A New Quadrifilar Helix Antenna for Space Communications

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***Abstract*—This paper presents a new quadrifilar helix antenna designed to deploy on a space craft for space communications. The quadrifilar helix is beryllium based and is deployed on top of a square ground plane. The ground plane is optimized to reduce back lobe radiation and achieve optimal gain and beam width. A trade off analysis is achieved and is discussed herein. The antenna dimensions and structure are studied to preserve operation in the S-band range while preserving stable radiation characteristics.**

I. Introduction

Deployable antennas are used in space to enable larger apertures or longer elements than can be stored inside a launch vehicle shroud during the trip to earth-orbit. Therefore, antennas are designed to fold compactly for launch then autonomously deployed once on-orbit. The structural material and system architecture solutions for this class of antennas are often times non-intuitive because of the microgravity and extreme thermal environments that these systems must operate in.

Many different types of deployable antennas have been used on orbit. Reflector types constitute their widest category [1]. Other deployable structures made with folded hoops or ribs are also used for space communications [2]. Other researchers have also resorted to tape springs and neutrally stable material to design their structures [3]

In this paper we present a new beryllium based quadrifilar helix antenna designed to operate at 2.34 GHz. The antenna is designed to deploy on an optimized ground plane. A trade off analysis is achieved to determine the size and shape of the ground plane to realize better gain and beamwidth..

II. Antenna Structure and Design

A typical quadrifilar helix antenna has four arms (wires) that are twisted in a helical shape. Each of the four orthogonal conductive turns is arranged to define two separate helically twisted loops that are excited in quadrature phase. The quadrifilar helix antenna is an omni-directional antenna, along with being circularly polarized. It has four orthogonal helices that share the same longitudinal axis and are rotated 90° with respect to each other. The wires can be fed at the top of the antenna or at the bottom while the opposite end of the feeding side is either shorted or opened. In addition to its natural circular polarization, the quadrifilar helix antenna is distinctive among other types of antennas for having a hemispherical radiation pattern.

In this paper we discuss a new open ended conductor quadrifilar helix antenna. The antenna has four arms equal in length. The antenna structure is shown in Fig.1. The antenna is designed to operate in S-band at 2.34 GHz. The antenna has a helix diameter of 1.8 cm. The helix diameter is the distance between two diametrically opposite conductors. The helix height which is the distance from the ground plane to the end of each conductor is 6.516 cm. The antenna has 1.125 number of turns and a helix spacing of 5.792 cm. The wire diameter constituting the antenna is taken to be 0.0254 cm. The antenna dimensions are summarized in Table 1. The antenna reflection coefficient is shown in Fig.2 exhibiting operation at 2.34 GHz.

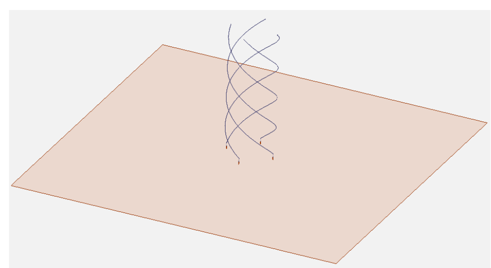

Fig. 1 Quadrifilar Helix Antenna with Ground plane.

Table 1: Antenna dimensions in cm

Helix Diameter	***1.8***
Helix Spacing	5.792
Number of turns	1.125
Wire diamter	0.0254

III. Ground Plane Effects and Trade off Analysis

The ground plane of the quadrifilar helix antenna plays an integral role in reducing the back lobe radiation and improving the antenna performance. It is important to relate the ground plane dimensions to the wavelength of the operating frequency to fully understand the correlation between dimensions, frequency of operation and radiation characteristics.

