ISSN 2349-6193
Impact Factor: 2.805

IJESMR
International Journal OF Engineering Sciences & Management Research

DESIGN AND SIMULATION OF I - SHAPE RECTANGULAR MICROSTRIP PATCH ANTENNA WITH COAXIAL FEEDING FOR C- BAND APPLICATION

Sunil Kumar Chaurasiya*[1], Namrata Sahayam[2]
*[1]M.E Student, Department of Electronics & Communication Engineering Jabalpur Engineering College, Jabalpur (M.P)
[2]Assistant Professor, Department of Electronics & Communication Engineering Jabalpur Engineering College, Jabalpur (M.P)

ABSTRACT
This paper presents the design and fabrication of I-shape Rectangular Microstrip patch antenna using coaxial feeding with frequency at 5.9772GHz. The Rectangular patch antenna is designed and fabricated on a FR-4 board with a substrate thickness of 1.6 mm and dielectric constant ε_r= 4.4 and mounted above the ground plane. The main aim of this paper is to obtained a better Return loss, Bandwidth, Bandwidth percentage, Gain, Directivity and radiation pattern with reduced size. The proposed patch antenna was designed and all the parameter are simulated using Computer Simulation Technology (CST) microwave studio 2014. I-shape rectangular microstrip patch antenna is being designed for radio and satellite applications and thus resonates in C-band. In this paper we calculate Return loss -51.17dB, Bandwidth 43.3MHz, Bandwidth percentage 7.24% VSWR 1.005, Gain 4.43dB and radiation pattern for I-shaped Rectangular Microstrip patch antenna.

Keywords: *Microstrip antenna, coaxial feeding, CST, Return loss, VSWR bandwidth percentage.*

INTRODUCTION
Antenna is a sensor and transducer that converts electrical signals into electromagnetic waves and electromagnetic waves into electrical signals. The Microstrip Patch Antenna is a single-layer design which consists generally of four parts: patch, ground plane, substrate, and the feeding part. The Microstrip antennas used for radio and satellite communication system, should have features like light weight, small volume, omni directional radiation properties, low fabrication cost and ease of installation. All these requisite features can be satisfied by using the microstrip patch antenna. Many researchers have witnessed the improvement of return loss, gain and impedance bandwidth of the microstrip patch antenna using different slot configurations[7]. This paper proposed a I-slot patch antenna C- band operations which can be used for circularly polarized applications. I-Shaped slot is gaining considerable attention because of its small structure, broad band and multiband response. A number of experimental and theoretical research papers have been published regarding different shape of slot in patch antenna[9]. The advantages associated with slots of Rectangular Microstrip patch Antenna for achieving the best Return loss, Bandwidth percentage, VSWR, Gain and Radiation pattern when compare with other antenna.

In addition to the theoretical design procedure, numerical simulation was performed using software (CST) to obtain design parameters such as size of patch and feed path. The antennas have been analysed and designed by using the software CST Microwave Studio 2014. There are so many systems that uses antenna such as television, cellular phones, satellite communications, spacecraft, radars, wireless phones and wireless computer networks [12]. Day by day new wireless devices are introducing which increasing demands of compact antennas. Increase in the satellite communication and use of antennas in the aircraft and spacecraft has also increased the demands a low profile antenna that can provide a reliable communication.

The microstrip patch antennas possess characteristics such as low profile, low weight and low manufacturing cost. So, the rectangular microstrip patch antenna can be used in Radars, missiles, space crafts, robots and mobiles, where size, weight and cost are constraints. Conventional microstrip patch antennas have a conducting patch printed on a substrate. The shape of patch of the antenna may be square, rectangular, circular, triangular, elliptical or of other specific configurations[14]. In this paper we use dielectric constant of 4.4 and height of the substrate is 1.6mm. There are many type of feeding method like as coaxial feeding,

IJESMR
International Journal OF Engineering Sciences & Management Research

microstrip line feeding, probe feeding, aperture coupled feeding proximity coupled feeding etc[16]. Here we use coaxial feeding for microstrip patch antenna which gives good result of Return loss, Bandwidth, Bandwidth percentage, VSWR, Gain and radiation pattern.

