QUADRIFILAR HELIX ANTENNA FOR SMALL SATELLITES

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Abstract: In this paper, we discuss the quadrifilar helix antenna used for small satellites. The quadrifilar helix antenna is designed at 250 MHz for both open and closed end configuration and their performance is analysed.

Index terms: Quadrifilar helix antenna, small satellites.

I Introduction

The quadrifilar helix antenna (QHA) is the multifilar helical antenna with four helical elements. The QHA is becoming a popular choice for mobile devices, satellites, GPS, satellite mobile phones, etc., because of their inherent properties like circular polarization, high gain and less weight designs.

Small satellites are satellites with less mass, size and low cost compared to their counter parts. Hence the antennas needed for the small satellites should be compact with less mass and low cost. The QHA suits the profile in an elegant manner.

The structure of QHA consists of two half turn bifilar or one half turn quadrifilar loops. The bifilar loops are oriented in mutually orthogonal axis. The diagrammatic representation is as follows

Figure 1: Structure of QHA

II Design

The geomentry of the QHA is similar to that of helix antenna with the performance characteristics given by the number of turns of the helix(N), height of the helix(H), pitch angle(α), spacing(S),helix radius(R) and the arm length(L). The relations between the various geometric parameters of the helix are given in (1)-(3).

$$H = N*S \quad (1)$$

$$L=\sqrt{S^2 + (2\pi R)^2} \quad (2)$$

$$\tan(\alpha) = S/(2\pi R) \quad (3)$$

The antenna model is simulated using HFSS 14.0. There are six main steps in HFSS for creating and solving a model. They are

- creating model/geomentry with feed
- assigning boundries

- assigning excitation
- setup solution
- solve
- post-process the results

This model creation can be done with HFSS using 3D modeller as shown in the figure 2 and 3.

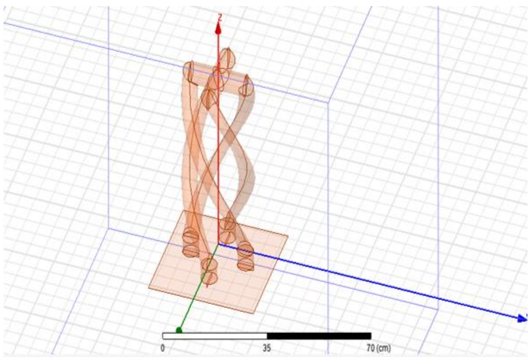

Figure 2 Close-ended QHA

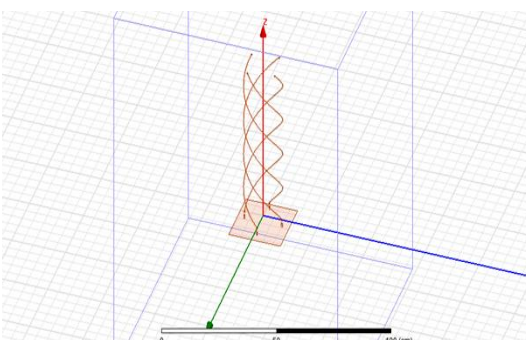

Figure 3 Open-ended QHA

The PEC boundary condition is applied to a ground plane as it has an option of being infinite ground plane and the radiation boundary is applied to the radiation box in order to calculate the near field radiation pattern.

Lumped port excitation is used in this antenna design as a feed point. Lumped ports are similar to traditional wave ports, but can be located internally and have a complex user- defined impedance.

The solution frequency is used by HFSS to determine the maximum initial tetrahedral size and is the frequency at which HFSS explicitly solves the given model. For this antenna design, the solution frequency is given as 250 MHz.

III Results and Analysis

The close-ended and the open-ended QHA are designed and simulated using HFSS. The results obtained are as follows:

Return loss:

Return loss is the ratio of incident power to reflected power.

$$RL\,(dB) = 10log_{10}\frac{Pi}{Pr}$$

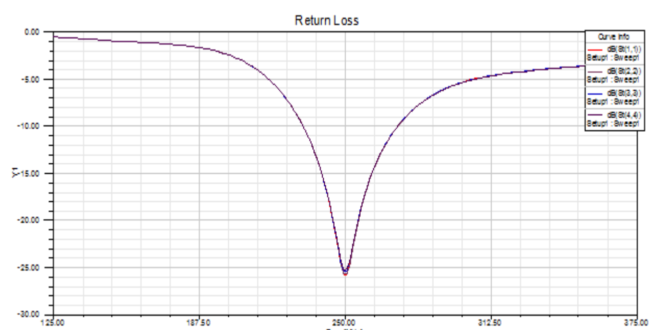

Figure 4 Return loss of close-ended QHA

The return loss of -26 dB and -20 dB is obtained respectively for the close-ended and open-ended QHA as in figure 4 and figure 5. A perfect matching antenna should have return loss below -10 dB and thus these two antennas have good return loss.

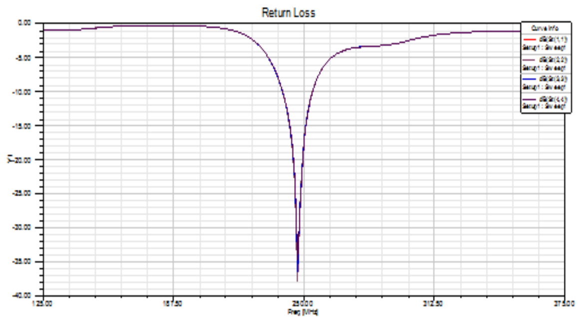

Figure 5 Return loss of open-ended QHA

Radiation pattern:

Radiation pattern gives the graphical representation of the strength of the radio waves spreading from the antenna.

