Design & Analysis of Close-Ended Quadrifilar Helix Aantenna At Ku-Band For Satellite Communication

Sachin Patel[1] Prof.Niraj Tevar[2]
[1,2]EC Department, Parul Institute of Technology
[1,2]PIT-Limda, Vadodara, India

Abstract--- The design & analysis of close-ended quadrifilar Helix antenna for Ku-band is proposed here. A hollow ceramic rod is used as a dielectric load to reduce antenna size of an air-loaded quadrifilar helix antenna. This antenna is proposed to be used for transmission of satellite telemetry data with Directional coverage in Ku-band for satellite communication. A hemispherical circular-polarized radiation pattern and reasonable gain will be measured. It will be measured and simulated return loss, axial-ratio, radiation pattern, and realized gain are presented and discussed together with design guidelines.
Keywords: Quadrifilar helix antenna, Satellite communication, telemetry data transmission.

I. INTRODUCTION

Quadrifilar helix antennas (QHAs) are widely used for both space and terrestrial communication systems where it is necessary to generate a circularly polarized cardioid shaped pattern with a high front to back ratio and low cross polarization. In addition, the antenna does not require a ground plane to radiate efficiently and therefore it is a particularly attractive option for use in mobile handsets and spacecraft payloads where real estate is very limited.
Nevertheless, it is desirable to reduce the axial length of the antenna particularly for satellite communications systems in the VHF and UHF bands where it is often difficult to accommodate these antennas in the launch vehicle. [2]

The quadrifilar helix antenna (QHA) is usually used in low Earth orbit (LEO) satellite communications, handsets of global positioning system receivers and satellite mobiles. The distinguishing features of this antenna are its cardioids pattern, circular polarization, and logical size compared to other antennas. In particular, the cardioid pattern is the favourite pattern for LEO satellite antennas.

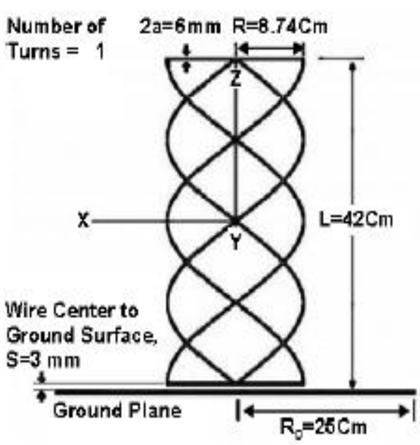

Fig. 1.Dimensions of the QHA.[1]

The QHA belongs to the family of resonant antennas. Hence, its dimensions have to be selected appropriately to obtain optimum characteristics in a desired narrow frequency band So far, several designs have been presented for dual-band QHAs. Almost all prior ideas are based on designing the QHA to achieve a cardioid pattern. This approach causes some restrictions either on gain or on size.

This work presents a miniature dielectric-loaded resonant QHA, which is a suitable way of miniaturizing an antenna without changing its geometry such that the radiation pattern is degraded. A ceramic rod is used due to its low loss and high permittivity. [3]

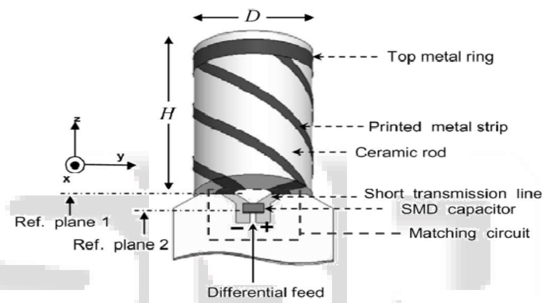

Fig. 2: Antenna structure including the adapted PCB with a SMD capacitor. [3]

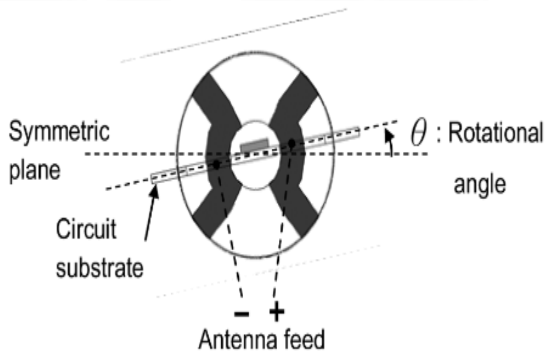

Fig. 3: Bottom view of the QHA. [3]

Fig. 4:.close-ended QHA.

