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Bandwidth Enhancement by Slot Loaded Proximity Coupled Equilateral Triangular Microstrip Antenna for IMT/WIMAX/SAR Applications

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 design and fabrication of inverted T-shape slot loaded on proximity coupled equilateral triangular microstrip antenna (ITSPCETMSA) for quad band operation is presented. The proposed antenna operates between 2.82 to 8.75GHz at four different frequency bands with enhancement in bandwidth to a maximum value of 52.52% to that of conventional microstrip antenna which resonates at 3GHz with bandwidth of 6.97%, by inserted inverted T-shape slot on the patch. The antenna parameters such as return loss, bandwidth and radiation pattern are discussed and presented. This antenna may find application in IMT, WIMAX and SAR (Synthetic aperture radar).

KEYWORDS: Equilateral triangular Microstrip antenna, proximity coupled, Inverted T-slot, bandwidth.

I. INTRODUCTION

In the present view first generation, second generation, third generation and recently, a fourth generation of mobile and wireless communication systems has already investigated. The growth of mobile and wireless communication systems has opened a wide range of opportunities to a new generation of antennas such as narrow single band, dual band, wide band and multi-band antennas. These necessities keep in mind, antenna designers to developed low profile antennas with a better bandwidth at each band [1]. The microstrip antennas are very popular due to their low profile, low-cost, ease of fabrication, bandwidth and radiation properties. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally square, rectangular, circular and elliptical [2-3]. Therefore, the bandwidth enhancement is becoming a main kind design consideration for most practical applications of microstrip antennas for wireless communications. A plenty number of techniques have been established by the researchers to enhance the bandwidth of antennas. Many more techniques are used to enhance the bandwidth, most of these techniques some are summarized in [4-15].

However, these techniques are very difficult to design, so in this paper we concentrate on designing of a simple inverted T-slot loaded proximity coupled equilateral triangular microstrip antenna for enhancing bandwidth.

II. ANTENNA DESIGN CONSIDERATION

The Fig. 1 shows 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. The equilateral triangular microstrip patch antenna is made up of side length ‘a’ cm over a substrate S1 with substrate thickness ‘h’ cm. The value of ‘a’ is obtained from equation (1),

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

The proposed antennas are developed using software AutoCAD to achieve better accuracy and are fabricated on low cost glass epoxy substrate material of thickness h=0.32 cm with dielectric constant of ε_r = 4.2 and tan ð = 0.02. The photolithography process is used to fabricate the antenna. The antenna is fed by using micostripline feeding. 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 center of the radiating patch coincide one over the other. The bottom surface of the substrate S_2 acts as the ground plane. The h and ε_r of substrates $S_1$and S_2 are same. The dimensions of the ground plane L_g and W_g are calculated from equation 2,

$$W_g = L_g = 6h+a \qquad (2)$$

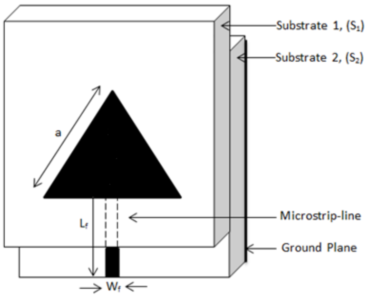

Figure.1. Geometry of PCETMSA

The proximity coupled uses a two-layer substrate with the microstrip line on the lower layer and the patch antenna on the upper layer as shown in Fig. 1. The feed line terminates in an open end underneath the patch. This feed is better known as an electromagnetically coupled microstrip feed. The main advantage of this feeding technique is that it eliminates spurious feed radiation and provides very high bandwidth, due to overall increase in the thickness of the microstrip patch antenna. The major disadvantage of this feed technique is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna.

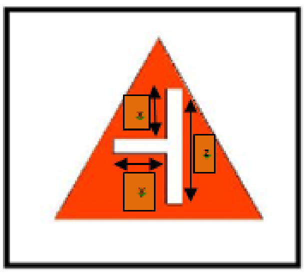

Figure.2. Top view of ITSPCETMSA

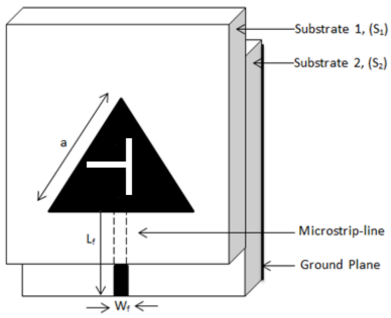

Figure.3. Geometry of ITSPCETMSA

Further the study is carried out by employing a inverted T-slot on the radiating patch which provides high extent in enhancement in bandwidth, where x, y and z are the dimensions of the slot. The top view and geometry of a

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inverted T-slot loaded proximity coupled equilateral triangular microstrip antenna (ITSPCETMSA) as shown in Fig. 2 and Fig. 3. All the specifications of designed antenna are given in Table. 1.