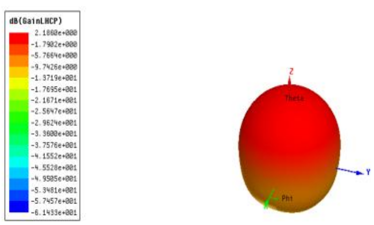

Figure 6 Radiation pattern of close-ended QHA

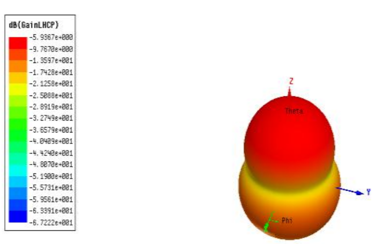

Figure7 Radiation pattern of open-ended QHA

The hemispherical radiation pattern for close-ended QHA and open-ended QHA is shown in figure 6 and 7.

Gain:

Gain is the ratio of power delivered by an antenna at a point to the ratio of power delivered by the isotropic antenna at the same point.

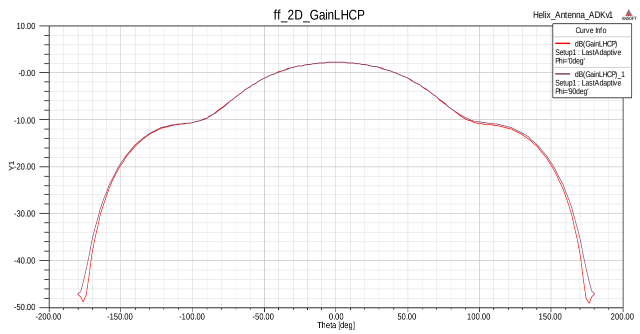

Figure 8 LHCPGain of close-ended QHA

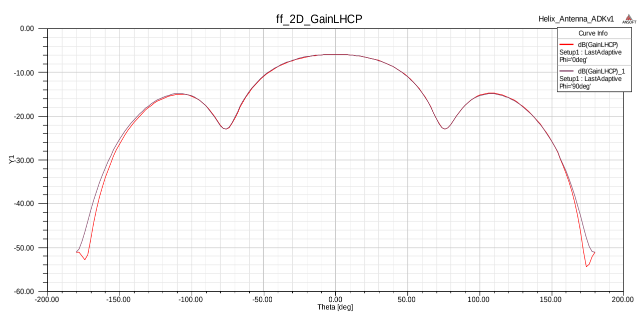

Figure 9 LHCPGain of open-ended QHA

The gain obtained for the close-ended QHA is 2.18 dB but for the open-ended QHA the gain was only -5.93 dB as in Figure 8 and 9.

VSWR:

VSWR is useful in measuring the imperfections in the line. For the reflection coefficient Γ, the VSWR is given by $VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$

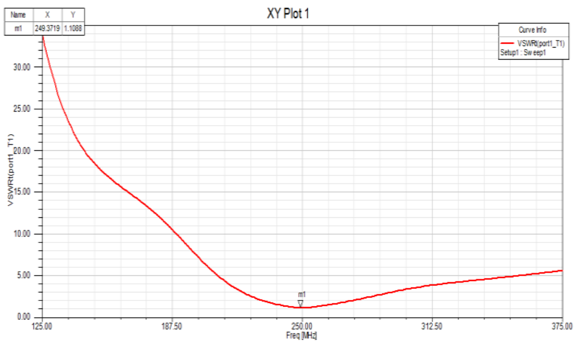

Figure 10 VSWR of close-ended QHA

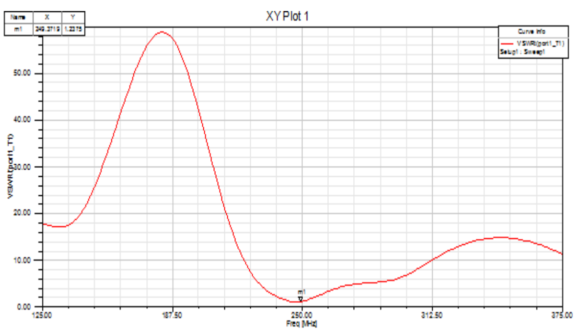

Figure 11 VSWR of open-ended QHA

The VSWR obtained for the close-ended QHA is 1.1088 and the open-ended QHA is 1.2375 as in figure 7.7 and 7.8.For a perfect operating antenna the VSWR should lie between 1 to 2 and thus these two antennas have good VSWR.

IV Conclusion and Future work

The structures of quadrifilar helix antenna, Open-ended and Close-ended QHAhave been designed at 250 MHz. Both the antennas are simulated using HFSS and theirperformance is analyzed. The return loss and gain of close-ended QHA are found to be -26 dB and 2.18 dB respectively. Similarly the return loss of -20 dB and gain of -5.93 dB is obtained for open-ended QHA and hemispherical radiation pattern is observed for both the antennas.The close-ended QHA is observed to be the better performing antenna and it will be used for the future work.

In future, the radiation pattern of the QHA can be modified to isoflux radiation pattern which will provide a maximum gain for the small satellites from the earth station during its limited visibility duration from the Low Earth Orbit. The antenna can also be made deployable, so that it will occupy less space on the small satellites leaving plenty of space for transmitter, receiver and other devices. The fabrication and testing of the antenna can be done and implemented for the small satellites.

V Refrences

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