Design and Bandwidth Enhancement of Rectangular Microstrip Patch Antenna using Double H-Slot Technique for Broadband Applications

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Abstract: In this paper, the bandwidth enhancement of microstrip patch antenna is done by cutting double H slot into dimension calculated rectangular patch. The design antenna obtained good results such as bandwidth 1786MHz (70.04% fractional bandwidth), efficiency (100%), VSWR (1.159) and gain 4.032dB at calculated resonant frequency of 2.391GHz and the operating frequency range of antenna is 1.657-3.443GHz. The broadband characteristics of antenna are shown in simulated application results of design double H slot microstrip patch antenna. The designed structure and performance of antenna is simulated using IE3D Zealand simulation software. The antenna is fed by 50Ωmicrostrip line feed.

Keywords: Calculated ground plane, Calculated microstrip patch [MSP], Enhance bandwidth, Double H-Slot, IE3D simulator, 50Ωmicrostrip line feed.

INTRODUCTION

At that time the demand of microstrip patch [MSP] antenna increases day by day because antennas play an important role for broadband devices such like mobile phone, radio, laptop with wireless connection [17].

The purpose of new design antenna presents to enhance the bandwidth of double slotted H shape MSP antenna for many broadband applications such as military, wireless communication, satellite communication, global positioning system (GPS), RF devices, WLAN/WI-MAX application [8, 11]. The major drawbacks of MSP antennas in basic form are narrow bandwidth and low gain [7] and many techniques are used to enhance bandwidth and gain of MSP patch antennas. By using thick substrate with low dielectric constant and compact slotted patch can enhance the bandwidth and gain of antennas [16]. The MSP antenna have good features such as low cost, low profile, light weight, high efficiency, simply manufacture and easy to implement with circuits [8, 10, 16].The design structure components of antenna become small in size and have low processing cost [11].

In this paper transmission line method are used to analysis the rectangular MSP antenna. The design resonant frequency of rectangular MSP antenna is 2.5GHz with 50Ωmicrostrip line feed. MSP antenna is characterized by using thickness (h), dielectric constant (εr), and length (Lg, L), width (Wg, W) of ground plane and patch. The performances of design MSP antenna such as radiation pattern, return loss, directivity, VSWR and gain are simulated by using IE3D software.

II. MATHEMATICAL FORMULAS TO CALCULATE DIMENSIONS OF MSP ANTENNA

The mathematical formula is used to calculate the dimensions of ground plane and patch in the form of length and width.

A. Width formula of Rectangular MSP is taken by [1, 8].

\[ W = \left( \frac{c}{2f_r} \right) \left( \frac{\varepsilon_r + 1}{2} \right)^{-\frac{5}{2}} \]

Where \( c = 3\times10^8 \text{ms}^{-1}, \varepsilon_r = 4.2, f_r = 2.5\text{GHz} \)

B. Formula of effective dielectric constant is taken by [4, 15].
\[ \varepsilon_{\text{eff}} = \left( \frac{\varepsilon_r + 1}{2} \right) + \left( \frac{\varepsilon_r - 1}{2} \right) \left( 1 + \frac{12W}{h} \right)^{-5} \]

At \( h = 1.6 \text{mm} \)

C. Formula of length extension is taken by [1, 4].

\[ \Delta L = 0.412h \left( \frac{\varepsilon_{\text{eff}} + 3}{\varepsilon_{\text{eff}} - 258} \right) \left( \frac{W}{h} \right) + 0.264 \left( \frac{W}{h} \right) + 0.8 \]

D. Length formula of Rectangular MSP is taken by [5, 8].

\[ L = \left( \frac{c}{2f_r \sqrt{\varepsilon_{\text{eff}}}} \right) - 2\Delta L \]

E. Formula of length and the width of the ground plane are taken by [1, 11].

\[ L_g = L + 6h \]

\[ W_g = W + 6h \]

III. ANTENNA DESIGN SPECIFICATIONS

Calculated dimensions of ground plane is constructed by using resonant frequency \( (f_r) \), dielectric constant \( (\varepsilon_r) \), substrate thickness \( (h) \) and loss tangent \( (\tan \delta) \) and 50Qmicrostrip line feed is fed into patch. Calculated dimensions are obtained by using formula and double H slot cut into the rectangular patch.