LITREATUVE REVIEW

There are several experimental works done on different shape Rectangular Microstrip patch antenna where author calculate Return loss(RL), Gain, Bandwidth percentage, VSWR (voltage standing wave ratio), Directivity and radiation pattern.

[1] Ashok Kumar and Shailesh kumar "Design& Simulation of 8–Shaped Coaxial Feed Patch Antenna"International Journal of Current Engineering and Technology Vol.6, No.3 (June 2016) describes the design and simulation of 8-shaped patch antenna using Hfss11.1 electromagnetic simulation software with coaxial feeding technique used. The 8-shaped patch antenna is being designed for amateur radio and satellite applications and thus resonates in X-band. FR4 epoxy dielectric material of relative permittivity 4.4 and loss tangent of 0.019. With the thickness of 1.6mm is used as a substrate of the antenna. The proposed antenna is excited by coaxial probe feeding technique and probe is located at (-2.9 mm, 0 mm,-3 mm). Dimension of patch of length 6.4 mm and width 9 mm. At this configuration the return loss of different shape Base shape, 8-shape and DGS-Optimise rectangular microstrip patch antenna are -16.0499dB, -27.4451dB and -44.1210dB respectively. The Bandwidth percentage of base shape 4.58%, for 8-shape patch antenna is 6.66% and for DGS-Optimise patch antenna is 6.68% at different resonance frequency of 8.5044GHz, 10.3316GHz and 10.3600GHz respectively.

[2] Srikanta Patnaik, Mihir Narayan Mohanty "Optimization of Z-Shape Microstrip Antenna with I- slot Using Discrete Particle Swarm Optimization (DPSO) Algorithm" 2nd International Conference on Intelligent Computing, Communication & Convergence (ICCC-2016) describes discrete particle swarm optimization technique has been utilized in HFSS software for optimization of the Z-shape patch antenna with I- slot dimensions in order to achieve return loss, VSWR, directivity and gain. The designed antenna is to operate in Wi-Max / S- band and C- band satellite application with the centre frequency at 3.5 GHz and 4.3 GHz and various important performance metrics of the patch antenna are analysed for performing comparative analysis between un-optimized patch antenna and optimized patch design.Inthis paper FR4 epoxy dielectric material of relative permittivity 4.4 and loss tangent of 0.02. With the thickness of 1.6mm is usedas a substrate of the antenna.The dimension of patch of length 38.04mm and width 29.44mm. At this configuration the optimized Z-shape patch antenna with I- slot exhibits return loss of -19.4077 dB at 3.5 GHz and -19.5182 dB at 4.3 GHz. Whereas the return loss plot of the un-optimized Z- shape patch antenna with I-slot is -18.88 dB at 3.5 GHz and -16.42 dB at 4.3 GHz. The un-optimized Z- shape patch antenna with I-slot has VSWR of 1.25 and 1.35 and the optimized Z- shape patch antenna with I-slot has a VSWR of 1.23 at 3.5 and 4.3 GHz. The directivity and gain for un-optimized Z- shape patch antenna with I-slot has 5.67dBi and 1.34dB respectively and directivity and gain for the optimized Z- shape patch antenna with I-slot has5.93dBi and 1.53dB respectively.

[3] Pawan kumar punia, Ria kalra and B. Mohapatra "Inset Fed Rectangular Microstrip Patch Antenna for UHF Radio Frequency Identification" International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181Vol. 4 Issue 08, (August-2015) describe a 0.92 GHz inset line fed rectangular microstrip patch antenna has been designed for UHF RFID(Radio Frequency Identification) application with return loss more than -32db, bandwidth 2.71 % and VSWR 1.0473 using HFSS software. In this paper substrate having relative permittivity (ε_r) = 4.5 and thickness (h) = 1.5mm with Tangent (tanδ) = 0.002.The length (L) of patch antenna is 77 mm and its width (W) is 98mm.The inset feed line (Zp) is 7 mm, with feed line width (W_g) of 1 mm and inset gap ($L1$) is 3 mm. Here the input impedance is 51.21Ω and VSWR is 1.0473.

