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Review Paper on Fractal Antenna Geometries and Its Applications

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Abstract— *This paper design of different fractal antennas and its applications. With the development in wireless communication and telecommunication system multiband and low profile antenna are higher in demand for both commercial and military applications. We provide review of development in the field of fractal antenna. Fractal antenna have two main properties such as self similarity and space filling property, which make multiband and small size antenna. It is main requirement of modern communication system. The areas of allocations are medical imaging, wireless communication, and military communication.*

Keywords—*Fractal antenna; frcatal geometry; space filling property*

I. Introduction

The demand of the modern communication system is required antenna with advance features like. Wider bandwidths. Multi bands, smaller size, high gain low profile antenna. This has initiated research in various directions, one of which is fractal shaped antenna. In resent year various geometries have been introduced for antenna applications with different dimensions and varying degree of success for improves antenna characteristics. Some geometry designed for reduce antenna size and other for multiband applications.

The term fractal was coined by the French mathematician B.B. Mandelbrot during 1970's after his pioneering research on several naturally occurring irregular and fragmented geometries not container\end within the realms of conventional Euclidian geometry. The word fractal is derived from Latin Greek word fractus which means irregular fragmented or shapes. Fractal antennas are widely used because its self similarity and space filling property reduce the antenna size and make it light weight antenna. The self similar property provides multiband behavior, because using this property, the portion of geometry which has same shape repeat at reduces scale. And the space filling property used to reduce the size of antenna. Fractal antenna is based on iterations means it repeating itself by reducing the size. The iteration function system is collection of self alien transformation. In other words a fractal is a rough or fragmented geometry shape that can be subdivided into parts, each of which is reducing size copy of whole. Using space filling property, a fractal makes reduce antenna size. In many cases the use of fractal antennas can simplify circuit design, reduce construction costs and improve reliability. Furthermore they are self-loading, no antenna parts such as coils and capacitors are needed to make them resonant. Fractal geometries have been applied to micro strip antenna design to make multiband and broadband antennas. In addition, fractal geometries have been used to miniaturize the size of the antennas. There are two categories of fractal geometry such ad deterministic and non deterministic. Deterministic fractal geometries are those which are constructed by several scales down and repeated copies of it. Random fractal is those which have randomness and exit in nature such as clouds. However, miniaturization has been mostly limited to the wire antennas. The geometry of the fractal antenna encourages its study both as a multiband solution and also as a small antenna.

Properties of Fractal Geometries

- Space Filling Properties: Space filling property is based on space filling curves.
- Self Similarity: A self similar object is exactly or approximately same.

II. Fractal Geometeryies for Patch Antenna

Fractal antenna provides better parameters and controlled design. It provides small size, multiband, wideband antennas. It overcomes all problems of congenital antenna, which works at only one frequency. Fractal antenna provides excellent performance at many different frequent ices simultaneously. There are four common used geometries.

A. Sierpinski Fractal

Sierpinski fractal geometry is a type, which has been used to design both monopole and patch type antennas. Several structures are derived from the original Sierpinski fractal structure and analyzed in order to get better multi-band behavior. The monopole type Sierpinski antenna provides well-defined multi-band characteristics however; the Sierpinski patch antenna does not behave like as the monopole. Several modifications have been reported to improve the performance of the antenna. The Sierpinski gasket is named after the Polish mathematician Sierpinski who described some of the main properties of the fractal shape in 1916. The original gasket is constructed by subtracting a central inverted triangle from main triangle shape. In this design system three equal triangles remain on the structure, each is the half of the size of the original one. Then same subtraction procedure applies on the remaining triangles and if the iteration is carried out an infinite number of times, the ideal fractal Sierpinski gasket is obtained.

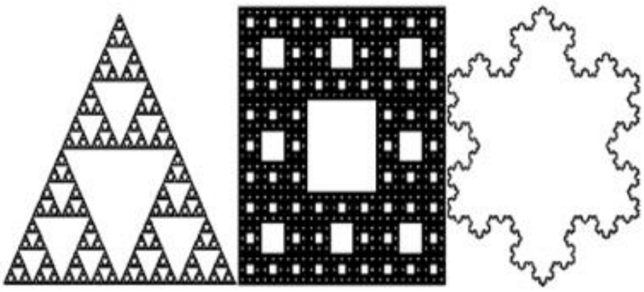

Fig. 1. Sierpinski fractal antenna.

A third order Sierpinski gasket constructed through three iterations with a scale factor of 2. For example the height of the Sierpinski fractal is taken as 40mm. Three scaled versions of the Sierpinski gasket, Sierpinski sub-gaskets, fed simultaneously at the apex are found on the antenna and are shown inside the circles. The first Sierpinski sub-gasket is third order Sierpinski of height 10mm, the second sub-gasket is second order Sierpinski of height 20mm and the third is first order Sierpinski of height 40mm. Based on this assumption, we can say that at higher frequencies, the current should concentrate on smallest sub-gasket because it is equivalent to the bowtie monopole of height 10mm which would resonate at higher frequency compared to bowtie Monopole of 20mm and 40mm.

