International Journal of Advance Foundation and Research in Computer (IJAFRC)
Volume 1, Issue 3, March 2014. ISSN 2348 - 4853

Equilateral Triangular Micro strip Patch Antenna Using Different Substrates

Raju verma, Namrata Dewangan
Student Member of IEEE, RCET Bhilai(C.G.),India , Asst. Prof. RCET,Bhilai (C.G),India
raju.rrr.arg.cit@gmail.com , namrata.dewangan@rediffmail.com

A B S T R A C T

The triangular geometry of microstrip antenna is one of the most common shapes having a wide range of wireless application ranging from circuit element to wireless antennas .The proposed equilateral triangular microstrip patch antenna is designed by using different substrates of different permittivity . Proposed paper gives an idea about bandwidth changes with change of substrate material.This antenna designed on Ansoft HFSS designer software, impedance bandwidth ,VSWR ,return losses & smith charts are observed and experimentally studied .Details of simulated results are presented and discussed. From results we concluded that proposed equilateral triangular patch antenna with co-axial probe feed gives better performance with substrate whose permittivity is 2.2(Rogers RT/duriod 5880(TM)).Which can be used in C-band operation .

Index Terms **: Microstrip Patch Antenna, Coaxial Feed, Finite Element Method (FEM), VSWR, Bandwidth, Return Loss.**

I. INTRODUCTION

Compact microstrip antennas have recently received much attention due to the increasing demand of small antennas for personal as well as commercial communication equipment. It has been demonstrated that equilateral triangular microstrip patch can effectively reduce the required patch size for a given operating frequency [1]. In mobile communication system such as satellite, RADAR, Global Position System (GPS) often require extremely small size, light weight. The 'C' band of frequency are used for the satellite communication and terrestrial application. Single band & Dual band frequency operation of triangular microstrip antennas have been studied by many researchers using coaxial probe feed[1]-[2]. This paper report the simulation result using equilateral triangular patch antenna with co-axial feed. This paper therefore proposed a design of single & dual band operation of equilateral triangular microstrip antenna using HFSS (high frequency structure stimulator) which is commercially available in the market and it depend on the FEM(finite element method) analysis.

MICROSTRIP PATCH ANTENNA

Microstrip patch antennas are the most common form of printed antennas. They are popular for their low profile, geometry and low cost [4].A microstrip device in its simplest form is a layered structure with two parallel conductors separated by a thin dielectric substrate. The lower conductor acts as a ground plane. The device becomes a radiating microstrip antenna when the upper conductor is a patch with a length that is an appreciable fraction of a wavelength (λ), approximately half a wavelength ($\lambda / 2$). In other words, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Fig. 1.1. The patch is generally made of conducting material such as copper or gold and can take any possible shape

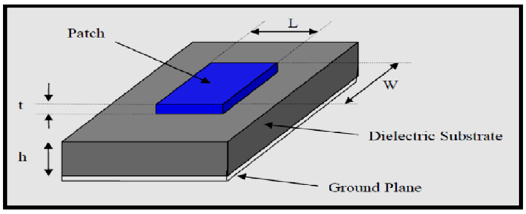

Fig.1.1: Typical microstrip patch antenna

COAXIAL FEED

The coaxial feed or probe feed is a very common contacting scheme of feeding patch antennas. The configuration of a coaxial feed is shown in figure 1.2 . As shown in figure1.2, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

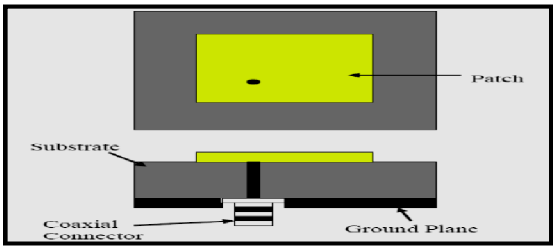

Fig. 1.2: Coaxial feed for patch antenna

FINITE ELEMENT METHOD (FEM)

