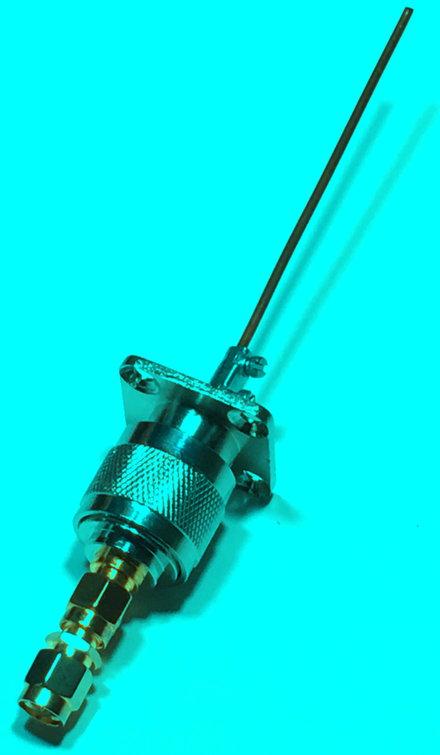
mobilefish.com

LORA / LORAWAN TUTORIAL 42

Monopole Antenna & Ground Plane



v1.0.1

INTRO

- In this tutorial I will explain what a monopole antenna is and why a ground plane is needed.

ATTENTION

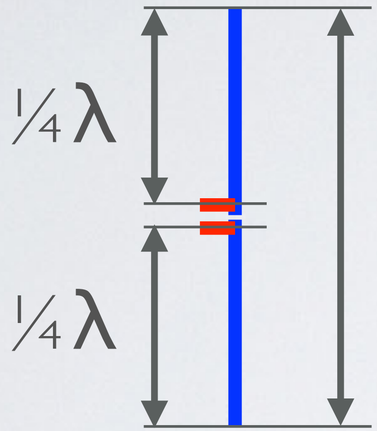
- **The antennas built in this tutorial are intended for test and educational purpose and should be used indoors.**

- **The antennas are constructed in such a way so it can be easily disassembled and its parts can be re-used in other antenna projects.**

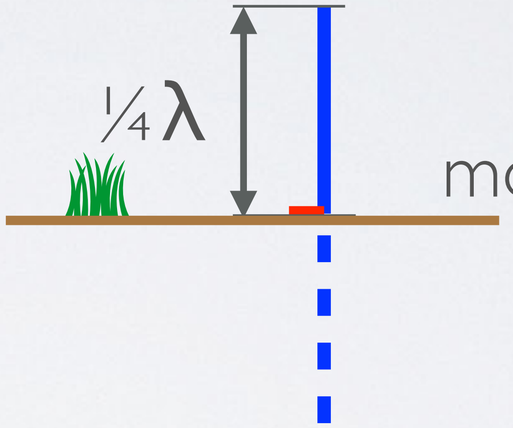
- **The antennas are not properly constructed and the antenna performance can be improved by using better materials, parts or another way of construction.**

1/4 WAVE MONOPOLE ANTENNA

- A ½λ dipole antenna has two elements (each element is L = ¼λ), but a monopole antenna has only one element (L = ¼λ).



dipole antenna
L = ½λ



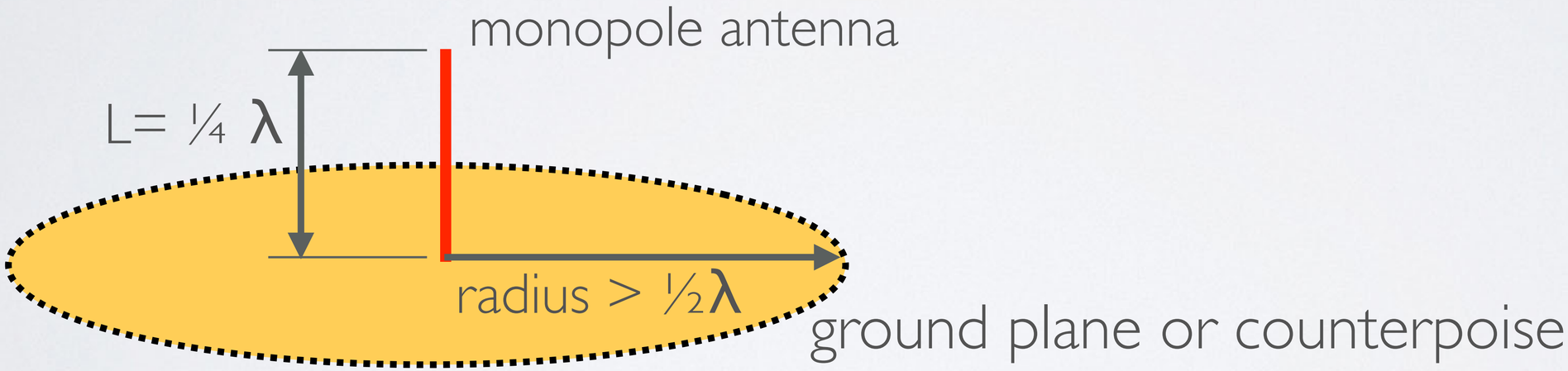
monopole antenna
L = ¼λ

- A monopole antenna relies on a good conducting plane for its operation.
  This plane is used as a mirror to create a "second imaginary" element.
  The ground (earth) is a conductor and RF energy is reflected from the ground.
  The monopole antenna performance can be improved by using a plane made of a better conductive material instead of using the earth itself.

GROUND PLANE / COUNTERPOISE

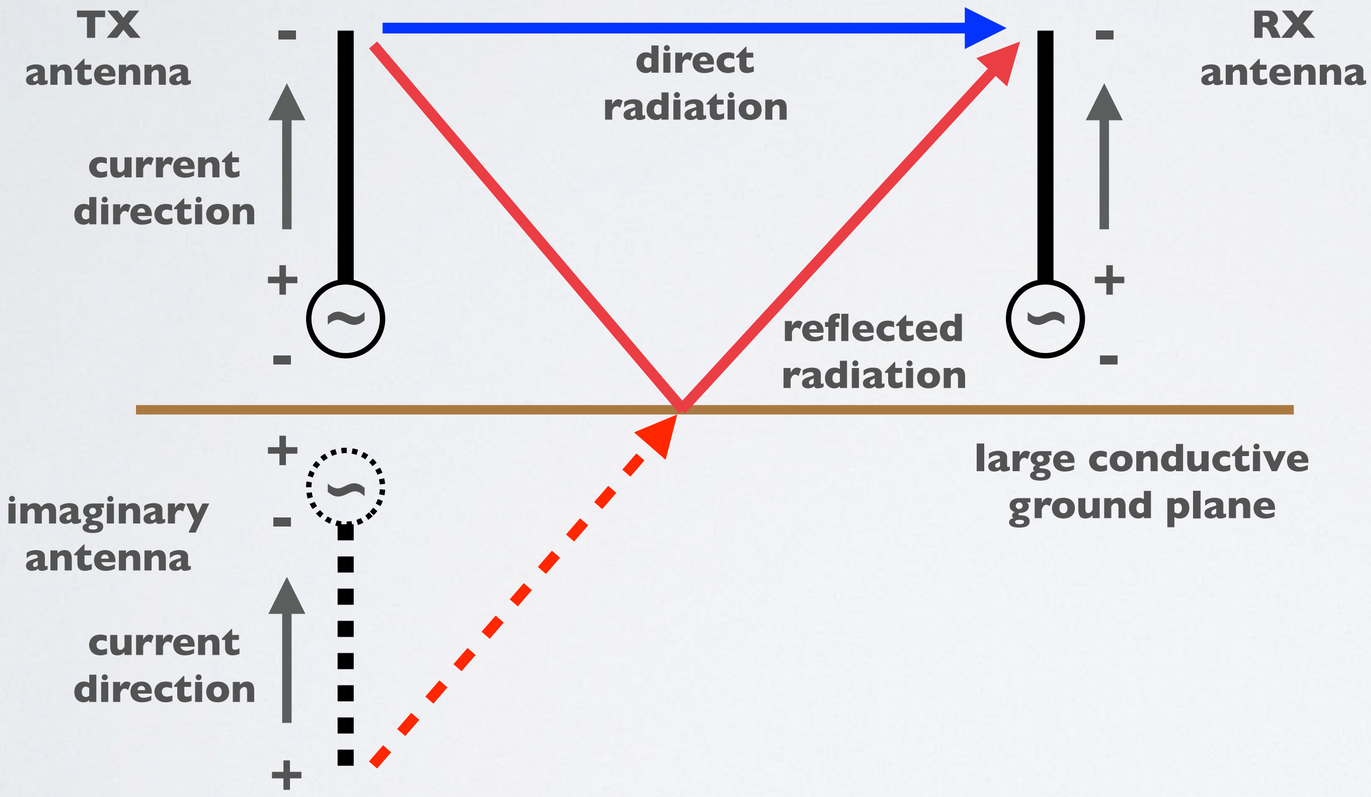
- This conducting plane is called the ground plane or counterpoise.

- The ground plane must have a radius greater than ½ wavelength from the base of the monopole antenna.



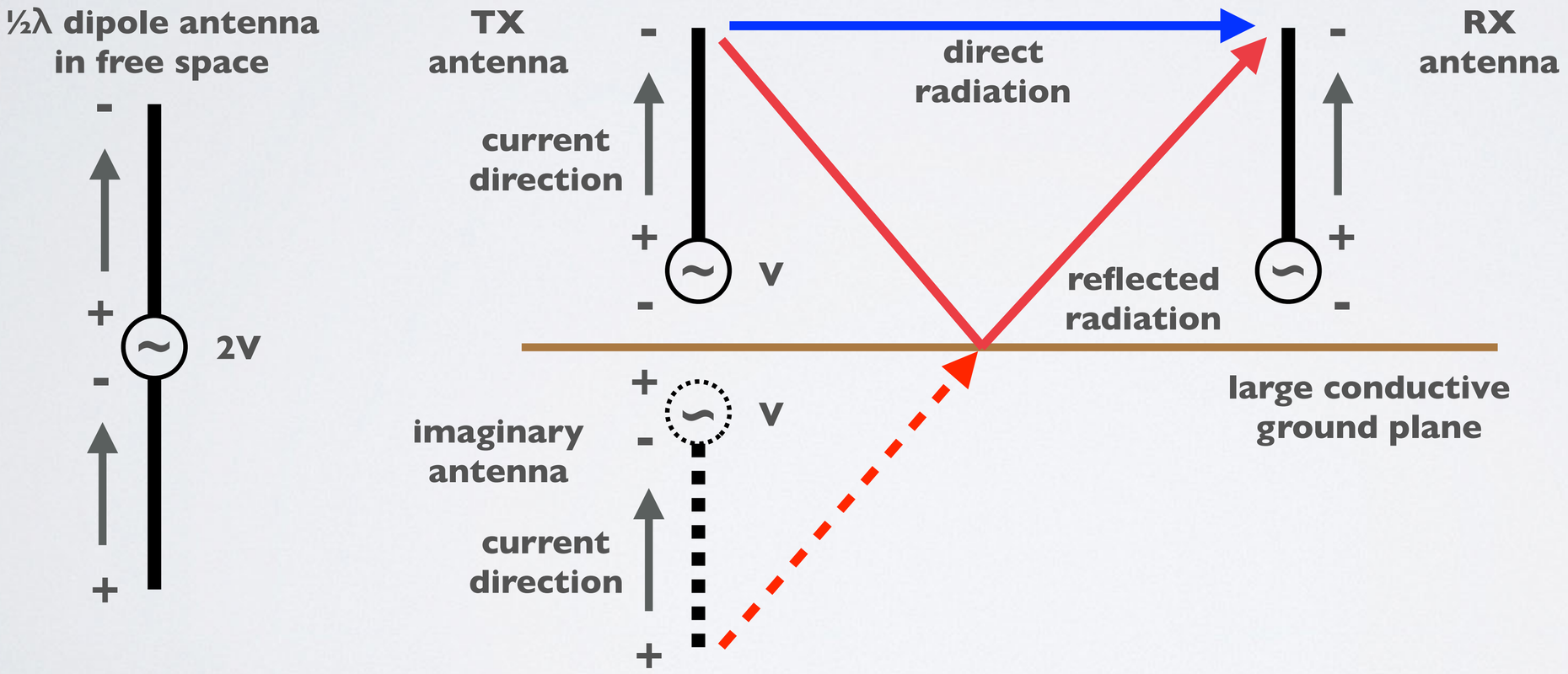
GROUND PLANE / COUNTERPOISE

- For a ¼λ monopole antenna the reflected radiation from the ground is in phase with the direct radiation.



GROUND PLANE / COUNTERPOISE

- The receiving antenna (RX) gets energy from the direct path **AND** from the reflected path which is in phase. A ¼**λ** monopole antenna will have twice the gain (3 dB) of a ½**λ** dipole antenna (in free space).

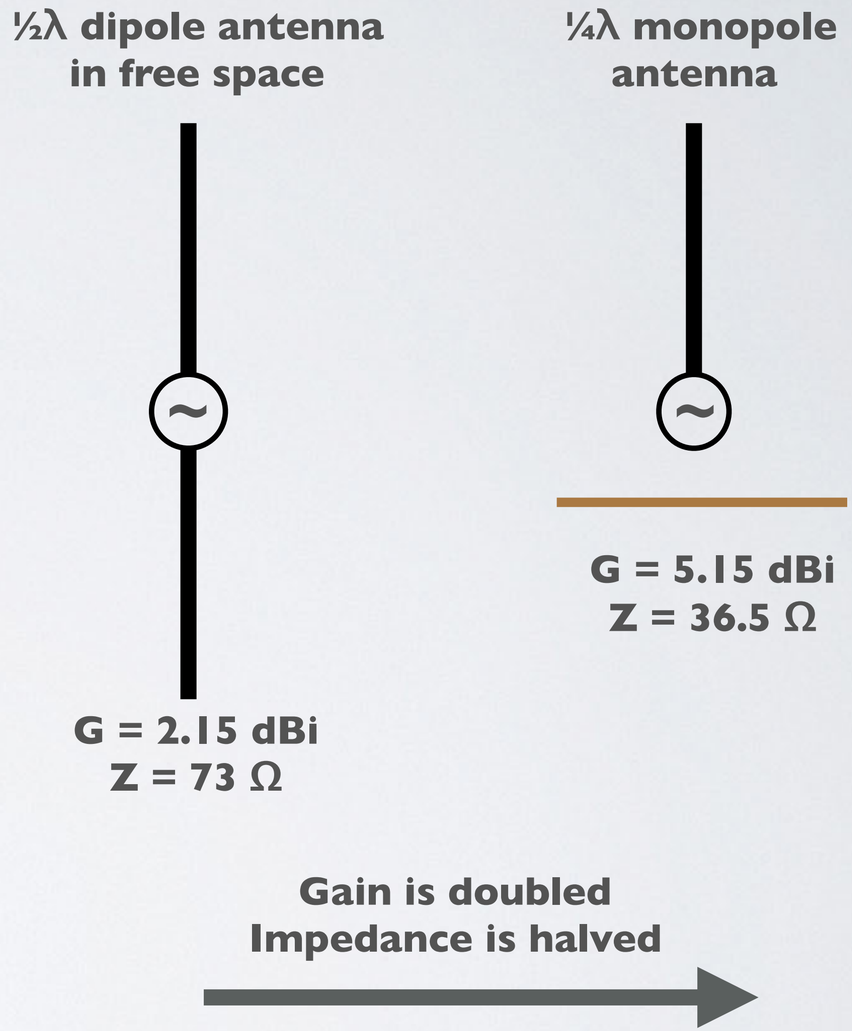


GROUND PLANE / COUNTERPOISE

- A ½λ dipole antenna has a gain (G) of 1.64 and an impedance (Z) of 73 Ω at its centre, which is the radiation resistance.

- By the way: G = 10 $\log_{10}$(1.64) = 2.15 dBi which is the same as 0 dBd

- A ¼λ monopole antenna has a gain (G) of 2.15 + 3 = 5.15 dBi (or 3 dBd) and a radiation resistance of 0.5 x 73 = 36.5 Ω when positioned over a large conductive ground plane.



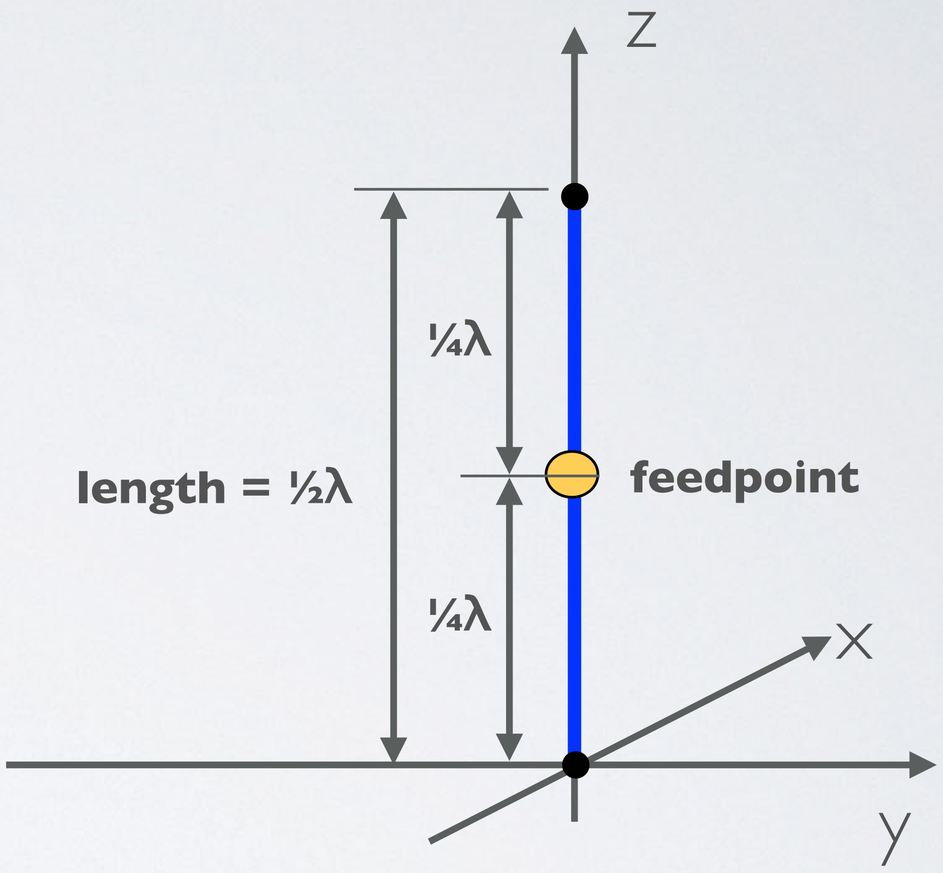
ANTENNA MODELLING 4NEC2

- ½λ dipole antenna 4NEC2 card deck:
  https://www.mobilefish.com/download/lora/dipole_freespace_868mhz_4nec2.nec.txt

- ¼λ monopole antenna 4NEC2 card deck:
  https://www.mobilefish.com/download/lora/monopole_ground_plane_868mhz_4nec2.nec.txt

ANTENNA MODELLING 4NEC2

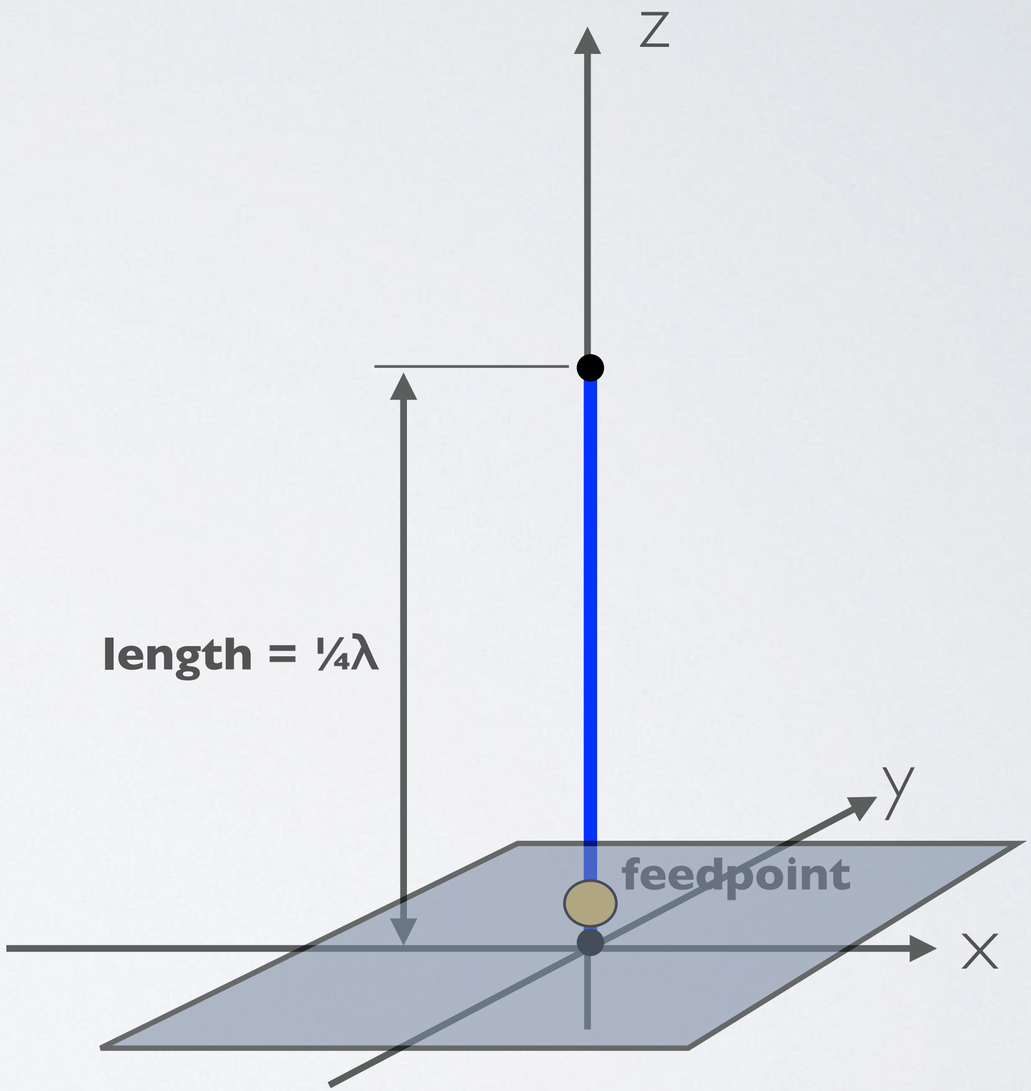
- ½λ dipole antenna parameters:
  f = 868 MHz
  wire material = copper
  wire diameter = 1.8 mm
  wire radius = 0.9 mm = 0.0009 m
  length = 0.164 m
  ground type: free space



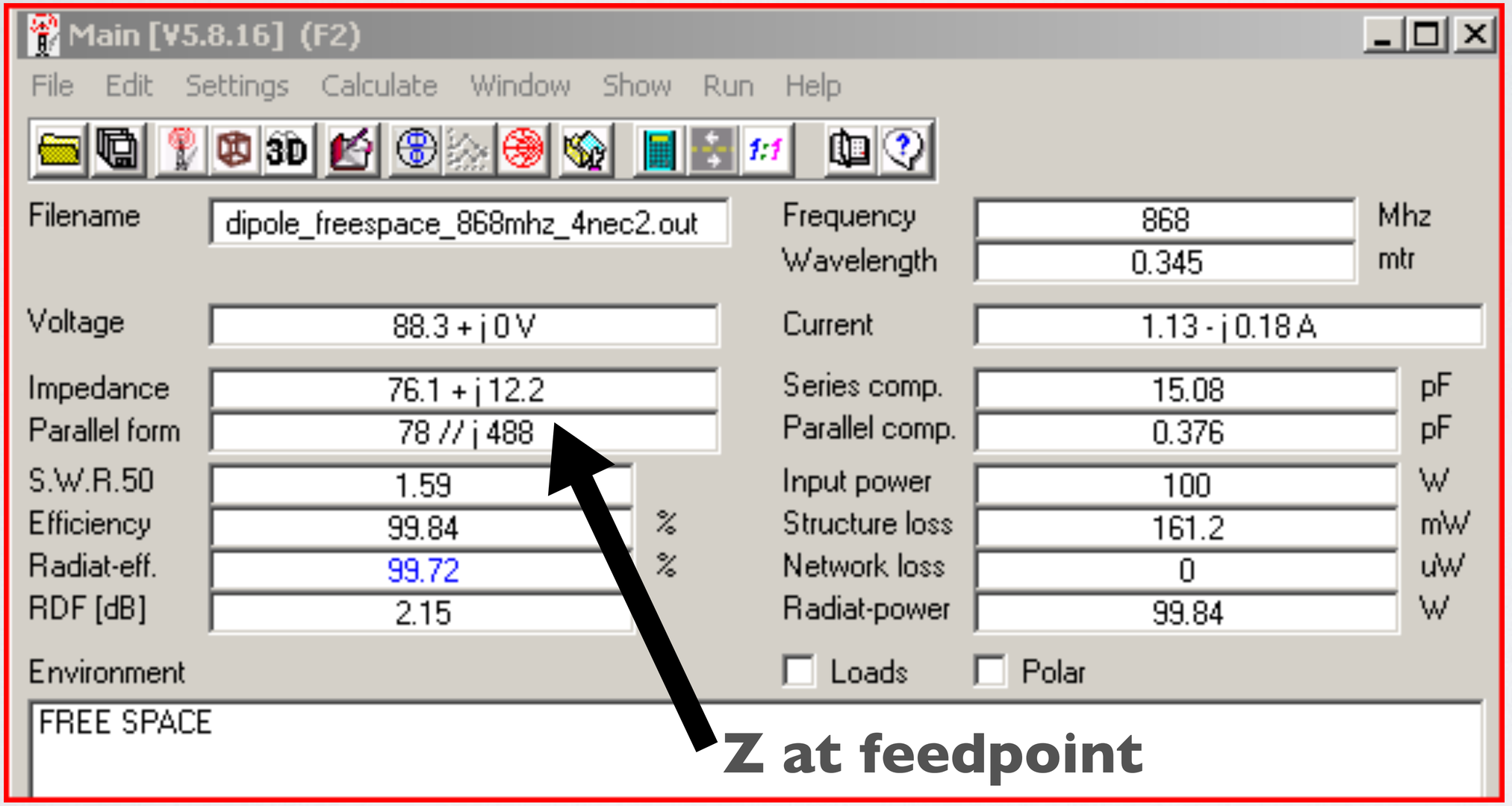
ANTENNA MODELLING 4NEC2

- ¼λ monopole antenna parameters:
  f = 868 MHz
  wire material = copper
  wire diameter = 1.8 mm
  wire radius = 0.9 mm = 0.0009 m
  length = 0.082 m
  ground type: perfect ground

- Perfect ground = ground has perfect conductivity, no losses. The ground acts like a mirror and creates an image antenna identical to the original.
  The ground area is infinite in size.

