A Modified Helical Shaped Deployable Antenna for CubeSats

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***Abstract* – This paper presents a new antenna design for CubeSat application. The antenna is a modified helix designed on top of 10cm x 30 cm satellite. The antenna deploys with a 120 cm x 120 cm ground plane to achieve a UHF wideband operation with a reduced back lobe radiation. The antenna exhibits circular polarization with a gain of at least 7 dB for most operating frequencies.**

1 INTRODUCTION

Deployable antennas are designed to fully deploy and remain stable once in orbit. Several deployable antenna concepts have been proposed in the past years for small and large satellites. Large satellites use mostly inflatable antennas, mesh antennas or reflector antennas. On the other hand small satellites such as CubeSat resort mostly to wire antennas, helical antennas or Yagi Yuda arrays. In general, the requirements for space communications on a small satellite platform is focused on a reasonable gain (>5 dB), and wide bandwidth as well as circular polarization

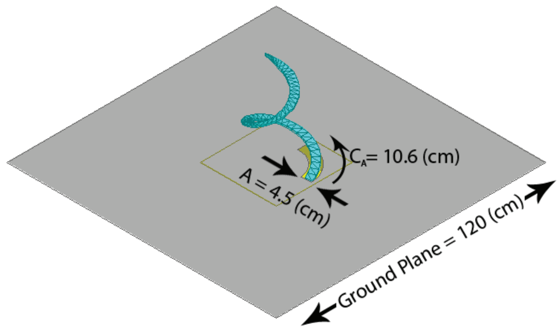
Wire antennas and dipoles in particular have been abundantly utilized [1-3] on CubeSats. However dipole antennas in their natural behavior don't exhibit circular polarization unless crossed together with some phase shifting mechanism. Dipoles also exhibit narrow band behavior and relatively low gain. Arraying such dipoles in a Yagi-Uda arrangement or a log-periodic arrangement is an option that several investigators have explored [2]. Deployable helical antennas [2] are proposed as a lead candidate for CubeSat space applications due to their wide bandwidth as well as their natural circular polarization behavior. Another candidate for CubeSat operation is the quadrifilar helix antenna [3]. This type of deployable antennas comes into configurations where the top of its conductors can be either open or short. This antenna structure exhibits a reasonable bandwidth. Patch antennas are also proposed as candidates [4]. Non-deployable patch antennas can be printed on the satellite's sides. These antennas can exhibit circular polarization and adequate bandwidth; however their operation in a UHF frequency band with at least 5 dB gain, such as the one required for CubeSat applications, requires a relatively large real estate which is not available on most CubeSats .

In this paper, we propose a new deployable modified helical shaped antenna designed on top of a cubesat of size 10 cm in depth and 30 cm in width. During the launching phase, the antenna is stowed and packed inside the satellite and once in space the antenna deploys along with a 120cm X 120 cm ground plane.

2 ANTENNA DESIGN AND STRUCTURE

The antenna presented in this paper is a modified helical shaped antenna. This antenna is designed to deploy on top of a cubesat of size 10 cm in depth and 30 cm in width. The antenna is stowed and packed inside the satellite before deployment and once in space the antenna deploys along with a 120cm X 120 cm ground plane. The thickness of the ground plane has to exceed the skin depth thickness at the operating frequency. In this work we assume the ground plane is a perfect electric conductor and thus the skin depth is negligible.

The ground plane also has an arc opening as shown in Fig.1a; this opening has a circumference of 10.6 cm. The antenna is designed with Berylium copper which allows a better stability and deployment capability. The antenna dimensions are shown in Fig.2. The antenna is fed from inside the satellite cavity as shown in Fig.1.b with an excitation of 65 Ω impedance for better impedance matching..



a.

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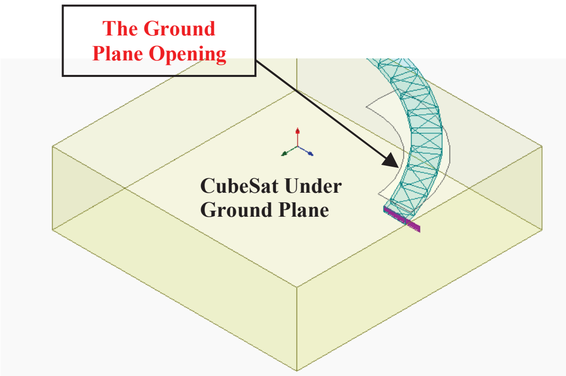

b.

