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Design and Bandwidth Enhancement of V-slot loaded Rectangular Microstrip Patch Antenna for Broadband Applications

Sunil Kumar[1], Ashish Chaudhary[2], N.S. Beniwal[3]

M.Tech Student, ECE, Bundelkhand Institute of Engineering and Technology, Jhansi, Uttar Pradesh, India[1,2]

Assistant Professor, ECE, Bundelkhand Institute of Engineering and Technology, Jhansi, Uttar Pradesh, India[3]

Abstract: In this paper, the bandwidth of rectangular Microstrip antenna is enhanced by V-slot loaded rectangular microstrip patch antenna. It can be seen that bandwidth of Microstrip antenna is increased up to great extant when v slot loaded and a rectangular cut. In some applications which the increased bandwidth is needed, proposed antenna is one of the alternative solutions.The proposed antenna has single frequency band. The proposed antenna has frequency band (1.338-2.953GHz) in which the fractional bandwidth is 75.27% which is suitable for broad band applications. The gain has been improved up to 4.190dBi, directivity 4dBi and efficiency 99.99%. The proposed loaded V slot Microstrip patch antenna is fed by 50Ω Microstrip feed line .The designed structures and performance of different structures are simulated by using IE3D Zealand simulation software.

Keywords: Loaded v slot, enhance bandwidth, compact Microstrip (MS) Patch, radiation pattern, gain,50Ω feed line.

I. INTRODUCTION

Microstrip patch antennas have its importance due to its light weight, low profile, low cost and ease of integration with microwave circuit. But the major problem of rectangular Microstrip antenna is its narrow bandwidth.

The bandwidth of Microstrip antenna may be increased using several techniques such as use of a thick or foam substrate, cutting slots or notches like U slot, E shaped H shaped patch antenna, introducing the parasitic elements either in coplanar or stack configuration, and modifying the shape of the radiator patch by introducing the slots [1]. In the present work the bandwidth of Microstrip antenna is increased by loaded V slot [2].

The proposed antenna has been designed on glass epoxy substrate (Єr=4.2) [3]. The substrate material has large influence in determining the size and bandwidth of an antenna. Increasing the dielectric constant decreases the size but lowers the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth but with an increase in size. The design frequency of proposed antenna is 2GHz.

The frequency band (1.338-2.953GHz) of proposed antenna is suitable for broad band applications(1.605-3.381GHz) such as military, wireless communication, satellite communication, global positioning system (GPS), RF devices, WLAN/WI -MAX application [4-7].

II. ANTENNA DESIGN

For designing a rectangular microstrip patch antenna, the length and the width are calculated as below [5, 1, and11]

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}}$$

Where c is the velocity of light, ϵ_r is the dielectric constant of substrate, fr is the antenna design frequency, W is the patch width, and the effective dielectric constant ϵ_{reff} is given as [9, 10]

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

At h = 1.6mm

The extension length ΔL is calculates as [9, 1 and 11].

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff}+0.3)(\frac{W}{h}+.264)}{(\epsilon_{reff}-.258)(\frac{W}{h}+0.8)}$$

By using the above mentioned equation we can find the value of actual length of the patch as, [12, 5, 11]

$$L = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L$$

The length and the width of the ground plane can be calculated as [4, 1 and 11]

L_g = 6h+L

W_g = 6h+W

III. ANTENNA PARAMETERS

The design of proposed antenna is shown in figure1. The proposed antenna is designed by substrate which has a dielectric constant 4.2 and the design frequency is 2 GHz.

Height of the dielectric substrate is 1.6 mm and loss tangent *tan* δ is .0013.

Antenna is fed through 50Ω Microstrip feed line. Antenna dimensions are given in table1 and other parameters are given in the table2 (lengths in mm and frequency in GHz).

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TABLE 1: ANTENNA DIMENSION

S.No	ANTENNA DIMENSION	SPECIFICATION
1.	Ground plane width , a	55.44
2.	Ground plane length , b	43.86
3.	Patch width , c	45.84
4.	Patch length , d	34.26
5.	E	7.2
6.	F	22.44
7.	g	17
8.	h	19
9.	i	10.06
10.	j	43.2
11.	k	6
12	l	8
13	m	5.86
14	n	10

TABLE 2: ANTENNA PARAMETER

S.No	ANTENNA PARAMETER	SPECIFICATION
1	Dielectric constant(ϵ_r)	4.2
2	Maximum frequency	3.5 GHz
3	Height of substrate(h)	1.6 mm
4	Loss tangent(tanδ)	0.0013

IV. ANTENNA DESIGN PROCEDURE

All the dimensions of proposed antenna are calculated by using the above mentioned equation. Design frequency taken is 2 GHz. The rectangular patch is first grown and then it is loaded V slot as shown in Fig. 1.

