Dual Band Rectangular Microstrip Antenna for Wireless Communication Systems

Kratika Jain
Department of Electronics and Communication Engineering,
Suresh gyan vihar university, jaipur, India.

Sandhya sharma
Department of Electronics and Communication Engineering,
Suresh gyan vihar university, jaipur, India.

Abstract- In this paper connected E and U shaped Microstrip antenna structure is designed for dual frequency wideband is proposed at a height of 3.5mm from the ground plane. Rectangular microstrip patch antenna along with the proposed structure is designed to resonate at two frequencies 12.48GHz and 10.40GHz, which exhibits -13.10dB and -10.93dB return loss at operating frequency and has impedance bandwidth from 1.933 to 1.958GHz. The return loss and impedance bandwidth of the patch antenna along with the proposed structure is improved. All the simulation work is done by using CST-MWS Software version 11.

Keywords: E and U shaped rectangular microstrip patch antenna, computer simulation technology (CST) microwave studio version 11 software.

I. INTRODUCTION

Microstrip patch antenna is a key building in wireless communication and Global Positioning system since it was first demonstrate in 1886 by Heinrich Hertz and its practical application by GuglielmoMarconi in 1901. Future trend in communication design is towards compact devices. Microstrip patch antenna have been well known for its advantages such as light weight, low fabrication cost, mechanically robust when mounted on rigid surfaces and capability of dual and triple frequency operations all these features, attract many researchers to investigate the performance of parch antenna in various ways. However, narrow bandwidth came as the major disadvantage for this type of antenna. Several techniques have been applied to overcome this problem such as increasing the substrate thickness, introducing parasitic elements i.e. co-planar or stack configuration, or modifying the patch's shape itself. Modifying patch's shape includes designing a connected E and Ushaped patch antennas. The main objective of this paper is to optimize the base design in to obtain wide bandwidth. This patch antenna operates at voltage standing wave ratio of less than 2 (VSWR < 2).

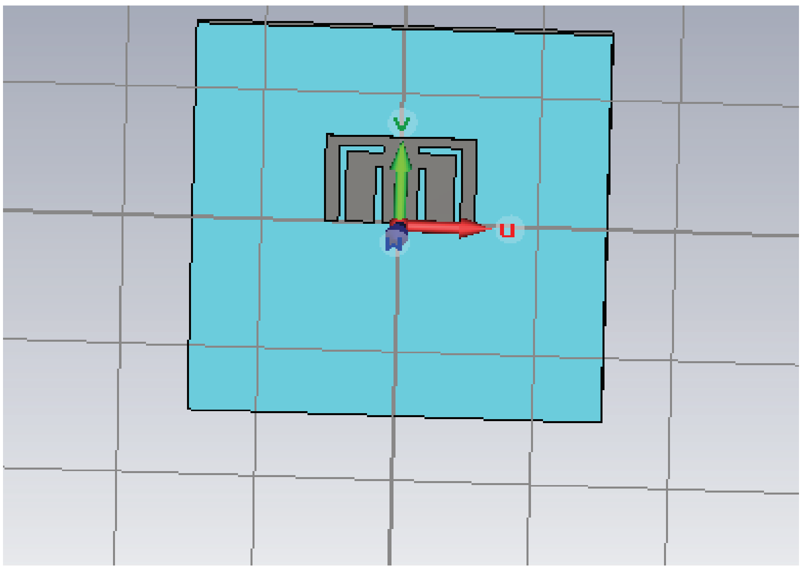


Fig.1 Structural view of connected E and U shaped patch antenna on CST Microwave studio

II. DESIGN SPECIFICATION

The designing specification for rectangular microstrip patch antenna width and length is given by:

$$W = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{v_0}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where vo is the free-space velocity of light.

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

Where the dimensions of the patch along its length have been extended on each end by a distance ΔL, which is a function of the effective dielectric constant εreff and the widthto- height ratio (W/h), and the normalized extension of the length, is

$$\Delta L = 0.412 h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad (3)$$

The actual length of the patch (L) can be determine as

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{reff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L \qquad (4)$$

III. PARAMETRIC STUDY

The default value of dimension for this antenna is presented in Table 1.Only parameter is allowed to change at a time while other variables remain constant as default except ground and substrate that will varied together. All dimension mentioned in graphs are in millimetre (mm).

