# Numerical Modeling of Magnetic Field Emissions From Am HDD Walkover Locating System

A. Jaganathan[1], J. Montoute[1]

[1]Louisiana Tech University, Ruston, LA, USA

## Abstract

Introduction: Horizontal directional drilling (HDD) is a popular construction technique employed to install underground utilities such as pipes, electrical and fiber optic cables. First, a borehole is created in the ground using a boring tool (drill head), and the utility to be buried is pulled back through this hole [1]. In practice, the drill head often deviates from its intended path during drilling. Therefore, it's crucial to keep track of the drill head precisely so that accurate 'as-built' records can be created. In a HDD walk-over locating technology commonly used to locate a drill head within soil a dipole transmitter called 'sonde' is placed within metallic casing of the drill head, and the magnetic field emitted by it (usually below 80 kHz) is measured at the surface using a handheld device [2]. Simplified closed-form solution of a dipole field is used as the model for these sondes [3, 4].

However, those analytical solutions are limited to ideal situations. Often the interaction of these fields with ferrous objects located in the vicinity, especially in a crowded urban setting, causes interference and a detailed modeling is necessary to understand these situations so that the performance of these devices could be improved. In this paper, a detailed numerical simulation of a realistic HDD drill head tracking system is presented. Numerical solutions are validated by comparing them against experimental measurements conducted using an actual drill head and also with the existing closed-form solutions. After validations, a parametric study is undertaken to simulate a few practical scenarios expected in the field.

A numerical model of the sonde integrated within a realistic drill head attached to a short drilling rod was created using COMSOL Multiphysics® software, its AC/DC Module, and the Magnetic Fields physics interface, and solved using the frequency domain solver. Ferrite loaded multi-turn coil antenna in the sonde was modeled using Coil Geometry Analysis and magnetic field within a confined volume was calculated to mimic a HDD operation. Figure 1 shows photograph of a drill head with sonde and its geometry created using COMSOL software.

Results: The numerical results were first validated by comparing them against experimental and closed-form solutions for an ideal condition. Coil current in the sonde was measured and used as an input parameter in the numerical model. Numerically predicted coil parameters including inductance were compared against the measured values and lumped model approximations. Finally, vector components of the magnetic field around the drill was measured at particular distances using a 3-axis receiver and

compared against the COMSOL results. Screenshot from the COMSOL model showing field lines emanating from the drill is shown in Figure 2.

Conclusion: The numerical results showed good agreement with the experimental and analytical solutions for an ideal test case studied. In this paper the model validated till date will be used to simulate few practical real-world conditions that could affect the performance of these tracking systems. The results presented are expected to help HDD practitioners to better understand the magnetic field interactions in a crowded urban environment and eventually improve the practice.

## Reference

1. H.J. Bayer. HDD practice handbook. Vulkan-Verlag GmbH, 2004.

2. J. E. Mercer. "History of Walkover Locating Technology." International Construction & Utility Equipment Expo, Louisville, KY, 1997.

3. J. E. Mercer. "Walk-over locating technology." No-Dig 2000 Conference, Perth, Australia. 2000.

4. M. F. Gard. "Magnetic field sensing in the underground construction environment." Sensors for Industry Conference, 2002. 2nd ISA/IEEE. IEEE, 2002.

## Figures used in the abstract

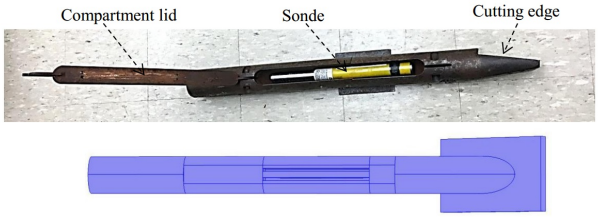


**Figure 1**: Photograph of sonde placed inside a HDD drill head along with its geometry model created using COMSOL software (drill head compartment lid is left open to show the inside).

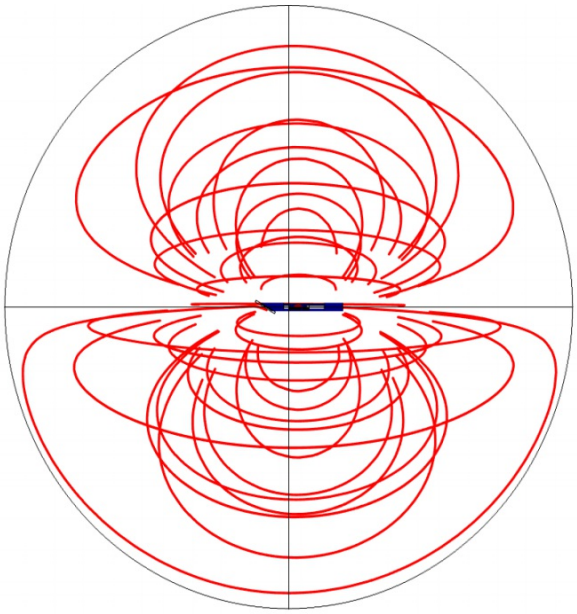

**Figure 2**: Results from the COMSOL model showing magnetic field lines emanating from the drill head.