# INVESTIGATING EMI RESPONSES FOR WIRES TO ENHANCE TUNNELS DETECTION

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Tunnels detection and monitoring remains number one problem for the military. Recently, wideband electromagnetic induction (EMI) sensing technologies, which operate from 50 kHz up to 15 MHz, have been identified as one most promising technology for locating tunnels. The system uses few frequencies and senses buried wires or other metal infrastructures in tunnels. In order to further improve the system's performance for tunnels detection, particularly in urban areas, first we need to investigate underline physics of EMI responses for wires and use these understating a new sensor design and optimization. In this paper we will studied wideband EMI responses for wires. During electromagnetic fields induction and scattering, an external primary electromagnetic field induces currents in metallic objects. The total electromagnetic force that exerts on electrons in the metals, according to the Lorentz's force equation consists two electric $\mathbf{F_e}=e\mathbf{E}$ and $\mathbf{F}_m = e[\mathbf{u} \times \mathbf{B}]$ magnetic forces. Where $e$ - electron charge, **E** and **B** are the total electric and magnetic fields, respectively, **u** is velocity. At low frequencies the electric field is small and because in metals, conductivity and electron mobility is high, the electric field force $\mathbf{F}_e$ is smaller than the magnetic field $\mathbf{F}_m$ force. As a result, the magnetic $\mathbf{F}_m$ force, which is perpendicular **u** velocity and **B** magnetic field, pushes electrons to move from interior volume of the metal towards its surface. In turn, the electrons form eddy currents (**J**), i.e. div **J**=0. The induce eddy currents produce magnetic field, which oppose the changing flux inside the object. As frequency increases electrons are redistributed in such a way as to make total electric **E** and magnetic **B** fields zero inside the conductor as well as the tangential $\mathbf{E}_t=0$ and normal $B_{\mathbf{n}}=0$ components of the electric and magnetic fields on the surface. In addition, at high frequencies the electric field force overcomes the magnetic field forces, which in return distributes electrons parallel to the conducting objects surface. These electrons form surface currents along the surface and accumulate charges at sharp edges. To illustrate this phenomenon, in this paper we will demonstrate modeled and actual data for wires at different frequencies. In addition, we will show comparisons between modeled and actual data for buried different size wires.