DESIGN AND ANALYSIS OF DUAL-BAND Ψ- SHAPED MICROSTRIP PATCH ANTENNA

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ABSTRACT

A conventional rectangular microstrip patch antenna is considered for this research and further cutting various notches in the conventional structure to make a ψ-shaped microstrip patch antenna structure. The designed antenna structure is further simulated and the simulation result in terms of bandwidth, gain, directivity and efficiency is observed. The observation includes the frequency bands in which the designed antenna can operate properly, the amount of gain in those frequency bands and their efficiency. The result shows that the designed antenna is suitable to work in two different frequency bands with a good amount of gain and efficiency. A good amount of bandwidth i.e. a bandwidth of 31.23% and 10.00%, gain of 3.275 dBi, antenna efficiency of 91.00% is obtained in this designed antenna structure. This whole task is performed over IE3D simulation software, a MoM based simulation software Ver. 15.2.

KEYWORDS: *ψ-shape, dual band, ground plane, microstrip antenna, patch antenna.*

I. INTRODUCTION

An antenna is generally a metallic object capable of transmitting and receiving radio waves. Antenna acts like a resonant circuit which converts electrostatic energy into electromagnetic energy and vice versa. On the basis of directional patterns antenna can be classified in two types namely directional and omni-directional antenna. Yagi Uda, Log Periodic, Corner Reflector are some examples of directional antenna and whip antenna is example of omni-directional antenna.

Different antennas used these days have high gain and bandwidth but a severe disadvantage of those antenna structures is their large size and complex 3D structure. As it is the era of wireless communication [13] and antenna is one of the basic and most important requirements of any wireless communication system. As various technologies are used to scale the devices used in wireless communication system, we need to reduce the antenna size too. To fulfil this requirement microstrip patch antenna is a good alternative and is widely used.

Along with small size and simple structure microstrip antenna has some more advantages such as low cost, can be easily integrated in MMIC's etc., along with these advantages these antenna structures also have some disadvantages which make this antenna suffer in terms of bandwidth, gain, efficiency etc.

Improving the bandwidth, gain, efficiency of this antenna is a challenging task and different researches are in progress to rectify these problems. Different patch structures such as E shaped [1], H shaped [2], W shaped [3] etc. are used for improved bandwidth of the antenna, some more techniques such as cutting notches [4] and slots [5, 10] in conventional rectangular patch geometry also improves the antenna bandwidth and gain.

A concept of using antenna array and the antenna having stacked configuration also provides good amount of improvement in terms of gain and bandwidth.
In this paper we are emphasising on the ψ shaped patch geometry. This patch geometry is designed and simulated over IE3D simulation software and its simulated results are studied. An optimum result in terms of bandwidth and gain is presented in further sections.

II. RESEARCH METHODOLOGY

The research methodology includes design of ψ shape antenna designed by cutting four notches in a rectangular microstrip patch antenna. Further probe feeding method is used to feed the antenna, and by varying the probe location we are aiming to find optimum result in terms of bandwidth, gain and efficiency [6-8]. For this we are using IE3D simulation software and analyze different parameters with the help of this software.

III. ANTENNA DESIGN

A ψ shaped patch geometry along with its dimension is shown in *fig. 1*. The antenna structure shown here is designed and simulated and the simulation result is shown in the next section. The antenna structure is designed considering FR4 type material [13] specifically glass epoxy as a substrate. The parameters include the substrate thickness of 1.6mm, dielectric constant 4.2 and loss tangent of 0.0013.

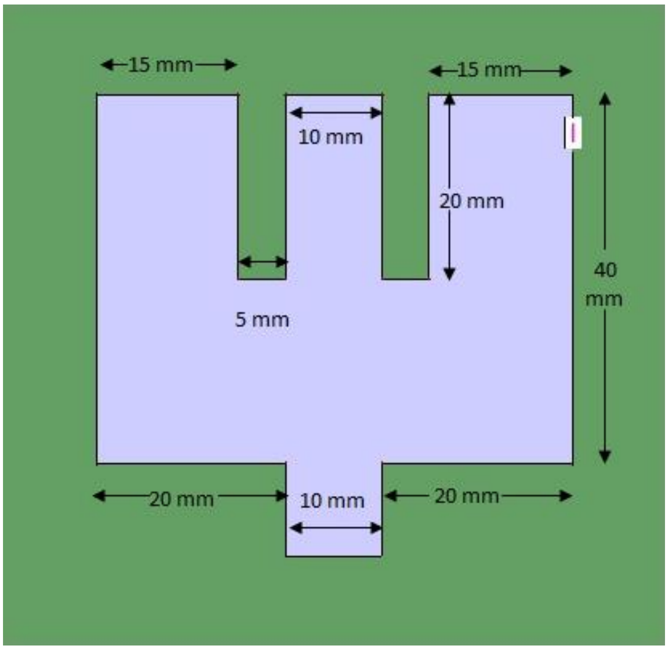

Fig.1 ψ- Shaped Microstrip Patch Antenna

The dimension of the designed antenna structure is shown in Table 1.

