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CORNERS TRUNCATED UNIPOLAR RECTANGULAR MICROSTRIP ANTENNAS FOR QUAD BAND OPERATION AND ENHANCEMENT OF GAIN

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ABSTRACT: A novel design of microstripline feed corners truncated unipolar rectangular microstrip antenna proposed for wideband operation. Two opposite corners of the rectangular radiating patch are truncated symmetrically to obtain quad-band operation in the frequency range of 4 to 16 GHz. By truncating four corners of the patch the antenna shows enhancement of gain in all operating bands. This antenna also retains quad-band operation and resonance frequencies of operating bands. The proposed antennas are simple in their structure and they use low cost substrate material. The antenna gives a peak gain of 11.18 dB with ominidirectional radiation characteristics. These proposed antennas may find applications in microwave communication systems.

Keywords: Microstrip Antenna, Unipolar, Slot, Ominidirectional, Corners truncation

I.INTRODUCTION

Microstrip antennas are popular because of compact size, simple in design, low cost and capable of operating more than one band of frequencies. Owing to its thin profile, light weight, low cost, planar configuration and easy fabrication, the microstrip antenna is the better choice for these requirements. Number of investigations has been reported in the literature for the design and development of monopole antennas [4-12]. In this paper a simple technique has been demonstrated to construct the unipolar antennas for quad band and enhancement of gain. Further most of the antennas presented in the literature are uses complex structure. In this study we have used a simple technique to achieve quad-band operation and enhancement of gain by truncating four corners of the rectangular radiating patch.

II. DESIGN OF ANTENNA GEOMETRY

The art work of the proposed antenna is sketched by using computer software Auto-CAD to achieve better accuracy and is fabricated on low cost FR4-epoxy substrate material of thickness of h = 0.16 cm and permittivity $\varepsilon_r = 4.4$.

Figure 1 shows the top view geometry of two corners truncated unipolar rectangular microstrip antenna (TCTURMSA). In Fig.1 the area of the substrate is $L \times W$ cm. On the top surface of the substrate a ground plane of height which is equal to the length of microstripline feed L_f is used on either sides of the microstripline with a gap of 0.1 cm desired gap is maintained between microstripline feed and top ground plane. However gap is maintained as small as possible for better coupling effect. The value lesser than 0.1 cm is difficult to fabricate practically and hence it has been chosen as 0.1 cm. On the bottom of the substrate a continuous ground copper layer of height L_f is used below the microstripline. The TCTURMSA is designed for 3 GHz of frequency using the equations available for the design of conventional rectangular microstrip antenna in the literature [2]. The length and width of the rectangular patch are L_p and W_p respectively. The feed arrangement consists of quarter wave transformer of length L_t and width W_t which is connected as a matching network between the patch and the microstripline feed of length L_f and width W_f. A semi miniature-A (SMA) connector is used at the tip of the microstripline feed for feeding the microwave power. In Fig.1

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two opposite corners of the radiating patch are truncated symmetrically with vertical and horizontal lengths X and Y. The values of X and Y are taken in terms of λ_o and these are equal to $\lambda_o/50$ and $\lambda_o/12.34$ respectively.

