IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 10, October 2016

Design and Analysis of Microstrip Patch Antenna for L-band Applications using IE3D v15

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Abstract: Here we are presenting the design of microstrip patch antenna with rectangular patch for L Band applications. We measure experimentally various parameters of rectangular patch antenna such as return loss, VSWR, %BW, gain, antenna efficiency and directivity. Now a day bandwidth of microstrip patch antenna is main concern. A lots of method such as slotting like E-slot, U-slot, L-slot, I-slot and many are carrying out in order to increase the percentage bandwidth of patch antenna, but these methods are complicated to design. Therefore we design a rectangular patch antenna using computer software Zealand IE3D v15, which improves the percentage bandwidth of proposed antenna by 28.95%. The proposed antenna covers the L Band, has many applications such as mobile services, satellite navigation, aircraft surveillance and digital broadcasting.

Keywords: Microstrip patch antenna, line feeding, L Band, mobile communications.

1. INTRODUCTION

Now a day in communication system, wireless technology has popularly increased and Antenna is main part of wireless communication [1] technology. The antenna is an electrical transducer device that convert the electric current into EM wave also called as radio waves while it is used in transmitter and vice versa while used in receiver. In order to expanding the market of wireless communication and its applications, microstrip patch antenna has become popular as its small size, light weight and easily fabricated on the printed circuit board.

The basic microstrip patch antenna also called as simple patch antenna [2], consists the radiating patch on one side which is isolated from plane by a dielectric substrate [3] on the other side. Such antenna sometimes is also called a printed antenna because the fabrication procedure is similar to that of a printed circuit board designing. The basic microstrip patch antenna is shown in fig.1 and its current distribution is shown in fig.2.

Common microstrip antenna shapes used in various applications are square shaped [4], circular shaped patch [5], Inverted S-Shaped [6] and elliptical and E-shaped patch [7-9] but any arbitrary shape [10] is possible. Microstrip antennas can be designed as very tinny planar printed antennas and they are very useful essentials for communication applications. The major advantages of patch antenna are ease of manufacturing, low fabrication cost, efficient radiation. It support both linear and circular polarization. But it suffers from low impedance bandwidth, low gain and excitation of surface waves. Here we increase the bandwidth and gain of patch antenna by designing a rectangular patch, which has eight rectangular notches of defined width and length.

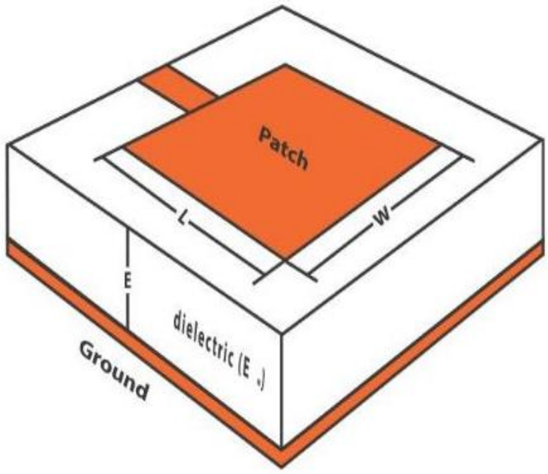

Fig.1. Basic Microstrip Patch Antenna

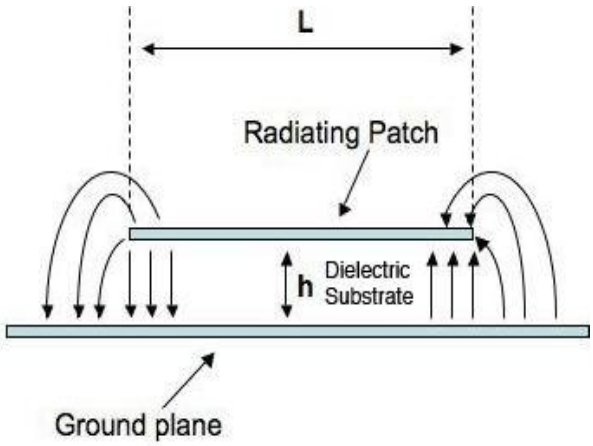

Fig.2. Current Distribution of Basic MSP Antenna

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1.1 Feeding Technique

Microstrip patch antennas can be served by a different feeding methods [11]. These methods can be divided into two parts- contacting and non-contacting. In the contacting method, the radio power is fed directly to the radiating patch by using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field link is completed by transferring radio power between the microstrip line and the radiating patch. The most four most popular feeding techniques used are microstrip line feeding and coaxial probe feeding, examples of contacting schemes feeding, aperture coupling and proximity coupling, examples of non-contacting schemes feeding. These techniques have several advantages and disadvantages. These are used according to their applications. In this paper we use the microstrip line feeding technique for proposed antenna.

