Antenna for satellite and UAV communications

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***Abstract*— This article presents a prototype of an antenna that will be part of the communication system between a picosatellite and an unmanned aerial vehicle UAV. The designed antenna is a 2x2 array of patch antennas and has an axial ratio below 3dB in a large beam width (140° roughly). The S_{11} parameter is below -10 dB in a good bandwidth. Two 1to 4 power dividers are used to feed the array antenna. In both cases, the impedance bandwidth is better than 680 MHz**

Keywords—antenna array; circular polarization; patch antenna; picosatellite.

I. Introduction

Cube Satellite (CubeSat) technology is an emerging alternative to conventional satellites in different fields of science, for example in radio astronomy, communications, earth observation, space research, and communications. Due to its small size, picosatellites present challenging restrictions in the circuitry and components design. One of the main components that requires a carefully design is the antenna, as this is needed to be lightweight and small in size, among other electrical and mechanical requirements.

A substrate that allows the operation of the antenna in a space of reduced dimensions and at extreme temperatures needs to be used. Two important parameters were the dielectric constant, to reduce the dimensions of the antenna, and the thickness of the substrate, to obtain the desired bandwidth but avoiding the appearance of surface waves [1].

In the present work, once the substrate has been selected as mentioned in [2], the antenna design will be carried out to achieve the necessary bandwidth as well as beamwidth. To obtain the bandwidth, recommendations given in [3] [4] [5] will be followed. To obtain the beamwidth, a 2x2 antenna array will be used as recommended in [6]. To get elliptical or circular polarization, recommendations mentioned in [7] [8] would be applied.

II. Antenna Design

The antena will work in extreme temperature conditions, since it will be shipped on a picosatellite, for this reason it must also be light in weight and small in size. A ROGERS TC600 substrate that has a permittivity of 6.15 and a thickness of 3.175 mm will be used for the design. The antenna will work at a central frequency of 5.8 GHz, with a bandwidth of 10%, circular polarization and a beam width of 60 degrees; to achieve this gain, a 2x2 array was used. In addition, to achieve the circular polarization of the whole set, the antennas will be fed with a phase shift of 90 degrees. Each of the radiating elements is based on circular polarized patch antenna that has the geometry shown in Fig 1.

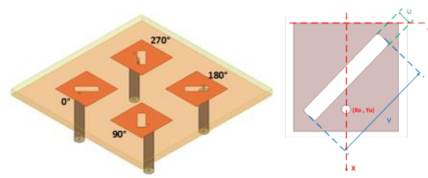

Fig. 1 Antenna model and design parameters

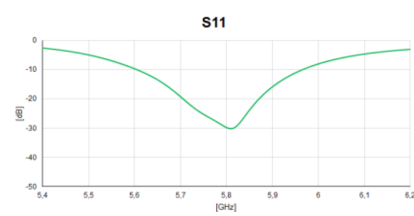

Fig. 2 Simulated S_{11} parameter of the array

To achieve circular polarization, a 45° inclined slot was used, in which dimensions ***u*** and ***v*** are used to improve the axial ratio and ***Xo*** and ***Yo*** to improve matching. Fig. 2 shows the simulated S_{11} parameter of the array, as it can be seen S_{11} is below -10 dB in the frequency range from 5.6 GHz to 5.96 GHz. In Fig. 3 it can be seen that axial ratio is below 3 dB between -70° and +70°, which means that circular polarization was obtained in a wide beam width.

To verify the operation of the array, two simple 1 to 4 power dividers were designed in microstrip technology. The phase shifts were obtained by varying the lengths of the feed lines. Fig. 4 shows the first network, which has an input with a microstrip line. As can be seen, this network presents a simulated S_{11} parameter below -20 dB in the range from 5.2 GHz to 6.4 GHz.

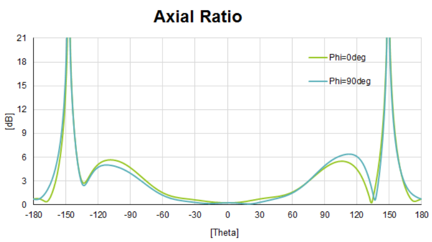

Fig. 3 Simulated axial ratio

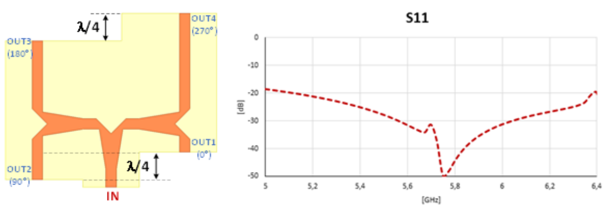

Fig. 4 Feed network N°1 and simulated S_{11} parameter

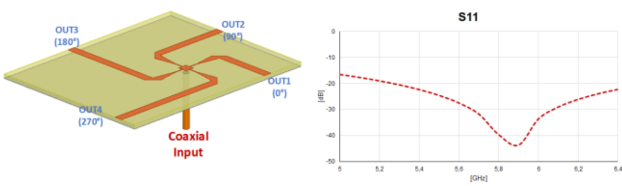

Fig. 5 Feed network N°2 and simulated S_{11} parameter

Fig. 5 shows the geometry of the second feed network, which uses a coaxial input that is perpendicular to the network. It can be seen that the S_{11} parameter is below -20 dB in the 5.3 GHz to 6.4 GHz range.

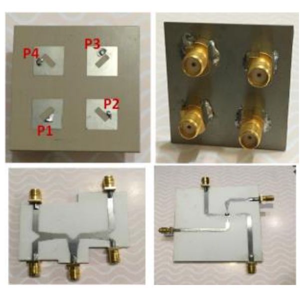

Fig. 6 Manufactured prototypes

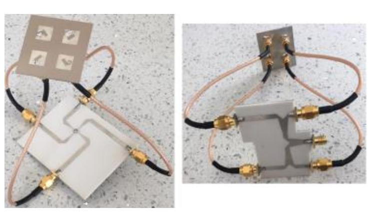

Fig. 7 Antenna array with feeding networks

III. Prototypes and Results

Prototypes of both the array, as well as the two power divider networks were manufactured. In Fig. 6 it can be seen pictures of the prototypes and Fig. 7 shows the photographs of the array connected to the two feeding networks.

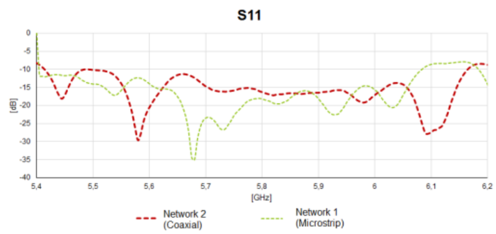

Fig. 8 Measumenents of S_{11} parameter

Fig. 8 shows the graph of the measured S_{11} parameter for two configurations. As can be seen, in both cases the S_{11} parameter is below -10 dB in a large bandwidth. In the case of network 1 (microstrip), the bandwidth is 680 MHz and for network 2 (coaxial) the bandwidth is 755 MHz.

IV. Conclusions

An antenna to remotely control unmanned aerial vehicles (UAVs) from a picosatellite, was designed and built. The antenna, which is formed by an array of 2x2 microstrip patches, is compact and lightweight. The axial ratio is below 3dB in a large beam width (140° roughly) and the S_{11} parameter is below -10 dB in a good bandwidth, for two prototypes. The bandwidth is 680 MHz for the first prototype and 755 MHz for the second.

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