Design & Analysis of C-Shaped & Circular Microstrip Patch Antennas

Prof. Muttu Yeshudas
Assistant Professor
Department of Electronics and Telecommunication Engineering
Industrial Automation & Radio Frequency
Goa College of Engineering, Farmagudi, India

Mr. Naik Shubham Dilip
PG Student
Department of Electronics and Telecommunication Engineering
Industrial Automation & Radio Frequency
Goa College of Engineering, Farmagudi, India

Mr. Kakodkar Sujay Govind
PG Student
Department of Electronics and Telecommunication Engineering
Industrial Automation & Radio Frequency
Goa College of Engineering, Farmagudi, India

Miss. Naik Shruti Shekhar
PG Student
Department of Electronics and Telecommunication Engineering
Industrial Automation & Radio Frequency
Goa College of Engineering, Farmagudi, India

Abstract

Antennas are specialized transducers that convert radio-frequency (RF) fields into alternating current (AC) or vice versa. In this paper, c-shaped microstrip and circular microstrip patch antennas are proposed. Five important characteristics of the antenna that are return loss, VSWR, maximum directivity, radiation efficiency and antenna efficiency are studied and analysed as a function of frequency. The analysis is carried out with the assistance of IE3D software.

Keywords: Specialized transducers; C-shape Patch; Circular Patch; Return Loss; VSWR; Directivity; Radiation Efficiency ; Antenna Efficiency ; IE3D Software

---

I. INTRODUCTION

An antenna or aerial, is an electrical device which converts electric power into radio waves, and vice versa.[1] It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce an electric current at its terminals that is applied to a receiver to be amplified.

A microstrip patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane [2]. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

The important characteristics or parameters of the antenna are defined as follows:

1) Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line or optical fibre. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB);[3]
2) Voltage Standing Wave Ratio (VSWR) is the ratio of the amplitude of a partial standing wave at an antinode (maximum) to the amplitude at an adjacent node (minimum), in an electrical transmission line.[4]
3) Directivity is a parameter of an antenna which measures the degree to which the radiation emitted is concentrated in a single direction. It measures the power density the antenna radiates in the direction of its strongest emission, versus the power density radiated by an ideal isotropic radiator (which emits uniformly in all directions) radiating the same total power [5].
4) Radiation Efficiency is defined as the ratio of the power radiated to the total power supplied to the radiator.
5) Antenna efficiency is defined as the ratio of the aperture effective area, A_e to its actual physical area A. It describes the percentage of the physical aperture area which actually captures radio frequency (RF) energy [6].

II. RESEARCH METHODOLOGY

In this research paper, we have carried out the analysis of the C-shaped and circular microstrip patch antennas on the basis of the above defined parameters. Both the antennas are designed using the IE3D software which is a MOM based simulation software [7].

The C-shaped antenna is developed from a simple rectangular patch antenna followed by cutting a notch in the structure to make it C-shaped. The structure is fed by using the coaxial feed method in which that the inner conductor of the coaxial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane.

The design of Circular microstrip patch is achieved by cutting a notch to a circular shape patch to provide microstrip line feed in which a conducting strip is connected to the patch making it an extension of the patch. It is simple to model and easy to match by controlling the inset position.

The graphs of the five parameters are obtained after meshing and simulating the structures at a meshing frequency of 3 GHz. The values obtained are compared and the tabulated results help us to determine the application range of the two antennas that is whether they are single band antennas or a duel band antennas.

III. ANTENNA DESIGN

A. *C- Shaped Microstrip Patch*

The C-shaped antenna is developed from a simple rectangular patch antenna followed by cutting a notch in the structure to make it C-shaped. The antenna structure shown in *fig. 1* is designed and simulated over IE3D simulation software. The dimensions of the antenna structure are shown in *table 1.*

1) *Design Steps:*

1) Open a new file in Mgrid.
2) Select meshing frequency as 3GHz.
3) Under the substrate layer set the following parameters: Ztop=1.6 , Ɛpsr=4.4
4) Design C -shaped microstrip patch antenna with design parameters.
5) Define the port by clicking on the probe feed icon.
6) Mesh the structure at 3GHz.
7) Simulate the design and observe the output.
8) Optimize the structure if return loss obtained is less negative.
9) Click on Window option and observe the required outputs.

