

Automated System Design Structure

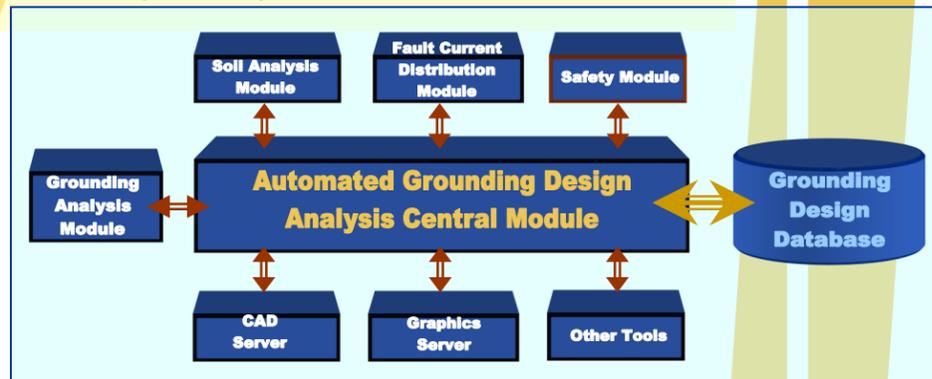
The automated grounding system design software integrates the following modules and has a structure as shown below.

Automated System Design Central Module

This core and controlling module has a simple interface that allows a user to establish an automated grounding system design quickly and efficiently. The ultimate objective of this module is to manage and coordinate input data, safety criteria and progress decisions in order to obtain a grid design that meets all requirements. The overall automated design parameters are controlled by this module to select the methodology used to obtain the initial design of the grounding systems, specify which grid database methodology is to be used for the automated design, and specify the maximum number of design iterations as well as the rate at which the design of the grid evolves.

Grounding Analysis Module

The main mode of operation of this module is used to analyze power system ground networks subjected to DC or AC currents discharged into soil. It computes the safety performance of the grounding grid, in terms of GPR, touch and step voltages. Furthermore, the Estimator, Configuration and Dimension Predictor modes allow users to quickly and accurately estimate the resistance of various grounding systems (grids, plates, array of rods, star and hemispherical electrodes, circular rings, etc.) or determine the size (dimension) or configuration that meets a target resistance value.



AutoGroundDesign

Soil Analysis Module

This module is dedicated to the development of equivalent earth structure models based on measured soil resistivity data. It can generate models with many horizontal layers, as well as vertically and exponentially layered soil models.

Fault Current Distribution and Line Parameter Analysis Module

This module calculates the fault current distribution in multiple terminals, transmission lines and distribution feeders using minimum information and a simple set of data concerning the network. It provides the actual fault current flowing into a grounding grid, as well as currents in the shield wires, tower structures and cable sheaths. Self and mutual impedances of shield wires and cable sheaths are also computed by a built-in line constant module.

Safety Module

This module generates safety threshold values based on IEEE Standard 80, IEC Standard 479, user's own standard or a hybrid combination of these standards. The computed safety voltage limits are used to decide whether to stop or continue the design process. The safety voltage limits are: fault clearing time, earth surface covering layer (e.g., crushed rock) resistivity, earth surface covering layer thickness, equivalent subsurface layer resistivity (this is the resistivity of the soil beneath the earth surface covering layer), body resistance, optionally specified foot resistance and resistance of protective wear, such as gloves or boots, and fibrillation current threshold computation method.

View, Plot and Report Tools

A CAD-based module is used to view or edit three-dimensional grounding grids consisting of straight-line segments. The line segments represent either metallic conductors or observation profiles. They can be viewed from any direction, in a variety of ways. A powerful and flexible report and graphics module serves as an integrated output processor to display the computation results in various graphical or print formats. This module also has the capability to view the input data and even launch the grounding analysis module.

