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SHIFTED ELLIPTICAL SLOT IN MICROSTRIP PATCH ANTENNA FOR INCREASING BANDWIDTH AND GAIN

Ridhi Gupta [1], Sanjay Gurjar [2]

Abstract: This paper describes the increment in Bandwidth and Gain of Rectangular Microstrip Patch antenna with Shifted Elliptical slot. First we have designed a Rectangular microstrip patch antenna. After that an elliptical slot is cut inside a rectangular patch which is shifted towards right. The results of both the designs are compared and it was found that an increase in the bandwidth of 21% and gain of 7.21 dBi is being achieved as that of a simple Rectangular microstrip patch antenna. Microstrip patch antenna is designed on a Duroid 5880 substrate with a dielectric constant of 2.2. The antenna is fed by a coaxial probe feed. The antenna designs and performances are analyzed using Zealand IE3D software. The antenna can be used for many modern communication systems.

Keywords: Bandwidth, Gain, Rectangular microstrip patch antenna, Shifted Elliptical Slot rectangular microstrip patch antenna.

I. INTRODUCTION

Microstrip patch antennas have drawn the attention of researchers over the past decades [4], [6], [8], [9]. 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. Throughout the years, authors have dedicated their investigations to creating new designs or variations to the original antenna that, to some extent, produce wider bandwidths. The microstrip antenna has now reached maturity, wherein only a few mysteries about its behavior are still undiscovered. 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 of manufacture and easy integration to circuits. More important is, these can be made out into various shapes like rectangular, triangular, circular, square etc. Many techniques have been suggested for achieving the high bandwidth. These techniques includes: using parasitic elements either in same or other layer, utilization of thick substrates with low dielectric constant [5], and slotted patch [2].

II. RECTANGULAR MICROSTRIP PATCH ANTENNA DESIGN

Designing of microstrip patch antenna depends upon three parameters. In this paper, selected three parameters are: Resonant Frequency = 5 GHz, Dielectric constant = 2.2, Height of the dielectric substrate = 0.787 mm. Fig.1 represents the design of Rectangular Microstrip Patch antenna. This Rectangular patch is designed by using Transmission Line Model:

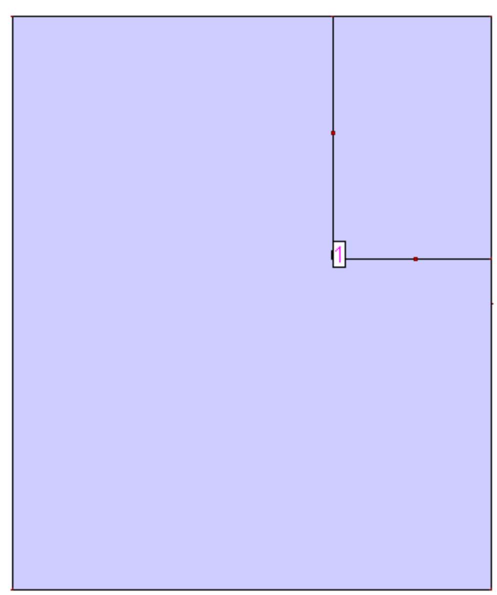

Fig 1.Rectangular Microstrip patch antenna Design

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A. Calculation of the Width (W):

The width of the Microstrip patch antenna is given by equation [1]:

$$W = \frac{c}{2f_r}\left(\frac{\varepsilon_r+1}{2}\right)^{-1/2} \tag{1}$$

On substituting the values, W= 23.71 mm. where c is the velocity of light.

B. Calculation of Effective dielectric constant:

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{12h}{W}\right]^{-1/2} \tag{2}$$

Refer to (1), $\varepsilon_{reff} = 2.107$

C. Calculation of the Effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} = 20.66 \text{ mm} \tag{3}$$

D. Calculation of the Length Extension (ΔL):

$$\Delta l = 0.412h\left(\frac{\varepsilon_{eff}+0.3}{\varepsilon_{eff}-0.258}\right)\left(\frac{W/_h+0.264}{W/_h+0.8}\right) \tag{4}$$

which comes out to be 0.41mm.

E. Calculation of actual length of patch (L):

$$L = L_{eff} - 2\Delta L = 19.84 \text{ mm} \tag{5}$$

F. Results and Discussions

The proposed antenna has been designed and simulated using *Zealand IE3D* software. Fig. 2 represents the variation of Return Loss with Frequency. Plot shows resonant frequency at 4.9 GHz. Minimum -29.85 dB return loss is available at resonant frequency.