Table 1: Dimension of designed antenna structure

Type	Size in mm
Ground plane	70×70
Patch size	50×50

IV. RESULT AND DISCUSSION

Designed ψ-shaped microstrip antenna structure is simulated over IE3D software. To calculate the bandwidth of the antenna we have to analyze the return loss curve which is shown in fig. 2.

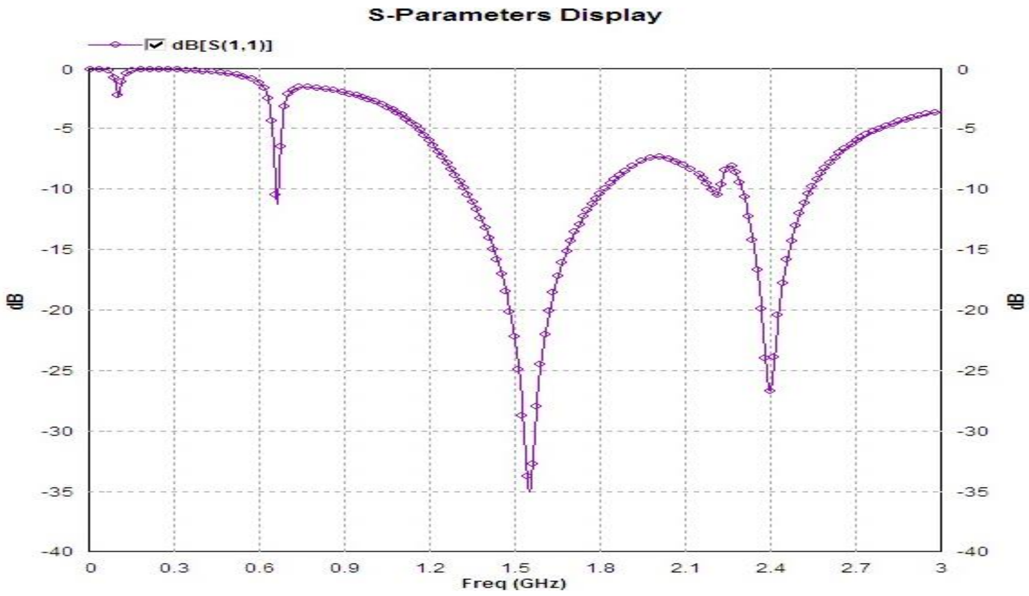

Fig.2 Return loss Vs Frequency curve of proposed antenna.

The return loss curve shown in *fig. 2* shows that the curve is crossing the -10dB line two times, hence the designed antenna can be operated in two different frequency bands. Due to this a single antenna structure can be used for two different types of applications. The bandwidth of antenna structure in *frequency band 1* and *frequency band 2* is calculated below.

Calculation Of Bandwidth

For Frequency Band 1

f_{l1} =1.32484, f_{h1} = 1.81529

f_{c1} =1.570065

$$\text{Bandwidth}_1 = \frac{1.81529-1.32484}{1.570065} \times 100 = \mathbf{31.23}\%$$

For Frequency Band 2

f_{l2} =2.29936, f_{h2} = 2.5412

f_{c2} =2.42038

$$\text{Bandwidth}_2 = \frac{2.5414-2.29936}{2.42038} \times 100 = \mathbf{10.00}\ \%$$

Based on the return loss curve and calculation above we can clearly observe that the designed antenna structure can be operated in two different frequency bands with a bandwidth of 31.23% and 10.00%.

