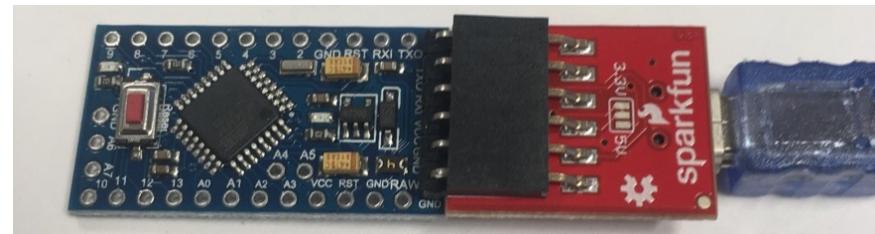
For the ProMini, you need to have an FTDI breakout cable working at 3.3v

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



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

```

27 */
28

Done uploading.

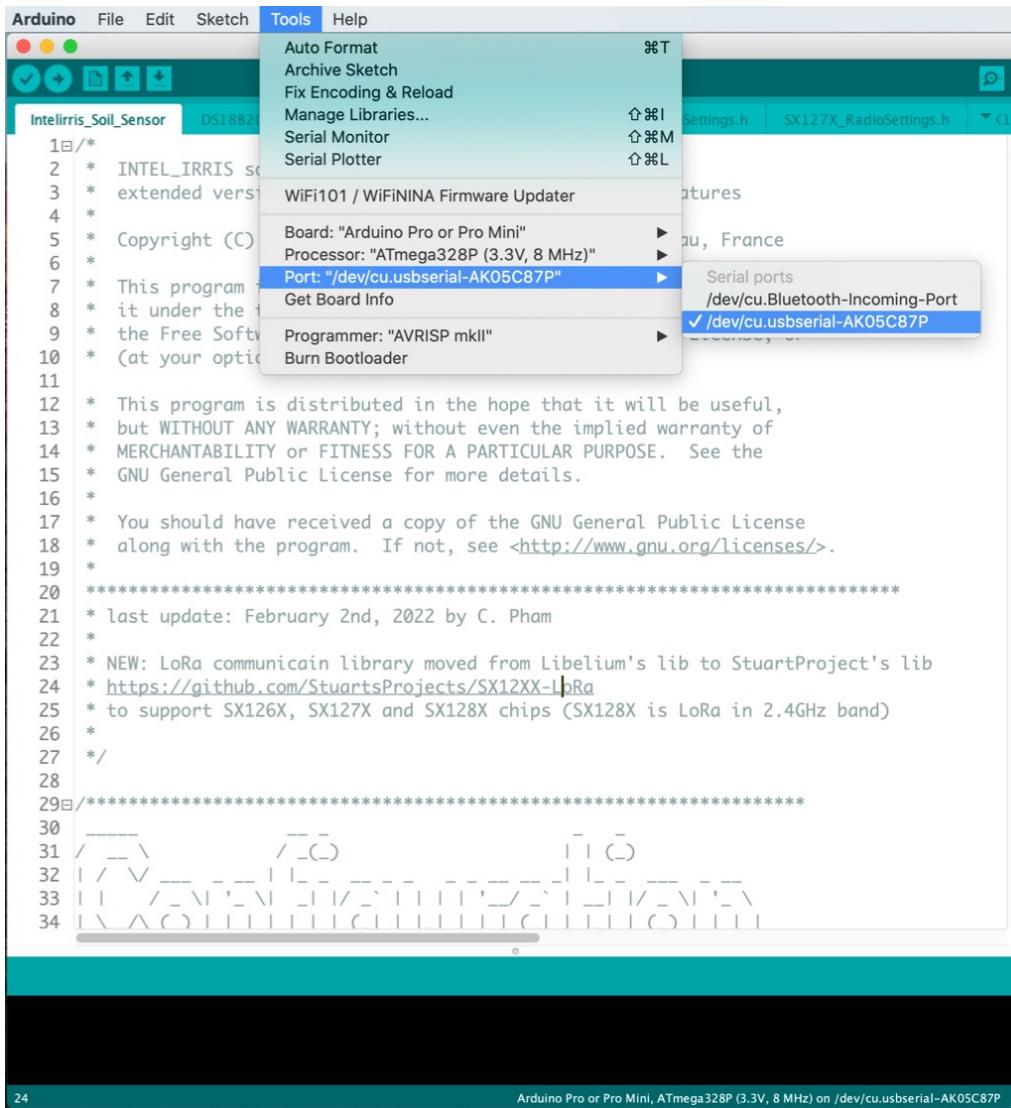
Using library LowPower at version 1.0 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/
Using library OneWire at version 2.3.2 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/
Using library Dallas-Temperature at version 3.7.7 in folder: /Users/cpham/Dropbox/Arduino/sketch/
Using library 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

31

