Design Of An RF Front End For A 1.2GHz Communication Chain

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The Interreg Sudoe Program

A Collaborative platform to provide a relevant training on nanosat technology through student challenges

Infrastructure for collaborative engineering

Robust work methodology

Catalogue of partner resources

7 Universities
2 Aerospace Clusters
3 ESA Business Incubation Centres

Introduction

The purpose was to have a tool for testing nanosat technologies

Credit : Eirspace

Eirballon 2.0 is supposed to be launch in September 2021 and is a participation for the 100 years of the school

Budget Link

Modulator power	14.77dBm
Attenuation of cables and connectors	-1dB
PA	17dB
Tx antenna	0dBi
PIRE	30.77dBm
Free space loss	-145dB
Rx antenna	9dBi
LNA	20dB
Filter	-2dB
Attenuation of cables and connectors	-5dB
Receiver sensitivity	-97dBm

Tab 1 : Budget link between the transmitting and receiving systems

Outline

1. Base Station (fixed and mobile)
   - ISM receiving antenna
   - LNA and filter
2. Embedded systems
   - ISM and LoRa transmitting antenna
   - Power supply for the balloon
   - Power Amplifier
3. Test of the complete Rx structure

1.2 GHz Yagi-Uda Antenna

- A Yagi Uda antenna made on PCB
- Operating at 1.2GHz
- Linear polarization

Fig 1 : Realized PCB of the Yagi-Uda antenna

Simulations (1)

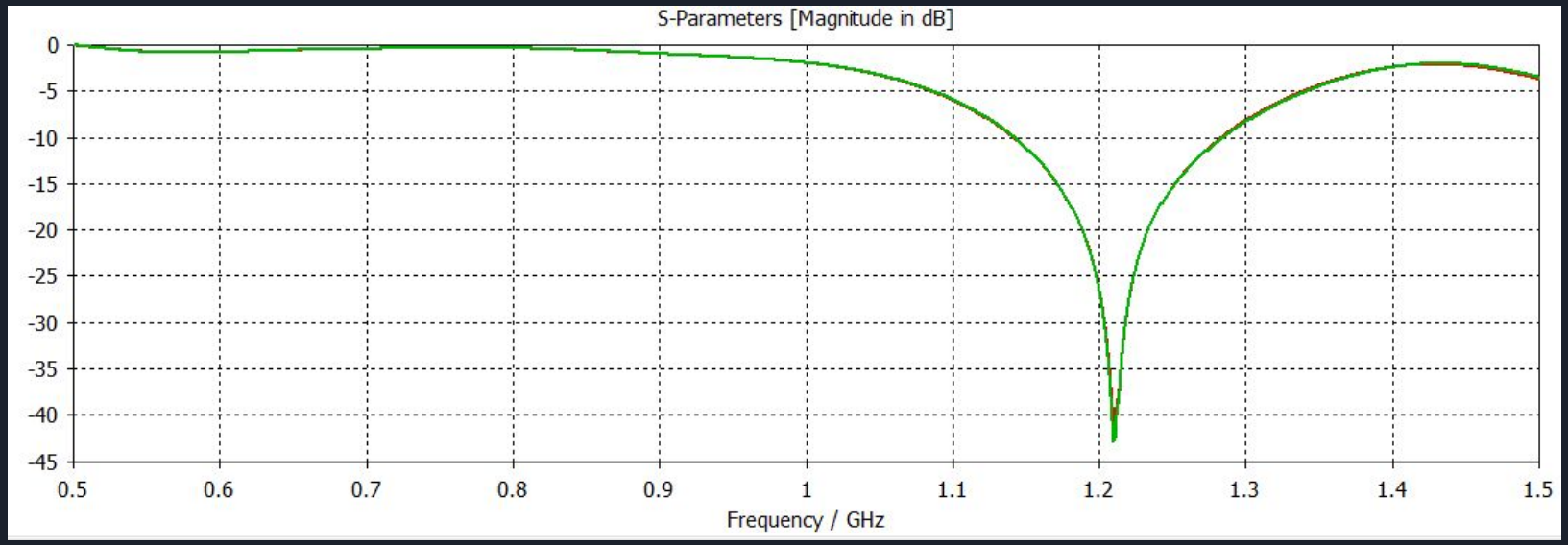


Fig 2 : Simulation results for S11

- S11 parameter of -25dB
- Bandwidth around 100MHz
- Z11 around 35 Ohms

Simulations (2)

