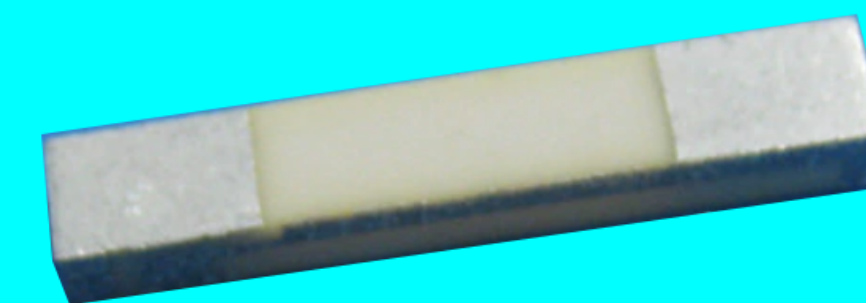
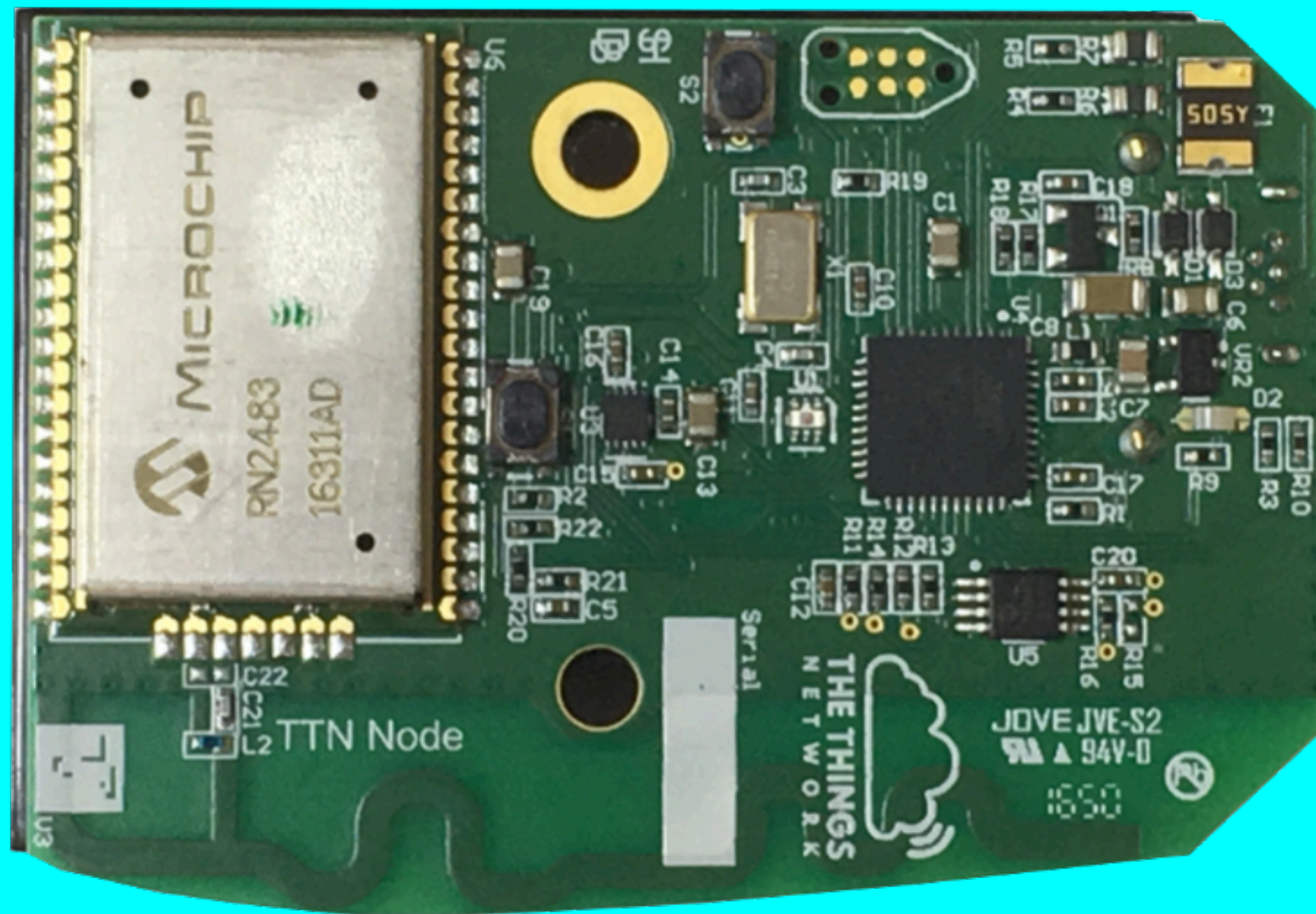


LORA / LORAWAN TUTORIAL 47

PCB Antennas & Ceramic Antennas



INTRO

- In this tutorial I will explain the pros and cons of using PCB antennas and ceramic antennas.

ANTENNA

- In an RF system the antenna is a key component and can have a major impact on the device performance.
- Selecting which antenna to use depends on: size of the device, costs and performance.
- In *general* PCB antennas (aka trace antennas) and ceramic antennas (aka chip antennas) have an average antenna performance compared to an external antenna.

EXTERNAL ANTENNA

- An external antenna is mounted outside the device or it can be mounted on a remote location.



- PCB or ceramic antennas are internal antennas and are built inside the device.

EXTERNAL ANTENNA

- Pros:

- Good antenna performance compared to PCB or ceramic antennas.

- Cons:

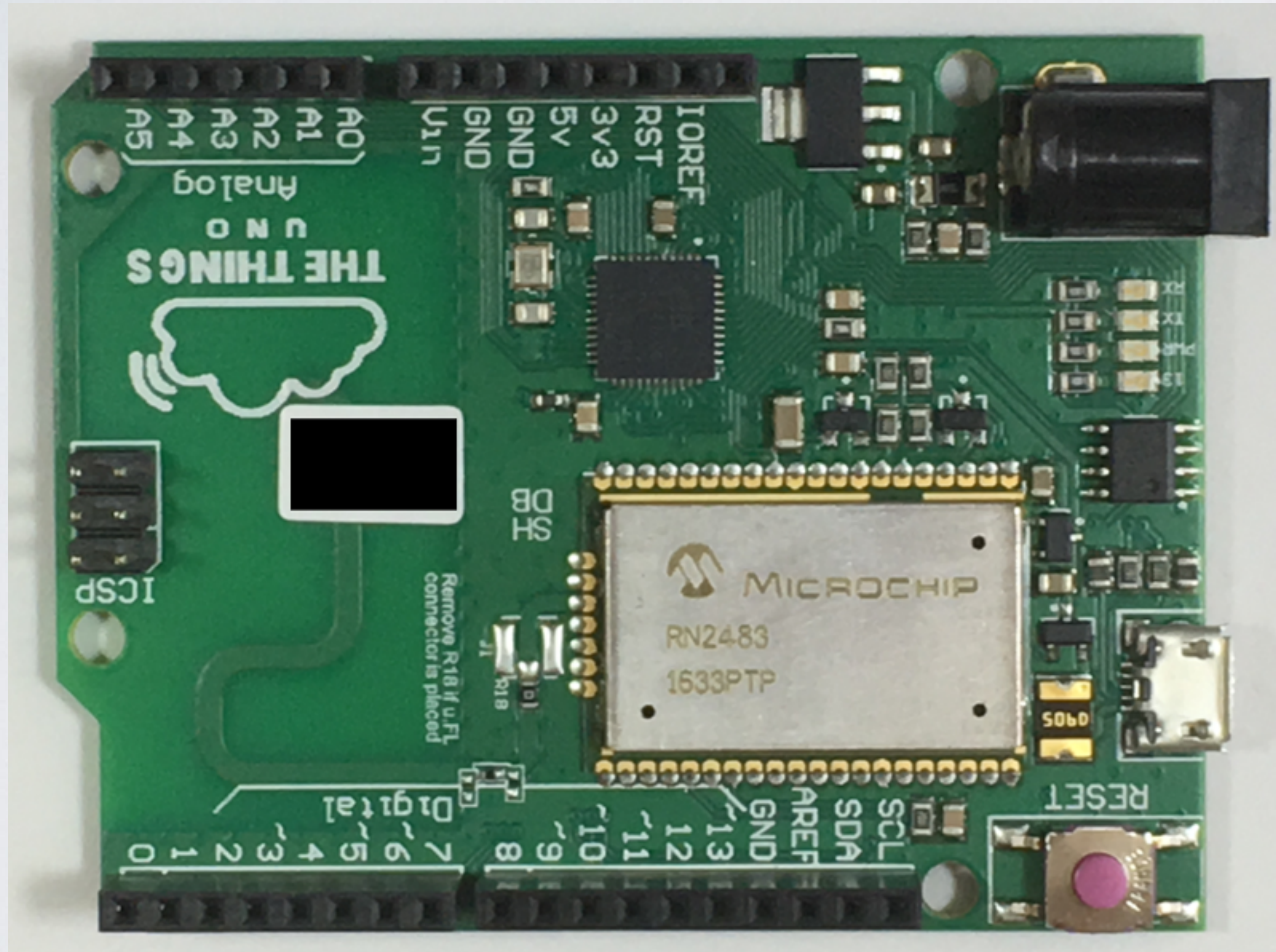
- Larger size.
- More expensive compared to PCB or ceramic antennas.

