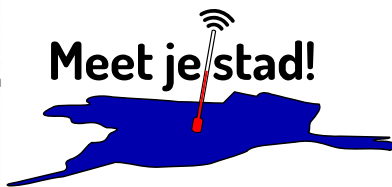
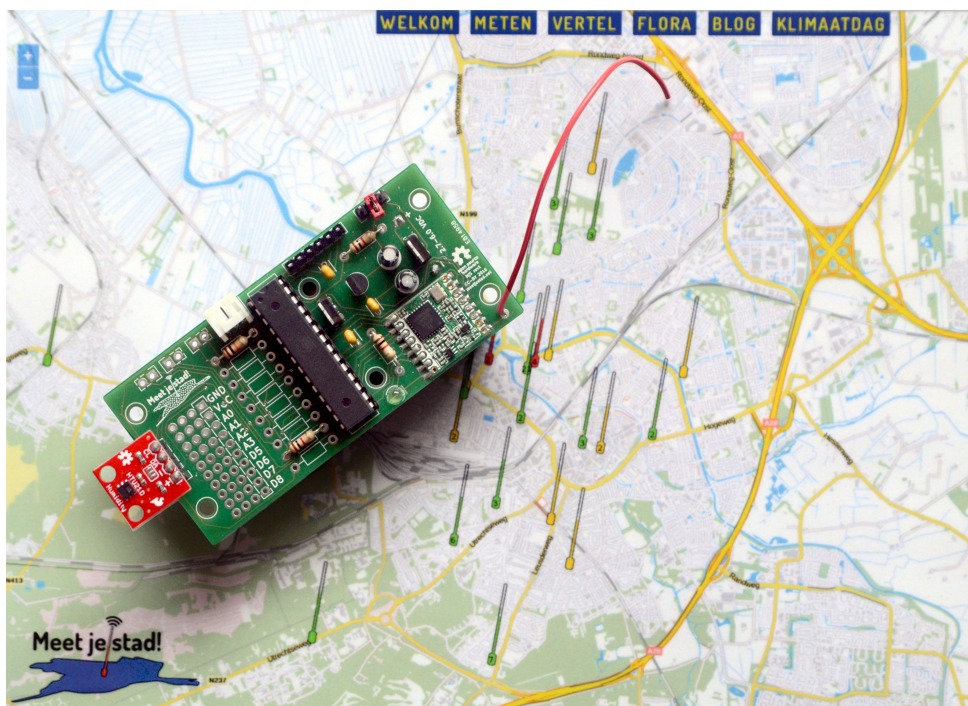


COÖPERATIEVE
UNIVERSITEIT
AMERSFOORT



Building instructions sensor station



for sensor station MjSv2 CC-BY Diana Wildschut, Harmen Zijp, Matthijs Kooijman, Flip de Leeuw – November 2018

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Introduction

This manual was written as a part of the Meet Je Stad! project of the Cooperative University of Amersfoort. In this project, effects of and experiences with climate change are being mapped.

One of the ways in which this is done is by measuring climate-related parameters in several places in the city. This allows the participants to map trends and differences within the city.

A sensor station has been developed that can be assembled by the participants themselves, during a workshop. This manual was meant as a guide to this workshop.

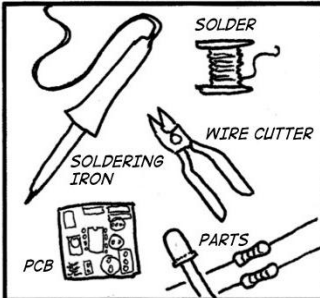
A sensor station is composed of two components:

- A Printed Circuit Board (PCB) with sensors, electronics and a transmitter. This PCB executes and transmits the measurements.
- A casing, to protect the PCB and sensors and to minimize the effects of sunlight.

In this manual both components are discussed.

SOLDERING IS EASY

HERE'S HOW TO DO IT



THE IRON IS HOT!! BE CAREFUL!



YOUR KIT SHOULD COME WITH INSTRUCTIONS FOR WHAT PARTS GO WHERE AND WHAT WAY!

CLEAN THE TIP OF YOUR IRON BEFORE EACH SOLDER CONNECTION!



PUT YOUR PART IN PLACE. BEND OUT THE LEADS SO IT STAYS IN PLACE



PUT THE PCB DOWN SO YOU CAN SOLDER.

CAREFUL WITH THE SURFACE UNDERNEATH!

FIND SOME GOOD WAY TO KEEP IT STEADY



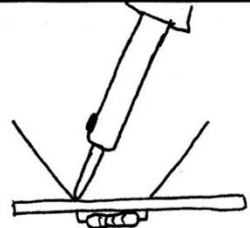
IF YOU NEED A THIRD HAND, YOU CAN MAKE A STANDING COIL OF THE SOLDER INSTEAD OF HOLDING IT IN YOUR HAND

OK, LET'S SOLDER!

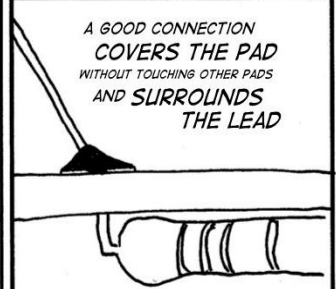
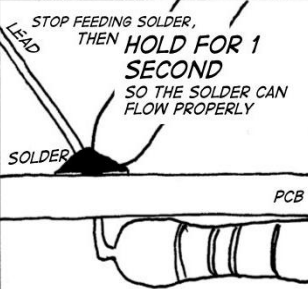
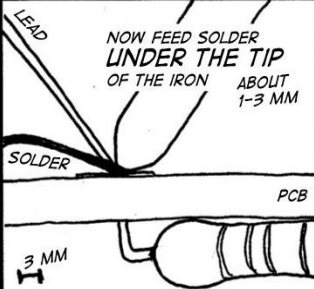
FIRST, YOU WANT TO **HEAT** BOTH THE PAD AND THE LEAD FOR ABOUT **1 SECOND**



PSST! CLEAN THE TIP FIRST!