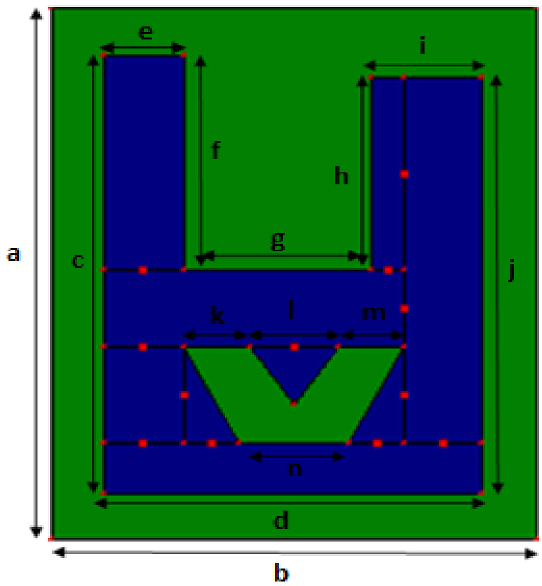

Fig. 1. Geometry of proposed antenna

V. SIMULATION RESULT AND DISCUSSION

The proposed rectangular microstrip antenna studied successfully and it is found that it provides 75.27% high bandwidth and return loss upto -59.83 dBi. Proposed microstrip antenna provides high gain up to 5.05 dBi, efficiency 99.99% and good return loss up to -59.83 dBi. The narrow bandwidth of microstrip antenna is one of the important features that restrict its wide usage. From the above it is clear that W shaped patch antenna which provides high bandwidth and high return loss. The gain of the antenna has been improved up to 4.190 dBi, directivity improved up to 4.190 dBi, efficiency of the antenna is found to be 99.99 %, and the VSWR of the antenna is in between 1 to 2 over the entire frequency band which shows good impedance matching.

The simulation performance of proposed micro strip patch antenna is analyzed by using IE3D version 9.0 software at select design frequency of 2GHz. The performance specifications like gain, radiation pattern etc of proposed antenna is shown in the Fig. 2 to 9.

The plot graph of return loss Vs frequency is taken at the maximum frequency of 3.5 GHz which is shown in Fig. 2. Bandwidth is increase to 1615MHz (75.27% fractional bandwidth) of design antenna.

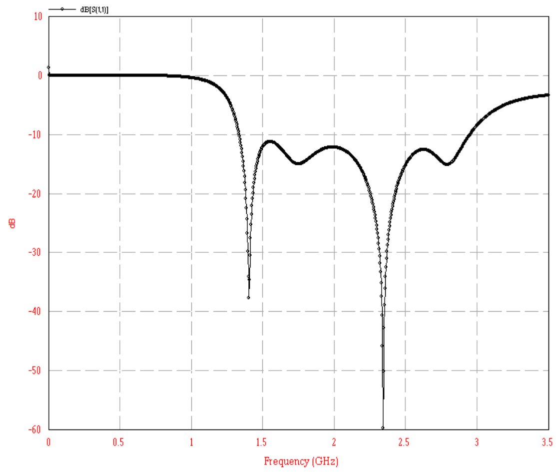

Fig. 2. Return loss v/s frequency graph

Fig. 3 shows the plot of 3D Radiation pattern of proposed antenna at resonant frequency 2.343 GHz.

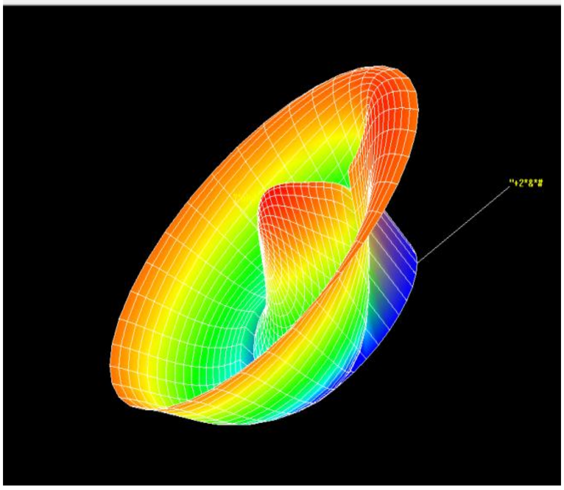

Fig. 3. 3D Radiation pattern of proposed antenna

In Fig. 4 the graph of Gain Vs Frequency shows the total field gain of the MSP antenna and obtain gain of antenna is 4.190 dBi.

