

Generalized Source Integral Equations using Reflective Shields: The Transverse Electric (TE) Case

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Generalized source integral equations (GSIEs) make use of modified Green's functions in order to reduce the broadside component of interactions between opposite sides of essentially-convex impenetrable surface scatterers. As such, they give rise to corresponding off-diagonal moment matrix blocks of ranks that scale slower with the electrical size than those of conventional integral equations. Thus, they enable faster low-rank compression of these blocks and, as a result, compressed matrix factorization. The reduction of broadside interactions is achieved by introducing auxiliary contributions to the free space Green's function that approximately cancel it in the relevant direction. These contributions are produced by auxiliary sources placed within the scatterer that can be designed in various manners. Among the designs of auxiliary sources that were successfully utilized for fast direct solver development are {induced, effective} electric current distributions {on, inside} reflective shields (Y. Dahan and Y. Brick, "Fast direct solvers with arbitrary admissibility using generalized source integral equations," *IEEE Trans. Antennas Propag.*, vol. 72, no. 10, pp. 7872-7882, Oct. 2024) and equivalent electric and magnetic current distributions on absorptive shields (A. Sharshevsky, Y. Brick, and A. Boag, "Direct solution of scattering problems using generalized source integral equations," *IEEE Trans. Antennas Propag.*, vol. 68, no. 7, pp. 5512-5523, July 2020). These were introduced for the transverse magnetic (TM) two-dimensional scattering problem, with the latter then extended to three-dimensional for acoustic scattering, using body-of-revolution symmetry (D. Zvulun, Y. Brick, and A. Boag, "A generalized source integral equation for enhanced compression in three dimensions," in *IEEE Trans. Antennas Propag.*, vol. 71, no. 12, pp. 9316-9325, Dec. 2023). To enable similar performance enhancement for full vector surface equations, the concept demonstrated by these scalar formulations should be extended to the design of auxiliary and modified Green's dyadics.

A first steppingstone in this direction is the design of auxiliary sources for transverse electric (TE) fields (Y. Dahan, A. Boag, and Y. Brick, "Toward vector generalized source integral equations," *ICEAA 2024—Int. Conf. Electromagn. Adv. Applicat.*, Lisbon, Portugal, Sept. 2024). Following the introduction of an auxiliary Green's dyadic, defined using effective longitudinal magnetic currents inside a reflective magnetic conductor shield, and the preliminary demonstration of its favorable compressibility, this talk will focus on a more extensive study of its properties. The choice of the auxiliary distribution parameters and their influence on the shadow depth of the modified Green's dyadic and, resultantly, the achievable compressibility, will be examined. For the selected shield designs, examples that validate the GSIE and corresponding moment formulation will be presented. The scaling of the off-diagonal block ranks and overall compressed memory requirements with the problem size will be studied. This will be done for hierarchical matrix structures, including ones that are formed according to strong admissibility criteria (W. Hackbusch, "A sparse matrix arithmetic based on H-matrices. Part I: Introduction to H-matrices," *Computing*, no. 62, pp. 89-108, 1999). In such settings, the favorable compressibility of GSIEs is achieved by leveraging the great attenuation of the modified Green's function compared to the free space one. Accordingly, the compression threshold is set with respect to the largest singular value of the free space interaction, in what can be thought of as a spectral counterpart of conventional (spatial) matrix thinning. Thanks to the attenuation, this aggressive compression does not jeopardize the overall accuracy of the moment matrix representation and the solver. The effectiveness of this dynamic compression threshold setting approach for the TE case will also be verified.