Fig.1 a) The antenna on top of the satellite with the dimensions of the ground plane and the arc opening. b.) The CubeSat under the ground plane with the antenna excitation

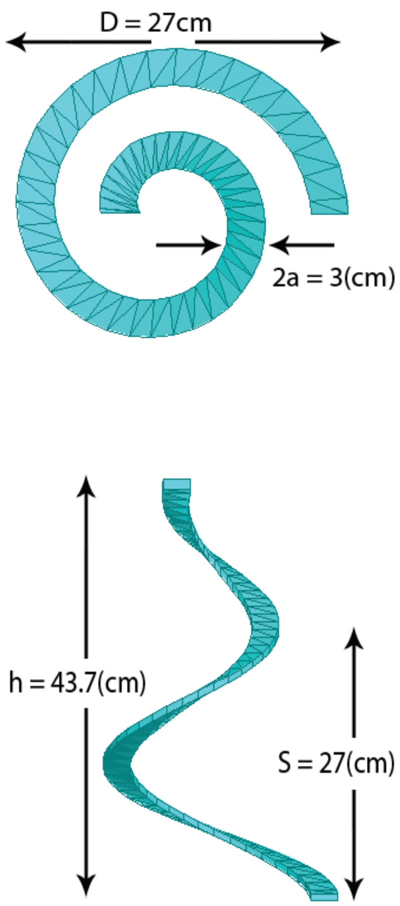

Fig.2 The antenna shape and dimensions

3 Results and Performance

The helical shaped deployable antenna operates a UHF band between 380 MHz and 780 MHz as shown in Fig.3. The antenna is an improvement to a typical helical antenna since it is composed of one turn and still exhibits a gain of at least 7 dB for most operating frequencies. The antenna also exhibits a smaller height than typical helical antennas at UHF frequencies. The antenna's height, pitch and dimensions are optimized using HFSS.

The three dimensional gain pattern at 550 MHz is shown in Fig.4, where the back lobe is significantly reduced due to the ground plane. Even though the size of the ground plane is significant however its presence is crucial to reduce the back lobe radiation towards the satellite. The size of the ground is also optimized to maximally reduce the back lobe radiation while maintaining the same UHF performance. Finally the antenna exhibits circular polarization with an axial ratio that varies between 0.25 dB and 3 dB for most frequencies at θ=30□ in the H plane of the radiation pattern. Based on all these characteristics the presented antenna constitutes a good candidate for small satellite communications application and especially for CubeSats.

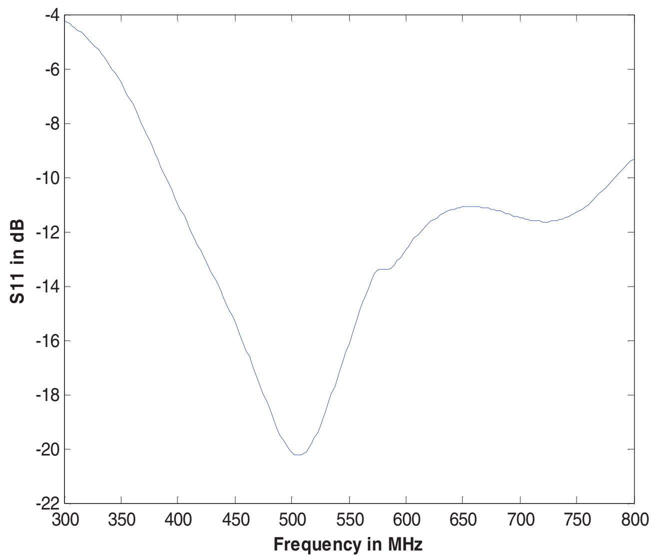

Fig.3 The reflection coefficient for the deployable antenna

4 Conclusion

In this paper we present a modified helical shaped antenna suitable for CubeSat deployment. The antenna exhibits a wide band operation over the UHF band with a reasonable gain (>5 dB). The antenna is circularly polarized and has a reduced back lobe with an Omni-directional front lobe. The reduction of the back lobe is achieved by deploying a large ground plane (120 cm x120 cm) with the antenna structure. The antenna is designed and simulated over a CubeSat prototype of depth 10 cm and width of 30 cm.

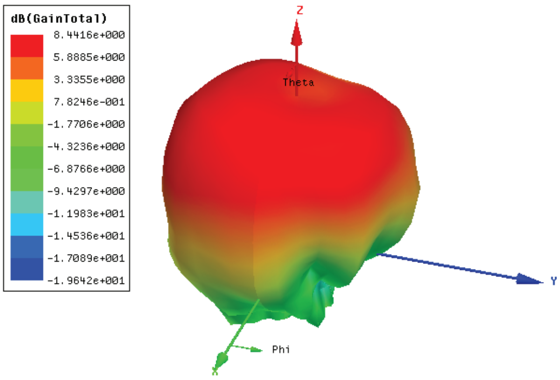

Fig.4 The 3D gain pattern of the antenna at 550 MHz

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