A Design of Diagonally Circular Slot fractal patch antennas For Multi Band Applications

Shubha Mishra, Prashant Singodiya, Dheeraj Singodia

***Abstract*— In this paper, a novel design of a Diagonally Circular Slot fractal patch antennas is presented. In this work a diagonally triangular slotted sierpinski fractal patch antenna is designed for 6.88333 GHz frequency.These fractal antennas are basically microstrip patch antenna. For designing this microstrip fractal patch antenna IE3D simulation software is used. In all fractal antennas FR4 epoxy is used as substrate with height 1.6 mm and dielectric constant 4.4 respectively. For feeding we have used Probe feeding method. In all iteration feeding point is same and radius of feeding point is 0.16mm In the first iteration one circular patches of radius 2.5 mm is cut from the geometry as shown in figure2 . In the second iteration again two circular patches of radius 1.25 mm is cut from the rectangular patch Antenna of the second iteration as shown in figure 3.Same procedure is done for third iteration radius 0.625 mm.**

***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 behavior 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]. Microstrip 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].This paper, we propose a novel space filling a fractal circular shaped meandered patch antenna to reduce the size of microstrip 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.

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II. PROPOSED ANTENNA DESIGN

In this paper, the performance of A Diagonally Circular Slot fractal patch antennas on probe fed patch antennas has been investigated till third order. Advantage of these configurations is that they lead to multiband antennas. The proposed antenna is designed on Fr4 epoxy substrate having the dielectric constant of 4.4 and 0.02 loss tangents. 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=28.5mm and width as w = 28.5 mm. The designed value of the antenna is optimized with IE3D tool. The first order design is created from first iteration . In the first iteration one circular patches of radius 2.5 mm is cut from the geometry .In the second iteration again two circular patches of radius 1.25 mm is cut from the rectangular patch Antenna of the second iteration. Same procedure is done for third iteration radius 0.625 mm.Figure 1 shows the base shape of proposed antenna of dimension 28.25×28.25 and figure 2 shows the first order shape after cutting the “circular” shaped of radius 1.0 mm.

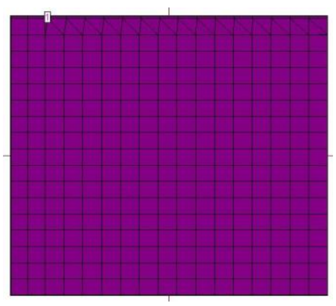


Fig. 1 Base Shape of diagonally circular Slot fractal patch antennas (l=28.5 mm, w = 28.5 mm)

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

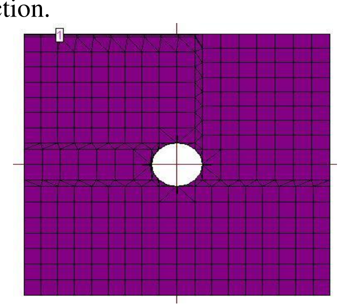


Fig. 2. First Order Shape diagonally circular Slot fractal patch antennas

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.

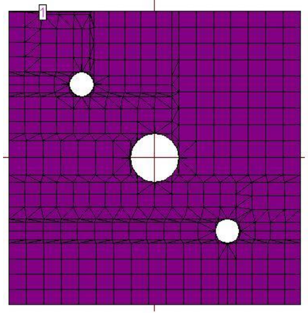


Fig. 3. Second Order Shape of diagonally circular Slot fractal patch antennas

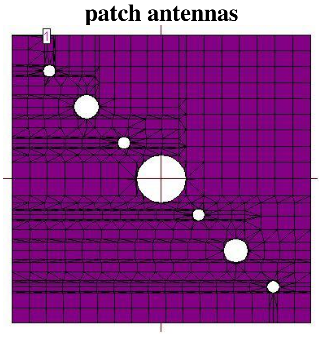


Fig. 4.Third Order Shape of diagonally circular Slot fractal patch antennas

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:

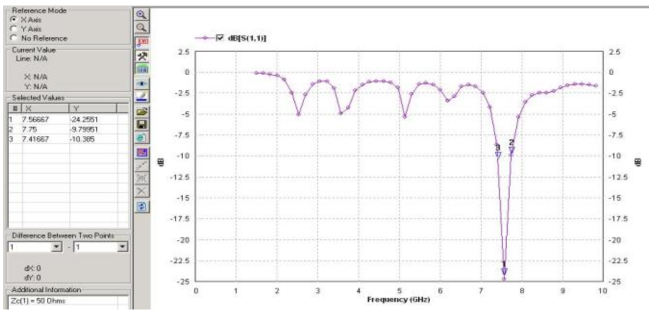


Fig. 5 Return Loss for Base Shape

Fig.5 shows that the antenna resonates at with 7.5667GHz return loss -24.2551dB. This design can be used in Fixed Satellite Service (FSS), Satellite Navigation system, Generic UWB and Radio determination applications.