Another important parameter which is related to the returnloss curve and bandwidth is the VSWR which determines if the bandwidth in the above said frequency bands are useful or not. According to theory the VSWR should be below 2dB for the entire frequency range in which antenna has to operate. The simulated VSWR curve is shown in *fig. 3.*

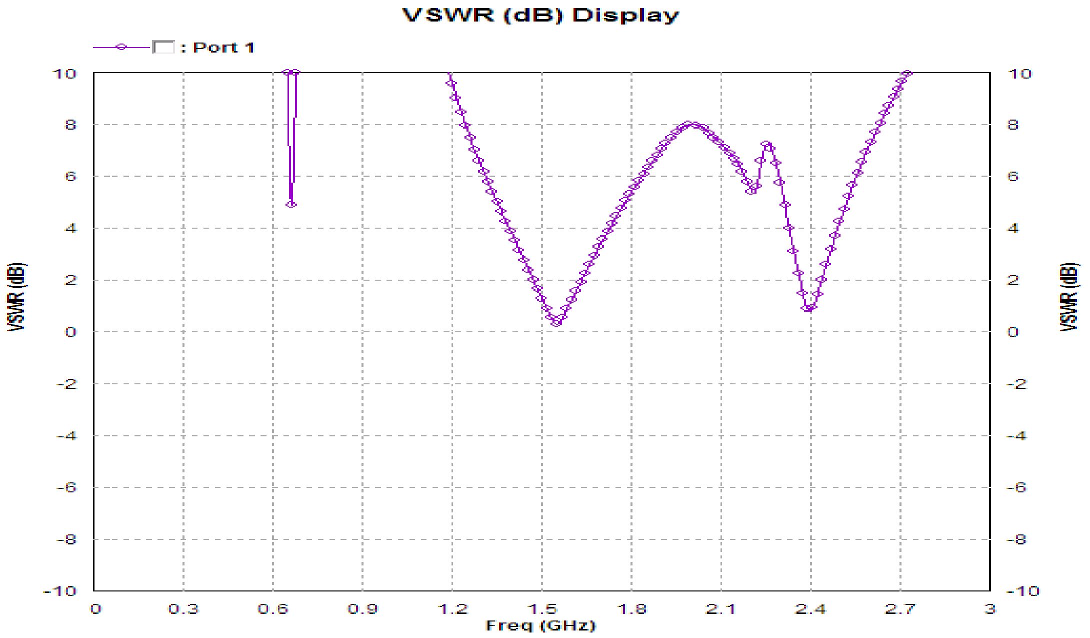

Fig. 3 VSWR Vs Frequency curve

Analysing *fig. 3* it can be clearly observed that the designed antenna has its VSWR lesser than 2dB in the entire range of frequencies in which the bandwidth is observed.
Another important parameter i.e. Antenna Gain is further calculated and is shown in *fig. 4.*