- Directivity: 9.6dB
- Gain: 9.214dBi

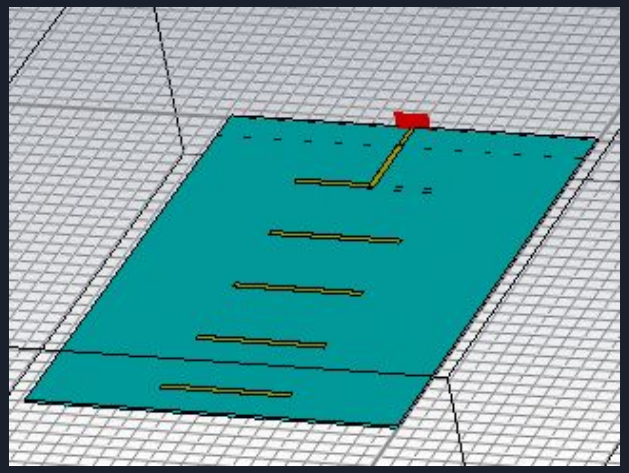


Fig 3 : CST schematic of the antenna

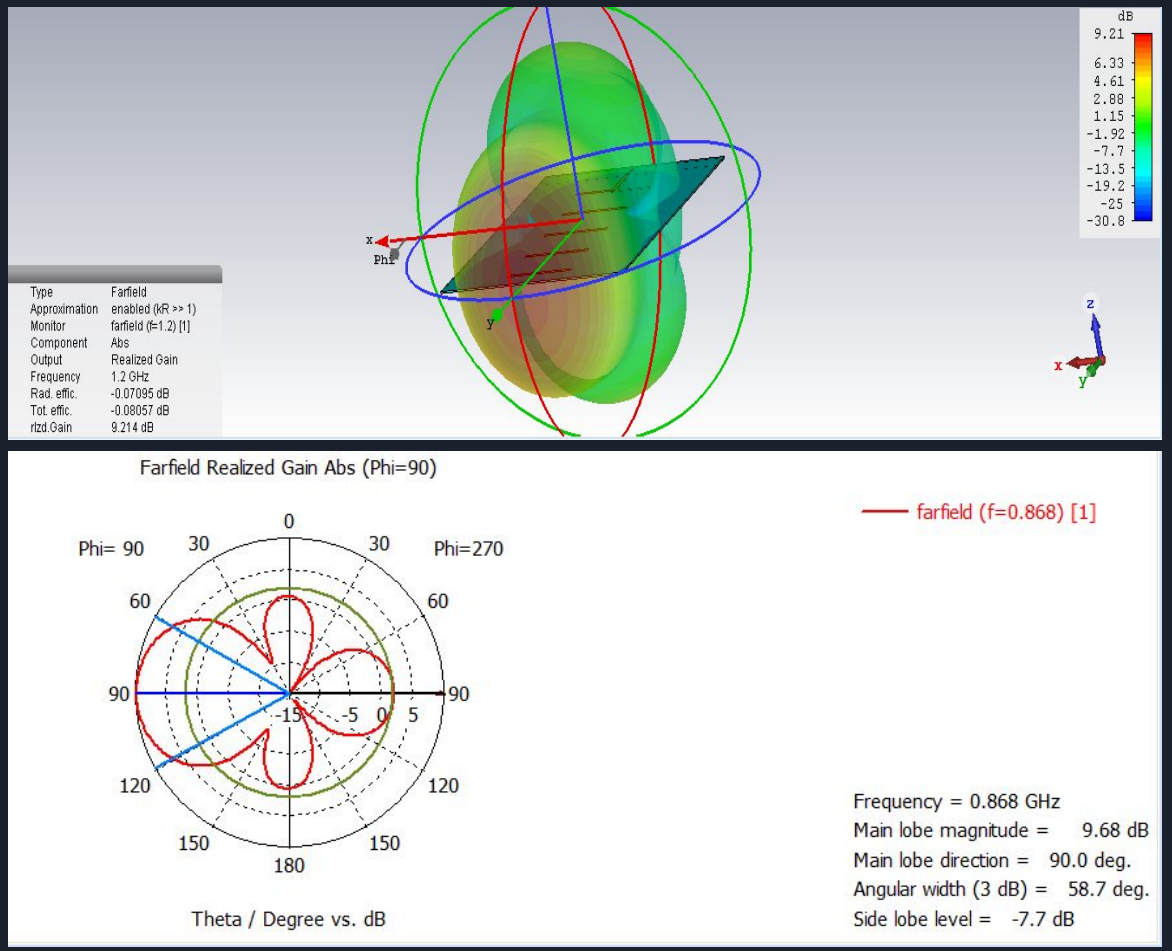


Fig 4 : Directivity diagram of the antenna

Measures (1)

- Antenna has been made and measures have been done on a VNA and in anéchoïc chamber

Fig 5 : Measurement of the S11 for both antenna

S11 for the two antennas is around -16dB

LNA and filter for fixed and mobile station

- Due to time constraints, the LNA have been ordered and are ready to be plugged in.
- Rx Filter have been made thanks to coupled lines

