ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015

Design and Development of Proximity Coupled Equilateral Triangular Microstrip Antenna for Quad Band Operation and Enhancement of Bandwidth

Mahesh C P[1], P M Hadalgi[2]

Research Student, Department of PG studies and Research in Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India[1]

Professor, Department of PG studies and Research in Applied Electronics, Gulbarga University, Kalaburagi, Karnataka, India[2]

ABSTRACT: This paper presents the design and development of horizontal I-shape slots loaded on proximity coupled equilateral triangular microstrip antenna (HISPCETMSA) for quad band operation and omnidirectional radiation characteristics. The quad band frequency points are achieved between 2.75GHz to 9.23GHz. The magnitude of operating bandwidth has been enhanced to a maximum value of 14.77% in comparison to that of conventional microstrip antenna which resonates at 3GHz with bandwidth of 6.97%, by varying the length of horizontal I- shape slots on the patch. The proposed antenna presents a method for increasing the bandwidth and gain of an antenna. The design considerations and experimentally measured results are presented and discussed. This antenna may find application in modern wideband wireless communication systems like LTE 2006(Long Term Evolution), IMT (International Mobile Communication) and in radar systems.

KEYWORDS: Proximity coupled, Equilateral triangular, bandwidth, Gain, VSWR and radiation patterns.

I.INTRODUCTION

Due to many attractive features and desirable characteristics, the microstrip antennas have gained importance in the modern wireless communication systems as well as an ultimate solution for development of handheld mobile devices in both commercial industries and research academia [1]. The present era of wireless communication, possess many desirable features such as light weight, wide bandwidth, low cost, direct integrability with microwave circuitry [2].

In view of the rapid progress in wireless communication systems, high-gain broadband antennas are of great demand. Even though, microstrip antennas have advantages like low profile and ease of fabrication, their usage is limited by their inherent narrow bandwidth. Various techniques like aperture coupling [3], use of coupled parasites [4], stacking [5] [6], E-shaped patch [7] and modifications in the feed [8]–[10] have been proposed to enhance the bandwidth of microstrip antennas.

Basically, a microstrip antenna consists of a planar radiating structure of desired geometrical shape on one side of a dielectric substrate and a ground plane on the other. Commonly used microstrip radiating geometries are rectangular and circular [11]. However, other shapes are also considered depending upon the application. By considering this aspect, a study is carried out by increasing the lengths of the slots in proximity coupled equilateral triangular microstrip antenna.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015

II. ANTENNA DESIGNCONSIDERATION

Fig. 1 shows the geometry of proximity coupled equilateral triangular microstrip antenna (PCETMSA). The proposed antenna is designed for the frequency of 3 GHz using the relations present in the literature for the design of equilateral triangular microstrip antenna. There are numerous substrates that can be used for the design of microstrip antenna and their dielectric constants are usually in the range of $2.2 \le \varepsilon_r \le 12$. The proposed antenna uses a low cost glass epoxy substrate material with a dielectric constant $\varepsilon_r = 4.2$. The equilateral triangular microstrip patch antenna is made up of side length 'a' cm over a substrate $S_1$with substrate thickness 'h' cm. The value of 'a' is calculated by the equation (1),

$$a = \frac{2C}{3 f_r \sqrt{\varepsilon_r}} \quad (1)$$

The microstripline feed of length L_f and width W_f is etched on the top surface of substrate S_2. The substrate S_2 is placed below substrate S_1 such that the tip of the feedline and the centre of the radiating patch coincide one over the other. The bottom surface of the substrate acts as the ground plane. The proposed antenna is designed using the computer software AUTOCAD to achieve better accuracy. The antenna is fabricated using the photolithography process.