[4] Liton Chandra Paul, Nahid Sultan, "Design, simulation and performance analysis of a line feed rectangular micro-strip patch antenna" International Journal of Engineering Sciences & Emerging Technologies, Volume 4, Issue 2, pp: 117-126 (Feb. 2013) describe a line feed rectangular micro-strip patch antenna with Dielectric constant of the substrate $\varepsilon_{r=}$4.4 and Height of dielectric substrate 1.3mm taken. In this paper micristrip line feed method is used. Here the length of patch is 23.5mm and width of patch is 30.4mm. The return loss of line feed

 ISSN 2349-6193
Impact Factor: 2.805

IJESMR
International Journal OF Engineering Sciences & Management Research

rectangular micro-strip patch antenna is -8.314dB at 2.937GHz. At this configuration of patch antenna Directivity Bandwidth percentage and gain 4.154dBi, 2.6515% and 2.059dB respectively.

[5] Kamariah Ismail and Siti Hasyimah Ishak, "Sierpinski Gasket Fractal Antenna with Defected Ground Structure (DGS)"978-1-4673-4828-7/12/$31.00 ©2012IEEE describe antenna design at 5.8GHz. A slot was used as a defected ground structure(DGS). The antenna was designed and simulated using Computer Simulation Technology (CST) software and fabricated on FR-4 board with a substrate thickness of 1.6 mm and dielectric constant of 5.0 and dielectric loss tangent 0.025. The return loss bandwidth percentage and VSWR at 5.8GHz is -24.41dB, 3.57% and 1.128 respectively.

After studying the literature review we observe that number of experimental and theoretical research paper have been published regarding Return loss(RL) ranging from -9dB to - 44dB, Gain from 1dB to 3dB, VSWR(voltage standing wave ratio) < 2, Bandwidth from 30MHz to 35MHz and Bandwidth percentage from 2% to 6.68% in the frequency band 4GHz to 8GHz (C-band). After analysing different published paper we observed that an approach to Rectangular Microstrip patch antenna with 'I' shape will bring better result in terms of Return loss (RL), Gain, VSWR (voltage standing wave ratio), Bandwidth, Bandwidth percentage and good radiation pattern.

DESIGNING OF I-SHAPED RECTANGULAR MICROSTRIP PATCH ANTENNA

Antenna proposed in this paper is particularly for C - band application operating at a frequency of 5.9772GHz. The rectangular Patch Antennais designed using Computer Simulation Technology (CST) software having dimensions Length (P_L) width (P_W) 20mm and 16mm respectively. Initially this patch is integrated with homogeneous substrate material ground plane having dimension 29.6mm*25.6mm. Here we used FR-4 lossless dielectric material of relative permittivity 4.4 with the thickness of 1.6mm as a substrate of the antenna. The proposed antenna is excited by coaxial probe feeding technique and probe is located at the center of the patch. The I-Shape slot is cut in the patch. The front view and side view of the I-shape rectangular microstrip patch antenna is shown in "fig.1(a) and fig.1(b)".The geometry in order to shape I- shaped rectangular microstrip patch anteena is shown in "fig. 2".

