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Slot Loaded Proximity Coupled Equilateral Triangular Microstrip Antenna for Penta Band Operation

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ABSTRACT: A novel technique for the bandwidth enhancement of conventional proximity coupled equilateral triangular microstrip antenna is proposed. When a notch-T shaped slot loaded over the patch, the bandwidth of the designed antenna was increased by more than eight times without affecting its radiation performance. The performance of the designed antenna was analysed in term of bandwidth, return loss and radiation pattern.The proposed antenna will be useful for IMT (International Mobile Communication), WLAN (Wireless local area network) and SAR (Synthetic aperture radar).

KEYWORDS: Equilateral triangular microstrip antenna, Proximity coupled, Notch-T slot, Bandwidth.

I.INTRODUCTION

The microstrip antenna have a number of useful properties such as small size, low-cost fabrication, low profile, light weight, conformability, ease of installation and integration with feed networks but one of the serious limitations of these antennas have been their narrow bandwidth characteristics as it limits the frequency ranges over which the antenna can perform satisfactorily [1]. But the fields of application of these antennas are limited by their inherent disadvantage of relatively low bandwidth. Some techniques are available in literature for enhancing the bandwidth of microstrip antennas such as use of thick substrates [2], inset feed design technique [3], addition of parasitic patches [4], some different shapes slot loaded on antenna [5-10] and proximity feeding techniques are used [11-13]. Moreover, the above techniques are complicated. To overcome these problems, in this paper a simple notch-T shaped slot loaded on proximity coupled equilateral triangular microstrip antenna to achieve the penta band operation with wide bandwidth.

II.ANTENNA DESIGN CONSIDERATION

The art work of the 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 δ = 0.02. The photolithography process is used to fabricate the antenna.The antenna is fed by using micostripline feeding. This feeding has been used because of its simplicity and it can be simultaneously fabricated along with the antenna element.

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 S_1 with substrate thickness ‘h’ cm. The value of ‘a’ is obtained from equation (1),

$$a = \frac{2C}{3 f_r \sqrt{\varepsilon_r}} \tag{1}$$

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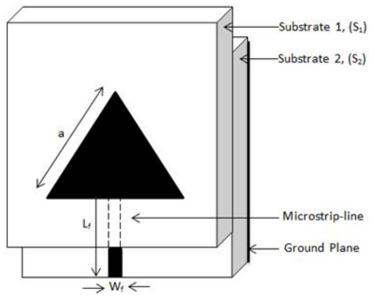

Fig.1 Geometry of PCETMSA

Where C is the velocity of light and f_r is the resonating frequency of the proposed antenna. 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. This type of feed technique is also called as the electromagnetic coupling scheme. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth due to overall in the increase in the thickness of the microstrip patch antenna.

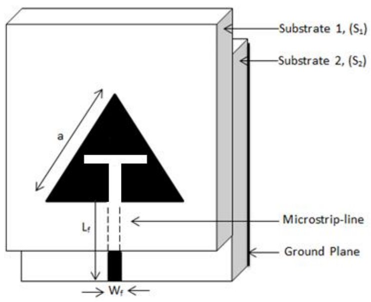

Fig.2 Geometry of NTSPCETMSA

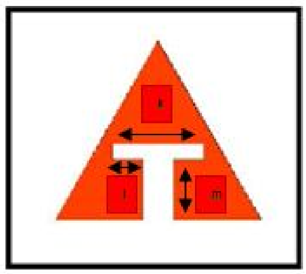

Fig.3 Top view of NTSPCETMSA

Further the study is carried out by employing a notch-T slot on the radiating patch which provides high extent in enhancement in bandwidth, where k, l and m are the dimensions of the slot. The geometry and top view of a notch-T slot loaded proximity coupled equilateral triangular microstrip antenna (NTSPCETMSA) 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 (L_g and W_g)	4.6
Thickness of substrate S1 and $S_2(h_1+h_2)$	0.64
k	1.2
l	0.4
m	0.8

