# PSS®E 33.4

# LINEPROP MANUAL

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# Chapter 1

# Line Properties Calculator

## 1.1 Overview: Line Properties Calculator

The Line Properties Calculator (LineProp) calculates electrical parameters for overhead transmission and distribution lines. These parameters are then used in many power system analysis programs (powerflow, short circuit) in their calculations and simulations. An example of a common transmission line is an overhead line having three phase conductors (A, B and C) and one or two shield (ground) wires. LineProp requires as input the physical dimensions of the line (height, spacing and sag), and the specification of the phase conductor and shield wires. For per unit (pu) output, the voltage level of the circuit and a power base must also be entered. The electrical parameters that LineProp then calculates include:

- Zero and positive sequence impedances for each circuit in the corridor.
- Zero and positive sequence admittances for each circuit in the corridor.
- Self and mutual impedances for each circuit in the corridor.
- Self and mutual admittances for each circuit in the corridor.
- Average mutual impedances and admittances for each pair of circuits in the corridor.
- Phase impedance and admittance matrices in the corridor.
- Sequence impedance and admittance matrices in the corridor.

LineProp uses the standard equations for line property calculations (Carson's earth correction, eigenvalues, eigenmodes, etc.). LineProp results have been extensively compared to other line property computer programs, including the EMTP Line Constants program and Siemens PTI's older TMLC program, and been proven accurate.

LineProp stores the circuit characteristics in a file with .cor suffix. The impedance and admittance calculations can be printed if desired. In addition, LineProp will print out a text document that lists basic calculation results and also lists the impedance/admittance data in a way that can be copied and pasted into PSSE.

### 1.1.1 Nomenclature

It is probably best to begin the LineProp explanation with the nomenclature that is used in the program and here in the manual. Although much of the nomenclature is that commonly used by power system engineers there is some opportunity for confusion.

- **Corridor** – This could also be called a Right-of-Way (ROW). It is a set of electrical Circuits, each with the (nearly) same geographic beginning and end point. A Corridor generally has a width, which may be from 30 to 500 ft, and a length, which may be up to hundreds of miles. The circuits sit spaced across the corridor.
- **Circuit** – A set of Positions used to transmit electrical power. A Circuit has a number of phases; the vast majority of transmission Circuits have three phases, which are given the tag names of ABC, RYB, etc. The phase of a Position is a tag designated by the electrical utility, and can be changed at any time. A Position can only have one phase, but multiple Positions in a circuit can have the same phase label. Multiple positions with the same phase label will be bundled together during calculations. This is complicated and will be covered again below with an example circuit.
- **Position** – A bundle of 1 to N Conductors of the same type arranged in a regular pattern around a center point, and electrically tied together at intervals much less than a wavelength, so each Conductor in the Position has the same voltage. Every position has either a single phase assignment or is grounded. A Position with only one Conductor is often called a Conductor instead of a Position. A position with more than once conductor is called a bundle. For example, 345 kV circuits usually have a bundle of two conductors at each position.
- **Ungrounded Position** – A Position not electrically connected to earth within the Corridor, i.e. a phase conductor or bundle of phase conductors.
- **Grounded Position** – A Position electrically connected to earth at regular intervals along the Corridor, i.e. a ground or shield wire.
- **Conductor** – A physical wire used to carry current. A conductor or a bundled set of conductors make up a Position.
- **Shield wire** – Another name for Grounded Position. A Position grounded often enough so it can be assumed to be continuously grounded and have zero voltage on it. Also called a ground wire or neutral wire. Shield wire Positions usually have only one Conductor, hence the name shield wire.
- **Conductor Type** – A designation that usually indicates the physical construction of a conductor. Common types for transmission and distribution lines are: ACSR, AAC, AAAC, ACAR, ALUMOWELD, CU, EHS, HS.
- **Conductor Name** – A tag applied to a particular conductor. Some conductors used by utilities in the United States have bird names (e.g., Drake, Robin, etc.).
- **Wire** – Another name for Conductor, especially used when referring to Grounded Positions.
- **Phase** – A tag applied to each ungrounded position of a line used for the transmission of ac electrical power. A line in a three-phase power system in the United States (and some other countries) usually has the phases labeled A, B, and C.
- **Conductor resistance** – The dc or ac resistance per unit length of the Conductor at a designated temperature.
- **Conductor reactance** – The ac reactance per unit length of the Conductor at a designated frequency and spacing (usually a 1 foot spacing, but 1 meter is also possible).
- **Conductor diameter** – The physical diameter of the Conductor.

- **Circuit impedance** – A measure of the gradient of voltage versus current along the Circuit. Usually expressed in ohms (Ω) or Ω per unit length. Impedance consists of a real part called resistance (R) and an imaginary part called reactance (X).
- **Circuit admittance** – A measure of the gradient of current versus voltage along a Circuit. Usually expressed in micro-Siemens (μS) or μS per unit length. An older name for Siemens was mho. Admittance consists of a real part called conductance (G) and an imaginary part called susceptance (B).
- **Sag** – For a Position or Conductor, the difference between the height at the structure and the height at the lowest point, which would be at mid-span for a Conductor over level ground.
- **Earth resistivity** – A specification of the bulk resistance properties of the earth, designated by the symbol ρ, and always in units of Ω•m. Occasionally the inverse of resistivity, called conductivity and designated by σ, may be encountered.

### 1.1.2 LineProp Dimension Capabilities

The maximum program dimensions of LineProp are as follows:

**Table 1-1. Maximum LineProp Program Capacities**

| LineProp Component | Maximum Number |
|---|---|
| Circuits per corridor | 12 |
| Phase positions per circuit | 6 (A,B,C,D,E,F) |
| Shield positions per circuit | 4 (Gr1,Gr2,Gr3,Gr4) |
| Conductors in a bundle | 8 |

So the most complicated corridor that could be modeled with LineProp would have 12 parallel circuits, each with up to 6 phases and 4 shield positions. Each phase and shield position could be a bundle of 8 conductors. This monster set of circuits would have 960 wires in the air (an ice storm could be a real disaster!). The calculated full impedance and admittance matrices would be dimensioned as 72 by 72 elements.

A more realistic example might be two 3-phase circuits contained within a single corridor (right-of-way). LineProp provides an easy method for entering the dimensions and composition of the circuits and will quickly calculate the positive and zero sequence parameters for each circuit (assuming within circuit transposition), the full 6x6 impedance and admittance matrices for the actual configuration, and other information such as between circuit zero sequence coupling.

The nomenclature used to describe a Corridor hierarchy is:

- Corridor
  - Circuit
    - Position
      - Bundle
        - Conductor

### 1.1.3 Specification of the Corridor and an Example

The user specifies the following for the corridor:

- Frequency, either 50 or 60 Hz
- Units, either English (in, ft, mi) or SI (cm, m, km)
- Whether calculations are to be per unit length or for the length of the corridor. For the latter a corridor length must be specified.
- Whether calculated output should be physical (Ohm, microSiemens) or pu. If pu output is selected, a corridor power base and line to line circuit voltage must also be specified.
- For total corridor length calculations, whether approximate or hyperbolic eq's are to be use.
- Location of the centerline of each circuit in the corridor
- Information about each circuit.

An example, used throughout this manual of a corridor with two 3-phase circuits is shown in Figure 1-1. The example is a fairly standard 345 kV circuit (in the U.S.) and a parallel distribution circuit. The view is across the width of the corridor. This example is included with your LineProp installation; you should find it at C:\Program Files\PTI\PSSE33\EXAMPLE\ExampleCorridor.cor (there may be some directory differences in your installation). You should now start LineProp and read this file in and hopefully will learn the program very quickly.

Lets discuss this example, and perhaps any confusion about positions, phases and conductors can be eliminated. The units selected are English, so bundle spacing is in inches, circuit positions are in feet and corridor length is in miles.. The 345 kV circuit is on the left side; it is named Circuit_1, perhaps not the most creative name. The relative position of the 345 kV circuit within the corridor is 0.0 ft. The circuit has three positions; the position on the left is assigned phase A, the middle is phase B and on the right is phase C. At the structure, the height of the three positions is 50 ft and the mid-span sag is 15 ft. The lateral locations of the three positions are -27, 0, 27 ft, referenced from the circuit position of 0.0 ft. As is commonly seen at 345 kV, each position consists of two conductors spaced 18 in apart horizontally. The conductors in the bundle are Drake. When you first open the example in LineProp you do not see all this information; you just see the view across the corridor. Double click on the 345 kV circuit and the information will come up. In addition to what was explained above you will see that the ground wires are at a structure vertical position of 62 ft with 9 ft of sag. The lateral positions are -10 and +10 ft. The ground wires are 37#9AW.

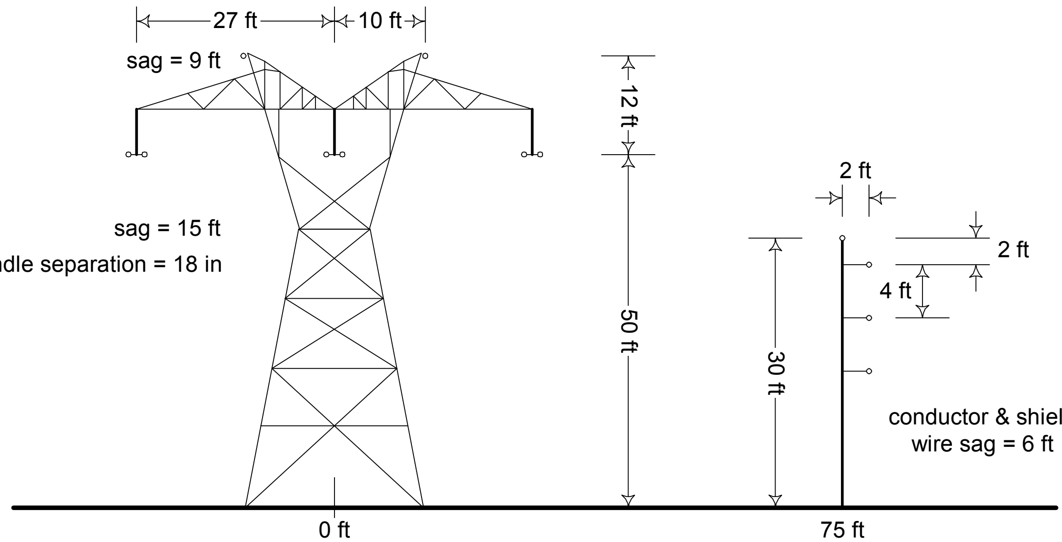


**Figure 1-1. Example Corridor for Illustration of Line Property Calculations**

The information on the distribution circuit on the right is partly shown in the figure and assuming you are running LineProp you can double click on the circuit and see that the conductors are AAAC6201_4/0, the ground wire is AAAC6201#2, etc. We won't spend any time here going over the characteristice of this second circuit. One thing you should realize is that horizontal positions for the positions in the right side circuit are with reference to its corridor position of 75 ft.

In LineProp if you click the Options button (should be 5th from the right) you will see the setting of units, etc.

### 1.1.4 Conductor Library and Conductor Characteristics

For each circuit LineProp makes resistance, reactance and admittance calculations. Calculations of inter-circuit values are also done. In order to do the calculations, LineProp needs three pieces of information about each conductor - resistance, reactance and capacitance. The conductor library, included within LineProp, has this data. The resistance is the AC resistance at 25 C (At the present time, calculations are done for a 25 C conductor temperature. Future LineProp versions may allow for conductor temperature specifications by the user); you will see it either per mi or per km according to the units selected (double click on a circuit, then click the button to the right of the conductor name). For reactance calcs, LineProp uses the conductor reactance per mi (km) at 1.0 ft spacing which is in the library. Sometimes conductor tables will list the geometric mean radius (GMR) of a conductor in addtion to/instead of the reactance at 1.0 ft spacing. GMR and 1.0 ft reactance are directly related, so both are not needed. For capacitance (admittance) calculations the conductor diameter is used. So you should realize that only 3 pieces of information from the conductor library are used; the rest of the data (weight, strength, etc.) is there merely for your information. The user specifies the conductor name, LineProp goes to the library and picks up the three needed data values.

In the example 345 kV circuit the conductor name is Drake. Experienced power engineers realize that there are a lot of conductor types, and the name "Drake" may be applied to more than one of them. If you open up the conductor library, sort the entries by name and scroll down to where Drake is you will see the following entries (just showing name and type here).

**Table 1-2. Conductors named Drake in the LineProp Library**

| Name | Type |
|---|---|
| DRAKE | ACSR |
| DRAKE/ACCC/TW | ACCC/TW |
| DRAKE/ACSS/AW | ACSS/AW |
| DRAKE/ACSS/TW | ACSS/TW |
| DRAKE/AW | ACSR/AW |
| DRAKE/SD | ACSR/SD |
| DRAKE/SSAC | ACSS |
| ACSR/TW | ACSR/TW |
| DRAKE1 | ACAR |
| DRAKE2 | ACAR |
| DRAKE3 | ACAR |
| DRAKE4 | ACAR |
| DRAKE5 | ACAR |
| DRAKE6 | ACAR |

The ACSR conductors were generally the first ones here, so just a plain name usually refers to the that type. Since each conductor name must be unique, something is added to the names of the other types. When you are selecting a conductor you might wish to look at all of the library information to be sure you are specifying the one you wish to use. As a historical note, the ACSS conductor type used to be catagorized SSAC. Since the conductor name is stored in the LineProp saved file, PTI has kept the name DRAKE/SSAC instead of changing it. That way, older files will still be read into the program correctly.