TOUCH THE SOLDERING IRON TO BOTH THE PAD AND THE LEAD!



KEEP SOLDERING EACH PART IN ITS CORRECT PLACE. REMEMBER SOME PARTS NEED TO GO IN A CERTAIN WAY!

IF ALL YOUR CONNECTIONS ARE GOOD, YOUR CIRCUIT WILL JUST WORK!

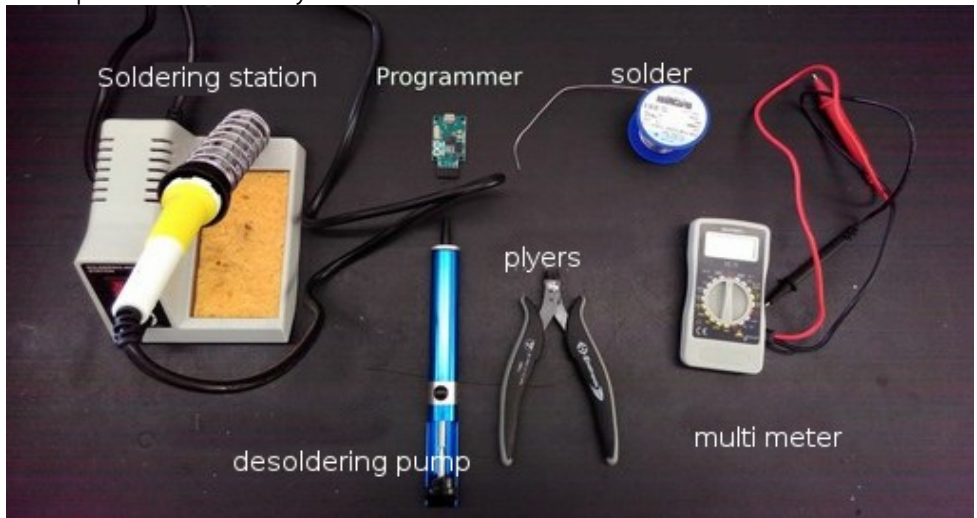
THERE ARE MORE TRICKS YOU WILL LEARN AS YOU KEEP SOLDERING, BUT NOW YOU KNOW ENOUGH TO MAKE MANY COOL THINGS.

SOLDERING COURSE BY MITCH ALTMAN
[HTTP://CORNFIELD ELECTRONICS.COM](http://cornfieldelectronics.com)

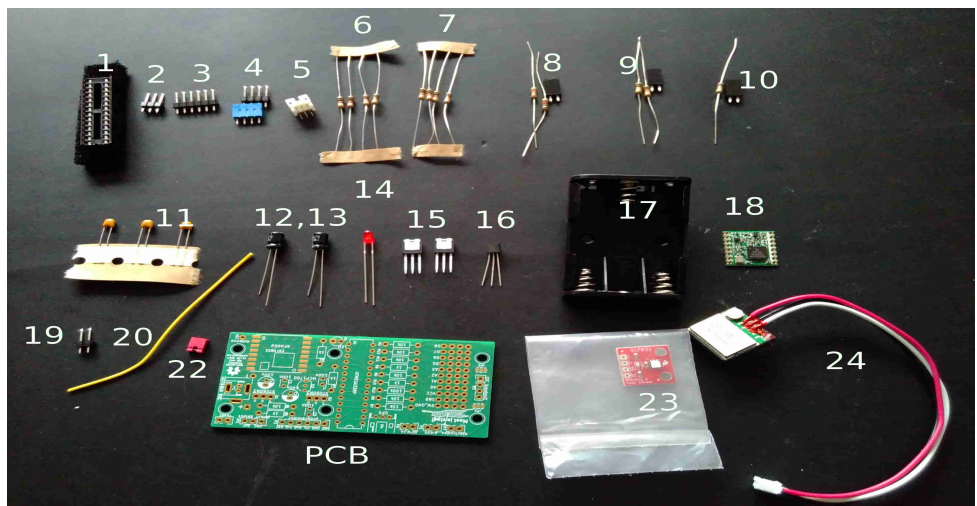
COMIC ADAPTATION BY ANDIE NORDGREN
[HTTP://LOG.ANDIE.SE](http://log.andie.se)

Soldering the sensor station

You will get a box with tools. In this box you will find everything you need. For a start, you will find the soldering station, solder and pliers. The multimeter and the programmer you will need later, the desoldering pump only if you have made a mistake. In the picture underneath you see the contents of the box.



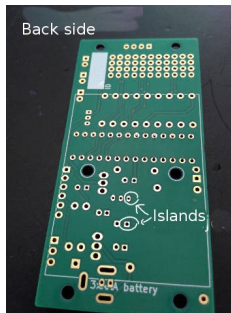
You will also get a bag of components. Below you can find the names of the components. The actual colours can differ from those depicted in the photograph.



You start with the circuit board, also called PCB or Printed Circuit Board. This is the basis that you solder all the components onto. On the PCB you see texts, like C1, R4 etc. These are the unique names for the components that tell you which component goes where. Sometimes there are also values of components or texts that make you work more easily.

Start by switching on your soldering station, it has to warm up. Don't put it too hot, it will fry your components, but too cold and it will not melt the solder. The setting on the photo is about right, 300 degrees centigrade.

Most of the components can be pushed through the holes of the PCB from above. Above is the side that has the texts. You can then solder them to the copper islands at the bottom (see photo). Exceptions are the transceiver, the battery holder and the 4-pin female header, but we will get to those later.