1.2 Microstrip Line Feeding

This type of feeding technique has a conducting strip that is associated directly to the edge of the Microstrip patch. The width of conducting strip is smaller as compared to the patch. This category of feeding arrangement has the advantage that this type of feeding can be removed on the same substrate to transport a planar structure.

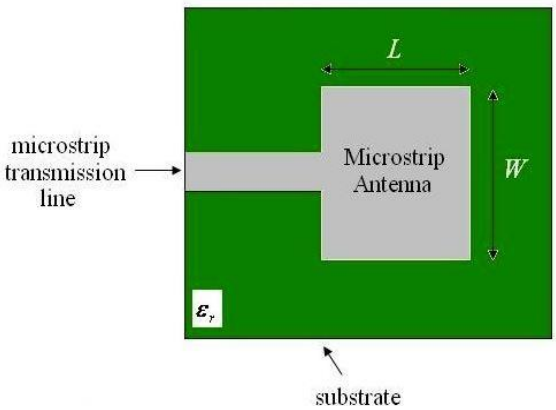

Fig.4. Side view of Microstrip Line Feeding

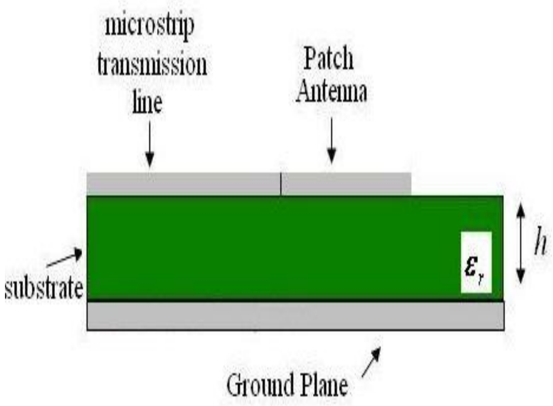

Fig.3. Top view of Microstrip Line Feeding

This method has many advantages due to its simple planar structure. Though as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth 1.5-5% of the antenna. This feed radiation also leads to undesired cross polarized radiation. The top and side view is shown in fig.3 and fig.4.

2. ANTENNA CONFIGURATION

This antenna is designed by using FR-4 as a dielectric substrate. The dielectric constant of FR-4 material is 4.4, loss tangent is 0.0013 and thickness is 1.6 mm. copper material is used for ground plane and patch. We are using microstrip line feeding for feeding power to this antenna**.**

2.1. Antenna Design

For designing a rectangular microstrip patch antenna, the length and the width of patch [3] are calculated by using following formulas as given below.

$$\text{Width (W)} = \frac{c}{2f_0\sqrt{\frac{\varepsilon_R+1}{2}}};\varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}}\right]$$

Where c=light velocity, f_0 =resonance frequency, ε_R = dielectric constant, h= dielectric thickness.

$$\text{Length (L)} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

If operating frequency f_0=1GHz the length and width of patch and ground are calculated as:-
Length of Patch= 71.31mm, Width of Patch= 91.28mm
As we know that Length of Ground (L_g) = L (patch) +6(h) = 80.91mm Width of Ground (L_w) = W (patch) +6(h) = 100.88mm
First we design a microstrip rectangular patch antenna of defined length and width as calculated above by using following equations. Then we make four rectangular notches of length L_1 and Width W_1. Then we make another four rectangular notches of Length L_2 and Width W_2. The 2D and 3D view of proposed antenna with eight rectangular notches with defined width and length is shown in fig.5 and fig.6.