```

Arduino Pro or Pro Mini on /dev/cu.usbserial-AK05C87P

Select serial port for uploading

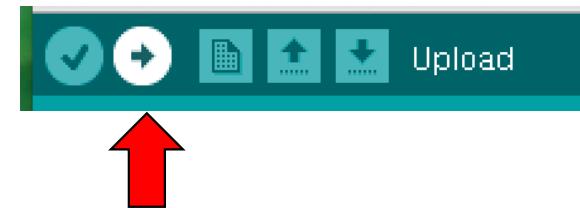


After connecting the cable to your computer/laptop USB port, try to find the serial port

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

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

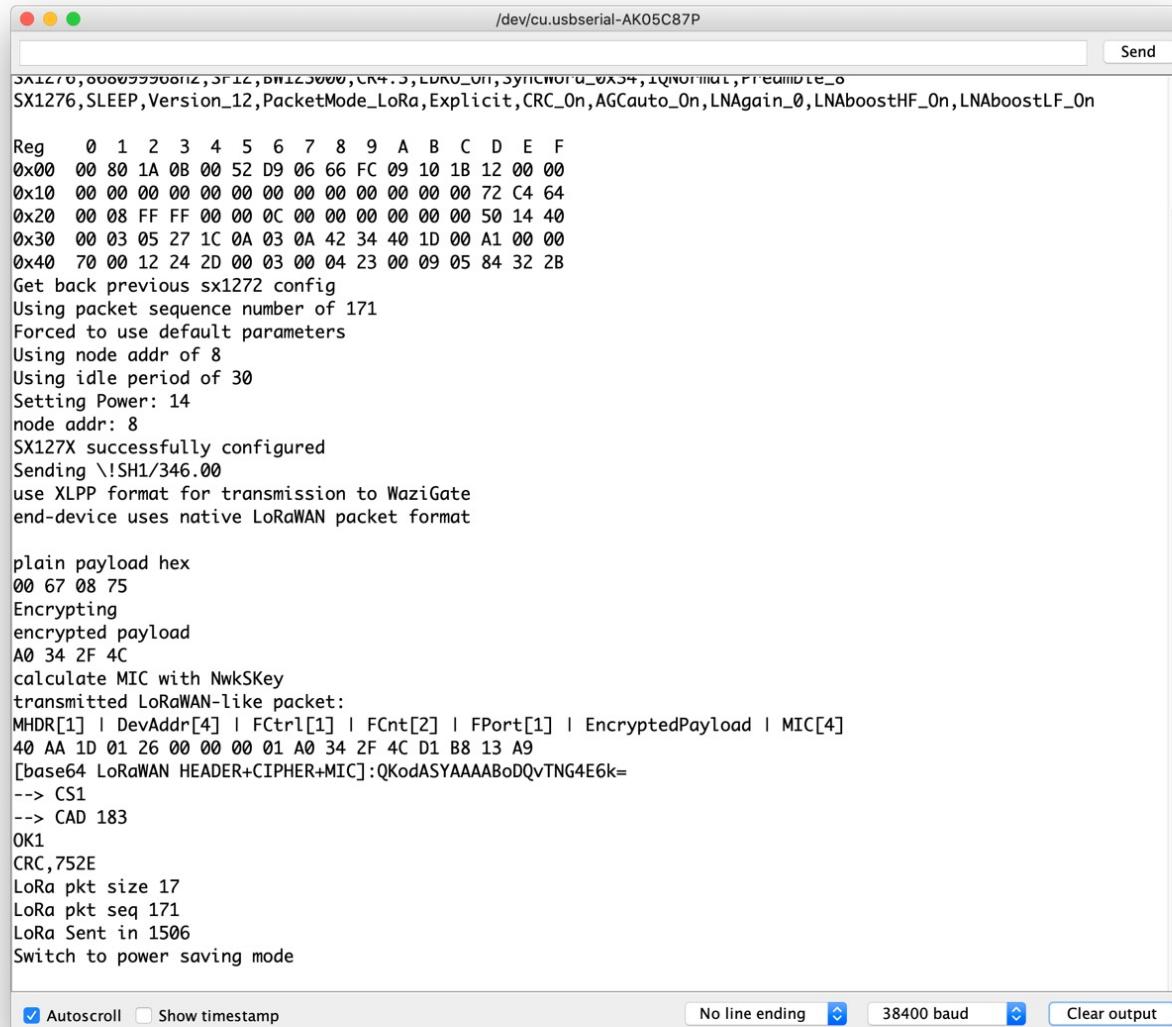
Click on the "upload" button



And wait until upload is completed

```
27 */  
28  
29 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/  
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



```

/dev/cu.usbserial-AK05C87P
Send

SX1276,0000000000000000,3F12,B0123000,CR4.5,LDRU_0H,SYNCHRO_0X34,TQNormal,Preamble_0
SX1276,SLEEP,Version_12,PacketMode_LoRa,Explicit,CRC_On,AGCAuto_On,LNAgain_0,LNAboostHF_On,LNAboostLF_On

Reg 0 1 2 3 4 5 6 7 8 9 A B C D E F
0x00 00 80 1A 0B 00 52 D9 06 66 FC 09 10 1B 12 00 00
0x10 00 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 34 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 171
Forced to use default parameters
Using node addr of 8
Using idle period of 30
Setting Power: 14
node addr: 8
SX127X successfully configured
Sending \!SH1/346.00
use XLPP format for transmission to WaziGate
end-device uses native LoRaWAN packet format

plain payload hex
00 67 08 75
Encrypting
encrypted payload
A0 34 2F 4C
calculate MIC with NwkSKey
transmitted LoRaWAN-like packet:
MHDR[1] | DevAddr[4] | FCtrl[1] | FCnt[2] | FPort[1] | EncryptedPayload | MIC[4]
40 AA 1D 01 26 00 00 00 01 A0 34 2F 4C D1 B8 13 A9
[base64 LoRaWAN HEADER+CIPHER+MIC]:QKodASYAAABoDQvTNG4E6k=
--> CS1
--> CAD 183
OK1
CRC,752E
LoRa pkt size 17
LoRa pkt seq 171
LoRa Sent in 1506
Switch to power saving mode

