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Multilevel Array Decomposition Algorithm for Fast Statistical Characterization of Conformal Arrays in the Presence of Excitation Errors

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Conformal array antennas offer well-known advantages over conventional planar arrays: aerodynamic shape, potentially greater effective aperture for a given platform, reduced weight. A new generation of radar imaging systems is based on multifunctional synthetic aperture radars that aim at providing high resolution and long range imaging capabilities as well as highly sensitive ground moving target indication. Such radars make use of highly reconfigurable array antennas, with severe demands on beam direction precision, beam-width, and side-lobe levels, as required by high resolution algorithms. Large number of densely packed radiating elements is highly desirable for this type of antennas to increase the performance and achieve high space-time resolution of the radiated fields over a wide angular sector of beam steering directions.

Evaluation of radiation patterns of such large arrays for a range of beam steering and observation directions poses a non-trivial computational challenge. Presence of excitation errors due to random noise and imperfect calibration further exacerbates the situation by requiring complex compensation techniques and making the radiation patterns nondeterministic (R. J. Mailloux, *Phased Array Antenna Handbook*, Artech House, 1994). Some statistical properties of radiation patterns such as averages can be deduced from those of the excitation coefficients. However, probability density functions of radiation patterns can be obtained from those of the excitation coefficients, only at special points such as the main lobe peak and zeros, and, even this, using far reaching approximations (A. K. Bhattacharyya, *Phased Array Antennas*, Wiley, 2006). Full statistical description can be obtained via Monte Carlo Type simulations at the cost of repeated evaluation of radiation patterns for various realizations of all random variables involved. Such brute-force approach comes at a substantial computational cost making a conventional radiation pattern evaluation for large conformal arrays impractical.

In this paper, a multilevel array decomposition (MAD) algorithm (A. Boag and C. Letrou, *IEEE Trans. Antennas Propagat.*, vol. 53, no. 6, pp. 2064-2072, June 2005; A. Shlivinski and A. Boag, *IEEE Trans. Antennas Propagat.*, vol 55, no. 12, pp. 3421-3432, Dec. 2007) is introduced as a numerically efficient scheme for statistical characterization of the field and power radiation patterns (RPs) of arbitrary shaped arrays. The computational scheme is based on a hierarchical decomposition of the array into smaller sub-arrays. At the finest level of decomposition, the radiation patterns of single element arrays are computed or measured over a sparse grid of directions. The subsequent computational sequence comprises interpolations and aggregations of sub-array contributions repeated until obtaining the radiation pattern of the array. The proposed algorithm attains a computational complexity substantially lower than that of the direct computation. The algorithm can be used to obtain average complex field patterns and power patterns in the presence of random amplitude and phase excitation errors or, alternatively, can be employed for Monte Carlo type statistical simulations.