

Optimization of UHF Cavity-Backed Slot Antenna Buried in the Earth

Arslan A. Nizami⁽¹⁾, Hugo G. Espinosa⁽¹⁾, and David V. Thiel⁽¹⁾

(1) School of Engineering and Built Environment, Griffith University, Queensland, Australia
(arslan.nizami@griffithuni.edu.au)

Antennas buried at shallow depths are relatively immune from high temperatures caused by fire. However, the frequency and radiation efficiency are impacted by the soil properties. In this study, a Cavity Backed Slot Antenna was optimized, using FEKO, to improve the antenna response in an underground-to-above ground communication link. The slot antenna was constructed using a rectangular aluminium box with a half-wave slot positioned at the centre of the smallest face. This robust design provides protection against mechanical damage, moisture and extreme temperatures. The design of the antenna was approximated through the size of the metallic cavity, the position of the feed and the size of the radiating slot at 2.4GHz (see Nizami, Espinosa & Thiel, “A UHF cavity backed slot antenna buried in sand”, Australian Microwave Symposium, February 2025). The antenna and the numerical model are shown in Figure 1.



Figure 1. Slot Antenna (left) and FEKO computer simulation model (right).

Underground propagation has been explored for numerous applications such as soil monitoring, mine environments, subways, sewer systems and precision agriculture. Electromagnetic (EM) wave propagation in soil and sand has been a growing interest for researchers around the world with a specific interest in EM techniques for modeling signal propagation.

King et al (2012) *Lateral electromagnetic waves*, Springer Verlag, calculated the EM field components from a buried source at the surface, including the reflected, refracted and lateral waves. The principal equation for the vertical E field antenna beneath the earth surface to a vertical E field antenna in air on the surface has been modelled for various media including sand and soil.

This work aims to quantify the relationship between antenna resonant frequency and the electromagnetic properties of the surrounding materials. The resonant frequency and bandwidth calculations guide designers to the most efficient subsurface radiation source.