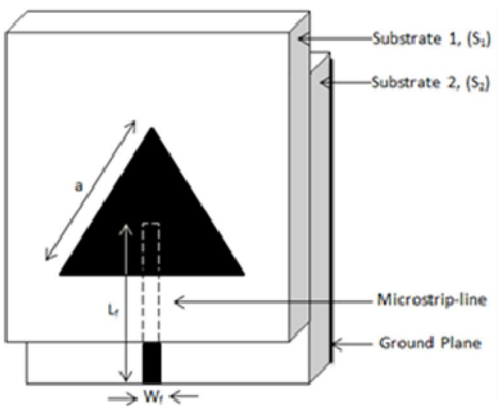


Fig. 1. Top view Geometry of PCETMSA

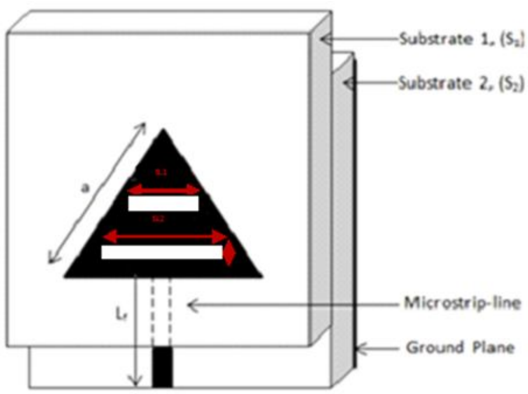


Fig. 2. Top view Geometry of HISPCETMSA

Further, the design is modified by employing two horizontal I-shape slots on the radiating patch by varying the dimensions of length of the slots and keeping width of the slots constant, which is shown in Fig. 2, where S_{L1} and S_{L2}

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015

are the length of the slots and S_W is width of the slots. All the specifications of the proposed antenna are given in Table. 1

Table.1. Designed parameters of the proposed antennas

Antenna Parameters	Dimensions in cm
Side length of equilateral triangle (a)	2.70
Length of the slots SL1 and SL2	10(SL1), 16(SL2)
Width of the slots SW	2
Length of the feedline Lf	2.5
Width of the feedlineWf	0.633
Length and width of the ground plane (Lg and Wg)	4.6
Thickness of substrate S1 and S2 (h1+h2)	0.64

III. RESULTS AND DISCUSSION

The impedance bandwidths over return loss less than -10 dB for the proposed antennas are measured.The measurements are taken on Vector Network Analyzer (Rohde & Schwarz, German make ZVK Model No. 1127.8651). The Fig. 3 shows the variation of return loss versus frequency of PCETMSA. It is seen that, the antenna resonates at 3 GHz. The percentage of experimental impedance bandwidth is calculated using the relation is given by equation (2),

$$BW = \left[\frac{f_2 - f_1}{f_c}\right] \times 100\% \qquad (2)$$

where f_2 and f_1 are the upper and lower cut off points of resonating frequency when its return loss reaches -10 dB and fc is a center frequency between f_1 and f_2. The impedance bandwidth of PCETMSA is found to be 6.97%. The Fig. 4 shows the variation of return loss versus frequency of HISPCETMSA. From this figure it is found that the antenna resonates at quad bands of frequencies f_1, f_2, f_3 and f_4 with their respective impedance bandwidths (BW_1) 4.74%, (BW_2) 6.49%, (BW_3) 4.16% and (BW_4) 14.77% respectively. The minimum return loss and VSWR measured are tabulated in Table 2.