The LineProp library has over 1000 conductor/ground wires; since the number seems to change daily no attempt is made here to list the exact number. Hopefully, the user will usually find the desired conductor already in the library. For unusual cases, where the library entry is missing, the user may supply their own conductor/ground wire library in the form of a comma separated file. The internal conductor/ground wire table format is described in Chapter 2.

### 1.1.5 Long Line/Hyperbolic Calculations

LineProp initially calculates circuit values per unit length, i.e. per mi or per km according to the unit specification the user makes. If the corridor/circuit being analyzed is to be modeled in PSSE, then the impedance/admittance of the complete length of the corridor will be wanted. There are two ways to make this calculation. The first is simply to take the values per unit length and multipy by the length of the corridor. For corridor lengths of perhaps 100 mi or less the error using this simple method is small. For a longer line, the hyperbolic equations should be used. If you are modeling a transmission line that is 200 mi in length, then for sure the hyperbolic method should be specified.

### 1.1.6 Doing a Calculation

If you have the example open it is easy to do a calculation. The third button from the right (tooltip is "Calculate Impedance") will do the calculation and show the results on the screen. The results will correspond to the the Options you have selected.

### 1.1.7 Zero Sequence Coupling within a Common Corridor

For a given corridor, LineProp calculates the full impedance and admittance matrices and then, from the values in these two matrices, derives properties like the positive and zero sequence impedance/admittance for each circuit. One of the LineProp reports, as shown in Figure 1-34 is named "Zm, Ym Avg (Circuit Pair)". This report lists the zero sequence coupling between each of the two circuits. Some programs use the zero sequence coupling information. For example, PSS®E uses the zero sequence impedance coupling.

Suppose for example, a corridor is 100 miles in length and two lines share the corridor for just 40 of those miles. To find the zero sequence coupling enable the "UseLength" option on the Corridor tab of the LineProp Options window (***Options>Setup...***) and set the Length to 40 miles. Then, perform the analysis calculation (***Analysis>Impedance...***) and read the values from the "Zm, Ym Avg (Circuit Pair)" report. The values will be in pu if that output option was specified in the LineProp Options window. If the resulting zero impedance coupling (Zm) values are being used in PSS®E then the pu output option should be selected.

If there are two circuits in a corridor, and one or both circuits have shield wires, the impedance and admittance characteristics of one or both circuits are slightly altered by the shield wires of the other (circuits share their shield wires). The effect is small, but if you want to be sure that your calculations are accurate (forgetting for the moment that the earth resistivity, tower heights and sag are never exactly known), then you need to exactly model the corridor. For example, if two lines are each 100 miles in length and for 40 miles they share a corridor with each other and for the other 60 miles are alone in a corridor, you should model each circuit in its own corridor for 60 miles to get the positive sequence impedances and admittances for each line and then model the two circuits in the same corridor for 40 miles to get the positive sequence impedances and admittances for each circuit for that section. Of course, with the two circuits in the same corridor you can also calculate the zero sequence coupling if needed.

### 1.1.8 Vertical Double Circuit Configuration Confusion

There is one type of circuit that seems to cause problems for LineProp users; it is the double circuit configuration on a single structure. On the left side of the structure there are three vertically spaced positions (first circuit) and on the right side there are also three vertically spaced positions, the second circuit. Before going on, consider the following question. In the example that was considered above with the 345 kV circuit and the parallel distribution circuit, what would happen in the 345 kV circuit if the bundle on the right side was specified as Phase A instead of Phase C. Well then it would be a two phase circuit instead of three phase. All the Phase A conductors would be bundled together; this would be a rather strange bundle, consisting of two Drake conductors spaced 18 in apart bundled together with two more Drake conductors 54 ft away! Strange, but that is what would happen. The point is - in a given circuit all conductors/positions with the same phase are bundled together.

Now to the vertical double circuit configuration. On the left side of the structure are phases A, B and C conductors, arranged more or less vertically. On the other side are also three conductors with phases A, B and C. Suppose too, that there are two shield wires, each above one of the vertical circuits.

How should this be modeled in LineProp? What users have tended to do is specify only one circuit and have six positions: three on the right and three on the left. Suppose the phases are arranged so the top phases on each side are A, the middle two B, and the lower ones C. Using the single circuit in LineProp, what is this a model of? It is a single circuit, 3 phase line with bundled conductors. The bundles are rather large. If the conductor horizontal spacing from the center of the tower is $\pm 6$ feet, then you have made a bundle with 12 ft between the conductors! Sometimes this configuration, where the phases match on each side is called the super-bundle configuration. If you stagger the phases, with ABC on the left and CBA on the right (top to bottom reference), it is called the low-reactance configuration.

To model the circuits separately in LineProp, you MUST make two separate circuits. Suppose we consider the horizontal position of the center of the tower to be 50 feet. Then, in LineProp place two circuits at the 50 foot location. For the first circuit all the phase conductors will be on the left (the horizontal positions will be -6 ft if we use the example from the above paragraph). For the other, the positions will be +6 ft. The shield wires can be placed one on each circuit or both on one circuit (remember we mentioned that all the shield wires in a corridor are shared by the circuits). In your example directory are two corridor files, wrongdouble.cor and rightdouble.cor. As you might expect from the names, the first file shows the wrong way to model the double circuit and the latter shows the correct way. Open each and examine the difference.

### 1.1.9 PSSE Output

LineProp now offers an easy way to input results into PSSE. If the options are selected so that output is in pu and corridor length is being used, then positive and zero sequence data can be written in PSSE format and zero sequence coupling data (if there is more than one circuit) will also be written. Lets do an example to illustrate the procedure. Open the ExampleCorridor.cor file in LineProp and change the options (fifth button from right) so that output is in pu, length is being considered and the corridor length is 100 mi. Lets not use the hyperbolic method. Earth resistivity should be 100 $\Omega$ m, frequency should be 60 Hz and the power base should be 100 MVA, the common base used in PSSE. Check the circuit voltages to be sure that the left circuit is specified as 345 kV and the right is 34.5 kV. Now push the button on the far right (the tool tip states "Document Circuit"). After a brief pause for calculations you will be asked to specify the name of a text file, call it something like ExampleCorridor.txt. Next take a text editor and open this file; it contains information about the corridor that can be filed, if desired. Down a little ways you will see the two lines.

```
PSSE pos seq branch data for circuit Circuit_1 for raw data file

100000,100001,1,  0.00509,  0.05037,  0.85559



PSSE zero seq branch data for circuit Circuit_1 for sequence data file

100000,100001,1,  0.03039,  0.10821,  0.61683
```

The 2nd and 4th lines are the data for the 345 kV circuit to be used in PSSE. The 2nd line is the positive seq data that can be pasted into a *.raw data file. As you can see bus numbers of 100000 and 100001 have been assigned; you will probably have to change these. A circuit ID of 1 has been assigned, this may also have to be changed. If desired by users, future versions of LineProp may include bus numbers and circuit ID in the circuit specification. The 4th line is the zero sequence data, to be pasted into a *.seq raw data file. There is similar information for the 34.5 kV circuit; bus numbers of 100002 and 100003 have been assigned. Further down is the zero sequence coupling data for the two circuits.

## 1.2 Operation of the Line Properties Calculator

In the next sections detailed operation of LineProp will be considered. If you have been using the example file discussed above you may already be able to use the program. In that case the following can be considered a reference.

To initiate the Line Properties Calculator go to the ***PSSE Utilities*** entry within the main PSSE Start Menu and choose the ***Line Properties (lineprop)*** program. After the copyright information window is displayed, the **Corridor View** window shown in Figure 1-2 will appear.

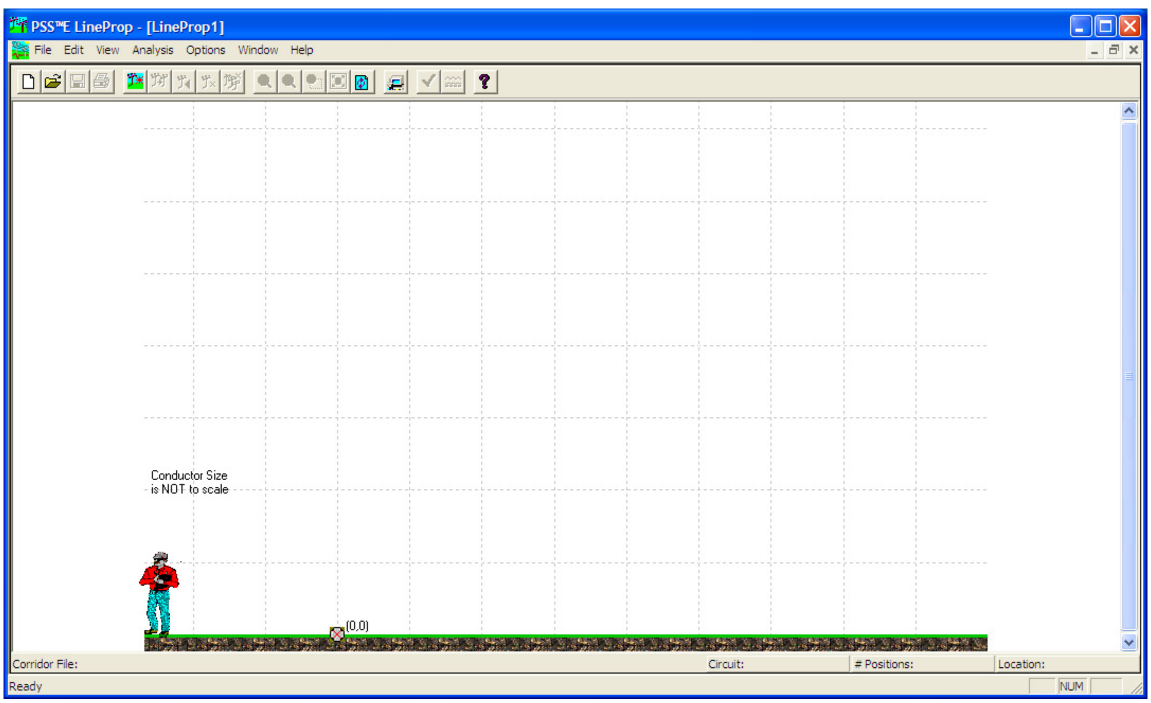


**Figure 1-2. Initial Corridor View**

### 1.2.1 Corridor View

To add a circuit to the corridor:

1. Select the ***Edit>Insert Circuit...*** menu option or click on the ***Add New Circuit*** button  on the LineProp Toolbar. The **Add New Circuit** window, Figure 1-3, appears on the screen.

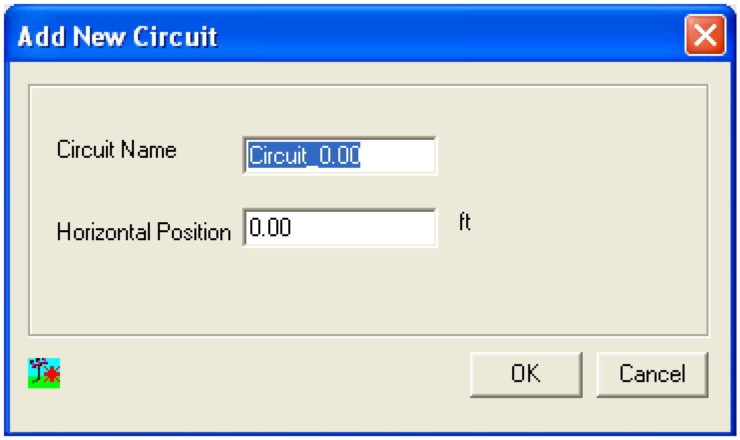


**Figure 1-3. Add New Circuit**

2. Enter the **Circuit Name**; the default name is Circuit_x, where x is the default horizontal position.

3. Enter the **Horizontal Position** of the new circuit. The first circuit assumes a horizontal reference point of (0.0) which is the base of the circuit tower. For subsequent circuits, you can specify the horizontal position (reference point of the base of the circuit tower). The horizontal position for circuits added after the first will default to 20 feet (or meters, depending on the units selected) from the center line of the last positioned circuit.

4. Click on ***OK*** to accept the input. The Corridor View is now changed as illustrated in Figure 1-4. Notice that there are two circles at position 0, one above the other. The top circle represents a Position.

