International Journal of Engineering Research and General Science Volume 3, Issue 2, Part 2, March-April, 2015
ISSN 2091-2730

Design of L Slot Loaded Rectangular Microstrip Patch Antenna for DCS/PCS Applications

Veerendra Kumar[1], Manish Kumar Singh[2], Kapil Gupta[3]

[1&2] M.Tech. Scholar, BBDNIIT, Lucknow, *virendra_ec91@rediffmail.com*

[3]Assistant Professor (Dep. of ECE), BBDNIIT, Lucknow, *kg3634@gmail.com*

Abstract— Rectangular microstrip patch antenna is most widely used antenna in current scenario because of its low size, low weight and high efficiency. Here we have selected L slot structure for our design and loaded it in a patch which is designed at 1.92 GHz frequency. When it is energized through feed line it is observed that the proposed antenna is radiated in the frequency band 1.55 GHz to 2.11GHz which is suitable for digital communication system (DCS) and personal communication system (PCS). Fractional bandwidth of proposed antenna is 30.60%. The gain has been improved up to 3.23 dBi, directivity upto 3.67 and antenna efficiency is 90.5%. The proposed slot loaded Microstrip antenna is fed by strip line feed. The proposed antenna is simulated by IE3D Zealand simulation software based on method of moments

Keywords— L-slot, Enhance Bandwidth, Microstrip Patch, Gain, Line Feed, VSWR, Resonate Frequency, Directivity, Efficiency

INTRODUCTION

Microstrip antenna is basically a printed board circuit over which power dividers, phasing circuits, matching networks and radiators are photo etched on one side of the board and other side of the board is metal ground plane, hence the antenna can be directly applied to metallic surface on an aircraft or missile. Microstrip patch antenna has many advantages such as low profile, light weight, small volume and compatibility with microwave integrated circuit (MIC) and monolithic microwave integrated circuit (MMIC) [1], but microstrip antenna has narrow bandwidth which is the major disadvantage of microstrip antenna. Generally, the impedance bandwidth of the traditional microstrip antenna is only a few percent (2% - 5%) [2]. Hence it is very important to develop a technique by which we can enhance the bandwidth of patch antenna. The proposed L- slot loaded patch antenna is shown in Figure 1 which is operates in the frequency band 1.55 GHz to 2.1 GHz and provides the enhance bandwidth of 30.60 %, this frequency band is suitable for DCS and PCS applications. In the past decade many planar antenna had been designed to meet the requirement of mobile cellular communication systems. The most demanding these days are Global system for mobile communication system (GSM) ranging from 890 MHz to 960 MHz, Digital communication systems (DCS) ranging from 1710 MHz to 1880 MHz, Personal Communication system (PCS) ranging from 1850 MHz to 1990 MHz and Universal Mobile telecommunication system (UMTS) ranging from 1920 MHz to 2170 MHz [2]. The proposed antenna has been designed on glass epoxy substrate having dielectric constant (ε_r=4.4) [3]. Determination of an antenna size and its bandwidth are largely influenced by substrate material. By Increasing the dielectric constant we can reduce the antenna size but its bandwidth and efficiency are also reduces while by decreasing the dielectric constant we can increases the bandwidth but with an increment in antenna size. The design frequency of proposed L slot antenna is 1.92 GHz.

ANTENNA DESIGN

For designing a rectangular Microstrip patch antenna, the length and width are calculated as below:

$$W = \frac{c}{2f_d}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where c is the velocity of light, ε_r is the dielectric constant of substrate, f_d is the antenna design frequency, w is the patch width, and the effective dielectric constant ε_{reff} is given as [4], [5]

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

at h = 1.6m,

The extension length ΔL is calculated as [4], [5]

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + .264\right)}{(\varepsilon_{reff} - .258)\left(\frac{W}{h} + 0.8\right)} \quad (3)$$

By using the above mentioned equation we can find the value of actual length of the patch as [4], [5]

$$L = \frac{c}{2f_d\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (4)$$

The length and the width of the ground plane can be calculated a [4], [5]

$$L_g = 6h + L \quad (5)$$

$$W_g = 6h + W \quad (6)$$

ANTENNA DESIGN SPECIFICATIONS

The design of proposed L-slot patch antenna is shown in figure 1. Glass epoxy substrate is used for designing the proposed antenna which has a dielectric constant 4.4 and the design frequency 1.92 GHz is taken. Antenna dimensions can be calculated by above given equations. The calculated patch length and width are 36.96 mm and 47.54 mm respectively. The ground plane length and width are calculated as 46.96 mm and 57.54 mm respectively. Height of the dielectric substrate is 1.6 mm and loss tangent tan δ is .0013. Microstrip line feed is used to radiate the antenna. IE3D simulation software is used to simulate the work

