Fractal Antenna Geometries: A Review

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ABSTRACT
With the rapid development of wireless communication system, the main objective is to design of wideband, multiband and small size antenna .To obtains these requirements the fractal antenna is used. The term "fractal" came into the existence in 1975 which means non-regular and never ending pattern .They are formed by repetition of single pattern over and over in ongoing feedback loop. In this paper we introduce about the fractal antenna design with different geometry structure and how the size of antenna gets reduced using different fractal geometries.

Keywords
Fractal antenna, Fractal Geometry, Compact size, Iteration factor

1. INTRODUCTION
On increasing the range of wireless and satellite communication system, the technology antenna were require with wider bandwidth and compact length antenna than traditional antenna [1]. Researchers had been doing their research to attain their requirement amongst them. Dr.Nathon conen makes the primary fractal antenna in 1988 and working on this generation. He founded antenna in 1995 to spread his research in commercial as well as military applications [2]. He has a world famous designer in the field of fractal antenna. It fulfilled all the requirements of the user in terms of compact size, wider Bandwidth, Lower price and ease of fabrication.

Fractal antenna resolves two limitation of traditional antenna [3].

1. Performance of the antenna is dependent upon the electrical size of the antenna like antenna parameter, gain, input impedance and radiation pattern.
2. By increasing the effective length of fractal antenna, it reduces the size of antenna .It has used in many in lots of utility like military and wireless communication.

2. CONCEPT OF FRACTAL
The fractal is derived from Greek word "Frangere" which means broken or irregular fragments [4]. It is change into first developed via mathematician Benoit Mandelbrot in 1975 [5].Fractal antennas are multiband, high gain and low profile antenna which is used for Wi-Fi package because of its capabilities and competencies [11]. An iterative geometry refers to the technique of subdividing a shape into smaller copies of itself [10]. Traditional antenna operates at single frequency band in which larger area is required to couple of antenna .Fractal geometry has been implemented to many fields and consequences were observed. Fractal antennas have following properties such as [8]

a. Self - similarity property -Antenna has the identical shape but repeated with reduction in length successively [15].
b. Space – Filling property –Hilbert curve are used in the miniaturization of antenna element because of its space filling property. Space filling property are electrically long that are fit into a compact space and lead to the miniaturization of antenna element [35].
c. One of the essential properties of antenna is frequency independent.

3. GEOMETRIES FOR FRACTAL ANTENNA
The Geometries of fractal antenna can be explained and constructed by iterative process that gives to self affinity structure [16].Fractal antenna can be categorized into two types : Deterministic and Random. Deterministic, like sierpinski gaskets and von Koch snowflake, are constructed by several scales down and rotated copies of itself .Random fractal ,it may look like a natural phenomenon such as dendrites and lightning bolts [9][17].These geometries have been used to characterize structure in nature that were difficult to demonstrate with Euclidian geometries. These fractal geometries are:

3.1 Sierpinski Gasket
The primary fractal geometry to be described is the sierpinski Gasket. It is deterministic fractal. The procedure for building of fractal begins with equilateral triangle [3]. So the midpoint of equilateral triangle is use for the vertices of new triangle. Then getting rid of the triangle massive part of triangle which is probably positioned on the midpoint of the triangle. This process is repeated N number of times that is known as iterations [4]. Where black triangle represent the metallic conductor and white element from where triangle has removed. The structure of Sierpinski Gasket of Iterations of equilateral triangle is[6].

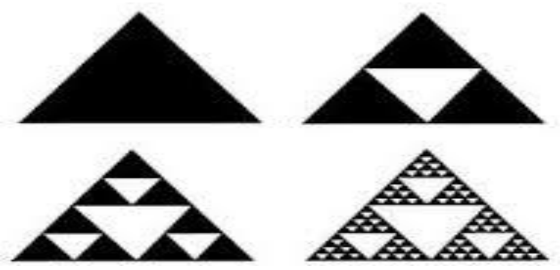

Fig 1 Basic Construction of Sierpinski Gasket Fractal [6]

3.2 Sierpinski Carpet
Sierpinski carpet is similar to the Sierpinski Gasket fractal Geometry. We use square shape in place of triangle. The original shape of square without any iteration on simple square patch is known as 0 iteration. The square of dimension identical to one third of original patch is subtracted from the centre of patch to acquire 2nd iteration [18][19]. This technique is repeated continuously to achieve number of iteration and multiband behavior.

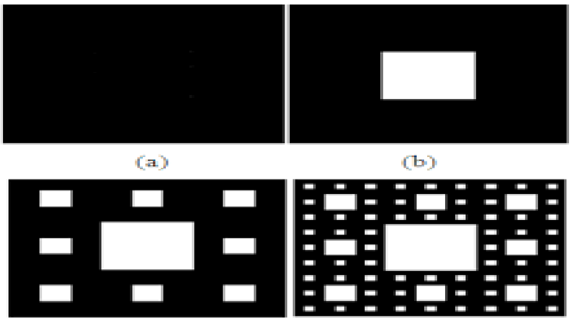

Fig 2 Basic Construction of Sierpinski Carpet Fractal [32]

3.3 Koch Curve

The Koch curves, named from the Swedish Mathematician helge von Koch who designed by in 1904. It improved the feature of classical antenna in terms of resonant frequency, radiation resistance and bandwidth. The construction of curve is very simple. The straight line is first divided into 3 equal segments and the middle segment is removed and replaced by two segments having equal length to obtained equilateral triangle. Now further this process is repeated for 4 line segments to attain 2nd iteration and repeated continuously for every straight line.[18-19].

