Review Paper on Fractal Antenna

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Abstract— Fractal microstrip antenna consists an irregular pattren on patch that can meet the requirements of designing a multiband, wideband, low profile and small antenna. In this paper, the field of fractal antenna is theoretically as well as structurally reviewed. Fractal antenna design is a geometric pattern that is repeated at every scale and hence cannot be represented by classic geometry. Fractal has unique property that it can make copies of itself at different scales .Recent studies shows that the fractal antennas show is used for low profile antenna and have their own specific characteristic that improve certain properties.

Key words: Fractal Antenna, Multiband Antenna

I. Introduction

The increasingly demand for the next generation Multiband wireless network applications motivates the antenna designers to study and fabricates new antennas that simultaneously appear miniaturized and at the same time useful for many multiband and wireless standards [1]. The important requirements for such kind of antenna are that the antenna should work for many applications simultaneously and must have small size [3-4]. For performing multi-application operations at a single time, multiband characteristic is required. These multiband characteristics can be achieved by using the concept of fractal antenna. Fractals describe a family of complex shapes in which geometrical structure possess an inherent self-similarity. Fractal has various properties like, infinite, self- symmetry, space filling and recursive, .Due to these properties fractals have more resonant frequency which contributes to lower return loss [5].

II. Fractal Theory

A *fractal* is a never-ending pattern. *Fractals* are infinitely complex patterns that are self-similar across different scales[8]. The term was derived by Benoit Mandelbrot[2], a French mathematician about 20 years ago in his book "The fractal geometry of Nature" .Names like G. Cantor (1872), G. Peano (1890), D. Hilbert (1891), Helge von Koch (1904), W. Sierpinski (1916) Gaston Julia (1918) and other personalities played an important role in Mandelbrot's concepts of a new geometry. Fractals are defined as shapes which have no characteristic size .Fractal geometry single elementary shape fractal multiple iteration that can continue infinitely, and formed a shape within a finite length finite boundary. That compactness property is desirable in multiband wireless communication applications.

Fractals antenna defined as natural and mathematical fractals.

A. Natural Antennas

This type of fractals antenna are available or found in nature all around us and also called as random fractals. These type of geometries having structures that defines to be difficult with the Euclidean geometries and these geometries are infinitely divisible and each division is being copy of the parent geometry. The most popularly examples of random fractal antennas are rivers, galaxies, length of the coastline, rivers, trees branches etc.

B. Mathematical Antennas

The mathematical antennas defined by the process which is based on equations following iterations. And also known as deterministic fractals which are visual. Generator is defined as the two dimensional fractals which are made of a broken line. For a step of algorithm, each segment that form the broken line is being replaced by generator i.e made of a broken line. And repeating these steps infinitely which results in geometrical fractals. The deterministic antennas examples are Mandelbrot sets, sierpinski carpet, Koch, sierpinski gasket, Mandelbrot sets etc. The number of iterations is based on iterated function systems [2].

III. Fractal Geometries

The fractal term was defined by the French mathematician B.B. Mandelbrot during 1970's after his research on different naturally irregular and fragmented geometries. The fractals term is derived from latin word fractus which is related to the fang ere (meaning: to break). These types of irregular geometries are discarded as formless, but in the meanwhile Mandelbrot suggested that there are certain special features that can be associated with these irregular geometries. But the research of Mandelbrot's is path-breaking: He discovered and formulated the theories of a common element of many of these irregular fractal geometries. In the meanwhile there are numbers of different fractal geometries that have been found from different scientists to be useful in developing innovative and new designs for antennas. Fractals have been used to model such complex natural objects such as galaxies, mountain ranges, snowflakes, trees, ferns, cloud boundaries, coastlines and much more[6].

A. Sierpinski Gasket

The very first fractal geometry that will be considered is the popular sierpinski gasket is shown in Fig.1 It is a deterministic fractal. For geometrical construction, the procedure begins with an equilateral triangle that contained in the plane as illustrated in stage 0 of Fig.1. The construction process next step (see stage1 of Fig 1.) is to remove the vertices of central triangle which are located at the midpoints of the sides of the original triangle, shown in stage 0. The process is then repeated for the three remaining triangles, as in stage 2 of Fig 1. The next two stages (stages 3 and 2) to constructing the sierpinski gasket are also shown in Fig 1 the gasket fractal is generated by carrying out this iterative process an infinite number of times. From this definition that the sierpinski gasket is an example of a self-similar fractal. Fig 1 Black triangular areas represent a metallic conductor, whereas the white triangular areas represented the regions where metal is removed. Another popular fractal is known as the Koch snowflake. This fractal also starts out as a solid equilateral triangle in the plane, as illustrated in stage 0 of Fig 2