Table I

Antenna Design Specifications

S.No.	Parameters	Value
1.	Design Frequency (f_d)	1.92GHz
2.	Dielectric Constant (ε_r)	4.4
3.	Substrate Height (h)	1.6 mm
4.	Feeding Technique	Line feed
5.	VSWR	1:5:1
6.	Patch Width (Wp)	47.54 mm
7.	Patch length (Lp)	36.96 mm
8.	Ground Plane Width (Wg)	57.54 mm

9.	Ground Plane Length (Lg)	46.96 mm

ANTENNA DESIGN PROCEDURE

All the required dimensions of the proposed antenna design should be calculated carefully by using above equations 1, 2, 3, 4, 5 and 6. Design frequency 1.92 GHz is taken. Design procedure of proposed antenna is very simple a L slot structure is introduced into a patch and it is investigated for different frequency ranges with different feed locations .Geometry of proposed antenna is shown in figure1. During the designing of proposed antenna on IE3D 9.0 version simulating software ground plane is starting from (X = 0, Y = 0) co-ordinate at lower left corner and a patch is cut on ground plane starting from (X = 10,Y = 5) co-ordinate at lower left corner of length and width 36.96 mm and 47.54 mm respectively. The probe feed is placed at co-ordinate point (X=7.5, Y=0.8) with 50Ω impedance matched co-axial cable to achieve maximum bandwidth. 50Ω impedance matched co-axial cable is because at this impedance maximum power is transferred to the radiating element.

