Geophysical Research Abstracts
Vol. 14, EGU2012-5085, 2012
EGU General Assembly 2012

Electromagnetic sensing for the monitoring of structures and infrastructures: a model for the diffraction by penetrable wedges

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As well-known, the observation of structures and infrastructures by radar remote sensing involves the investigation of the high-frequency electromagnetic scattering by canonical shapes, such as cylinders and wedges. For instance, the ruptures caused by natural disasters can be represented in the form of a wedge-shaped fracture [1]. They modify the electromagnetic response of the scene under investigation and the Geometrical Theory of Diffraction (GTD) can be used as efficient tool for describing this occurrence. Diffraction by a wedge is a well-covered topic in the scientific literature, but the available results mainly concern impenetrable structures.
The aim of this work is to provide Uniform Asymptotic Physical Optics (UAPO) diffraction coefficients in the case of lossless penetrable wedges illuminated by plane waves having normal incidence with respect to the edge. To this end, the original problem is subdivided into two parts relevant to the internal region of the wedge and the surrounding space. For what concerns the evaluation of the field diffracted in the outer region, equivalent electric and magnetic PO surface currents are used as sources in the radiation integral. They lie on the external faces of the wedge and their expressions change in accordance with the incidence direction. As a matter of fact, they involve the reflection and transmission Fresnel's coefficients when one external face is directly illuminated, and only the reflection Fresnel's coefficients if both the external faces are considered. A useful approximation and a uniform asymptotic evaluation of the resulting radiation integrals allow one to obtain the diffraction coefficients in terms of the Geometrical Optics (GO) response and the standard transition function of the Uniform Theory of Diffraction (UTD) [2]. The evaluation of the field diffracted in the inner region is tackled and solved by using equivalent PO surface currents on the internal faces of the wedge. Once such currents are determined, the diffracted field is evaluated by using a method like that employed for the exterior problem.
The UAPO solutions for the diffracted field allow one to compensate the GO field discontinuities in the interior and exterior regions. Furthermore, they are simple to handle and implement in numerical simulators for radar remote sensing. Their accuracy is well assessed by comparisons with Finite-Difference Time-Domain (FDTD) results.

[1] A.I. Kozlov, L. Lighart, A.I. Logvin, "Radar reflection from surfaces with ruptures," Proc. of MIKON 2000, vol. 1, pp. 347-350.
[2] R.G. Kouyoumjian, P.H. Pathak, "A uniform geometrical theory of diffraction for an edge in a perfectly conducting surface," Proc. of IEEE, vol. 62, pp. 1448-1461, 1974.