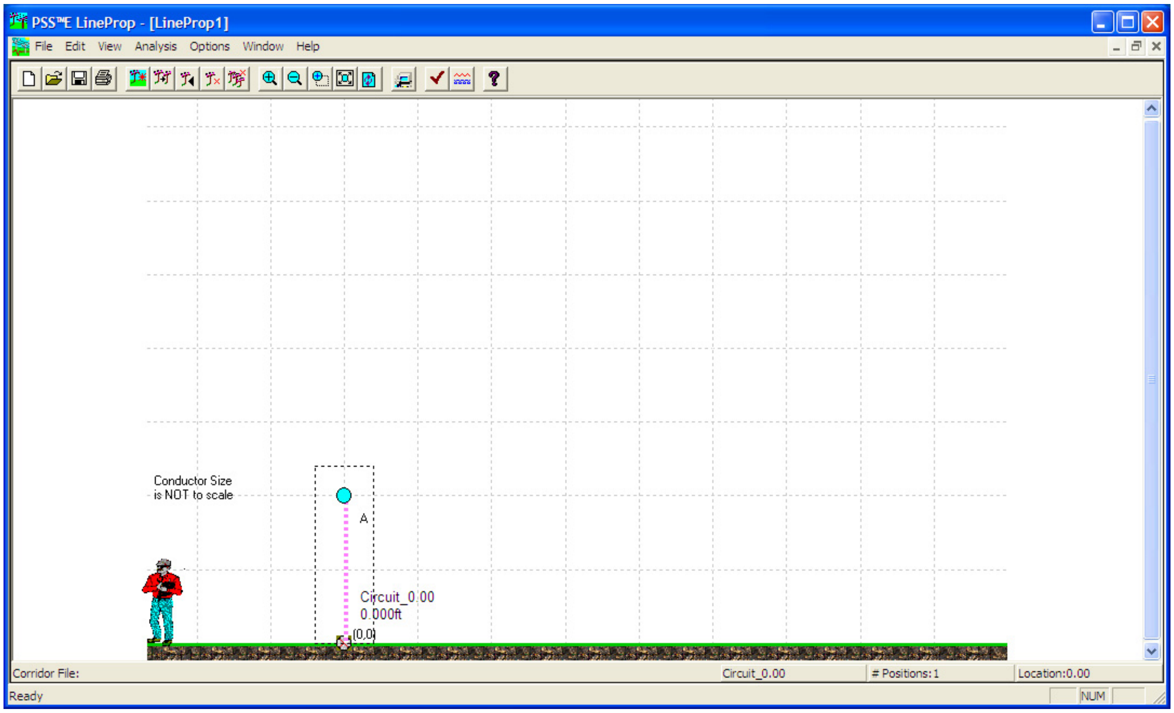


**Figure 1-4. Initial Circuit View**

5. Click anywhere on or near the circle or line and a dashed box will appear around the circuit. This selects the circuit.

6. Double-click anywhere inside the dashed box and the **Current Circuit Properties** window shown in Figure 1-5 will be displayed. Default values are filled in and may be modified as desired. Typically, one of the first steps is to define the base voltage and select the total number of phase and ground positions that are to be configured.

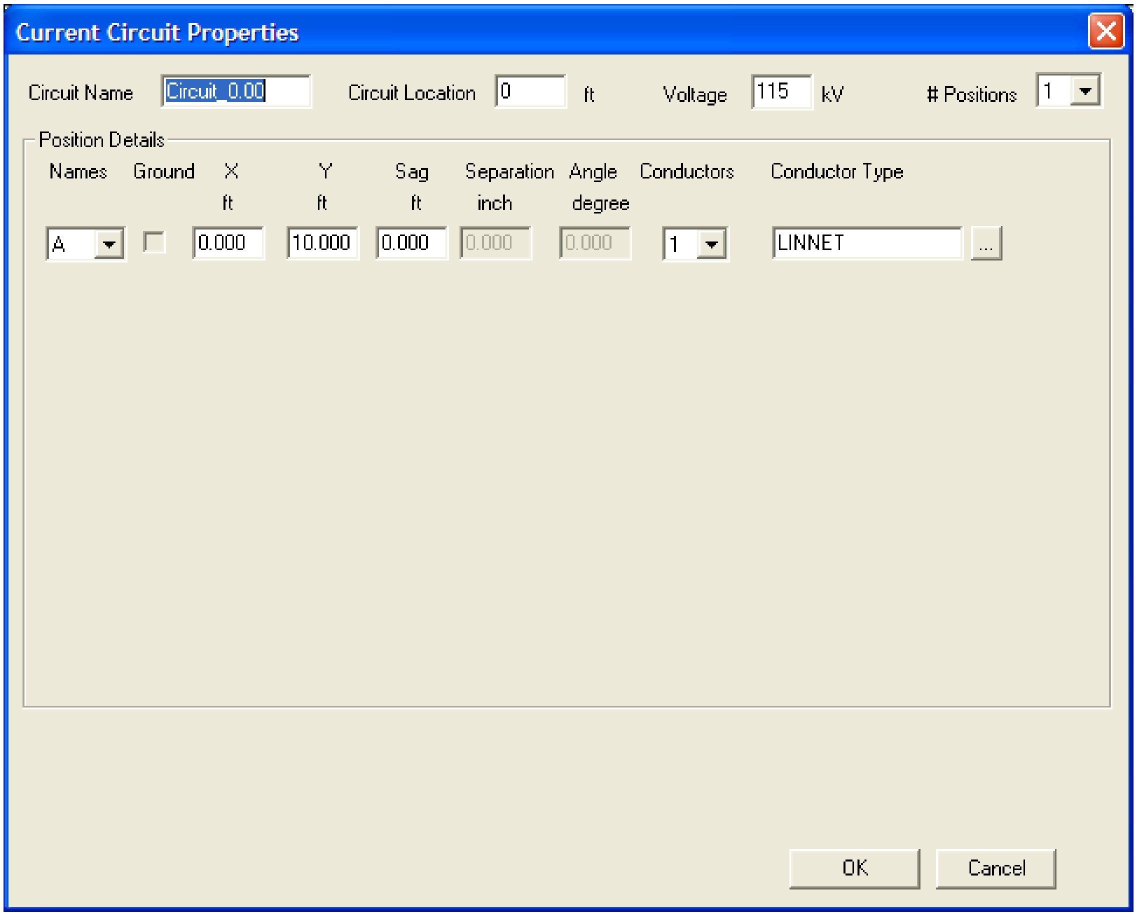


**Figure 1-5. New Circuit Properties View**

Using the previously described parallel circuit configuration as shown in Figure 1-6, the completed Circuit Properties dialog boxes corresponding to each circuit is shown in Figure 1-7 and Figure 1-8.

