Genetically Optimized Two-Dimensional Fractal-Random Arrays

Joshua S. Petko* and D. H. Werner
The Pennsylvania State University
Department of Electrical Engineering
University Park, PA 16802
jsp160@psu.edu and dhw@psu.edu

In has been known to antenna engineers that periodic arrays can be used to effectively suppress radiation pattern side-lobes with just a small number of elements but are more susceptible to effects from element failure. Random arrays on the other hand are more robust in terms of element failure but are not typically able to suppress side-lobe levels as effectively as their periodic counterparts. In an effort to design robust arrays which are able to effectively reduce side-lobe levels, a compromise was proposed that included both fractal and random features called the fractal-random array (Y. Kim and D.L. Jaggard, *Proc IEEE.*, **74** (9), 1278-1280, 1996; D.H. Werner and R. Mittra, *Frontiers in Electromagnetics.*, Ch. 3, 96-100, 1999). Fractals are objects that have a self-similar structure repeated periodically throughout their geometry produced by the repeated application of a simple Euclidian structure called the generator. In order to introduce randomness into a fractal-random array, one can randomly choose from several different generators and apply them at different stages of the fractal structure. In this way fractal-random arrays can possess good qualities of both the periodic and random classes of arrays.

Not every fractal-random array configuration is capable of producing radiation patterns that have low side-lobe levels. In fact, often the designs with the most optimal solutions call for unconventional array layouts that may not be obvious to the antenna engineer. A technique based on genetic algorithms will be introduced as a design tool for optimizing the performance of fractal random arrays. Genetic algorithms are useful because they allow antenna designers to optimize radiation parameters by creating a large population of candidate antennas. The laws of natural selection are then applied to the population in order to evolve an effective layout scheme. Fractal-random arrays are ideally suited for optimization via genetic algorithms because their self-similarity can be exploited to reduce the number of calculations needed to be performed for each antenna, thus making it possible to find solutions for much larger antenna arrays. The purpose of this paper is to present a methodology for optimizing the layout of fractal-random arrays by using a novel genetic algorithm technique in conjunction with fractal tree theory. The genetic algorithm breaks the data (chromosome) representing each antenna structure apart into smaller pieces called subchromsomes, which contain the genes for each individual tree branch. This process allows the various genetic manipulations to be performed at a subchromosome level, providing an effective means of evolving optimal fractal-random arrays that vary widely in size, structure, and even number of elements. This genetic algorithm approach shows that fractal-random arrays can be designed to be effective in suppressing radiation pattern side-lobes and yet remain relatively robust with respect to element failure.