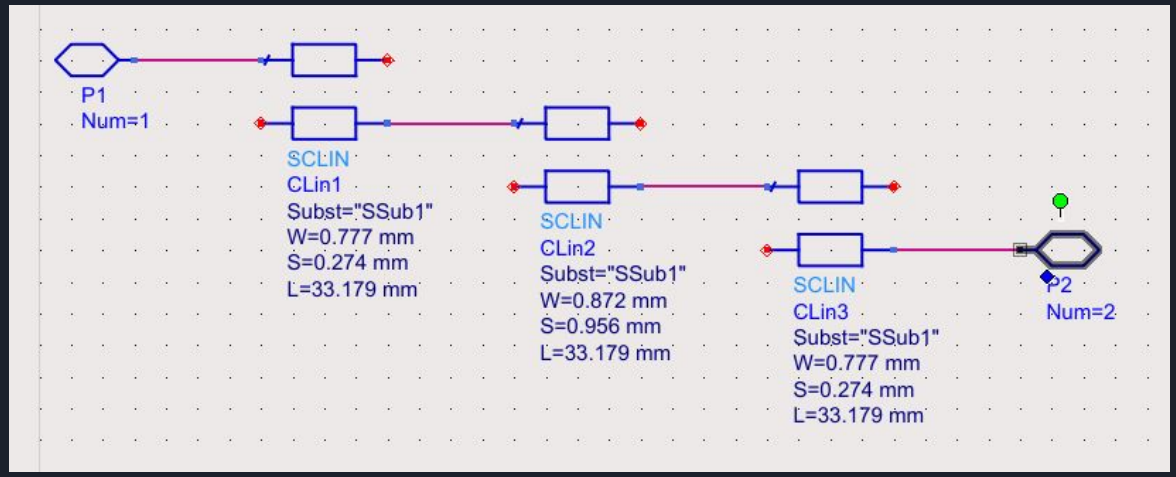
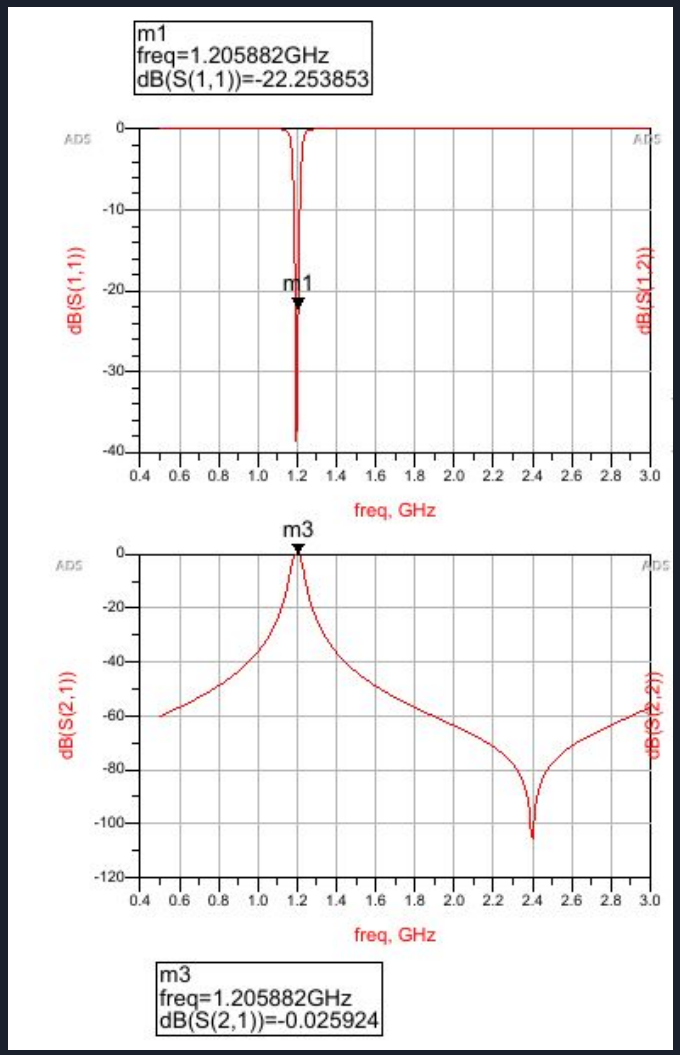


Fig 6 : Electrical schematic of the filter

Simulations (1)



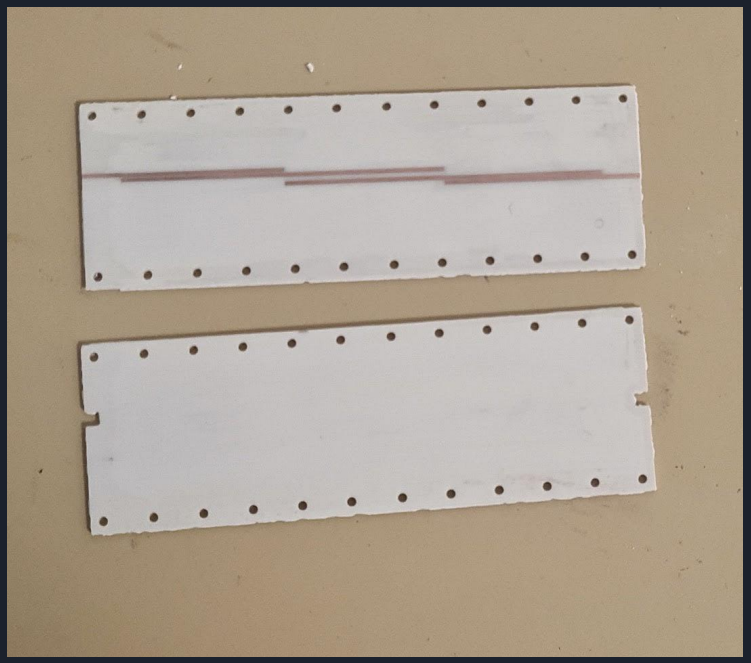


Fig 7 : PCB of the filter

Fig 8 : Simulation results for S-Parameters

Measures (1)

