A Design of Diagonally circular Slotted Fractal Patch Antenna for Multi Band Applications

Prashant Singodiya, Devendra Soni , Sanjay Gurjar, Saurabh Sharma

***Abstract*— In this paper, a novel design of Diagonally circular Slotted Fractal Patch Antenna is presented. It is a compact design of 30 ×30 mm^2 area on FR_4 substrate with dielectric constant of 4.4, thickness of 1.6 mm and fed by a probe feeding technique. Micros trip patch antenna consists of a fractal patch with circular- shaped meandered lines to provide multi band operations. The proposed antenna resonates at four different frequencies 2.2933GHz, 4.68GHz, 5.21GHz and 6.81GHz with high return loss of -14.48 dB, -15.71 dB ,-10.70dB and -18.88 dB respectively with satisfactory radiation properties. The antenna operated in quad band, viz. 2.25-2.34GHz with percentage bandwidth of 3.92 % at 4.60-4.76 GHz with percentage bandwidth of 3.41%, at 5.2-5.23 GHz with percentage bandwidth of 0.57%, and 6.70-6.90 GHz with percentage bandwidth of 2.94% .The parameters that affect the performance of the antenna in terms of its frequency domain characteristics are investigated. The antenna design has been simulated on IE3D, an electromagnetic (EM) simulation software tool. This antenna is good for mobile and wireless applications.**

***Index Terms*— Fractal Antenna, Quad Band, IE3D Return Loss.**

I. INTRODUCTION

Fractal shaped antennas exhibit some interesting features that stem from their inherent geometrical properties. The self-similarity of certain fractal structures results in a multiband behaviour of self-similar fractal antennas and frequency-selective surfaces (FSS) [1-3].The interaction of electromagnetic waves with fractal bodies has been the study of many researchers in the recent years [4]. The word "Fractal" is outcome of Latin word "fractus" which means linguistically "broken" or "fractured". Benoit Mandelbrot, a French mathematician, introduced the term about 20 years ago in his book "The fractal geometry of Nature" [5].The term fractal was coined by Mandelbrot in 1975, but many types of fractal shapes have been proposed long before. Fractals are generally self-similar and independent of scale [6]. Micro strip patch Antennas are very popular in many fields as they are low-profile, low weight, robust and cheap. In last year's new techniques employing fractal geometries are studied and developed [7].One of them is the fractalizing of antennas boundary where new qualitative effect as the higher mode Localization appears that result in directive radiation patterns [7]. In this paper, we propose a novel space filling a fractal circular shaped meandered patch antenna to reduce the size of micro strip patch antenna. The original meander is constructed by removing a strip of constant width and length from central main rectangle. The proposed antenna is designed and simulated using IE3D Software. The fractal Antenna is advantageous in generating multiple resonances.

II. PROPOSED ANTENNA DESIGN

In this paper, the performance of space-filling Diagonally circular Slotted shaped meandered fractal lines on probe fed patch antennas has been investigated till third order. It may be contended that the bends and corners of these geometries would add to the radiation efficiency of the antenna, thereby improving its gain.[7] Advantage of these configurations is that they lead to multiband conformal antennas[6].The proposed antenna is designed on Fr4 epoxy substrate having the dielectric constant of 4.4 and 0.02 loss tangent. In the design of this type of antennas, the width „W" and length „L" of base shape (zero order) patch play a crucial role in determining the resonant frequency. Here for the zero order or base shape the length of rectangular patch is taken as l=30 mm and width as w = 30 mm. The designed value of the antenna is optimized with IE3D tool. The first order design is created from first iteration by removal of one "circular" shaped slots placed as shown in the figure 2. In next second iteration to create order shape we will repeat this process and increase two "circular" shaped slots inside first and in second order increase twice more than first order. A ground plane of copper is printed on the back of the substrate as a ground plane for the probe feed line technique .Figure 1 shows the base shape of proposed antenna of dimension 30 ×30 mm^2 and figure 2 shows the first order shape after cutting the "circular" shaped meanders of radius 2.5 mm.