The FEM is suitable for volumetric configurations. In this method, the region of interest is divided into any number of finite surfaces or volume elements depending upon the planar or volumetric structures to be analyzed. These descriptive units, generally referred to as finite elements can be any well defined geometrical shapes which are even suitable for curved geometry. It involves the integration of certain basic functions over the entire conducting patch, which is divided into a number of subsections. The problem of solving wave equations with inhomogeneous boundary conditions is tackled by decomposing it into two boundary value problems, one with Laplace's equation with an inhomogeneous boundary and the other corresponding to an inhomogeneous wave equation with a inhomogeneous boundary condition.

VOLTAGE STANDING WAVE RATIO (VSWR)

For a radio (transmitter or receiver) to deliver power to an antenna, the impedance of the radio and transmission line must be well matched to the antenna's impedance. The parameter VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna. If the reflection coefficient is given by ρ , then the VSWR is defined as:

$$VSWR=(1+|\rho|)/(1-|\rho|) \quad .... \quad (1)$$

The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal.

BANDWIDTH

The bandwidth of the antenna is defined as the range of frequencies, over which the performance of the antenna with respect to some characteristic conforms to a specific standard. The bandwidth of the antenna depends on the patch shape, resonant frequency, dielectric constant, and the thickness of the substrate. The bandwidth enhancement of a microstrip antenna has been directed towards improving the impedance bandwidth of the antenna element. The impedance variation with the frequency of the antenna element results in a limitation of the frequency range, over which the element can be matched to its feed line. Impedance bandwidth is usually specified in terms of a return loss or maximum SWR typically less than 2.0 or 1.5 over a frequency range. Conversion of bandwidth from one SWR level to another can be accomplished by using the relation between bandwidth (BW) and quality factor (Q):

$$\text{Bandwidth} = (S-1)/(Q\sqrt{S}) \quad .... \quad (2)$$

Where,

S = standing wave ratio,

Q = quality factor

RETURN LOSS

Return loss is a convenient way to characterize the input and output signal sources.Return loss can be defined in dB as follow:

$$RL = -20 \log \rho \text{ (dB)} \quad ...... \quad (3)$$

Where,

ρ is the reflection Coefficient.

II. ANTENNA GEOMETRY

The geometry of the proposed triangular antenna using a co-axial probe feed is shown in fig.2.1. The proposed antenna is constructed on a dielectric substrate on different substrates such as:-

1. Rogers RT/duriod 5880(TM) which has a dielectric constant 2.2, & loss tangent 0.0009.
2. FR-4 EPOXY which has a dielectric constant 4.4, & loss tangent 0.002
3. Rogers TMM6 which has a dielectric constant 6, & loss tangent 0.0023.
4. Rogers RT/duroid 6010/6010 LM(TM) which has a dielectric constant 10.2, & loss tangent 0.0023.

The area of the equilateral triangular patch antenna is situated on the substrate with dimension 1/2(31.1*26.97779) mm^2.Height of substrate is 4mm.

