Optimization of Gain, Input Impedance and Bandwidth of Yagi-Uda Antenna Arrays using Hybrid Genetic Algorithms

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Abstract
This paper tries to compare the gain, input impedance, Z_{in}, and bandwidth characteristics of five-element nu-dipole Yagi-Uda antenna and that of five-element vee-dipole Yagi-Uda antenna. A combination of method of moment (MOM) and Genetic Algorithm (GA) was used to maximize directive gain as a single objective function for both antenna arrays and directive gain and input impedance of (12.31dB and Z_{in}=8.46+j27.08 Ω) and (12.14dB and Z_{in}=9.04+j1.03 Ω) were obtained for nu-dipole array and vee-dipole array, respectively. Composite objective function comprising of directive gain with input impedance, Z_{in}˜ 50Ω, produced values of (9.98dB and Z_{in}=50.39+j0.42 Ω) and (10.66dB and Z_{in}=49.14-j1.64 Ω) for the nu-dipole and vee-dipole arrays, respectively.

Keywords: Directive gain, input impedance, bandwidth, method of moment, genetic algorithms.

INTRODUCTION

Genetic Algorithms (GA) stochastically evolve a population towards a solution using the concept of survival of the fittest. This algorithm allows the global optimum, which is the design goal to be attained. Optimization scheme such as gradient descent method performs better for problems with fewer number of variables/design parameters since it searches the entire solution space. As the number of parameters increases hence affecting the solution space, the location of the initial guess greatly affect the quality of the solution. If the initial guess falls outside the global optimum, then a local optimum result shall be obtained.

Certain performance criteria (gain, input impedance, low sidelobe level, bandwidth, beamwidth and size) must be met in the design of antennas and because one or more parameter may have effect on the general output of a particular design, a good initial guess becomes difficult. An algorithm like the GA which simultaneously searches the wide sample of the cost surfaces is best suited for this problem.

Landstorfer and Sacher (1986) and, Petkovic and Krstic (2002) showed that shaped dipole antennas tend to have higher directivity when compared to those of straight dipole. The vee-dipole and the nu-dipole are both types of shaped dipole. The vee-dipole has its two arms forming the letter V and the nu-dipole has its lower arm only taking the shape of an arc (Okereke (1999)). Kuo and strait (1972) wrote a program using moment method for analysis of radiation and scattering of arbitrary thin bent wires. Okereke (1999) and Okereke (2007) did characteristics analysis of a single nu-dipole antenna and that of six-element Yagi-Uda array, respectively. Directive gain was maximized in Liang and Cheng (1983) by optimizing length, shape and position of a symmetrical three-element Yagi-Uda array. Elkamchouchi and Abu Nasr (2004) compared Swastika, Turnstile S-dipole and Turnstile antenna in terms of their radiation characteristics.