After soldering a component with long legs, you can shorten the legs by cutting off the excess. Hold the part of the leg that you cut off, so it won't fly off into somebody's eye.

Order of assembly

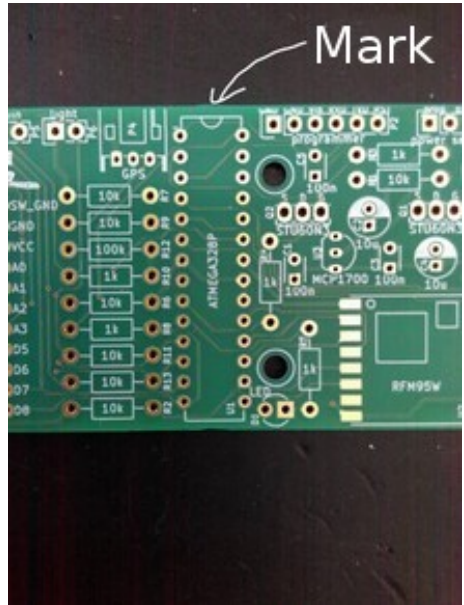
It does not matter in what order you solder the components, but if you stick to the order in this manual, the components will not get in each other's way during soldering. On the next pages the components will be handled one by one, but here is a list of all of them in order of soldering:

- 1) IC holder U1: DIP-28: mind the orientation!
- 2) connector JP1: 3-pin male header
- 3) connector P2: 6-pin male header
- 4) connector P3: 4-pin female header + 4 pins male header
- 5) connector P4: 3-pin JST connector
- 6) resistors R3, R4, R5, R8: 1k
- 7) resistors R1, R2, R6, R7: 10k
- 8) optional for rain meter: R9 (10k), R10 (1k), P5 (2-pin female header)
- 9) optional for light meter: R11 (10k) and R12 (100k), P6 (2-pin female header)
- 10) optional for soil humidity: R13 (10k), P7 (2-pin female header)
- 11) capacitors C1, C3, C5: 100nF
- 12) capacitor C2: 100µF: mind the orientation!
- 13) capacitor C4: 100µF: mind the orientation!
- 14) LED D1: mind the orientation!
- 15) MOSFETs Q1 and Q2: STU60N3LH5: mind the orientation!
- 16) LDO U3: MCP1700: mind the orientation!
- 17) battery holder P1
- 18) transceiver U2: RFM95W: mind the orientation!
- 19) connector for reset: 2-pin male header
- 20) antenna AE1
- 21) Atmega328p microcontroller
- 22) jumper for power
- 23) sensor relative humidity and temperature
- 24) GPS module

Start with the **IC holder**(IC1). It has a mark on one side. With this mark you can see how the IC should be oriented later.

On the PCB there is also a mark, as well as on the IC. Mount the IC holder so that the mark is aligned with the mark on the PCB.

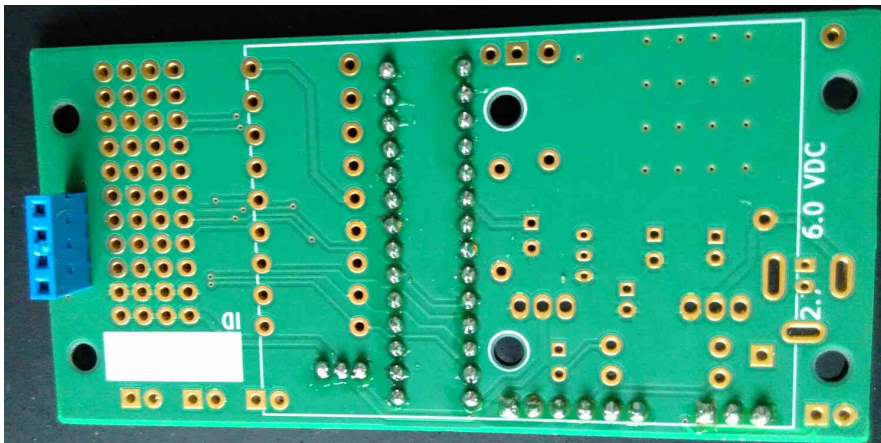
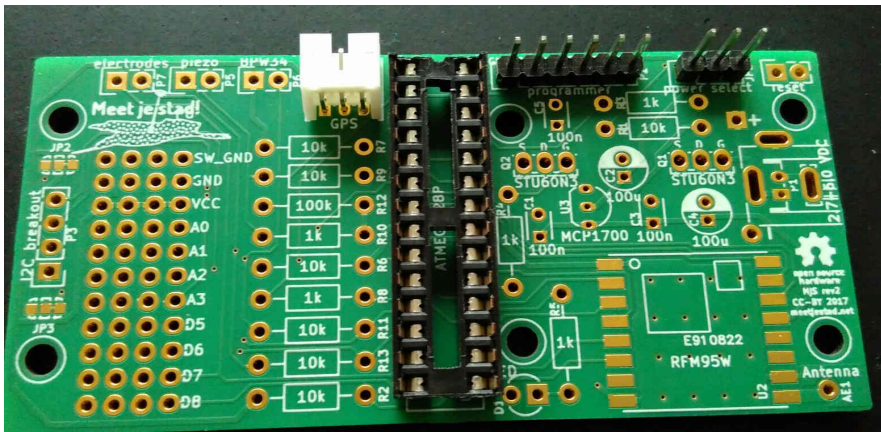
Turn the PCB and solder the pins at the back.



The male pinheaders (JP1, P2) have a side with long legs and a side with short legs. Stick them through the print with their short legs, and solder them at the back. Make sure they are at least a bit straight. Leave the 4-pin male header for later.

