International Journal of Research in Signal Processing, Computing & Communication System Design
ISSN: 2395 – 3187
Vol: 01, Issue: 01, Jan-June, 2015

Multiple frequency Polyhedron Ring Slot Microstrip Antenna

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Abstract:* A polyhedron shaped annular ring slot antenna is presented. A simple 50 ohms Microstrip line is used to excite the slot. . Parametric Design and Analysis is carried out with permutations of the feed length from edge to the centre of annular ring. RT-duriod substrate is used because of its high directivity and high power radiation[7]

Keywords Microstrip Antenna, Wideband, Annular Slot

1. INTRODUCTION

Microstrip Patch antennas generally consists of dielectric substrate with radiation patch on one side and ground plane on the other side of the substrate. They are mainly four types of Microstrip antennas. Microstip dipole, Microstrip patch, Microstrip slot antennas and Microstrip travelling wave antennas.[4] The Microstrip antennas are widely used in wireless communications because of its small size, light weight, less fabrication cost, planar shape and integrability with other parts of the system. many of Microstrip antennas are used in different applications like Radar systems, Space communication systems etc. The main disadvantage of Microstrip antennas is low bandwidth. Normally the bandwidth for single frequency annular slot is about 10 percent.

However the development of wireless communications experiencing an exponential growth hence increase the need for wideband Microstrip antennas. As a result, new antennas have to developed to provide larger bandwidth and this, within small dimensions. challenge which arises is that the gain and bandwidth performances of an antenna are directly related to its dimensions. These applications include WWANs, WLANs and WPANs. Usually, broad band characteristics are tough to achieve, because good impedance matching is difficult. In this paper a polyhedron ring shaped slot antenna is proposed, there by increasing the surface current path and enabling wide bandwidth of the slot antenna. By adjusting the parameters of the antenna parametric analysis is carried out using HFSS software by changing the feed length. A simple 50 ohms Microstrip line is used to excite the slot. The results are explained below.

The annular ring antennas has received attention when it is to be operated in in fundamental TM_{11} mode. Annular ring slot antenna is smaller than rectangular and circular patch antenna at a given frequency. The annular ring also has broad bad nature when operated near the TM12 resonance mode. [3]

A polyhedron ring antenna is designed for TM_{11} mode at the resonant frequency 2.4 GHz and analyzed for various results such as VSWR, Return loss, input impedance, 2Dimensional and 3D radiation patterns. Gain vs frequency results are also analyzed.

2. Method of Analysis of Microstrip Antenna.

There are three methods to analyze Microstrip Antennas. Transmission line method, Cavity method and full wave model. Transmission line method is simple to implement, but is less accurate. Cavity model is complex to analyze and is more accurate than transmission line model. Full wave model is most complex and is very accurate for finite , infinite arrays and stacked structures. There are different full-wave methods to solve EM structures. Finite difference method, finite element method, Method of moment etc.

In this paper finite element method is used in the analysis. The quantity associated with EM wave is the poynting vector $\boldsymbol{S = EXH}$ w/m^2. [5]This paper is aimed to design and analyzed a polygonal annular ring antenna suitable at ISM band.

The basic shape of the antenna is circular and polyhedral slot is incorporated in the ground plane as shown in the figure 1. And design equations of circular patch antenna are taken to consideration.

ISSN: 2395 – 3187
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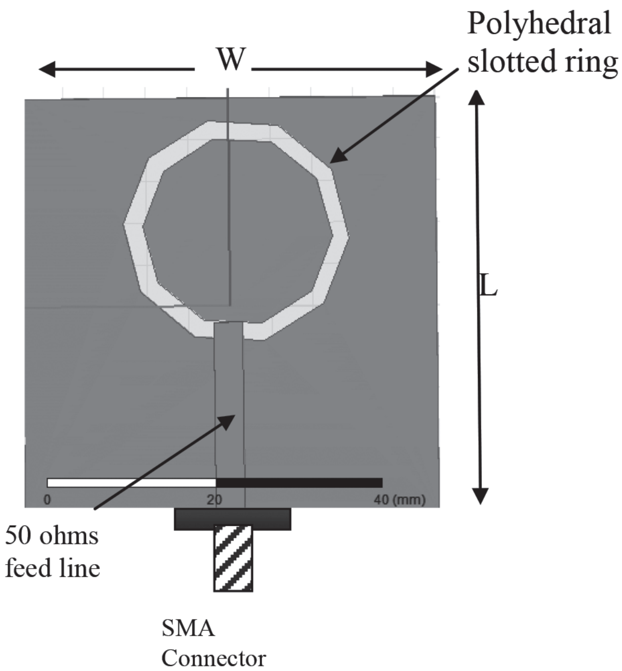