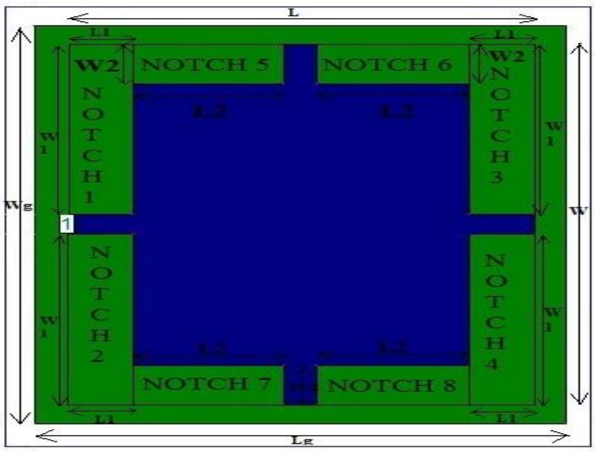

Fig.5. 2D view of Proposed Microstrip Patch Antenna with eight rectangular notches

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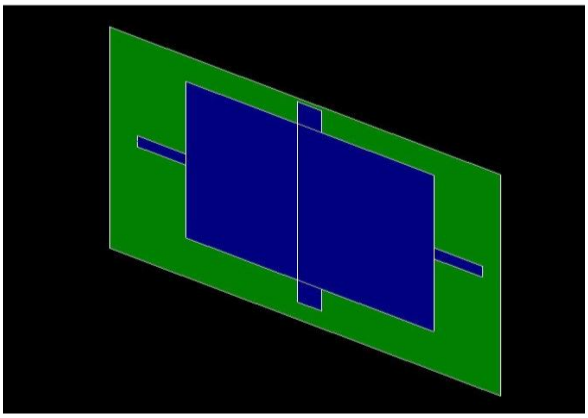

Fig.6. 3D view of Proposed Microstrip Patch Antenna with eight rectangular notches

Table.1: The Parameters of proposed Microstrip Patch Antenna with eight rectangular notches

Antenna Parameters	Values	Antenna Parameters	Values
Lg	80.91mm	L1	10mm
Wg	100.88mm	W1	43.14mm
L	71.31mm	L2	23.155mm
W	91.28mm	W2	10mm

3. SIMULATIONS AND RESULTS

We design and simulate microstrip patch antenna by using a computer software called IE3D (v15).

We design simple rectangular microstrip patch antenna with eight notches of defined length and width. The simulated results are shown in figures below.

3.1 Return loss

Return loss signifies the amount of reflected power from antenna. It is denoted by S11. It is also known as reflection coefficient. If it is 0dB that means all power is reflected from antenna and nothing is radiated. The value of S11 is usually below -10dB. We get return loss less than -10dB (in negative sense) in microstrip patch antenna with eight rectangular notches. We get return loss of -36.31dB at the resonant frequency 1.113GHz. The graph for return loss vs frequency of proposed antenna with eight rectangular notches is shown in fig.7. It is given by following formula.

$$\text{Return Loss} = 10\log_{10}\frac{P_i}{P_r}$$

$$P_i = \text{Incident Power}, P_r = \text{Reflected Power}$$

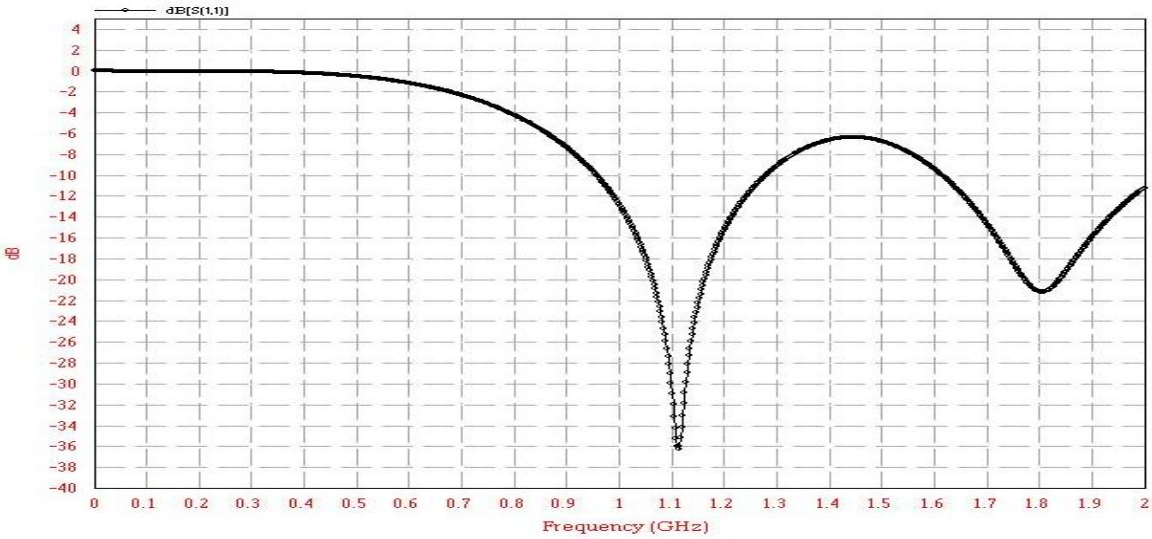

Fig.7. Return Loss of Proposed Microstrip Patch Antenna with eight rectangular notches

