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Research Paper

Vertical Rectangular Ring Slot Loaded Proximity Coupled Equilateral Triangular Microstrip Antenna for Wireless Applications

Engineering

KEYWORDS : Equilateral triangular microstrip antenna, Proximity coupled, Vertical rectangular ring slot, bandwidth.

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ABSTRACT

A generalized method is presented to determine vertical rectangular ring shaped slot loaded proximity coupled equilateral triangular microstrip antenna for quad band operation. The quad band frequency points are achieved at 2.84 to 8.57 GHz. Effect of slot implemented on the patch is evaluated experimentally for enhancing much better bandwidth with reference to conventional microstrip antenna. The various parameters are measured and practical results are presented and discussed. The proposed antennas may find applications for IMT, WIFI IEEE802.11 and radar systems.

INTRODUCTION

Microstrip antennas are used in a wide range of applications, but due to its narrow impedance bandwidth restriction occurs. The microstrip patch antenna is very well known form of printed antenna. Microstrip patch antennas are getting popular in wireless application due to their simple geometry and low fabrication cost. It is a very important element in communications and radar applications since it provides a wide variety of designs, either planar or conformal. The microstrip antennas can be fed by various techniques, besides its advantage of being compact and suitable for antenna designs. The microstrip antenna generally consists of a radiating element (patch), an intermediate dielectric layer and a ground plane. The radiating element or patch is generally made of conductingmaterial such as copper or gold and can take any possible shape like rectangular, square, circular, elliptical, etc [1, 2].

Microstrip antenna performance is affected by the patch geometry, substrate properties and feed techniques. The advantages of microstrip antennas are the freedom to choose from a variety of patch designs [3]. However, the general microstrip antennas have some disadvantages such as narrow bandwidth. There are many and new technique methods to enhance the bandwidth of microstrip antennas, implementing in increase thickness of dielectric substrate, slotted patch antenna and use of several feeding techniques [4-14].

This paper concentrate on enhancing bandwidth of an antenna inserting a new vertical rectangular slot on the proximity coupled equilateral triangular patch. By selecting a suitable slot shape, choosing proper feeding technique, a large operating bandwidth is achieved.

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

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

In this paper 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 tanδ =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 S1 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,

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

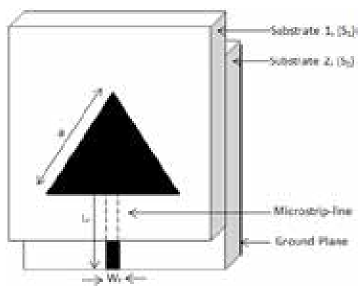

Figure 1: Geometry of PCETMSA

vThe 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.

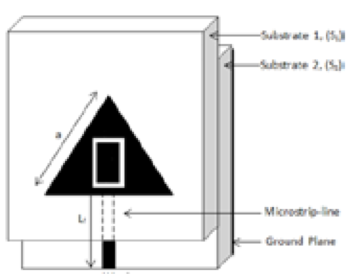

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Figure 2: Geometry of VRRSPCETMSA

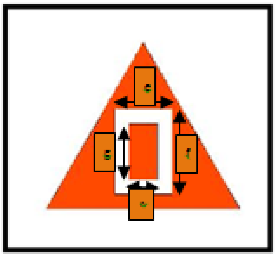


Figure 3: Top view of VRRSPCETMSA

Further the study is carried out by employing a vertical rectangular ring slot on the radiating patch which provides high extent in enhancement in bandwidth, where e, f are the dimensions of outer ring and g, h are the dimensions of inner ring of the slot. The geometry and top view of vertical rectangular ring slot loaded proximity coupled equilateral triangular microstrip antenna (VRRSPCETMSA) 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 S_1 and S_2 (h_1+h_2)	0.64
e	0.8
f	1.2
g	0.8
h	0.4

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=2.84 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 3GHz with impedance bandwidth of 6.97% (2.91GHz - 3.12GHz). From the fig. 5, it is found that the VRRSPCETMSA resonates at quad bands of frequencies f_1= 2.84 GHz (2.73GHz -2.93GHz), f_2= 4.92 GHz (4.61GHz - 5.16GHz), f_3= 7.10 GHz (7.03GHz -7.17GHz) andf_4= 8.57 GHz (8.08GHz-10GHz), so the overall band width measured for VRRSPCETMSA is 42.70%. The proposed antennais compared with conventional microstrip antenna. All the results are reported in Table. 2.