PCB ANTENNA

- A PCB antenna is a trace antenna printed on a circuit board.
- A PCB antenna is feeded by a micro strip line from the radio module.

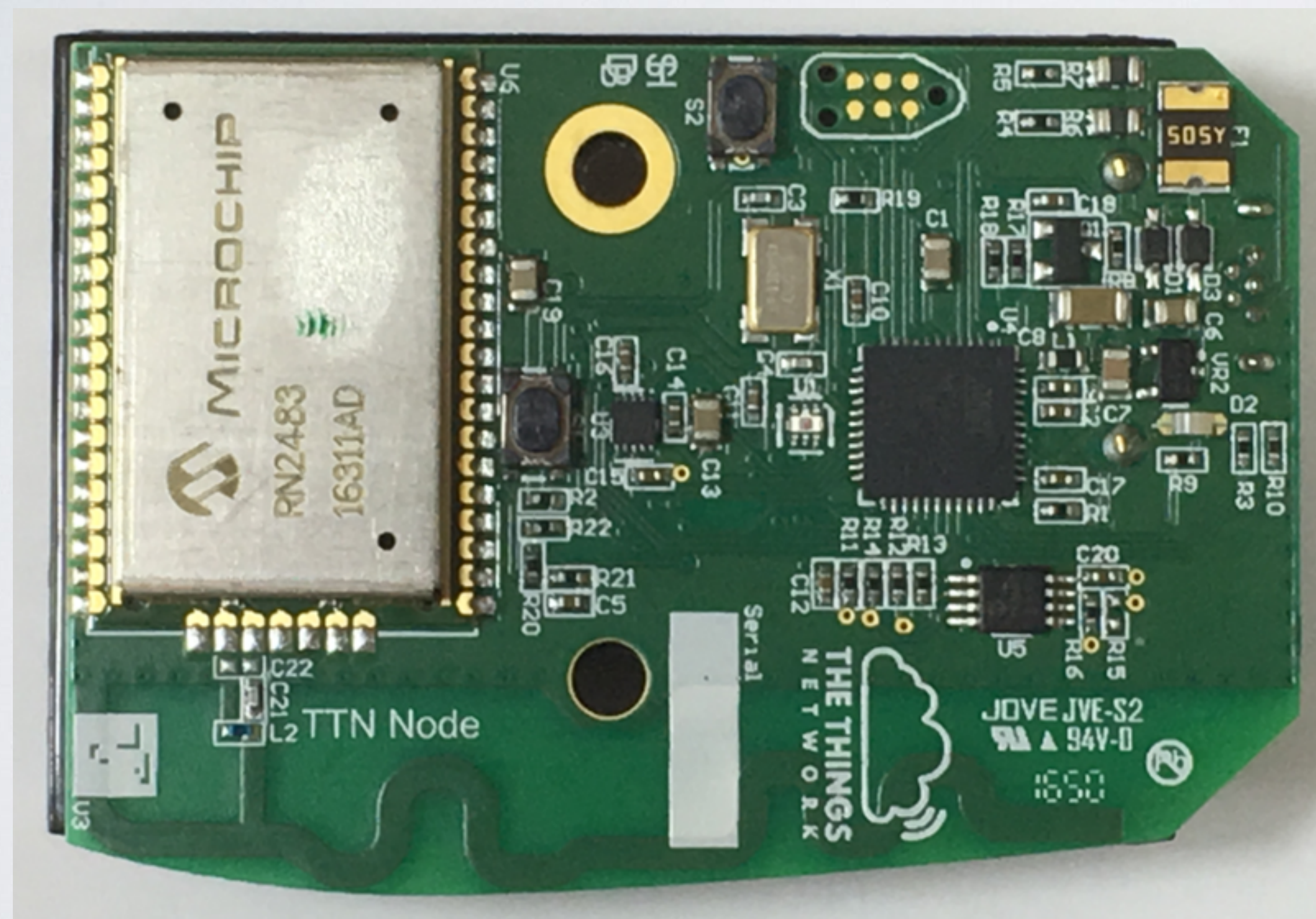
PCB ANTENNA

- PCB antenna example 1 (The Things Uno):



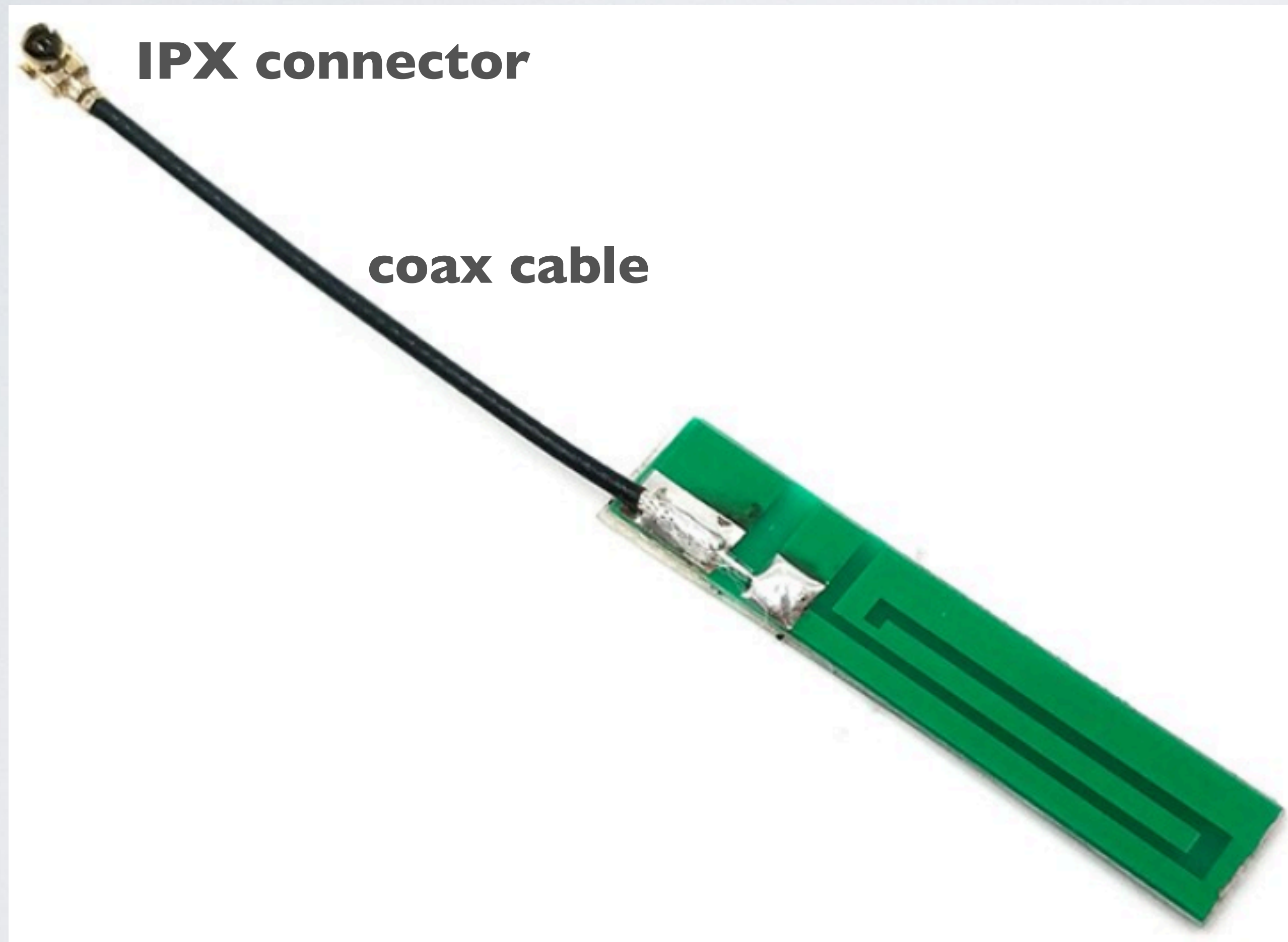
PCB ANTENNA

- PCB antenna example 2 (The Things Node):