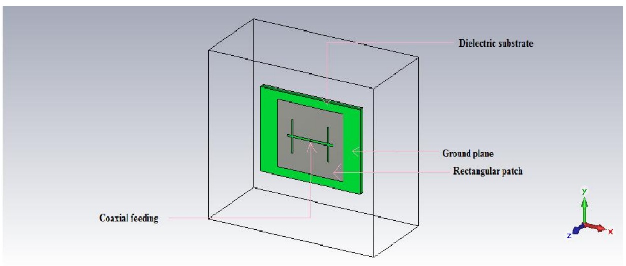

Fig.1(a) Front view of I-shaped rectangular microstrip patch antenna

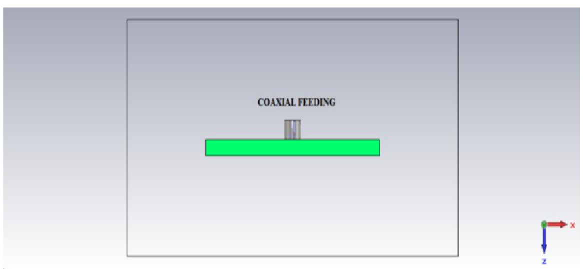

Fig. 1(b) Side view of I-shaped rectangular microstrip patch antenna

IJESMR
International Journal OF Engineering Sciences & Management Research

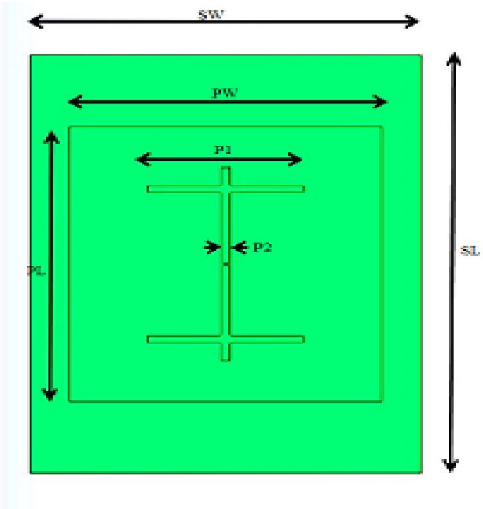

Fig. 2 I-shaped rectangular microstrip patch antenna

The parameters and their dimensions of I-shape rectangular microstrip patch antenna as shown in table 1 which gives best Return loss, Bandwidth, Bandwidth percentage , VSWR, Gain and Radiation pattern on this configuration.

Table 1. Parameters and their dimensions

Parameters	Dimensions	Units
Resonance frequency (F_r)	5.9772	GHz
dielectric constant(ε_r)	4.4	-
substrate thickness (h)	1.6	Mm
Width of substrate (S_W)	25.6	Mm
Length of substrate (S_L)	29.6	Mm
Width of patch (P_W)	16	Mm
Length of patch (P_L)	20	Mm
Length if cut (P_1)	8	Mm
Width of cut (P_2)	0.5	Mm

SIMULATION AND RESULT ANALYSIS

The Rectangular microstrip patch antenna parameters are calculated from the formulas given Below:
Calculation of Width (W):

$$\mathbf{w} = \frac{c_0}{2f_r}\left(\frac{\varepsilon_r+1}{2}\right)^{-1/2} \quad (1)$$

Where, c = free space velocity of light
c = 3*10^8 m/sec
ε_r= Dielectric constant of substrate

IJESMR
International Journal OF Engineering Sciences & Management Research

The effective dielectric constant of the Microstrip antenna to account for fringing field. The Effective dielectric constant is calculated by

$$\varepsilon_{ff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right) \qquad (2)$$

Where ε_{ff}= effective dielectric constant
h = height of the dielectric substrate
W = width of the patch

The actual length of the Patch (L):

$$\mathbf{L = Leff - 2\Delta L} \qquad (3)$$

Where ΔL = Length Extension
L_{eff} = Effective length of the patch

$$L_{eff} = \frac{c}{2F_r\sqrt{\varepsilon_{eff}}} \qquad (4)$$

Calculation of Length Extension:

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (5)$$

The antenna resonates (without taking fringing into account) at the frequency given by

$$f_r = \frac{c_0}{2L\sqrt{\varepsilon_{reff}}} \qquad (6)$$

When considering the effective dielectric constant the antenna will radiate at the frequency

$$f_r = \frac{c_0}{2(L+2\Delta L)\sqrt{\varepsilon_{reff}}} \qquad (7)$$

The Length of the ground substrate (L_g) is given by

$$\mathbf{L_g = 6h + L} \qquad (8)$$

The Width of the ground substrate (W_g) is given by

$$\mathbf{W_g = 6h + W} \qquad (9)$$

Return loss: In antenna the return loss (RL) is a parameter which indicates how the impedance matching has occurred in between transmitter and antenna. For the case of good impedance matching the power losses become minimum and the antenna becomes more efficient. The proper impedance matching is obtained through the proper selection of the input feed point. The return loss of the designed coaxial feed I-shape microstrip patch antenna is shown in fig.3 in this figure X-axis shows frequency in GHz and Y-axis shows return loss in dB. The Return loss for the Microstrip patch antenna is given by

$$\mathbf{RL = -20\log\,[\Gamma]} \qquad (10)$$

Γ = Reflection coefficient of the transmilne line
and $\Gamma = \frac{V_r}{V_i}$
So Return loss (RL) for the I- shape rectangular microstrip patch antenna is -51.17dB at 5.9772GHz.

