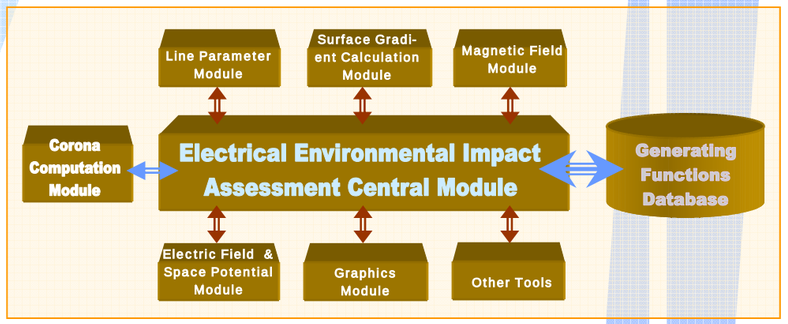
Main System Design Structure

SES-Enviro Central Module determines Radio Interference, Audible Noise levels and AC and DC losses generated by HV lines. It computes line parameters such as, electric fields, magnetic fields, scalar potentials and corona. HV lines may have arbitrary configurations involving parallel transmission and distribution lines, each with varying number and type of aerial conductors. The fields and corona parameters can be evaluated at any location in the vicinity of the line. SES-Enviro can determine the corona impact on individual phases, circuits or lines. The program is able to handle AC and DC lines as well as hybrid lines for the calculation of the static electric field, the scalar potential (non-ionized field), the magnetic field and the gradient.



Corona Computation Module

There are three main corona parameters that are evaluated by this module for AC and DC lines: corona loss (CL), radio interference (RI), and audible noise (AN). For each of these parameters, several alternative evaluation methods are available, based on the current state of the art. Each of these published methods is valid for a certain range of conductor radius and surface gradient. These ranges have been determined in field tests conducted during the elaboration of these methods. For historical reasons, the generating functions which convert conductor surface electric fields into radio interference, audio noise levels, and corona losses are separated in two main categories, namely semi-empirical and empirical methods. In general, the semi-empirical methods cover a wider range of designs and line types. The evaluation methods used are based on the work of research centers, such as, EdF, IREQ, GE, BPA, CRIEPI, ENEL, Westinghouse, and FGH. Along side these semi-empirical methods are also the empirical methods which have been developed to evaluate predetermination criteria for corona parameters.

Line Parameter Module

This module computes the Maxwell potential coefficients, shunt capacitances and self and mutual impedances. Moreover, the line parameters can be computed on a per-conductor basis or a per-phase basis, with shield wires being either eliminated or treated as distinct conductors. It takes into account power frequency, skin effects, earth characteristics and high frequency RI parameters in the evaluation of the corona and line parameters. An extensive conductor database is available to easily choose the appropriate conductor.

Conductor Surface Gradient Module

The electric field gradient on the surface of any conductor can be computed using two methods. One of the methods, the Strip Simulation method, computes accurately the gradient even if the conductors of a bundle are in contact.

Electric, Magnetic and Space Potential Modules

The currents in the ground return conductors (i.e., neutral, shield, or static wires) contribute significantly to the magnetic fields in a balanced three-phase transmission system. The magnetic fields are computed automatically based on the assumption that the impedances of the terminations are always small compared with the total self-impedance of the ground return conductors (this is true when these conductors are sufficiently long. The electric field and space potential are computed using a modified “successive images” method. This method yields a very accurate evaluation of the modified “Maxwell coefficient matrix”, the charges on the conductors, and the surface gradient. The program can compute the static (non-ionized field) and dynamic electric field and space potential (scalar potential) anywhere in the vicinity of the line for a general case where AC and DC lines coexist.

View, Plot and Report Tools

SES-Enviro Plot module is a powerful and flexible report and graphics tool that serves as an integrated output processor to display the computation results in various graphical or print formats.