3.2 VSWR

VSWR is called as Voltage Standing wave Ratio and is also referred as Standing Wave Ratio (SWR). It is related to reflection coefficient of the antenna. The value of VSWR should be as small as possible. For an antenna it should be less than 2. Hence the value of VSWR of proposed antenna is 1.031 at resonant frequency 1.113GHz. The graph for VSWR vs frequency of proposed antenna with eight rectangular notches is shown in fig.8. The relationship between reflection coefficient and VSWR is defined by following formula:

$$\text{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

$$\Gamma = \text{Reflection Coefficient}$$

3.3 Antenna Directivity

The directivity is a figure of merit (FOM), usually for an antenna. It calculates the power density emitted by antenna in the direction of its strongest radiation versus the power density radiated by an ideal isotropic antenna (which emits uniformly in all direction) for same input power.

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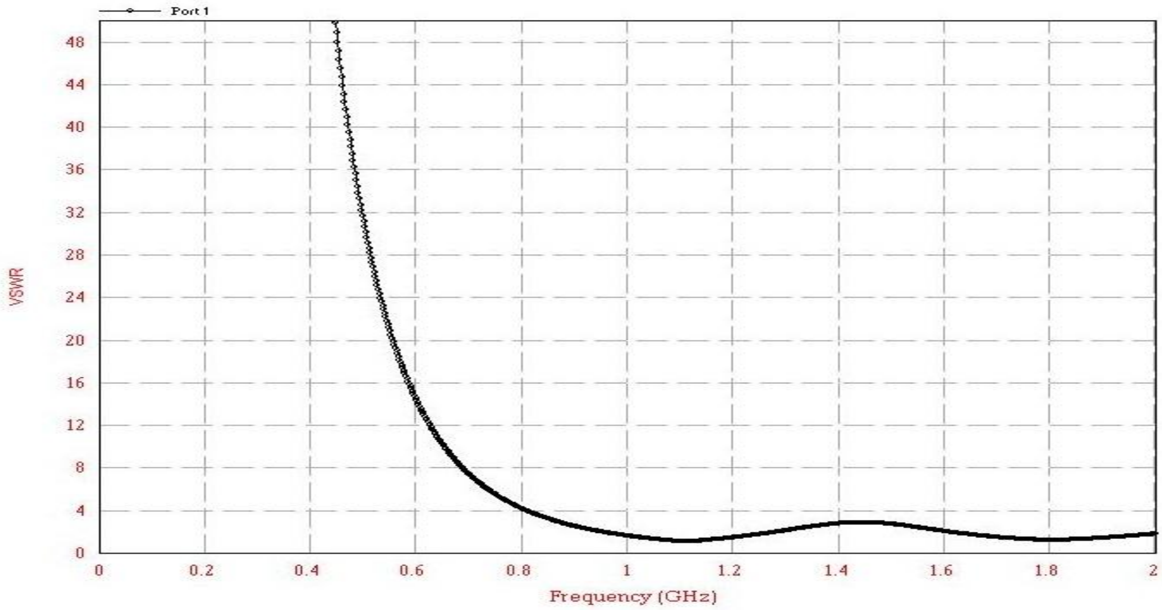

Fig.8. VSWR of Proposed Microstrip Patch Antenna with eight rectangular notches

It is represented by D. Directivity of antenna is linked to its gain and is calculated in dBi. It represents the maximum value of its directive gain. The directivity of proposed antenna is 3.241dBi at resonant frequency 1.113GHz. The graph for directivity vs frequency of proposed antenna with eight rectangular notches is shown in fig.9.

