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ANTENNA MINIATURIZATION USING FRACTAL ANTENNA AND ITS DESIGN

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Abstract:

Fractal, which means broken or irregular fragments. Fractal antennas can obtain radiation pattern and input impedance similar to a longer antenna, but take less area due to the many contours of the shape Fractus is a global developer and supplier of low profile multi-band mobile phone antennas for current and next generation mobile handsets. it uses a self similar design to maximize the length, or increase the perimeter of material that can transmit or receive EM radiation with a given total surface area or volume.

Keywords: Koch fractal antenna, Sierpinski

Introduction

Today world of wireless communications, there has been an increasing need for more compact and portable communications systems A fractal element antenna, or FEA, is one that has been shaped in a fractal fashion, either through bending or shaping a volume, or introducing holes. They are based on fractal shapes such as the Sierpinski triangle. Mandelbrot tree, Koch curve, and Koch island. Size can be shrunk from two to four times with surprising good performance. In order for an antenna to work equally well at all frequencies, it must satisfy two criteria: it must be symmetrical about a point, and it must be self-similar, having the same basic appearance at every scale: that is, it has to be fractal. In many cases, the use of fractal element antennas can simplify circuit design, reduce construction costs and improve reliability. Because FEAs are self-loading, no antenna tuning coils or capacitors are necessary. Often they do not require any matching components to achieve multiband or broadband performance**.** The fractal antenna not only has a large effective length, but the contours of its shape can generate a capacitance or inductance that can help to match the antenna to the circuit. Fractal antennas can take on various shapes and forms

FRACTAL DIPOLE ANTENNAS- KOCH FRACTAL

Figure 1a shows the first three iterations in the construction of the square Koch curve [1]. This curve is simply constructed using iterative procedure beginning with the initiator of the set as the unit line segment (iteration 0). The unit line segment is divided into three segments, and the middle segment is removed. The middle segment is then replaced with three equal segments, which are of the same length as the first segment, which form a square (iteration 1). This step is the generator of the curve. At the next step (iteration 2), the middle segment is removed from each of the five segments and each is replaced with three equal segments as before.

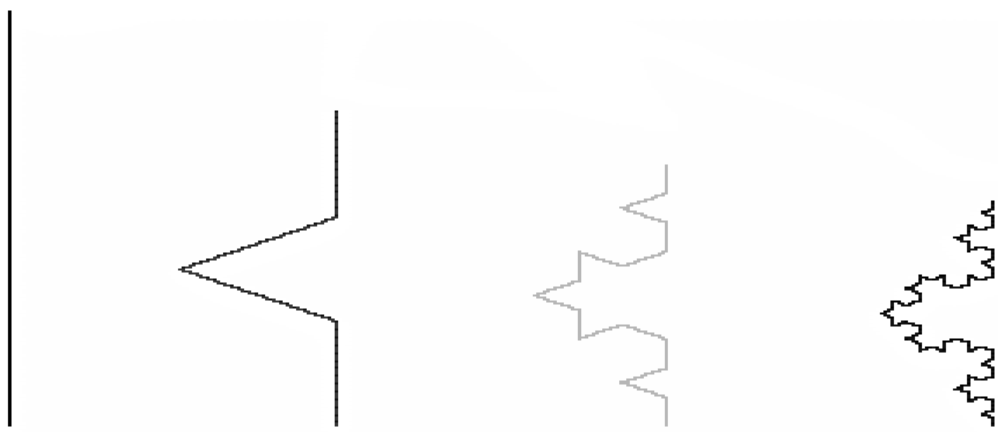

Fig. 1a- Geometry of Koch dipole

This process is repeated an infinite number of times to produce square Koch curve. Different from Euclidean geometries, fractal geometries are characterized
by their non-integer dimensions. Fractal dimension contains information about the self-similarity and the space-filling properties of any fractal structures [2].