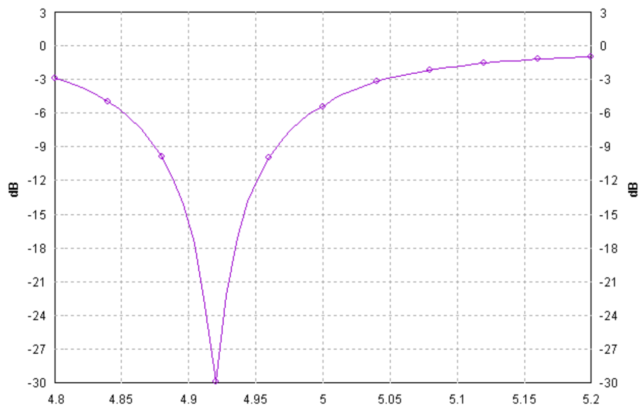

Fig.2 Return Loss vs. Frequency for TABLE I

Bandwidth of the antenna is defined as the *range of frequencies*, over which the performance of the antenna with respect to some characteristic conforms to a specific standard. The bandwidth of the antenna depends on the patch shape, resonant frequency, dielectric constant and the thickness of the substrate. The bandwidth enhancement of a microstrip antenna has been directed towards improving the impedance bandwidth of the antenna element. Impedance bandwidth is usually specified in terms of a return loss

Performance of Rectangular microstrip patch antenna is given in Table I

TABLE I PERFORMANCE FOR RECTANGULAR MICROSTRIP PATCH ANTENNA

Feed Location (X_f, Y_f)	Return Loss (dB)	F_r (GHz)	BW (MHz)	Gain (dBi)
3.9, 2.4	**-20.40**	**4.9**	**31.22**	**6.33**
3.5 , 2.2	**-.29.85**	**4.9**	**74.9**	**6.77**
4 , 5	**-17.00**	**4.9**	**28.56**	**6.22**

From TABLE I, at Feed Location (3.5, 2.2), minimum -29.85 dB return loss is available at resonant frequency 4.9 GHz which is significant. At this feed location calculated bandwidth is 74.9 MHz. Gain vs. frequency plot for rectangular microstrip patch antenna is given in Fig. 3 which is 6.77 dBi.

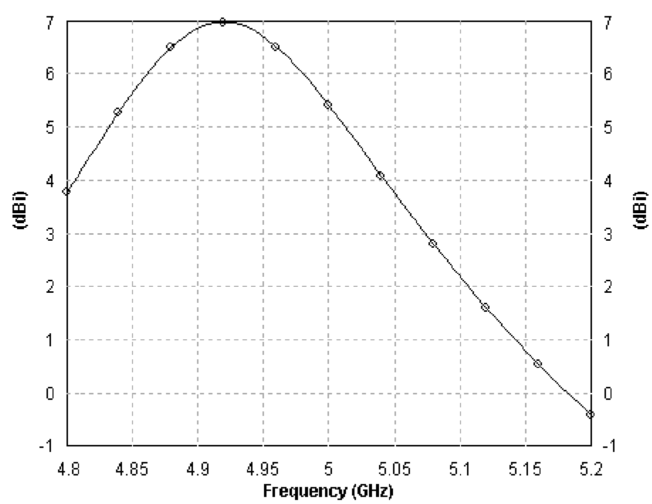

Fig. 3 Gain vs. frequency for TABLE I

The efficiency vs. frequency graph for rectangular microstrip patch antenna is shown in Fig 4.Calculated efficiency is 86.42 %.

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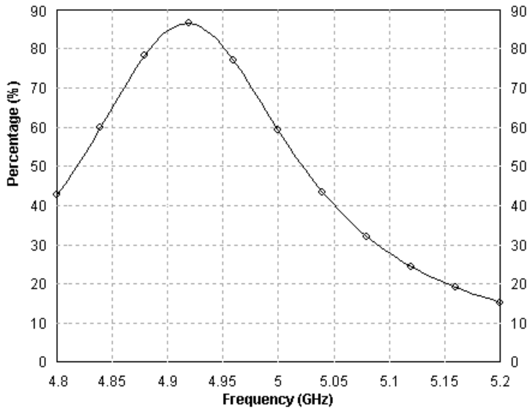

Fig. 4 % Efficiency vs. Frequency for TABLE I

III. SHIFTED ELLIPTICAL SLOT RECTANGULAR MICROSTRIP PATCH ANTENNA DESIGN

In this design, an Elliptical slot is positioned at the centre of the Rectangular microstrip patch which is shifted towards right with X = 9.5mm and Y = 0 mm. With shifted elliptical slot, the overall antenna bandwidth is increased by 21% and more gain of 7.21 dBi is obtained. Elliptical slot is having a primary radius r_p = 6mm and secondary radius r_s = 9mm. Fig. 5 represents the design of Shifted Elliptical Slot Rectangular Microstrip Patch Antenna:

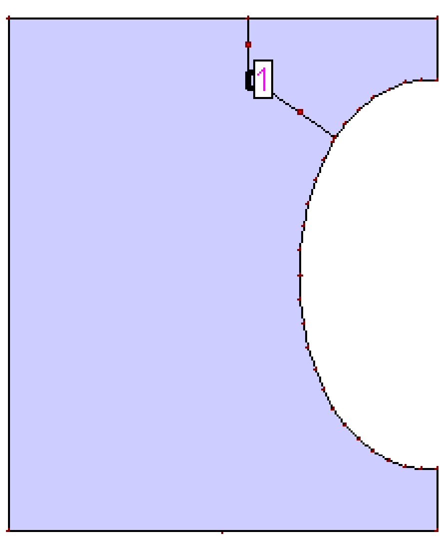

Fig. 5 Shifted Elliptical Slot Rectangular Microstrip Patch Antenna Design

A. Results and Discussions

Return Loss is a parameter which indicates the amount of power that is "lost" to the load and does not return as a reflection. From Fig. 6, Return Loss is at - 21.15 dB

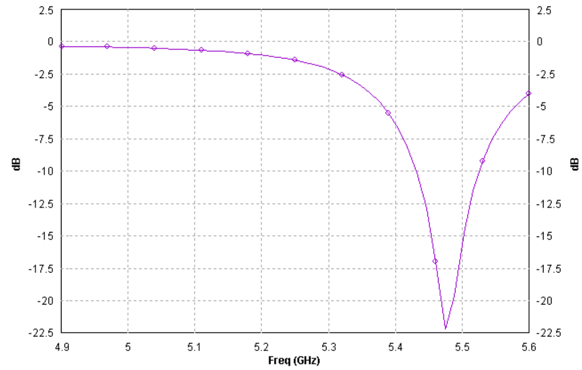

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Fig. 6 Return Loss vs. Frequency for TABLE II

Performance of Shifted Elliptical Slot Rectangular microstrip patch antenna is in TABLE II which gives the performance of bandwidth at different feed locations. Coaxial probe feed is used to feed the rectangular microstrip patch antenna.

TABLE II PERFORMANCE OF SHIFTED ELLIPTICAL SLOT RECTANGULAR MICROSTRIP PATCH ANTENNA

Feed Location (X_f, Y_f)	Return Loss (dB)	F_r (GHz)	BW (MHz)	Gain (dBi)
2 , 9	**-14.00**	**5.4**	**87.66**	**7.18**
1.7, 9	**-18.25**	**5.4**	**95.2**	**7.20**
1.5, 9.2	**-22.00**	**5.4**	**95.63**	**7.21**

Calculated bandwidth is 95.63 MHz which is 21% more than that of Rectangular microstrip patch antenna. Gain vs. frequency plot for Shifted Elliptical Slot Rectangular microstrip patch antenna is given in Fig.7 which is 7.21 dBi.

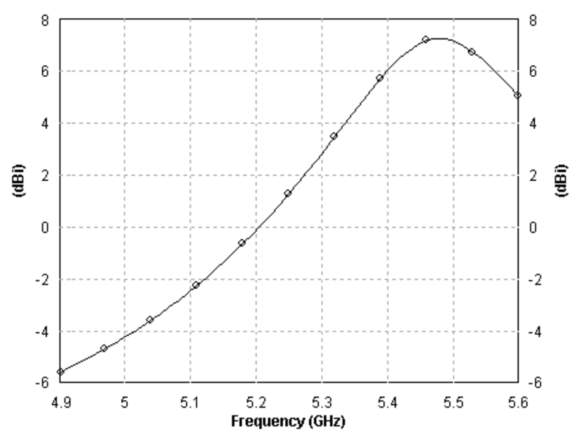

Fig.7 Gain vs. frequency for TABLE II

This calculated Gain is more than that of rectangular microstrip patch antenna. Efficiency vs. frequency graph for Shifted elliptical slot patch antenna is shown in Fig 8.

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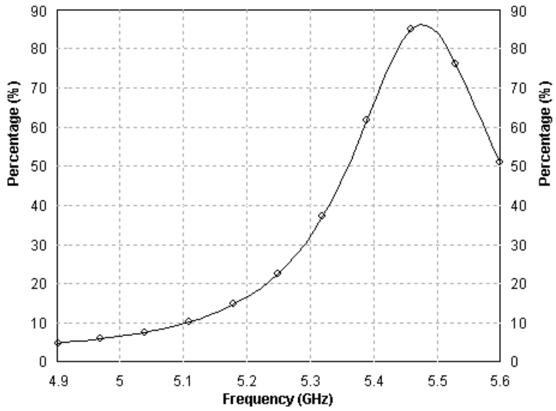

Fig. 8 % Efficiency vs. Frequency for TABLE II

IV CONCLUSIONS

The Rectangular Microstrip Patch antenna has been analyzed. It has been observed, to improve the bandwidth and gain of rectangular microstrip patch antenna, Shifted Elliptical Slot is used. The Slot dimension, feed point variations are the parameters that should be optimized for maximum bandwidth and gain. With shifted elliptical slot, bandwidth of the rectangular patch antenna is increased by 21 % and more gain is achieved i.e.7.21dBi. Patch antenna has been implemented using Zealand IE3D software.

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BIOGRAPHY

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