DESIGN AND ANALYSIS OF HEXA BAND MICROSTRIP PATCH ANTENNA FOR WIRELESS APPLICATION

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Abstract - Design of hexaband microstrip rectangular patch antenna is presented in this paper. This antenna is fed by stripline feeding technique. The proposed patch antenna is designed and simulated using HFSS simulation software.

Index Terms - Microstrip Patch Antenna, Return Loss, Stripline-Feed, VSWR.

I. INTRODUCTION

In this current age of advancements, wireless communication systems are evolving toward multi functionality. This multi functionality provides users the options of connecting to different kinds of wireless services for different purposes at different times. Hence it is highly desirable to develop single radiating element having capabilities of performing different functions and/or multiband operation in order to minimize the antenna’s weight and area to enhance portability.

Microstrip patch antennas are widely used in multiband antenna designs for their simplicity and compatibility. Also they are attractive type of antennas due to their low cost, conformability and ease of manufacture.

Several types of multiband antennas are being proposed by researchers and process is still going on. In [1] multiband PIFA is designed with slotted ground plane to improve the bandwidth at both low and high frequencies without increasing the volume of the antenna. In [2] E shaped fractal patch antenna is presented which can cover LTE and S bands. In [3] reconfigurable patch design is proposed for cognitive radio communication. In paper [7] defected ground structure S-shaped multiband microstrip patch using complementary split ring resonator is presented which is suitable for various medical applications.

This paper proposes rectangular shaped multiband patch antenna, resonating at six different frequencies, which can be used for multiple applications.

II. MICROSTRIP PATCH ANTENNA

Microstrip patch antennas have played an increasingly significant role in the antenna field since the mid-1970s, contributing new developments and applications. Planar techniques provide significant advantages namely low profile and reduced weight, relatively low manufacturing cost, the potential to group many identical patches to build arrays and to integrate with circuit elements.

A. Antenna configuration

A microstrip patch antenna consists of a radiating metallic patch (generally made up of conducting material such as copper or gold) of any planar on one side of a dielectric material substrate backed by a ground plane on the other side, as shown in Fig. 1.

Fig.1 Microstrip patch antenna
In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular and elliptical or some other common shape.

B. Design calculations

The width and length of the patch antenna are calculated by using transmission line design equations.

Step 1: Calculation of the width (W):

The width of the microstrip patch antenna is given as:

\[ W = \frac{c}{2 f_0 \sqrt{\varepsilon_r + 1}} \]

where \( \varepsilon_r \) = dielectric constant of substrate,

\( f_0 \) = frequency of operation.

Step 2: Calculation of effective dielectric constant (\( \varepsilon_{reff} \)):

The effective dielectric constant is:

\[ \varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + \frac{h}{W} \right]^{\frac{1}{2}} \]

where \( h \) = height of substrate.

Step 3: Calculation of the effective length (\( L_{eff} \)):

The effective length is given as:

\[ L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}} \]

Step 4: Calculation of the length extension (\( \Delta L \)):

The length extension is:

\[ \Delta L = 0.412h \left( \varepsilon_{reff} + 0.3 \left( \frac{W}{h} + 0.264 \right) \right) - 0.258h \left( \varepsilon_{reff} - 0.258 \left( \frac{W}{h} + 0.8 \right) \right) \]

Step 5: Calculation of actual length of patch (L):

The actual length is obtained by:

\[ L = L_{eff} - 2\Delta L \]

Step 6: Calculation of the ground plane dimensions (\( L_g \) and \( W_g \)):

For the design, the ground plane dimensions would be given as:

\[ L_g = 6h + L \]
\[ W_g = 6h + W \]

Step 7: Determination of strip line feeding:

A strip line fed type feeding technique is to be used in this design. The feeding point must be located at that point on the patch where the input impedance is 50 ohms for the resonant frequency.

III. PROPOSED ANTENNA GEOMETRY

The conventional rectangular microstrip patch antenna is designed on FR4 Epoxy substrate material, having following specifications:

Substrate: FR4 Epoxy

Height: 1.6 mm

Dielectric constant: 4.4

Here the rectangular patch has length and width 36.56mm and 46.81 mm respectively. Four narrow slits are taken out from the patch to improve the performance of antenna as multiband functionality. The frequency of operation is taken as 1.95GHz.

IV. STRUCTURE OF PROPOSED DESIGN IN HFSS

The designed patch antenna is shown in Fig. 2 in 3D model. It consists of patch elements on one side of the dielectric substrate and planar ground on the other side. It is assigned with an air box boundary and virtual radiation to create far field radiation pattern and assigned with an excitation of lump port.
V. RESULTS & ANALYSIS

The patch antenna is simulated using Ansoft HFSS. Fig. 3 and Fig. 4 show Return Loss and VSWR plot of the design.

A. Return loss

It is a measure of the reflected energy from a transmitted signal which is commonly expressed in decibels (dB). Larger the value, lesser is the energy reflected. The results obtained are mentioned below.

B. VSWR

VSWR stands for voltage standing wave ratio. It is a function of the reflection coefficient, which describes the power reflected from the antenna. For small VSWR, the antenna is better matched to the transmission line and more power is delivered to the antenna. Figure shows VSWR plot of proposed design.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Return loss</th>
<th>VSWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.34GHz</td>
<td>-13.94dB</td>
<td>1.50</td>
</tr>
<tr>
<td>1.99GHz</td>
<td>-22.78dB</td>
<td>1.16</td>
</tr>
<tr>
<td>2.98GHz</td>
<td>-21.02dB</td>
<td>1.19</td>
</tr>
<tr>
<td>3.27GHz</td>
<td>-15.70dB</td>
<td>1.39</td>
</tr>
<tr>
<td>3.56GHz</td>
<td>-24.64dB</td>
<td>1.12</td>
</tr>
<tr>
<td>3.86GHz</td>
<td>-11.17dB</td>
<td>1.78</td>
</tr>
</tbody>
</table>

From the above results we can say that the designed antenna is having six bands of operations. Return loss parameter obtained at all these frequencies has values less than -10dB. The value of VSWR at all these resonating frequency bands is also between 1 and 2. Hence we can say that designed antenna, which is resonating at six different resonating frequencies, is a multiband antenna. Fig. 5 shows 3D polar plot of the proposed design. Total directivity of the proposed antenna is 3.5597dB.
VI. CONCLUSION

Microstrip antenna has become a rapidly growing area of research. Their potential applications are limitless because of their light weight, compact size and ease of manufacturing. Here rectangular shaped microstrip patch antenna is designed for multiband applications. This antenna is suitable for UMTS, WLAN, WiMAX and other wireless applications. The modeling and iterative simulations are carried out at central frequency of 1.95 GHz. Further design can be modified to have more bands for various applications.

REFERENCES


