A Well-Conditioned Solution of a Combined Field Formulation Without the Search for Global Loops

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All known integral equation techniques for simulating scattering and radiation from arbitrarily shaped, perfect electrically conducting objects suffer from one or more of the following shortcomings: (i) they give rise to ill-conditioned systems when the frequency is low (ii) and/or when the discretization density is high; (iii) their applicability is limited to the quasi-static regime; (iv) they require a search for global topological loops; (v) they suffer from numerical cancelations in the solution when the frequency is very low. A recent paper (Andriulli et al., *On a Well-Conditioned Electric Field Integral Operator for Multiply Connected Geometries*, IEEE-TAP 2013) presented a new integral operator of the electric type that does not suffer from any of the above drawbacks.

When the scatterer under consideration is closed, integral operators of the electric and magnetic type suffer from interior resonances, i.e. null-spaces for wavenumbers that correspond to a resonance of an interior problem. The presence of these resonances often negatively impacts the accuracy and solution time of solvers leveraging these operators. When standard electric and magnetic field operators are used, this problem can be remedied by using a combined field operator, viz. a linear combination of the electric and magnetic field operator that is provably resonance-free. Unfortunately, standard combined field operators inherit all the drawbacks (i)-(v).

This contribution extends the recently developed electric type operator immune from (i)-(v) by developing a new magnetic type operator that can be used to construct a combined field operator that does not suffer from (i)-(v) *and* is immune from interior resonances, i.e. that is uniquely solvable for all frequencies. The new formulation is obtained starting from a Helmholtz decomposition of two discretizations of the electric field integral operator and from a suitably symmetrized mixed discretization of the magnetic field integral operator, obtained by using RWGs and dual bases functions, respectively. The new decomposition does not leverage Loop and Star/Tree basis functions; rather, it employs projectors that derive from them and does not require the explicit detection of global topological loops. The theoretical developments will be corroborated by numerical results, confirming the effectiveness of the newly developed method.