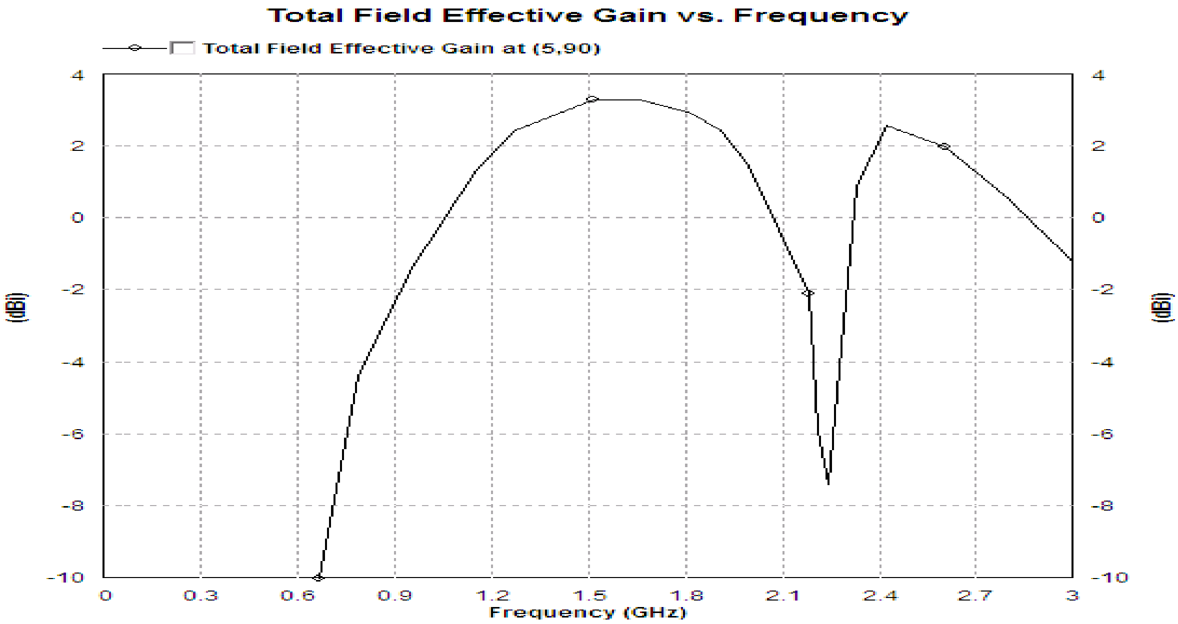

Fig. 4 Total Field Gain Vs Frequency Curve

Analysing the Total Field Gain Vs Frequency curve shown in *fig. 4* we can clearly say that the antenna gain is nearly 3.275 dBi. Which is very useful for various applications including wireless application.
Another important parameter related to the antenna gain is antenna directivity which is shown in *fig. 5.*

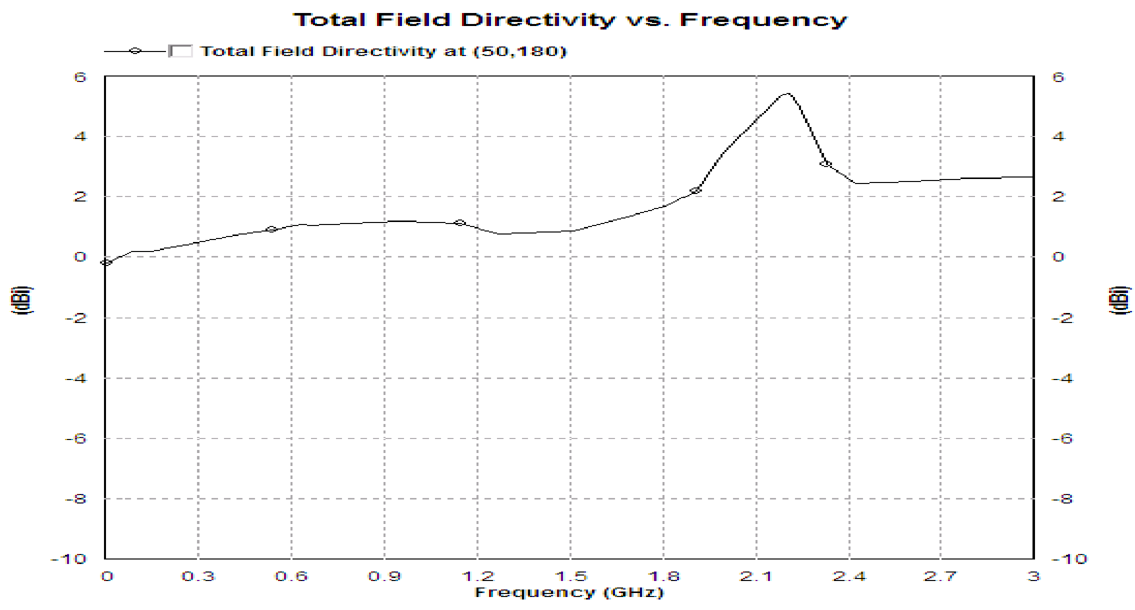

Fig. 5 Directivity Vs Frequency Curve.

Analysing the directivity curve shown in *fig. 5* it can be observed that the designed antenna structure provides a good directivity of 5.40 dBi.

Next important term associated with the performance of the antenna is the efficiency of the antenna. The efficiency is generally calculated in terms of antenna efficiency and radiation efficiency. The curve shown in *fig. 6* shows the relation between Antenna Efficiency and Frequency.

