Characterizing surface wave propagation over roadbeds using a Finite Difference Time Domain Method

Joseph W. Schuster*, Stephen A. Fast, James F. Stack, Jr. and Ruth S. Belmonte
Remcom, Inc., State College, PA, 16801, http://www.remcom.com

This paper used the moving window finite difference time domain (MWFDTD) method to analyze propagation between near to the ground antennas over various types of surfaces. Of particular interest is the interaction of the electromagnetic energy and the layered media that are used in road construction. Because the skin depth at certain low VHF frequencies is often larger than the depth of the surface material, modeling the layers is required. The MWFDTD method allows detailed modeling of the propagation effects caused by the roadbed layers. At these frequencies over distances of a few hundred meters, the surface wave component is significant for some materials and not others. When both the transmitter and receiver antennas are located very close to the earth's surface, the direct and ground reflected terms in the space wave nearly cancel each other, and transmission is by means of the surface wave. Although the Norton-Sommerfeld surface wave formulas or the Parabolic Equation method can be applied to surface wave propagation over a smooth, homogeneous, lossy ground, the impedance boundary condition methods may not be valid for layered media.

A variety of methods have been applied to the prediction of radio propagation over irregular terrain. For the widely used ray-based models, it is recognized that the results must be based on several levels of approximations. These approximations typically include homogeneous atmosphere, a simplified approximation to the terrain variations, and approximate reflection and diffraction coefficients. For some situations the ray-based methods provide sufficient accuracy. In other situations they do not, and must be augmented by other calculation methods. A full wave oriented approach to modeling radiowave propagation based on extended finite difference time domain (FDTD) method can accurately account for all of the aforementioned effects of the physical environment on propagation between near to the ground antennas. The use of a full wave method also eliminates the need to make many of the approximations that other methods require. In the past full wave methods have not been used for propagation predictions due to the large amount of computation time and memory that would be required. However, the Moving Window FDTD (MWFDTD) method overcomes these restrictions by taking advantage of the fact that when a pulsed radio wave propagates over a long distance the significant pulse energy exists only over a small part of the propagation path at any instant of time. This allows the use of a relatively small FDTD computational mesh that exists only over a portion of the propagation path and moves along with the pulse. At the leading edge of the FDTD mesh inside the moving window the appropriate surface and atmospheric parameters are added to the mesh. At the trailing edge the surface and atmosphere that have been left behind by the pulse are removed.

The propagation path loss between 50 and 300 MHz is computed and compared for several types and configurations of roadbeds exhibiting different materials and thicknesses. The losses are studied in the lower ten meters of a 200 meters path from various types and heights of antennas.