Effect of Antennae Polarization Relative to Tunnel Orientation on Electromagnetic Wave Scattering due to Underground Tunnels

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Introduction

In this paper, the challenge of underground tunnel detection, with potential applications of preventing prison escapes, illegal immigration, and drug trafficking is studied. Human and drug trafficking at the border have always been a concern. Real-time monitoring of the ground around the borders and prisons has always been a need. Underground tunnels have also become a homeland security threat, especially due to an ever-emerging threat posed by international terrorism.

Previous research has shown strong potential for tunnel detection using radar with detecting deep and small tunnels as most challenging cases. The goal of this project is to study the effect of antennae polarization relative to tunnel orientation and its use as a tool to overcome this challenge. Most tunnels are usually horizontal or slightly sloped, but their orientation may not be known. Therefore, a versatile tunnel detection technology requires above surface transmitting and receiving antennas with rotating horizontal polarizations. At first, the problem is theoretically explored by producing an RF model in COMSOL-Multiphysics, then, it will be validated by the experimental results.

To study the wave propagation and scattering in soil surrounding tunnels experimentally, the two antennas should be placed vertically across the ground profile and tunnel. Although, this experimental configuration may be most desired, it is not practical. Therefore, an equivalent configuration of the setup (Figure 1) is used by rotating the field configuration by 90^{o}. In this configuration, the horizontally polarized antennas from the field are equivalent to the vertically polarized ones in the lab (Figure 1), if the tunnel is placed in a vertical plane, perpendicular to the plane of the two antennas at different orientation not parallel to the antennas.

COMSOL RF-module is used to model the experiment with a dipole transmitting antenna as the source, which is later placed in a cube surrounded by PML boundaries of the type Cartesian as the absorbing boundary condition. Finally, the simulated scattered field will be validated with the experimental measurements. A picture of the experimental setup is shown in Figure 2.

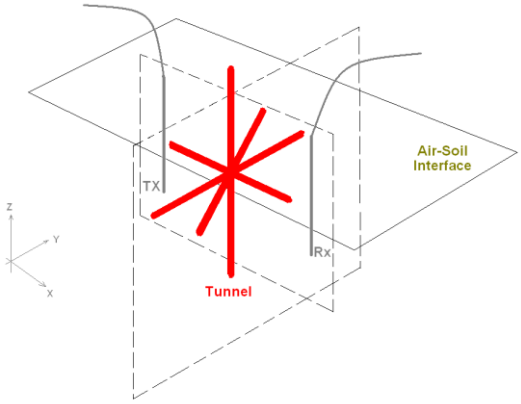

Figure 1. A schematic of experimental setup

Figure 2. Soil filled box insulated with grounded tin foil