ISSN: 2321-8169
1511 - 1514

Performance Enhancement of Triangular Patch Antenna by Optimizing the Feed Point Location

Mandeep Singh

Department of Electronics and Communication Engineering
Shekhawati Institute of Engineering & Technology, Sikar,
Rajasthan, India
mandeep702@rajasthan.in

Abstract: In this paper, a design and analysis of microstrip fed triangular patch antenna is presented for microwave applications. The performanceof an edge fed antenna design is enhanced by selecting proper dimension and feed point location of matching quarter wave transformer. The designed antenna resonates at 10 GHz with S_{11} = -18.28 dB and with maximum gain of 8.73dB and radiation efficiency is 99.24% for the centre location of the feed. The gain, directivity and other parameters of the triangular patch antenna are affected by localizing the feed point with the constant thickness of substrate. The design has been simulatedby the application of HFSS software based on finite elemental method.

Keywords: *Triangular patch microstrip antenna, Edge feed point, Feed location, HFSS, Finite element method.*

I. INTRODUCTION

In recent years, low profile systems became much area of interest for researchers because of the increased demands of portable systems. For designing of low profile communication systems, critical parameter is the antennasize due to advancement in integrated circuit technology. With the advantages of low cost, light weight, and robustness microstrip fed antenna is the suitable choice for higher frequency band, X-band with a range of 8-12 GHz for various applications in the field of military, defense tracking, meteorology, air traffic control, automobile speed detection,etc. [1-2]. In past rectangular and circular shaped patch antennas have been used commonly because of simplicity of analysis, fabrication and their attractive radiation pattern. Instead of having narrow-band properties, triangular patch antennas are now preferred because of having smaller coverage area attributes however similar to rectangular patches.The triangular patches are suitable for hemispherical application as they have broad half-power beam widths in both planes.[3]

B. J. Kwaha et al. (2011) simulated the basic parameters of circular patch and performed comparative study for four different substrates - GaAs, Duroid, InP and Si. The authors concluded that GaAs is suitable for smaller antenna size and low power handling capability. Duroid performs excellent when size is not a limitation. As the patch radius decreases, the resonant frequency increases the radius being 0.2374cm at 10.0GHz [4]. M.V. Chaitanya Kumar et al. (2013) designed and simulated triangular patch antenna operating at 2.5GHz frequency using HFSS software. The analysis of the antenna was performed with two different substrates materials, Taconic TLC and Roger RT 5880 Duroid. The optimal performance was obtained by considering different substrate thickness values of 1.6mm and 2.4mm [5]. T. Durga Prasad et al. (2011) discussed the formulation of the radiation problems based on the combined field integral equations coupled to the Method of Moments (MoM) to obtain numerical solution of the integral equations. [6]. Khan et al. (2012) designed triangular microstrip patch antenna to be used in X-band applications at 10 GHz. The comparative study had been performed for dielectric properties of five different substrates which affect antenna performance. The authors have considered RTDuroid dielectric material with $\varepsilon_r = 3.2$ showing the best results [7].

A microstrip feed line has been used here for feeding the triangular patch antenna due to its ease of fabrication and robustness of microstrip line and its suitability in microwave circuits. The coaxial probe feed has some advantages over microstrip feed line such as less spurious radiation, but coaxial probe is not much reliable because of soldering to the centre of the conductor patch, which creates problem when exposed to severe environmental conditions [8].To excite the microstrip patch, a transmission line with characteristic impedance Z_0 of 50Ω is used and quarter wavelength transformer (QWT) can be incorporated for perfect impedance matching [9].

Microstrip line edge fed equilateral triangular patch antenna (ETMSA) design is presented in this paper.The optimization of the antenna has been done here by varying the dimensions of quarter wave transformer and location of feed point at the edge of patch.Section 2 details the geometrical configuration and methodology the design and principle of the triangular microstrip patch antenna. Section 3 is concerned with the analysis of simulated design and results obtained are investigated. Finally, Section 4 concludes the overall work.

II. ANTENNA DESIGN

The equilateral triangular patch has a side length "a" and printed on a substrate of thickness "h" with relative dielectric constant "ε_r" as shown in Fig. 1. The resonant frequency for triangular patch corresponding to various modes can be given by [10-12]

$$f_r = \frac{c k_{mn}}{2\pi\sqrt{\varepsilon_r}} = \frac{2c}{3a\sqrt{\varepsilon_r}}\sqrt{m^2 + mn + n^2} \quad (1)$$

