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We report new developments in the analytical evaluation of the near-field contribution to the matrix elements of the electric and magnetic field operators for planar conducting structures embedded in a layered medium. The method is applicable to Rao-Wilton-Glisson (RWG) basis functions supported on parallel interfaces in the medium. Our method is an extension of the approach described in [1] of representing a Green function as a two-dimensional Laplacian of an auxiliary function. Such Laplacian representations can be obtained for the asymptotic forms of the Green functions, which are being subtracted in order to regularize the behavior of the Sommerfeld-type integrals. Matrix elements resulting from these asymptotic forms, given originally as quadruple surface integrals with singular integrands, are then reduced to double contour integrals over the perimeters of the surface elements, involving simple closed-form non-singular auxiliary functions.
The new developments include:
(1) Derivation of simpler relations between elements of the asymptotic dyadic Green functions and the kernels of the mixed-potential representation of the fields. As a result, we constructed simplified expressions for four independent matrix elements (discussed in [2]), expressed in terms of contour integrals over triangle perimeters with nonsingular integrands; these integrands are represented as two-dimensional Laplacians of only two independent auxiliary functions and their derivatives.
(2) Construction of simplified analytic expressions for the matrix elements of the asymptotic parts of the pertinent dyadic Green functions. In contrast to the previous lengthy expressions reported in [2], the new formulae can be written in several lines. Further, they can be represented in a form immune to numerical round-off errors in “nearly singular” configurations of triangles, such as nearly parallel edges. Simplification of the analytic formulae has been achieved by a change of the integration variables and then by a convenient and economical choice of the parameterization of the geometry of pairs of edges, in terms of vertex-vertex distances and of appropriate angles. In deriving expressions behaving in a smooth way for nearly singular and singular geometries we also took advantage of an arbitrariness in the specification of indefinite integrals, whose linear combinations provide the required matrix element; with our choice not only the linear combination, but also the individual terms are well-behaved, and no cancellations of large terms are necessary.

References

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2. D. R. Wilton, “Interpolatory methods for efficient computation of layered media Green's functions”, 2011 Computational Electromagnetics International Workshop (CEM), p. 159-162, 2011.