5 SES-Enviro: Evaluation of Environmental Impact of High Voltage Transmission Line

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5.1 Introduction

It is very important to consider the problems associated with corona when designing high voltage (HV) lines, as it greatly influences the dimensioning of conductors, insulators, and fittings.

To arrive at a feasible solution, it is necessary for the designer to estimate both the line conditions once in operation and the acceptable values ranges[1].

Three main corona criteria are Radio Interference (RI), Audible Noise (AN) and Corona Loss (CL). These are evaluated, by and large through the use of conductor gradient and line voltage. RI and AN affect mostly the environment and the cost related to the transmission line construction. Conversely, corona loss affects mainly operation cost.

The new SES-Enviro software package is an analysis tool developed for the design of overhead AC and DC transmission lines. Its user-friendly interface is of great help in rapid line design.

5.2 SES-Enviro module

5.2.1 General points.

SES-Enviro is a tool for HV line architects to help them determine RI, and AN levels. It also can evaluate AC and DC losses in HV lines whose main structural characteristics are known. It quickly estimates line parameters such as, electric fields, magnetic fields, scalar potentials and corona. HV lines may have arbitrary configurations involving parallel transmission lines, electric distribution lines, each with varying number and type of aerial conductors. The field and corona parameters can be evaluated at any location in the vicinity of the line.

To help in the design process, corona impact on 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. The SES-Enviro module that is part of CDEGS version 11 offers a beta release for the DC methods. They are fully functional but do not yet have associated user documentation. The DC methods have been added as a bonus beta tool for the user. Although these methods have been implemented as accurately as possible using current scientific published papers, there may be some discrepancies present. These DC methods may become official in the next SES-Enviro release.

The application has been designed to accelerate the design of transmission lines, providing useful information with minimal data entry; part of the user interface is based on that of TRALIN - the line parameters program.

5.2.2 Methods of Evaluation

As far as the corona parameters for conductors are concerned, various “semi-empirical” methods have been developed and published. These methods are based on actual measurements of the noise and the losses that are characteristic of the line elements. Theoretical consideration comes from the complete schematization of the propagation phenomenon of the electromagnetic fields generated by RI noise and the acoustical propagation of AN.

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. Their methods use generating functions[2] on every conductor that is submitted to corona. The evaluation methods used are based on the work of several individuals and research centers. This includes such research centers 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. These methods involve fewer theoretical considerations and instead work by extrapolating values based on measured references.

Semi-empirical methods allow for an absolute determination of the corona parameters at a given point, while empirical predetermination formulas are more limited in their applicability context, due to the fact that they use comparative evaluations.

Never the less, it must be kept in mind that comparative evaluations are for the most cases quite sufficient for HV line design. This is due to the fact that, by and large, a designer's concerns will generally focus on knowing whether the line is within a given limit rather than obtaining a specific value, with respect to RI and AN.

5.2.3 Line optimization

For transmission lines with operating voltages in excess of 345 kV, the key cost-determining factor of the design are legally imposed restrictions placed to limit radio interference and audio noise that are generated by corona resulting from high electric field levels at the conductor surface. Reduction of these noise pollutants can be accomplished by increasing either the conductor size, the number of conductors per bundle or by moving the conductors further away from one another. In addition, the overall line geometry is quite important. All of these measures have a considerable impact on the construction cost of the line. Inversely, a poor line design may initially have a lower construction cost but will generate higher operating cost caused by power loss due to corona.

5.2.4 Technical Features in SES-Enviro

Corona Parameters

There are three main corona parameters evaluated by the SES-Enviro program for AC and DC lines: corona loss (CL), radio interference (RI), and audio noise (AN). For each of these parameters, several alternative evaluation methods have been introduced, 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.

Line Parameters

SES-Enviro allows you to compute the following line parameters: Maxwell potential coefficients, modified Maxwell potential coefficients, shunt capacitances, self and mutual impedances. Moreover, selection can be preformed on a per-conductor basis or a per-phase basis, with shield wires being either eliminated or treated as distinct conductors.

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

For regular overhead conductor arrangements, the conductor characteristics are specified on a per-circuit basis. Phase configuration can be specified using the default, quick entry, symmetrical bundle generator, or through the bundle geometry window that allows the user to specify asymmetrical bundles.

For overhead conductor arrangements with little regularity, conductors can be specified individually, using the single mode entry. Although this allows the greatest configuration flexibility, defining the circuit in this manner is more tedious. One major advantages of this entry mode is that it allows all conductors to be of different types. Once entered, the SES-Enviro processing engine will then regenerate the appropriate bundle phases.

An extensive conductor database is available to allow the user to easily choose different conductor characteristics.

Option to Examine the Individual Contributions of Bundles and Circuits to the Corona Performance of a System.

The effect of each phase bundle or circuit upon the total corona performance of the system can be evaluated independently by forcing the corona on all other phases to zero while maintaining corona on the circuit or phase being studied. Note that it would not suffice 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, or the addition of a new circuit, in terms of the surface gradient, the high frequency propagation characteristics, the radio interference, the audio noise and the corona losses.

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 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). With this assumption, the value of the termination can be set to zero.

5.2.5 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. The program can compute the static electric field (non-ionized field) and space potential (scalar potential) anywhere in the vicinity of the line for a general case where AC and DC lines can coexist.

5.3 SES-Enviro input interface

5.3.1 Introduction

SES-Enviro is a new module that integrates into the current version of TRALIN. It permits the evaluation of environmental impact of transmission lines with respect to radio interference, acoustical noise, and corona loss.

Along with SES-Enviro computation module comes a set of graphical interfaces which bring forth a clean new look. All SES-Enviro specific parameters are presented in one main window which contains a multi-tab control. From this multi-tab control one can quickly access such parameter group as, Radio Interference (RI), Acoustical Noise (AN), Corona Loss (CL), Atmospheric Conditions and Surface State. The “Settings” tab allows users to fine tune the degree of accuracy required.

The interface uses both text and visual clues to help the user. This has the following benefits:

- ✓ All methods are accompanied by the flag of the country of origin where the method was developed.
- ✓ Methods not applicable for the currently defined system are grayed out; trying to select them will display the reason why they are not applicable.
- ✓ Labels usually have an icon depicting their action. Most inappropriate settings are immediately reported using both an error icon and a background color change.

A code viewer window allows the user to quickly glance at the SES-Enviro specific code that will be produced from the data that was entered. If the user is so inclined, there is also a code editor window that allows the entry of SES-Enviro data directly. Validation is then performed by a built-in parser that will flag any errors it encounters. Once valid, all of the controls on multi-tab are updated to reflect these values.

