International Journal of Electronics and Electrical Engineering
ISSN : 2277-7040 Volume 1 Issue 1
http://www.ijecee.com/ https://sites.google.com/site/ijeceejournal/

Design and Development of simple low cost Rectangular Microstrip Antenna for multiband operation.

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Abstract- This paper presents the design and development of simple low cost rectangular microstrip antenna for multiband operation. By incorporating U-slot of optimum geometry and open stubs at two opposite corners on the rectangular radiating patch the antenna operates between 1.815 to 9.01 GHz at different frequency bands with a virtual size reduction of 44.84% and gives broadside radiation characteristics at each operating band. By placing U-slot and open stubs at the corners, the copper area of the patch is reduced to 8.50%, when compared to the copper area of conventional rectangular microstrip antenna designed for the same frequency. The experimental and simulated results are in good agreement with each other. The design concept of antenna IS given and experimental results are discussed. The proposed antenna may find applications in mobile, WLAN, WiMax and SAR.

Key words : Open stubs, U-slot, multiband.

1. INTRODUCTION

In the present communication scenario microstrip antennas are becoming popular because of their numerous advantages like low profile, low fabrication cost, mechanical robustness, conformability to curved surfaces and integrability with MMICs [1]. Modern communication systems such as mobile, WLAN, WiMax and SAR are uses antennas operating at definite frequency bands. But a antenna operating at differen frequency bands simultaneously is more useful and avoids the use of multiple antennas. The multiband antennas are realized by using many methods such as, variable inductive or capacitive loads to the patch [2], loading of shorting walls at different locations [3-4], stub loading technique [5], integrating varactor diodes to the radiating patches and changing their biasing voltages [6] etc. But in this study a simple technique has been used by loading U-slot and placing open stubs at the corners of the patch for multiband operation. This kind of study is found to be rare in the literature.

2. ANTENNA DESIGN

The conventional rectangular microstrip antenna (CRMSA) and the proposed U-slot rectangular microstrip antenna (USRMSA) are fabricated on low cost glass epoxy substrate material of thickness h = 0.166 cm, loss tangent = 0.01 and ε_r = 4.2. The art work of proposed antennas is sketched using the computer software AUTO CAD to achieve better accuracy. The antennas are etched using the photolithography process.

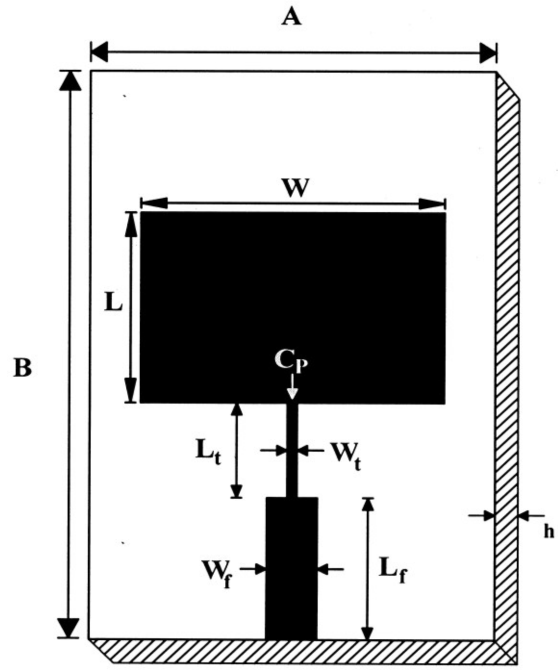


Figure 1 Top view geometry of CRMSA.

Figure 1 shows the top view geometry of CRMSA. The radiating patch of length L and width W are designed for the resonant frequency of 3.5 GHz, using the basic equations available in the literature [7]. A quarter wave transformer of length L_t and width W_t is used between C_P along the width of the patch and microstripline feed of length L_f and width W_f for matching their impedances.