Where c is velocity of light in free space and k_{mn} is the wave number given by

$$k_{mn} = \frac{4\pi\sqrt{m^2+mn+n^2}}{3a} \quad (2)$$

The dominant resonant frequency for lowest order mode is hence given by

$$f_r = \frac{2c}{3a\sqrt{\varepsilon_r}} \quad (3)$$

The resonant frequency is taken to be 10 GHz here. The side ofequilateral triangular patch, "a" can be evaluated by equation (3)

$$a = \frac{2c}{3\sqrt{\varepsilon_r} f_r} \quad (4)$$

Where c= velocity of light =3× 10^8 m/s

$$a = \frac{2\times3\times10^8}{3\times\sqrt{3.4}\times10\times10^9} = 1.084\ cm \quad (5)$$

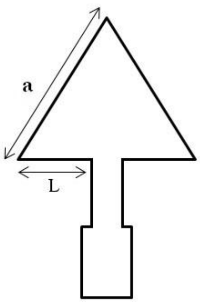

Fig. 1 Triangular patch design

The design parameters selected for the patch antenna are as given in Table 1.

Table 1. Various parameters of designed patch antenna

Side length of triangular patch	1.084 cm
Width of edge feed	0.35 cm
Length of edge feed	0.75 cm
Length of $\lambda/4$ transformer	0.42 cm
Width of $\lambda/4$ transformer	0.11cm
Height of substrate	100 mil

The patch is patterned on Rogers RO4003 as substrate material with dielectric constant of$\varepsilon_r = 3.4$ .The length of the quarter wave transformer is approximated to be λ/4($\sqrt{\varepsilon_r}$) [9].Quarter wavelength transmission line of characteristics impedance Z_1 can be changed by altering the width of the quarter wave strip. The wider the strip is, lower the characteristics impedance of the line. The width of the matching stripline is initially selected and the optimization of the patch antenna is then done by varying the feed point location hence keeping the dimensions of quarter wave transformer to a calculated fixed value.

III. RESULTS AND DISCUSSION

The design and analysis of microstrip line edge fed triangular patch antenna is performed by using software Ansoft HFSS v.13 based on FEM which is a numerical technique to solve the partial differential equations representing the mathematical model of a 3-D structure. The model of design is shown in Fig. 2

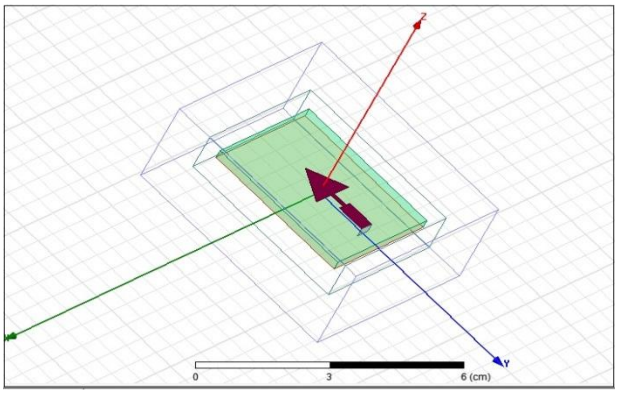

Fig. 2 HFSSdesign of triangular patch microstrip antenna

The location of QWT is varied for various values of length as L = 0 cm, 0.325 cm, 0.49cm, 0.705 cm and 0.815cm

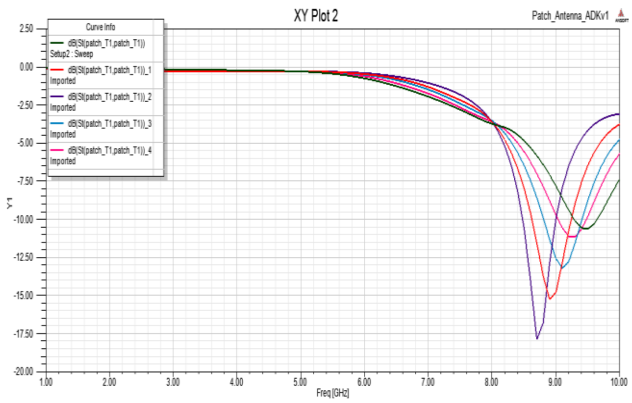

Fig.3 Return loss (S_{11} Parameters) curves, (a) L=0cm, (b) L=0.325cm, (c) L=0.49cm, (d) L=0.705cm, (e) L=0.815cm

By moving the feed point from left corner to right the different values obtained of $S_{11}$for return loss curves are plotted in Fig.3. Among all the feed locations, the perfect matching condition is obtained at L=0.49cm and the resulting value of return loss is at peak maxima of -18.28dB at resonating frequency of 8.73GHz whereas other locations for feeding exhibit smaller return loss valuesrelatively. As the feed position is deviated from the symmetric value of 0.49cm the resonating frequency shifts towards the higher value. The corresponding bandwidth observed for this case is 400MHz. The antenna resonates at 8.73GHz in contrast to the selected design frequency of 10GHz, the shift in frequency being caused due to the fringing fields from the sides of the patch. The dimensions of antenna can however be changed by 2-4% in order to resonate exactly at 10GHz. However, the main concern here is to analyse the radiation characteristics for optimized design of the triangular patch antenna hence ignoring minor deviations resonant frequency.

