Design of Quadrifilar Helical Antenna For S-Band Applications

Sonia Sharma, Jagmehender Sheoran, Om Prakash Goswami

Abstract-In this paper, a new open ended Quadrifilar Helical Antenna (QHA) is proposed. A Quadrifilar Helical Antenna with parasitic helical strips for circular polarization. The mutual coupling effect between the grounded helical strips and the feeding helical arms provides a good impedance match and wider hemispherical coverage. The impedance bandwidth corresponding to VSWR < 2 is 200 MHz, from 2.28 GHz to 2.48 GHz. This antenna is design on FEKO software and prototype model is tested for the transmission of voice, video and different digital data with satisfactory results. This antenna works well for wi- fi signals reflected off from building and moving vehicles. This antenna is small in size, low cost, and light in weight. Quadrifilar helix antennas are used in the lower microwave band, from L-band to X-band. Typical applications are for TT&C-links in satellites and narrow band data links. The other applications are in GPS-receivers, both in satellite based and ground based systems.

Index Terms: Cardiod, Circular Polarization, Helix, hemispherical coverage, QHA, S-Band, Satellite Communication

1 . INTRODUCTION

The Quadrifilar Helix Antenna (QHA) invented by Gerst [1], consists of four tape helices equally spaced circumferentially on a cylinder and fed with equal amplitude and in phase quadrature of 0°, 90°, 180° and 270° as shown in fig.1[2]. All methods employed for phase quadrature involves couplers created using microstrip line. A branch line coupler produces two equal magnitude outputs ±90 out of phase and could be used in combination with a ±180 or rat race hybrid which produces two equal magnitude outputs ±180 out of phase to produce the desired phase shift [3].The top view of QHA is shown in fig.2. The quadrifilar helix antenna can transmit and receive circular polarized signals over a large angular region. Its radiation characteristics are determined mainly by the shape of the helices, i.e. the number of turns, pitch angle, antenna height and antenna diameter, and for conical shaped helices also the cone angle. These are typically fixed in space by winding them on some substrate of dielectric material, or by etching them on a substrate which is then formed into a cylinder. Helical antennas offer many advantages over dipole structures. Helical antennas are compact because of its cylindrical geometry .The antenna's which offers good gain factor and can operate over wideband. The unique property of circular polarized radiation pattern makes them more suitable for satellite communication. A helical antenna can also be used as a feed for a parabolic dish for higher gains [4].

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2. THEORY

The QHA, while typically fed as an unbalanced antenna, is best considered a balanced structure. The opposing filars tend to form a dipole like structure. The two separate pair of filars fed in phase quadrature forms a hemispherical circular polarized radiation pattern [5]. It is capable of radiating a cardiod shaped, circularly polarized pattern [6]. There are a number of different types QHA including the multi-turn backfire, self-resonant and fractional-turn QHA. Fractional turn helices are used on board satellites due to their cardiod shaped and circularly polarized radiation patterns [7].The backfire helix can be realized by extending the multi-turn QHA to an integral number of turns results in excellent circular polarization as well as shaped beam. The QHA can either be shorted at the top [6] of the antenna or left open [8]. Almost all helical antennas are designed with uniform diameter and turn spacing. Long helical antennas requires variations in diameter and spacing over the length of the antenna, similar to the optimized Yagi- Uda antenna for very high gain which has varied element lengths and spacing in between the elements [4]. Antenna radiation characteristics can be changed by varying the antenna's physical parameters and using various materials in helical antenna design. Helical antenna provides good axial ratio and precisely measures the polarization of the received signal due to immunity of the circularly polarized wave to Faraday rotation of the signal propagating through the ionosphere. In addition to circular polarization, helical antennas offer the advantage of high gain in axial direction over a wide range of frequencies which makes them suitable for applications in broadband satellite communications.[9]

3. DESIGN OF ANTENNA

The QHA can be described according to a number of parameters.

Number of turns, **N**: The number of revolutions each helix of the QHA makes. The performance of the QHA is greatly affected by the number of turns. The QHA with the lower number of turns has better VSWR.

