

Design Of Coaxial Probe Fed Slotted V Microstrip Patch Antenna For Uplink Frequency Of 6ghz In Satellite Communication

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ABSTRACT

This paper presents microstrip antenna in the application for a satellite band microwave communication system for super high frequency (SHF), at a frequency range of 4.0 GHz - 6.0GHz. Currently, most security, research and education platforms are equipped with SHF communication systems. For their operational requirements, a design study is needed for the development of a light weight, low volume, low profile antenna. Hence, in this paper, we have designed and simulated the antenna for uplink frequency of 6GHz used in satellite communication for C band. Bandwidth enhancement techniques such as, use of various substrate with low relative dielectric constant (ϵ_r), size of antenna as well as V slotted patch antenna with coaxial probe feed technique are discussed and explained.

Keywords

Micro strip patch antenna, FR4 dielectric substrate, Feeding technique, IE3D.

1. INTRODUCTION

Because of the booming demand in wireless communication system and satellite communication, micro strip patch antennas have attracted much interest due to their low profile, light weight, ease of fabrication and compatibility with printed circuits. However, they also have some drawbacks, such as narrow bandwidth, low gain spurious feed radiation limited power handling capacity. To overcome their inherent limitation of narrow impedance, bandwidth and low gain, many techniques have been proposed and investigated, e.g., for probe fed stacked antenna, micro strip patch antennas [1] on electrically thick substrate, slotted patch antenna and stacked shorted patches.

Micro-strip patch antennas have drawn the attention of researchers over the past decades. However, the antennas inherent narrow bandwidth and low gain is one of their major drawbacks. This is one of the problems that researchers around the world have been trying to overcome. The patch antenna has been rapidly used in various fields like space technology, aircrafts

missiles, mobile communication, GPS system, and broadcasting. Patch antennas are light in weight, small

size, low cost, simplicity [2] of manufacture and easy integration to circuits. More important is these can be made out into various shapes like rectangular, triangular, circular, square etc.

When we change the shape of a microstrip antenna and it is covered with a dielectric layer, its properties like resonance frequency, gain are changed which may seriously degrade or upgrade the system performance. Therefore, in order to introduce appropriate correctness in the design of the antenna, it is important to determine the effect of dielectric layer and shapes on these antenna parameters. The bandwidth is analyzed by changing the substrate material at the frequency range 4 GHz to 6 GHz and introducing the slots V.

By cutting two modified V slot of suitable dimensions at the radiating patch a new fed configuration can be constructed. In this paper, a compact size micro-strip V shaped slot antenna is proposed with dielectric substrate FR4 with $\epsilon_r=4.36$. Various attempts are made to adjust the dimensions of the patch to improve the parameters like efficiency, directivity, radiation pattern in 2-D and 3-D using IE3D [4].

2. COAXIAL FEEDING

The Coaxial feed or probe feed is a very common technique used for feeding Micro strip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

The coaxial probe feed is also easy to fabricate and match, and it has low spurious radiation [5], [6], [7], [8], [9], [10]. However, it also has narrow bandwidth and it is more difficult to model, especially for thick substrates ($h > 0.02\lambda_0$). The main advantage of this type of feeding method is that it can be applied to any desired location inside the patch, with ease of manufacture.

3. ANTENNA CONFIGURATION

For the V-slotted patch, the slots are embedded to the rectangular patch. Where, L and W are the length and width of the patch. A micro-strip patch antenna in its basic form consists of a metallic radiating patch on one side of dielectric substrate, which has a ground plane on other side[11]. The radiating elements and feed lines are usually photo etched on the dielectric substrate. ϵ_r is the dielectric constant, ΔL is the length due to the fringing field. The fringing fields along the width can be model as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions.