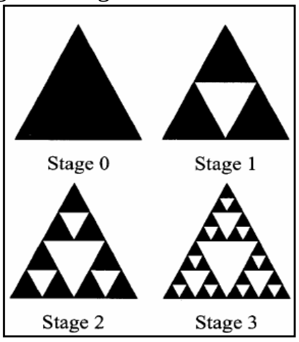

Fig. 1: Several Stages in the Construction of a Sierpinski Gasket Fractal

B. Koch Snowflakes

The second most popular of fractal geometry is known as the Koch snowflake. This fractal geometry also starts out as a solid equilateral triangle in the plane, as illustrated in stage 0 of Fig 2 the difference between the sierpinski gasket and Koch snowflake is that the former is formed the from original structure by systematically removing the smaller and smaller triangles whereas later is being constructed by adding smaller and smaller triangles to the equivalent structure in an iterative manner fashion. The process is clearly shown in Fig 2.

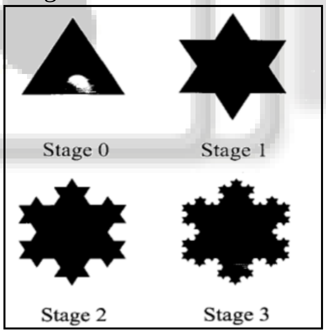

Fig. 2: The First Few Stages in the Construction of a Koch Snowflake

There are number of structure which is extremely useful for developing and generating new methodologies based on purely deterministic or random fractal trees. Fig3 this particular is taternary tree structure is almost similar to the sierpinski gasket which is shown in shown in Fig. 1

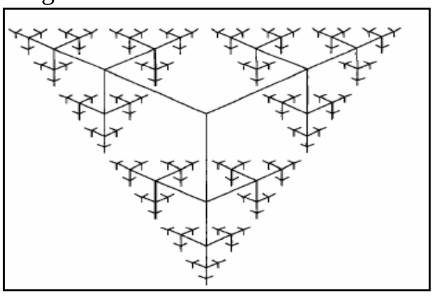

Fig. 3: A Stage 2 Ternary Fractal Trees

For the design of fractal microstrip antenna, the space filling properties of the Hilbert curve and their curves is used. The first four steps for the construction of the Hilbert curve are shown in Fig4.

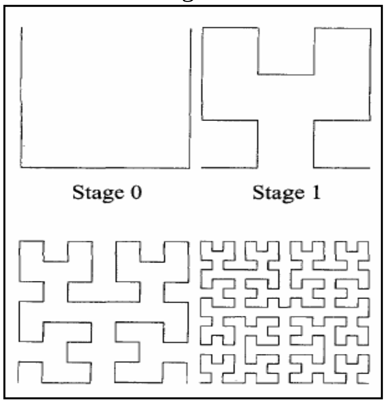

Fig. 4: The First Few Stages in the Construction of a Hilbert Curve

To develop the new design for microstrip patch antenna and new miniature loop design ,the Koch snowflakes and islands is generally We develop number of designs for miniaturized dipole antennas based on a the variety of Koch curves and fractal trees

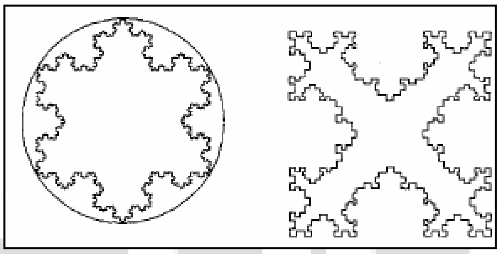

Fig. 5(a): Koch snowflakes/islands[2]

Fig. 5(b): Koch curves and fractal trees as miniaturized dipole antennas.

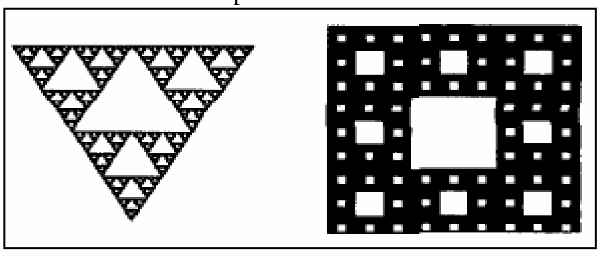

Fig. 5(c): Sierpinski Gaskets and Carpets fractal shapes

Koch snowflakes is created by adding smaller or smaller triangles to the original structure in an iterative way

