Accurate Integration of the Weakly Integrals from EFIE

Seung Mo Seo* and Jin-Fa Lee
ElectroScience Lab., Dept. of Electrical Engineering
The Ohio State University
sms@esl.eng.ohio-state.edu

The accuracy of the Electric Field Integral Equation (EFIE) depends significantly on the double integrals, which involve kernels that are weakly singular. Previously, the common approaches to take account of the weakly singular integrals are the singularity extraction and the Duffy transformation methods. When the observation and the source triangles are separated only by a small fraction of wavelength, the numerical results can be catastrophically unreliable.

This paper aims to provide an accurate and yet efficient integration of these weakly singular integrals and subsequently improve the robustness and the accuracy of the EFIE. The current proposed approach is based on the combination of the Gray's approach (L. J. Gray, J. M. Glaeser, and T. Kaplan, *Siam J. Sci. Comput.*, Vol. 25, No. 5, pp. 1534-1556, 2004), which is simply polar (ρ,θ)-coordinate transformation, and the analytic integration to result in an element matrix. The approach resembles a common practice employed in the finite element community (P. P. Silvester and R. L. Ferrari, *Third edition*, Cambridge University Press, 1996). With the Galerkin statement of the EFIE, the vector and scalar potentials are defined as the contribution of the local current within a source triangle. Further, we interpolate these vector and scalar potentials by piecewise quadratic polynomials within an observation triangle. For simplicity, we only consider local matrices of these vector and scalar potentials. The outer integral part is computed using the analytic integration of the Finite Element Method (FEM). However, the inner integral part is transformed into a polar (ρ,θ)-coordinate. The integration of ρ is analytically computed, but that of θ is numerically done. Therefore, the accuracy and stability of the EFIE is then greatly improved. The details of the methods and implementations will be shown in the presentation.