DESIGN AND DEVELOPMENT OF MICROSTRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION WITH OMEGA SLOT IN THE GROUND PLANE

Prashant R. T, Vani R. M, Hunagund P. V

ABSTRACT:

In this paper, compact rectangular microstrip patch antenna whose size is reduced via the use of metamaterial is presented. When Omega shaped slot is placed in the ground, the shift in the resonant frequency to lower value is promising because it suggests a reduction in patch size. Hence, microstrip patch antenna with omega slot on the ground plane is designed and simulated by using mentor graphics IE3D simulation software and practically studied the antenna parameters by using Vector Network Analyzer. The study is carried out by loading a single omega slot in the antenna ground plane beneath the radiating patch. The optimized antenna with omega slot is resonating at three particular frequencies i.e., 2.72GHz, 5.62GHz and 8.78GHz. But, antenna without omega slots i.e., conventional antenna is resonating at 5.89GHz. The virtual size reduction of 54.15% is achieved along with increase in the simulated gain 3.90dBi as compared to conventional microstrip patch antenna which is 2.86dBi. These antennas find application in Wireless Communications and X-band applications.

Keywords: microstrip patch antenna, omega slot, return los, miniaturization, gain, bandwidth.

[1] INTRODUCTION

Wireless communication has penetrated into the life of many peoples. The demand for wireless communication is still growing. As a result, demand for multiband or wideband antennas to support different technologies and standards [1-2]. Therefore, there is a need to produce antennas that can accommodate different frequency bands to support different technologies and standards. There are several papers on dual or multiband antennas by loading slots, shorting pins, slits etc. are there in literature. But in the year 1996 Prof. Pendry was first developed Negative permeability medium, which consist of an array of split ring resonators (SRR). By combining this structure with the array of strip wires, the first left handed medium (LHM) with both negative permittivity and permeability was developed in
2002 [3]. Based on this concept, i.e., metamaterial many types of SRR variation such as double S-shaped, Complimentary split ring resonator (CSRR) and Ω-like structures are designed and fabricated to exhibit the LH properties [4-8].

In view of this consideration, a reduced size with triple-band rectangular microstrip patch antenna with Omega shaped [9-10] slot structure on the ground plane of a rectangular microstrip antenna and corresponding behavior have been studied using method of moment full wave electromagnetic simulation software IE3D™ [11].

[2] DESIGN OF ANTENNA AND OMEGA SLOT STRUCTURE

A. Design of Reference Antenna:
[Figure-1(a)] shows the geometry of the reference rectangular microstrip patch antenna (RMPA), where a low cost glass epoxy FR4 dielectric material with relative permittivity (εr) of 4.4 with thickness (h) of 1.6mm is chosen. The conventional RMPA is designed [1-2] for 6GHz with dimensions L=11.33mm and W=15.24mm as radiating part, which is excited by simple 50 Ω microstrip feed having dimensions length Lf=6.15mm and width Wf=3.05mm using quarter wave length transformer of dimension length Lt=4.90mm and Wt=0.50mm for their impedance matching. The length Lg=40mm and Wg=40mm of the ground plane of the reference antenna is calculated by using Lg=6h+L and Wg=6h+W.

B. Design of Omega slot structure:
The study is carried out by putting single omega slot exact at the center behind the radiating patch on the ground plane which is shown in [Figure-1 (b)]. The parameters of the omega slot are shown in table 1. Here Wg the gap width is varied from 1mm to 3mm. With Wg=1mm antenna is named as antenna 1, with Wg=2mm antenna is named as antenna 2 and finally Wg=3mm antenna is named as antenna 3 and it is the optimized antenna. The geometry of omega slot is shown in [Figure-2]. [Figure-3(a)] shows photograph of top and bottom view of reference antenna and [Figure-3(a)] shows photograph of top and bottom view of antenna 3.

Figure: 1. Geometry of proposed microstrip patch antenna (a) Reference antenna and (b) bottom view of Antenna3
TABLE 1: DIMENSIONS OF OMEGA SLOT

<table>
<thead>
<tr>
<th>Outer Radius (R1) mm</th>
<th>Inner Radius (R2) mm</th>
<th>Width (d) mm</th>
<th>Length arm (La) mm</th>
<th>Gap width (Wg) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4.5</td>
<td>0.5</td>
<td>10</td>
<td>1, 2, 3</td>
</tr>
</tbody>
</table>

Figure: 3. (a) Fig. 3 (b)
Figure: 3(a). Photograph of top and bottom view of reference antenna and 3(b). antenna 3

[3] RESULTS AND DISCUSSION

IE3D simulation software version 14.65 is used for simulation of proposed microstrip antennas. Return loss was measured using Vector Network Analyzer (VNA) (Rhode and Schwarz, Germany make ZVK model 1127.8651). The simulated return loss characteristics all proposed microstrip patch antennas are shown in [Figure 4]. The impedance bandwidth over return loss less than -10dB is determined by using the equation

\[ f_1 \text{ and } f_2 \text{ are the lower and upper cut-off frequencies of the band respectively, when its return loss reaches } -10\text{dB and } f_c \text{ is the centre frequency between } f_1 \text{ and } f_2. \]

Figure: 4. Simulated return loss characteristics of proposed antennas with and without Omega slot
Table 2: Simulated Results of Proposed Antennas