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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 (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 f_c is a center frequency between f_1 and f_2.The PCETMSA resonates at 3GHz with impedance bandwidth of 6.97% (2.91GHz - 3.12GHz).From the Fig. 5, it is found that the NTSPCETMSA resonates at penta bands of frequencies f_1= 2.82 GHz (2.75GHz -2.87GHz), f_2= 4.91 GHz (4.44GHz - 5.28GHz), f_3= 7.11 GHz (6.97GHz -7.39GHz), f_4= 7.28 GHz (7.89GHz-8.03GHz)and f_5= 8.98 GHz (8.43 GHz – 10 GHz), so the overall band width measured for NTSPCETMSA is 46.61%. The proposed antenna is compared with conventional microstrip antenna. All the results are reported in Table. 2.

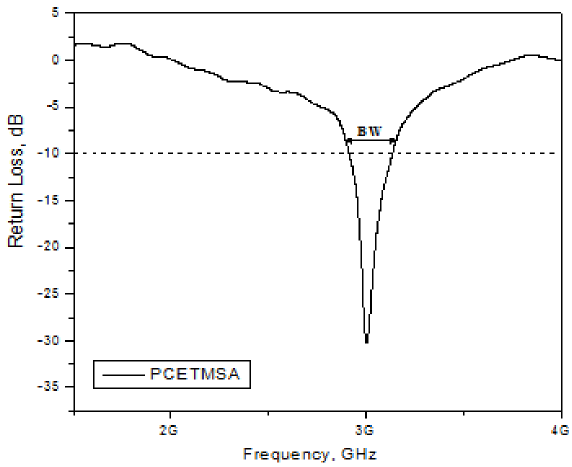

Fig. 4 Variation of Return Loss v/s Frequency of PCETMSA

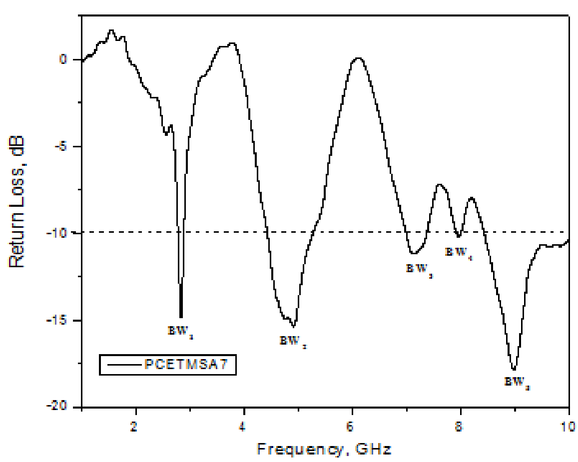

Fig. 5 Variation of Return Loss v/s Frequency of NTSPCETMSA

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Table. 2Results 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
NTSPCETMSA	2.82 4.91 7.11 7.98 8.98	-14.85 -15.45 -11.21 -10.33 -17.93	4.27 17.28 5.84 2.01 17.21	46.61

The X-Y plane co-polar and cross-polar radiation patterns of PCETMSA and NTSPCETMSA are measured at their resonating frequencies and are shown in Fig.6 to Fig.11. 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. From these figures it is clear that, there is reduction in back lobes and broader side in radiation characteristics.