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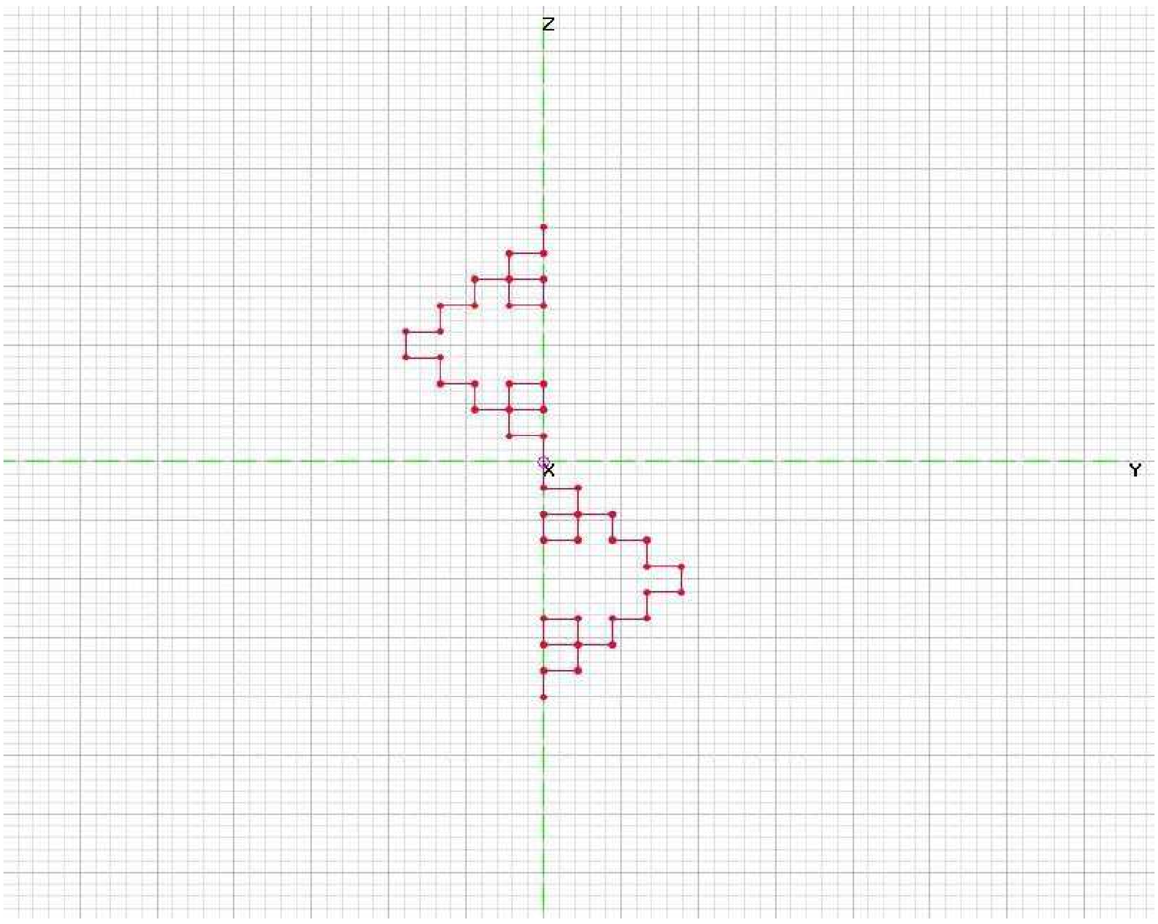

Figure 2a: Square Koch Curve Dipole Antenna

The Sierpinski gasket

There is another property of fractals that can be utilized in antenna construction. This can lead to multiband characteristic IN antennas, which is displayed when an antenna operates with a similar performance at various frequencies