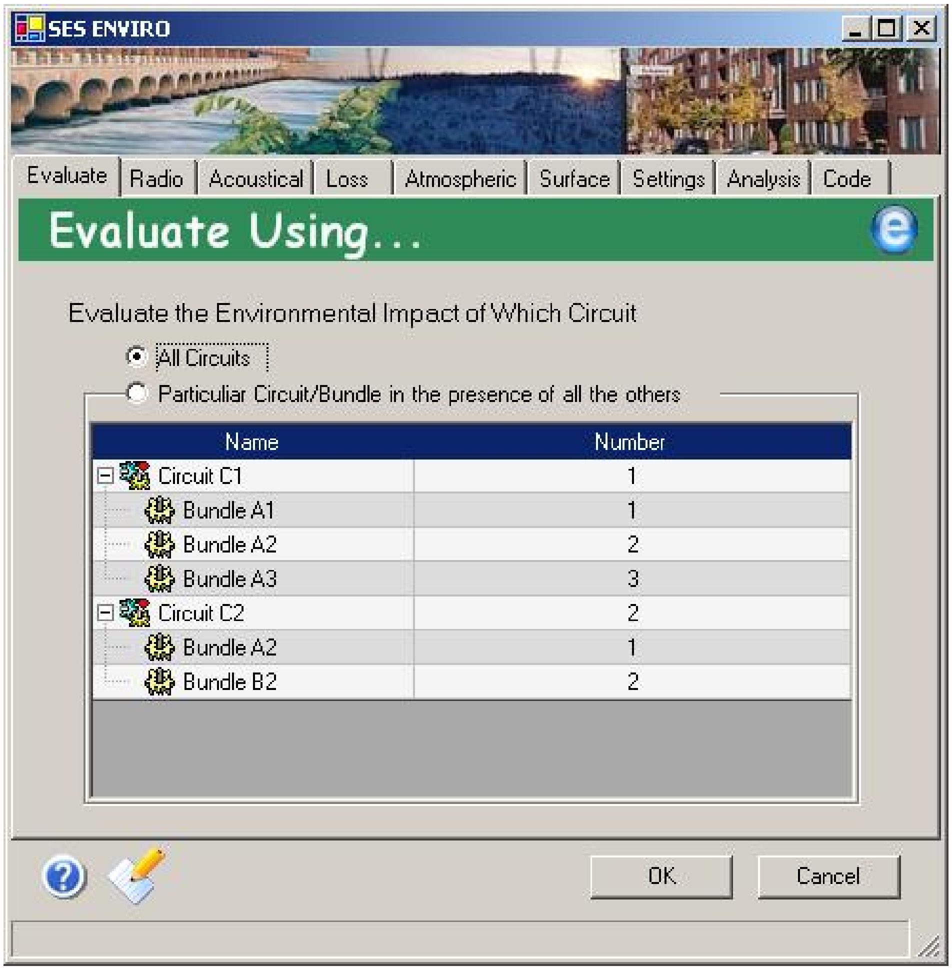

Figure 5-1 Radio Interference tab for SES-Enviro.

5.3.2 Validation

A new validation model is used in the SES-Enviro module. A Typical error response can be seen below.

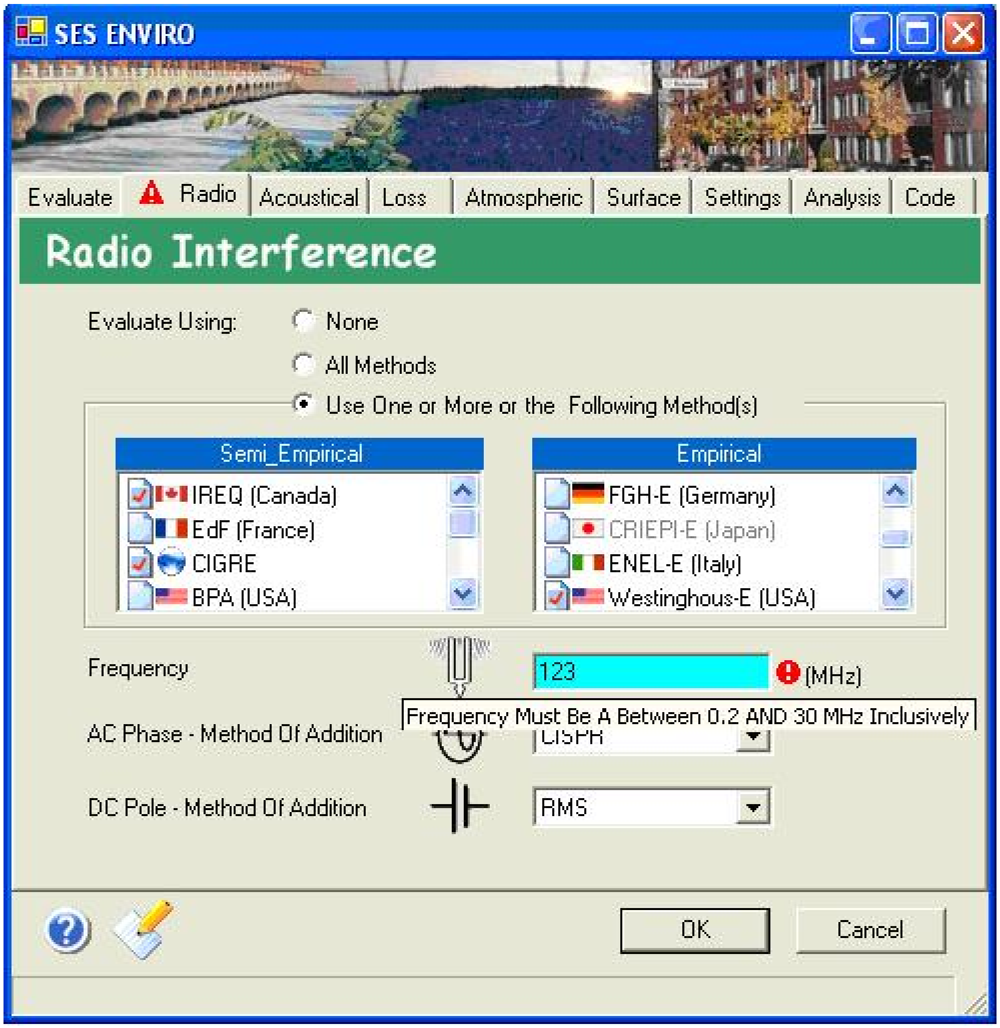

Figure 5-2 Typical error response. In this case, the specified frequency value is too high.