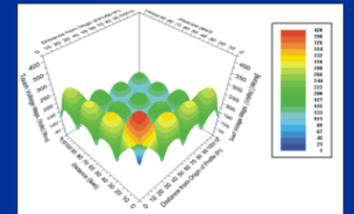


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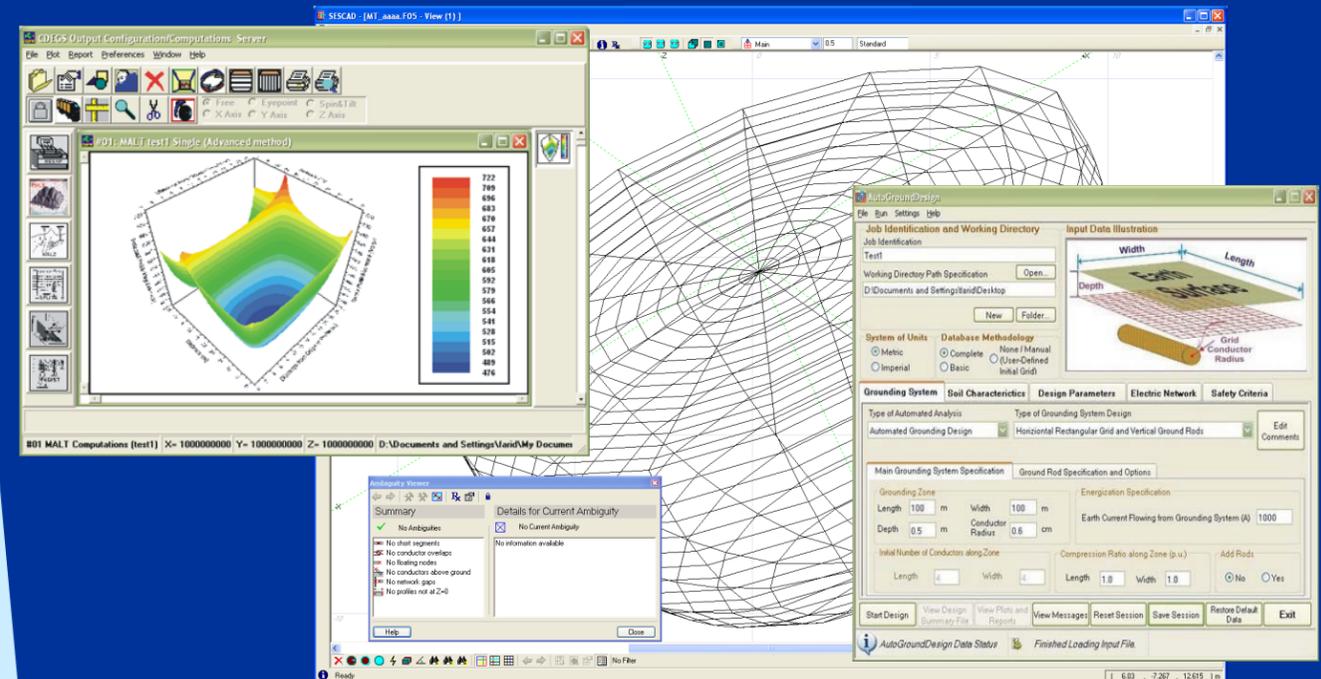
AutoGroundDesign®

Design Safe Grounding Installations Quickly and Efficiently

The AutoGroundDesign engineering tool is the only fully automated software package that can analyze and design grounding / earthing systems without the intervention of the user between various phases of the design thanks to its intelligent database driven algorithms.



Touch Voltages



- Integration of soil resistivity, fault current distribution, and delayed safety assessment analyses during the grounding design automation;
- An innovative graphical interface that defines the network ;
- A powerful iterative approach and improved observation point selection procedure that speed up computation time;
- A robust and flexible grid and rod creation procedure that allows the specification of unequally spaced grids and rods;
- Complete observation profiles for the entire grid are automatically turned on in the final stage of the design process only.

AutoGroundDesign

AutoGroundDesign

This new software package offers powerful and intelligent functions that help electrical engineers design safe grounding installations quickly and efficiently. A two-step approach is used for the automated grounding system design. The grid database is, optionally, the starting point of any automated design and will cover most grids that are encountered in practice. Next, the initial design is refined recursively using rule-based techniques and algorithms to improve its performance and meet safety constraints, while reducing the overall cost of the grid. Extensive collections of predefined grids have been

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analyzed, constructed and can be easily updated by the user. A strategy has been devised to quickly find an appropriate grid, while at the same time minimizing the size of the database. The time devoted to design a safe and cost-effective grounding grid is minimized by the use of such automation techniques and appropriate databases.

Introduction

The design of grounding systems is often based on rough guidelines, derived from engineering experience. It is frequently a trial-and-error procedure and can be quite time-consuming, since it is too difficult to account for the large number of variables (geometrical proportions of the grid, its depth, the nature of the soil and of the grid's conductors, whether or not grounding rods are attached to the grid, etc...) that can affect the grid's performance. The ultimate objective of AutoGroundDesign is to use a database and rule-based automated grounding system design method to meet design requirements (such as ground potential rise, touch voltage, step

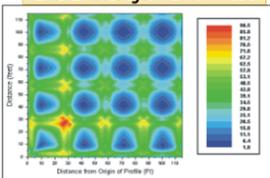
voltage, and ground resistance limits), given the soil structure, dimensions of the grid area, characteristics of conductors, configuration of the grid, and fault current discharged by the grid.