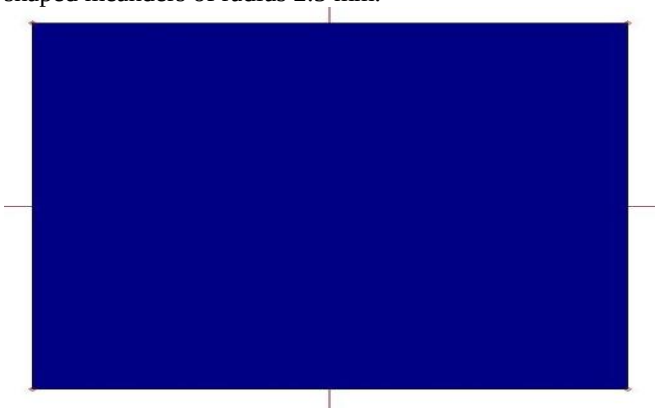

Fig. 1:- Base Shape of Diagonally circular Slotted fractal Antenna (l=30mm, w=30mm)

The main advantages of the proposed antenna are: (1) compact size, (2) multiband characteristics (3) size reduction.

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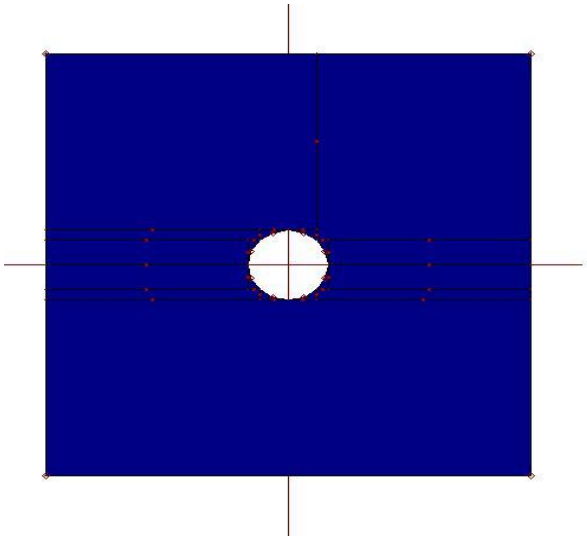


Fig. 2:- First Order Shape Diagonally circular Slotted fractal antenna

Here the size of the antenna will be depending on the resonant frequency which will be reducing as we keep on iterating the first order design. The correct resonant frequencies and impedance matching of the proposed antenna can be established by adjusting the location of feed point and the distance between the Circular - shaped meandered portions. Figure 3 and 4 show the second and third order shape of the Diagonally circular Slotted -shaped meandered fractal antenna with dimension of Circular -shaped radius chosen as 1/2 of higher order circular - shaped dimensions.

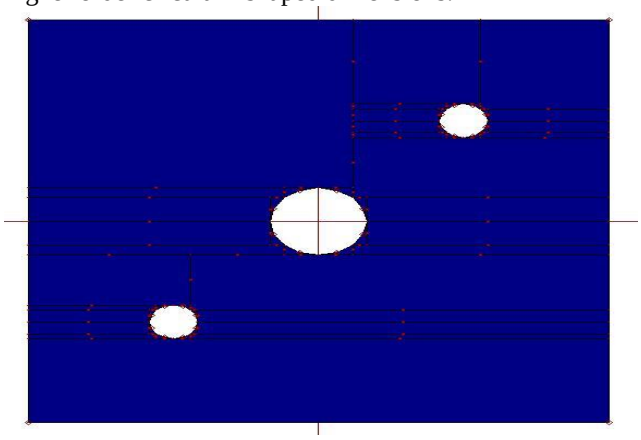


Fig. 3:- Second Order Shape of Diagonally circular Slotted fractal antenna

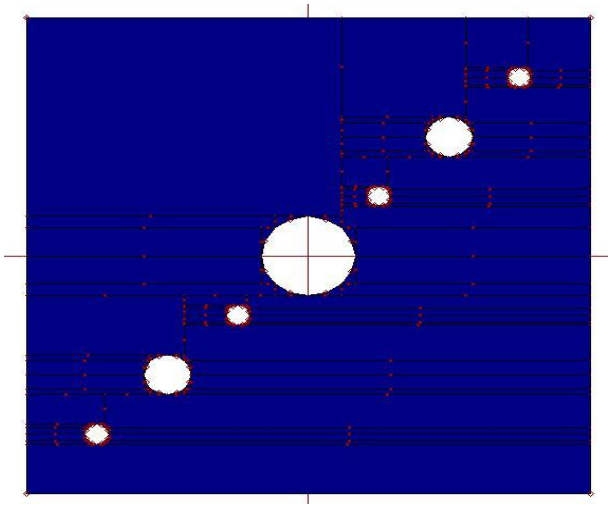


Fig.4:- Third Order Shape of Diagonally circular Slotted fractal antenna

III. RESULTS AND DISCUSSION

The results for the three iterations performed on the rectangular patch to get the desired Diagonally circular Slotted - shaped meandered fractal antenna are as follows:

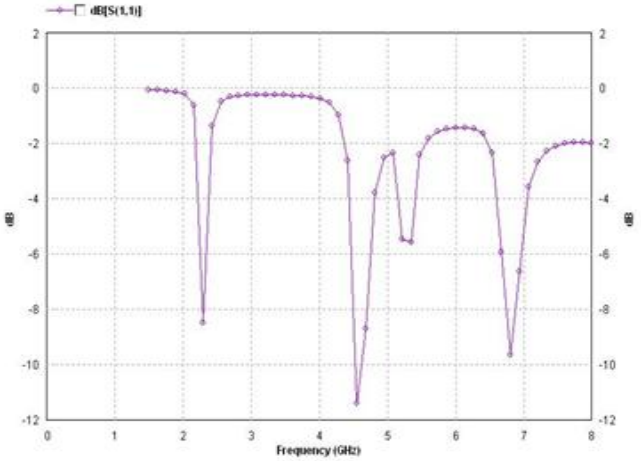


Fig. 5:- Return Loss for Base Shape

Fig.5 shows that the antenna resonates at 4.56 GHz with Return loss of -11.1971dB. This design can be used in Fixed Satellite Service, Defence systems, Mobile applications, UWB applications and Radio determination applications

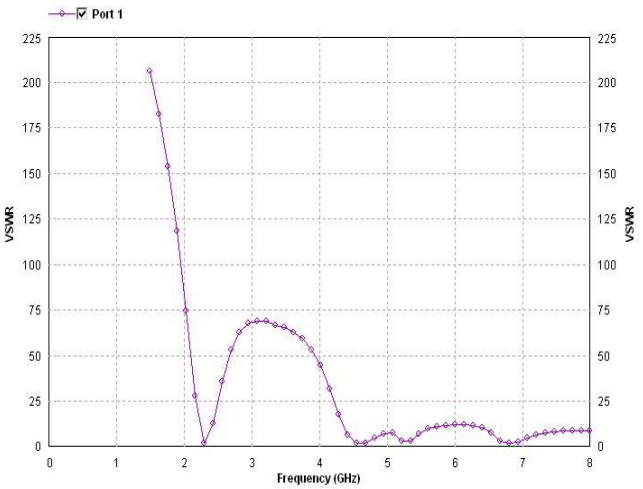


Fig. 6:- VSWR of Base Shape

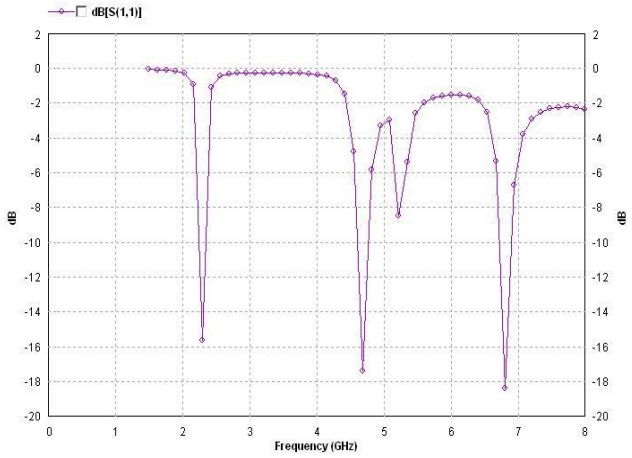


Fig. 7:- Return Loss of First Order

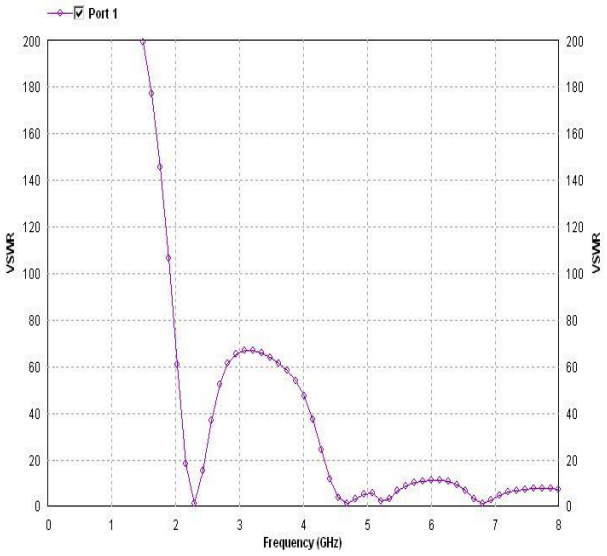


Fig. 8:- VSWR of First Order

For First Order There are three Bands Occurring with Resonance Frequencies at 2.2933 GHz, 4.68 GHz And 6.81333 GHz

