Design of Blade Antennas for Experimental Rocket Telemetry Application

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***Abstract*—This document presents the research topic that consists in the design and manufacturing of two blade antennas that will be part of a complete experimental rocket telemetry system based on a tracking base station. This system will be used to improve the communication with experimental rockets launched by the EirSpace student association of which Mr. Grauwin is a member and that has successfully launched rockets each summer since 2011 during the C'Space international student contest organized by the CNES (Centre National d'Etudes Spatiales) French space agency. The aim of this project is to set up a strong link for data transmission from the rocket to the ground, and create video transmission. All measurements will be transmitted on 138.5 MHz ISM band and a ground station will receive the data. The video transmission will use the 868 MHz ISM band, which allows a higher datarate. Mr. Grauwin is in charge of designing, manufacturing and testing the blade antennas for both frequencies and then a 868 MHz emitter based on COST (components of the shelve). The 138.5 MHz transmitter, the Kiwi Millenium telemetry system, is provided by the CNES. The 138,5 MHz receiver will be provided by the CNES Spatiobus, and the 868 MHz one will be conducted by Eirspace. The designed antennas and transmitter will be implemented in the EirSpace experimental rocket that will be launched during the C'Space event of August 2020.**

***Index Terms*—Blade antennas, Inverted-F antennas, telemetry system, experimental rocket**

I. Introduction

This project will be realized in collaboration with EirSpace: the aeronautics student association of the Enseirb-Matmeca engineering school. 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.

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

This document presents the work made on the telecommunication system, especially on the antennas. On an experimental rocket, the frequencies used for telecommunications are relatively low, resulting in a large antenna size. The main problem then lies in the location of these antennas, which must under no circumstances disturb the aerodynamic shape of the rocket. A good way to integrate these antennas is to place them as a patch on additional fins that provide greater stability for the rocket without necessarily weighing it down. Some designs are reported in [1]-[5].

It was therefore decided to build Inverted-F antennas (IFA) integrated directly on these fins. The rocket body is then made of aluminum to reduce the mass and serve as a ground plane for the antennas. This type of antenna has an approximate length of λ /4, the sizes to operate at 868MHz and 138MHz are about 9cm and 54cm, respectively. The maximum size of the additional fins to maintain a correct trajectory and good stability was calculated using the Stabtraj tool provided by CNES. This size being 35cm, it is necessary to reduce the space occupied by the 138MHz antenna by making it twist on the blade.

II. Design and Simulation of Antennas

The software used to design and to simulate both antennas is CST. First, the fins were modelled according to the dimensions obtained with StabTraj. For both practical and aesthetic reasons, the material chosen for these blades is PMMA, with a dielectric strength of 3.6 F/m. In these fins, furrows in the shape of the IFA antennas were then traced. It was decided to engrave them in the PMMA instead of applying them directly to the surface to facilitate the construction of the system and the insertion of the connector. Once the fins were formed and engraved, a thin layer of silver was added to the grooves to form the antenna bodies. A SMA connector is added to power the antenna. Finally, the cylindrical aluminium body of the rocket is added to serve as a ground plane. The designed antennas are shown in Fig. 1.

As the radiation and resonance frequency of these antennas depend on the silver layer and the shape of the furrows, several simulations were carried out until satisfactory results were obtained.

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The CST Studio simulator was used to plot the S11 parameters of the antennas and their radiation pattern.

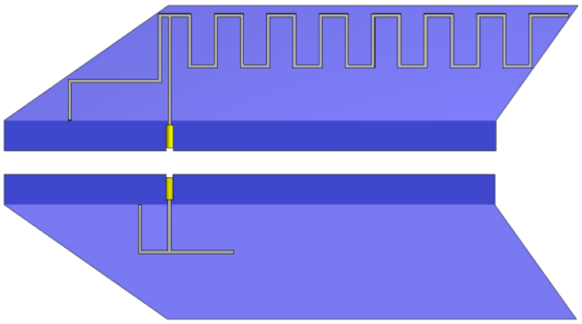

Fig. 1. Designed blade antennas for the experimental rocket. On the top is the 138 MHz antenna and on the bottom is the 868 MHz one.
The darker parts of the blades will be inside the rocket body.