Features

AutoGroundDesign has the following unique features:

- Generates grounding system designs based on a simple description of the substation site. The data entry requirements are reduced to a minimum: environment settings, soil data, grounding grid zone, fault current in the grid, safety related data, and automated design parameters & controls.
- Models grounding systems and evaluates their performance; it is suited to analyze and design a grounding grid as long as the longitudinal impedances of the ground conductors can be neglected.
- Analyzes and designs rectangular grounding grids consisting of horizontal and vertical arrangements of bare conductors buried in uniform and multilayered soils.
- Carries out automated design with several procedures, such as Automatic, Midpoint, Linear, and User-Defined methods. These procedures will specify the performance and progress of the automated design process appropriately and use ground grid databases, smart search algorithms and techniques, and user-supplied criteria and constraints more efficiently.
- Allows users to specify if ground rods are to be used in the design of the final grid and ground rod characteristics. If yes, the rods can be distributed along the edges of the grid or over the whole grid area, as desired.

Touch Voltages above Grid



- Computes earth potentials at specific soil locations called observation points that are determined automatically by the program.
- Offers three other modes of operations, namely, the Estimator, Configuration and Dimension Predictor modes that allow users to quickly and accurately estimate the resistance of various grounding systems (such as grids, plates array of rods, star electrodes, circular rings, etc.) or predict the size (dimension) or configuration of the grounding system that meets that resistance.

Program Development History

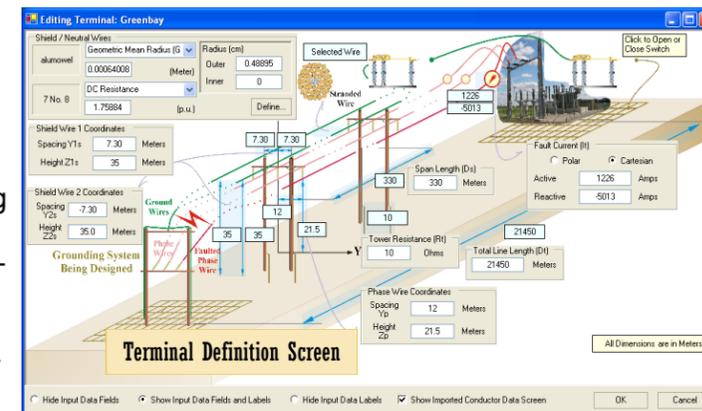
SES implemented the first automated grounding grid design software in the early 90's. It had a character-

based menu interface and was restricted to rectangular grids buried in uniform and two-layer soils. Computation time was the main obstacle to the systematic use of this software. Since then, SES has developed a new and unique automated design method that reduces considerably the time needed to determine an adequate design for arbitrarily shaped grounding systems buried in various soil types.

The easiest way to carry out a grounding system design is to find somebody else to do it for you. However, if you can not find somebody competent enough to do it, then you can rely on AutoGroundDesign...

Grounding System Design Technologies and Procedures

Consider the traditional process of designing a substation grounding system. Based on experience and on the substation ground bonding requirements, a preliminary grounding system configuration is developed and analyzed. The calculated results are examined to determine if all design requirements are met. If all design requirements are not met or if these requirements are exceeded by a considerable margin suggesting possible significant savings, design modifications are made to the grounding system and the design analysis is started again. To produce an optimized design, better knowledge of the soil structure and the actual fault current flowing into the substation is needed. Also, a large number of factors such as the geometrical proportions of the grid, its depth, the type of grid conductors and whether or not



grounding rods are attached to the grid are essential.

The automated grounding system design uses the following technologies and procedures.

First, an appropriate preliminary grid design is selected and retrieved from a database of predefined grids,

based on the input data provided, such as the size and the geometrical proportions of the grid, the soil structure, the fault current injected, and the safety criteria. These predefined grids have been previously analyzed and stored in databases which contain grid performance information in uniform and layered soil models. The database can be dynamically updated based on the currently analyzed grounding systems.

Second, this initial design is refined automatically and dynamically by varying the number of horizontal and vertical conductors in the grid in an attempt to improve its performance and meet the safety constraints, while reducing the overall cost of the grid. Note that the real soil model (not the equivalent layered soil used in the database search) is used in this process. The analysis and

safety evaluation are carried out by a grounding analysis module. The ground potential rise (GPR), touch and step voltages are computed and compared to the maximum values given by the IEEE or IEC standards, or by user-supplied thresholds. Horizontal or vertical conductors are added or removed depending on the GPR, touch and step voltage deviations from the desirable safe values. The method used to conduct the design refinement steps employs appropriate functions to

The new soil resistivity measurement analysis, fault current distribution analysis, and safety assessment modules provide a fully integrated and automated design that is unique in the industry. The time devoted to design a safe and cost-effective grounding grid is significantly minimized by the use of the efficient automation techniques.

The process provides a manual option that allows the user to specify an initial grid design defined by the number of conductors along the grid sides and the characteristics of the conductors and rods. The program then refines this grid automatically.