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Approximate Boundary Conditions in Electromagnetics

In Memory of Professor Thomas B.A. Senior

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The solutions of Maxwell's equations to many boundary value problems with wide range of applications in antenna design, wave propagation, and scattering of EM waves from objects are often very complex and cannot be treated by just analytical methods. Because of this limitation, computation methods based on integral equation and method of moments, finite difference time domain (FDTD), and finite element method (FEM) have been considered and significantly developed over the past six decades. Despite the significant advancements in computation techniques and the advent of computational capabilities, brute force computational methods are still not capable of addressing many problems that the computational domain is many wavelength large and involve multi-scale inhomogeneities in a time efficient manner. However, analytical methods can be developed and used in a hybrid computational and analytical methods to alleviate some complexities of the computational domain and render time efficient solutions. Professor Senior spent much time developing analytical methods that could help computational algorithms. Many of his methods are summarized he coauthored with Professor Volakis [1]. Impedance sheets and resistive sheets and the associated boundary conditions known as impedance boundary condition (IB) and resistive sheet boundary conditions (RSBC) have had many applications in scattering problems [2] ,[3]. Higher order boundary conditions, known as generalized impedance boundary condition (GIBC) were further developed to improve the accuracy.

Motivated by developing a reliable detection approach for landmines and unexploded ordinance, in early 2000, I started working on working on a multimodal detection approach based on combination of acoustic and electromagnetic. The approach utilizes the properties acoustic waves that can propagate soil and standoff imaging capability of electromagnetic systems. Inspired by the work on GIBC, Daniel Lawrence and I developed a new set of boundary conditions known as Time-Varying Sheet Boundary Conditions (TVSBC) for the efficient computation of doppler spectrum of dielectric objects under acoustic vibration [4]. This paper will present the general formulation of TVSBC and its application for acousto-electromagnetic detection of buried objects. The TVSBC accounts for the object vibration and is applied to the unperturbed boundary of the dielectric object that can be solved only once. The time-varying nature of the boundary, due to acoustic vibration, is accounted for by the sheet impedance/admittance expressions and can be isolated from the unperturbed component of the scattered field, resulting in an accurate calculation of the Doppler spectrum no matter how small the vibration.

References

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