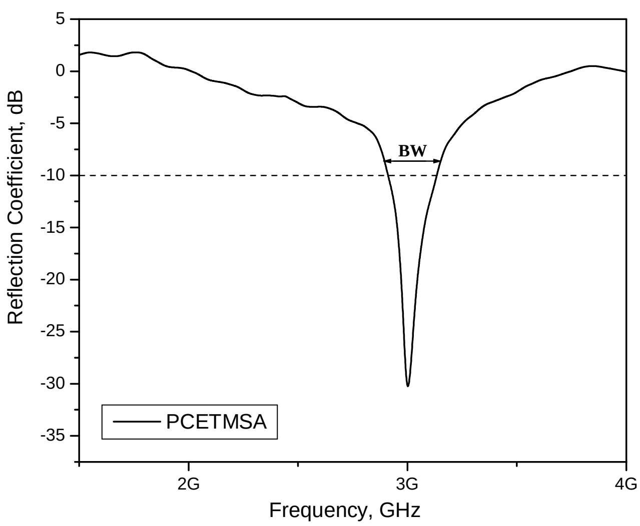


Fig. 3. Variation of return loss v/s frequency of PCETMSA

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015

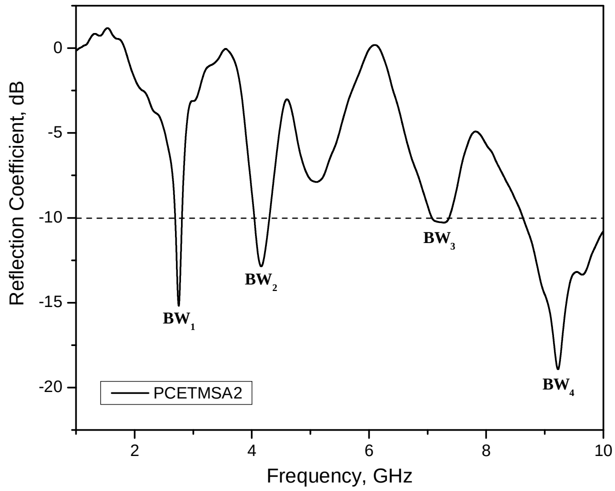


Fig. 4. Variation of return loss v/s frequency of HISPCETMSA

Table.2. Measured Min. Return Loss and VSWR

Antennas	Freq. in GHz.	Min. Return loss in dB.	VSWR
PCETMSA	3.00	-30.26	1.12
HISPCEMSA	2.75	-15.24	1.82
	4.15	-12.86	1.83
	7.27	-10.32	1.70
	9.23	-18.89	1.49

The X-Y plane co-polar and cross-polar radiation patterns of PCETMSA and HISPCETMSA are measured at their resonating frequencies and are shown in Fig. 5 to Fig. 9. These figures indicate that the antennas show broad side radiation characteristics. Further the calculated HPBW is shown in Table 3.

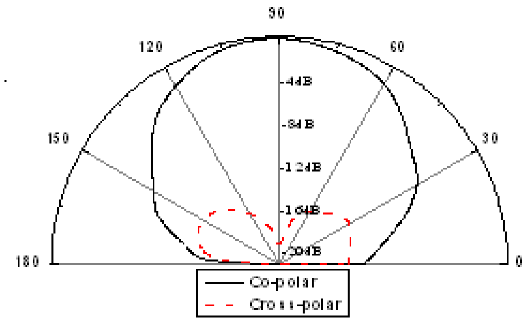


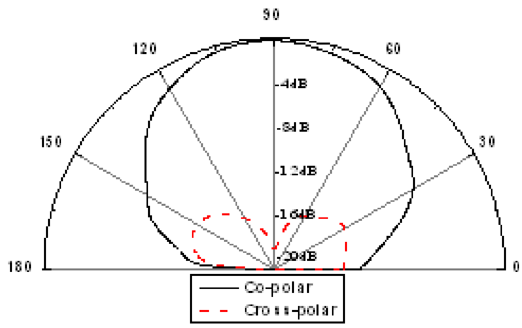
Fig. 5. Radiation pattern at 3 GHz

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015



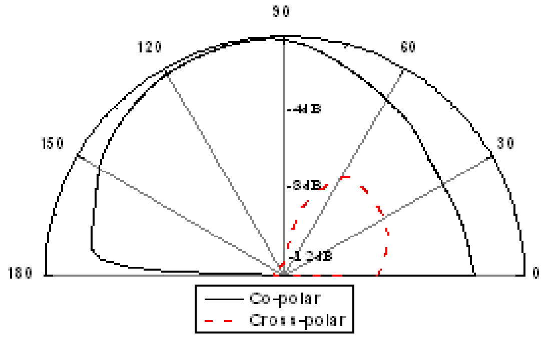


Fig. 6.Radiation pattern at 2.75GHzFig. 7. Radiation pattern at 4.15GHz

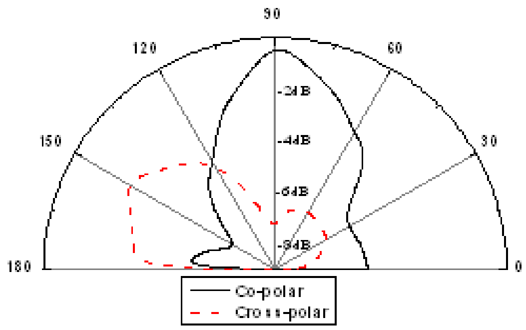


Fig. 8.Radiation pattern at 7.27GHz

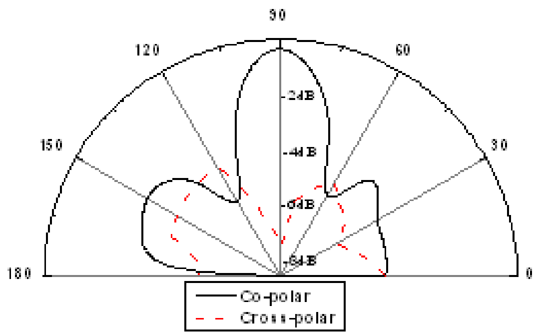


Fig. 9. Radiation pattern at 9.23GHz

The gain of proposed antenna is calculated using absolute gain method given by the equation (3),

