

USER'S MANUAL



# Getting Started with SES Software Packages



SES



## REVISION RECORD

Date	Version Number	Revision Level
September 1996	1	0
October 1996	1	1
December 1997	2	0
December 1998	7	0
January 1999	7	1
January 2000	8	0
September 2000	9	0
November 2002	10	0
May 2004	11	0
February 2007	13	0
June 2009	14	1
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December 2019	16	2
February 2022	17.1	0

## SPECIAL NOTE

*Due to the continuous evolution of the CDEGS software, you may find that some of the screens obtained using the present version of the CDEGS package are slightly different from those appearing in this manual. Furthermore, small differences in the reported and plotted numerical values may exist due to continuous enhancements of the computation algorithms.*

Address comments concerning this manual to:



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# 1 Introduction

## 1.1 Intended Readers

This manual is intended for all users of SES software, i.e., the CDEGS software package and its subpackages (AutoGround, MultiGround, MultiLines, and MultiFields), and all other fully integrated software packages (AutoGrid Pro, AutoGroundDesign, CorrCAD, Right-of-Way, SESEnviroPlus, SESShield-2D, SESShield-3D, and SESTLC) and associated tools running on Microsoft Windows. Note that this manual uses the brand name CDEGS to designate all SES software packages. CDEGS stands for “Current Distribution, Electromagnetic fields, Grounding, and Soil structure analysis.”

## 1.2 Objective of this Manual

The objective of this manual is threefold:

- To introduce the user to SES software packages and tools.
- To show the user how to use SES software in the Windows environment.
- To guide the user through the most pertinent documents included in the **Documentation** shortcut folder that comes with SES software

## 1.3 Organization of this Manual

This manual is organized as follows:

### **Introduction:**

*Chapter 1* Introduces SES software, its structure, available documentations, and technical support.

### **Getting Started:**

*Chapter 2* Describes the capabilities and features of all software packages, software tools, and utilities and briefly describes how to start all SES software packages.

### **Using the CDEGS Group of SES Software:**

*Chapter 3* Describes how to start the CDEGS group of software packages.

*Chapter 4* Describes how to use the various input data processors in order to specify and visualize the system data of the CDEGS group of software packages.

*Chapter 5* Describes how to process a case to carry out the required computations of the CDEGS group of software packages.

*Chapter 6* Describes how to report and display the computation results using the various output data processors of the CDEGS group of software packages.

**References:**

- Chapter 7* Refers the user to the manuals and guides that include complete tutorials depicting comprehensive and realistic engineering problems.
- Chapter 8* Presents the default file naming conventions and default file assignments applicable to the software environment.
- Chapter 9* Describes the functions and main features of the computation modules.

## **1.4 Essential Software Documentation and Support**

### **Using the Documentation Effectively & Online Help**

For installation and general information on the software, please refer to the documents included in the SES software distribution media. For example: for software installation, refer to the **\PDF\Installation\_Guide.pdf** file on the SES software distribution media.

For a first-time user, we recommend reading the “**How-to...**” engineering manuals suggested below for each software package. The “**How-to...**” engineering manuals as PDF files can be accessed with the following path through the SES Software installation folder program shortcut, **SES Software X.Y\Documentation\Manuals**<sup>1</sup>. For example: for the AutoGround or MultiGround software package, refer to the tutorial entitled “**A Simple Substation Grounding Analysis**” located at *C:\Users\Public\Documents\SES Software\X.Y\Manuals\Ground.pdf*.

An extensive online help reference is available by default to all SES software users. For help during a session, context-sensitive online help is available to provide the user with fully detailed information about specific commands or options. *Just press the F1 key.*

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<sup>1</sup> The How-to manuals are also available as PDF files on the SES software distribution media (**\PDF\HowTo Manuals\**).

## Telephone/Fax/E-Mail Assistance

SES's specialists are available to answer any questions on weekdays from 8:00 A.M. to 7:00 P.M. Eastern Time. Do not hesitate to ask for help in:

- Installing or running the software.
- Understanding the input data or engineering concepts related to each software package or defining appropriate computer models in studies.

For more extensive help, SES organizes regular webinars or in-person training seminars and can provide training on-site. Call us or send us emails for more details.

Toll Free:	(800) 668-3737
Telephone:	(450) 622-5000
Fax:	(450) 622-5053
Email:	<a href="mailto:support@sestech.com">support@sestech.com</a>
	<a href="mailto:info@sestech.com">info@sestech.com</a>
Web Site:	<a href="http://www.sestech.com/">www.sestech.com/</a>

Click this link [www.sestech.com](http://www.sestech.com) or type it in your browser for an up-to-date list of our international toll-free numbers.

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## 2 Starting SES Software

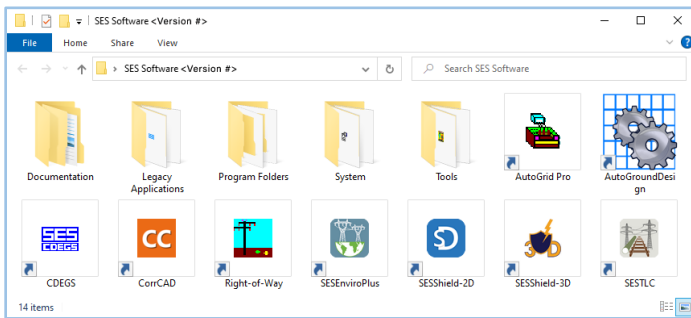
### 2.1 Introduction

This chapter describes how to start a session using the various environments available on a PC.

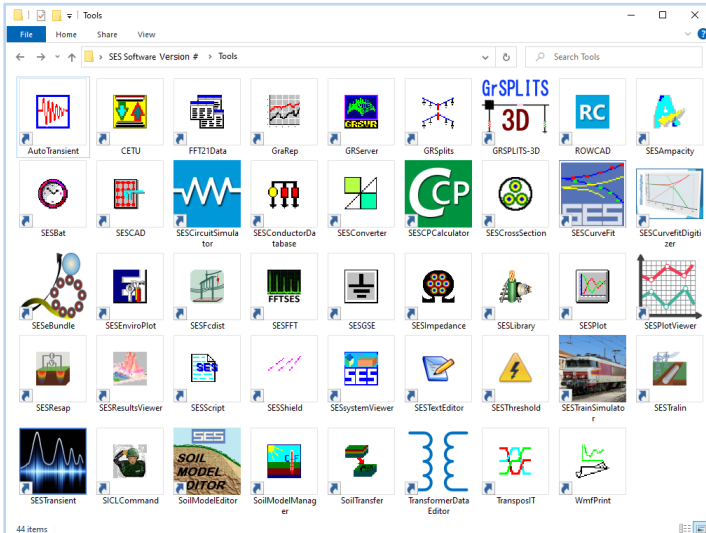
### 2.2 Description of the SES Software Folder Icons

Once the installation is complete, the user will find the following SES software folders in the **Start | Programs** menu.

Main Folder:



Subfolder Tools:



In the **SES software** <Version#> group folder, where <Version#> is the version number of the software, you should see the icons representing **AutoGrid Pro**, **AutoGroundDesign**, **CDEGS**, **CorrCAD**, **Right-of-Way**, **SESEnviroPlus**, **SESShield-2D**, **SESShield-3D**, and **SESTLC** software packages, as well as four folders. The **Documentation** folder contains help documents for various utilities and software packages. The **Program Folders** provide shortcuts to documents, installation, and project folders. The **System** folder allows the user to set up software protection (security) USB keys conveniently. Various utilities can be found in the **Tools** folder. The main function of each software package and utility is described hereafter.

## 2.3 Software Packages

- **Autogrid Pro** provides a simple, integrated environment for carrying out detailed grounding studies. This package combines the computational power of the RESAP, MALT, and FCDIST computation modules with a simple, largely automated interface.
- **AutoGroundDesign** offers powerful and intelligent functions that help electrical engineers design safe grounding installations quickly and efficiently. The time devoted to designing a safe and cost-effective grounding grid is minimized by automation techniques and appropriate databases. This module can help considerably reduce the time needed to complete a grounding design.
- **Right-of-Way** is a powerful integrated software package for analysis of electromagnetic interference between electric power lines and adjacent installations such as pipelines and communication lines. It is specially designed to simplify and automate the modeling of complex right-of-way configurations. The Right-of-Way interface runs the TRALIN, SPLITS, and MALZ computation modules and several other related components in the background.
- **SESEnviroPlus** is a sophisticated program that evaluates the environmental impact (radio interference, audible noise, corona losses, and electromagnetic fields) of AC, DC, or mixed transmission line systems.
- **SESShield-2D** is used to assess risks associated with lightning strikes to structures and to the services entering those structures, in accordance with IEC 62305.
- **SESShield-3D** is a powerful graphical program for designing and analyzing protective measures for substations and electrical networks against lightning. Its 3D graphical environment can be used to accurately model systems with complex geometries.

- **SESTLC** is a helpful simplified analysis tool that quickly estimates electromagnetic interference levels (inductive, conductive and capacitive) on metallic utility paths, such as pipelines and railways located close to electric lines (not necessary to be straight and parallel), as well as the magnetic and electric fields of arbitrary configurations of parallel transmission and distribution lines. It can also compute line parameters.
- **CorrCAD** tackles many cathodic protection design tasks and related issues, onshore and offshore, and can also predict the degree of corrosion control provided by a system. Typical applications for corrosion control include Impressed Current Cathodic Protection systems (ICCP) and the use of sacrificial anodes; also, anodic protection systems, where the anodic current is impressed on a corroding material to enforce passivation. Another application is to estimate the effect of stray currents such as those produced by HVDC electrodes or dc rail traction systems on the corrosion of buried metallic structures. CorrCAD can evaluate the corrosion status of the structure and help optimize the location and characteristics of the corrosion protective system (such as ICCP) to minimize stray current interference effects on protected structures such as pipelines.
- **CDEGS** is a robust set of integrated software tools designed to accurately analyze problems involving grounding, electromagnetic fields, electromagnetic interference, including AC/DC interference mitigation studies and various aspects of cathodic protection and anode bed analysis with a global perspective starting literally from the ground up. It consists of eight computation modules: RESAP, MALT, MALZ, SPLITS, TRALIN, HIFREQ, FCDIST, and FFTSES. This software package is the primary interface used to enter data, run computations, and examine results for all software packages other than Autogrid Pro, AutoGroundDesign, Right-of-Way, SESEnviroPlus, SESShield-2D, SESShield-3D, SESTLC, and CorrCAD. This interface also provides access to the utilities listed below.

CDEGS is accessible via a modern, user-friendly, and flexible main interface. A legacy interface, called CDEGS-Legacy, is also available.

## 2.4 Tools, Utilities and Interfaces

- **AutoTransient** automates the process required to carry out a transient analysis with the HIFREQ and FFTSES modules.
- **CETU** simplifies the transfer of Right-of-Way and SPLITS output data to MALZ or HIFREQ. A typical application is the calculation of conductive interference levels in an AC interference study.

- **F05TextEditor** is an enhanced text editor that recognizes the command structure of the module indicated by the file prefix. The program provides syntax highlighting and a command parameter identification tooltip to greatly simplify the manual editing of an F05 command input file.
- **FFT21Data** extracts data directly from FFTSES output database files (files with F21 extension) in a spreadsheet-compatible format or in a format recognized by the SESPLOT utility.
- **GraRep** is a program that displays and prints graphics or text files. For more information on GraRep, see Chapter 6 of the **Utilities Manual** or invoke the Windows Help item from the menu bar.
- **GRServer** is an advanced output processor which displays, plots, prints, and modifies configuration and computation results obtained during previous and current CDEGS sessions.
- **GRSplits** plots the circuit models entered in SPLITS and FCDIST input files. This program greatly simplifies the task of manipulating, visualizing, and checking the components of a SPLITS or FCDIST circuit.
- **GRSplits-3D** is a powerful interactive 3D graphical environment that allows you to view and edit the circuit data contained in SPLITS input files and to simultaneously visualize the computation results.
- **RowCAD** is a graphical user interface for the visualization and specification of the geometrical data of Right-of-Way projects. Its 3D graphical environment can be used to visualize, specify and edit the path data of Right-of-Way, and to define the electrical properties of those paths.
- **SESampacity** computes the ampacity, the temperature rise, or the minimum required size of a bare buried conductor during a fault. It also computes the temperature of bare overhead conductors for a given current or the current corresponding to a given temperature, accounting for environmental conditions.
- **SESBatch** is a utility that allows you to submit several CDEGS computation module runs at once. The programs can be run with different JobIDs and from different Working Directories.
- **SESCAD** is a CAD program that allows you to create, modify, and view complex grounding networks and aboveground metallic structures in three dimensions. It is a graphical utility for the development of conductor networks in MALT, MALZ, and HIFREQ.

