Themed Section : Engineering and Technology
© 2018 IJSRSET | Volume 5 | Issue 3 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099

Circular Patch FSS Antenna with different Resonating Frequencies for Satellite Applications

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ABSTRACT

A compact size, flexible and low profile FSS antenna is proposed in this paper. The substrate used is FR4 epoxy with relative permittivity 4.4. The antenna is of dimension 150mm×150mm×1.6mm.The shape of the patch is circular with a radius of 20 mm. Ground plane of negligible height is present below the substrate. Microstrip line feeding is used for feeding the antenna. The proposed antenna design can be used for satellite communication. HFSS is used for simulation of the antenna and results are obtained in C band.
Keywords: FSS(Frequency selective surface), micro strip line feeding,FR4 epoxy, HFSS

I. INTRODUCTION

The use of microstrip antenna in modern days has increased in communication arena. Microstrip antennas are used in satellites, radars, WLAN, mobile communications etc.[1] Advantages of microstrip antenna include low profile, light weight, ease of fabrication etc. But microstrip antenna has low gain and power handling capacity[2]-[3]. Hence a concept called FSS is used in microstrip antennas to enhance the antenna parameters.

FSS are periodic structures which are one or two dimensional lattices designed to achieve band pass or band stop response.[4]FSS has good electromagnetic characteristics so it is used in various applications. Multiband features is a major requirement of antennas used in satellite communication. Using multilayered structure, loading multiple resonant elements, fractal elements and FSS leads to multiband characteristics. Frequency response of FSS is a function of incident angle, polarisation and frequency[5]. In 1990s, FSS were used as sub reflectors of reflectors to obtain multiband characteristics. When FSS is integrated with substrate integrated waveguide (SIW), it reduces cross polarisations, widens impedance bandwidth and increases efficiency [6].FSS can be used for chip less RFID.

FSS are used where high performance is required. The parameters controlling frequency response of FSS are dielectric substrate, element geometry, physical dimensions and periodicity [7].NASA Cassini project required multiple frequencies for communication at S, X, Ku and Ka band. There two FSS were used for band separation. To overcome side lobes, array configurations can be used. Multiband frequency antennas operate at different frequency bands.

II. ANTENNA DESIGN

The dimension of antenna proposed in this paper is 150mm×150mm. The substrate used is FR4 epoxy with relative permeability 1 and magnetic loss tangent 0.The height of the substrate is 1.6mm. Antenna is a 3×4 array consisting of 12 patches. Ground of negligible thickness lies below the substrate. The patch is fabricated above the substrate is of circular shape. The radius of the circular patch is 20mm. The patches are interconnected so that equal surface current distributions occur. Micro strip line feeding technique is used for the antenna. The material of the radiation box is air, contains the antenna setup.