Table 1 Design specification for dual band microstrip antennas

Design Parameter	value
Substrate length = Lg	60mm
Substrate width = Wg	60mm
Main patch length = La	10.8mm
Main patch width = Wa	15.7mm
Outer patch slot length = Lb	13.3mm
Outer patch slot width = Wb	21.8mm
Main slot width = Wsb	17.7mm
Slot A length = Lsa	8.5mm
Slot B length = Lsb	11.8mm
Substrate height = h	3.5mm
Connection width = W1	2.5mm
Core diameter = Dc	1.285mm
Teflon diameter = Dt	4.18mm

IV EXPERIMENT AND RESULT

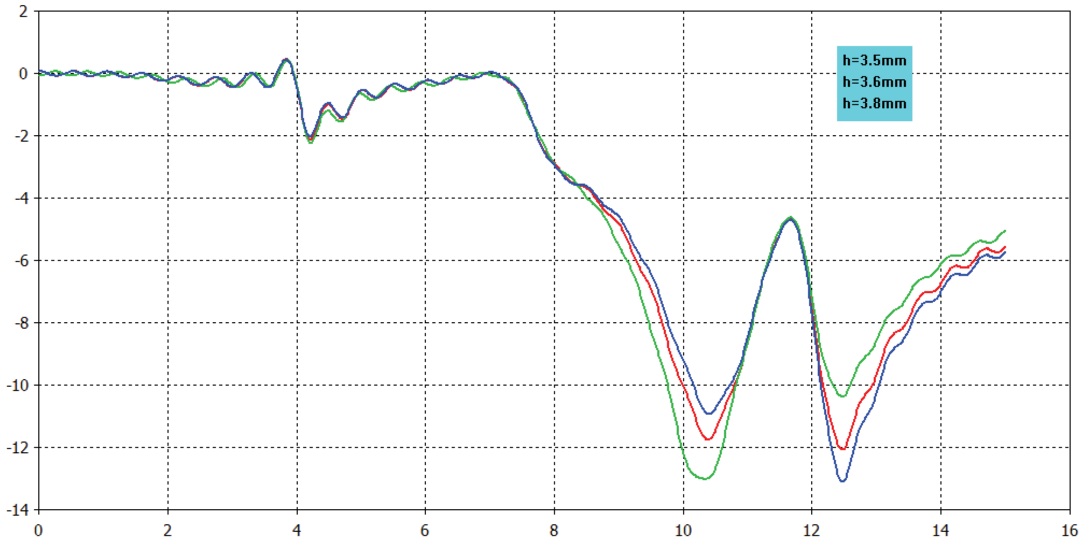
A. The Effects of change in Substrate Height (h)

Figure 2 shows the simulation result of the connected E shaped and U sahaped patch antenna based on the variation value of substrate height (h). It is clear from the figure that the substrate height is varying from 3.5mm to 3.8mm, which causes the resonant frequencies decreases and the magnitude of S11 increases. Therefore by choosing the response of 3.5mm gives the best result.

Table 2

Substrate height = h (mm)	**Return loss (GHz)**	**Magnitude (dB)**
3.5mm	10.40GHz & 12.48GHz	-11.74dB & -12.07dB
3.6mm	10.33GHz & 12.47GHz	-13.02dB & -10.37dB
3.8mm	10.34GHz & 12.47GHz	-10.88dB & -13.10dB

S-parameter magnitude in dB



Frequency(GHz)

Fig.2 Return loss plot for various size of substrate height h

B. The Effects of change in Slot A Length (Lsa)

Figure 3 shows the simulation result of the connected E shaped and U sahaped patch antenna based on the variation value of the length of slot A. It is shown in figure that slot length varied from 8.5mm to 10.5mm with 1mm increment.As the slot length increases,the magnitude of S11 decreases and the resonant frequencies wil also decreases. Therefore by choosing the response of 8.5mm gives the best result.