IJESMR
International Journal OF Engineering Sciences & Management Research

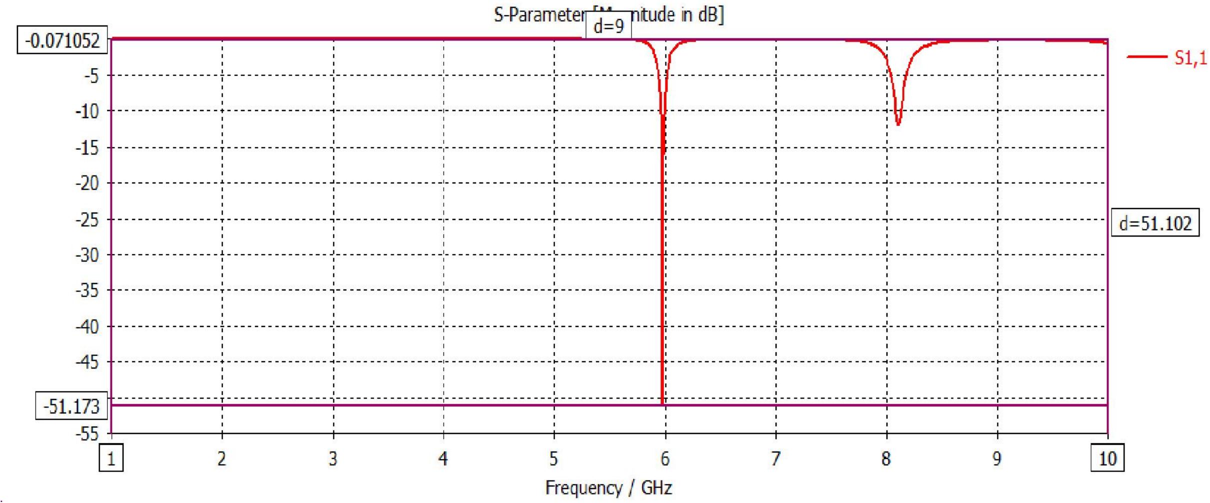

Fig.3 Return loss (RL) plot

Fig.4 shows Polar plot and smith chart for return loss of I- shape rectangular microstrip patch antenna at 5.9772GHz.

Fig.4 Polar plot and smith chart for return loss

Bandwidth and Bandwidth percentage (BW%): The bandwidth of the Rectangular Microstrip patch antenna is given by

Bandwidth = F_h- F_l (11)

So Bandwidth for the I- shape rectangular microstrip patch antenna is 43.3MHz at -10dB return loss.

The Bandwidth percentage of the Rectangular Microstrip patch antenna is given by

Bandwidth percentage $= \frac{F_h - F_l}{\sqrt{F_h F_l}} X\ 100\%$ (12)

Where F_h= Upper cutoff frequency
F_l =Lower cutoff frequency

So Bandwidth percentage for the I- shape rectangular microstrip patch antenna is 7.24%.Bandwidth and Bandwidth percentage (BW%) plot for the I- shape rectangular microstrip patch antenna as shown in fig.5 in this figure X-axis shows frequency in GHz and Y-axis shows return loss in dB and bandwidth taken at -10dB return loss.