 Autoscroll  Show timestamp
  No line ending  38400 baud  Clear output

```

Open serial monitor

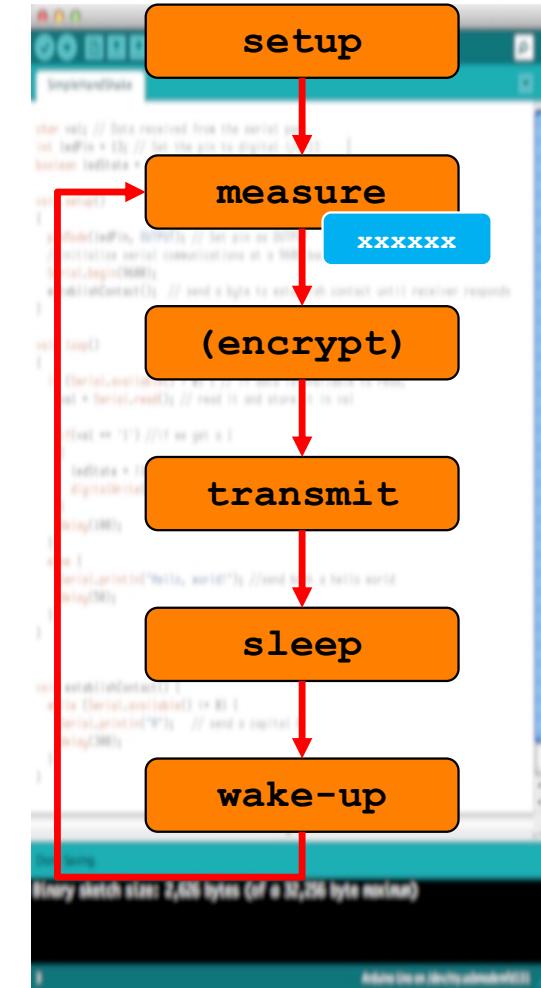
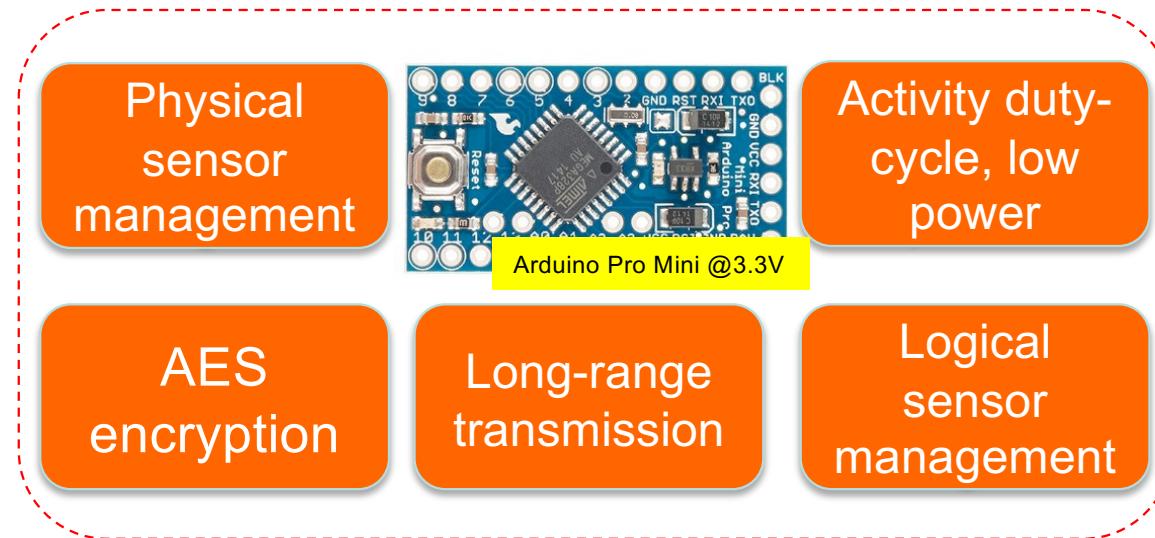
Set baud rate to 38400

See output from board

**Check that
transmission is OK**

Generic & cyclic behavior

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



Transmission to gateway



Parameters for
INTEL-IRRIS gateway



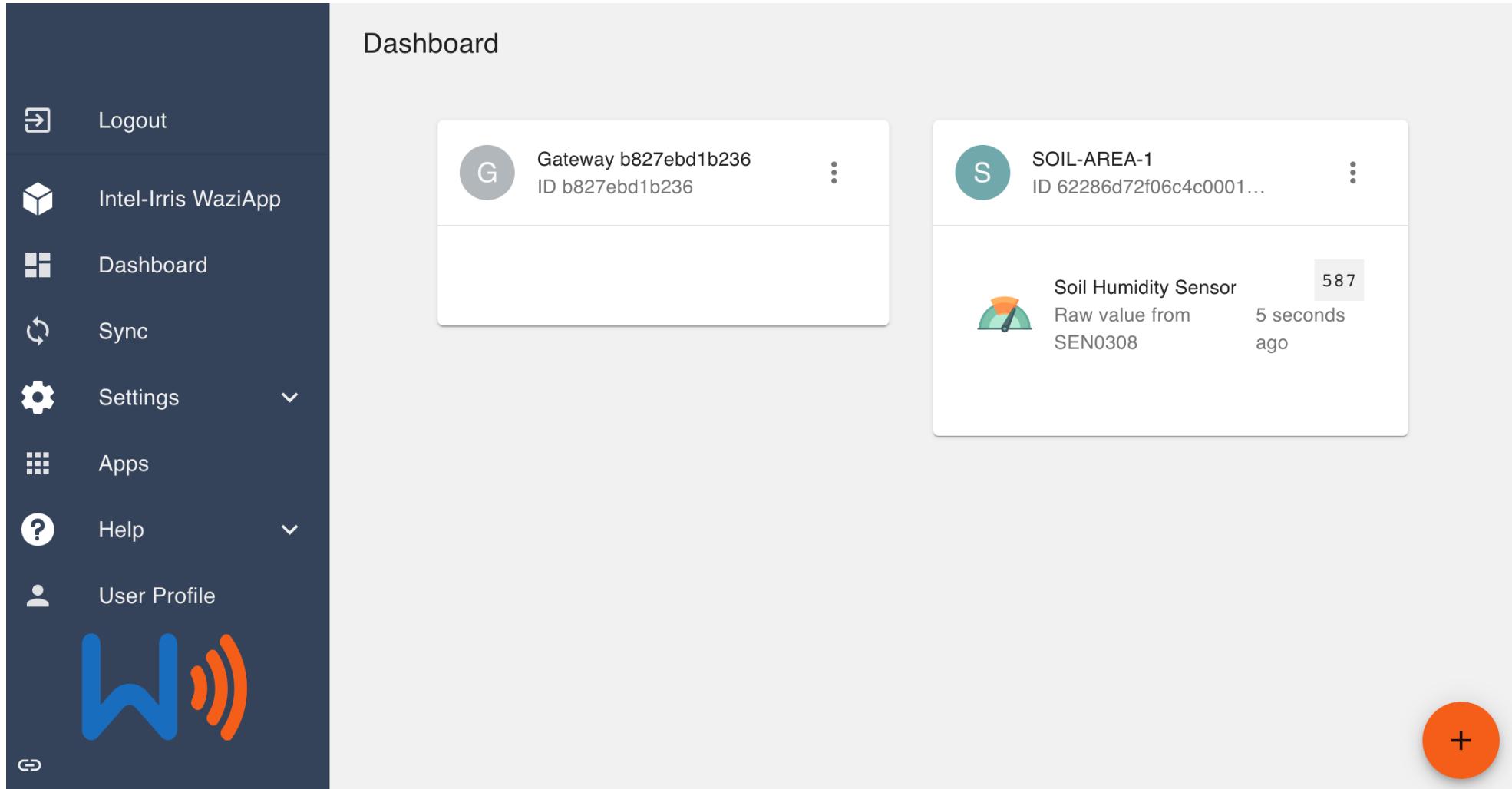
SF12BW125
 868.1MHz | 433.175MHz
 Node id is 26011DAA