Table 3

Slot Length A = Lsa (mm)	Return loss (GHz)	Magnitude (dB)
8.5mm	10.75GHz & 12.38GHz	-12.23dB & -09.87dB
9.5mm	10.18GHz & 12.38GHz	-11.66dB & -11.50dB
10.5mm	10.39GHz & 12.48GHz	-10.93dB & -13.10dB

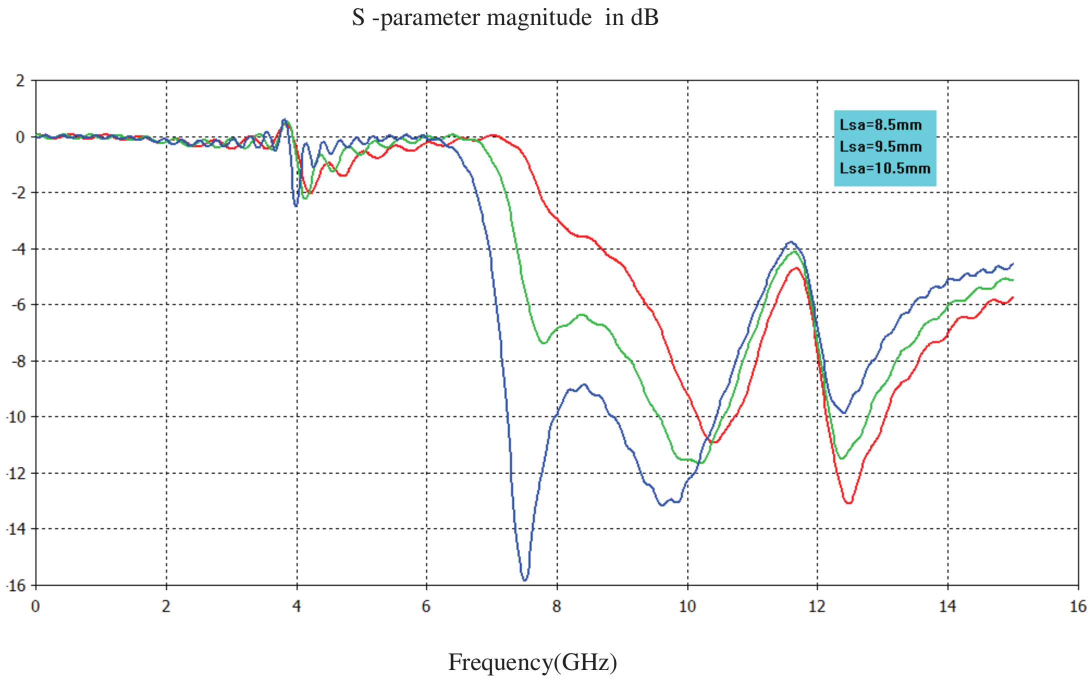


Fig.3 Return Loss plot for various size of Lsa

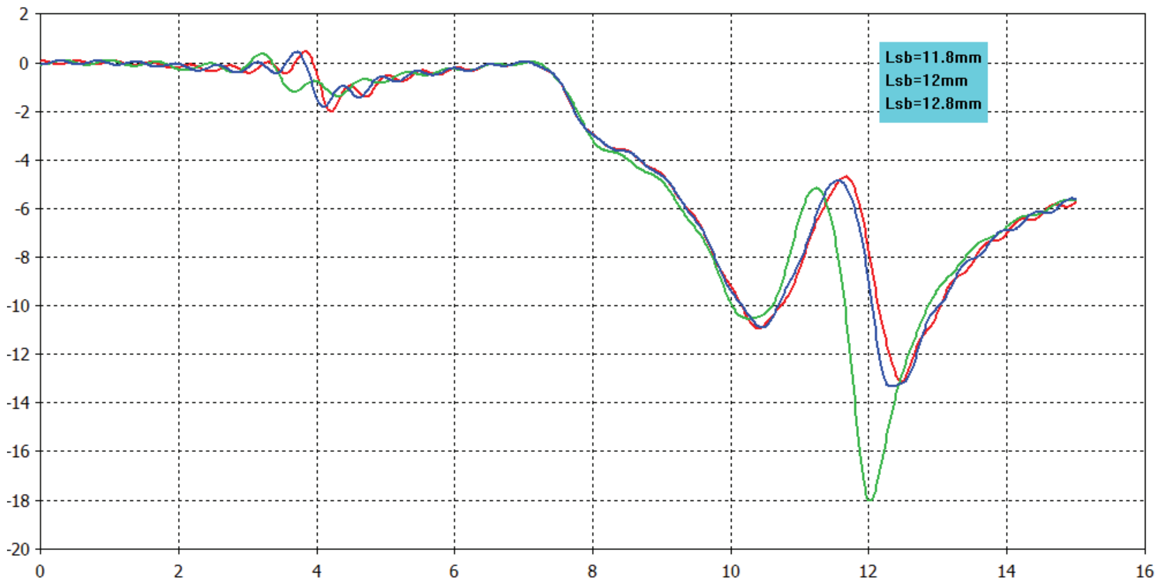
C. The Effects of change in Slot B Length (Lsb)

