DUAL OPEN STUB LOADED SQUARE MICROSTRIP ANTENNA FOR WLAN AND WIMAX APPLICATIONS

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ABSTRACT

In this communication the square microstrip antenna consisting of dual open stubs is presented for quad band operation. The antenna operates between 2.88 to 8.55 GHz. The antenna is constructed with its structure of dimension 8 X 5 X 0.16 cm$^3$. The microstripline feed arrangement along with quarter wave transformer is used to excite the antenna. The antenna exhibits a broadside and linear radiation characteristics. The peak gain of 3.21 dB is obtained in the operating band. The results are presented and discussed. This antenna may find its applications in WLAN and Wimax communication system.

Key words: Square, gain, microstrip antenna.

1. INTRODUCTION

The microstrip antennas (MSAs) have gained popular position in today’s communication system because of their inherent attractive features like light weight, planar in structure, ruggedness, different geometries and shapes, easy installation, low fabrication cost [1] etc. It is the need of the hour to select the antenna that uses single antenna for transmit/receive purpose. The microstrip antenna designers worked hard to put forth many methods and techniques such as cutting slots of different geometries like triangular, bow-tie, rectangular narrow slot, square, circular ring etc. on the radiating patch [2-7], use of corner truncated patches, implementing stubs and shorts on the patches [8-10] etc. to achieve dual, triple and multiband operations. But the antenna operating at four independent bands is presented with simple stub loading technique. This kind of study is found to be rare in the literature.

2. DESIGNING

The low cost glass epoxy substrate material of area $A \times B$, thickness $h = 0.16$ cm and dielectric constant $\varepsilon_r = 4.2$ is used to fabricate the proposed antenna. The artwork of the antenna is
sketched using computer software Auto CAD to achieve better accuracy. Photolithography process is used to fabricate the antenna.

Figure 1: Top view geometry SMSA

Figure 1 shows the top view geometry of square microstrip antenna (SMSA), which is designed for the resonant frequency of 3.5 GHz using the equations available in the literature for the design of square microstrip antenna [11]. The SMSA consists of a square radiating patch of equal length (L) and width (W). The \( L_f \) and \( W_f \) are the length and width of the microstripline used to excite the patch. A semi miniature-A (SMA) connector of 50\( \Omega \) impedance is used at the tip of the microstripline to feed the microwave power. A quarter wave transformer of length \( L_t \) and width \( W_t \) is used to match the impedances between lower radiating edge of the patch and microstripline feed.

Figure 2: Geometry of DOSMSA

Figure 2 shows the geometry of dual open stub loaded square microstrip antenna (DOSMSA). Two open stubs of horizontal and vertical lengths \( X \) and \( Y \) respectively are placed at two diagonally opposite corners of the SMSA. Table 1 gives the design parameters of SMSA and DOSMSA.

<table>
<thead>
<tr>
<th>Antenna</th>
<th>( L )</th>
<th>( W )</th>
<th>( L_f )</th>
<th>( W_f )</th>
<th>( L_t )</th>
<th>( W_t )</th>
<th>( A )</th>
<th>( B )</th>
<th>( X )</th>
<th>( Y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMSA</td>
<td>2.04</td>
<td>2.04</td>
<td>2.18</td>
<td>0.32</td>
<td>1.09</td>
<td>0.06</td>
<td>5</td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DOSMSA</td>
<td>2.04</td>
<td>2.04</td>
<td>2.18</td>
<td>0.32</td>
<td>1.09</td>
<td>0.06</td>
<td>5</td>
<td>8</td>
<td>0.8</td>
<td>0.2</td>
</tr>
</tbody>
</table>

3. EXPERIMENTAL RESULTS

The Agilent Technologies make (Agilent N5230A: A.06.04.32), Vector Network Analyzer is used to measure the experimental return loss of SMSA and DOSMSA.
Figure 3: Variation of return loss versus frequency of SMSA

Figure 3 shows the variation of return loss versus frequency of SMSA. From this figure it is seen that, the SMSA resonates at 3.43 GHz of frequency which is nearer to the designed frequency of 3.5 GHz. The experimental impedance bandwidth over return loss less than -10 dB is calculated using the formula,

\[
\text{Impedance bandwidth (\%) } = \frac{f_H - f_L}{f_C} \times 100 \% \tag{1}
\]

where, \( f_H \) and \( f_L \) are the upper and lower cut off frequencies of the resonating bands when their return loss reaches -10 dB and \( f_C \) is a centre frequency of \( f_H \) and \( f_L \). The impedance bandwidth is found to be 2.94 %.

Figure 4: Variation of return loss versus frequency of SMSA

Figure 4 shows the variation of return loss versus frequency of DOSMSA. The antenna resonates at four modes of frequencies \( f_1, f_2, f_3 \) and \( f_4 \) with their respective impedance bandwidths are \( BW_1 = 5.7 \% \text{ (2.88-3.05 GHz)} \), \( BW_2 = 6.1 \% \text{ (4.71-5.01 GHz)} \), \( BW_3 = 3.2 \% \text{ (6.60-6.82 GHz)} \) and \( BW_4 = 19.65 \% \text{ (7.02-8.55 GHz)} \). The first band \( BW_1 \) is due to the fundamental resonance of the patch and the bands \( BW_2 \) to \( BW_4 \) are due to insertion of open stubs on the radiating patch. Further it is noted that, the use of stubs on the patch, the frequency ratio between the successive bands is nearly 1.63. The copper area of DOSMSA reduces by 7.8 % when compared to the copper area of SMSA.
Fig 5 and 6 show the radiation patterns of SMSA and DOSMSA respectively. It can be noted from these figures that, the patterns are broadside and linearly polarized. The cross-polar power level is much lower when compared to the co-polar power level indicates the broad nature of radiation. The gain of SMSA and DOSMSA is calculated using the absolute gain method given by the relation,

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

where, \( G_t \) is the gain of the pyramidal horn antenna and \( R \) is the distance between the transmitting antenna and the antenna under test (AUT). The power received by AUT, ‘\( P_r \)’ and the power transmitted by standard pyramidal horn antenna ‘\( P_t \)’ is measured independently. The gain measured for SMSA is found to be 0.8 dB maximum and the peak gain of DOSMSA is found to be 3.21 dB. This indicates that the novel geometry of DOSMSA enhances the gain of the antenna by 4 times in its operating band when compared to the gain of SMSA.

4. CONCLUSION

From this detailed study, it is concluded that DOSMSA enhances the gain from 0.8 dB to 3.21 dB which is nearly 4 times more when compared to the gain of SMSA. The use of dual open stubs on the two diagonally opposite corners of DOSMSA make antenna to operate for four independent bands between 2.88 to 8.55 GHz with a frequency ratio nearly 1.63 between the bands. The placement of stubs also makes the antenna to use less copper area of about 7.8 % when compared to the copper area of SMSA. The radiation characteristics of SMSA and DOSMSA are broadside and linearly polarized. The proposed antenna is simple in its geometry and construction. This antenna may be used for WLAN and Wimax communication system.
REFERENCES


BIO-DATA

Dr. Nagraj K. Kulkarni received his M.Sc, M.Phil and Ph. D degree in Applied Electronics from Gulbarga University Gulbarga in the year 1995, 1996 and 2014 respectively. He is working as an Assistant professor and Head, in the Department of Electronics Government Degree College Gulbarga. He is an active researcher in the field of Microwave Electronics.