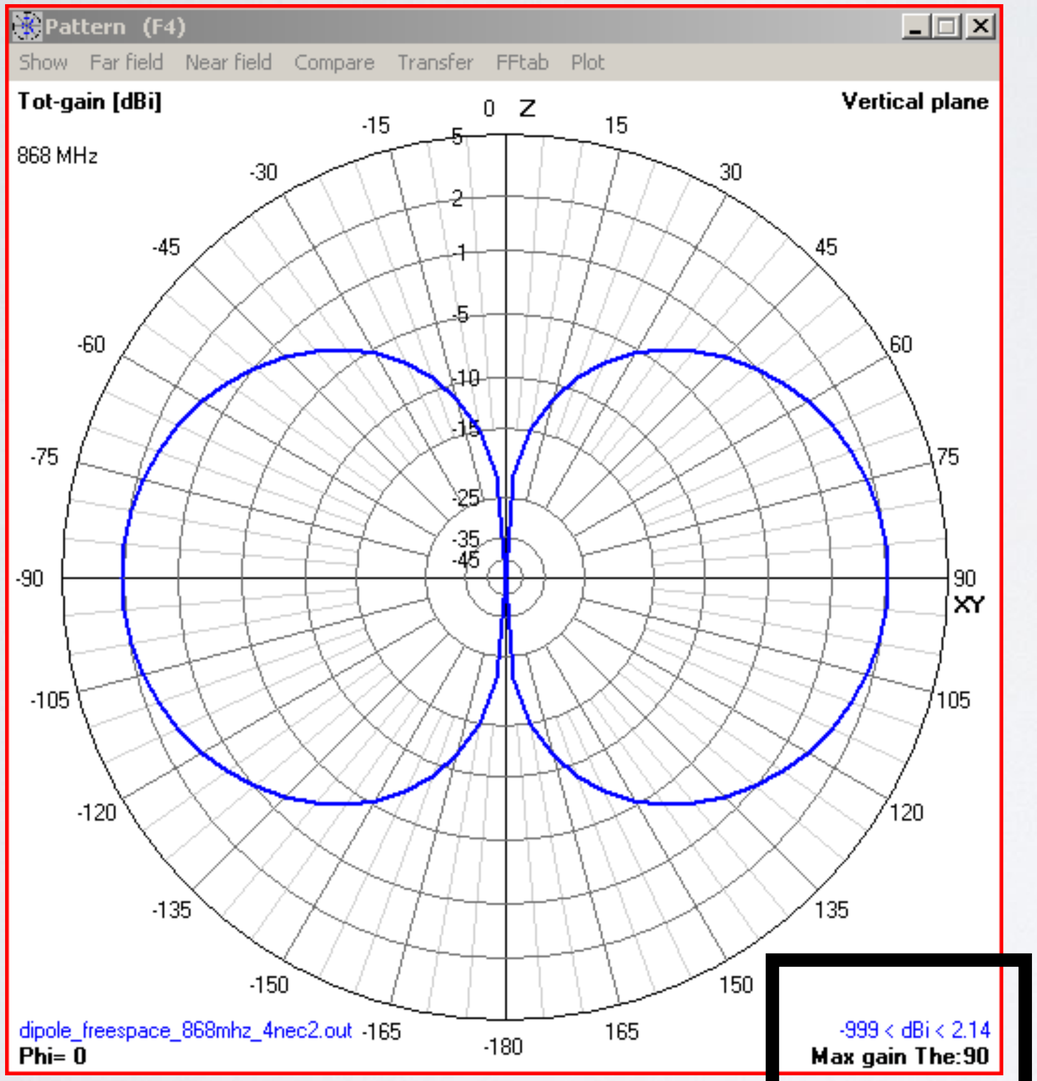


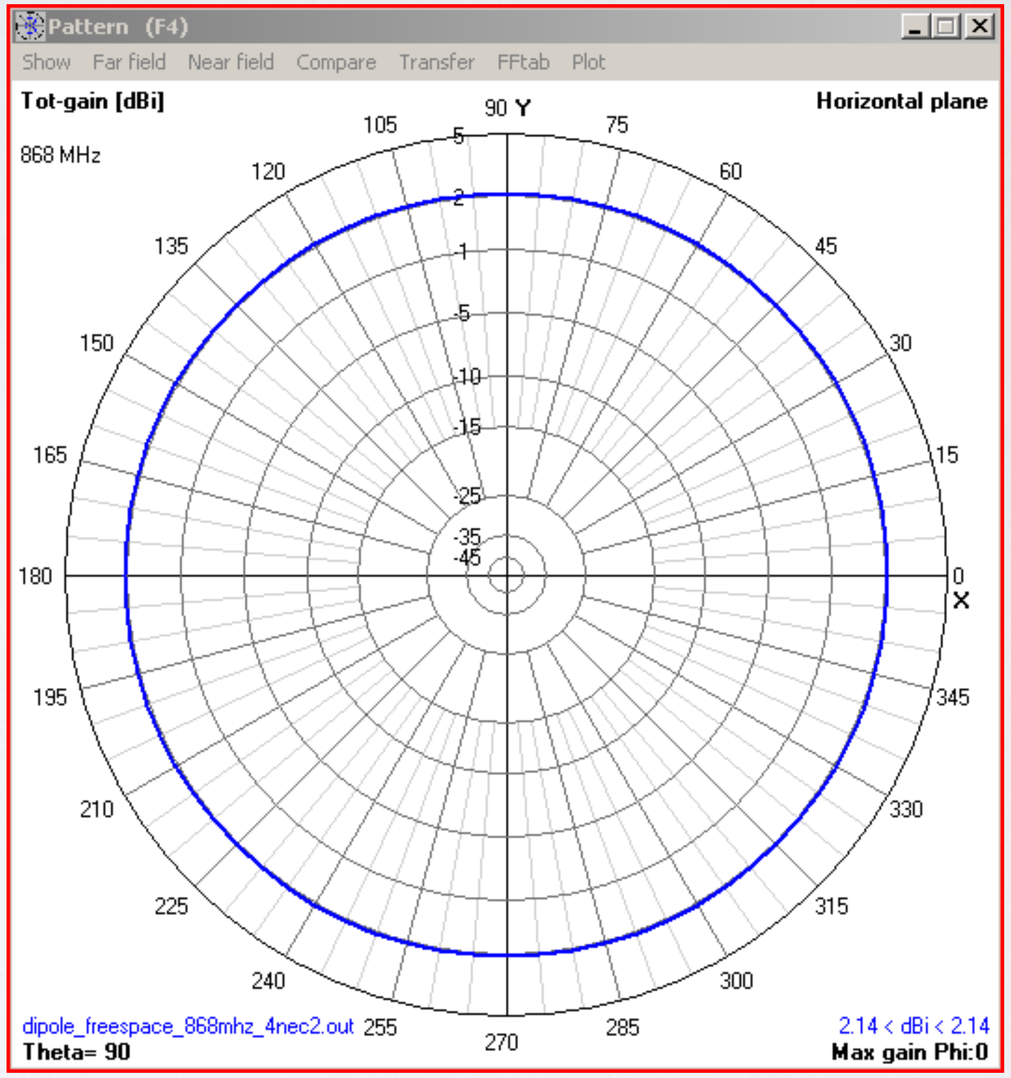
ANTENNA MODELLING 4NEC2



½λ dipole antenna in free space

ANTENNA MODELLING 4NEC2

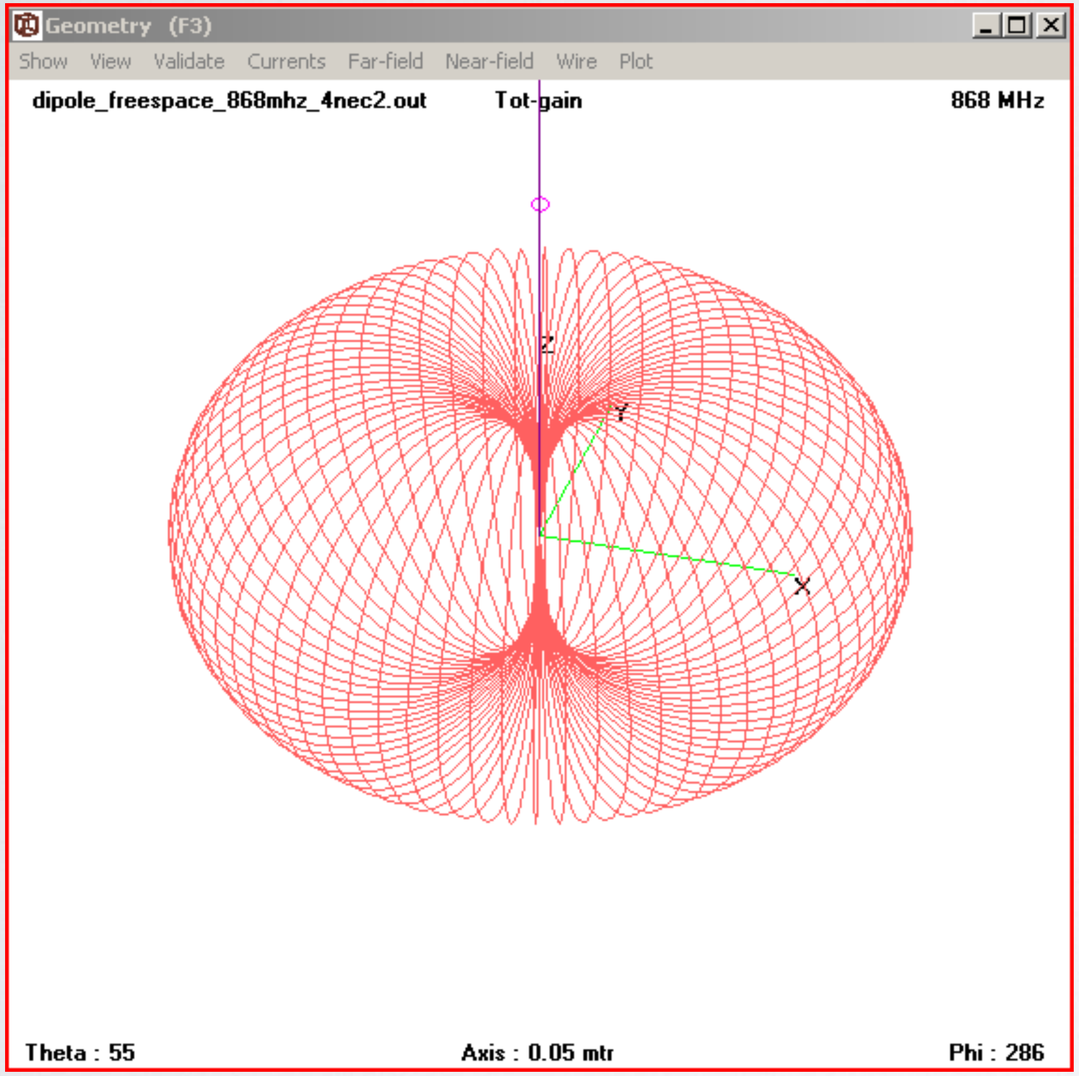


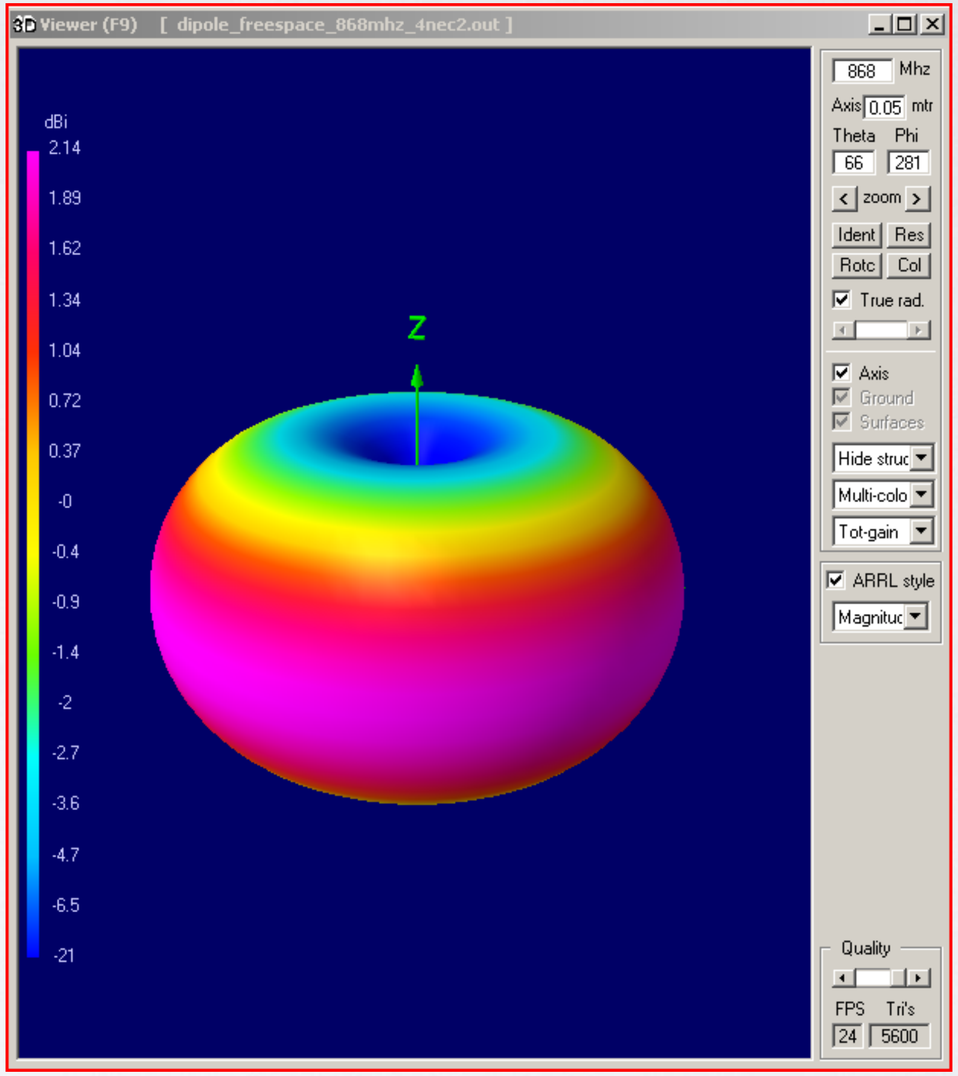


Gain

½λ dipole antenna in free space

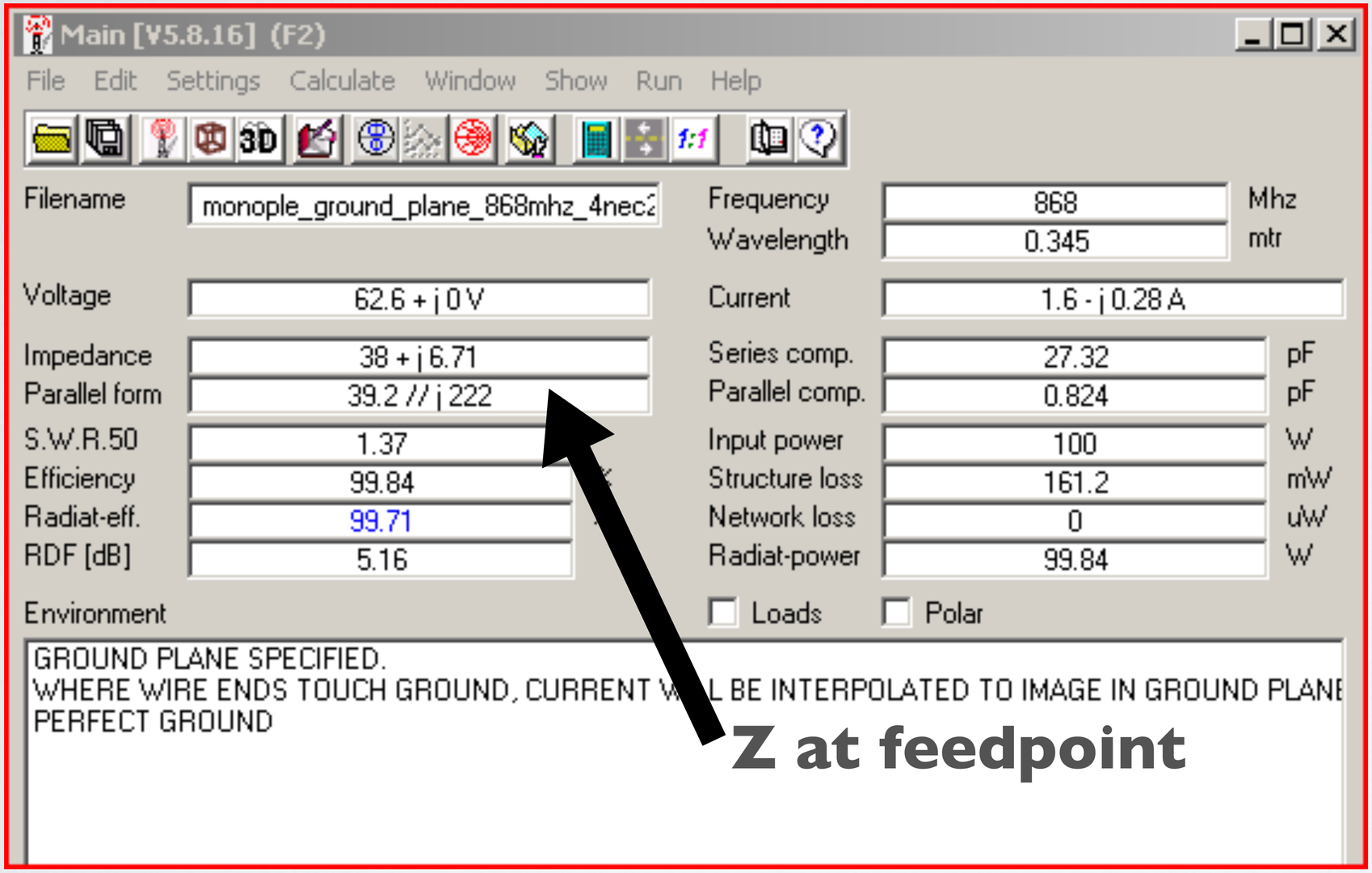
ANTENNA MODELLING 4NEC2





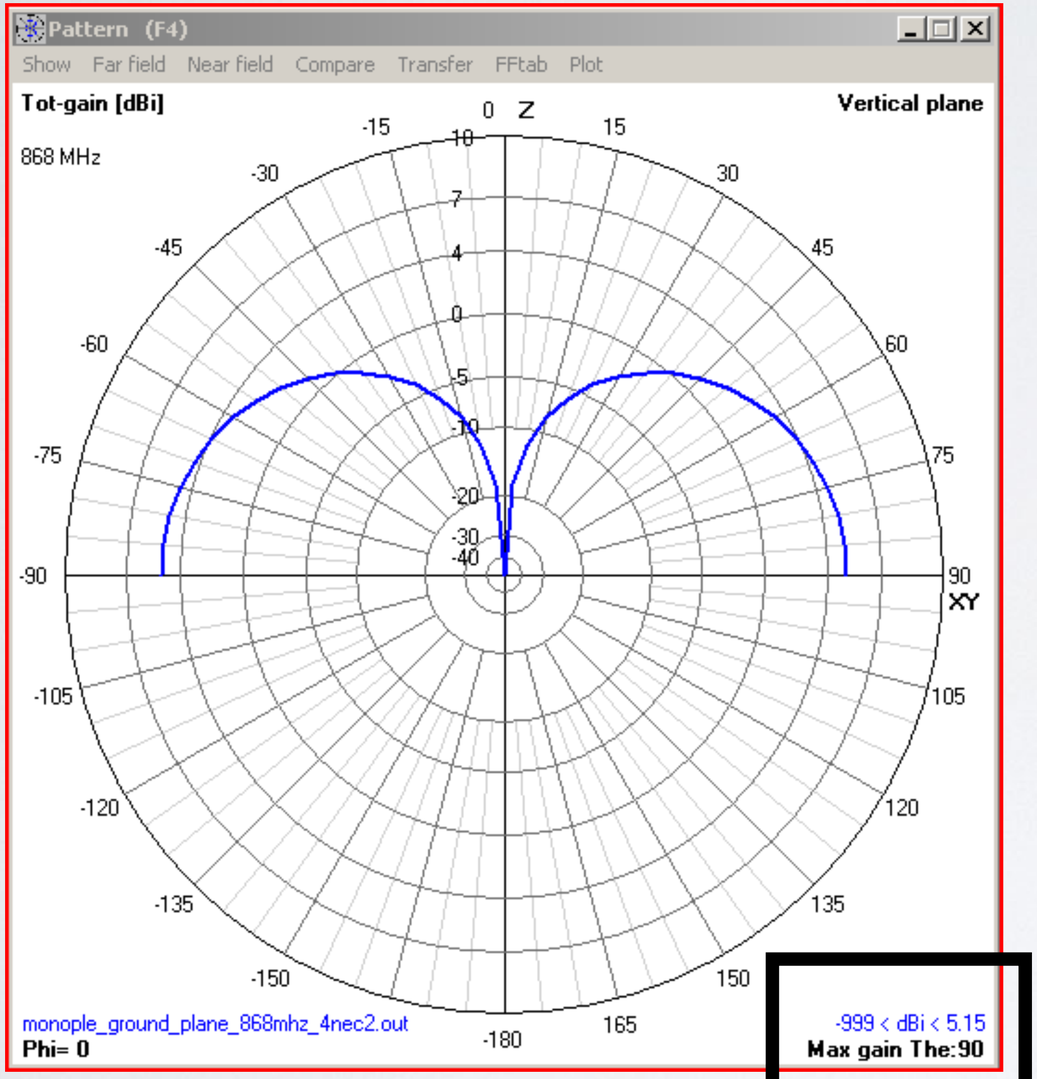
½λ dipole antenna in free space

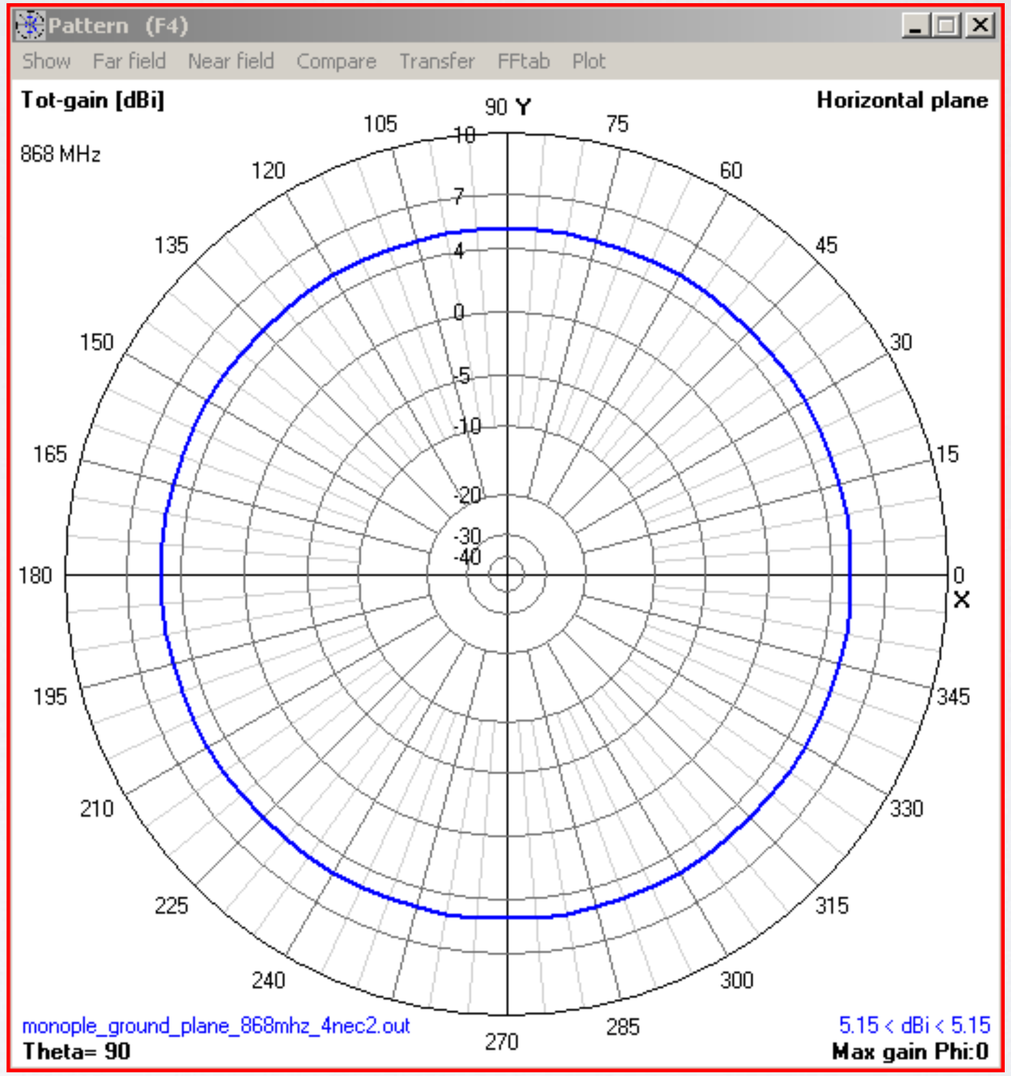
ANTENNA MODELLING 4NEC2



¼ λ monopole antenna over perfect ground.