PCB ANTENNA

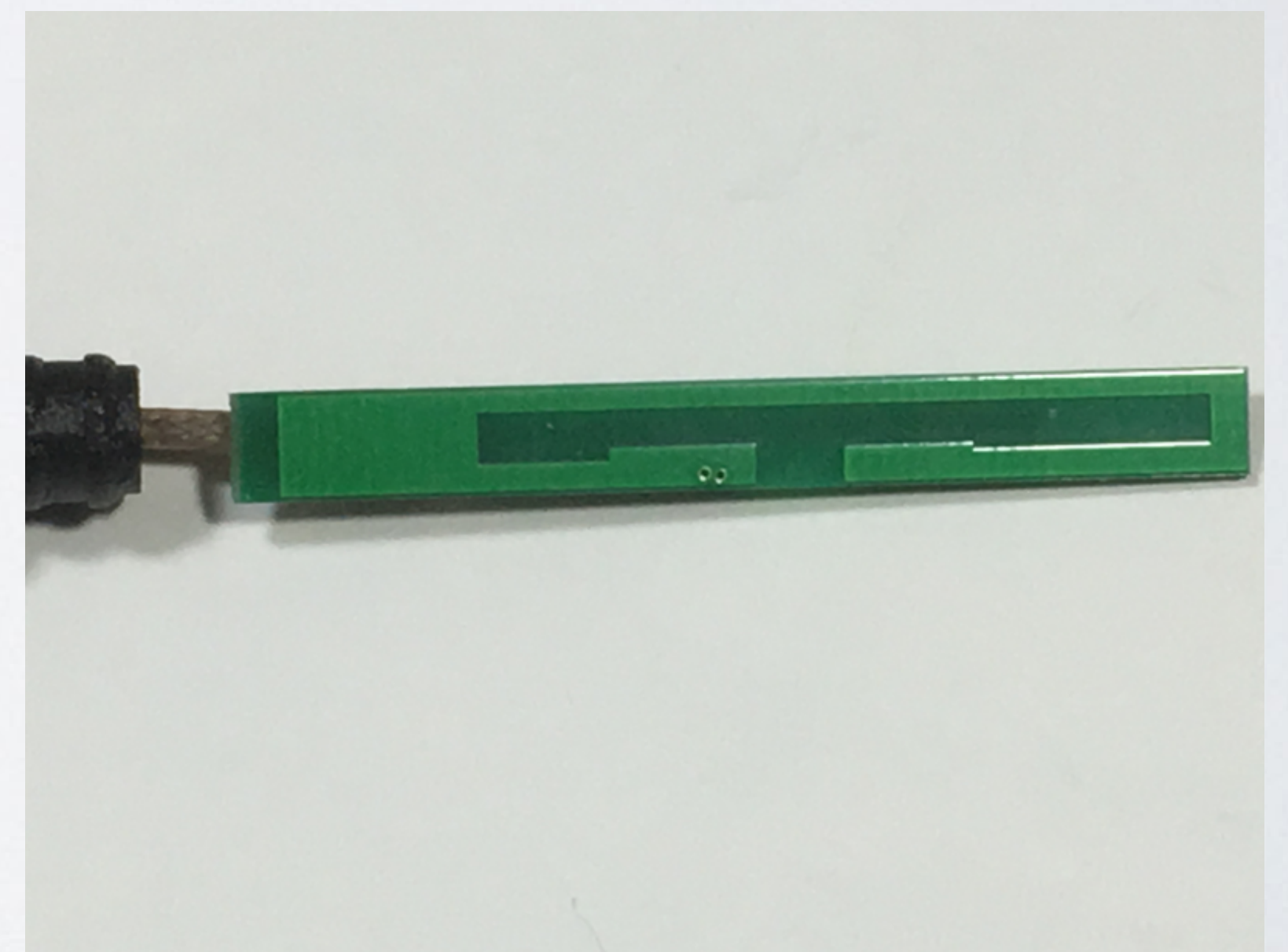
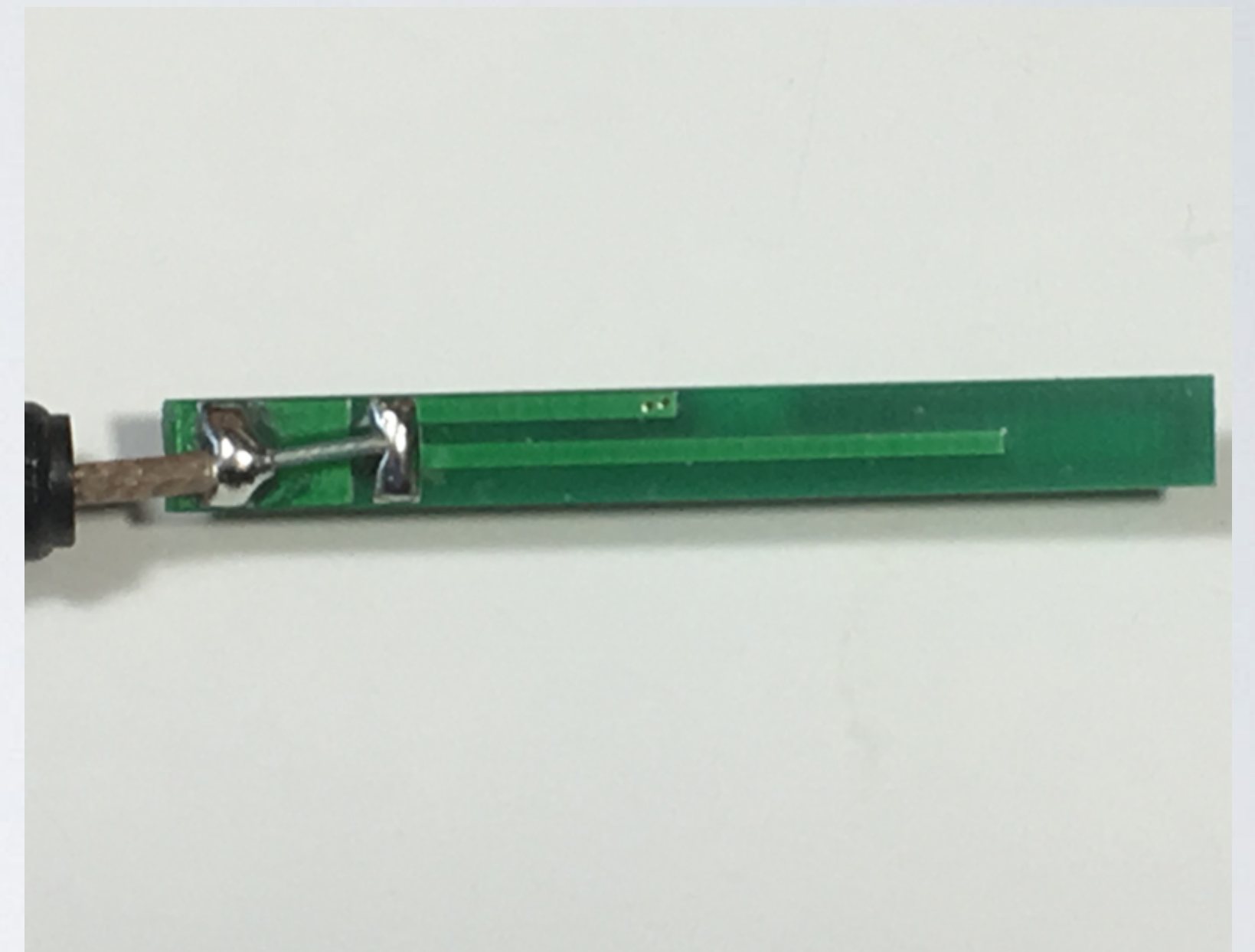
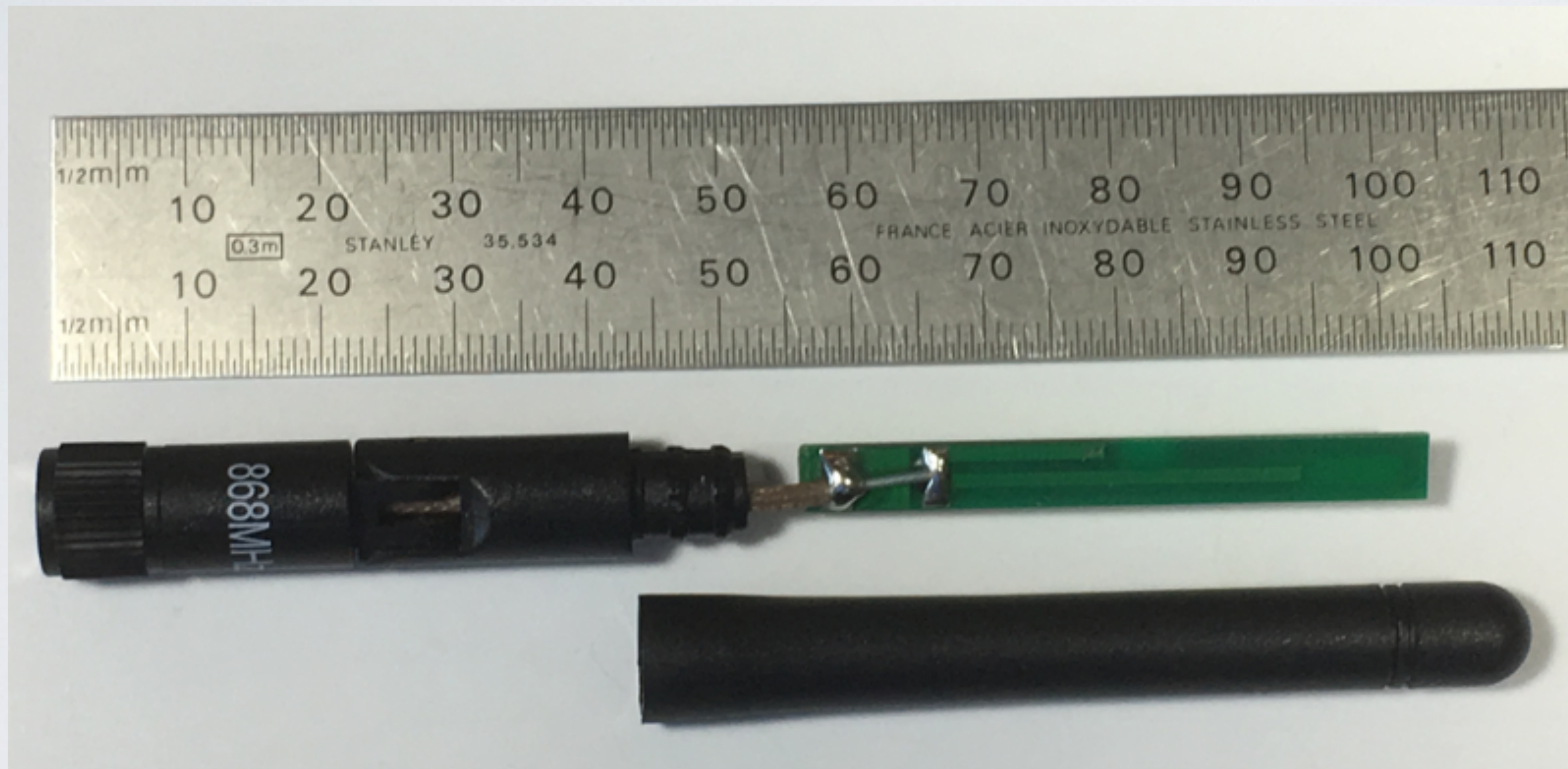
- PCB antenna example 3:



This PCB antenna is used inside a device.

PCB ANTENNA

- PCB antenna example 4:



This external antenna is a PCB antenna.

PCB ANTENNA

- Pros
 - Smaller size.
 - Cheaper to manufacture.
 - Costs less than an external antenna and ceramic antenna.

PCB ANTENNA

- Cons

- Average antenna performance compared to an external antenna.
- Components in close proximity of the antenna severely detune the antenna. An area around the antenna must be kept clear of components.
- A PCB antenna is highly susceptible to environmental interferences, for example when it is in close proximity of humans or animals.
- A PCB antenna can only be tuned by redesigning and manufacturing the PCB board again.
- Designing a PCB antenna requires a simulation tool.

CREATE YOUR OWN PCB ANTENNA

- To create a PCB antenna, check out this PCB UCA antenna layout created by Fabien Ferrero:
https://github.com/FabienFerrero/UCA_Board
- Check out his presentation at the Things Conference in Amsterdam in 2018 where he discusses the UCA antenna layout:
<https://youtu.be/AhFy4-kForA>

CERAMIC ANTENNA

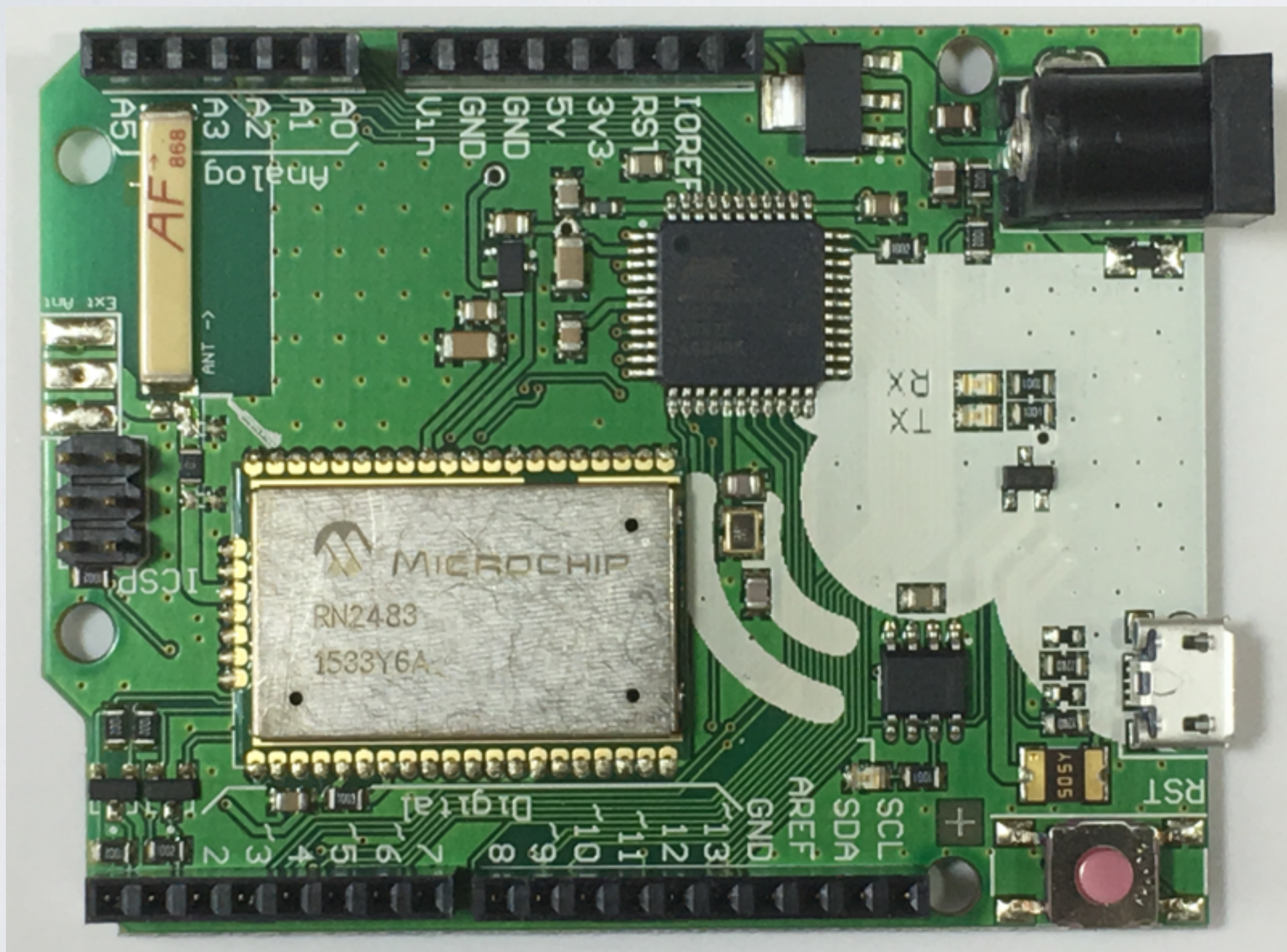
- A ceramic antenna (aka chip antenna) is a small module made of a ceramic material.
- There are several ceramic antenna types for example monopoles and inverted F antennas (IFA).



Ceramic antenna

CERAMIC ANTENNA

- Ceramic antenna example (The Things Uno Beta version)



CERAMIC ANTENNA

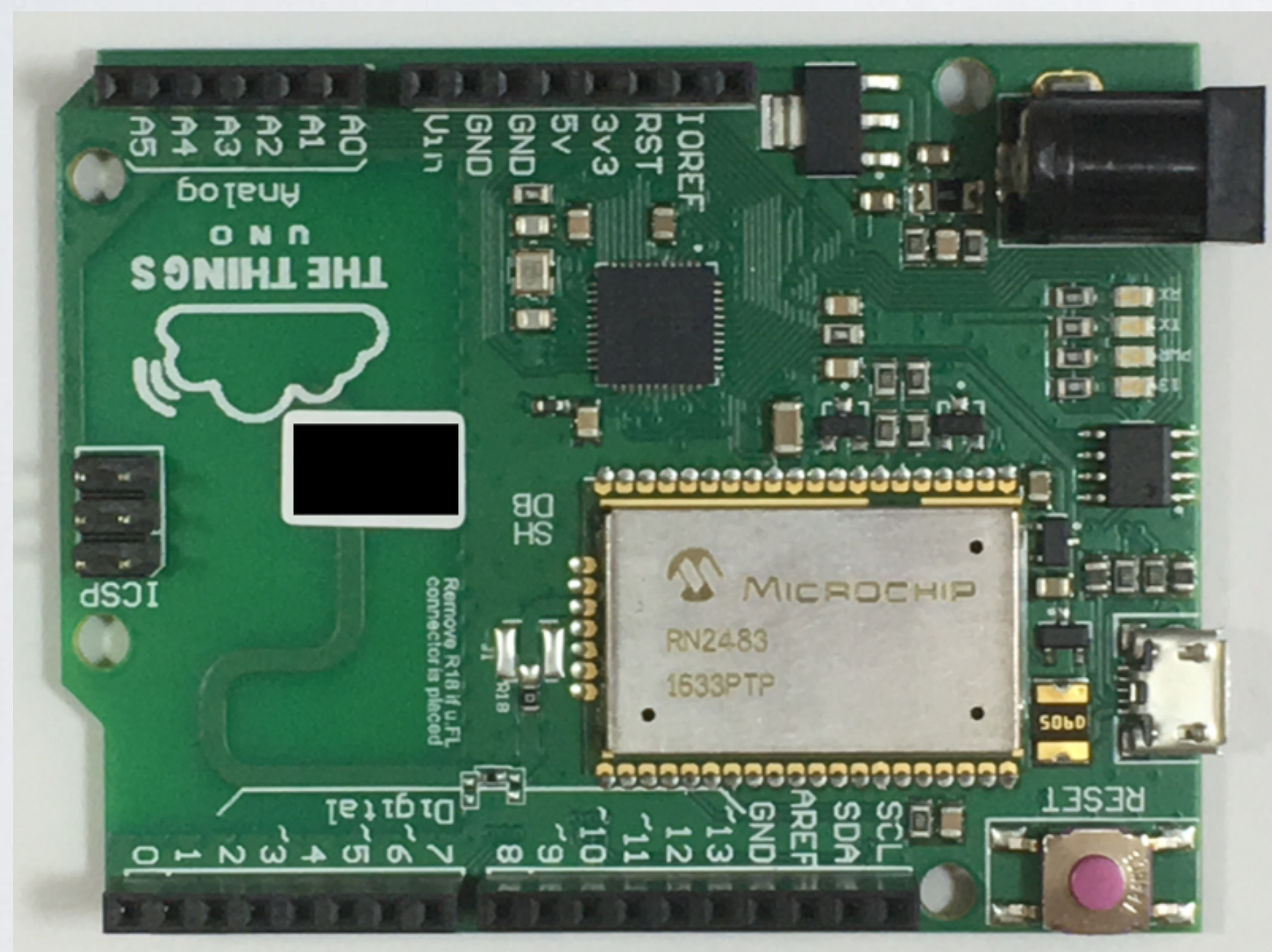
- Pros
 - Smaller size compared to a PCB antenna.
 - Components in close proximity of the ceramic antenna does not cause severe detuning.
 - A ceramic antenna is less susceptible to environmental interferences (humans or animals).
 - Less PCB area is needed compared to a PCB antenna.
 - A ceramic antenna can be tuned or even replaced without redesigning the PCB board.

