On the Low-Frequency Behavior of Decoupled Vector Potential Integral Equations for Perfect Electrically Conducting Scatterers

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Electromagnetic scattering from perfect electrically conducting (PEC) objects is often analyzed by solving surface integral equations. Traditionally, these equations are constructed using magnetic and/or electric fields resulting in electric field integral equation (EFIE), magnetic field integral equation (MFIE), or their linearly combined version (CFIE). However, it is well-known that the EFIE suffers from low-frequency and dense-discretization breakdowns [1]. The MFIE is always well-conditioned regardless of the frequency but its solution becomes inaccurate at low frequencies [2]. Several preconditioning techniques and novel discretization schemes have been developed to alleviate these problems [1-2]. However, these either come with additional computational cost and/or they increase the complexity of code development. Recently, potential integral equations have been proposed as “breakdown-free” alternatives to the field integral equations [3-7]. Depending on the type of potentials used, these integral equations can be cast in coupled or decoupled form. The coupled potential integral equation formulation is obtained using the vector and scalar potentials together [3], while the decoupled potential integral equation formulation allows for individual equations in vector or scalar potential [4-7].

In this work, the low-frequency behavior of the decoupled vector potential integral equation (DVPIE) enforced on a PEC scatterer is studied. The vector potential formulation is first derived using the generalized Green theorem and equivalence principle [4]. Taking the tangential and normal components of the vector potential formulation yields the DVPIE. Two surface unknowns, namely the surface electric current and the normal component of the vector potential are expanded using the Rao-Wilton-Glisson (RWG) and pulse basis functions, respectively. Inserting these expansions into the DVPIE and Galerkin testing the resulting equation with the RWG and pulse functions yield a linear matrix system. There is no explicit frequency dependence scaling the integrals involved in the DVPIE. Therefore, it is free from low-frequency breakdown. However, numerical results demonstrate that the solution of the DVPIE is inaccurate at low frequencies. This is supported by an analysis showing that the different components of this solution have the wrong frequency scaling.

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