Analysis of UWB Scattering from Dielectric Objects Buried in a Lossy Layered Ground using FDTD and TLM

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In this paper we investigate the use of the finite difference time domain (FDTD) and the Transmission Line Matrix (TLM) methods for analyzing the time domain ultra-wideband (UWB) scattering response from a dielectric object buried in a lossy layered ground. The main purpose of this research is to investigate the scattering features available in such a response which could be used to detect/identify buried land-mines. It is important that a numerical analysis of the problem not introduce any computational artifacts into the scattered signal which may obscure salient and sometimes subtle scattering features which are important to the detection/identification problem. Both the FDTD and the TLM methods have been used in the past for such a purpose (see for example [1] and [2]). In [1] the problem analysed was a scaled experimental model which was enclosed in a conducting box. The main purpose was to validate the numerical FDTD results using experimental results. The FDTD mesh was terminated in PEC (perfect electric conductor) boundary conditions and the effect of using ABC's (absorbing boundary conditions) to truncate the mesh was not encountered. In [2] the TLM method was applied to quantify the interaction of an electrically short dipole source and various conducting objects buried in the ground. The quantification was limited to the change in dipole input impedance caused by the presence of the object and lossy ground. For reliable identification, more information such as that contained in the UWB response is required.

In order to investigate a realistic UWB ground penetrating radar (GPR) application we must first evaluate the effect of ABC's when they are used to truncate a mesh in which an infinite lossy layered ground is being modelled. We first compare the FDTD and TLM solutions of an electric dipole above a lossy layered ground (with no buried object) to a semi-analytic frequency domain solution using the transfer matrix formulation. The comparison includes the use of the various ABC's, such as the perfectly matched layer (PML) and Mur's first and second order ABC's, found in the literature. The effect of implementing dispersive ground layers is also studied for its effect on the performance of the ABC's.

Next we calculate, using FDTD and TLM, the time domain scattering from various dielectric objects with dimensions and material properties chosen to represent typical land-mines. The scattered signal is investigated for features which can be used for detection/identification of the land-mines. A complete system, including UWB transmitting and receiving antennas, is analyzed. The effect of the antennas on the scattering features of the targets is investigated.

References

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