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Effects on the Electromagnetic Scattering of a Plane Wave due to the Surface Roughness of a Buried Perfectly Conducting Pipeline

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In this work we present a numerical study of the effects that can be observed in the electromagnetic scattering of a plane wave due to the surface roughness of a buried scatterer. The latter is supposed to be a metallic pipeline modeled as a perfect-electric conducting cylinder immersed in a half-space occupied by a lossy medium. Considering the pipeline's cross-section, the surface roughness is modeled as a sinusoidal variation of the radius of the cylinder's surface with respect to the revolution angle. A linearly-polarized plane wave impinging normally to the interface between air and the previously-mentioned medium excites the structure. As a result, we monitor the three components of the scattered electric field along a line just above the interface between the two media. To perform the study, a commercially available simulator which implements the Finite Element Method was adopted. In order to discriminate the effects due only to the surface roughness, we compare the results obtained by the rough surface scatterers with the reference case of a perfect cylinder in which the surface roughness is absent, for a fixed depth and a fixed mean radius of the cylinder. In our study, we vary the amplitude and the angular frequency of the sinusoidal disturbance to model different surface roughness scenarios. For all the scenarios taken in consideration, a frequency sweep of the impinging radiation is performed. This allows us to investigate the relation between the excitation frequency and the sinusoidal disturbance frequency of the rough surface. The study has several implications in the field of civil engineering. One example might be the one in which the geometrical characteristics of the buried pipeline are known in advance, and it is important to continuously monitor the structural variations of its external surface due to the deterioration in time under the action of various environmental factors.