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A SELF-AFFINE 8-SHAPED FRACTAL MULTIBAND ANTENNA FOR WIRELESS APPLICATIONS

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ABSTRACT

Advanced telecommunication systems require antennas with smaller dimensions and wider bandwidth. The fractal antennas are preferred due to small size, light weight and multiband. The authors have presented the design of 8-shaped fractal multiband antenna based on the self-affinity property. The 8-shaped fractal antenna has been designed through Iterated Function System (IFS) up to second iteration. Resonance frequencies of second iterated (K2) fractal antenna are 2.421GHz, 3.35GHz and 3.763GHz with VSWR 1.16, 1.025 and 1.057 respectively. The size of antenna is reduced to 24.88% at second iteration from conventional rectangular microstrip patch antenna and 474MHz overall bandwidth obtained. Simulation is carried out using commercial simulation software IE3D code.

Keywords: Fractal antenna, Eight shaped antenna, Multiband antenna, Self-affine antenna.

I. INTRODUCTION

The new science of fractal offers us new interesting possibilities for designing small, broadband, and efficient antennas for restricted space. So, we focus on nature-based antenna design concepts employ fractal geometry. Fractals are abundant in nature, with a few examples of natural fractals being trees, ferns, coastlines, mountain ranges etc. [1]. Fractals are space-filling contours; means having electrically large features can be efficiently packed into small areas. Since electrical lengths play an important role in antenna designs, this efficient packing can be used as a viable miniaturization technique [2].

The term fractal, meaning broken or irregular fragments, was originally used by Benoit Mandelbrot [1] to describe a family of complex shapes that contain an inherent self-similarity or self-affinity in their geometrical structure.

A self-similar [3] set is one that consists of scaled down copies of itself, i.e., a contraction which reduces an image by same factors horizontally and vertically. A Self-affine [3] set is a contraction which reduces an image by different factors, horizontally and vertically.

II. PROPOSED ANTENNA

The self-affine 8-shaped fractal geometry considered in this paper is constructed by scaling a rectangle by a factor of 3 in the horizontal direction and by a factor of 5 in the vertical direction, giving fifteen rectangles, out of which the 2 central rectangles removed to make 8-shape as shown in figure.1. This is the first iteration. The process is now repeated on the remaining rectangles in the second iteration. This procedure is known as the iterated function system (IFS) and is described by the matrix equation [3], [4], [5]

$$W\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix} \qquad (1)$$

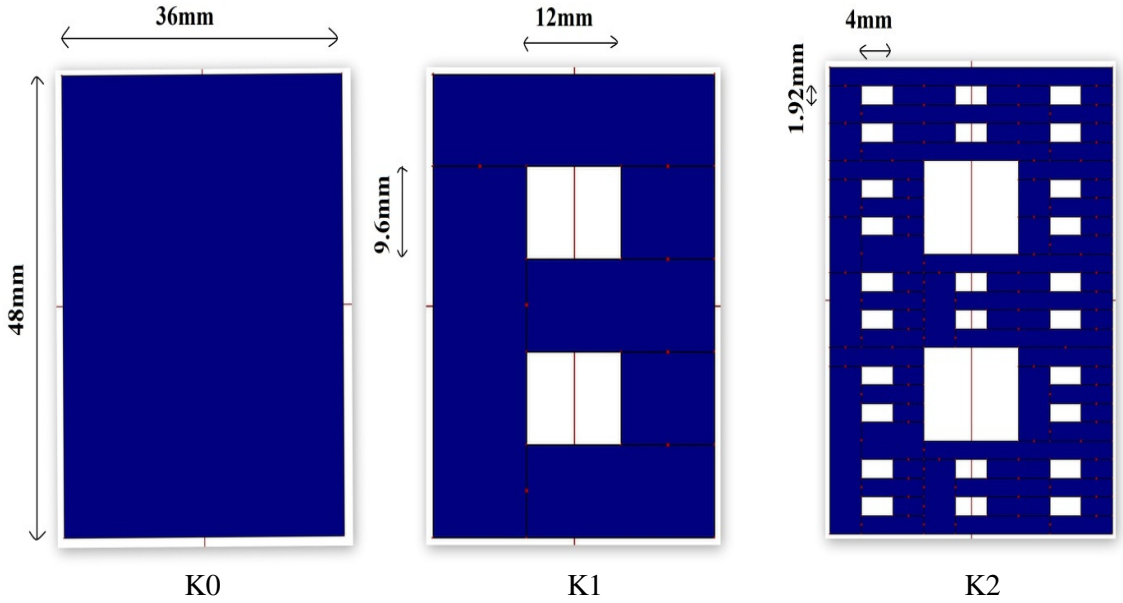


Fig.1: First two iterations of the fractal geometry.

