Sounding Rocket Telemetry Emitter, MID Antenna and Ground Receiver Antennas

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***Abstract*—The goal of this research project is to design a complete 2.45 GHz data link for telemetry application between a sounding rocket and a ground station. The emission part is embedded in the rocket and has a lot of mechanical constraints. The design for the emitter, the rocket antenna and the ground station receiver are detailed.**

***Index Terms*—Emitter, MID antenna, sounding rocket antenna, receiver, telemetry.**

I. Introduction

THIS project has been achieved in collaboration with EirSpace [1], the airspace association of the ENSEIRB-MATMECA French engineering school [2]. EirSpace aims at designing experimental rockets that are launched during a campaign organized by the *CNES* (Centre National d'Etudes Spatiales) and *Planète Sciences* as shown on Fig. 1.

This type of rockets embed a multitude of experiments defined by the students, including for example atmospheric, positioning or trajectory measurements. Acquired data are recorded in the rocket and sent to the ground during the flight. All of the mechanics and the electronics are designed and fabricated by the association student members, in particular the transmission chain including the emitter, the antennas and the receiver.

II. Project Description

Last year, the telemetry was assured by an emitter provided by *CNES* and a ground receiver called "Spatiobus".

(a) (b)

Fig. 1. Launch of the previous experimental rocket during the C'SPACE 2013 (a).The Spatiobus (b)

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This emitter is not adapted to our new project as more bandwidth is required to transmit trajectory data. That is the reason why it has been decided to design our own 2.45 GHz data link. In order to make a redundancy of this important function, a second emitter at 869.5 MHz based on a commercial module is also embedded in the rocket. These two spectral bands are chosen because they are ISM bands. As the "Spatiobus" does not have a 2.45 GHz receiver, we designed our own receiver to decode and analyze data during the rocket flight.

III. Avionic Emitter Module

The transmission system is constituted of two different emitters as shown on Fig. 2. The modulation chosen for the 2 45 GHz emitter is QPSK, it allows to double the band pass of the signal. The emitter have the architecture depicted on Fig. 2 and is based on COTS.

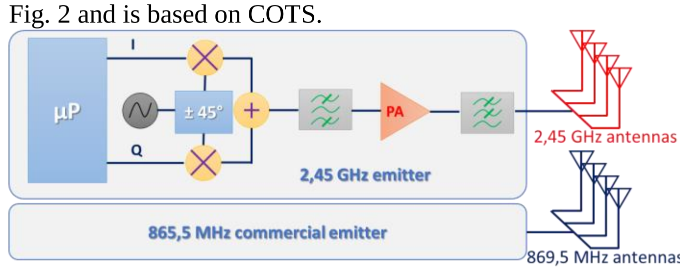

Fig. 2. Dual-band transmitter with 2.45 GHz emitter detailed architecture.

To comply with the electronic standards chosen for this rocket, all PCB are circular are illustrated on Fig. 3.

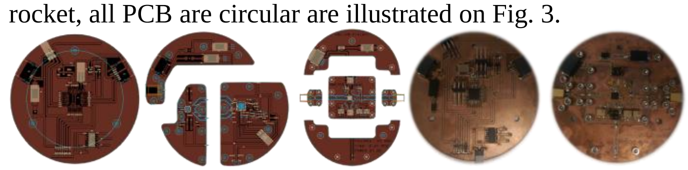

Fig. 3. Designed emitter including, digital stage (a), the modulation stage (b), the power stage (c), pictures of the digital stage (d) and the assembled power stage (e).

Boards were realized by mechanical drilling on Rogers 4003 of 0.6 mm height. As each component is on a different board, to connect them together, they are placed on a base which is also useful for thermal dissipation of the power amplifier.

The sensitive point of the emitter compliance toward the mechanical structure is the realization of the antenna. Indeed, the challenge is to create an antenna which can transmit the signal to the ground and which fulfill constraints as weigh, size, rocket aerodynamics and robustness.

IV. ROCKET ANTENNA

On its first sounding rocket (Fig. 1), EirSpace designed a VHF folded monopole antenna [3]. However a non-extruding antenna is desired. Therefore, a MID based antenna has been investigated.

A. MID Technology

The principle of Molded Interconnect Devices (MID) is to inject molded thermoplastic parts with integrated, selectively metalized circuit traces. The MID-technology combines the integration of mechanical, electrical and packaging functions in one subassembly. It is one of the advantages of this technology, antennas or electrical circuits can be adapted onto 3D shapes.