Table. 1 Designed specifications of the proposed antennas

Antenna Specifications	Dimensions in cm
Side length of equilateral triangle (a)	2.70
Length of the feedline L_f	2.5
Width of the feedlineW_f	0.633
Length and width of the ground plane (Lg and Wg)	4.6
Thickness of substrate S_1 and S_2 (h1+h2)	0.64
x	0.65
y	0.7
z	1.5

III. RESULT 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 variation of return loss versus frequency of PCETMSA is as shown in Fig. 4. From the figure it is clear that, the antenna resonates at f_1=2.82 GHz which is much closer to the designed frequency of 3 GHz and hence the validates the design. From this graph, the experimental impedance bandwidth is calculated using the formula (3),

$$BW = \left[\frac{f_2 - f_1}{f_c}\right] \times 100\% \qquad (3)$$

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 f_c is a center frequency between f_1 and f_2.The PCETMSA resonates at 3 GHz with impedance bandwidth of 6.97% (2.91GHz - 3.12GHz).From the Fig. 5, it is found that the ITSPCETMSA resonates at quad bands of frequencies f_1= 2.82 GHz (2.73GHz -2.93GHz), f_2= 4.74 GHz (4.44GHz - 5.44GHz), $f_{3=}$ 7.17 GHz (6.99GHz -7.39GHz) and $f_{4=}$ 8.75 GHz (8.28GHz-10GHz), so the overall band width measured for ITSPCETMSA is 52.52%. The proposed antenna is compared with conventional microstrip antenna. All the results are reported in Table. 2.

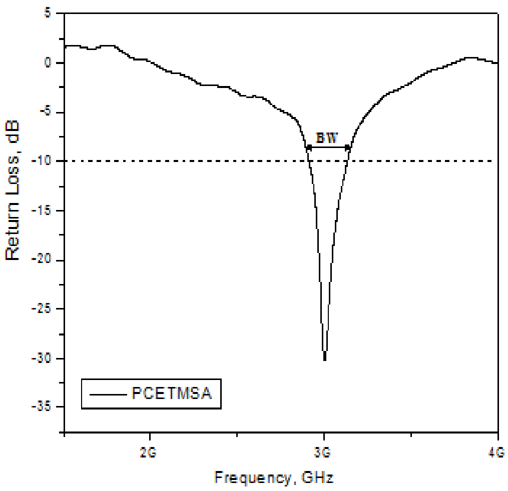

Figure. 4. Variation of Return Loss v/s Frequency of PCETMSA

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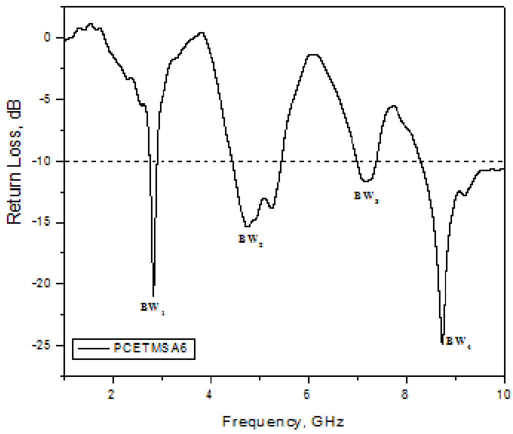

Figure. 5. Variation of Return Loss v/s Frequency of ITSPCETMSA

Tabel. 2. Results of all the proposed antenna

Antenna	Resonant Frequency(GHz)	Return loss (dB)	Bandwidth in (%)age	Overall Bandwidth in (%)age
PCETMSA	3	-30.26	6.97	6.97
ITSPCETMSA	2.82 4.74 7.17 8.75	-21.15 -15.49 -11.75 -24.89	7.06 21.09 5.56 18.81	52.52

The X-Y plane co-polar and cross-polar radiation patterns of PCETMSA and ITSPCETMSA are measured at their resonating frequencies and are shown in Fig.6 to Fig.10. For the measurement of radiation pattern, the antenna under test (AUT) i.e., the proposed antennas and standard pyramidal horn antenna are kept in far field region. The AUT, which is receiving antenna, is kept in phase with respective transmitting pyramidal horn antenna. The power received by AUT is measured from -0^0 to $+360^0$ with the step of 10^0. These figures indicate that the antennas show broad side radiation characteristics.