The close-ended Quadrifilar helix antenna design as below figure 4.outes side of a close-ended QHA should be closed in a shape.

II. DESIGN PROCEDURE

Simulation of the close-ended quadrifilar helix antenna at ku-band is proposed here. Frequency range of ku-band is 12-18 GHz. The design procedure used throughout thesis is applicable for antennas that work in the frequency range of ku-band. The frequency band is used in satellite communication, spacecraft system, ground station GPS, shipborne platforms and airborne application etc. The design techniques are also applicable to any frequency ranges, which can be selected according to the designer's wish.The parameters that describe a helix are summarized below.

D = diameter of helix
S = spacing between turns
N = number of turns
C = circumference of helix = πD
A = total axial length = *NS*
α = pitch angle

If one turn of the helix is unrolled the relationships between *s*,*c*,αand the length of wire per turn *L*, are obtained as:

$$S = L\sin\alpha = c\tan\alpha \qquad (1)$$

Axial ratio: The polarization of this mode is elliptical with an axial ratio given by

$$AR = \frac{2S\lambda}{\pi^2 D^2} \qquad (2)$$

The normal-mode helix will be circularly polarized if the condition *AR* = 1 is satisfied. This condition is satisfied if the diameter of the helix and the spacing between the turns are related as

$$C = \sqrt{2S\lambda} \qquad (3)$$

Half-Power Beamwidth: The empirical formula for the half-power beamwidth is

$$HBPW = \frac{52}{C\lambda\sqrt{NS\lambda}} \qquad (4)$$

Input Impedance: Since the current distribution on the axial-mode helix is assumed to be a travelling wave of constant amplitude, its terminal impedance is nearly purely resistive and is constant with frequency. The empirical formula for the input impedance is

$$R = 140C\lambda \text{ohms} \qquad (5)$$

Bandwidth: It is define as the ratio of upper frequencies to the lower frequencies.

$$f_U / f_L (6)$$

III. SIMULATION

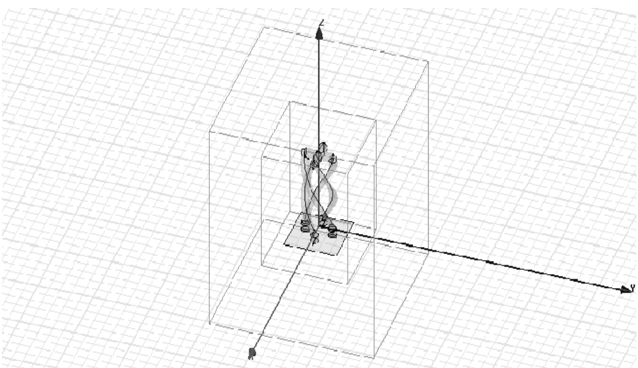

Fig. 5: Design of close-ended QHA.

The Close-ended Quadrifilar Helix Antenna at 15 GHz resonant frequency as shown in figure 5. Design of close-ended helix is shown in above result generated in HFSS software

The close-ended QHA is formed by duplicating and rotating at 90°. In which it is use for satellite communication for telemetry data transmission.

IV. RESULTS

Return loss: It is the graph of Frequency verses Gain.

