Miniaturized and Dual Band Hybrid Koch Dipole Fractal Antenna Design

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***Abstract*—There are many techniques to improve the characteristic of antennas. In this work the performance and analysis of a small size , low profile and dual band hybrid Koch curve dipole antenna is introduced. The proposed antenna design , analysis and characterization has been performed using the Method of moments (MoM) technique. The radiation characteristics, reflection coefficient, VSWR and Input Impedance of the proposed antenna were described and simulated using 4NEC2 software package and MATLAB R2008a . Also the gain of the proposed antenna is calculated and described in the three planes: XY-plane, XZ-plane, and YZ-plane, where the antenna is placed in the XY-plane. Moreover, in order to quantify the advantages provided by the hybrid nature ,the proposed study performs a comparison of the proposed antenna with the quadratic Koch dipole fractal antenna and triangular Koch dipole fractal antenna.**

***Index Terms*— Fractal antenna, Koch curve, Multi-band antenna, Wire antenna .**

I. INTRODUCTION

As part of an effort to further improve modern communication system, researchers are now creating new and innovative antennas. In the possibility of developing new types of antenna that employ fractal rather than Euclidian geometry. The term fractal was coined by the French mathematician B.B. Mandelbrot during 1970s after his pioneering research on several naturally occurring irregular and fragmented geometries not contained within the realms of conventional Euclidean geometry [1]. Fractal geometry accurately characterize many non-Euclidean features of the natural including the length of coastline, branching of trees and density of clouds and find their application in many engineering field. Fractal shaped antenna is becoming a useful way to design advanced antenna such as multiband antenna with approximately the same input or radiation characteristics for different frequency band. Self-similarity of this fractal geometries has since been qualitatively associated with multiband behavior of antenna using them. In addition to the simplicity and self-similarity ,fractal curves have the property of approximately filling a plane [2]. Koch fractal antennas are among the first antennas based on a fractal geometry designed as small sized antenna. The Koch monopole and dipole had been demonstrated in [3]. This paper presents the design and simulation of hybrid Koch fractal antenna and draw a comparison of performance parameter between this with square Koch fractal and triangular Koch fractal antenna based on the first iteration Koch curve geometry. The proposed antenna has been called hybrid because it has a square Koch geometry on the upper half and triangular Koch geometry on the lower half.

II. PROPOSED ANTENNA GEOMETRY

A. Generation of Koch curve

The geometric construction of basic quadratic Koch curve I shown in Fig.1. It is also known as Mikowski sausage [4]. The starting element, corresponding to the iteration 0 is a line segment ,called initiator, and the geometrical object obtained at the first iteration is called