- Filter has been characterized thanks to a VNA

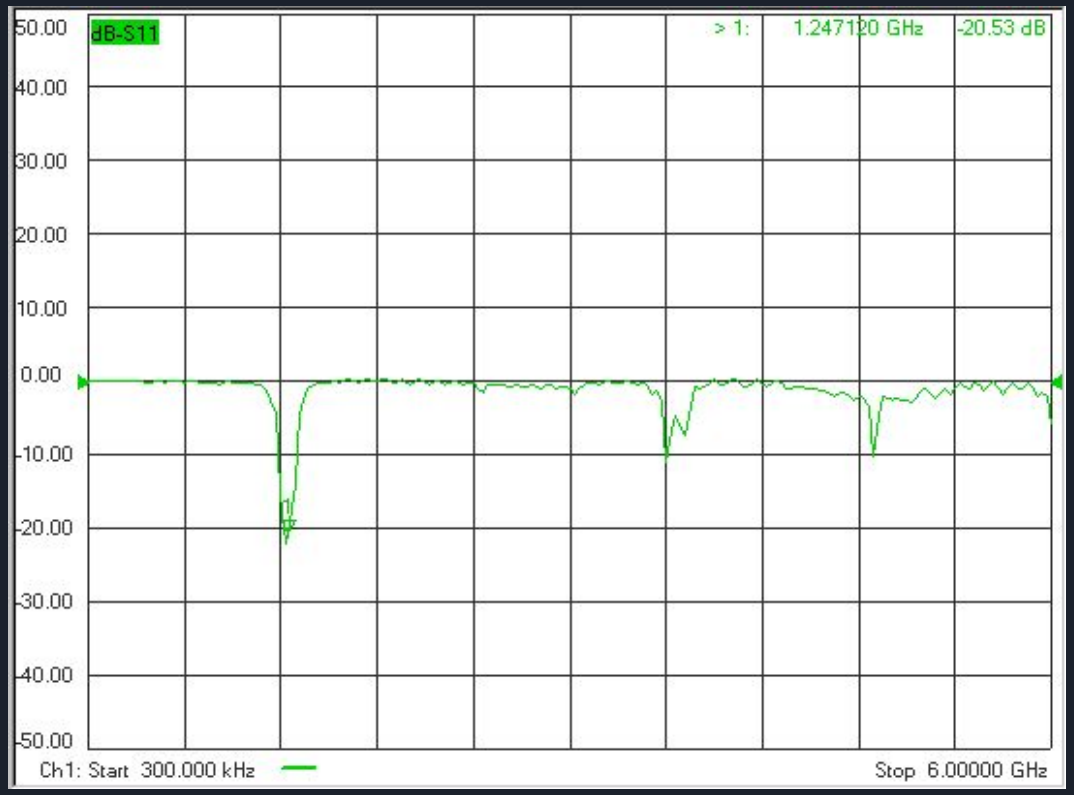


Fig 9 : Measurement of the S11 of the filter

S11 for the filter is around -20dB

2 monopoles antenna for ISM and LoRa communication

- Monopole antenna
- Operating at 865MHz and 1.2GHz
- Both Omnidirectionnal

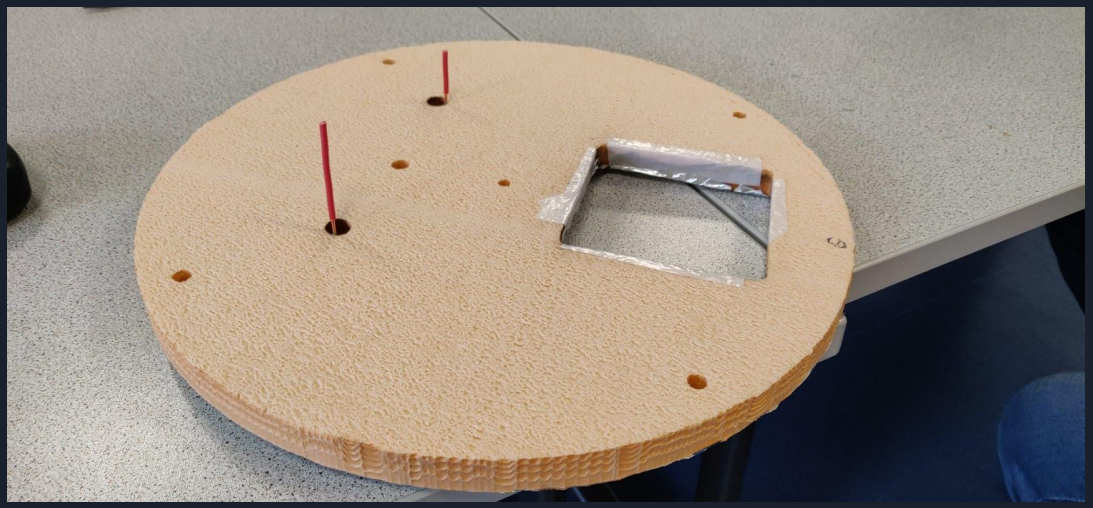
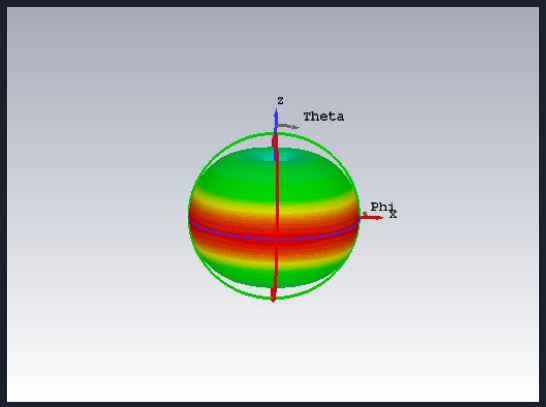


Fig 10 : Structure of the two monopole antenna put on the balloon

2 modules : one at 865MHz (LoRa same as Eirballoon 1) and Image transmission at 1.2GHz

Simulations

- Directivity: 1dB
- Gain: 0.8dBi (@865MHz)