GEOMETARY OF DESIGN ANTENNA

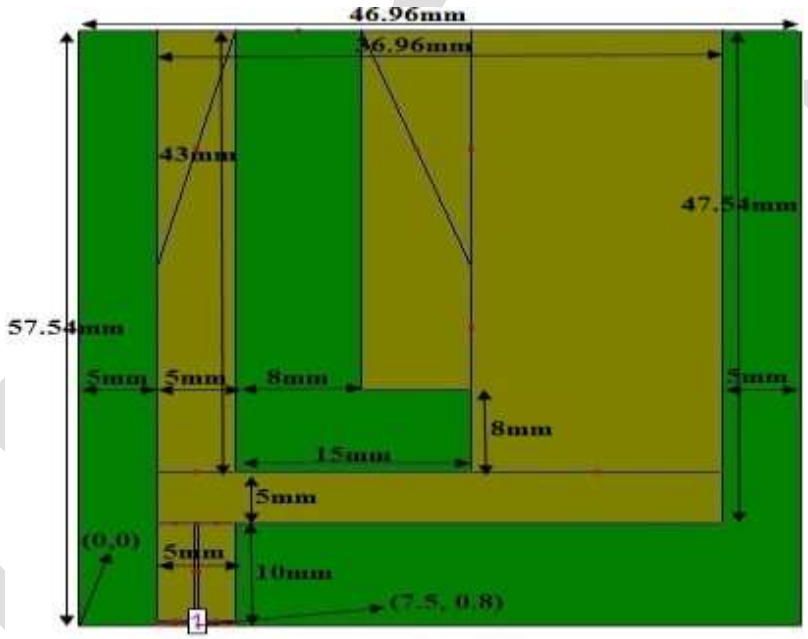

Fig.1. Construction Geometry of Proposed Antenna

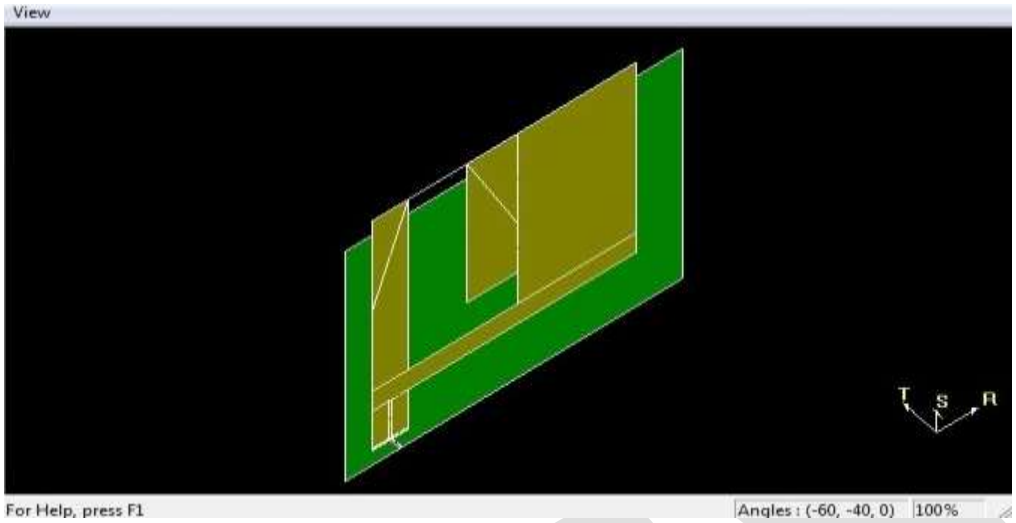

Fig.2. 3D View of Proposed Antenna

SIMULATION AND RESULT DISCUSSION

The design of proposed antenna is shown in above figure 1.The length and width of patch and slot is clearly mentioned in the figure 1. The probe feed is placed at (X = 7.5, Y = 0.8) on strip line. Moicrostrip antenna has narrow bandwidth which restricts its uses at abroad label. Hence in the present work bandwidth of rectangular microstrip antenna is improved by loading L-slot structure into the patch. Simulated output specifications of proposed antenna like Bandwidth, Return loss, VSWR, Gain, Efficiency, 2D & 3D Radiation patterns and Smith chart are obtain by IE3D 9.0 version Zeland simulating software which is based on method of moments. All the graphical representation output of proposed antenna is shown in following given figure.

The return loss of proposed antenna is around -21 dB and the antenna is resonate at 1.9 GHz as shown below in given figure 3. The frequency band of proposed antenna is 1.55 GHz to 2.11 GHz. The fractional bandwidth of proposed antenna is around 30.60%.

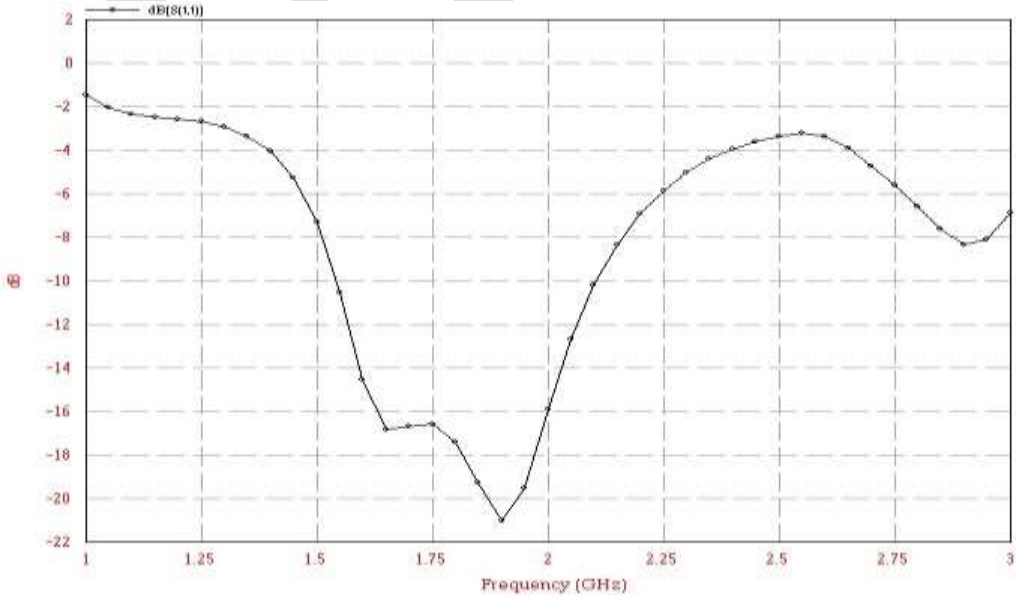

Fig.3. Return loss v/s Frequency Graph of Proposed Antenna

The VSWR of proposed antenna is between 1 and 2 as shown below in given figure 4 which shows that antenna is efficiently radiates.

