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Enhanced Bandwidth Proximity Coupled Equilateral Triangular Microstrip Antenna Loaded with Horizontal Rectangular Ring Slot

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ABSTRACT:In this communication proximity coupled equilateral triangular microstrip antenna consisting a horizontal rectangular ring shaped slot for quad band operation is designed and its performance is calculated with reference to conventional antenna. The proposed antenna operates between 2.71 to 8.66 GHz at four different frequency points. The antenna shows enhancement in bandwidth with broadside radiation characteristics has been achieved. The design concept of the antenna is given and experimental results are presented and discussed. This antenna will be useful for IMT, WLAN (Wireless local area network) and SAR (Synthetic aperture radar).

KEYWORDS: Equilateral triangular microstrip antenna, Proximity coupled, Horizontal rectangular ring slot, Bandwidth.

I. INTRODUCTION

In these days, there is a very big demand of microstrip patch antennas for use in mobile and wireless applications due to of its very cheap in cost, easily available in market, light weight and compact in size. Also the design and fabrication process of antennas is very simple and their production is also easy. There are plenty of varieties patch designs available but the square, rectangular, circular and elliptical shapes are most frequently used. In this paper we use equilateral triangular patch antenna. But these microstrip antennas have some disadvantages in low bandwidth, low gain and also low in efficiency [1-7]. There are many ways by which we can enhance the bandwidth of microstrip antennas. In order to enhance the bandwidth of a patch antenna, several techniques have been proposed, such as, by using thick substrates [8], cutting slots on the patch [9], by using aperture coupled stacked patch antennas [10], coaxial feeding technique [11], stacked patch fed through microstrip line technique [12], proximity coupled feeding techniques [13-15] etc.

The main achievement of this paper is to present the enhancement bandwidth of microstrip antenna using horizontal rectangular ring slot loaded on the patch of proximity coupled equilateral triangular microstrip antenna. The experimental result indicates that when inserting slot on the conventional microstrip antenna which gives a wide operating bandwidth and good radiation patterns.

II. ANTENNA DESIGN CONSIDERATION

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 $\varepsilon_r = 4.2$ and tan ð = 0.02. The photolithography process is used to fabricate the antenna. The antenna is fed by using micostripline feeding. This feeding has been used because of its simplicity and it can be simultaneously fabricated along with the antenna element.

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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),

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

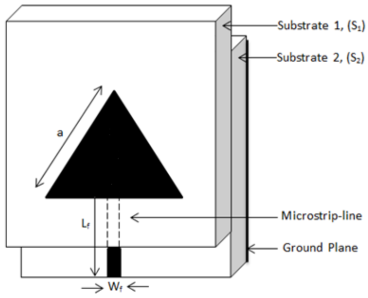

Figure.1. Geometry of PCETMSA

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.

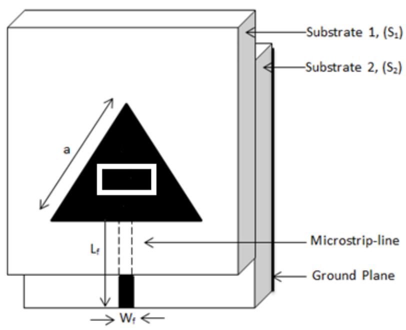

Figure.2. Geometry of HRRSPCETMSA

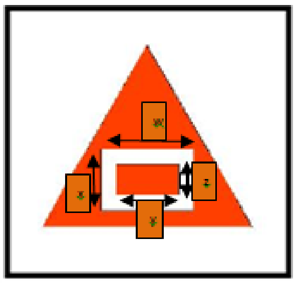

Figure.3. Top view of HRRSPCETMSA

The extended work is carried out by employing a horizontal rectangular ring slot on the radiating patch which provides high extent in enhancement in bandwidth, where w, x are the dimensions of outer ring and y, z are the dimensions of inner ring of the slot. The geometry and top view of horizontal rectangular ring slot loaded proximity coupled equilateral triangular microstrip antenna (HRRSPCETMSA) as shown in Fig. 2 and Fig. 3. All the specifications of designed antenna are given in Table. 1.

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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 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
w	1.2
x	0.8
y	0.8
z	0.4

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=2.71 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 HRRSPCETMSA resonates at quad bands offrequencies f_1= 2.71 GHz (2.66GHz -2.77GHz), f_2= 4.72 GHz (4.30GHz - 5.27GHz), $f_{3=}$ 7.06 GHz (6.99GHz -7.17GHz) and$f_{4=}$ 8.66 GHz (8.13GHz-10GHz), so the overall band width measured for HRRSPCETMSA is 48.45%. The proposed antenna is compared with conventional microstrip antenna. All the results are reported in Table. 2.

