The Point Objective Function for Optimization of Side Lobes of Linear Antenna Arrays

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Abstract—A new form of objective function is suggested for the problems of point optimization of complex radiation patterns of discrete antenna arrays. The function takes the properties of individual antenna radiators and the antenna array phase characteristic into account. Several examples of various antenna arrays help consider some properties of the point objective function and peculiarities of application of optimization of side lobes’ level using this function.

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One of advantages of antenna arrays (AA) composed of discrete radiators is the possibility for fast changing their radiation pattern (RP) when the array has some elements able to control the amplitude and phase of excitation of each array element. Usually, when we deal with the problem of determination of the required amplitude-phase distribution of excitation of AA radiators, we have to meet various conditions imposed on the main lobe shape and distribution of levels of side lobes (SL) of the radiation pattern. Here we must remember that some RP parameters, such as SL maximum level and the width of the main lobe at the half-power level are closely related to each other and cannot be set arbitrarily.

By convention, the known methods of RP optimization and synthesis may be classified under two groups: analytical and iterative ones. The most interesting representative of the first group is the classical work of Dolph [1], which gives the solution permitting to relate the main lobe width to a prescribed level of all uniform side lobes of radiation pattern. This solution is often used for checking the working capacity of other methods of RP optimization ([2], for instance). As applied to discrete arrays, Villeneuve [3] resolved the problem of shaping the Taylor-type RP for discrete arrays, where only several side lobes, close to the main lobe, can be set equal to some prescribed level, while the levels of other lobes decrease in accordance with a certain law.

The exact solution to the optimization problem cannot be obtained for all cases: to make it possible, the function describing the required shape of RP must belong to a certain class of functions [4]. Hence, in most cases we consider the task of approximation of the current RP to the required one. This problem can be treated by various methods: the method of steepest descent [5], the adaptive array method [6, 7], the least squares method [8], the genetic algorithm [9], the method based on quadratic programming [10], and other. Some methods of optimization cannot give acceptable solution during a single run, and require iterative algorithms for their implementation — to reduce the error function step by step. Traditionally, the error function represents the squared module of difference between the current and required RP. In the process of iterative search we seek for a minimum of the error function in the whole space of observation angles, and at some angles the error function may be large enough.

A peculiar feature of the majority of optimization methods is that they can be applied only to certain types of antennas, or, in some cases, do not take the directivity of AA radiators into account. Moreover, when we regard the AA radiation pattern as a complex-valued function, most optimization methods deal only with approximation of its amplitude, while the correct description of RP phase characteristic may facilitate the problem treatment considerably [4].

In the present work we consider the issues of optimization of side lobe levels of a discrete AA radiation pattern. We introduce a new (as distinct from those available in literature) form of complex-valued point objective function (POF), analyze its main properties, and give several examples illustrating the possibility for application of the point approximation method with the use of POF for optimization of RP of discrete AA in the side lobe domain.