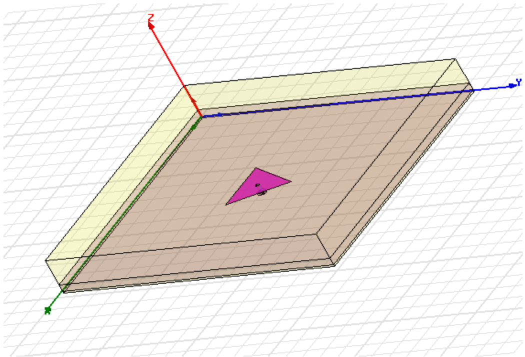

Fig. 2.1: Antenna Geometry

III. SIMULATION RESULT

1. Rogers RT/duriod 5880(TM):-

The impedance bandwidth of proposed antenna at the centre frequencies is shown in Fig. 3.1.1, This result shows single band width below to the -10dB so we can operate this antenna in the single bands and the return loss is-19.67dB. proposed antenna can operate efficiently at frequency 3.42GHz. impedence Bandwidth achieved by this antenna is 34.23%.The VSWR is 1.26. The impedance bandwidth and VSWR shows in fig. 3.1.1 & fig 3.1.2 and we can see here the antenna have resonance at 3.42GHz . The radiation pattern is shown in fig 3.1.3 which shows the antenna is unidirectional. By varying the position of coaxial probe for the input impedance matching of the feeding system can be characterized. Furthermore, the radiation pattern of the proposed antenna is also measured with respect to gain. The radiation pattern of the antenna are shown in Fig. 3.1.3.Smith chart is shown in fig 3.1.4

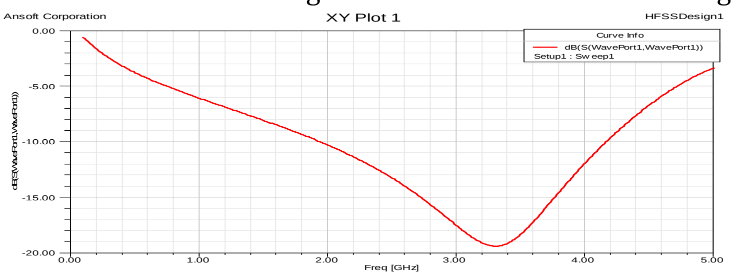

Fig. 3.1.1 :Measured impedance bandwidth

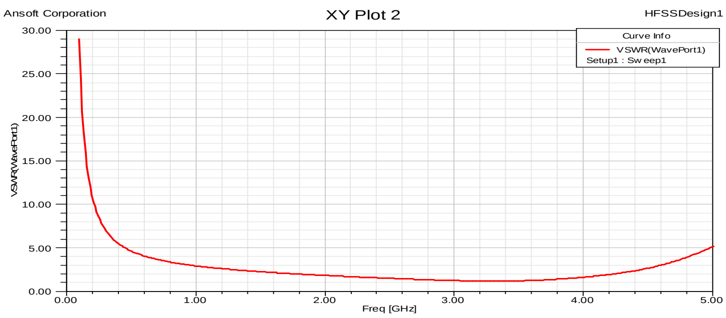

Fig. 3.1.2: Measured VSWR

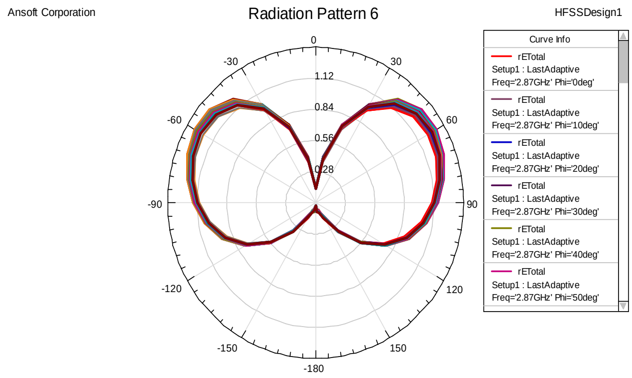

Fig.3.1.3: Radiation pattern 2D

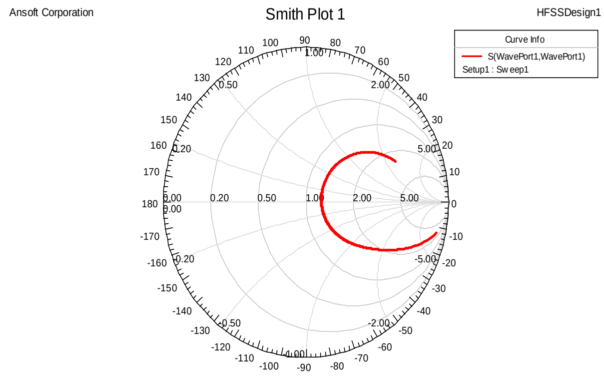

Fig.3.1.4 :Input impedance loci using smith Chart

2. FR-4 EPOXY :-

When we use FR-4 EPOXY as Substrates the measured return loss is -18dB & impedance bandwidth is 32%. In this case measured VSWR is 1.24 & resonance frequency is 2.9 GHZ. Measured return loss, VSWR, radiation pattern, and smith chart is shown in fig.3.2.1-fig 3.2.4.