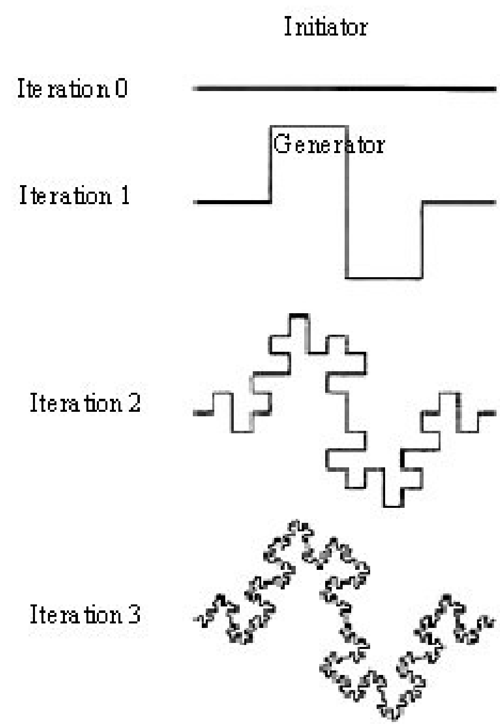


Figure 1 : First three iteration of square Koch curve

Initiator generator

iteration=0 iteration=1 iteration=2 iteration=3

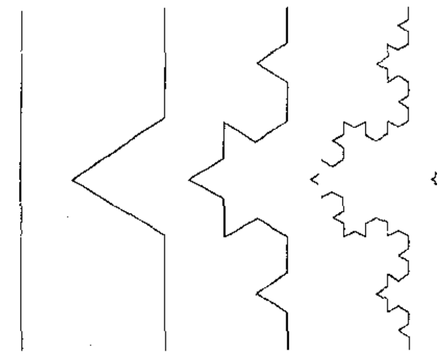


Figure 2 First three iteration of triangular Koch curve

generator. This curve is by repeatedly replacing each line segment , composed of four quarters, with the generator consisting of eight pieces, each one quarter long. Each smaller segment of the curve is an exact replica of the whole curve.

Fig.2 shows the first three iteration of triangular Koch curve. It starts with a straight line, called initiator. This is divided into three equal parts, and the segment at the middle is replaced with two others of the same length. This is called generator. The same process is recursively used to get the next higher iterated curve [5].

B. Fractal Dimension

Fractal dimension can be defined in many ways, however the most easily understood is for self similarity dimension [6]. The similarity dimension is defined as follows:

$$D = \frac{\log(}{\log(}$$

Where N is no. of self similar pieces in the geometry and R is scaling factor. For Fig.1

$$D = \frac{\log(}{\log(} = 1.5$$

For Fig.2

$$D = \frac{\log(}{\log(} = 1.26$$

The antenna designed in this paper is hybrid in nature means upper half of the dipole is rectangular Koch and lower half is triangular Koch. So the antenna have different dimension in two half.

Fig. 3 shows the first iteration of hybrid Koch curve antenna. The antenna design and simulation is performed using the 4NEC2 package.

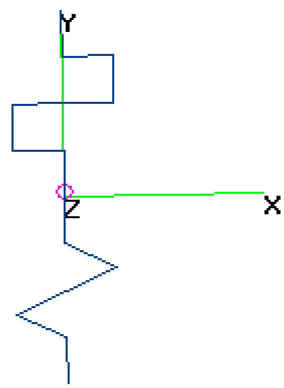


Figure 3 Hybrid Koch curve dipole antenna

III MATHEMATICAL MODELLING

The antenna is numerically simulated via method of moment (MoM) [7]. The fundamental concept behind the MoM employs orthogonal expansion and linear algebra to reduce the integral equation problem to a system of simultaneous linear equation. Numerical modeling is performed here using 4NEC2. The modeling process is done by dividing all wires into short segments where the current in one segment is considered constant along the length of the short segment. The length of each segment is made as short as possible without violation of maximum segment length to radius ration computational restrictions.

IV ANTENNA DESIGN

The hybrid antenna shown in Fig.3 is designed in 4NEC2 software [8]. The antenna is modeled without any dielectric present though practical implementation require dielectric support.

The antenna is along XY axis. Along positive Y axis the antenna has rectangular geometry and that along negative Y axis has triangular geometry. The feed source point of this antenna is placed at origin (0,0,0) and this source set at 1 volt. The designed frequency has been chosen to be 750 MHz . the corresponding wavelength λ is 0.4 m (40 cm). The length of the half wave dipole is 20 cm. The conductor diameter has been chosen to be 1 mm.

V. RESULTS

The real and imaginary parts of the input impedance of the proposed antenna are shown in Fig. 4 over a frequency range from 0GHz-4GHz. At two frequency band the reactance value of Input Impedance is almost zero.

The VSWR of the proposed antenna is shown in Fig.5. From the VSWR and Input Impedance plot of the proposed antenna it is found that the proposed antenna has a dual band behavior at the resonant frequencies 944 MHz and 2689 MHz and these frequencies VSWR< 2.