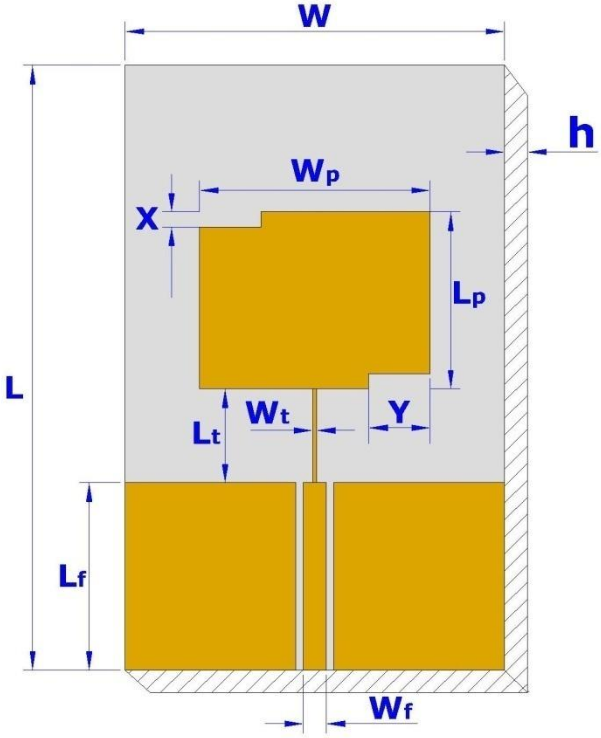

Fig. 1 Top view geometry of TCTURMSA

Figure 2 shows the geometry of four corners truncated unipolar rectangular microstrip antenna (FCTURMSA). In this figure four corners of the rectangular radiating patch are truncated symmetrically with vertical and horizontal lengths of X and Y. The values of X, Y and the other geometry of Fig. 2 remain same as that of Fig.1. The design parameters of the proposed antenna is shown in Table 1

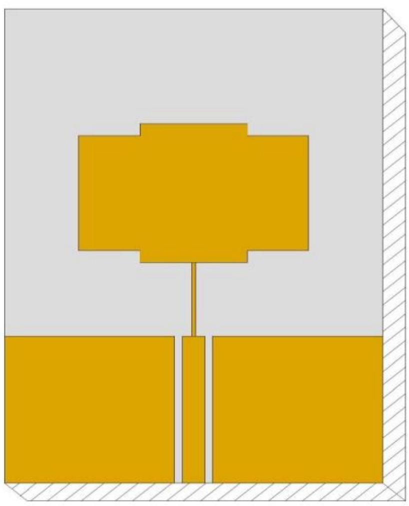

Fig. 2 Top view geometry of FCTURMSA

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TABLE 1

DESIGN PARAMETERS OF PROPOSED ANTENNA

Antenna parameter	L	W	L_p	W_p	L_f	W_f	L_t	W_t	X	Y
Dimensions in cm	8.0	5.0	2.34	3.04	2.48	0.3	1.24	0.05	0.2	0.81

III. EXPERIMENTAL RESULTS

The antenna bandwidth over return loss less than -10 dB is simulated using HFSS simulating software and then tested experimentally on Vector Network Analyzer (Rohde & Schwarz, Germany make ZVK model 1127.8651). The variation of return loss verses frequency of TCTURMSA is as shown in Fig. 3. From this graph the experimental bandwidth (BW) is calculated using the equations,

$$\mathrm{BW} = \left[\frac{f_2 - f_1}{f_c}\right] \times 100\ \% \qquad (1)$$

were, f_1 and f_2 are the lower and upper cut of frequencies of the band respectively when its return loss reaches – 10 dB and f_c is the centre frequency of the operating band. The variation of return loss verses frequency of TCTURMSA is as shown in Fig. 3. From this figure it is seen that, the antenna operates for four bands of frequencies BW_1 to BW_4. The magnitude of these operating bands measured at BW_1 to BW_4 is found to be 90 MHz (1.90 %), 540 GHz (7.27 %), 1.71 GHz (18.65 %) and 2.74 GHz (41.32 %) respectively.

The resonant mode f_1 at 4.76 GHz is due to the fundamental resonant frequency of the patch and others modes f_2 and f_3 are due to the novel geometry of TCTURMSA. The multi mode response obtained is due to different surface currents on the patch. The fundamental resonant frequency mode f_1 shifts from 3 GHz designed frequency to 4.76 GHz due to the coupling effect of microstripline feed and top ground plane of TCTURMSA. The simulated results of TCTURMSA is also shown in Fig. 3. The experimental and simulated results are in close agreement from BW_2 to BW_4.
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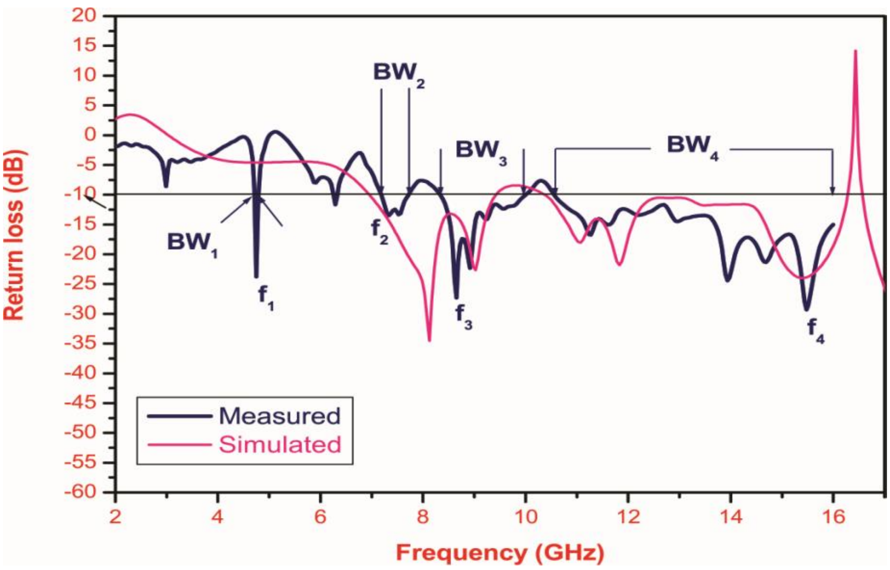