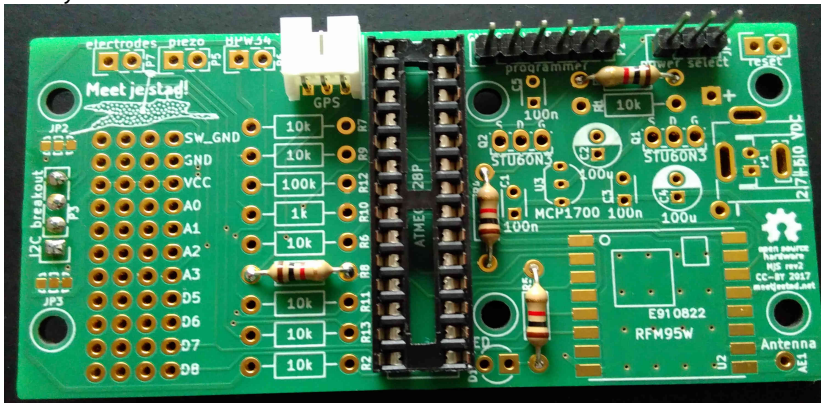
The 4-pin female pinheader (P3) is the next component. Mind you: this has to be placed at the back of the PCB and soldered at the front!

The JST connector (P4) is a bit difficult to push through the holes. It is no big deal if it is not all the way through. Look at the photo for its orientation.



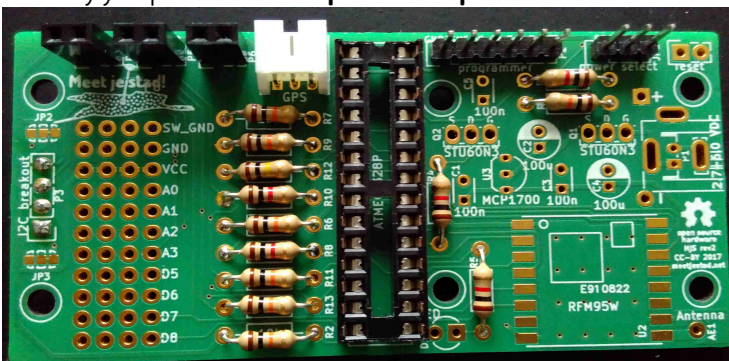
The 1 k Ω (kilo-ohm) resistors (R3, R4, R5, R8) are next. We use resistors with several values. You can tell the value of a resistor by its colour code. The code for 1k Ω is brown-black-red. The golden band can be ignored in this case, it only tells you the accuracy of the component.

Stick the resistors as far as possible through the PCB from above, the left-right orientation is not important. Bend the legs a bit at the back, so the resistor stays in place while you solder it to the islands.

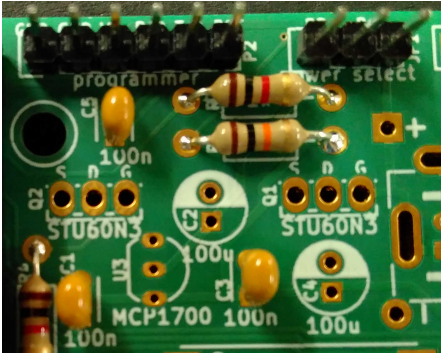


The 10k Ω resistors (R1, R2, R6 and R7) are next. The colour code for 10k Ω is brown-black-orange.

Then you solder the components for the rain meter: **R9 (10k Ω)**, **R10 (1k Ω)** and on P5 a **2-pin female pinheader** and for the light meter: **R11 (10k Ω)** and **R12 (100k Ω)**, with colour code brown-black-yellow and on P6 also a **2-pin female pinheader**. For soil humidity you place the last **2-pin female pinheader** on P7 and a **10k Ω resistor** on **R13**.



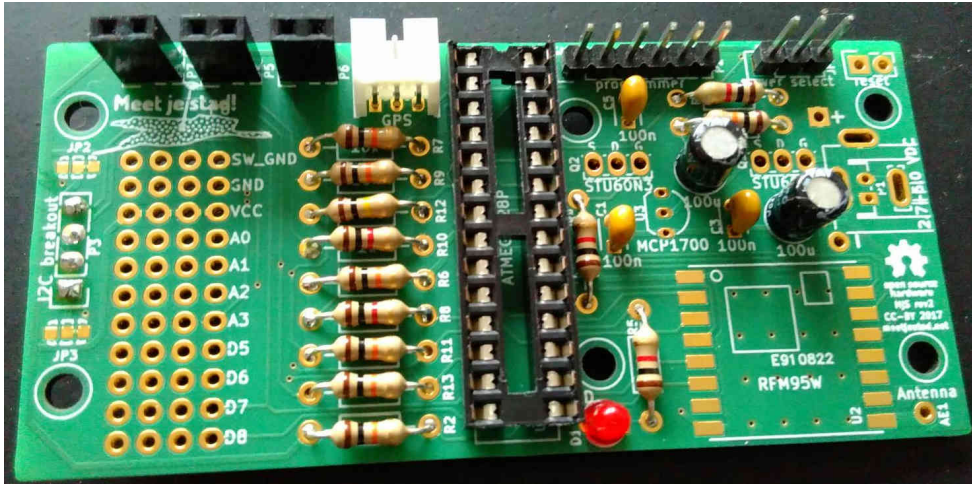
Now you turn to the **100 nanofarad capacitors** (C1, C3 and C5). These are the small coloured balls, on the photo they are orange but they can be a different colour in your kit. The text on the capacitor usually says "104", which means 10×10^4 pF (that is 100.000 pico-farad, so 100 nanofarad). Here the left-right orientation does not matter.