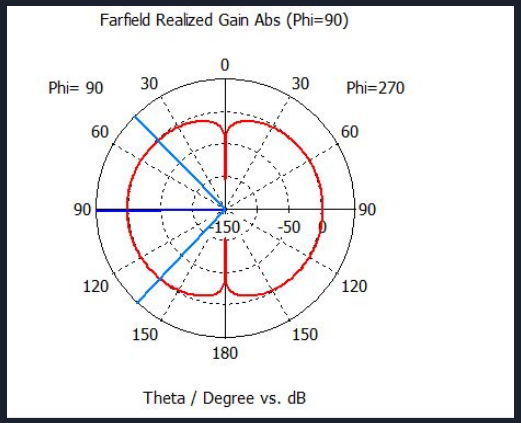
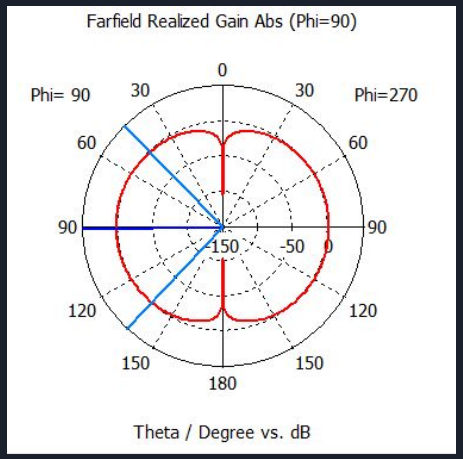


Fig 11 : Directivity of the LoRa Tx antenna

- Directivity : 1dB
- Gain : 0.79dBi (@1.2GHz)



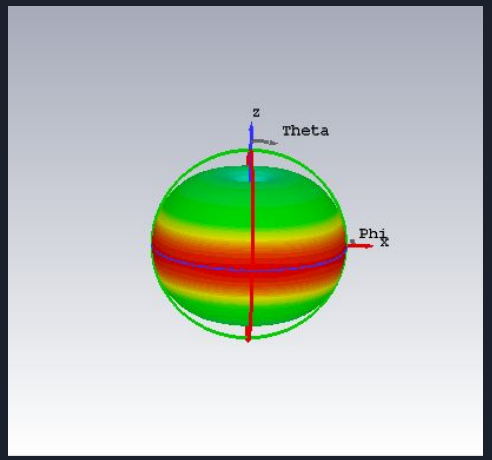


Fig 12 : Directivity of the image Tx antenna

Measures (1)

- Measures have been made on a VNA to verify that we are a the needed frequency especially for the image Tx antenna

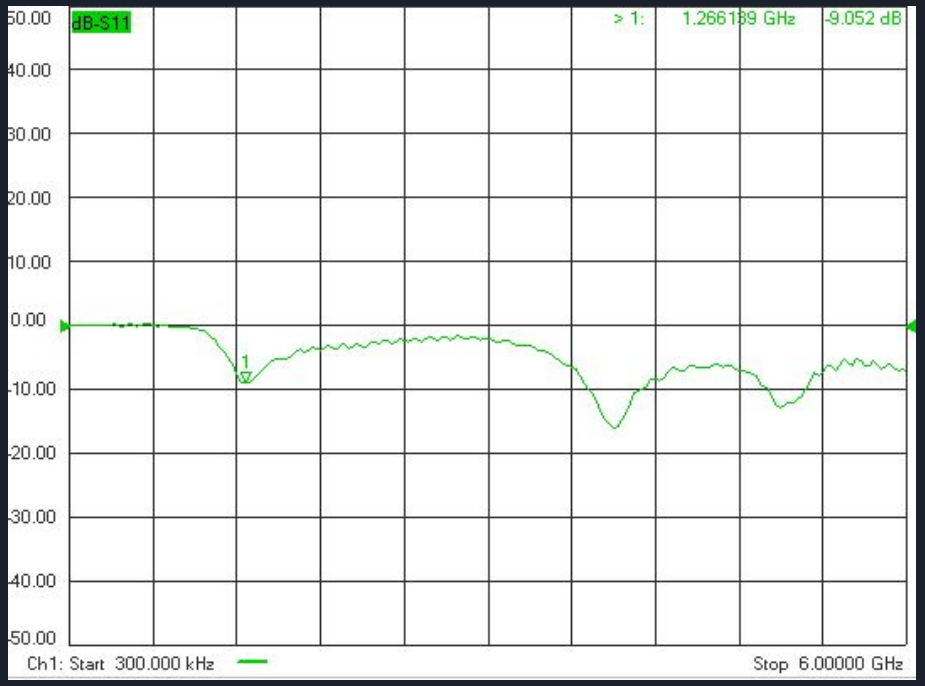
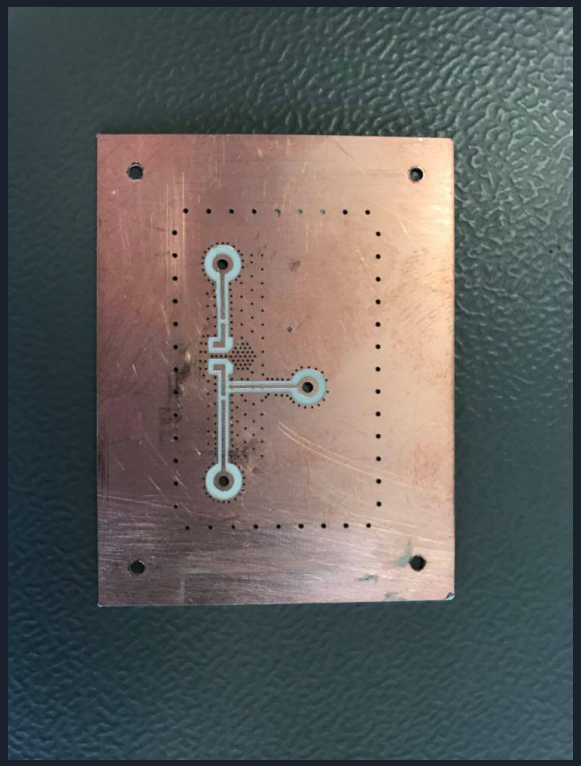