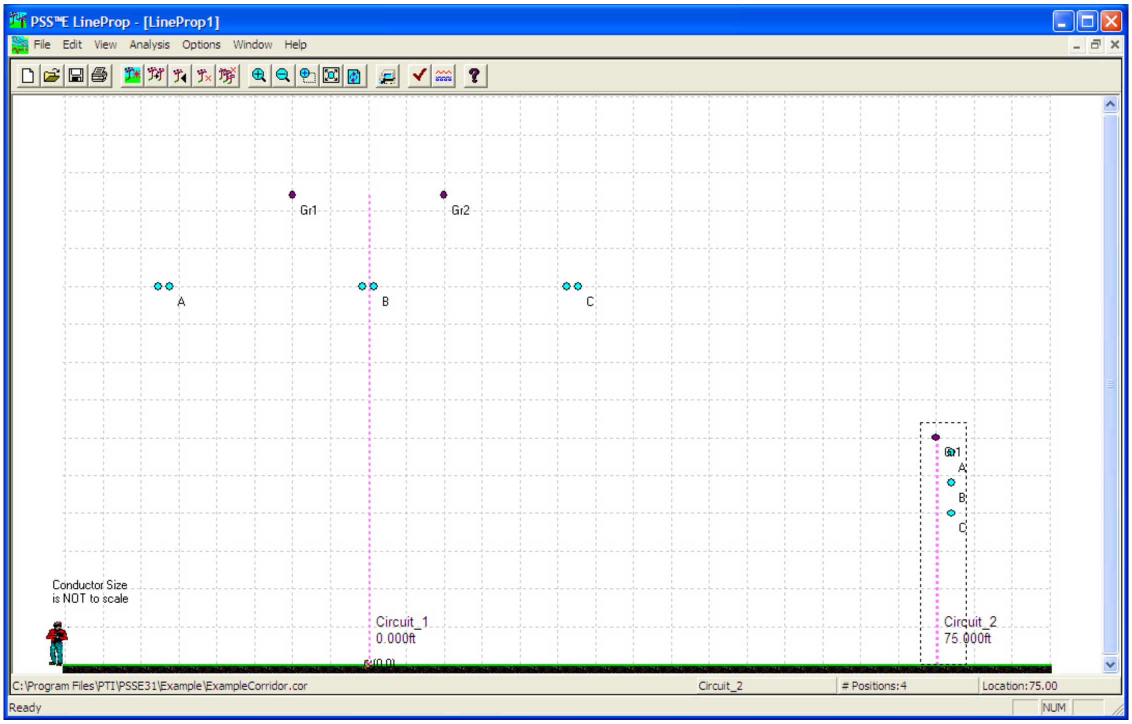


**Figure 1-6. Example Circuits**

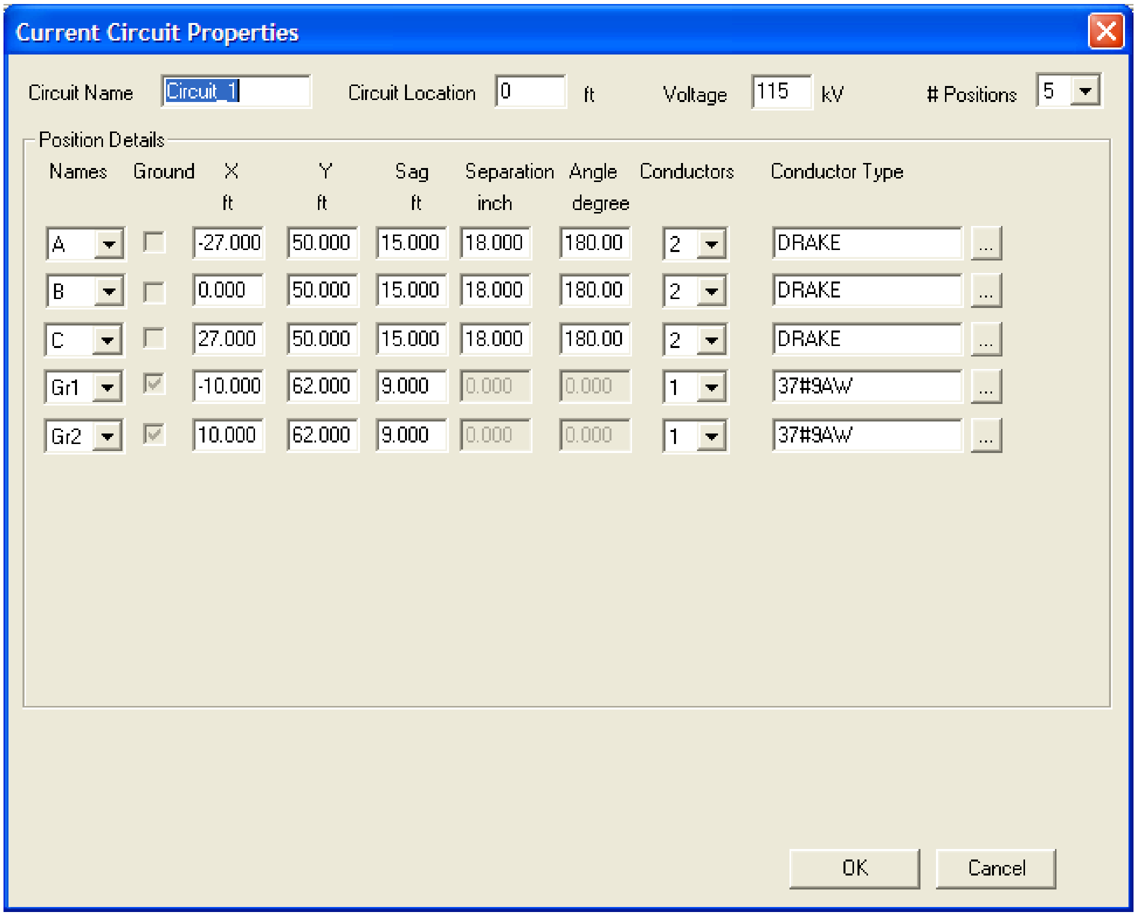


**Figure 1-7. Example Circuit_1 Properties View**

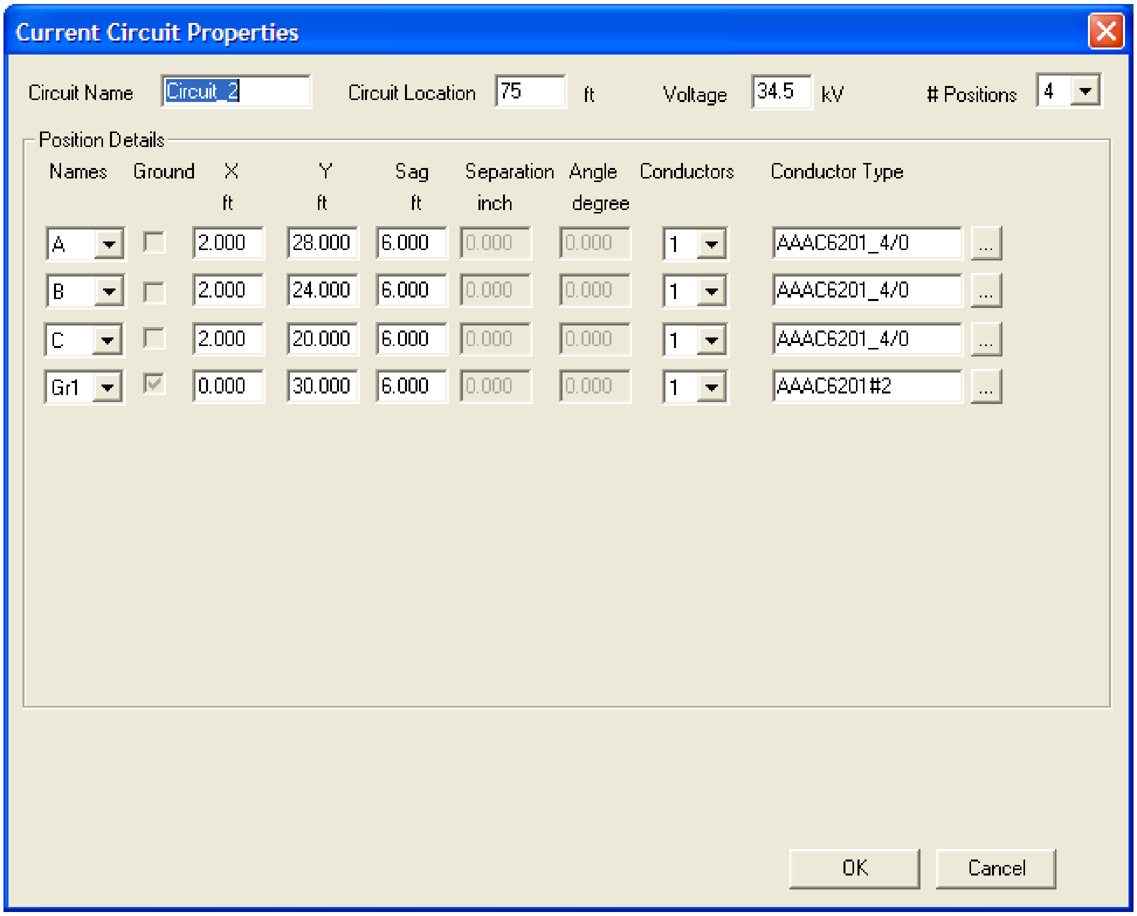


**Figure 1-8. Example Circuit_2 Properties View**

7. In the Current Circuit Properties window:

   - The **Circuit Name** and **Circuit Location** may be changed.
   - The base **Voltage** of the circuit may be specified, with units of kV line to line. This value is particular important for use in reporting results in per unit. By default, this is set to the value indicated on the Circuit tab of the ***Options>Setup...*** window. The program default value is 115 kV.
   - The **Number of Positions** for the circuit can be specified by clicking on the down arrow to the right of the field and then selecting the desired number. This will display the desired number of **Position Details** lines in the lower portion of the window. The maximum number of positions is 10; the default number is 1.
   - The **Name** (phase) of each position can be selected from the list of acceptable names by clicking on the arrow to the right of the field. Ground wires are noted by a name with the first two characters of "Gr". The **Ground** checkbox will automatically be checked if one of the "Gr" Names are specified.

   The same position name may be assigned to one or more positions within a circuit. Be aware however that all conductors in all positions with the same phase in a circuit are equivalenced to a single entry in the Z impedance matrix and the Y admittance matrix for the circuit.

- Specify the horizontal (**X**) and vertical (**Y**) location and midspan **Sag** for each of the positions. X location is specified relative to the circuit origin. Y location is specified as the height at the structure connection relative to the earth.
- The number of **Conductors** per position (bundle) can be adjusted by clicking on the arrow to the right of the field and selecting the desired number. If the number of conductors in the bundle is greater than one (max=8), then the **Separation** and **Angle** fields can be modified.
- When the number of Conductors is greater than one, then the **Separation** field can be edited. The value entered indicates the distance between the adjacent positional conductors (measured center to center) and the position of the first conductor relative to a zero horizontal position. Another term used to describe this separation is "bundle spacing".
- Along with the Separation value, the position **Angle** can also be modified when the number of Conductors is greater than one. The previously entered X and Y position of a bundle is used as its center point.

A configuration occasionally seen on U.S. 345 kV lines is a vertical bundle of two conductors with 18 inch separation. This is specified as two conductors (in the bundle), separation of 18 inches (also bundle diameter in this case) and 90 degrees to the first conductor. A drawing of the bundle is shown in Figure 1-9.

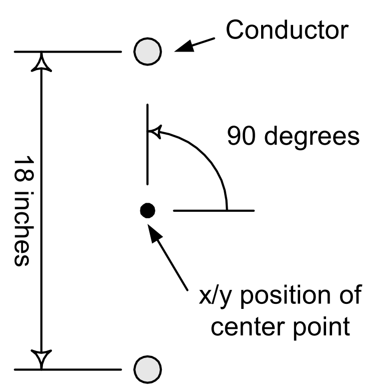


**Figure 1-9. Conductor Bundle Diagram**

- A conductor name can be typed directly into the **Conductor Type** data field or be selected from a list of available conductors by clicking on the ... button to the right of the **Conductor Type** data field. Be aware that if the name is typed directly into the data field, it must identically match a name in the conductor database, including whether it’s specified in upper or lower case.

If the ... button is clicked, then the **Select Conductor Type** window shown in Figure 1-10.

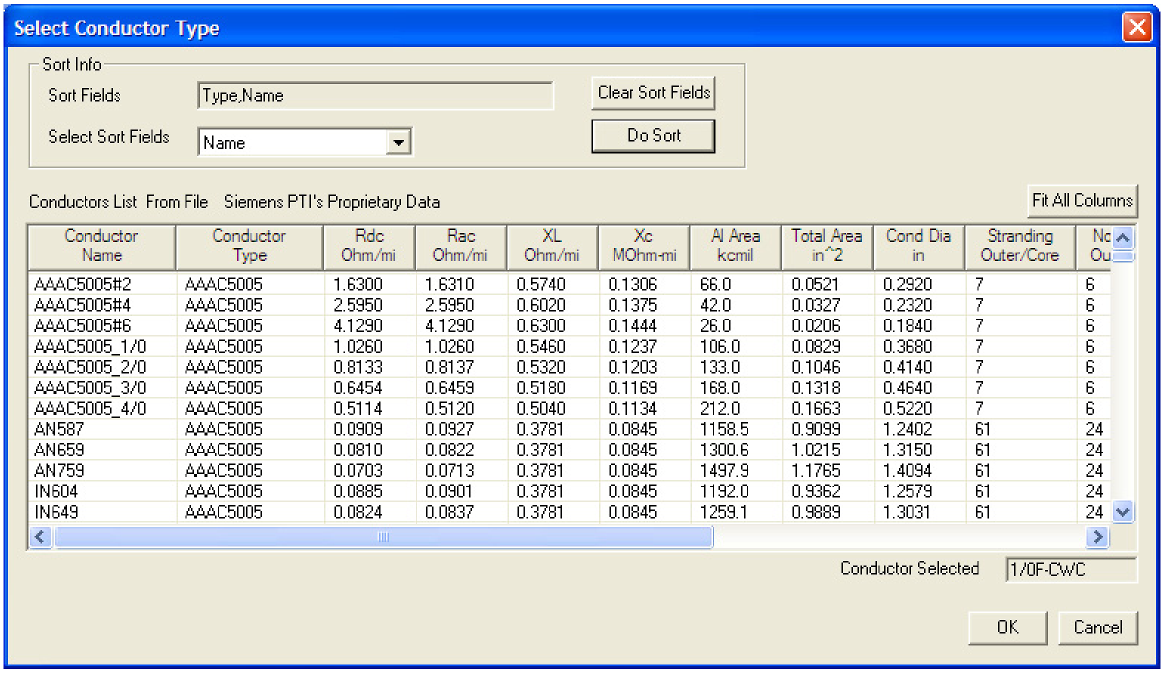


**Figure 1-10. Select Conductor Type Window**

8. The **Select Conductor Type** window allows you to view the properties of various conductors and to select the conductor for the previously selected position. This window has the following features:

   - You can sort the conductor data based on a combination of several sort criteria. When the ***Clear Sort Fields*** button is clicked, the sort criteria are cleared.
   - To select a sort criteria, click on the **Select Sort Fields** box and select the desired criteria from the drop down list. The criteria name will automatically be shown in the **Sort Fields** criteria field. The criteria selections are cumulative, thus each selection will be appended to the Sort Fields list. In the example shown above, conductors are to be sorted by Type and then by Name.
   - To perform the sort, click on the ***Do Sort*** button. For the example shown above the conductors in the database are sorted by Type and then by Name.
   - Conductor properties will be shown in English or SI (metric) units depending on the option chosen.
   - Scroll through the conductor database. To select a conductor, click on the conductor name (the selected conductor is shown in the box in the lower right side of the window) and select ***OK***, or double-click on the conductor name to select it and return to the Current Circuit Properties window.
   - The ***Fit All Columns*** button to the right of the window, above the conductor table, allows the user to view all data columns for the conductors on one screen, as shown in Figure 1-11.

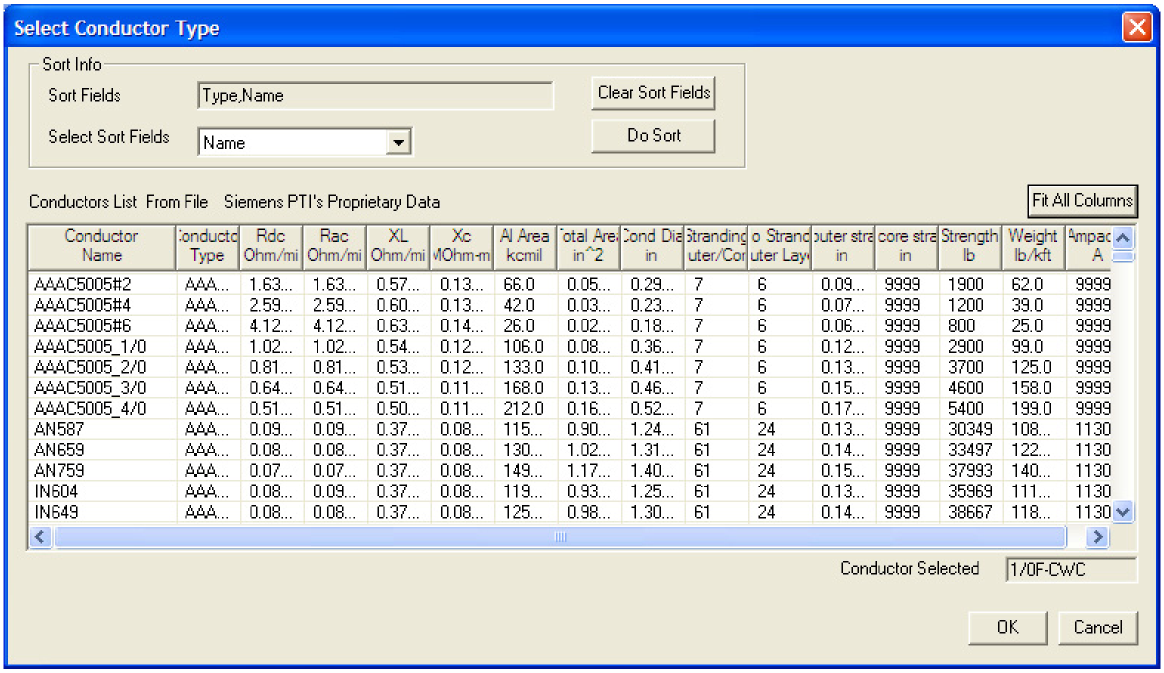


**Figure 1-11. Select Conductor Type Window after "Fit All Columns" is Pressed**

9. When you click the ***OK*** button in the Current Circuit Properties window, validity checks are made on the circuit properties and configurations. Appropriate messages are displayed in the lower portion of the window to indicate infeasible specifications (e.g., conductor separations that are not feasible, phase positions that are not feasible, etc.).

Corrections must be made to the data before the program can proceed. Once all infeasible data items are corrected, the Current Circuit Properties window is closed and the defined circuit will be displayed in the LineProp Corridor View. Similar to the example in Figure 1-12, each position of the circuit is shown and labeled.

