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Design and Analysis of Miniaturized Cohen Minkowski Patch Hybridized Fractal Antenna

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***Abstract*— In this paper, we propose hybrid patch antenna which is a combination of square patch antenna and Cohen Minkowski fractal. The Cohen Minkowski geometry is applied over the patch antenna to improve the performance of antenna. As the iterations are increased the resonant frequency decreases and gives better reflection coefficient and VSWR characteristics which is shown in simulation results. Cohen Minkowski patch antenna fills up the occupied volume with electrical length and results in increased efficiency and compact size. The fractal geometry is applied on the patch as it provides miniaturization and better performance and the antenna is designed and simulated using HyperLynx 3D EM software. This proposed antenna is mainly used for GSM, GPS, WLAN and USB applications.**

***Index Terms*— Miniaturization, Cohen Minkowski, hybridization.**

I. Introduction

The fractal shaped antennas are a new class of antennae which gives the relationship between geometric properties and antenna features [1]. The primary motivation for the use of fractals in antenna engineering is to extend antenna design and synthesis concepts beyond Euclidean geometry [2]. Any geometric shape can constitute the fractal geometry and there are a number of geometric properties that characterize fractals. The multiband operation and miniaturization of antennas can be easily obtained by the unique features of fractals such as self similarity and space filling property [3].

A self similar set is one that consists of scaled down copies of itself and this property of self similarity provides the multiband characteristic to the fractal antennas [4]. The space filling property of fractals, as name suggests fills the area of the antenna as the number of iterations are increased. The higher order fractal antennas exploit the space filling and enable miniaturization of antennas [5] .

This paper shows the designing of Cohen Minkowski patch antenna which is formed by the hybridization of patch and Cohen Minkowski antenna. Hybridization is a process in which two different antenna geometries are merged to give a new geometry with better results. Here, Cohen Minkowski and square patch are hybridized to give Cohen Minkowski patch antenna. In this paper, design of proposed antenna is discussed along with its simulation results.

II. Cohen Minkowski Fractal

The two iterations of Cohen Minkowski fractal can reduce the total size of an antenna almost by three times. Its similarity dimension (D) is 1.46 evaluated from the formula:

$$D = \frac{\log N}{\log \frac{1}{\delta}}$$

Where N = number of similar segments
δ = scaling factor

A. IFS of Cohen Minkowski Fractal

This geometry consists of repetitive procedure of the application of IFS transformations. The first iteration of the Cohen-Minkowski geometry is presented in figure 1. The parameter h defines the height of the third section of the structure. Height of the section can vary according to the application. We have used h = 0.67 cm.

In this iteration, first we scale a line to 1/3 of its original length using the affine transform W1. The transform W2 scales a line to 1/h along with the rotation of 90° and moves it to 1/3 in x axis. The transform W3 scales by 1/3 and also gives a translation of 1/3 in x and y axis directions. The transform W4 scales a line to 1/h and again rotates it to 90° and provides translation of 2/3 to x axis and 1/3 to y axis. The transform W5 sales by 1/3 of its original length and provide translation of 2/3 to x axis.

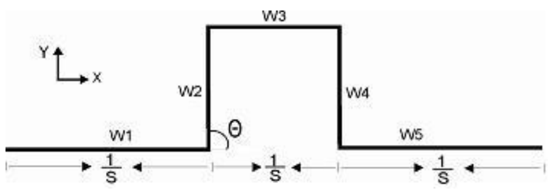

Fig. 1.First iteration of Cohen Minkowski [3]

$$W_1(x) = \begin{bmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{h} \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$W_2(x) = \begin{bmatrix} 0 & -\frac{1}{h} \\ \frac{1}{3} & 0 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} \frac{1}{3} \\ 0 \end{bmatrix}$$

$$W_3(x) = \begin{bmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{h} \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} \frac{1}{3} \\ \frac{1}{3} \end{bmatrix}$$

$$W_4(x) = \begin{bmatrix} 0 & \frac{1}{h} \\ -\frac{1}{3} & 0 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} \frac{2}{3} \\ \frac{1}{3} \end{bmatrix}$$

$$W_5(x) = \begin{bmatrix} \frac{1}{3} & 0 \\ 0 & \frac{1}{h} \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} \frac{2}{3} \\ 0 \end{bmatrix}$$

$$W(A)=W_1(A) \cup W_2(A) \cup W_3(A) \cup W_4(A) \cup W_5(A) \quad \text{--- (1)}$$

Similarly, the patch antennas are small in size, light weight and good radiations. So here, the hybrid of Cohen Minkowski fractal and patch is represented which provides the properties of both.