Fig. 3 Variation of return loss versus frequency of TCTURMSA

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The variation of return loss verses frequency of FCTURMSA is as shown in Fig. 4. From this figure it is seen that, the antenna operates for four bands of frequencies BW_5 to BW_8. The magnitude of these operating bands measured at BW_5 to BW_8 is found to be 150 MHz (3.12 %), 330 GHz (4.51 %), 1.66 GHz (18.16 %) and 2.76 GHz (41.84 %) respectively. The resonating modes f_5, f_6, f_7 and f_8 remain same when compared to f_1, f_2, f_3 and f_4 of Fig.3 of TCTURMSA. The highest impedance bandwidth of FCTURMSA is found at BW_8 which is equal to 41.86 with minimum return loss of -32.97 dB. The simulated results of FCTURMSA is also shown in Fig. 4. The experimental and simulated results are in close agreement from BW_6 to BW_8.

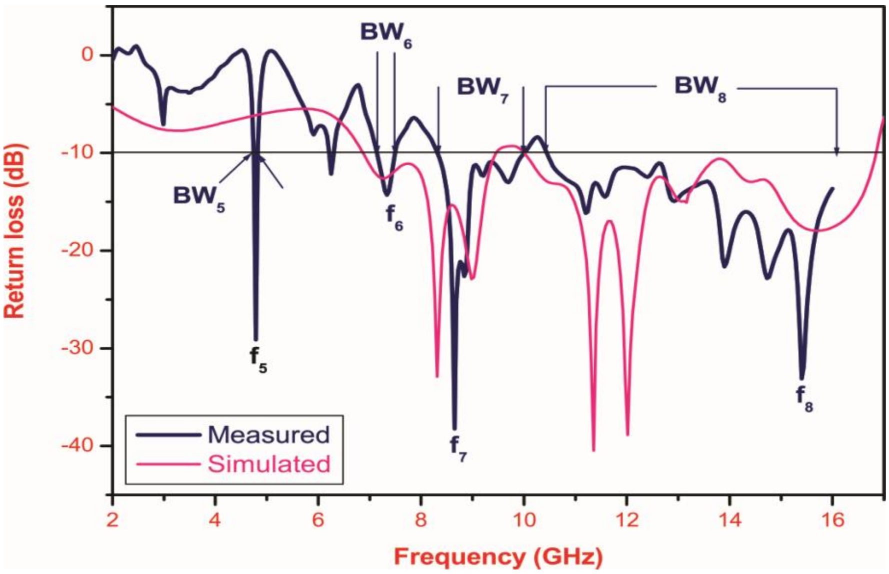

Fig. 4 Variation of return loss versus frequency of MHCRMA

The gain of the TCTURMSA and FCTURMSA is measured by absolute gain method. The power transmitted 'P_t' by pyramidal horn antenna and power received 'P_r' by antenna under test (AUT) are measured independently. With the help of these experimental data, the gain (G) dB of AUT is calculated by using the formula,

$$(G)\ \mathrm{dB} = 10 \log\left(\frac{P_r}{P_t}\right) - (G_t)\ \mathrm{dB} - 20\log\left(\frac{\lambda_0}{4\pi R}\right)\mathrm{dB} \quad (2)$$

where, G_t is the gain of the pyramidal horn antenna and R is the distance between the transmitting antenna and the AUT. Using equation (2). The maximum gain of proposed antennas measured in their operating bands BW_1 to BW_8 is tabulated in Table 2. From this table it evident that, the FCTURMSA is capable of giving lager gains in all operating bands when compared to the gain of TCTURMSA

