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Design and Analysis of Triple-Band Multi Slotted Microstrip Patch Antenna

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Abstract: *In this paper, a multi slotted microstrip patch antenna design has been proposed. The characteristics of the antenna are obtained in terms of return loss, gain and bandwidth. It is observed that the new proposed configuration can operate in three different frequency bands with a good amount of bandwidth i.e. bandwidth of 21.12% at 1.1GHz frequency band, bandwidth of 11.65% at 2.11 GHz and bandwidth of 13.05% at 2.76GHz frequency band . The resonating behavior in different frequency bands makes this antenna structure suitable for different types of applications with an antenna gain of 6.163dBi and antenna efficiency of 86.82%.The substrate material with relative permittivity of 4.2 and loss tangent of 0.0013 is used in this proposed antenna. The designing and simulation of the antenna structure is done over IE3D simulation software version 15.02.*

Keywords: *Ground plane, Multi slotted, Patch Antenna, Triple band*

I. Introduction

With the wide spread proliferation of wireless communication technology in recent years, the demand for compact, low profile and broadband antennas has increased significantly. To meet the requirement, the microstrip patch antenna has been proposed because of its low profile, light weight and low cost [1]. However, conventional microstrip patch antenna suffers from very narrow bandwidth, this poses a design challenge for the microstrip antenna designer to meet the broadband techniques [2, 3]. There are several well-known methods to increase the bandwidth of patch antennas, such as the use of thick substrate, cutting a resonant slot inside the patch, the use of a low dielectric substrate, multi- resonator stack configurations, the use of various impedance matching and feeding techniques, and the use of slot antenna geometry [4, 6]. A good amount of increment in the performance of the antenna structure is achieved by using these techniques but the application of these antenna structures are limited to be operated in single frequency band. In this paper a multi slotted rectangular shaped patch antenna structure is designed by cutting three slots in a rectangular microstrip patch antenna. The designed antenna structure is further simulated over IE3D version 15.02. First of all its return loss curve is considered, using this curve the bandwidth of the designed antenna is calculated, further the VSWR curve is considered which will help to decide whether this antenna structure can work in the frequency bands shown in the return loss curve. Another important parameter gain is further considered to analyze the antenna gain, further another important parameter i.e. directivity is shown. At last the efficiency is considered which includes the antenna efficiency as well as radiation efficiency. These all results are analyzed in this paper. The coaxial probe feed method is used for feeding.

II. Antenna Design

The proposed antenna structure is designed by cutting three slots in the rectangular patch antenna which is shown in *fig. 1*. The antenna structure shown in *fig. 1* is designed and simulated over IE3D simulation software. The dimensions of the antenna structure are shown in the figure itself along with *table 1.*

Table 1: *Dimensions of antenna structure*

Description	***Dimensions(in mm)***
Ground plane	l=80,w =95
Patch	l=60,w=75
Slot	l=20,w=10

