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CWA Characterization of Buried Infrastructures

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The Cylindrical-Wave Approach (CWA) is an efficient spectral-domain technique developed for the solution of the full-wave two-dimensional electromagnetic forward scattering by a finite set of perfectly-conducting or dielectric targets, buried in a dielectric half-space or in a finite-thickness slab. In this method, the field scattered by underground objects is represented in terms of a superposition of cylindrical waves. Use is made of the plane-wave spectrum to take into account the interaction of such waves with the planar interfaces between air and soil, and between different layers in the ground. Suitable reflected and transmitted cylindrical functions are defined. Adaptive integration procedures of Gaussian type, together with acceleration algorithms, are employed for the numerical solution of the relevant spectral integrals. All the multiple-reflection and diffraction phenomena are taken into account.

The CWA may deal with both TM and TE polarization fields. It can be applied for arbitrary values of permittivity, size, and position, of the targets. Obstacles of general shape can be simulated, by means of a suitable set of small circular-section cylinders. Since the CWA is implemented in the frequency domain, dispersive soils can be modelled. The technique has been extended to study the scattering of an incident pulsed wave, with a rather general time-domain shape. The method is accurate and fast, therefore it may be exploited in iterative algorithms for the solution of inverse problems.

In this work, new results are presented, showing the effectiveness of the method for the sensing of cylindrical inhomogeneities buried in the earth. An electromagnetic characterization is performed, in both the frequency and time domains, of suitable scenarios in the context of civil engineering applications. In particular, the scattering by buried utility lines, metallic and dielectric pipes, conduits, and tunnels, is studied. Moreover, the scattering by reinforced concrete is considered.

References

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