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Design and Analysis of Quad-Band Rectangular Microstrip Patch Antenna

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Abstract: *This paper proposes the rectangular microstrip patch antenna suitable to operate in different frequency bands. The rectangular microstrip patch antenna is designed and simulated using IE3D simulation software. The result obtained shows that the designed antenna is suitable for operation in four different frequency bands with bandwidth of 6.90%, 2.33%, 12.02% and 2.74% .The resonating behavior in different frequency bands makes this antenna structure suitable for different types of applications with an antenna gain of 5.509dBi and antenna efficiency of 89%.*
Keywords: *Ground Plane, Microstrip Antenna, Patch Antenna, Probe Feed, Quad Band.*

I. Introduction

Advancement in the technology leads to the miniaturization of the devices along with good performance capabilities. 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. Several antenna structures such as yagi antenna, horn antenna, parabolic reflectors are used to fulfill these needs, but in some cases where two dimensional antennas are needed these antennas can't be used due to their bulky size and 3D structures, this is a case which leads to the requirement of 2D planer antenna and microstrip patch antenna is the most important type of planar antenna structure. There are several patch shapes which provides good bandwidth and gain for various applications.

Several researches has already been done to enhance the bandwidth and gain of the antenna, such as by using various shapes i.e. square, circular, elliptical shapes of the patch provides a good increment the bandwidth of the antenna. Some other researchers used stacked antenna configuration, antenna array etc. to enhance the gain and bandwidth of the antenna. These researches provide a good result in terms of gain and bandwidth but still these patch antennas can work up to a maximum of two to three frequency bands. Various applications need narrow bandwidth and some needs larger one. Similarly, some antenna need high gain and some needs lesser and if any antenna design is suitable enough to work in different frequency bands without changing its location and dimensions it will be an added advantage for the user.

II. Research Methodology

The research methodology inculcates the designing of the rectangular microstrip patch antenna. This designed antenna structure is fed by using single coaxial probe feed. After feeding the antenna structure these designed antennas are further simulated over IE3D simulation software, a MoM based simulation software. These simulations are continued till an optimum result is obtained.

III. Antenna Design

A rectangular microstrip patch antenna shown in *fig. 1* is designed and simulated over IE3D. The dimensions are shown in *fig. 1* along with in *table 1.*

Table 1

Discription	*Dimensions(in mm)*
Ground Plane	*l=60 , w= 120*
Patch	*l=48, w=96*

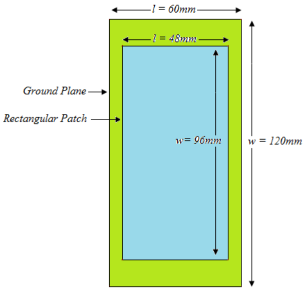

Fig. 1 Design Of The Rectangular Microstrip Patch Antenna

IV. Result and Discussion

The simulation of this antenna structure provides good result and makes this antenna well suited to work in four different frequency bands.

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. The simulation of the antenna structure provides the return loss curve which is shown in *fig. 2*.

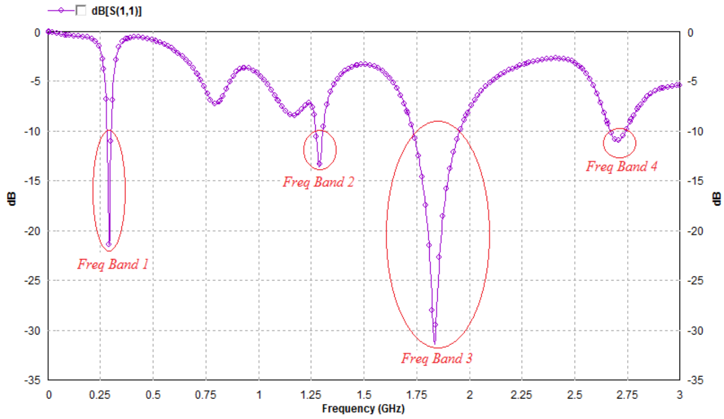

Fig. 2 Return Loss Curve Of The Designed Antenna Structure

Analyzing the curve shown in *fig. 2* we can clearly mention four different frequency bands in which this rectangular patch antenna can work. Calculating the bandwidth of the antenna as shown in equation I, II, III and IV we can see the amount of bandwidth achieved in different frequency bands.