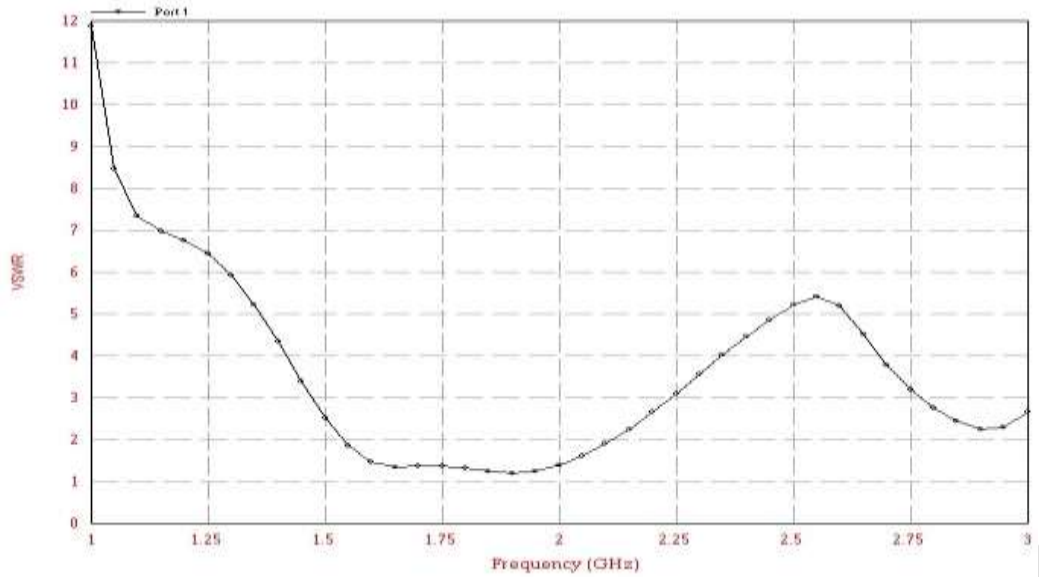

Fig.4. VSWR v/s Frequency Graph of Proposed Antenna

The gain of proposed antenna is 3.23 dB at resonate frequency 1.9 GHz as shown below in given figure 5

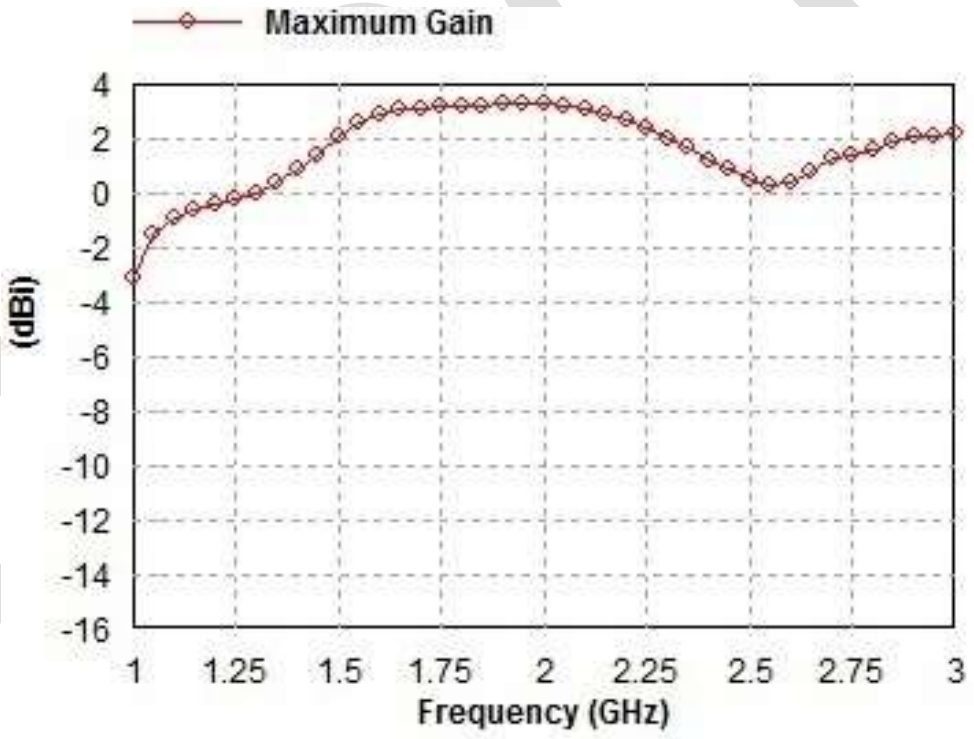

Fig.5. Gain v/s Frequency Graph of Proposed Antenna

The directivity of proposed antenna is 3.67 at resonate frequency 1.9 GHz as shown below in given figure 6.

