Computational Algorithm of the Matrix Fresnel Function for the Discrete-Time UTD Analysis of Scattering from Curved Wedges

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Previously an alternative formulation of time domain uniform geometrical theory of diffraction (TD-UTD) for the scattering from curved edges was developed by representing the time variation in terms of a discrete time (DT) basis functions, which is thus referred as DT-UTD (H.T. Chou etc., IEEE Trans. Antenna Propat, 53 (11), 3633-3643, 2005) hereafter, and results in a matrix-type formulations retaining the forms and parameters analog to the frequency domain (FD) UTD solutions. This DT-UTD retains the advantages of FD-UTD solutions by using same ray parameters. The development of DT-UTD arises from a time discretization to represent the time variation in the Maxwell's equations in terms of simple basis functions, which is further tested by a set of testing functions following the procedure of moment method, and transforms the corresponding vector time-varying equations into a set of matrix-type equations, where the matrix's elements represent the field values at the discretized time steps, and hence in general, make the matrix equations functions of the locations. The forms of these resulting matrix equations are analogous and dual to the Maxwell's equations for the harmonic time dependent case. As a result, the DT-UTD formulations can be similarly developed as one developed the FD-UTD solutions of a harmonic time dependence.

This paper presents a computational scheme to efficiently evaluate the matrix Fresnel's transition function associated with this DT-UTD for the curved wedge diffraction problems. In this scheme, power and inverse power series are employed to compute the transition function while its argument is either smaller or larger than a certain value, respectively, and a linear interpolation is employed for intermediate values of the argument as previously employed in FD-UTD. The computation of the linear interpolation relies on the eigen-value and eigen-vector decomposition on the matrix equation and performs the interpolation over the resulted eigen-values at a time. Since the eigen-values and the associated eigen-vectors are complex in general, the interpolation becomes two dimensional and is performed over the real and imaginary parts of eigen-values simultaneously, which makes the procedure more complicated but retains the final results real in time domain. Numerical examination is presented to validate the scheme.