 1 msg/60mins
 1 sensor
 XLPP data



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



See it on the dashboard



The screenshot shows the Intel-Irris WaziApp dashboard. On the left is a sidebar with the following menu items:

- Logout
- Intel-Irris WaziApp
- Dashboard
- Sync
- Settings
- Apps
- Help
- User Profile

At the bottom of the sidebar is a blue icon consisting of a stylized 'W' and a red signal-like shape.

The main area is titled "Dashboard". It displays two cards:

- Gateway b827ebd1b236**
ID b827ebd1b236
- SOIL-AREA-1**
ID 62286d72f06c4c0001...

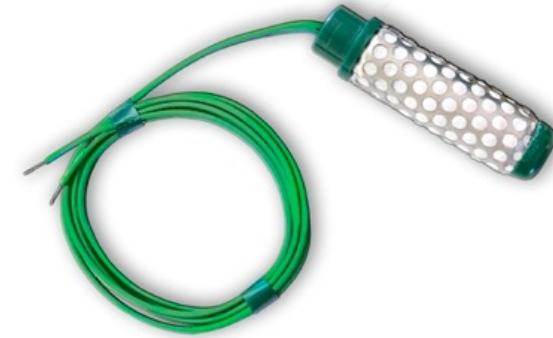
Below the first card is a smaller card for a soil sensor:

- Soil Humidity Sensor**
Raw value from SEN0308
- 587 (value)
- 5 seconds ago

A large orange button with a white plus sign is located in the bottom right corner of the dashboard area.

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 if needed
- The fully assembled version has a 10kOhms resistor

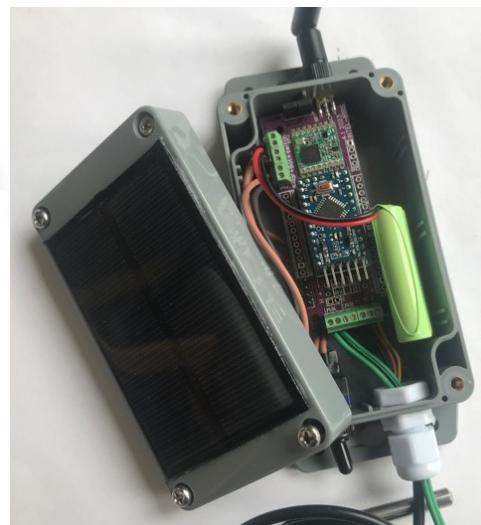


