Performance of the 3D MFIE Using Curl-conforming Bases

Andrew F. Peterson
School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0250
peterson@ece.gatech.edu

The solution of 3D electromagnetic radiation and scattering problems using numerical methods is relatively mature, with a large experience base focused on the electric-field integral equation (EFIE) discretized using divergence-conforming rooftop or RWG basis functions. For electrically large applications some form of the combined field equation, incorporating the EFIE and the magnetic field integral equation (MFIE), is necessary to avoid fictitious internal resonances. Most MFIE implementations to date also employ divergence-conforming RWG bases to represent the current density, which lead to weak singularities in the scattered field at cell edges. Since the MFIE is only applicable to closed structures, the experience base with the MFIE has been limited.

In this presentation we report the relative performance of the 3D MFIE when discretized with three different types of curl-conforming vector basis functions: constant-tangential/linear-normal (CT/LN), linear-tangential/linear-normal (LT/LN), and linear-tangential/quadratic-normal (LT/QN) functions. When used with the MFIE, curl-conforming bases should produce better-behaved near fields. The basis functions are defined on curved-cell surface models and the equations are enforced by either point-matching or by numerical approximations of Galerkin's method (same testing functions as basis functions). Matrix entries are obtained using adaptive quadrature in conjunction with singularity cancellation schemes, such as the Khayat and Wilton approach. The error in the surface current density and the scattering cross section is determined for perfectly conducting spheres. The performance relative to the EFIE is also reported.

Results suggest that the MFIE with the CT/LN bases performs poorly compared to the EFIE with RWG bases, at least for scattering cross section calculations. There appears to be no advantage to a Galerkin testing scheme with the MFIE. As the polynomial order of the basis functions increases, improvements are obtained in both the accuracy and the rate by which the error decreases. The use of LT/LN bases results in an improvement in the accuracy of the surface current density compared with CT/LN bases, but not in the accuracy of the scattering cross section (for a similar number of unknowns). LT/QN functions improve the accuracy of the MFIE scattering cross section, but are still not competitive with the EFIE/RWG implementation. These results have implications for numerical treatments of the combined-field integral equation.