CERAMIC ANTENNA

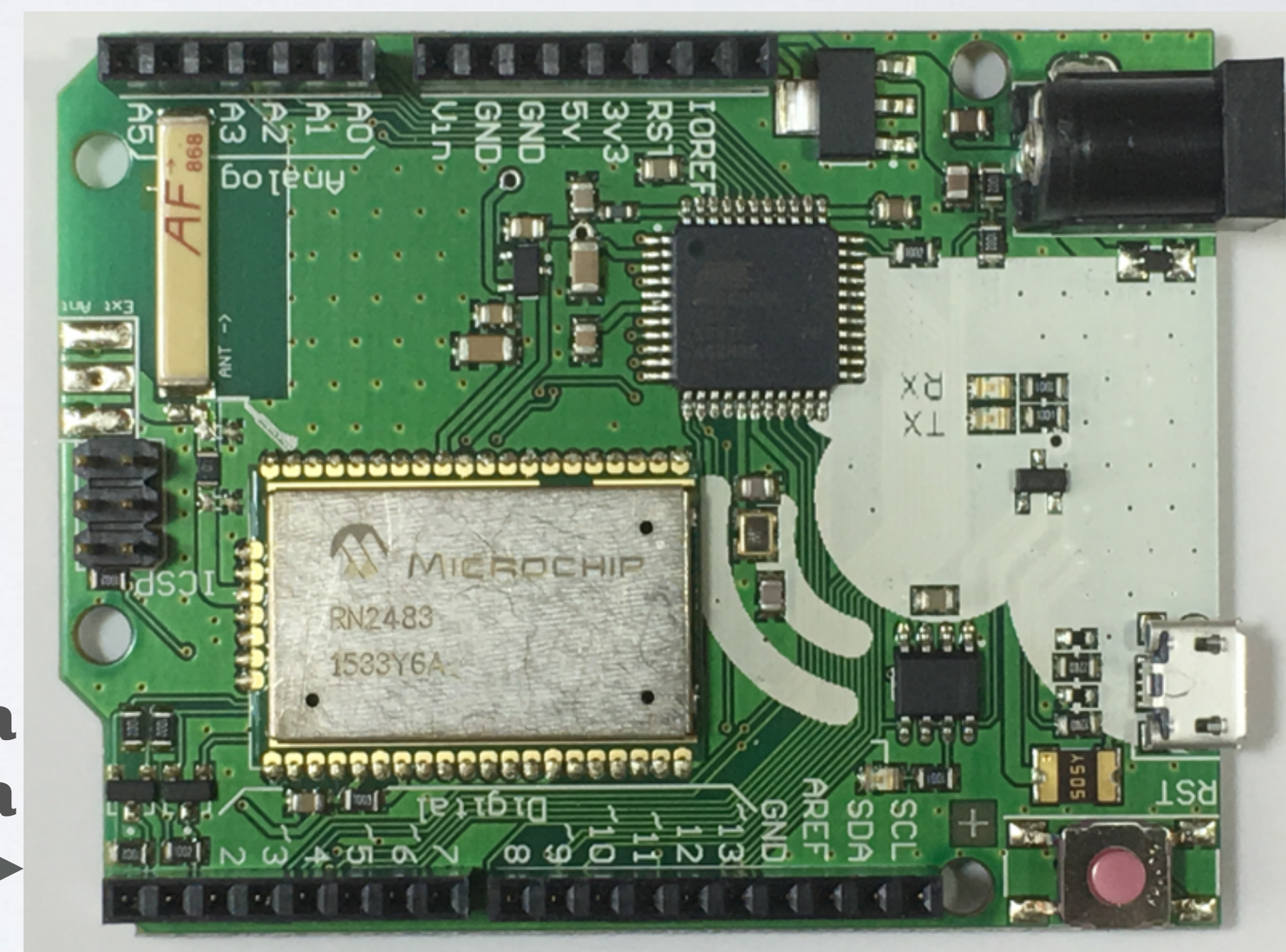
- Cons
 - Average antenna performance compared to an external antenna.
 - A ceramic antenna costs more compared to a PCB antenna.

PERFORMANCE TESTS

- A PCB, ceramic and monopole antenna performance is compared with a sleeve dipole antenna.
- For the PCB antenna test, the Things UNO is used.
For the ceramic antenna test, the Things UNO (Beta version) is used.