Most errors are detected immediately and are visually flagged in a four-point manner:

1. The background of the control may change color.
2. A red circle containing an exclamation mark appears besides the control. Placing the cursor over this circle displays the error message.
3. A red triangle marks the tab which contains a control in error.
4. An Analysis tab holds a list of all parameters in error. Double-clicking any item in the list brings forth the tab and the cursor flashes on the control in error.

5.3.3 Activating SES-Enviro

Since SES-Enviro is currently implemented as an extension of TRALIN, it is possible to enable or disable it by checking the SES-Enviro checkbox on the main TRALIN window, as shown in the figure below. When disabled, one only gets TRALIN specific functionality. Enabling the SES-Enviro option, activates a series of powerful new features designed to compute transmission line environmental impacts, namely radio interference, acoustical noise and corona loss. Please refer to the section below entitled "Extended TRALIN Functionality" for more details on these extended features.

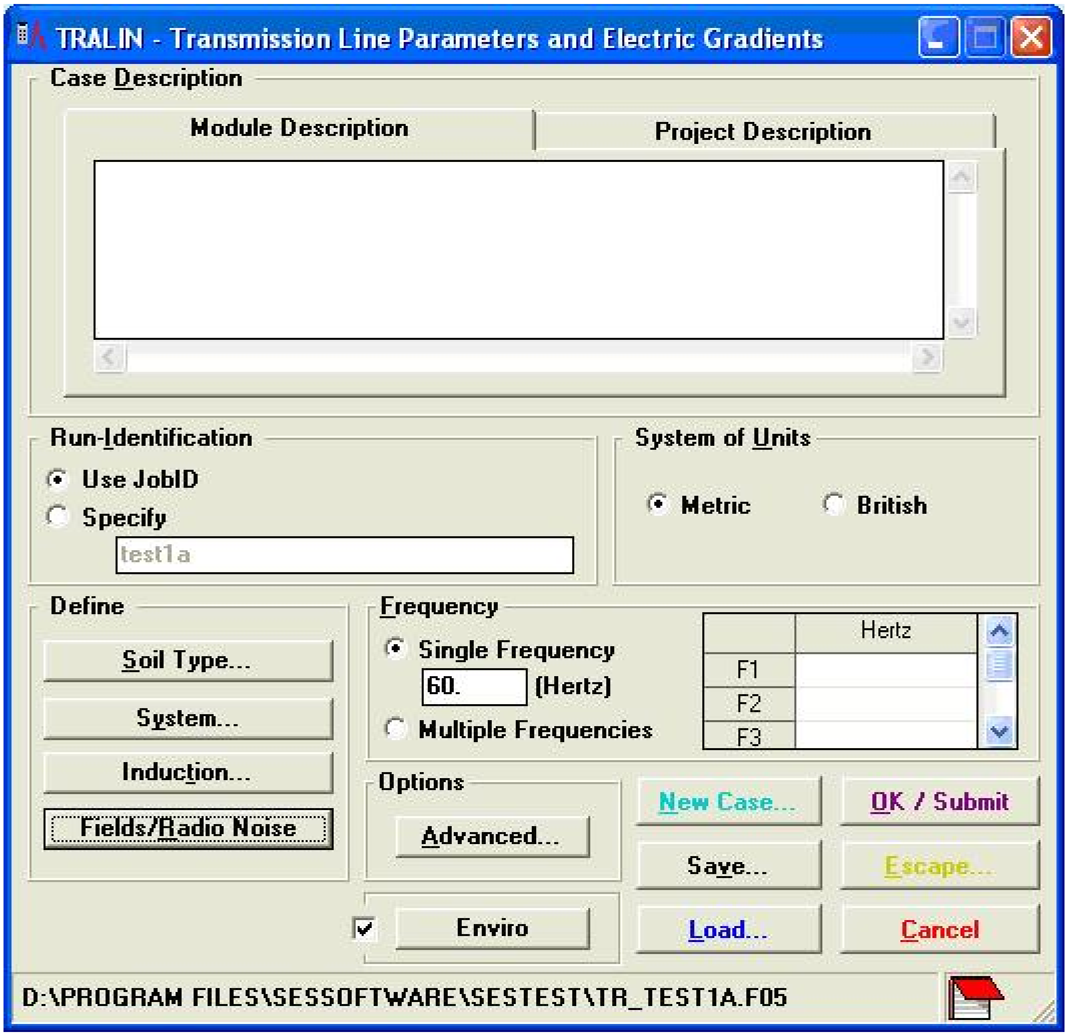

Figure 5-3 Main TRALIN window displaying the new SES-Enviro button.

5.3.4 Extended TRALIN Functionality

SES-Enviro has revamped and extended the functionality of TRALIN in a number of ways. As seen in the figure below, the TRALIN system windows has changed somewhat. Most notable functionality changes are:

1. Neutrals are now associated to a specific circuit.
2. Bundle geometry can be explicitly defined.
3. Phase number are sequentially assigned, which may then be changed if desired.
4. X-Y coordinate system has become the Y-Z (standard in electro-magnetism), where X is along the line, Y is perpendicular to the line and Z is upwards.
5. Actual conductor height (Zpa) has been added to allow both average height (Zp) and the height of the transmission line at the point of evaluation (Zpa).