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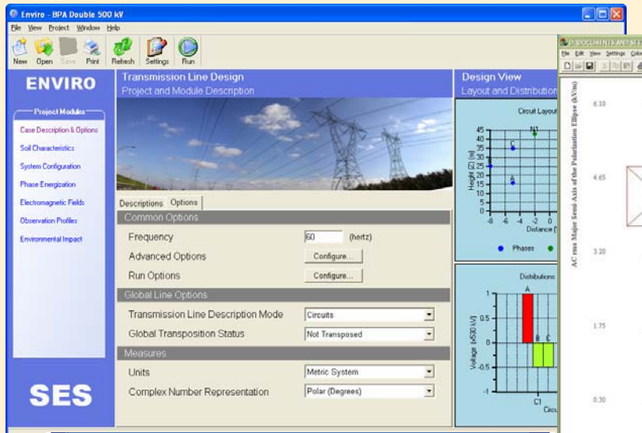
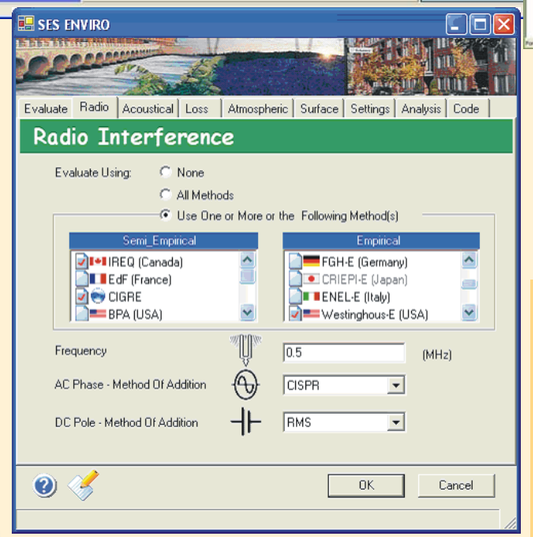
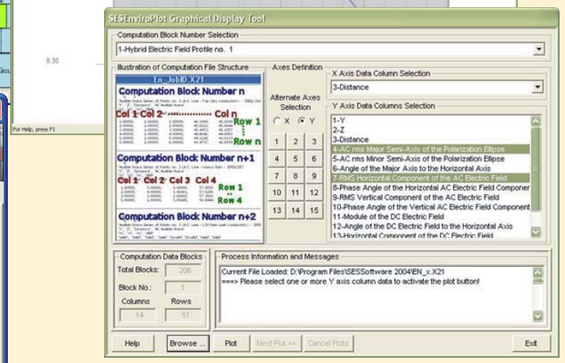
SES-Enviro®

Electromagnetic Environmental Impact Analysis of Overhead AC and DC Transmission Lines

It is extremely important to assess the overall effects of transmission lines on the environment, particularly, in populated areas. One of the most important aspects of this assessment is what is commonly designated as Electrical Environmental Impact Assessment (EEIA) caused by electromagnetic interference , radio noise, audible noise and corona.







Despite the obvious economic importance of optimizing a design with respect to corona effects, until now, no commercially available software adequately addresses this design problem at present. SES-Enviro has eliminated this heavy burden.

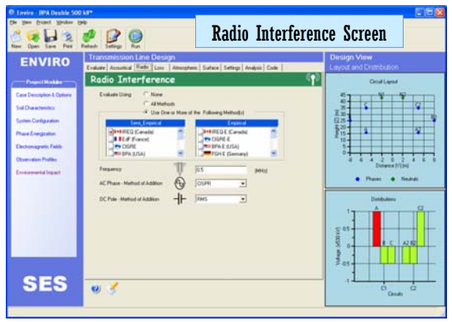
SES-Enviro

SES-Enviro *Plus*

Introduction

The SES-Enviro Plus software package analyzes the environmental impact of transmission lines. It calculates the levels of radio interference, audible noise and other corona-related effects and computes electric and magnetic fields around transmission lines.

For transmission lines with operating voltages in excess of 345 kV, the key construction cost factors of the design are legally imposed measures taken to limit radio and audible noise, generated by corona as a result of high electric field levels at the conductor surface. Reduction of this noise can be accomplished by increasing the conductor size or the number of conductors per bundle or by moving the conductors further away from one another, keeping in mind that the overall geometry is important. All of these measures have a considerable impact on cost. For example, simply raising 735 kV tower cross-arms by 1 m has been known to increase the cost of a line by as much as 10%! Power loss due to corona, during operation, represents another concern. Despite the obvious economic importance of optimizing a design with respect to corona effects, until now, no commercially available software adequately addresses this design problem at present. SES-Enviro has eliminated this heavy burden.



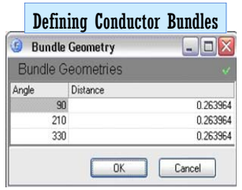
The SES-Enviro software package is an analysis tool developed for the design of overhead AC and DC transmission lines. It quickly estimates line parameters, electric fields, magnetic fields, scalar potentials and corona parameters (loss, radio noise, audio interference) associated with arbitrary configurations of parallel transmission and distribution electric lines, with any number and type of aerial conductors. The field and corona parameters can be evaluated at any location in the vicinity of the line. The corona parameters calculated for high voltage AC lines are the surface gradient, the corona loss, the radio interference level, and the audible noise level. To aid the designer, the corona impact of individual phases, circuits or lines on corona-related parameters can be evaluated. The program is able to handle AC and DC lines as well as hybrid lines for the calculation of the static electric field, the scalar potential (non-ionized field), the magnetic field and the gradient.

SES Enviro evaluates the environmental impact of high-voltage transmission lines with respect to radio interference, acoustical noise, corona loss, and electromagnetic fields. It is the most versatile and powerful design and analysis software package available in the industry.

