Time-domain Source-model Technique Analysis of Two-dimensional Electromagnetic Scattering Problems

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Time-domain integral equation solvers for analyzing transient scattering phenomena continue to be a subject of considerable interest in the computational electromagnetics community. In this paper, we study a somewhat different time-domain integral-equation solution. Instead of using a standard surface formulation, we present a mesh-free formulation for the solution of the electromagnetic scattering problem of a two-dimensional metallic cylinder illuminated by a TM (transverse magnetic) plane wave pulse. In the proposed solution, we adapt the frequency-domain source model technique, which has been found to be efficient and versatile computational tool for analysis of time-harmonic wave scattering problems, to allow direct time-domain analysis of transient scattering problems. In this solution, the scatterer is replaced with a discrete set of spatially impulsive filamentary sources, each carrying longitudinally-uniform but time-dependent electric currents that are subsequently expanded in terms of pulse functions of yet-to-be-determined amplitudes. The filamentary sources are located on a mathematical surface interior to the cylinder surface. They are assumed to radiate in an unbounded free-space and their fields, which are known analytically, span the transient scattered field in the region exterior to the cylinder. The source amplitudes are determined by requiring that the boundary condition for the total tangential electric field be satisfied at a suitably chosen set of time instances and at a selected set of testing points on the boundary of the cylinder. The effect of solution method parameters, such as the spatial density and temporal discretization of the fictitious sources, on the accuracy and stability of the results is studied. A spatio-temporal discretization criterion for an explicit formulation of the time-domain source-model solution is presented to allow the use of a simple marching-on-in-time algorithm. The modification of this algorithm to treat an implicit formulation of the time-domain source-model solution is discussed, and the advantages of such a formulation are outlined. Finally, the use of a combined-source formulation and its effect on the resulting stability is studied.