High Bandwidth F-Shaped Microstrip Patch Antenna for C-band Communications

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Abstract: In this paper, a F-shape microstrip patch antenna is designed and analyzed. The antenna design is simulated using a tool named Sonnet Suites, a planar 3D planar electromagnetic simulator that use Method of Moments. Probe feed technique is used in the proposed F-shape patch antenna. Simulation results show that the impedance bandwidth is 36.6% of the center frequency. The measured return loss is below -10dB. The proposed microstrip patch antenna is suitable for C-band communications.

Keywords: Patch Antenna, F-shape, Dielectric Substrate, Bandwidth, Return Loss, C-band, Sonnet.

I. INTRODUCTION

The drastic and dynamic development in the field of wireless communication leads towards miniaturization of the device size without compromising with its features. Same is the case with antenna technology, as the antenna technology is advancing day by day the small antenna size with good performance are in high demand.

Many conventional antenna structures such as Yagi, Parabolic Reflector, Helical, Horn etc. have wider bandwidth and gain but large size of these antennas restrict their use in various applications, so these antennas cannot be used in the devices which are smaller in size and are used as an moving object. To meet this requirement of wireless communication, microstrip antennas are widely used which satisfies the requirements of the wireless communication system.

The microstrip patch antenna is employed for the recent deployment in wireless communications such as radar, space communication, satellite communication, microwave and mobile communication etc. [1] because of its light weight, low volume, low profile planar configurations, inexpensive and easy to integrate with microwave integrated circuits [2]. Over the past two decades, microstrip patch antenna received attention for communication due to its advantages. Microstrip patch antenna has also disadvantages are narrow bandwidth, excitation of surface waves, low gain and depleted radiation pattern [3]. Intensifier research has been carried out to overcome the cons of patch antenna. Different techniques with different shaped patch antennas are applied to increase the bandwidth and overcome the limitations.

In this paper, designed an F-shaped microstrip patch antenna for C-band communication covering 4-8 GHz [4] primarily used for satellite communications [4] and full-time satellite TV networks or raw satellite feeds. C-band also used for long-distance radio telecommunications, some Wi-Fi devices, cordless telephones, some weather radar systems and commonly used in areas that are subject to tropical rainfall which is the absorption of radio signals by atmospheric rain, snow or ice [4] to improve bandwidth as well as to mitigate the problems.

II. PATCH DESIGN & CONFIGURATION

The proposed F-shaped microstrip patch antenna has the resonant frequency f₀ = 4.1GHz and used dielectric substrate of a unitA to design this antenna. The dielectric constant of the substrate εᵣ = 9.9, thickness of the substrate h = 2.032 mm and Co-axial probe feeding technique also been used to design the F-shaped microstrip patch antenna. The Proposed F-shape microstrip patch antenna has over all dimensions W (15.7 mm) × L (11.1 mm). The width and length of the microstrip antenna are determined as follows [5]:

Width Calculation (W)

\[
W = \frac{c}{2\lambda_0 \sqrt{1 + \frac{1}{\epsilon_{reff}}} (1)
\]

Where C is the free-space velocity of light, εᵣ is the dielectric constant of substrate, f₀ is the antenna working frequency, W is the patch non resonant width, and the effective dielectric constant is \( \epsilon_{reff} \) given as

Calculation of Effective dielectric constant (\( \epsilon_{reff} \))

\[
\epsilon_{reff} = \frac{\epsilon_r + 1}{2} \frac{\epsilon_r - 1}{2} \left[ 1 + \frac{12}{h} \left( \frac{W}{h} \right)^2 \right] (2)
\]

Where the dimensions of the microstrip patch along its length have been extended on each end by a distance ΔL, which is a function of the effective dielectric constant and the width-to-height ratio (W/h), and the normalized extension of the length, is

Calculation of the Effective length (\( L_{eff} \))

\[
L_{eff} = \frac{c}{2\lambda_0 \sqrt{\epsilon_{reff}}} (3)
\]

