PERFORMANCE ENHANCEMENT OF CIRCULAR PATCH BY MODIFIED GROUND MICROSTRIP FEED DESIGN

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Abstract—This paper described the design of circular microstrip patch antenna operating at 3.8 GHz, suitable for various wireless communication systems covering the 2–12 GHz frequency band, with below -10 dB return loss. The design and development also focuses on bandwidth enhancement by introduction of modified microstrip feed in circular patch antenna in order to make an ultra wideband (UWB) antenna covering significant bandwidth. Computer Simulation Technology (CST) Microwave Studio is used as an effective tool for 3D electromagnetic simulation of high frequency components. A microstrip structure with modified ground plane is used to feed the antenna structure. The objective of this project is to compare the bandwidth enhancement of a circular patch antenna by introduction of an effective modified microstrip feed design. The simulation result so obtained shows substantial bandwidth enhancement. Then later a simple comparison of circular patch with two different feeding technique, in respect of return loss and impedance bandwidth have been produced.

Keywords—Circular patch, Bandwidth enhancement, CST, CPW feed.

I. INTRODUCTION

Microstrip antennas, which are quickly taking place of conventional antennas by their advantages such as light weight, small size, less production cost, and conformal nature. The generally employed radiating elements are rectangular and circular patches. The attached disadvantage of such antennas is their extremely narrow impedance bandwidth, obtained by the use of conventional feeding technique to the radiating patch structure. This is mainly due to the limited use of the circular patch antenna because of high input impedance along its circumference, which puts the constraint in the direct use of a 50 ohm microstrip line as feed. A method to overcome this constraint has been proposed in the paper, wherein, a microstrip feed with modified ground plane structure with 50 ohm microstrip line is been used as the feeding technique to enhance the transmission bandwidth (with considerable improvement in the impedance bandwidth).

With the definition and acceptance of ultra-wideband (UWB) impulse radio technology in the USA, there is increasing demand for antennas capable of operating at an extremely wide frequency range. In recent years, several broadband monopole configurations, such as circular, square, elliptical, pentagonal and hexagonal, have been proposed for UWB applications. These broadband monopoles feature wide operating bandwidths, satisfactory radiation properties, simple structures and ease of fabrication. However, they are not planar structures because their ground planes are perpendicular to the radiators. As a result, they are not suitable for integration with printed circuit boards. This drawback limits practical applications of these broadband monopoles.

In this paper, a novel design of a printed circular disc monopole fed by a microstrip line with modified ground is presented. A design of a printed circular disc monopole fed by a microstrip line feed with modified ground is proposed and been compared to the circular patch structure with same design parameters but with coaxial feed line. The parameters which affect the operation of the antenna are analyzed and compared both numerically and experimentally. It has been shown that the optimal design of this type of antenna can yield a transmission bandwidth sufficient for ultra wideband (UWB) operation, suitable for various wireless communication purpose, with satisfactory radiation properties over the entire bandwidth.

II. ANTENNA DESIGN

A. Design of a circular patch antenna with coaxial feeding

A circular microstrip patch antenna with radius \( a \) has been designed. The patch antenna having substrate thickness \( (h<<\lambda) \), substrate dielectric constant \( \varepsilon_r \) and relative permeability \( \mu_r=1 \) has been designed over a large ground plane as shown in fig 1. For patch design, it is assumed that the dielectric constant of the substrate \( (\varepsilon_r) \), the resonant frequency \( (f \text{ GHz}) \) and the height of the substrate \( h \text{ (in mm)} \) are all known. The geometry of the radiating element, which is a circular microstrip patch in this paper, is shown below.

![Fig. 1. Structure of circular patch antenna with coaxial feeding.](image)

Performance Enhancement Of Circular Patch By Modified Ground Microstrip Feed Design
The radius of the patch has been calculated using equations given in.

