Efficient Higher Order MoM-VIE/MoM-SIE/Diakoptics Computation of Scattering from Finite Arrays of Arbitrary Dielectric Objects

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The method of moments (MoM) has been established as a powerful general tool for discretizing integral equations arising in numerical analysis of radiating and scattering structures. In MoM techniques based on the volume integral equation (VIE) approach, a structure is represented by a distribution of unknown volume polarization and conduction currents radiating in free space. MoM techniques based on the surface integral equation (SIE) approach treat electric and magnetic equivalent surface currents as unknowns in the numerical process. However, one general way to enhance the practical applicability and efficiency of both the MoM-VIE and MoM-SIE techniques is by means of the diakoptic method (E. Chobanyan, D. I. Olcan, M. M. Ilic, and B. M. Notaros, "Combining Diakoptic, VIE-MoM, and SIE-MoM Approaches in Analysis of Dielectric Scatterers," Proc. 2013 IEEE Antennas and Propagation Society International Symposium).

This paper focuses on the full-wave MoM analysis of finite arrays of arbitrary dielectric scatterers, and presents accurate end efficient modeling of such structures based on the diakoptic enhancement of MoM-VIE and MoM-SIE techniques. In the method, we wrap each scatterer with a closed surface (diakoptic surface) and place equivalent electric and magnetic surface currents over it. Each scatterer, together with the associated equivalent surface currents, is analyzed completely independently, using the higher order MoM-VIE/SIE method, with the objective to find linear relations between coefficients of the equivalent current expansions (diakoptic coefficients). The relations for all scatterers are combined into a system of linear equations (diakoptic system), whose solution is a set of diakoptic coefficients. Once known, these coefficients are used to obtain various parameters of interest for the original system. The efficiency of the diakoptic approach is further enhanced by using higher order geometrical and current modeling of the diakoptic subsystems and diakoptic surfaces, based on Lagrange-type interpolation generalized curved VIE hexahedra and SIE quadrilateral patches with hierarchical divergence-conforming polynomial vector basis functions.

The MoM-VIE/MoM-SIE/diakoptics method is validated, evaluated, and discussed in a variety of examples of two-dimensional finite arrays of scatterers of various geometries and material compositions, which demonstrate computational features of the diakoptics, as well as of particular higher order bases and elements, used in MoM-VIE and MoM-SIE approaches. Some examples are aimed at demonstrating the effectiveness of the higher order MoM-VIE technique in treating curved and highly inhomogeneous practical structures. With emphasis on the *p*-refinement and conformal geometrical modeling, the results show excellent agreements with alternative full-wave numerical solutions of different types, and demonstrate high accuracy and efficiency of the MoM-VIE/MoM-SIE/diakoptics method. The solutions use current expansions of very high orders and large-domain VIE and SIE meshes with a very small number of large conformal curved hexahedral and quadrilateral elements, which results in minimal total numbers of unknowns. Finally, the examples demonstrate advantages of the diakoptics over computation by individual original methods.