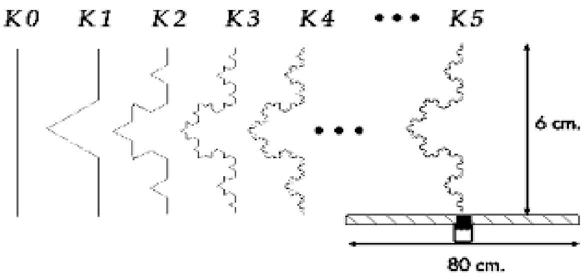

Fig3 Basic Construction of Koch Curve Fractal [12]

3.4 Koch Snowflake

From the Koch curves, comes the Koch Snowflake. It was first described by the Swedish Mathematician Helge von Koch in 1904 [7].The construction of Koch snowflake is begins with equilateral triangle with sides of length .In the middle of each sides, we will add a new triangle which is one third of the size and repeat this process infinite number of times to obtained infinite number of iterations. The Koch snowflake is an example of self similar property, meaning it looks like a same at every scale. Four steps of Koch snowflake structure is given below [25].

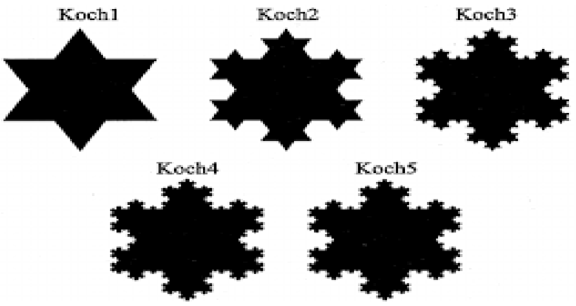

Fig 4 Basic Construction of Koch Snowflake Fractal [24]

4. LITERATURE REVIEW

Shinde Poonam, M.M.Jadhav (2016) [17] it describes the concept and technique to reduce the size of antenna by using fractal geometry. Its application include military , commercial and wireless the large bandwidth is required which is obtained by means of using one of kind fractal geometry i.e Sierpinski carpet and Gasket.

Ashish Ranjan, Manjeet Singh, Mohit Kumar Sharma and Narendra Singh(2014) [32] Designed a Sierpinski Carpet fractal antenna. They are used self similarity property of antenna with low field , low profile and which is used for wireless application and optimize to operate in multiband range from 2-6GHz.

V.Indhumathi, B.I.S.Ronica(2015) [7] they presented a Koch snowflake fractal geometry with triangular patch antenna with CPW feed which is compatible for UWB applications having wider Bandwidth from 4.67 to 10.89GHz with -10db return loss.

Sachendra N. Sinha and Manish Jain (2007) [35] designed a multiband fractal antenna based on self-affinity property. Experimentally they compared the return loss with the results of method of moments. They demonstrated that the fractal antenna attains multiband characteristics.

Amit Ranjan and Sunil Kumar Singh (2015) [22] designed multi-fractal triangular patch antenna for UWB applications. They achieve a better return loss and bandwidth with reduced size by using Koch and sierpinski geometry. They designed a proposed antenna which works on resonant frequency at 5.41GHz with return loss -42.43db, bandwidth 2.1219GHz and VSWR 1.0152.

4.1 Advantages

- Fractal Antenna is small in size.
- Higher input impedance matching wideband/multiband (use one antenna rather many).
- Frequency unbiased (constant efficiency over huge frequency range)
- Diminished material coupling in fractal array antennas

4.2 Disadvantages

- Gain loss

  Complexity
- Numerical Limitations
- The benefits begin to diminish after first iteration.

5. APPLICATIONS

There are many applications of fractal antennas.

1. Fractal antennas can make a real impact. The recent growth in the wireless communication needs the compact integrated antennas. So the fractals antenna has efficiency to fill a limited amount of space. Example of three types of application includes personal hand-held wireless devices such as cell phones.
2. Fractal antennas can also have applications that include multiband transmission.
3. Fractal antennas also decrease the area of resonant antenna, which could lower the radar cross section. These benefits can be used in military applications.

6. CONCLUSION

This paper presents the various types of fractals can be used to design an antenna and these fractals play very vital role to reduce the size of antenna and optimize the gain. If the number of iterations of fractal was increases then the resonant frequency also increases and it gives lower return losses. By using Fractal geometry the multiband and wideband characteristics were achieved which are used for different applications like military and wireless communication by using different feeding techniques. For better impedance matching its very important to select proper feeding technique and proper position of feed .In further other types of feeding techniques, different shapes of patch and different substrate materials can be used for the designing and analyzing the performance parameters of antennas.

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