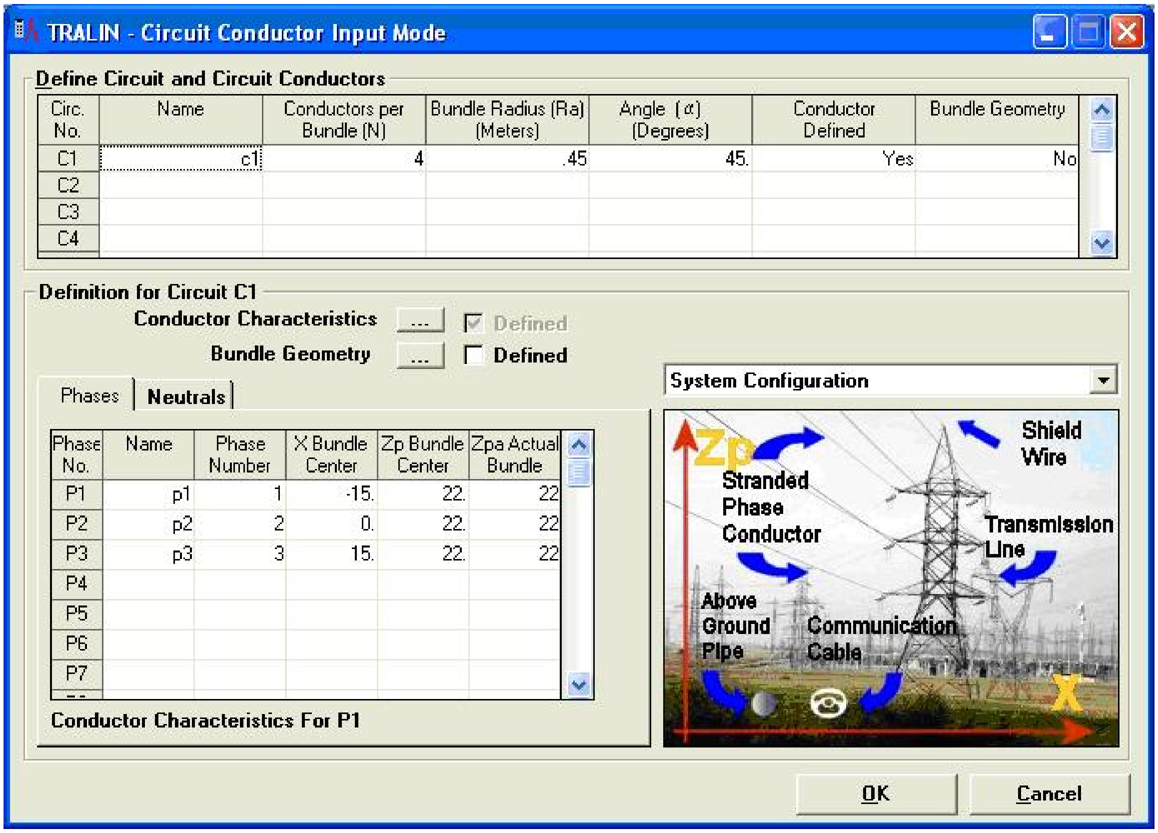

Figure 5-4 Revamped TRALIN system window with new SES-Enviro options.

A very convenient and powerful new feature is the possibility of specifying asymmetrical bundles. When initially calling up the bundle geometry window the user is presented with a list of all conductors in a bundle as defined in the circuit list; that is, number of conductors, radius and starting angle. The user is then free to modify the bundle as desired, placing conductors in any position.

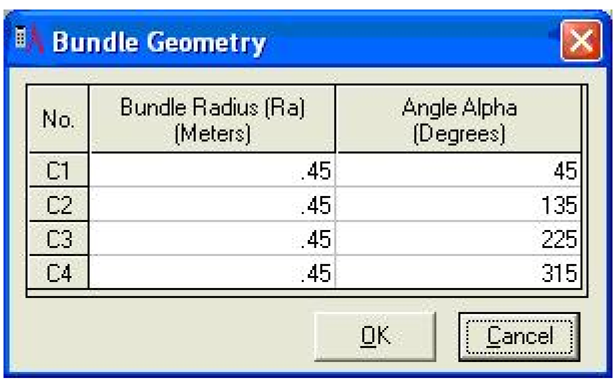

Figure 5-5 Bundle geometry window allowing asymmetrical bundle definition.

SES-Enviro has also brought changes to the gradient window, such as:

1. DC voltage - with or without AC voltage on the same conductor.
2. AC Current - both magnitude and angle.
3. The distribution grid is filled automatically once the reference voltage is entered.
4. If two phases are detected, the distribution defaults to DC, if three phases are detected then the distribution is set as AC. Either of which can then be changed by the user.

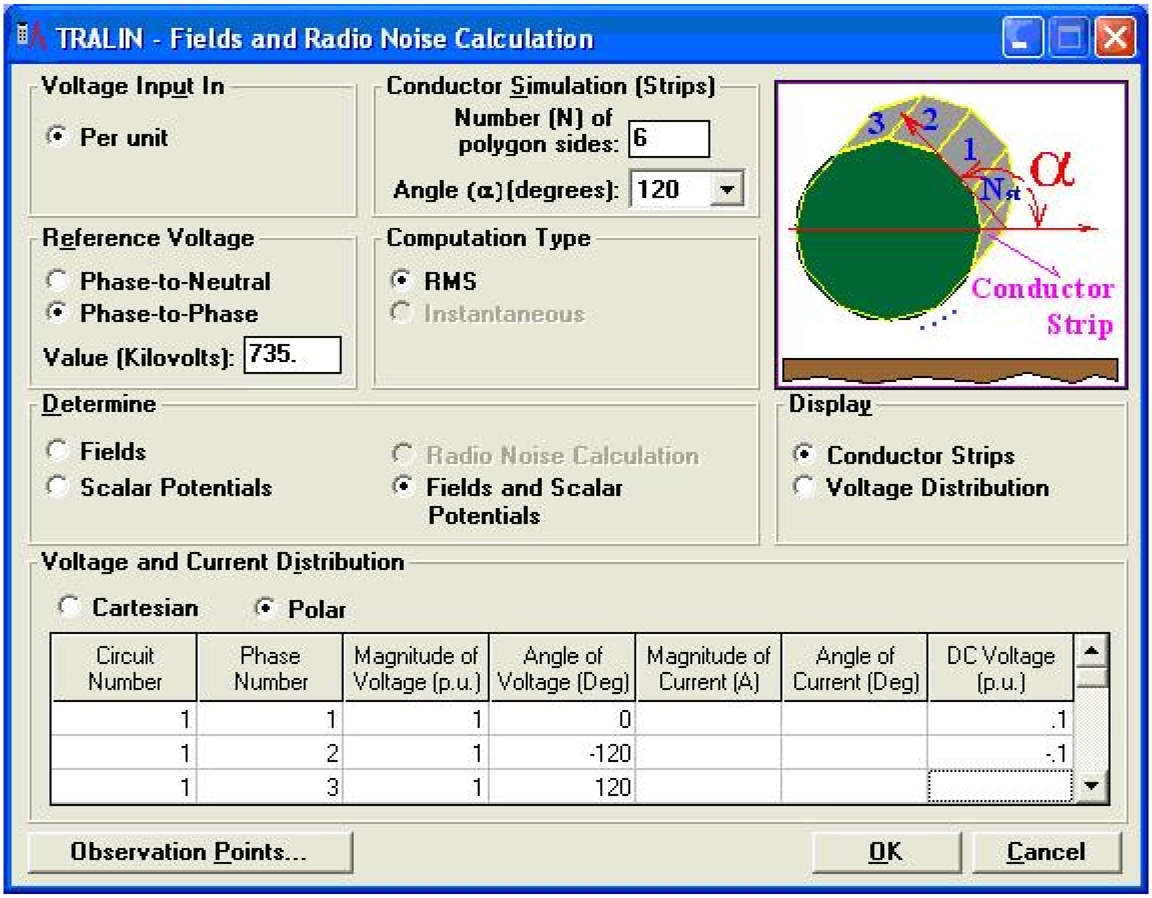

Figure 5-6 Fields window showing new fields for Current and DC voltage entry.

