Transient Electromagnetic Scattering from Dielectric Objects Using Laguerre Polynomials as Temporal Basis Functions

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Several time domain formulations have been presented for the solution of the electromagnetic scattering from arbitrarily shaped 3-D structures using triangular patch modeling technique. For the solution of a time-domain integral equation, the marching-on in time (MOT) method is usually employed. A serious drawback of this algorithm is the occurrence of late-time instabilities in the form of high frequency oscillation. In this paper, we present a new technique to obtain stable responses of the time-domain electric field integral equation (TD-EFIE) for arbitrarily shaped 3-D dielectric objects using Laguerre polynomials as temporal basis functions.

The Laguerre series are defined only over the interval from zero to infinity, and hence, are considered to be more suited for the transient problem, as they naturally enforce causality. Using the Laguerre polynomials, we construct a set of orthonormal basis functions. Transient quantities that are functions of time can be spanned in terms of these orthogonal basis functions. The temporal basis functions used in this work are completely convergent to zero as time increases to infinity. Therefore, transient response spanned by these basis functions is also convergent to zero as time progresses. Using Galerkin's method, we introduce a temporal testing procedure, which is similar to the spatial testing procedure of the method of moments. By applying the temporal testing to the TD-EFIE, we can eliminate the numerical instabilities. Instead of the MOT procedure, we employ a marching-on in-degree procedure by increasing the degree of the temporal testing functions. Therefore, we can obtain the unknown coefficients of the expansion by solving a matrix equation recursively with a finite number of basis functions.

Transient equivalent currents and far field obtained by the method presented in this paper are accurate and stable. The agreement between the solutions obtained using the proposed method and the IDFT of the frequency-domain solution is excellent.