ANTENNA MODELLING 4NEC2

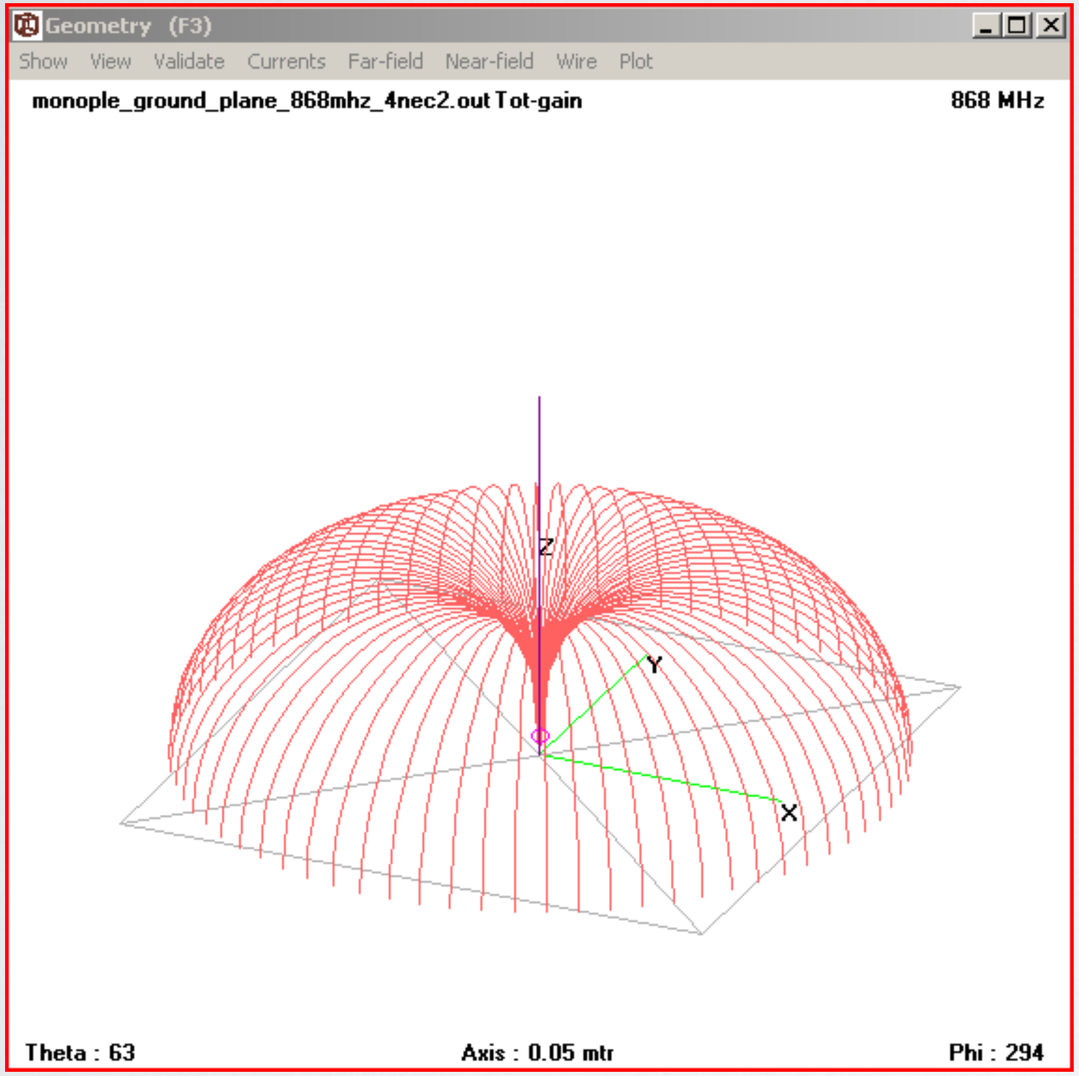


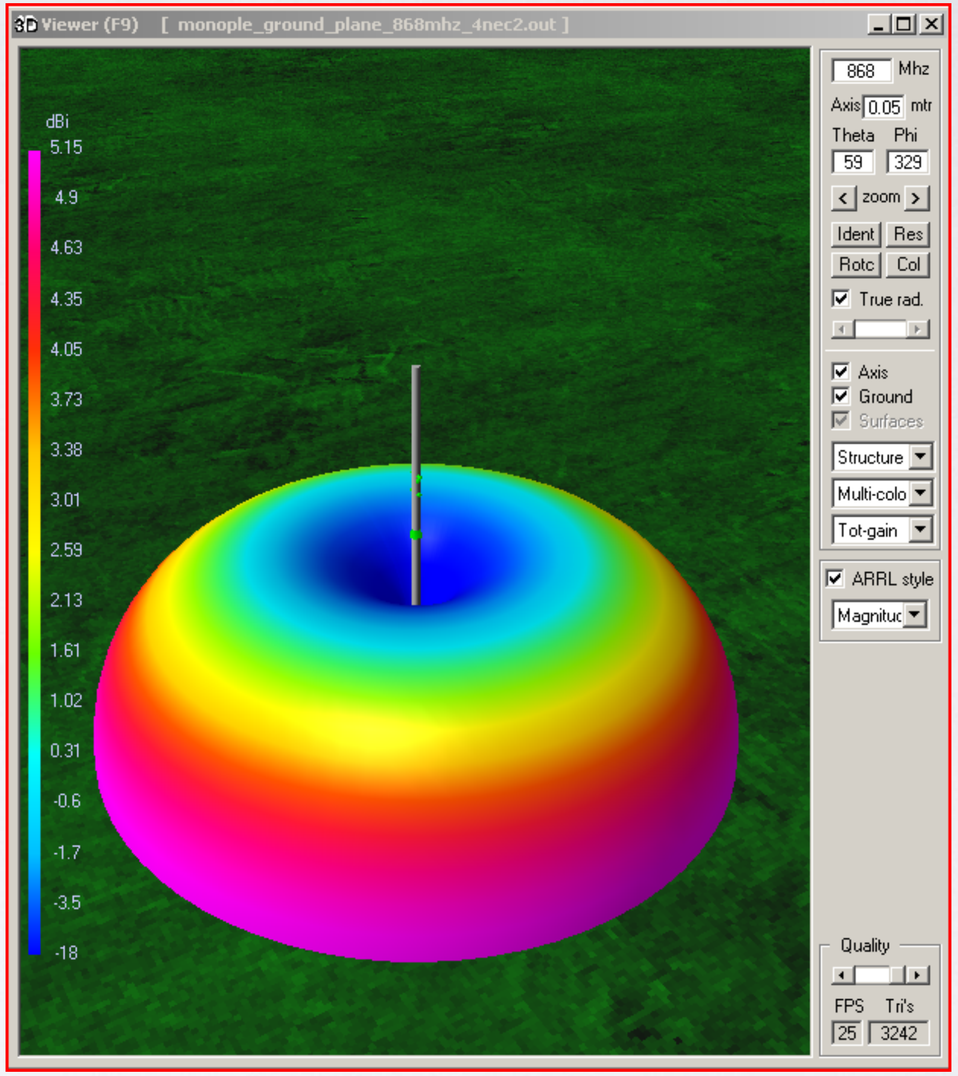


Gain

¼λ monopole antenna over perfect ground.

ANTENNA MODELLING 4NEC2

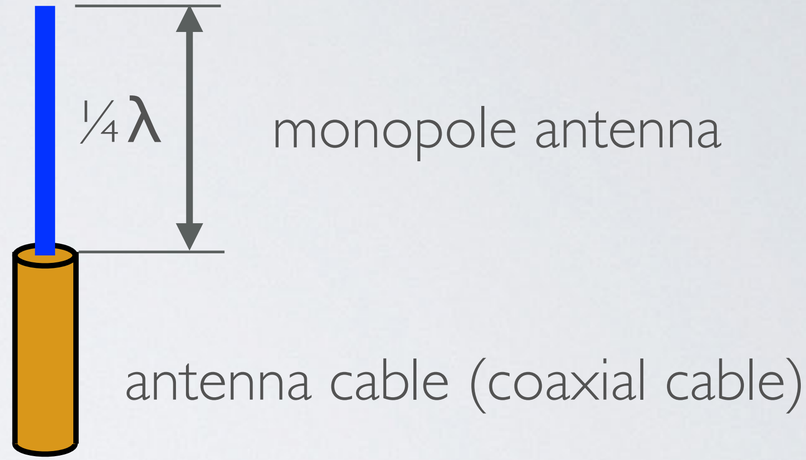


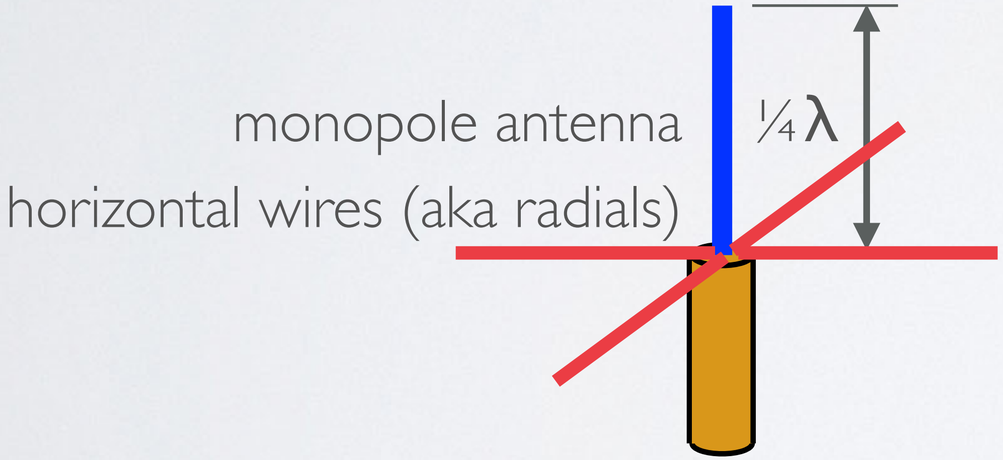


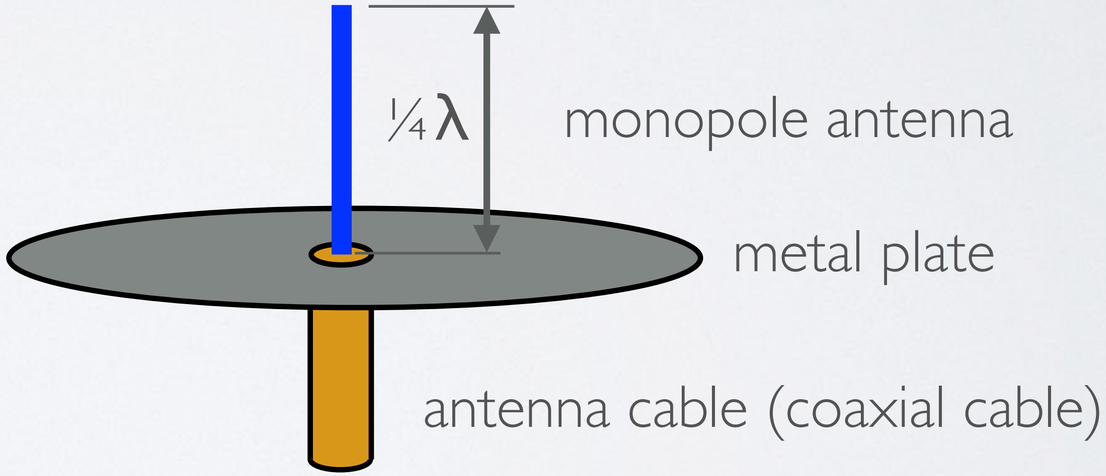
¼λ monopole antenna over perfect ground.

MONOPOLE ANTENNA

- By default a monopole antenna will perform poorly without the use of a ground plane.
- A ground plane can be a network of horizontal wires or a metal plate.

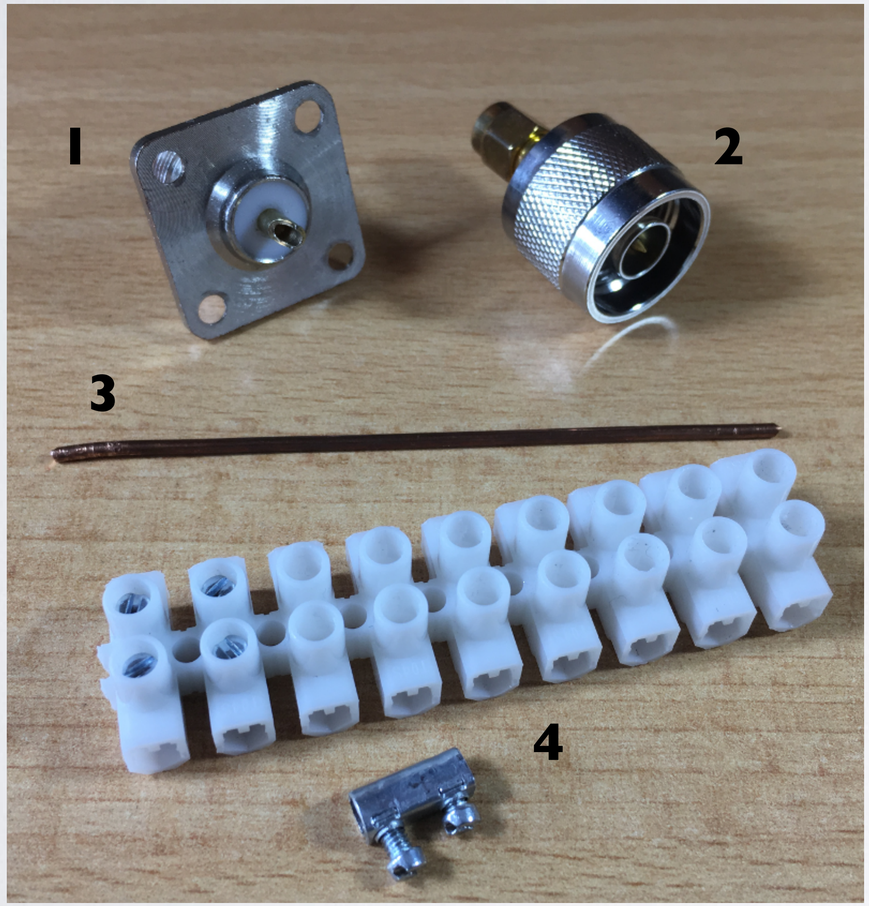






MONOPOLE ANTENNA WITHOUT GROUND PLANE

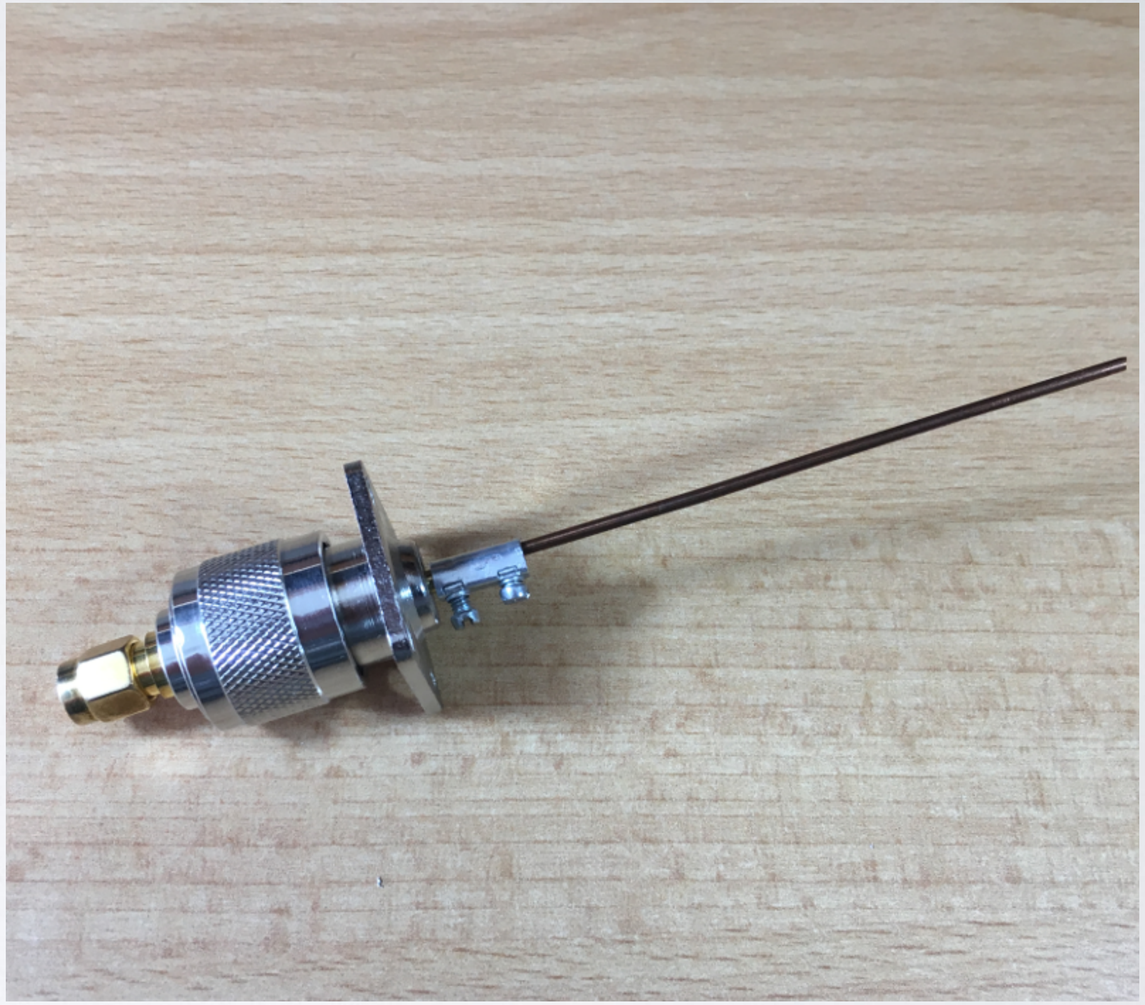
- For demonstration purpose I created a monopole antenna (868MHz) without using a ground plane.



1. Type N female chassis mount 4-hole connector
2. Type N male to RP-SMA male plug adapter coaxial cable connector
3. Copper wire (d=1.65 mm, length=86 mm)
   For f=868 MHz:
   Length = ¼λ = ¼ x 345.38 mm = 86 mm
   Note: I have not multiplied it with the VF=0.95 because the VSWR will still be > 2
4. Terminal strip block 1.5-4.0 mm^2

MONOPOLE ANTENNA WITHOUT GROUND PLANE

Assemble monopole antenna



Attach plug adapter

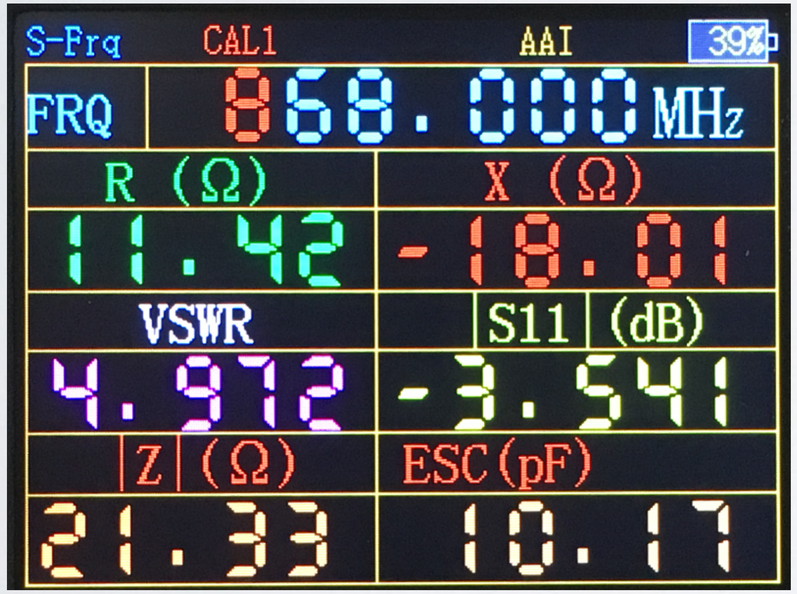
MONOPOLE ANTENNA WITHOUT GROUND PLANE

Measuring antenna parameters

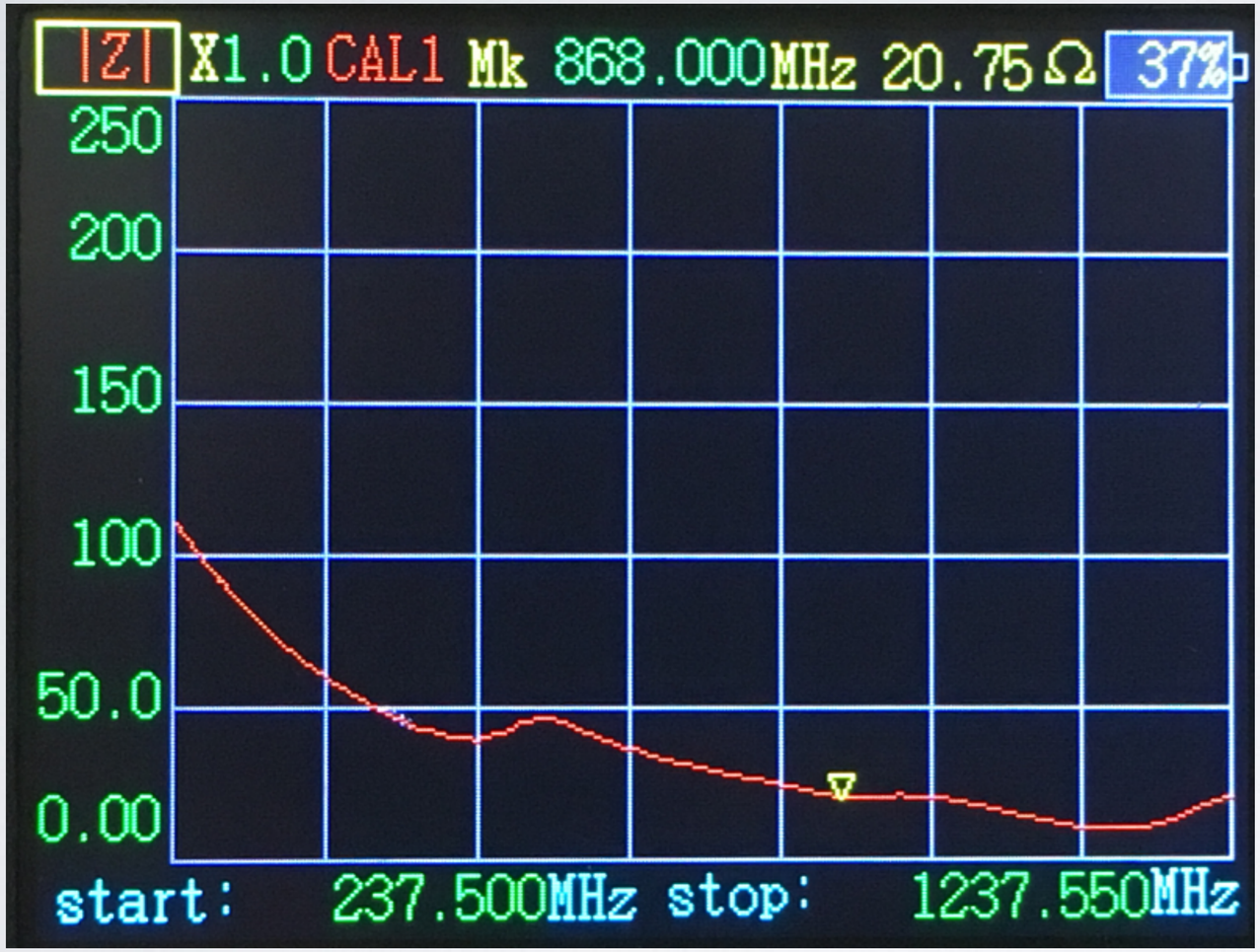
The antenna analyser with the ¼λ monopole antenna without ground plane.

MONOPOLE ANTENNA WITHOUT GROUND PLANE

- In **MY** situation I got the following results:
  VSWR ≈ 4.9 ⟵ Not good. Should be < 2
  Z ≈ 21Ω ⟵ Not good. Should be approx. 50Ω
  S11 ≈ -4 dB



MONOPOLE ANTENNA WITHOUT GROUND PLANE



ANTENNA TEST SETUP WITHOUT GROUND PLANE

- The monopole antenna, no ground plane, performance is compared with a sleeve dipole antenna. More information about sleeve dipole antennas, see tutorial 43.