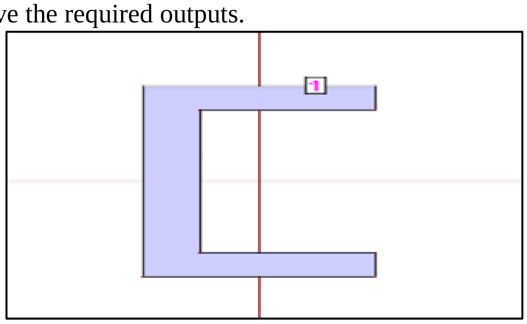


Fig. 1: Design of C shaped Microstrip Patch Antenna

Table – 1
Dimensions of C shape antenna structure

Description	*Dimensions(in mm)*
Patch	*l=48, w=96*
Width of the arm	*12*

B. *Circular Microstrip Patch Antenna*

The design of Circular microstrip patch is achieved by cutting a notch to a circular shape patch to provide microstrip line feed. For these the circular patch radius a is calculated as :

$$a = \frac{1}{\sqrt{F\left\{1+\frac{2h}{\pi F \varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}}}$$

Where

$$F = \frac{8.791 \times 10^{9}}{f_r\sqrt{\epsilon_r}}$$

The dimensions of the antenna structure are shown in *table 2*

Table - 2
Dimension of Circular shaped antenna structure

Radius(a)	*25mm*
Input Resistance of Patch	*50Ω*
Inset Depth of Patch	*5 mm*
Inset width of patch	*2mm*
Width of microstrip line(wo)	*1mm*
Length of microstrip line	*25mm*

A Circular shaped antenna structure is shown in fig. 2.

