Flared Ground Loaded Triple Band CPW Antenna With Dual Polarization Characteristics

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Abstract

This letter presents a triple band coplanar waveguide antenna with dual polarization characteristics. The proposed antenna exhibits both linear polarization and circular polarization characteristics. Triple band nature is achieved by using a flared ground plane. Circular polarization is achieved by terminating the feed line by a λg/4 length stub, as this result in excitation of even-odd modes in phase quadrature. Resonating frequency of higher band is tuned by embedding a narrow slit (ws) in the ground plane. The antenna has compact 0.78 λg × 0.78 λg × 0.03 λg geometry with circular polarization characteristics extending from 2.7 GHz - 3.42 GHz and linear polarized characteristics from 4.4 GHz - 5.16 GHz and 6.2 GHz - 6.9 GHz. The lower band is circular polarized while the middle and upper bands are linear polarized and can be applied for WiMAX and C-band broadcasting applications.

1. Introduction

Multiband antenna with multiple polarization characteristics improves the antenna compactness and robustness of communication link. Linear polarized antennas are majorly used for broadcasting purpose (AM/FM), while satellite communication link requires use of circular polarized antennas. So recent efforts have been made to generate both kinds of polarization from the same antenna. In [1] dual polarization is achieved by using shorting pins and cut loop, in [2] slot coupled power dividers are utilized, in [3] concepts of stacked patch and parasitic patch are implemented together for dual polarization characterization, in [4] meta materials are implemented using split ring resonators, while in [5] stacking patch technique is used to meet dual polarization characteristics. In this letter coplanar waveguide (CPW) is used as a new variant for obtaining dual polarization characteristics with compact geometry. So far this is the first work on realizing dual polarization using CPW slot antennas. Three resonating bands are realized with one band exhibiting circular polarized behavior while other two bands are linear polarized.

2. Antenna Design And Analysis

![Top view of proposed antenna](image)

**TABLE I: Geometrical Dimensions (mm)**

<table>
<thead>
<tr>
<th>l1</th>
<th>l2</th>
<th>l3</th>
<th>l4</th>
<th>l5</th>
<th>l6</th>
<th>w1</th>
<th>w2</th>
<th>w3</th>
<th>wg</th>
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<tr>
<td>2.4</td>
<td>2.9</td>
<td>5.7</td>
<td>2.9</td>
<td>9.3</td>
<td>29</td>
<td>9.7</td>
<td>7.0</td>
<td>7.1</td>
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<table>
<thead>
<tr>
<th>ws</th>
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<th>f1</th>
<th>f</th>
<th>l</th>
<th>w</th>
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<tbody>
<tr>
<td>5.7</td>
<td>6.2</td>
<td>12.1</td>
<td>3.2</td>
<td>35</td>
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</tbody>
</table>

The schematic view of the proposed antenna is shown in fig. 1 along with its geometrical dimensions (mm) illustrated in Table I. A flared slot is etched in the ground plane instead of conventional rectangular slot and is energized by a 50Ω feed line of width 3.2 mm placed at 0.4 mm from the ground plane. FR4 substrate of height
1.6 mm, dielectric constant 4.4 and loss tangent 0.02 is used to model the antenna. Central feed line is terminated by an inverted F-shaped metallic arm inorder to tune circular polarized band (3 dB axial ratio bandwidth).

2.1 CP mechanism and Mode analysis

![Figure 2. Magnetic current distribution at 3.0 GHz](image)

Magnetic current vector distribution at 3.0 GHz is depicted in fig. 2 for studying CP behavior of lower band. Considering $\pm z$ axis as direction of propagation, dominant current vectors follows clockwise sense of rotation in azimuthal plane, conforming LHCP nature of lower band. Two orthogonal propagating modes (even-odd) are maintained in phase quadrature for realizing circular polarization performance, demonstrated in fig. 3. Antenna regions responsible for dominant CP radiations are analyzed in fig. 4, which demonstrates surface current density at 3.0 GHz on ground and patch.

2.2 Prototype analysis

Hierarchal steps involved for antenna improvement are illustrated in fig. 5 using antenna prototypes and corresponding return loss values and axial ratio values are shown in fig. 6 and fig. 7. Antenna design initiates with etching a tapered slot in the ground plane and introducing a feed line, as depicted by antenna I. Gradual transition in slot impedance is controlled by flared ground plane. This improves antenna matching, resulting in linear polarized triple band characteristics. Degenerate orthogonal field components in phase quadrature are generated by connecting a $\lambda_g/4$ stub to the feed line, as shown by antenna II. 3 dB axial ratio bandwidth for lower band is tuned by connecting an inverted F-shaped structure to the feed line, shown by antenna IV. Effect of ground slit is studied seperately in section 2.3 keeping other parameters constant, which illustrates leftward shift of upper band due to introduction of ground slit (fig. 9).

![Figure 4. Surface current density distribution at 3.0 GHz](image)

![Figure 5. Steps for improvement of antenna](image)

![Figure 6. S11 of antenna prototypes](image)
3. Result And Discussions

$S_{11}$ of proposed antenna is depicted in fig. 10 which shows that the 10 dB impedance bandwidth extends from 2.5 - 3.8 GHz, 4.4 - 5.16 GHz and 6.2 - 6.9 GHz. The 3 dB axial ratio bandwidth extends from 2.7 - 3.42 GHz, illustrated in fig. 11. Input impedance matching is studied with the help of VSWR plot, depicted in fig. 12. Normalized radiation patterns for circular polarized and linear polarized bands are depicted in fig. 13 and fig. 14. Gain of the proposed antenna is depicted in fig. 15, conforming increase in gain for linear polarized bands.

### TABLE II: Comparison Table

<table>
<thead>
<tr>
<th>Reference</th>
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<tbody>
<tr>
<td>$l \times w$</td>
</tr>
<tr>
<td>[6]</td>
</tr>
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<td>[7]</td>
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<td>[8]</td>
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<tr>
<td>[9]</td>
</tr>
<tr>
<td>Proposed</td>
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</tbody>
</table>

2.3 Effect of ground slit

Figure 8. Proposed antenna with and without ground slit

Figure 9. Shift in resonant frequency of upper band

Figure 10. $S_{11}$ of antenna

Figure 11. Axial ratio of antenna

Figure 12. VSWR of antenna
4. Conclusion

A triple band dual polarized antenna using coplanar waveguide feed has been presented in this letter. The antenna exhibits both circular polarized and linear polarized characteristics. Controlled transition of slot impedance is achieved by using flared ground plane resulting in triple band characteristics. Circular polarization is generated by connecting a $\lambda/4$ stub to the feed line and terminating the signal strip by an inverted F-shaped metallic strip. The lower band is left handed circular polarized while upper bands are linear polarized. The proposed antenna has compact geometry with simplified structure and can be implemented for WiMAX application (monopole pattern) and C-band broadcasting applications.

5. References