Calculation of the bandwidth

For frequency band 1

$f_{l1} = 0.282GHz, f_{h1} = 0.302GHz,$

$f_{r1} = 0.290GHz$

$$Bandwidth_1 = \frac{0.302 - 0.282}{0.290} \times 100 = \mathbf{6.90\%}$$

For frequency band 2

$f_{l2} = 1.272GHz, f_{h2} = 1.306GHz,$

$f_{r2} = 1.288GHz$

$$Bandwidth_2 = \frac{1.306 - 1.272}{1.288} \times 100 = \mathbf{2.33\%}$$

For frequency band 3

$f_{l3} = 1.733GHz, f_{h3} = 1.955GHz,$

$f_{r3} = 1.830GHz$

$$Bandwidth_3 = \frac{1.955 - 1.733}{1.830} \times 100 = \mathbf{12.02\%}$$

For frequency band 4

$f_{l4} = 2.668, \quad f_{h4} = 2.742,$

$f_{r4} = 2.703$

$$Bandwidth_4 = \frac{2.742 - 2.668}{2.703} \times 100 = \mathbf{2.74\%}$$

The curve shown in *fig.2* and the calculation done shows different amount of bandwidth at different frequency bands i.e. the bandwidth of 6.90%, 2.33%, 12.02% and 2.74% in different frequency bands which make this antenna structure suitable for four different types of applications.

Another most important parameter for the antenna is the gain of the antenna. The gain vs frequency curve obtained as a result of the simulation and shown in *fig. 3* is used to calculate the gain of the antenna.

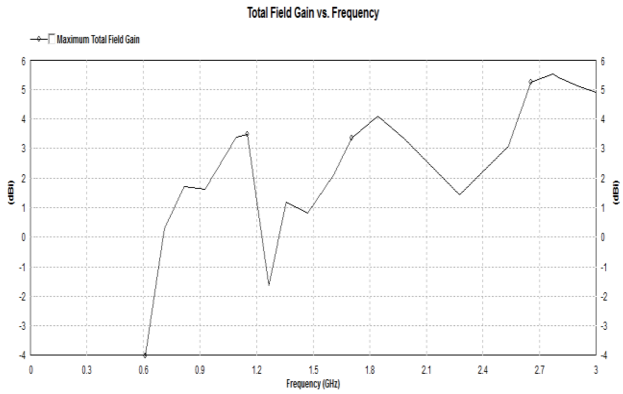

Fig. 3 Total Field Gain Vs Frequency Curve

The curve shown in *fig. 3* shows a maximum gain of 5.509dBi at 2.769GHz frequency. Analysing the results shows that the amount of gain achieved is quite good for various applications.

Directivity is another important parameter of the antenna which is closely related to the antenna gain. To analyse the directivity of the antenna a curve between antenna directivity and frequency is shown in *fig. 4.*

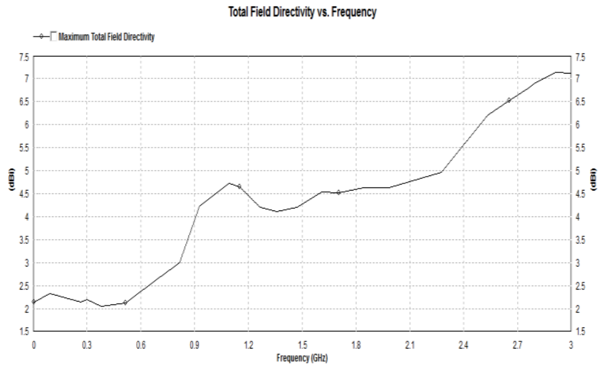

Fig. 4 Total Field Directivity Vs Frequency

The graph shown in *fig. 4* shows a directivity having a maximum value of 7.145dBi at 2.914GHz frequency.