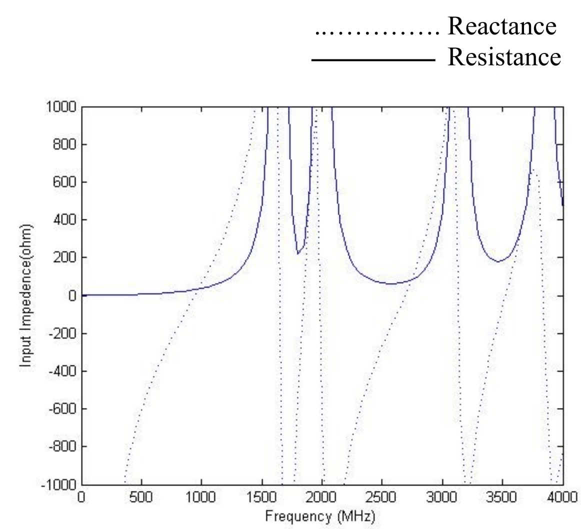


Figure 4 Input impedance characteristics of Hybrid Koch fractal antenna.

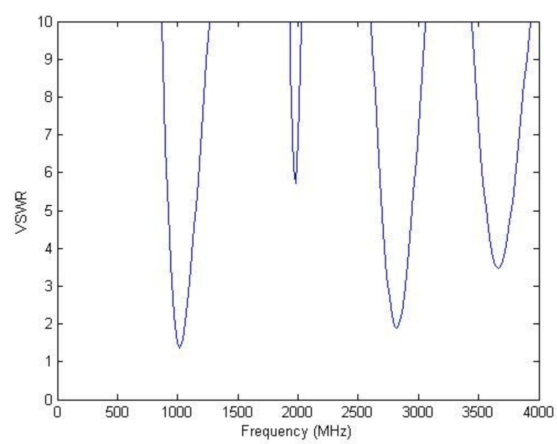


Figure 5 VSWR characteristics of Hybrid Koch fractal antenna

TABLE I
RESONANT FREQUENCY AND OTHER PARAMETERS OF PROPOSED ANTENNA

Frequency (MHz)	Input Impedance (Ω)		VSWR	Reflection coefficient (dB)
	R	X		
944	31.53	0.016	1.585	-12.899
2689	72.79	-0.090	1.455	-14.626

Table I shows the resonant frequencies and corresponding input impedance, VSWR and reflection coefficients.

Table II shows the gain of the proposed antenna at resonant frequencies in the three planes.

It has found that as the iteration of fractal curve is increased the number of times Imaginary part of impedance becomes zero increases.So, as iteration is

increased, more and more resonance frequency will make the antenna multi-band in nature.

In Fig. 6 and Fig.7 radiation patterns of the proposed antenna is shown in three principle planes at resonant frequencies.

TABLE II
GAIN OF PROPOSED ANTENNA AT THE RESONANT FREQUENCIES IN THE THREE PLANES

Frequency (MHz)	Gain(dB)		
	XY-plane	XZ-plane	YZ-plane
944	1.72	1.83	1.83
2689	4.33	1.26	1.32

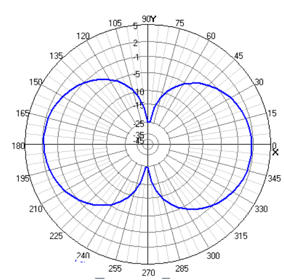
VI. A COMPARATIVE STUDY

Here the proposed antenna is half wave hybrid type. Same half wave dipole antenna of same length (20 cm) can be designed by rectangular Koch curve and Triangular Koch curve. Table III shows the value of the performance parameters of different type of dipoles.

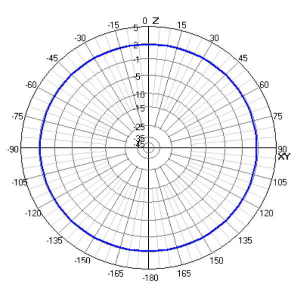
TABLE III
DIFFERENT PARAMETERS VALUE OF FRACTAL ANTENNA AT RESONANT FREQUENCY

Rectangular Koch dipole			
Resonant frequency (MHz)	VSWR	Reflection Coefficient(dB)	Maximum gain(dB)
420 1200	1.54 2.80	-13.37 -13.37	1.27 1.27
Triangular Koch dipole			
Resonant frequency (MHz)	VSWR	Reflection Coefficient(dB	Maximum gain(dB)
1100 3180	1.189 1.35 1	-21.2 -16.52	2.05 0.87