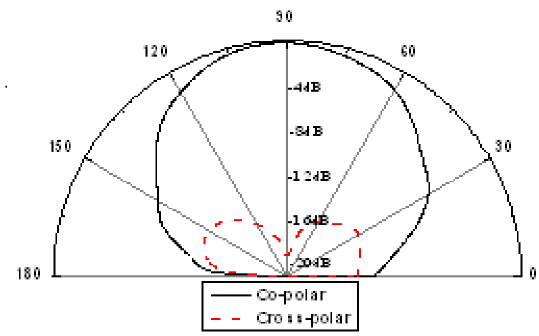

Figure. 6. Radiation pattern at 3 GHz

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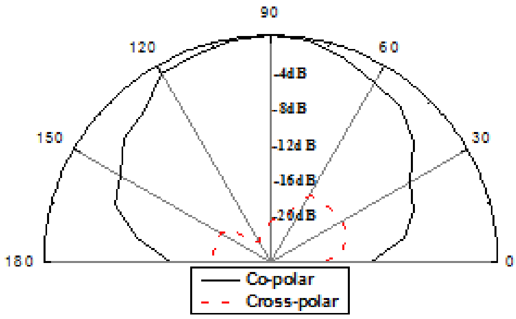

Figure. 7. Radiation pattern at 2.82 GHz

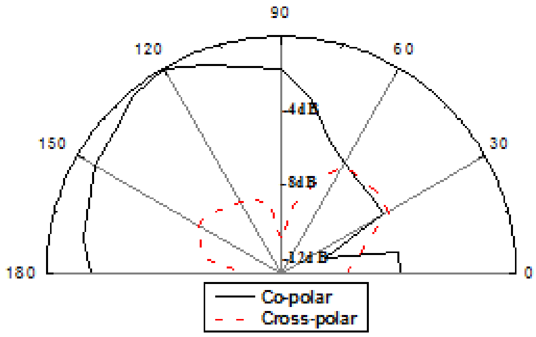

Figure. 8. Radiation pattern at 4.74 GHz

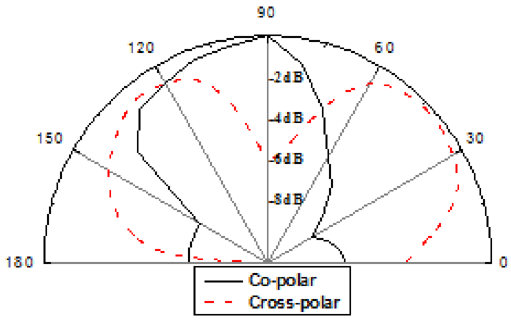

Figure. 9. Radiation pattern at 7.17 GHz

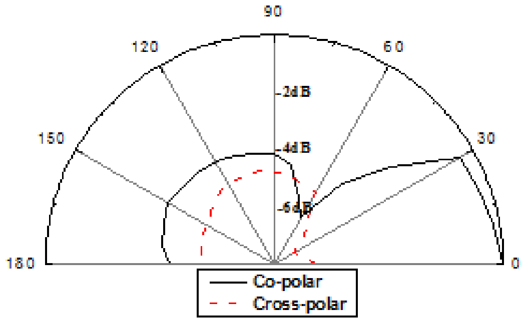

Fig. 10. Radiation pattern at 8.75 GHz

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IV. CONCLUSION

From the study, it is clear that the quad band operations of proposed antenna at four different bands of frequencies are possible by inserting a inverted T-slot on the patch with enhancement in bandwidth without affecting the primary band. The proposed antennas are very simple in their design and construction and they use low cost substrate material. These antennas may find application in IMT, WIMAX and SAR (Synthetic aperture radar).

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