All SES-Enviro specific parameters are presented in one main window, which contains a multi-tab control that can quickly access such parameter groups as Radio Interference Acoustical Noise, Corona Loss, Atmospheric Conditions and Conductor Surface State.
Validation is performed by a powerful parser that flags all errors.

Analytical Methods Used in SES-Enviro

SES-Enviro is based on the following analytical methods.



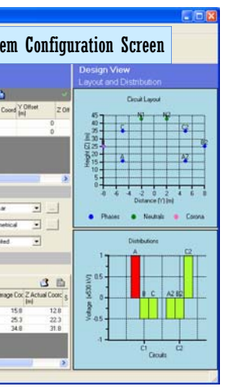
- **Line Parameters.** All line parameters are computed using enhanced algorithms based on the method used by the FCDIST engineering module. The bundle reduction, ground-wire elimination and sequence components algorithms are all based on the TRALIN engineering module.

- **Individual Contributions of Bundles and Circuits to the Corona Performance of a System**. The effects of each phase bundle or circuit upon the corona performance of the system can be evaluated independently by forcing the corona on any number of circuits or phase bundles to zero while keeping all the others. Note that it is not enough to simply de-energize or physically remove phase bundles or circuits from the system under study to perform such an analysis, as the high frequency behavior of one circuit is modified by the presence of another parallel circuit, energized or not. SES-Enviro thus allows the user to evaluate, conveniently and accurately, the impact on an existing circuit of the addition of a new circuit, in terms of the surface gradient, the high frequency propagation characteristics, the radio interference and the audible noise.

SES-Enviro Plus offers an integrated environment for a complete assessment of the environmental impact of transmission lines. You can specify data, carry out computations, and visualize the computation results all from a single interface.

- **Magnetic Field**. The currents in the ground return conductors (i.e., neutral, shield, or static wires) contribute significantly to the magnetic fields in a balanced three-phase transmission system. The determination of the currents in the ground return conductors is based on the observation that the impedances of the terminations are small compared with the total self-impedance of the ground return conductors in long transmission lines.

- **Electric Field and Space Potential.** The electric field and space potential are computed using a modified successive images method. This method yields a very accurate evaluation of the (modified) Maxwell coefficient matrix, the charges on the conductors, and the surface gradient.

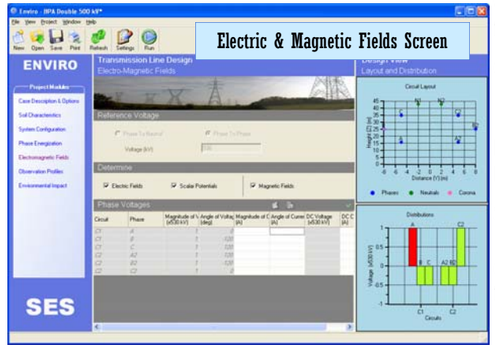


- **Corona Parameters.** There are three main corona parameters evaluated by the SES-Enviro program for AC lines: corona loss, radio interference, and audible noise. For each of these parameters, several alternative evaluation methods have been introduced, based on the current state of the art.

- **Generating Functions.** The generating functions which convert conductor surface electric fields into radio interference, audio noise levels and corona losses are separated in two types of methods: semi-empirical and empirical methods. In general, the semi-empirical methods are less specific to a particular type of transmission line and cover a wider range of designs. The evaluation methods used are based on the work of several research centers such as EDF, IREQ, GE, BPA, CRIEPI, ENEL and FGH.

Technical Features

SES-Enviro, computes the Maxwell potential coefficients, shunt capacitances, self and mutual impedances, and admittances for all conductors on a per-conductor basis and a per-phase basis, with shield wires being either eliminated or treated as distinct conductors.

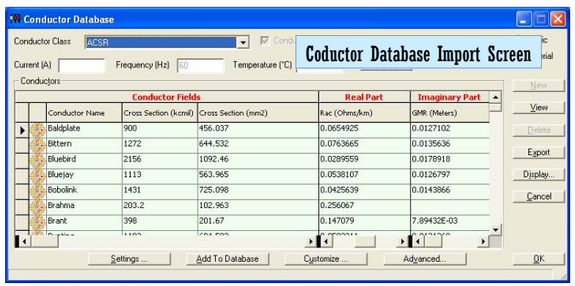


Corona-related parameters are based on the best evaluation methods currently available: i.e., EDF, IREQ, BPA, CRIEPI, ENEL, FGH, and GE.

SES-Enviro takes into account power frequency, skin effects, and earth characteristics in the evaluation of the corona and line parameters.

For overhead conductor arrangements with little regularity, conductors are specified one at a time and may be completely different from one another.

For regular overhead conductor arrangements, the conductor characteristics are specified on a per-circuit basis and the phase bundle configuration is specified to reduce data entry time. The per-circuit basis and phase bundle input configuration allow asymmetrical bundles to be entered.



An extensive conductor database is available to ease input operations.