Figure 4 shows the simulation result of the E shaped and U sahaped patch antenna based on the variation value of the length of slot B. It is shown in figure that slot length varied from 11.8mm to 12.8mm.As the slot length increases,the magnitude of S11 decreases and the resonant frequencies wil also decreases. Therefore by choosing the response of 11.8mm gives the best result.

Table 4

Slot Length B = Lsb (mm)	Return loss (GHz)	Magnitude (dB)
11.8mm	10.40GHz & 12.48GHz	-10.92dB & -13.10dB
12.00mm	10.26GHz & 12.33GHz	-10.38dB & -13.33dB
12.8mm	10.26GHz & 12.01GHz	-10.54dB & -18.03dB

S-parameter magnitude in dB



Frequency(GHz)

Fig.4 Return Loss plot for various size of Lsb

D. The Effects of change in slot width (Sa)

Figure 5 shows the simulation result of the E shaped and U sahaped patch antenna based on the variation value of the slot width Sa. It is shown in figure that slot width Sa is varied from 0.8mm to1.2mm with the increment of 0.2mm.The magnitude of the S11 at first resonant frequency increases as increasing the slot width Sa,While at the second resonant frequency is same as increasing in magnitude of S11.

Table5

Slot width = Sa (mm)	**Return loss (GHz)**	**Magnitude (dB)**
0.8mm	10.51GHz & 12.48GHz	-10.41dB & -14.82dB
1mm	10.40GHz & 12.48GHz	-11.30dB & -11.63dB
1.2mm	10.48GHz & 12.48GHz	-10.81dB & -13.10dB