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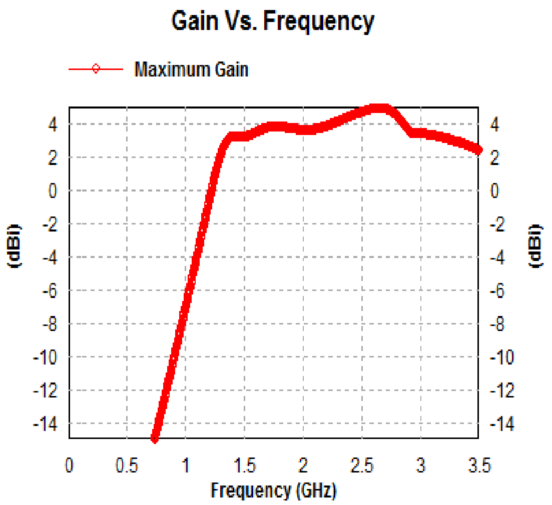

Fig. 4. Gain vs. frequency plot

Fig. 5 the plot of VSWR Vs Frequency represents that the bandwidth of design antenna is useful or not. The obtain VSWR is 1.01 at resonant frequency of 2.343 GHz.

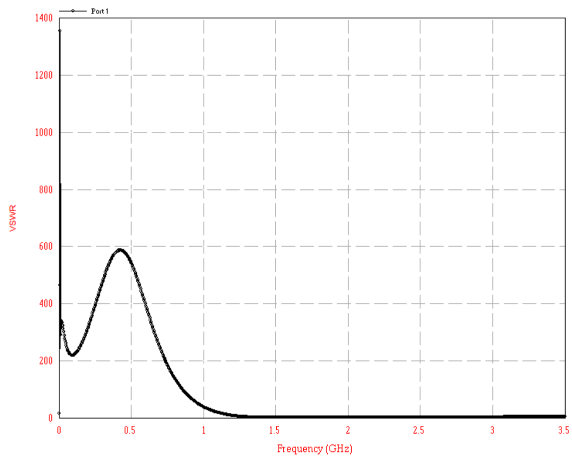

Fig. 5. VSWR of proposed antenna

In Fig. 6 the plot graph of total field Directivity Vs Frequency represents the ratio of radiation intensity in a given direction from the antenna to the radiation intensity averaged over all direction [13]. The obtain directivity of antenna is 4.190dBi.

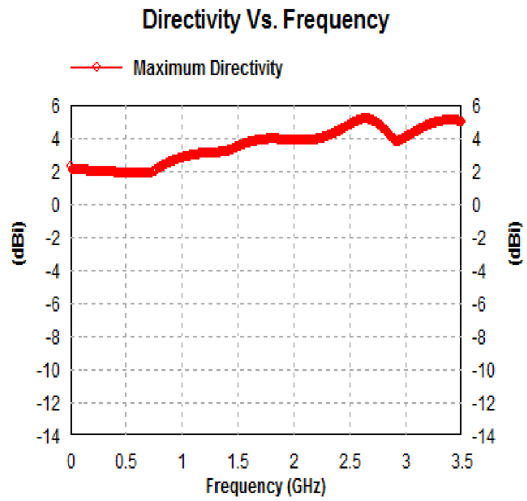

Fig. 6. Directivity v/s frequency plot

In Fig. 7 Smith chart of proposed antenna is shown.

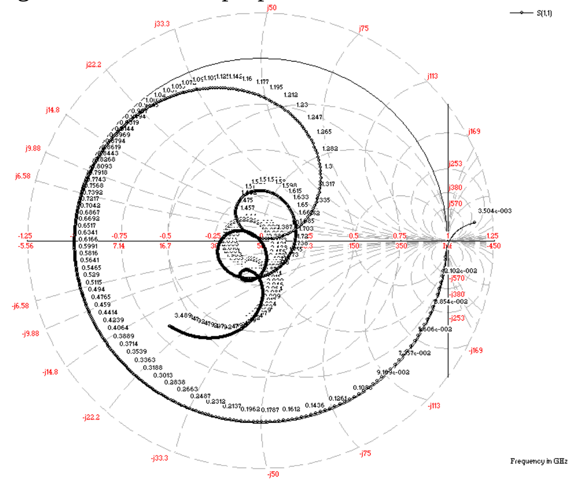

Fig. 7. Smith chart

In Fig. 8 the plot graph of 2D radiation pattern of antenna represents radiating all power in one direction therefore design antenna has unidirectional radiation pattern. 2D radiation pattern of antenna is shown at resonant frequency 2.343GHz and phi=0(deg).