SIEMENS

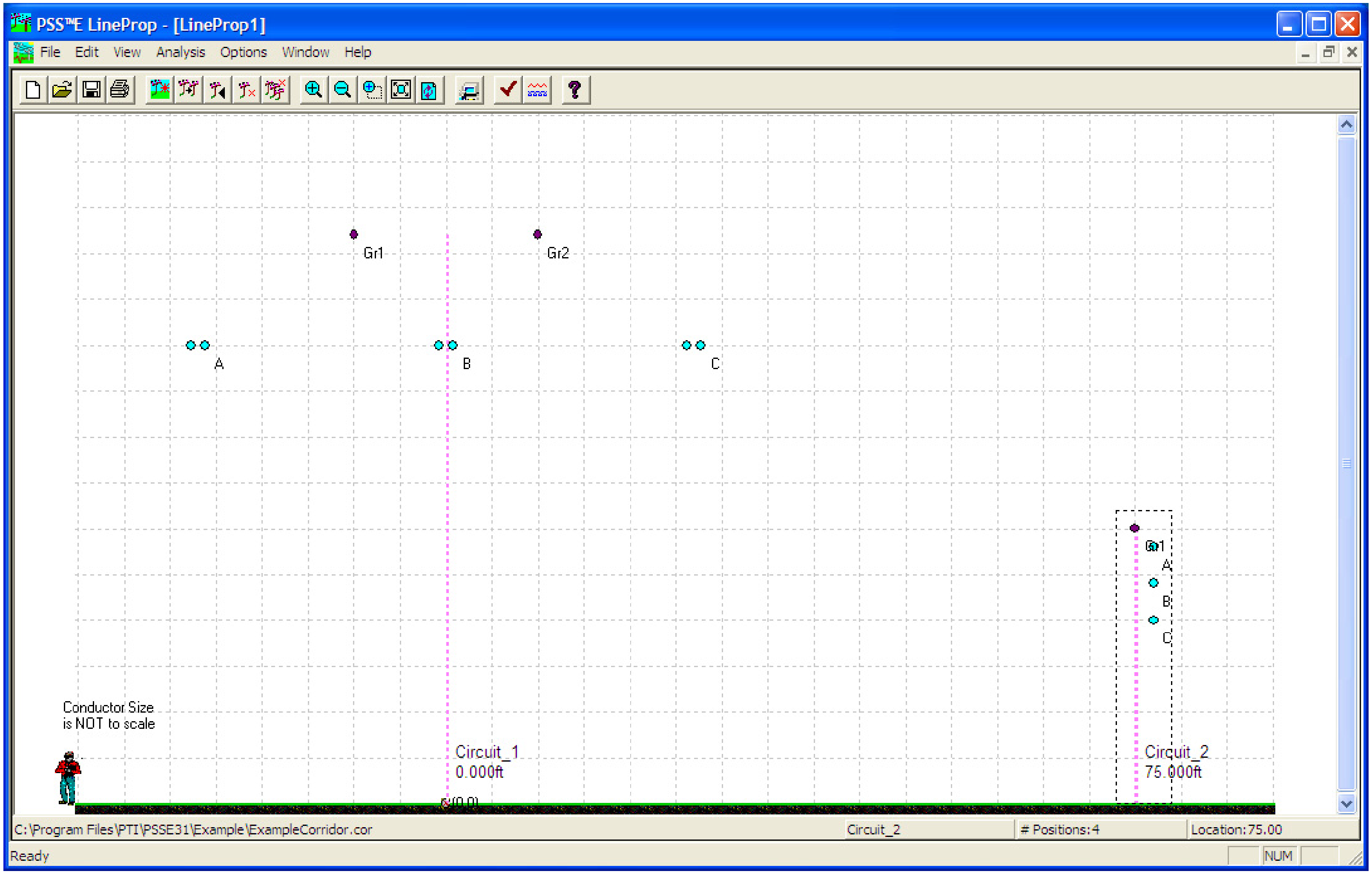


**Figure 1-12. Corridor View**

### 1.2.2 Status Bar

The **Status Bar** at the bottom of the main LineProp Corridor View window, as seen in Figure 1-12, serves two purposes. First, when the mouse is positioned over one of the LineProp **Toolbar Icons**, the meaning or use of the icon is described on the status bar. Second, when the cursor is not over a LineProp Toolbar icon the Status Bar shows:

- The name of the Corridor File currently being viewed. The name is blank if the current circuit view has not yet been saved to a file.
- The name of the circuit that is currently highlighted (the circuit surrounded by a dashed box).
- The number of positions associated with the highlighted circuit.
- The location of the centerline of the circuit.

### 1.2.3 Menu Bar

The **LineProp Menu Bar**, as seen Figure 1-13, is located at the top of the main Line Properties window.

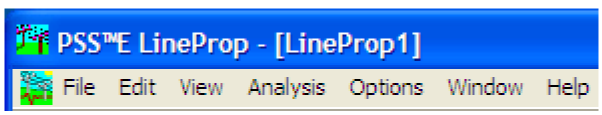


**Figure 1-13. LineProp Menu Bar**

#### File Menu

The **File Menu** provides options for opening an existing Corridor file, saving an existing Corridor file, saving the current corridor data to a new file, printing the corridor view, and exiting LineProp.

#### Edit Menu

The **Edit Menu** provides options to insert a circuit at a specified location, go to and highlight a specified circuit, delete one or all circuits, copy a circuit, and paste a circuit.

#### View Menu

The **View Menu** allows you to zoom in or out of the corridor view, zoom to a selected portion of the corridor, zoom to the full extent of the corridor, and to refresh the corridor view.

#### Analysis Menu

The **Analysis Menu** allows you to calculate and report the circuit impedances and admittances. The results of this calculation are described in Section  Performing an Analysis.

#### Options Menu

The **Options Menu** allows you to specify default settings for **Corridor Options**, **User Options**, and **Circuit Options**. These are discussed in more detail in Section 1.2.6 Setting Options.

## Window Menu

The **Window Menu** options allow you to control the placement of windows in the application. New instances of corridor windows may be created and multiple windows may be cascaded or tiled. Windows that have been previously minimized may be arranged by choosing **Arrange Icons**.

## Help Menu

The **Help Menu** options provides version information about the program.

## 1.2.4 Toolbar

The **LineProp Toolbar**, shown in Figure 1-14, provides convenient access to all the LineProp functions. By clicking on one of the toolbar buttons you can quickly create, open, or save a corridor file; print the corridor file; add, copy, or delete circuits; change the viewing area; change defaults; validate the circuit dimensions; and calculate impedances. The **About LineProp** button provides information on the LineProp version that is being used.

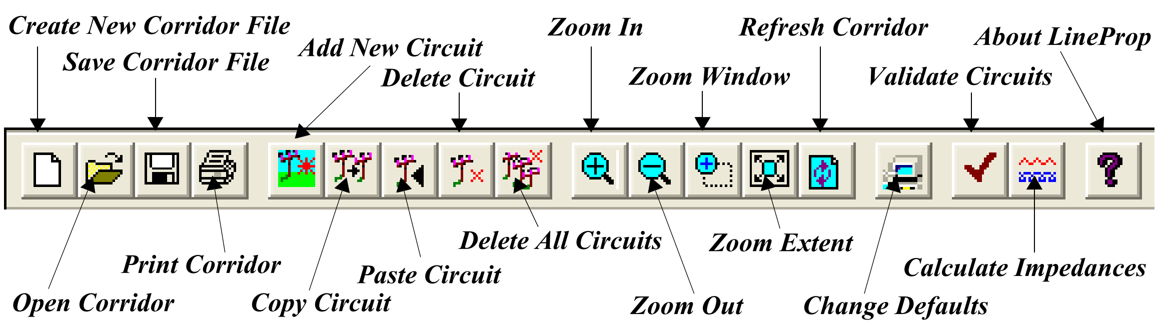


**Figure 1-14. LineProp Toolbar**

## 1.2.5 Zoom and Refresh Capabilities

The Zoom and Refresh capabilities allow you to view specific areas of the Corridor View in more or less detail. The Zoom In and Zoom Out features operate much like a camera's zoom lens. You see more (Zoom Out) or less (Zoom In) of the view centered on the starting point of the zoom operations.

The toolbar **Zoom Window** icon and the Main Menu ***View>Zoom Rect*** option operate in the same manner. To activate this feature:

- select ***View>Zoom Rect*** from the Main Menu or select the ***Zoom Window*** icon from the toolbar,
- position the mouse pointer in the drawing area near the area of interest,
- hold the left mouse button down and drag the mouse diagonally (you should see a rectangle around the objects of interest),
- release the mouse button, and
- the area of interest is the focus of the corridor view.

The Refresh Window and Zoom Extent options cause the Corridor View to return to a view of the full corridor.

### 1.2.6 Setting Options

The LineProp module has several default settings that you may alter.

To view and edit the LineProp defaults:

- Select ***Options>Setup*** from the Main Menu, or
- Click on the ***Change Defaults*** toolbar icon.

The defaults are arranged into three groups: **Corridor Options**, **User Options** and **Circuit Options**.

### Corridor Options

When you elect to view and/or change the defaults, the window shown in Figure 1-15 appears. The first tab is for modifying the **Corridor Options**. These options include:

- **Units:** Specify whether all measurement units used in LineProp are to be in English or International System (SI (metric)). English units specify resistance and reactance in ohms/mile, diameter in inches, conductor locations in feet, bundle spacing in inches and output per mile.

  SI units specify resistance and reactance in ohms/km, diameter in mm, conductor locations in m, spacing in cm and output per km.

  Changing units while a circuit corridor is opened will not automatically convert the specified conductor positions. This must be done manually. For example, if English units are specified and phase A of the circuit is 25 feet above ground, then a change to SI units will now indicate that phase A is 25 meters above the ground! So set the units before you start to build the configuration.

  The units, as well as the frequency, as used in obtaining conductor characteristics, are saved in the corridor file. This allows the settings to be restored to the desired values when the file is opened.

- **Output:** Data Output in either Physical units (Ohm or μS) or pu (per unit). The display of results in pu requires that the power base and circuit voltage be specified. The circuit voltage is specified on the Circuit Tab.
- **Frequency:** Click on the arrow to select either 50 or 60 Hertz. The frequency can be changed at any time. Whenever a calculation is performed, LineProp will automatically consult the internal Conductor Dictionary to obtain the values corresponding to the frequency and the units specified.
- **Power Base:** The three phase system Power Base for the corridor, in MVA. By default this in 100.0 MVA.
- **Earth Resistivity:** Specified in Ohm-m. By default this is 100 Ohm-m and can be modified by entering a new value directly in the field.
- **Description:** A description of the corridor. Multiple lines may be entered.
- **Use Length:** When enabled this activates the Length Specifications options. If not enabled, output results will be shown in per mile (English) or per km (SI).
- **Length Specifications:** If the Use Length option is enabled, then the line length can be specified.
  - The **Length** is specified in either miles or kilometers, depending on the Units.

- The **Hyperbolic** option is used for impedance correction calculations of long lines. If not checked, the approximate calculation will be used. Hyperbolic calculations are normally done for lines around 100 miles or longer.

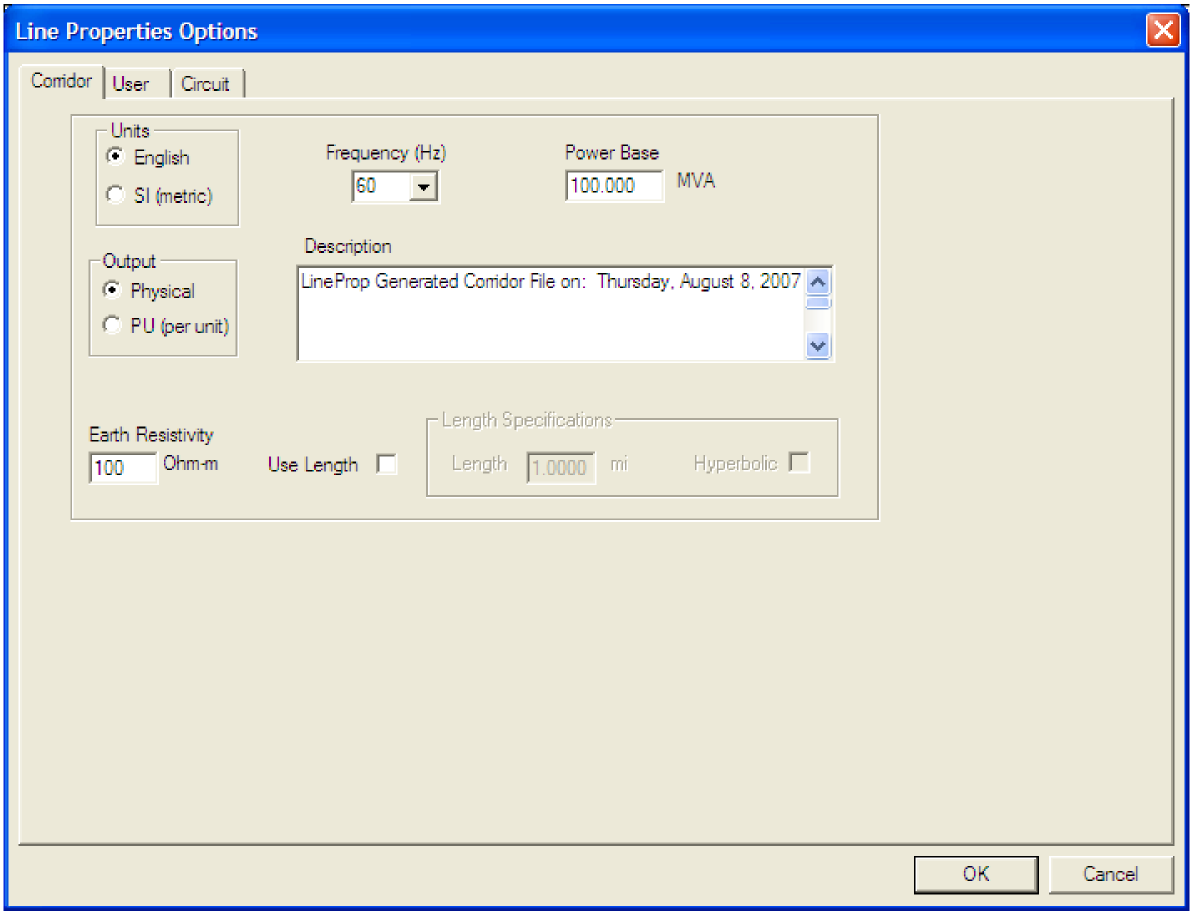


**Figure 1-15. Line Properties Options Window - Corridor Tab**

## User Options

The second group of defaults that you can modify is the **User Options** (Figure 1-16). These options provide ways to alter the appearance of the main Corridor View and to specify an alternate conductor library and default conductor types. These option settings will be preserved between LineProp sessions.