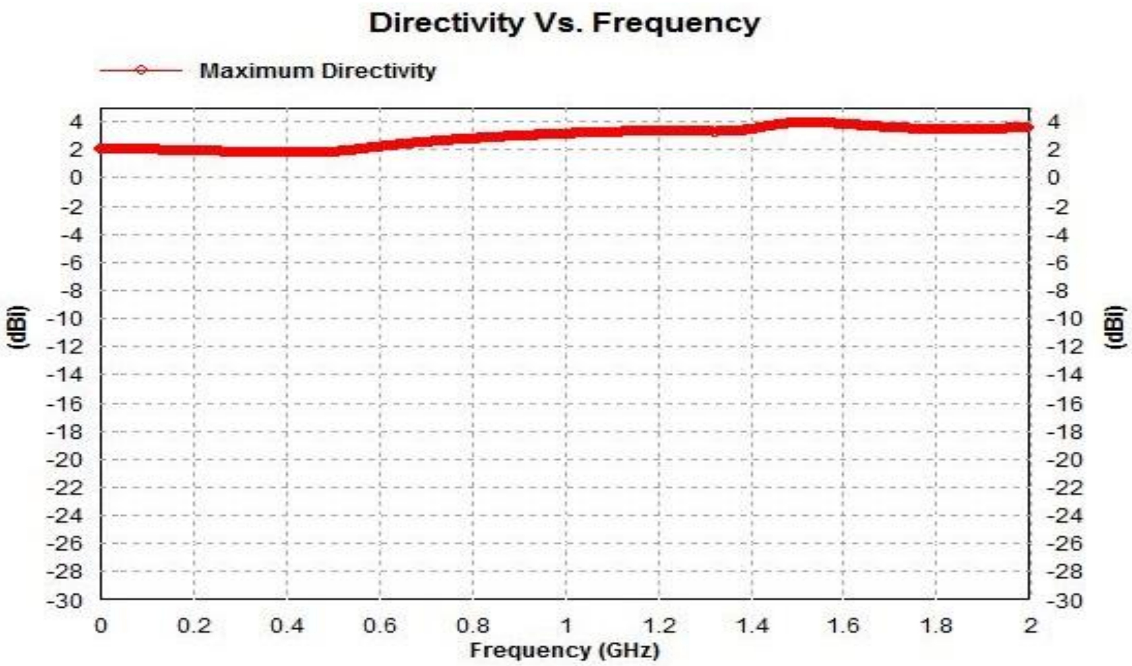

Fig.9. Directivity vs frequency of Proposed Microstrip Patch Antenna with eight rectangular notches

3.4 Antenna Efficiency

The efficiency of antenna is defined as the ratio of emitted power from antenna to power sent to the antenna. It is represented by η. High efficiency means a large amount of input power is delivered by antenna and low efficiency means a large amount of input power is absorbed by antenna. The efficiency of antenna should be as high as possible for good performance. The efficiency of proposed antenna is 99.976% at resonant frequency 1.113GHz. The graph for efficiency vs frequency of proposed antenna with eight rectangular notches is shown in fig.10.

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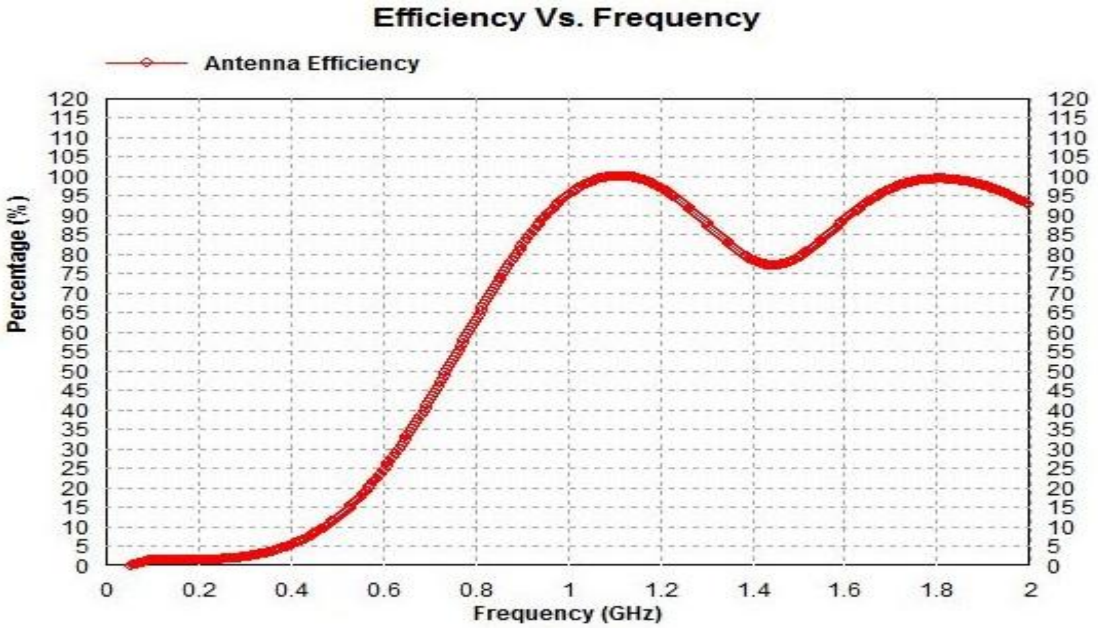