5.4 Examples of Corona Parameters Evaluation

For the purpose of demonstration, the following figure shows two examples of transmission line Radio Noise profile evaluation. The two lines are a typical 750 kV horizontal line and a 500 kV double-circuit line. The following figures show profiles of radio noise calculated for a rod antenna and a loop antenna, and demonstrate the necessity of clearly indicating the kind of antenna used when taking measurements under a transmission line.

5.4.1 Example 1 – Three Phase Typical Horizontal 750 kV Line

The first example profile evaluates a typical horizontal 750 kV line whose constructional characteristics are shown in Figure 5-7. It is made up of three phases 15 meters apart and 18 meters above the ground. Each bundle is composed of 4 conductors of 3.1 cm in diameter separated by 0.5 meters.

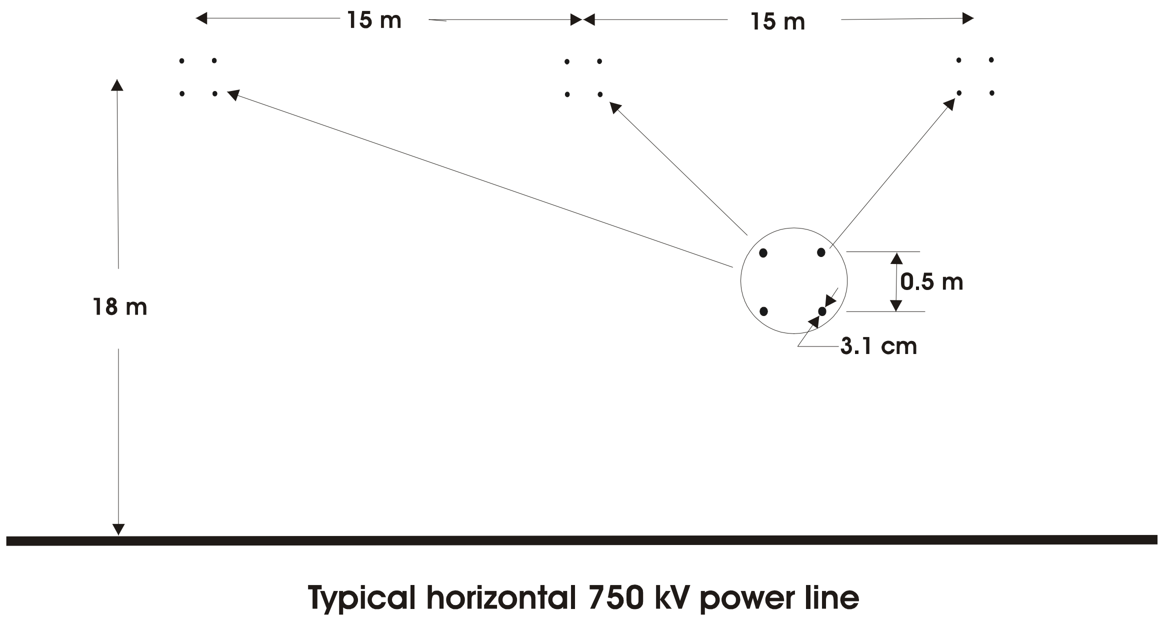

Figure 5-7 Typical horizontal 750 kV line.

The Figure 5-8 shows the lateral profile evaluated at ground level for a frequency of 0.5 MHz. Two curves are presented corresponding to the value of electric field (rod antenna) and the magnetic field (loop antenna), respectively. As one can see, the two curves are quite similar. At a distance of 15 meters on either side of the center phase, the two antennas will measure similar field intensity. Immediately underneath the line, small discrepancies exist.

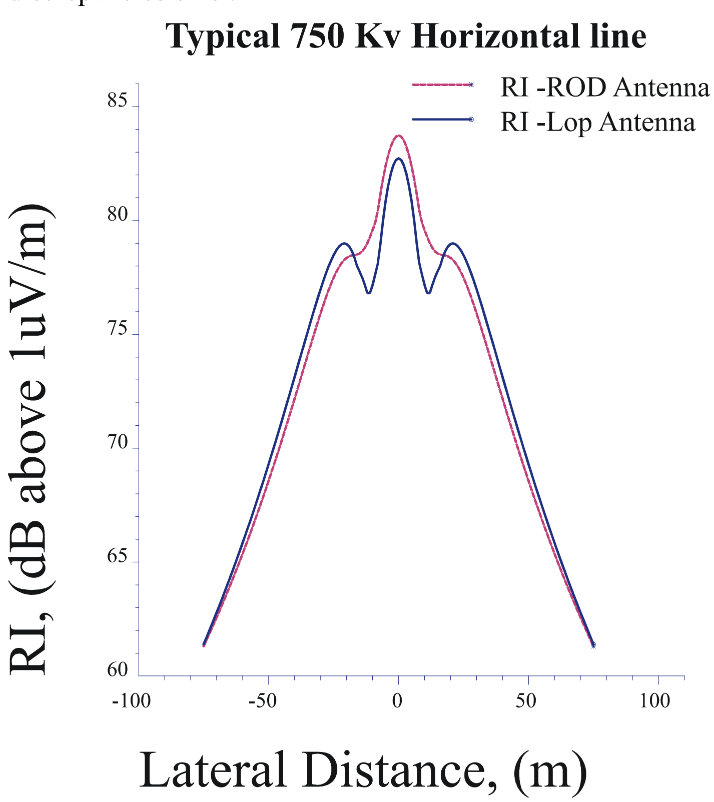

Figure 5-8 Lateral profile of RI at 0.5 MHz evaluated at ground level.

5.4.2 Example 2 – Three phase 500 kV Double-Circuit line

This second example will focus on the evaluation of a 500 kV double-circuit line described in reference 3. It is an existing line constructed at high altitude with known measured characteristics. Measurement of RI has been made with a loop antenna at a distance of 22.9 meters from the centerline and at a height of 2 meters above ground. The long term L5 value measured is 73 dB above 1 µV/m (CISPR) for a line voltage of 530 kV[3]. Figure 5-9 shows a schematic diagram of this line.