IJESMR
International Journal OF Engineering Sciences & Management Research

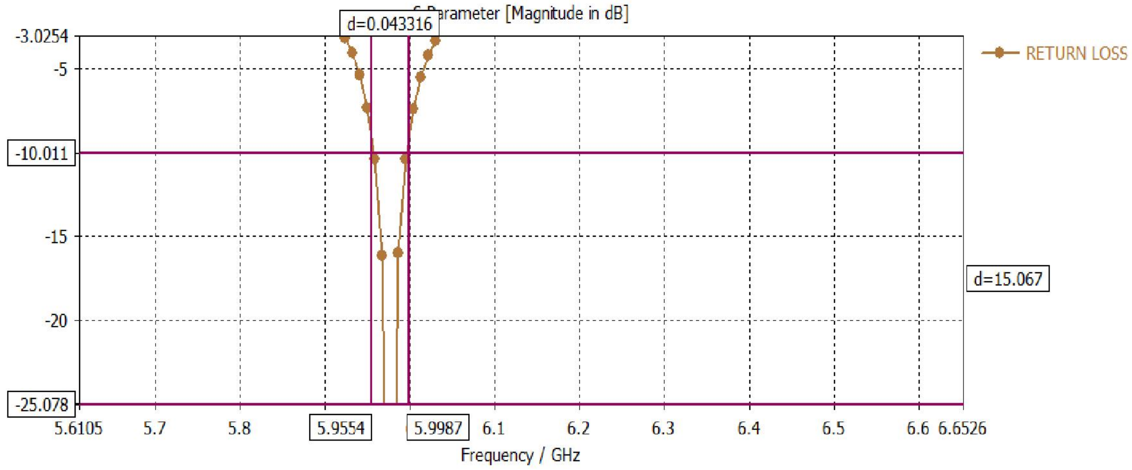

Fig. 5 Bandwidth plot

VSWR (voltage standing wave ratio):It is an important parameter for a microstrip antenna to obtain proper impedance matching is VSWR. It shows that the value of VSWR of our designed antenna is below 2 for the whole bandwidth where for a practical antenna the value of VSWR should be less than or equal to 2 is acceptable. So this parameters indicates that the designed antenna is operable in required frequency band. The VSWR (voltage standing wave ratio) is given by

$$\mathbf{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|} \tag{13}$$

So VSWR for the I- shape rectangular microstrip patch antenna is 1.005 and fig. 6 shows VSWR plot for I-shape rectangular microstrip patch antenna. In fig.6 X-axis shows frequency in GHz and Y-axis shows VSWR (voltage standing wave ratio).

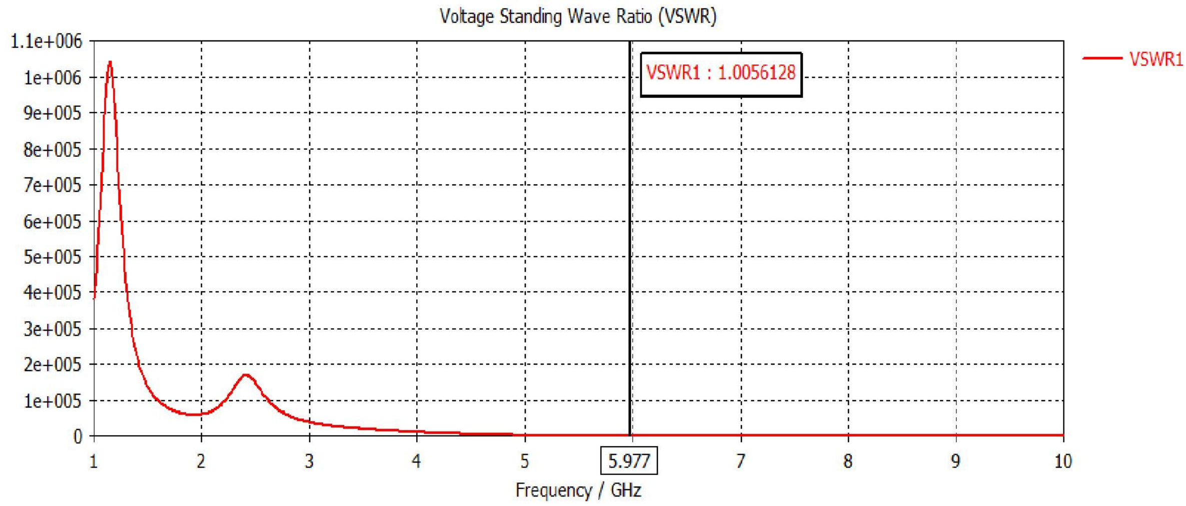

Fig.6 VSWR plot

Fig.7(a) and 7(b) shows 3D plot and polar plot of farfeild radiation pattern for I- shape rectangular microstrip patch antenna at 5.9772GHz. Here we found Gain for I- shape rectangular microstrip patch antenna at 5.9772GHz is 4.43dB.

