A Wide-band Circular Polarization Stacked Patch Antenna for the Wireless Communication Applications

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Abstract — A wide-band ‘corners-truncated rectangular’ stacked patch antenna for use in the circular polarization applications was proposed. The antenna proposed in this paper an axial ratio of less than 3 dB and a VSWR of less than 2 : 1 were shown to be achievable over a 25% bandwidth for use in the wireless communication applications, and this antenna can achieve higher gain, lower side lobes and wider bandwidth compared to the traditional microstrip patch antenna.

1. INTRODUCTION

The most serious limitation of the circularly polarized (CP) microstrip antennas is its narrow bandwidth [1], to overcome its inherent limitation of narrow impedance and axial ratio (AR) bandwidth, many techniques have been research and development for the enhancement of microstrip antenna bandwidth e.g., for probe fed stacked antenna, slotted patch antenna, microstrip patch antennas on electrically thick substrate [2–7].

Increased bandwidth can be achieved with [8, 9] or [10, 11]. The AR bandwidth can be enhanced by [12, 13] concept. Hence, the present design of propose antenna is choice of a high permittivity substrate to situate the bottom layer for the feed line element and a lower permittivity substrate on the top layer for the radiate while an adoption of a higher air-spaced. The objective of the proposed design is to generate a CP and to improve the bandwidth of the patch antenna.

2. ANTENNA DESIGN

The proposed antenna configuration is shown in Figure 1, that was designed consists of four layers where first layer is ground plane, second layer is feed line, and the third and the fourth layer are radiate and a parasitic patch, respectively.

![Figure 1: Geometry of the proposed antenna: (a) snapshot of proposed antenna, (b) top view, (c) side view.](image)

By making use of stacked patch concept one can obtain enhanced impedance and using high permittivity can enhance the AR bandwidth. All of we mention antecedently, the stacked layers are FR4 and RO dielectric substrate.

In the present configuration of antenna we employ a lower permittivity of RO dielectric substrate in the top layer for the radiate element and a coupled parasitically patch, using a R4 dielectric substrate situated in the bottom layer for the feed line and the ground plane.
A less than quarter-wavelength impedance transformer, is placed at the back of the radiate patch, that is consists of two structures of the rectangular feed line and a cylindrical conductor, a tuning of stub wire is place at the rectangular feed line end, one can improve matching capabilities by properly adjusting the stub. The signal is fed at back of bottom substrate to the impedance transformer, while the bottom side is being a ground plane for the antenna.

By properly adjusting above the mentions sizes (including the coupled parasitically patch, corners-truncated rectangular radiate element, rectangular feed line, cylindrical conductor, stub wire), then we can obtain a better and wider bandwidth of CP antenna. Figure 1 depicts the detailed antenna structure of the propose antenna, the values of various parameters involved in Figure 1 are given in Table 1.

### Table 1: The relative parameters of the proposed antenna (UNIT: mm).

<table>
<thead>
<tr>
<th></th>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Coupled parasitically patch</td>
<td>( W_3 = L_3 = 13.28 )</td>
</tr>
<tr>
<td>2</td>
<td>Rectangular radiate element</td>
<td>( W_2 = L_2 = 17.7 )</td>
</tr>
<tr>
<td>3</td>
<td>Rectangular microstrip feed line</td>
<td>( W = 3, L = 4.12 )</td>
</tr>
<tr>
<td>4</td>
<td>Ground plane</td>
<td>( W_1 = L_1 = 30 )</td>
</tr>
<tr>
<td>5</td>
<td>SMA connector</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Stub wire</td>
<td>Radius = 1.6</td>
</tr>
<tr>
<td>7</td>
<td>Cylindrical conductor</td>
<td>Length = 10, Radius = 1.6</td>
</tr>
<tr>
<td>8</td>
<td>Polymer</td>
<td>60 \times 60 \times 10</td>
</tr>
<tr>
<td>9</td>
<td>FR4 Dielectric substrate</td>
<td>( \varepsilon_{r1} = 4.4, \tan\delta = 0.022 )</td>
</tr>
<tr>
<td>10</td>
<td>RO Dielectric substrate</td>
<td>( \varepsilon_{r2} = 3.38, \tan\delta = 0.0025 )</td>
</tr>
<tr>
<td>11</td>
<td>Feed position</td>
<td>((x_1, y_1, z_1) = (13, 8, 11.6)) ((x_2, y_2, z_2) = (17, 11, 11.6))</td>
</tr>
</tbody>
</table>

### 3. SIMULATION RESULTS

Referring to the configuration shown in Figure 1, the right or left hand circularly polarization depends on choosing the feeding point positions, by changing the signal fed positions \( P_1, P_2 \), then the right or left hand CP can easily achieved. The proposed antenna is designed for Right-Hand CP (RHCP) radiation. The proposed antenna was designed and simulated at a center frequency

![Figure 2: Measured and simulated return losses of the proposed antenna.](image1)

![Figure 3: Measured and simulated axial ratios of the proposed antenna.](image2)
of 2.3 GHz with the aid of IE3D software, which is based on the method of moments [14].

Figure 2 shows that the simulated and measured return losses (−S11 in dB) of the proposed antenna are less than −20 dB over 2.0 GHz to 2.6 GHz. The measurements show that the antennas are very well matched to the impedance transformer and the optimum impedance bandwidth more than 30% with the −10.0 dB return loss has been obtained, when cutting corners-truncated rectangular is 8.5 mm (∼0.07λ0). There is a frequency shift of about 100 MHz for measured return loss with respect to simulated results, which may be mainly caused by the fabrication tolerance as well as the possible uncertainty of in-house antenna assembly.

The measured and simulated 3 dB AR shown in Figure 3 covers the range of 2.0–2.7 GHz and the AR is lower than 2.5 dB across 2.0–2.65 GHz is in excess of 28% bandwidth. Figure 4 depicts that the measured CP gain is more than 5 dBi over 1.8 GHz to 2.6 GHz. The measured far field radiation patterns in two orthogonal planes (the x-z and y-z planes) at 2.3 GHz for the proposed antenna are shown in Figure 5, the symmetry and wide angular radiation patterns are observed.

Figure 4: Measured and simulated gains of the proposed antenna.

Figure 5: Measured radiation patterns of the proposed antenna.

4. CONCLUSIONS

In this paper, a broadband CP stacked probed-fed patch antenna has been made and measured. The measurement result has showed that good impedance matching and AR can be obtained with this method at the same time. The proposed antenna permits a better purity of the CP and a significant improvement impedance bandwidth with respect to conventional antennas. The structure is easily fabricated, and the effects of the locations and dimensions of the proposed antenna are very limited. The information presented in this paper will be suitable design and optimize the antenna for engineering applications.

REFERENCES

14. IE3D Software Release 8 developed by M/S Zeland Software, Inc.