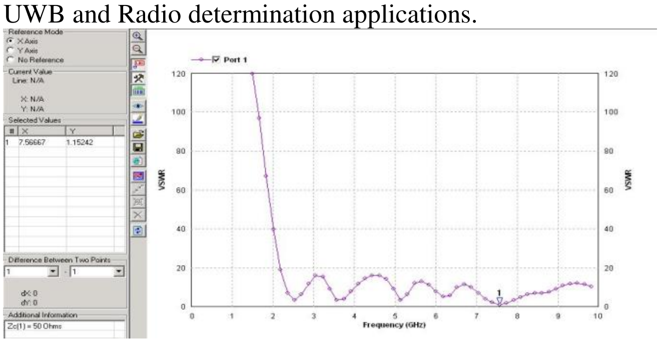


Fig. 6 VSWR of Base Shape

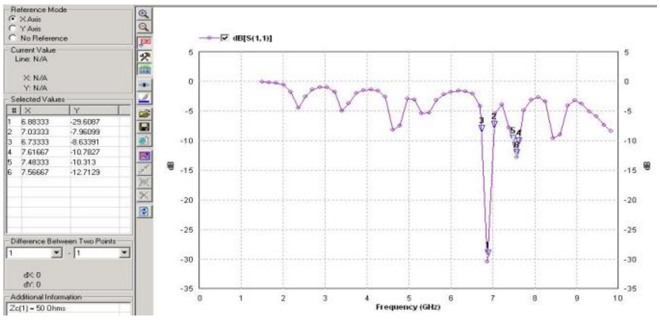


Fig. 7 Return Loss of First Order

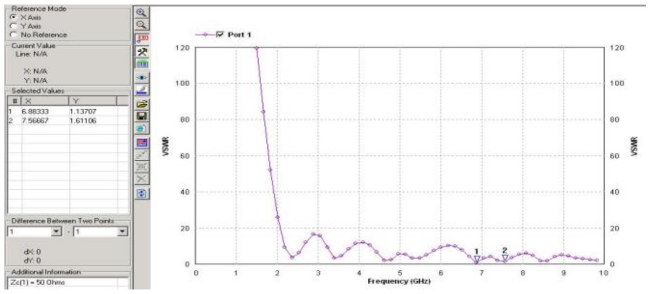


Fig. 8. VSWR of First Order

For First Order There are three Bands Occurring with Resonance Frequencies at 6.8833GHz and 7.56667GHz.

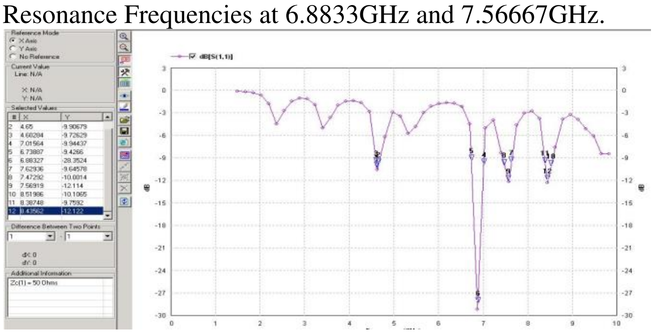


Fig. 9. Return Loss of Second Order

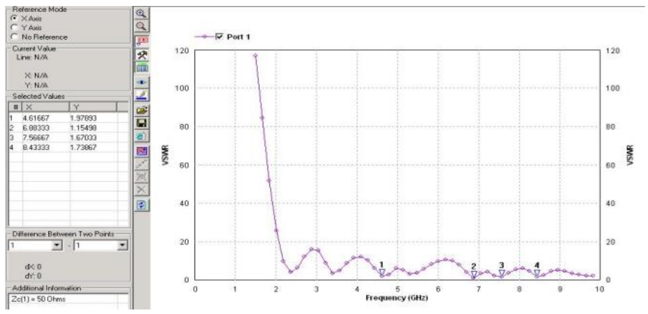


Fig. 10. VSWR of Second Order

For second iteration three bands are occurs at resonance frequency of VSWR is 1.97893 1.15498, 1.67033 and 1.73867 at 4.61667GHz, 6.88333 GHz , 7.56667GHz and 8.4333GHz respectively.