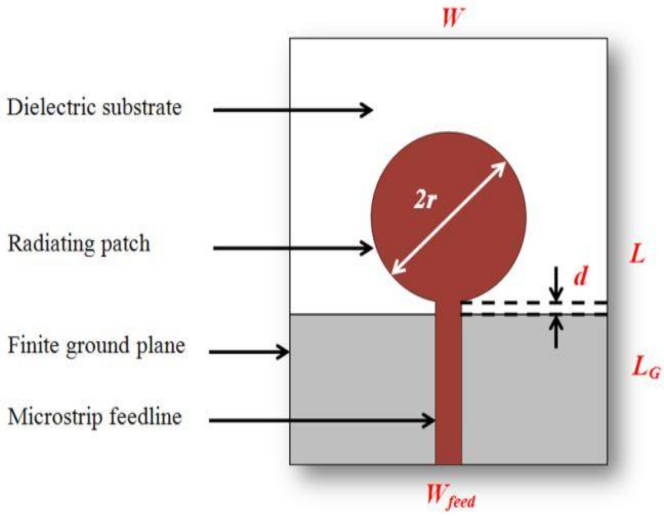

Figure 3 : Antenna elements

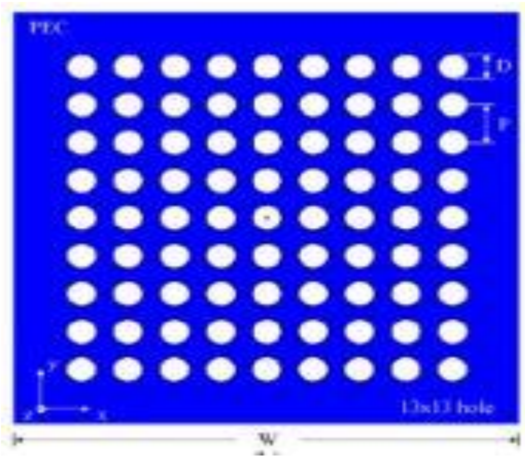

Figure 1. Array of FSS

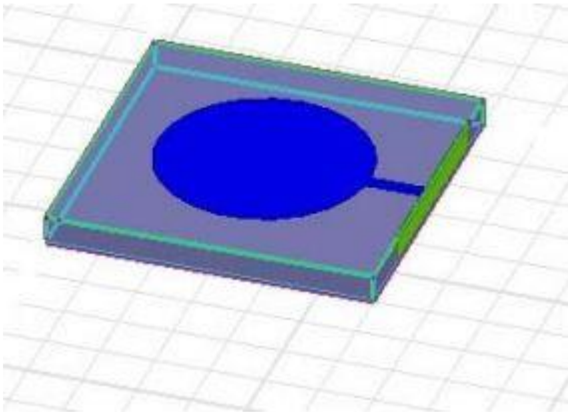

Figure 4. Circular patch

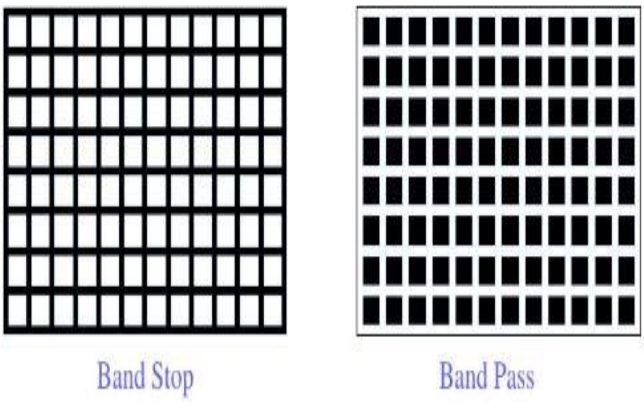

Figure 2. Characteristics of FSS

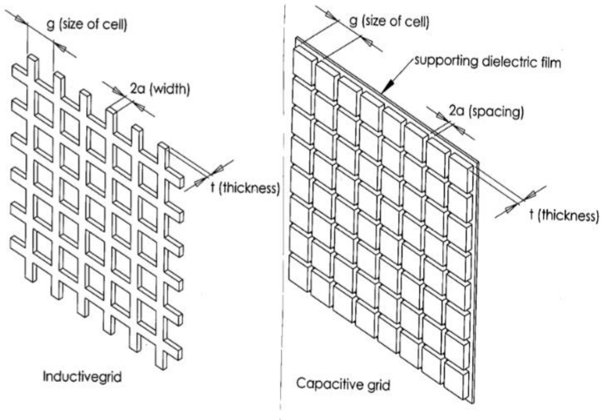

Figure 5. FSS properties

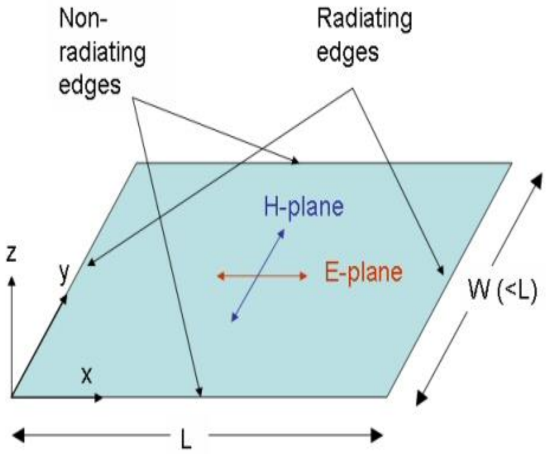

Figure 6. Patch edges

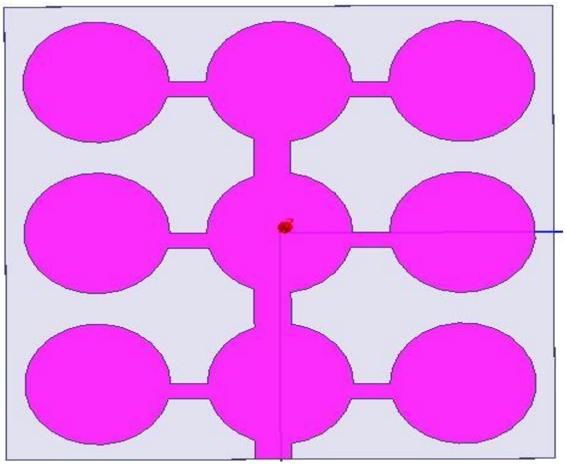

Figure 7. Proposed Antenna Design

Figure1 shows array of FSS. Figure2 illustrates characteristics of FSS. Figure 3 gives antenna elements. Figure 4 shows circular patch. Figure 5, gives FSS properties. Figure 6 shows patch edges.Figure7 shows proposed antenna design.