Fig. 4 plots the magnitude of impedance for various feed locations w.r.t. frequency. The impedance matching for varying feed locations is achieved around the resonant frequency of 8.73GHz. From the plot it is observed that the impedance of nearly 50Ω at 8.73GHz is obtained at symmetrical feed point location of L=0.49cm.

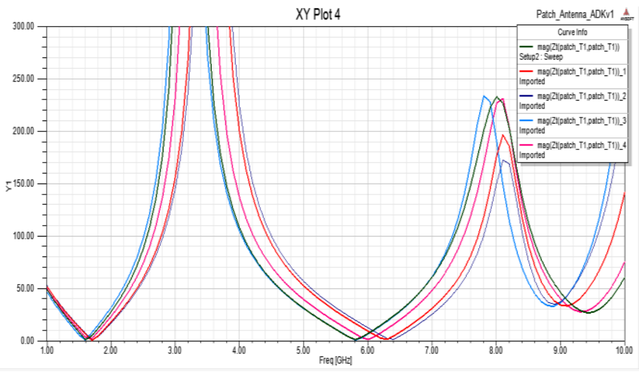

Fig.4 Impedance v/s frequency plot, (a) L=0cm, (b) L=0.325cm, (c) L=0.49cm, (d) L=0.705cm, (e) L=0.815cm

The 2D gain plotted in Fig. 5 depicts an increasing trend towards the symmetric feed location with maximum gain of 8.73dB and radiation efficiency is 99.24%.

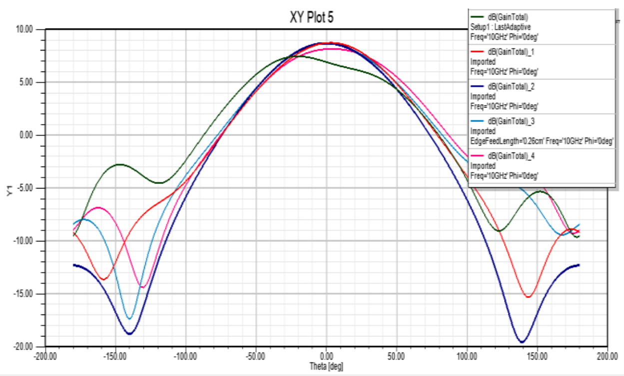

Fig.5 2D gain plot, (a) L=0cm, (b) L=0.325cm, (c) L=0.49cm, (d) L=0.705cm, (e) L=0.815cm

In Fig. 6 smith chart for various feed locations can be analyzed.

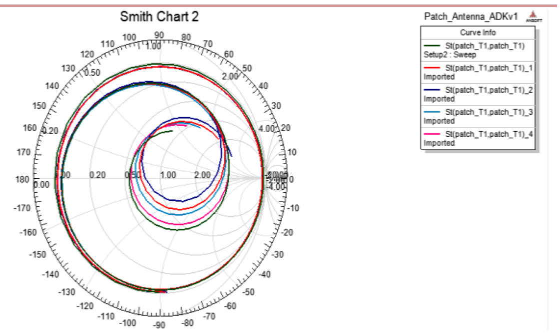

Fig. 6 Smith chart for various feed locations, (a) L=0cm, (b) L= 0.325 cm, (c) L = 0.49cm, (d) L=0.705cm, (e) L=0.815cm

The increase in radiation from the patches decreases the overall radiation resistance of the antenna which decreases input impedance and the loop shifts to left side of the Smith Chart.If the feed point is moved toward the edge the impedance value increases and the plot shifts right to high impedance value. As the length of parasitic patch increases resonant frequency decreases and the loop moves in anticlockwise direction (towards low frequency region).

Fig. 7 plots 3D radiation pattern of antenna for the optimized feed location at L=0.49 cm.

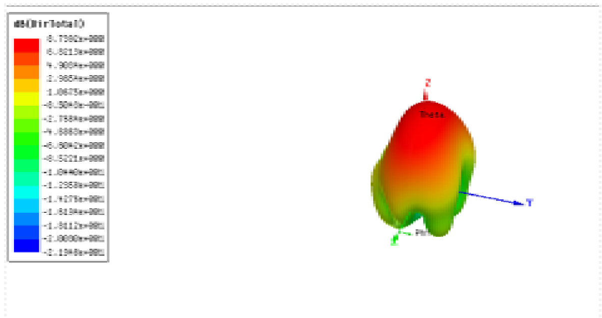

Fig. 7 3D Radiation pattern for the feed location at L=0.49cm

In Table 2 comparative analysis has been performed for different feed locations for optimizing design parameters used for the modeling of triangular patch antenna.