Table 2
Measured gains of antennas TCTURMSA and FCTURMSA

Frequencies in GHz	Gain of antenna TCTURMSA in dB	Gain of antenna FCTURMSA in dB
4.76 GHz	9.70	11.18
7.32 GHz	6.39	6.73
8.63 GHz	8.46	8.85
15.40 GHz	5.95	6.27

The co-polar and cross-polar radiation pattern of TCTURMSA and FCTURMSA are measured at 4.76 GHz. The typical radiation patterns measured at 4.76 GHz are shown in Fig 5 to 6 respectively. The obtained patterns are

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ominidirectional in nature. The cross-polar power levels of proposed antennas are -4.69 and −5.72 dB respectively. The cross-polar power levels are down compared to co-polar power level.

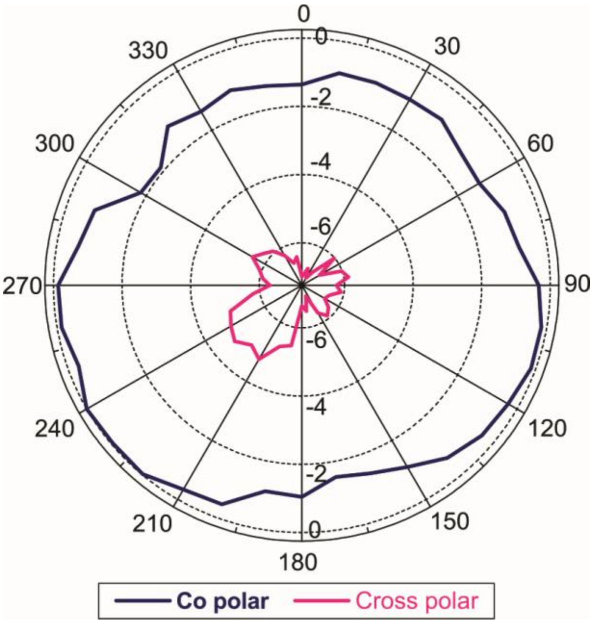

Fig. 5 Typical radiation pattern of TCTURMSA measured at 4.76 GHz

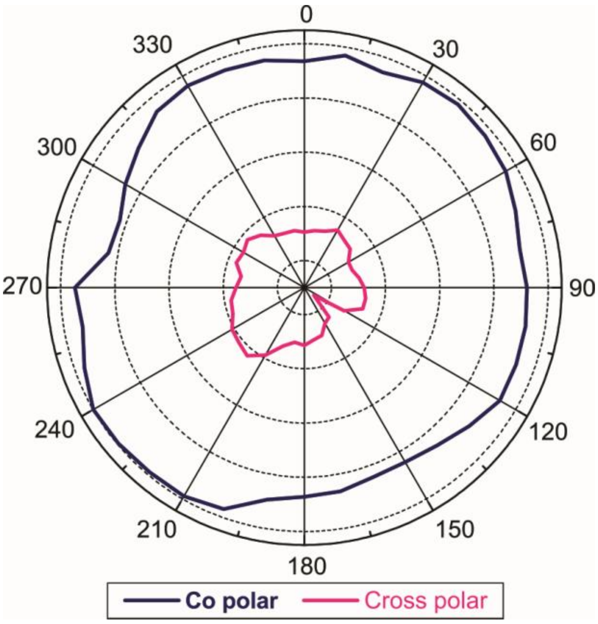

Fig. 6 Typical radiation pattern FCTURMSA measured at 4.76 GHz

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IV. CONCLUSION

From the detailed experimental study, it is concluded that, the TCTURMSA with microstripline feed have been designed for quad-band operation with a peak gain of 9.70 dB. The antenna operates for four bands of frequencies in the range of 4 to 16 GHz. If four corners of the patch are truncated symmetrically, the antenna operates again for four bands and also retains same resonant frequencies. The antenna shows enhancement of gain in all operating bands with ominidirectional radiation characteristics. The proposed antennas are simple in their structure and they use low cost substrate material FR4. With these features the proposed antennas may find applications in microwave communication systems operating in the frequency range of 4 to 16 GHz.

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BIOGRAPHY

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