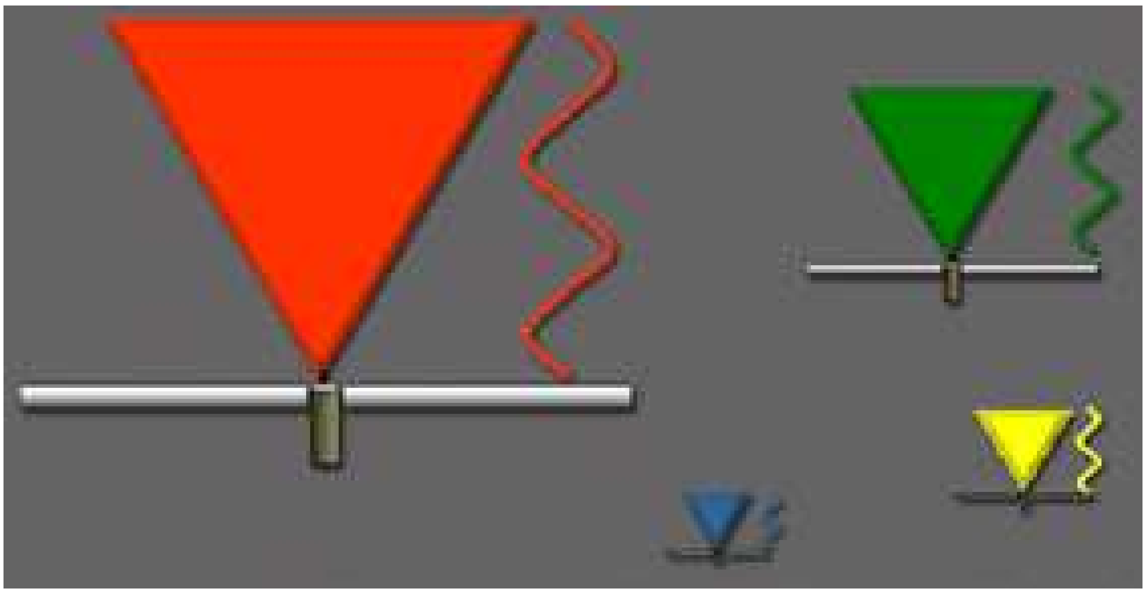

Figure 1 Four separate antennas

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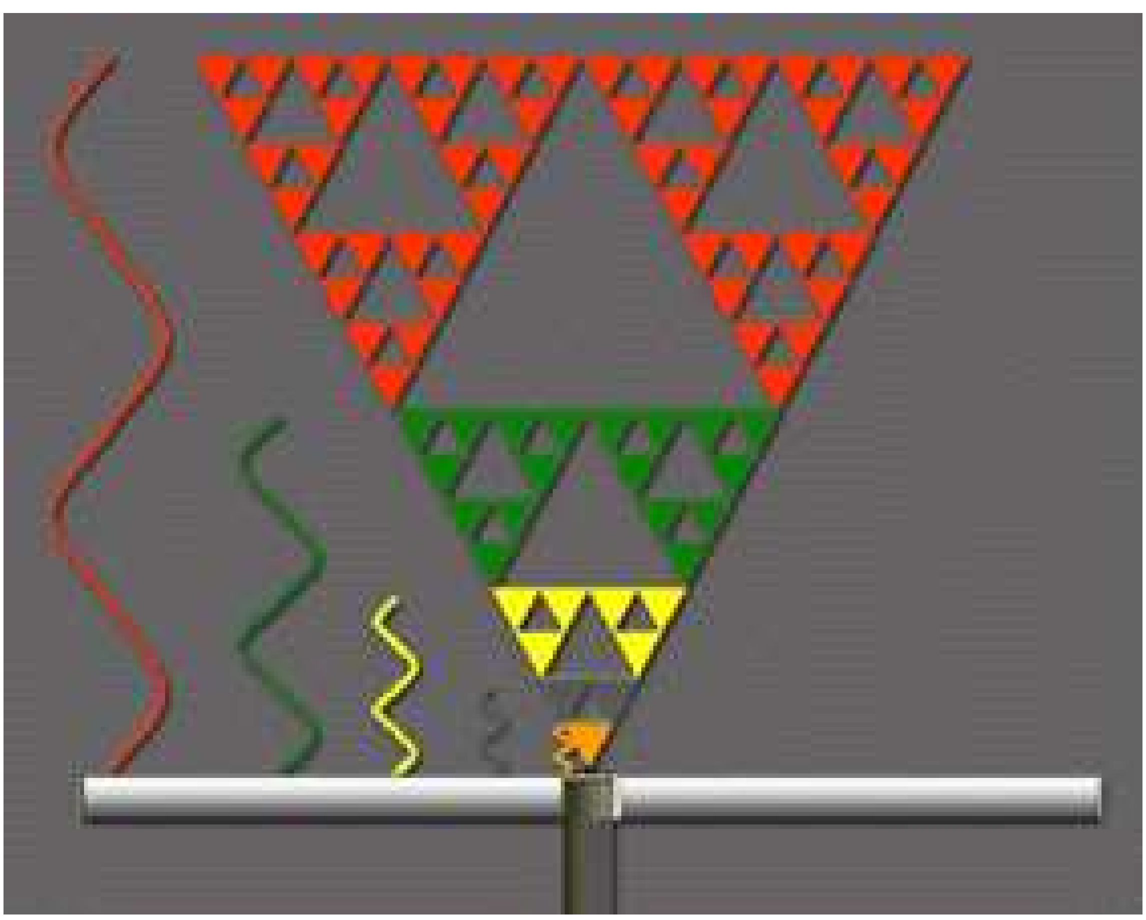