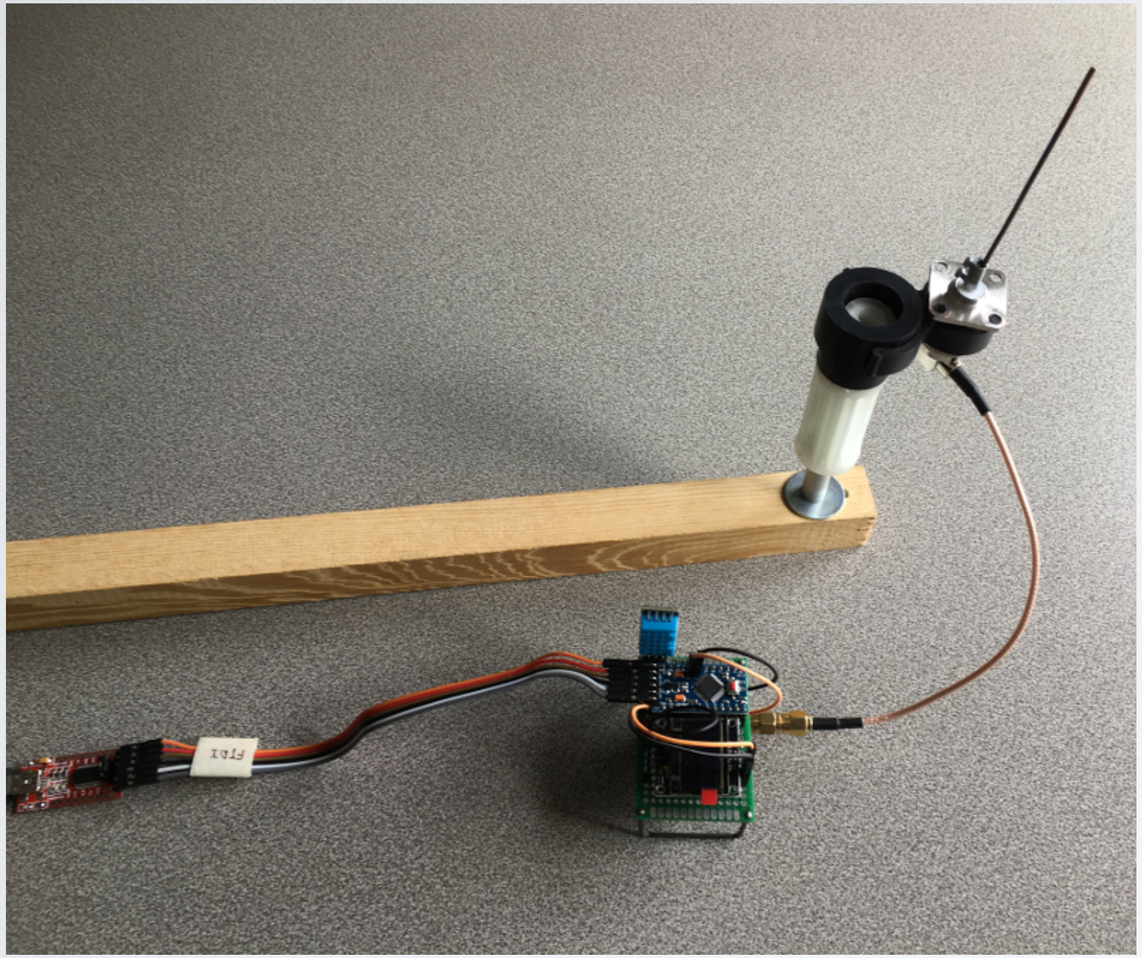
- For this test I am using the end node and antenna C as demonstrated in tutorial 33.

- More information about this end node, see: https://www.mobilefish.com/developer/lorawan/lorawan_quickguide_build_lora_node_rfm95_arduino_pro_mini.html

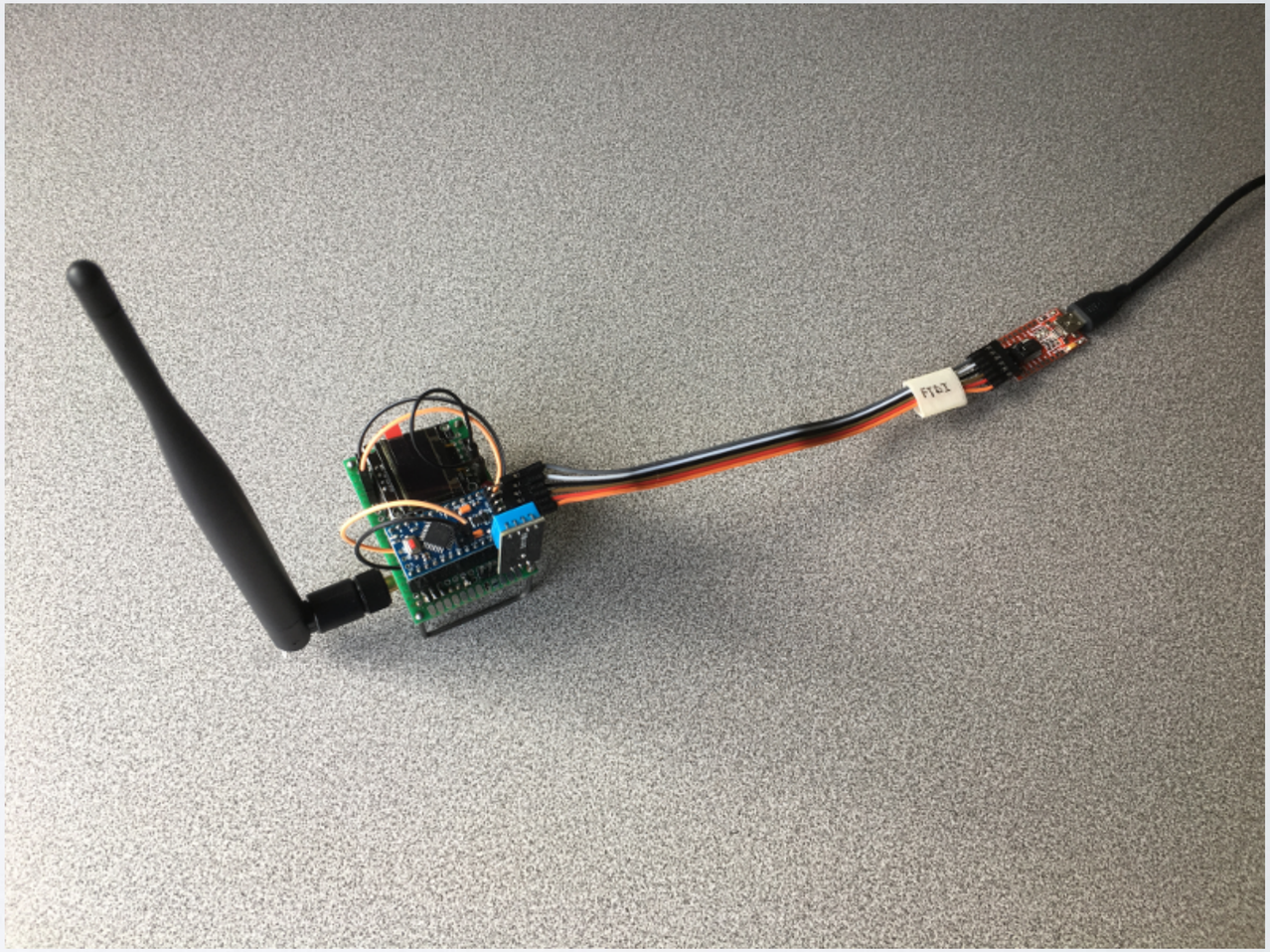
- The end node uses the MCCI LoRaWAN LMIC Library: https://github.com/mcci-catena/arduino-lmic

- The end node uses the following sketch: https://www.mobilefish.com/download/lora/ttn-otaa-pro-mini-sensors.ino.txt

ANTENNA TEST SETUP WITHOUT GROUND PLANE

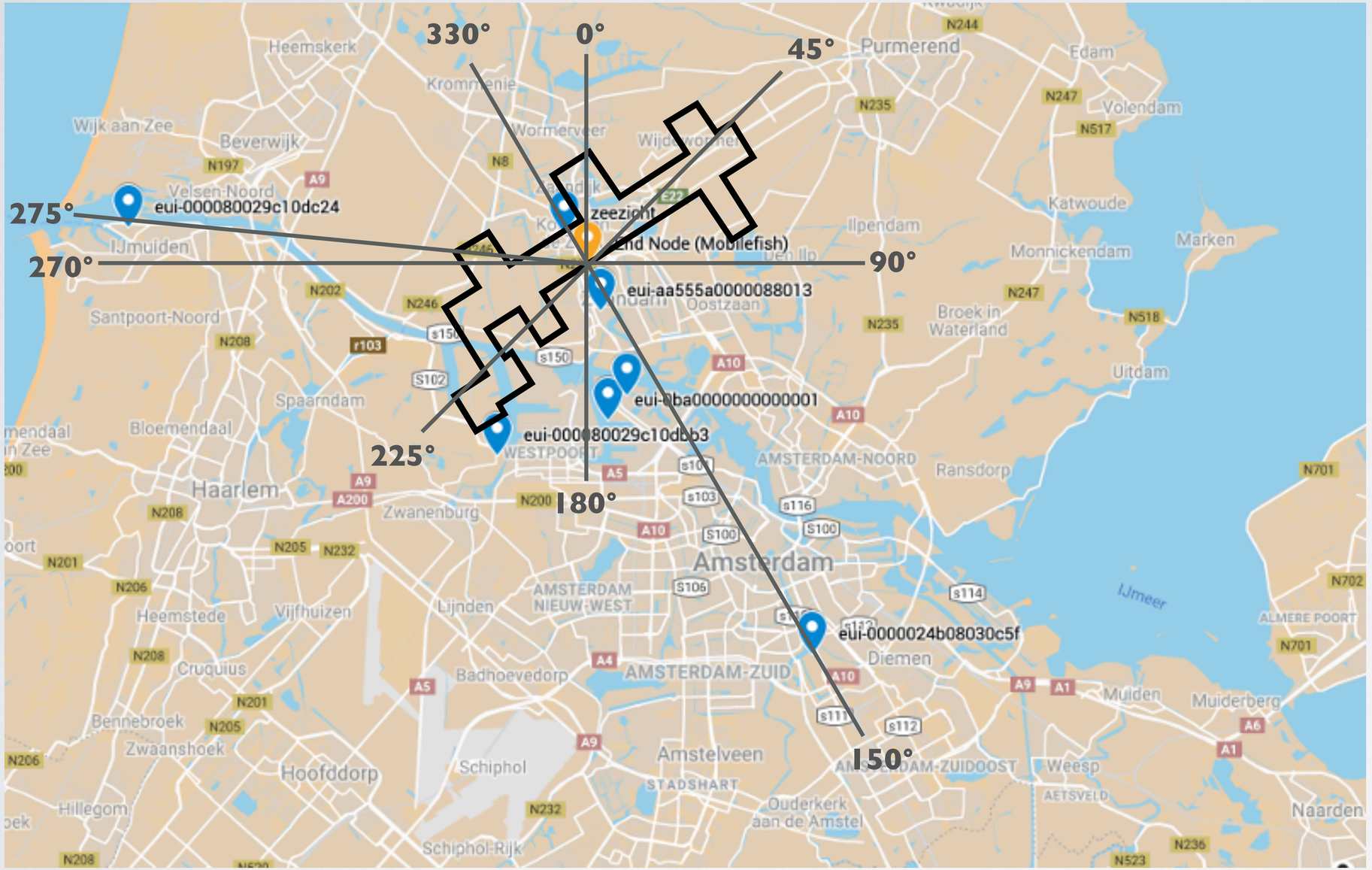


¼λ monopole with no ground plane and end node connected by a coax cable



Sleeve dipole and end node

ANTENNA TEST SETUP WITHOUT GROUND PLANE



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

ANTENNA TEST SETUP WITHOUT GROUND PLANE

- I have NOT modified the end node transmission power when using the ¼λ monopole antenna without ground plane.

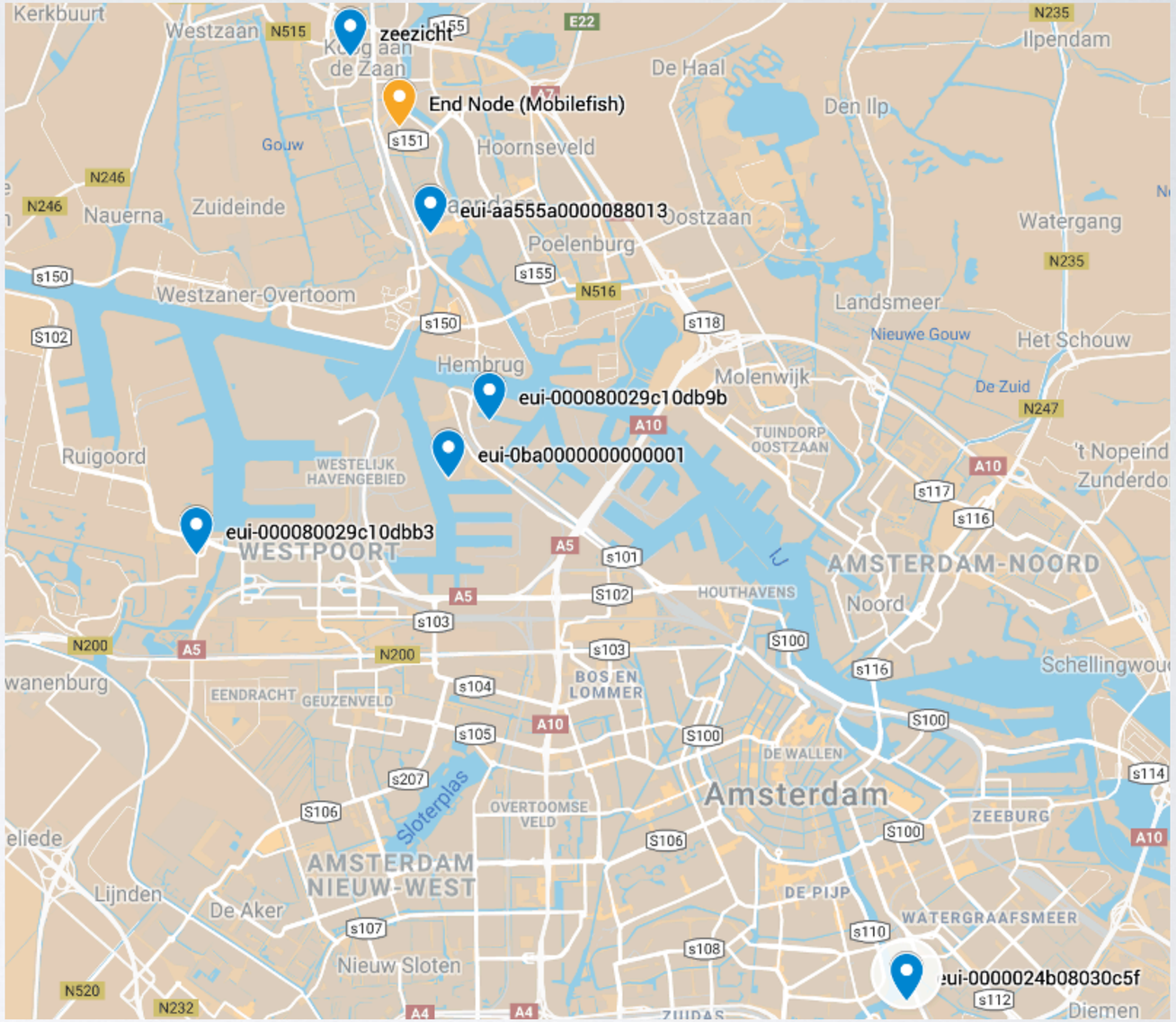
- In my area there are several gateways and I know that these gateways, which are connected to The Things Network, can receive my transmitted data.

- The ¼λ monopole antenna without ground plane is attached to an end node at location A and transmits data. I have done the same with a sleeve dipole antenna. In both cases two messages per minute were transmitted.

- The logged data can be found at: https://www.mobilefish.com/download/lora/monopole_test_results.txt

ANTENNA TEST RESULTS WITHOUT GROUND PLANE

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



ANTENNA TEST RESULTS WITHOUT GROUND PLANE

- End node tx power = 14 dBm
  Data from: monopole_test_results.txt

Gateway	Distance from end device [km]	Altitude [m]	¼λ monopole no ground plane Average RSSI [dBm]	Sleeve dipole Average RSSI [dBm]
eui-aa555a0000088013	1.57	42	-119.5	-118.1

ANTENNA TEST RESULTS WITHOUT GROUND PLANE

- If you only look at the results you may notice there is no significant difference in the average RSSI values.

- But if you look at the time it took to receive 15 messages there is a difference.

- When using the monopole antenna without ground plane it took 36 minutes to receive 15 messages.
  When using the sleeve dipole antenna, which is my reference antenna, it took 10 minutes to receive 15 messages.

- The Arduino sketch is configured to transmit 2 messages per minute. In a perfect situation it should take 7.5 to 8 minutes to receive these 15 messages.

ANTENNA TEST RESULTS WITHOUT GROUND PLANE

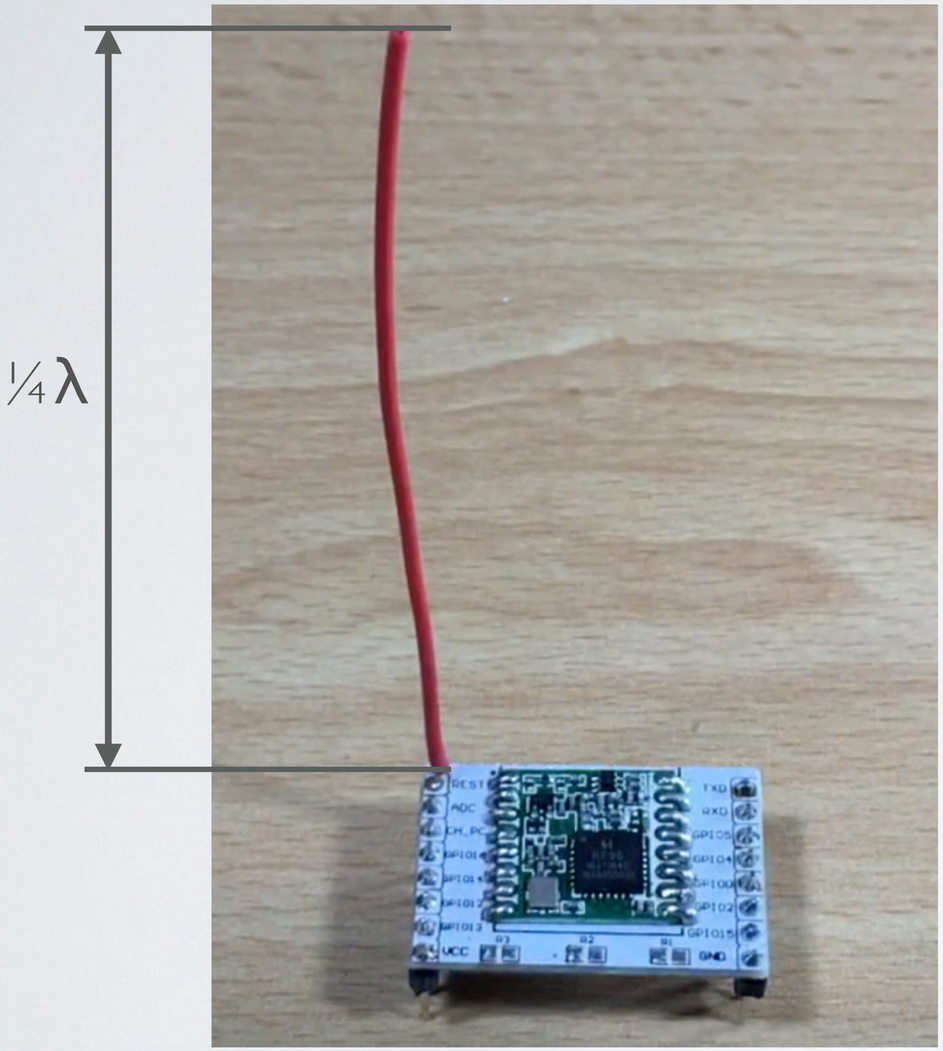
time	counter	port						
15:22:46	51	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
15:22:10	50	1	dev id: youtube_demo_device	payload: 0A 28 09 C4	humidity: 26	temperature: 25
15:20:57	48	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
15:19:43	46	1	dev id: youtube_demo_device	payload: 0A 28 09 C4	humidity: 26	temperature: 25
15:17:17	42	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
15:15:26	39	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
15:14:13	37	1	dev id: youtube_demo_device	payload: 0A 28 09 C4	humidity: 26	temperature: 25
15:11:49	33	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
15:11:12	32	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
14:57:13	9	1	dev id: youtube_demo_device	payload: 0A 8C 09 C4	humidity: 27	temperature: 25
14:52:23	1	1	dev id: youtube_demo_device	payload: 0C 80 09 C4	humidity: 32	temperature: 25
14:51:46	0	1	dev id: youtube_demo_device	payload: 0DAC 09 60	humidity: 35	temperature: 24

Many lost messages, see counter.

ANTENNA TEST RESULTS WITHOUT GROUND PLANE

- So looking at the results I can conclude that the sleeve dipole antenna performs much better than my self build monopole antenna without ground plane.

MONOPOLE ANTENNA WITHOUT GROUND PLANE



LoRa module with a monopole antenna.
It lacks a good ground plane.
The module itself is used as the ground plane, which is not perfect!

The antenna performance will not be good.

MONOPOLE ANT. WITH GROUND PLANE (METAL PLATE)

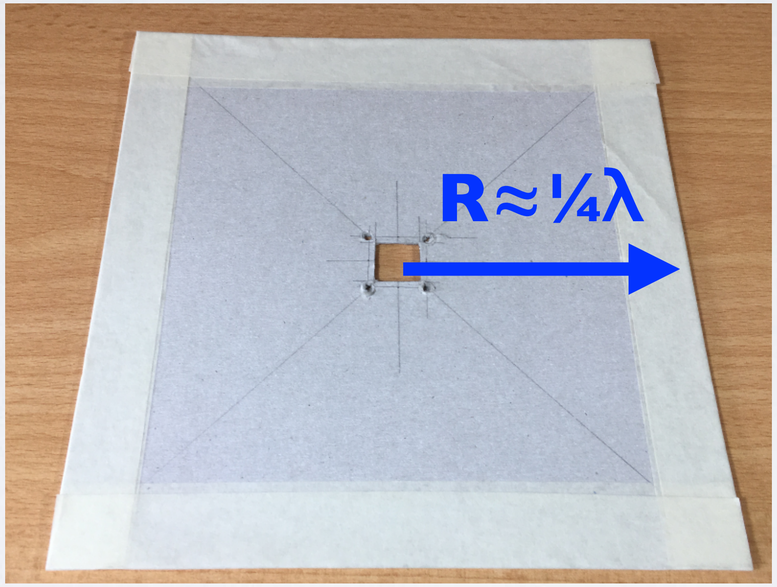
- For demonstration purpose I created a monopole antenna (868 MHz) using two different size ground planes.

- Ground plane A consists of a cardboard, size 181 mm x 181 mm and 4 layers of household aluminium foil taped to the cardboard (Radius ≈ ¼λ).

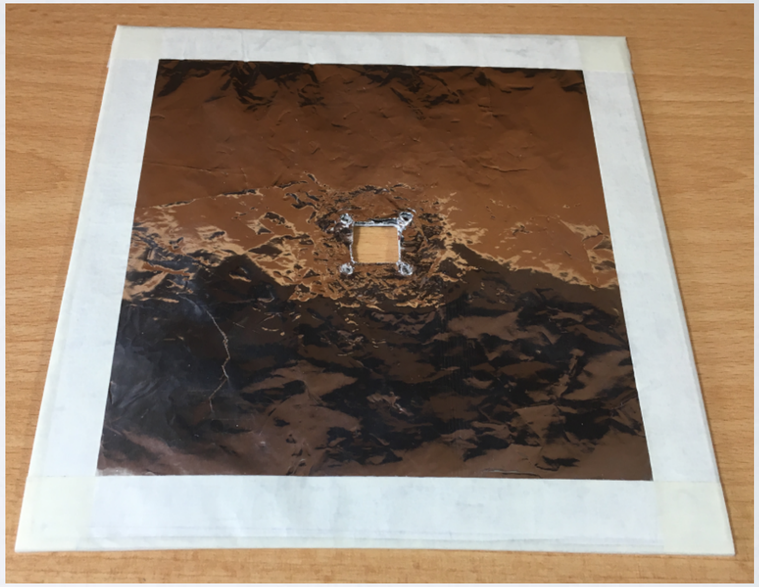
- Ground plane B consists of a cardboard, size 335 mm x 369 mm and 4 layers of household aluminium foil taped to the cardboard (Radius ≈ ½λ).