- **SESCircuitSimulator** is an electrical circuit analysis program for studying the performance of a power system network, considering the presence of all grounding return conductors (such as neutral and shield wires), metallic ground networks, and earth media under normal, imbalance, or fault conditions. It is the successor of the SPLITS input and output toolbox known to legacy users.
- **SESConductorDatabase** gives access to the SES Conductor Database. It allows you to view the electrical properties of conductors in the database and to add new conductors to the database or modify their properties.
- **SESCPCalculator** is a new tool that performs simple calculations to estimate appropriate cathodic protection to specific target structures that need protection against corrosion.
- **SESCrossSection** provides an interactive interface with direct visual system representation for the specification of conductor characteristics and locations within a conductor path cross-section. The program allows data specification for eventual use in CorrCAD, Right-of-Way, Cable and Conductor modes of SESLibrary, SESeBundle, and Circuit, Group and Single modes of the TRALIN module.
- **SESCurveFit** is a general curve-fitting tool with a special focus on Polarization Curves used in CorrCAD. It incorporates a curve digitizer utility as well.
- **SESCurvefitDigitizer** is a corrosion-analysis supporting tool that offers full digitizer functionalities and general scientific curve-fitting capabilities.
- **SESeBundle** finds the characteristics of an equivalent single conductor accurately representing the series impedance of a bundle of conductors. This utility is particularly useful to simplify models in modules, such as HIFREQ, where reducing the number of conductors is important to keep the computation time low.
- **SESEnviroPlot** is an intuitive Windows application that dynamically displays computation data produced by the SESEnviroPlus software module.
- **SESFcdist** is an interactive and flexible interface that allows you to prepare and run input files for and view results from the FCDIST computation module.
- **SESFFT** is a *Fast Fourier Transform* computation module designed to help you automate time domain (lightning and switching surges) analyses based on frequency domain results obtained from CDEGS computation modules

such as SPLITS, MALZ, and HIFREQ. The forward and inverse *Fast Fourier* transformations, the sample selection of the frequency spectrum, and related reporting and plotting functions have been automated in SESFFT.

- **SESGSE** rapidly computes the ground resistances of simple grounding systems, such as ground rods, horizontal wires, plates, rings, etc., in uniform soils. SESGSE also estimates the required size of such grounding systems to achieve a given ground resistance.
- **SESImpedance** computes the internal impedance per unit length of long conductors of arbitrary geometry and composition and whose cross section does not vary over the length of the conductor. The program uses the Finite Element Method (FEM) to calculate the electrical characteristics of conductors and can handle conductors of arbitrary shape and realistic material properties. The calculations fully account for skin effects and can be carried out at low or high frequency.
- **SESLibrary** allows you to inspect the properties of a large number of *components* that can be imported into many SES Software computation modules. It currently includes a comprehensive database of conductors as well as several power cables.
- **SESPlot** provides simple plots from data read from a text file.
- **SESPlotViewer** is a tool used by SESEnviroPlus, SESResap, SESTLC for plot rendering.
- **SESResap** is an interactive and flexible interface used to prepare and run input files for and view results from the RESAP computation module.
- **SESResultsViewer** processes the computation data and results of all computation modules in CDEGS, offering a complete solution for displaying the plots and reports in an integrated viewer. It presents a light layout with the intuitive organization of its settings that use sensible defaults that, in turn, allow for a fast configuration of the settings to achieve the desired output results.
- **SESScript** is a script interpreter that adds programming capabilities to SES input files. SESScript can systematically generate hundreds of files from a single input file containing a mixture of the SICL command language, scripting code, and user-defined parameter ranges and increments.
- **SESShield** provides optimum solutions for the protection of transmission lines and substations against direct lightning strikes and optimizes the location and configuration of shield wires and masts to prevent the exposure

of energized conductors, busses, and equipment. It can also perform risk assessment calculations associated with lightning strikes on various structures.

- **SESSystemViewer** is a powerful 3D graphics rendition tool that allows you to view a complete system, including the entire network and surrounding soil structure. Furthermore, computation results are displayed right on the system components.
- **SESThreshold** is a utility that is used to compute touch and step voltage limits, as recommended by industry standards. Coupled with an intuitive graphical environment, it allows you to specify geometrical zones that represent areas with different threshold limits. The computed thresholds and zone boundaries are shown on generated Spot 2D plots, which enable safe and unsafe regions to be easily identified. SESThreshold can be used as a standalone application, or it can be accessed through SESResultsViewer.
- **SESTrainSimulator** is the most recent addition to the CDEGS family of electromagnetic simulation tools. It provides an intuitive and simple design environment to help create a railway model efficiently to assess average and maximum electromagnetic fields and electric quantities related to the railway.
- **SESTralin** is an interactive and flexible interface to prepare and run input files for and view results from the TRALIN computation module.
- **SESTransient** automates the analysis of transient phenomena carried out with HIFREQ and FFTSES. It runs both programs in turn, using the computation frequencies recommended by FFTSES to run HIFREQ, until user-defined termination criteria are met. It also builds the FFTSES computation databases from the resulting HIFREQ databases (F21 files). In summary, this integrated tool is used to define the system and its energization in order to compute a time-domain response.
- **SESZoom** is an interactive 3D tool used to define a bounding zoom polygon representing an area to be plotted in MALT, MALZ, or HIFREQ modules.
- **SoilModelEditor** is a standalone module with an interactive graphical interface that assists in the creation of soils models for all relevant target SES Modules.
- **SoilModelManager** is a software tool that automates the selection of soil model structures that apply during various seasons.
- **SoilTransfer** is a utility that allows you to transfer soil models found in several SES files into several MALT, MALZ, or HIFREQ input (F05) files.

- **TransformerDataEditor** is used by supporting applications to specify the characteristics and locations of single-phase and three-phase transformers.
  - **TransposIT** is a tool for the analysis of line transpositions on coupled electric power line circuits. To ensure that voltage unbalance is kept within predefined limits, it allows the user to determine the optimal number of power line transpositions and their required locations.
  - **WMFPrint** displays and prints WMF files (Windows Metafiles) generated by CDEGS or any other software.
-

## 3 Starting CDEGS in the Windows Environment

As already mentioned in Chapter 2, because of the flexible and intentionally partitioned structure of the CDEGS interface, its components are loosely connected. Therefore, it is important to have a good understanding of the interface structure, how the components are related, and how to navigate within each component. This chapter and the following Chapters 4, 5, and 6 are devoted to this task. They describe the CDEGS group environment and how to operate a software package within the group. More precisely:

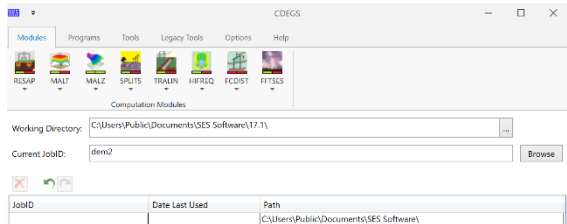
- Chapter 4 describes the Input Data Processor interface, i.e., how to specify the required input data.
- Chapter 5 describes the Computation Modules interface, i.e., how to process and compute the results pertaining to the specified system.
- Chapter 6 describes the Output Data Processor interface, i.e., how to display, view, and plot the computation results.

Start the CDEGS Windows interface by double-clicking on the **CDEGS** icon located in the SES software group folder. A JobID list appears in the main CDEGS window. At this point, it is worthwhile to describe in greater detail the Working Directory (or project folder location) and JobID (or project scenario) before proceeding further.

### 3.1 Working Directory and JobID

The JobID string you supply in the Start-up CDEGS window is used to uniquely identify all your input and output files. The interface module will automatically append the JobID string to all file names created during a session according to the following format:

*XY\_JobID.Fnn*



The file prefix XY indicates a two-letter abbreviation used for the name of the computation module associated with the input file, which will be created, modified, or simply read as input. The abbreviations are RS for RESAP, MT for MALT, MZ for MALZ, HI for HIFREQ, and so on. The two digits “nn” are used to indicate the type of file (e.g., 09 for output, 05 for input, and 21 for the computation database files). See Chapter 8 for file naming conventions and default files assignments. In the JobID dialog box, you have the following options:

- Users can define the working directory by entering the directory of their choice in the **Working Directory** field. If you specify a directory that

does not exist, it will be created automatically. You can also browse for an existing directory using the **Browse** button.

- Users can utilize a JobID name previously used by highlighting the name of their choice in the JobIDs list.
- Users can create a new JobID by typing a new JobID name in the **Current JobID** field. If that field is left blank, the buttons corresponding to the computation modules (programs) will become inactive.
- A previously used JobID name can be deleted by highlighting that name in the JobIDs list and clicking on the Delete **X** button.
- By pressing the **Browse** button, the JobID list box will be replaced by a **Browse** window with different search criteria. The most common search filters are available in the Criteria list (in the **Browse** section) but one can optionally type in a custom search criterion. Once you have found the file you are looking for, simply double-click on the file, or select the file and press **Open**. The working directory and JobID will automatically be deposited in the correct fields and the **Browse** section will close, reverting to the JobID list.
- To restore the previously deleted JobID entry in the list, click on the **Undo** **↶** button.

### 3.2 Start-up CDEGS Window-Modules

The start-up window requires the following inputs:

- Identification of the case (i.e., the JobID and working directory as explained in the previous section).
- Selection of the intended computation module (program) in which the design will be specified, computed, or examined.
- Selection of the session type mode: **Specify**, **Compute** or **Examine**.

Specifies Computation Module

Specifies Session Mode (Specify, Compute and Examine)

Defines Working Directory and JobID

JobID	Date Last Used	Path
TUT3	2/21/2022 5:34:00 PM	C:\Users\Public\Documents\SES Software\17.1\HowTo\Cdegs\Ground
TUT2	2/21/2022 5:34:00 PM	C:\Users\Public\Documents\SES Software\17.1\HowTo\Cdegs\Ground
TUT1	2/21/2022 5:34:00 PM	C:\Users\Public\Documents\SES Software\17.1\HowTo\Cdegs\Ground
DEM2	12/28/2011 5:27:32 PM	C:\Users\Public\Documents\SES Software\17.1\Examples\CDEGS\Dem2
DEM1	12/28/2011 4:40:01 PM	C:\Users\Public\Documents\SES Software\17.1\Examples\CDEGS\Dem1
DEMO	12/28/2011 4:25:32 PM	C:\Users\Public\Documents\SES Software\17.1\Examples\CDEGS\Demo

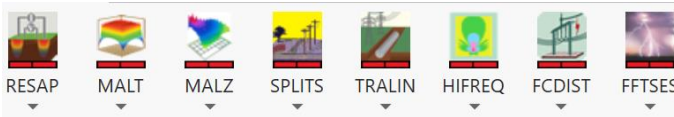
### 3.2.1 Definition of the Case

The case is defined either by selecting the JobID and working directory from the list or by creating a new JobID and/or working directory.

An existing case that is not in the JobID list can be selected by clicking on the **Browse** button and selecting either an input file or output file that belongs to the case.

### 3.2.2 Selection of the Computation Module

Each computation module, which will be further detailed in Chapter 5, has a button representing it in the start-up window.



Clicking on the program button will show the available session types for the specified case (i.e., JobID and working directory).