W	a	b	c	d	e	f
1	0.3333	0	0	0.20	0	0
2	0.3333	0	0	0.20	0.3333	0
3	0.3333	0	0	0.20	0.6666	0
4	0.3333	0	0	0.20	0	0.2
5	0.3333	0	0	0.20	0.6666	0.2
6	0.3333	0	0	0.20	0	0.4
7	0.3333	0	0	0.20	0.3333	0.4
8	0.3333	0	0	0.20	0.6666	0.4
9	0.3333	0	0	0.20	0	0.6
10	0.3333	0	0	0.20	0.6666	0.6
11	0.3333	0	0	0.20	0	0.8
12	0.3333	0	0	0.20	0.3333	0.8
13	0.3333	0	0	0.20	0.6666	0.8

Table -1: IFS Transformation coefficients for the self-affined fractal

The first two iterations of the fractal structure are shown in Fig. 1 and the IFS coefficients are given in Table -1.

When Teflon (PTFE) material is used as substrate .Then, these parameters taken into account for the design of fractal antenna at the resonant frequency $(f_r = 2.6GHz)$, such as thickness of substrate is 4.8 mm and dielectric constant of PTFE, $(\varepsilon_r = 2.1)$ .Calculated dimensions of rectangular patch fractal antenna is 36 mm × 48 mm (without iteration). The IE3D simulation engine by Zeland software has been used to design the antenna.

This geometry can lead to an antenna with multiband characteristics and has been fabricated using a coaxial probe feed. The feed point must be located at that point on the patch, where the input impedance is 50 ohms for the resonant frequency. Hence, a trial and error method is used to locate the feed point.

III. SIMULATION RESULTS AND DISCUSSIONS

Simulation of the proposed antenna is carried out by Zeland Inc.'s IE3D software based on method of Moment (MoM). The simulated return loss of second iterated (K2) fractal antenna is shown in Fig. 2.

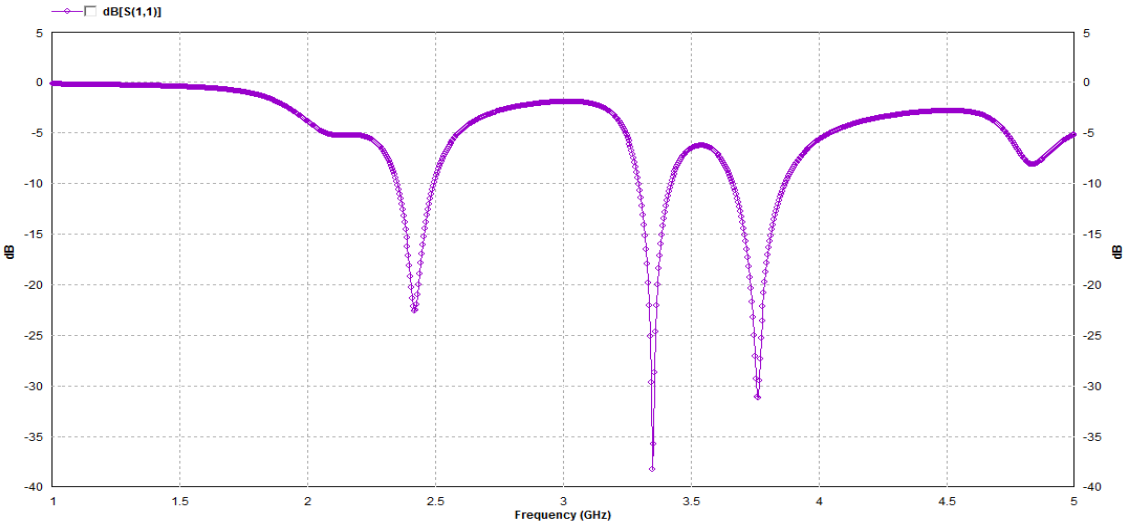
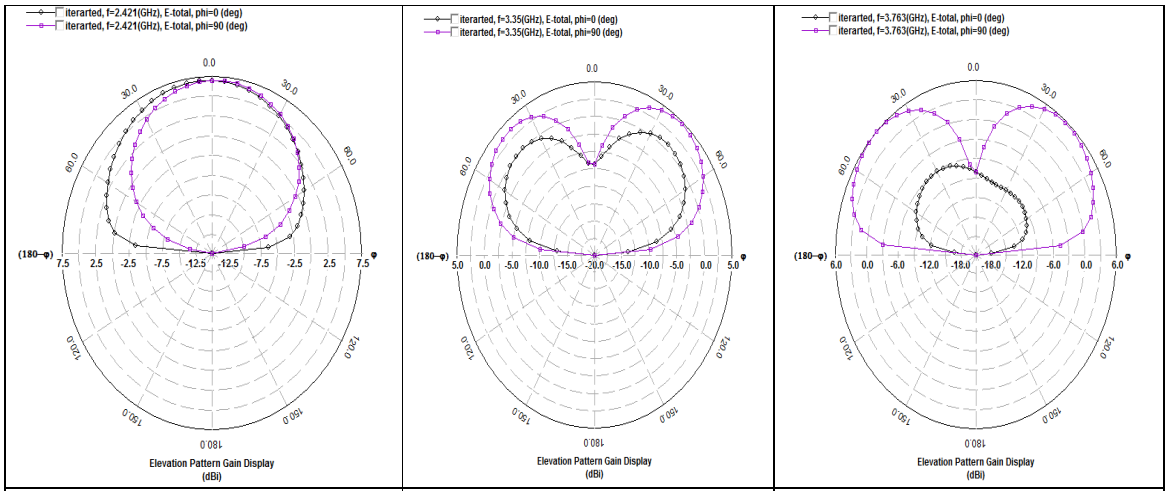


