1. INTRODUCTION

Fractal geometries [John Gianvittorio, 2000] have found an intricate place in science as a representation of some of the unique geometrical features occurring in nature. Fractals are used to describe the branching of the tree leaves and plants, the sparse filling of water vapors that forms clouds, the random erosion that carves mountain faces, the jaggedness of coastlines and bark, and many more examples in nature.

Euclidean structures have whole number dimensions, such as a one dimensional line or two dimensional planes. Benoit Mandelbrot first defined the term ‘fractal’ meaning fractional dimension to handle geometries with dimensions that do not fall neatly into a whole number category [T. Kikkawa, K.K. Kimoto and S. Watanabe, 2005]. One property of a certain class of fractals is that it can have an infinite length while fitting in a finite volume. Fractal is defined by a set of F such that:

1) F has a fine structure with details on arbitrarily small scales.
2) F is too irregular to be described by traditional geometry.
3) F having some form of self-similarity.
4) F can be described in a simple way, recursively.
5) Dimension of F is greater than its topological dimension.

The dimension of geometry can be defined in several way, some examples are topological dimension, Euclidean dimension, self similarity dimension, and Haussdorf dimension. The most easily to understand definition is self similarity dimension. An object is said to be self similar if it looks roughly the same on any scale. The estimated length, L of an object, equals the length of ruler, r multiplied by a number, N; of such rules needed to cover the measure object. For example if there are n copies of original geometry scaled down by a fraction f, the similarity dimension D is defined as

\[ D = \frac{\log N}{\log r} \]

D does not need to be integer as in the Euclidean geometry but can be a fraction as in the fractal geometry and it is known as the Haussdorf dimension. These have been proven useful in describing natural objects and specifically object that can be used as fractal antennas.
Figure 1.1: A fern is example geometry in nature that is easily modeled using fractal

Figure 1.2: Landscape scene that also can be modeled using fractal geometry.

Figure 1.3: Fractals are geometric forms that can be found in nature, being obtained after millions of years of evolution, selection and optimization.
There are many benefits when we applied this nature power (fractals) to develop various antenna elements. By applying fractals to antenna elements:

1) We can create smaller antenna size.
2) Achieve resonance frequencies that are multiband.
3) May be optimized for gain.
4) Achieve wide band frequency band.

Most fractals have infinite complexity and detail that can be used to reduce antenna size and develop low profile antennas. For most fractals, self-similarity concept can achieve multiple frequency bands because of different parts of the antenna are similar to each other at different scales. The combination of infinite complexity and detail and self similarity makes it possible to design antennas with very wideband performance.

When antenna elements or arrays are designed with the concept of self-similarity for most fractals, they can achieve multiple frequency bands because different parts of the antenna are similar to each other at different scales. Application of the fractional dimension of fractal structure leads to the gain optimization of wire antennas.

The combination of the infinite complexity and detail and the self-similarity makes it possible to design antennas with very wideband performance.

There has been an ever-growing demand, in both the military as well as the commercial sectors, for antenna designs that possess the following highly desirable attributes [Douglas H.Werner and Suman Ganguly, feb2003].

1) Compact size
2) Low profile
3) Conformal
4) Multiband or broadband.

There are a variety of approaches that have been developed over the years, which can be utilized to achieve one or more of these design objectives. Recently, the possibility of developing antenna designs that exploits in some way the properties of fractals to achieve these goals, at least in part, has attracted a lot of antenna.

Traditional approaches to the analysis and design of antenna systems have their foundation in Euclidean geometry. There has been a considerable amount of recent interest, however, in the possibility of developing new types of antennas that employ fractal rather than
Euclidean geometric concepts in their design. We refer to this new and rapidly growing field of research as fractal antenna engineering. Because fractal geometry is an extension of classical geometry, its recent introduction provides engineers with the unprecedented opportunity to explore a virtually limitless number of previously unavailable configurations for possible use in the development of new and innovative designs.