Fig.10. Efficiency vs frequency of Proposed Microstrip Patch Antenna with eight rectangular notches

3.5 Antenna Gain

It is also called as power gain of antenna. It is a combination of antenna's directivity and its efficiency. Its definition is very close to antenna directivity. The only difference between gain and directivity is that gain takes into account of efficiency of antenna and its directivity together. It is represented by **G**. Hence gain of an antenna is given by:

$$(\text{Gain})G = \eta * D$$

Where η is antenna efficiency and D is antenna directivity. The gain of proposed antenna is 3.240dBi at resonant frequency 1.113GHz. The graph for gain vs frequency of proposed antenna with eight rectangular notches is shown in fig.11.

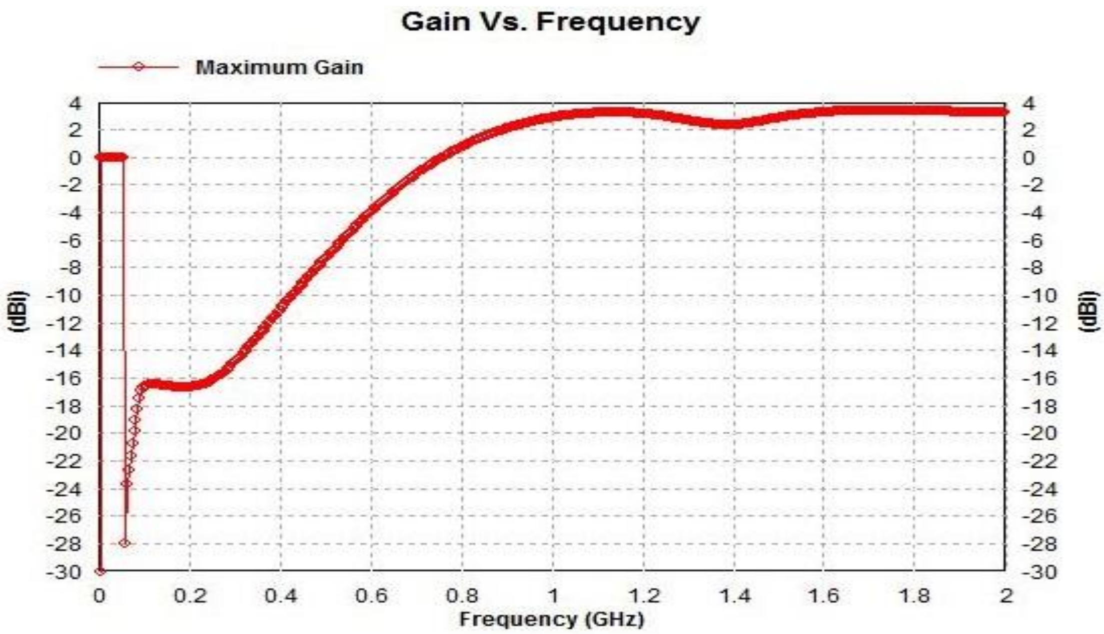

Fig.11. Gain vs frequency of Proposed Microstrip Patch Antenna with eight rectangular notches

3.6 Smith Chart

It is very good tool for picturing the impedance of antenna as a function of frequency. It can be used to consecutively represent the impedances, admittances, reflection coefficient, scattering parameter and noise figure of antenna. The smith chart of proposed antenna with eight rectangular notches is shown in fig.12.