```
//put here the resistor value, in Ohms
#define WM_RESISTOR 10000
//we defined WM_MAX_RESISTOR=32760 because the transmitted value would be 32760/10=3276
//and currently a bug in WaziGate XLPP decoding code will limit the maximum value to 3276
#define WM_MAX_RESISTOR 32760
```

- ```
///////////
// 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



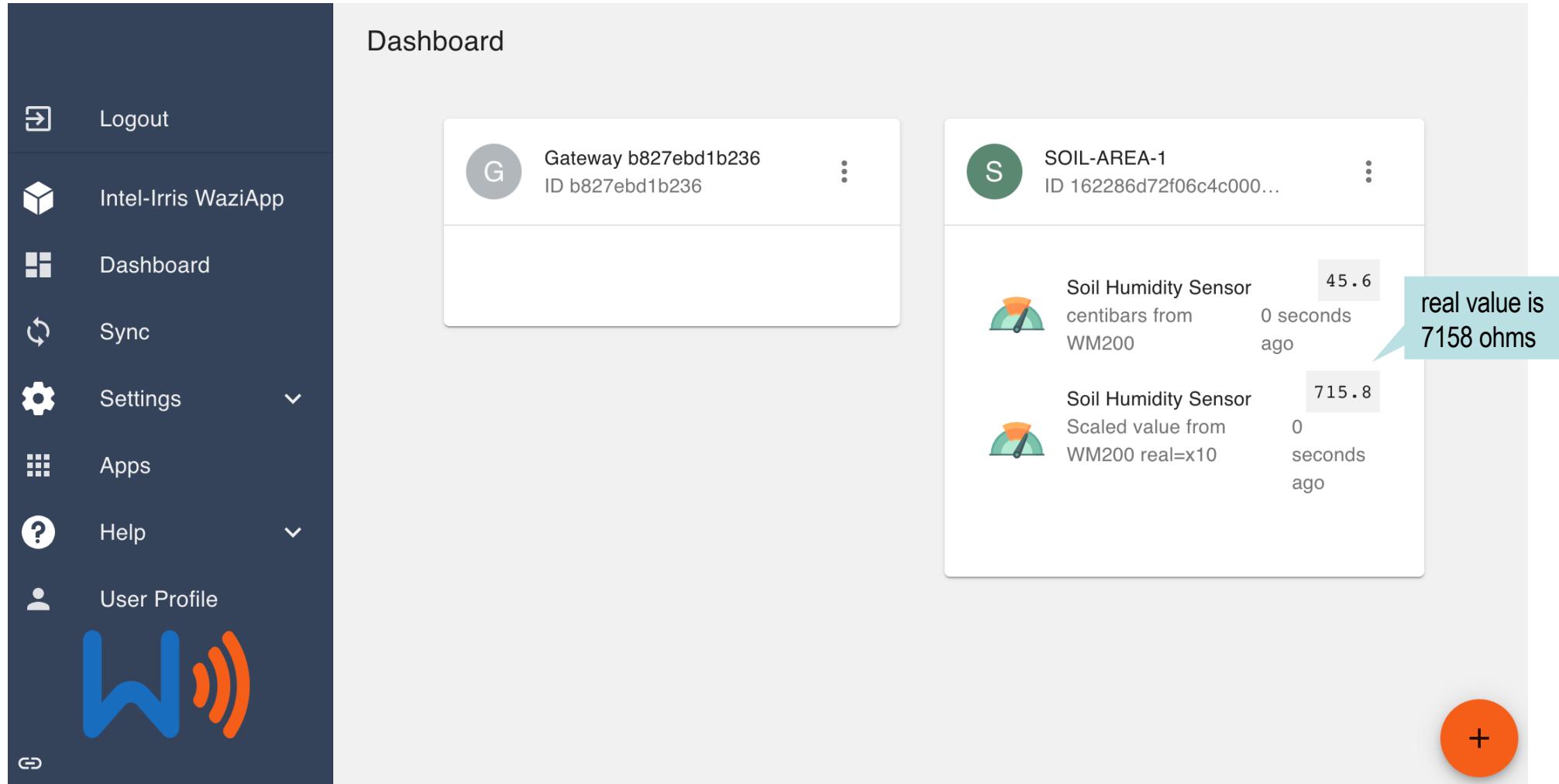
Parameters for  
INTEL-IRRIS gateway

**LoRaWAN™**

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



# See it on the dashboard



The screenshot shows the Intel-Irris WaziApp dashboard. On the left is a sidebar with the following menu items:

- Logout
- Intel-Irris WaziApp
- Dashboard
- Sync
- Settings
- Apps
- Help
- User Profile

At the bottom of the sidebar is a blue icon containing a blue 'W' and orange signal waves.

The main area is titled "Dashboard". It displays two main components:

- Gateway b827ebd1b236** (ID b827ebd1b236) - represented by a grey circle with a 'G' icon.
- SOIL-AREA-1** (ID 162286d72f06c4c000...) - represented by a green circle with a 'S' icon.

Under the "SOIL-AREA-1" component, there are two data entries:

- Soil Humidity Sensor centibars from WM200 - Value: 45.6, Last updated: 0 seconds ago
- Soil Humidity Sensor Scaled value from WM200 real=x10 - Value: 715.8, Last updated: 0 seconds ago

A blue callout bubble points to the second data entry with the text: "real value is 7158 ohms".

In the bottom right corner of the dashboard area is a large orange circle with a white plus sign (+).