A circular patch of radius 10 mm with resonant frequency at 3.8 GHz has been designed on one side of a dielectric substrate of thickness (h) 1.5mm and relative permittivity (εr) 4.7, and the ground plane is located on the other side of the substrate with dimension 50mm×42mm. The antenna structure is fed by a coaxial cable with a characteristic impedance of 50 ohm by employing the outer conductor of dielectric material of relative permittivity 4.7 and inner conductor is made of PEC material. The inner and outer diameter of co-axial probe is 1mm and 6mm respectively. The feed point for the proposed antenna is found to be of the distance (y0) 2.7mm away from the center of the patch along the y-axis, where the appropriate impedance matching of 50Ω has been achieved.

B. Design of Circular patch with modified ground microstrip line feeding.

In this design, circular patch design parameters remain the same as of the earlier one, but with different feeding technique. The proposed monopole antenna is illustrated in Fig. [2]. A circular disc monopole with a radius of a=10 mm and a 50 Ohm microstrip feed line are printed on the same side of the dielectric substrate (in this study, the FR4 substrate of thickness 1.5 mm and relative permittivity 4.7 was used). L and W denote the length and the width of the dielectric substrate, respectively which has the dimension 50 x 42mm. The width of the microstrip feed line is fixed at (Wf) 2.6 mm and length of the feed (Lf) 20.3mm to achieve 50 Ohm impedance. On the other side of the substrate, the conducting ground plane with a length of (Lg) 18 mm only covers the section of the microstrip feed line. H, is the height of the feed gap between the feed point and the ground plane.

![Fig. 2. Structure of microstrip feedline patch antenna.](image)

### III. RESULTS AND DISCUSSIONS

The simulated results of the antennas are obtained using CST microwave studio. Table-1 shows the dimensions of the circular patch antenna.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius of the Patch(a)</td>
<td>10</td>
</tr>
<tr>
<td>Thickness of the substrate(h)</td>
<td>1.5</td>
</tr>
<tr>
<td>Length of the microstrip line(Lf)</td>
<td>20.3</td>
</tr>
<tr>
<td>Width of microstrip feed (Wf)</td>
<td>2.6</td>
</tr>
<tr>
<td>Width of the modified ground(Wg)</td>
<td>18</td>
</tr>
<tr>
<td>Gap between the feed point and ground plane(H)</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Figure 4(a) shows the return loss plot of a circular patch antenna with coaxial feeding at resonating frequency of 3.85 GHz. From the plot, return loss was observed -12.44dB at 3.85 GHz frequency of operation. At this frequency, an impedance bandwidth of approximately 109MHz and a percentage bandwidth of 2.85% were observed. Figure 4(b) shows the return loss plot of a circular patch antenna with microstrip feeding at resonating frequency of 3.7GHz. From the plot, return loss was observed -22.5dB at 3.7GHz frequency of operation. At this frequency, an impedance bandwidth covering approximately 2-12GHz band is observed.

![Fig. 4. (a): Return loss plot of circular patch antenna with coaxial feeding. (b): Return loss plot of a circular patch antenna with microstrip feeding.](image)

From the return loss plot we observed that improvement in the values of return loss and impedance bandwidth has been achieved by the use of microstrip feed for the antenna structure. The performance parameters comparison, in terms of resonant frequency, bandwidth and return loss has been tabulated below in Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>With coaxial feeding</th>
<th>With microstrip Feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return Loss (dB)</td>
<td>-12.44</td>
<td>-22.5</td>
</tr>
<tr>
<td>Bandwidth (MHz GHz) at -10 dB reference level</td>
<td>109</td>
<td>106GHz</td>
</tr>
<tr>
<td>Resonant Frequency (GHz)</td>
<td>3.85</td>
<td>3.7</td>
</tr>
</tbody>
</table>
CONCLUSIONS

A circular patch antenna with microstripline feed has been simulated and been compared to the circular patch antenna design with coaxial feed. The antenna structure with microstrip line feed with modified ground has been able to achieve ultra wide band (UWB) transmission bandwidth. Tabulated comparison between the two antenna geometries with different different feeds for the performance parameters also shows that, the design with microstrip feed has more effectiveness than the design with coaxial feed with both structures radiating at 3.85GHz.

REFERENCES


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