S-parameter magnitude in dB

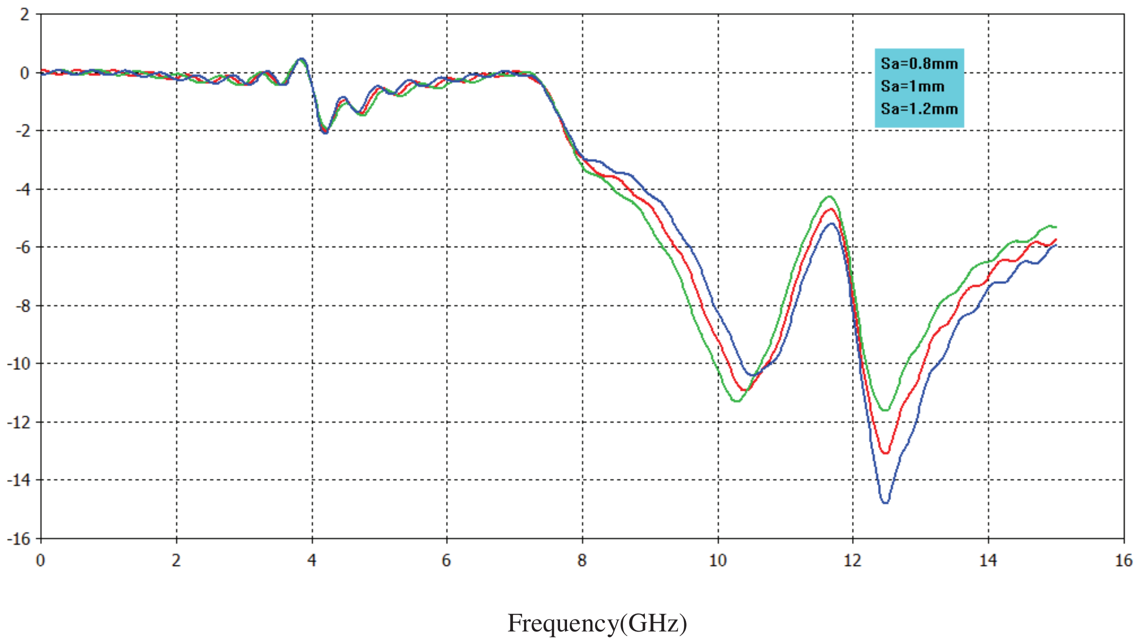


Fig.5 Return Loss plot for various size of Sa

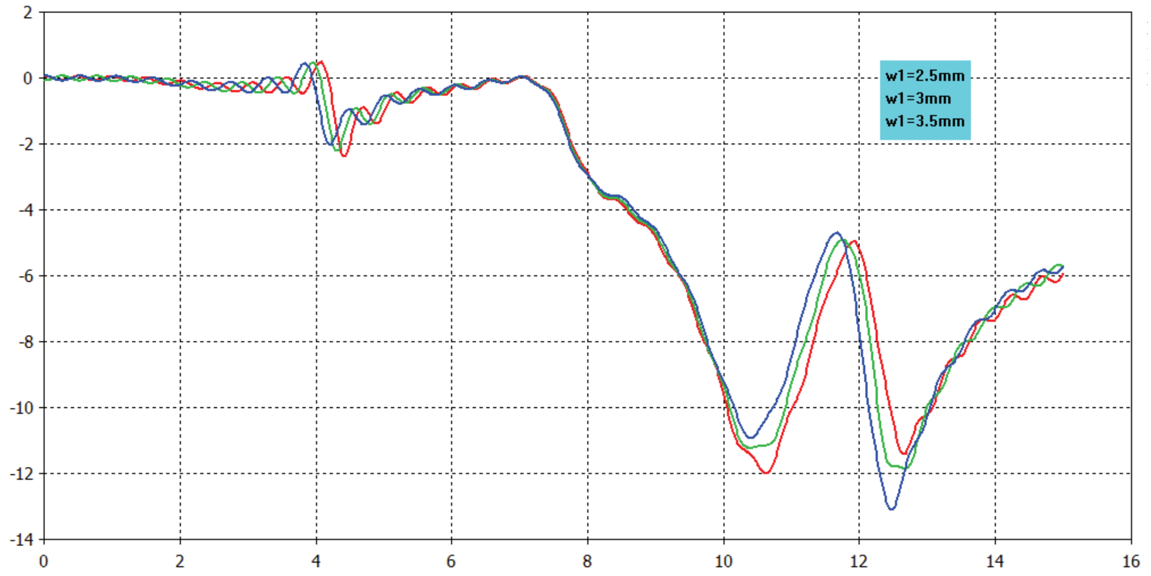
E. The Effects of change in Connection Width (w1)

Figure 6 shows the simulation result of the E shaped and U sahaped patch antenna based on the variation value of the connection width w1. It is shown in figure that the connection width varied from 2.5mm to 3.5mm with 0.5mm increment. The magnitude of S11 parameter at resonant frequency increases as increasing the connection width.

Table 6

connection width = w1 (mm)	**Return loss (GHz)**	**Magnitude (dB)**
2.5mm	10.40GHz & 12.48GHz	-10.93dB & -13.10dB
3mm	10.53GHz & 12.65GHz	-11.17dB & -11.85dB
3.5mm	10.63GHz & 12.65GHz	-12.00dB & -11.42dB

S-parameter magnitude in dB



Frequency(GHz)

Fig.6 Return Loss plot for various size of W1

F. The Effects of change in Substrate Size (Lg=Wg=Lsub=Wsub)

Figure 7 shows the simulation result of the E shaped and U sahaped patch antenna based on the variation value of the substrate size Lg=Wg=Lsub=Wsub. It is shown in figure that the substrate size is varied from 58mm to 62mm with 2mm increment.The result doesn't show much difference in terms of bandwidth but slightly affect the magnitude of S11.The magnitude is almost same at different value of size.