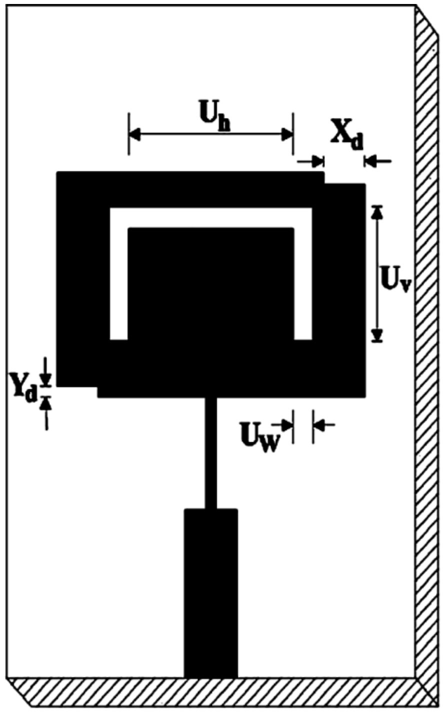
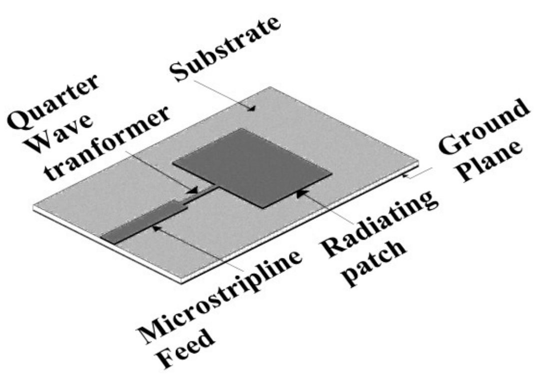
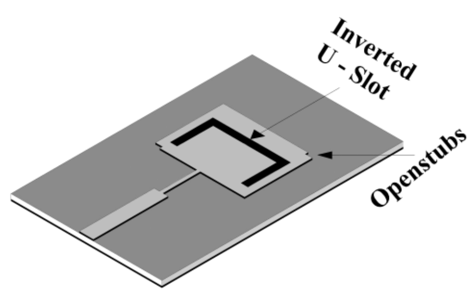


Figure 2 Top view geometry of USRMSA

Figure 2 shows the top view geometry of USRMSA. This antenna is developed by placing open stubs at two diagonally opposite corners of CRMSA with the dimensions of X_d and Y_d. The U-slot is placed symmetrical about the center on the patch. The horizontal arm length U_h and the vertical arm length U_v of U-slot are taken as $\lambda_0/6$, where λ_0 is the free space wavelength in cm corresponding to the designed frequency of 3.5 GHz. The U_w is the width of the horizontal and vertical arms of U-slot. Figure 3 (a) and (b) show the three dimensional view of CRMSA and USRMSA respectively. Table-1 shows the designed parameters of proposed antennas.



(a) 3D view of CRMSA



(b) 3D view of USRMSA

Figure 3 3D views of CRMSA and USRMSA

Table 1. Design Parameters of proposed antennas

Antenna Parameters	W	W_f	W_t	L	L_f	L_t	U_h	U_v	X_d	Y_d	A	B
Dimensions in cm	2.66	0.32	0.06	2.04	2.18	1.09	$\lambda_0/85$	$\lambda_0/42$	0.8	0.2	5	8

3. RESULTS AND DISCUSSION

The German make (Rohde and Schwarz, ZVK model 1127.8651) Vector Network Analyzer is used to measure the experimental return loss of CRMSA and USRMSA. The simulation of the CRMSA and USRMSA is carried out by using Ansoft HFSS simulation software.

Figure 4 shows the variation of return loss versus frequency of CRMSA. From this figure it is seen that, the CRMSA resonates at 3.39 GHz of frequency which is close to the designed frequency of 3.5 GHz. The experimental bandwidth is calculated using the formula,

$$\text{Bandwidth (\%)} = \frac{f_2 - f_1}{f_c} \times 100\%$$

where, f_2 and f_1 are the upper and lower cut off frequencies of the resonated band when its return loss reaches -10dB and f_c is a centre frequency between f_1 and f_2. The bandwidth of CRMSA is found to be 3.27 %. The simulated result of CRMSA is also shown in Fig. 4.