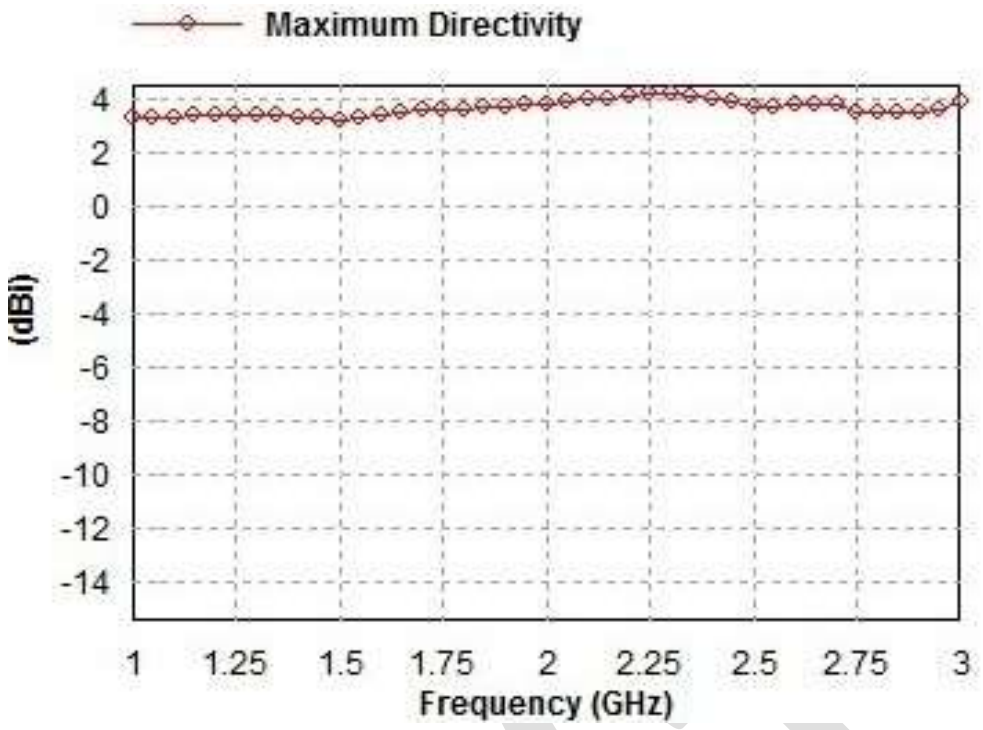

Fig.6. Directivity v/s frequency Graph of Proposed Antenna

The efficiency of proposed antenna is 90.5% at resonate frequency 1.9 GHz as shown below in given figure 7

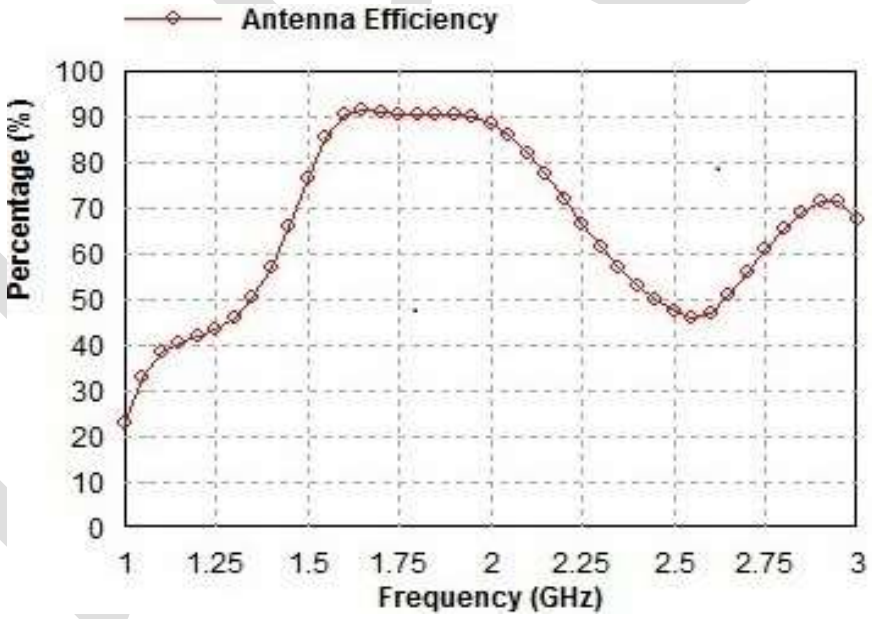

Fig.7. Efficiency v/s Frequency Graph of Proposed Antenna

2D pattern of the proposed antenna shows that antenna has bidirectional radiation pattern as shown below in given figure 8.