<table>
<thead>
<tr>
<th>S. NO</th>
<th>Antenna Parameter</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Resonant frequency ( (f_r) )</td>
<td>2.5GHz</td>
</tr>
<tr>
<td>2.</td>
<td>Substrate thickness ( (h) )</td>
<td>1.6mm</td>
</tr>
<tr>
<td>3.</td>
<td>Dielectric constant ( (\varepsilon_r) )</td>
<td>4.2</td>
</tr>
</tbody>
</table>

IV. ANTENNA DESIGN PROCEDURE

Using the above equations and geometrical parameters, dimensions of antenna is calculated. In the design of antennas first calculate the dimensions of ground plane and patch then antenna is designed by using dimensions after that slots cut into the microstrip patch.

TABLE 2: CALCULATED ANTENNA DIMENSIONS

<table>
<thead>
<tr>
<th>S. NO</th>
<th>Antenna Dimension</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ground plane length ( (L_g) )</td>
<td>37.4 mm</td>
</tr>
<tr>
<td>2.</td>
<td>Ground plane width ( (W_g) )</td>
<td>46.8 mm</td>
</tr>
<tr>
<td>3.</td>
<td>Patch width ( (W) )</td>
<td>37.2 mm</td>
</tr>
<tr>
<td>4.</td>
<td>Patch length ( (L) )</td>
<td>27.8 mm</td>
</tr>
</tbody>
</table>

The calculated design of double H slot shape MSP antenna is shown in Fig. 1.

![Fig. 1.Geometry of design antenna and all dimensions in mm](image-url)
V. SIMULATION RESULT AND DISCUSSION

The simulation performances of design MSP antenna is analyzed by using IE3D software at define resonant frequency of 2.5GHz and antenna successfully obtained 2.391GHz resonant frequency at peak point of return loss.

The plot graph of return loss Vs frequency is taken at the maximum frequency of 3.5GHz which is shown in Fig. 2. The enhances bandwidth 1786MHz (70.04% fractional bandwidth) of design antenna is obtained at calculated resonant frequency of 2.391GHz.

![Fig. 2. Return loss vs. frequency graph](image)

In Fig. 2, the plot graph of Gain Vs Frequency shows the total field gain of the MSP antenna and obtain maximum gain of antenna is 4.032dB at resonant frequency 2.391GHz.

![Fig. 3. Gain vs. frequency plot](image)

In Fig. 3, the plot graph of Efficiency Vs Frequency represents that the bandwidth of design antenna is useful or not. The obtain VSWR is 1.159 at resonant frequency of 2.391GHz.

![Efficiency Vs. Frequency](image)

In Fig. 4, the plot graph of Efficiency Vs Frequency represents radiating efficiency and antenna efficiency. The obtain percentage antenna efficiency is 100 at 2.391GHz.

![Fig. 4. Efficiency vs. frequency plot](image)

In Fig. 4, the plot graph of VSWR Vs Frequency represents radiating all power in one direction therefore design antenna has unidirectional radiation pattern. 2D radiation pattern of antenna is shown at resonant frequency 2.391GHz and phi=0(deg).

![Fig. 5. VSWR vs. frequency plot](image)

In Fig. 5, the plot graph of 2D radiation pattern of antenna represents radiating all power in one direction therefore design antenna has unidirectional radiation pattern.
In Fig. 7, the plot graph of total field Directivity Vs Frequency represents the ratio of radiation intensity in a given direction from the antenna to the radiation intensity averaged over all direction [14]. The obtain directivity of antenna is 3.92dB at resonant frequency 2.391GHz.

In Fig. 8, the plot graph of Axial-Ratio Vs Frequency represents the ratio of the major axis to the minor axis of the polarization ellipse and the resulting pattern shows an oscillating pattern [9].

VI. CONCLUSION

In this paper, the simulated results of double H slot rectangular MSP antenna with 50Ωmicristrip line feed are obtained. The obtain results of design antenna are enhance bandwidth 1786MHz (70.03% fractional bandwidth), operating frequency range 1.657-3.443GHz, gain (4.032dB), efficiency (100%), return loss (-22.6dB), VSWR (1.159) at resonant frequency of 2.391GHz. The obtain good performance results of design antenna can be used as various broadband applications such as missile, wireless, satellite, mobile communication, and military.

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REFERENCES

BIOGRAPHIES

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