### 3.2.3 Selection of the Session Type

The session types that are available for each computation module (as shown here in the screen capture to the right) are listed below:



1. **Specify**

This is the input session that allows you to enter the input specifications for the computer model in the intended software package.


2. **Compute**

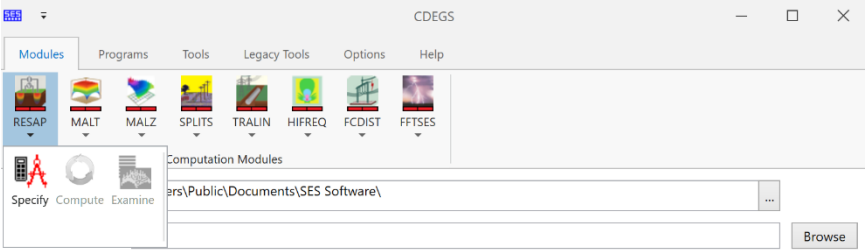
This is the computation session that allows you to execute the computation modules for the input specifications entered in the input session for the intended software package.

3. **Examine**

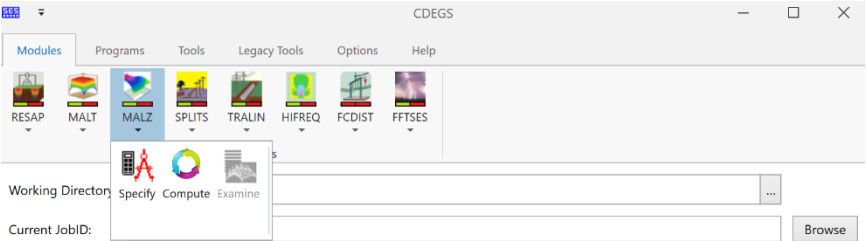
This is the output session that allows you to view the results of the computation modules in the form of plots and reports for the intended software package.

Before launching any computation module, note the following about the CDEGS user interface:

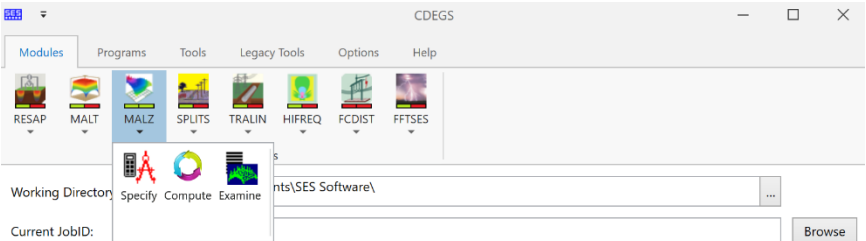
- If the computer model has not been created for the selected module, the two status indicators under the module icon will be red (  ), as shown below. You can then click on the drop-down ▼ arrow and select **Specify** to build a new model.



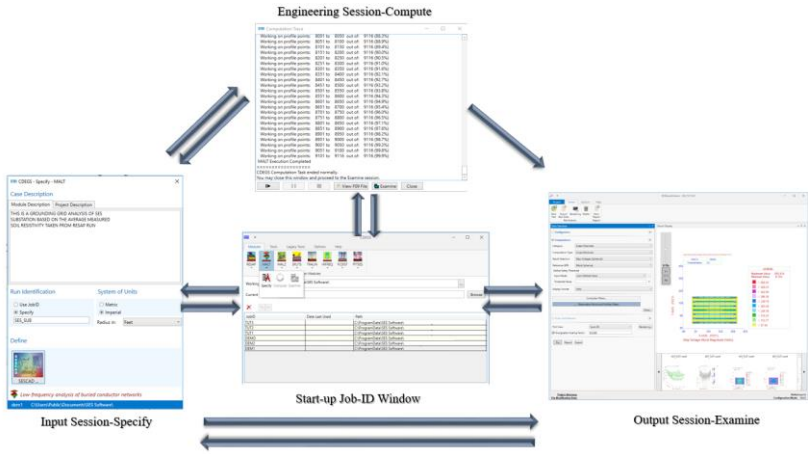
- If the model of the selected module is created but has not been run yet (i.e., a valid \*.F05 input file exists, but no output files), the color of the left indicator will change to green (the right one remains red). You can click **Specify** to modify the model or **Compute** to launch the computations, as shown in the following figure. Note that for the modules not included in your license, this **Compute** option is locked.



- Once the model for the selected module is computed (i.e., a valid \*.F21 computation database file exists), the second status indicator turns to green. You can click **Specify** to modify the model, **Compute** to relaunch the computations or **Examine** to view and plot the results. For the example shown below, the MALZ model is created (F05 file), and it has been run (F21 file), therefore, the results can be viewed. Note that if for any reason, the F21 file is the only one present in the project folder, only the second indicator will turn green.

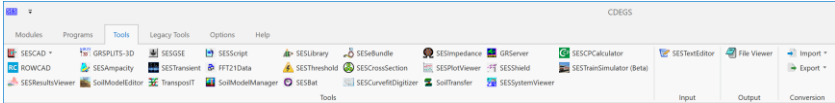


The flow of switching from one session to another is graphically shown below. Note that you can always return to the start-up JobID window from any session.



### 3.3 Tools Tab

The **Tools** tab launches the tools that are part of the CDEGS environment. An advantage to starting the utilities from the CDEGS interface (instead of from Windows Explorer or the SES software program shortcut folder) is that the JobID and working directory for those utilities are automatically set by whatever is selected in CDEGS.

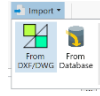


The Tool items are briefly explained in the same order as shown in the Tools tab. See also Chapter 2 for a more detailed description. Most of the tools are also accessible via the above toolbar buttons.

Tools	Description
<b>SESCAD</b>	A graphical utility for the development of conductor networks in the MALT, MALZ, and HIFREQ computation modules.
<b>RowCAD</b>	A graphical user interface for the visualization and specification of the geometrical data of Right-of-Way projects. Its graphical environment can be used to visualize, specify and edit the path data of Right-of-Way, and to define the electrical properties of those paths.
<b>SESBat</b>	The computation modules can be queued in a batch process under different JobIDs and working folders.
<b>SESResultsViewer</b>	Processes the computation data and results of all computation modules in CDEGS, offering a complete solution for displaying the plots and reports in an integrated viewer.

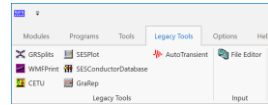
<b>GRServer</b>	An alternative to the SESResultsViewer Output Processor in CDEGS; it can generate advanced plots.
<b>GRSPLITS-3D</b>	A powerful interactive 3D graphical environment to view and edit the circuit data contained in SPLITS input files and to simultaneously visualize the computation results.
<b>SESAmpacity</b>	Computes the minimum size of a conductor for a given current, its ampacity, or its temperature rise during a fault.
<b>SoilModelEditor</b>	A standalone module with an interactive graphical interface that assists in the creation of soil models for all relevant target SES modules.
<b>SESGSE</b>	Quick determination of the type of ground system required to achieve a specified ground resistance value in a uniform soil.
<b>AutoTransient</b>	Automates the process required to carry out a transient analysis with the HIFREQ and FFTSES computation modules.
<b>TransposIT</b>	Automates the analysis of the optimum transposition scenario on a power system network.
<b>SESScript</b>	Generates files for parametric analyses of a combination of parameters in an input file (.F05). It automatically creates the input files for the specified values of the parameters.
<b>FFT21Data</b>	Simplifies the task of plotting results from the computation module database not yet supported by FFTSES.
<b>SoilModelManager</b>	Winter and spring condition equivalent soil model builder.
<b>SESShield</b>	A 2D lightning shielding analysis program.
<b>SESLibrary</b>	Includes three comprehensive separate databases containing respectively conductors, power cables and fence posts.
<b>SESThreshold</b>	An application for computing acceptable threshold limits, as recommended by industry standards, for touch and step voltages.
<b>SESeBundle</b>	Finds the characteristics of an equivalent single conductor representing a bundle of conductors, as far as their series (longitudinal) impedance is concerned.
<b>SESCrossSection</b>	Provides an interactive interface with direct visual system representation for the specification of conductor characteristics and locations within a conductor path cross-section.
<b>SESCurveFit</b>	A general curve fitting tool with a special focus on "Polarization curves" used in CorrCAD.
<b>SESImpedance</b>	Computes the internal impedance per unit length of long conductors of arbitrary geometry and composition, and whose cross-section does not vary over the length of the conductor.
<b>SESPlotViewer</b>	A tool used by SESEnviroPlus and SESTLC for plot rendering.
<b>SESSystemViewer</b>	An interactive 3D viewer of the entire network, surrounding soil structure, and computation results.
<b>SoilTransfer</b>	Transfers the soil model found in several SES files into several MALT, MALZ, or HIFREQ input (F05) files.

The **Import | Input** and **Export | Output** options, available in the **Tools** tab, launch SESConverter, which can be used to import CAD based files to various SES software package compatible input files, or export various SES software package input command files to CAD files compatible with the DXF or DWG format. The program allows filtering of data to be imported thanks to a 2D viewer that shows the selected data to avoid excessive conductor creation in the SES software package compatible files. Export from computation database files to text files, and import from appropriate text files to computation database files are other possible options that can be selected.



### 3.4 Legacy Tools Tab

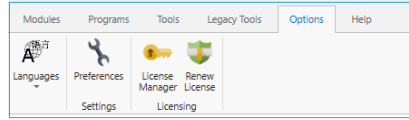
Some of the SES tools are kept under the **Legacy Tools** tab, which are explained briefly below in the same order as shown under the **Legacy Tools** tab.



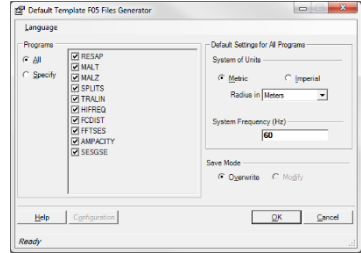
Tools	Description
<b>GRSplits</b>	Draws the circuit modeled in the SPLITS or FCDIST module as a 2D passive plot.
<b>WMFPrint</b>	Displays and prints Windows metafiles.
<b>CETU</b>	Automates the transfer of leakage currents computed by Right-of-Way and SPLITS to conductive analysis software such as MALZ or HIFREQ.
<b>SESPlot</b>	Plotting utility for results computed for 2D or 3D perspective plots.
<b>SESConductor Database</b>	It is a standalone SES conductor database utility.
<b>GraRep</b>	Displays and prints graphics and reports. The project can be saved as metafiles or PDF.

### 3.5 Options Tab

The **Options** tab provides the necessary tools to customize the overall CDEGS environment and its modules. These settings should be determined from the start-up JobID window before starting any available sessions. The functionality of each option is briefly described here.

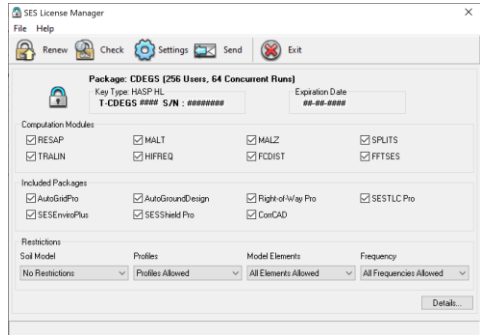


The **Languages** button changes the display language of the program. English, French, Chinese, Spanish and Portuguese can be selected as the input language, by clicking on the arrow button.



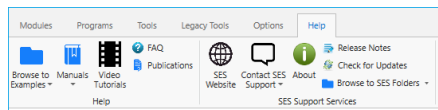
The **Preference** utility enables the creation of templates for all of the programs in the input session. Also, user-defined defaults for the **System of Units** and **System Frequency** can be assigned to all or individual programs.

**SESLicenseManager** is an important utility monitoring the license for SES software. It has two main features. The first shows the computation modules enabled on the hardware protection key or dongle (the active ones will be checked). The second is the expiration date that reminds the user when the key must be reset for those who subscribe to the SES hardware protection key insurance program. Unsupported users and those who have decided to manage their insurance (following the first automatically supported year) receive a license code that allows them to reset their keys at selectable intervals. In this case, however, the licensee should insure the key against loss or theft.