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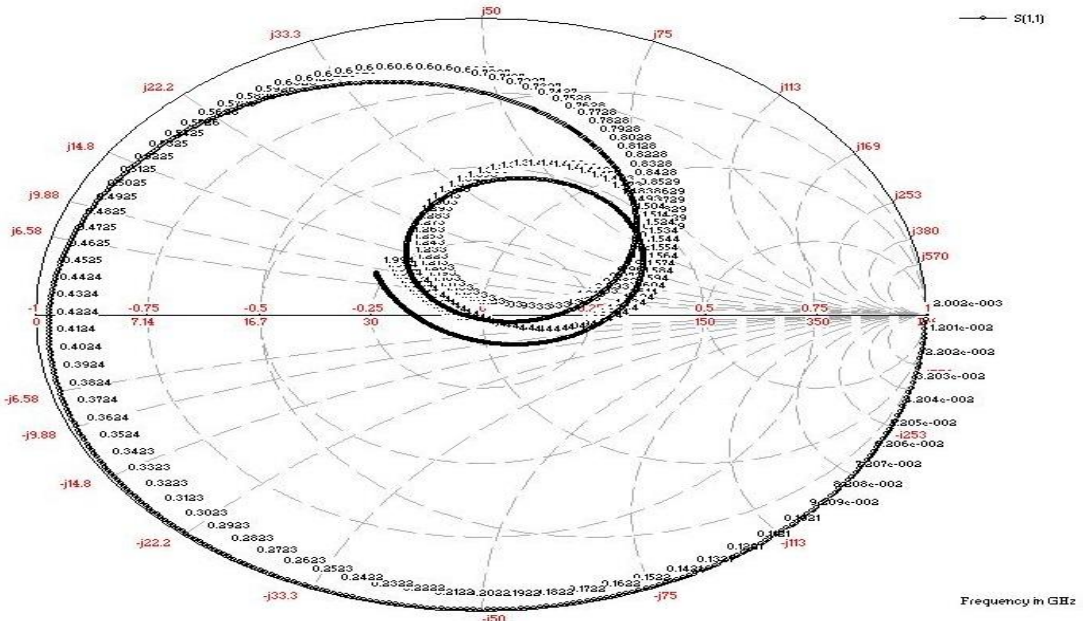

Fig.12. Smith chart of Proposed Microstrip Patch Antenna with eight rectangular notches

3.7 Radiation Pattern

A radiation pattern describes the variation of the power radiated by an antenna as a function of the direction away from the antenna. This power variation as a function of the arrival angle is calculated in the antenna's far field. The 3D view of radiation pattern of proposed antenna with eight rectangular notches is shown in fig.13.