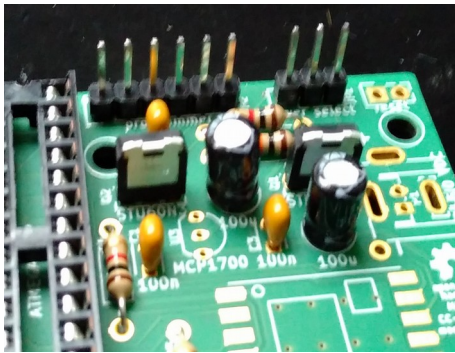
For the **electrolytic capacitors** (C2, C4) it does matter! Usually when the orientation of a component matters there is a mark. In simple components the mark is at the side of the -. In this case there is a white stripe with little minusses printed in it on the - side. On the PCB there is a mark as well: when the island has a square shape, it is the + side. So now you have two ways to see what the orientation should be.



With the **LED** (Light Emitting Diode, that's a kind of lamp) on D1 the orientation also matters. The plus side (anode) of an LED has a slightly longer leg. The minus-side (cathode) of an LED has a slightly flat edge. The plus-side goes into the square hole.



With the **MOSFETs** (transistors) on Q1 and Q2 the orientation again matters. Make sure the metal side of the MOSFET is oriented towards you, like in the photo.

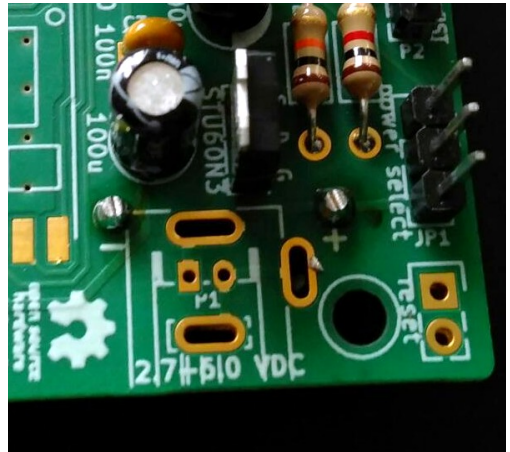
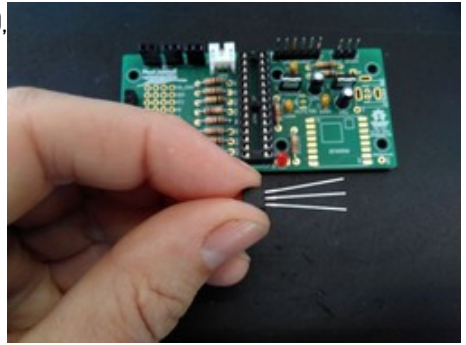


For the **voltage regulator** (U3, also called LDO, low-dropout or linear regulator) you have to bend the legs out a bit before you can place it. That also means it cannot be mounted very closely to the PCB.

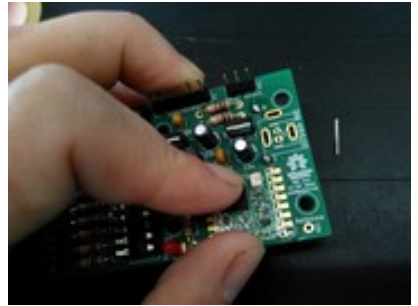
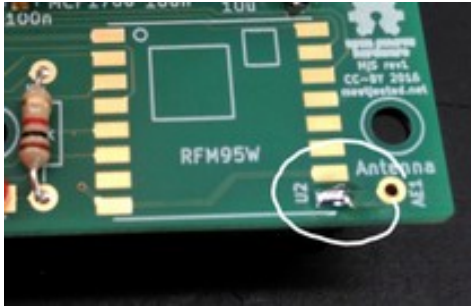
Again you have to mind the orientation, the regulator has a round and a flat side that is also drawn on the PCB.

This is a good moment to have your soldering checked. When the battery holder is placed, you can no longer check your connections.

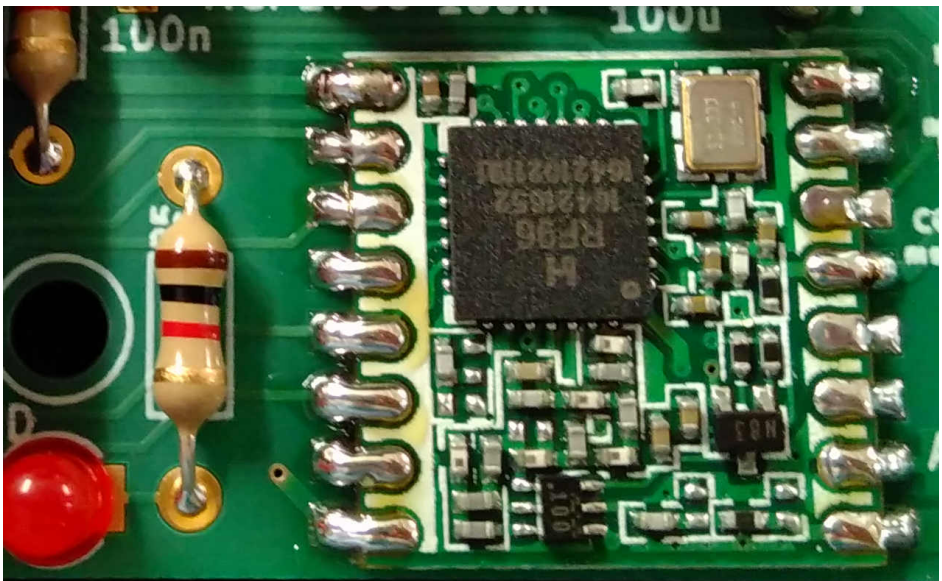
The **battery holder** is placed at the bottom of the BCB. At the front you see a + and a -, the legs of the battery holder go through those holes.