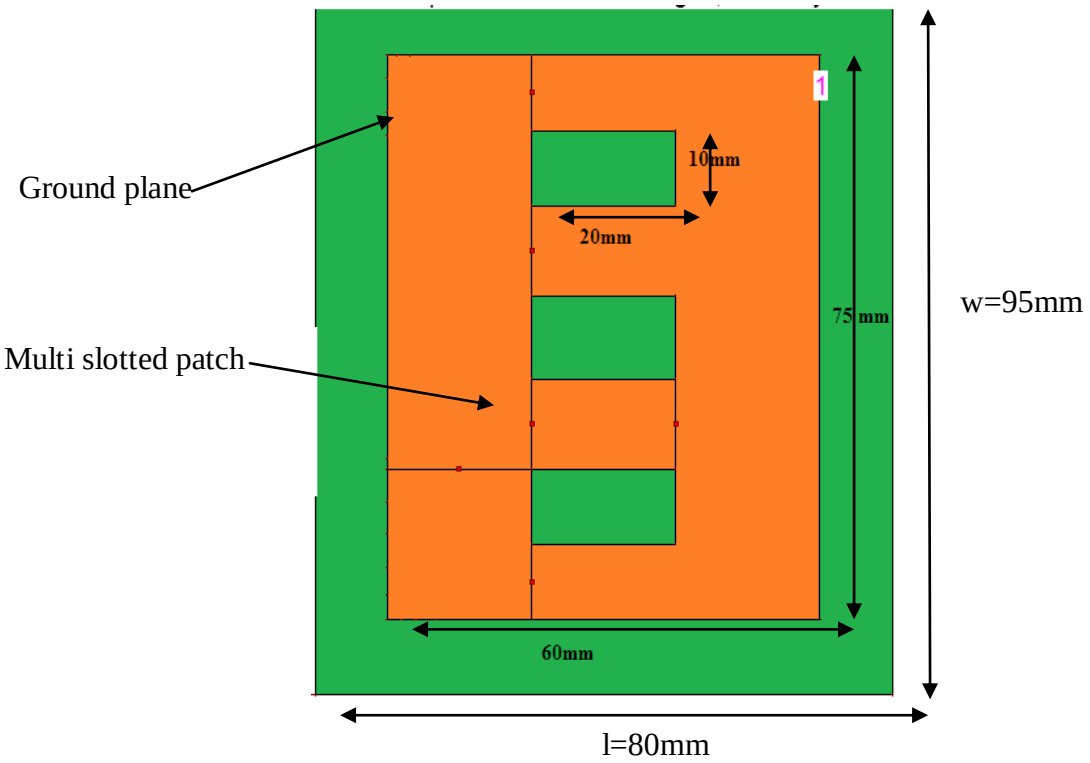

Fig.1 Design of multi slotted Microstrip Patch Antenna

III. Results And Discussion

The antenna structure when designed and simulated over IE3D provides good result in terms of bandwidth and makes this antenna well suited to work in three different frequency bands.

3.1 Return Loss

The most important parameter to be analyzed is the bandwidth of the antenna and to analyze it the return loss curve is drawn and studied. For any antenna structure with good performance the return loss should be minimum. A standard value of the return loss i.e. -10dB is considered for the calculation of the bandwidth of the antenna structure. The simulation of the antenna structure provides the return loss curve which is shown in fig. 2.

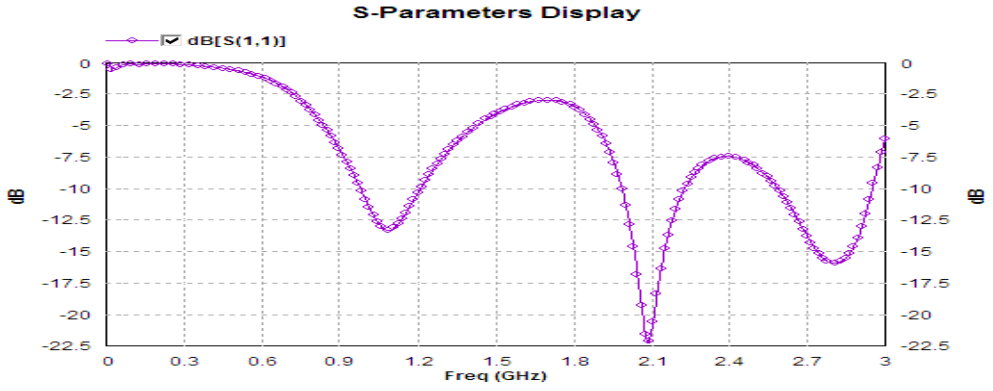

Fig. 2 Return Loss Curve of the Designed Antenna Structure

Calculation of the bandwidth

For frequency band 1

f_{l1}=0.982GHz, f_{h1}=1.214GHz, f_{c1}=1.098GHz

$$\text{Bandwidth}_1 = \frac{1.214 - 0.982}{1.098} = \mathbf{21.12\%}$$

For frequency band 2

f_{l2}=1.984GHz, f_{h2}=2.229GHz, f_{c2}=2.107GHz

$$\text{Bandwidth}_2=\frac{2.229-1.984}{2.107}=\mathbf{11.65\%}$$

For frequency band 3

f_{l3}=2.584GHz, f_{h3}=2.946GHz, f_{c3}=2.765GHz

$$\text{Bandwidth}_3=\frac{2.946-2.584}{2.765}=\mathbf{13.07\%}$$

The curve shown in *fig.2* and the calculation done shows different amount of bandwidth at different frequency bands i.e. the bandwidth of 21.12%, 11.65% and 13.07% in different frequency bands which make this antenna structure suitable for three different types of applications.