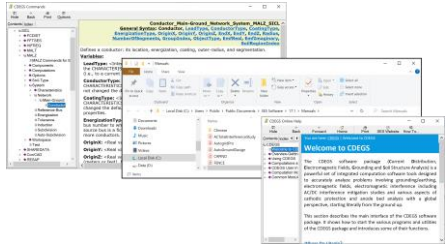
### 3.6 Help Tab

The **Help** tab provides the user with help-related functionality. The **Help** section includes the entries: **Browse to Examples**,



**Manuals & Help**, **Video Tutorials**, **FAQ**, and **Publications**. **Browse to Examples** gives direct access to **Examples Folder** and **How To Folder**. As shown below, selecting **Manuals & Help | Interface Help (F1)** from the **Help** tab will invoke the main CDEGS context-sensitive online help.

Selecting the **Manuals & Help | Command Help** option from the **Help** tab will bring up the complete reference of the SES Command Language (SICL), and by clicking on the **Manuals & Help | How To Manuals** option, one can access the complete CDEGS PDF manuals.



From the **Help | SES Support Services** section, links and utilities are available to aid in using the support services of SES:

- The **SES Website** button will open the Web browser to the home page of SES.
- The **Contact SES Support** menu item automates the packaging of deliverables (e.g., input & output files for support) via email to SES for analysis.
- The **About** option displays the software version currently installed on the user's computer. Moreover, the **SES License Information** window can be accessed by selecting the **License** tab from the **About CDEGS** window. The expiration date of the license, the computation modules and included packages, and the soil model type enabled on the protection key (or dongle) are shown in this window.
- The **Check for Updates** option directs the browser to the SES Web Site **Software Update** to upgrade the software to the latest version.
- **Browse to SES Folders** gives direct access to the installation and command folders.



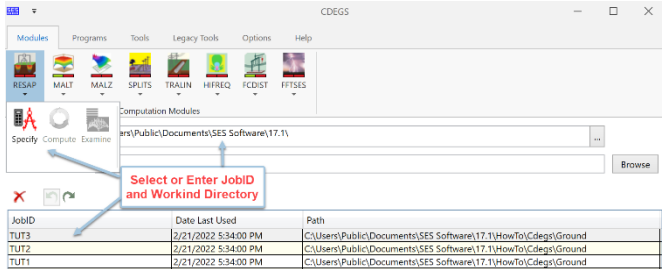
## 4 CDEGS Input Session – Model Specification

The input session of a CDEGS software package allows the user to create input data files for the computation modules easily. It supports all of the features available directly from the use of the powerful **SES Input Command Language (SICL)**. In addition, it boasts several options and features that are not available in some other input modes and are described later in this chapter.

### 4.1 Starting an Input Session

The input session in the CDEGS application specifies the necessary system data to carry out the engineering design or study. After selecting or entering the desired JobID (i.e., scenario) and a working directory (i.e., project folder), click on the **Specify** item from the drop-down **Module** list to invoke the input session.

The main input windows of some of the computation modules have a similar layout as described in Section 4.4.



### 4.2 Field Types

The following describes and explains several convenient field types that will help the user to determine how to easily handle and enter data.

#### Radio Buttons

System of units

- Metric  
 Imperial

Present two or more mutually exclusive choices. The user must pick one of the choices by clicking the associated button to highlight it. They are usually displayed in a frame.

#### Check Boxes

- Bundle reduction  
 Sequence components

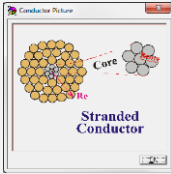
Enable or Disable a particular command option. The option is enabled when a checkmark appears in the check box; it is disabled when that box is empty.

### Table Entries

Layer	Resistivity, $\rho$ ( $\Omega$ -m)	Thickness, $t$ (ft)
Top	100	2
Bottom		00

Allows the user to enter several numeric and alphanumeric entries displayed in a spreadsheet-type grid.

### Display Boxes



Gives the user a visual representation of the current selection. Some of the representations are static, while others are interactive and display the actual numerical entries in a graphical format.

### Scroll Arrows



Allows the user to scroll through a table or a list.

### Text Entries

Job Identification

Allows the user to enter text strings. The entry can be typed when the cursor is positioned in the field.

### Drop-Down List Boxes

Complex number format

Cartesian

Gives the user a list of several options. To select an item that is not displayed, click the arrow button at the right of the list box and select the item by clicking on it.

### Inactive Features

Energization and environmental study

They are grayed out and are not accessible to the user.

### Numeric Entries

Average Soil Characteristics

Resistivity  Ohm-Meters

Relative Permeability  p.u.

They are used to enter numeric values, and the user types in the values.

## 4.3 Key and Mouse Behavior

In CDEGS windows, the following key and mouse behavior are applicable:

#### Tab Key

Will move the cursor (focus) from the current field to the following logical field.

#### Alt+Character

Will move the cursor (focus) directly to the field identified by that character (i.e., the character that appears underlined).

## In-text or numeric fields:

<b>Backspace key</b>	Use the backspace key to delete a character to the left of the cursor.
<b>Delete Key</b>	Use the delete key to delete a character to the right of the cursor.
<b>Insert Key</b>	By default, the user is in insertion mode. If adding text is needed, this allows to position the cursor where the text is to be entered and type it. When the user hits the insert key, whatever is typed overwrites previously entered text.
<b>Ctrl+X</b>	Will cut highlighted text to the Clipboard.
<b>Ctrl+C</b>	Will copy highlighted text to the Clipboard.
<b>Ctrl+V</b>	Will paste the Clipboard content in the current entry field.
<b>Shift+Arrow Left or Right Keys</b>	Will highlight text.

## In table fields:

<b>Commas</b>	Will enter the data in the current cell and move the cursor to the next cell in the table.
<b>Arrow keys</b>	Will enter the data in the current cell and move the cursor by one cell in the arrow that was used.
<b>Spacebar</b>	Will enter the data in the current cell and move the cursor to the next cell in the table.
<b>Shift+Arrow Left, Right, Up or Down Keys</b>	Will highlight cells.
<b>Slash (/)</b>	If a series of cells are highlighted, it will open a Gradient Fill dialog box. The Gradient Fill is used to increment values in a series of rows or columns automatically.
<b>Delete Key</b>	Will delete the data in the current cell or a selected block of cells.
<b>Shift+Delete Keys or Ctrl+X</b>	Will delete the data in the current cell or a selected block of cells and copy it to the Clipboard.
<b>Ctrl+Insert Keys or Ctrl+C</b>	Will copy the data in the current cell or in a selected block of cells to the Clipboard.
<b>Shift+Insert Keys or Ctrl+V</b>	Will copy Clipboard contents to the table using the current cursor position as its starting point.

In most Interactive Display Boxes (Show Data) fields:

<b>Show Data</b>	Will display the interactive plot.
<b>Top View</b>	Will display the top view of the interactive plot.
<b>Animate</b>	Will rotate the display automatically.
<b>Stop</b>	Will stop the automatic rotation of the display.
<b>Left mouse button</b>	The mouse cursor in the display window will move the plot to various convenient viewing positions.
<b>Shift Key and Left mouse button</b>	When the mouse cursor is in the display window, it will zoom in or out of the plot. Moving up, the mouse will zoom in and moving down, the mouse will zoom out.
<b>Ctrl Key and Left mouse button</b>	When the mouse cursor is in the display window, it will modify the view angle as the mouse is moved.

In Drop-Down List boxes fields:

<b>Arrow Keys</b>	Will cycle through the various items available.
<b>Down Arrow at the right of the List Box</b>	When clicked, it will display additional list items.

## 4.4 Common Fields, Buttons & Windows

Many fields, buttons, and windows are common to some computation modules.

### 4.4.1 Input Window of MALT, MALZ, and HIFREQ Modules

The input (Project) window of MALT, MALZ, and HIFREQ is an example of common structures in the computation modules. These main menus customize the input data and provide an entry point or road map to the different categories of data required by the module. The Window shown below corresponds to the MALT module.

The **Case Description** containing the **Module Description** and **Project Description** is used to identify and document the project for which the data is prepared.

The **Run-Identification** is used to identify the outputs for the case. This Run-ID appears in all printouts, output, and graphics files created by the program. Unless specified otherwise, it is automatically set to be identical to the JobID (which is functionally equivalent to a scenario name). This is the recommended choice. It provides a unique identification name for different input data prepared with the same JobID. Note that cases with different Run-ID but with the same JobID will overwrite each other. Note that the **JobID** will also become a synonym of the project **Scenario** name in future versions.

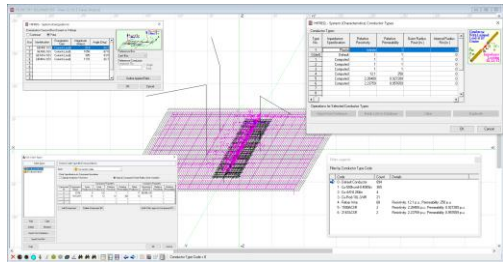
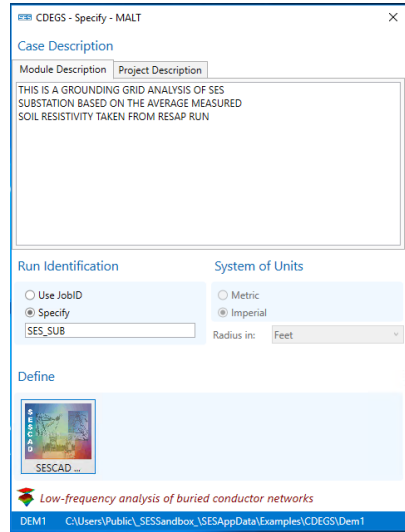
The **System of Units** radio button specifies the units in which the data will be entered.

The **Define** button (SESCAD) is the road map for entering data. It simplifies and accelerates the data input process. In MALT, MALZ, and HIFREQ computation modules, the SESCAD is used to build the entire system input data in a graphical interface which greatly simplifies the design of the network.

SESCAD is a complete graphical interface environment that allows the user to create, modify, and view complex grounding networks and aboveground metallic structures. In SESCAD, the user can specify the conductor configuration, type, energization, and observation points. The user can also define the soil layer characteristics in terms of electrical resistivity, positioning, depth and horizontal thickness.

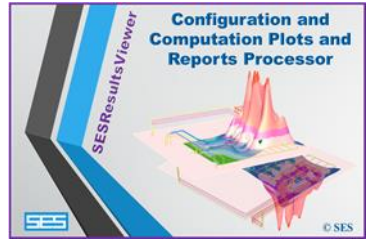
Depending on the Soil Type selected, the input data required in the Soil Characteristics frame will be displayed. Similarly, the 3D Viewer panel will illustrate the requested type of soil and the orientation of the axes relative to the soil.

An added benefit of launching SESCAD here is that it takes the conductors already defined and loads them into the interface. There, they can be handled as needed. Once the modifications are complete, the new configuration is reloaded into the input conductor list. This benefit greatly facilitates the grid design.



## 4.4.2 Output Window of MALT, MALZ, and HIFREQ Modules

The Examine option from the drop-down menu of the MALT, MALZ, and HIFREQ computation module interfaces will request the **SESResultsViewer** Output Processor, which shows again one of the standard utilities and windows used by these modules. The utility **SESResultsViewer** will be explained in detail in Chapter 6 Section 6.3.1.



