Compact Microstrip Antenna for WLAN and H-LAN Communication

Samiran Chatterjee, Partha Pratim Sarkar, Debasree Chanda (Sarkar), Santosh Kumar Chowdhury

Abstract: A single layer, single feed compact rectangular antenna is proposed. Resonant frequency has been reduced drastically by cutting unequal rectangular slots at the edge of the patch & a circle in the middle. The width of the rectangular slots is different to improve the gain bandwidth performance of the antenna. The antenna size has been reduced by 41.8% when compared to a conventional rectangular microstrip patch antenna with a maximum of 24.9 MHz bandwidth at −16.3 dB return loss at 3.41 GHz. The characteristics of the designed structure are investigated by using MoM based electromagnetic solver, IE3D. There is reasonable agreement between these simulated data and measured value. An extensive analysis of the return loss, radiation pattern, gain of the proposed antenna is shown in this paper. The simple configuration and low profile nature of the proposed antenna leads to easy fabrication and make it suitable for the applications in Wireless communication system.

Keywords: Compact, Frequency ratio, Patch, Resonant frequency, Slot.

I. INTRODUCTION

In recent years demand for small antennas on wireless communication has increased the interest of research work on compact microstrip antenna design among microwave and wireless engineers [1]. To support the high mobility necessity for a wireless telecommunication device, a small and light weight antenna is likely to be preferred. For this purpose Compact Microstrip antenna is one of the most suitable applications. The development of antenna for wireless communication also requires an antenna with more than one operating frequency. This is due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies. Therefore one antenna that has multiband characteristic is more desirable than having one antenna for each frequency band. To reduce the size of the antenna one of the effective techniques is cutting slot in proper position on the microstrip patch [2-4]. Compact microstrip antenna is a topic of intensive research in recent years because of increasing demand for small antennas used in various types of communications including mobile communication [5-8]. The size of the antenna may be effectively reduced by cutting rectangular slots on printed antennas. The work to be presented in this paper is also a compact printed antenna obtained by cutting rectangular slots which gave a resonant frequency much lower than the resonant frequency of the conventional printed antenna with the same patch area. The work to be presented in this paper is also a compact microstrip antenna design obtained by cutting rectangular slots on the patch to increase the return loss and gain-bandwidth performance of the antenna. To reduce the size of the antenna substrates are chosen with higher value of dielectric constant [9-14]. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with εr = 4.4) presents a size reduction of 41.8% when compared to a conventional rectangular microstrip patch. The simulation has been carried out by IE3D [15] software which uses the MOM method.

II. ANTENNA DESIGN

The configuration of the conventional printed antenna is shown in Figure 1 with L=16 mm, W=20 mm, substrate (PTFE) thickness h = 1.5875 mm, dielectric constant εr = 4.4. Coaxial probe-feed (radius=0.5mm) is located at W/2 and L/2.

Assuming practical patch width W= 20 mm for efficient radiation and using the equation [6],

fr =\left(\frac{c}{2(Wr)}\right)\sqrt{(2/(1+εr))},

where, c = velocity of light in free space. Using the following equation [7, 8] we determined the resonant frequency fr (= 4.57 GHz). Where, L = resonant frequency much lower than the resonant frequency of the conventional printed antenna with the same patch area. The work to be presented in this paper is also a compact microstrip antenna design obtained by cutting rectangular slots on the patch to increase the return loss and gain-bandwidth performance of the antenna. To reduce the size of the antenna substrates are chosen with higher value of dielectric constant [9-14]. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with εr = 4.4) presents a size reduction of 41.8% when compared to a conventional rectangular microstrip patch. The simulation has been carried out by IE3D [15] software which uses the MOM method.

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Figure 1: Antenna 1 configuration
Figure 2 shows the configuration of antenna 2 designed with similar PTFE substrate. Four unequal rectangular slots (L1, L2, L3, L4) and one circle whose dimensions and the location of coaxial probe-feed (radius=0.5 mm) are shown in the figure 2.

Figure 2: Antenna 2 configuration

III. RESULTS AND DISCUSSION

Simulated (using IE3D [15]) results of return loss in conventional and slotted antenna structures are shown in Figure 3-4. A significant improvement of frequency reduction is achieved in antenna 2 with respect to the conventional antenna 1 structure.