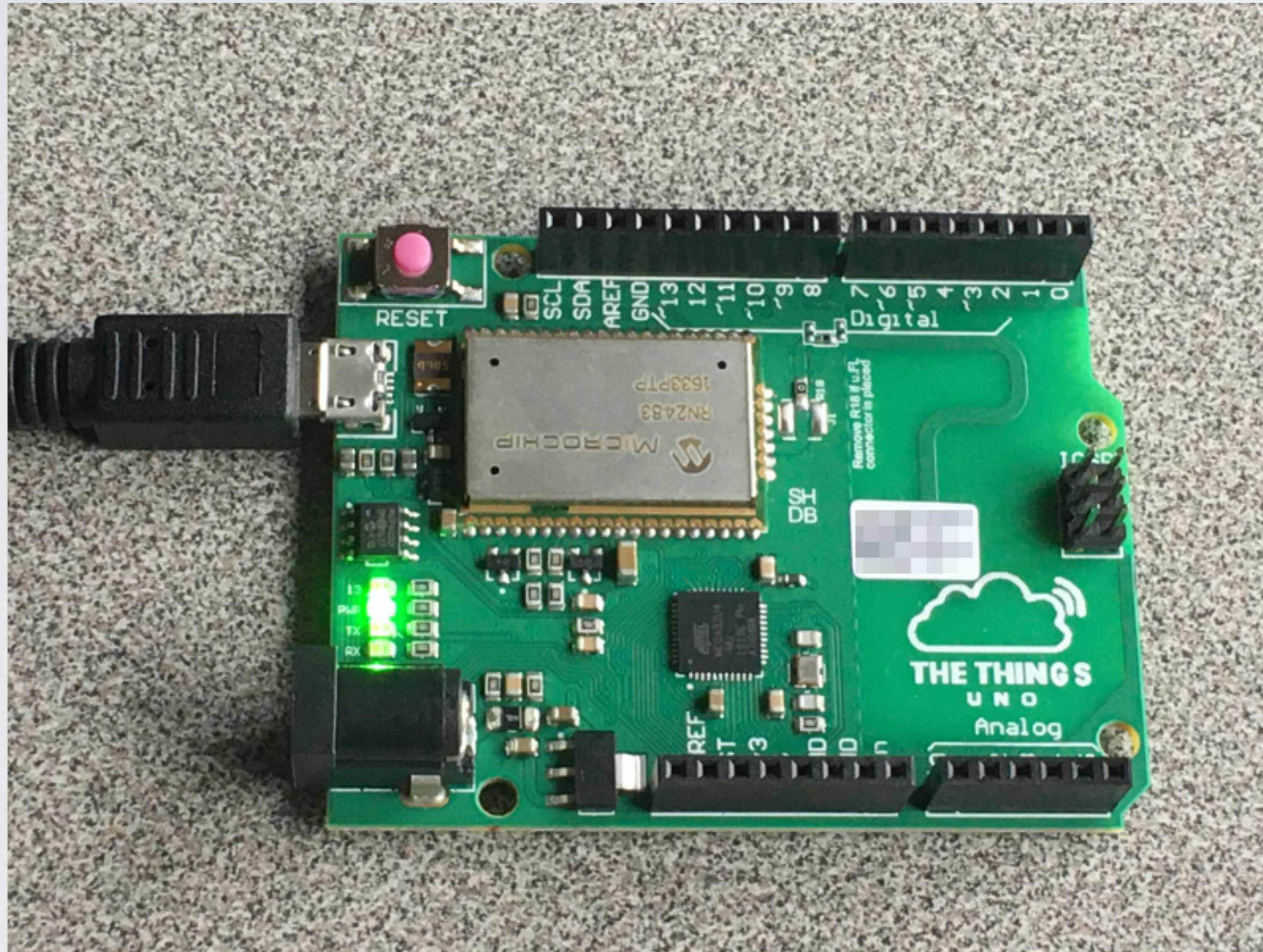
**The Things Uno
PCB antenna**



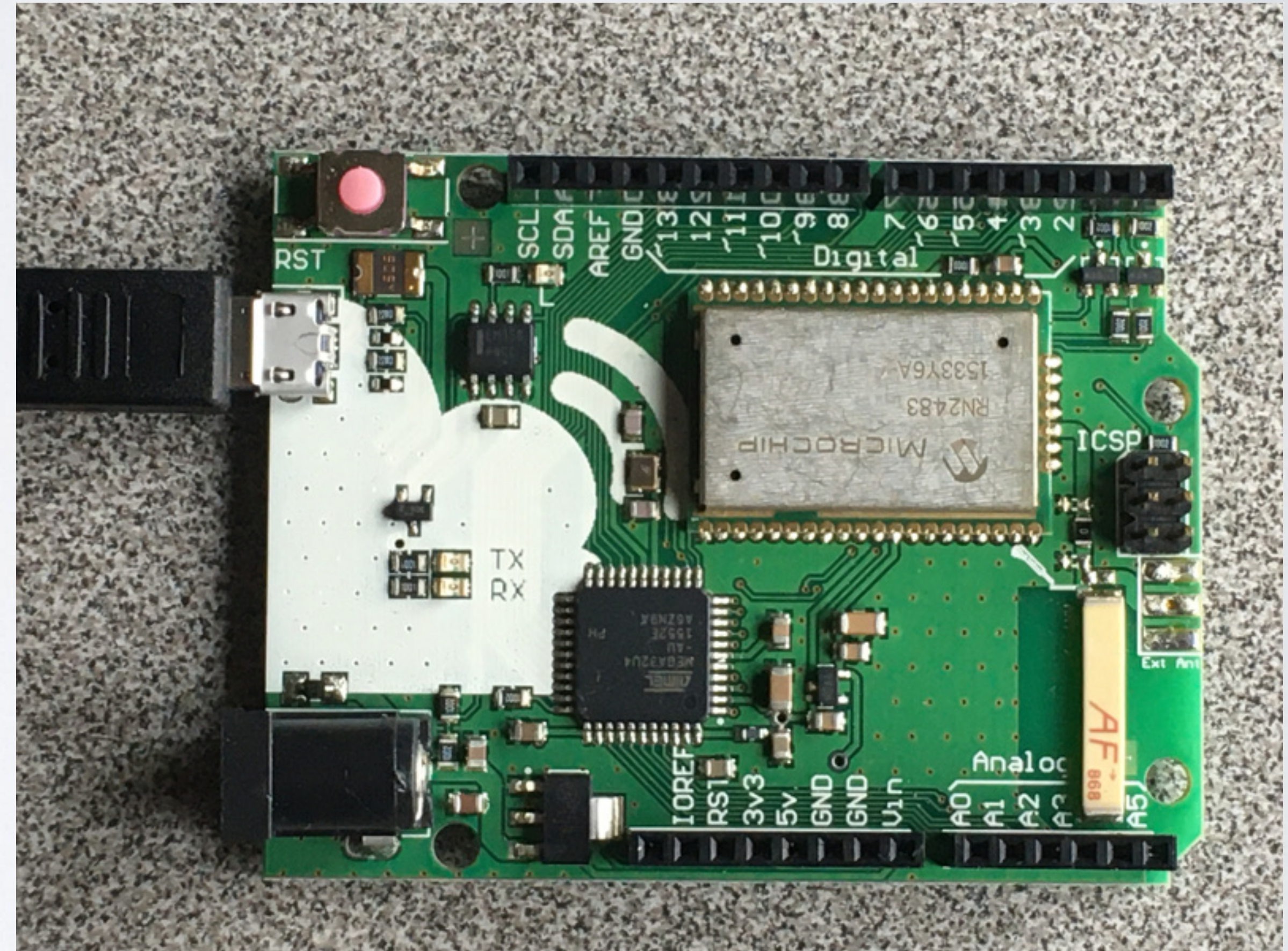
**The Things Uno Beta
Ceramic antenna**

PERFORMANCE TESTS

- The Things Uno and The Things Uno Beta.



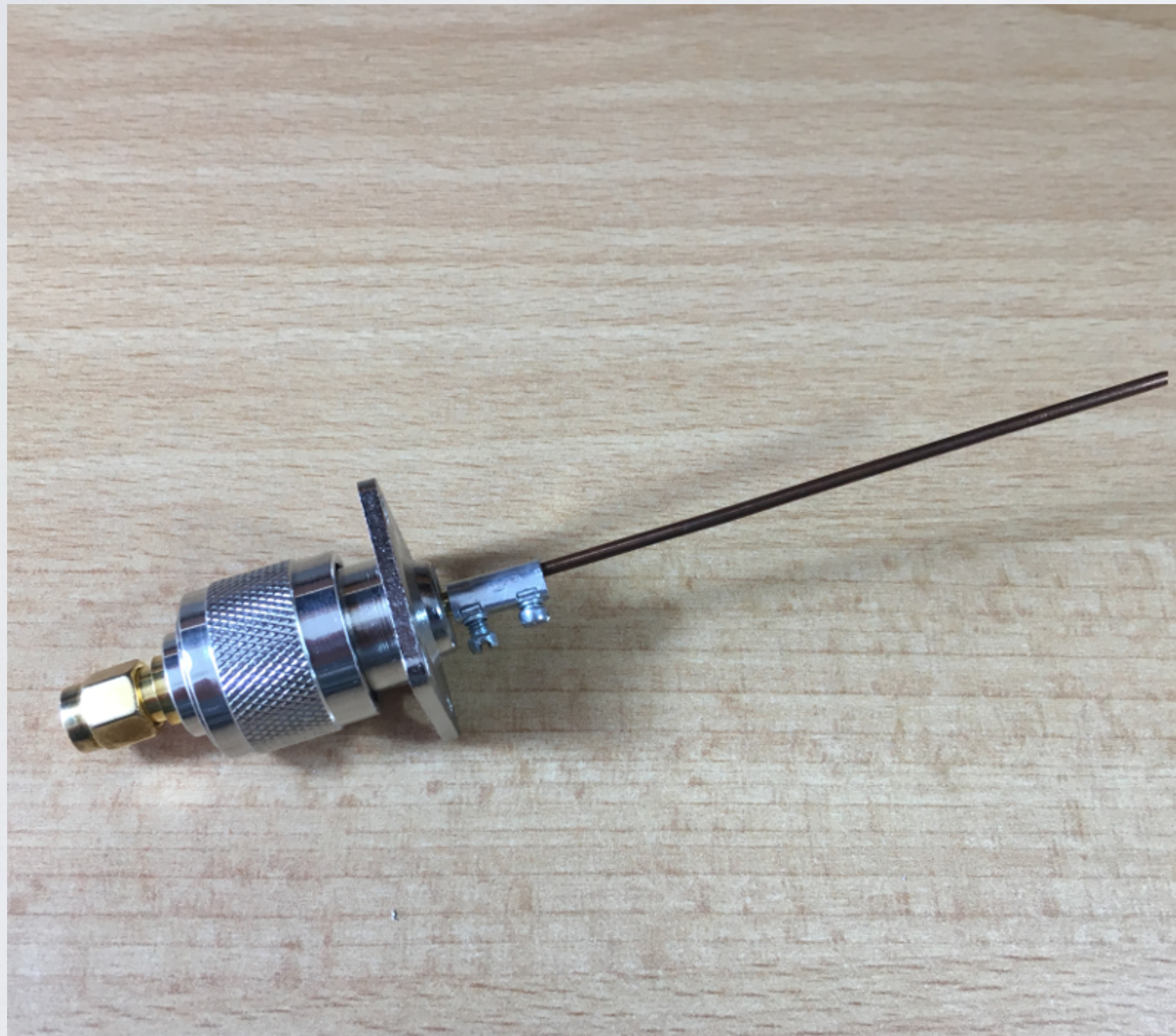
The Things Uno (PCB antenna)