GROUND PLANE A

Aluminium foil

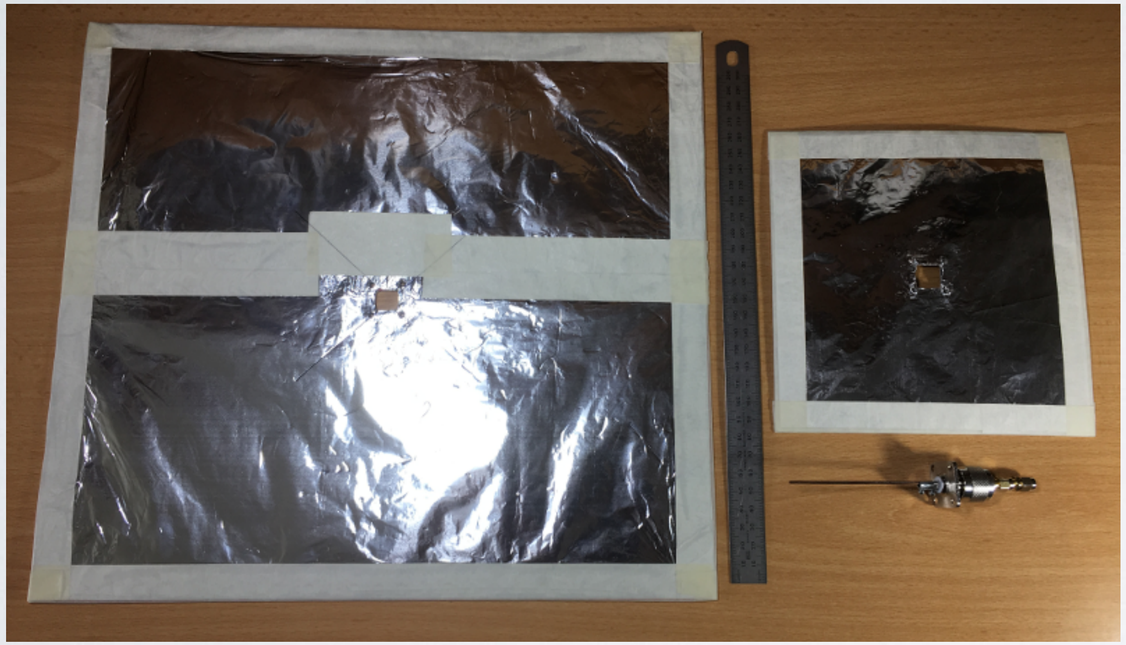


Card board 181 x 181 mm top



Card board + alu foil bottom

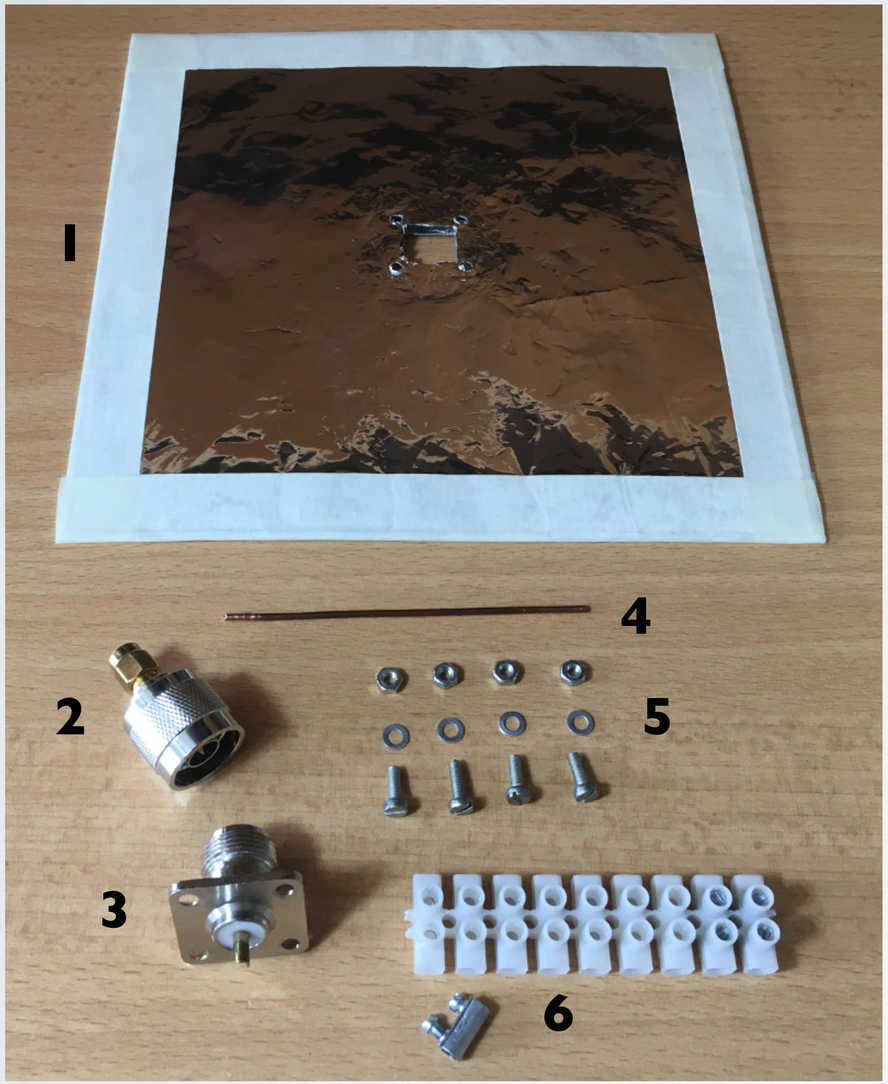
GROUND PLANE B



Ground plane B and A

Ground plane B size 335 mm x 369 mm

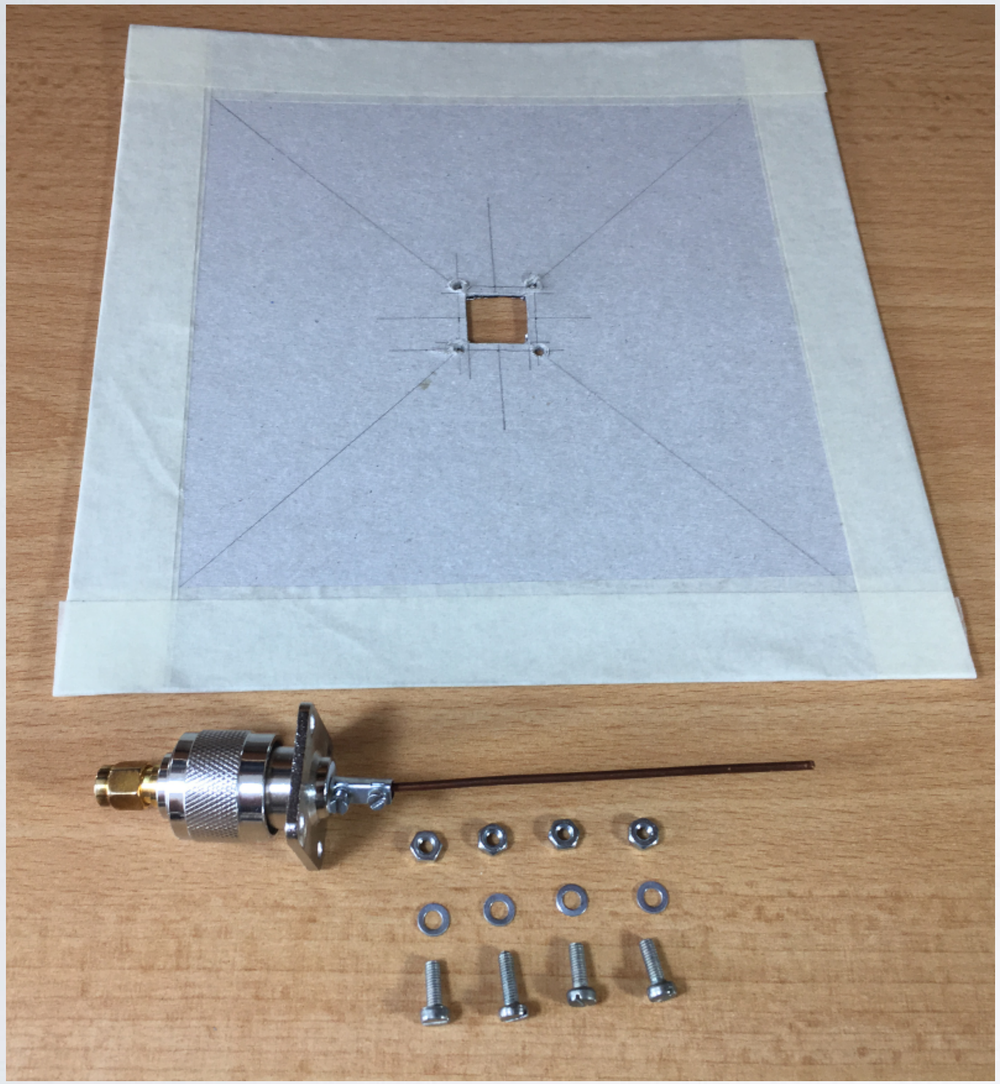
MONOPOLE ANTENNA WITH GROUND PLANE A



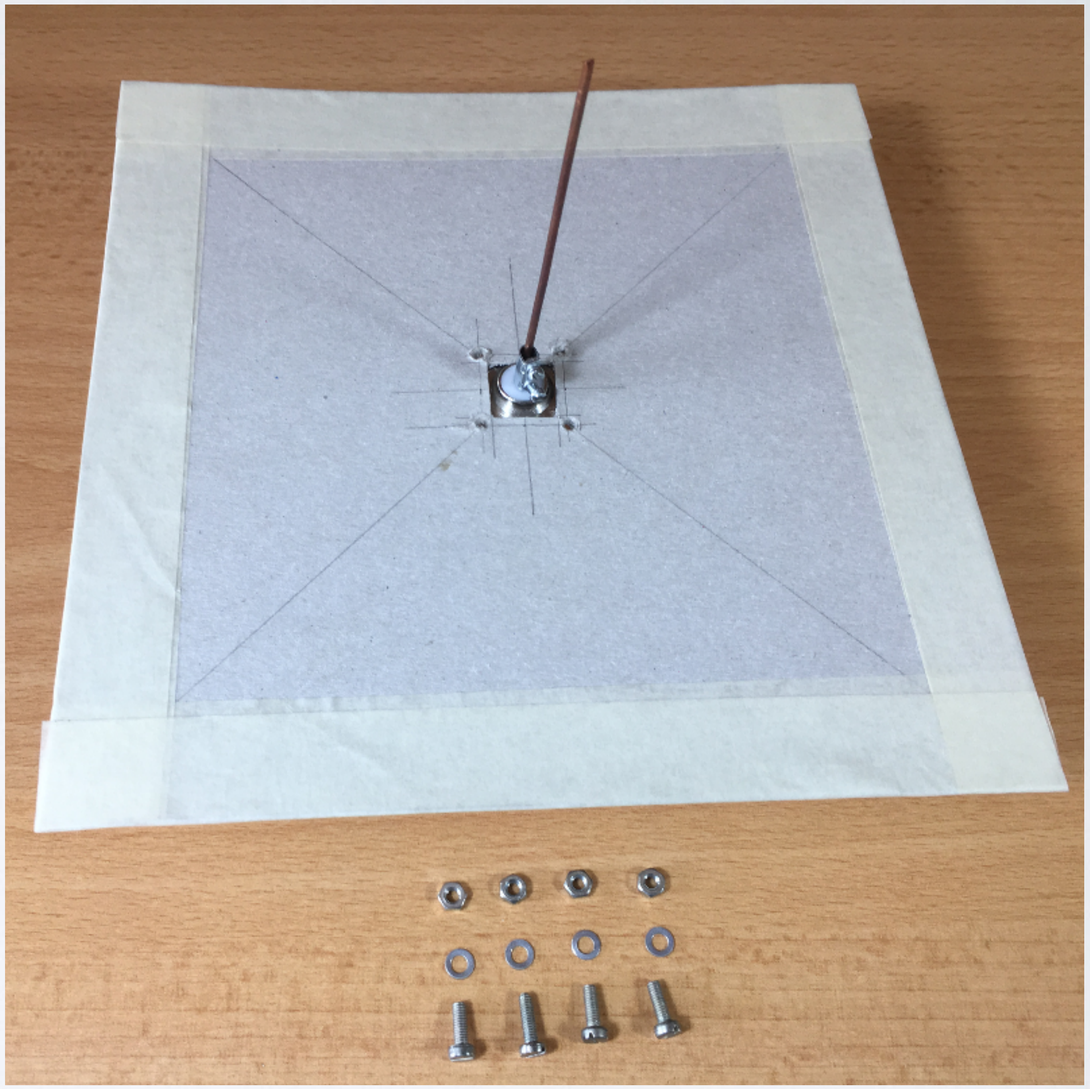
All components

1. Ground plane A
2. Type N male to RP-SMA male plug adapter coaxial cable connector
3. Type N female chassis mount 4-hole connector
4. Copper wire (d=1.65 mm, length=86 mm) For 868 MHz
5. Bolts, nuts and metal washers (4x)
6. Terminal strip block 1.5-4.0 mm^2

MONOPOLE ANTENNA WITH GROUND PLANE A

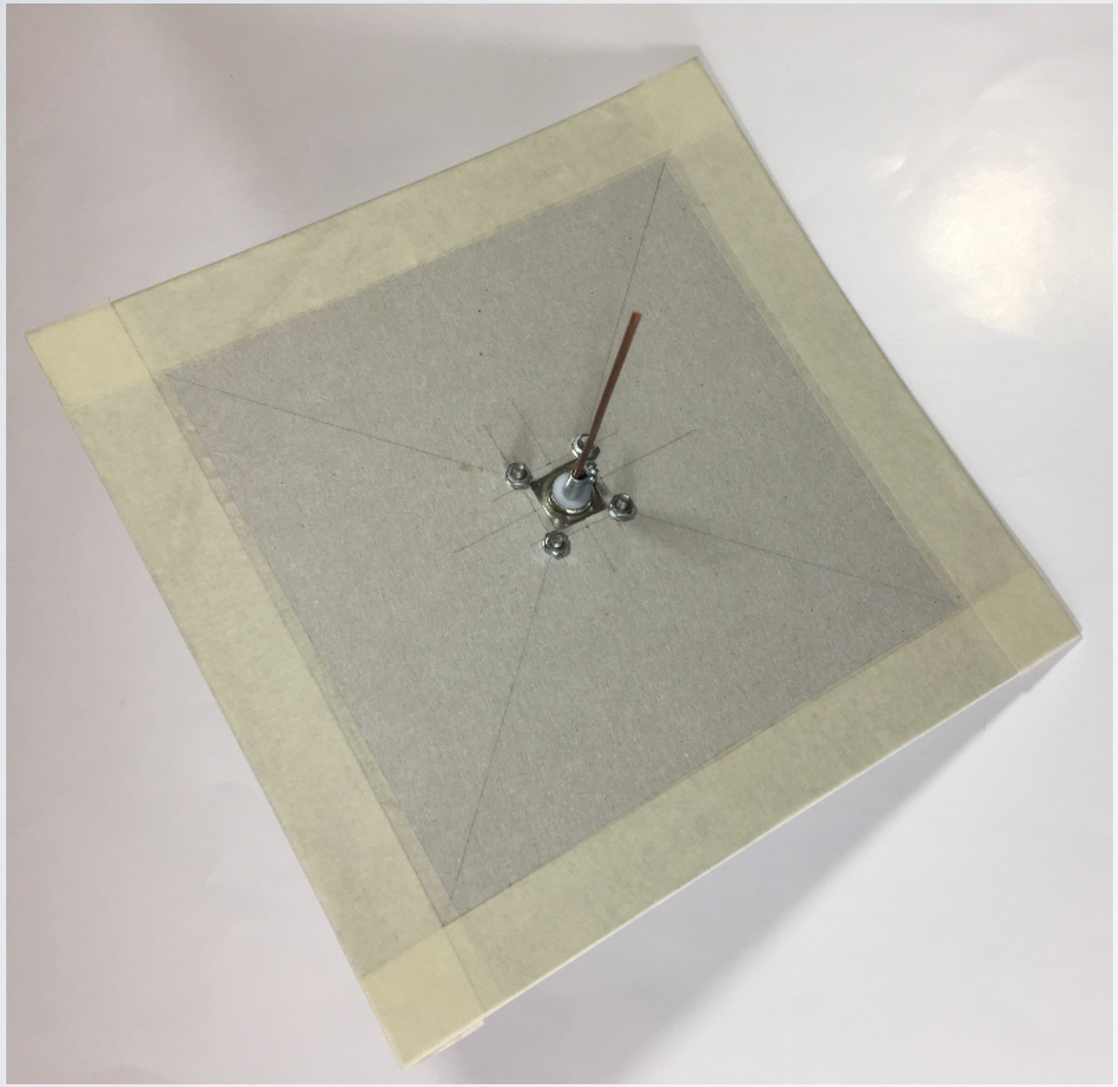


Monopole + Ground plane A



Monopole + Ground plane A

MONOPOLE ANTENNA WITH GROUND PLANE A



Monopole + Ground plane A

Monopole + N1201SA

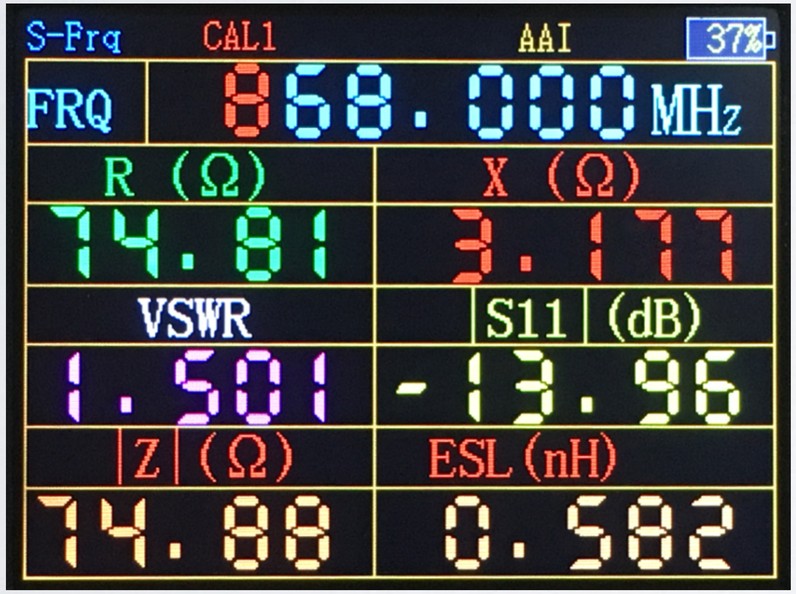
MONOPOLE ANTENNA WITH GROUND PLANE A

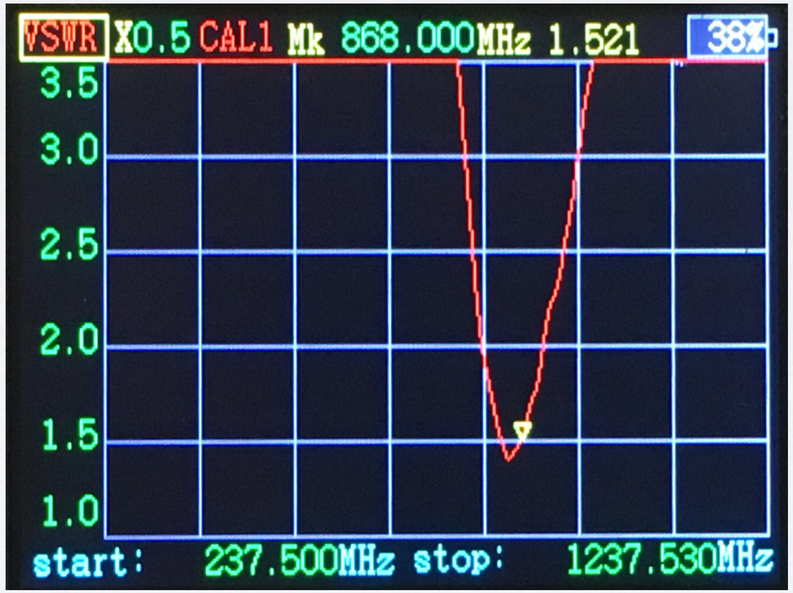
Measuring antenna parameters

The antenna analyser with the monopole antenna and ground plane A.

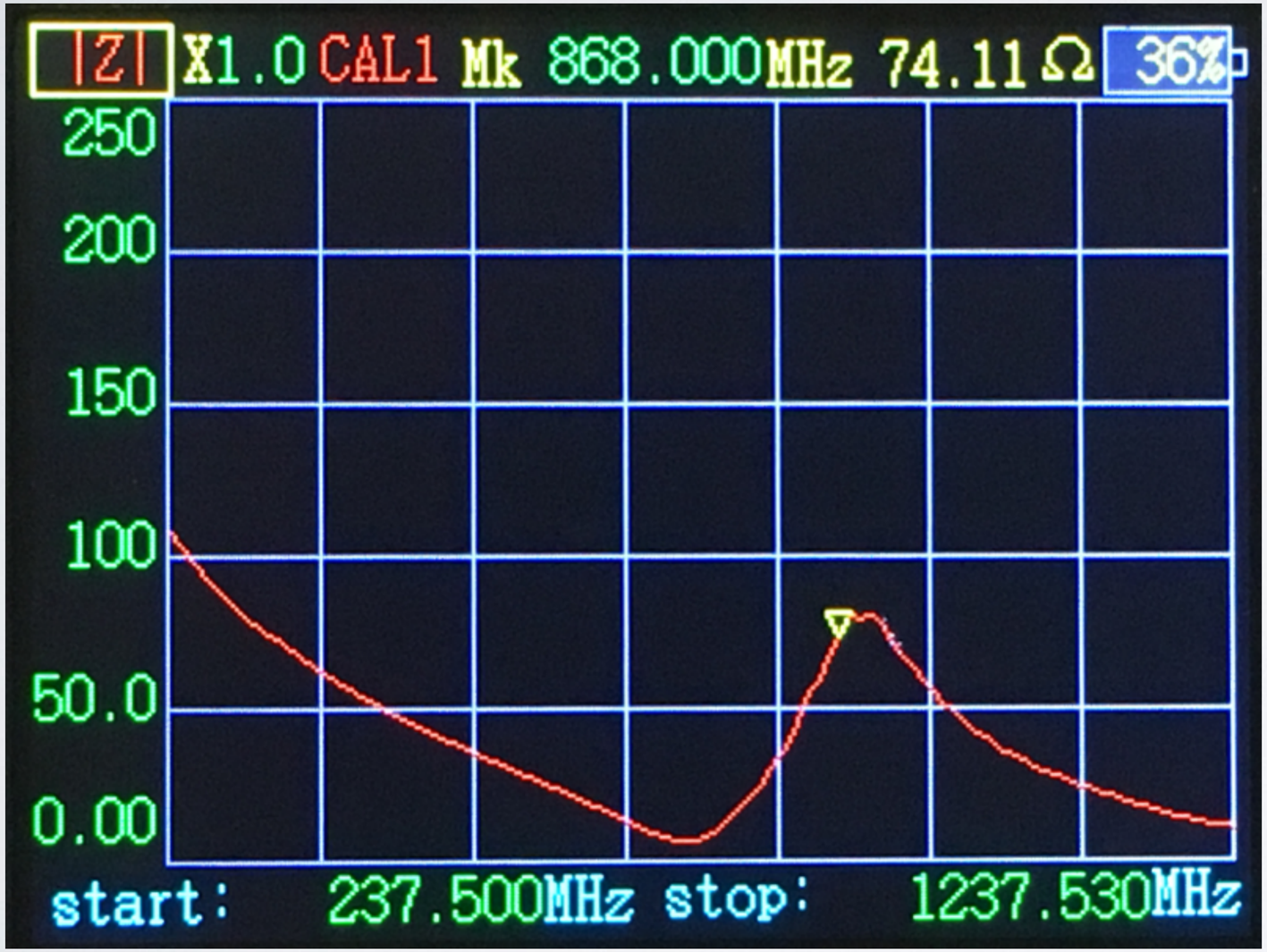
MONOPOLE ANTENNA WITH GROUND PLANE A

- In **MY** situation I got the following results:
  VSWR ≈ 1.5 ⟵ Good. It is < 2
  Z ≈ 75Ω ⟵ Not good. Should be approx. 50Ω
  S11 ≈ -14 dB

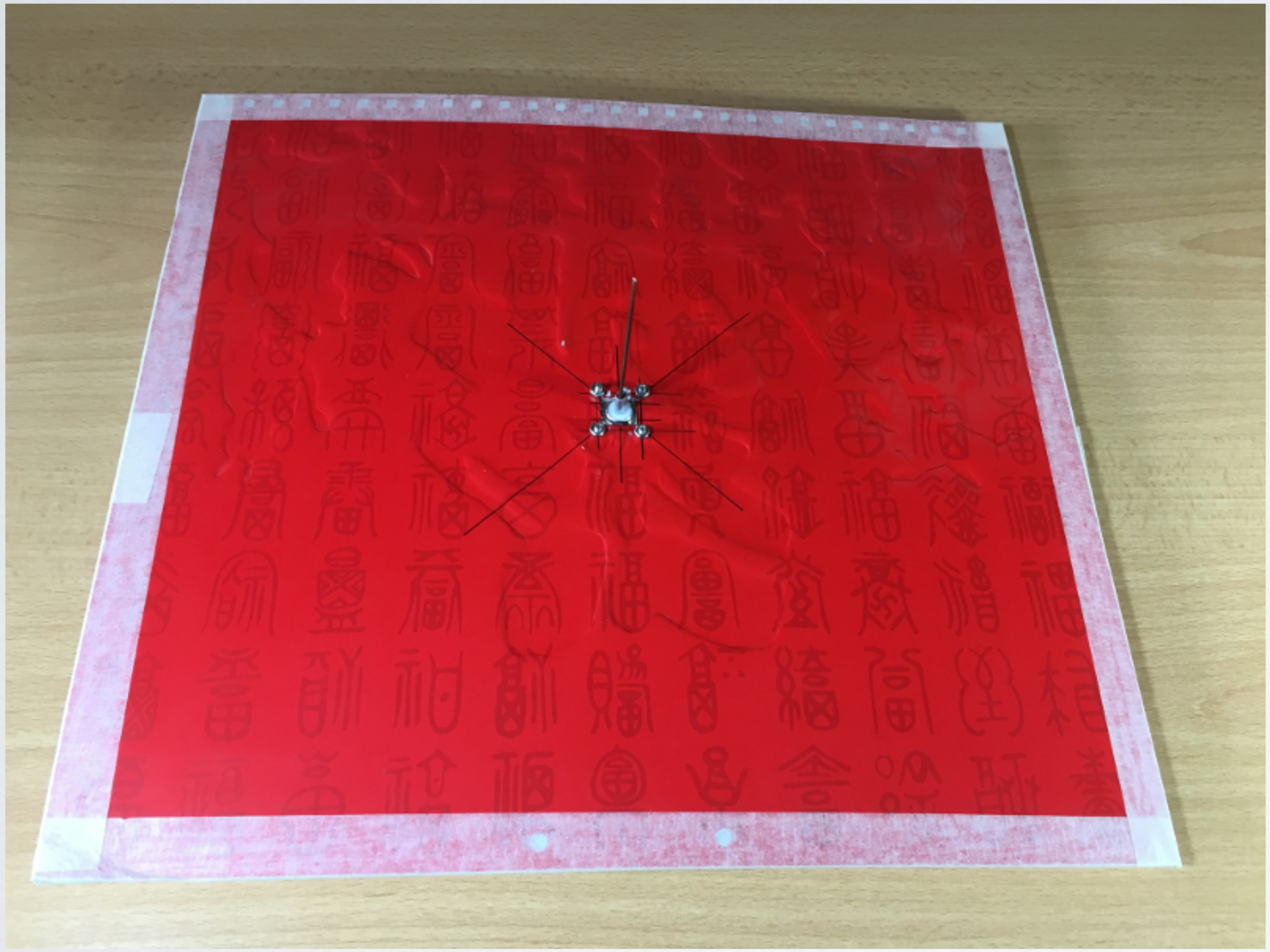




MONOPOLE ANTENNA WITH GROUND PLANE A



MONOPOLE ANTENNA WITH GROUND PLANE B



Monopole + Ground plane B

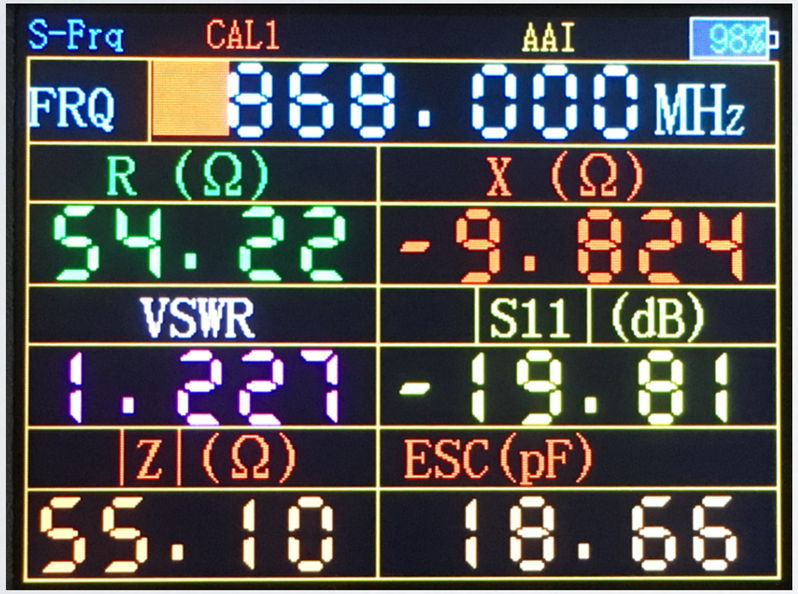
MONOPOLE ANTENNA WITH GROUND PLANE B

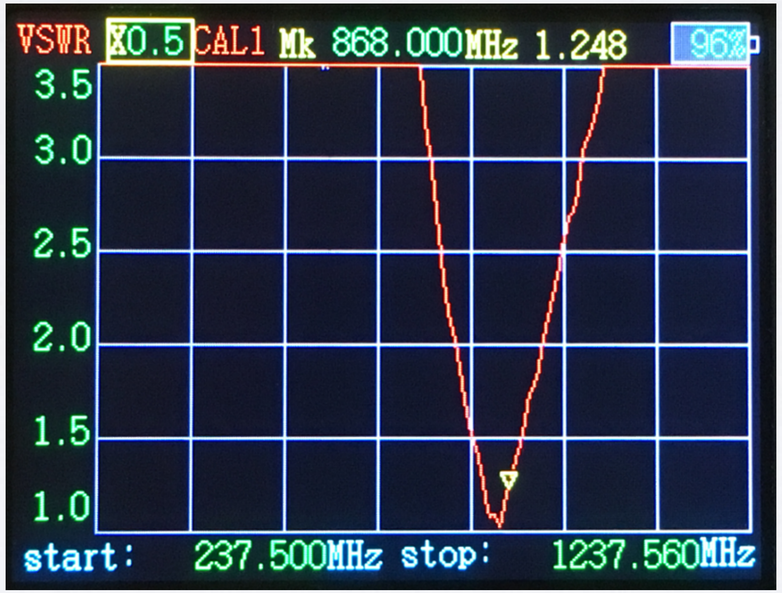
Measuring antenna parameters

The antenna analyser with the monopole antenna and ground plane B.