Table 2 Comparative analysis of different feed locations fortriangular patch microstrip antenna.

Length "L" (cm)	Frequency (GHz)	Return loss (dB)	Total gain (dB)
L=0	9.5	-10.48	6.9
L=0.35	8.9	-15.16	8.7
L=0.49	8.73	-18.28	8.73
L=0.705	9.1	-13.92	8.67
L=0.815	9.3	-11.19	8.1

IV. CONCLUSION

The performance of microstrip fed triangular patch antenna has here enhanced with the design of varying the

ISSN: 2321-8169
1511 - 1514

dimension of QWT and the localising the feed points for different feed locations. The antenna has designed and analysed by HFSS software based upon Finite Element Method. Among all the feed location, the perfect matching condition is obtained at L=0.49cm (i.e. the mid-point of edge of patch) and the corresponding value obtainedfor return loss is -18.28 dB. The maximum gain of 8.73dB with 99.24% radiation efficiency is achieved at optimized feed point location symmetrically placed on the feeding edge of the patch. It is concluded that selection of proper feed point location is a very important feature in achieving desiredgain, directivity, efficiency and the antenna dimensions.The patch antennas are the most popular antennas for Integrated Radio Frequency systems as they are compatible with microwave integrated circuits. The performance evaluation of the microstrip triangular patch antenna has been done for Rogers RO4003 substrate material with permittivity 3.4.

V. REFERENCES

[1] Md. Tanvir Ishtaique-ul Huque et al.(Vol. 2, No.8, 2011) "Performance Analysis of Corporate Feed Rectangular Patch Element and Circular Patch Element 4x2 Microstrip Array Antennas '', International Journal of Advanced Computer Science and Applications.

[2] M. F. Islam et al. (4(10): 4585-4591, 2010), "Dual Band Microstrip Patch Antenna for Sar Applications", Australian Journal of Basic and Applied Sciences.

[3] Swati, Tarun Kumar and Amul Kr. Aggarwal,(Vol. 15 Issue 5, September 2012) "Dual band Equilateral Triangular Patch Antenna'', IJCEM International Journal of Computational Engineering & Management.

[4] B. J. Kwaha, O. N Inyang& P. Amalu, (Vol. 8 Issue1 July2011)"the circular microstrip patch antenna – design and implementation," IJRRAS.

[5] R.Anita and Dr.M.V.Chaitanya Kumar, (Vol. 1, Issue 5, October-November, 2013) "Analysis of triangular microstrip patch antenna for different substrate materials,'' International Journal of Research in Engineering & Advanced Technology.

[6] T. Durga Prasad, K. V. Satya Kumar, MD Khwaja Muinuddin, Chisti B.Kanthamma, V.Santosh Kumar,(Vol 02, Issue 04; July 2011),"Comparisons of Circular and Rectangular Microstrip Patch Antennas,'' IJCEA.

[7] Anzar Khan, Rajesh Nema, (0975 –8887 Volume 55– No.14, October 2012), "Analysis of Five Different Dielectric Substrates on Microstrip Patch Antenna,'' International Journal of Computer Applications.

[8] Kumar, G and Ray, K.P (2003) "Broadband Microstrip Antenna", Artech House.

[9] John D. Kraus, Ronald J. Marhefka, (2006) "Antennas for All Applications", McGraw Hill, Third Edition. New York.

[10] R. Garg and S. A. Long, (Vol. AP-36, p. 570, Apr. 1988) "An improved formula for the resonant frequency of triangular microstrip patch antenna," IEEE Trans. Antennas Propagation.

[11] J. S. Dahele and K. F. Lee, (Vol. AP-35, p. 100- 101, January 1987) "On the resonant frequencies of the triangular patch antenna," IEEE Trans. Antennas Propagation.

[12] K. Guney, (Vol.6, No.9, p. 555-557, 1993) Resonant Frequency of a triangular Microstrip Antenna" Microwaveopt.Technol.Lett

VI.AUTHOR'S PROFILE

Mandeep Singh
is presently working as assistant professor in Department of Electronics and Communication Engineering at Shekhawati Institute of Engineering and Technology Sikar. He has completed M. Tech (ECE) from SLIET Longowal Punjab and B. Tech from Rajasthan Technical University Kota Rajasthan. His area of interest is Electromagnetics, antenna design and photonic crystals.