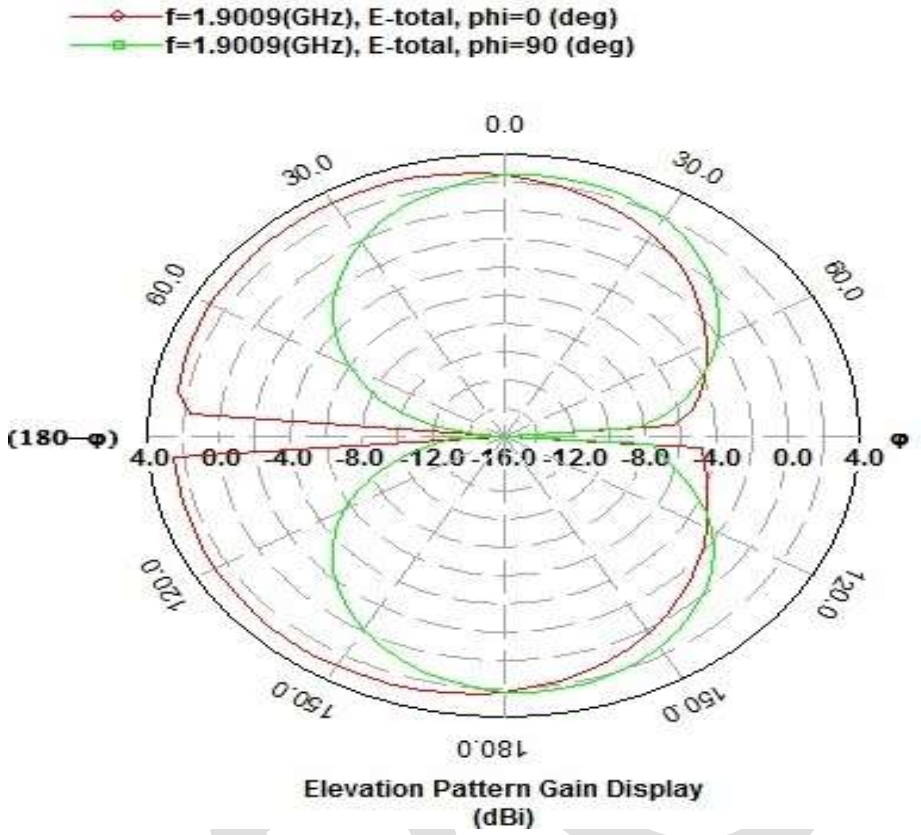

Fig.8. 2D Pattern Of proposed antenna

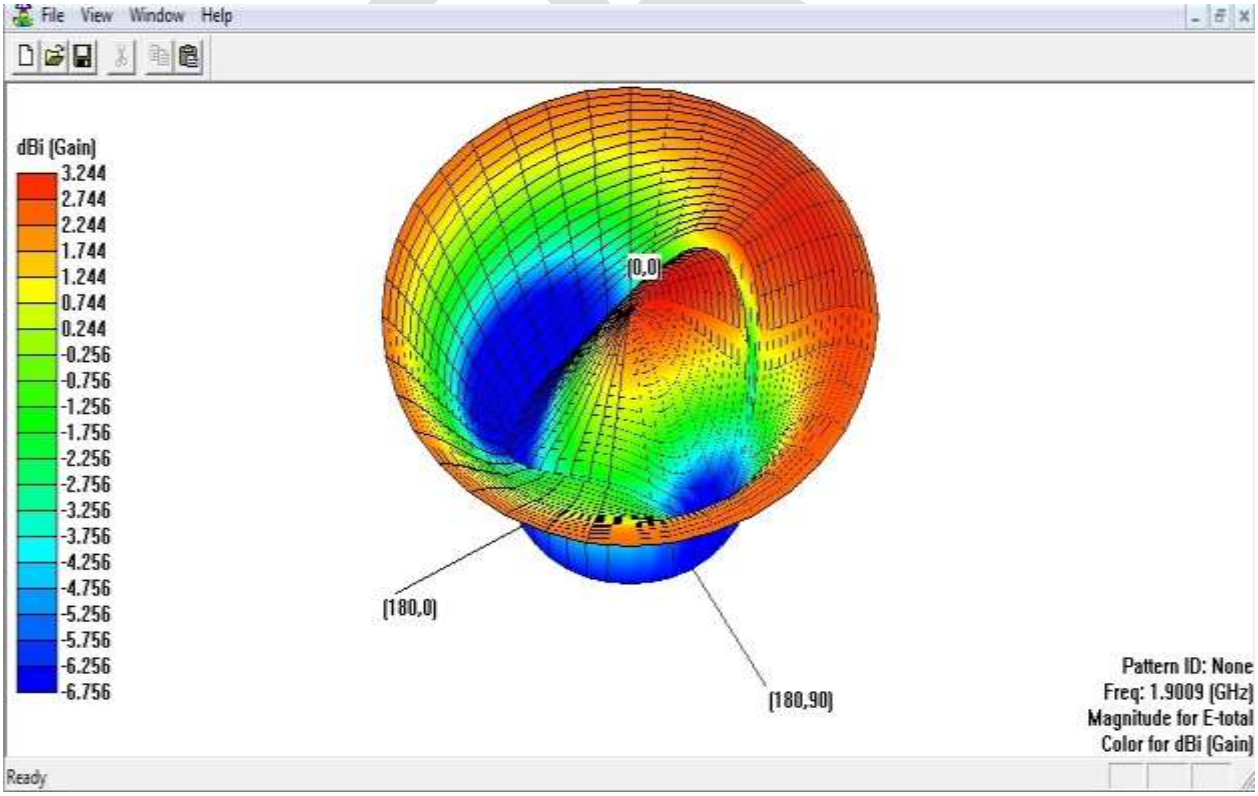

Fig.9. 3D Radiation pattern of proposed antenna

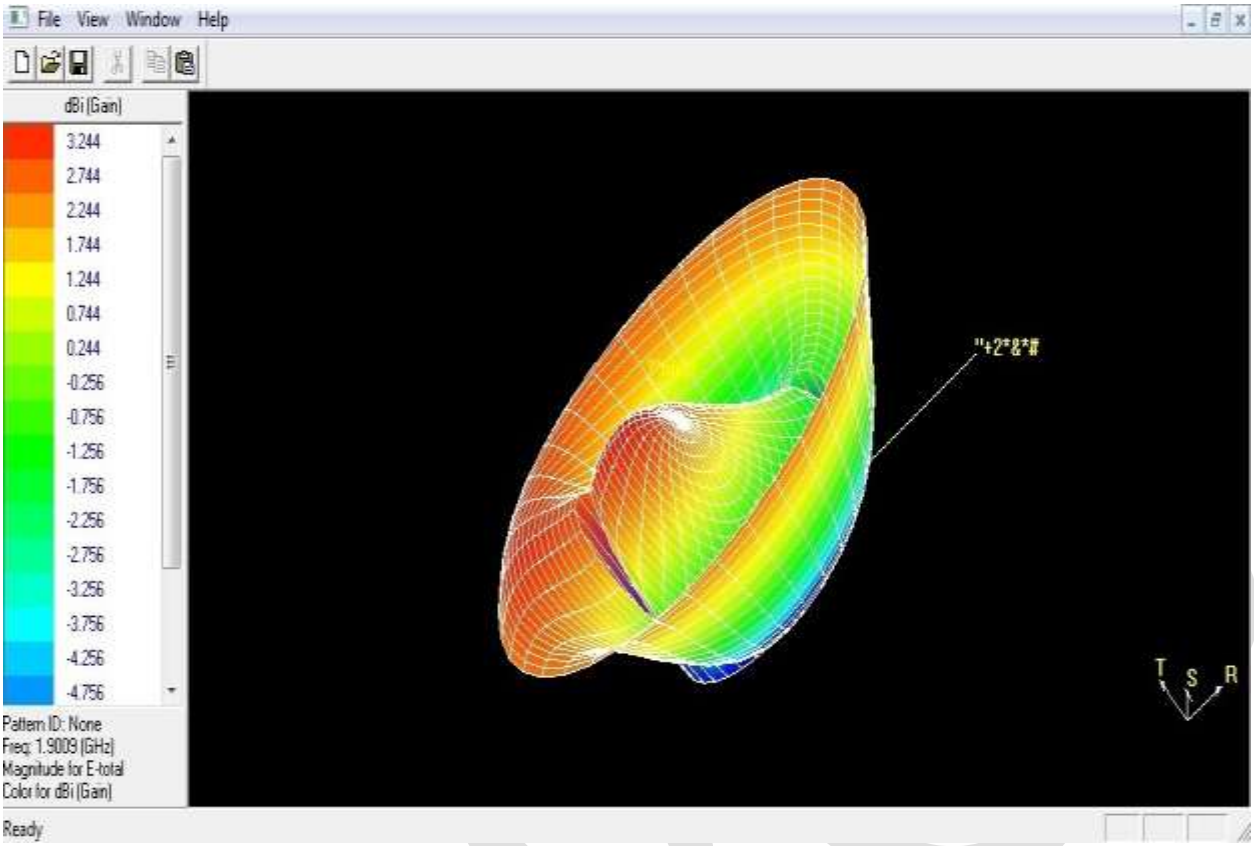

Fig.10. 3D Open Radiation pattern of proposed antenna

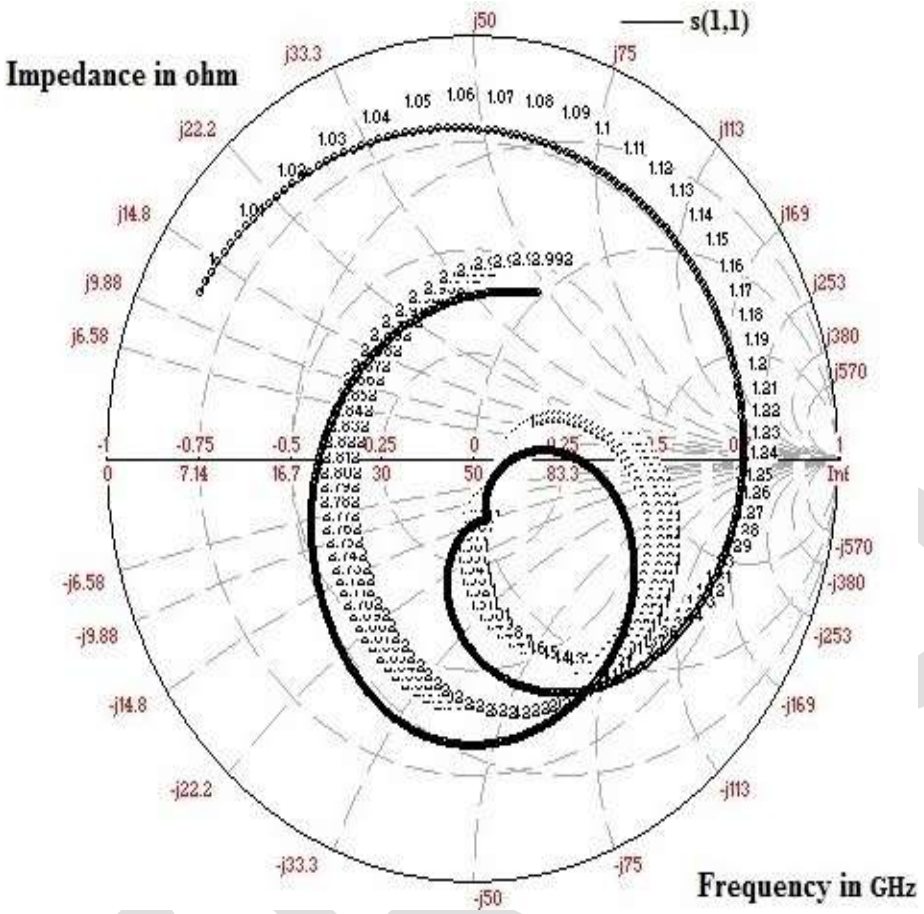

Fig.11. Smith chart of proposed antenna

CONCLUSION

All the characteristics of proposed L slot loaded rectangular microstrip antenna are studied. Usually in the most of the cases, the impedance bandwidth of the conventional microstrip antenna is only a few percent (2% -5%) [2]. The resultant graph between return loss and frequency regarding proposed antenna shown in figure 3 gives the enhanced fractional bandwidth upto 30.60%.The designing work of the proposed antenna is done on glass epoxy substrate to achieve maximum radiation efficiency about 90.5 %, directivity 3.67 and gain 3.23 dB .Obtained band of frequency is suitable for DCS and PCS application.