Fig 13 : Measure of the S11 for the image Tx antenna

Power amplifier made for the balloon



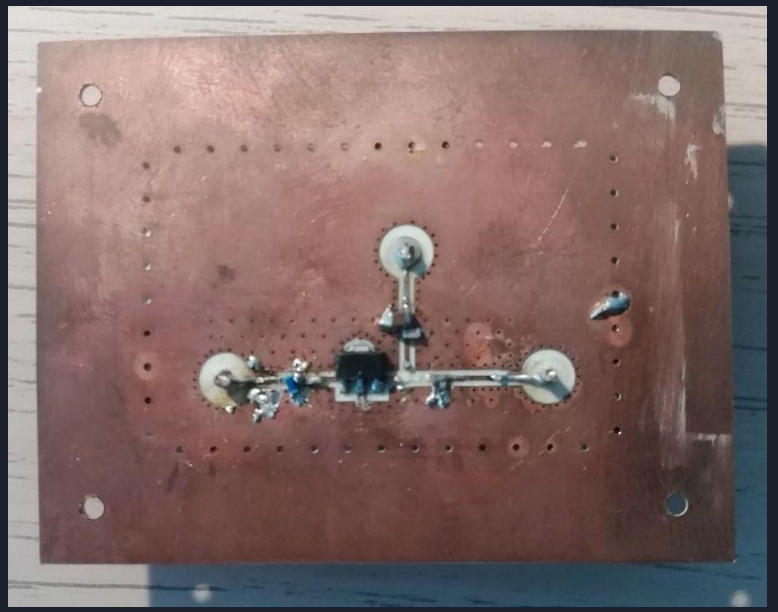


Fig 14 : Realized PCB of the power amplifier

Measures (1)

- We have to measure and test the power amplifier board in order to check the operating frequency and compression point

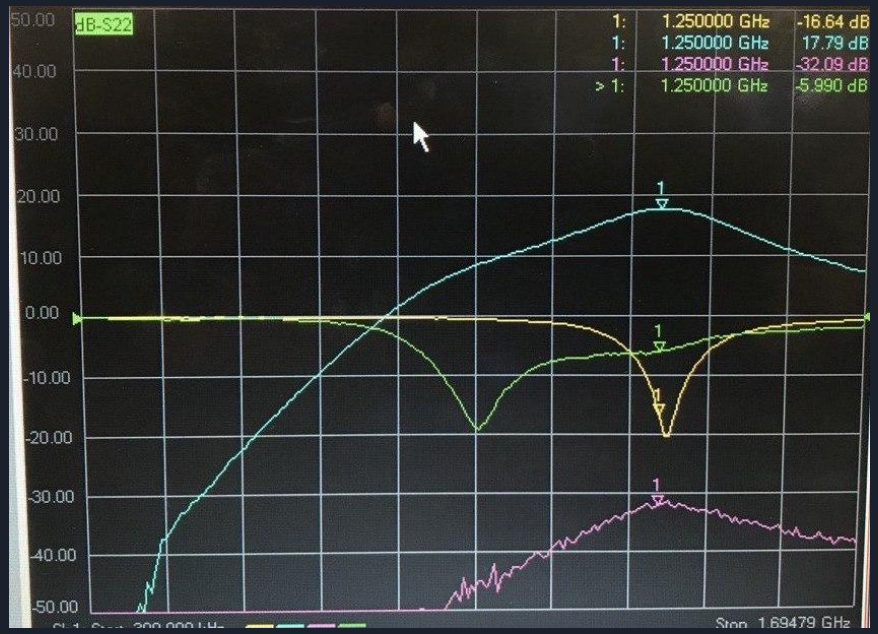


Fig 15 : S-Parameters of the PA obtained on the VNA

Measures (2)

Fig 16 : Gain, PAE and CP1 obtained for the PA

Power supply for Eirballoon embedded system

Need to manage the power supply of the different systems of the balloon with the supplied battery (9V)