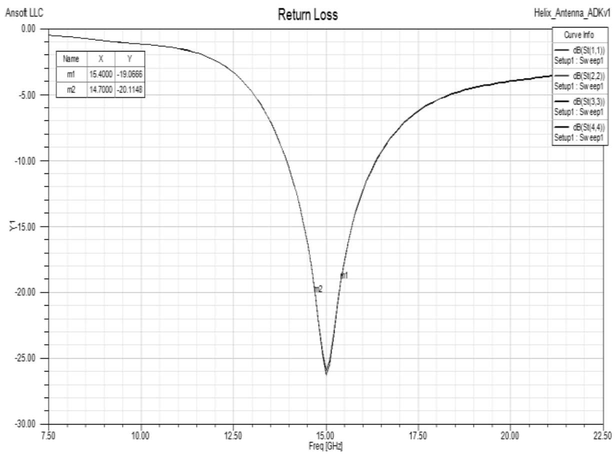

Fig. 6: graph of Frequency verses Gain

In above result shows the return loss in close-ended QHA. Bandwidth of this antenna is near about 700MHz at central frequency 15 GHz.

Input impedance: It is use for matching impedance and co-axial cable.

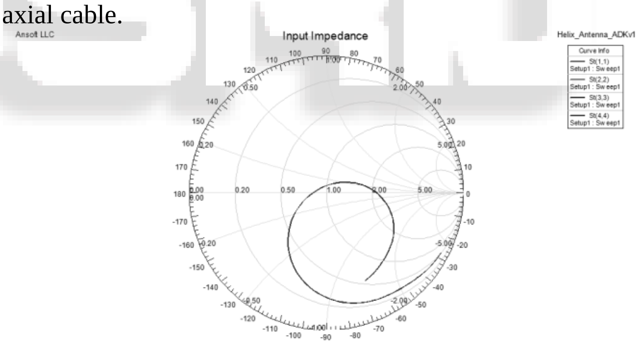

Fig. 7: Input impedance

Result defines the inductive, capacitive and resistive value.

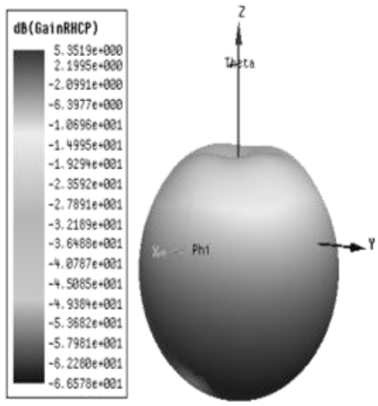

Fig. 8: 3D gain RHCP

Above result shows the 3D gain of right hand side circular polarization.

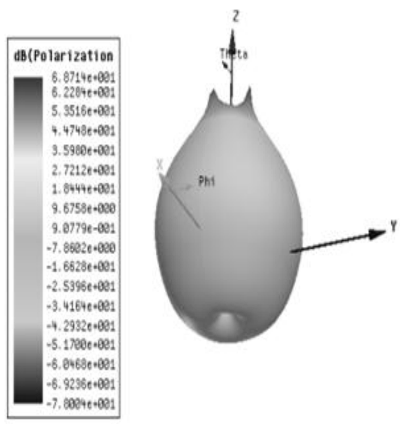

Fig. 9: 3D (polarization)

Above result shows the 3D (polarization) of right hand side circular polarization of the close-ended quadrifilar helix antenna.