3.2 VSWR

Another very important factor which is related to the bandwidth is the VSWR. The VSWR should be less than 2 in the frequency band in which the antenna has to operate. The VSWR curve of the antenna structure is shown in fig 3.

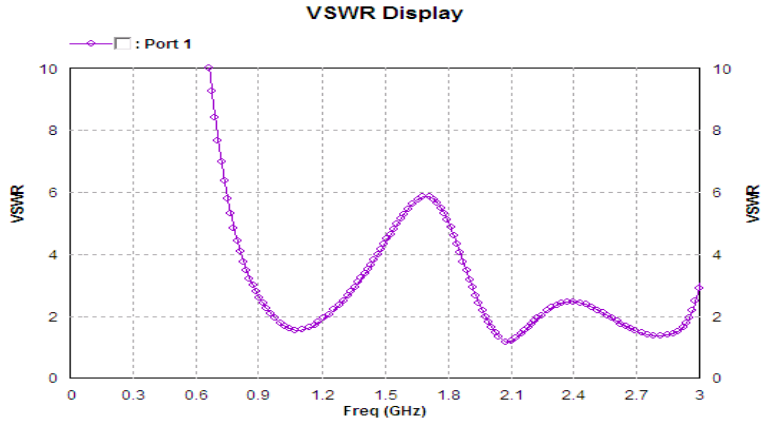

Fig. 3 VSWR Curve

Analyzing the curve shown in *fig. 3* it is clearly observed that the VSWR is less than 2 in the frequency bands shown in the return loss curve. Hence this antenna structure can perform well in the above said frequency bands.

3.3 Gain

Another important parameter which has to be considered is the gain of the antenna. The total field gain Vs frequency curve is shown in *fig. 4.*

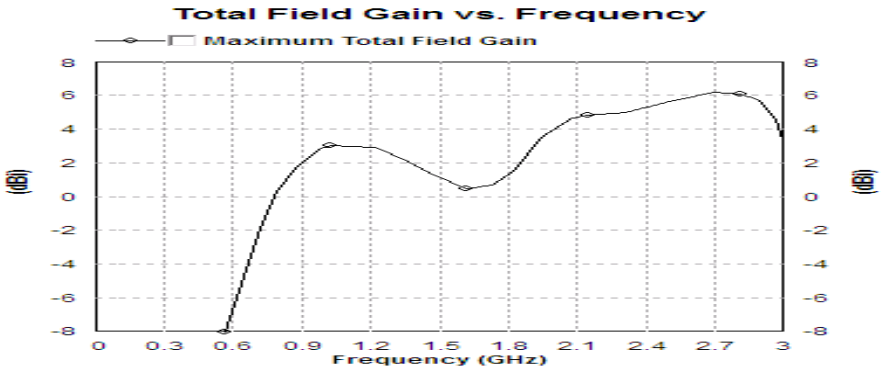

Fig. 4 Total Field Gain Vs Frequency Curve

Analyzing the curve shown in *fig. 4* it can be clearly observed that the designed antenna structure provides a good amount of gain i.e. 6.163 dBi which is highly desirable for various applications.

3.4 Directivity

Another important parameter which is highly considered is the directivity of the antenna. *Fig. 5* shows a curve between Total Field Directivity vs. Frequency

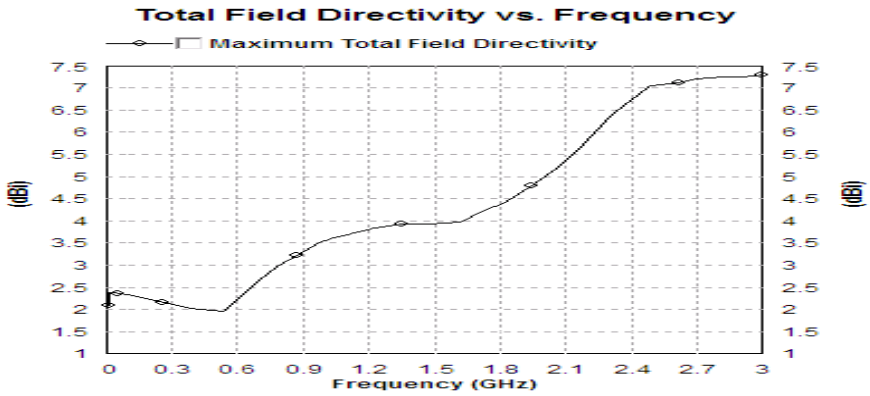

Fig. 5 Total Field Directivity Vs Frequency

Analyzing the curve shown in *fig. 5* it can be clearly observed that the designed antenna structure provides good amount of directivity i.e. 7.28dBi at 2.99 GHz frequency.

