INVESTIGATION OF THE EFFECT OF FRACTAL SHAPES ON THE BROADBAND BEHAVIOR OF 1-DIMENSIONAL OPTIMIZED ANTENNAS

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The irregularity has been very attractive to the antenna and packaging engineers. More specifically, the self-similarity has inspired many researchers to use them for broadband designs, due to the fact that a fractal antenna is a repeated shape in different scales, which can be interpreted as a multiscale ("multi-wavelength") radiator. In addition to this, the space filling property seems to be ideal for the antenna miniaturization. Although many experiments have verified the above properties, there are also counter examples that show the opposite. Comparison of fractal antennas with non-fractal ones that have some common characteristics, such as total wire length and same geometrical dimension, has shown that the last exhibit better behavior. Another drawback of the fractal antennas is that they are not fully realizable since they require infinite resolution. They can be manufactured up to a limited scale known also in the literature as prefractals. Despite the fact that there is no theorem to guarantee that a prefractal shape maintains the same properties with a fractal, it is empirically known that some properties such as fractal dimension is kept by a prefractal if the scale is small enough. For example internet traffic is a fractal curve although it is discrete.

In order to answer the question whether a fractal antenna is the optimal in bandwidth or miniaturization basis, it is suggested to optimize a generic-model 1-D wire antenna. Measurement of the fractal dimension of the optimal antenna can prove whether fractal properties are the main reason for the broadband behavior. A simple way to parameterize an antenna is to use a delta modulation algorithm. So if a piece of wire is divided into N segments, then it can be described as an N-size vector of $-\Delta$, $+\Delta$ values, leading to a staircase approximation. The cumulative sum of the vector gives the actual shape of the antenna within an error of Δ (quantization error). The authors believe that this is well suited parameterization since it fits to methods like simulated annealing and genetic algorithms. These stochastic optimization methods give a set of suboptimal solution as the uniqueness of the optimum cannot be proved mathematically. The fractal dimension of the suboptimal solutions will be measured with the Minkowski cover algorithm which gives very accurate estimations. The authors hope that the results will give an intuition about the effect of fractal geometry in design and show a direction for the design and optimization of more complex antenna geometries that will not require heavy computations in the future.