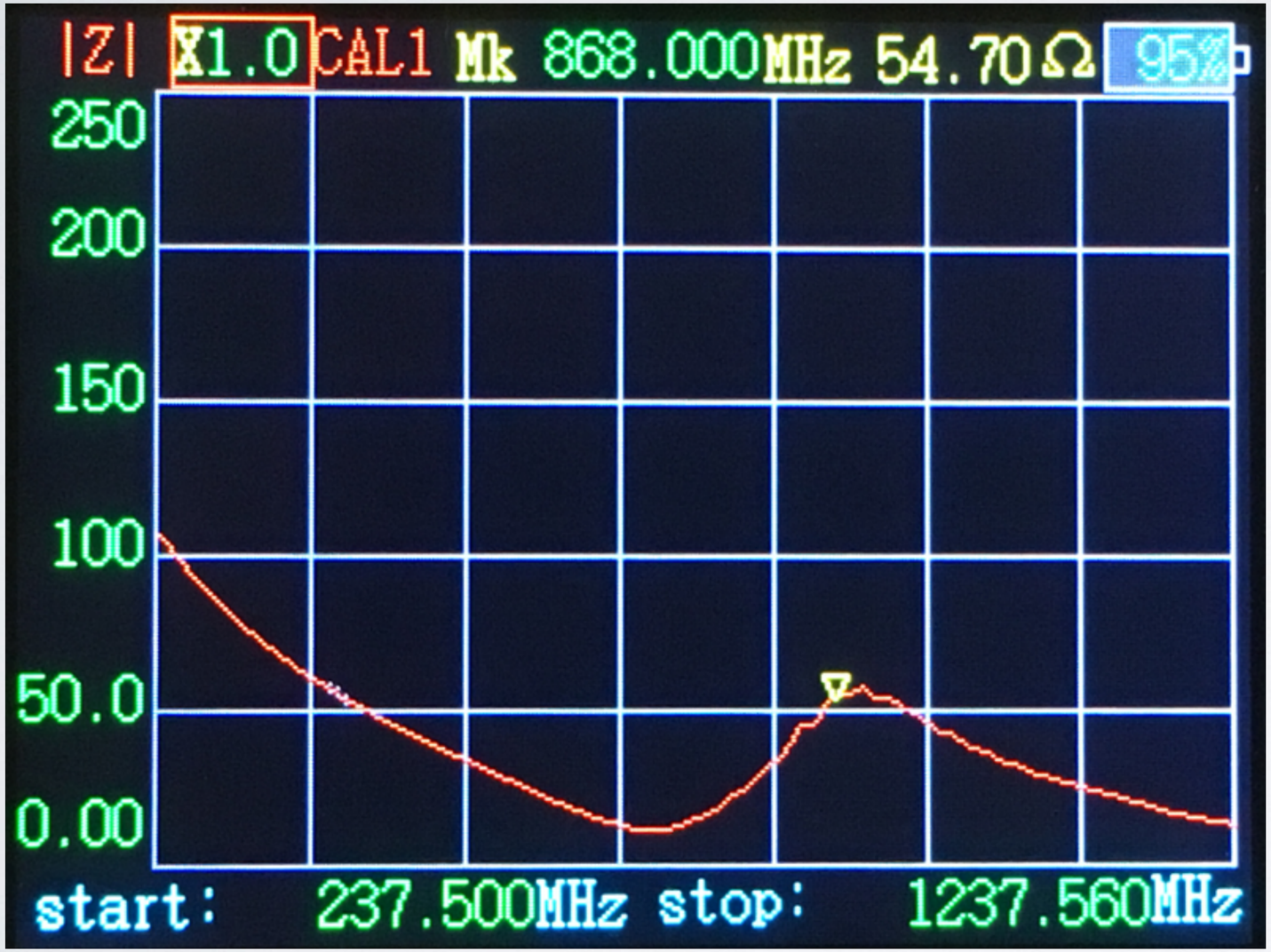
MONOPOLE ANTENNA WITH GROUND PLANE B

- In **MY** situation I got the following results:
  VSWR ≈ 1.2 ⟵ Good. It is < 2
  Z ≈ 55Ω ⟵ Good. Should be approx. 50Ω
  S11 ≈ -20 dB





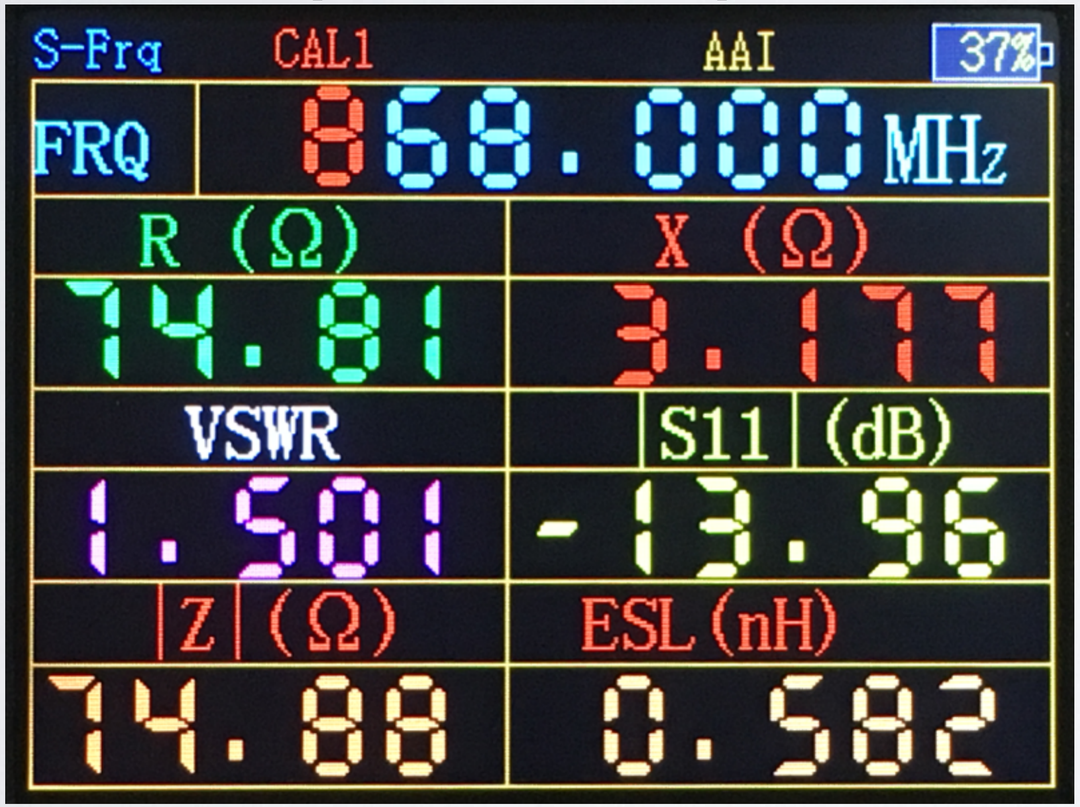
MONOPOLE ANTENNA WITH GROUND PLANE B



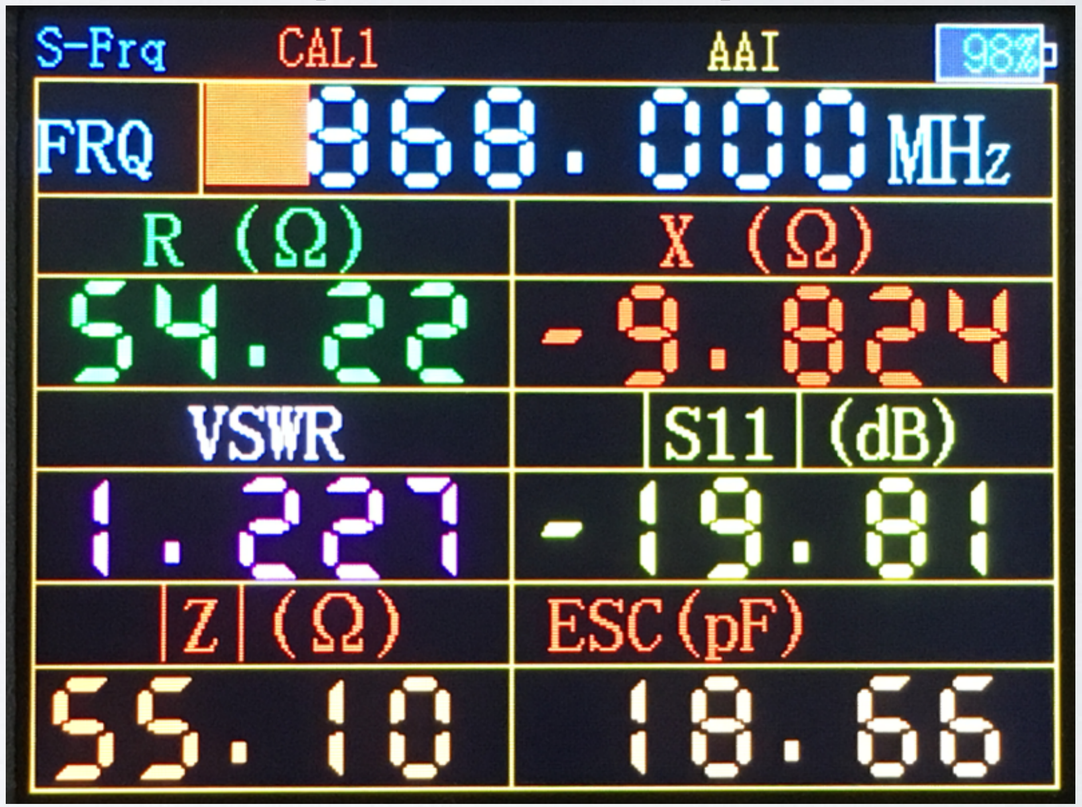
MONOPOLE ANTENNA WITH GROUND PLANE

- Using ground plane A, R≈¼λ, the VSWR ≈ 1.5, Z ≈ 75Ω
  Using ground plane B, R≈½λ the VSWR ≈ 1.2, Z ≈ 55Ω

Monopole + Ground plane A



Monopole + Ground plane B



MONOPOLE ANTENNA WITH GROUND PLANE

- If the ground plane radius is greater than 1/2 wavelength the antenna performance is close to that of an infinite ground plane. In these cases the ¼λ monopole antenna has the best performance.

- Antenna performance is significant reduced when the ground plane radius is a 1/4 wavelength or less.

ANTENNA TEST SETUP WITH GROUND PLANE A

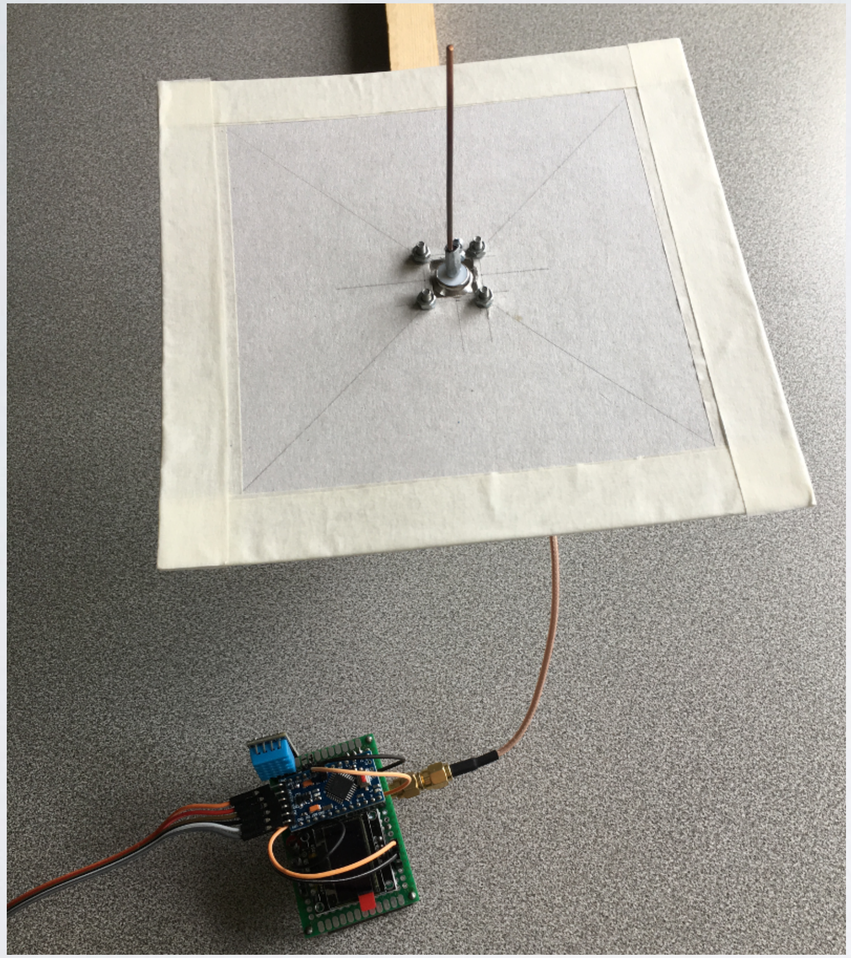
- I have NOT modified the end node transmission power when using the ¼λ monopole antenna with ground plane A.

- 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.

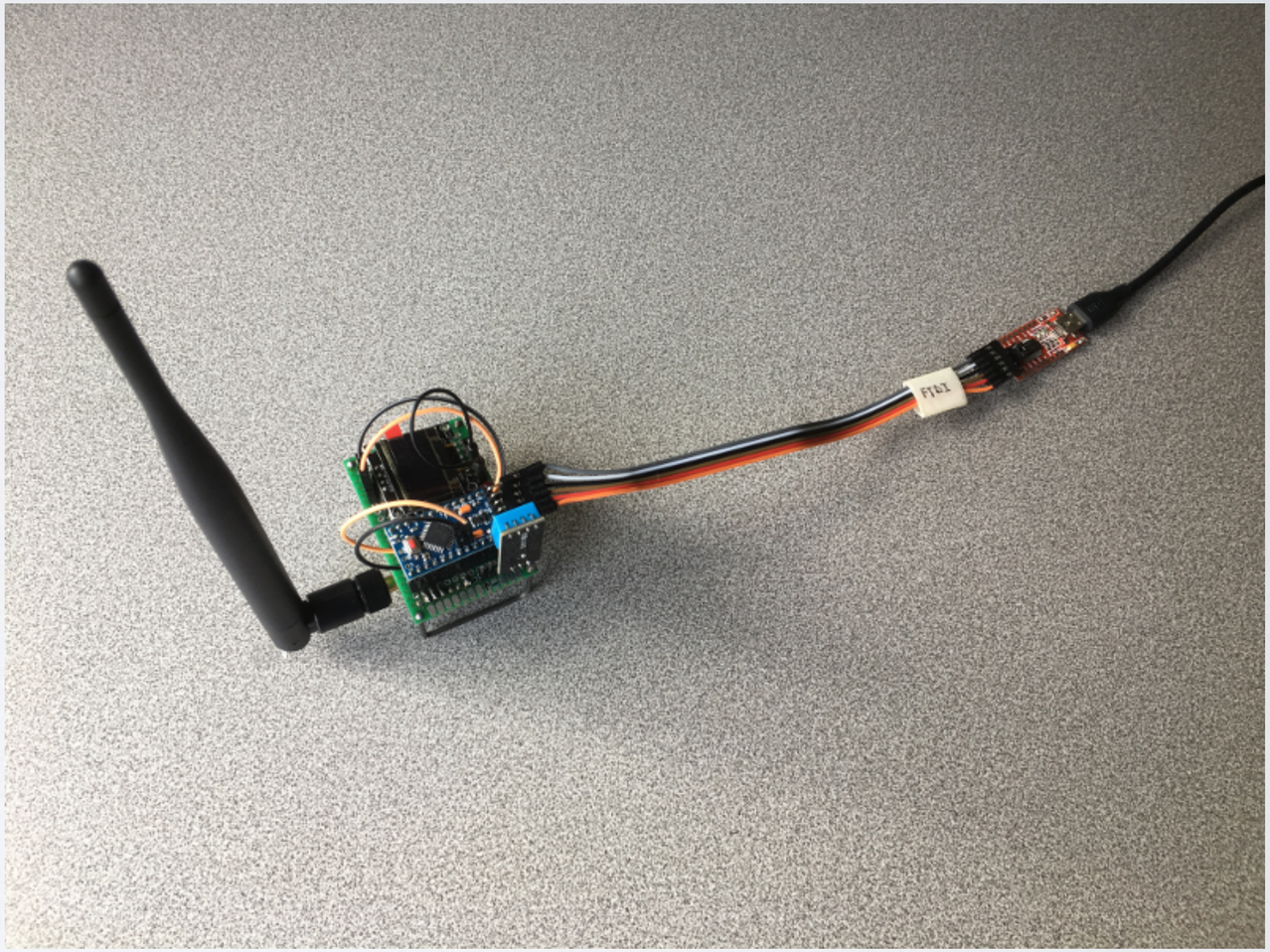
- The ¼λ monopole antenna with ground plane A is attached to an end node at location A and transmits data. I have done the same with a sleeve dipole antenna. In both cases two messages per minute were transmitted.

- The logged data can be found at:
https://www.mobilefish.com/download/lora/monopole_test_results.txt

ANTENNA TEST SETUP WITH GROUND PLANE A



Monopole with ground plane A + end node



Sleeve dipole + end node

ANTENNA TEST RESULTS WITH GROUND PLANE A

- End node tx power = 14 dBm

Gateway	Distance from end device [km]	Altitude [m]	monopole with ground plane A Average RSSI [dBm]	Sleeve dipole Average RSSI [dBm]
eui-aa555a0000088013	1.57	42	**-118.8**	**-118.1**
eui-000080029c10dc24	14.7	45	-120 *	-120.3 *
eui-000080029c10db9b	4.36	30	-119 *	-120 *

* Only one or few measurements. I will ignore these results.

ANTENNA TEST RESULTS WITH GROUND PLANE A

- If you only look at the results you may notice there is no significant difference in the average RSSI values.

- But if you look at the time it took to receive 15 messages there is a difference.

- When using the monopole antenna with ground plane A it took 38 minutes to receive 15 messages.
  When using the sleeve dipole antenna, which is my reference antenna, it took 10 minutes to receive 15 messages.

- The Arduino sketch is configured to transmit 2 messages per minute. In a perfect situation it should take 7.5 to 8 minutes to receive these 15 messages.

ANTENNA TEST RESULTS WITH GROUND PLANE A

- So looking at the results I can conclude that the sleeve dipole antenna performs much better than my self build monopole antenna with ground plane A (radius ≈ ¼λ).

ANTENNA TEST RESULTS WITH GROUND PLANE A

time	counter	port						
16:07:05	19	1	dev id: youtube demo device	payload: 0A 28 09 60	humidity: 26	temperature: 24
16:06:27	18	1	dev id: youtube demo device	payload: 0A 28 09 60	humidity: 26	temperature: 24
16:05:15	16	1	dev id: youtube demo device	payload: 09 C4 09 60	humidity: 25	temperature: 24
16:04:38	15	1	dev id: youtube demo device	payload: 0A 8C 09 60	humidity: 27	temperature: 24
16:04:01	14	1	dev id: youtube demo device	payload: 0A 8C 09 60	humidity: 27	temperature: 24
16:02:46	12	1	dev id: youtube demo device	payload: 0A 28 09 60	humidity: 26	temperature: 24
16:02:10	11	1	dev id: youtube demo device	payload: 0A 28 09 60	humidity: 26	temperature: 24
16:01:35	10	1	dev id: youtube demo device	payload: 0A 8C 09 60	humidity: 27	temperature: 24
16:00:59	9	1	dev id: youtube demo device	payload: 09 C4 09 60	humidity: 25	temperature: 24
15:59:45	7	1	dev id: youtube demo device	payload: 09 C4 09 C4	humidity: 25	temperature: 25
15:57:20	3	1	dev id: youtube demo device	payload: 09 C4 09 C4	humidity: 25	temperature: 25
15:55:30	0	1	dev id: youtube demo device	payload: 0DAC 09 C4	humidity: 35	temperature: 25

Many lost messages, see counter.

ANTENNA TEST SETUP WITH GROUND PLANE B

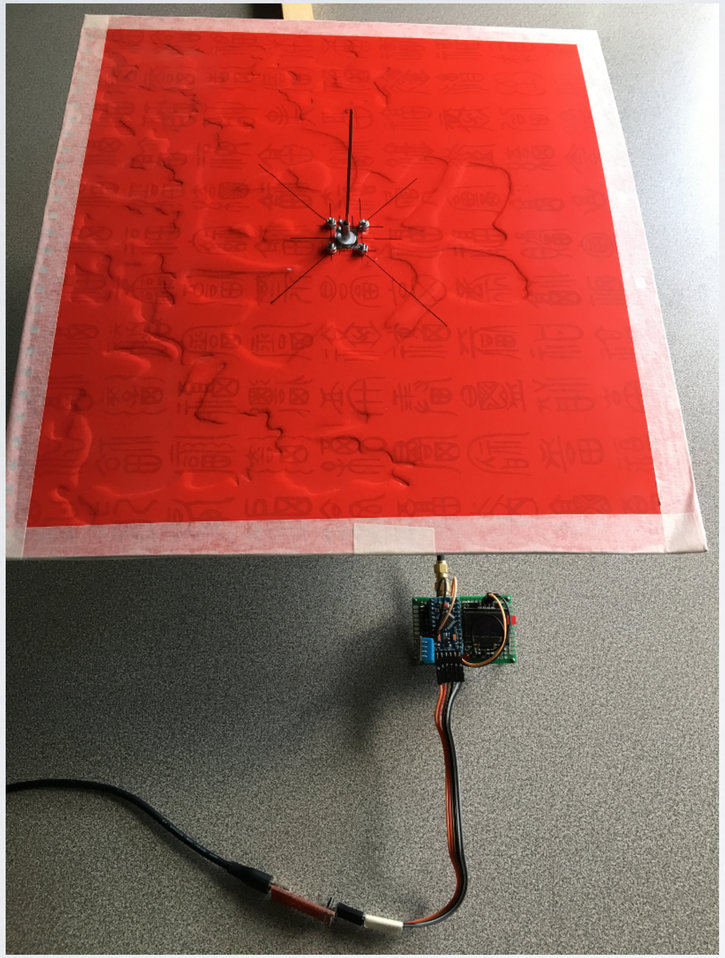
- I have NOT modified the end node transmission power when using the monopole antenna with ground plane B.

- 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.