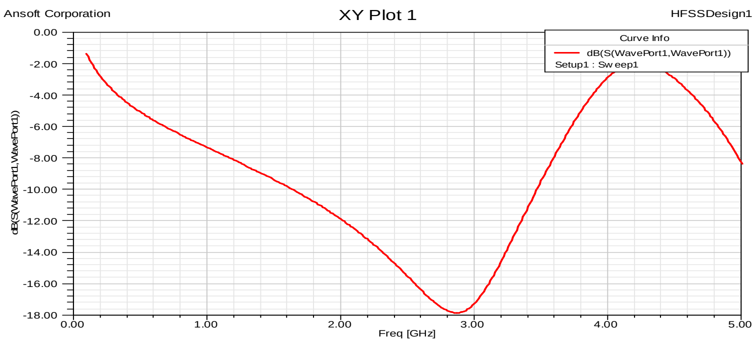

Fig. 3.2.1: Measured impedance bandwidth

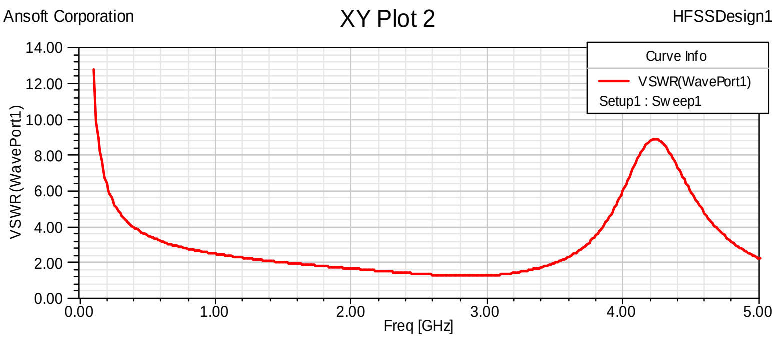

Fig.3.2.2: Measured VSWR

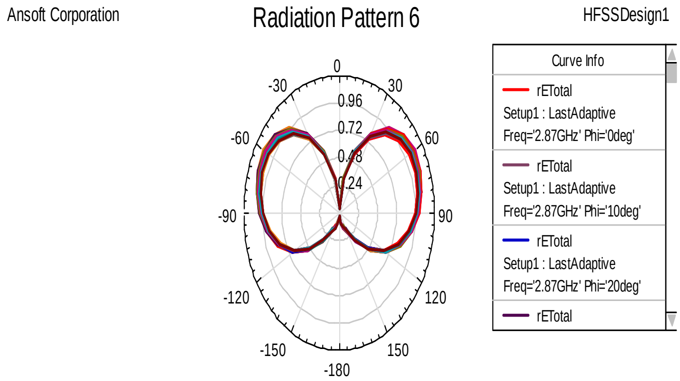

Fig. 3.2.3: Radiation pattern

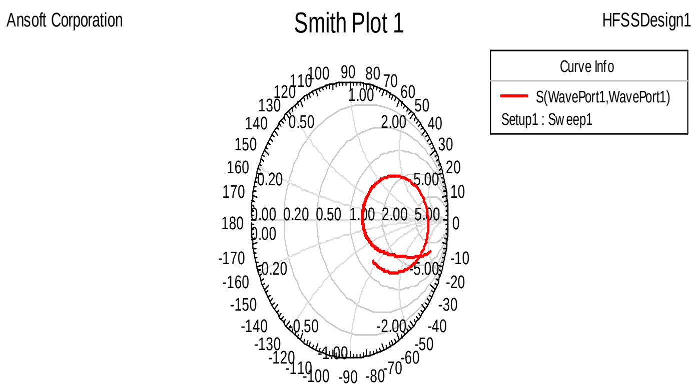

Fig. 3.2.4 : Input impedance loci using smith chart

3. Rogers TMM6 :-

By using Roger TMM6 as substrate dual band has achieved which is resonant at 2.68 GHZ and 4.88GHZ ,in this case the measured return loss is -17.43dB & -20.33dB respectively. impedence bandwidth is 30.85% & 6.25% respectively. In this case measured VSWR is 1.34 & 1.16 respectively. Measured return loss, VSWR, radiation pattern, and smith chart is shown in fig. 3.3.1-fig 3.3.4.

