Beam Steering of a Large Phased-array Antenna with Fixed Major-lobe Beamwidth and Side-lobe Levels

Song-Han Yang and Jean-Fu Kiang
Graduate Institute of Communication Engineering
National Taiwan University, Taipei, Taiwan, ROC
E-mail: jfkiang@cc.ee.ntu.edu.tw

Large phased-array antennas have been used for radar applications through beam-steering maneuvers. The beamwidth of the major-lobe increases when it is steered away from the broadside direction. While one tries to reduce the major-lobe beamwidth, the side-lobe level usually increases.

Several methods have been proposed to reduce the side-lobe level of antenna arrays. A real-coded genetic algorithm (GA) has been used to reduce the side-lobe level of linear and circular arrays by adjusting complex excitations of all the elements. For example, the maximum side-lobe level can be reduced to −36 dB and −29 dB, when it is applied to 30-element linear and circular arrays, respectively.

In this type of optimization problems, one often deals with objective functions that are highly nonlinear and have a large number of optimization parameters. Evolutionary optimization techniques have been successfully applied to such electromagnetic problems. For example, the particle swarm optimization (PSO) has been proposed to optimize the spacings of a 32-element linear array, to minimize the side-lobe level and to control the null locations. The maximum side-lobe level can be reduced to about −20 dB, and the nulls can be pushed to −60 dB.

Another comprehensive learning particle swarm optimization (CLPSO) algorithm can reduce the maximum side-lobe level to −22.75 dB, with the same null depth of −60 dB. A position mutated hierarchical PSO (PM-HPSO) has been applied to a 108-element planar thinned array, and the maximum side-lobe is reduced to about −26.85 dB.

In this work, a large 76,000-element phased-array antenna is optimized in terms of its beam-steering capability. A tapering technique is proposed to maintain a constant beamwidth of the major-lobe when it is steered away from the broadside direction. An adaptive particle swarm optimization (APSO) algorithm is applied to adjust the phases of all the elements so that the maximum side-lobe level can be restrained to an acceptable level of −17.36 dB.