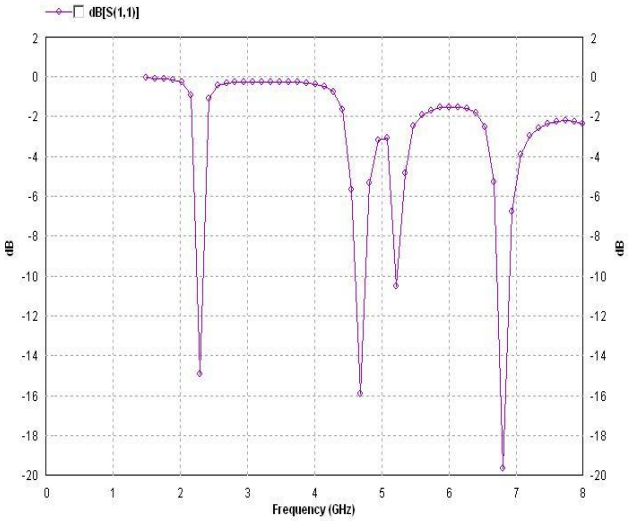


Fig. 9:- Return Loss of Second Order

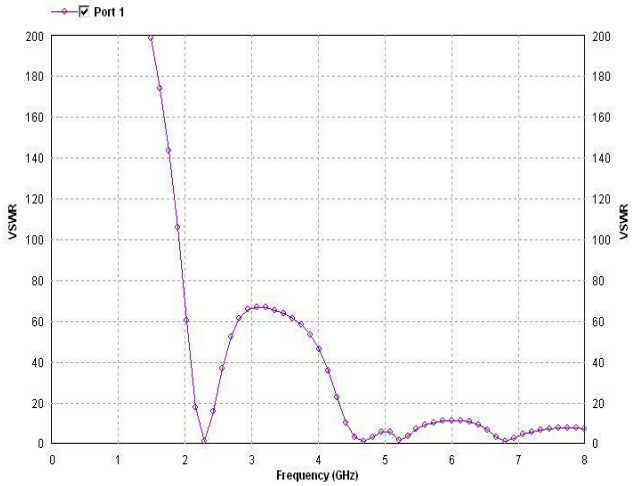


Fig. 10:- VSWR of Second Order

For second iteration three bands are occurs at resonance frequency of 2.2933 GHz, 4.68 GHz, 5.21333 GHz And 6.81333 GHz