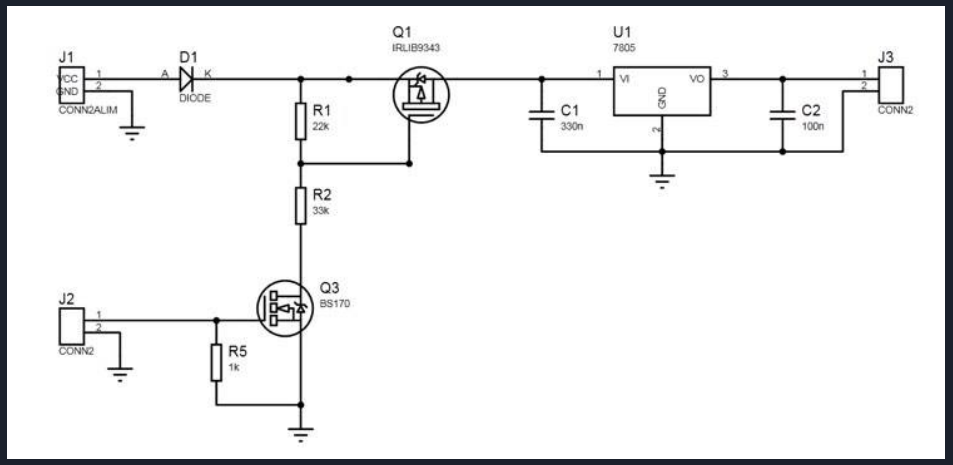


Fig 17 : Electrical schematic of the power supply board

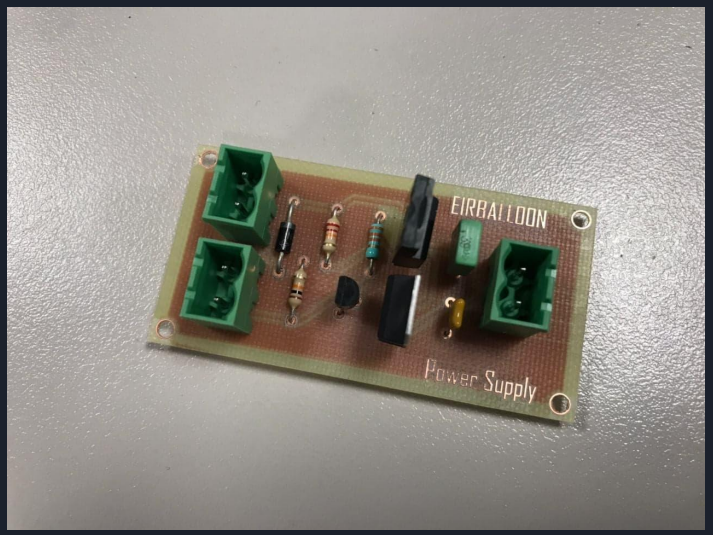


Fig 18 : Realized PCB of the power supply board

Test of the complete Rx structure

Purpose of these tests :
- Corona discharge
- Thermal runaway
- flight temperature maintenance

1rst test conditions :
- Approx. 0.1Pa
- 30min

2nd test conditions :
- Approx -20°C
- 30min

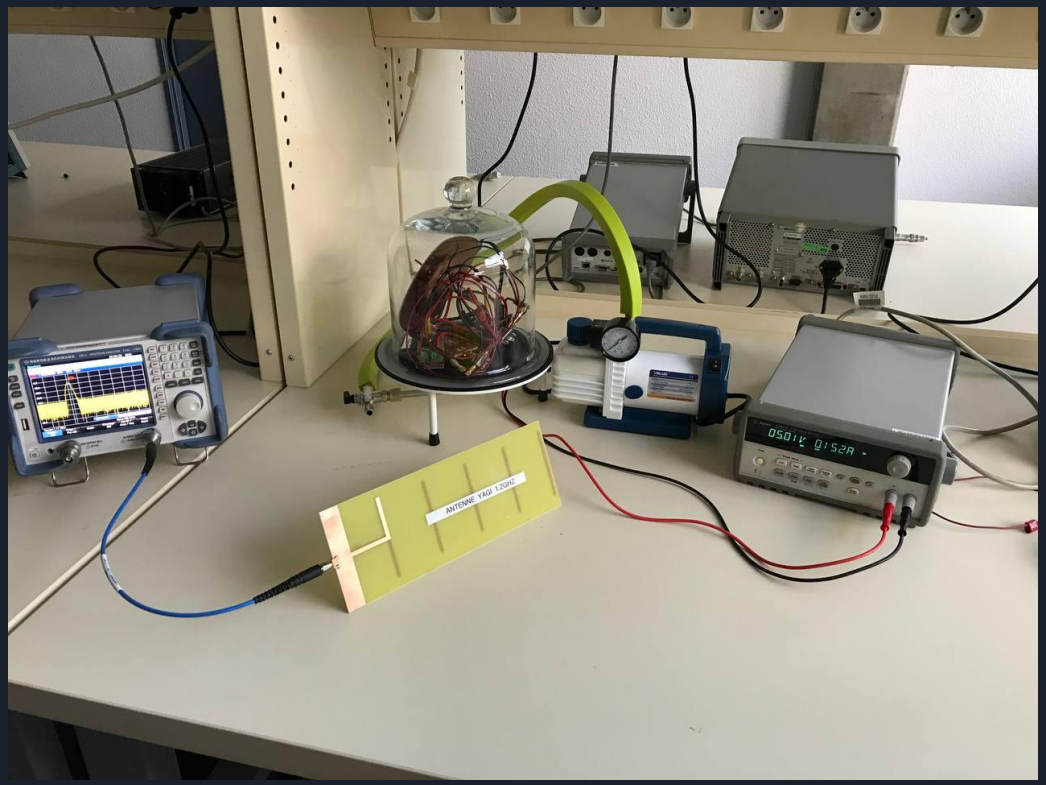


Fig 19 : Test bench for the Rx transmission chain

Measures

- The purpose was to verify in hard condition (vacuum chamber and -20°C) if the Rx transmission chain was able to send data

