A Three Dimensional Extension of the Self-Structuring Antenna to Improve Beam Steering

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A self-structuring antenna (SSA) responds to changes in its operating environment by changing its electrical shape. Existing variants of the SSA show great promise for tuning across wide bands and for self-healing when subject to damage. However, their ability to steer the main beam of radiation to a chosen direction has, so far, been limited.

The majority of SSA designs examined to date incorporate a two-dimensional template. By using a three dimensional template of interconnected radiating elements, additional flexibility is provided for the directing genetic algorithms to find configurations with adequate directivity along the desired directions. A structure is conceived in which two dimensional templates are arranged into a three dimensional structure, allowing the performance improvement over the original two dimensional structure to be evaluated. The simplest structure is merely a rectangular box with five sides formed from two-dimensional templates, and the bottom left open for placement of a feed network. Such a structure could be placed onto the surface of a case, cabinet, or container using embedded wires or etched conducting lines as radiating elements, and computer-controlled electronic switches to connect the elements under control of a genetic algorithm. Use of a multi-criterion optimization algorithm allows the development of a Pareto-optimal front from which to choose configurations that show both good input impedance and desired directivity along a chosen direction.

This paper will examine the beam-steering capabilities of a three-dimensional extension of a two-dimensional SSA template for steering the main beam to a chosen direction. Numerical simulations will be used to compare the directivity of the best configurations from the two dimensional structure with the best configurations from the three-dimensional extension. Promising configurations will be selected by use of a multi-criterion optimization algorithm that considers the multiple components of realized gain (return loss, efficiency, and directivity). Consideration will also be given to the number of switches required to achieve desired radiation performance. Once the feasibility of the concept has been established, construction of a prototype antenna will be undertaken using a simple etched circuit board implementation.