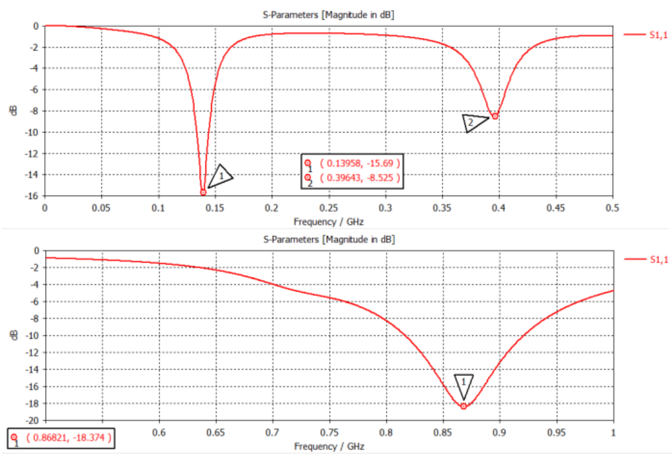

Fig. 2. S11 parameters simulated with CST Studio . At the top are the results for the 138 MHz antenna and at the bottom those for the 868 MHz antenna.

Fig. 2 shows that after having carried out several simulations by modifying the length and width of the furrows, the position of the feed point and the connection to the ground, the modelled antennas correspond to our expectations and resonate well at the desired frequencies.

III. Fabrication and Measurements

In order to properly manufacture the antenna system, the laser cutting machine of the Enseirb-Matmeca Engineering School was used to cut the shapes of the fins and engrave the antenna grooves into PMMA sheets according to the dimensions previously determined. The bottom of the furrows was then covered with silver paint to create the antennas. Several layers were applied to improve conductivity.

The blade antennas thus produced were then measured at the Canadian Poly-Grames research laboratory where I completed an internship. As shown in the Fig. 3, the measured S11 parameters of the two antennas correspond globally to those obtained in simulation. The 138 MHz antenna is less resonant than expected in the simulation but remains acceptable, while the 868 MHz antenna is of better quality than expected.

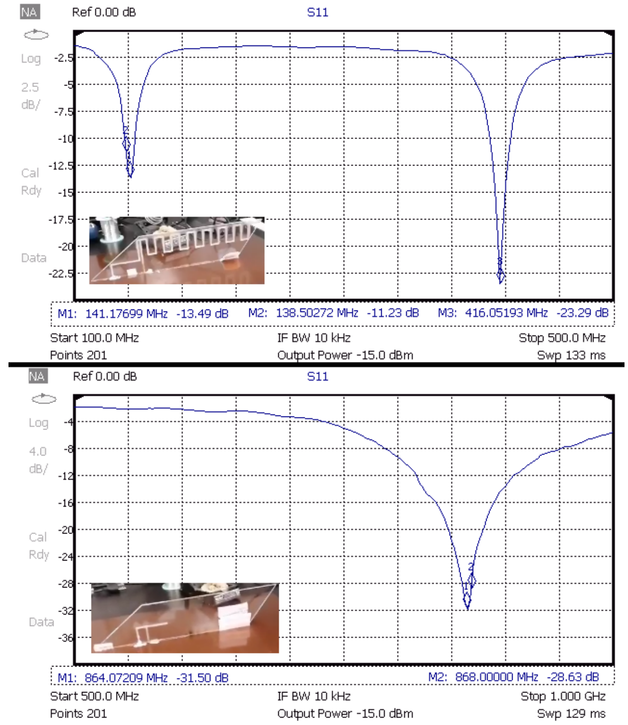

Fig. 3. S11 parameters measured. At the top are the results for the 138 MHz antenna and at the bottom those for the 868 MHz antenna.

IV. Conclusion

As the fin antennas have been tested and validated, the 868 MHz transmitter and receiver now remain to be designed. The telecommunications system will then be integrated into the body of the rocket and connected to the on-board camera and Kiwi transmitter to send the telemetry data and video signal.

The MTT-S Scholarship Program had a significant impact on the Eirspace association and our experimental rocket project through funding, but also on a more personal level. It allowed me to attend the IMS 2019 conference in Boston where I was able to meet many researchers and doctoral students, discover new research themes and understand the current and future challenges in the radiofrequencies industry.

The IEEE Certificate of Recognition I received there opens many doors for me and has already allowed me to do my internship in one of the best radiofrequency research laboratories in Canada, Poly-Grames. After my studies, it will increase my chances of achieving my professional projects, in particular that of working as a researcher on a scientific basis in Antarctica.

References

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