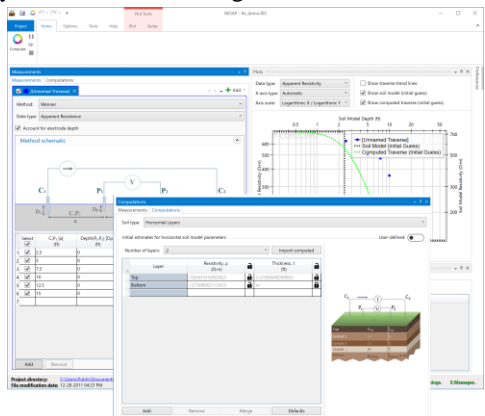
## 4.5 Other Input Toolbox Features

### 4.5.1 RESAP Computation Module

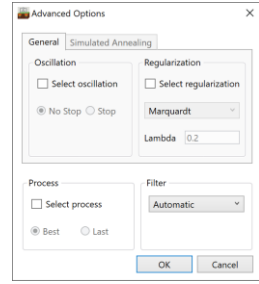
In the **Measurements** panel, specify the method used to gather the data. Several popular and advanced resistivity measurement techniques are available. The **Plots** panel allows the user to immediately inspect the results in a linear/linear or log/linear fashion to determine the shape of the curve or the presence of noise in the measurements.

The **Measurement** menu selects the **Wenner Method** and the **Account for electrode depth** option by default. The measurement data are entered in the option, **Traverse parameters**. The results are automatically plotted in the **Plots** panel.

The **Computations** panel is used to access a screen where the user can define the type of soil model to be applied, as well as the initial (estimated) values of the soil characteristics one wishes to compare to the actual soil structure. The field **Number of Soil Layers** allows the user to explicitly request the number of layers for a horizontally layered soil type (**User-Defined**). If the resistivity and thickness under **Initial estimates for horizontal soil model parameters** are left blank (default setting), the program will determine suitable initial values for the requested soil characteristics.



The screen **Advanced Options** helps the user define computation settings for the optimization process or generate different filters. By default, RESAP chooses Automatic filter, which is sufficient for most practical cases. The High Precision filter is sometimes needed when extreme soil conditions are encountered (for example, very large soil resistivity contrast ratios), and will greatly increase the computation time. Unless RESAP encounters a missing or corrupted filter database file, generating new filters is seldom needed.



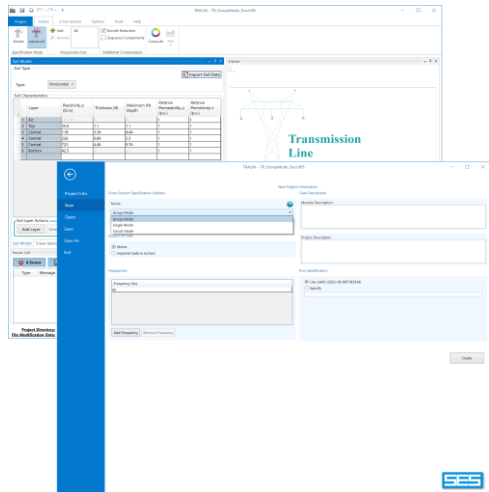
#### 4.5.2 TRALIN Computation Module

TRALIN performs line parameter calculation of conductors and cables. There are three modes to enter conductors in the transmission line system, identified in the **Cross Section Specification Options** (in the Project info); **Single Mode**, **Circuit Mode**, and the **Group Mode**. The **Single Mode** is used for systems consisting entirely of aboveground, uninsulated conductors. The conductors are described one at a time.

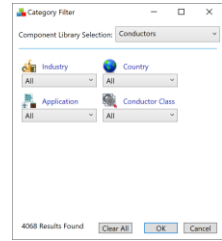
The **Circuit Mode** is used for systems consisting entirely of aboveground, uninsulated bundled conductors. The soil model used in both **Single Mode** and **Circuit Mode** allows the specification of up to three earth layers in addition to the air layer. The **Group Mode** is used for overhead transmission lines and aboveground and buried cables. It should be used if the system contains underground, insulated, pipe-enclosed, or cable-type conductors.

The location, size, and characteristics of conductors are entered by clicking on the **Cross-section** tab. The data in the **Phase/Line Number** field specifies the phase number of the conductor. The phase number indicates which conductors share the same energization sources (points) and are to be reduced to an equivalent single conductor when the **Bundle Reduction** option (in the **Home** tab) is in effect.

The characteristics of the conductors are defined by clicking on **Component Type** | **Create New** | **From Database**, which invokes the **SESLibrary** tool. The



**Conductor Database** window from SESLibrary offers a comprehensive list of conductor specifications based on various countries and internationally commonly used conductors and cables. When the screen on the right appears, select the desired category from the Conductor Class list. Scroll down the screen to find the desired conductor, select it and click the **Import** button.

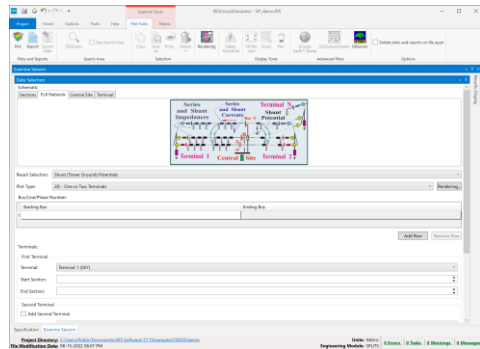


Item	ID	Name	Cross-Section (mmil)	Cross-Section Area (in <sup>2</sup> )	Inner Radius (in)	Outer Radius (in)	Current (A)	Frequency (MHz)	Temperature
1	JM-ACCR_Octave 300	343.367	108.740	0.124016	0.138063	50,000	25,000		
2	JM-ACCR_Lined 306	394.700	124.274	0.133908	0.162205	50,000	25,000		
3	JM-ACCR_Hawk 477	346.667	172.120	0.137480	0.433197	50,000	25,000		
4	JM-ACCR_Drake 557	467.052	210.023	0.173228	0.470472	60,000	25,000		
5	JM-ACCR_Grobback 636	710.807	239.228	0.185319	0.501968	60,000	25,000		
6	JM-ACCR_Drake 795	655.186	300.744	0.208661	0.562992	60,000	25,000		
7	JM-ACCR_Curlew 1033	766.25	367.230	0.208661	0.624916	60,000	25,000		
8	JM-ACCR_Barnes 1272	1089.43	437.202	0.208661	0.675197	60,000	25,000		
9	JM-ACCR_Martin 1301	1001.85	472.883	0.226229	0.706693	60,000	25,000		
10	JM-ACCR_Lighting 1506	1704.33	555.566	0.267568	0.767568	60,000	25,000		
11	JM-ACCR_Ibis 387	471.673	148.508	0.193659	0.393659	50,000	25,000		
12	JM-ACCR_Cardinal 654	898.39	342.887	0.200787	0.602362	50,000	25,000		
13	JM-ACCR_Finch 1153	1259.11	396.405	0.216533	0.647538	50,000	25,000		
14	JM-ACCR_Pheasant 1272-426.86	449.251	0.230515	0.688876	60,000	25,000			

### 4.5.3 SPLITS Computation Module

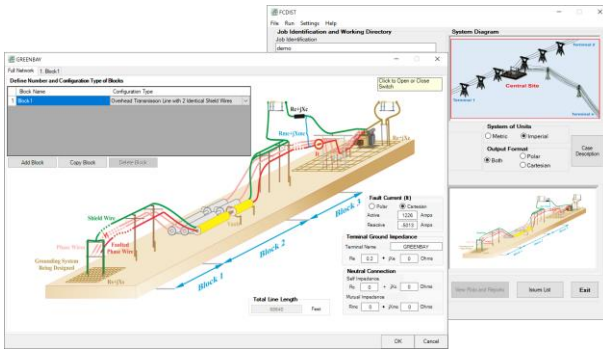
The module SPLITS is a powerful circuit solver that has a flexible **Import Data** feature in the **System (Terminal)** window. This feature allows the import of self and mutual impedances of transmission line conductors computed by **TRALIN** (Line Parameters) for the various transmission line sections (spans). It is used along with the tool GRSplits-3D to visualize, edit and display computation results of the defined circuit network.

The interface of the module SPLITS has not yet been replaced by a new one, mainly because it will be combined and integrated with the tool GRSplits-3D, and become a component of the Right-of-Way software package.



### 4.5.4 FCDIST Computation Module

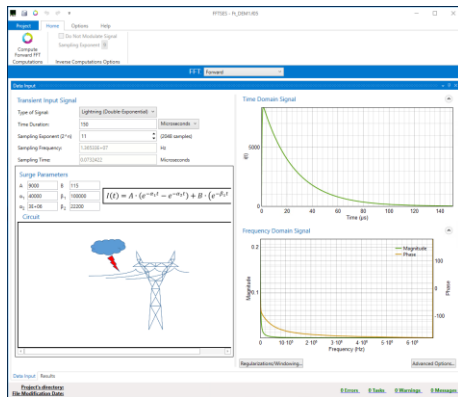
FCDIST is a line parameter and fault current distribution module that provides a simpler equivalent to the combination of the computation modules TRALIN and SPLITS. The conductor characteristics can be obtained from the same database in SESLibrary described above.



### 4.5.5 FFTSES Computation Module

FFTSES is an efficient and flexible Fast Fourier Transform computation module that provides time-domain computation capabilities to SES software frequency-based computation modules such as SPLITS, MALZ, and HIFREQ.

FFTSES offers several standard and classical time-domain surge functions and a user-specified arbitrary surge that can be imported from measured data or other computation sources.



## 5 Software Computation Module Interface

### 5.1 Introduction

As the user begins to use one of CDEGS software packages, they must keep in mind that their engineering solving capabilities will continually increase along with their familiarization with the software and understanding of the related engineering concepts.

CDEGS software packages yield the greatest rewards to those who persistently explore their analytical capabilities. Furthermore, CDEGS software packages allow users to study complex engineering problems with an exceptional level of detail and accuracy. Consequently, significant reductions in design and construction costs will result from building accurate and realistic computer models. Users will no longer have to make frustrating and unnecessary conservative assumptions or be subject to the uncertainty of simplified models.

While CDEGS can be applied to a wide variety of engineering problems, it is most often used for the following types of studies:

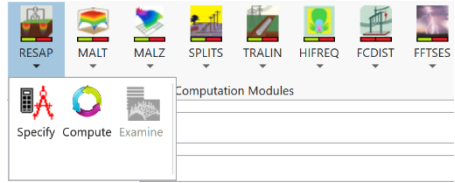
- Soil resistivity measurement interpretation (RESAP module).
- Grounding studies (MALT, MALZ, HIFREQ, and FFTSES modules).
- Line and cable parameter calculations (TRALIN, FCDIST, and HIFREQ).
- Determination of fault current distribution in power systems (FCDIST, SPLITS, and HIFREQ).
- Inductive interference studies involving power systems, pipelines, communications cables, etc. (TRALIN, SPLITS, HIFREQ, and FFTSES modules).
- Cathodic protection studies (MALZ and HIFREQ).
- EMF and transient studies (MALZ, HIFREQ, and FFTSES).
- Analysis of arbitrary 3D conductor networks using accurate Maxwell electromagnetic field theory. Solutions range from line parameter calculations to lightning studies to antenna performance analysis (HIFREQ).

### 5.2 Invoking the Computation Modules

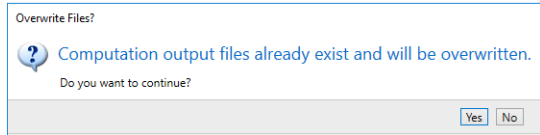
The computations are performed by the software computation modules RESAP, MALT, MALZ, TRALIN, SPLITS, FCDIST, HIFREQ, and FFTSES. Each of these modules (sometimes called programs) reads the data it requires from a structured command input file generated by one of the input processors. For illustrative purposes, assume that a RESAP input file was already prepared. From the Windows CDEGS main interface, proceed as follows:

To invoke the RESAP computation session, click **RESAP** under **Modules** in the ribbon of CDEGS program and select **Compute** from the opened options.

Note that if the option **Compute** for RESAP is disabled (i.e., grayed out), this is a visual indicator that the program could not locate the input file. In this case, make sure that the specified working directory and the JobID point to the input file that has been selected. It could also be that there is, indeed, no input file available yet. Below are possible windows or messages that the user may encounter in the computation session.