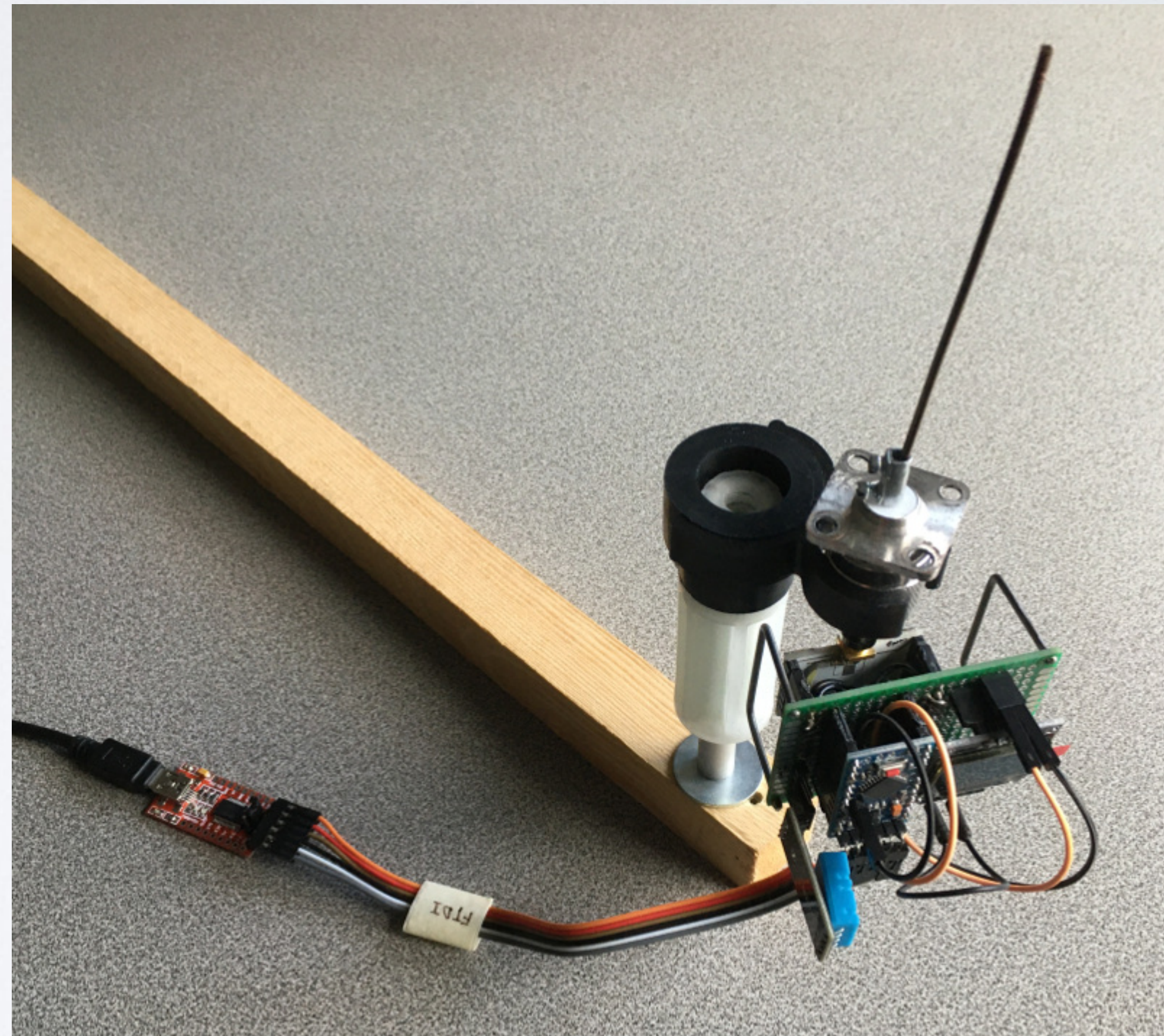
The Things Uno Beta (ceramic antenna)

PERFORMANCE TESTS

- For the monopole antenna test, the monopole antenna is used as described in tutorial 42.



Monopole antenna



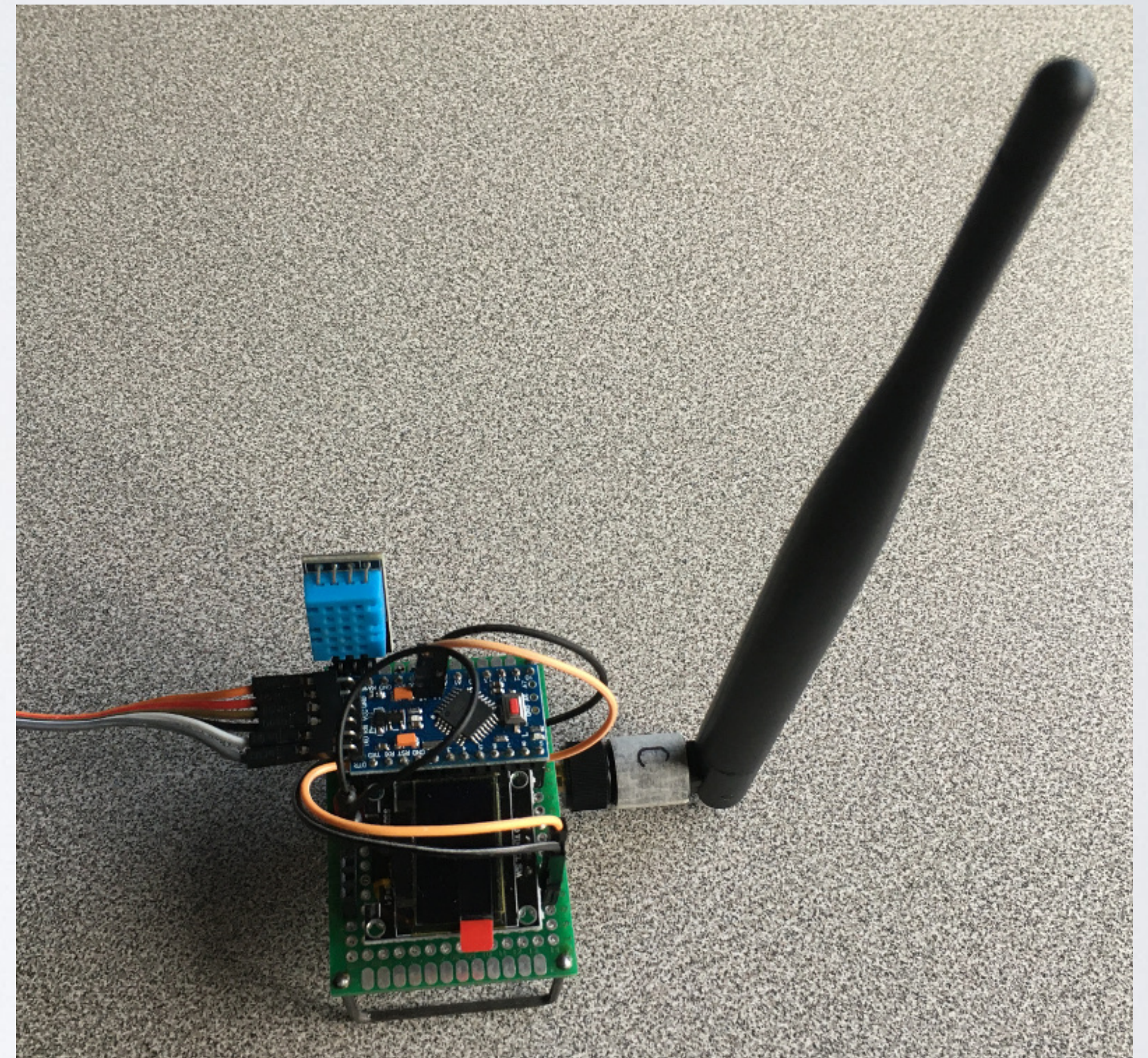
Monopole antenna with end node

PERFORMANCE TESTS

- For the sleeve dipole antenna, antenna C is used as demonstrated in tutorial 33 and 43.



Sleeve dipole antenna (Antenna C)