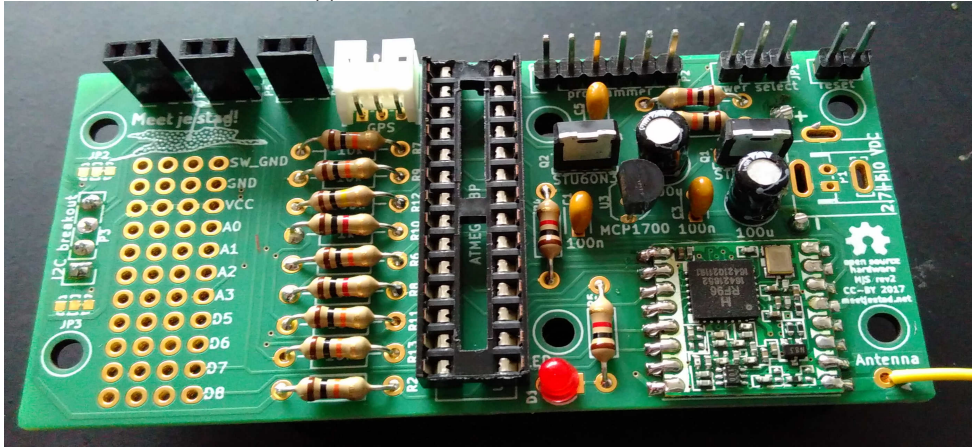
Now that you have learned to solder, you can handle the more vulnerable components. The **transceiver** contains many small components that cannot handle heat very well. Don't solder those too long!



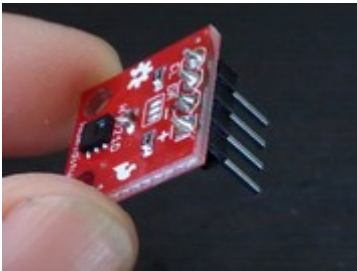
The transceiver does not have legs. You just lay it carefully on the PCB. There is a trick that helps you mount the transceiver neatly. First put some solder on one of the islands in the corner. Then put the transceiver on top of the soldered island and heat the solder again. The transceiver will snap into place. When the connections on the transceiver are properly aligned with the soldering pads on the PCB, solder the rest of the islands. Make sure there is no connection between neighbouring islands.



The last parts that are soldered to the PCB are the **antenna** and the 2-pin pinheader at the reset spot in the upper right corner. The antenna is simply a wire. The length of the wire depends on the frequency of the radio signal. For our transmitter we use a wire of 82mm, of which 3mm is stripped to be soldered.



Now we get to the sensors. In the transparent bag is the temperature- and humidity sensor. You have to solder the 4-pin pinheader to that. It has to be soldered from the bottom of the sensor.

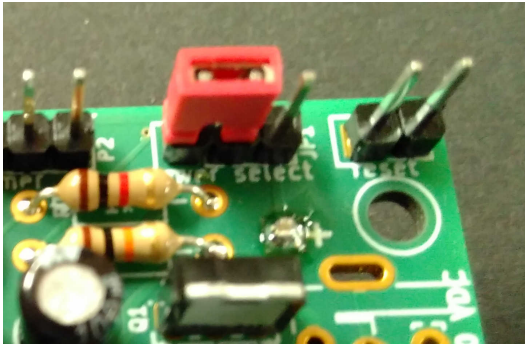


Now you can connect all the sensors to the PCB. The GPS-module you plug into the white JST-connector. The temperature- and humidity sensor is plugged into the 4-pin female pinheader (look at the photo for the orientation!).

The IC can be plugged into the IC holder. Make sure that the mark is in the right place. Sometimes you have to bend the pins of the IC inwards a bit. You can do that best by laying the IC on its side and bending it towards the table. When you put the IC in its holder, make sure all the legs go neatly in their sockets.

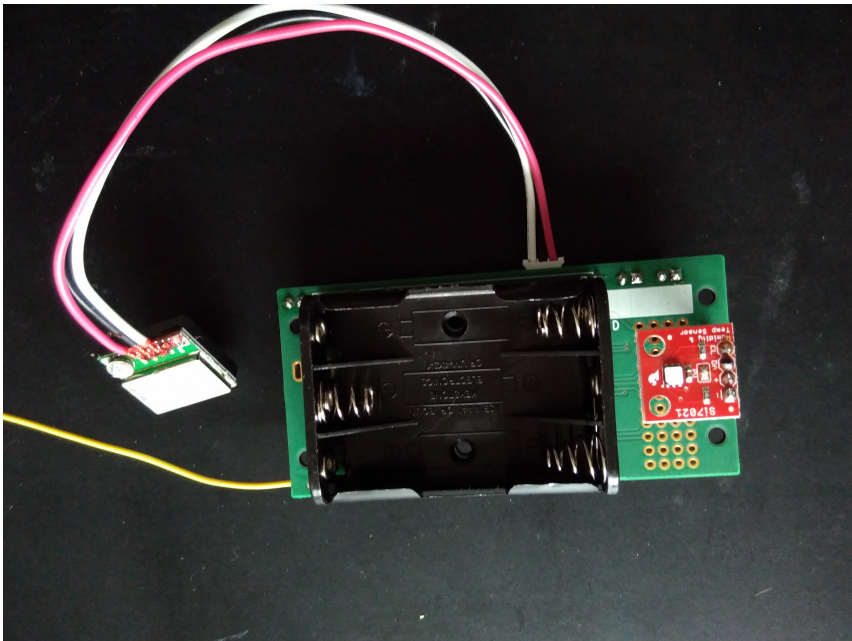
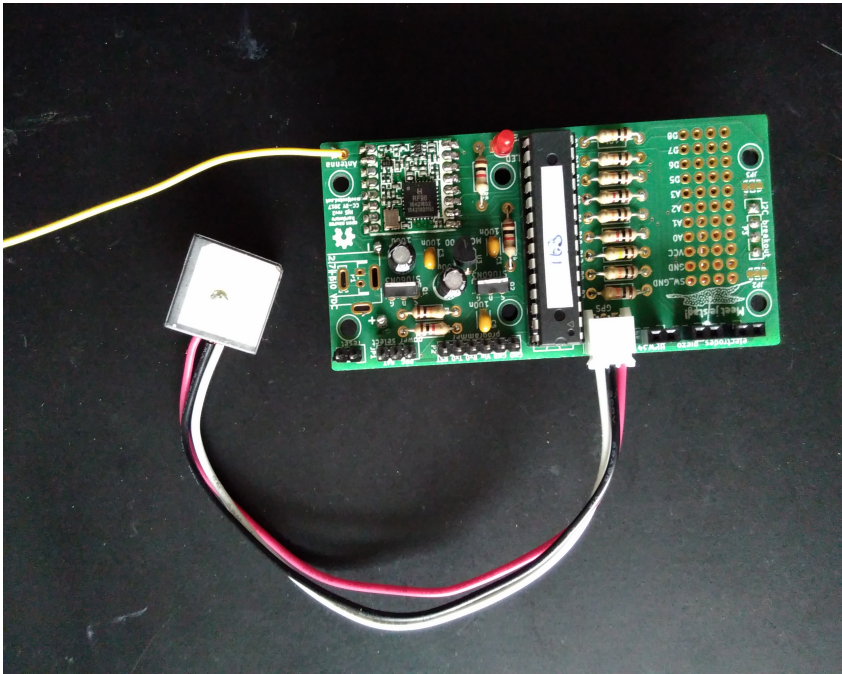
Before the batteries go in, you have to check the connections again.