Fig1: Geometry of tetrahedral annular ring slot antenna

The fundamental resonant frequency of conventional annular circular ring slot antenna comprises in the ground plane of a dielectric substrate fed by a microstrip conductor can be calculated according to the following[6]

$$f_0 = \frac{300}{2\pi R_m \sqrt{\varepsilon_{re}}} \qquad \text{—— 1}$$

Where R_m is the average radius of inner ring radius and outer ring radius in mm. f_0 is the resonant frequency in GHz. And ε_{re} is effective dielectric constant of annular ring patch is given by[2]

$$\varepsilon_{re} = \frac{2\varepsilon_r}{1+\varepsilon_r} \qquad \text{—— 2}$$

To improve the impedance bandwidth one more annular linked slot is introduced. Using below equation width of the microstrip line width for 50 ohms is calculated[5].

$$Z_0(\Omega) = \frac{87}{\sqrt{\varepsilon_r + 1.41}} \ln[\frac{5.98h}{(0.8w+t)}] \qquad \text{—— 3}$$

3. ANALYSIS AND STUDY OF THE PARAMETERS

Polyhedron slot ring parameters are discussed and analyzed using HFSS software which is a FEM based simulator. Annular slot antennas have relatively broad band characteristics compare to conventional patch antennas.

A single layer with Polyhedron ring shaped slot is taken out of infinite ground plane. FR4 substrate was selected to reduce the cost, which has a relative permittivity of 4.4, loss tangent of 0.01 and a thickness of 1.56 mm. The ground plane size was 50mmX50mm. Radius of inner ring of the slot is Ri=4 mm, Radius of the outer ring slot is taken as Ro=6mm.

The 50 ohms feed line length is fl= 24mm, and width is fw=3mm was designed for good impedance matching. Radius of the inner slot ring is R_i=4 mm , radius of the outer circle of ring is R_o=6 mm,. The dimensions fl is optimized to get multiple frequency resonance.

Feed line length is varied form 19mm to 34 mm for optimum results.

4. RESULTS AND DISCUSSIONS

It was analyzed for the different feed lengths from 19mm to 34 mm and observed at fl= 26mm results are good and the corresponding result is shown in the figure 2.

For faith full radiation return loss should be less than -10dB. In the figure 3 return loss is represented. The antenna is resonating at multiple frequencies 2.4GHz , 5GHz and 9.5 GHz with return loss less than -10db. Anthe corresponding band widths are 200MHz,400MHZ and 600MHz. Figure 10 representing the VSWR characteristics.

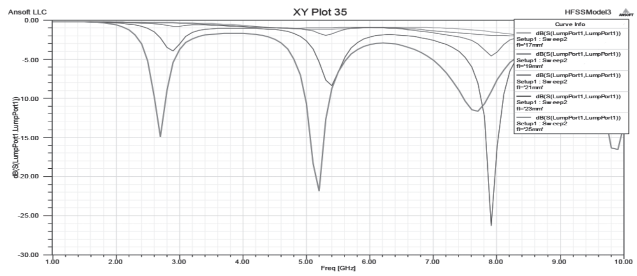

Fig 2: Optimization of return losss for various feed lengths.

It was observed that VSWR is less than 2 in the ISM band.