III. SIMULATION RESULTS AND DISCUSSIONS

Based on transmission line model, antenna parameters are calculated.

S parameters are scattering parameters, which are vector entities. They are popularly used in microwave circuit design and testing. At high frequencies, measurement of Y,H or Z parameters are difficult. S_{11} is called return loss. When it is ideal short, S_{11}= -1 and for ideal termination S_{11}=0. S_{11} is measured below -10dB and is minimised at the resonating frequencies.Figure8 shows the S_{11} parameter graph. There are six resonating frequencies. The resonating frequencies of the proposed antenna design are 4.81 GHz,5.27GHz, 5.68 GHz, 6.56 GHz, 6.72 GHz and 6.83 GHz.

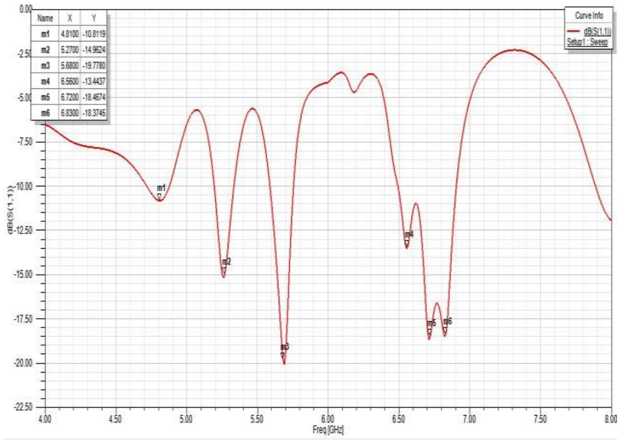

Figure 8. S_{11} parameter graph

VSWR indicates the mismatch between antenna and the feed lines connected to it. VSWR for a ideal system is 1 but practically it is below 2. If the antenna is poorly matched then VSWR value exceeds 2.Reflections are caused by mismatched impedances. The load must not have any reactance elements. Figure 9 shows VSWR graph. It is observed that at the resonating frequencies the VSWR value is below 2.

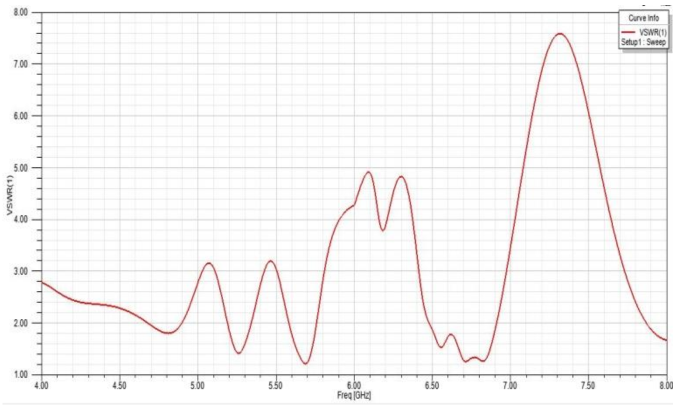

Figure 9. VSWR graph

Radiation is not uniform for all antennas in all directions. Radiation pattern is plotted in azimuth or E plane and elevation or H plane respectively.

Figure 10 gives the radiation at 4.81 GHz Figure 11 shows the radiation characteristics at 5.27 GHz Figure 12 illustrates the radiation characteristics at 5.68 GHz Figure 13 shows the radiation characteristics at 6.56 GHz .Figure 14 shows the radiation characteristics at

6.72 GHz. Figure 15 shows the radiation characteristics at 6.83 GHz . All radiation pattern are for $\varphi = 0^0$ and $\varphi = 90^0$ respective.