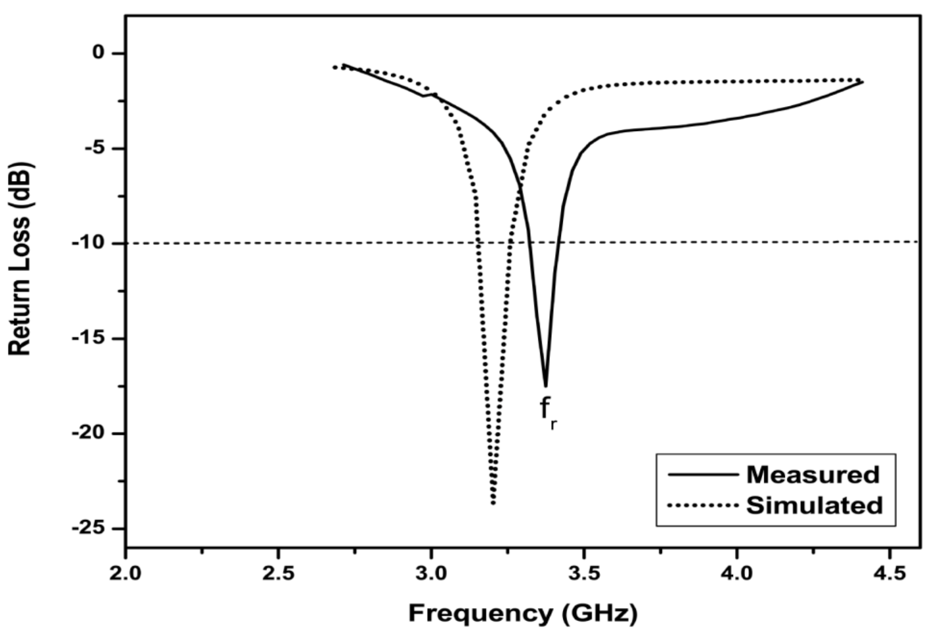


Figure 4 Variation of return loss versus frequency of CRMSA

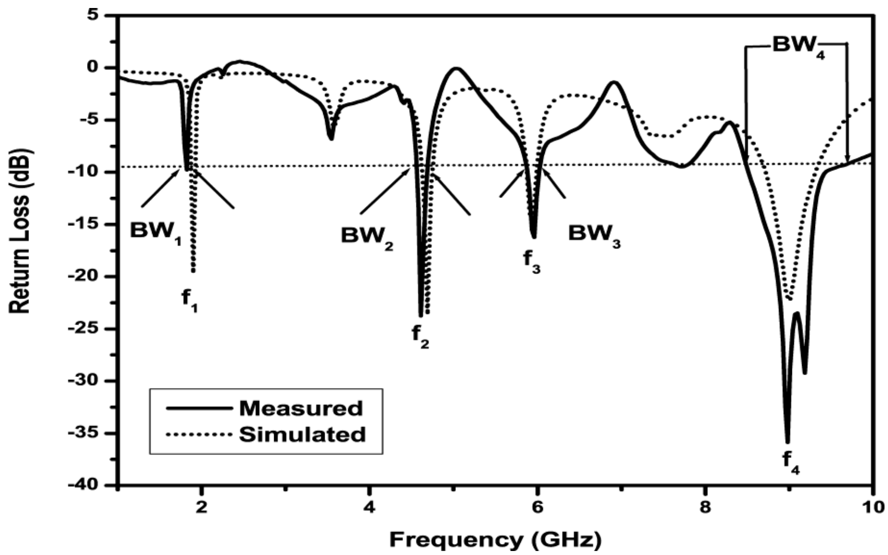


Figure 5 Variation of return loss versus frequency of USRMSA when U_w = 0.1 cm

Figure 5 shows the variation of return loss versus frequency of USRMSA. It is clear from this figure that, the antenna operates for four bands BW_1 (1.779-1.851 GHz), BW_2 (4.53-4.72 GHz), BW_3 (5.83-6.1 GHz) and BW_4 (8.44-9.75 GHz) for the resonating modes of f_1, f_2 f_3 and f_4 respectively, when U_w = 0.1 cm. The four bands BW_1, BW_2, BW_3 and BW_4 are due to the independent resonance of patch, two open stubs and U-slot of USRMSA respectively. The simulated result of USRMSA is also shown in Fig. 5 which is in good agreement with the experimental results. The magnitude of operating bandwidth BW_1, BW_2, BW_3 and BW_4 are found to be 3.96 %, 4.11 %, 4.525 % and 14.4% respectively. By comparing the resonant mode f_1 of USRMSA to f_r of CRMSA it is clear that, the USRMSA gives virtual size reduction of 44.84%. Further USRMSA uses less copper area of 8.50% when compared to the copper area of CRMSA by placing U-slot and open stubs on the patch.

The far field co-polar and cross-polar radiation patterns of the proposed antennas are measured in their operating bands. The typical radiation patterns of CRMSA and USRMSA measured at 3.39 and 4.62 GHz are as shown in Fig. 6 and 7 respectively.

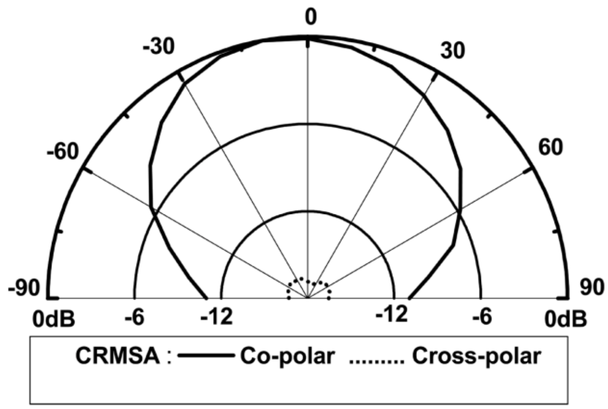


Figure 6 Radiation pattern CRMSA measured at 3.39 GHz

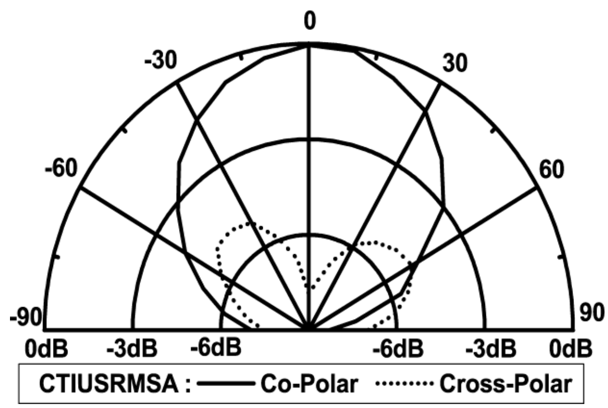


Figure Radiation pattern of USRMSA measured at 4.62 GHz