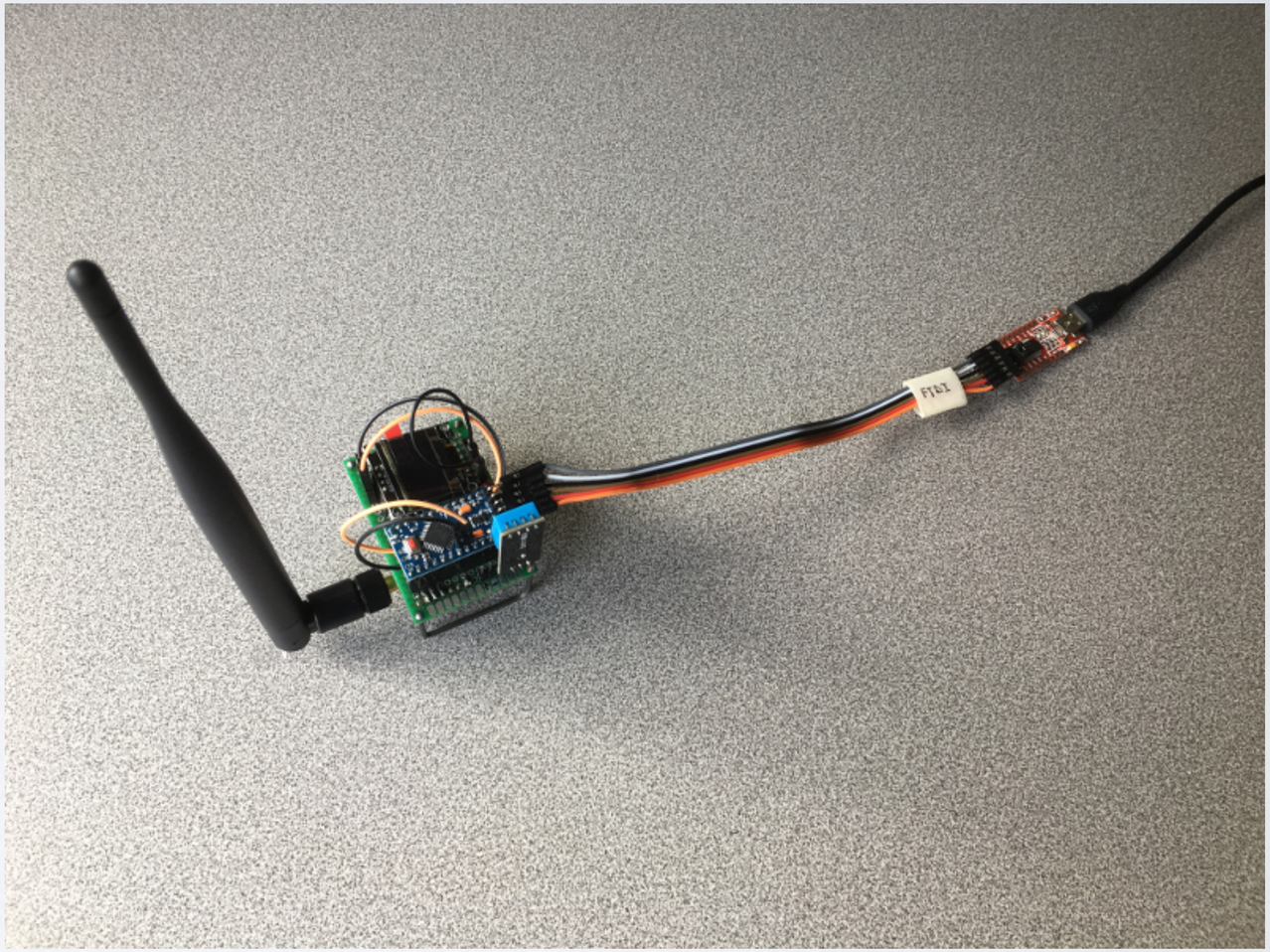
- The ¼ λ monopole antenna with ground plane B is attached to an end node at location A and transmits data. I have done the same with a sleeve dipole antenna. In both cases two messages per minute were transmitted.

- The logged data can be found at:
https://www.mobilefish.com/download/lora/monopole_test_results.txt

ANTENNA TEST SETUP WITH GROUND PLANE B



Monopole with ground plane B + end node



Sleeve dipole + end node

ANTENNA TEST RESULTS WITH GROUND PLANE B

- End node tx power = 14 dBm

Gateway	Distance from end device [km]	Altitude [m]	monopole with ground plane B Average RSSI [dBm]	Sleeve dipole Average RSSI [dBm]
eui-aa555a0000088013	1.57	42	**-117.7**	**-118.1**
eui-000080029c10dc24	14.7	45	-120 *	-120.3 *
eui-000080029c10db9b	4.36	30	-121 *	-120 *

* Only one or few measurements. I will ignore these results.

ANTENNA TEST RESULTS WITH GROUND PLANE B

- If you only look at the results you may notice there is no significant difference in the average RSSI values.

- But if you look at the time it took to receive 15 messages there is a difference.

- When using the monopole antenna with ground plane B it took 12 minutes to receive 15 messages.
  When using the sleeve dipole antenna, which is my reference antenna, it took 10 minutes to receive 15 messages.

- The Arduino sketch is configured to transmit 2 messages per minute. In a perfect situation it should take 7.5 to 8 minutes to receive these 15 messages.

ANTENNA TEST RESULTS WITH GROUND PLANE B

- So looking at the results I can conclude that the sleeve dipole antenna performs slightly better than my self build monopole antenna with ground plane B (radius ≈ ½λ).

ANTENNA TEST RESULTS WITH GROUND PLANE B

time	counter	port						
16:36:19	17	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:35:06	15	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:34:30	14	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:32:02	10	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:31:26	9	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:30:50	8	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:30:13	7	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:28:59	5	1	dev id: youtube_demo_device	payload: 0B 54 09 60	humidity: 29	temperature: 24
16:28:22	4	1	dev id: youtube_demo_device	payload: 0C 1C 09 60	humidity: 31	temperature: 24
16:27:46	3	1	dev id: youtube_demo_device	payload: 0C 80 09 60	humidity: 32	temperature: 24
16:26:33	1	1	dev id: youtube_demo_device	payload: 0E 10 09 60	humidity: 36	temperature: 24
16:25:57	0	1	dev id: youtube_demo_device	payload: 0E D8 09 60	humidity: 38	temperature: 24

Less lost messages, see counter.

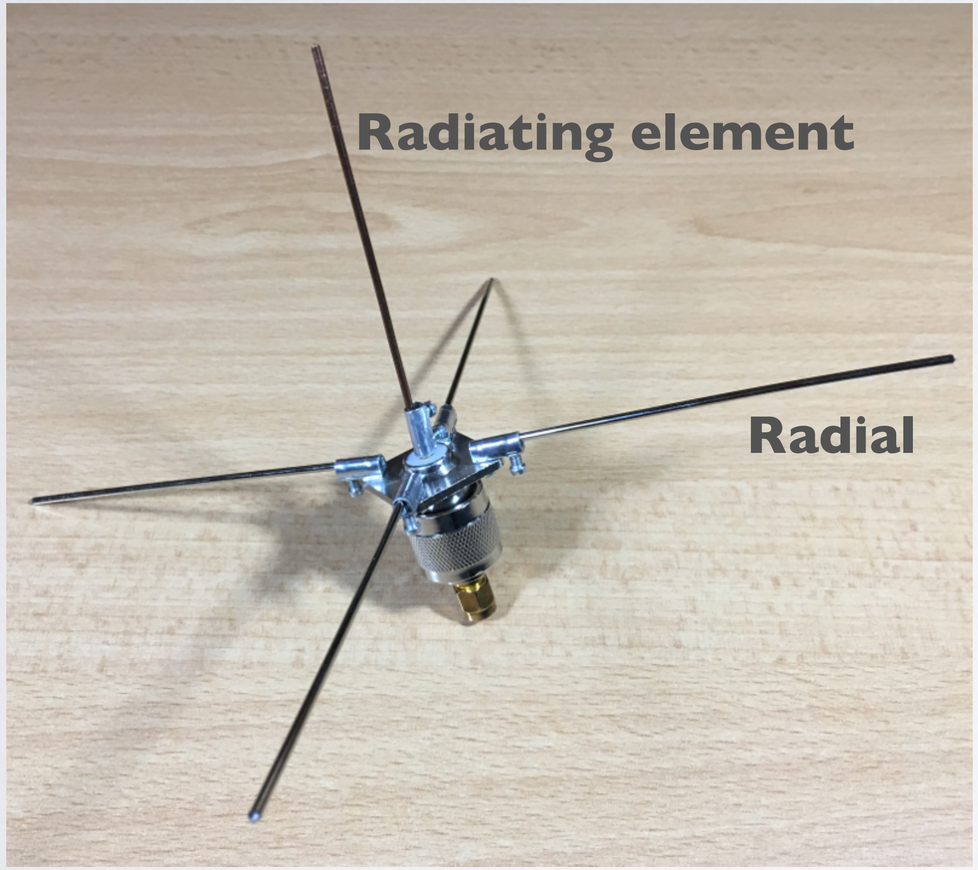
ANTENNA TEST RESULTS OVERVIEW

Type	Radius	Time to transmist 15 messages [min]
Monopole no ground plane	-	36
Monopole ground plane A	≈ ¼λ	38
Monopole ground plane B	≈ ½λ	12
Sleeve dipole	-	10

- Conclusion:
  A ¼λ monopole without ground plane has a bad antenna performance.
  A ¼λ monopole with ground plane with a radius **GREATER** than ½λ has a good antenna performance.

MONOPOLE ANT. WITH GROUND PLANE (RADIALS)

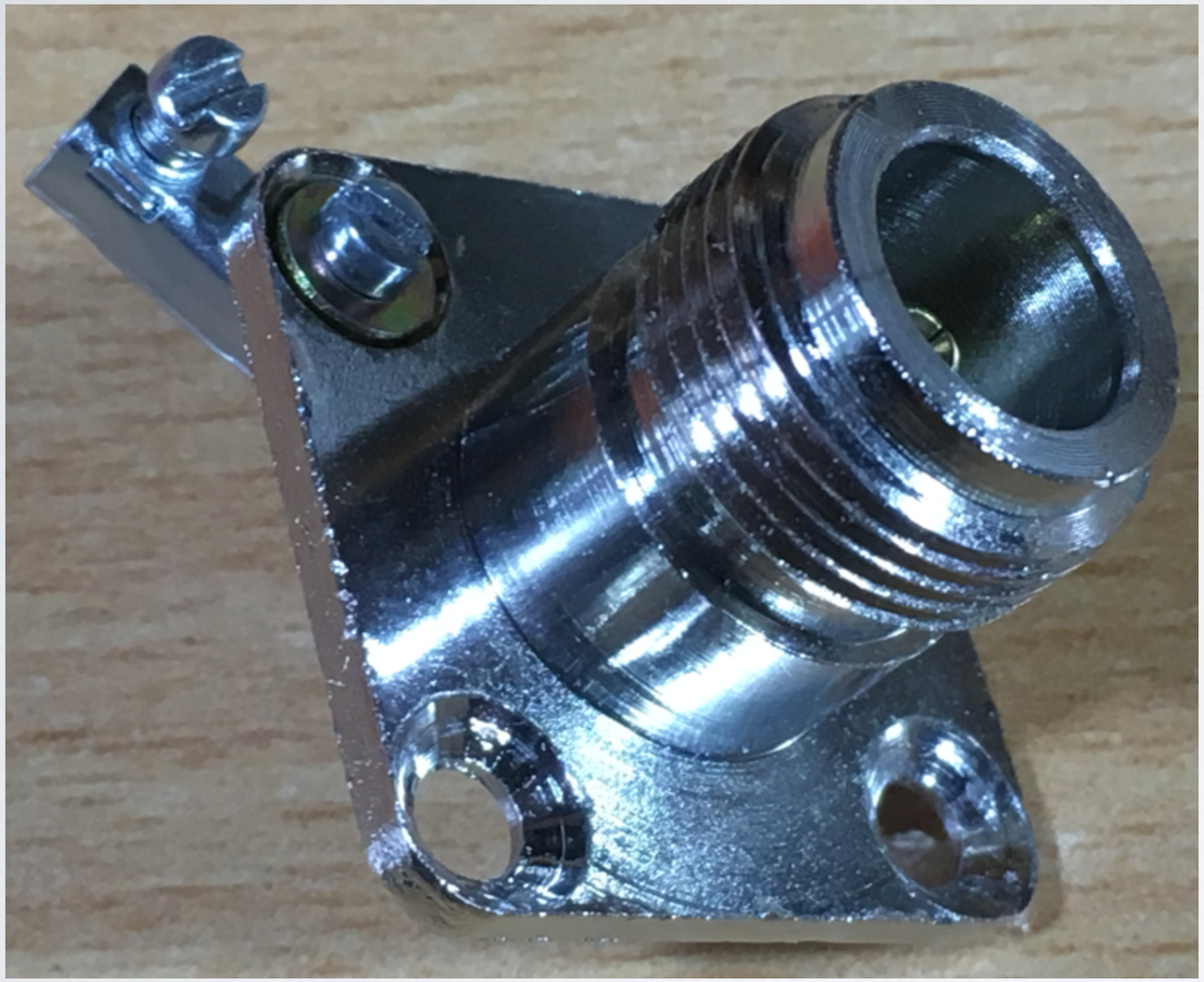
- For demonstration purpose I created a monopole antenna (868 MHz) with a ground plane. The ground plane consists of 4 wires (aka radials).



MONOPOLE ANT. WITH GROUND PLANE (RADIALS)

1. Copper wire (d=1.65 mm, length=86 mm), for 868 MHz
2. 4 radials (d=1.8 mm, length=90mm)
3. Terminal strip block 1.5-4.0 mm^2
4. Metal washers (4x)
5. Type N male to RP-SMA male plug adapter coaxial cable connector
6. Type N female chassis mount 4-hole connector

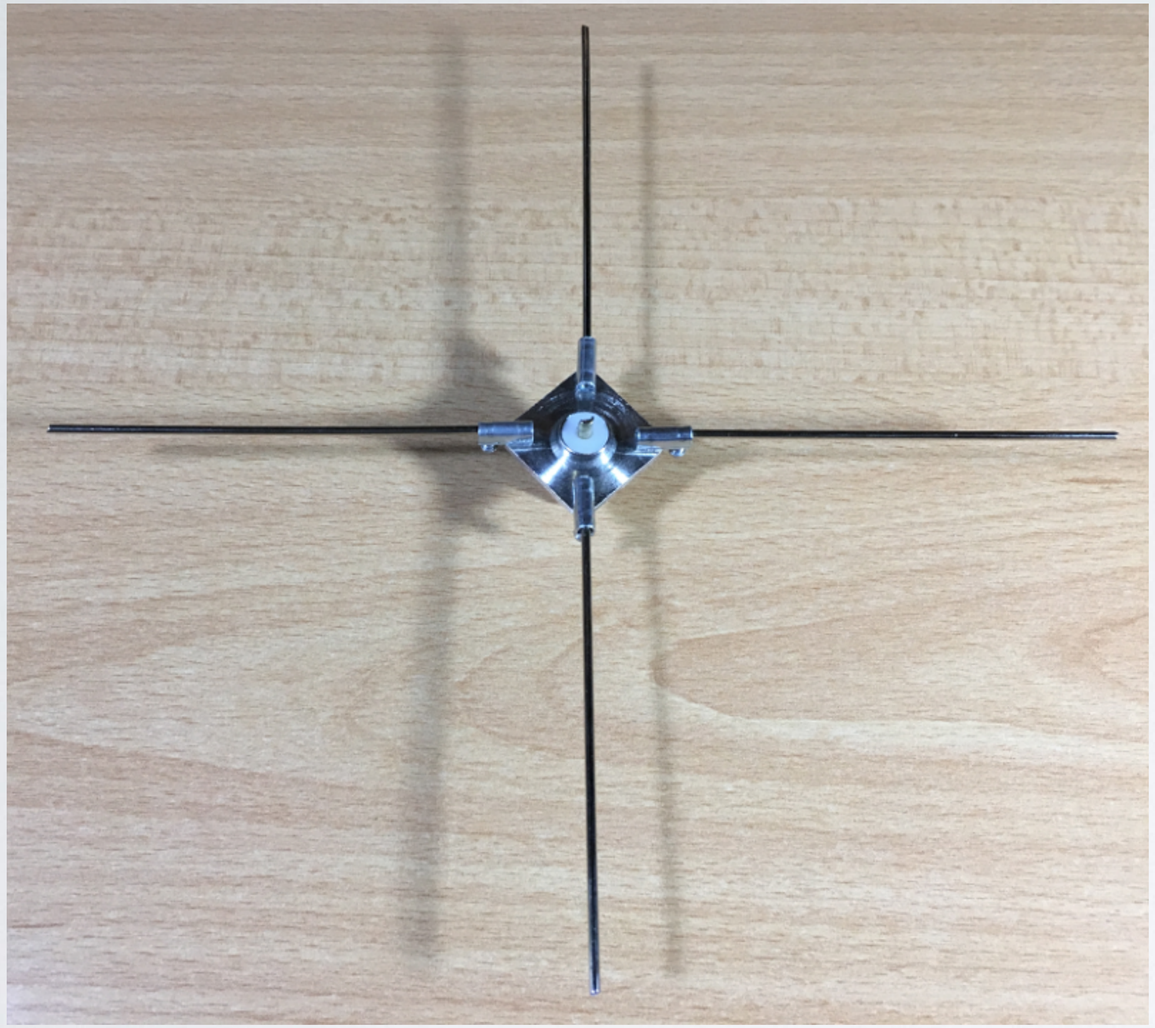
MONOPOLE ANT. WITH GROUND PLANE (RADIALS)



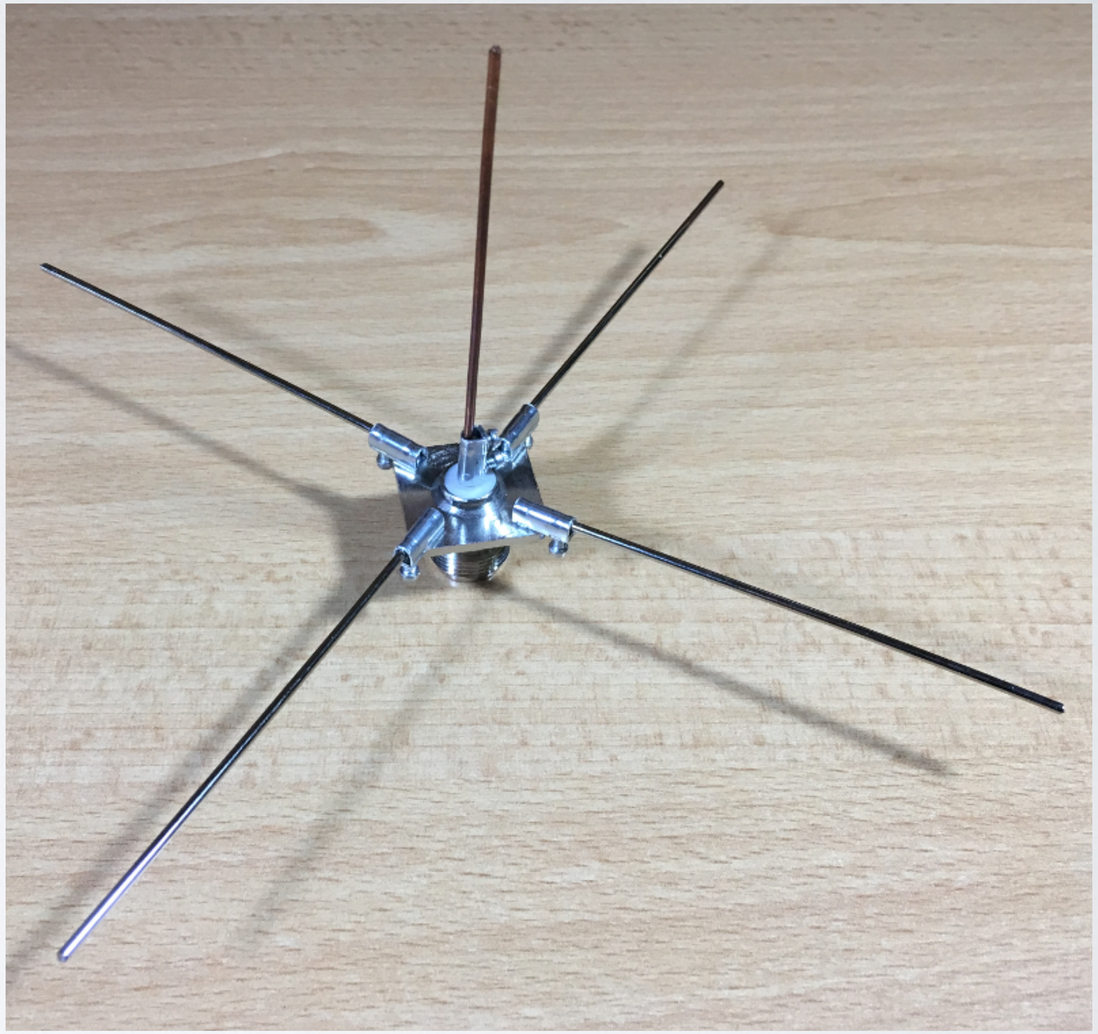
Attach terminal to type N female chassis

Attach all terminals

MONOPOLE ANT. WITH GROUND PLANE (RADIALS)

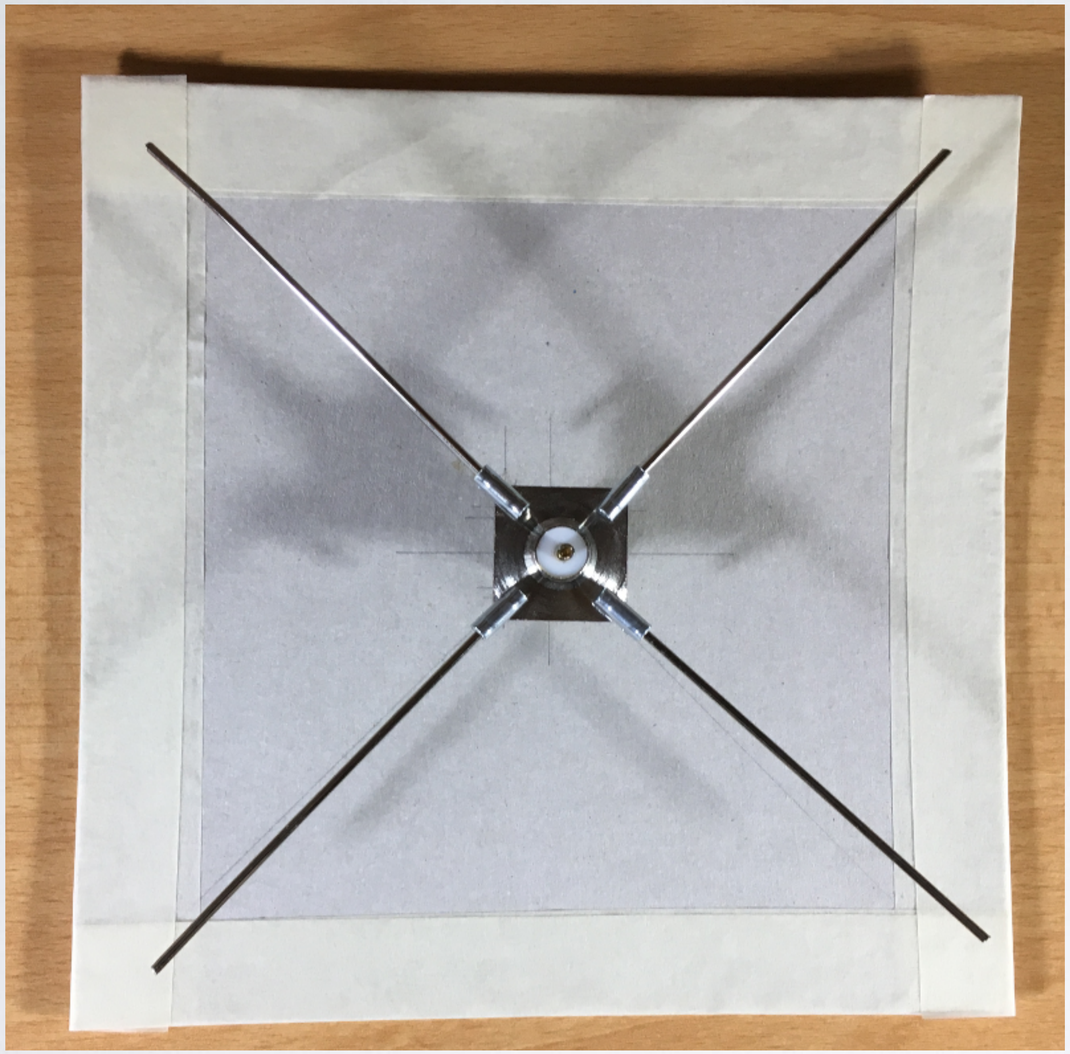


Attach radials

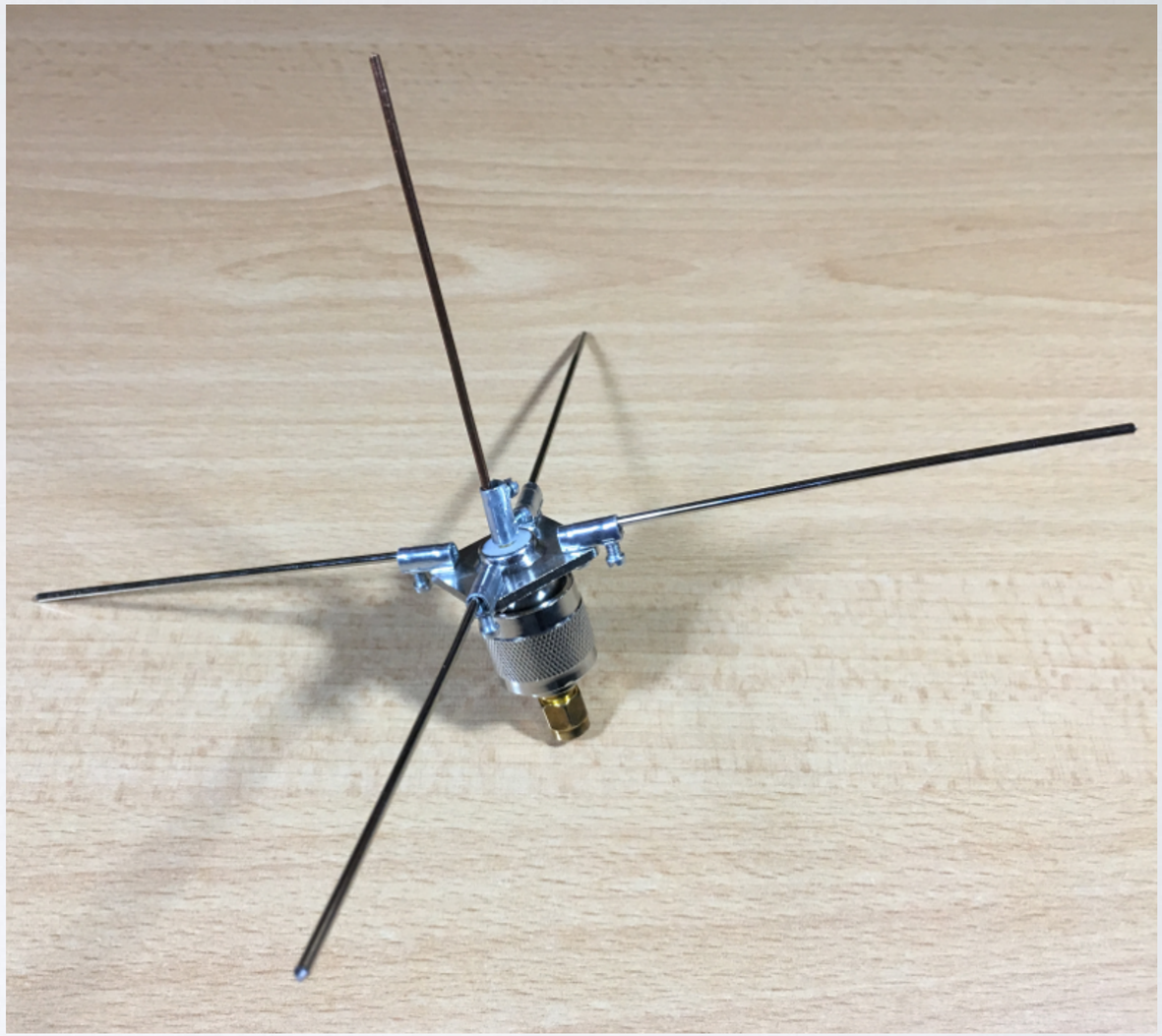


Attach radiating element

MONOPOLE ANT. WITH GROUND PLANE (RADIALS)