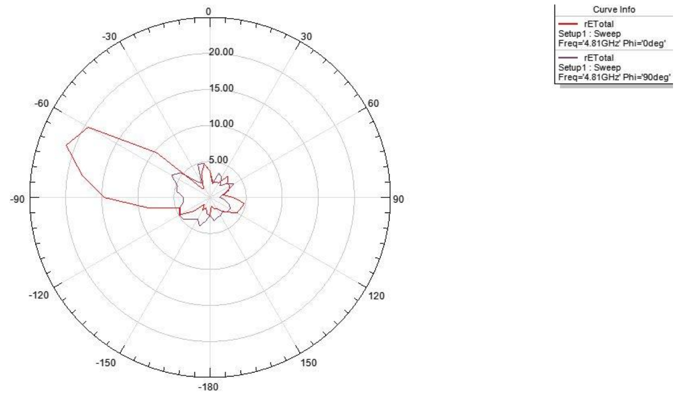

Figure 10. Radiation characteristics at 4.81 GHz

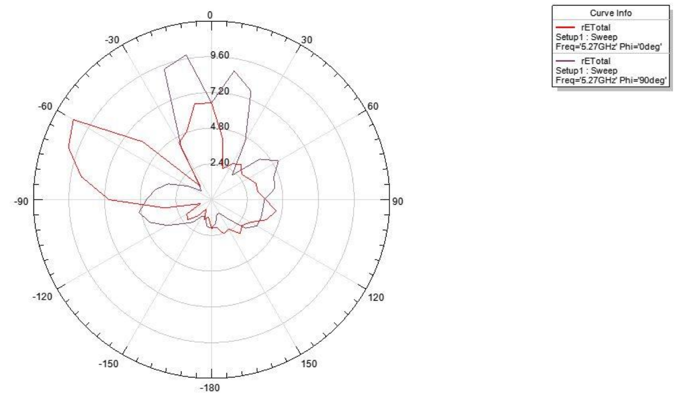

Figure 11. Radiation characteristics at 5.27 GHz

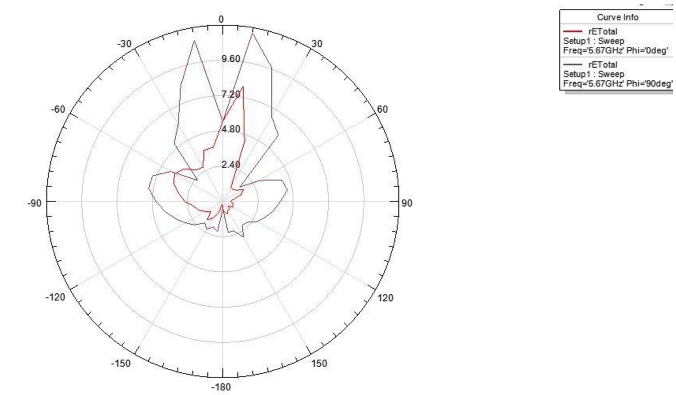

Figure 12. Radiation characteristics at 5.68 GHz

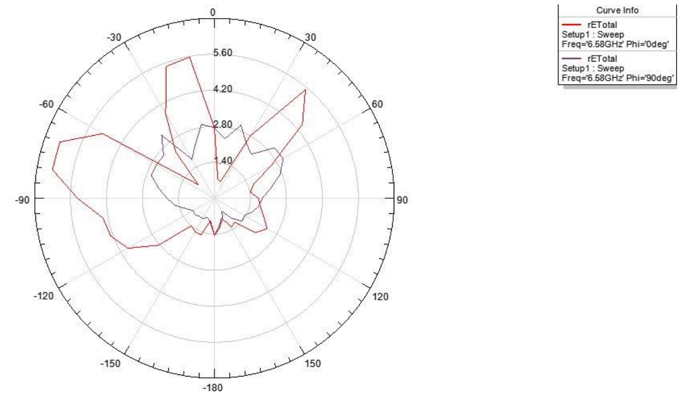

Figure 13: Radiation characteristics at 6.56 GHz

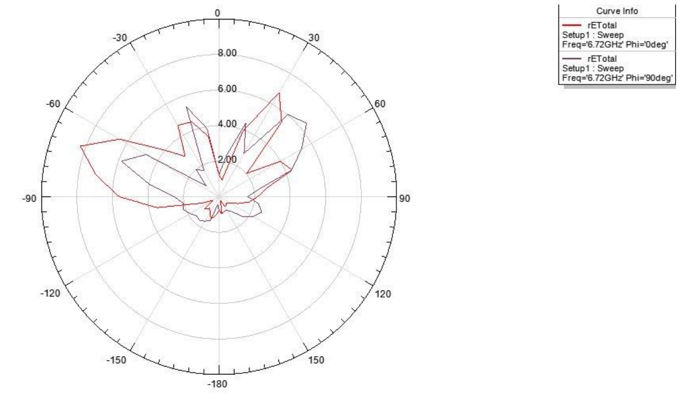

Figure 14. Radiation characteristics at 6.72 GHz

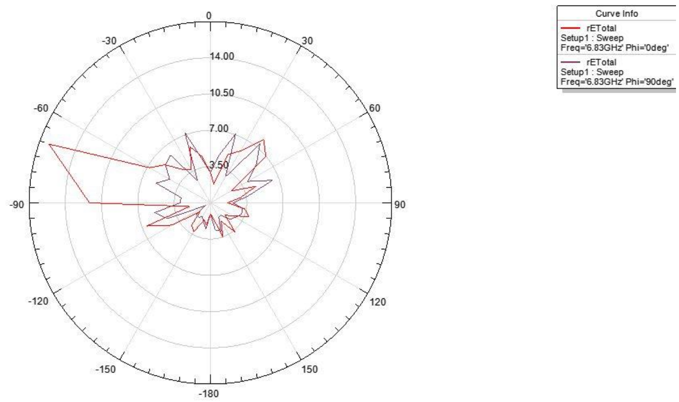

Figure 15. Radiation characteristics at 6.83 GHz

Gain of an antenna is measured in dBi or dBd. Direction of maximum radiation is referred as gain. It can be discussed as a function of angle. All the gain shown below are 3D polar plot of gain. Figure16 shows gain at 4.81 GHz. Figure17 gives gain at 5.27 GHz. Figure18 gives gain at 5.68 GHz. Figure19 gives gain at 6.56 GHz. Figure20 gives gain at 6.72 GHz. Figure21 gives gain at 6.83 GHz.

