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Design of A Single Band Pentagonal Microstrip Patch Antenna for purpose of Medical Equipment

Bipa Datta[1,a], Moumita Mukherjee[2,b]

[1] *ECE Dept., Brainware Group of Institutions, Barasat, MAKAUT-WB, Kolkata, W.B., India.*
[2] *Associate Dean & Academic Coordinator - School of Science, ADAMAS UNIVERSITY Kolkata - 700126, INDIA*
[a] *bipa.datta@gmail.com*, [b] *mm_drdo@yahoo.com*

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Abstract: In navigational applications, radar, wireless communications, military applications and satellites we require a system that works with low weight, low profile and high gain. The above mentioned applications are possible with microstrip antenna. This paper presents design of a single band pentagonal microstrip patch antenna to improve gain and efficiency with operating frequency of 10.7591 GHz and 11.1806 GHz (purpose of medical equipment). The idea behind design patch is to decrease the return loss and wider band width by changing the shapes of patch. The proposed antenna consists of a single substrate layer on one side with ground plane on other side. Simulated antenna size has been reduced by 52.64% with an increased frequency ratio. The characteristics features of antenna are investigated on Zealand IE3D simulation software.

1. Introduction

In recent years, the demand for high gain antennas has increased for use in high-frequency and high-speed data communication. Microstrip patch antenna [1-3] characterized by attractive features such as low cost and compact size, but the important problems of patch antenna are its small gain, law directivity and narrow bandwidth because of substrate dielectric has surface wave losses, so to improve the gain [4-6] and directivity has become an important issue in the antenna design field. Improving bandwidth, gain and directivity can be obtained by an antenna with periodic elements (FSS). Frequency selective surface (FSS) is a 2D planar structure consisting of a two dimensional array of slot elements in a metal sheet or an array of metal patch elements fabricated on dielectric substrate. The frequency [7-10] response of FSS is determined by the shape and size of the structure in one period called a unit cell. Aperture and patch screens generally give complementary frequency responses; the field is totally transmitted at the resonant frequency of the aperture while a screen comprised of patches will be nearly totally reflected at the resonant frequency of the patches.

2. Antenna Design

The proposed antenna is shown in the Figure 1. This antenna consists of a pentagonal shape and a Co-axial feed. Two irregular square and two regular triangular shapes are used to design the two given antennas. The characteristics parameters of the antenna are determined by using the design

[16-22] methods available in the literature [1].The length and the width of the patch are calculated by using below equations. The patch width W shown in Fig. 1 is given by,

$$A = \frac{c}{2fr}\sqrt{\frac{€+1}{2}} \qquad (1)$$

The length of patch is given by,

$$L=\frac{c}{2fr\sqrt{€}} - 2\Delta l \qquad (2)$$

Where

$$\Delta l = .412h\,\frac{(\epsilon+0.3)+(\frac{W}{h}+0.264)}{(\epsilon+0.258)(\frac{W}{h}+0.8)} \qquad (3)$$

$$\in e = \left(\frac{\epsilon r+1}{2}\right) + \left(\frac{\epsilon r-1}{2}\right)\sqrt{1+\frac{12h}{w}} \qquad (4)$$

The Pentagonal, Irregular Square Slotted Patch Antenna (PISSPA) is designed for the resonant frequency (fr) of 10.7591 GHz and 11.1806 GHz.

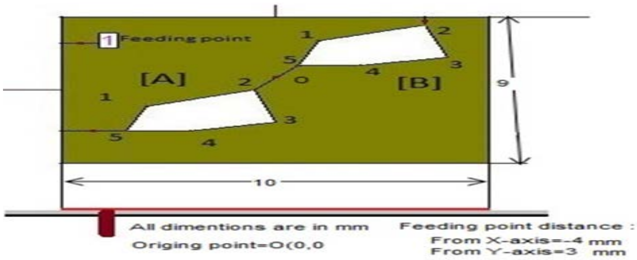


Figure 1: Simulated antenna configuration

3. Results And Discussion

Simulated (using IE3D) [23] results of return loss in conventional and simulated antenna [11-15] structures are shown in Figure. A significant improvement of frequency reduction is achieved in simulated antenna.