3.1 Methodology

The proposed antenna is designed by cutting two V shaped slots in Rectangular patch as shown in fig. (1). Cutting of these slots in antenna increases the current thickness $h=2.4$ mm. The coaxial probe feeding is used for optimum results shown in fig. (2)

The dimensions of the patch along its length have now been extended on each end by a distance ΔL , which is given empirically by Hammerstad [1]. The path which increases current intensity as a result efficiency is increased. The dimension of the patch are $L=8.6072$ mm and $W=15.33$ mm. The antenna is fabricated on a substrate of dielectric constant 4.36 and Substituting

$$\Delta L = 0.412h \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \quad \text{eqn. (3.1)}$$

$\epsilon_{eff} = 5.530$, $W = 15.33$ mm and $h = 2.4$ mm we get:

$$\Delta L = 1.01142 \text{mm}$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\Delta L$$

The actual length is obtained by:

$$L = L_{eff} - 2\Delta L \quad \text{eqn. (3.2)}$$

Substituting $L_{eff} = 10.63$ mm and $\Delta L = 1.01142$ mm we get:

$$L = 8.6072 \text{mm}$$

For a given resonant frequency f_0 , The effective length is given as: $L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{eff}}}$ **eqn. (3.3)**

Substituting $\epsilon_{eff} = 6.021$, $c = 3.00e+008$ m/s and $f_0 = 6$ GHz we get:

$$L_{eff} = 0.01063 \text{ m} = 10.63 \text{mm}$$

For a rectangular Microstrip patch antenna, the resonance frequency for any TM_{mn} mode is given by James and Hall [2] as:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-1/2} \quad \text{eqn. (3.4)}$$

Substituting $\epsilon_r = 4.36$, $W = 15.33$ mm and $h = 2.4$ mm we get:

$$\epsilon_{eff} = 5.530$$

The width W is given by Bahl and Bhartia [3] as:

$$W = \frac{c}{2f_0\sqrt{\frac{\epsilon_r + 1}{2}}} \quad \text{eqn. (3.5)}$$

Substituting $c = 3.00e+008$ m/s, $\epsilon_r = 4.36$ and $f_0 = 6$ GHz, we get:

$$W = 0.01533 \text{m} = 15.33 \text{ mm}$$

Ground planes

It has been shown that a finite ground plane can be used for if the ground plane is 6 times larger than the height of the dielectric substrate plus the used length or width. The ground plane can now be calculated as:

$$W_g = 6h + W = 29.73 \text{mm} \quad \text{eqn. (3.6)}$$

$$L_g = 6h + L = 23.007 \text{mm} \quad \text{eqn. (3.7)}$$

3.2 Antenna design

This design procedure is a set of simple design steps for the rectangular V-slots microstrip patch antenna on microwave substrates. Determine

- a. Resonant frequency, $f_0 = 6$ GHz
- b. Lower bound frequency, $f_{low} = 4$ GHz
- c. Upper bound frequency, $f_{high} = 6$ GHz

The proposed design of the antenna with its dimensions and slotted V dimensions are shown in the fig. (1) below:

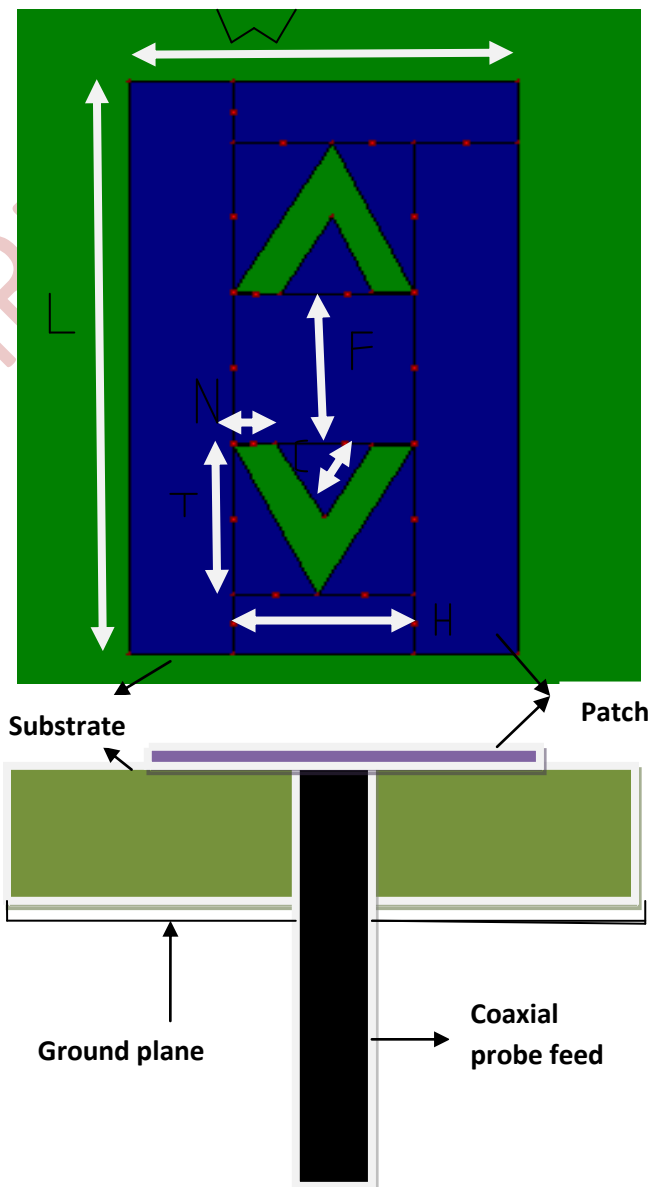


Fig 1: Proposed design of Microstrip patch slotted V antenna

Table 1: Optimized antenna parameter

Normal patch reading		V slots patch reading	
Dielectric constant	4.36	Slot width(H)	4mm
Length(L)	8.6072 mm	Slot length 1(T)	4mm
Width(W)	15.33mm	Slot length2(C)	2mm
Effective dielectric constant	6.021	Length between two slots(F)	4mm
Feedpoint location(X,Y)	3.9,7.3	Width of single cut(N)	1mm
Height	2.4mm		

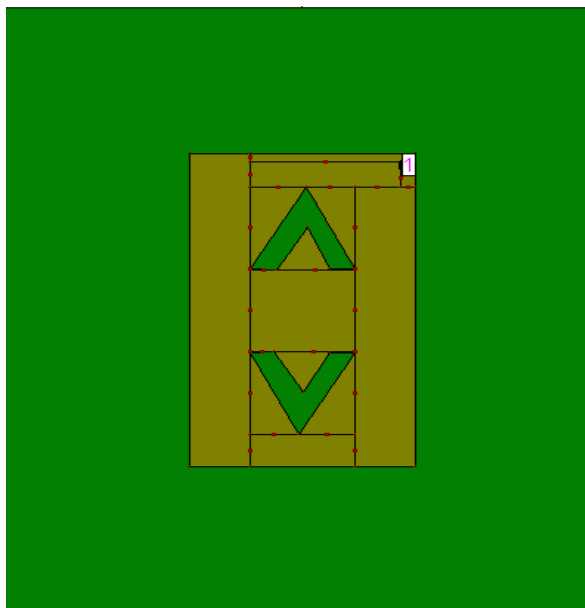


Fig 2: Proposed Rectangular micro-strip patch antenna with two V-shaped slots at feeding points (3.9, 7.3)

4. SIMULATION RESULTS

The simulation of micro-strip patch antenna is done by using IE3D simulation software [4]. The Return loss graph for a V shaped slotted rectangular patch antenna is shown in fig.(4.1).The return loss of the patch antenna is -28dB. The VSWR value is close to unity and is shown in fig.(4.2). The VSWR for this V shaped slotted antenna is 1.082. The simulated mapped radiation pattern in 3D is shown in fig. (4.3), the true 3D radiation pattern is shown in fig. (4.4), the Smith chart in fig. (4.5)

antenna efficiency & frequency is shown in fig. (4.6) and is plotted as 60%, , the axial ratio is shown if fig. (4.7) as 0.277, the current distribution is shown in fig. (4.8) and the total field directivity & frequency graph is shown in fig. (4.9) and is 4 dBi.