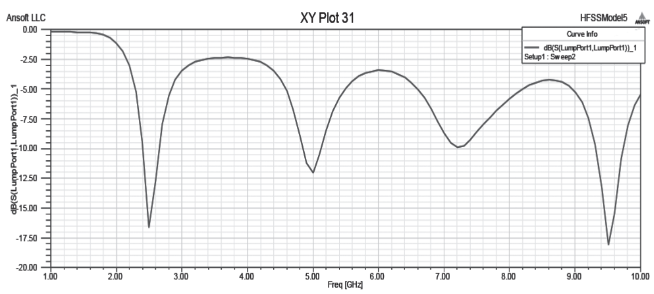

Figure 3: Return loss plot

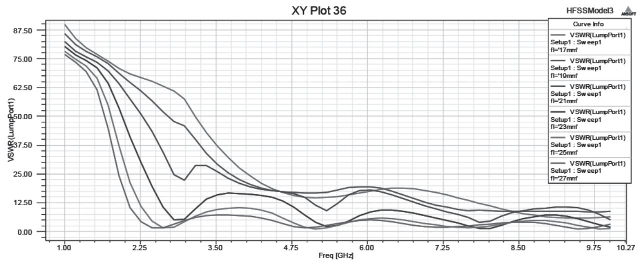

Figure 10. VSWR characteristics for different fl

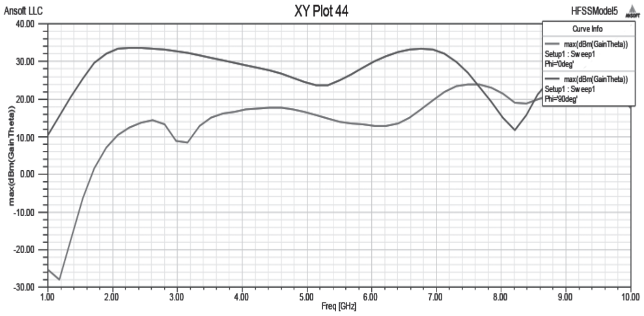

Figure 4: Gain vs frequency

Figure shows that the average gain of antenna along phi= 0 and phi = 90 degrees is 15dBm and 25dBm is the ISM band.

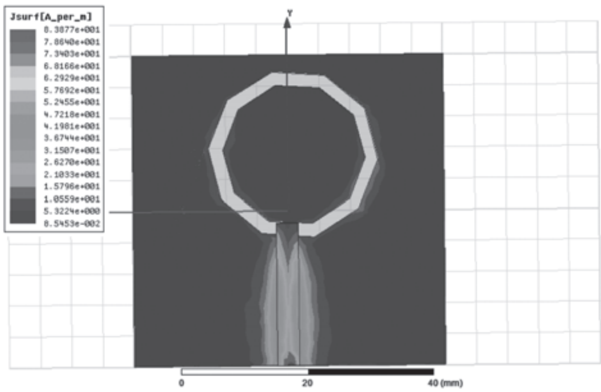

Figure5: Current distribution of the antenna

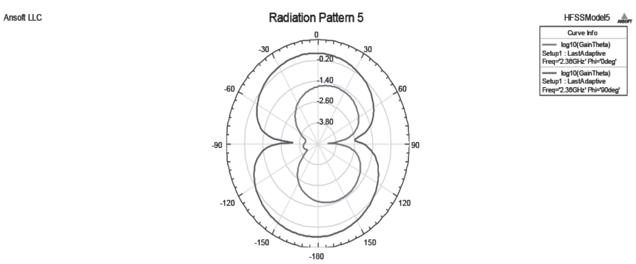

Figure 6: Radiation pattern at 2.36GHz

Figure 4

Figure 8: 3D Radiation pattern at 2.36GHz.

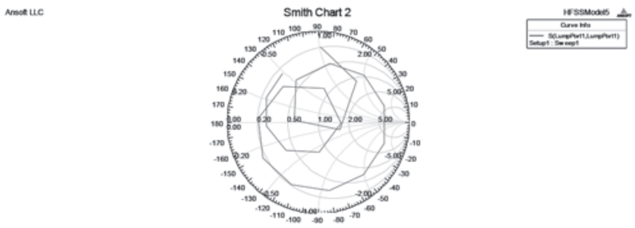

Fig.9: Impedance characteristics of the antenna

Figure 5 shows the distribution of the current along the feed and ground plane and slot.

Figure 7 and 8 are representing the two dimensional and three dimensional Radiation pattern. Figure 9 representing the impedance characteristics with respect frequency.

5. CONCLUSION

A Polyhedron slotted ring antenna is designed and analyzed. Simulation results are presented. The antenna is resonating at multiple frequencies 2.4GHz, 5GHz and 9.5 GHz with return loss less than -10db. And the corresponding band widths are 200MHz,400MHZ and 600MHz. VSWR<2 is achieved in at 2.4 GHZ and 5GHZ and 9.5GHZ.

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