High Order Scattering from Undulations on a Cylindrical Surface

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Scattering from undulations on a cylindrical surface has been traditionally studied using the small perturbation method (SPM). This is based on a first order perturbation analysis where the amplitude and slopes of the undulations are assumed to be small. The restrictions imposed by these assumptions can be rather inconvenient in several applications. In order to address such limitations of the SPM a second order scattering method has been recently used for this problem. In this paper we employ a high order method that substantially expands the domain of validity of the SPM.

We have considered an EM plane wave incident on a PEC cylinder with angular undulations on the surface. A boundary variation approach is employed and the scattered fields are expressed as a perturbation series where a small parameter is attached to the surface undulation function. The coefficients of the perturbation series are presented as a recurrence relation, which is very convenient for high order scattering calculations. Unfortunately, the perturbation series thus obtained does not converge unless the amplitude of fluctuations is very small. In other words, the radius of convergence is very small. However, on renormalizing the series we find that convergence domain can be considerably expanded.

Our numerical simulation results using the SPM shows that the upper bound for the amplitude of undulations is given by $kh = 0.5$ for the case of TE polarization, and $kh = 0.35$ for the case of TM polarization. This is based on constraining the maximum relative error to be 1%. Outside this convergence domain the error in the SPM results rapidly increases. However, the use of renormalized high order method leads to considerable expansion of the radius of convergence thereby bringing the error within prescribed limits. Contrary to our expectation, we noticed that the performance of the high order method is better for TM than for TE. Moreover, our results show that the presence of small undulations can dramatically alter the scattering behavior of cylinders at certain frequencies. This anomalous behavior is due to the interactions of the resonance effects.