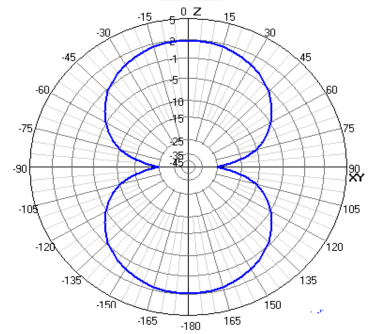
From Table III we can easily understand for rectangular Koch gain is very low and for triangular Koch reflection coefficient is high. These problems can be avoided by using hybrid Koch curve. Fig. 8 shows the VSWR plot of different Koch fractal antenna with frequency.



XY-plane

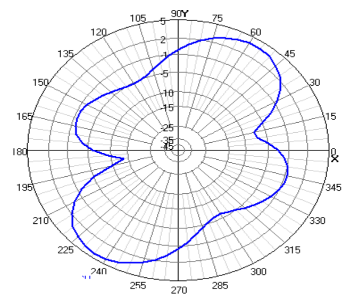


XZ-plane

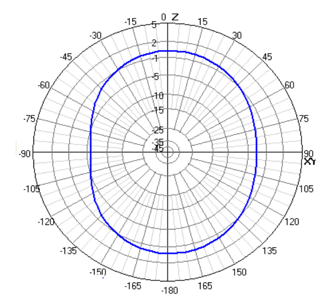


YZ-plane

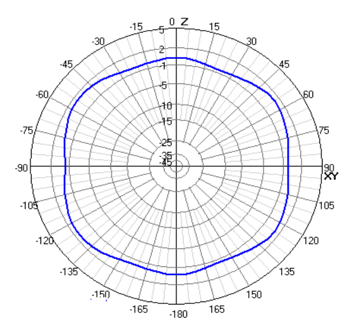
Figure 6 Radiation pattern of the proposed antenna at resonant frequency of 944 MHz .



XY-plane



XZ-plane



YZ-plane

Figure 7 Radiation pattern of the proposed antenna at resonant frequency of 2689 MHz .

………………. Hybrid Koch curve

__________Rectangular Koch curve

_._._._._._._.Triangular Koch curve

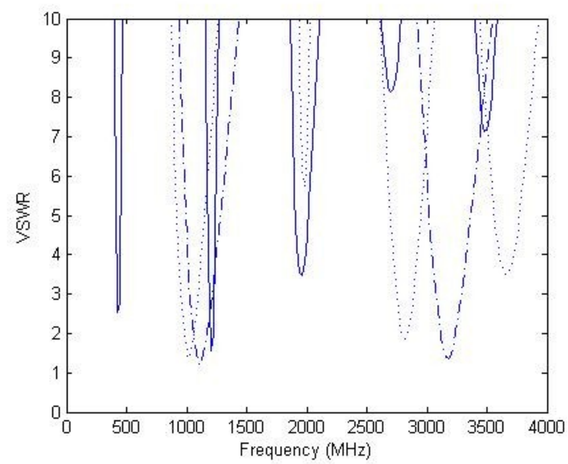


Figure 8 VSWR plot of different Koch fractal antenna

VII CONCLUSION

In this research , the hybrid Koch curve dipole antenna based on the first iteration has been investigated and its performance has been evaluated. The simulation result shows that the proposed antenna can used as a dual band antenna. To get the same resonance frequency in non-fractal antenna , the size will be much more than fractal antenna. So, fractal antenna will be much compatible insize. The proposed antenna has two resonating bands at frequencies of 944MHz and 2689 MHz . At these frequencies this antenna have VSWR < 2 . To achieve desired resonant frequency band , we may optimize the length and geometry of the proposed antenna. This proposed antenna can be used as a multiband antenna in the UHF application.

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