Table 7

Substrate size = (Lg=Wg=Lsub=Wsub) (mm)	**Return loss (GHz)**	**Magnitude (dB)**

58mm	10.39GHz &12.48GHz	-10.75dB & -13.30dB
60mm	10.40GHz & 12.48GHz	-10.92dB & -13.10dB
62mm	10.41GHz & 12.48GHz	-10.60dB & -12.91dB

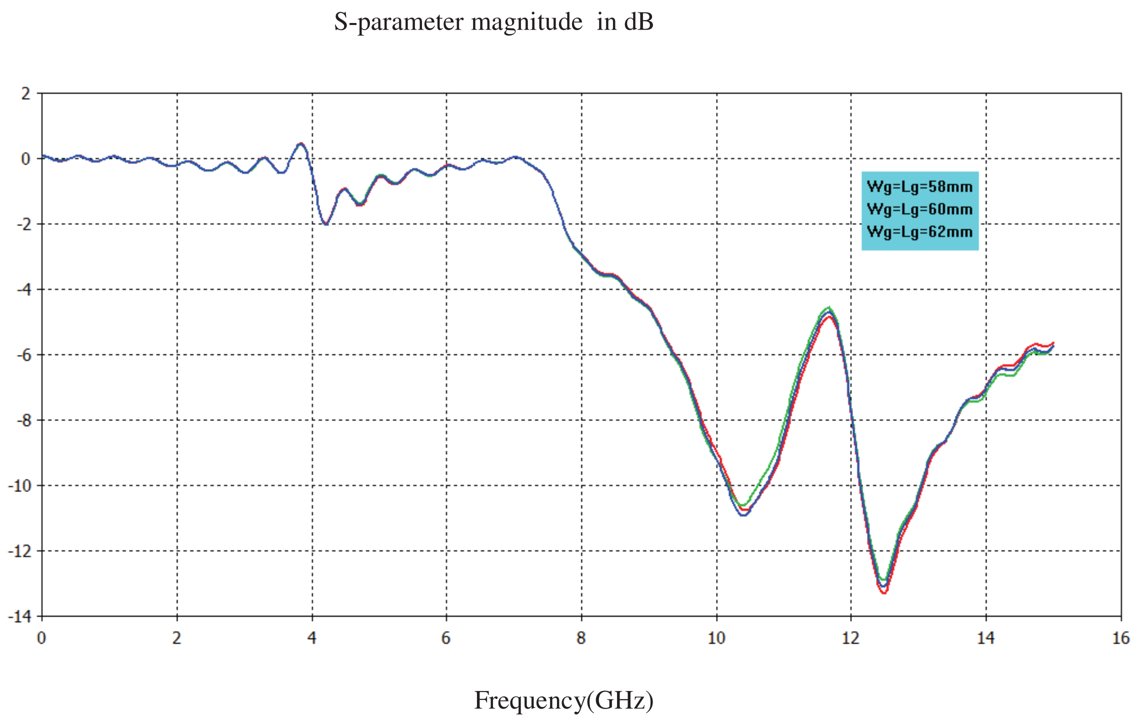
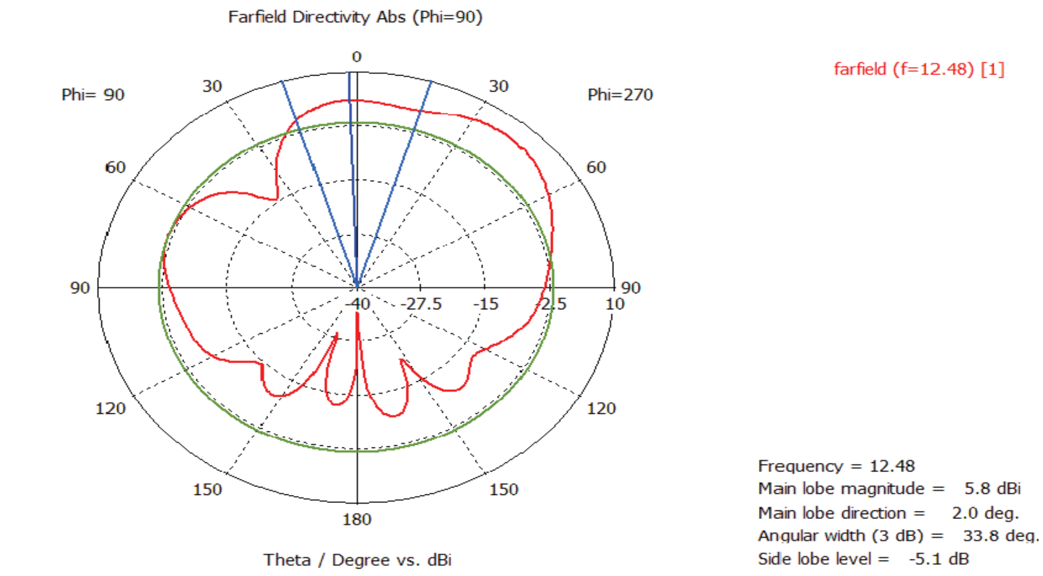


