A New Matrix-free Approach to the Computation of Electromagnetic Fields Generated by a Surface Current Distribution

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A major step in the numerical solution of electromagnetic scattering problem entails the computation of the electric field generated by a surface current distribution. The scattered electric field, thus computed, is used to derive the total tangential electric field on the surface of the scatterer, upon which the boundary condition is imposed to solve the scattering problem. Typically, the scattered field computations involve a matrix-vector product, with the matrix generated by using the RWG bases and the vector representing the induced current on the surface of the scatterer. This process can be highly CPU-intensive, both in terms of time and memory, especially when the object size is large. Although the Fast Multiple Method (FMM) has been introduced to speed up the required product, the near-field interaction matrices, which must be stored in the CPU, can still burden the memory quite considerably for large problems, and the matrix-vector operation can be costly despite the application of FMM to off-diagonal blocks.

For planar structures, such as thin plates, an FFT approach has been successfully employed to reduce the memory and CPU time considerably. In this approach, the convolution operation between the induced current **J** and the Green's function **G** is transformed in a product in the spectral domain by first sampling the **J** in a uniform Cartesian grid. The electric field is subsequently derived over the entire surface via an inverse transform operation on $(\tilde{J} \cdot \tilde{G})$, again using the FFT. To the best of our knowledge this procedure has not been extended to the case where the surface on which the E-field is desired is not coplanar with that of the current distribution **J** (or parallel to it), except via the use of multiple inverse FFT's of $(\tilde{J} \cdot \tilde{G})$ for different values of z, a procedure that is numerically very inefficient.

In this paper, we show how the desired $\overline{E}$ -field can be computed over the entire surface in one step, rather than one point at a time, in a highly efficient manner by using a spectral domain technique combined with an analytic continuation procedure. The procedure is valid for all distances and angles between the planes and totally bypasses both the matrix generation as well as evaluation of matrix-vector products employed in conventional schemes. The procedure is well suited for use in the Characteristic Basis Function Method (CBFM) for solving EM scattering problems, which has been recently introduced in the literature by a number of workers for efficient solution of the problem of EM scattering from large scatterers. These functions are often analytically transformable, and their use obviates the need to carry out the FFT of the current distribution, a procedure that can suffer from aliasing and discretization problems.

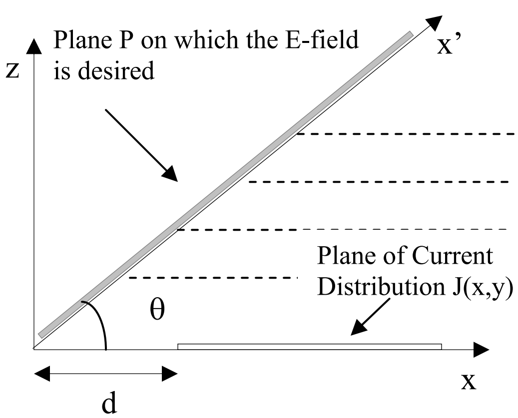

Fig.1. Geometry of System

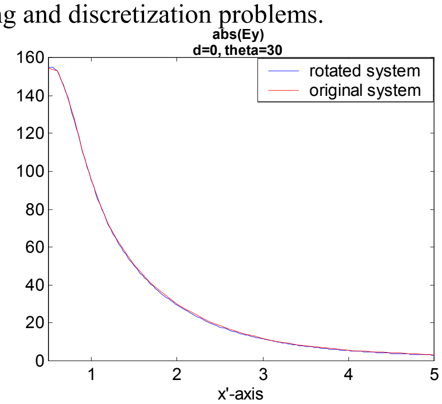

Fig.2. Comparisons of Fields computed by two different methods