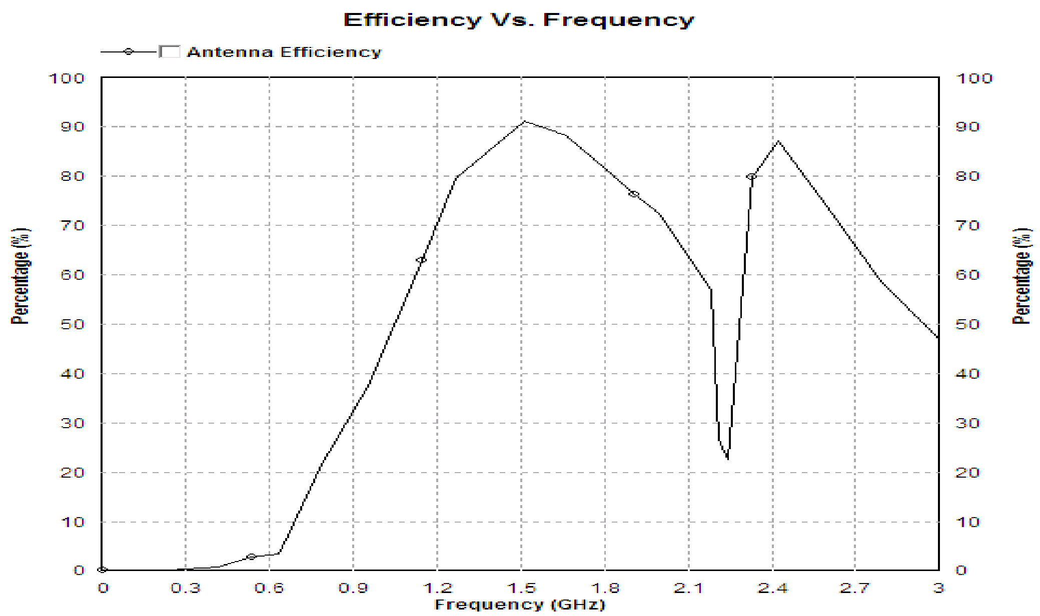

Fig.6 Antenna Efficiency Vs Frequency Curve

Analysing the efficiency curve shown in *fig. 6* it can be clearly observed that the designed antenna structure provides an antenna efficiency of 91%.

Further radiation efficiency of the antenna structure is shown in *fig. 7*.

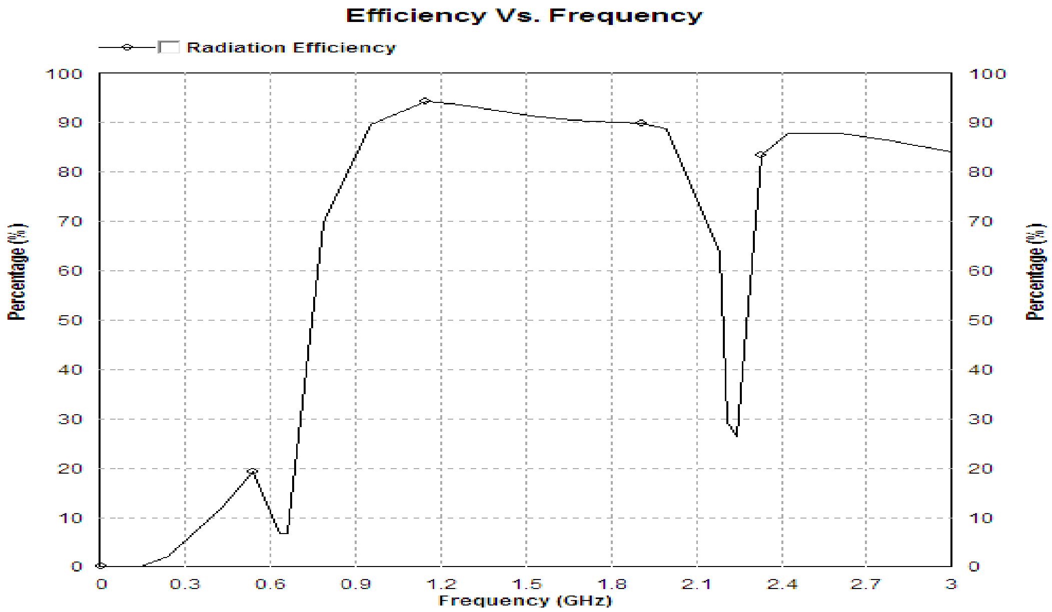

Fig. 7 Radiation Efficiency Vs Frequency Curve

Analysing the radiation efficiency curve it can be clearly observed that the designed antenna structure provides a radiation efficiency of 94% which is much better in context of microstrip antenna.

V. CONCLUSION

A ψ- shaped antenna is designed and simulated over IE3D simulation software Ver. 15.2. The substrate used for the designing purpose has substrate thickness of 1.6mm, dielectric constant 4.2 and loss tangent 0.0013. The designed antenna structure provides good results in terms of bandwidth i.e. bandwidth of 31.23% and 10.00% in two different frequency bands, gain i.e. a gain of 3.275 dBi and efficiency i.e. antenna efficiency of 91.00% and radiation efficiency of 94.00%.

On the basis of the results observed in this research we can say that the designed antenna can be used in two different frequency bands with good amount of gain as well as efficiency.

VI. FUTURE WORK

Based on the results in this research article we can further proceed towards the designing of the antenna structure having multiple notches and can work in more than two frequency bands with a good amount of bandwidth. Further research will be quite useful if the designed antenna has good gain and efficiency along with good bandwidth in multiple frequency bands.

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