Metal plate vs radials



Attach coaxial adapter

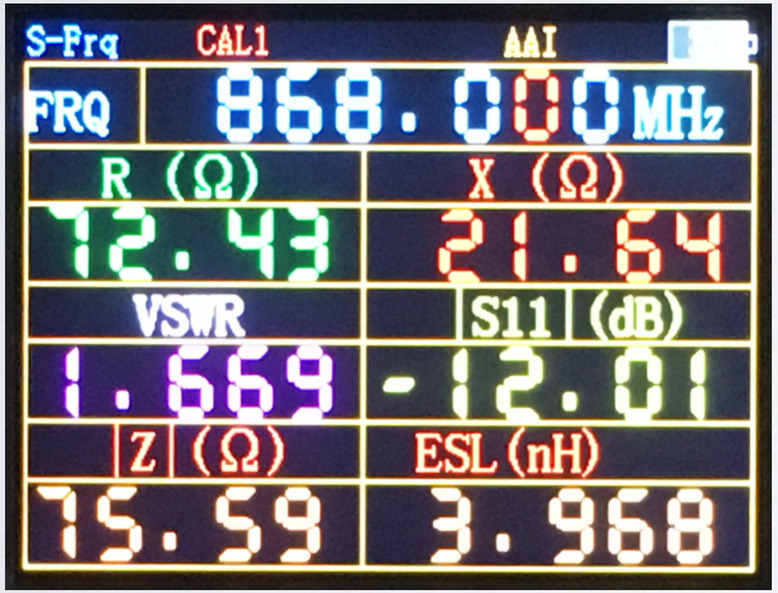
MONOPOLE ANT. WITH GROUND PLANE (RADIALS)

Measuring antenna parameters

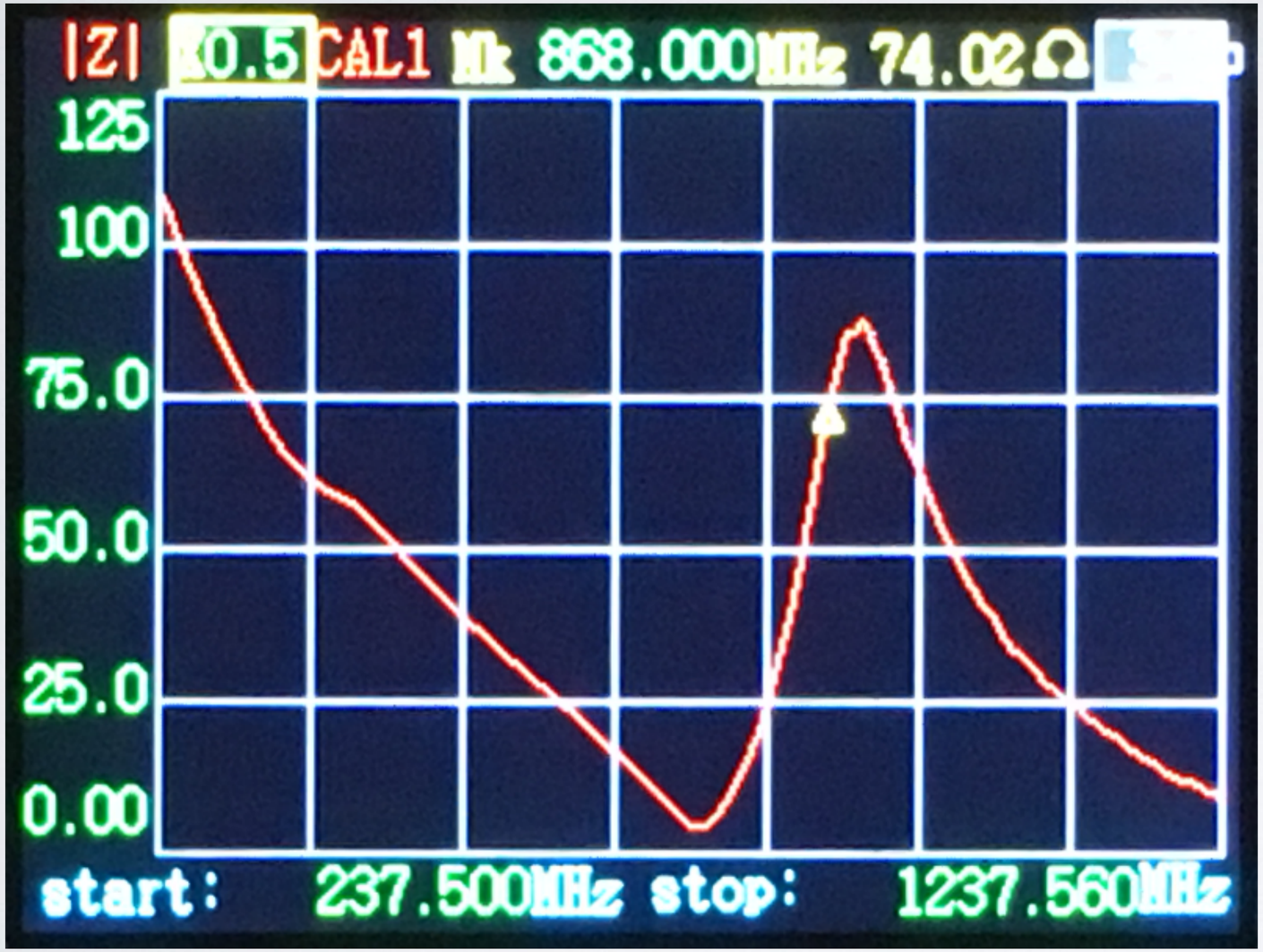
The antenna analyser with the monopole antenna and ground plane (radials).

MONOPOLE ANT. WITH GROUND PLANE (RADIALS)

- In **MY** situation I got the following results:
  VSWR ≈ 1.7 ⟵ Good. It is < 2
  Z ≈ 76Ω ⟵ Not good. Should be approx. 50Ω
  S11 ≈ -12 dB



MONOPOLE ANT. WITH GROUND PLANE (METAL PLATE)



ANTENNA TEST SETUP WITH RADIALS

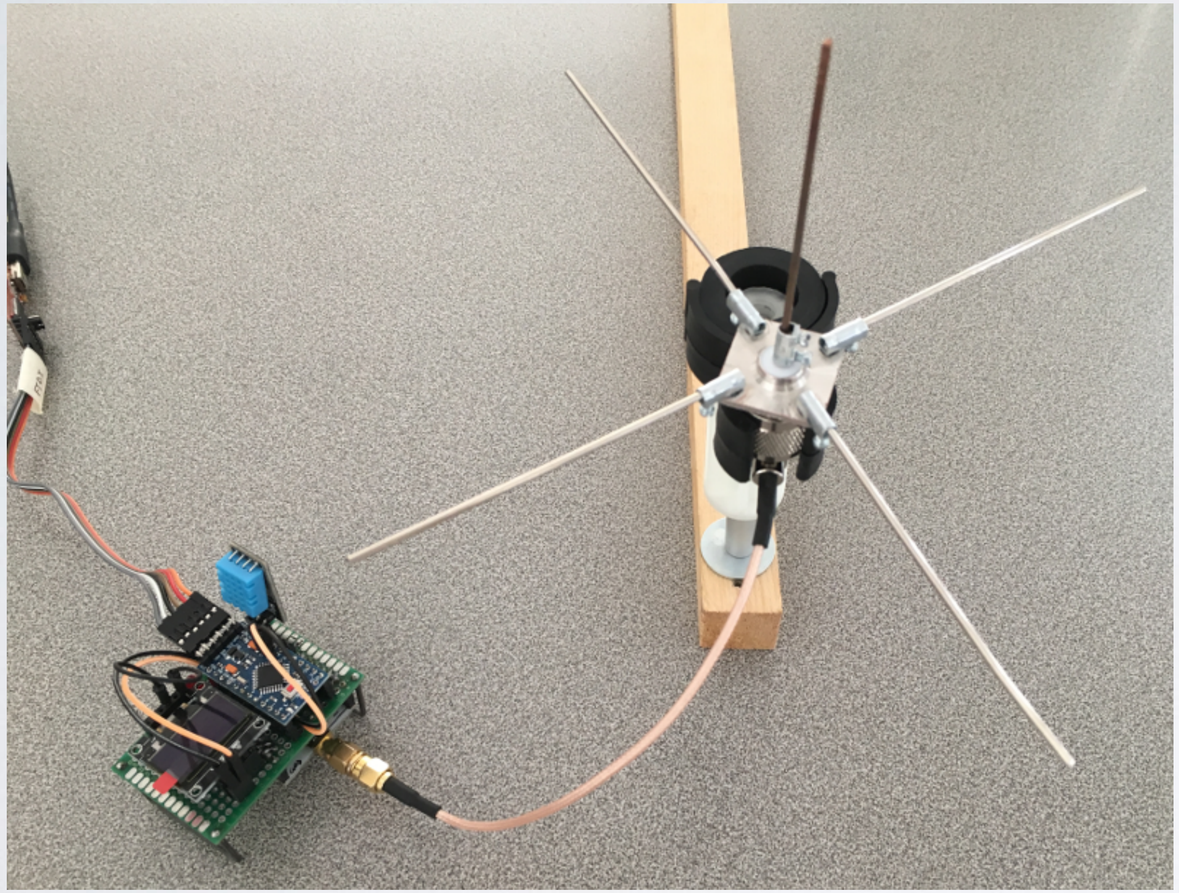
- I have NOT modified the end node transmission power when using the monopole antenna with radials.

- 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.

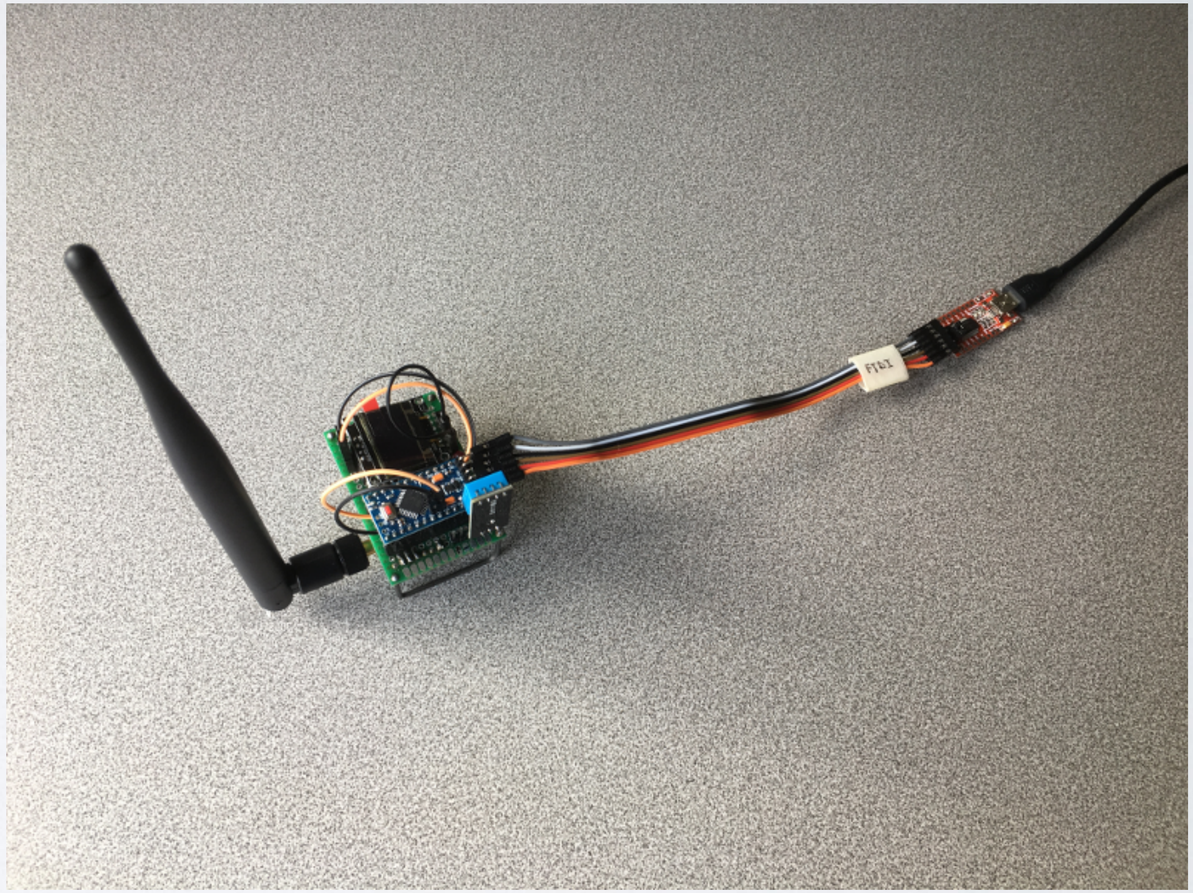
- The ¼ λ monopole antenna with radials is attached to an end node at location A and transmits data. I have done the same with a sleeve dipole antenna. In both cases two messages per minute were transmitted.

- The logged data can be found at: https://www.mobilefish.com/download/lora/monopole_radials_test_results.txt

ANTENNA TEST SETUP WITH RADIALS



Monopole with radials + end node



Sleeve dipole + end node

ANTENNA TEST RESULTS WITH RADIALS

- End node tx power = 14 dBm

Gateway	Distance from end device [km]	Altitude [m]	monopole with radials Average RSSI [dBm]	Sleeve dipole Average RSSI [dBm]
eui-aa555a0000088013	1.57	42	**-117.2**	**-114.9**
eui-000080029c10dc24	14.7	45	-119 *	-121.5 *
eui-000080029c10db9b	4.36	30	-120 *	-118.5 *

* Only one or few measurements. I will ignore these results.

ANTENNA TEST RESULTS WITH RADIALS

- If you only look at the results you may notice there is no significant difference in the average RSSI values.

- But if you look at the time it took to receive 15 messages there is a difference.

- When using the monopole antenna with radials it took 12 minutes to receive 15 messages.
  When using the sleeve dipole antenna, which is my reference antenna, it took 10 minutes to receive 15 messages.

- The Arduino sketch is configured to transmit 2 messages per minute. In a perfect situation it should take 7.5 to 8 minutes to receive these 15 messages.

ANTENNA TEST RESULTS WITH RADIALS

- So looking at the result I can conclude that the sleeve dipole antenna performs slightly better than my self build monopole antenna with radials.

ANTENNA TEST RESULTS WITH RADIALS

time	counter	port					
11:28:50	16	1	payload:	07 6C 0B 54	humidity:	19	temperature: 29
11:28:12	15	1	payload:	07 6C 0B 54	humidity:	19	temperature: 29
11:26:23	12	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:25:48	11	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:25:11	10	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:24:35	9	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:23:21	7	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:22:45	6	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:22:07	5	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:20:54	3	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:20:17	2	1	payload:	07 D0 0A F0	humidity:	20	temperature: 28
11:19:04	0	1	payload:	0C 1C 0A F0	humidity:	31	temperature: 28

Few lost messages,
see counter.

METAL PLATE VS RADIALS

- As demonstrated using a metal plate (radius > ½λ) or radials as the ground plane produces approximately the same result.

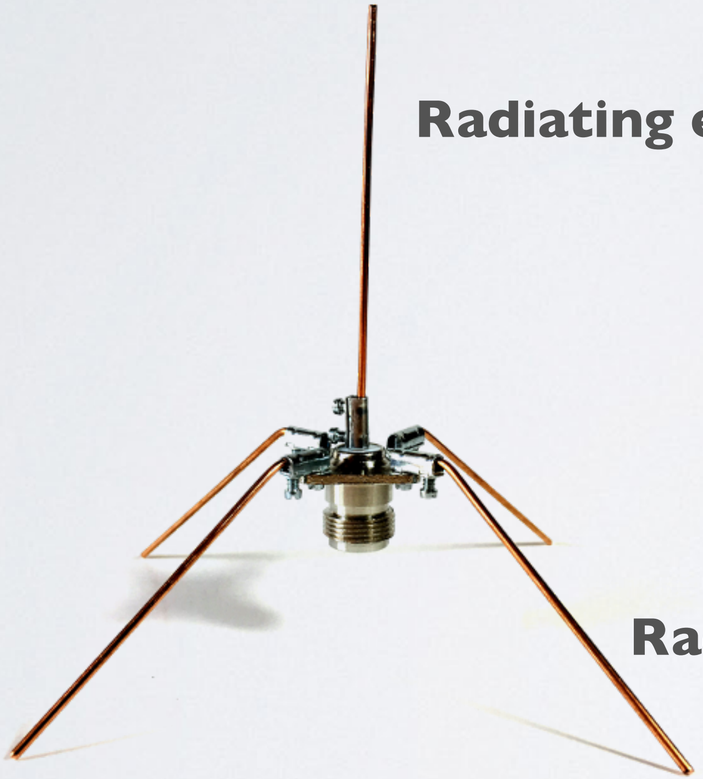
- Using radials is often preferred:
  The radials are lighter than a metal plate.
  The radials are cheaper than a metal plate.
  The radials are more resistant to weather conditions (wind, rain).

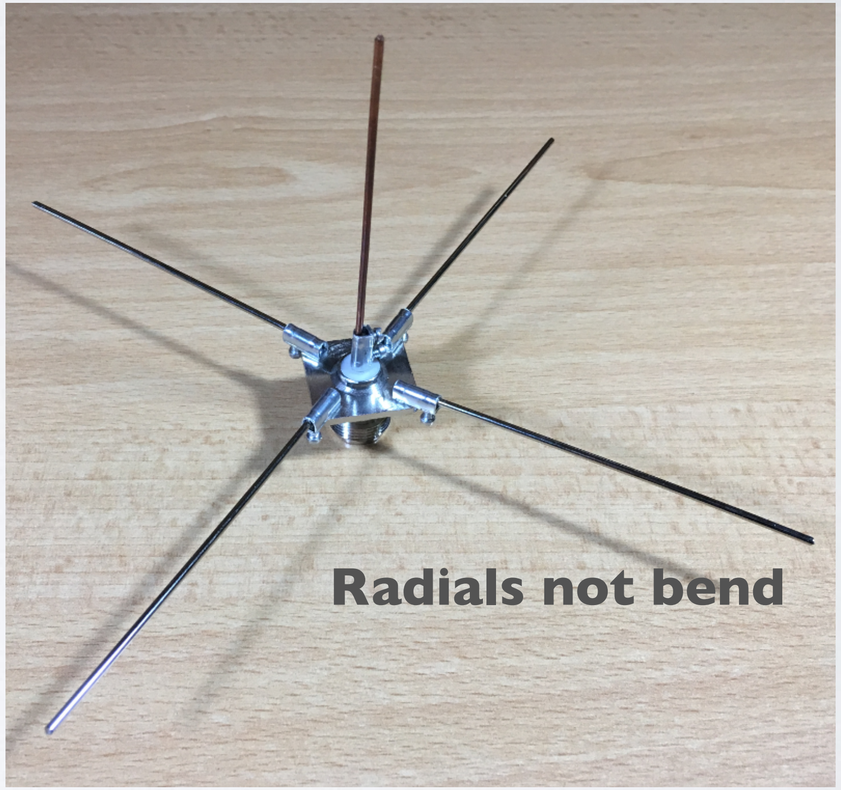
- When using a metal plate or radials as a ground plane, in both cases the impedance is around 75Ω instead of 50Ω. How to fix this?

- When radials are used, bend it to a certain angle and the impedance will be 50Ω and the VSWR will remain below 2.

METAL PLATE VS RADIALS

- You get a ¼ wave ground plane antenna (aka spider antenna).
  In tutorial 44, I will explain the spider antenna in detail.

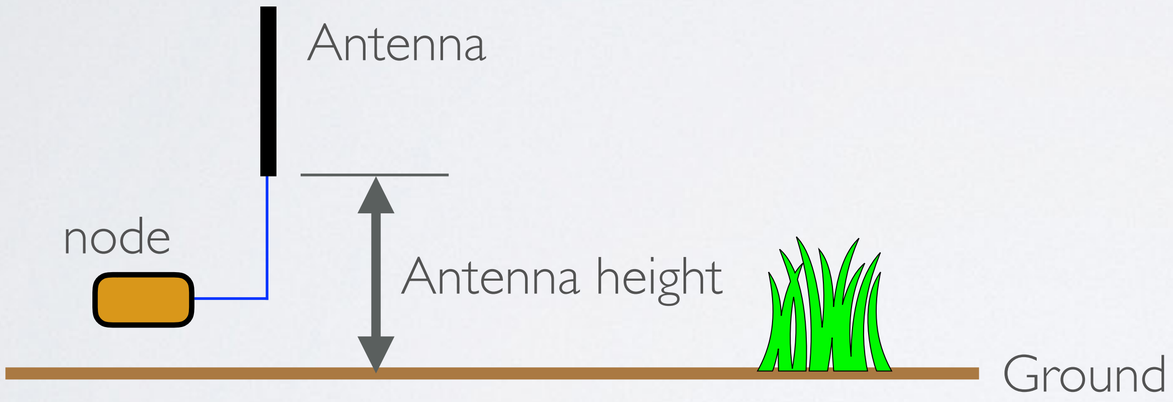




GROUND EFFECT

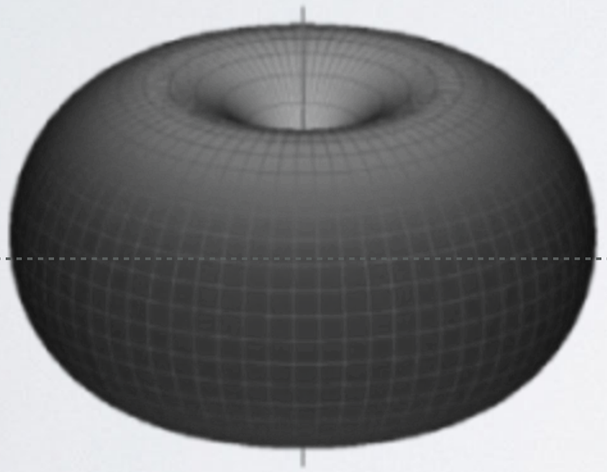
- The effect of a ground near any antenna (for example: monopole, dipole, Yagi-Uda, Moxon, etc) can be significant. The antenna performance can be positive or negative.

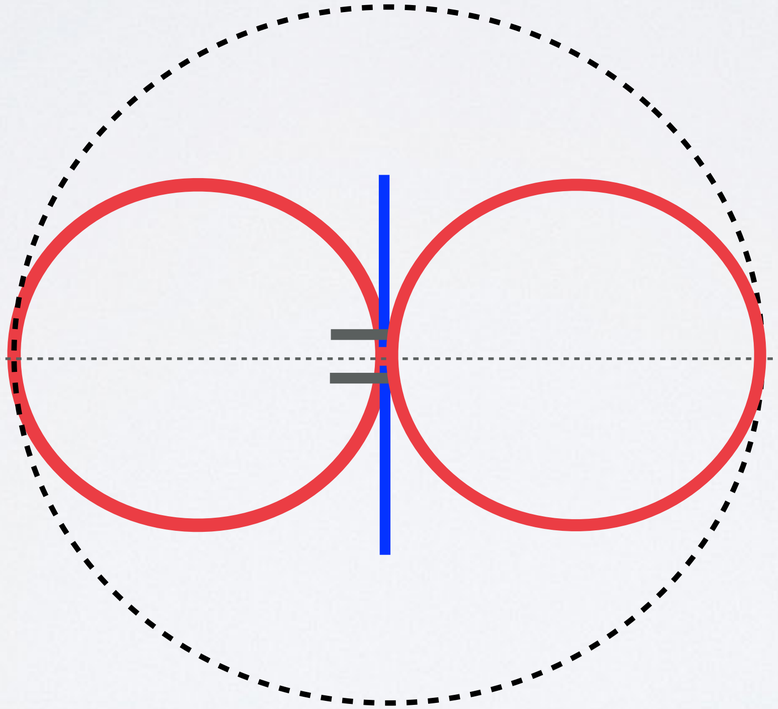
- The effect can be simulated using an antenna modelling software (see tutorial 38).



GROUND EFFECT

½λ dipole antenna (free space)
radiation pattern





½λ dipole antenna near grond
radiation pattern