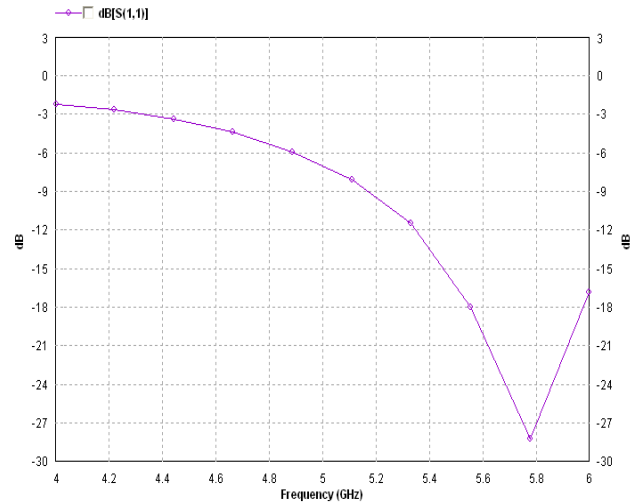


Fig 4.1: Return loss of the proposed slotted microstrip

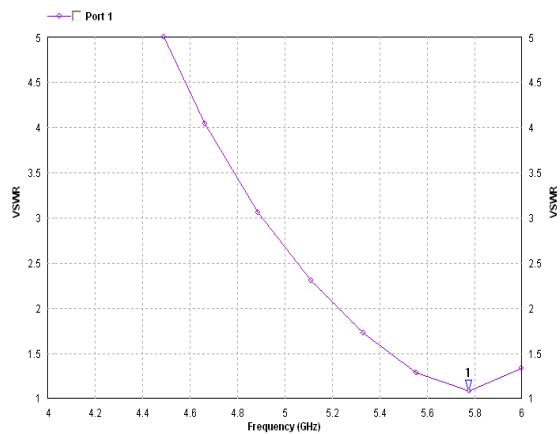


Fig 4.2: VSWR v/s Frequency graph of the proposed slotted V antenna

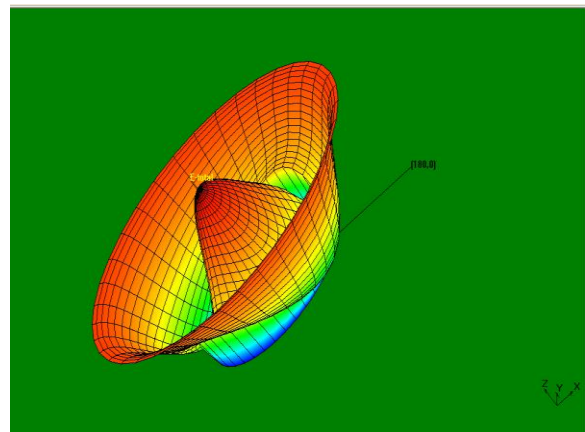


Fig 4.3: Mapped 3-D Radiation pattern of the proposed Rectangular Micro-strip Patch Antenna with V slots