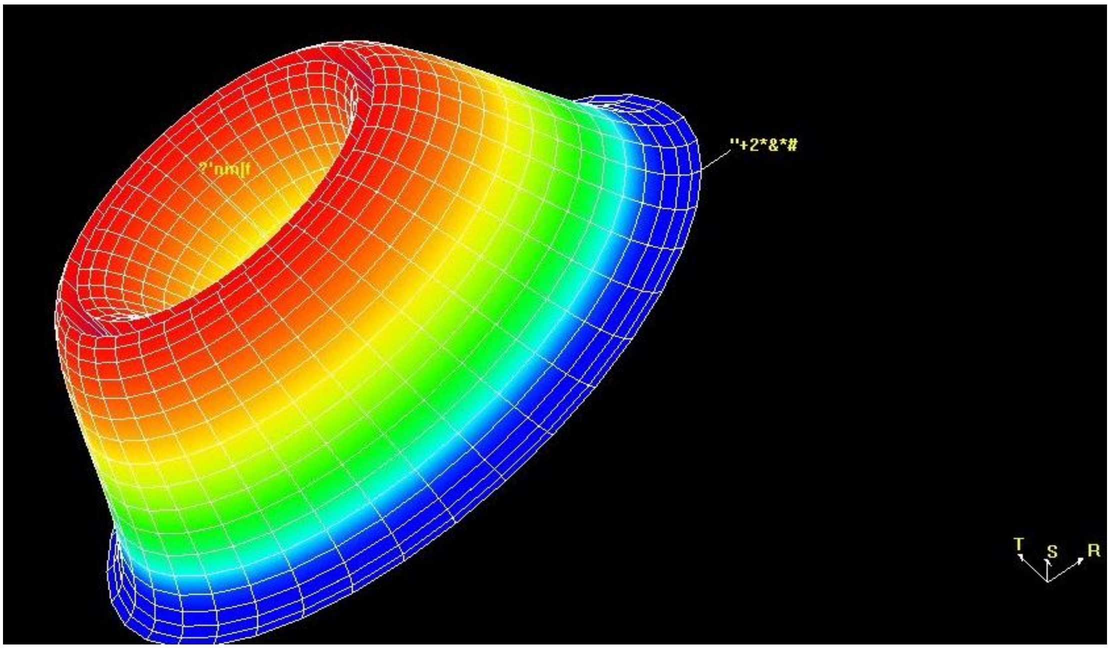

Fig.13. 3D view of Radiation Pattern of Proposed Microstrip Patch Antenna with eight rectangular notches

Table.2: The Radiation parameters of proposed MSP Antenna with eight rectangular notches

Resonant Freq. (GHz)	**Gain (dBi)**	**Bandwidth (GHz)**	**Bandwidth (%)**	**Efficiency (%)**	**Directivity (dBi)**
f_o=1.113	3.240	0.324	28.95	99.98	3.241

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4. CONCLUSION

Hence we designed and analyzed an antenna with dimension of 80.91 X 100.88 X 1.60mm^3. For designing the proposed antenna structure, first we designed a simple microstrip patch antenna then we make eight rectangular notches. By designing the proposed antenna with eight rectangular notches we get a frequency band consecutively from 0.957GHz to 1.281GHz, with gain 3.240dBi, the percentage bandwidth 28.95%, return loss -36.31dB and efficiency 99.976% for respective band. Thus the proposed antenna covers the L band with good percentage bandwidth, gain, return loss and efficiency. Hence the proposed antenna has many applications such as mobile service, satellite navigation, telecommunication uses such as GSM phones, aircraft surveillance such as Automatic dependent surveillance-broadcast, amateur radio, digital audio broadcasting used by military for telemetry and astronomy.

REFERENCES

[1] Wireless Communications and Networking, J. W. Mark & W. Zhuang, Prentice Hall India, 2006.
[2] Mohammed Younssi , Achraf Jaoujal , Ahmed El Moussaoui, Noura Aknin "Miniaturized Probe-Fed Elliptical Microstrip Patch Antenna for Radiolocation Applications" Mohammed Younssi et al. / International Journal of Engineering and Technology (IJET) ISSN : 0975-4024 Vol 4 No 5 Oct-Nov 2012.
[3] A. Balanis, Antenna Theory: Analysis and Design, Wiley, pp. 722783, 1997.
[4] Bhongale, Sanjay R., and Pramod N. Vasambekar. "Square Shaped Microstrip Patch Antenna at 2.45 GHz."
[5] C. Wood, "Analysis of microstrip circular patch antennas," lEE Proc., vo1.128H, pp. 69-76, 1981.
[6] M. Samsuzzaman and M.T. Islam, "Inverted S-Shaped Compact Antenna for X-Band Applications" in the Scientific World Journal, vol. 2014, 2014, Hindawi Publishing Corporation.
[7] Wenwen Yang and Jianyi Zhou, "Wideband Low-Profile Substrate Integrated Waveguide Cavity-Backed E-Shaped Patch Antenna", IEEE Transactions on Antenna and Propagation, vol.12, 2013.
[8] M. T. Ali, I. Pasya, M. H. M. Zaharuddin and N. Yaacob, "E-Shape Microstrip Patch Antenna for Wideband Applications", IEEE International RF and Microwave Conference Malaysia.
[9] Y. Chen, S. Yang and Z. Nie, "Bandwidth Enhancement Method for Low Profile E-Shaped Microstrip Patch Antennas", IEEE Trans Antennas Propag, vol. 58, no. 7, pp. 2442-2447, July 2010.
[10] R. Garg, "Analysis of arbitrarily shaped microstrip patch antennas using segmentation technique and cavity model", IEEE Trans. on Antennas and Propag. Vol. AP-34, no. 10, 1986.
[11] Anushi Arora, Aditya Khemchandani, Yash Rawat, Shashank Singhai and Gaurav Chaitanya, "Comparative study of different Feeding Techniques for Rectangular Microstrip Patch Antenna," International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering, ISSN: 23215526 vol. 3, Issue 5, May 2015.

DOI 10.17148/IJARCCE.2016.51048