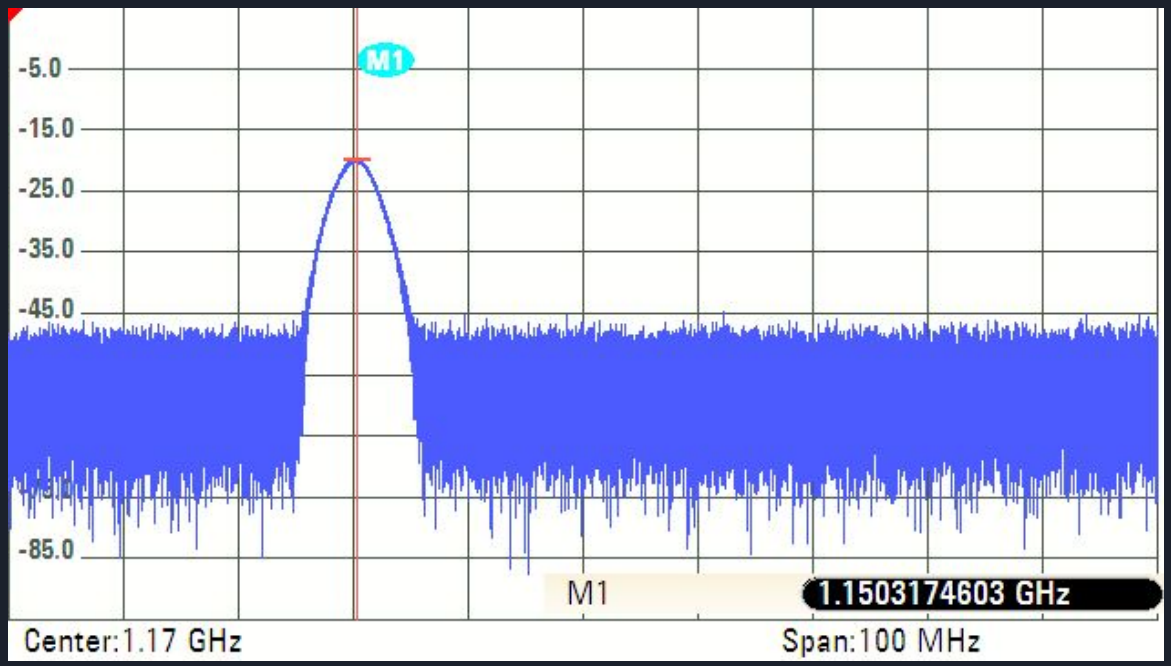
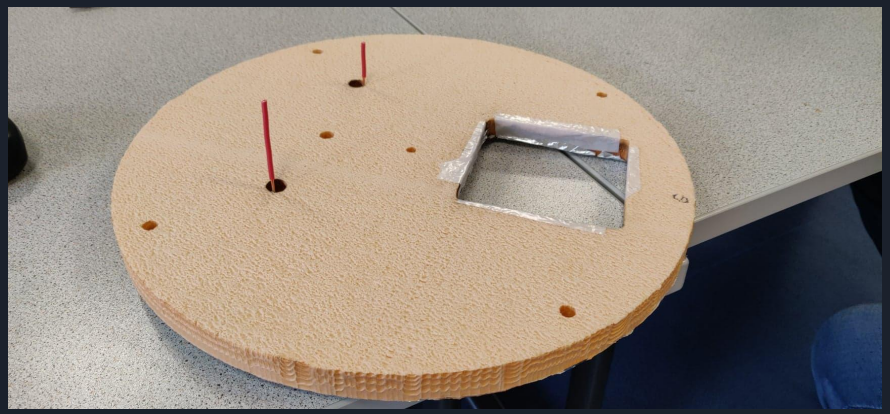


Fig 20 : Spectrum analyser during the test

Structure of the balloon

We have redone the structure of the balloon to make it lighter, most of the parts have been made, sanded and painted



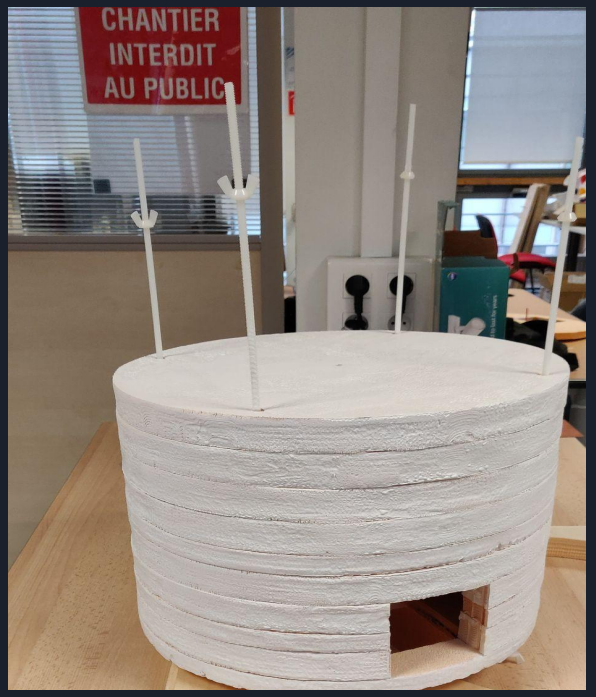


Fig 21 : Realized structure of the ballon

Conclusion

- Significant parts of the project are done
- Antennas are built and functional
- Power amplifier PCB and power supply are designed
- Rx filters have been realized and characterized
- Eirballoon structure was built using the laser cutting machine
- Test antennas inside anéchoïc chamber have been done
- PCB have been realised
- Test of the entire Tx structure in a vacuum chamber and at -20°C

This project was conducted in collaboration with a team of students from the telecommunication department

THANKS FOR YOUR ATTENTION !