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Open Stubs Loaded Rectangular Microstrip Antenna

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ABSTRACT: In this paper a open stubs loaded rectangular microstrip antenna (OSRMSA) is designed, fabricated and analysed. This antenna resonates from 2.23 GHz to 9.93 GHz of frequencies and exhibits multiband operation with a maximum gain of about 7.43GHz. A centre fed 50Ω microstripline feed arrangement is used to excite antenna. The other antenna parameters like return loss, bandwidth and radiation pattern are studied and discussed. This antenna may be useful for C and S band applications.

Keywords: Microstrip antenna, open stub, multiband and gain.

I. INTRODUCTION

The rapid development of the wireless communication systems is currently observed in the microwave band. Since for past few decades, the microstrip antennas (MSA) have gained popularity because of their inherent features like light weight, low cost, simple design and capacity to resonate at more than one frequency bands [1-2], which can avoid the use of multiple antennas for different wireless applications.

Several methods and techniques have been reported in the literature. The miniaturization of antenna and multiple frequency bands can be achieved by cutting slots of different geometries like rectangular, triangular, H-shape, U-shape etc. on radiating patch [3 – 6]. Moreover, in the modern communication era, it would be a difficult task to design the single antenna capable of performing transmission and reception operations. A similar study is made for multi band operation and virtual size reduction using slits on rectangular microstrip antenna [7]. In this paper, a simple technique has been proposed for multiple frequency operation by loading the rectangular patch antenna with open stubs. This kind of technique is found to be rare in the literature.

II. DESIGN CONSIDERATION

The proposed antenna has been realized from conventional rectangular microstrip antenna (CRMSA) designed for the frequency of 3.2 GHz. The geometry of CRMSA is as shown in Fig. 1. The radiating patch with size W x L is etched on glass epoxy substrate material of dielectric constant $\varepsilon_r = 4.2$ and tan $\delta = 0.02$, having dimension of X x Y with thickness h = 0.16 cm. A simple 50Ω microstripline feed structure of length L_f and width W_f is used to excite the antenna at the center of the rectangular radiating patch. The quarter wavelength matching transformer of length L_t and width W_t is used to match the impedance of microstripline feed and radiating patch.

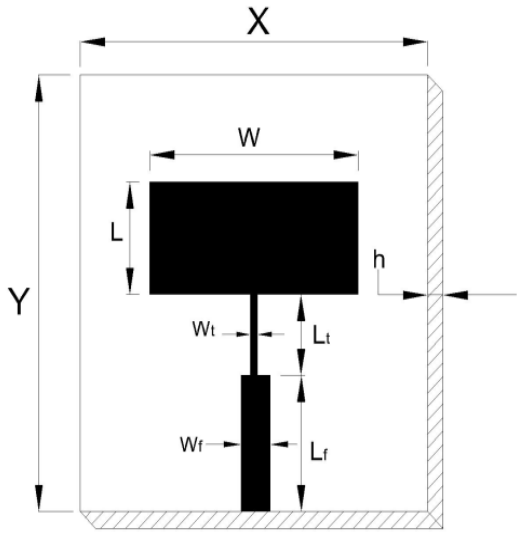

Fig. 1. Top view geometry of CRMSA.

The configuration of OSRMSA is shown in Fig. 2. All the open stubs from S_1 to S_4 are of same length L_s and width W_s. The open stubs S_1 and S_3 are inserted vertically from the bottom side of the radiating edge of the patch, while the open stubs S_2 and S_4 are inserted vertically from the top side of the radiating edge of the patch. All the stubs are extended such that they are perpendicularly crossing the center axis of the patch by a distance of 0.18cm. The distance D between adjacent stubs S_1, S_2 and S_3, S_4 is 0.4cm. The distance of S_2 and S_3 from the center axis is d_C = 0.4cm. The distance between the stub and edge of the patch is taken as d_1 = 0.255cm and d_2 = 0.255cm.

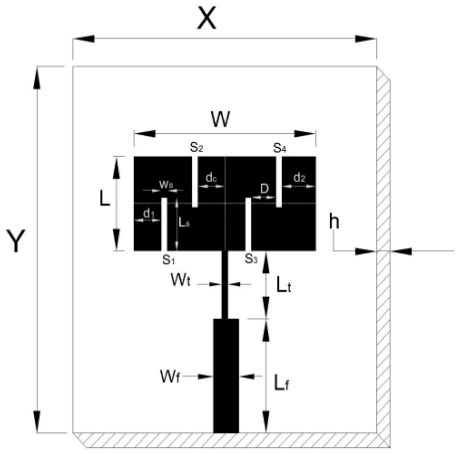

Fig. 2. Top view geometry of OSRMSA.

The designed parameters of CRMSA and OSRMSA are shown in Table 1 and Table 2 respectively.

Table 1.

Antenna parameters	Dimensions in cm
X	5.3
Y	9.82
W	2.91
L	2.24
W_f	0.317
L_f	2.183
W_t	0.078
L_t	1.372
h	0.16

Table 2.

Antenna parameters	Dimensions in cm
W_S	0.2
L_S	1.3
D	0.4
d1	0.255
d2	0.255
d_C	0.4

III. EXPERIMENTAL RESULTS AND DISCUSSION

The Vector Network Analyzer (Rohde Schwarz, Germany make ZVK model 1127.8651) is used to measure the experimental return loss less than -10dB.

Table 3.