IJESMR
International Journal OF Engineering Sciences & Management Research

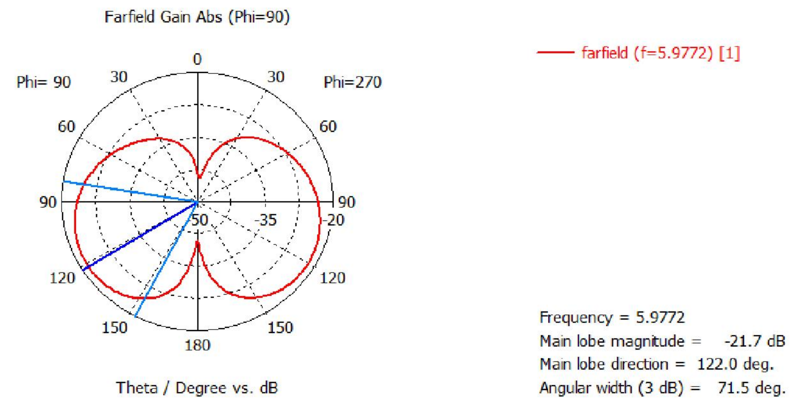

Fig. 7(a) polar plot of far feild radiation pattern

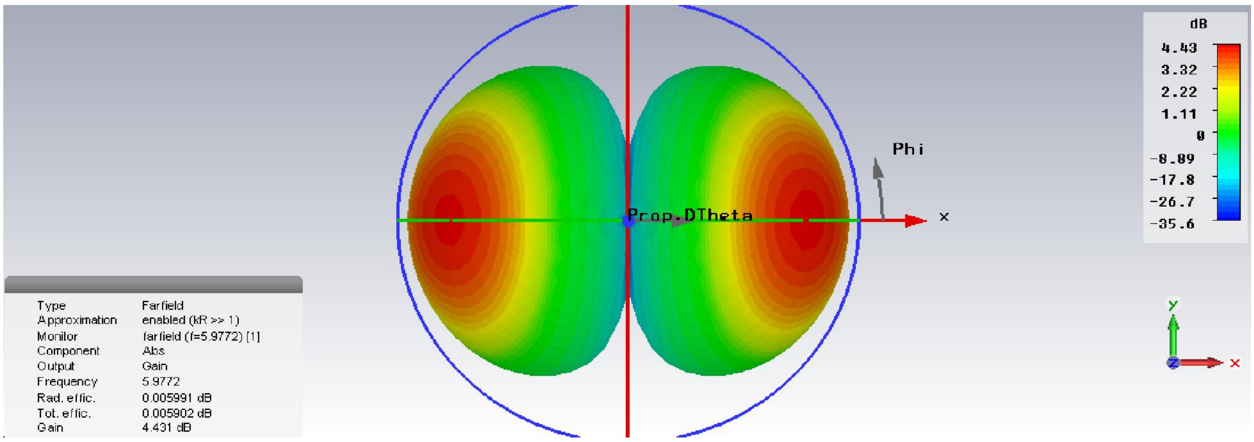

Fig.7(b) 3D plot of far feild radiation pattern

CONCLUSION

We discussed in detail the structure, theoretical models, and performance characteristics of a Rectangular Microstrip patch Antenna with I-shape at 5.9772 GHz. Here we calculate Return loss -51.17dB, Bandwidth 43.3 MHz, Bandwidth percentage 7.24%, VSWR(voltage standing wave ratio) 1.005 and Gain is 4.43dB and good radiation pattern for the Rectangular Microstrip patch Antenna with I-shape at 5.9772 GHz. This antenna can be used for satellite and wireless communication.