B. Koch Curve

The koch curve is designed by Swedish mathematician Helge Von Koch in 1904. Koch curve antenna is introduced to improve the features of traditional antenna in term of resonant frequency, bandwidth and radiation resistance.

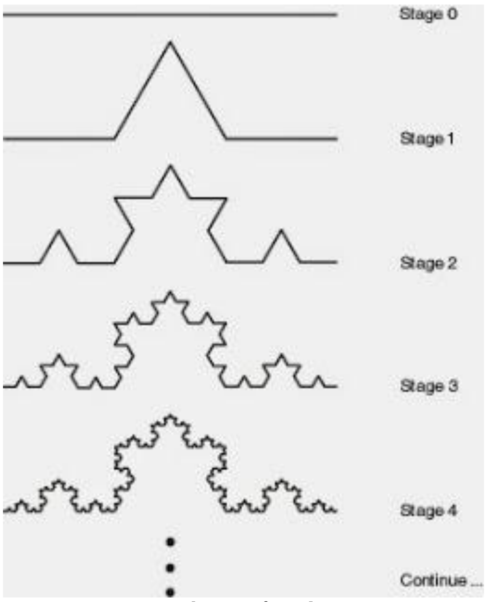

Fig. 2. Koch curve fractal antenna.

The construction of the Koch curve is initiated with the straight line. Then this straight line is divided into three equal parts and the middle parts from these three parts is replaced by two equal length segment for obtain equilateral triangle, this is the first iteration. This process is repeated to obtain 2nd iteration and repeated continuously for every straight line. Each segment in first iteration curve is 1/3 of length of the initiator. To making a Koch curve fractal antenna is simpler than other antennas because the straight line segment is replaced by pattern of multiple line segments. Then straight line segment of that pattern is replaced with same pattern up to infinity. It means Koch curve contain Koch curve which also contain Koch curve until finally the curve I straight line.

C. Minkowski Fractal Antenna

The minkowaski fractal antenna is based on space filling property of fractal geometry. Minkowaski loop is used to reduce the size of antenna and it also increases the electrical length. Minkowaski fractal antennas are used where the perimeter is near one wavelength. The minkowaski antenna designs are generally based on rectangular, square, triangle geometry structure. This antenna reduces the size of conventional loop antenna and lead to compactness and miniaturization, so that i receive lot of attention (cohen 1995). As shown in figure 3 in minkowaski fractal antenna design the each side of the patch is divided into four equal parts, then the middle part of each side is replaced by projection inward with two equal lengths horizontal and two equal length vertical segments. The same process is repeated for next iterations. It is clear from figure the fractal geometry reduce the physical area of antenna, but also increase the number of frequency bands at which the antenna resonate. Minkowaski fractal antenna basically use square shape where there are symmetrical parts are removed and use the self similarity, repetition and scaling property of fractal geometry. This antenna type gives various advantages:

- Small size
- Multiple resonant frequencies
- High gain

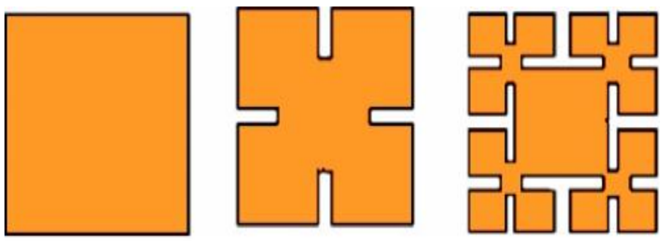

Fig. 3. Different iterations of minkowaski fractal antenna.

III. ADVANTAGES OF FRACTAL ANTENNA

Miniaturization- size of the geometry can be reduce three or four times. Better matching of input impedance. Compressed resonant behavior. Multiband performance at non harmonic frequency. One antenna is sufficient to take care of multiple bands both narrow band and wideband. There will be reducing mutual coupling in array antenna made using fractal geometry. This geometry are self loading, no other hardware is required. Matching component are not required.

IV. Disadvantages

Complexity involve in the design and manufacturing process. Numerical limitation. Low Gain. After few iteration in the fractal antenna design simulation benefit of this technology based approach with diminish.

V. Conclusion

This paper presents the review of various fractal geometries that have been used for different wireless applications. Some of geometries used for reduce antenna size and some are used for multiband purpose. In this paper, we have discussed various design and applications of fractal patch antenna. From this paper we have conclude that specific geometries are used for some specific application and each one have different benefits. And also conclude that sierpinski gasket shape is most widely used fractal geometry because in this shape a single antenna can operate on multiple frequencies.

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