III. Antenna Design

The proposed antenna is designed using FR-4 epoxy glass as substrate having thickness (Z-top) h = 1.6 mm, dielectric constant (ε_r) = 4:4 and loss tangent (tan δ) = 0:02.
The base shape is a square patch of dimension 3 cm. The coaxial feed is provided along the diagonal at a distance of 0.42 cm from the centre [6].

In the first iteration the Cohen Minkowski geometry is applied on all sides of the patch with a scale factor of 1/3 and the other dimensions are shown in figure 2.

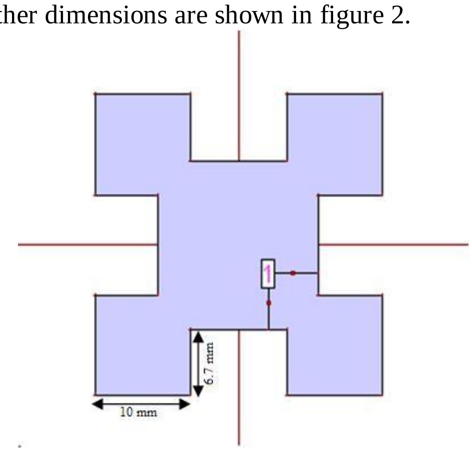

Fig.2. Prototype antenna in iteration 1

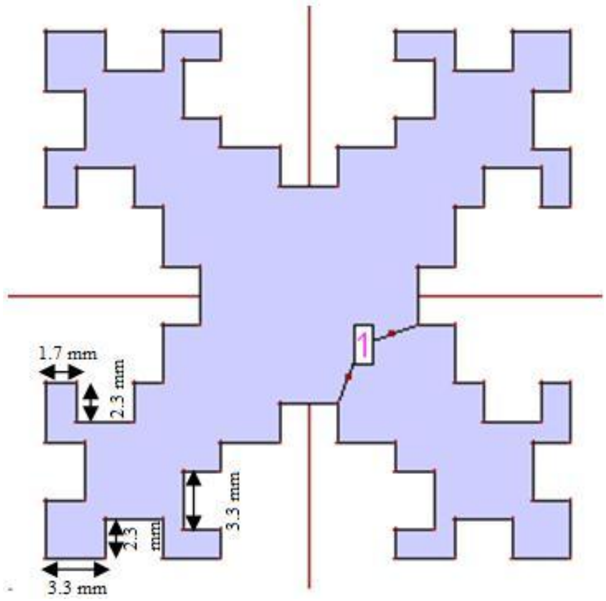

Fig. 3. Prototype antenna in iteration 2

IV. Simulation And Results

The proposed antenna is designed and simulated using HyperLynx 3D EM software. The simulated reflection coefficient characteristics of the different iterations are given in figure 4 and figure 5 show that the resonant frequency decreases as the number of iterations is increased. Moreover in the first iteration the value of reflection coefficient is -8.5 at 8.5 GHz which improves to 13.4 in the next iteration and at lower resonant frequency of 5.5 GHz. The VSWR also improves on increasing the iterations.