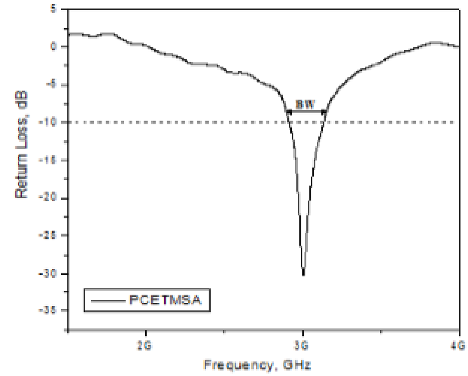


Figure 4: Variation of Return Loss v/s Frequency of PCETMSA

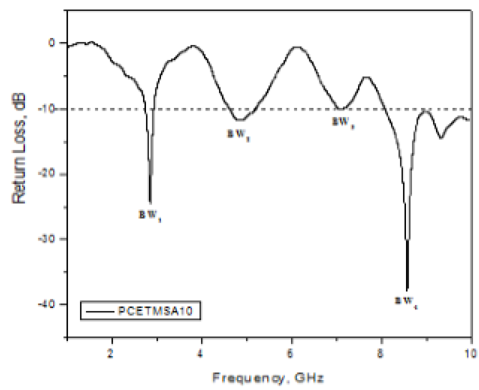


Figure 5: Variation of Return Loss v/s Frequency of VRRSPCETMSA

Table - 2
Results of the entire proposed antenna

Antenna	Resonant Frequency (GHz)	Return loss (dB)	Bandwidth in (%)age	Overall Bandwidth in (%)age
PCETMSA	3	-30.26	6.97	6.97
VRRSPCET-MSA	2.84 4.92 7.10 8.57	-24.49 -11.89 -10.06 -37.96	7.08 11.25 1.97 22.40	42.70

The X-Y plane co-polar and cross-polar radiation patterns of PCETMSA and VRRSPCETMSA 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 figuresindicate that the antennas show broad side radiation characteristics.

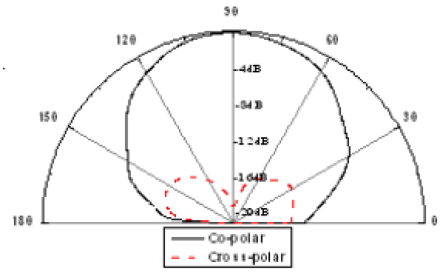


Figure 6: Radiation pattern at 3 GHz

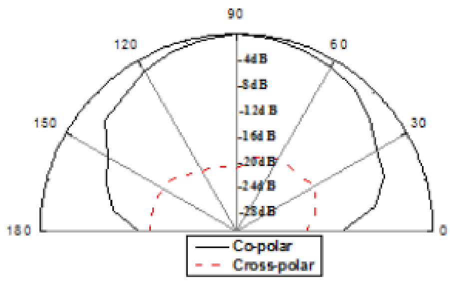


Figure 7: Radiation pattern at 2.84 GHz

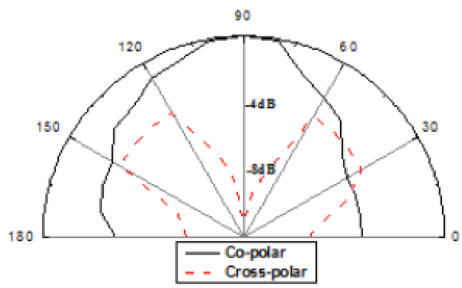
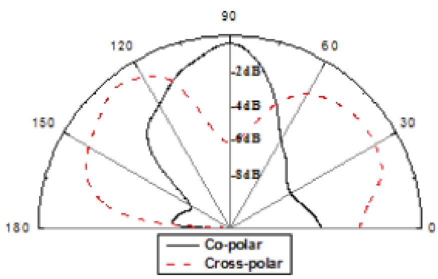


Figure 8: Radiation pattern at 4.92 GHz



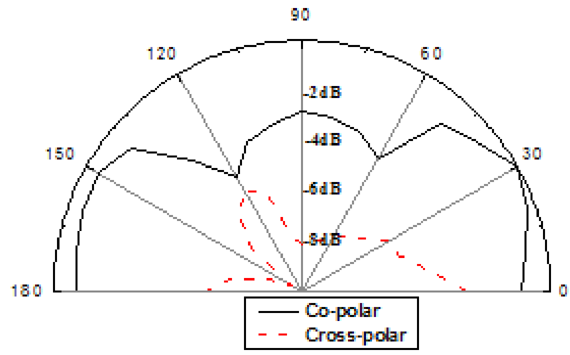


Figure 10: Radiation pattern at 8.57 GHz

CONCLUSIONS

From the detailed experimental study it is concluded that, the proposed antenna VRRSPCETMSA is quite capable of enhancing the bandwidth by 42.70%, when compared to PCETMSA. The radiation characteristics of PCETMSA and VRRSPCETMSA broadside in nature and reduction in back lobes. These antennas are very simple in their geometries and fabrication. Such antennas may find applications for IMT, WIFI IEEE802.11 and radar systems.

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