Figure 2 One antenna for four bands.

Fractals are space filling geometries:

Euclidean geometries are limited to points, lines, sheets & volumes, Fractal include geometries that fall in between these distinctions .Therefore, a fractal can be line that approaches a sheet. These space filling properties lead to curve that are electrically very long [5] , but fit into a compact physical space. This property leads to miniaturization of antenna elements. Fractals could be used to define the spacing in arrays for thinning or to define radiation pattern [6].

With successive iteration the length of koch increases by 1/3 of the original length.

Length of koch after nth iterations :

ln□*lo* (4 / 3)

where *ln* and *lo* are the length after nth iteration and original length.

Sierpenski Triangle with each iteration the area of the holes and circumference of solid pieces changes. If the area of original triangle is 1 , then first iteration removes ¼ of the area., second iteration removes a further 3/16 and third iteration 9/64.

ADVANTAGES

- Minituratization
- Better input impedence matching
- Frequancy independent
- Multiband/wideband

Antenna Design Specifications

The antenna designed for this project should have the following specifications:

(a) Planar antenna

Antenna is built on a flat surface double layer PCB (copper layered).

(b) Operating at the lower frequency of the UHF band (470-890MHz)

The frequency band 470-890 MHz is chosen because it is the band that is used for terrestrial UHF TV channels and for new applications like a Digital TV Broadcasting.

(c) Dipole antenna

Dipole is chosen because it has the omnidirectional radiation pattern so it cans receive TV signals no matter which side the antenna is facing.

(d) Koch curve fractal geometry

The Koch curve fractal structure is chosen because of it's miniaturization characteristic.

(e) Uses FR4 substrate.

The PCB that is used is the FR4 (Fire Retardant – 4) type board. The reasons for choosing this type of board are because of the low cost and ease of fabrication. The

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FR-4 board has a relative dielectric constant of = 4.7 *r* ε with tangent loss of 0.019; it has a 1.6 mm substrate thickness and a 0.035 mm copper thickness.

(f) Antenna is used to receive signals.

Antenna is receive only because terrestrial TV is broadcast one way communication which does not need any reply or acknowledgments signals from the receiver side.

Proposed Antenna Design

The dipole antenna, based on the second iteration square Koch antenna, has been modeled, analyzed,

and its performance evaluated using the commercially available software 4NEC2. The Method of Moment (MoM) is used to calculate the current distribution along the square Koch curve, and hence the radiation characteristics of the antenna [3]. Typical geometry of square dipole antenna is based on the second iteration as shown in Figure 2a, where the antenna is placed in the YZ-plane.

The feed source point of this antenna is placed at the origin (0, 0, 0), and this source is set to 1 volt. The design frequency has been chosen to be 750 MHz for which the design wavelength λ is 0.4m (40 cm) then the length of the corresponding λ/2 dipole antenna length will be 20 cm, as shown in Figure 2a.