Fig. 2: Simulated Return Loss of second iterated (K2) fractal antenna.

S.No.	Resonant Frequency (GHz)	Return Loss (dB)	Band width (MHz)	VSWR
1	2.421	-22.61	144.52	1.16
2	3.350	-38.27	124.9	1.025
3	3.763	-31.20	204.85	1.057

Table -2: Simulated Results of second iterated (K2) proposed fractal antenna



(a) 2.421 GHz	(b) 3.35 GHz	(c) 3.763 GHz

Fig. 3: Elevation pattern Gains display (dBi) of second iterated (K2) fractal antenna.

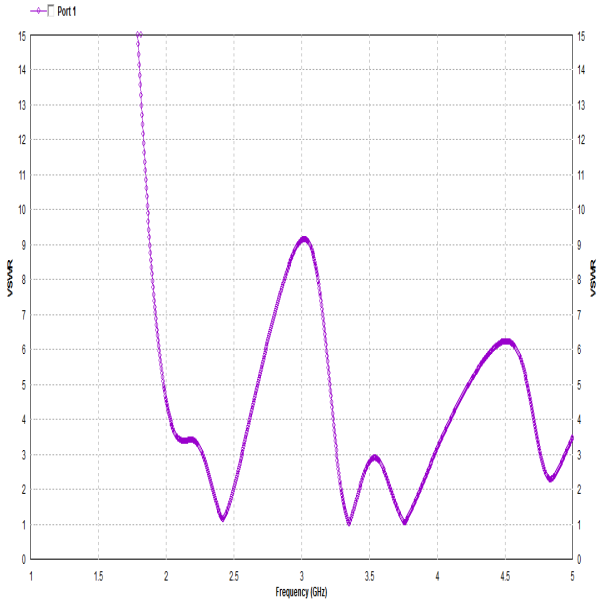


Fig. 4: VSWR v/s Frequency Characteristics of Second iterated (K2) fractal antenna.

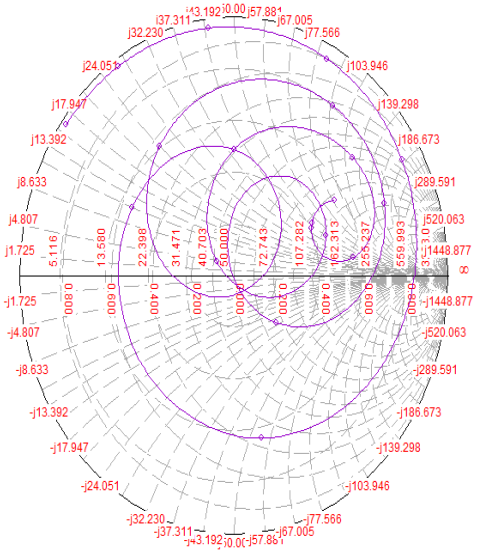


Fig. 5: Smith Chart of Antenna

The proposed antenna resonates at (2.421, 3.35, 3.763) GHz frequencies as shown in Fig.2 with the VSWR of (1.16, 1.025, 1.057) as shown in Fig.4 for respective resonance frequencies.

IV. CONCLUSION

The self-affine fractal antenna is observed to possess multiband behavior similar to the Sierpinski gasket antenna [6]; this paper has presented a new 8-shaped multiband fractal antenna. The antenna has designed for multi-band frequencies (2.421, 3.35 and 3.763) GHz. The proposed antenna show a significant size reduction compared to conventional rectangular microstrip patch antenna. The size of antenna is reduced to 24.88% at second iteration from conventional rectangular microstrip patch antenna.

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