A Microstrip Wideband Antenna for Underground Applications

Daniel Kim*, Gregory Makar, and Tutku Karacolak
School of Engineering and Computer Science
Washington State University Vancouver
Vancouver, WA 98686, USA

Designing antennas for underground use is a challenge due to the material the antenna will be buried in, most commonly soil. Dielectric properties such as relative permittivity and loss tangent of soil change with many factors that include moisture content, soil composition, temperature, salinity, etc. Any change in these environmental factors will affect the antenna performance through frequency shifting and more. Thus, a wideband antenna is needed to ensure desired frequencies remain operational with minimal signal loss. Additionally, lower frequencies of operation are necessary for acceptable communication as path loss increases at higher frequencies and lead to a significant degradation of transmission range. However, this also requires antenna miniaturization techniques due to the increase in antenna size.

In this study, a wideband spiral microstrip antenna is presented to operate in the mid-high MHz range (500 – 800 MHz) for underground applications. The current antenna design has dimensions 80 x 65 x 1.5 mm^3. A spiral configuration was selected for the conductor to achieve a wideband operating range and smaller size. The antenna is fed by a 2.9 mm wide feed line, sized to approximate 50 Ω matching impedance, and a coaxial SMA connector is used to feed the antenna. The design was created manually under a parametric approach in ANSYS HFSS. Each configuration of the antenna was then fabricated and several were tested in multiple soil samples with varying moisture contents. Under these different soil types, the tested antennas demonstrated a shift in operational frequencies of approximately 100 – 150 MHz, justifying the need for a wideband configuration. Additional designs were developed to lower the lowest operating frequency and improve various parameters, including the bandwidth of the operating range, the impedance matching characteristics, and an omni-directional radiation pattern. The current design has its operating frequency at approximately 700 MHz, with a bandwidth of 200 MHz, which is sufficient to ensure the observed operational frequency shifts do not significantly interfere with the antenna's operating range.