Fig.7 Return Loss plot for various size of substrate(Wg=Lg=Wsub=Lsub)

G Radiation pattern

The radiation pattern is a graphical depiction of the relative field strength transmitted from or received by the antenna. Antenna radiation patterns are taken at one frequency, one polarization, and one plane cut. The patterns are usually presented in polar or rectilinear form with a dB strength scale. Since a Microstrip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. The radiation pattern plots for dual frequency at 12.48GHz and 10.40GHz for connected E and U shaped patch antennas at φ=900 are given below in (figure 8).



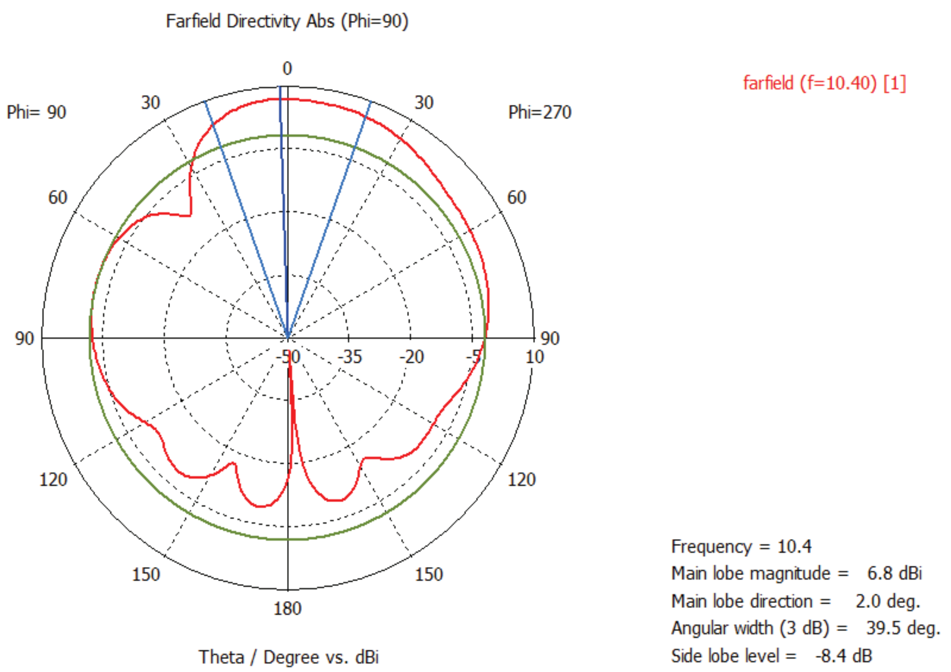


Fig.8 Radiation Pattern of dual band microstrip patch antenna at $\varphi=90^0$ for frequency (a) at 12.48GHz & (b) at 10.40GHz

V. CONCLUSION

In this paper, a connected E & U-shaped wideband microstrip patch antenna has been designed, simulated, optimized and analyzed using CST(computer simulation technology) software version 11. A parametric study is presented with the results showing that the antenna can be operated at 10.40 GHz up to 12.48 GHz frequency band. This result is an improvement when compared to the original specifications. Other parameters such as S11 and VSWR also have been improved.