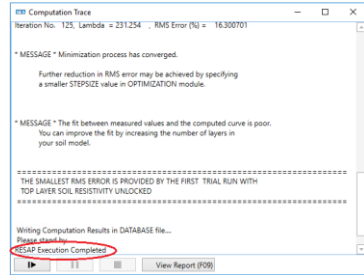


The **Overwrite Files** message window indicates that the RESAP computation module was previously launched using an input file of the same name. Consequently, the output files associated with the



previous run will be replaced by the results of the new computation run if the button **Yes** is clicked. Clicking on the button **No** will abort the engineering run since the computations cannot begin without overwriting the existing output files.

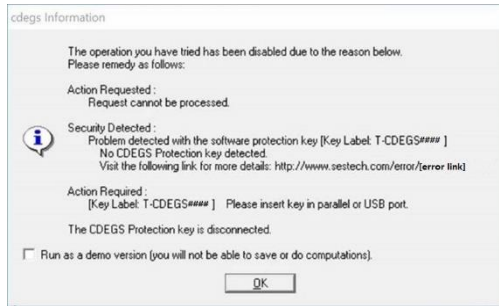
The engineering session window to the right indicates a proper completion of the engineering application since the “RESAP Execution Completed” message is displayed.



If the program cannot communicate with the software license security key during the computations, the execution will be aborted, displaying “*No CDEGS Protection key detected.*” Further details can be found in the Web site link provided along with the error message. For example, in this specific instance, the protection key might have been removed or not seated properly in the physical port. If the computation module has been completed normally, the following output files will be generated:

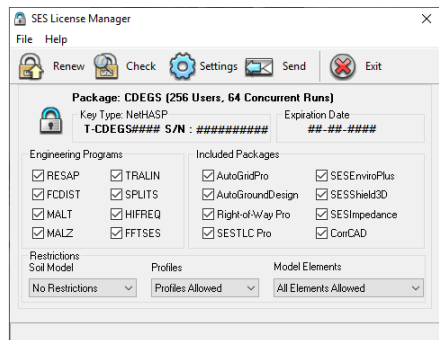
- A printout listing input data, user-selected options, some computation results and error or warning messages (\*.F09).
- A computation database file (\*.F21) in binary format (i.e., you cannot read the information in this file using a text editor) containing the computation results for subsequent use by the output processor or by the output Binary/ASCII converter.
- Plots, if requested by the user.

The validity of the license protection key is queried at several checkpoints during the execution of any CDEGS program. In particular, CDEGS verifies whether the key has expired as soon as it loads. The following message should appear if it finds that the key has expired.



Moreover, the user will be warned, up to 14 days before, that the key is about to expire. The message “\* **WARNING** \* **Hardware Key limit will expire in x day(s). Please renew using the Renew License menu item**” (where  $x$  represents the number of days left before the key expires) will be displayed in the status bar of the CDEGS program. This message remains visible until the hardware security key has been renewed with a new expiration date. Please keep in mind that the protection key that comes with CDEGS is of the reset type. This means that it must be periodically reset in order for the CDEGS program to function. The reason for this security method is twofold. First, the key is shipped within a limited period during which CDEGS can function. Should the package get lost or stolen, the key will function for only a very short period. Second, once the key has been installed into the host system, this method protects the user of CDEGS from theft should the key get stolen; the key, again, will function for a short time.

For such safety reasons, the owner of CDEGS can control the allowable time during which the software can function only over one year. For example, even though the license agreement typically extends over 50 years, the protection key has a maximum allowable of one year. In such a case, the owner of CDEGS can download his or her license file using the utility **SESLicenseManager** to reset the expiration date of the key (*valid only for those who subscribed to the SES hardware security key theft or loss insurance program*).



### 5.3 RESAP

To use the computation module RESAP to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> GROUND, GISGRND, SUBURBAN, URBAN, AutoGrid Pro, and AutoGroundDesign.
- The RESAP engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

### 5.4 MALT

To use the computation module MALT to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> GROUND, GISGRND, AutoGrid Pro, and AutoGroundDesign.
- The MALT engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

### 5.5 MALZ

To use the computation module MALZ to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> SUBURBAN and URBAN.
- The MALZ engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

### 5.6 SPLITS

To use the computation module SPLITS to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> SUBURBAN, URBAN, and ACTotalInterferenceStudy.
- The SPLITS engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

### 5.7 FCDIST

To use the computation module FCDIST to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> GROUND, AutoGrid Pro, and AutoGroundDesign.
- The FCDIST engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

## 5.8 TRALIN

To use the computation module TRALIN to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> SUBURBAN, URBAN, and ACTotalInterferenceStudy.
- The TRALIN engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

## 5.9 HIFREQ

To use the computation module HIFREQ to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> RLC, TOWER, LIGHTN, GISGRND, FENCE, CAPIND, and ACTotalInterferenceStudy.
- The HIFREQ engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

## 5.10 FFTSES

To use the computation module FFTSES to its fullest capability, read the following documents:

- The “**How-to...**” engineering manuals: see<sup>1</sup> RLC and LIGHTN.
- The FFTSES engineering application manual.
- The Seminar Reference binder (if you attended an SES seminar).

<sup>1</sup>**Note:** The abbreviations used to name the “**How-to...**” engineering manuals are as follows:

ABBREV.+extension	TITLE
AutoGroundDesign.pdf	Automated Grounding System Design Using AutoGroundDesign
AutoGrid Pro.pdf	A Simple Substation Grounding Grid Analysis Using AutoGrid Pro
GROUND.pdf	A Simple Substation Grounding Analysis
GISGRND.pdf	NCC-SES Gas Insulated Substation Grounding Analysis
SUBURBAN.pdf	Large Suburban Substation Grounding System Analysis: Measurements & Computer Modeling
URBAN.pdf	Urban Area Substation Analysis

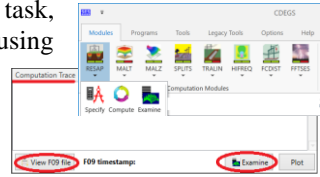
CAPIND.pdf	Computation of Capacitance and Inductance of Conductor Networks
RLC.pdf	Computation of Transient Currents in RLC Circuits
SESEnviroPlus.pdf	Electromagnetic Environment Study using SESEnviroPlus
SESTLC.pdf	Electromagnetic Fields and AC Interference Study using SESTLC
TOWER.pdf	Electromagnetic Fields Near a Transmission Line Tower
FENCE.pdf	Electromagnetic Fields Under a Transmission Line and Induced Currents on a Fence
LIGHTN.pdf	Lightning Transient Study of a Communication Tower
SESCurvefitDigitizer	Understanding and Using SESCurvefitDigitizer
ACTotalInterferenceStudy.pdf	A Simple AC Total Interference Mitigation Study Using SES software
Importing DXF Drawing Into SESShield-3D	Two main ways to generate SESShield-3D models from DXF drawing of a picture
Quick Start Guide CorrCAD (Offshore)	Sacrificial Anode on Offshore
Quick Start Guide CorrCAD (Onshore)	Cathodic Protection System Design and Corrosion Evaluation
Quick Start Guide SESCPCalculator	Cathodic Protection System Design Calculator
Quick Start Guide SESTrainSimulator	High-Speed Train Simulation
Quick Start Guide ROW	Quick start guide for Right-of-Way
Quick Start Guide ROWCAD	Quick start guide to the user interface to input the data of Right-of-Way
Quick Start Guide SESShield-3D	Quick start guide for lightning shielding protection system
SESShield-3D-Direct Lightning Stroke Shielding of a Substation	Lighting protection analysis of a simple substation using SESShield-3D

Note that the above manuals can be read onscreen using Acrobat Reader and similar software supporting the PDF convention. To open a manual, locate the file name in the **SES Software X.Y\Documentation\Manuals** folder.

## 6 Output Data Processor


### 6.1 Introduction

Once a particular computation module has ended its task, the user can start examining the computed results using the button **Examine** from the module drop-down menu, or view the output as a file (F09) and examine the results by clicking either **View F09 file** or **Examine**, which are available in the **Computation Trace** window, once the computation is finished.



The examination of the output results can only be done if the computation module has been run for the case (i.e., a computation database exists for the case). The program's state indicator acts as visual indicators to help the user decide which program to examine. As mentioned earlier in Section 3, the module (program) buttons will be shown in either of their two states: green or red. Once the model for the selected module is computed (i.e., a valid F21 file exists), both status indicators turn green.

### 6.2 Viewing, Printing, Plotting and Exporting Computation Results

The user can examine or print the computation output files (\*.F09) by either selecting the button **Examine** from the drop-down menu of the module or the item **Tools | Output | File Viewer** .

The user can export conductor network data to DXF-compatible CAD systems by selecting the menu item **Tools | Output | Export | To DXF** (see the context-sensitive online help for more details). Finally, the user can convert computation database files (\*.F21) to the ASCII format for subsequent processing by non-SES graphics or report packages, or simply to transfer them to other non-Intel PC-compatible computer platforms (see the context-sensitive online help for more details).


### 6.3 Plotting and Reporting Results Using SES Output Processors

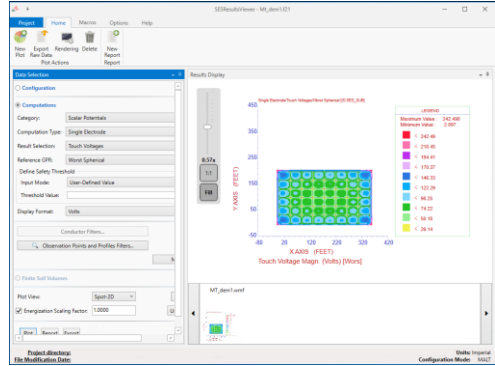
The following three different tools can be used to report and view computation results.

- SESResultsViewer
- GRServer
- SESSystemViewer

Note that users still have access to the legacy Output Toolbox if desired or necessary.

### 6.3.1 SESResultsViewer Configuration and Computation Plots and Reports Processor


SESResultsViewer  in the **Tools** folder processes the computation data and results of all computation modules in CDEGS, offering a complete solution for displaying the plots and reports in an integrated viewer. It presents a light layout with the intuitive organization of its settings that use sensible defaults that, in turn, allow for a fast configuration of the settings in order to achieve the desired output results. This tool replaces the legacy Output Toolbox.

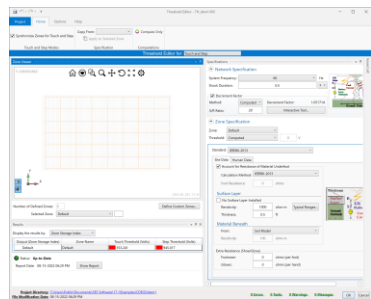


Data selection falls under the following general modules:

- **Configuration** option (found in MALT, MALZ, and HIFREQ modules, for plotting conductors and their currents or GPR, etc.).
- **Computation** option (all modules for plotting computed earth currents, voltages, resistances, etc.).

Clicking on the button **Plot** results in plotting the desired data, while clicking on the button **Report** results in the display of the computation results in character-based format. One can choose to plot 3D, side and top views of systems and focus on the area of interest with the zoom ribbon on the left of the plot. Users can also direct plots and reports to the screen or a file.

There is also a **Define Safety Threshold** in the **Computations** tab with three drop-down options; **User-Defined Value**, **Default/Actual Threshold Stored Value**, and **Specify in Threshold Module**. Choosing **Specify in Threshold Module** from the drop-down menu and clicking on the right-side button  brings up the **Threshold Editor** window, where you can define the safety criteria on which the safety assessment of the conductor network should be based. In other words, this feature provides the user with the safe touch and step voltage thresholds as well as the safe body current reference value.



Users will notice that various standards, as well as new guidelines or rules, can be selected by using various options displayed as drop-down lists or in the write-in numerical fields in the **Zone Specification**.


Upon clicking the button **Show Results**, from the Results section on the left side of the window, a safety report is generated for a single fault clearing time.

