Application of Iterative Techniques for Electromagnetic Scattering from Dielectric Random and Re-entrant Rough Surfaces

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Accurate and efficient evaluation of scattering from rough surfaces has great importance for military and commercial applications. Therefore, various integral equation (IE) based methods have been proposed for perfectly and imperfect conducting as well as dielectric random rough surfaces. However, the order of N^3 [i.e. $O(N^3)$], where N is the number of unknowns, computation cost for the direct solution procedure of the resultant system of linear algebraic equations has led to the use of iterative methods and their accelerated versions in particular for electrically large, perfectly and imperfect conducting rough surfaces. Unfortunately, when the scattering of electromagnetic waves from dielectric random rough surfaces is considered, the solution procedure for majority of the IE-based studies is restricted to the conventional method of moments (MoM), which suffer from the excess computational cost requirements when applied to electrically large profiles.

Therefore, in this paper, stationary (Forward-Backward Method (FBM)) and nonstationary (Conjugate Gradient Squared (CGS), Quasi Minimal Residual (QMR) and BiConjugate Gradient Stabilized (Bi-CGSTAB)) iterative techniques are applied to the solution of electromagnetic wave scattering from dielectric random rough surfaces with arbitrary complex dielectric constants. The convergence issues as well as the efficiency and accuracy of all the approaches, considered in this paper, are investigated by comparing obtained scattering (in the form of normalized radar cross section (NRCS)) and surface field values with the conventional MoM solution. It has been observed that similar to perfectly and imperfect conducting rough surface cases, the stationary iterative FBM converges faster when applied to geometries yielding best conditioned systems, but exhibits convergence difficulties for general geometries due to their inherit limitations. However, nonstationary techniques are, in general, more robust when applied to arbitrarily general dielectric random rough surfaces which yield more ill-conditioned systems. Therefore, they might prove to be more suitable for general scattering problems. Besides, as opposed to the perfectly and imperfect conducting rough surface cases, Bi-CGSTAB method and FBM show two interesting behaviors for dielectric rough surface profiles. (*i*) FBM generally converges for re-entrant surfaces when the vertical polarization is considered. (*ii*) Bi-CGSTAB method consistently exhibits convergence problems for the horizontal polarization.