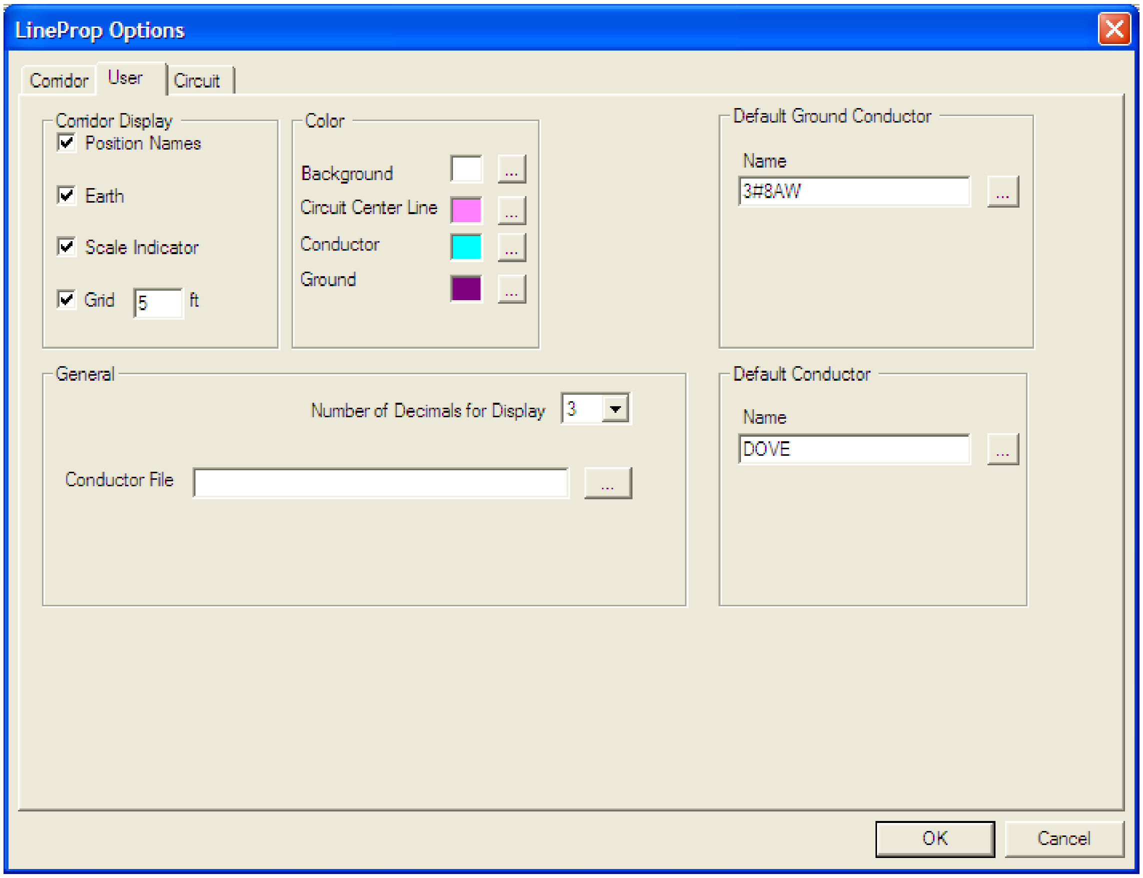


**Figure 1-16. Line Properties Options Window - User Tab**

These options include:

- **Corridor Display:** Select whether or not to have Position Names displayed in the Corridor View, to have the earth shown in the diagram, to have the scale indicator shown, and to have the grid shown. If you want to have the grid shown, the grid spacing must also be specified.
- **Colors:** Specify the colors for the background, the circuit centerline, and the conductor and ground wires. Clicking on the button to the right of the display box allows you to pick a color from the color palette.
- **Default Ground Conductor:** Specify the default ground conductor or select it from the conductor file by clicking on the button to the right of the field. The operation to select a new default ground conductor is the same as that used to select a specific conductor for a position (see Section 1.2.1 Corridor View, Step 8).
- **Default Conductor:** Specify the default phase conductor or select it from the conductor file by clicking on the button to the right of the field. The operation to select a new default conductor is the same as that used to select a specific conductor for a position (see Section 1.2.1 Corridor View, Step 8).

- **General:** This allows you to select the number of decimal places for display, and the default conductor file library if the internal library is not used.

## Circuit Options

The third group of defaults that you can modify is **Circuit Options** (Figure 1-17). This option sheet is similar to the sheet used to specify the current circuit properties. In fact, the format designated here will be used whenever a new circuit is placed in the Corridor View. Note that before you can accept and exit the options window, position locations must not conflict with each other.

- **Circuit Name**: The default name to be given to new circuits. When a new circuit it created the new name will consist of the default Circuit Name appended with the horizontal location of the circuit.
- **Voltage:** The line to line voltage in kV. This value is used in when pu output is specified.
- **# Positions:** Click on the arrow to the right of the field and select the desired number. This will display the desired number of Positions in the lower portion of the window, whose characteristics can then be modified. The maximum number of positions is 10; the default number is 1.
- As outlined in Section 1.2.1 Corridor View Step 7, the **Position Details** can be modified as desired. The values indicated will be used as the default configuration for all new circuits placed in the corridor view within the current LineProp session.

One note of caution: Many of the circuit options work only for the current session, so you may not want to rely too heavily on their settings.

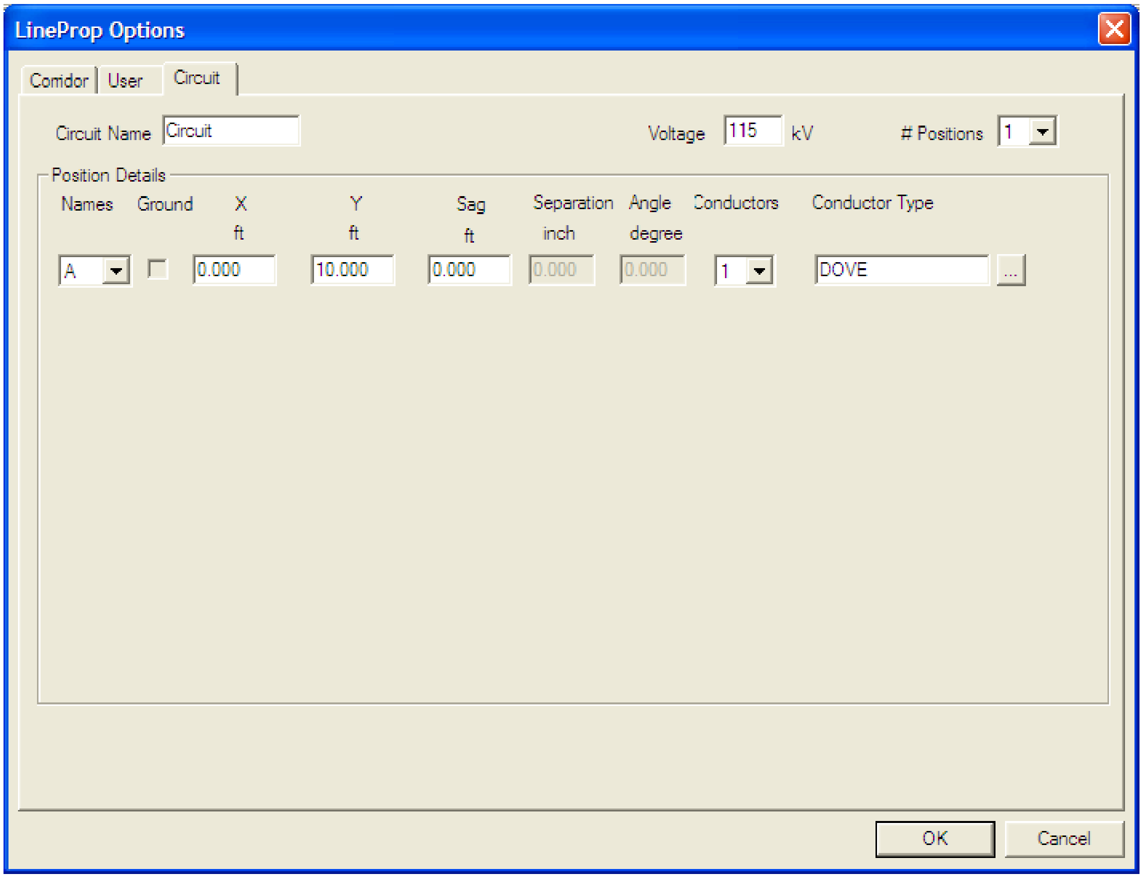


**Figure 1-17. Line Properties Options Window - Circuit Tab**

# 1.3 Corridor Files

## 1.3.1 Opening/Saving/Printing Corridor Files

### Opening a Corridor File

To open an existing corridor file:

1. Select ***File>Open*** from the Main Menu or click the ***Open*** button  on the LineProp Toolbar. The Open dialog box is displayed (Figure 1-18).

2. Enter/select the directory and filename of the desired corridor file.

3. Click the ***Open*** button to display the diagram.

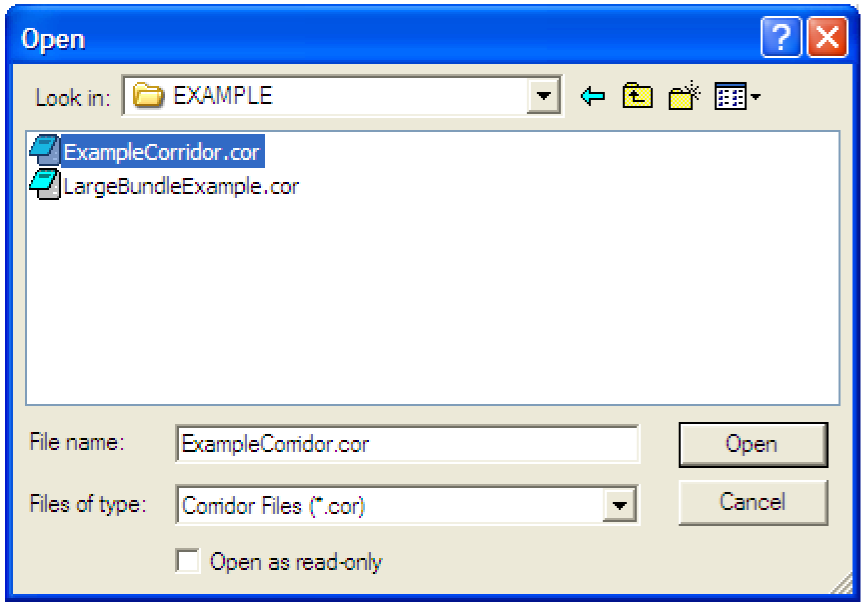


**Figure 1-18. Open Dialog Box**

## Saving a Corridor File

To save a corridor view:

1. Click the ***Save*** button  on the LineProp Toolbar, or choose ***File>Save As...*** or ***File>Save*** from the Main Menu. The Save As dialog box is shown in Figure 1-19.
2. Specify the directory path and filename you want for the file.
3. Click the ***Save*** button to save the data.

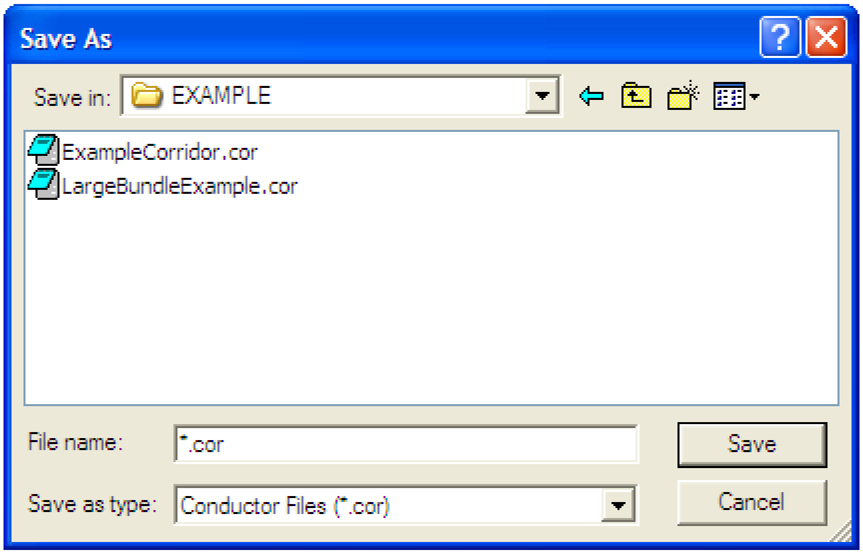


**Figure 1-19. Save As Dialog Box**

## Printing a Corridor File

The corridor diagram may be printed, and, if desired, previewed on the computer terminal screen.

