Composite Patch With Elliptical Ground Microstrip Patch Antenna

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ABSTRACT

A composite patch with elliptical ground microstrip patch antenna is proposed for broadband application. Proposed antenna is designed on FR 4 substrate that covers the bandwidth from 0.822 GHz to 4.64 GHz. Current distributions and radiation pattern at resonating frequency is also investigated. Numerical analysis is carried out by CST simulation software. Parametric study is also carried out to know the behavior of antenna.

Keywords— Bandwidth; Transmission line model

I. INTRODUCTION

Microstrip patch antenna is a separate entity in microwave communication because of its several advantages like low profile, low cost, planar structure and easy integration with printed circuit board. These features make the microstrip antenna very attractive for use in high-speed vehicles, such as missiles, rockets and satellites. But it has some draw back like low gain, low impedance bandwidth and less power handling capability [1-2]. To reduce the limitation of conventional patch antenna thicker substrate was used but limitation of this technique is volume of antenna is increased [3-4]. Another approach to enhance the bandwidth of antenna is embedding slot on surface of the patch [5-6]. In reference [7], author has proposed a new method of step cut corner and achieved the bandwidth from 0.9 GHz to 3 GHz. Above articles proposed less impedance bandwidth. In this paper composite patch elliptical ground with notch is designed for broadband application that covers the bandwidth from 0.822 GHz to 4.46 GHz.

II. TRANSMISSION LINE MODEL

In transmission line model the rectangular microstrip patch antenna can be represented by two slots of width (W) and height (h) separated by transmission line of length (L). The width of the patch can be calculated from the following equation

\[ W = \frac{c}{2\pi} \sqrt{\frac{1}{\varepsilon_r+1}} \]  

(1)

The effective dielectric constant (\( \varepsilon_{\text{eff}} \)) is less than (\( \varepsilon_r \)) because the fringing field around the periphery of the patch is not confined to the dielectric also spreed in the air also.

\[ \varepsilon_{\text{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \left[ 1 + 12 \frac{h}{W} \right]^{-1/2} \]  

(2)

Because of fringing field, extension in length and width is given by empirically.

\[ \Delta L = 0.412h \left( \frac{\varepsilon_{\text{eff}}+0.3}{\varepsilon_{\text{eff}}-0.256} \right) \]  

(3)

\[ \Delta W = 1.6ln(4/\pi) \]  

(4)

Effective length (\( L_e \)) and effective width (\( W_e \)) is given by

\[ L_e = L + \Delta L \]  

(5)

\[ W_e = W + \Delta W \]  

(6)

The length of the patch is given by

\[ L = \frac{c}{2\pi \sqrt{\varepsilon_{\text{eff}}}} - 2\Delta L \]  

(7)

Where,

\( c = \) speed of light

\( \varepsilon_r = \) operating frequency

\( \varepsilon_{\text{eff}} = \) effective dielectric constant

III. ANTENNA CONFIGURATION

Geometry of proposed antenna is shown in figure 1. Composite structure of radiating element is made after intersecting three elements. Element 1.2 and 3 designed for 0.9 GHz, 1.4 GHz and 2.6 GHz respectively. Physical dimension of elements is calculated by transmission line equation. Proposed antenna is designed on FR-4 with relative permittivity 4.4, loss tangent 0.02 and thickness 1.6mm and excited by 50 ohm microstrip line. Elliptical ground plane with rectangular notch is made on another side of the substrate. Evolution of antenna is shown in figure 2. Firstly two elements are intersected. Further one more element is added in antenna 1. To improve the performance of antenna 2 four triangular elements are added. Overall volume of the antenna is 130mm×90mm×1.6mm. The structural parameter of the
antenna is given in table 1 and table 2 shows the dimensions of elements.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>DIMENSION FOR PROPOSED ANTENNA</th>
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<tbody>
<tr>
<td>Parameter</td>
<td>Length of substrate Lsub</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>130mm</td>
<td>90mm</td>
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<table>
<thead>
<tr>
<th>TABLE II</th>
<th>DIMENSION OF ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Element 1</td>
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<tr>
<td>Length</td>
<td>102mm</td>
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<tr>
<td>Width</td>
<td>80mm</td>
</tr>
</tbody>
</table>

IV. EVOLUTION OF ANTENNA

Evolution of antenna is shown in figure 2 and their frequency response these antennas are shown in figure 3. In antenna one two elements are intersected. Further to improve the for performance of antenna one more element is added. Finally Four triangular elements are added to improve the bandwidth of the antenna. It is clear from the figure antenna 1 is resonating in three operating bands while antenna 2 shows better return loss characteristics. Antenna 3 covers the bandwidth from 0.822 GHz to 4.46 GHz for VSWR < 2. Figure 4 shows the variation of input impedance of antenna 1, 2 and 3. It is clear from the figure antenna shows higher impedance and by modifying the structure of antenna, input impedance is reduced and moves around 50 ohm.

V. CURRENT DISTRIBUTION AND RADIATION PATTERN

Simulated current distribution at resonating frequencies is displayed in figure 5. By inspection the current pattern at every resonance frequency is changed along the periphery of the patch along micro strip line and periphery of the elliptical ground plane. At fundamental frequency 0.3 GHz current is mainly distributed at the bottom portion of the patch.
Simulated radiation pattern at resonating frequencies is displayed in figure 6 and 7. By investigation, in H plane the pattern is omnidirectional at lower frequencies but at higher frequency the pattern is distorted because of presence of higher order modes. In E plane multiple lobes are found at higher frequency while pattern is bidirectional at lower frequency. Figure 8 shows the efficiency of antenna in entire operating frequency band.

VI. PARAMETRIC STUDY

(A) Effect of notch

Figure 9 shows the impact of depth of notch. As notch depth increases impedance bandwidth of antenna decreases. It is clear from the figure for a=2mm maximum bandwidth is observed.

(B) Effect of elliptical radius

Figure 10 shows the impact of elliptical radius. As radius increases impedance bandwidth of antenna increases. It is clear from the figure for 45mm maximum bandwidth is found.

VII. CONCLUSION

Composite patch micro strip fed with elliptical ground plane antenna has been simulated. It is found proposed antenna covers the bandwidth from 0.822 GHz to 4.46 GHz. Current distribution and radiation pattern at resonating frequencies are also studied. The parametric study has been carried out, observed the effect on return loss and resonance frequency.

REFERENCES