Dual Resonant Microstrip Patch Antenna Design employing triangular slotted substrate for Active Satellite Sensors and Aeronautical Navigation applications

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Abstract— This paper presents dual resonant triangular substrate slotted microstrip patch antenna design for active satellite sensors and aeronautical navigation. The proposed antenna has been designed over FR4 substrate having thickness of 1.57mm and dielectric constant εr=4.4 using silver as radiating patch and groundplane. The thickness of patch and groundplane is 0.02mm. The proposed antenna resonates at two different frequencies: 9.612GHz and 9.77GHz with operating bandwidth of 304MHz and return loss plot (S11) of -29.07dB at 9.612GHz and -25.22dB at 9.77GHz. The antenna is omnidirectional with gain and directivity of 6.246dB and 6.33dBi respectively at 9.77GHz and 4.27dB and 4.22dBi respectively at 9.612GHz. The proposed antenna can be suitably employed for active satellite sensors, aeronautical navigation, military and civil radiolocation for shipborne or airborne surveillance.

Keywords —CST Microwave Studio 2014, dual resonant, substrate slotted, gain, directivity.

I. INTRODUCTION

The rectangular microstrip patch antennas have received much attention because of their low cost, low profile, and lightweight properties [1]. The microstrip patch antenna also termed as patch antenna, is usually fabricated on a dielectric substrate which acts as an intermediate between a ground plane at the bottom side of substrate and a radiating patch on the top of substrate [2], [3]. The selection of substrate is the most important parameter while designing an antenna. The most commonly used dielectric substrate in antenna designing is Flame Retardant 4 (FR4). The feeding can be defined as a means to transfer the power from the feed line to the patch, which itself acts as a radiator. The antenna can be fed by various feeding methods like coaxial feed, proximity coupled microstrip feed and aperture coupled microstrip feed [4] [5] [6]. One of the limitations of the microstrip patch antennas is the narrow impedance bandwidth.

Several techniques have been investigated to improve the impedance bandwidth of microstrip patch antenna [7]. This includes meandering slots in the ground plane [8], and optimally designed impedance matching network [9]. X band technology has been broadly used in various applications because of its high data transmission rate, large bandwidth and short-range features.

Designing X band antennas has tempted the interest of many researchers and is still a major challenge to equalize these applications [10], [11], [12].

Section II deals with the antenna design specifications which describes the dimensions of the designed antenna. Section III illustrates the performance of proposed antenna in terms of bandwidth, return loss (S11), gain, directivity and VSWR plot. Section IV describes the nutshell of the research along with its application areas.

II. ANTENNA CONFIGURATION

The proposed antenna has been designed and simulated in CST Microwave Studio 2014. The FR4 substrate of thickness 1.57mm has been sandwiched between silver radiating patch and groundplane of thickness 0.02mm and conductivity of 6.30×107 Siemens/m as shown in fig. 1. The triangular slot with inner diameter Dα=51mm and outer diameter Dα=60mm has been cut through the substrate in order to improve the return loss(S11) as shown in fig. 2. Further to enhance the bandwidth defected ground has been by depositing the pentagonal shaped structure as illustrated in fig. 3. As depicted in fig. 4 the antenna has compact area of 60x60mm². The dimensions of antenna have been listed in Table I.
The proposed antenna design has been simulated using CST Microwave Studio 2014. The performance of the proposed antenna has been analyzed in terms of bandwidth (MHz), return loss ($S_{11}$) plot, gain (dB), directivity (dBi), Voltage Standing Wave Ratio (VSWR) and Smith chart. The proposed antenna is resonant at two frequencies:

**III. SIMULATED RESULTS**

![Fig. 1 Side view of proposed antenna](image1)

![Fig. 2 Perspective view of proposed antenna](image2)

![Fig. 3 Bottom view of proposed antenna](image3)

![Fig. 4 Top view of proposed antenna](image4)