First of all, considering a square ground plane, an iterative optimization process is achieved using HFSS, taking into consideration the antenna's back lobe radiation, gain and beam width. The dimensions of the ground plane have a direct effect on the antenna performance. The larger the ground plane, the

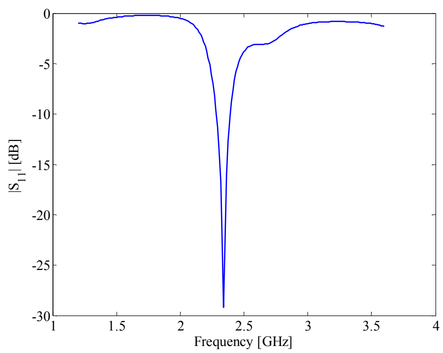

Fig.2 Reflection coefficient showing operation at 2.34 GHz

more pronounced is the back lobe reduction. However the gain and the beamwidth are affected by the dimensions of the ground plane in a different way. The antenna's reaches its peak gain of around 8 dB when the side of the ground plane is 1.25 λ. However the beamwidth reaches its peak of 100° at around 0.5 λ . A comparison between the gain and beamwidth of the antenna for various ground plane dimensions is shown in Fig.3. The radiation pattern at 2.34 GHz for a ground plane side dimension of 1.25λ is shown in Fig.4 in the E-plane cut where the back lobe is greatly reduced.

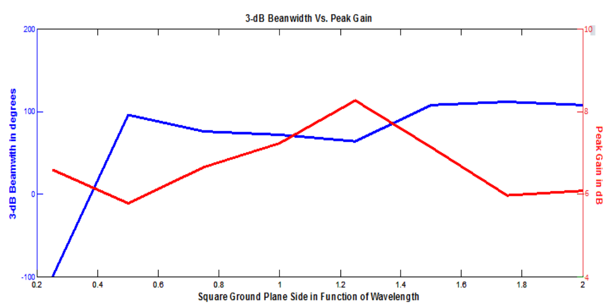

Fig.3 3-dB Beamwidth Vs. Peak Gain in function of ground plane side dimension

IV. Feeding Mechanism of the Quadrifilar Helix Antenna

The four arms of the quadrifilar helix antenna have a unique property of being in quadrature phase one with respect to the other. The antenna is fed with one port and this port redistributes the power as well as the phase shift between the different arms to achieve a progressive 90° phase shift between the different ports. The feeding network used herein consists of one to two port 180° hybrid coupler with power splitter and two 90° hybrid couplers with power splitters. Each output port of the 180° hybrid is connected to an input port of the 90° hybrid the different ports of the 90° hybrids excite the antenna arms with a progressive 90° phase shift as shown in Fig.4[4]. The feeding network is summarized in Fig.4 [4].

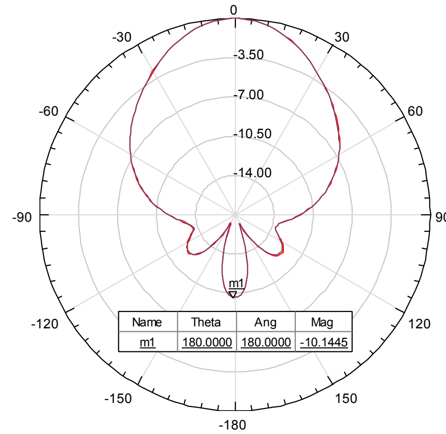

Fig.4 Radiation pattern of Antenna at 2.34 GHz in E-plane

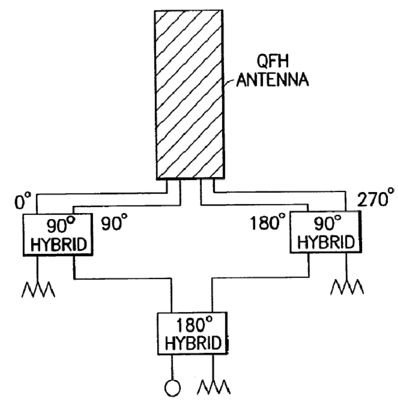

Fig.4 Feeding network of the quadrifilar helix antenna [4]

IV. Conclusion

In this paper we present a quadrifilar helix antenna suitable for space communications for the S-Band. The antenna is designed using Berylium and is deployed on a square ground plane. The dimensions of the ground plan are iteratively optimized to reduce back lobe radiation and to optimize its gain and beamwidth.

References

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