Dual-Band Circularly Polarized Antenna With CPW Feeding Structure

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Abstract—A new design of a dual-band circularly polarized antenna is introduced. The introduced antenna consists of a rectangular patch surrounded by a circular ground with additional two circles, one located above the radiating patch and the other on lower right side, result in both right hand and left hand circular polarized radiation. The antenna operates in two bands 3.3 GHz and 4.8 GHz. The first band is used in WiMax applications. The second band is used in some WLAN applications, it also works in WiMax applications. The antenna is compact in size with overall dimensions $40 \text{mm} \times 40 \text{mm}$. The antenna has a low profile and printed on a single side of the substrate. The feeding structure is a $50\Omega$ CPW. The antenna is RHCP and LHCP at 3.3 GHz and 4.8 GHz, respectively. The antenna is fabricated on FR4 substrate and the results of the return loss are measured and are in a good agreement with the simulated results.

Index Terms—Circular polarized Antennas, dual band, CPW-Feed Antenna

I. INTRODUCTION

Recently, circularly polarized antennas has received a considerable attention due to the fact that it transmits in all planes thus providing any communication link with better receiving factor[1]. CP also proved that it is much susceptible to multipath and absorption as compared with linear polarization. The proposed design is circularly polarized coplanar waveguide fed structure, thus it is printed on a single side making it easy in fabrication. The antenna operates in two bands at 3.3 GHz and 4.8 GHz, therefore it can be used for various applications. WiMedia OFDM uses a band from 3.3 GHz to 4.8 GHz, such an application could be applied in both bands. WiMax frequency ranges covered today: 1.765 to 1.815 GHz, 2.15 to 2.7 GHz, 3.3 to 3.8 GHz and 4.8 to 6.0 GHz thus the proposed antenna design works on the middle and last band of WiMax. The Federal 4 GHz spectrum spans from 4.4 GHz to 4.99 GHz. This spectrum is designated in the U.S. and NATO countries for military fixed and mobile communications. Typical uses include point-to-point microwave, drone vehicle control and telemetry. Some WLAN applications work on the 4.8 GHz band as set by IEEE.

The proposed antenna is compact with overall size of $40\text{mm} \times 40\text{mm}$ printed on FR4 substrate. The feeding line is a $50\Omega$ CPW and it produces right hand and left hand circular polarized radiation due to the circles located between apart from each other almost diagonally.

Figure 1. Geometry and configuration of the proposed antenna design

The antenna is fabricated and measured. The measured results were satisfactory compared to the simulated results.

II. ANTENNA DESIGN

The geometry of the proposed antenna is shown in Figure 1. The antenna consists of a circular substrate of thickness $x$ mm and diameter $G$ mm. The feeding line of width $W_f$ mm and length of $L_f$ mm. The main radiation comes from the center patch following the feeder, it has width of $W_c$ mm and length of $L_c$ mm. The antenna was made first without the two circles as shown in Figure 2, it results in a wide bandwidth. Figure 3 shows the return loss of this antenna. Upon presenting the two circles, a dualband appeared instead of a wideband design. These circles are equal in size with diameter of $D_t$ mm. Different values for the variables in the design were varied and the outcome is studied to get the satisfactory results. Figure 4 shows the return loss curve on changing the location of the circles. Several variations for the variables $L_f$ and $W_f$ were made and the results of the return loss curves were shown in Figure 5 and Figure 6.
On varying the width and length of the radiation patch, the axial ratio changes but in random variation. The final dimensions were retrieved based on having a suitable axial ratio in the bands of radiation. The variation of the location of the circles, caused great change in both return loss and axial ratio. The best results were also in the given dimension and this is due to having a suitable axial ratio in the band of radiation.

The substrate of the antenna is FR4 material with $\varepsilon_r = 4.4$, loss tangent $\tan\delta = 0.019$ and thickness of $h$ mm. The antenna designed in this paper is right-hand CP for the lower band and left-hand CP for the upper band.

### III. Experimental results and discussion

The design is made to be simple, small in size and the final dimensions after the trials discussed in the previous section is listed in Table I.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G$</td>
<td>44</td>
</tr>
<tr>
<td>$W_c$</td>
<td>8</td>
</tr>
<tr>
<td>$L_c$</td>
<td>22</td>
</tr>
<tr>
<td>$W_f$</td>
<td>4.4</td>
</tr>
<tr>
<td>$L_f$</td>
<td>9.0</td>
</tr>
<tr>
<td>$X$</td>
<td>3.0</td>
</tr>
<tr>
<td>$h$</td>
<td>1.5</td>
</tr>
</tbody>
</table>
The return loss curve in Figure 7 shows that the antenna radiates in two bands which are the 3.3 GHz and 4.8 GHz. The first band radiates from 3.05 GHz to 3.45 GHz, with a percentage bandwidth of 12.1%. The second band radiates from 4.7 GHz to 5.7 GHz, with a percentage bandwidth of 20.83%.

Figure 8 shows that the axial ratio curve of the proposed design reaches 1 dB and it reaches 2 dB at the second band. Figure 9 shows the radiation pattern at 3.3 GHz, it is clearly shown that it RHCP in the +ve z-direction and LHCP in the -ve z-direction. The radiation pattern in Figure 10 shows that is LHCP +ve z-direction and RHCP in the -ve z-direction which is opposite to the case of the 3.3 GHz. This shows that the antenna is not only dual-band, but also a dual sense circularly polarized antenna.

On approaching the desired results from the simulation, the proposed antenna is fabricated. The fabricated antenna shown in Figure 11 is measured on the vector network analyzer and the results are compared to simulated one. The results were in a good agreement and this is clearly identified in the return loss curve of the measured and simulated antenna design in Figure 13.
IV. CONCLUSION

A novel compact dual-band circularly polarized CPW antenna introduced. The antenna is fabricated on FR4 substrate. The design is compact in size which makes it easy to be implemented in applications requiring small sized antennas. The fabricated antenna results are similar and quite satisfactory to the simulated results. Circular polarized radiation is achieved by introducing two circles in an almost diagonal distribution. The antenna could be used in WiMax application and broadband multiplexers for point to point or multi point to point communication systems.

REFERENCES