Buffer-zone iterative method for wide-band electromagnetic scattering problems

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The method of moment discretisation of integral equation formulations of electromagnetic scattering problems is hampered by the excessive computational burden associated with its solution. The necessity to use a large number of basis functions to adequately describe the fast variations in the unknown surface fields leads to impedance matrices of very large order which are impossible to invert. Instead iterative techniques build a solution by sequentially updating the unknown vector in some prescribed fashion. Recently developed iterative methods achieve this by sequentially stepping the calculation forward and backward along the discretised scatterer surface thereby incorporating forward and backward propagated fields in an ordered fashion. This is in contrast to, for example, a conjugate gradient based solution which, lacking the injection of physical information, generally takes much longer to converge. However the rigorous design of these forward-backward iterative methods for general scattering problems is a challenging problem.

This paper extends work presented by the authors in [1] so as to make it more efficient for application to wide-band problems. Reference [1] documents the development of a novel iterative method for solving the electric field integral equation as applied to perfectly conducting three-dimensional open bodies. Firstly the structure is conceptually divided into regions. The solution is then obtained by considering each region sequentially in turn and formulating and solving a matrix equation for the region which takes account of the incident field and the field scattered from other regions. [1] shows how the introduction of a small amount of redundancy into the computations (in the form of interactions with nearby buffer zones) removes the introduction of spurious diffraction effects which would otherwise arise and ensures that the solution converges. In addition it is possible to pre-process the sub-problems, identifying the local regions in advance and pre-computing and storing the inverse of local impedance matrices for use during the iterative sweeps etc.

While [1] represents a significant and interesting technique a number of challenging problems remain. This paper will extend the technique already developed to render it applicable to wide-band simulation. Specifically, we exploit the fact that decomposing the scatterer into sub-domains allows us to pre-process the impedance matrix associated with each sub-domain. This paper will illustrate how one can apply a model reduction technique such as Asymptotic Waveform Evaluation to each local impedance matrix, allowing it to be efficiently solved over a wide frequency band. In addition, similar reduction methods are applied to the matrices describing the interactions between sub-domains, expediting their wide-band computation accordingly. The incorporation of acceleration techniques to expedite the computation of these non-self terms will be shown to further improve the algorithm performance.

(1) 'A novel iterative solution to the three-dimensional electric field integral equation',Brennan et al, IEEE Trans. Ant. Prop., Vol. 52 No. 10 pp. 2781-2784 October 2004