Calculation of the length extension (\( \Delta L \))

\[
\Delta L = 0.412h \left( \frac{\epsilon_{reff} + 0.39}{\epsilon_{reff} - 0.264} \right)^n \left( \frac{W}{h} \right)^{0.8} \left( \Delta L \right) (4)
\]

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DOI 10.17148/IJARCCE.2017.6330
Calculation of actual length of patch (L)
The actual length of the patch can be determine as
\[ L_{\text{eff}} = L + 2\Delta L \]  
(5)

Microstrip antenna is designed and simulated by using Sonnet Software that use method of moments. The geometry of F-shape microstrip patch antenna with box wall port which is the most common types of port that use reference plane to remove the effects of the transmission line effect as shown in Fig. 1.

And the 3D view of F-shaped patch antenna is shown in Fig. 2.

Design parameters of the proposed F-shaped microstrip patch antenna is shown in Table I.

<table>
<thead>
<tr>
<th>Antenna Design Parameter</th>
<th>Material / value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric Material</td>
<td>Alumina</td>
</tr>
<tr>
<td>Dielectric Constant(( \epsilon_r ))</td>
<td>9.9</td>
</tr>
<tr>
<td>Loss Tangent</td>
<td>1.0e-4</td>
</tr>
<tr>
<td>Height of Substrate(Thickness) (h) (mm)</td>
<td>2.032</td>
</tr>
<tr>
<td>Width of the Patch (W) (mm)</td>
<td>15.7</td>
</tr>
</tbody>
</table>

Table I: Proposed F-shaped Patch Antenna Design Parameters

III. SIMULATION RESULTS

In this research, broad banding technique F-shaped patch is presented. The simulation results are presented below. Finally, the results are discussed. The results are explained in terms of the return loss, input impedance. The current density on the antenna is also showed.

A. Return Loss Curve
This can be defined as difference in dB between the forward and reflected power measured at a given point in an RF system.

The first important parameter is return loss curve which is very much helpful to calculate the bandwidth of the antenna structure is its S11 parameter in decibel versus frequency. The return loss curve of the designed antenna is shown in Fig. 3, and minimum S11 level of -13.11 dB is shown in m3 caption. Figure shows that the antenna resonates at 4.1GHz band.

![Simulated Return Loss of F-shaped patch antenna](image)

The bandwidth can be described in terms of percentage of the center frequency of the band.

Calculation of the bandwidth
\[ WB = \frac{F_H - F_L}{F_C} \times 100 \]  
(6)

Where \( F_H \) = Higher Frequency, \( F_L \) = Lower Frequency and \( F_C \) = Center Frequency.

Here \( F_H \) = 4.7 GHz, \( F_L \) = 3.2 GHz and \( F_C \) = 4.1GHz. So the obtained bandwidth is 1.5 GHz which is 36.6% of the center frequency.

B. Input Impedance Curve
The input impedance curve tells us the magnitude, phase angle and VSWR of the input impedance of the antenna at the respective frequencies.
was seen that proposed F-shaped patch is better than previous.

V. CONCLUSION

In this research paper, the main target is to improve the bandwidth of microstrip antenna constructed with dielectric material with higher dielectric constant. A novel design technique for small and compact size F shaped patch antenna is presented, simulated and discussed for wireless communication specifically the satellite communication covering 4-8 GHz and box wall port is used to feed the antenna. The thickness of the proposed patch antennas is 2.032mm. The vswr parameter is less than 2 within the operating frequency range and resonant frequency is found at vswr = 1.56. The Bandwidth obtained for C-band communications is greater than other existing F-shaped microstrip patch antenna.

REFERENCES


BIOGRAPHIES

Muhammad Afsar Uddin received his B.Sc. (Engg.) degree in Computer Science and Telecommunication Engineering & M.Sc.(Engg.) in Telecommunication Engineering from the department of Computer Science and Telecommunication Engineering of Noakhali Science and Technology University, Noakhali, Bangladesh. He was a Lecturer in the department of Computer Science and Technology University, Noakhali, Bangladesh. He was a Lecturer in the department of Computer Science and Technology University, Noakhali, Bangladesh.
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