# Analytic and Numerical Aspects of the Nonsingular Laplacian Representation of the Asymptotic Part of the Layered-Medium Green Function in the Mixed Potential Formulation



(Article begins on next page)

# Analytic and Numerical Aspects of the Nonsingular Laplacian Representation of the Asymptotic Part of the Layered-Medium Green Function in the Mixed Potential Formulation

E. Bleszynski(1), M. Bleszynski 1), T. Jaroszewicz 1), W. Johnson(2), J. Rivero(3), F. Vipiana(3), and D. Wilton(4)

(1) Monopole Research, Thousand Oaks, CA 91360, USA, e-mail: elizabeth@monopoleresearch.com
(2) Consultant, 219 Sharon Dr. NE, Albuquerque, NM 87123-2421, USA
(3) Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, 10129 Torino, Italy
(4) Department of Electrical and Computer Engineering, University of Houston, Houston, TX 77204-4005, USA

We report on developments in the evaluation of matrix elements of the electric and magnetic field operators involving the asymptotic (large transverse wave-number or small transverse distances) components of the mixed-potential Green's function of a layered medium. Subtracting these asymptotic terms significantly accelerates numerical computation of the Sommerfeld-type integrals required in constructing Green's function and then the matrix elements [1].

The described method is applicable to planar conducting structures embedded in a multi-layered medium. Ability of a fast and accurate evaluation of matrix elements for such structures is critical in many applications, especially in solving forward problems in design and optimization of electromagnetic metasurfaces,

In our approach, which is an extension of the technique described in [2], we represent the asymptotic terms in Green's function and its normal derivative as two-dimensional Laplacians of appropriate auxiliary functions. Matrix elements, given originally as quadruple surface integrals with singular integrands, are reduced in this way to double contour integrals over the perimeters of the surface elements, involving simple non-singular functions.

We investigate numerical accuracy aspects of the four kernels constituting the asymptotic Green's function by comparing matrix element values evaluated by using (i) conventional method-of-moments techniques of numerical double surface integration, (ii) numerical computation of double line integrals arising in the Laplacian formulation, and (iii) analytic formulae we obtained for some terms in the line integrals (a complete fully analytic evaluation of all the matrix elements, with RWG basis functions, is an on-going effort).

The comparison shows significant differences in the behavior of the individual terms in the asymptotic Green's function. In particular, the two kernels which involve the normal derivative of Green's function require a substantially higher number of quadrature points, especially in configurations where projections of the basis functions' supports (on two different interfaces) are nearly overlapping. In applications to electromagnetic metasurfaces such configurations represent mutual couplings between nearby cells of the surface and are essential for correct modeling of the entire structure.

References

[1] D. R. Wilton, "Interpolatory Methods for Efficient Computation of Layered Media Green's Functions", 2011 Computational Electromagnetics International Workshop (CEM), p. 159-162, 2011.
[2] E. Bleszynski, M. Bleszynski, T. Jaroszewicz, W. Johnson, J. Rivero, F. Vipiana, and D. Wilton "New Simplified Analytic Expressions for the Matrix Elements of the Asymptotic Part of the Layered Medium Green Function in the Mixed Potential Formulation ", in proceedings of ICEAA-IEEE APWC, Honolulu,USA,2021.