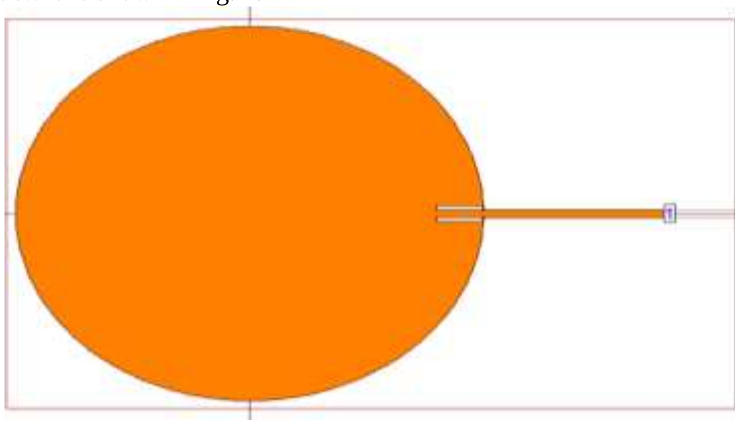


Fig. 2: Circular Microstrip patch antenna

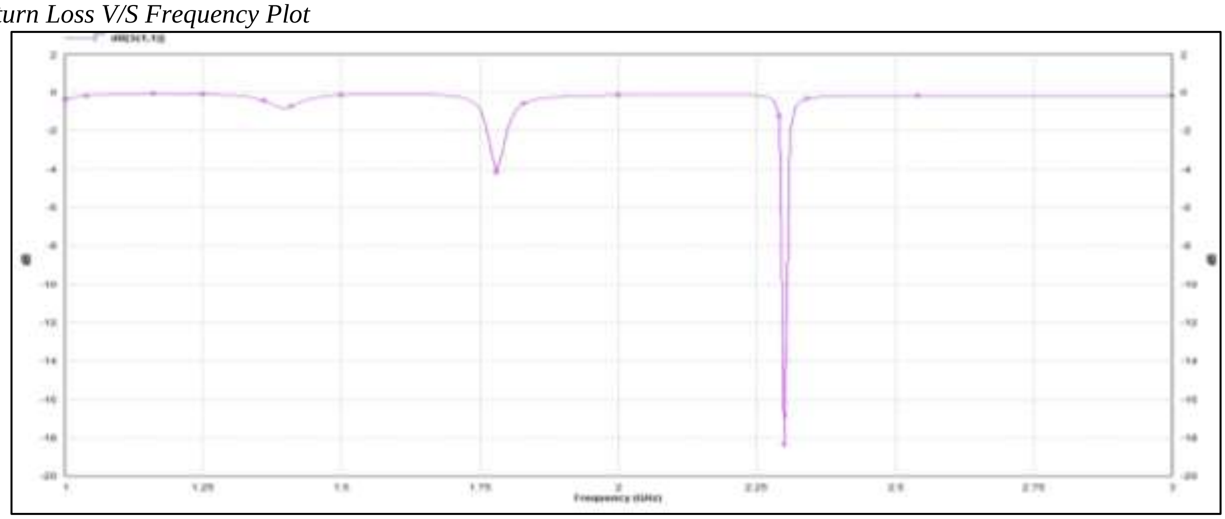
1) *Design Steps:*

1) Open a new file in Mgrid.
2) Select meshing frequency as 3GHz.
3) Under the substrate layer set the following parameters: Ztop=1.6, Ɛpsr=4.4
4) Design Circular microstrip patch antenna with design parameters.
5) Design the microstrip line by making a notch in the circle and then merging both the feed and the circular patch.
6) Mesh the structure at 3GHz.
7) Simulate the design and observe the output.
8) Optimize the structure if return loss obtained is less negative.
9) Click on Window option and observe the required outputs.