REFERENCES:

[1]. Indra Surjati, Yuli KN and Yuliastuti, "Increasing Bandwidth Dual Frequency Triangular Microstrip Antenna For WiMAX Application", International Journal of Electrical & Computer Sciences IJECS-IJENS Vol: 10 No: 06.

[2]. C. A. Balanis, Antenna Theory - Analysis and Design,3rd edition, Wiley, 2006

[3]. Saurabh Jain, Vinod Kumar Singh, Shahanaz Ayub, "Bandwidth and Gain Optimization of a Wide Band Gap Coupled Patch Antenna", IJESRT, ISSN: 2277-9655, March 2013.

[4]. K. V. Rop, D. B. O. Konditi, H. A. Ouma and S. M. Musyoki, "Parameter optimization in design of a rectangular microstrip patch antenna using adaptive neuro-fuzzy inference system technique", IJTPE Journal, ISSN 2077-3528,September 2012.

[5]. Constantine A. Balanis, ''Antenna theory, Analysis and Design", John Wiley & Sons, Inc Hoboken, New Jersey, 2005.

[6]. Saurabh Jain, Vinod Kumar Singh, Shahanaz Ayub, "Bandwidth and Gain Optimization of a Wide Band Gap Coupled Patch Antenna", IJESRT, ISSN: 2277-9655, March 2013

[7]. Ramesh Garg, Prakash Bartia, Inder Bahl, Apisak Ittipiboon, ''Microstrip Antenna Design Handbook'', 2001, pp 1-68, 253-316 Artech House Inc. Norwood, MA.

[8]. W.L. Stutzman, G.A. Thiele, Antenna Theory and design, John Wiley & Sons, 2nd Ed., New York, 1998.

[9]. Pozar, D. M., and D. H. Schaubert, "The Analysis and Design of microstrip antennas and arrays", 4th edition, Wiley Interscience,NewYork,2001.

[10]. J. R. James and P. S. Hall, Handbook of Microstrip Antennas, vol. 1, London: Peter Peregrinus Ltd., 1989.
[11]. Kin –Lu Wong , " Compact and Broadband Microsrtrip Antenna", John Wiley & Sons,2002.

[12]. Ramesh Garg, Prakash Bhartia, Inder Bahal, Apisak Ittipiboon, "Microstrip Antenna Design Handbook", 3rd edition, Artech house, London, 2001