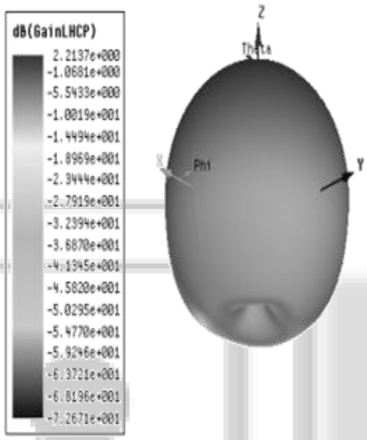

Fig. 10: 3D gain LHCP

Above result shows the 3D gain of left hand side circular polarization in dB

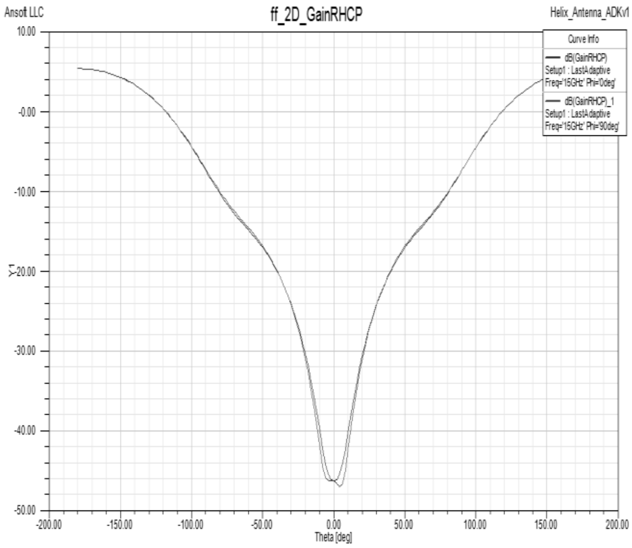

Fig. 11: 2D gain RHCP

Above result shows the 2D gain of right hand side circular polarization.

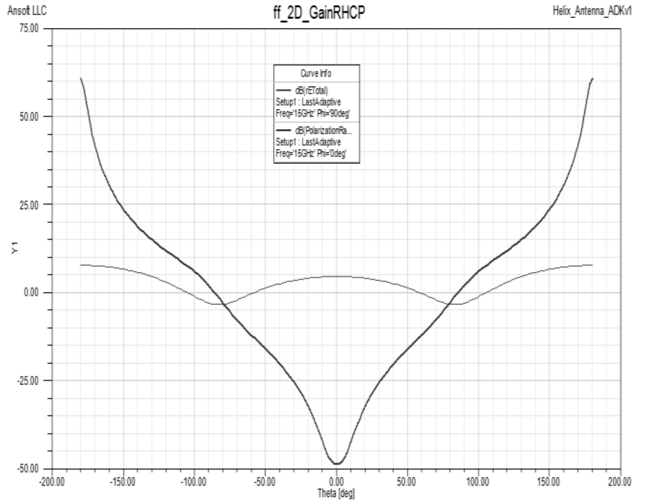

Fig. 12: 2D polarization ratio circular RHCP

Above result shows the 2D Polarization ratio in circular form of right hand side circular polarization.

Fig. 13: 2D gain LHCP

Above result shows the 2D gain of left hand side circular polarization.

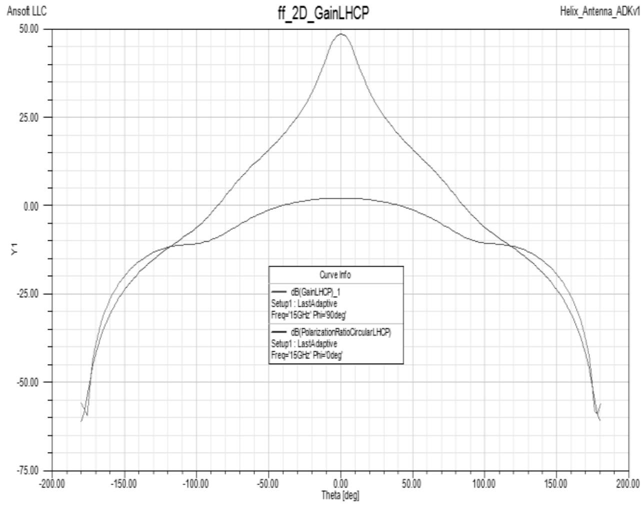

Fig. 14: 2D polarization ratio circular LHCP

Above result shows the 2D Polarization ratio in circular form of left hand side circular polarization.