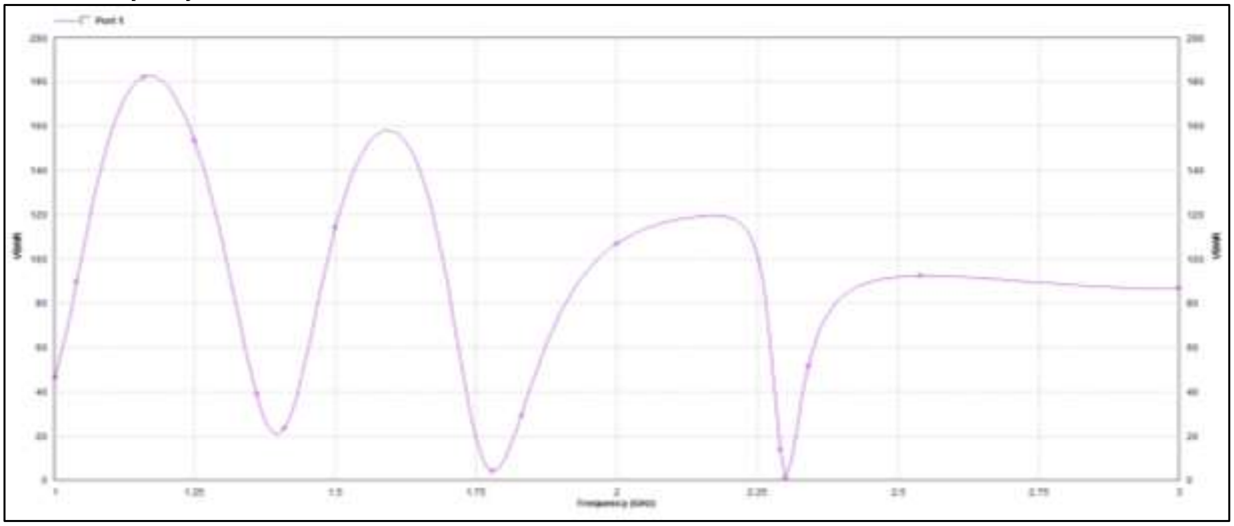
IV. RESULTS AND DISCUSSION

A. *C- Shape Microstrip Patch*

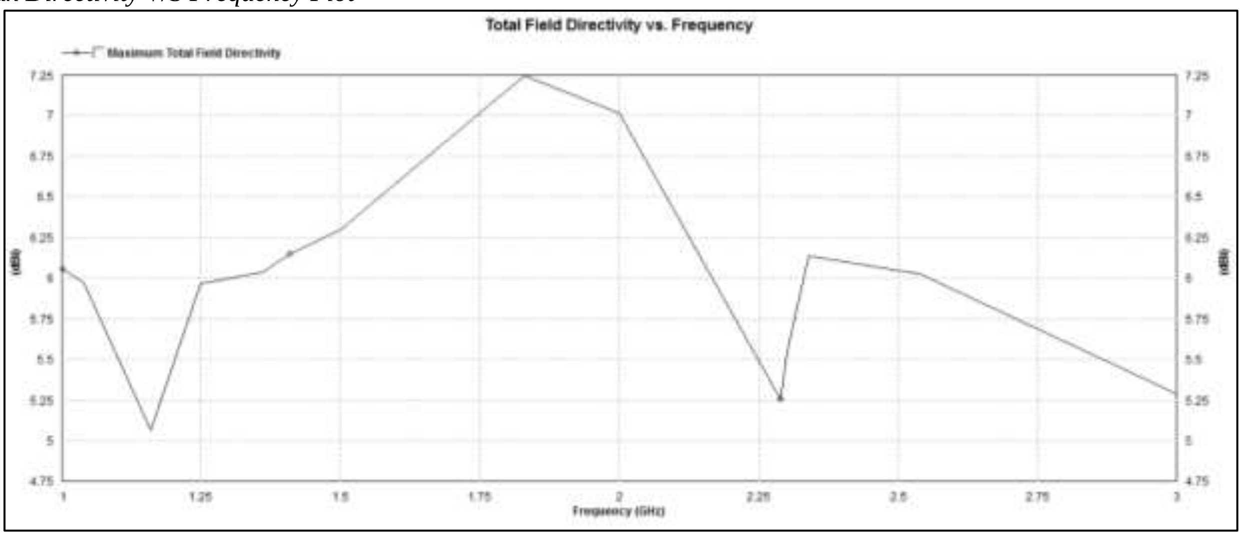
1) *Return Loss V/S Frequency Plot*



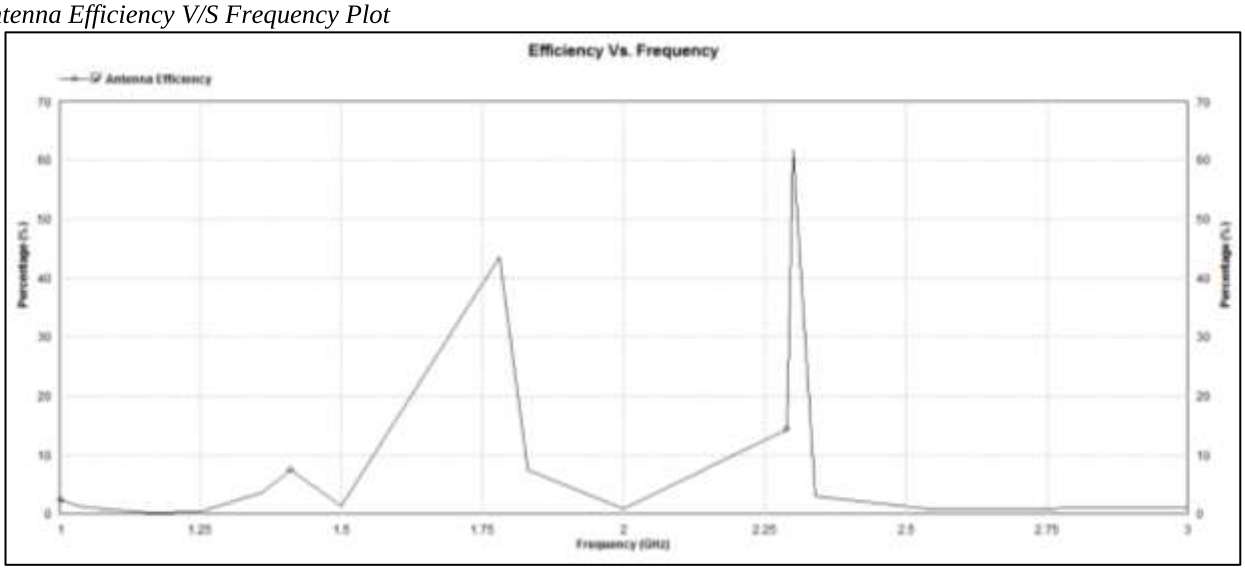
2) VSWR V/S Frequency Plot



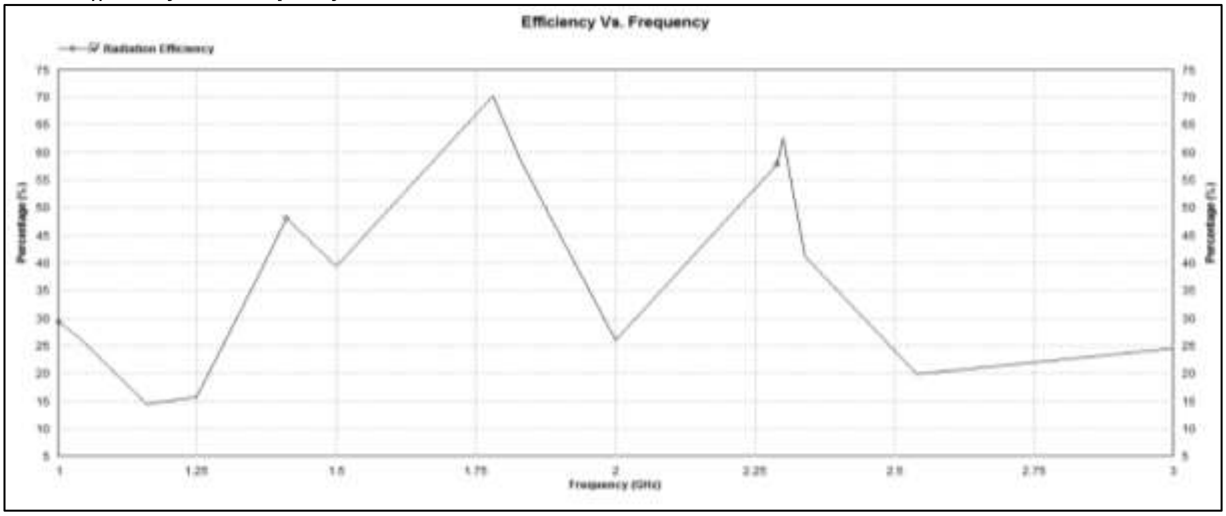
3) Max Directivity V/S Frequency Plot



4) Antenna Efficiency V/S Frequency Plot

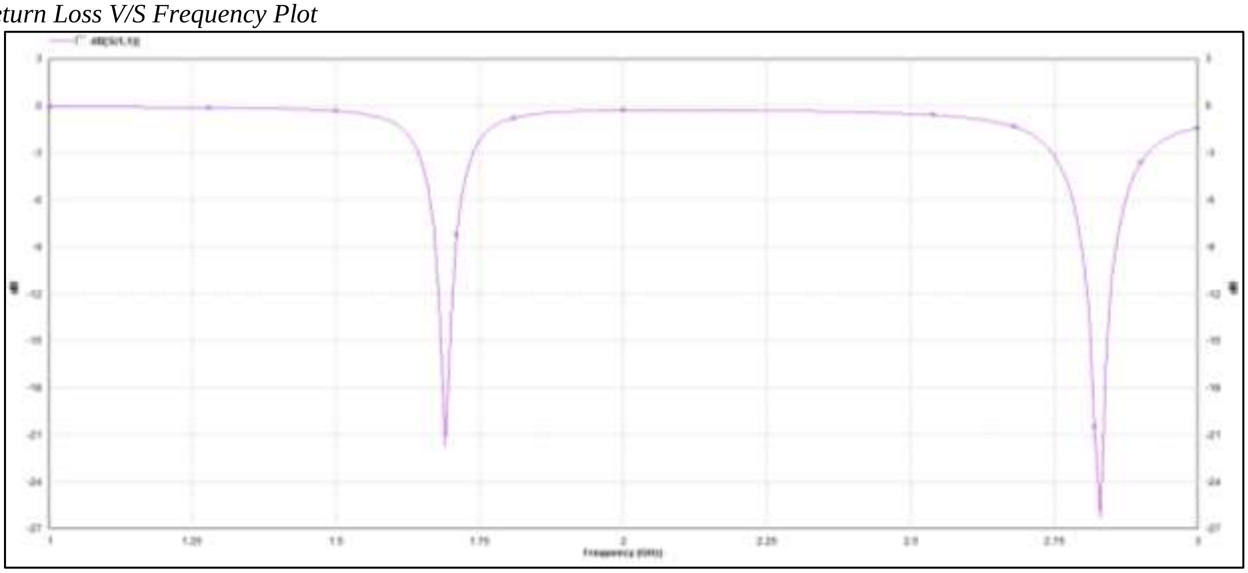


5) Radiation Efficiency V/S Frequency Plot

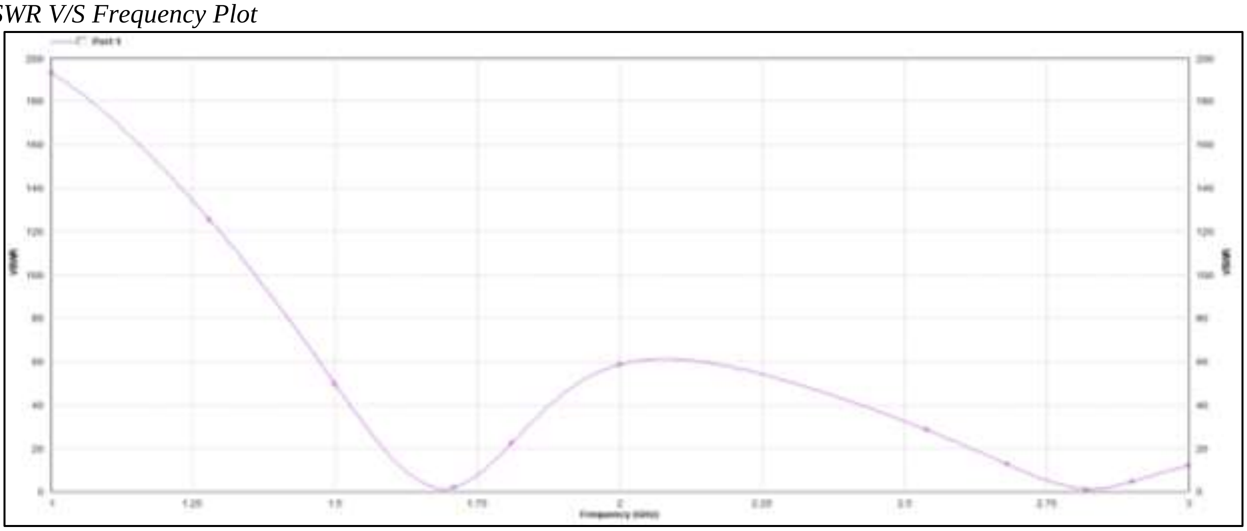


B. Circular Shape Microstrip Patch

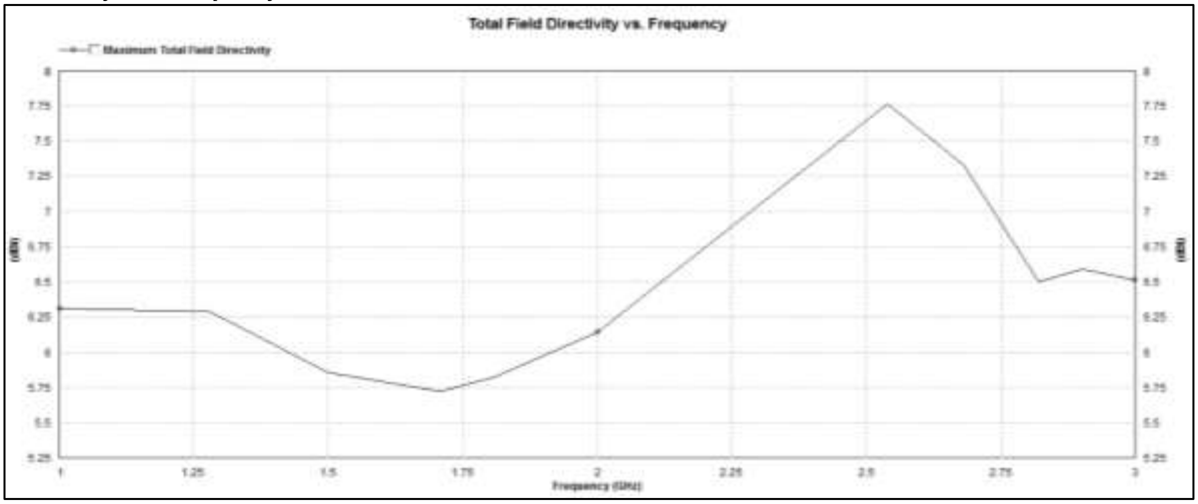
1) Return Loss V/S Frequency Plot



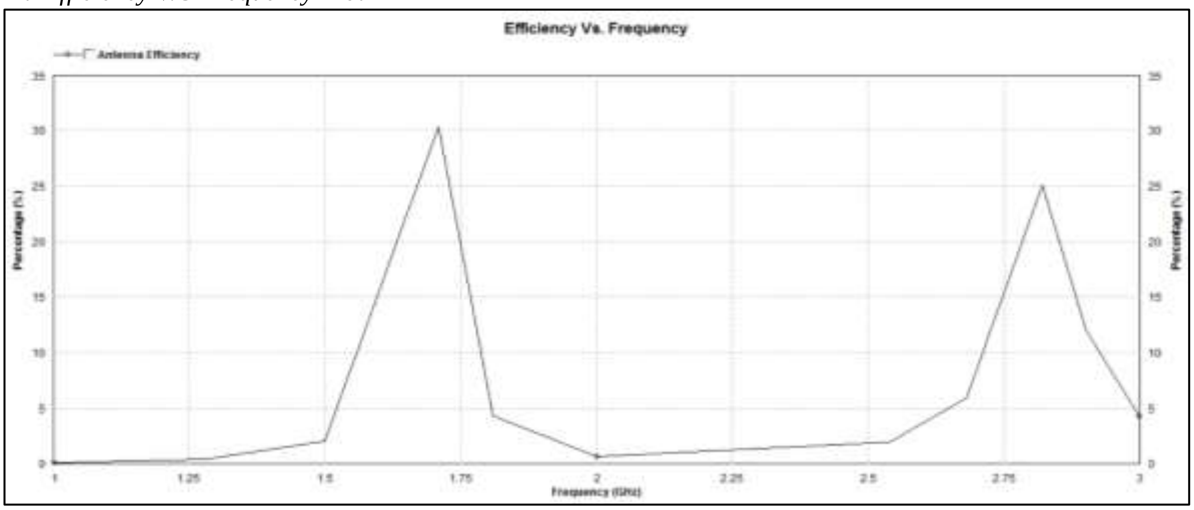
2) VSWR V/S Frequency Plot



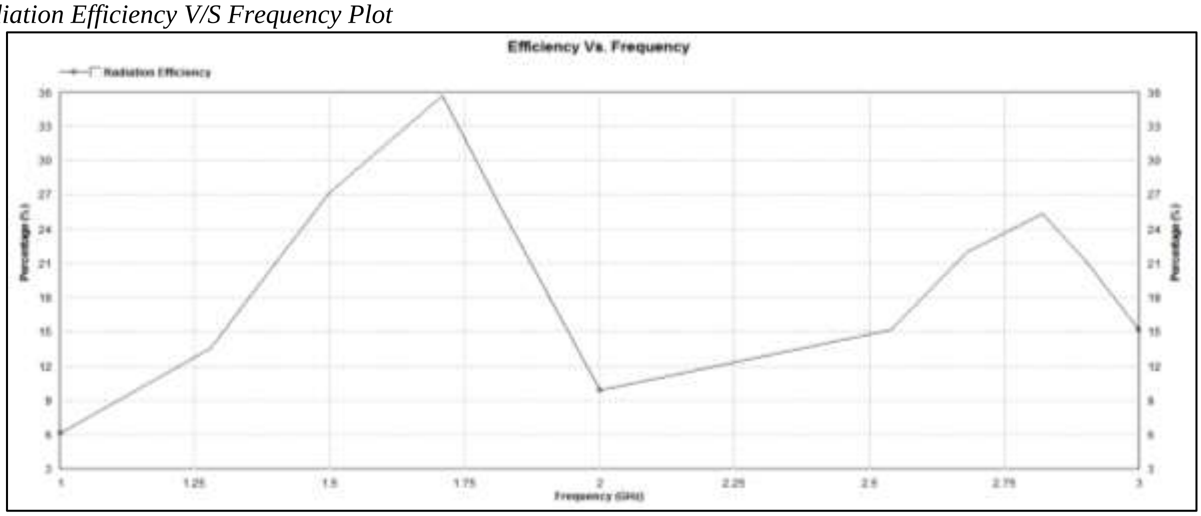
3) Max Directivity V/S Frequency Plot