Due to the presence of slots in simulated antenna resonant frequency operation is obtained with large values of frequency ratio. The first and second resonant frequency is obtained at f1= 10.7591 GHz with return loss of about -12.9705 dB and at f2 = 11.1806 GHz with return losses -13.4424 dB respectively.

Corresponding 10dB band width obtained for Antenna at f1, f2 are 0.6392 GHz and 0.7954 GHz respectively. The simulated E plane and H-plane radiation patterns are shown in Figure 2. The simulated E plane radiation pattern of simulated antenna for 10.7591 GHz is shown in figure 3.

Values of the co-ordinates of the two figure (A,B) are as mentioned below:

Table 1: Value of the coordinates.

Co-ordinate no.	Figure A		Figure B	
	X	Y	X	Y
1	1	3	-3	-1
2	3.5	4	-0.5	0
3	4	2	0	-2
4	2	1.5	-2	-2.5
5	0.5	1.5	-3.5	-2.5

Return loss vs frequency graph is shown in the figure below. Return loss for frequency 10.7591 GHz is 130.867 dB and 71.3423 dB w.r.t. E-phi and E-theta, and for frequency 11.1806 GHz is 126.681 GHz w.r.t. E-phi and E-theta.

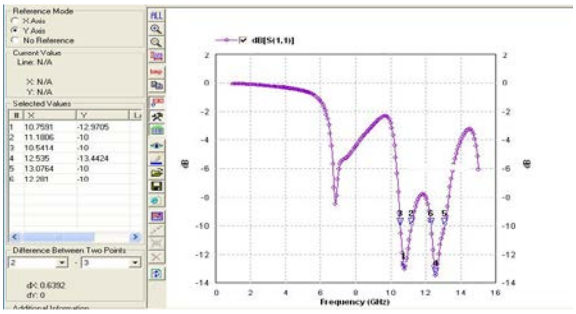


Figure 2: Return Loss vs. Frequency (Slotted Antenna)

E-phi and E-theta radiation patterns (polar plot) for frequencies 10.7591 GHz and 11.1806 GHz are shown in below:

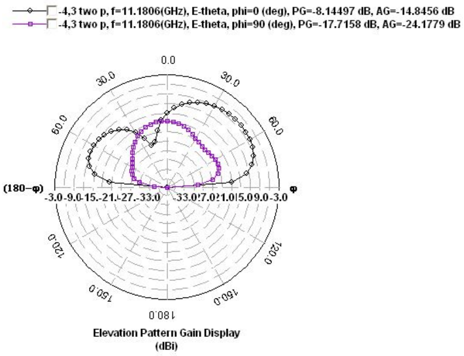


Figure 3: E-theta Radiation Pattern for Slotted Antenna at 11.1806 GHz

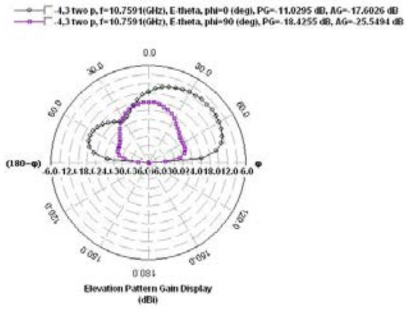


Figure 4: E-theta Radiation Pattern for slotted Antenna at 10.7591 GHz

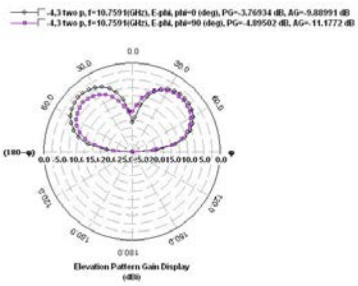


Figure 5: E-phi Radiation Pattern for slotted antenna at 10.7591 GHz

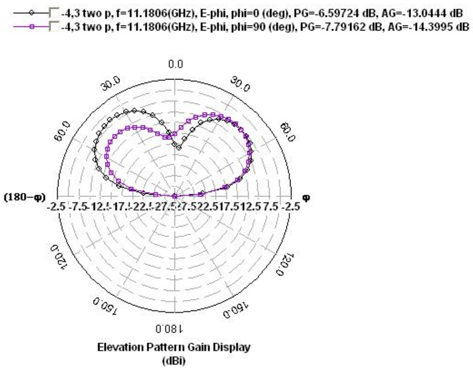


Figure 6: E-phi Radiation Pattern for slotted antenna at 11.1806 GHz

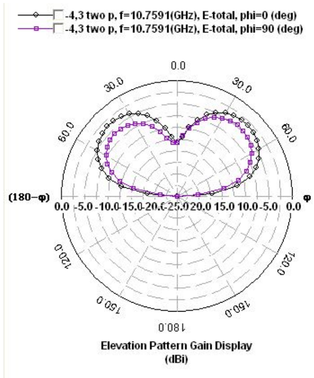


Figure 7: E-Total Radiation Pattern for slotted antenna at 11.1806 GHz

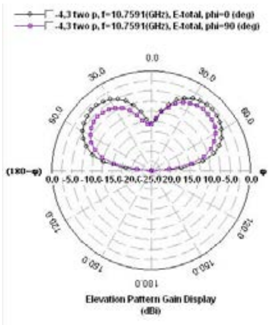
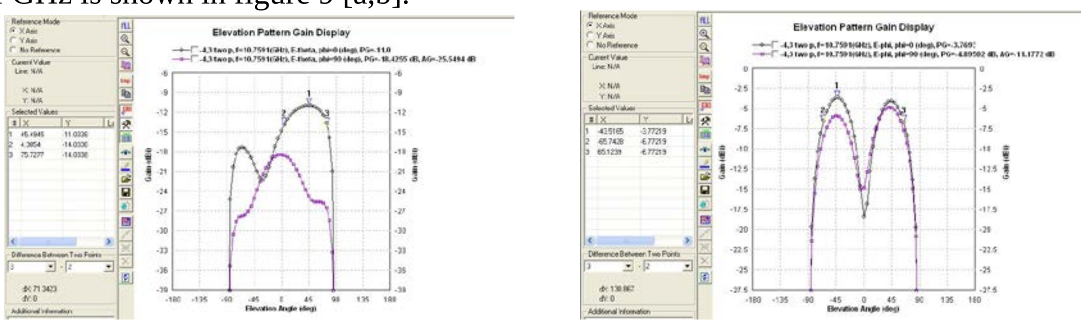


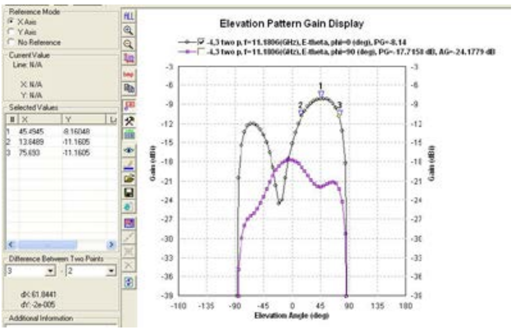
Figure 8: E-Total Radiation Pattern for slotted antenna at 10.7591 GHz

The simulated Cartesian E-theta and E-phi radiation pattern (2D) of simulated antenna for 10.7591 GHz is shown in figure 9 [a,b].

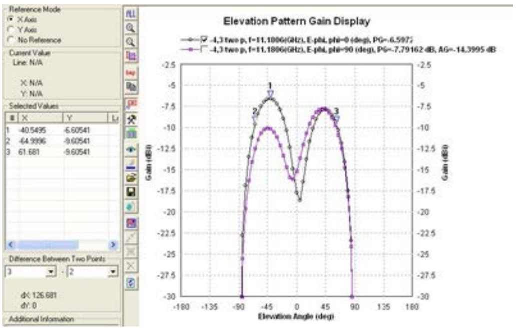


(a) (b)

Figure 9: E-Plane Radiation Pattern (2D) for slotted antenna at 10.7591 GHz (a) E-theta, (b) E-phi



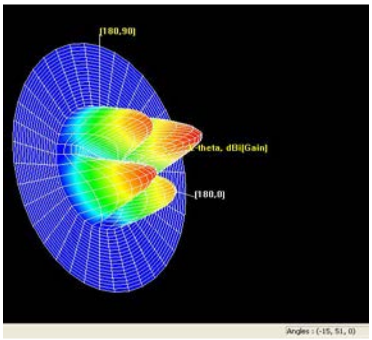
(a)