Figure 3: Antenna 1 Return Loss vs. Frequency (Conventional Antenna)

Figure 4: Antenna 2 Return Loss vs. Frequency (Slotted Antenna)

In the conventional antenna return loss of about -17.212 dB is obtained at 4.170 GHz. Corresponding 10 dB bandwidth is 70.91 MHz.

Due to the presence of slots in antenna 2 resonant frequency operation is obtained with large values of frequency ratio. The resonant frequency is obtained at f1=3.412 GHz with return loss of about -16.30 dB. The second resonant frequency is obtained at f2 = 7.87 GHz with return losses -10.55 dB. Corresponding 10 dB bandwidth obtained for Antenna 2 at f1, f2 are 24.9 MHz, 19.12 MHz respectively.

IV. RADIATION PATTERN

For the antenna 1 (Conventional Antenna) radiation patterns of E plane & H plane are shown in Figure 5-6. The simulated E plane radiation pattern of antenna 1 (Conventional Antenna) for 4.17 GHz is shown in figure 5.
The simulated H plane radiation pattern of antenna 1 (Conventional Antenna) for 4.17 GHz is shown in figure 6.

The simulated E plane radiation pattern of antenna 2 (Slotted Antenna) for 3.41 GHz is shown in figure 7.

The simulated H plane radiation pattern of antenna 2 (Slotted Antenna) for 7.87 GHz is shown in figure 9.

The simulated E plane radiation pattern of antenna 2 (Slotted Antenna) for 3.41 GHz is shown in figure 8.
All the simulated results are summarized in the following Table 1 and Table 2.

### TABLE I: SIMULATED RESULTS FOR ANTENNA 1 AND 2

<table>
<thead>
<tr>
<th>ANTENNA STRUCTURE</th>
<th>RESONANT FREQUENCY (GHz)</th>
<th>RETURN LOSS (DB)</th>
<th>10 DB BANDWIDTH (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$f_1 = 4.17$</td>
<td>-17.212</td>
<td>70.91</td>
</tr>
<tr>
<td>2</td>
<td>$f_2 = 3.41$</td>
<td>-16.50</td>
<td>24.90</td>
</tr>
<tr>
<td></td>
<td>$f_3 = 7.87$</td>
<td>-10.55</td>
<td>19.12</td>
</tr>
</tbody>
</table>

### TABLE II: SIMULATED RESULTS FOR ANTENNA 1 AND 2

<table>
<thead>
<tr>
<th>ANTENNA STRUCTURE</th>
<th>RESONANT FREQUENCY (GHz)</th>
<th>FREQUENCY RATIO</th>
<th>3 DB BEAM WIDTH ($^\circ$)</th>
<th>ABSOLUTE GAIN (DB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$f_1 = 4.17$</td>
<td>$f_2 / f_1 = 1.702$</td>
<td>0.543</td>
<td>5.43</td>
</tr>
<tr>
<td>2</td>
<td>$f_2 = 3.41$</td>
<td>$f_2 / f_1 = 1.702$</td>
<td>0.39</td>
<td>3.29</td>
</tr>
<tr>
<td></td>
<td>$f_3 = 7.87$</td>
<td>$f_3 / f_1 = 2.308$</td>
<td>101.33</td>
<td>0.71</td>
</tr>
</tbody>
</table>

V. EXPERIMENTAL RESULTS AND DISCUSSION

The prototype of the antenna 2 (proposed antenna) was fabricated and tested, which are depicted in Fig.s 11-12 the measurements were carried out using Vector Network Analyzer (VNA) Agilent N5 230A.

![Figure 11: Measured return loss for proposed antenna.](image)

![Figure 12: Comparison between simulated & measured return loss for proposed antenna.](image)

The comparisons of the measured return loss with the simulated ones for conventional antenna are shown in

![Figure 13: Comparison between simulated & measured return loss for conventional antenna.](image)

VI. CONCLUSION

Theoretical investigations of a single layer single feed micro strip printed antennas have been carried out using Method of Moment based software IE3D. Introducing slots at the edge of the patch size reduction of about 41.8% has been achieved. The 3dB beam-width of the radiation pattern 170.52° which is sufficiently broad beam for the applications for which it is intended.

The resonant frequency antenna presented in the paper for a particular location of feed point (3mm, 3mm considering the centre as the origin) was quite large as is evident from table 1. Alteration of the location of the feed point results in narrower 10dB bandwidth and less sharp resonances.

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REFERENCES