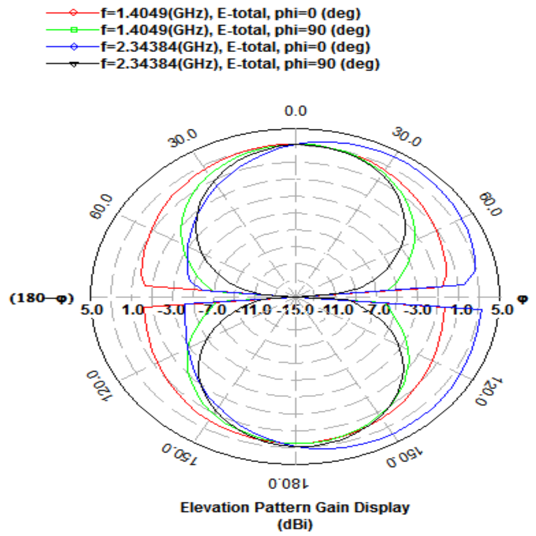

Fig. 8. 2D radiation pattern of antenna

In Fig. 9 the plot graph of Efficiency Vs Frequency represents antenna efficiency. The obtain percentage antenna efficiency is 99.99% at 2.343GHz.

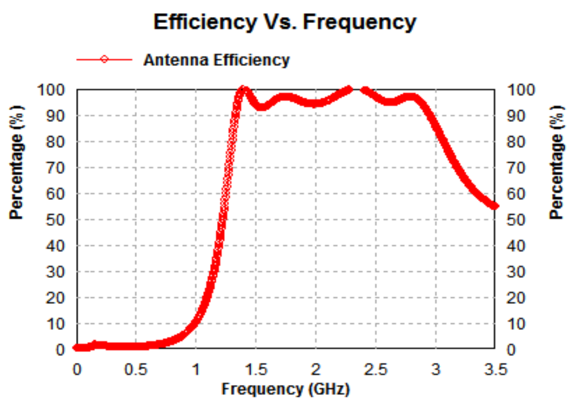

Fig. 9. Efficiency graph of proposed antenna

VI. CONCLUSION

The characteristics of proposed antenna are studied. In general, the impedance bandwidth of the traditional Microstrip antenna is only a few percent (2% -5%) [8]. Therefore, it becomes very important to develop a technique to enhance the bandwidth of the Microstrip antenna. Proposed antenna improved the fractional bandwidth upto 75.27%. Microstrip patch antenna for broad band applications covering 1.338 to 2.953 GHz frequency has been presented.

The proposed antenna has been designed on glass epoxy substrate to give a maximum radiating efficiency of about 99.99% and gain of about 4.190 dBi. Also provide good return loss up to -59.83dBi. The simulated result of design antenna shows good performance and thus can be used as various broadband applications such as missile, wireless, satellite, mobile communication, and military.

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BIOGRAPHIES

Sunil Kumar received his B.Tech(ECE) from Anand Engg. College, Agra, Uttar Pradesh, India and M.Tech (Digital Comm.) student in ECE department of Bundelkhand Institute of Engineering and Technology, Jhansi, Uttar Pradesh, India. His area of interest lies in the field of Antenna designing and Microwave engineering.

Ashish Chaudhary received his B.Tech (ECE) from K.N.G.D. Modi Engg. College, Modinagar, Uttar Pradesh, India and M.Tech (Digital Comm.) student in ECE department of Bundelkhand Institute of Engineering and Technology, Jhansi, Uttar Pradesh, India. His area of interest lies in the field of Antenna designing and Microwave engineering.

N.S. Beniwal is an assistant professor in the ECE department of Bundelkhand Institute of Engineering and Technology, Jhansi, Uttar Pradesh India. He has more than 12 years of experience. He has published around twelve papers in reputed international journals and also he has presented many research articles in national and international conferences. His Field of specialization are Control Systems and Transformers.