Accurate Modeling of Advanced Reflectarrays

Analysis and optimization methods for the design of advanced printed reflectarrays have been investigated, and the study is focused on developing an accurate and efficient simulation tool. For the analysis, a good compromise between accuracy and efficiency can be obtained using the spectral domain method of moments (SDMoM) assuming local periodicity (LP) and the focus in this work has therefore been on this technique. In the LP-SDMoM, several factors contribute to errors in the analysis and these include: the periodicity assumption, the assumption of infinite ground plane, the representation of the incident field, the choice of basis functions, and the technique to calculate the far-field. Based on accurate reference measurements of two offset reflectarrays carried out at the DTU-ESA Spherical NearField Antenna Test Facility, it was concluded that the three latter factors are particularly important for an accurate analysis. Solutions for these sources of error have been proposed, implemented, and validated. Based on the techniques for the enhanced analysis, a generalized direct optimization technique (GDOT) has been developed. The GDOT is based on the LP-SDMoM and a minimax optimization algorithm. Contrary to the conventional phase-only optimization technique (POT), the geometrical parameters of the array elements are directly optimized to fulfill the far-field requirements, thus maintaining a direct relation between optimization goals and optimization variables. As a result, better designs can be obtained compared to the POT. The GDOT can optimize for the size as well as the orientation and position of arbitrarily shaped array elements. Both co- and cross-polar radiation can be optimized for multiple frequencies, dual polarization, and several feed illuminations. Several contoured beam reflectarrays have been designed using the GDOT to demonstrate its capabilities. To verify the accuracy of the GDOT, two offset contoured beam reflectarrays that radiate a high-gain beam on a European coverage have been designed and manufactured, and subsequently measured at the DTU-ESA Spherical Near-Field Antenna Test Facility. An excellent agreement between the simulated and measured patterns is obtained, showing accuracies that are comparable to those obtained for shaped reflectors.

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