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# Open Stub Loaded Rectangular Microstrip Antenna for WLAN and WiMAX Applications

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***Abstract:*** This paper presents a simple design of open stub loaded rectangular microstrip antenna for multiband operation. Two open stubs of suitable dimensions are placed at two diagonally opposite corners on the rectangular radiating patch. The antenna operates between 3.555 to 8.66 GHz at five independent frequency bands with almost constant frequency ratio of 1.45. The proposed antenna exhibits broadside and linearly polarized radiation characteristics in its operating band and gives a peak gain of 1.43 dB. This technique also reduces the copper area of the patch by 8.84% when compared to the copper area of conventional patch 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 WLAN and WiMAX.

***Keywords:*** Open stubs, frequency ratio, multiband.

## 1. INTRODUCTION

In the present communication era the microstrip antennas have attained wide applications because of their numerous advantages like low profile, low cost, planar, robustness, and conformability to curved surfaces, ease of installation and fabrication [1]. Modern communication systems, such as wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) use antennas operating at definite frequency bands. The need of the hour is to design and develop an antenna operating for different frequency bands simultaneously which 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 placing open stubs at the diagonally opposite corners of the rectangular patch to achieve multiband operation. This kind of study is found to be rare in the literature.

## 2. ANTENNA DESIGN

The conventional rectangular microstrip antenna (CRMSA) and open stub loaded rectangular microstrip antenna (OSRMSA) are fabricated using low cost glass epoxy substrate material of thickness h = 0.166 cm and relative permittivity $\varepsilon_r$ = 4.2. The art work of these antennas is sketched using computer software auto CAD to get better accuracy. The proposed antennas are etched using photolithography process.

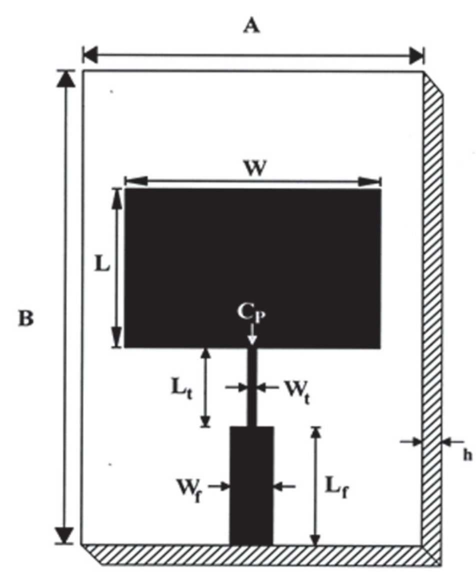



**Figure 1: Top View Geometry of CRMSA**

Figure 1 shows the top view geometry of CRMSA which is designed by using the basic equations available in the literature [7]. The bottom surface of the substrate is tight copper shielding. The L and W are the length and width of the radiating patch corresponding to the designed frequency of 3.5 GHz. 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.

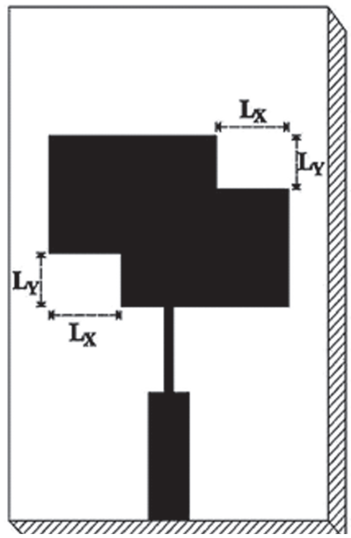
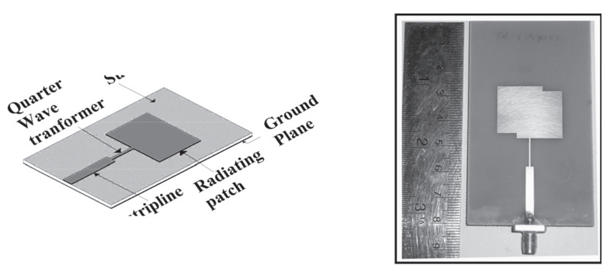



**Figure 2: Top View Geometry of OSRMSA**

Figure 2 shows the top view geometry of OSRMSA. This antenna has been realized by modifying the top geometry of CRMSA. In Figure 2, two open stubs of dimensions $L_X$ and $L_Y$ are placed at diagonally opposite corners on the patch. Figure 3 (a) and (b) show the three dimensional view of CRMSA and photo graph of OSRMSA respectively. Table 1 shows the designed parameters of proposed antennas.




