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A Design of Sierpinski Triangular Slotted Sierpinski Fractal Patch Antenna For Multi Band Applications

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Abstract— **In this paper, a novel design of Sierpinski Triangular slotted Sierpinski fractal patch antenna is presented. In this work a diagonally triangular slotted sierpinski fractal patch antenna is designed for 4.27 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 base shape a rectangle patch of length 10.56 mm X 15.24mm is chosen as base shape shown in figure1. In the first iteration four triangular patches of 1 mm X 1 mm X 1mm X 1 mm are cut from the geometry(from four corners) at a gap of 0.50 mm.. In the second iteration again four triangular patches of 1 mm X 1 mm X 1 mm X 1 mm are cut at a gap of 0.25 mm from the triangle of the first iteration.. Same procedure is done in third iteration.**

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 space-filling Sierpinski Triangular slotted Sierpinski 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. 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=10.56 mm and width as w = 15.24 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 four "circular" shaped slots inside first and in second order increase two time 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 $10.56 \times 15.24 mm^2$ and figure 2 shows the first order shape after cutting the triangular shaped patches of 1mm x 1 mm x 1 mm x 1 mm are cut from the geometry from four corners at the gap of 0.5 mm

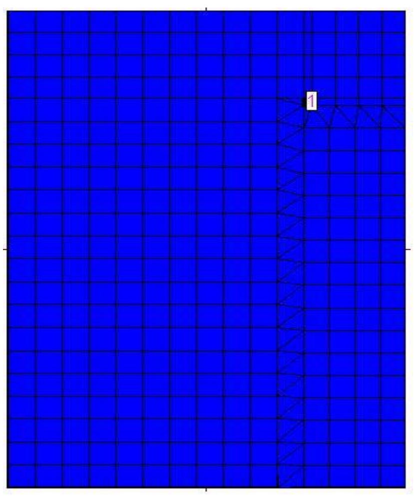

Fig. 1 Base Shape of triangularly slotted sierpinski fractal Antenna (l=10.56 mm, w = 15.24 mm)

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

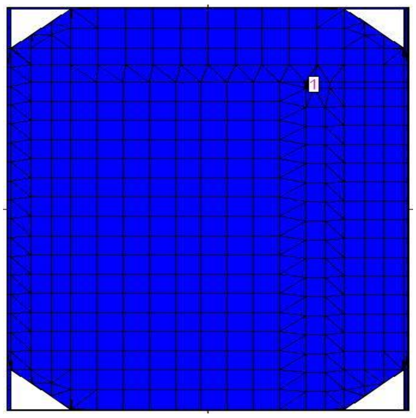

Fig. 2. First Order Shape triangularly slotted sierpinski fractal Antenna

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 triangular shaped fractal antenna with dimension. In the second iteration again four triangular patches of 1 mm x 1 mm x 1 mm x 1 mm are cut at the gap of 0.25 mm from the triangle of the first iteration.. Same procedure is done for third iteration

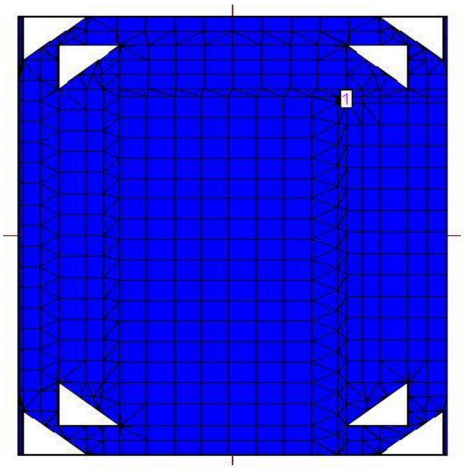

Fig. 3. Second Order Shape of triangularly slotted sierpinski fractal Antenna

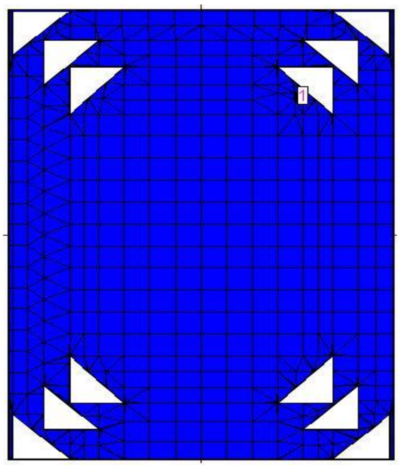

Fig. 4. Third Order Shape of triangular slotted sierpinski fractal Antenna

III. RESULTS AND DISCUSSION

The results for the three iterations performed on the rectangular patch to get the desired triangular slotted Sierpinski shaped meandered fractal antenna are as follows:

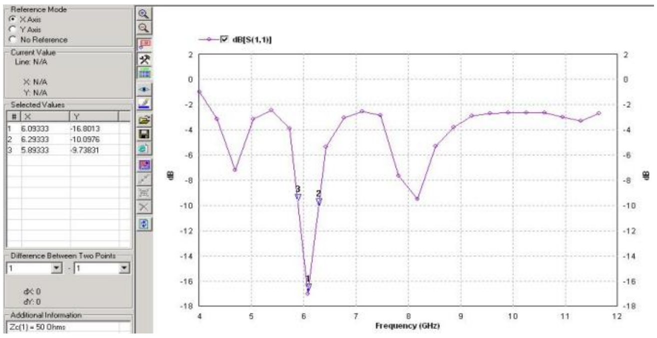

Fig. 5. Return Loss for Base Shape

Fig.5 shows that the antenna resonates at with 6.0933 GHz return loss -16.8013 dB.

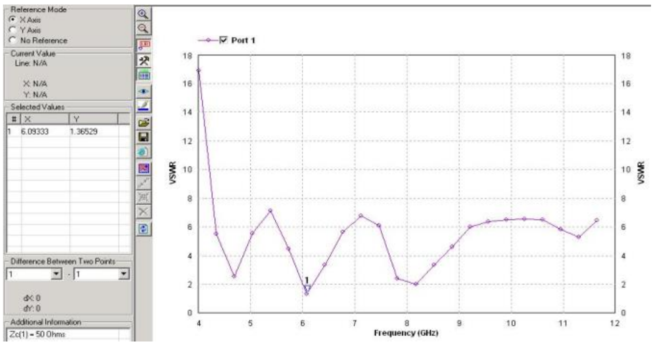

Fig. 6. VSWR of Base Shape

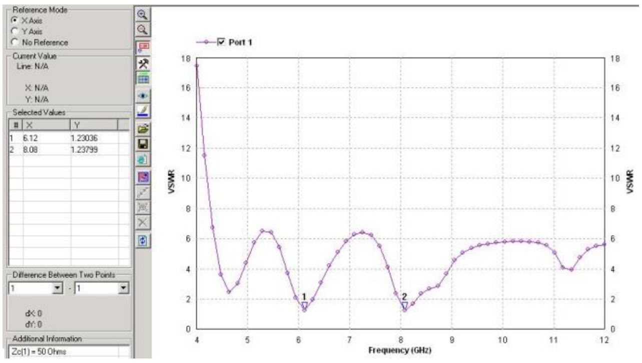

Fig. 7. VSWR of First Order

For First Order There are three Bands Occurring with Resonance Frequencies at 1.230 and 1.237 at 6.12 GHz and 8.08 GHz respectively

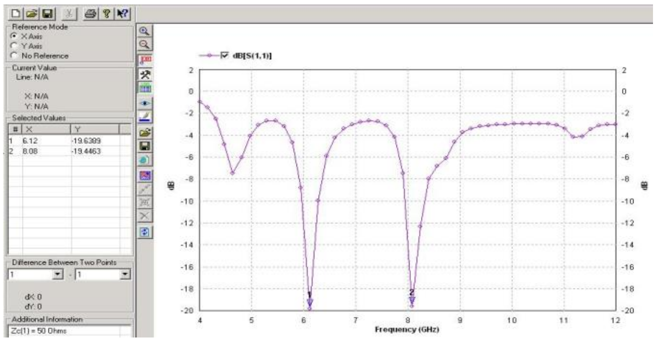

Fig. 9. Return Loss of Second Order

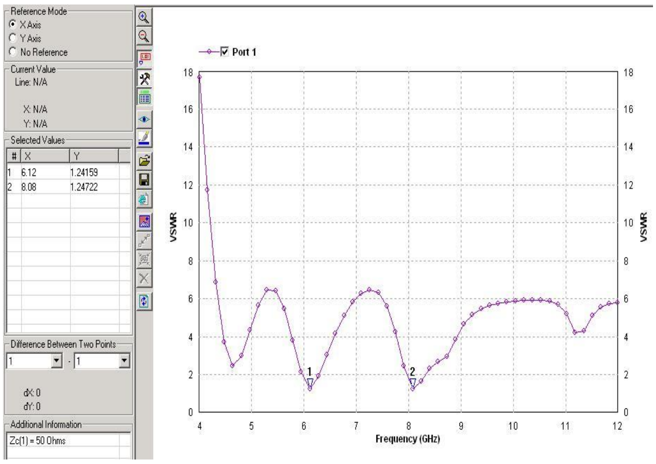

Fig. 10. VSWR of Second Order

For second iteration three bands are occurs at resonance frequency of 1.241 and 1.247 at 6.12 GHz and 8.08 GHz