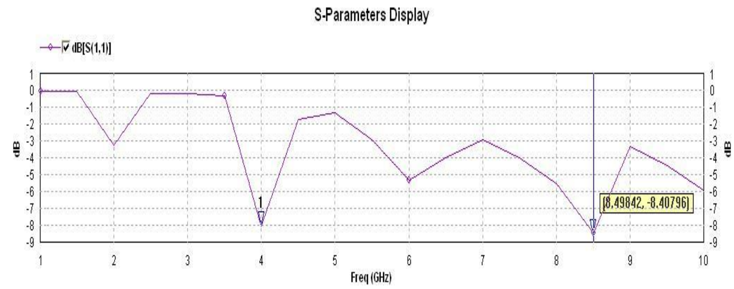

Fig.4. For first iteration S_{11}=-8.4 at 8.49 GHz

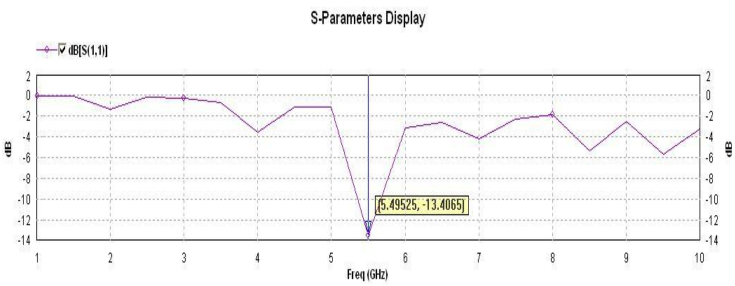

Fig.5.For second iteration S_{11}= -13.4 at 5.49 GHz

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TABLE I
RETURN LOSS AND VSWR OF COHEN MINKOWSKI PATCH FRACTAL ANTENNA

Cohen Minkowski Patch Fractal Iterations	Resonant Frequency (GHz)	Reflection Coefficients (dB)	VSWR (dB)
Iteration 1	4	-8	1.28
	8.49	-8.4	1.27
Iteration 2	5.49	13.4	1.16

A. Radiation Pattern of Cohen Minkowski Patch Fractal Antenna

Radiation patterns for antenna prototype in iteration 1 are shown in figures 6 and 7 and for iteration 2 in figure 8 and 9. There is minimal change observed in the radiation pattern.

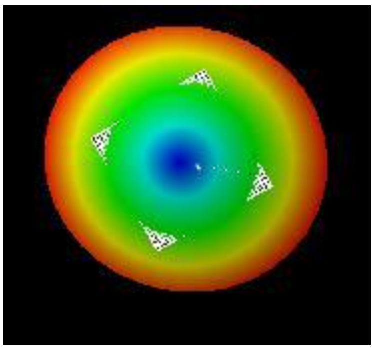

Fig. 6. Top view of prototype antenna in iteration 1

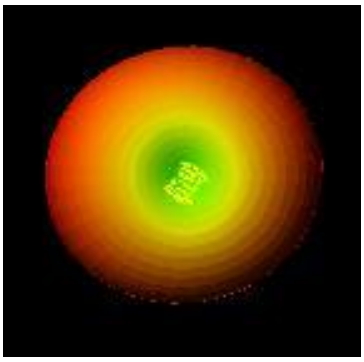

Fig. 7.Rear view of prototype antenna in iteration 1

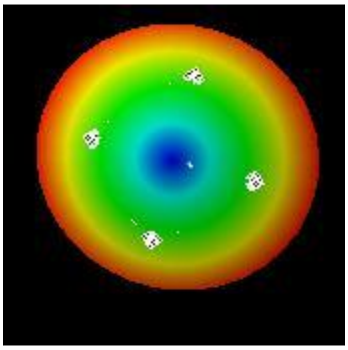

Fig. 8. Top view of prototype antenna in iteration 2

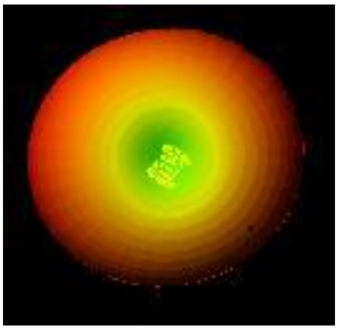

Fig. 9. Rear view of prototype antenna in iteration 2

V. Conclusion

The fractals are extensively used in antenna engineering which make the communication easier as the fractal properties are very helpful. We propose hybridization of patch and Cohen Minkowski fractal geometry for the design of Cohen Minkowski patch antenna to achieve optimum degree of antenna miniaturization. Here mainly the miniaturization and self similar properties of fractals are used to improve the performance of antenna. With the help of miniaturization property it can be used for wireless application, USB application. It is helpful in GSM, GPS and WLAN applications as on increasing the iterations the resonant frequency decreases.

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