3.5 Antenna efficiency

Antenna efficiency and radiation efficiency are two important parameters which we have to analyze. *Fig 6* and *Fig. 7* shows the antenna efficiency and radiation efficiency respectively

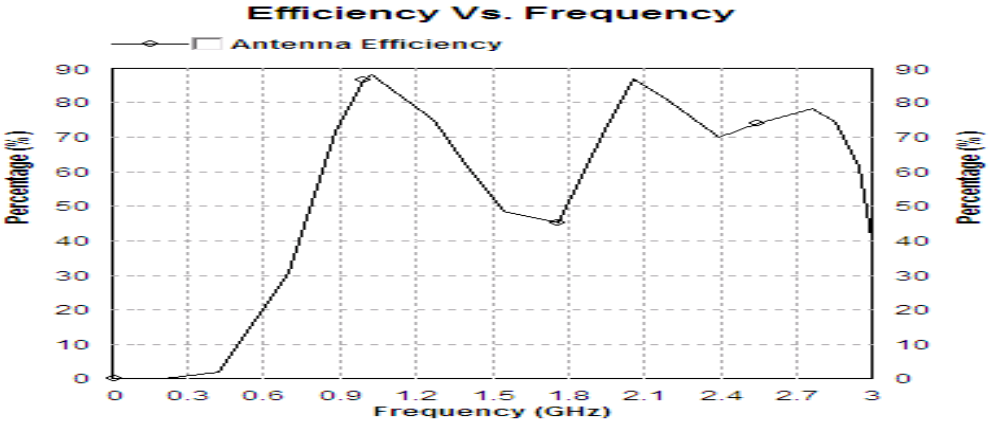

Fig. 6 Antenna Efficiency

Analyzing the antenna efficiency curve we can see antenna efficiency of 86.82% which quite good while considering the microstrip patch antenna structure.

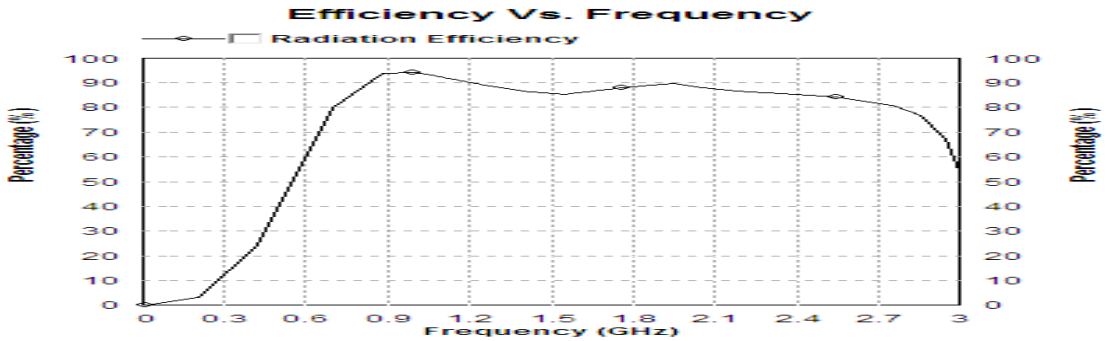

Fig. 7 Radiation Efficiency

3.6 Radiation efficiency

Similarly analyzing the radiation efficiency curve we can see a radiation efficiency of 94.34% which is quite good while considering the microstrip patch antenna structure

IV. Conclusion

A multi slotted microstrip patch antenna is designed and simulated over IE3D simulation software. The simulation results of this antenna structure is quite good as this antenna structure can work in three different frequency bands with good amount of bandwidth i.e. 21.12%,11.65 and 13.07% , along with the bandwidth the

antenna structure also provides good amount of gain i.e. 6.16 dBi, directivity of 7.28dBi, antenna efficiency of 86.82% and radiation efficiency of 94.34%.

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