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Magnetic Field Inductive Coupling and Electric Field Capacitive Coupling: Right-of-Way Pro versus MultiFields

Introduction

SES offers two software products that calculate voltages transferred from energized power lines to non-energized metallic conductors, such as de-energized power line circuits under maintenance, pipelines, railways, communications cables, fences, etc. In both cases, the software accounts for magnetic field inductive coupling, electric field capacitive coupling and through-earth conductive coupling. These two products, MultiFields and Right-of-Way Pro, are compared below.

MultiFields

Data entry into the HIFREQ component of MultiFields is much like that of MALT and MALZ, i.e., the user describes a network of conductors in three-dimensional space, either by typing their Cartesian coordinates, or by importing them from a CAD file (in DXF format), or by drawing them with a mouse, or a combination of these methods. Unlike MALT and MALZ, HIFREQ allows aboveground conductors to be modeled in addition to buried conductors. Another important difference is that HIFREQ considers not only conductive, through-earth coupling between conductors, but also accounts for magnetic field inductive coupling and electric field capacitive coupling, thus providing a complete and accurate prediction of the interactions between the conductor systems modeled. Furthermore, HIFREQ allows conductors to be energized by the specification of either a GPR (ground potential rise) or a longitudinal current flow. Finally, HIFREQ computes not only current flows and GPR values for all conductors modeled, it also computes earth and air potentials, electric field levels and magnetic field levels at user-specified locations.

With this powerful program, which solves Maxwell's equations numerically for a system of conductors that can just as well be a substation, complete with grounding system and overhead busbars, or a power line corridor, complete with multiple overhead lines, pipelines, railways, communication cables and lattice towers, you can perform EMF analyses, AC interference studies, and grounding studies. If you add the FFTSES program to HIFREQ, you can decompose transient/lightning waveforms into their frequency components, run HIFREQ, then reconstitute the time-domain response of the system you are studying.

For AC interference studies, particular advantages of HIFREQ include the simplicity of data entry and the seamless calculation and combination of inductive, capacitive and conductive components together.

When compared with Right-of-Way Pro, the primary limitation is the representation in each simulation of a single soil structure, which can be uniform, two-layer, or multi-layer for the entire corridor. Thus, depending upon the application, more than one run may be necessary, if the soil structure changes significantly throughout the corridor.

Right-of-Way Pro

Right-of-Way Pro is specifically designed for AC interference studies. Based on the TRALIN and SPLITS engineering software modules, it can rapidly model a corridor in which multiple energized and de-energized power line circuits and other utilities run alongside one another, at varying separation distances, for hundreds of miles. Based on a circuit model of the joint-use corridor, Right-of-Way Pro computes voltages and currents occurring in all circuits and parallel metallic conductors, throughout the corridor, accounting for magnetic field inductive coupling and electric field capacitive coupling. With the MALZ module, conductive through-earth coupling is addressed as well. The newest version of the MALZ engineering module supports the combined conductive and inductive interference effects through the EMF energization feature that can be imported directly from Right-Of-Way. In other words, the Right-of-Way package can now be used to conduct complete AC interference studies under fault conditions, including inductive, conductive, and capacitive couplings. A new "Total Interference" module was introduced. This module generates a MALZ file (the Total Interference Model) that includes an EMF

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(calculated with SPLITS) applied to selected conductors. The computation results for this MALZ file thus contain both the inductive and the conductive components of the interference.

Typical applications are gas pipeline, railway or communication cable induction studies and safety studies involving de-energized circuits running parallel to energized circuits. Right-of-Way Pro examines both load and fault conditions, automatically running faults throughout the entire length of any energized circuit and plotting the maximum induced voltages occurring in the other metallic structures modeled, throughout the length of the joint use corridor.

For the determination of through-earth coupling and for the design of mitigation, Right-of-Way Pro provides the MALZ software module, which can accommodate any number of soil layers, coated conductors, pipes, and account for longitudinal voltage drop in conductors due to their non-zero impedance. The RESAP software module is also provided for the transformation of soil resistivity measurements into a layered soil model that can be used by MALZ.

Right-of-Way can accommodate changing soil characteristics throughout the entire length of the corridor under study. Furthermore, Right-of-Way runs the inductive and capacitive coupling calculations very quickly.

Data entry into Right-of-Way consists essentially of entering typical cross-sectional configurations of each power line, along with the electrical characteristics of each conductor, and then specifying the map coordinates of the center lines of each power line and other metallic structure modeled. Other details, such as ground impedances, interconnections between conductors, source voltages or currents, desired fault locations (if any) etc. are also specified to complete the circuit model. Right-of-Way can model pipe-enclosed groups of cables, with each cable consisting of three concentric elements.

When compared with HIFREQ, the primary limitation of Right-of-Way Pro is the approximation it introduces through its use of an enhanced version of Carson's equations, rather than a direct solution of Maxwell's equations. Furthermore, for simple studies, data entry in HIFREQ is more rapid and more intuitive.