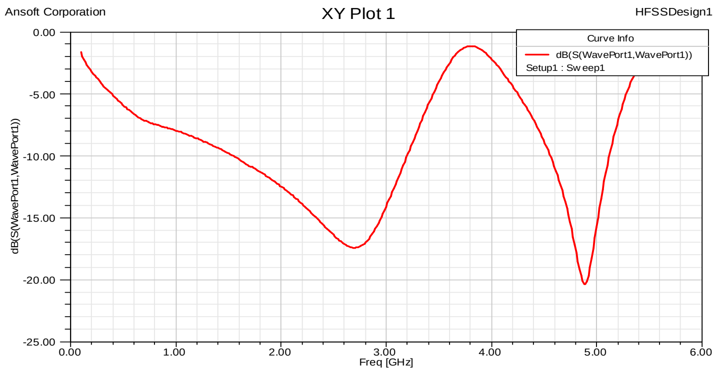

Fig. 3.3.1 :Measured impedance bandwidth

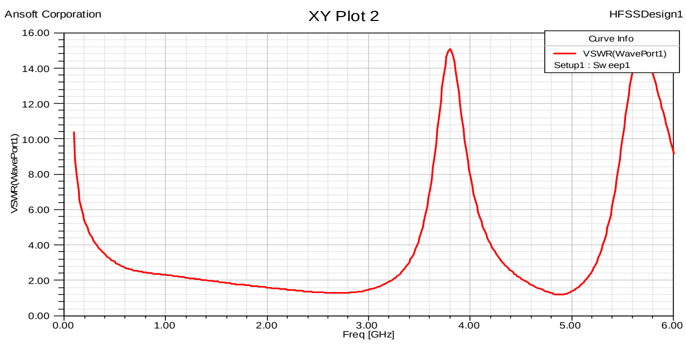

Fig. 3.3.2 : Measured VSWR

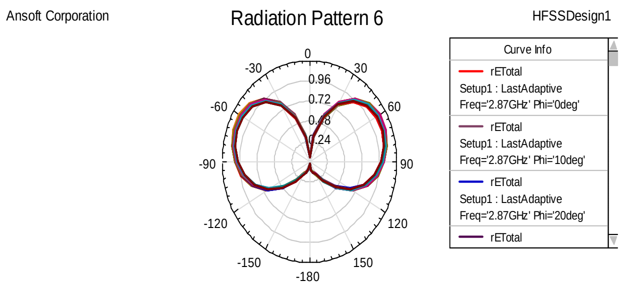

Fig. 3.3.3 : Radiation Pattern

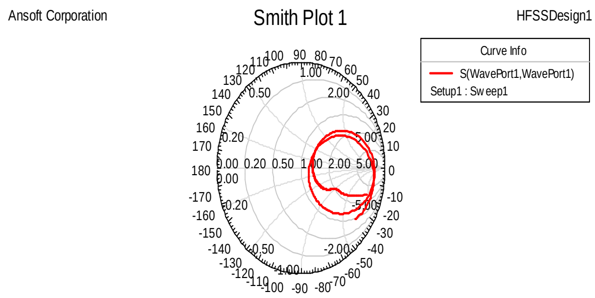

Fig. 3.3.4 : Input impedance loci using smith Chart

4. Rogers RT/duroid 6010/6010 LM(TM) :-

Dual band operation can also be achieved by using Rogers RT/duroid 6010/6010LM(TM).
I n this case Resonant frequencies are 2.29GHZ & 3.87GHZ.measured return losses are -16.1dB & -20.33dB.