Pitch: The distance between the same points on the consecutive turns of each element. The QHA with pitch less than 0.6 λ has good performance. The desired cardiod shaped is commonly found in QHA having mid range pitches. High antenna gain and good axial ratio over a broad frequency band are easily achieved by various designs of helical antenna which can take many forms by varying the pitch angle.[9]

Radius Rh: The radius of the circular by QHA. At a set pitch the performance of antenna varies with radius. The VSWR of the antenna improves for increased radius. The QHA with lower pitch has good overall performance for all radii.

The helix dimensions are targeted for a center frequency of 2.37 GHz and different parameters from 2.28 to 2.48 GHz.. The schematic of the QHA is shown in fig.1. The numbers of turns, N of QHA are 1.018 with QHA radius**,** Rh of 8.631mm shown in fig.2. The wire diameter of the antenna, D is 633.9 um with ground plane radius, Rg of 17.26 mm.The QHA height, Hh and height of feed points, Hf are 69.79 mm And 1.328 mm respectively. The antenna is right handed circularly polarized.

4. CONCLUSION

The performance of the quadrifiler helix antenna depends on the number of turns, pitch and radius of the antenna. The number of wires in helical antenna is used to control the directivity pattern of the antenna. Monofilar and multifilar helical antennas are the most widely proposed antennas in satellite communications systems because of circular polarization. The proposed antenna covers 2.28 GHz to 2.48 GHz on VSWR <2.0. A QHA with bandwidth of 200 MHz is designed and simulated which gives a good overall gain. The crossed dipoles and reflectors used for different applications provide circular polarization. Quadrature feed used in QHA gives phenomenal results for receiving good noise immune signal.

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5. RESULTS

The low simulated VSWR result is shown in Fig.3 which is 2 or <2.0 from 2.28 GHz to 2.48 GHz. At center frequency, 2.37 GHz the value of VSWR is 1.04. The value of impedance for the antenna is about 52Ω as shown in Fig 4. The Fig.5 shows the reflection coefficient which is below -10db for the specified range and the value of reflection coefficient is -31 db at 2.37 GHz. Other results such as different pattern, 3-D pattern are shown in Figs. 6 to 9. Table 1 shows physical parameters of the antenna.