(a) 3D view of CRMSA (b) Photograph of OSRMSA

**Figure 3: 3D View of CRMSA and Photograph of OSRMSA**

**Table 1**
**Design Parameters of Proposed Antennas**

| *Antenna* | *W* | $W_f$ | $W_t$ | *L* | $L_f$ | $L_t$ | $L_X$ | $L_Y$ | *A* | *B* |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | | | | | | | | | | |
| Dimensions in cm | 2.66 | 0.32 | 0.06 | 2.04 | 2.18 | 1.09 | 0.6 | 0.4 | 5 | 8 |

## 3. RESULTS AND DISCUSSION

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

$$\text{Bandwidth } (\%) = \frac{f_H - f_L}{f_C} \times 100\%$$

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

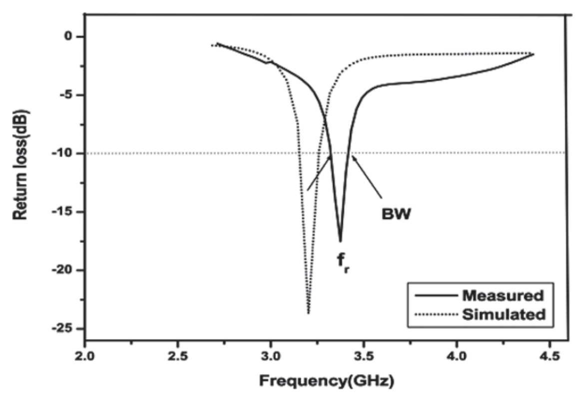



**Figure 4: Variation of Return Loss versus Frequency of CRMSA**

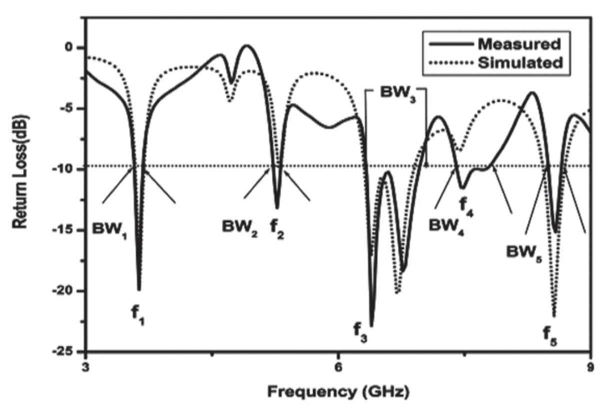



**Figure 5: Variation of Return Loss versus Frequency of OSRMSA**

Figure 5 shows the variation of return loss versus frequency of OSRMSA. It is clear from this figure that, the antenna operates for five band of frequencies $BW_1$ (3.555-3.7036 GHz), $BW_2$ (5.20-5.34 GHz), $BW_3$ (6.29-7.00 GHz), $BW_4$ (7.39-7.83 GHz) and $BW_5$ (8.48-8.66 GHz) for the resonant modes of $f_1$, $f_2$, $f_3$, $f_4$ and $f_5$ respectively. The five bands $BW_1$ to $BW_5$ are due to the independent resonance of patch and two open stubs placed on the patch. The simulated result of OSRMSA is also shown in Figure 5 which is in good agreement with the experimental results. The magnitude of each operating band $BW_1$ to $BW_5$ are found to be 4.1%, 2.66%, 10.68%, 5.78% and 2.1% respectively. The frequency ratio is calculated by taking the resonant frequency of consecutive bands of OSRMSA as shown in Figure 5 which is nearly equal to 1.45. This indicates that the operating bands lie at equal distance from each other. Further OSRMSA uses less copper area of 8.84% when compared to the copper area of CRMSA by placing open stubs on the patch.

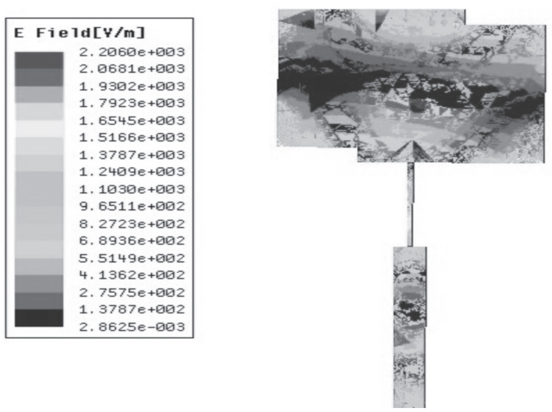



**Figure 6: Current Distributions on OSRMSA**

Figure 7 shows the current distribution on OSRMSA. It is clear from this figure that, by inserting the open stubs along the opposite corner of the patch, the density of current distribution is more along the edges, when compared to the current at the center of the patch which helps the patch for better radiation.