B. MID Antenna Design

The antenna will be realized in the thickness of the nose cone of the rocket [4]. The development of this innovative antenna using MID Technology will get rid of all issues raised before. The radiation pattern must be omnidirectional for both frequencies. The chosen architecture is shown below: several monopole antennas are equally distributed around the tube.

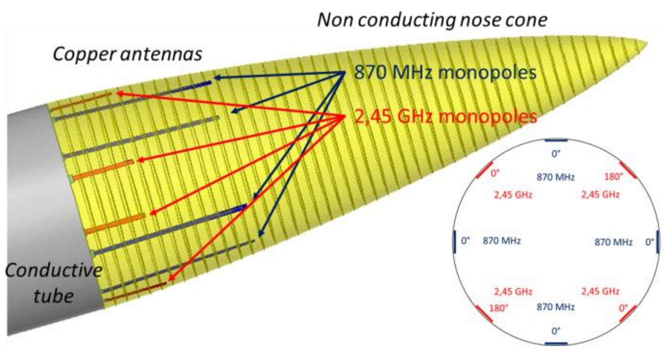

Fig. 4. Architecture of the embedded antenna and phase repartition.

The feeding network must be adjused in order to obtain constructive waves and reach the maximum gain. The best solution is given in Fig. 4. The radiation pattern is omnidirectional as required and the maximum gain is around 4 dB at 2.45 GHz and 2 dB at 869.5 MHz (Fig. 5). The -10 dB bandwidth for both bands are shown in Fig. 6.

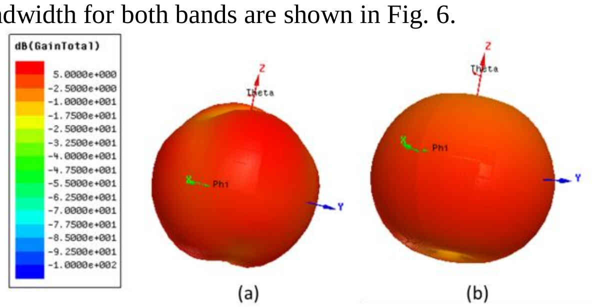

Fig. 5. Radiation pattern at 2.45 GHz (a) and 869.5 MHz (b).

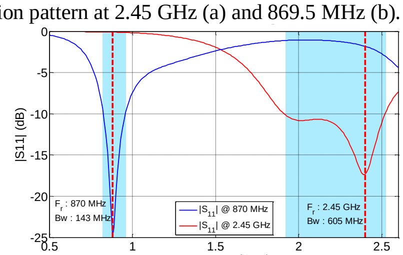

Fig. 6: Impedance matching of the 869.5 MHz and 2.45 MHz antennas.

An advantage of this antenna is its light weight. Furthermore this antenna is robust and there is no risk of breaking it when handling the rocket or in the launching pad.

V. GROUND RECEIVER

The ground receiver is designed in order to receive data from the rocket. The amplification needed to decode the signal emitted by the rocket is calculated based on an estimation of the distance between the rocket and the receiver on the worst case. From this information, and the choice of the demodulator, it was possible to elaborate the architecture of the receiver. For each component, a board was designed in order to get a modular receiver and to be able to easily replace any component. Each card was designed in order to have easy connections between them. The fabricated receiver is illustrated on Fig. 7.

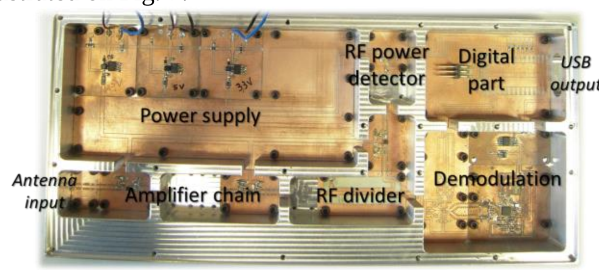

Fig. 7. Picture of the fabricated receiver.

Each part has a cavity in order to avoid parasitic influence from a component to another. Some absorber will be stick on the housing cover to avoid resonant mode to appear in the cavities. The power supply is also split into three parts, one to supply the LNAs, another for the demodulation part and the last one for the digital part.

In order check the reception of the signal and to estimate the distance between the rocket and the receiver, a RF detector has been added.

VI. CONCLUSION

In this project a new type of light and robust embedded antenna was designed for telemetry purpose. A modular 2.45 GHz emitter and its associated ground receiver was studied to transmit a high data rate from the rocket to the ground for telemetry purpose.

VII. ACKNOWLEDGEMENTS AND FUTURE PLAN

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