Impedence bandwidth 27% & 6.47% respectively. VSWR measured are 1.37 & 1.13 resp. Measured return loss, VSWR, radiation pattern, and smith chart is shown in fig. 3.4.1-fig 3.4.4.

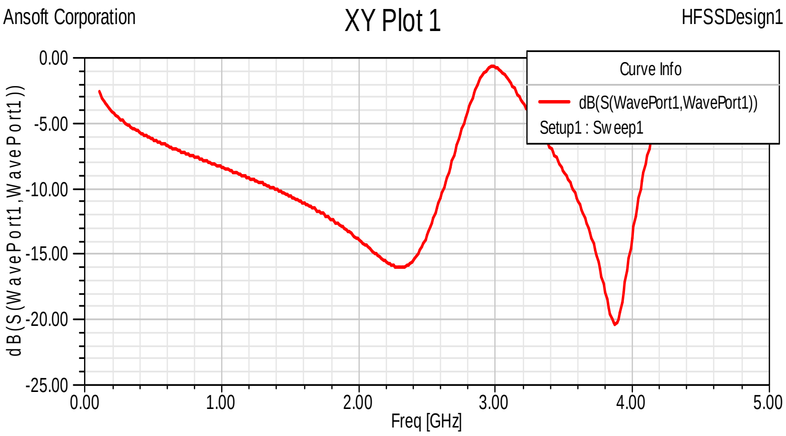

Fig. 3.4.1 : Measured impedence bandwidth

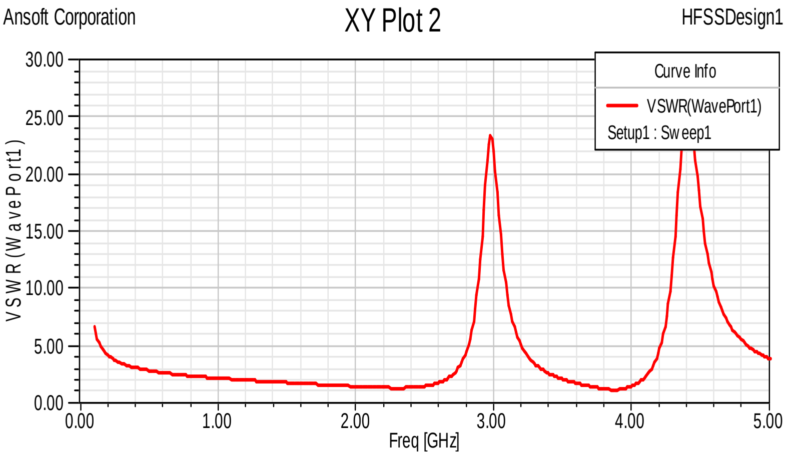

Fig. 3. 4.2 : Measured VSWR

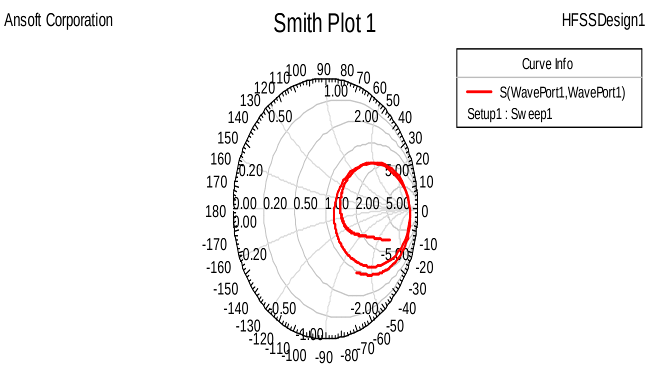

Fig. 3.4.3 : Input impedance loci using smith chart

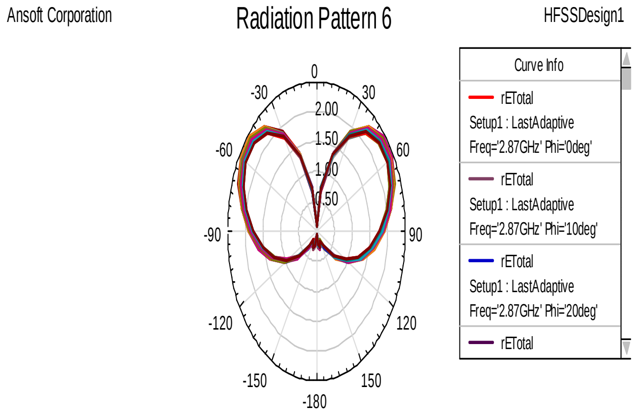

Fig. 3.4.4 : Radiation pattern

IV. COMPARISON TABLE

Table 1. Comparison of simulated Result

Permitivity	Resonant frequency	Return losses	Bandwidth	VSWR
□1=2.2	3.42GHz	-19.67 dB	34.23%	1.26
□2=4.4	2.90 GHz	-18 dB	32%	1.24
□3=6.0	2.68 GHz	-17.43 dB	30.85%	1.34
	4.88 GHz	-20.33 dB	6.25%	1.16
□4=10.2	2.29 GHz	-16.10 dB	27%	1.37
	3.87 GHz	-20.33 dB	6.47%	1.13

Where

- **ε_1-** Rogers RT/duriod 5880(TM)
- **ε_2-** FR-4 EPOXY
- **ε_3-** Rogers TMM6
- **ε_4-** Rogers RT/duroid 6010/6010LM(TM)

V. CONCLUSION

From Comparison table we observe that as we increase the permittivity of substrate, resonance frequency & bandwidth are decreases, and return losses increases. From results we concluded that proposed equilateral triangular patch antenna with co-axial probe feed gives better performance with substrate whose permittivity is 2.2(Rogers RT/duriod 5880(TM)).Which can be used in C-band operation .

VI. ADVANTAGES & DISADVANTAGES

Some of the principal advantages of microstrip patch antenna discussed by Kumar and Ray are [5]:

- Lightweight and low volume.
- Low profile planar configuration which can be easily made conformal to host surface.
- Low fabrication cost, hence can be manufactured in large quantities.
- Supports both, linear as well as circular polarization.
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