If the user does not specify one or more parameters, the touch and step voltage limits computations will be based on the following default parameter values:

• Body Resistance = 1000 ohms
• Surface Resistivity = 1000 ohm-m
• Foot Resistance Calculation = IEEE Exact
• Fault Duration = 0.5 s
• Surface Layer = 6 inches (15.2 cm) of crushed rock

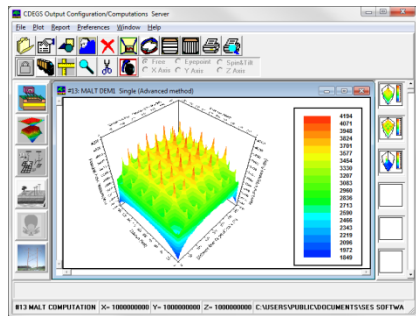
For detailed online help, hit the **F1** key after selecting an input field in the window.

### 6.3.2 GRServer Plotting and Reporting Software Tool


GRServer , in **Tools**, is an Advanced Graphics and report output processor with input processing capabilities. GRServer can display, plot, and print configuration and computation results obtained through the SES software package. GRServer also has the capability to view the input files, run the computation modules to populate the computation databases and view output files.

The plots created in each of the display windows are also created as thumbnails (plot icons) on the sidebar. Its multi-document structure makes it an efficient means to compare results and draw conclusions.

The window menu has six distinct components, as shown here. The toolbar provides easy access to the most used features that can also be found in the menu bar. The six program (module) buttons on the left sidebar are for loading the computation module databases for the programs other than the currently opened one. Clicking on any of these enabled buttons will automatically load the corresponding database. The plot icons (in the right sidebar) are the thumbnails of the plots created in the plot window space. Since the plot icon sidebar is scrollable, there is no limitation on the number of icons it can contain. Clicking on a plot icon activates the plot window associated with the icon. A popup menu shows up when right-clicking on a plot icon. It is used to print, save, and delete the plots.



### 6.3.3 SESSystemViewer Interactive Plotting Tool

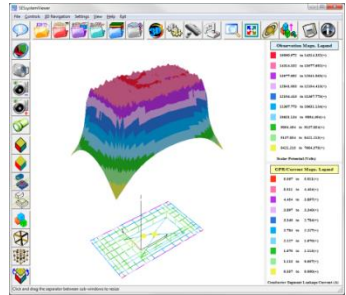
SESSystemViewer  in **Tools** is a powerful 3D graphics rendition software that allows the user to visualize the complete system, including the entire network and surrounding soil structure, realistically as observed from a moving platform. Furthermore, computation results are displayed right on the system components.

It has the capability to display the system configuration specified by the MultiGround, MultiGroundZ, or MultiFields software packages. Furthermore, all computation results pertaining to the system configuration can be displayed right on the system component itself in vivid spot colors that reflect the intensity of the displayed quantity (such as leakage and longitudinal currents, ground potential rises (GPR), etc.).

The OpenGL industry-standard protocol drives the main graphics computation engine of SESSystemViewer. It is possible to display the conductor network, soil model structure, and observation point computation results alone or simultaneously. Conductor data such as radius, material type, coating type, or energization type can be displayed in various colors for accessible rendition.

Computation results displayed in various color intensities include the leakage currents, longitudinal currents at the origin or end of a conductor segment, the GPR of its metal, that of its coating, or the coating stress voltage.

Plots of computation results at specified observation points can be displayed in 3D or color spot form right on the system configuration model.



## 6.4 Further Details

The preceding description of the output session in CDEGS is by no means exhaustive. Many useful features are explained in the “**How-to...**” engineering manuals and in the context-sensitive online help. These documents can be found in the **SES Software X.Y\Documentation\Manuals** folder. The user should refer to these documents for a wealth of information on how to display useful reports and plots based on the computation results.

## 7 Tutorials and Getting Started with your Engineering Projects

### 7.1 Documentation

Now that the user is familiar with the various SES software packages and associated tools, the main concern can be tackled, i.e., studying a practical engineering project. SES recommends to proceed as follows:

#### SES Software Tools and Utilities Manuals

Read the appropriate manual to become familiar with the various tool and utility programs provided with the software packages. The discussion of these utilities can be found in each utility's online help. An efficient way to become familiar with the tool or utility software is to start it and then use the context-sensitive online help to learn and understand the software further.

#### “How-to...” Engineering Manuals

If the engineering problem is similar to one of the many “**How-to...**” engineering manuals provided with SES software, you should consult it for detailed guidance on how to proceed with your problem. The “**How-to...**” engineering manuals provide extensive details on how to complete a typical engineering study using the SES software. These manuals can be found in the **SES Software X.Y\Documentation\Manuals** folder.

### 7.2 Reaching SES via EMAIL

E-mail us at:

<a href="mailto:info@sestech.com">info@sestech.com</a>	Product and software brochure requests as well as project engineering requests.
<a href="mailto:sales@sestech.com">sales@sestech.com</a>	Pricing, sales-related, accounting, and administrative requests.
<a href="mailto:support@sestech.com">support@sestech.com</a>	Software and engineering support services for SES software users (includes demonstration packages to users).

## 7.3 Accessing the SES Website Through the Internet

### SES Website

Visit us on the Internet at [www.sestech.com](http://www.sestech.com). The SES Website contains CDEGS program updates, SES corporate profile, upcoming events sponsored by SES software packages produced by SES, projects that SES has participated in over the years, pertinent peer-reviewed technical papers, various technical guidelines for measurements and project data requests, FAQs, information on SES training and certification courses and its training facility, etc. To give suggestions on what could be added to our Web site, please send it to [webmaster@sestech.com](mailto:webmaster@sestech.com). The SES Website can also be reached by clicking the **Help** item (**Support Services**) of the main CDEGS menu bar.

### Downloading Files

For direct access to our software updates download area, visit the following: [www.sestech.com/Downloads/ServicePack.aspx](http://www.sestech.com/Downloads/ServicePack.aspx) or click on the SES software Downloads from the Help | Support Services submenu in the CDEGS program.

For ordering download software updates, a user name and password is required. All licensees under current support are given a valid user name and password to download software updates. If those credentials were lost, please contact us. After logging in, a web page similar to the one shown here is displayed. There, one can download the desired updates.

For more information on the maintenance contract, please call SES: (450) 622-5000 or send an email to [sales@sestech.com](mailto:sales@sestech.com) or [support@sestech.com](mailto:support@sestech.com).

The screenshot shows a web browser window displaying the 'Software Updates' page. The page has a blue header with navigation links: HOME, PRODUCTS, SERVICES, SUPPORT, DOWNLOADS, LICENSES, TRAINING, EVENTS, and EN. The main content area is titled 'Software Updates' and includes a sub-header 'Software Updates' and 'Conference Presentings Engineering Now To'. Below this, there is a paragraph stating: 'The latest version of CDEGS software can be downloaded by registered users with an active Additions, Enhancements, Updates Service, including Maintenance and Insurance (AEU-MI)'. Another paragraph says: 'To access the download site, please provide your CDEGS username and password, full name, name of your organization, email address, and phone number. If you do not have a CDEGS account, please contact SES at [support@sestech.com](mailto:support@sestech.com).' Below the text is a 'Login Contact Details' section with a red asterisk indicating required fields. The form includes: Username \* (input field), Password \* (input field), Full Name \* (input field), Organization \* (input field), Email \* (input field with 'name@domain.com' as a placeholder), and Phone Number \* (input field). A green 'Submit' button is located at the bottom of the form.

## 8 File and Extension Naming Conventions

### 8.1 Introduction

SES provides a standardized environment for file and extension naming conventions. Standardization is essential to recognize the different data files easily.

### 8.2 File Naming Conventions

The **JobID** labels all the files produced during a given CDEGS software package run. It is similar to using a scenario name to a given case to be studied. This label helps identify the corresponding input, computation, results, and plot files. The **JobID** will also become a synonym of the project **Scenario** name in future versions. The CDEGS interface module will automatically insert the **JobID** string in the names of all files (unless manually overridden) created during a session. The default file naming convention is as follows:

$$XY\_JobID.Fnn$$

Where **XY** is a two-letter abbreviation corresponding to the name of the program that created the file or that will read the file as input. The abbreviations used for the Software Computation Modules are as follows:

Application	Abbreviation		Application	Abbreviation
RESAP	RS		FCDIST	FC
MALT	MT		HIFREQ	HI
MALZ	MZ		FFTSES	FT
TRALIN	TR		SPLITS	SP
SESTLC	TC		SESShield-3D	SD
CorrCAD	CC		SESShield-2D	SL
RowCAD	RC		SESShield	LS
GRSPLITS-3D	SP		SESEnviroPlus	TR
AutoGroundDesign	AD		SESeBundle	BE
SESAmpacity	AP		SESThreshold	TH
SESImpedance	FM		SESCrossSection	XS
SESCircuitSimulator	SP		CSIRPS*	CS
SESCurveFitDigitizer	CD		TransformerDataEditor	SP/HI
TransposIT	TP		SESPlotViewer	PL
SESCPCalculator	CP		SESTrainSimulator	TN

For the input processors, the following abbreviations are used:

<b>Interface Module</b>	<b>Abbreviation</b>
SICL	SC

For the output processor SIRPS, the following abbreviations are used:

<b>Interface Module</b>	<b>Abbreviation</b>
CSIRPS	CS

### 8.3 Extension Naming Conventions

The default extension naming convention is as follows:

*XY\_JobID.Fnn*

The **nn** digits are an extension used to indicate the type of file, the main file types are as follows:

<b>FILE TYPE</b>	<b>FILE TYPE</b>
Command input (for Software Computation Modules)	.INP, .F05
Computation results (for Software Computation Modules)	.F09
Computation database results of electromagnetic fields (EMF) produced by SPLITS	.F89
Auxiliary input (command and save files for input and output processors)	.F12
Computation database (for reports and graphic displays)	.F21
Plot files	.EMF, .WMF, .PS and .F30

Unique file types used by specific programs are as follows:

<b>MODULE</b>	<b>FILE TYPE</b>	<b>EXTENSION</b>
<b>MALT</b>	Current Distribution (output)	.F07
<b>MALZ</b>	Current Distribution (output)	.F17
<b>TRALIN</b>	Line Impedance Data (output)	.F27
<b>SPLITS</b>	Summary Computation Results (output)	.F07
<b>HIFREQ</b>	Current Distribution (output)	.F17
<b>FFTSES</b>	Spectrum Storage File	.F07
<b>FFTSES</b>	Recommended Frequency List	.F27
<b>SICL</b>	Session save file (output)	.F08
<b>MALZ</b>	Current distribution recovery file (input and output)	.F33
<b>HIFREQ</b>	Current distribution recovery file (input and output)	.F33

	output)	
<b>SIRPS</b>	Summary report file (output)	.F17
<b>Share File</b>	Session save file (output)	.F08
<b>AutoGrid Pro</b>	Data Exchange File (share file)	SF_jobid.F11

## Right-of-Way Software Package:

FILE TYPE	EXTENSION
Project file	RW_ProjectName.row
Scenario file	RW_Scenario*.F05
Self and mutual impedances of all phases for all section cuts in a region (output)	TS_Scenario*_T*_R*.out
A SPLITS-compatible file. Where Scenario is the ScenarioName for the project and X is an integer representing the circuit ID for a SPLITS file, typically, 0, 1 ...	SP_ScenarioName_X.F05
A SPLITS-compatible file (before modification). Where ScenarioName is the scenario name for the project and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	SP_ScenarioName _ReferenceCircuitModelID.F05
A SPLITS-compatible file (after modification). Where NewCircuitModelID is an integer representing the new ID for SPLITS file, typically, 1, 2...	SP_ScenarioName _NewCircuitModelID.F05
The command file that records the operations made on a SPLITS file can be loaded by this module. X and Y are integers, X is the reference circuit model ID, and Y is the new circuit model ID.	MODSP_ScenarioName_X_Y.F05
Contains the maximum GPR of the exposed line at every section. Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	ExposedlineGPR_ScenarioName_Re ferenceCircuitModelID_Exposedline PhaseNumber.out
Contains the GPR of the exposed line at the fault locations. Here, ScenarioName is the scenario ID for the project and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	ExposedlineGPR_FTLCT_Scenario Name_ReferenceCircuitModelID_Ex posedlinePhaseNumber.out
Contains the maximum section current of the exposed line at every section. Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	ExposedlineCUR_ScenarioName_Re ferenceCircuitModelID_Exposedline PhaseNumber.out
Contains the section current of the exposed line at the fault locations. Here, ScenarioName is the scenario ID for the project and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	ExposedlineCUR_FTLCT_Scenario Name_ReferenceCircuitModelID_Ex posedlinePhaseNumber.out