To print or preview the diagram:

1. Click on the ***Print*** button  on the LineProp Toolbar and choose ***Print Corridor...*** or ***Print Preview Corridor*** or choose ***File>Print...*** or ***File>Print Preview*** from the Main Menu.

2. If **Print Preview** is selected, the corridor diagram will be displayed on the computer screen as shown in Figure 1-20. Within this window you can:

   a. Zoom In to see a particular area of the diagram,

   b. Close the Print Preview Screen and return to the Corridor View,

   c. Print the corridor diagram.

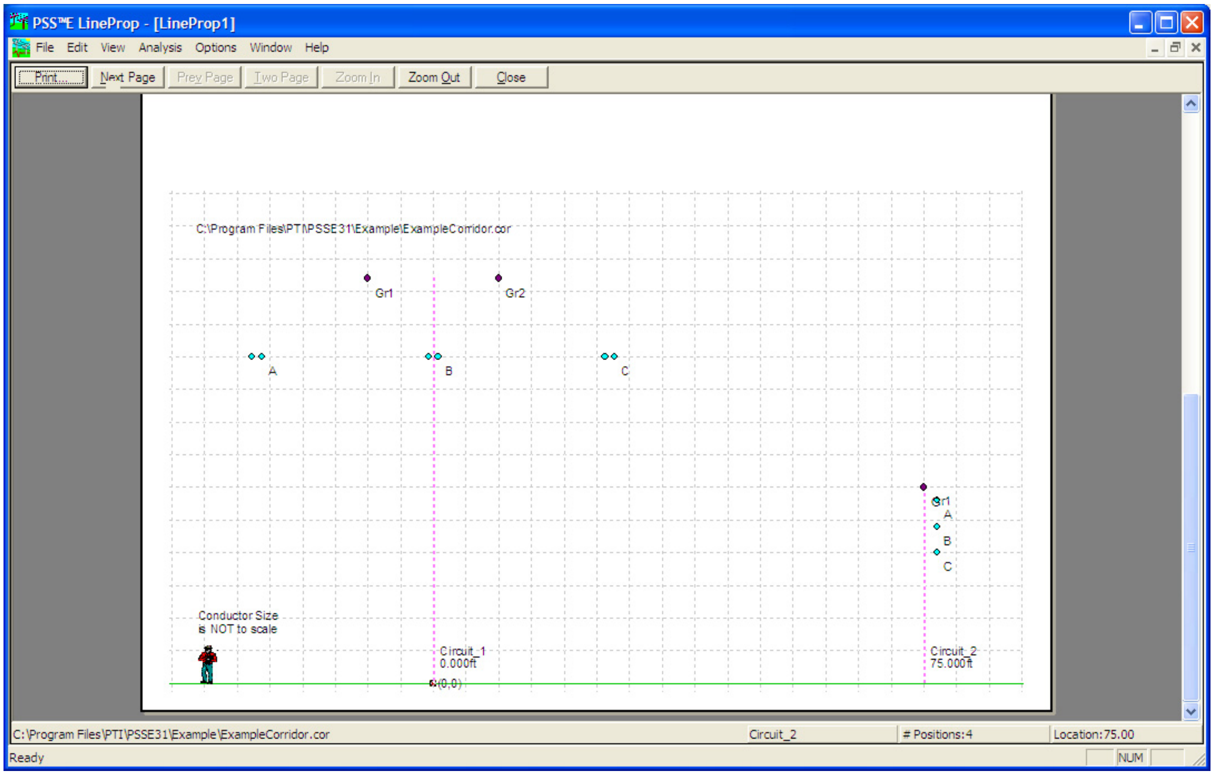


**Figure 1-20. Print Preview Screen**

3. When you click on the ***Print*** button, the window illustrated in Figure 1-21 is displayed.

4. In the Print dialog box you can specify where the printed output is to go, the number of pages to print, and the number of copies to print.

5. Click ***OK*** to print the corridor diagram.

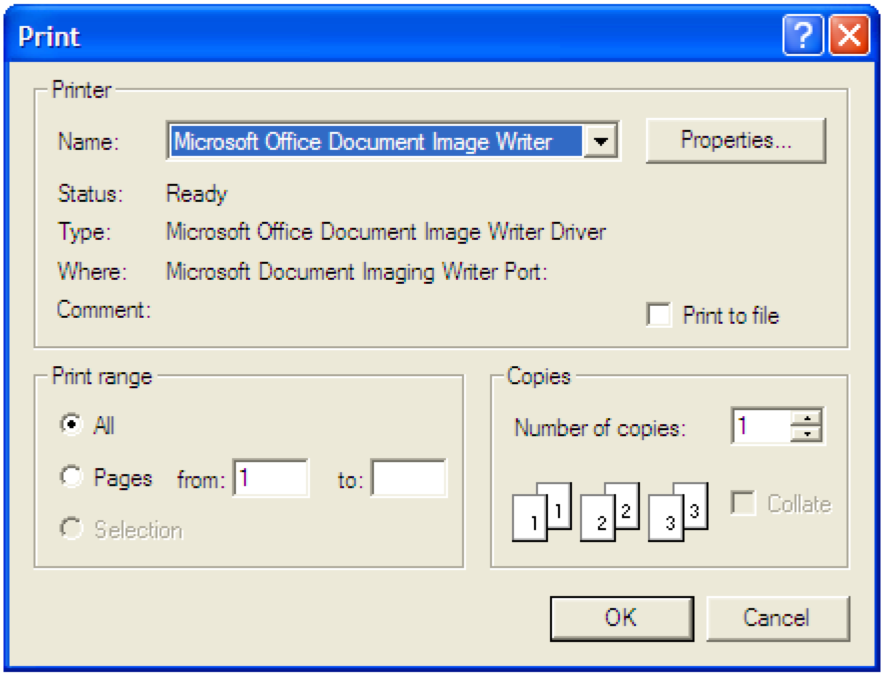


**Figure 1-21. Print Dialog**

### 1.3.2 Modifying Corridor Files

There are several ways that existing corridor files may by modified. You need to first select the circuit and then operate on the circuit.

### Selecting a Circuit

To select a circuit, move the mouse pointer near the circuit and click once. A dashed rectangle should appear around the circuit. If the rectangle does not appear, move the mouse closer to the circuit tower and click once again. The Corridor View will appear similar to Figure 1-22. Note the dashed box surrounding the selected circuit.

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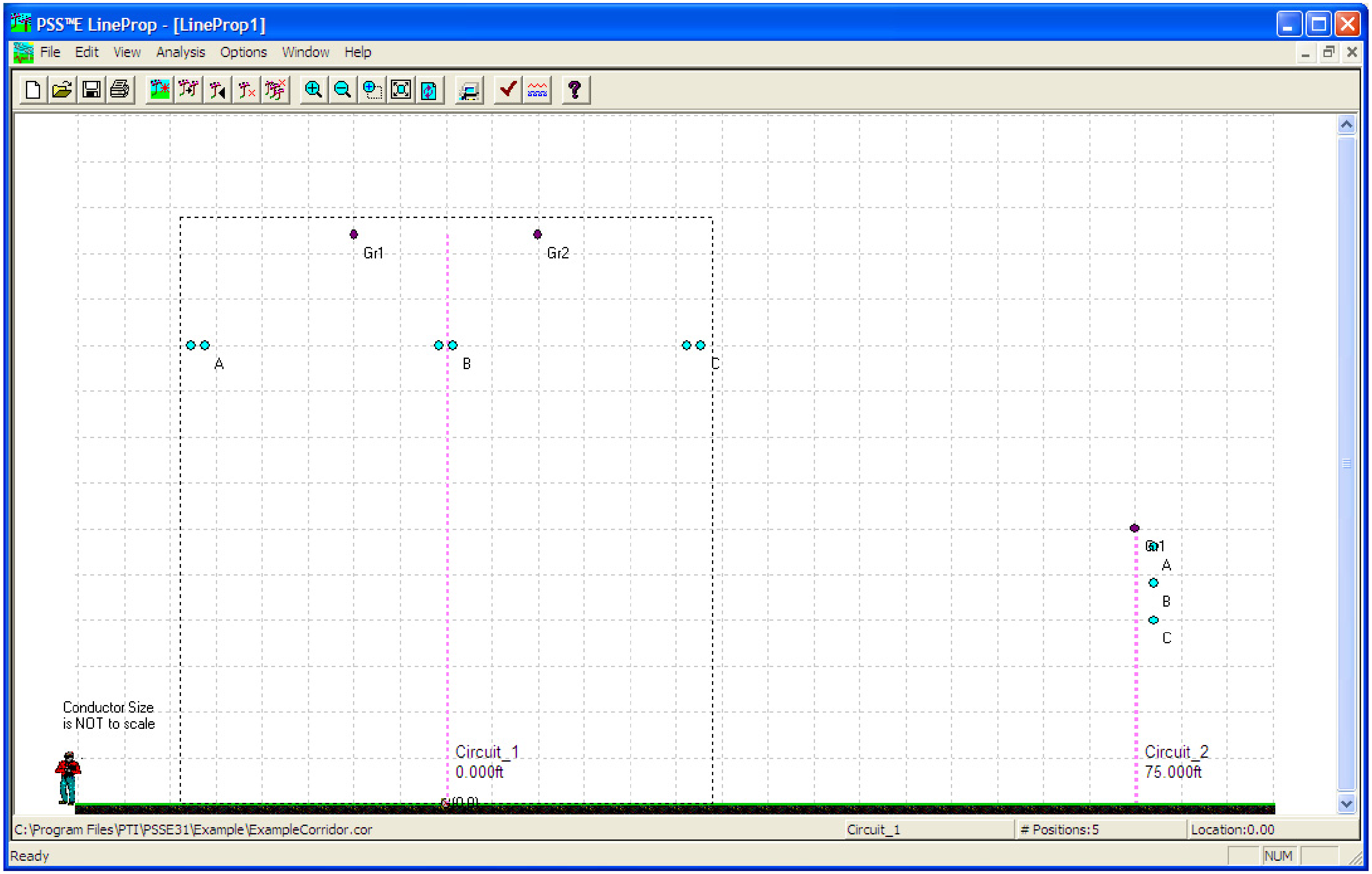



Figure 1-22. Selected Circuit

## Adjusting Circuit Properties

To adjust the current circuit properties, double-click inside the dashed box surrounding the circuit. The **Current Circuit Properties** dialog box, illustrated in Figure 1-23, will appear. You may change any of the values shown in this properties window. Click ***Cancel*** to reject any changes and to return to the Corridor View. Click ***OK*** to accept all changes and to return to the Corridor View.

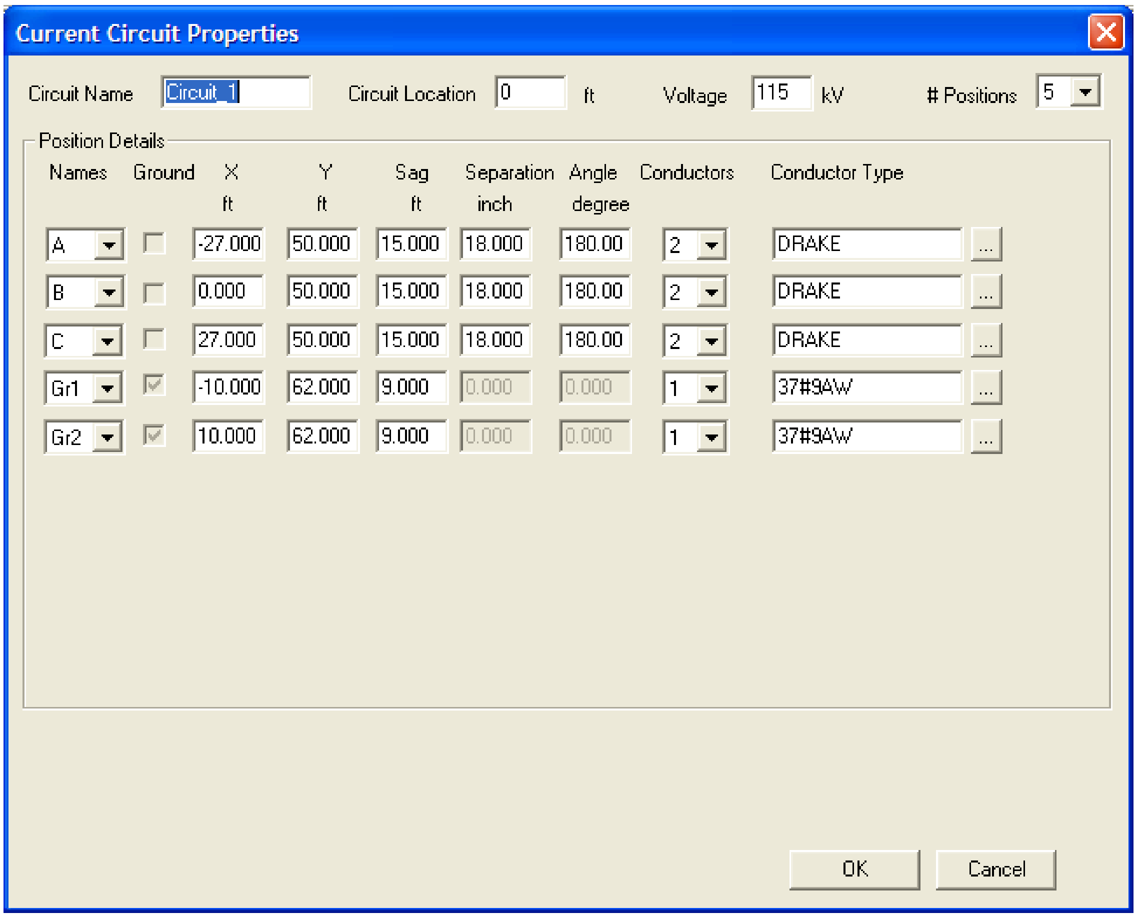



**Figure 1-23. Current Circuit Properties Window**

## Copying a Circuit

To copy a circuit:

1. Select the circuit to be copied. A dashed box should surround the circuit.
2. Click on the ***Copy*** button  on the LineProp Toolbar or select ***Edit>Copy Circuit*** from the Main Menu.
3. Paste the circuit at a new location as instructed in the next section of this manual.