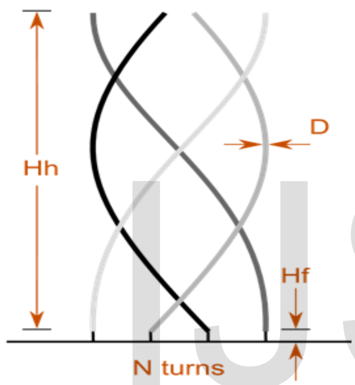

Fig.1: Schematic Open Ended Quadrifilar Antenna

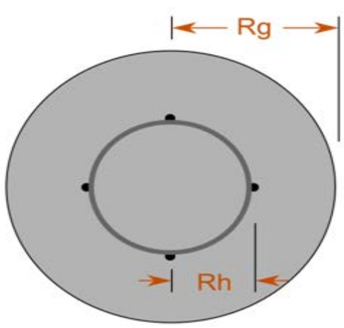

Fig. 2 Top view of QHA

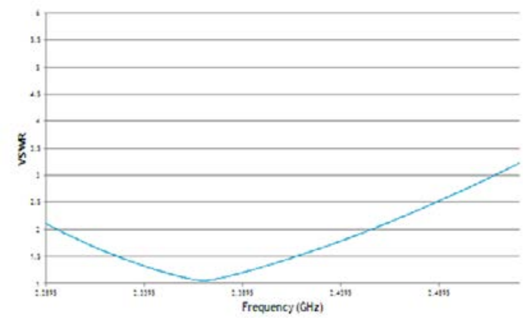

Fig.3 VSWR

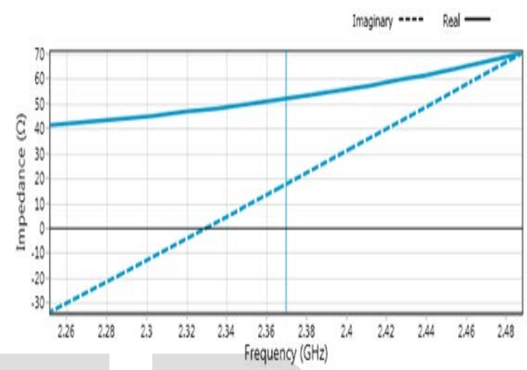

Fig. 4 Impedence

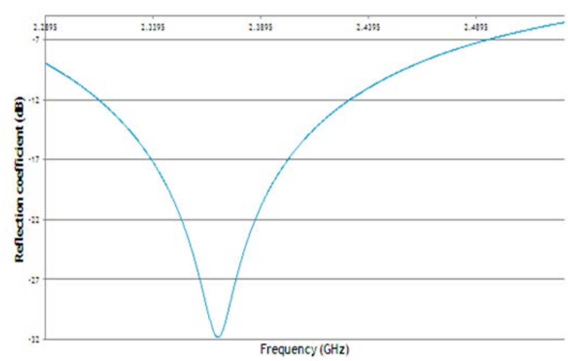

Fig. 5 Reflection Coefficient

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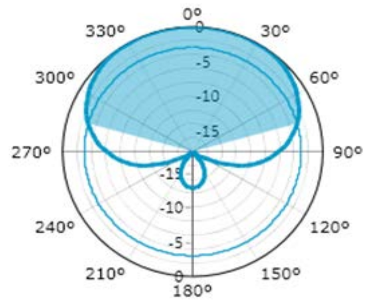

Fig.6 Horizontal Gain

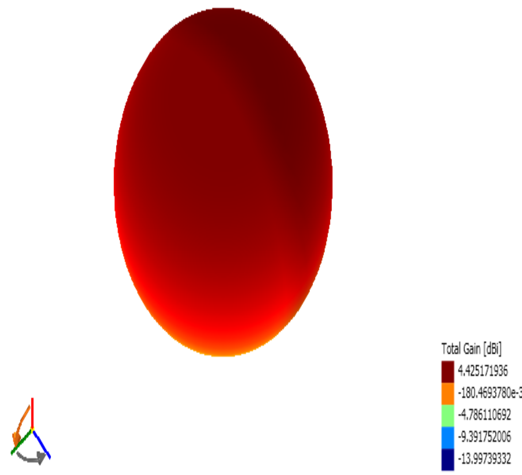

Fig. 9 3D Radiation Pattern

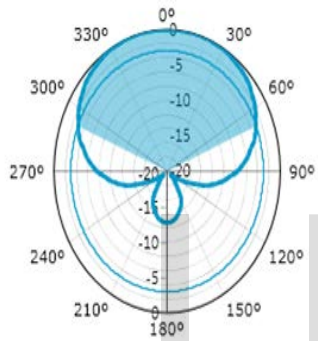

Fig.7 Vertical Gain

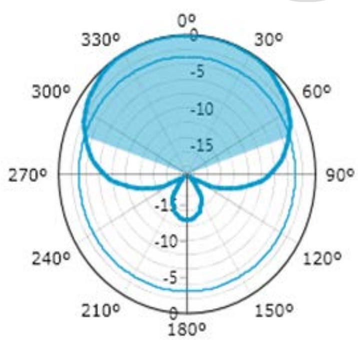

Fig. 8 Total Gain

TABLE 1
Physical parameter of antenna

Name	Description	Value
Fo	Center frequency	2.37GHZ
P	Polarizations (transmitting)	RHC
N	Number of turns	1.018
Rh	QHA radius	8.631mm
Rg	Ground plane radius	17.26mm
Hh	QHA height	69.79mm
Hf	Height of the feed-points	1.328mm
D	Wire diameter	633.9um
X	The width of the antenna (2 ground plane radius)	34.52mm
Y	The width of the antenna (2 ground plane radius)	34.52mm
Z	The height of the antenna (helix height + feed height + 1/2 wire diameter)	71.45mm

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