Figure c shows the visualization of this dipole antenna geometry by using NEC-viewer software.

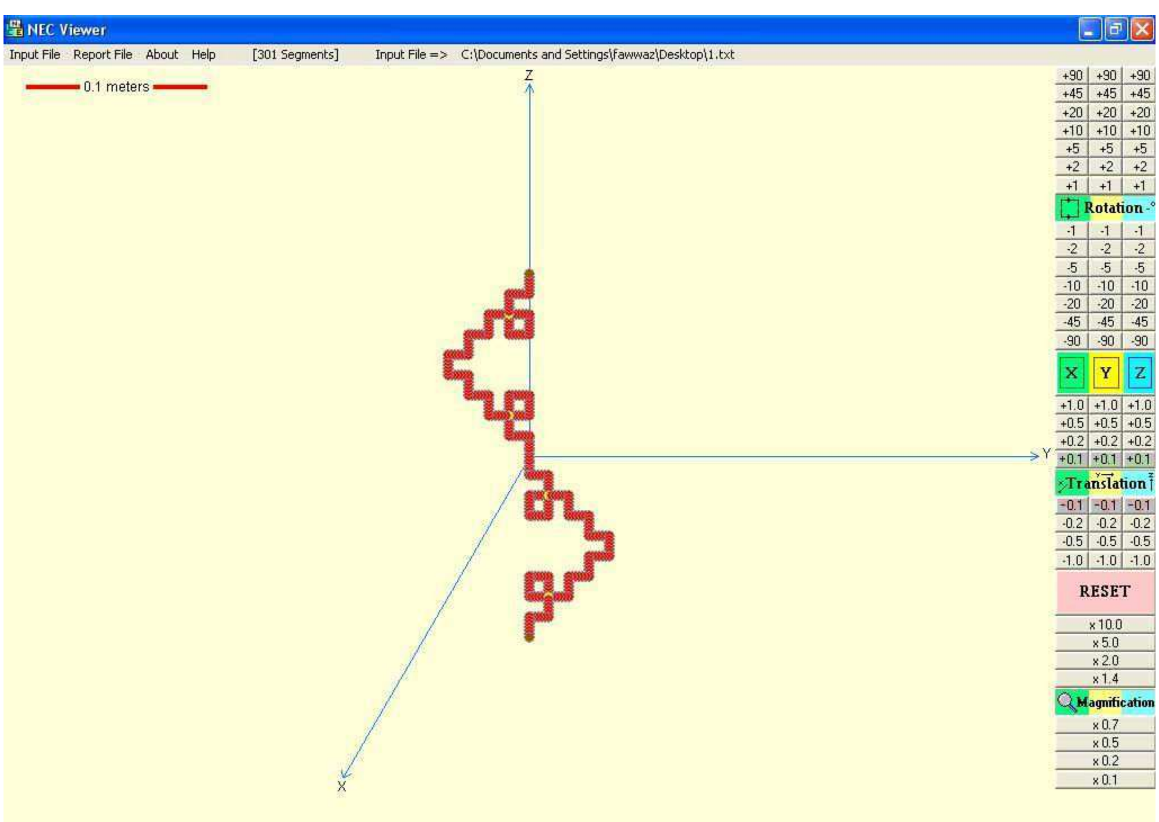

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Figure c: Visualization of the Modeled Dipole Antenna Geometry

Design of the antenna using antenna design software

There are various software in the market that can be used to design the antenna or RF component for example Computer Simulation Technology, Advance Design System ADS, HFSS, Applied Wave Research AWR and many more. In this design, three software have been used to design the antenna. The design of the antenna is divided into 2 steps.

The first one is designing the antenna structure using circuit in the schematic feature of the AWR Microwave Office. This step is taken only for the Koch curve structure.

Figure 1 shows the circuit of the 1st order Koch which is made of segments of copper combined together.