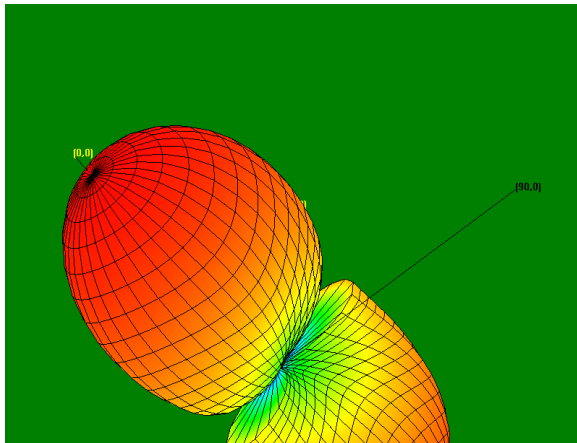


Fig 4.4: True 3D radiation pattern of proposed antenna

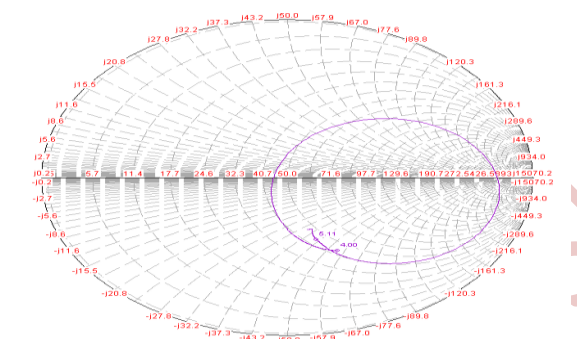


Fig 4.5: Smith chart of the microstrip patch antenna

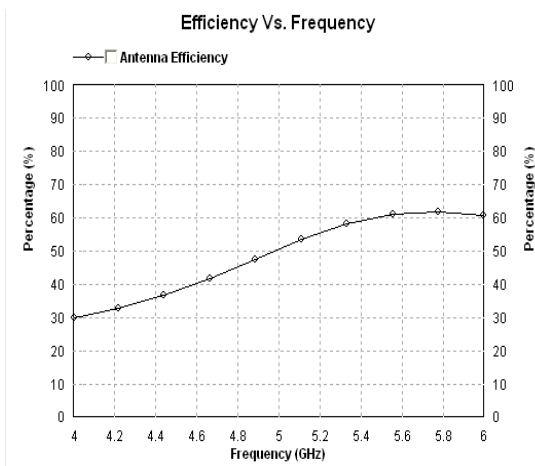


Fig 4.6: Efficiency of the proposed antenna

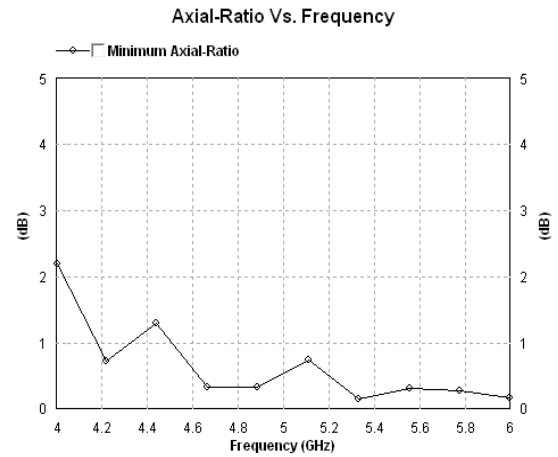


Fig 4.7: Axial ratio v/s frequency graph plot

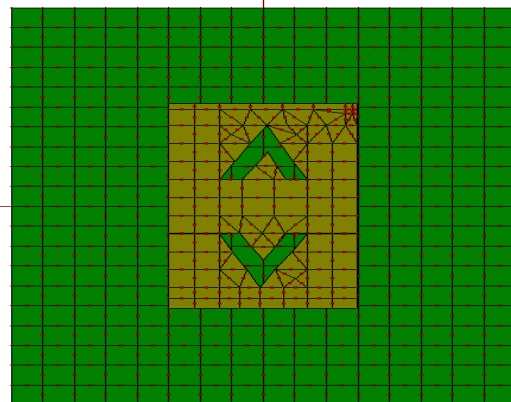


Fig 4.8: Current distribution of the antenna

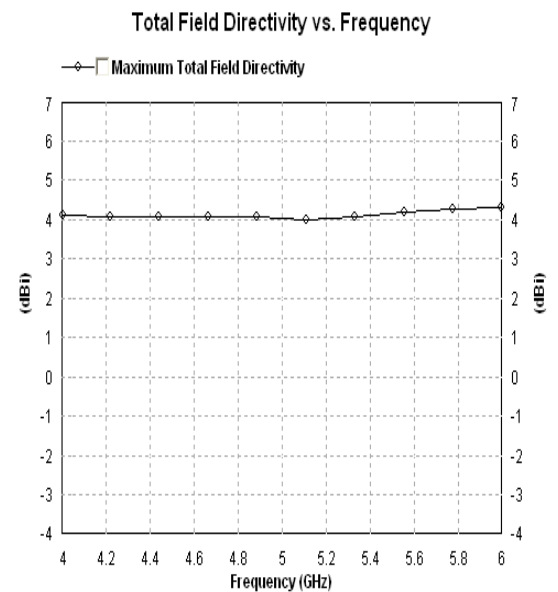


Fig 4.9: Total field directivity v/s frequency of the
5. CONCLUSION

It is observed that a probe feed, V shaped slotted rectangular micro-strip patch antennas is presented. The proposed antenna has a compact size of (8.6072 x 15.33 x 2.4) and it can effectively covers the Satellite Communication, and the application of C band of communication system. It shows RL of -28dB, VSWR of 1.08, Efficiency of 60%, Directivity of 4dBi and many other related parameters.

6. ACKNOWLEDGMENT

I owe special debt of gratitude to Mr.Rahul Vishnoi, Associate Professor, Department of Electronics and Communication, College of Engineering and Technology, Teerthanker Mahaveer University, Moradabad for his constant support and guidance throughout the course of our work.

I also take the opportunity to acknowledge the contribution of Mr. Neeraj Agarwal, Head Department of Electronic & Communication, College of Engineering and Technology, Teerthanker Mahaveer University, Moradabad for his full support and assistance during the development of the project. Last but not the least, I acknowledge my friends and parents for their contribution and support in the completion of the project.

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proposed antenna

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