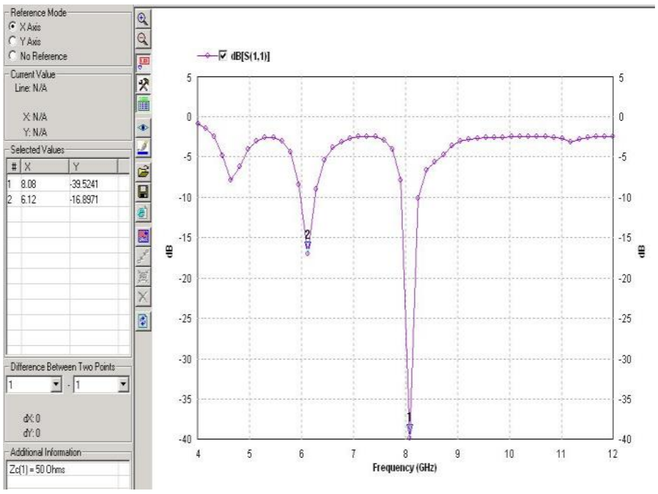

Fig. 11. Return Loss for Third Order

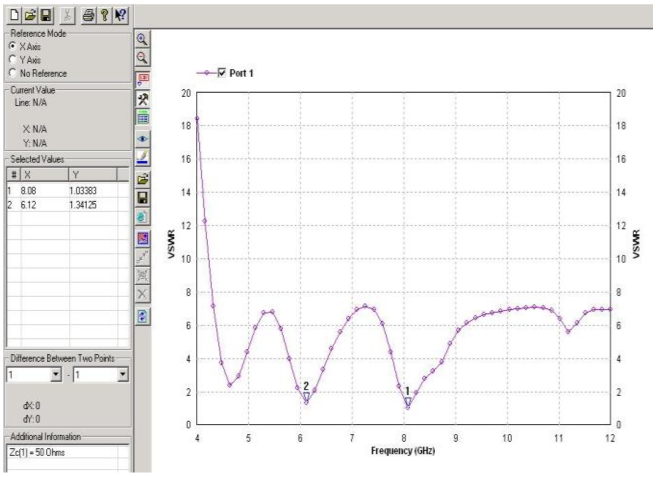

Fig. 12. VSWR of third order

The proposed antenna resonates at two different frequencies 6.12 GHz and 8.08 GHz with high return loss of -16.897 dB and -39.52 dB respectively with satisfactory radiation properties. The antenna operated in twice band, viz. 5.986-6.266 GHz with percentage bandwidth of 4.575 % and 7.933-8.2533 GHz with percentage bandwidth of 3.64 %. A Comparative table for all the iterations is given in Table 1 for detailed performance evaluation of the proposed design.

Table 1.Frequency Detail Table of Third Order

Frequency Detail

Property	Value
Frequency	6.12245 (GHz)
Incident Power	0.01 (W)
Input Power	0.00980168 (W)
Radiated Power	0.00479172 (W)
Average Radiated Power	0.000381313 (W/s)
Radiation Efficiency	48.8867%
Antenna Efficiency	47.9172%
Total Field Properties	
Gain	3.68747 dBi
Directivity	6.88255 dBi
Maximum	at (5, 330) deg.
3dB Beam Width	(61.4342, 130.18) deg.
Theta Field Properties	
Gain	3.56462 dBi
Directivity	6.75971 dBi
Maximum	at (5, 360) deg.
3dB Beam Width	(10.6274, 69.4982) deg.

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IV. CONCLUSION

In this paper, the triangular 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.

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APPENDIX-I

Comparative Table of Circular Sierpinski - Shaped Meandered Quad Band Fractal Patch Antenna

S. No.	Shape	Resonant Freq. (GHz)	Return Loss	Band width	VSWR
1	Base Shape	F_{r1} =6.0933 GHz	-16.80 dB	6.56%	1.3652
2	1st Iteration	Fr_1 =6.12 GHz	-20.00dB	5.02%	1.23
		F_{r2} =8.08 GHz	-19.72dB	4.62%	1.237
3	2nd Iteration	F_{r1} =6.12 GHz	-19.63dB	4.80%	1.241
		F_{r2} =8.08GHz	-19.44dB	4.62%	1.247
4	3rd Iteration	F_{r1} =6.12 GHz	-16.897dB	4.58%	1.3412
		F_{r2} =8.08GHz	-39.52dB	3.64%	1.033


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