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Development of 5.8 GHz circular polarized 2x2 patch array antenna for CubeSat

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Abstract

Meeting the limited power budget requirements of CubeSats while increasing the radio link data rate is a challenging task. It is necessary to develop a compact and reliable RF subsystem which must include an antenna with excellent directivity and efficiency characteristics. This paper focuses on 5.8 GHz planar technology antenna design for a CubeSat. Antenna was designed as 2x2 patch array with corner truncations to achieve circular polarization. Planar type antenna was chosen by their low cost and volume, lightweight and need for mechanically robust construction as well as ease of installation and aerodynamic profile.

1. Introduction

Over the recent years there has been an increasing trend in count of launched nanosatellites, especially the CubeSats. With the most popular commercial application being earth observation, the demand for increased communication downlink data rate has sharply risen. Based on it there is necessity for communication systems with high data rates. The goal of this work is to develop planar technology antenna prototype for C-band transceiver payload of ESTCube-2 nanosatellite [1]. The transceiver in this case is an experimental reconfigurable communication subsystem [2].

2. Antenna design

Antenna is designed and simulated with CST electromagnetic solver to achieve specification requirements which determines the need of circular polarization, 6 dB as minima antenna gain, 3 dB beamwidth of 60 degrees or less and 50 ohm impedance. It is necessary for communication channel link budget to use large diameter antenna for satellite radio signal reception, like RT-16 radiotelescope (Latvia, Irbene). Also antenna must be able work effectively in two bands: uplink from 5.65 – 5.67 GHz and downlink 5.83 to 5.85 GHz. Hence, theoretically there is minimum of 200 MHz impedance bandwidth, where input impedance of antenna has to be 50 ohms, in order to avoiding from undesirable reflections. Form factor restrictions of substrate along its length L is 100 mm and along width W 82.80 mm (see fig. 1).

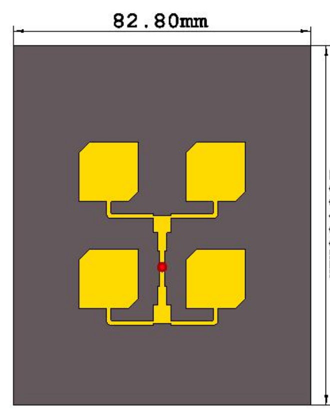

Figure 1: Antenna design and dimensions (red point is the RF signal feed point).

To reach set conditions, 2x2 patch array with corporate feed network using Rogers RT 5880 laminate as substrate (h = 1.6 mm, ε_r = 2.2) was used in design process to achieve high directivity and efficiency, therefore to meet demand of high gain antenna. Square patch elements with corner truncations were chosen to achieve circular polarization.

Simulation results show, that achievable gain is approximately 12 dB and 3 dB beamwidth ~ 45 degrees either for uplink and downlink frequency bands. Return loss at 5.66 GHz (downlink band middle frequency) is -23.5 dB and at 5.84 GHz (uplink band middle frequency) -18.8 dB. The total efficiency over band is above 90% and VSWR is below 1.5.

Antenna radiation pattern in 3D space is shown in fig. 2. Patterns for principal E and H planes for 5.66 GHz as example are shown in fig. 3 and fig.4, respectively.

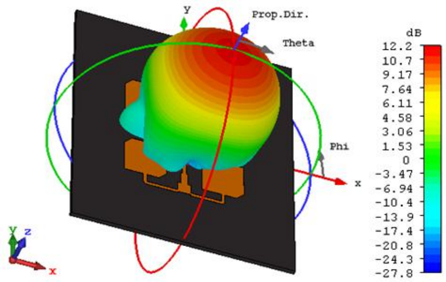

Figure 2: Simulated antenna radiation pattern (3D, log scale).

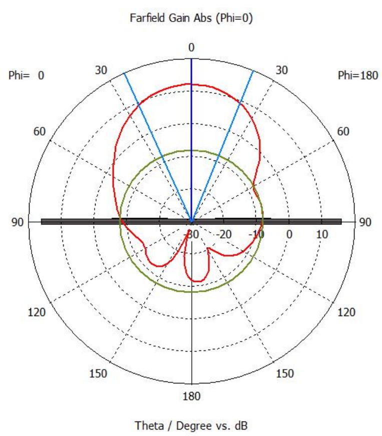

Figure 3: Simulated H plane pattern at 5.66 GHz (log scale).

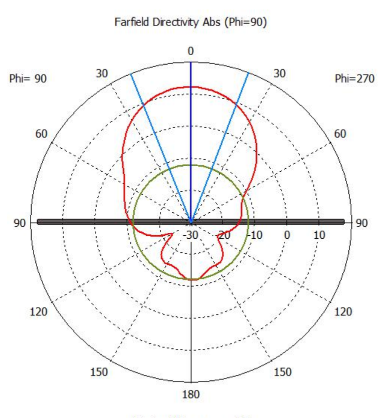

Figure 4: Simulated E plane pattern at 5.66 GHz (log scale).

3. Summary and Conclusions

This paper presents the simulation results of a 2x2 patch array antenna. The results are shown and discussed, such as principal E and H plane patterns for uplink band middle frequency, 3 dB beamwidth, return loss, efficiency and VSWR. All characteristics of antenna comply with initial requirements.

This antenna design will be used to manufacture a prototype that will be measured in order to compare it's characteristics with the simulated model. If successful the antenna design will be used in ESTCube-2 mission as a part of the high speed communication subsystem payload.

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