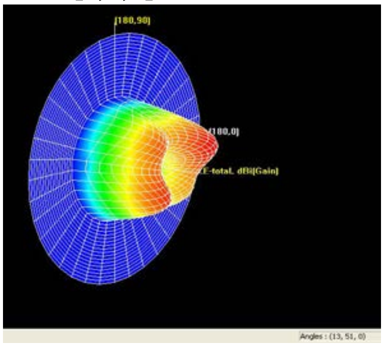
(b)

Figure 10: E-plane Radiation Pattern (2D) for slotted antenna at 11.1806 GHz (a) E-theta, (b) E-phi

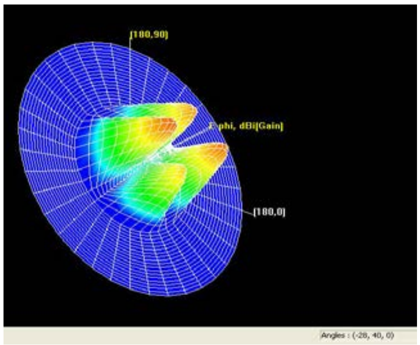
The simulated E plane radiation patterns (3D) of E-theta and E-phi of simulated antenna for 10.7591 GHz is shown in figure 11 [a,b,c].



(a)

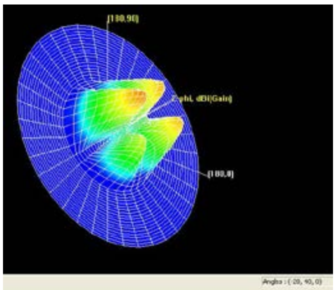


(b)

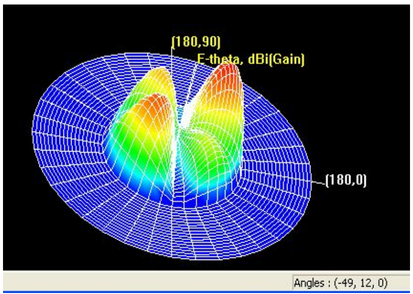


(c)

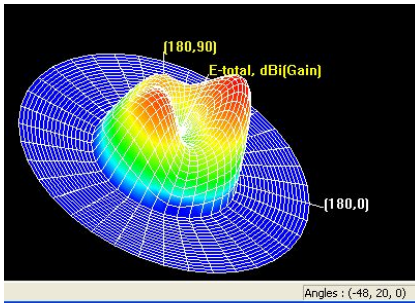
Figure 11: E-Plane Radiation Pattern (3D) for slotted antenna at 10.7591 GHz (a)theta (b) total (c) phi



(a)



(b)



(c)

Figure 12: E-plane Radiation Pattern (3D) for slotted antenna at 10.7591 GHz (a) phi (b) theta (c) total

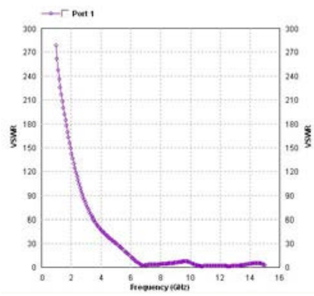


Figure 13: Simulated VSWR for slotted antenna

All the simulated results are summarized in the following Table 2 and Table 3.

Table 2: Stimulated result for antenna A and B w.r.t return loss.

Antenna structure	Resonant Frequency (GHz)	Return Loss (dB)	10 dB Bandwidth (GHz)
Slotted	F1=10.7591 GHz	E-phi=130.867	0.6392
		E-theta=71.3423	
	F2=11.1806	E-phi=126.681	0.7954
		E-theta=61.8441	
Frequency Ratio for Slotted Antenna		f2 / f1 =1.1650	

Table 3: Stimulated result for antenna A and B w.r.t radiation pattern

Antenna Structure	Resonant Frequency (GHz)	3dB Beam width	Absolute Gain (dBi)
Slotted	F1= 10.7591	E-Phi=-43.5165	-3.77219
		E-Theta=45.4945	-11.0338
	F2 =11.1806	E-Phi=-40.5495	-6.60541
		E-Theta=45.4945	-8.16048

4. Conclusion

In this work, with the help of IE3D simulation software tool, a single band pentagonal microstrip patch antenna Slotted Patch Antenna carried out. The results obtained from IE3D [23] shows almost 52.64% improvements in bandwidth. Significantly better radiation patters with low values of VSWR are also achieved which is suitable for X-Band for purpose of medical equipment applications.

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