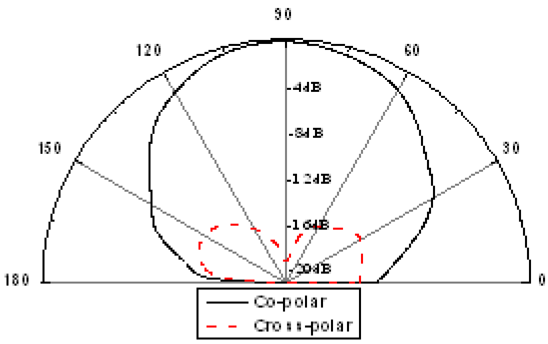

Fig. 6 Radiation pattern at 3 GHz

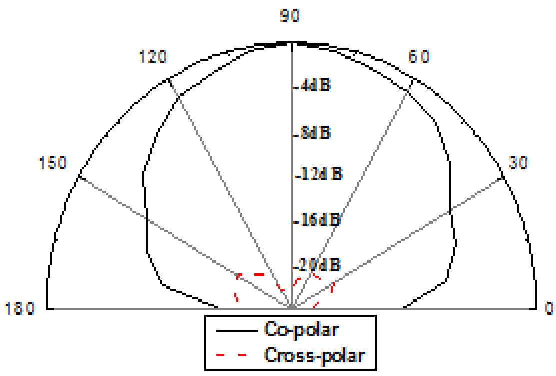

Fig. 7 Radiation pattern at 2.82 GHz

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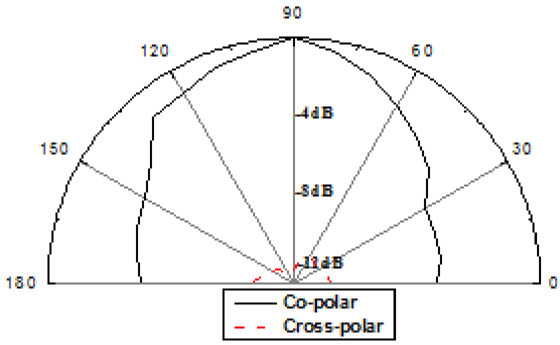

Fig. 8 Radiation pattern at 4.91 GHz

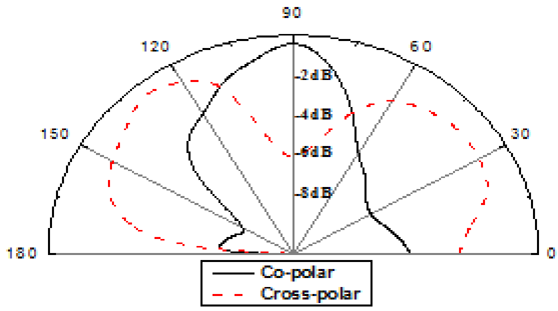

Fig. 9 Radiation pattern at 7.11 GHz

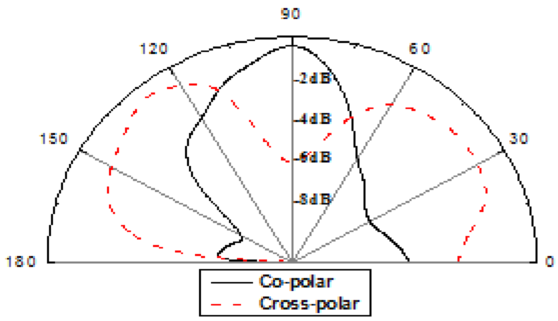

Fig. 10 Radiation pattern at 7.98 GHz

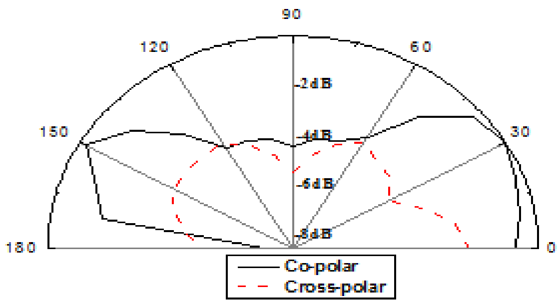

Fig. 11 Radiation pattern at 8.98 GHz

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IV.CONCLUSION

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 inserting notch-T slots i.e., NTSPCETMSA resonates for penta operating frequency bands and is quite good in enhancing the bandwidth with broadside radiation patterns at the resonating frequencies, which makes the antenna useful for IMT, WLAN (Wireless local area network) and SAR (Synthetic aperture radar) applications.

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