

Modeling Vibrating Boundaries with the Finite-Difference Time-Domain Method

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Over the past two decades, the finite-difference time-domain (FDTD) method has been widely used to model wave propagation, scattering, antennas, high-speed circuits, ground penetrating radar systems, etc. However, very little discussion has been given to modeling moving or vibrating boundaries. In this work, modeling of vibrating material boundaries is investigated using the FDTD method. This investigation is part of a project in which a land mine detection system that simultaneously uses both acoustic and electromagnetic waves is being studied. The system consists of an electromagnetic radar and an acoustic source. An acoustic wave is induced in the earth that travels through the earth and interacts with the mine; this causes the surface of the earth and the mine to vibrate. These vibrations are different near the mine. The radar is used to detect the vibrations and, thus, the mine. The vibrations are difficult to model with the FDTD method; because they are very small, and their frequency and propagation velocity are many orders of magnitude less than those for the electromagnetic waves.

A two-dimensional FDTD code has been written to study the feasibility of using the FDTD method for modeling the vibrating surfaces. A diagram of the model is shown below. An electromagnetic plane wave is injected and its reflection is recorded at the positions indicated. The acoustic wave travels across the surface and causes the surface to be displaced (vibrate). The reflected electromagnetic waves are recorded both when the acoustic wave is and is not present. The displacements are obtained by comparing the phase of these reflected electromagnetic waves. Displacements as small as 10^{-8} of a FDTD cell have been detected using this method, and displacements have been detected as a function of time and position for acoustic waves traveling across the boundary.