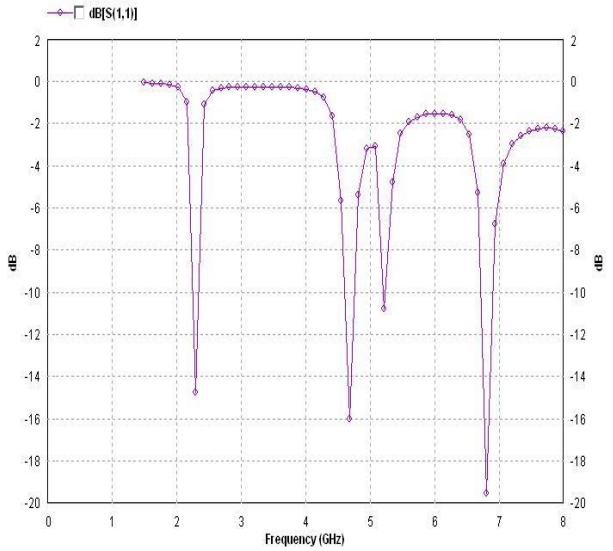


Fig. 11:- Return Loss for Third Order

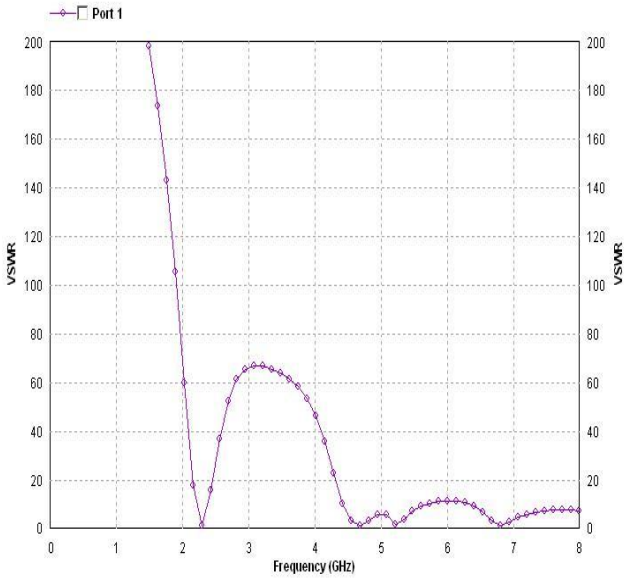
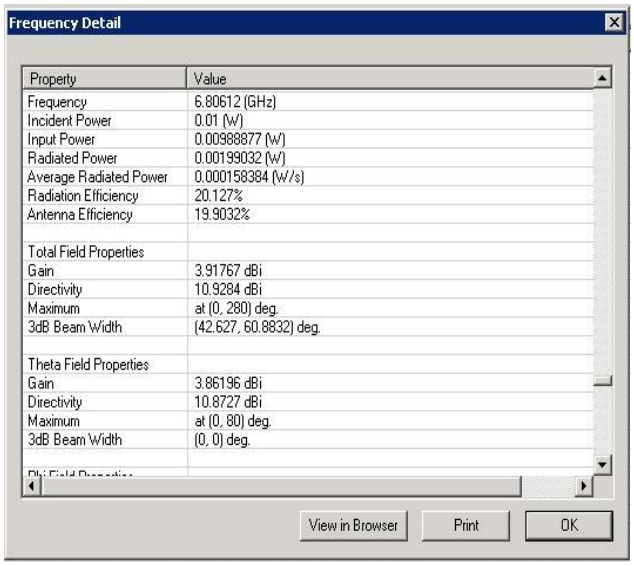


Fig. 12:- VSWR of third order

The proposed antenna resonates at four different frequencies 2.2933 GHz, 4.68 GHz, 5.21333 GHz And 6.81333 GHz with high return loss of -14.48 dB,-15.71 dB ,-10.70 dB and -18.88 dB respectively with satisfactory radiation properties .The antenna operated in quad band, viz. 2.25-2.34GHz with percentage bandwidth of 3.92 % at 4.60-4.76 GHz with percentage bandwidth of 3.41%, at 5.2-5.23 GHz with percentage bandwidth of 0.57%, and 6.70-6.90 GHz with percentage bandwidth of 2.94% **.**The table 1 below shows the frequency detail of the third order of the Diagonally circular Slotted fractal antenna. Frequency detail table we see that the antenna gives the gain of 3.9176 dBi with directivity of 10.9284 dBi. A Comparative table for all the iterations is given in appendix-I for detailed performance evaluation of the proposed design.



In this paper, the Diagonally circular Slotted fractal antenna up to third order has been designed & simulated using the IE3D. It has been observed that with the increase in number of orders the band-width of the antenna, VSWR and return loss also increased. In third order, antenna is showing multiband results at higher bandwidth and maximum return loss. The self-similarity properties of the fractal shape are translated into its multiband behavior . The simulation shows a size reduction is achieved by the proposed fractal antenna, without degrading the antenna performance, such as return loss and radiation pattern due to the meandered circular shaped slots which have increased the length of the current path.

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APPENDIX

Comparative Table of Diagonally circular Slotted - Shaped Meandered Quad Band Fractal Patch Antenna

S. No.	Shape	Resonant Freq. (GHz)	Return Loss (db)	Bandwidth (%)	VSWR
1	Base Shape	Fr1 =4.56	-11.1971	1.798	1.76777
2	1st Iteration	Fr1 =2.2933	-15.3145	4.23	1.72859
		Fr2 =4.68	-17.0629	3.52	1.37795
		Fr3 =6.81333	-17.7389	2.49	1.35279
3	2nd Iteration	Fr1 =2.2933	-14.63	3.92	1.76057
		Fr2 =4.68	-15.61	3.09	1.44074
		Fr3 =5.21	-10.47	0.28	1.84397
		Fr4=6.81	-18.93	2.79	1.31096
4	3rd Iteration	Fr1 = 2.2933	-14.48	3.92	1.76265
		Fr2 =4.68	-15.71	3.41	1.52928
		Fr3 =5.21	-10.70	0.57	1.8125
		Fr4=6.81	-18.88	2.94	1.3146