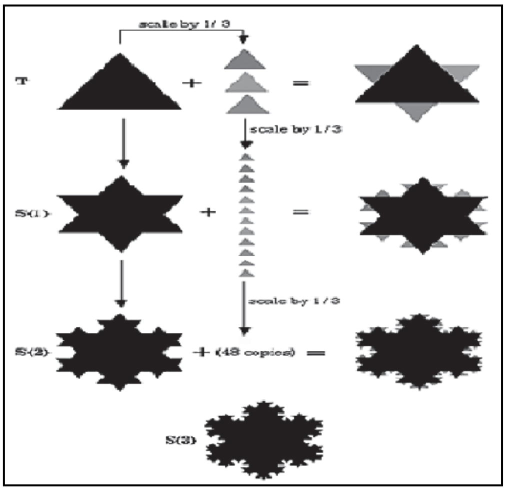

Fig. 6: First few stages in the construction of a koch snowflake

C. Minkowski Fractal Gometry

Minkowski fractal a square shape geometry in which each of four straight sides of square is being replaced with generators and then we applied cut of iteration width by scaling 1/3 of each straight sides of square at every iteration and the depth is adjust a optimization to get accurate result few steps in construction of minkowski geometry is shown fig7.

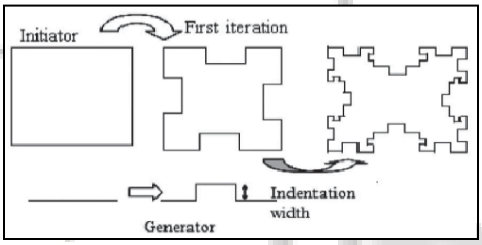

Fig. 7: several stages in the construction of a Minkowski fractal

D. Sierpinski Carpet

An iteration is applied on a square patch as shown in fig8 which is called zeroth order iteration. To retrieve fierst order iteration, a square patch of dimension equal to one third of the main patch antenna is subtracted from the center of the patch as shown in fig. 8(b). The next step to design the sierpinski carpet is to etched the squares which are nine times and twenty seven times smaller than the main patch as demonstrated fig. 8(c) and 8(d) respectively[7] from the ai patch the second and third order iterations are carried out eight times and sixty four times respectively . This fractal can be termed as third order fractal as it is designed by carrying out three iterations.

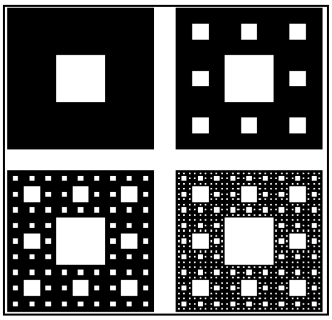

Fig. 8: Steps of Sierpinski Carpet

E. Sierpinski Sieve

A generator which is called sieve is used to create the fractal. The middle third triangle is removed from the sierpinski gasket, which leaves three equally sized triangle which are half the height of the original gasket triangle. The process of removing the middle third is then repeated on each of the new triangles. This process is going on for an infinite no. of times to design ideal fractal antenna.

F. Giuseppe Peano Fractal

The recursive procedure which is applied to the edges of the square patch up to second iteration as depicted in fig 9.

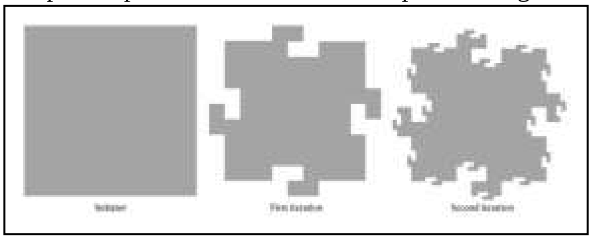

Fig. 9: Steps of Giuseppe Peano Fractal[8]

G. Advantages and Disadvantages

1) Advantages

- Antennas are more versatile, powerful and compact.
- Existing micro strip antenna types have fractal version.
- The Technology behind fractals leads to unique improvements in microstrip antenna arrays which lead to increase their bandwidth, allowing multiband capabilities.
- Increased bandwidth, gain

2) Disadvantages

- Gain loss in some cases
- Complexity
- Numerical limitations
- The benefits begin to diminish after first few iterations

H. Applications

- Fractal microstrip antenna provides universal wideband antenna
- Wireless network such as Zigbee, WiMAX and MIMO
- Universal tactic communication
- Mobile devices
- Telematics
- Fractal image rendering and image compression schemes.
- RFID
- Astronomy
- Computer science
- Fluid mechanics

IV. CONCLUSION

We studied different types of fractal geometries which derived certain property like reduced size and optimized gain. All Fractal geometries can be applied on all existing types of antenna including dipole, monopole, patch, conformal bicone, discone, and spiral, helical and so on. In future we can work on the designing of fractal antenna by using any one of geometries as per the required applications and achieved better results using simulation techniques by the help of HFSS simulation software and we can also work in the designing of fractal patch antenna by using different fractal geometries and compare their results of VSWR, Gain. Bandwidth, Input Impedance, Directivity and on more important constraint for which fractal technology is widely used compact size.

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