Some other important parameters such as the VSWR of the antenna structure is shown in *fig. 5.* To make the antenna work properly the VSWR should be less than 2 for each frequency bands and the VSWR curve shown in *fig. 5* shows a VSWR less than 2 in all four frequency bands.

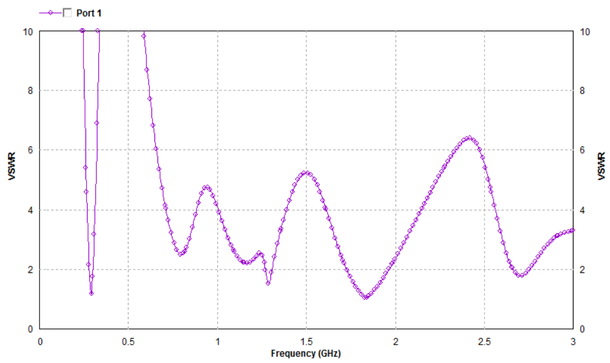

Fig. 5 VSWR Curve

Antenna efficiency and radiation efficiency are also very important terms and are used to analyse whether the antenna is efficient or not, similarly the radiation efficiency is used to analyse whether the antenna is radiating properly or not. The curves for antenna efficiency and radiation efficiency are shown in *fig. 6* and *fig. 7* respectively.

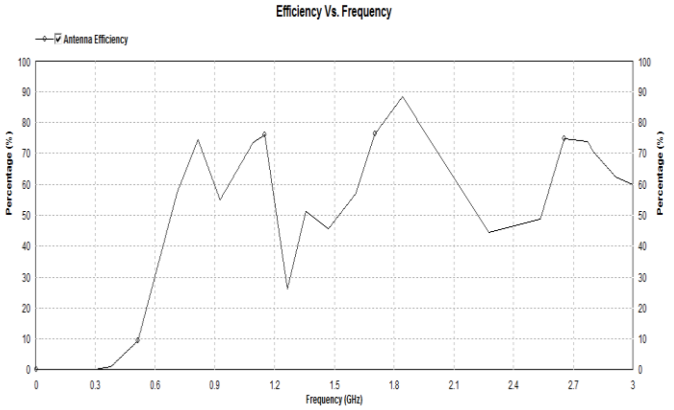

Fig. 6 Antenna Efficiency Vs Frequency

Analyzing the curve shown in *fig. 6* and *fig. 7* it can be clearly observed that the antenna structure designed provides an antenna efficiency of 88.270% at 1.84GHz frequency and the radiation efficiency of 95.14%.

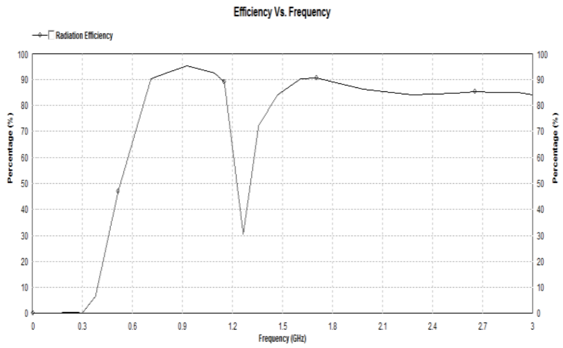

Fig. 7 Radiation Efficiency Vs Frequency

V. Conclusion

A rectangular microstrip patch antenna is designed and simulated over IE3D version 15.2. The designed antenna structure includes probe feeding method for the exciting the antenna. This antenna works in four different frequency bands as shown in the return loss curve, the bandwidth in all the four frequency bands are calculated and analysed. The antenna structure also provides a good amount of gain i.e. 5.509dBi and directivity i.e. 7.145dBi. The antenna efficiency and the radiation efficiency of the designed antenna structure are about 90%, which is good enough.

Analysing this type of structures we can further provide increment in the gain and bandwidth of the antenna.

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