![Fig. 5 Return loss ($S_{11}$) plot of proposed antenna showing resonant frequencies in CST Microwave Studio 2014](image5)

**TABLE I. ANTENNA DIMENSIONS**

<table>
<thead>
<tr>
<th>Antenna Dimensions</th>
<th>Value (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length Of Substrate, $L_s$</td>
<td>60.00</td>
</tr>
<tr>
<td>Width Of Substrate, $W_s$</td>
<td>60.00</td>
</tr>
<tr>
<td>Thickness Of Substrate, $T_s$</td>
<td>1.57</td>
</tr>
<tr>
<td>Thickness Of Ground Plane, $T_g$</td>
<td>0.02</td>
</tr>
<tr>
<td>Length Of Patch, $L_p$</td>
<td>40.00</td>
</tr>
<tr>
<td>Width Of Patch, $W_p$</td>
<td>44.00</td>
</tr>
<tr>
<td>Thickness Of Patch, $T_p$</td>
<td>0.02</td>
</tr>
<tr>
<td>Inner Diameter Of Slot, $D_{in}$</td>
<td>30.00</td>
</tr>
<tr>
<td>Outer Diameter Of Slot, $D_{out}$</td>
<td>0.02</td>
</tr>
<tr>
<td>Width Of Impedance Transformer, $W_{imp}$</td>
<td>2.00</td>
</tr>
<tr>
<td>Radius Of Pentagonal Shaped Ground, $R_g$</td>
<td>30.00</td>
</tr>
</tbody>
</table>
9.612GHz and 9.77GHz with the minimal return loss of -29.07dB and -25.22dB respectively as shown in fig. 5. The operating bandwidth of the proposed antenna has been depicted in fig. 6. The antenna operates within frequency range of 9.5GHz-9.8GHz thus making total operating bandwidth of 304.9MHz. The gain and directivity of proposed design at 9.612 GHz is 4.27dB and 4.22dBi as shown in fig. 7(a) and 7(b) respectively whereas the gain and directivity at second resonant frequency(9.77GHz) is 6.24dB and 6.33dBi as shown in fig. 8(a) and 8(b). Fig. 9 represents the VSWR value of proposed antenna in operating range of frequencies lie within 1.8372 to 1.0006, which is less than the maximum acceptable value of 2. The smith chart as clearly shown in fig. 10 illustrates that input impedance of the proposed antenna has been matched to 50Ω impedance of SMA connector. The impedance of simulated antenna has been found to be 50.13Ω.

Fig. 6 Return loss (S11) plot of proposed antenna showing bandwidth in CST Microwave Studio 2014

Fig. 7(a) Gain of proposed antenna at 9.612GHz in CST Microwave Studio 2014

Fig. 7(b) Directivity of proposed antenna at 9.612GHz in CST Microwave Studio 2014

Fig. 8(a) Gain of proposed antenna at 9.78GHz in CST Microwave Studio 2014

Fig. 8(b) Directivity of proposed antenna at 9.78GHz in CST Microwave Studio 2014

Fig. 9 VSWR plot of proposed antenna in CST Microwave Studio 2014

Fig. 10 Smith chart of proposed antenna in CST Microwave Studio 2014
IV. CONCLUSION

The proposed antenna has been simulated and designed in CST Microwave Studio 2014. The proposed antenna resonates at 9.612GHz and 9.77GHz with operating bandwidth of 304MHz and minimal return loss ($S_{11}$) of -29.07dB and -25.22 dB. The proposed antenna has gain of 4.27dB and directivity of 4.22dBi at 9.612GHz and gain of 6.24dB and directivity of 6.33dBi at 9.77GHz. The proposed antenna can be suitably employed for active satellite sensors, aeronautical navigation, radio determination, radiolocation (military and civil), shipborne and land and airborne surveillance and in ground based and airborne radar for weather broadcasting (9.5GHz-9.8GHz).

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REFERENCES