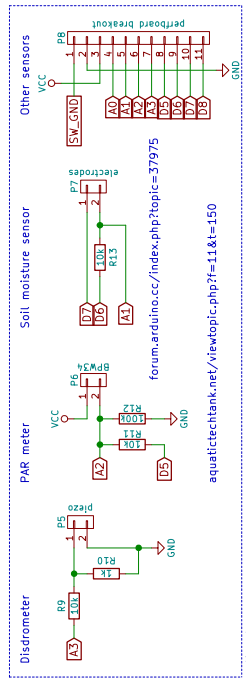
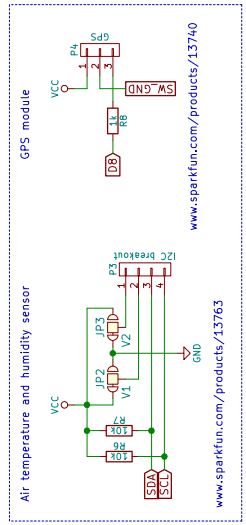
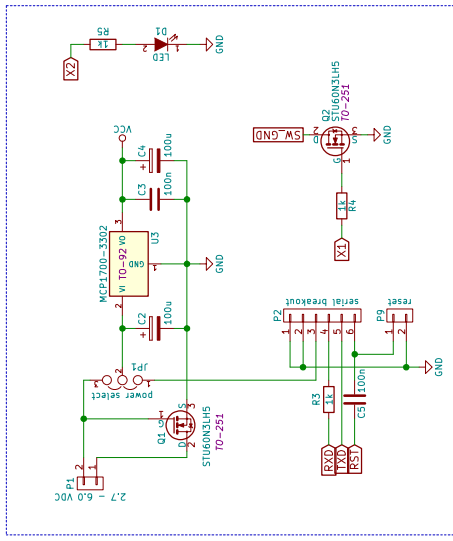
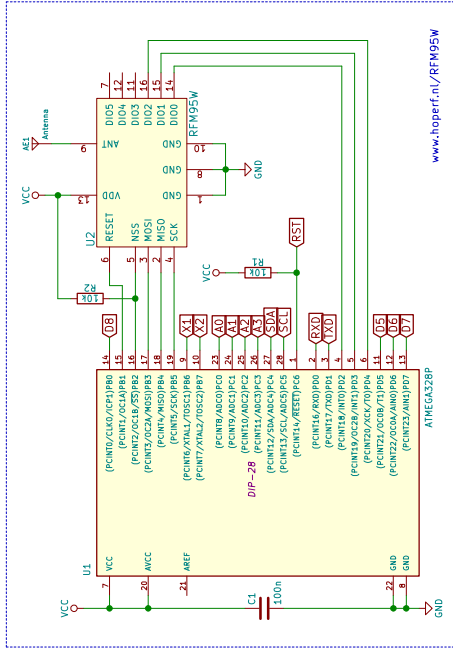
The position of the jumper decides whether the circuit is on or off, and what power source it uses. A jumper is just a wire that connects two legs of a pinheader: you slide it over two pins and those pins are connected.



To switch on the sensor station you have to connect the middle pin of JPI to either the right side for battery power (BATT) or the left side for usb power (PROG). When the jumper is not connected, the sensor station is switched off. The best place to park it when it is switched off is in the RESET location.

If you want to know how the circuit works, you can read the next pages. If you want to leave that for later, you can continue to the chapter called “Programming the microcontroller”.





Arduino UNO and LoRAWAN compatible Powered by 3xAAA, 1xLiPo or 5V DC CC-BY Harmen G. Zijl Universiteit Amsterdam	
Project: File: iisnpcb.sch	0
Title: Meetplatform Meet je stad!	
Schematics: KiCad: E.D.A. ticed_4.0.5+dsj1-4ppo8-1	Row: 2 of: 1/1
5	0

Building the housing



The housing of the sensor has to meet a number of requirements. It has to be easy to build, from materials that are cheap and readily available. This way everybody can build the housing. Other requirements are for the functionality of the station. The housing has to protect the electronics from the weather, but has to allow for a good airflow passing the sensors. Also, the housing should not warm up too much in the sun, so the real air temperature can be measured.