Antenna	Resonant frequency in GHz	Return Loss in dB	Band Width %
CRMSA	2.98	-20.02	2.34
	f_1 = 2.23	-20.08	1.79
OSRMSA	f_2 = 5.24	-19.30	3.81
	f_3 = 5.70	-16.33	5.08
	f_4 = 6.25	-23.52	4.96
	f_5 = 7.78	-12.89	2.95
	f_6 = 9.93	-12.11	1.51

It is also used to measure characteristic parameters of an antenna like resonant frequency, radiation pattern, bandwidth etc.
The calculated results are summarized in Table 3.

The return loss versus frequency of CRMSA is shown in Figure 3. It is seen from this figure that, the resonant frequency for CRMSA is 2.98 GHz which is nearer to designed frequency 3.2 GHz and the impedance bandwidth over return loss less than -10 dB is found to be 2.34%.

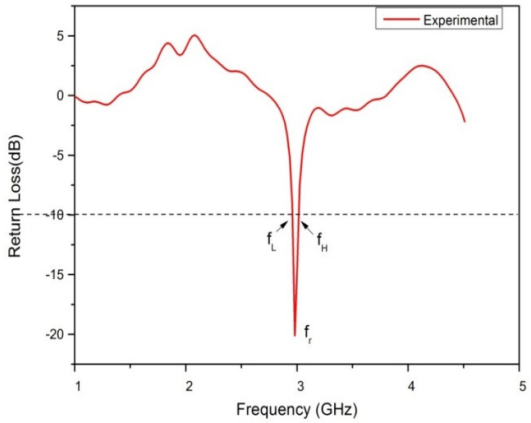

Fig. 3 Variation of return loss versus frequency of CRMSA

The return loss versus frequency of OSRMSA is shown in Figure 4. From this figure it is clear that, the open stubs loaded antenna resonates for six bands of frequencies from 2.23 GHz to 9.93 GHz, i.e. f_1= 2.23 GHz, f_2 = 5.24 GHz, f_3 = 5.70 GHz, f_4 = 6.25 GHz, f_5 = 7.78 GHz and f_6 = 9.93 GHz with their respective bandwidths, BW_1 = 1.79%, BW_2 = 3.81%, BW_3 = 5.08%, BW_4 = 4.96%, BW_5 = 2.95% and BW_6 = 1.51%. The first bandwidth BW_1 is due to the fundamental resonance of the patch and the other bands from BW_2 to BW_6 are due to open stubs on the rectangular patch. The first resonant frequency f_1 = 2.23 GHZ is observed to be shifted towards the lower frequency side from the designed frequency of 3.2 GHz when compared to resonating frequency of CRMSA.

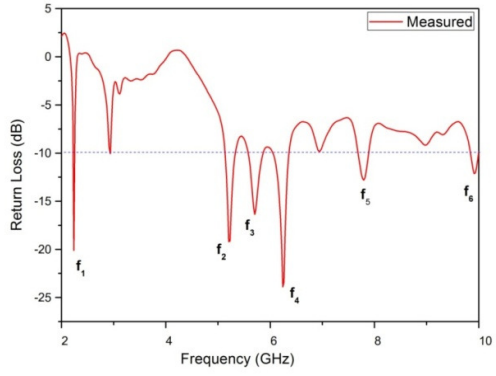

Fig. 4 Variation of return loss versus frequency of OSRMSA.

Fig. 5(i) and (ii) shows the radiation patterns of CRMSA and OSRMSA measured at resonating frequencies 2.98 GHz and 2.23 GHz respectively. The radiation patterns are observed to be broadside in nature and linearly polarized.

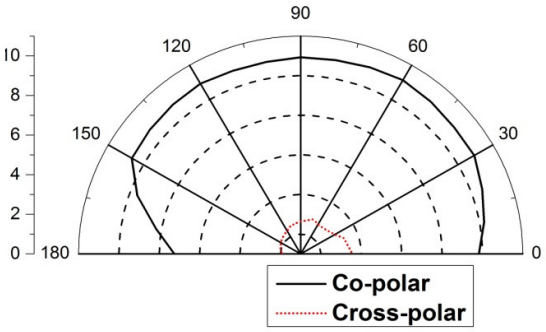

Fig.5 (i) Radiation pattern of CRMSA at 2.98GHz.

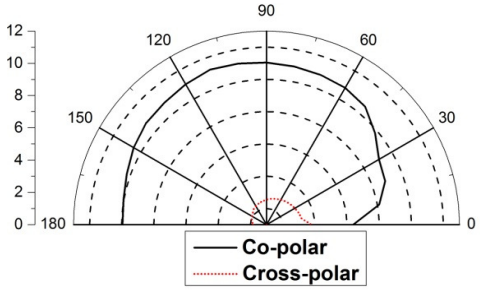

Fig.5 (ii) Radiation pattern of OSRMSA at 2.23GHz.

The gain of CRMSA and OSRMSA is calculated using absolute gain method given by the formula,

$$(G)dB = 10\log\left(\frac{Pr}{Pt}\right) - (G_t)dB - 20log\left(\frac{\lambda_0}{4\pi R}\right)dB \quad ...(2)$$

where G_t is the gain of the pyramidal horn antenna and R is the distance between the transmitted antenna and the antenna under test (AUT). The power received by AUT, "P_r", and the power transmitted by standard pyramidal horn antenna "P_t" are measured independently. The gain measured for CRMSA and OSRMSA is found to be 5.75 dB and 7.43dB respectively.

CONCLUSION

The designed antennas CRMSA and OSRMSA are studied and discussed. The proposed antenna resonates between 2.23 GHz to 9.93GHZ. The introduction of open stubs make the OSRMSA to show multiband operation with a maximum gain of about 7.43GHz and better broadside radiation characteristics.

The design method is simple and this antenna may be useful for C and S applications.

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