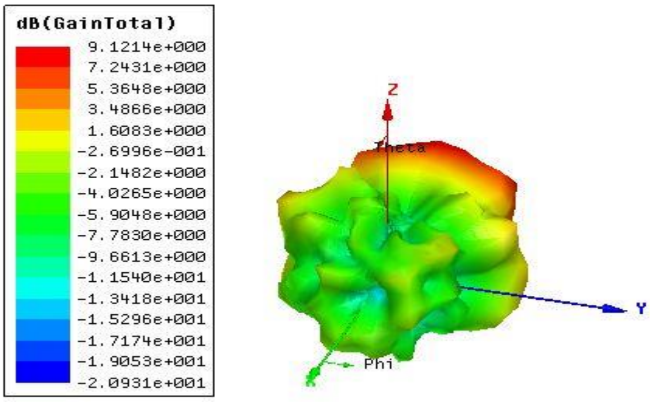

Figure 16. Gain at 4.81 GHz

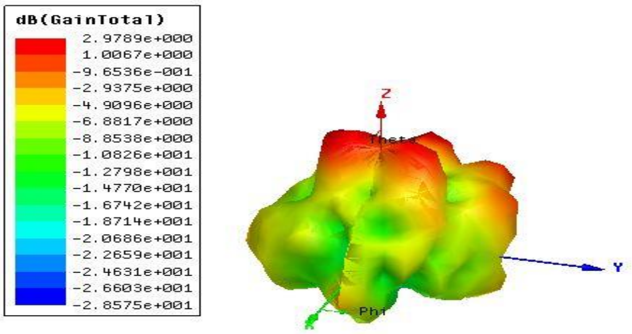

Figure 17. Gain at 5.27 GHz

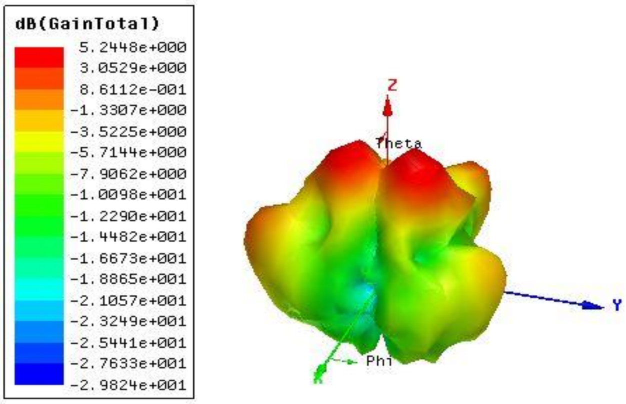

Figure 18. Gain at 5.68 GHz

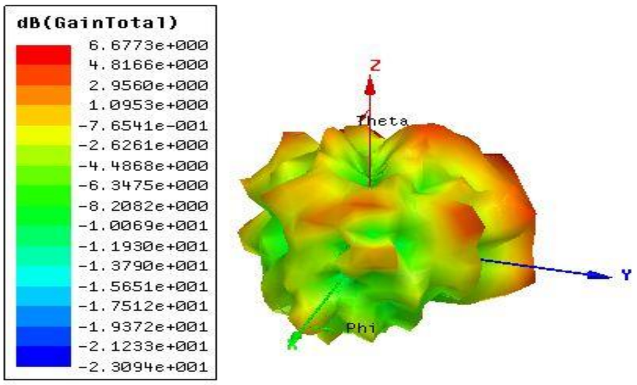

Figure 19. Gain at 6.56 GHz

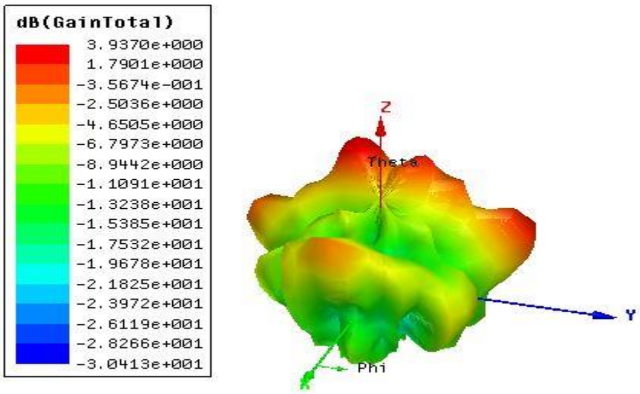

Figure 20. Gain at 6.72 GHz

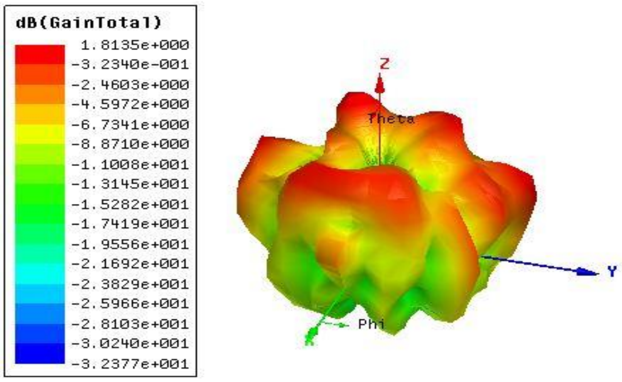

Figure 21. Gain at 6.83 GHz

Methods using current distribution curve are used to calculate antenna impedance, resistance, radiation resistance, reactance, radiation pattern etc. Figure 22 illustrates current distribution.