Figure 1 Circuit schematic of the first order Koch

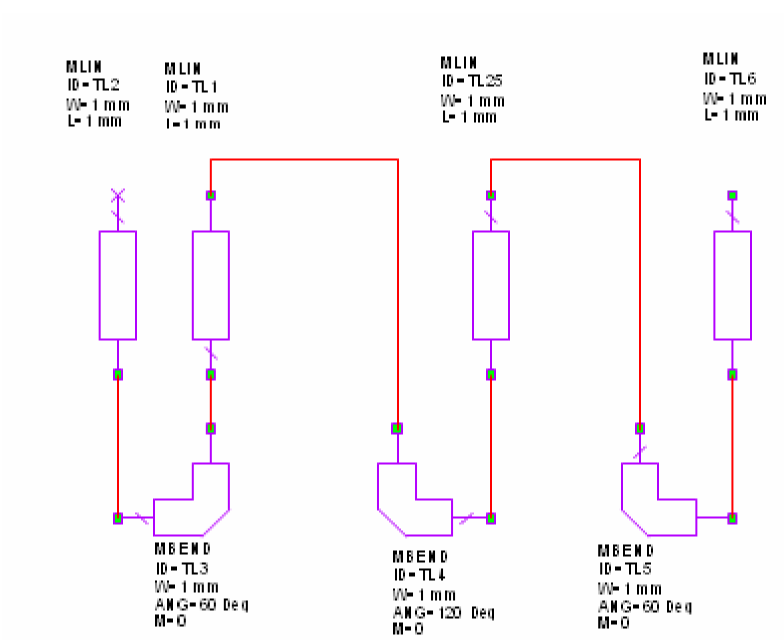

Figure 2 shows the circuit of the 2nd order Koch which is made out of the 1st order Koch circuits combined.

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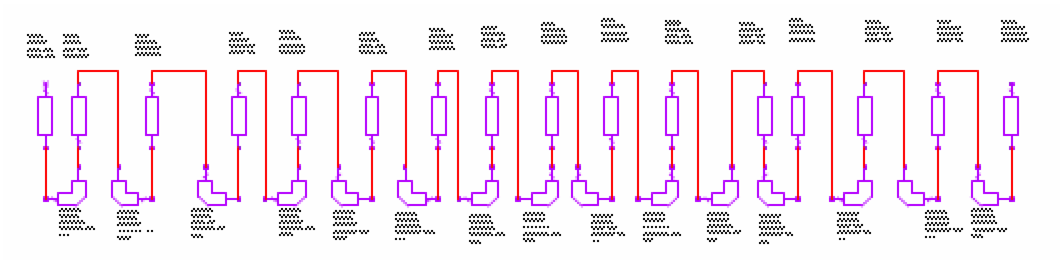
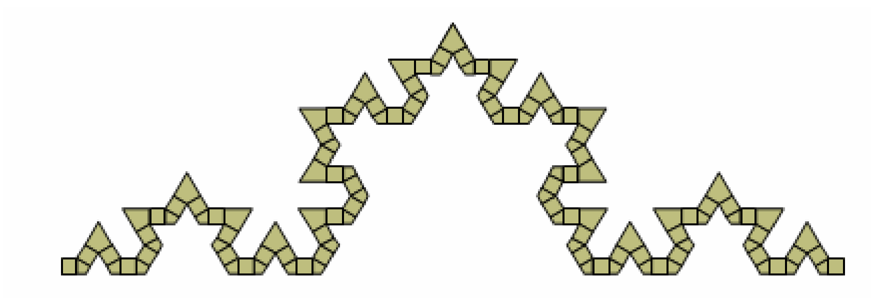


Figure .3 : The layout of the 3rd order Koch



Future and options

Although a young extension in antenna engineering, fractals have already made great strides in expanding design space for applications.The path is there as long as the limiting physics are understood and appreciated. The design space for fractal antennas affords vast new opportunities in design and application, many realized and proven beyond theory.

The folded dipole configuration can be used to increase bandwidth of a standard dipole.

The Koch fractal can be used to miniaturize the length of a standard straight line dipole.

The Koch fractal can be used to miniaturize the length of a standard straight line dipole.

The fractal Koch dipole array can used to reduce the length of the straight dipole and also to increase the bandwidth.

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