# 2 versions of the soil device



# Soil temperature with WM sensor (1)

- Without a real temperature sensor, the INTEL-IRRIS 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)

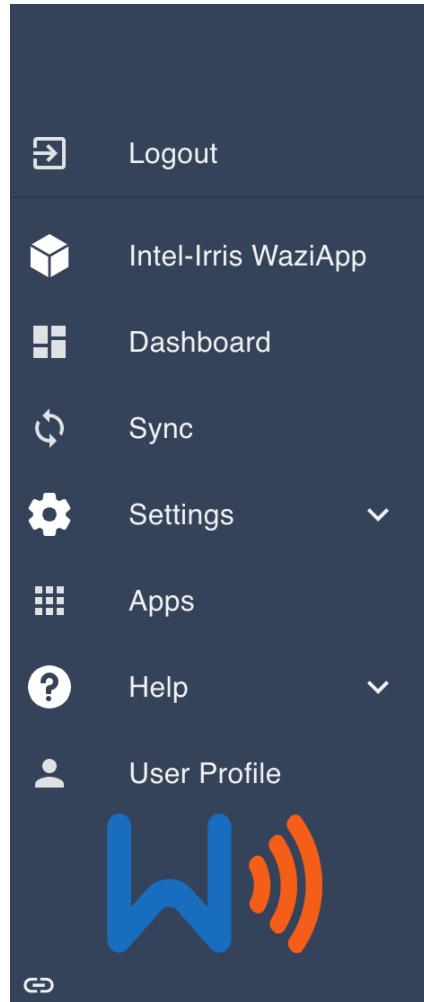
- A DS18B20 temperature sensor can be connected to the device



```
///////////////////////////////
// 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



- [!\[\]\(c249d3b422ec66f624d7a2d12883b582\_img.jpg\) Logout](#)
- [!\[\]\(f5dade2ecb9712648a63e19fbdff3934\_img.jpg\) Intel-Irris WaziApp](#)
- [!\[\]\(a5a8507a2e323b1a048c61c042b93d15\_img.jpg\) Dashboard](#)
- [!\[\]\(c23a3dbac3bb18eb2d52ad90153cc336\_img.jpg\) Sync](#)
- [!\[\]\(8bd36eaff470c0077fe52638dbf9a5fc\_img.jpg\) Settings](#)
- [!\[\]\(0272e6da9c0535d8c25266ff7df7962c\_img.jpg\) Apps](#)
- [!\[\]\(ea54df46d782c6cef332375973e0e60a\_img.jpg\) Help](#)
- [!\[\]\(8d8e163921e6df64acabbc3290fd8aae\_img.jpg\) User Profile](#)



## Dashboard

 **Gateway b827ebd1b236**  
ID b827ebd1b236

 **SOIL-AREA-1**  
ID 162286d72f06c4c000...

 Soil Humidity Sensor  
centibars from WM200      45 . 6  
6 seconds ago

 Soil Humidity Sensor  
Scaled value from WM200 real=x10      714 . 5  
6 seconds ago

 Soil Temperature Sensor  
degree Celsius      26 . 3  
6 seconds ago

Here, real soil temperature is 26.3°C but the device is not linking the centibar conversion with the temperature sensor and uses the default 28°C value. The final centibar conversion could be realized by a dedicated irrigation application run on the WaziGate gateway.



# Low battery voltage indication

- The INTEL-IRRIS code has low battery voltage indication feature, by default, low battery voltage threshold is set to 2.85V