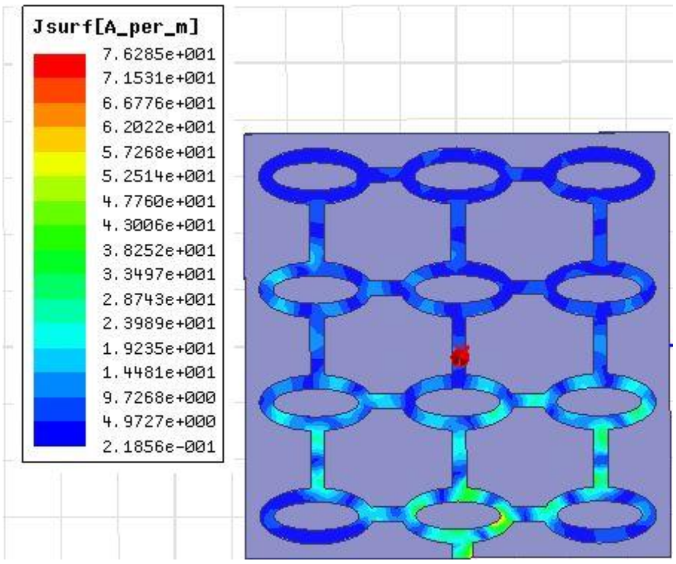

Figure 22. Current distribution of proposed antenna

IV. CONCLUSION

An antenna consisting of periodic array of circular patch was designed and simulated. It is a 3×4 array consisting of 12 patches. Desirable gain and bandwidth was achieved. The design is applicable for satellite applications. VSWR and S parameters were observed and was satisfactory. The designed antenna has multiband characteristics.

V. REFERENCES

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