REFERENCES

1. *Ashok Kumar and Shailesh Kumar, "Design & Simulation of 8–Shaped Coaxial Feed Patch Antenna" International Journal of Current Engineering and Technology Vol.6, No.3 (June 2016).*
2. *Srikanta Patnaik, Mihir Narayan Mohanty "Optimization of Z-Shape Microstrip Antenna with I- slot Using Discrete Particle Swarm Optimization (DPSO) Algorithm" 2nd International Conference on Intelligent Computing, Communication & Convergence (ICCC-2016).*
3. *Pawan kumar punia, Ria kalra and B. Mohapatra "Inset Fed Rectangular Microstrip Patch Antenna for UHF Radio Frequency Identification" International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181Vol. 4 Issue 08, (August-2015).*

IJESMR
International Journal OF Engineering Sciences & Management Research

4. *Liton Chandra Paul, Nahid Sultan, "design, simulation and performance analysis of a line feed rectangular micro-strip patch antenna" International Journal of Engineering Sciences & Emerging Technologies, Volume 4, Issue 2, pp: 117-126 (Feb. 2013).*
5. *Kamariah Ismail and Siti Hasyimah Ishak "Sierpinski Gasket Fractal Antenna with Defected Ground Structure (DGS)"978-1-4673-4828-7/12/$31.00 ©2012IEEE.*
6. *Bimal Garg, Himanshu Shrivastava, Prem Kumar, "Microstrip Patch Antenna with Parameters Improvement Using "Symmetric Cylinder Shapes of Zero & Four Segments" Metamaterial Structure" IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501 Vol.2, No.3,(June 2012).*
7. *Ali HanafiahRambe, Eddy Marlianto, Nasruddin M.N., FitriArnia "Optimizing Rectangular Patch Antenna with Microstrip Line Feed Using Single Stub"International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 12, December – 2013.*
8. *Hemant Kumar Gupta, Bhupesh Gautem, Poonam Sinha,AbhaSoni "Design of Very Low Return Loss, Rectangular Microstrip Patch Antenna for Cellular and Mobile Communication" nternational Journal of Electronics and Electrical Engineering Vol. 1, No. 3, September, 2013.*
9. *Chandan Kumar Ghosh, Arabinda Roy, and Susanta Kumar Parui "Elevated CPW-Fed Slotted Microstrip Antenna for Ultra-Wideband Application"Hindawi Publishing Corporation International Journal of Antennas and Propagation Volume 2012, Article ID 425919,8pages doi:10.1155/2012/425919.*
10. *Sheikh Dobir Hossain, K. M. Abdus Sobahan, Md. Khalid Hossain, Md. Khalid Hossain Jewel, Rebeka Sultana, Md. Al Amin "A Linearly Polarized Coaxial Feeding Dual Band Circular Microstrip Patch Antenna for WLAN Applications" I.J. Wireless and Microwave Technologies, 2016, 3, 50-60 Published Online May 2016 in MECS DOI: 10.5815/ijwmt.2016.03.06.*
11. *R. L. Yadava, M. Ram and S. Das, " Multiband Triangular Fractal Antenna For Mobile Communications," International Journal of Engineering Science and Technology, Vol. 2(11), (2010).*
12. *Amit A. Deshmukh, M. Parulekar, S. Kadam and Ameya Kadam, "Broadband Proximity Fed Modified E -Shaped Microstrip Antenna," National Conference on Communications (NCC), Bangalore, pp.1-5, (2011).*
13. *Garg, R., Bhartia, P. and Ittipiboon, A., "Microstrip Antenna Design Handbook, Boston Artech, House", (2001).*
14. *Padros, N., J. Ortigosa, J. Baker, M. Iskander, and B. Thomberg, "Comparative study of high-performance GPS receiving antenna design,"IEEE Trans. Antennas Propagat., Vol. 45, No. 4, 698–706, (1997).*
15. *T. P. Wong and K. M. Luk, "A wideband L-probe patch antenna array with wide beamwidth,"IEEE Trans. Antennas Propag., vol. 51, no. 10, pp. 3012–3014, Oct.(2003).*
16. *W. Yun and Y.-J. Yoon, "A wide-band aperture coupled microstrip array antenna using inverted feeding structures,"IEEE Trans. Antennas Propag., vol. 53, no. 2, pp. 861–862,(Feb. 2005).*
17. *C.A.Balanis,"Antenna Theory Analysis and Design", third edition, Wiley, New Jersey, (2005).*