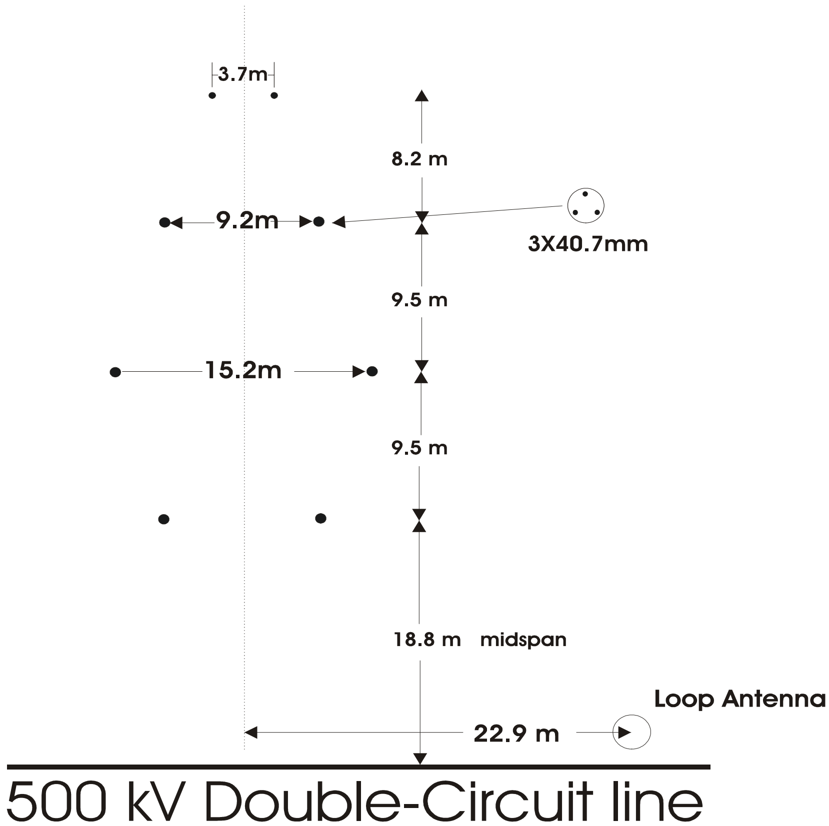

Figure 5-9 Double circuit 500 kV line.

Figure 5-10 shows the lateral profile evaluated at 2 meters above ground level for a frequency of 0.5 MHz. The IREQ integration method was used with the modal theoretical approach of propagation at high frequency[4]. As in Figure 5-8, two curves are presented corresponding respectively to the value of electric field (rod antenna) and the magnetic field (loop antenna). In this case, the curves are not similar.

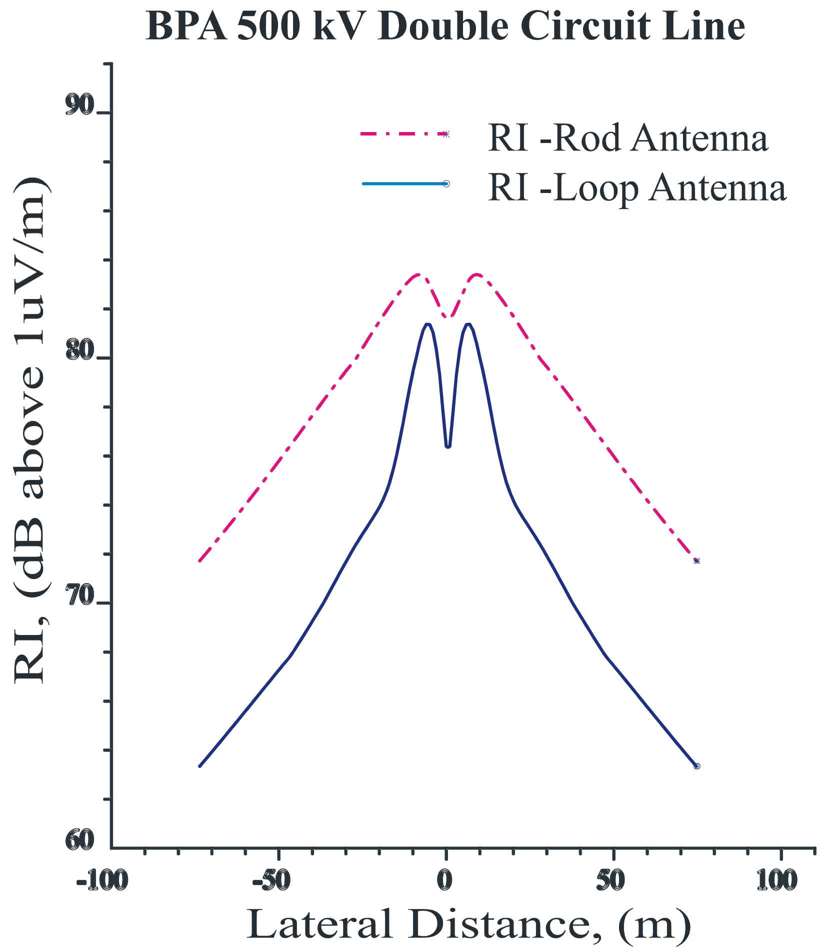

Figure 5-10 Lateral profile of RI at 0.5 MHz evaluated at 2 meters above ground level.

As the Figure 5-10 shows, when the measurement is taken at 15 meters from the outer phase (22.9m on either side of the center), the difference between the rod and the loop antenna is 7.6 dB (80.6dB – 73dB); At this point on the line, the ratio of the electric field to the magnetic field is not equal to 120π, and therefore, the standard conversion technique to compute electric field value cannot be used (This technique usually involves adding 51.53 dB directly to the measured magnetic field value taken with the loop antenna and expressing it in an equivalent electric field value). This also indicates that, for readings to have any meaning, one must clearly specify the type of antenna used.

5.5 Comparison of Methods

In order to validate the methods used in the process of computing the corona parameters, Table 5-1 is shown. This table shows the results of computation made with several methods. The published results for radio interference levels of twelve different lines, with readings taken in close proximity of the right of way, have been added for comparison.

For each transmission line, Table 5-1 shows the value calculated by each method and the difference with the measured value. At the bottom of the table, the mean of the differences and the RMS value of the difference are given.

For the first four methods (IREQ, IREQ-SI, EdF, BPA), the same propagation and radiation method is used, namely IREQ method[4]. The differences in the calculated value come from the method of evaluation of the generating function. In the case of the EPRI method, it is using Juette criteria for the simplification of the calculation of the modes[7]. The BPA-E method uses a technique developed as described in « EMI Performance of Bonneville Power Administrations Prototype 1200 kV Transmission Line."[8].