4) Antenna Efficiency V/S Frequency Plot



5) Radiation Efficiency V/S Frequency Plot



1) Results of C Shaped Antenna

SR.NO.	*PARAMETERS*	*FREQ=1.78GHz*	*FREQ=2.3GHz*
1.	*Return Loss(dB)*	*-4.197*	*-18.35*
2.	*VSWR*	*4.203*	*1.275*
3.	*Directivity*	*7.095*	*5.555*
4.	*Antenna Efficiency(%)*	*43.19*	*59.96*
5.	*Radiation Efficiency(%)*	*69.88*	*61.95*

2) Results of Circular Patch Antenna

SR.NO.	*PARAMETERS*	*FREQ=1.68GHz*	*FREQ=2.83GHz*
1.	*Return Loss(dB)*	*-21.130*	*-26.34*
2.	*VSWR*	*1.179*	*1.101*
3.	*Directivity*	*5.743*	*6.510*
4.	*Antenna Efficiency(%)*	*26.51*	*25.01*
5.	*Radiation Efficiency(%)*	*34.50*	*25.27*

V. CONCLUSION

In this paper we have designed and optimized a C-shaped microstrip patch antenna and Circular shaped microstrip antenna and carried out comparative analysis of the same.

As seen from the results, in the frequency range 1GHz to 3GHz, the Return Loss of the C-Shaped Microstrip Patch antenna is minimum at frequency 2.3GHz compared to frequency at 1.78GHz and thus it is suitable for Single Band applications, whereas for Circular Microstrip Patch Antenna, in the same frequency range the Return Loss is minimum at 1.68GHz as well as 2.83GHz. The values of VSWR should be less than 2 at the operating frequencies. Thus the C-Shaped Microstrip Antenna has one operating frequency that is 2.3GHz whereas Circular Microstrip Antenna has two operating frequencies that is 1.68GHz and 2.83GHz