The far field co-polar and cross-polar radiation patterns of CRMSA and OSRMSA measured in their operating bands i.e. at 3.39 and 3.63 GHz are as shown in Figure 7 and 8 respectively.

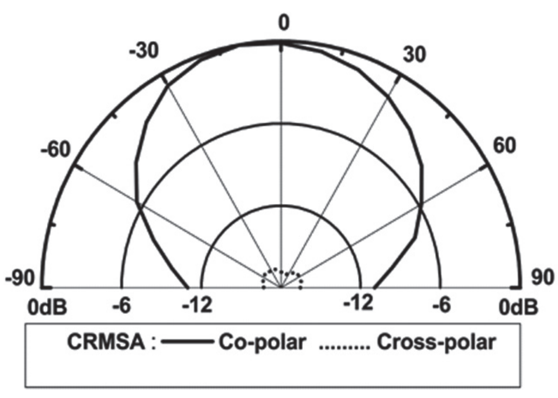



**Figure 7: Radiation Pattern CRMSA Measured at 3.39 GHz**

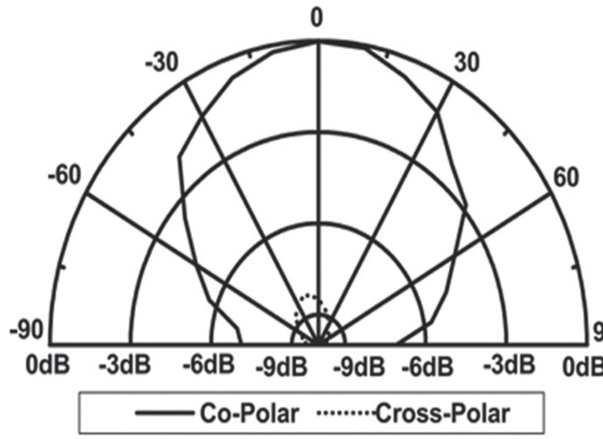



**Figure 8: Radiation Pattern of OSRMSA Measured at 3.63 GHz**

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

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

where, $P_t$ and $P_r$ are transmitted and received powers respectively. $R$ is the distance between transmitting antenna and AUT. The peak gain of CRMSA and OSRMSA measured in BW and $BW_1$ respectively are found to be 0.9 and 1.43 dB.

## 4. CONCLUSION

From the detailed study it is clear that, the multiband operation of antenna can be achieved through the simple design of OSRMSA which is constructed from CRMSA. The antenna operates between 3.555 to 8.66 GHz at five independent frequency bands. By placing open stubs at the corners, the copper area of the patch is reduced to 8.84% and the gain is increased by 1.58 times when compared to the copper area and gain of CRMS respectively. The experimental result of return loss versus frequency of proposed antenna is in good agreement with the simulated result. The proposed antenna is simple in its design and uses low cost substrate material for its fabrication. This antenna may find applications in WLAN (3.46-5.125 GHz) and WiMAX (4.25- 5.75GHz).

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## REFERENCES

[1] Constantine A. Balanis, Antenna Theory: Analysis and Design, John Wiley, NewYork, 1997.

[2] Girish Kumar and K. P. Ray, Broadband Microstrip Antennas, Artech House, Boston, London, 2003.

[3] J. Ollikainen, M. Fischer and P. Vainikainen, Thin Dual Resonant Stacked Shorted Patch Antenna for Mobile Communications, *Electron Lett.,* 35 (1999), 437-439.

[4] A. Mishra, P. Singh, N. P. Yadav, J. A. Ansari and B.R. Vishvakarma, Compact Shorted Microstrip Patch Antenna for Dual Band Operation, PIER C, 9 (2009), 171-182.

[5] K. P. Ray and G. Kumar, Stub Loaded Circular Microstrip Antennas Proc. APSYM-98, Kochi, India, (1998), pp. 84-87.

[6] S. V. Shynu, G. Augastin, C. K. Aanandan, P. Mohanan and K. Vasudevan, C-shaped Slot Loaded Reconfigurable Microstrip Antenna, *Electron Lett.,* 42, (2006), 316-318.

[7] Bahl, I. J. and P. Bhartia, Microstrip Antennas, Artech House, New Delhi, 1.