The reference for each line configuration and measured data of Table 5-1 is given in the following:

1. V. L. Chartier, L. Y. Lee, L. D. Dickson, K. E. Martin, "Effect of High Altitude on High Voltage AC Transmission Line Corona Phenomena.", IEEE Trans., Vol. PWRD-2, No. 1, pp. 225-237, January 1987.
2. D.E. Perry, V.L. Chartier, G.L. Reiner, "BPA 1100 kV Transmission System Development – Corona and Electric Field Studies.", IEE Trans. On P.A.S., Vol. PAS-98, No. 5, Sept/Oct. 1979, pp. 1728-1738.
3. R. Lacroix, H. Charboneau, «Radio Interference from the First 735-kV Line of Hydro-Québec.», IEEE Trans., Vol. PAS-87, No.4, pp. 932-939, April 1968.
4. Giao Trinh, P. Sarma Maruvada, J. Flamand, J.R. Valotaire, «A Study of the Corona Performance of Hydro-Québec's 735-kV Lines.», IEEE Trans., Vol. PAS-101, No. 3, March 1982, pp. 681-690.
5. R. Cortina, W. Serravalli, M. Sforzini, «Radio Interference Long-Term Recording on an Operating 420-kV Line.», IEEE Trans., Vol. PAS-89, May/June 1970, pp.881-892.
6. B. Flink, L. Svensson, « Report by the Swedish National Committee on Recordings of Radio Interference from a 400 kV Power Line. », International Electrotechnical Commission CISPR/C, UDC 621.391.8, April 1975.
7. R. Bartenstein, E. Schafer, « Continuous Measurements of the High Frequency Interference Level of H. V. Transmission Lines ant their Statistic Evaluation.", CIGRÉ paper #409, 1962.
8. V. L. Chartier, A. L. Gabriel, J. D. Simpson, R.D. Stearns, « EMI Performance of Bonneville Power Administrations Prototype 1200 kV Transmission Line.", 3rd Symposium on Electromagnetic Compatibility, Rotterdam, paper no. 90N7, pp. 475-480, May 1979.
9. V. L. Chartier, "Results of Long-Term Audible Noise Measurement Made Before and After Reconductoring of the Spans from Tower 6/4 to 7/4 of Ostrander-Pearl 500 kV Transmission Line.", ELE-89-34, March 1989.
10. R.G. Olsen, «Radio Noise due to Corona on a Multi-Conductor Power Line Above a Dissipative Earth», IEEE Trans., Vol. PWRD-3, January 1988, pp. 272-287. (Fig. 8)
11. R.G. Olsen, «Radio Noise due to Corona on a Multi-Conductor Power Line Above a Dissipative Earth», IEEE Trans., Vol. PWRD-3, January 1988, pp. 272-287. (Fig. 9)
12. N. Kolcio, J. Di Placido, R. J. Hass, D. K. Nichols, "Long Term Audible Noise and Radio Noise Performance of American Electric Power's Operating 765 kV Lines.", IEEE Trans., Vol. PAS-98, No. 6, pp. 1853-1859, Nov./Dec. 1979.

Comparison of RADIO NOISE calculated with different method with published measured data.															
				IREQ		IREQ-SI		EdF		BPA		EPRI		BPA-E	
Line	**Ref. #**	**Line**	**Measured**	**Calculated**	**Difference**	**Calculated**	**Difference**	**Calculated**	**Difference**	**Calculated**	**Difference**	**Calculated**	**Difference**	**Calculated**	**Difference**
number		**Type**	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
1	5	ENEL	**73.5**	75.37	1.87	77.42	3.86	76.42	2.92	67.77	-5.73	72.69	-0.81	77.61	4.11
2	6	Swedish	**66**	66	0	66.8	0.8	64	-2	61.77	-4.23	66.84	0.84	69.06	3.06
3	3	HQ-Levis	**70.5**	70.9	0.4	69	-1.5	70.1	-0.4	68.2	-2.3	71.6	1.1	75.3	4.8
4	7	Bartenstein	**58**	57.2	-0.8	55.22	-2.78	52.18	-5.82	52.36	-5.64	58.53	0.53	64.59	6.59
5	12	AEP-760kV	**70.5**	70.59	0.09	67.8	-2.7	72.9	2.4		0	69.44	-1.06	77.55	7.05
6	8	BPA-D525kV	**74**	75.55	1.55	76.49	2.49	77.24	3.24	72.32	-1.68	75.53	1.53	79.32	5.32
7	4	HQ-IREQ	**70.5**	72.72	2.22	70.59	0.09	72.94	2.44	70.05	-0.45	71.87	1.37	76.21	5.71
8	4	HQ-Pres.	**66**	65.71	-0.29	64.23	-1.77	64.54	-1.46	63.07	-2.93	67.1	1.1	67.14	1.14
9	10	BPA_525_T8	**68**	66.5	-1.5	66.93	-1.07	68.38	0.38	63.6	-4.4	66.65	-1.35	70.36	2.36
10	11	BPA_525_T9	**61**	60.78	-0.22	59.62	-1.38	59.15	-1.85	57.96	-3.04	62.56	1.56	62.98	1.98
11	1	BPA-500kV	**73**	73	0	73.24	0.24	70.76	-2.24	64.3	-8.7	68.45	-4.553	72.14	-0.86
12	2	BPA-1100kV	**61**	61.1	0.1	60.7	-0.3	55.8	-5.2			68.6	7.6	60.4	-0.6
	Mean of the differences				0.2631		-0.309		-0.584		-3.554		0.6046		3.128
	Variance				1.1867		3.999		9.248		5.649		7.907		7.041
	Sigma				1.0893		1.999		3.041		2.377		2.811		2.653
13															
	RMS difference				**1.0388**		**1.867**		**2.8625**		**4.3035**		**2.662**		**4.067**
	All measurement made with ANSI receivers have been converted to CISPR by subtracting 2 dB														

Table 5-1 Comparison of radio noise calculated with different methods using published measured data.

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As showed in Table 5-1, the different evaluation methods compare well with each other. For most of them, the RMS difference between the calculated values and the measured values are in the same range of magnitude as the measuring error. All of which depend on many factors such as the ground resistivity, the conductors surface conditions, the atmospheric conditions, etc.

The Figure 5-11 shows a comparison between the values calculated with the IREQ method and the EPRI method. With the exception for two points, which correspond to line 11 and line 12, the correlation is very good. Note that, at low gradient, the EPRI method decreases more rapidly then the IREQ method, as is shown by the 1/x dependency graph.

