Dual-Band Transmitter and Stabilization Blade Antenna for Experimental Rocket Telemetry Application

Rémy Bouché, *Student Member, IEEE,* and Anthony Ghiotto, *Senior Member, IEEE*

***Abstract*—This report summarizes the results of research activity conducted during 2015, supported by the MTT-S Undergraduate research scholarship. The aim of this project is to design and manufacture a dual-band transmitter, working at 870 MHz and 2.45 GHz, using an aerodynamic blade antenna. This kind of antenna allows to transmit data while stabilizing the rocket. It also includes the design of a diplexer and a splitter working on both frequencies.**

***Index Terms*—Blade antenna, diplexer, sounding rocket antenna, splitter.**

I. Introduction

This project has been realized in collaboration with EirSpace: the aerospace student association [1] of the ENSEIRB-MATMECA engineering school [2]. EirSpace aims at designing and launching experimental rockets that are launched during launch campaigns organized each year during the summer by the CNES French agency (Centre National d'Études Spatiales).

Multiple experiences are setup in the rockets, as for example weather or trajectory measurement. All the data acquired by the various embedded sensors are recorded within the rocket and sent to the ground during the flight for real time monitoring. All the mechanics and electronics are designed and fabricated by the student members of the association.

II. Description of the Project

To ensure the telemetry of the rockets, the *CNES* provides a 137MHz emitter and ground receiver called "Spatiobus". However, this emitter is not adapted to some projects as more bandwidth is required to transmit trajectory data. That is the reason why the last rocket designed by the club had its own 2.45 GHz data link, as well as a second emitter at 869.5 MHz for redundancy purpose. This experimental rocket was launched successfully in August 2015.

R. Bouché is with the ENSEIRB-MATMECA engineering school and the EirSpace Student association, 33400 Talence, France (e-mail: rbouche@enseirb-matmeca.fr).

A. Ghiotto is with the ENSEIRB-MATMECA engineering school and the University of Bordeaux, IMS Laboratory, CNRS UMR 5218, IPB, 33405 Talence, France (e-mail: anthony.ghiotto@ims-bordeaux.fr).

Fig. 1. Photo of the EirSpace 2015 experimental rocket (named Artemis) and its wideband bi-cone antenna [3].

For these reasons, it has been decided to use the same ISM bands on this project. The architecture of the project is shown in Fig. 2. For mechanical symmetry, four dual-band blade antennas are fed by a splitter, and a diplexer allows the transmission on the two ISM bands. Commercial receivers and transmitters will be used for both frequencies.

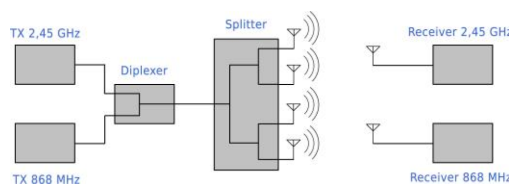

Fig. 2. Global architecture.

III. Design of the Antenna

A. Purpose

When the center of mass of a rocket is too high, a solution is to bring more stability with another range of upper ailerons. They also could be used to send data by integrating an antenna inside the aileron, resulting in an aerodynamic antenna as used in the airspace industry.

B. First prototype

The first antenna was designed by using an electromagnetic simulation software provided by the IMS laboratory [4]. The design was achieved by testing different shapes and analysing the results of parametric simulations. Then, the prototype was manufactured using a PCB board with vias on the surface to connect the two conductive sides. The metallic tube of the rocket is used as a ground plane.

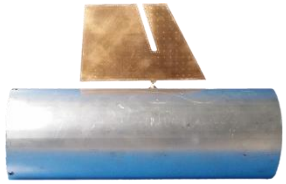

Fig. 4. Photo of the first antenna prototype.

The measurements of this first prototype were close to the simulations. The S_{11} parameter reached -30 dB in the 868 MHz band, and -15 dB in the 2.45 GHz band.

C. Final prototype

However, this first prototype presented two disadvantages: its surface was too large and it was not strong enough to support high mechanical constraints. That is why another antenna was designed, using a 3D-printed support to strengthen the antenna.

They were two main difficulties. First, the plastic used by the 3D printer changed the parameters of the antenna. It was necessary to evaluate the permittivity of this material to obtain better results. Moreover, the screws used to fix the antenna to the tube of the rocket also changed the results because they were in contact with the metallic tube. Their position had to be optimized.

A second series of simulations was achieved. These new simulations permitted to design a smaller antenna, so that the mechanical constraints are weaker, and to rectify the changes due to the 3D-printed support. The new design permits to reach a S_{11} parameter of -20 dB in the 868 MHz band, and -12 dB in the 2.45 GHz band.

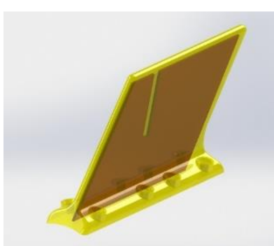

Fig. 5. 3D-model of the final prototype with its support.

IV. Splitter and diplexer

The aim of the diplexer is to gather the two signals into one to transmit it. It can be done with passive components. It was designed using ADS with the Murata library [5] to simulate real components. The simulations showed good results: the two inputs are well-isolated for the selected frequencies with a loss of 0.6 dB on both path. However, the measurements do not match entirely the simulations, this part of the architecture is still in progress.

The diplexer is followed by a splitter that equally divides the energy of the signal to the four antennas. This splitter simulation was inspired on a dual-band Wilkinson divider, proposed by [6]. The S_{11} and S_{12} measurements are satisfying but the isolation between the output ports still need to be optimized.

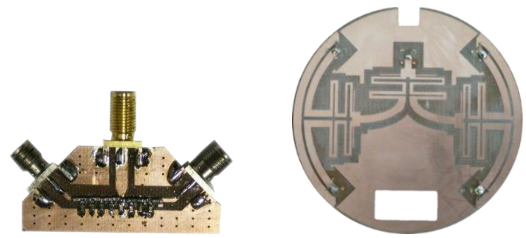

Fig. 6. Photo of the diplexer and splitter prototypes.

V. Conclusion

A dual-band aerodynamic antenna was designed and manufactured. A splitter and diplexer were also designed for two frequencies but are still in development. The emitters and receivers circuit will be designed next year. All these components will be integrated in the next rocket of the EirSpace club (named Déméter), that will be launched during the C'Space event of 2017.

VI. Acknowledgements and Future Plan

I would like to thank my adviser, Prof. Anthony Ghiotto, for his support on that project. I also give my thanks to the MTT Society for providing me the scholarship and the opportunity to attend the International Microwave Symposium 2016. It was a great and rewarding experience.

I am currently pursuing my studies in ENSEIRB-MATMECA and am expected to graduate next year. The MTT Society Awardee motivated me to work in the microwave field.

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[3] J. Prades, A. Ghiotto, E. Kerhervé and K. Wu, "Broadband Sounding Rocket Antenna for Dual-Band Telemetric and Payload Data Transmission," in *IEEE Antennas and Wireless Propagation Letters*, vol. 15, no. , pp. 540-543, 2016.

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