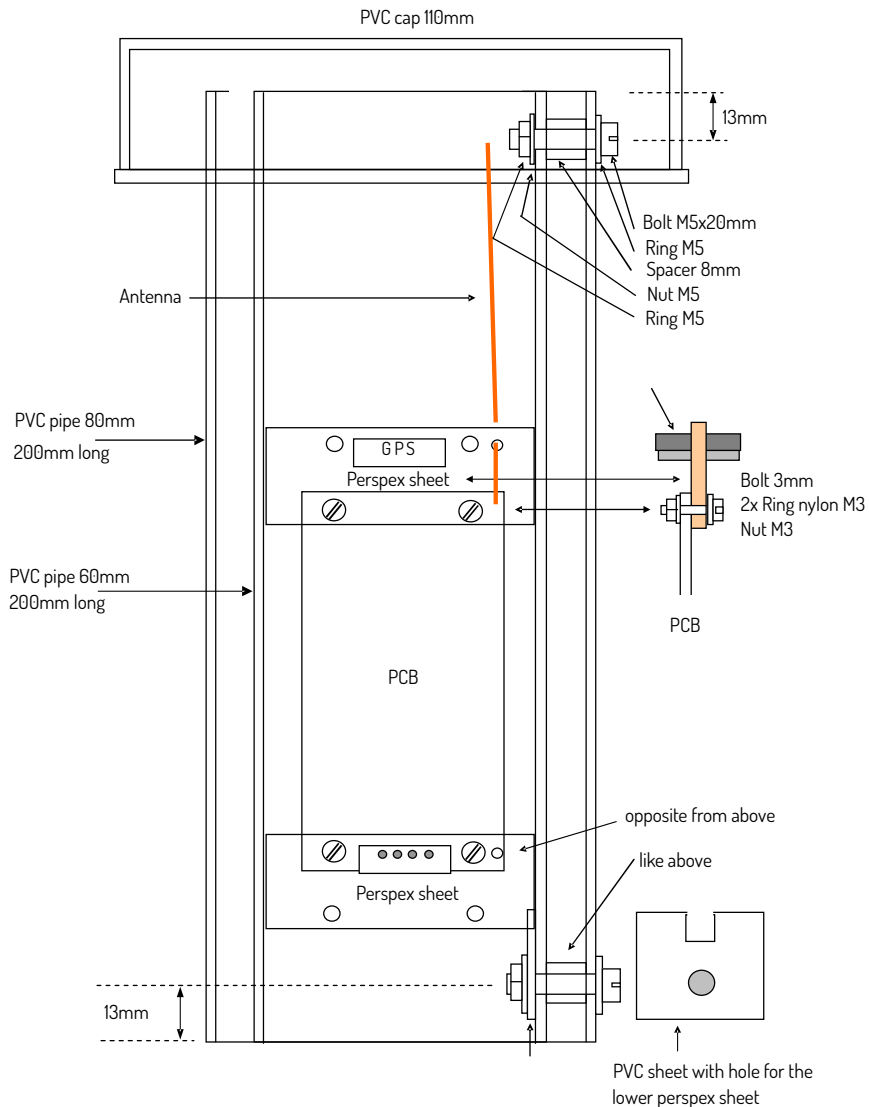
The housing exists of two pvc drainage pipes. The space between the pipes insulates the electronics, to even out the effect of passing clouds. On top of the pipes a cap is mounted a few centimeters above the top of the pipes. This way, air can circulate through the housing. The whole thing is painted white so we avoid warming up through direct sunlight.

Parts list housing

- 1x Cap 110 mm
- 1x Pipe 80 mm x 200 mm
- 1x Pipe 60 mm x 200 mm
- 2x Plastic spacer 8 mm long
- 2x Bolt M5 x 20 mm
- 4x Ring M5
- 2x Nut M5
- 2x Perspex sheet
- 4x Bolt M3 x 10 mm
- 8x Ring nylon M3
- 4x Nut M3
- 1x PVC sheet
- 3x Rubber blind rivet nut M4
- 3x Pointed bolt M4 x 20 mm

Building instruction

Combine the two PVC pipes to create one double walled pipe using the M5 bolts, nuts and spacers. The side with the 3 holes in the outer pipe is the top. Mount the PVC sheet under the lower nut in the inside of the inner pipe, and with the cut out part at the top.



Mount the two perspex sheets to the PCB using the M3 bolts, nuts and rings. On the side of the antenna the sheet is attached on top of the antenna, which becomes locked up between the sheet and the PCB. On the sensor side the perspex sheet is mounted on the battery side of the PCB, with the square hole around the female pinheader to give it some protection.

The GPS module can now be mounted in the square hole at the top of the upper sheet. The antenna of the GPS should be mounted with the all metal-side up, to have the best view on passing GPS satellites.

Now the cap can be mounted. To do this you have to first stick the three rubber blind rivet nuts into the holes in the cap, from the outside. Then you can, also from the outside inwards, screw in the three pointed M4 bolts, while holding the rubber nuts on the inside. This way, the rubber nuts will become thicker inside the cap, and they will no longer be able to get out. Screw in the bolts very tightly.

The cap can now be placed on the pipe by letting the points of the bolts fall into the tiny holes in the pipe, one by one. The pipe can be squeezed a bit to give the last bolt access to the hole.

You can now write the number of your sensor station, located on the little sticker on the microcontroller, on the housing.

Curious passers-by can now look up the data of your sensor, using the QR-code and the sensor number.

That's it for now!