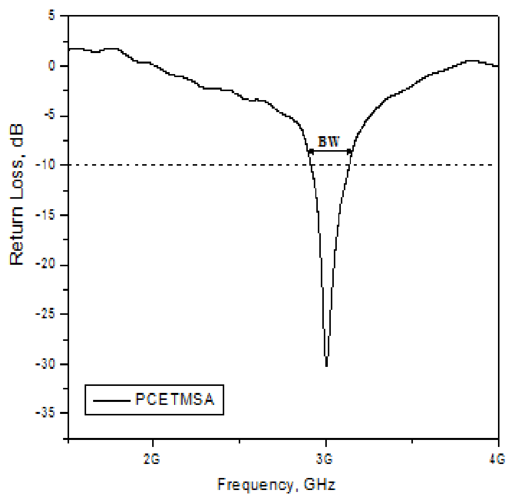

Figure. 4. Variation of Return Loss v/s Frequency of PCETMSA

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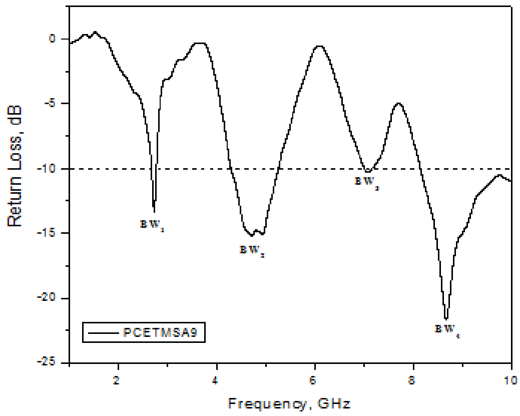

Figure. 5. Variation of Return Loss v/s Frequency of HRRSPCETMSA

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
HRRSPCETMSA	2.71 4.72 7.06 8.66	-13.39 -15.27 -10.42 -21.80	4.05 20.27 2.54 21.59	48.45

The X-Y plane co-polar and cross-polar radiation patterns of PCETMSA and HRRSPCETMSA 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. From these figures it is clear that, there is reduction in back lobes and broader side in radiation characteristics.

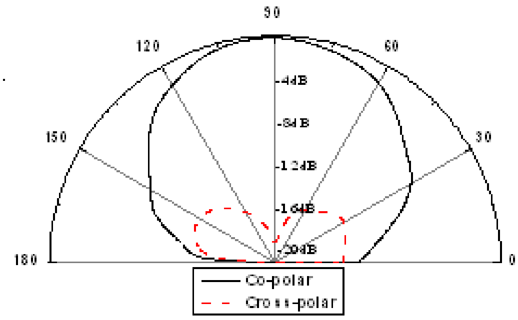

Figure. 6. Radiation pattern at 3 GHz

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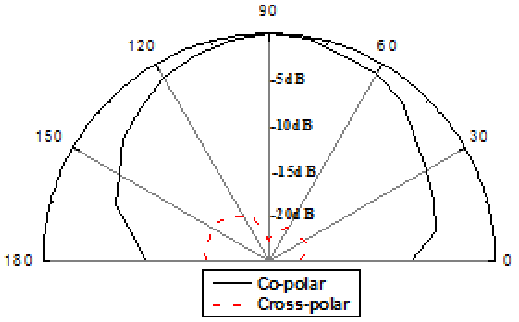

Figure. 7. Radiation pattern at 2.71 GHz

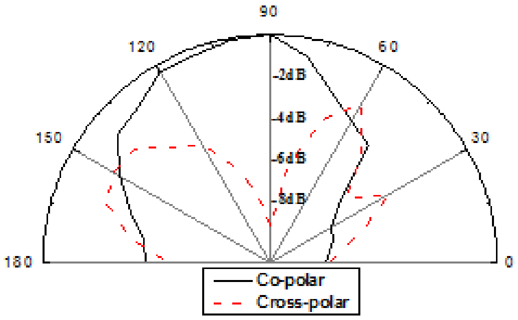

Figure. 8. Radiation pattern at 4.72 GHz

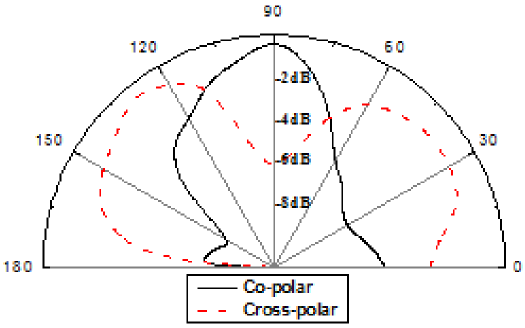

Figure. 9. Radiation pattern at 7.06 GHz

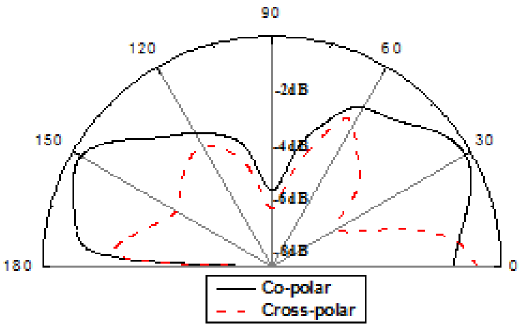

Figure.10. Radiation pattern at 8.66 GHz

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IV. CONCLUSION

Experimental results indicate that impedance bandwidth of the conventional antenna can be significantly improved by employing horizontal rectangular ring slot on the patch i.e., HRRSPCETMSA resonates for quad 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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