In spite of the many advantages, these antennas also suffer from a number of disadvantages. Some of them have been discussed by Kumar and Ray in and Garg *et al.* in and they are given below [5] :

- Narrow bandwidth
- Low efficiency.
- Low gain.
- Extraneous radiation from feeds and junctions.
- Poor end fire radiator except tapered slot antennas.
- Low power handling capacity.
- Surface wave excitation.

Microstrip patch antennas have a very high antenna quality factor (Q). Q represents the losses associated with the antenna. Typically there are radiations, conduction (ohmic), dielectric and surface wave losses. For very thin substrates, the losses due to surface waves are very small and can be neglected. However, as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave. This surface wave contribution is considered as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics. The surface waves can be minimized by use of photonic bandgap structures as discussed by Qian *et al*[6]. Other problems such as lower gain [5] and lower power handling capacity can be overcome by using an array configuration for the elements.

VI. FUTURE SCOPE

The above simulation result of design antenna is without applied the EBG Structure, in future we have to apply the EBG Structure on the design antenna. EBG or photonic bandgap (PBG) materials are artificial periodic objects, which can stop the propagation of electromagnetic waves in certain directions, within certain frequency bands. The method employed to improve its bandwidth is use of mushrooms like Electromagnetic Bandgap Structure and then using a dielectric layer over triangular patch .The EBG pattern proposed and simulated results confirm that antennas having EBG pattern have considerable improvement in bandwidth when compared to a reference antenna having no EBG pattern .