REFERENCES

[1] Kin-Lu Wong, Wen-Hsiu Hsu, "A broad-band rectangular patch antenna with a pair of wide slits", IEEE Transaction on Antennas and Propagation, vol.49, pp- 1345-1347, 2001.
[2] Sheng- Ming, M. –D. Wu and P. Hsu, "Analysis of coplanar waveguide- fed Microstrip antenna", IEEE Transaction on Antennas and Propagation Letters, vol. 43, No. 7, July 1995.
[3] S. Maci and G. BifJi Gentili, "dual frequency patch antennas", IEEE Antennas and Propagation Magazine, Vol. 39, No. 6, pp 13-20, December 1997.
[4] C.A. Balanis, "Antenna Theory Analysis and Design", third edition, Wiley, New Jersey, 2005.
[5] Adil Hameed Ahmad and Basim Khalaf Jar'alla, "Design and Simulation of Broadband Rectangular Microstrip Antenna", Eng. Tech. Vol-26, No-1, 2008.
[6] Pues H., Vande Capelle A., "accurate transmission-line model for the rectangular Microstrip antenna", Microwaves, Optics and Antennas, IEEE Proceedings H, vol-131, pp-334-340, 1984.
[7] J. Van densande, H. Pues, A.V.de Capelle, "Calculation of the bandwidth of Microstrip resonator antenna", Microwave Conference, pp-116-119,1979.
[8] http:en.wiki .edia.org/wiki/WiMAX/Wlan.
[9] Yuehe Ge, Karu P. Esselle, Trevor S. Bird, "E-Shaped Patch Antennas for High-Speed Wireless Networks", IEEE Transactions on Antennas and Propagation, vol. 52, no. 12, pp-3213- 3219, December 2004.
[10] J. Bahl and P. Bhartia, Microstrip Antennas, Artech House, Dedham, MA,1980.
[11] D. M. Pozar and D. H. S. (Ed.), Microstrip Antennas: Analysis and *Design*. New York: John Wiley & Sons, lnc., 1995.
[12] R. Q. Lee, T. Huynh and K. F. Lee, "Experimental study of the cross- polarization characteristics of rectangular patch antennas",*IEEE* International Symposium on Antennas and Propagation, vol. 2, pp. 624–627, June 1989.
[13] B. Lee and F. J. Harackiewicz, "Miniature Microstrip antenna with a partially filled high- permittivity substrate", IEEE Transactions on Antennas and Propagation, vol. 50, no. 8, pp. 1160–1162, 2002.
[14] D. R. Jackson and N. G. Alexopoulos, "Simple approximate formulas for input resistance bandwidth and efficiency of a resonant rectangular patch", IEEE Transactions on Antennas and Propagation, vol. 39, no. 3, pp. 407–410, 1991.
[15] T. Huynh and K. F. Lee, "Single-layer single-patch wideband Microstrip antenna", Electron. Lett., vol. 31, no. 16, pp. 1310–1312, Aug. 3, 1995.
[16] E.O. Hammerstad, "Equations for microstip Circuit Design", Pro. Fifth European Microwave Conference, page 268-272, 1975.
[17] W. F. Richards, S. E. Davidson, S. A. Long, "Dual-Band Reactively Loaded Microstrip Antenna", IEEE Transactions on Antennas and Propagation, AP-33, 5, May 1985, pp. 556-560.
[18] S. Maci, G. Biffi Gentili, G. Avitabile, "Single-Layer Dual- Frequency Patch Antenna", Electronics Letters, 29, 16, August 1993.
[19] S. S. Zhong and Y. T. Lo, "Single Element Rectangular Microstrip Antenna for Dual-Frequency Operation", Electronics Letters, 19, 8, pp.298-300, 1983.
[20] J. S. Chen and K. L. Wong, "A single-layer dual-frequency rectangular Microstrip patch antenna using a single probe feed", Microwave Opt. Technol. Lett. **11**, 83–84, Feb. 5, 1996.
[21] R. Waterhouse, "Small Microstrip patch antenna," Electron. Lett., Vol.31, pp. 604-605,1995.