Nystrom Implementation of a Combined Field Integral Equation Using Approximate Helmholtz Decompositions of the Current on a PEC

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Surface integral equations (SIE) are extensively used in solving electromagnetic field radiation and scattering problems. The electric field integral equation (EFIE) and the magnetic field integral equation (MFIE) are the two fundamental surface integral equations used for perfect electric conductor (PEC) objects. MFIE has a better conditioned system matrix compared to the EFIE. However, the EFIE can be applied to a wider range of structures including open structures and structures with geometric singularities. On the other hand, EFIE suffers from a low-frequency breakdown. A common disadvantage of EFIE and MFIE is the interior resonance problem for closed surfaces. The problem can be remedied by applying combined field integral equation (CFIE) which is a linear combination of EFIE and MFIE. Furthermore, CFIE provides a better conditioning than both EFIE and MFIE. However, the low-frequency breakdown inherited from EFIE still exists in CFIE. Recently, EFIE-hd has been proposed, which is an EFIE-based formulation that relies on global surface integral constraints to enforce an approximate Helmholtz decomposition (HD) of the current. It has been demonstrated that the low-frequency breakdown of the EFIE is alleviated by the EFIE-hd.

In this work, a new formulation named CFIE-hd to solve for the electromagnetic scattering from PEC surfaces is introduced. The HD framework is extended to the CFIE formulation by imposing appropriate global constraints on the current to effect an approximate Helmholtz decomposition of the current. In addition to benefiting from the advantages of CFIE, the new formulation gives accurate solution for electric and magnetic fields at high and low frequencies. Another specification of the proposed formulation is that it makes it possible to use locally corrected Nystrome method for discretization.