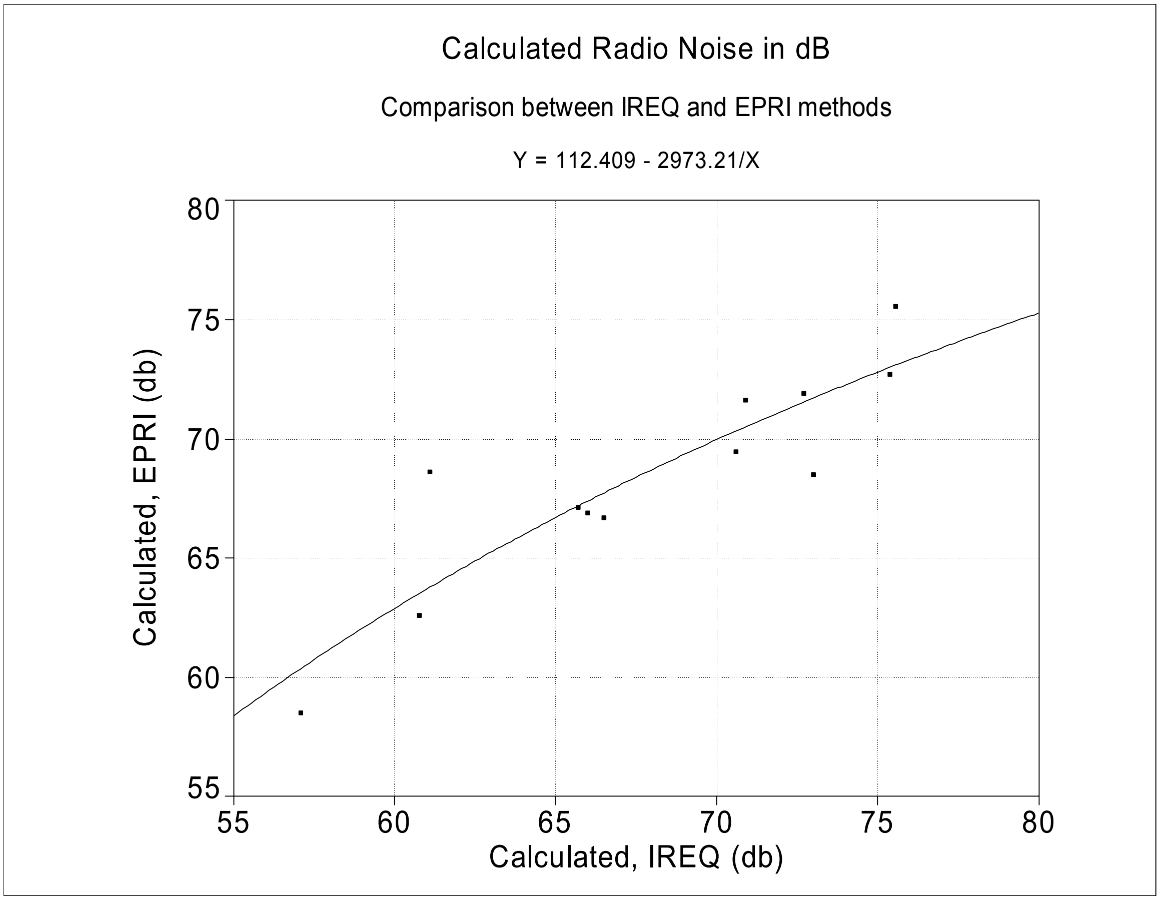

Figure 5-11 Comparison of radio noise level calculated with IREQ and EPRI methods (Data taken from Table 5-1).

5.6 Conclusion

The new SES-Enviro module is a powerful addition to the current TRALIN functionality. It is an indispensable tool in the design and evaluation of power lines impact on the environment with respect to radio interference, acoustical noise, corona loss, magnetic field and electric field.

The SES-Enviro module has been designed to simplify and reduce the work required to optimize transmission lines when considering corona and environmental parameters, as well as the ability to reduce the cost of the transmission lines while remaining within acceptable operation limits.

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), and the gradient. In this first version, only AC transmission lines are officially supported for the corona parameters. The SES-Enviro module that is part of CDEGS version 11 offers a beta release for the DC methods.

5.7 References

1. IEEE Committee Report, «Radio Noise Guide for High-Voltage Transmission Lines.», IEEE Trans., Vol. PAS-90, No.2, March/April 1971, pp.833-842.
2. C.H. Gary, «The Theory of Excitation Function: A Demonstration of its Physical Meaning.», IEEE Trans., Vol. PAS-91, Jan/Feb 1972, pp. 305-310.
3. V. L. Chartier, L. Y. Lee, L. D. Dickson, K. E. Martin, "Effect of High Altitude on High Voltage AC Transmission Line Corona Phenomena.", IEEE Trans., Vol. PWRD-2, No. 1, pp. 225-237, January 1987.
4. R.D. Dallaire, P.S. Maruvada, "Analysis of Radio Interference from Short Multi Conductor Lines. Part 1. Theoretical Analysis.", IEEE Trans., Vol. PAS-100, April 1981, pp.2100-2108.
5. Olsen R.G., Stimson, B.O., "Predicting VHF/UHF electromagnetic noise from corona on power-line conductor.", IEEE Trans. On Electromagnetic. Compatibility, EMC-30, pp. 13-22, 1988.
6. R.G. Olsen, S.D. Schennum, V.L. Chartier, «Comparison of Several Methods for Calculating Power Line Electromagnetic Interference Levels and Calibration with Long-term Data.», IEEE Trans., Vol. PWRD-7, No.2, April 1992, pp.903-913.
7. Electric Power Research Institute (EPRI), «Transmission Line Reference Book. 345 kV and Above/Second Edition», Palo Alto, CA, 625 p., 1982
8. V.L. Chartier, «Empirical Expressions for Calculating High Voltage Transmission Line Corona Phenomena», First Annual Seminar Technical Program for Professional Engineers, Bonneville Power Administration (BPA), 1983.

5.8 Input files for TRALIN comparison of evaluating methods with measured values

All the input files necessary to compute the Table 5-1 are available on the CD at the following location:

USERS_GROUP\Users_2004\Input Files\SES-Enviro\

Line number	Reference	File name
1	ENEL	tr_Spezia_Baggio_420.f05
2	Swedish	tr_Swedish_400kV.f05
3	HQ-Levis	tr_HQ_First_735_kV.f05
4	Bartenstein	tr_Bartenstein_387kV2.f05
5	AEP-760kV	tr_AEP_760kV.f05
6	BPA-D525kV	tr_BPA_Double_525kV.f05
7	HQ-IREQ	TR_HQ_Line_7013_735kV.f05
8	HQ-Pres.	TR_HQ_Line7005_735kv.f05
9	BPA_525_T8	TR_BPA_525kV_T8.f05
10	BPA_525_T9	TR_BPA_525kV_T9.f05
11	BPA-500kV	tr_BPA_540kV_A.f05
12	BPA-1100kV	tr_BPA_1100kV_Lyons.f05

Table 5-2 List of input files for SES-Enviro.