Solution of 2D Scattering from Large Inhomogeneous Dielectric Cylinders with Shifted Frequency Internal Equivalence Principle

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Radiation and scattering problems involving dielectric objects can be formulated by using surface integral equation (SIE) methods or volume integral (VIE) equation methods. SIE methods employ unknown currents that reside on the surface of the geometry and are employed to formulate problems involving homogeneous bodies. VIE methods, on the other hand, employ unknown current densities that are distributed inside the geometry and allow problems involving inhomogeneous bodies to be solved. Numerical solution to these problems start with the discretization of the integral equations by a method of moments (MoM) scheme. Discretized integral equations are then converted into matrix equations which are solved to obtain unknown current coefficients. Number of elements in these matrix equations are closely related to the electrical size of the problem. Since VIE methods use voluminous currents, matrix sizes can quickly become very large. Usually these computationally intensive operations are required in multiple frequencies covering a bandwidth. In this case, lengthy solution process needs to be repeated for each frequency of interest.

It has been shown that by using Shifted Frequency Internal Equivalence (SFIE), it is not necessary to calculate all of the matrix elements for different incident frequencies. It is possible to reuse volume interactions within a wide frequency band by performing only algebraic manipulations. Only the matrix elements which correspond to surface interactions needs to be recalculated for different incident frequency. By reusing a large part of the matrix, computational complexity of the problem is effectively reduced to that of a homogeneous problem although the body is inhomogeneous.

Analysis results for different, electrically large inhomogeneous scatterers with slowly and rapidly varying material properties will be presented. Near and scattered far fields will be calculated to assess the accuracy of SFIE. When possible, comparisons with analytical results will be made. When analytical results are not available, comparisons with MoM results will be made. It will be shown that SFIE produces accurate results within a wide frequency band. Since computational complexity of the problem is effectively reduced, it will also be shown that SFIE accelerates frequency sweeps of the scattering problems.