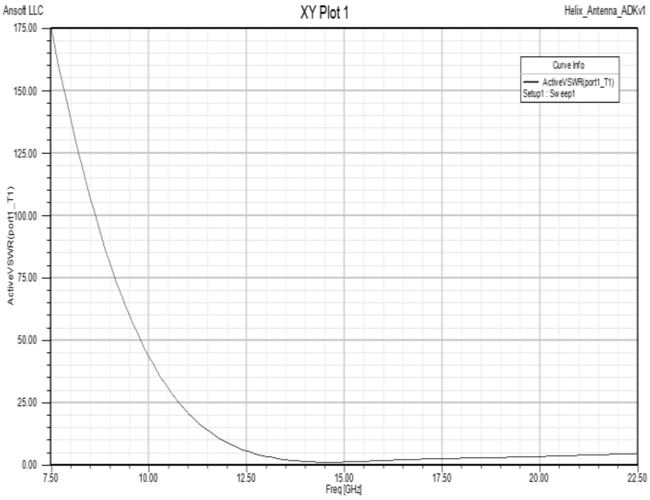

Fig. 15: Active VSWR

VSWR is a voltage standing wave ratio.Above result shows the VSWR value which is zero at 15GHz.

V. CONCLUSION

The close-ended quadrifilar helix antenna for satellite communication for telemetry data transmission at ku-band is proposed here. The work will do to solve the several challenging problems still exist in the previous designs, particularly the antenna bandwidth is 700MHz, gain is 2.21317dB and design complexity.As observed in above literature papers that the proposed thing will work to make a change inshape of the antenna with the help of HFSS software. In which antenna can design with change in some important parameters such as Input Impedance, Resonant Frequency of the Antenna, Relative permittivity of the substrate, Dielectric loss tangent.

REFERENCES

[1].M. Hosseini, M. Hakkak, Senior Member IEEE, "Design of a Dual-Band Quadrifilar Helix Antenna" IEEE antennas and wireless propagation letters, VOL. 4, 2005

[2].Muhammad Amin and Robert Cahill, "Effect of Helix Turn Angle on the Performance of a Half Wavelength Quadrifilar Antenna", IEEE microwave and wireless components letters, VOL. 16, NO. 6, June 2006

[3].Yu-Shin Wang and Shyh-Jong Chung, Senior Member A Miniature Quadrifilar Helix Antenna for Global Positioning Satellite Reception ,IEEE transactions on antennas and propagation, VOL. 57, No. 12, December 2009

[4].Alireza Motevasselian, Anders Ellgardt, and B. L. G. Jonsson A Circularly Polarized Cylindrical Dielectric Resonator Antenna Using a Helical Exciter, IEEE transactions on antennas and propagation, VOL. 61, NO. 3, March 2013

[5].Alain Laurent, Marc Lefèvre, Tiziana Barsotti, David Chesnel, Arnaud Brechenmacher, and Philippe Thouvenin, "High-Power C- and X-Band Radar Helix TWTs", IEEE transactions on electron devices, VOL. 56, NO. 5, May 2009

[6].Alexandru Takacs, Tonio Idda, Herve Aubert, Hubert Diez, "Miniaturization of Quadrifilar Helix Antennas for Space Applications" ,978-1-4673-0292-0/12/$31.00 ©2012 IEEE

[7].P. G. Elliot, E. N. Rosario, R. J. Davis The mitre Corporation, Bedford, MA 01730, "Novel Quadrifilar Helix Antenna Combining GNSS, Iridium, and a UHF Communications Monopole", 978-1-4673-3/12/$31.00 ©2013 IEEE

[8].Jan zackrisson saab space AB, "Wide Coverage Antennas,21st annual AIAA/USU Conference on small satellite".

[9].Xiaozhong Shui , Haibo Tang, "A S-band Printed Quadrifilar Helical Antenna for Communication Devices", Proceedings of the 2nd International Conference on Computer Science and Electronics Engineering (ICCSEE 2013)