From these figures it is observed that, the patterns are broadsided and linearly polarized. The gain in dB of antenna under test (AUT) is calculated using absolute gain method given by the equation [14],

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

where, P_t and P_r are transmitted and received powers respectively. R is the distance between transmitting antenna and AUT. The peak gain USRMSA measured in BW_1 is found to be 0.60dB.

4. Conclusion

From the detailed study it is clear that, multiband operation of antenna can be achieved through the novel design of USRMSA which is constructed from CRMSA. The antenna operates between 1.815 to 9.01 GHz at different frequency bands with a virtual size reduction of 44.84% and gives broadside radiation characteristics at each operating band.

By placing U-slot and open stubs at the corners, the copper area of the patch is reduced to 8.50%, when compared to the copper area of conventional rectangular microstrip antenna. The experimental results of return loss versus frequency of proposed antennas are in good agreement with the simulated results. The proposed antennas are simple in their design and fabrication and they use low cost substrate material. These antennas may find applications in mobile communication, wireless local area network (WLAN), worldwide interoperability for microwave access (WiMAX) and synthetic aperture radar (SAR).

Acknowledgement

The authors thank the authorities of Dept. of Sc. & Tech. (DST), Govt. of India, New Delhi, for sanctioning the Vector Network Analyzer under the FIST project to the Department of Applied Electronics, Gulbarga University, Gulbarga.

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