<table>
<thead>
<tr>
<th>Antennas</th>
<th>Resonating Frequency (GHz)</th>
<th>Return loss (dB)</th>
<th>Band Width (MHz)</th>
<th>Band Width (%)</th>
<th>Size Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Antenna</td>
<td>5.89</td>
<td>-17.16</td>
<td>191</td>
<td>3.24</td>
<td>-</td>
</tr>
<tr>
<td>Antenna 1 (Wg=1mm)</td>
<td>5.59</td>
<td>-1985</td>
<td>145</td>
<td>2.59</td>
<td>5.09</td>
</tr>
<tr>
<td>Antenna 2 (Wg=2mm)</td>
<td>2.78</td>
<td>-11.61</td>
<td>16</td>
<td>0.57</td>
<td>52.80</td>
</tr>
<tr>
<td>Antenna 3 (Wg=3mm)</td>
<td>2.70</td>
<td>-11.86</td>
<td>10</td>
<td>0.37</td>
<td>54.15</td>
</tr>
</tbody>
</table>

Table 2 shows the simulated parameters of the proposed antennas. From the table we observe that the reference antenna (without omega slot) is resonating at 5.89GHz with bandwidth of 3.24%. Next the antennas are loaded with omega slot and the corresponding behaviors have been studied. Antenna 1 (Wg=1mm) is resonating at two frequency points 5.59GHz (2.59%) and 8.78GHz (2.71%). Next antenna 2 (Wg=2mm) is resonating for three frequency points 2.78(0.57%), 5.69 (2.14%) and 8.80(2.75%). Here we can observe that by increasing the gap from 1mm to 2mm the antenna is resonating for three frequency points. Further again by increasing the gap from 2mm to 3mm i.e., Antenna 3 which is also resonating for three frequency points with virtual size reduction of 54.15%.

Figure: 5. Simulated and Measured return loss characteristics of Reference Antenna (Without Omega slots)

After the simulations the reference antenna and antenna 3 are fabricated by using photolithographic process. Next the return loss characteristic of reference microstrip patch antenna is compared with fabricated reference microstrip patch antenna and which is shown in Fig. 5. The practically measured reference antenna is resonating at 5.89GHz with 240MHz (4.20%) of bandwidth (Eq. 1). Then the antenna 3 (i.e., Wg=3mm) is measured and it is
observed that the antenna is resonating at three different frequency points 2.72GHz, 5.62GHz and 8.78GHz with bandwidths of 10MHz (0.37%), 134MHz (2.38%) and 264MHz (3.00%) respectively which is shown in [Figure-6]. From the figures it is observed that, all the simulated and measured results are in good agreement with each other.

![Graph](image1)

**Figure: 6. Simulated and Measured return loss characteristics of Antenna 3**

![Elevation Patterns](image2)

**Figure: 7. Typical elevation radiation patterns of reference antenna at frequency 5.89GHz and Antenna 3 at 5.70GHz and 2.70GHz**

The radiation patterns of all proposed antennas are studied at their resonating frequencies. [Figure-7] shows typical elevation radiation patterns of reference antenna at frequency 5.89GHz and Antenna 3 at 5.70GHz and 2.70GHz. From the figures it is seen that, the patterns are broadside in nature.

[4] CONCLUSION

In conclusion, a technique for size reduction of microstrip patch antennas is presented. Because of the inclusion of single omega slot, the reference antenna which is resonating at one particular frequency point, now resonating at three frequency points. At each resonating frequency good impedance bandwidth with minimum return loss and virtual size reduction of
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54.15% is obtained along with simulation gain of 3.90dBi. These antennas find application in wireless communications and X-band applications.

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REFERENCES


Author[s] brief Introduction

Prashant R T received his M Sc from the department of Applied Electronics Gulbarga University, Gulbarga in the year 2011. He worked as a Project Fellow in the UGC sponsored Major Research Project during the year 2012-2013. Currently he is pursuing his Ph. D in the field of Microwave Antennas from the department of Applied Electronics, Gulbarga University, Gulbarga.
Vani R M received her B.E. in Electrical and Electronics from the B.I.E.T., Davanagere and M.Tech in Industrial Electronics from S.J.C.E., Mysore, Karnataka. She has received her Ph.D in Applied Electronics from Gulbarga University, Gulbarga, India, in year 2005. She is working as Reader & Head, University Science Instrumentation Center, Gulbarga University, Gulbarga, since 1995. She has more than 85 research publications in national and international reputed journals/Conference proceedings. she presented the research papers in National/ International conferences in India and abroad. She has conducted several courses, workshops for the benefits of faculties and field engineers. Her areas of interest are microwave antennas, PC based instrumentation, embedded controllers and Wireless communication. She has one UGC major research project to her credit.

P. V. Hunagund received his M.Sc and Ph.D from the Dept. of Applied electronics, Gulbarga University, Gulbarga, in the year 1982 and 1992 respectively. He is working as professor and chairman of Applied Electronics department, Gulbarga University, Gulbarga. He has more than 100 research publications in national and international reputed journals, more than 180 research publications in international symposium/Conferences. He presented the research papers in National/International conferences in India and abroad. He has guided many Ph.D and M.Phil students. He has three major research projects at his credit.

Corresponding Address-

Mr. Prashant R T  
Research Student  
University Science Instrumentation Center (USIC)  
Opp. to department of Physics,  
Gulbarga University,  
Kalaburagi-585106  
Karnataka  
M No: 9972067674