VII. REFERENCES

[1] Fang, S.T and Kin Lu Wong, "A Dual Frequency Equilateral Triangular Microstrip Antenna With Pair Of Narrow Slots", *Microwave And Optical Technology Letters*, Vol.23, No.2, October 1999

[2] Lu, J.H and Kin Lu Wong, "Single Feed Dual Frequency Equilateral Triangular Microstrip Antenna With Pair Of Spur Lines", *Electronics Letters*, vol.34, No.12, June 1998(i) (ii)

[3] I. J. Bahl and P.Bhartia microstrip antennas.Dedham,MA:Artech House ,1980

[4] Balanis, C.A., Antenna Theory: Analysis and Design, John Wiley & Sons, Inc, 1997.

[5] "Broadband Microstrip Antennas" Girish Kumar K. P. Ray

[6] Qian Y., Coccioli R., Sievenpiper D., Radisic V., Yablonovitch E., and Itoh T., "A Microstrip Patch Antenna using novel photonic bandgap structures", Microwave J., vol 42, pp. 66-76, Jan 1999.

[7] Rajeshkumar V, Priyadarshini K, Glory Devakirubai D, Ananthi C, Snekha P"Design and Comparative Study of Pin feed and Line feed Microstrip Patch Antennafor X-band Applications" *International Journal of Applied Information Systems (IJAIS) –ISSN: 2249-0868 Foundation of Computer Science FCS, New York, USA Volume 1–No.5, February 2012–www.ijais.org*

[8] Stutzman, W.L. and Thiele, G.A., Antenna Theory and Design, John Wiley & Sons, Inc, 199

[9] Kin-Lu Wong ,John Wiley & Sons, Inc *"Compact and Broadband Microstrip Antennas"* ISBNs: 0-471-41717-3 (Hardback); 0-471-22111-2 (Electronic).

[10] S. R. Chowdhury and Dr. S. Basu, "Miniaturization of Equilaterl Triangular Microstrip Patch Antenna using [arallel Sotting Technique", *IJECT Vol.3 ,JAN-MARCH 2012*

[11] Wonkyu Choi , Yong Heui Cho, Cheol –Sik Pyo and JAE- Ick Choi.,"A High Gain Microstrip Patch Array Antenna Using a Superstrate Layer", *ETRI Journal ,Volume 25,No, 5, oct-2003*

[12] Teruhisa Nakamura,Takeshi FUKUSAKO "Broadband Design of Circularly Polarized Microstrip Antenna Using EBG Structure with Rectangular Unit Cells", *The 2009 International Symposium on Antenna and Propagation (ISPA 2009)Oct.20-23,2009,Bangkok,THAILAND*

[13] K.L. Lau and K. M. Luk, "A novel wide band circularly polarized patch antenna based on L- probe and aperture –coupling techniques ", *IEEE Trans antennas propagate ., vol. 53, no. 1, jul. 2005,pp.577-580*

[14] Electromagnetic Band GapStructures in Antenna Engineering,Fan Yang,University of Mississippi Yahya Rahmat-Samii,University of California at Los Angeles,Page130-132

[15] L. Yang, M.Y. Fan, F.L. Chen, J.Z. She, and Z.H. Feng, “A novel compact Electromagnetic Bandgap structure and its applications for microwave circuits,” in IEEE Trans. Microwave Theory and Techniques, vol. 53, no. 1, pp. 183-190, Jan 2005.

[16] M. Fallah, F. H. Kashani, and S. H. Mohseni “Side Effect Characterization of EBG Structures in Microstrip Patch Antenna ” Published on Progress In Electromagnetics Research Symposium Proceedings, Cambridge, USA, July 5-8, 2010.