The radiation efficiency and antenna efficiencies of C-shaped (69.88% and 61.95% respectively) are higher as compared to circular patch antenna (34.50% and 25.27% respectively).

From the Return Loss graph and VSWR graph it is observed that the C-shaped microstrip antenna is suitable for a single band operation. Similarly, Circular microstrip antenna is suitable for Dual band applications.

VI. FUTURE WORK

The future work that can be carried out are as follows:

1) Analysis of the radiation patterns of the antennas.
2) Design and simulation using $\lambda/4$ microwave transformer.
3) Design and simulation using microstrip edge feed with gap.

REFERENCES

[1] Graf, Rudolf F. (1999). Modern Dictionary of Electronics. Newnes. p. 29. ISBN 0750698667.
[2] C.A. Balanis, Antenna Theory, 2nd Ed., John wily & sons, inc., New York.1982.
[3] C.A. Balanis, Advanced Engineering Electromagnetic, John Wiley & sons, New york, 1989.
[4] David M. Pozar, "Microstrip Antennas", Proceedings of IEEE, Vol. 80, January 1992.
[5] Pavan Kumar Sharma, Hemant Kumar Gupta, Veerendra Singh Jadaun, Ritesh Kumar Tambulkar," Design of Sierpinski Microstrip Patch Antenna for Wireless Power Transmission for ISM Band (2.45GHz)", international conference e-manthan 2012, 6-7 April 2012, Jhansi.
[6] Ravi Kant, D.C.Dhubkarya, "Design and Analysis of H-Shape Microstrip Patch Antenna", Global
[7] Journal of Researches in Engineering, Vol. 10 Issue 6 (Ver. 1.0), p.p. 26-29, November 2010.
[8] Zeland Software Inc.,"IE3D Electromagnetic Simulation and Optimization Package, Version 9.35", Zeland Software Inc., Fremont, CA, 2003.