Sleeve dipole antenna with end node

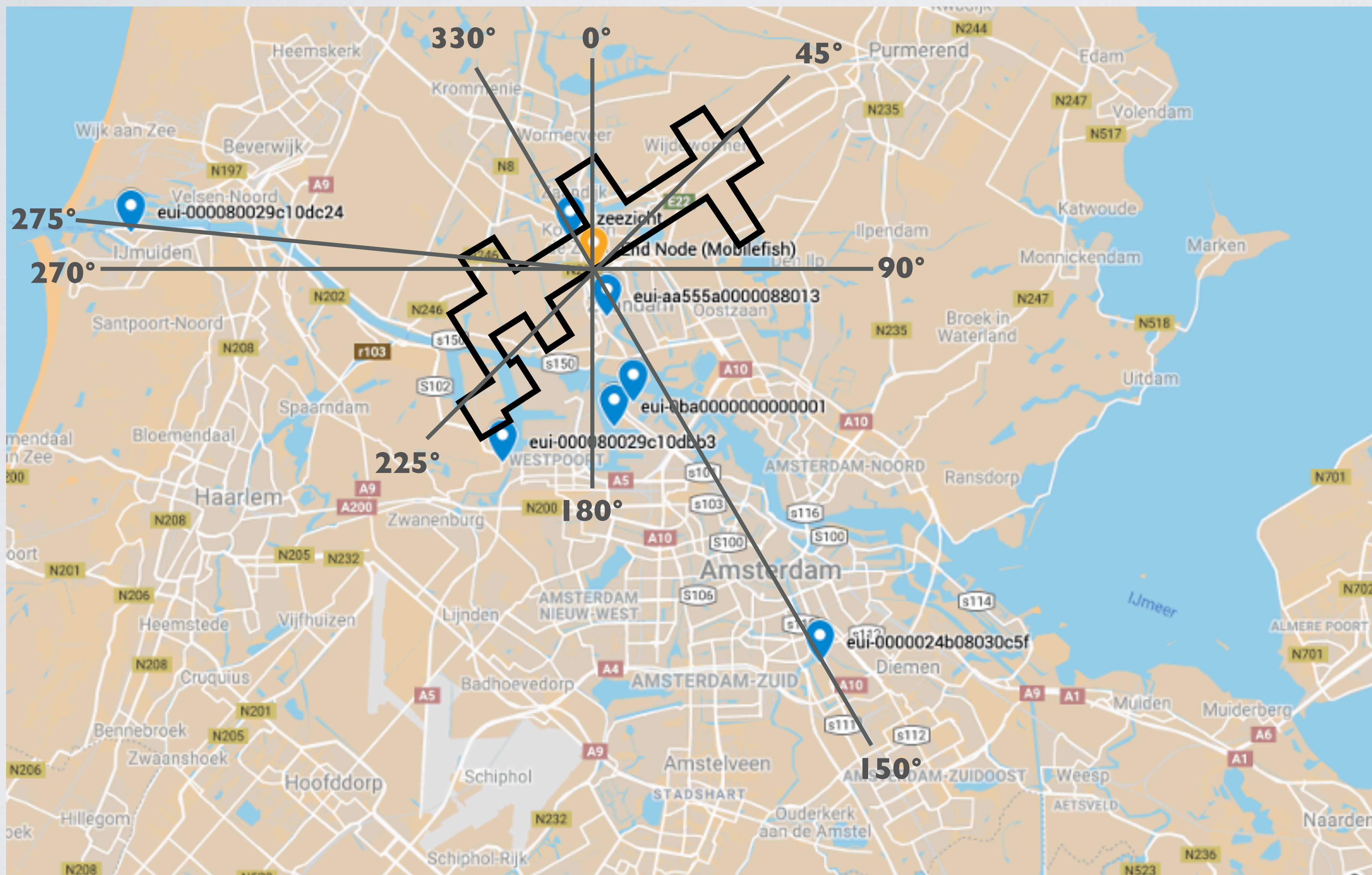
PERFORMANCE TESTS

- For both The Things Uno (with PCB antenna) and The Things Uno Beta (with ceramic antenna) the same sketch is used:
<https://www.mobilefish.com/download/lora/SendOTAA.ino.txt>
- More information about this sketch and which libraries to use, see:
<https://youtu.be/28Fh5OF8ev0>
- The sketch transmits 10 messages per minute.

PERFORMANCE TESTS

- For both the monopole antenna and sleeve dipole antenna tests the same end node is used, see:
https://www.mobilefish.com/developer/lorawan/lorawan_quickguide_build_lora_node_rfm95_arduino_pro_mini.html
- The end node uses the MCCI LoRaWAN LMIC Library:
<https://github.com/mcci-catena/arduino-lmic>
- The end node uses the following sketch:
<https://www.mobilefish.com/download/lora/ttn-otaa-pro-mini-sensors.ino.txt>
- The sketch is modified to transmit 2 messages per minute.

ANTENNA TEST SETUP



The building circumference.

The end node is placed inside the building in front of a window.

Two end node locations:

Location A, facing East and South. Altitude = ~11m

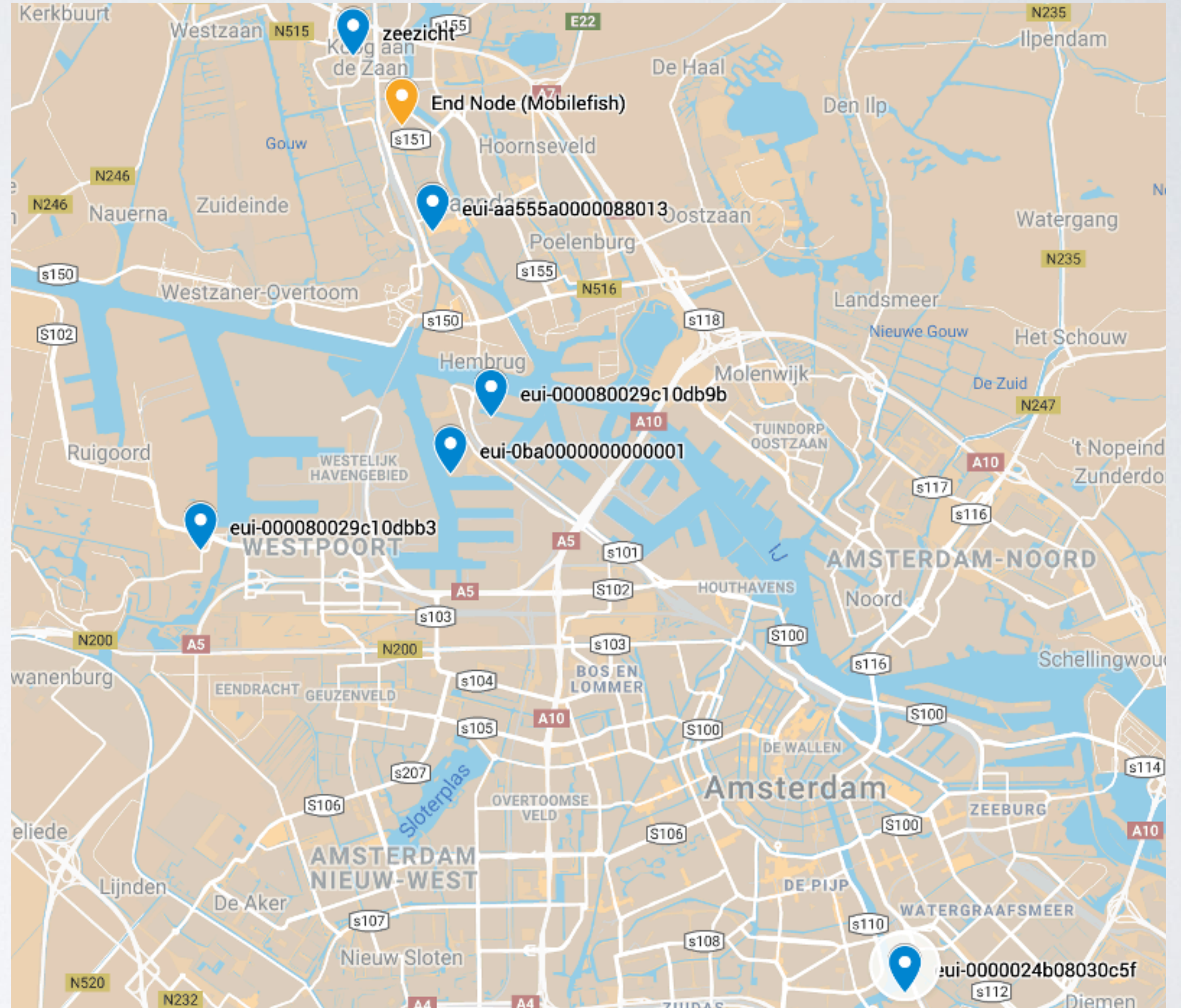
Location B, facing West and North. Altitude = ~11m

PERFORMANCE TESTS

- For all four tests the transmission power is not modified and all the devices are positioned at the same location.
- In my area there are several gateways and I know that these gateways, which are connected to The Things Network, can receive my transmitted data.
- The logged data can be found at:
https://www.mobilefish.com/download/lora/pcb_ceramic_antenna_test_results.txt
- Note: I am only interested which gateways have received the transmitted data.

ANTENNA TEST RESULTS

- One or more gateways were able to receive my transmitted sensor data, see: <https://drive.google.com/open?id=18SKbHVEIFHU6YjzYpgZL98vuHcmV4OPQ&usp=sharing>



PERFORMANCE TEST RESULTS

- End node tx power = 14 dBm

Data from: pcb_ceramic_antenna_test_results.txt

Gateway	Distance from end device to gateway[km]	Ant. Altitude [m]	PCB	Ceramic	Monopole	Sleeve Dipole
eui-000080029c10dc24	14.7	45				
eui-000080029c10db9b	4.36	30				
eui-7276ff000b031ebb	0.73	38				
eui-dca632fffe43df3e	0.458	10				
eui-0ba00000000000001	5.02	20				
eui-aa555a0000088013	1.57	42				

Green = Gateway has received the transmitted sensor data.

PERFORMANCE TEST RESULTS

- The sleeve dipole antenna clearly has a better performance compared to the PCB, ceramic and monopole antenna.
- The eui-aa555a0000088013 gateway also receive sensor data when using the PCB antenna.
- To be honest I know that this gateway would also receive sensor data when using the ceramic and monopole antenna if the test was conducted for a slightly longer period.
- My conclusion is: PCB, ceramic and monopole antennas are great antennas for short distances.