```
#ifdef WITH_WATERMARK
//the ATMega328P reboots at about 2.65 - 2.75
#define VCC_LOW 2.85
#else
//capacitive sensors can be impacted by low voltage, especially for very dry soil conditions
#define VCC_LOW 2.85
#endif
```

- The battery voltage will be transmitted to the gateway as well and will appear on the WaziGate's dashboard to warn end-user
- When low battery voltage is detected, the measure & transmission time interval will increase from 1h to 4h to preserve battery

# See it on the dashboard

**G** Gateway b827ebd1b236  
ID b827ebd1b236

**S** SOIL-AREA-1  
ID 6314f8f4127dbd0001...

**S** SOIL-AREA-2  
ID 63160162127dbd000...

 Soil Humidity Sensor 402.5  
Raw value from SEN0308 8 minutes ago

 Battery voltage 3.48  
volt, low battery when lower than 2.85V 8 minutes ago

 Soil Humidity Sensor 132.9  
centibars from WM200 42 minutes ago

 Soil Humidity Sensor 2045.9  
scaled value from WM200 real=x10 42 minutes ago

 Soil Temperature Sensor 22.3  
degree Celsius 42 minutes ago

 Battery voltage 2.85  
volt, low battery when lower than 2.85V 42 minutes ago

# 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

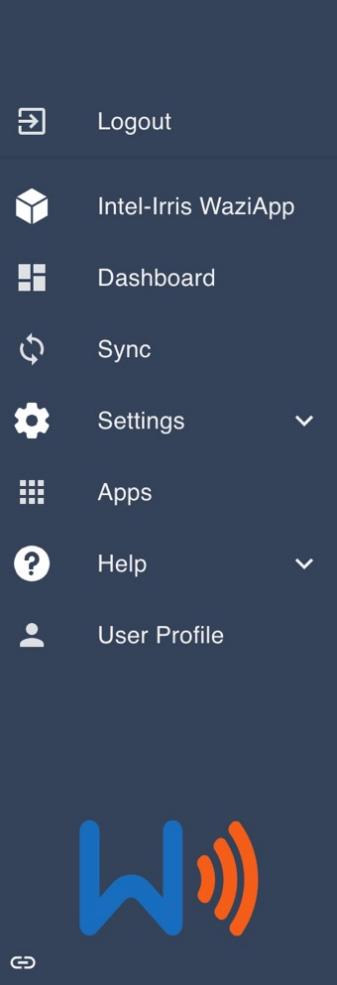
///////////////////////////////
// uncomment to have 2 tensiometer watermark sensor on the same device
#define TWO_WATERMARK
```



- You can still have a soil temperature sensor



# See it on the dashboard



- Logout
- Intel-Irris WaziApp
- Dashboard
- Sync
- Settings
- Apps
- Help
- User Profile

**Dashboard**

G Gateway b827ebd1b236  
ID b827ebd1b236

S SOIL-AREA-1  
ID 162286d72f06c4c000...

Watermark 1  
centibars from WM200

Watermark 1  
Scaled value from WM200 real=x10

Watermark 2  
centibars from WM200

Watermark 2  
Scaled value from WM200 real=x10

Soil Temperature Sensor  
degree Celsius

+

Here, the device has been compiled to link the centibar conversion with the real value measured by the temperature sensor

If the default 28°C value was used, centibar for WM1 with 1374 ohms would have been 13.1 and centibar for WM2 with 685 ohms would have been 2.0