$$G(dB) = 10\log\left(\frac{P_r}{P_t}\right) - (Gt)dB - 20log\left(\frac{\lambda_0}{4\pi R}\right)dB \qquad (3)$$

where, P_t and P_r are transmitted and received powers respectively, G_t is the gain of the pyramidal horn antenna and R is the distance between transmitting antenna and antenna under test. The gain of the antenna is also tabulated in Table 3.

Table.3. Calculated HPBW and Gain

Antennas	**Freq. in GHz.**	**HPBW in degrees**	**Gain in dB**
PCETMSA	3	720	6.38
HISPCETMSA	2.75	830	6.57
	4.15	1450	1.34
	7.27	530	3.42
	9.23	400	6.00

IV. CONCLUSIONS

From the detailed experimental study, it is concluded that the antennas are quite simple in design and fabrication. The PCETMSA antenna gives a single frequency band but after loading horizontal I-shape slots i.e. HISPCETMSA resonates for quad operating frequency bands and is quite good in enhancing the impedance bandwidth and gives better gain with broadside radiation patterns at the resonating frequencies. The antenna is also superior as it uses low cost substrate material and finds applications in wireless communication systems such as LTE 2006, IMT and in radar systems.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 2, February 2015

V. ACKNOWLEDGEMENT

The authors express their thanks to the Department of Science and Technology (DST), Govt. of India, New Delhi, for sanctioning Vector Network Analyzer under the FIST Programme to the Department of Applied Electronics, Gulbarga University, Gulbarga

REFERENCES

1. Constantine. A. Balanis “Antenna theory analysis and design”, John Willey, New York, 1997.
2. D.M.Pozar, “Microstrip Antennas,” Proceeding, IEEE, Vol. 80, pp.79- 81, January,1992.
3. D. M. Pozar and B. Kaufman, “Increasing the bandwidth of a microstrip antenna by proximity coupling,” Electron. Lett., vol. 23, no. 8, pp. 368–369, 1987.
4. C.K.Aanandan, P.Mohananand and K.G.Nair“Broad-band gap coupled Microstrip antenna, IEEE Trans. Antennas Propag.,vol.38,no.10,pp. 1581–1586, Oct. 1990.
5. S. D. Targonski, R. B. Waterhouse, and D. M. Pozar, “Design of wide- band aperture stacked patch microstrip antennas,” IEEE Trans. Antennas Propag., vol. 46, no. 9, pp. 1245–1251, Sep. 1998.
6. M. A. Martin, B. S. Sharif, and C. C. Tsimenidis, “Probe fed stacked patch antenna for wideband applications,” IEEE Trans. Antennas Propag., vol. 55, no. 8, pp. 2385–2388, Aug. 2007.
7. F. Yang, X.-X. Zhang, Z. Ye, and Y. Rahmat-Samii, “Wide-band E-shaped patch antennas for wireless communications,” IEEE Trans. Antennas Propag., vol. 49, no. 7, pp. 1094–1100, Jul. 2001.
8. Y.-X. Guo, M. Y. W. Chia, Z. N. Chen and K.-M.Luk, “Wide-band L-probe fed circular patch antenna for conical-pattern radiation,” IEEE Trans. Antennas Propag., vol. 52, no. 4, pp. 1115–1116, Apr. 2004.
9. J. Park, H.-g. Na, and S.-h. Baik, “Design of wideband aperture stacked patch microstrip antennas,” IEEE Antennas Wireless Propag. Lett., vol. 3, pp. 117–119, 2004.
10. C.-L.Mak, H.Wong and K.-m.Luk “High-gain and wide-band single- layer patch antenna for wireless communications,” IEEE Trans. Veh. Technol., vol. 54, no. 1, pp. 33–40, Jan. 2005.
11. Ashish Kumar “Rectangular Microstrip patch antenna using L slot structure” International Journal of Research in Electrical and Electronics Engineering (IJREEE), Vol. 2, Issue. 2, pp. 15-18, March 2013.