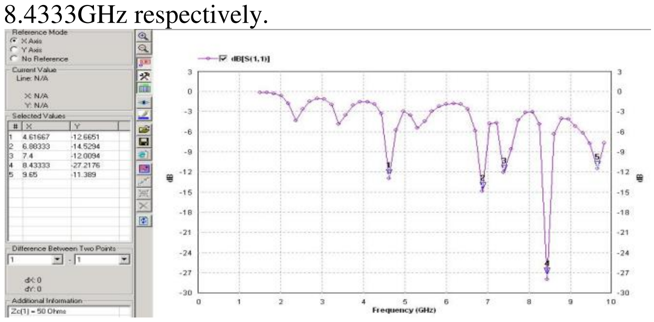


Fig. 11. Return Loss for Third Order

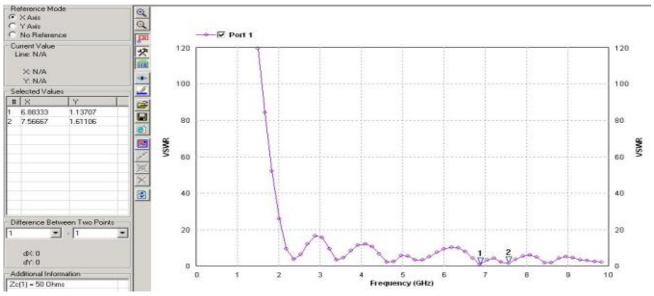
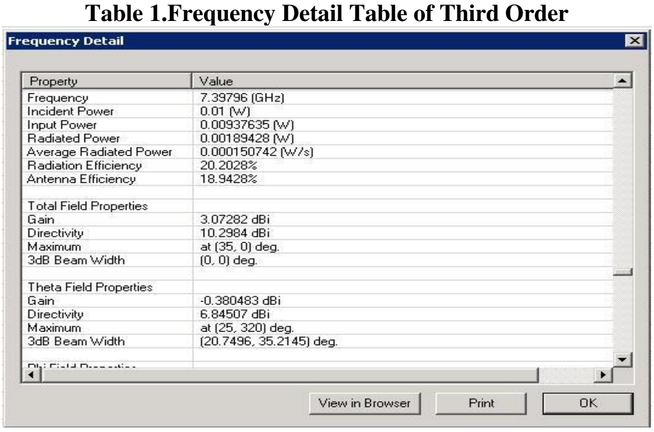


Fig. 12. VSWR of third order

The proposed antenna resonates at five different frequencies 4.61667 GHz and 6.88333 GHz , 7.4 GHz ,8.4333 GHz and 9.65 GHz with high return loss of first iteration is -29.6087dB at 6.88333GHz , high return loss of second iteration is --28.3524dB and high return loss of third iteration is -27.217db respectively with satisfactory radiation properties. The antenna operated in five band, viz. 4.6167 to 4.7 GHz with percentage bandwidth of 2.89% , 6.7833-6.9833 GHz with percentage bandwidth of 2.90 %,7.35 to 7.51667 GHz with percentage bandwidth of 2.25% , 8.3 to 8.5833 GHz with percentage bandwidth of 3.35% and 9.5833 to 9.7333 GHz with percentage bandwidth of 1.55%.

Table 1.Frequency Detail Table of Third Order



Frequency Detail

Property	Value
Frequency	7.39796 (GHz)
Incident Power	0.01 (W)
Input Power	0.00937635 (W)
Radiated Power	0.00189428 (W)
Average Radiated Power	0.000150742 (W/s)
Radiation Efficiency	20.2028%
Antenna Efficiency	18.9428%
Total Field Properties	
Gain	3.07282 dBi
Directivity	10.2984 dBi
Maximum	at (35, 0) deg.
3dB Beam Width	(0, 0) deg.
Theta Field Properties	
Gain	-0.380483 dBi
Directivity	6.84507 dBi
Maximum	at (25, 320) deg.
3dB Beam Width	(20.7496, 35.2145) deg.

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IV. CONCLUSION

In this paper, the circular Sierpinski shaped 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. The proposed antenna shows the satisfactory gain in the desired frequency range.

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APPENDIX-I

Comparative Table of diagonally circular slotted Fractal Patch Antenna

S.No.	Shape	Resonant frequency	Return loss	Bandwidth	VSWR
1	Base shape	7.65GHz	-24.255db	4.40%	1.15242
2	1st Iteration	6.88333GHz	-29.6087db	4.35%	1.3707
		7.56667GHz	-12.7129db	1.76%	1.61106
3	2nd Iteration	6.88327GHz	-28.3524db	4.02%	1.5498
		7.56919GHz	-12.144db	2.06%	1.87033
		8.43562GHz	-12.122db	1.57%	1.73867
4	3rd Iteration	4.61667GHz	-12.6651db	2.89%	1.70315
		6.88333GHz	-14.5294db	2.90%	1.51646
		7.4GHz	-12.0094db	2.25%	1.67191
		8.4333GHz	-27.2176db	3.35%	1.16494
		9.65GHz	-11.389db	1.55%	1.7418

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