**Right-of-Way Software Package (continued):**

FILE TYPE	EXTENSION
Contains the maximum shunt current of the reference line (i.e., tower shunt current) at every section. Here, ScenarioName is the scenario ID for the project and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	REFCUR_ScenarioName_ReferenceCircuitModelID.out
Contains the maximum GPR of the reference line (i.e., tower shunt potential) at every section. Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	REFPOT_ScenarioName_ReferenceCircuitModelID.out
Contains the section current on the right side of the fault location (i.e., fault current contributed from the right side of the fault location). Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	FAULTCURRIGHT_ScenarioName_ReferenceCircuitModelID.out
Contains the section current on the left side of the fault location (i.e., fault current contributed from the left side of the fault location). Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	FAULTCURLLEFT_ScenarioName_ReferenceCircuitModelID.out
Contains the maximum line-to-line voltages of the assigned exposed line (e.g.rail-to-rail voltage) at every section. Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	LTLDIFF_ScenarioName_ReferenceCircuitModelID.out
Contains the maximum GPR differences between the two points along an exposed line. Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	PIPEDIFF_ScenarioName_ReferenceCircuitModelID.out
Contains the maximum total interference GPR. Here, ScenarioName is the scenario ID for the project and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	TotMetalGPR_ScenarioName_ReferenceCircuitModelID.out
Contains the maximum total interference coating stress voltage. Here, ScenarioName is the scenario ID for the project, and ReferenceCircuitModelID is an integer representing the reference ID for a SPLITS file, typically, 0, 1 ...	TotCoatingStressV_ScenarioName_ReferenceCircuitModelID.out

Please note that not all of the modules may be accessible; the purchased license determines which modules will be fully functional.

## **8.4 Shared Files for RESAP, MALT, SPLITS, FCDIST, and SIRPS**

Some crucial data can be shared between the computation modules RESAP, MALT, SPLITS, FCDIST, and SIRPS. This way, the data entry is facilitated in complex studies where the output of one program becomes the input of another.

The RESAP program stores the computed soil model in a shared database file. That soil model is read and used by MALT if no other soil model is specified in its input file.

MALT prints the computed Main Ground resistance to the shared file, which SPLITS or FCDIST will then read if the user does not enter the Central Site ground impedance. SPLITS and FCDIST store the current injected into the Central Site ground in the shared file, which can then be read by MALT (if it is run after SPLITS or FCDIST) if no Main Ground injection current is specified in MALT.

SIRPS reads the SPLITS or FCDIST central site ground current and divides it by the MALT input current (main ground) to obtain a scaling factor that can be applied to all values in SIRPS.

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## 9 Description of SES Software Computation Modules

### 9.1 Command Input Mode (SICL)

SICL (SES Interactive Command Language) is a flexible, command-driven input processor to the SES software packages. The user controls the operations of the processor by embedding in the input files simple English-like commands that are structured in a logical hierarchy. As a result of the command structure, SICL input files are highly readable (they are backward compatible since the introduction of the SICL command input files) and, therefore, handy for documentation and reference purposes, especially when the input files are interspersed with pertinent comments.

On-line help provides the syntax and usage of SICL commands and discussions on special topics. SICL commands are clustered into groups according to function and thus form a hierarchy. These commands can be entered in ASCII (text) files using the dedicated **SESTextEditor** tool and any text editor including SES MultiPad editor.

The Software Computation Modules described hereafter read the SICL input files to gather the necessary system data and perform the requested computations.

### 9.2 Software Computation Modules

The calculations are performed by the Software Computation Modules. Each of these modules reads data from a structured command input file and computes various results useful to electrical engineers and scientists, as explained hereafter.

#### RESAP

The computation module RESAP interprets measured soil resistivity data and determines equivalent earth structure models. The user enters apparent resistance or resistivity values measured using Wenner, Schlumberger, Dipole-Dipole, Unipolar Wenner, or arbitrary electrode arrays and RESAP determines a multilayered or exponential soil structure that most closely matches the measured results.

Soil models generated by RESAP can be used to analyze grounding systems, conduct cathodic protection studies, examine electromagnetic induction (EMI) problems, and compute transmission line parameters.

## MALT

MALT is the oldest and most widely known computation module of SES software package. It is a powerful grounding analysis tool, which is useful whenever electrical conduction through earth must be studied; typically, MALT is used to analyze and design ground networks for HVAC and HVDC power stations, substations, or transmission towers, or to design anode beds for cathodic protection installations.

Other electrical engineering problems can also be accurately solved by using MALT. It can analyze complex ground networks of bare or coated conductors buried vertically, horizontally, spherically, spheroidally, inclined, or cylindrically layered soil, or in the air for Perfect soil model (bare or coated plates are also available for horizontally and Perfect soil models). MALT can also account for arbitrarily shaped regions of varying resistivities embedded in a uniform or horizontally layered soil.

Generally, MALT is suited to analyze all practical problems where DC or AC power frequency currents are injected into the earth by a ground network or multiple electrodes, so long as the longitudinal impedances of the ground conductors can be neglected. In this situation, the locations of the current injection points within the ground network do not play a significant role. At higher frequencies or increased ground network size, or low soil resistivities, the longitudinal impedances of buried conductors cannot be neglected; consequently, MALT results may become inaccurate. It is preferable to use other computation modules, such as MALZ or HIFREQ, for such analyses. HIFREQ is a unique analytical computation software code that can solve any electromagnetic problem involving a network of arbitrarily oriented aboveground and buried conductors energized by any number of current and voltage sources.

## MALZ

MALZ analyzes the frequency domain performance of networks of buried, current-carrying conductors and computes the following quantities:

- Magnetic field in the air.
- Conductor and earth potentials.
- Current distribution in the conductors and in the soil.

It is particularly suited to analyzing extensive ground networks that cannot be considered equipotential surfaces or interact with nearby coated pipelines. MALZ is also an excellent tool for analyzing conductor networks energized by currents at frequencies varying from 0 to about 0.5 to 1 MHz or studying the cathodic protection of coated structures.

MALZ is similar to MALT, with the following main differences:

- MALZ computes magnetic fields, while MALT does not.
- MALZ accounts for attenuation along conductors and computes the potential drop, typically occurring in large conductor systems (e.g., along pipelines or in large plants), while MALT assumes ideal conductors (a valid assumption for power line structure and most small or moderate grounding systems in relatively moderate or high resistivity soils).
- MALZ allows the user to specify the injection currents with arbitrary phase angles at multiple locations throughout the grounding system or systems modeled. In contrast, MALT allows multiple current or voltage injections of real-valued quantities (positive, zero, or negative) on an arbitrary number of equipotential electrodes.

Note that MALZ can accommodate all the soil structures, except Perfect soils that can be modeled by MALT.

## TRALIN

TRALIN analyzes electric line cross-sections to determine conductor line parameters, electrostatic and electromagnetic induction effects on ungrounded conductors, and electric fields in the air. TRALIN can be applied to industrial, distribution, and transmission lines with any number and type of conductors or phases configured in any arbitrary positions: combinations of cables, pipelines, stranded and composite conductors, insulated and bare conductors, overhead and buried conductors, and irregular phase configurations.

Computations take into account the non-uniform nature of soil structure characteristics. TRALIN can be used to analyze complex Right-of-Way situations containing transmission lines, cables, and pipelines just as easily as it can be used for simple power line corridors.

The most usual application of TRALIN is to compute series and shunt impedances of electric line conductors and nearby non-energized conductors such as pipelines and communications cables. These impedances are then used to create a circuit model which can be analyzed by the computation module SPLITS to compute currents flowing in all parts of the system (including metallic return paths) and potentials throughout the system.

## SPLITS

SPLITS is one of the most versatile computation modules of SES software. It determines the load and short circuit currents distribution in every section or span of a multi-conductor, multi-phase electric transmission, distribution, or industrial network. It is also used to investigate electromagnetic interference effects caused by such conductors on neighboring facilities such as pipelines, communication lines, rails, fences, etc.

## **FCDIST**

FCDIST computes the distribution of fault currents between a grounding system and the overhead ground wires or neutral wires connected to it.

FCDIST is a synthesis of the programs TRALIN and SPLITS, which has been simplified to permit rapid modeling of a number of electric lines connected to a substation or plant. Only the faulted phase or conductor of each line is modeled, and the characteristics of each span can be different. For more detailed modeling, SPLITS and TRALIN should be used instead.

## **HIFREQ**

HIFREQ analyzes the performance of networks of buried and above-ground current-carrying conductors (thin metallic plates are also available for infinite, uniform and horizontally 2-layer soil models) and cables, and computes the following quantities:

- Magnetic field in the air and the earth.
- Electric field in the air and the earth.
- Conductor and earth potentials.
- Current distribution in the conductors.
- Self and mutual impedances and capacitances of conductors and arbitrarily shaped circuits.

HIFREQ is particularly suited for analyzing extensive conductor networks, including energized grounding systems at frequencies ranging from 0 Hz to hundreds of MHz. It can also model transformers, GIS, GIL, power cables and pipe-type cables. Using appropriate software such as FFTSES, the transient response of any network of conductors is easily determined. Electromagnetic compatibility studies, safety EMF studies involving the determination of magnetic and electric field levels, and interference studies are a few of the many possible applications of this powerful computer program.

## **FFTSES**

FFTSES performs Forward, and Inverse Fast Fourier Transforms on arbitrary transient waveforms to be studied by frequency domain computation modules such as MALZ, HIFREQ, and SPLITS.

Since MALZ, SPLITS, and HIFREQ all operate in the frequency domain, FFTSES is an important complement to these programs for the study of transients and surges. FFTSES can also be used independently whenever Fast Fourier Transforms on waveforms are studied.

### 9.3 How-to... Engineering Manuals

The following table provides a quick reference to help the user locate the appropriate software package “**How-to...**” engineering manual.

Pertinent PDF “How-to ...” Manual	CDEGS Software Package																	
	SES-Shield 2D	SES-Shield 3D	SES-EnviroPlus	AutoGroundDesign	AutoGrid Pro	AutoGround	MultiGround	MultiGround +	MultiGroundZ	MultiGroundZ +	MultiLines	MultiFieldsPro	MultiFields	MultiFields +	SESTLC Pro	Right-of-Way Pro	Full CDEGS	CorrCAD
AutoGroundDesign				<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>
AutoGrid Pro					<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>
Ground				<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>
GISGRND				<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Suburban									<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Urban									<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
RLC												<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Capind												<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Fence												<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Tower												<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Lightn												<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
SESEnviroPlus			<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
SESCurvefitDigitizer																		<input checked="" type="checkbox"/>
ACTotalInterference Study								<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
SESTLC EMF and AC Interference								<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Quick Start Guide SESShield-3D		<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
Quick Start Guide CorrCAD (Offshore)									<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>
Quick Start Guide CorrCAD (Onshore)									<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>
Quick Start Guide SESCPCalculator																		<input checked="" type="checkbox"/>
Quick Start Guide SESTrainSimulator												<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
QuickStartGuide ROW									<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
QuickStartGuide RowCAD									<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

<b>SESShield-3D-Direct Lightning Stroke Shielding of a Substation</b>	<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
<b>Importing DXF Drawing Into SESShield-3D</b>	<input checked="" type="checkbox"/>						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>



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