Geophysical Research Abstracts
Vol. 15, EGU2013-11729-1, 2013
EGU General Assembly 2013

Electromagnetic response of buried cylindrical structures for line current excitation

Lara Pajewski and Cristina Ponti
"Roma Tre" University, Department of Engineering, Rome, Italy (lara.pajewski@uniroma3.it)

The Cylindrical-Wave Approach (CWA) rigorously solves, in the spectral domain, the electromagnetic forward scattering by a finite set of buried two-dimensional perfectly-conducting or dielectric objects [1]-[2]. In this technique, the field scattered by underground objects is represented in terms of a superposition of cylindrical waves. Use is made of the plane-wave spectrum [1] to take into account the interaction of such waves with the planar interface between air and soil, and between different layers eventually present in the ground [3]. Obstacles of general shape can be simulated through the CWA with good results, by using a suitable set of small circular-section cylinders [4]. Recently, we improved the CWA by facing the fundamental problem of losses in the ground [5]: this is of significant importance in remote-sensing applications, since real soils often have complex permittivity and conductivity, and sometimes also a complex permeability.

While in previous works concerning the CWA a monochromatic or pulsed plane-wave incident field was considered, in the present work a different source of scattering is present: a cylindrical wave radiated by a line source. Such a source is more suitable to model the practical illumination field used in GPR surveys. The electric field radiated by the line current is expressed by means of a first-kind Hankel function of 0-th order. The theoretical solution to the scattering problem is developed for both dielectric and perfectly-conducting cylinders buried in a dielectric half-space. The approach is implemented in a Fortran code; an accurate numerical evaluation of the involved spectral integrals is performed, the highly-oscillating behavior of the homogeneous waves is correctly followed and evanescent contributions are taken into account. The electromagnetic field scattered in both air and ground can be obtained, in near- and far-field regions, for arbitrary radii and permittivity of the buried cylinders, as well as for arbitrary arrangements of cylinders in the soil.

As future work, the presented analysis, carried out in the spectral domain, will be extended to a time-domain solution following an approach analogous to the one developed in [6] for pulsed plane-wave excitation.

[1] M. Di Vico, F. Frezza, L. Pajewski, and G. Schettini, "Scattering by a Finite Set of Perfectly Conducting Cylinders Buried in a Dielectric Half-Space: a Spectral-Domain Solution," IEEE Transactions Antennas and Propagation, vol. 53(2), 719-727, 2005.

[2] M. Di Vico, F. Frezza, L. Pajewski, and G. Schettini, "Scattering by Buried Dielectric Cylindrical Structures," Radio Science, vol. 40(6), RS6S18, 2005.

[3] F. Frezza, L. Pajewski, C. Ponti, and G. Schettini, "Scattering by Perfectly-Conducting Cylinders Buried in a Dielectric Slab through the Cylindrical Wave Approach," IEEE Transactions Antennas and Propagation, vol. 57(4), 1208-1217, 2009.

[4] F. Frezza, L. Pajewski, C. Ponti, and G. Schettini, "Accurate Wire-Grid Modeling of Buried Conducting Cylindrical Scatterers," Nondestructive Testing and Evaluation (Special Issue on "Civil Engineering Applications of Ground Penetrating Radar"), vol. 27(3), pp. 199-207, 2012.

[5] F. Frezza, L. Pajewski, C. Ponti, G. Schettini, and N. Tedeschi, "Electromagnetic Scattering by a Metallic Cylinder Buried in a Lossy Medium with the Cylindrical Wave Approach," IEEE Geoscience and Remote Sensing Letters, vol. 10(1), pp. 179–183, 2013.

[6] F. Frezza, P. Martinelli, L. Pajewski, and G. Schettini, "Short-Pulse Electromagnetic Scattering from Buried Perfectly-Conducting Cylinders," IEEE Geoscience and Remote Sensing Letters, vol. 4(4), pp. 611-615, 2007.