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Detection of Two Buried Cross Pipelines by Observation of the Scattered Electromagnetic Field

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In this work we present a numerical study on the effects that can be observed in the electromagnetic scattering of a plane wave due to the presence of two crossed pipelines buried in a half-space occupied by cement. The pipeline, supposed to be used for water conveyance, is modeled as a cylindrical shell made of metallic or poly-vinyl chloride (PVC) material. In order to make the model simpler, the pipelines are supposed running parallel to the air-cement interface on two different parallel planes; moreover, initially we suppose that the two tubes make an angle of 90 degrees. We consider a circularly-polarized plane wave impinging normally to the interface between air and the previously-mentioned medium, which excites the structure in order to determine the most useful configuration in terms of scattered-field sensitivity. To perform the study, a commercially available simulator which implements the Finite Element Method was adopted. A preliminary frequency sweep allows us to choose the most suitable operating frequency depending on the dimensions of the commercial pipeline cross-section. We monitor the three components of the scattered electric field along a line just above the interface between the two media. The electromagnetic properties of the materials employed in this study are taken from the literature and, since a frequency-domain technique is adopted, no further approximation is needed. Once the ideal problem has been studied, i.e. having considered orthogonal and tangential scenario, we further complicate the model by considering different crossing angles and distances between the tubes, in two cases of PVC and metallic material. The results obtained in these cases are compared with those of the initial problem with the goal of determining the scattered field dependence on the geometrical characteristics of the cross between two pipelines.
One of the practical applications in the field of Civil Engineering of this study may be the use of ground penetrating radar (GPR) techniques to monitor the fouling conditions of water pipelines without the need to intervene destructively on the structure.

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