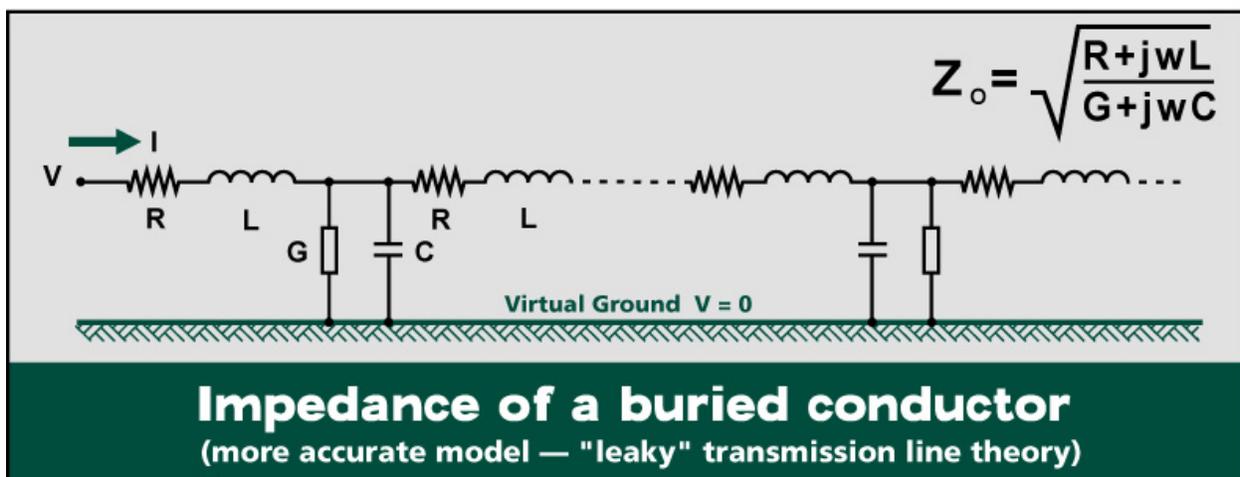
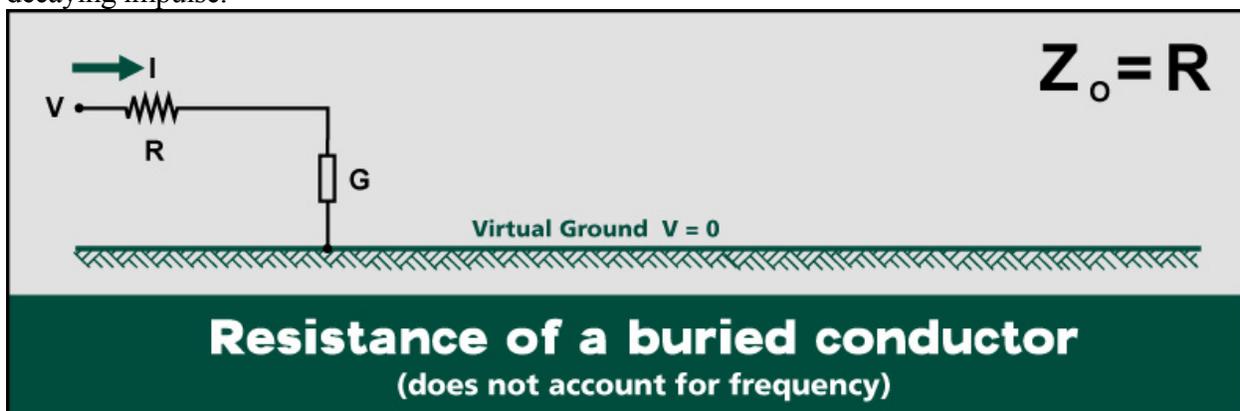


Ground Resistance or Impedance?

The goal of any grounding system is to provide a low impedance path for fault or transient currents to the earth. “**Grounding**” may be described as the process of making this electrical connection to the general mass of the earth. The characteristic primarily determining the effectiveness of a grounding system is the impedance this connection provides to the earth.

The importance of ensuring that the system provides a low earth *impedance*, and not simply a low earth *resistance*, must be understood. A spectral study of the typical waveform associated with transient impulses such as those characteristic of lightning and switching surges, reveals both high frequency and low frequency components. The high frequency is associated with the extremely fast rising "front" of the transient while the lower frequency component resides in the long “tail” of the decaying impulse.



A grounding system appears to such transient events as an impedance rather than simply a resistance. Correct interpretation of the effectiveness of this ground system requires an understanding of transmission line theory where the normal rules of wave propagation and group velocity apply. A low impedance grounding system is only achieved by considering the roles played by each of resistance, capacitance and inductance within the system.

The *capacitance* of the ground system dominates during the steep rising front of the impulse by providing a path to ground for these high frequency components. To assist this process, the capacitance of the ground system should be maximized. In practice this means that the surface area of contact made with the ground, must be as large as possible. The use of flat conductors instead of round, buried metal plates, meshes and ground enhancing materials (which effectively increase the surface contact of driven rods) are all ways of increasing the capacitance of the ground system's coupling to true earth.

The *inductance* of the ground system dominates during the rapid change of current with time as the current is injected into the earth. The voltage developed due to the inductive term is given by $L di/dt$. This may become dangerously large, creating the risk of a flash over, if attention is not paid to ensuring that inductance is minimized in the system. Sharp bends in down conductors and bonding connections should be avoided and the use of flat conductors, instead of radial ones, encouraged.

Finally, the *resistance* of the contact to the earth medium is particularly important during the decaying "tail" of the surge as this is where the large energy content (Joules) of the impulse resides. A low resistance contact ensures the safe dissipation of this excess energy into the ground. In practice this can be achieved by using longer driven rods, multiple rods, or by encasing the rods with conductive ground enhancing materials.

In summary - an effective ground system should exhibit a low impedance, rather than simply a low resistance, thereby ensuring it maximizes the dissipation of both the high and low frequency components characteristic of surges and fault transients.