## Pasting a Circuit

To paste a circuit:

1. Click on the ***Paste*** button  on the LineProp Toolbar or select ***Edit>Paste Circuit*** from the Main Menu.
2. The dialog box illustrated in Figure 1-24 will appear.
3. Enter the name and horizontal position of the new circuit. Default values are given which may be accepted or altered by you.
4. Click on ***OK*** to paste the new circuit into the corridor. Note that the circuit just pasted into the Corridor View is now selected.

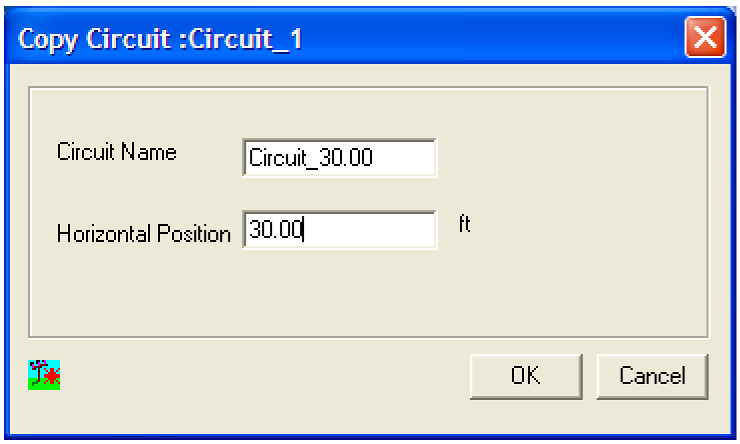
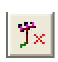



**Figure 1-24. Copy Circuit Dialog Box**

## Deleting a Circuit

To delete a circuit:

Select the circuit to be deleted.

1. Click on the ***Delete*** button  on the LineProp Toolbar or select ***Edit>Delete Circuit...*** from the Main Menu.
2. You are asked to verify that the indicated circuit is to be deleted, as illustrated in Figure 1-25. A response of Yes will remove the circuit from the Corridor View.

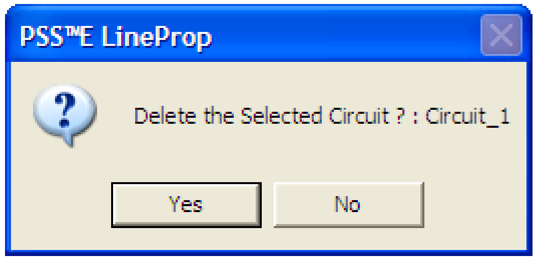



**Figure 1-25. Verify Circuit to Delete**

### Deleting All Circuits

All circuits in the Corridor View may be deleted at one time:

1. Click on the ***Delete All*** button  on the LineProp Toolbar or select ***Edit>Delete All Circuits*** from the Main Menu.

2. You are asked to verify that all circuits are to be deleted, as illustrated in Figure 1-26. A response of Yes will remove all circuits from the Corridor View.

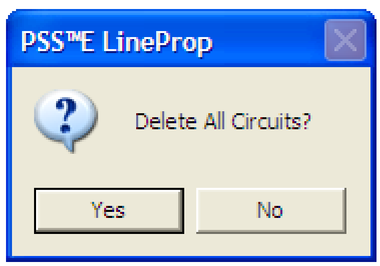



**Figure 1-26. Verify to Delete All Circuits**

## 1.3.3 Analyzing Corridor Files

Once the corridor configuration has been set it is time to analyze the corridor by:

- validating the corridor data,
- performing an analysis, and
- reporting the results.

### Automatic Validation

Validation of the circuit parameters is automatically done when you click on ***OK*** in the Current Circuit Properties window. Any physical property errors detected by the LineProp logic are displayed below the Properties window, as illustrated in Figure 1-27. Note that the height of phases A, B and C at their lowest point of sag would touch phases D, E and F, which is reported.

The following validation checks are made:

- Two or more conductor bundles are not touching at the structure.

- Two or more bundles are not touching at their effective height. The bundle effective height is the height at the structure minus 2/3 of the sag.
- Two or more conductors within a bundle are not touching each other.
- Conductor bundle does not touch the ground.
- Corridor length is greater than or equal to 0.0.
- Earth resistivity is greater than or equal to 0.001.
- Conductor Y position (vertical) is greater than or equal to 0.
- Conductor sag is greater than or equal to 0.0.
- Conductor diameter is greater than 0.001.
- Conductor resistance is greater than or equal to 0.
- Conductor reactance is greater than or equal to 0.
- Conductor separation is greater than or equal to 0. Conductor separation is allowed to be zero when only one conductor per bundle is specified.

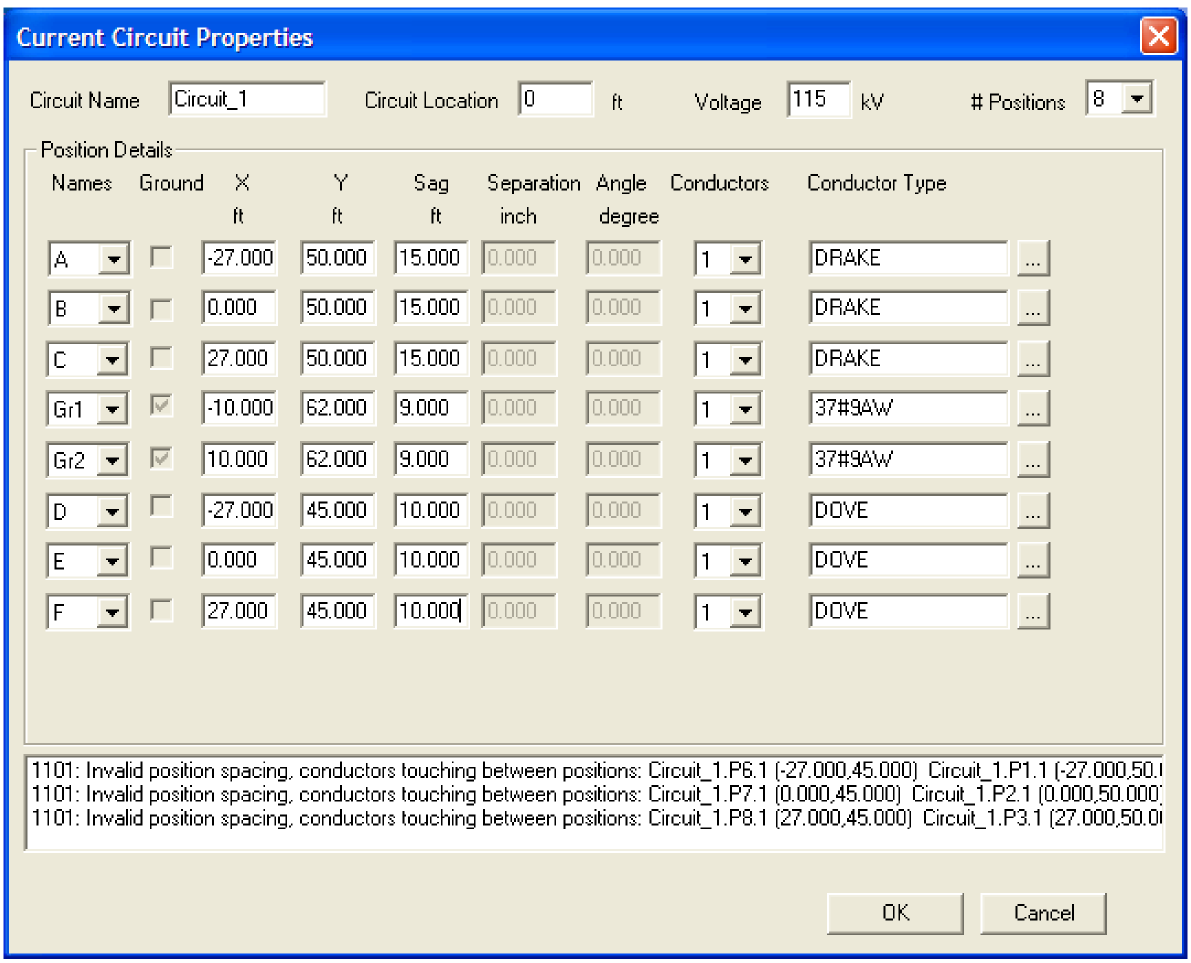



**Figure 1-27. Validation of Circuit Properties**

## User-Initiated Validation

You can initiate the validation process by clicking on the ***Validate Circuits*** button on the LineProp Toolbar.

## Performing an Analysis

To calculate the impedances and admittances of the corridor either click on the ***Calculate*** button on the LineProp Toolbar or select ***Analysis>Impedance...*** from the Main Menu. When the calculations are complete, the **Results Window** appears on the screen.

The results shown in this section are for a two circuit corridor. The circuit data is shown in Figures 1-28 and 1-29.

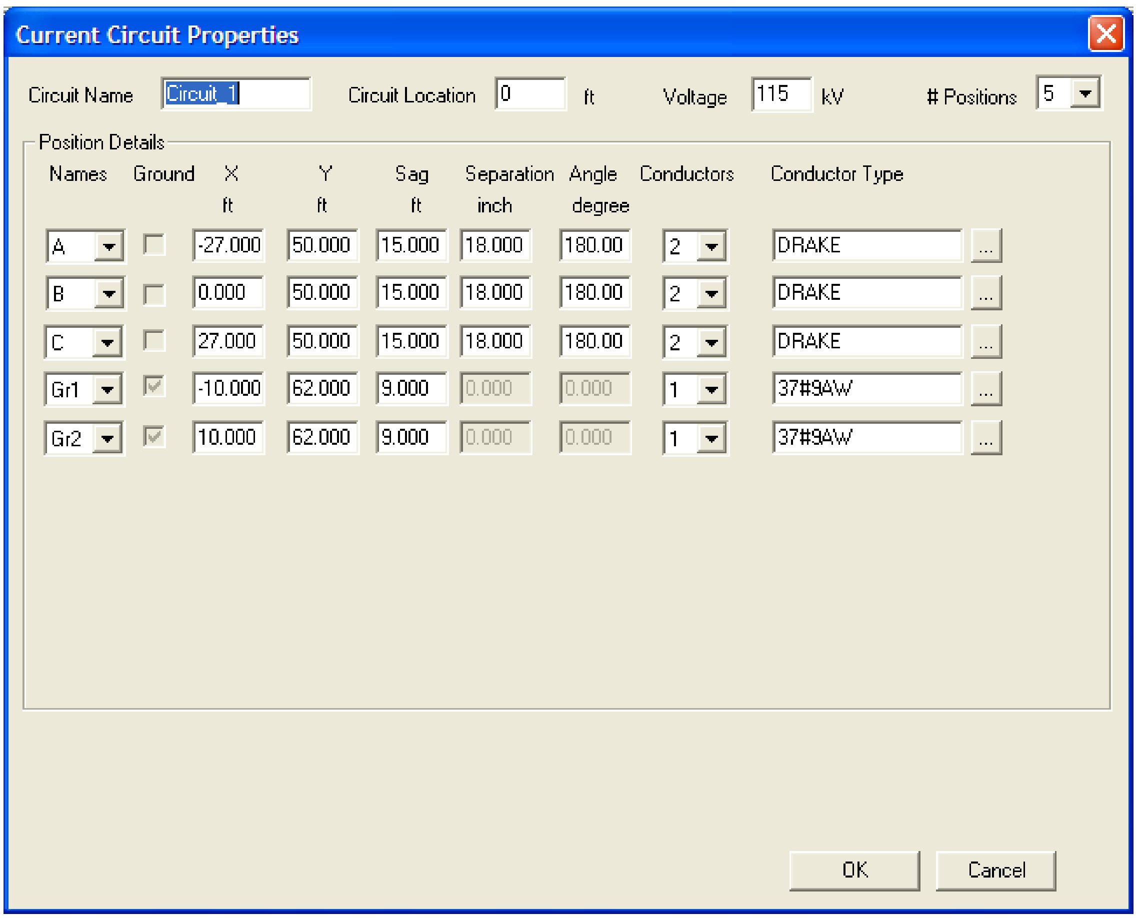



**Figure 1-28. Corridor Circuit Data for Circuit #1**

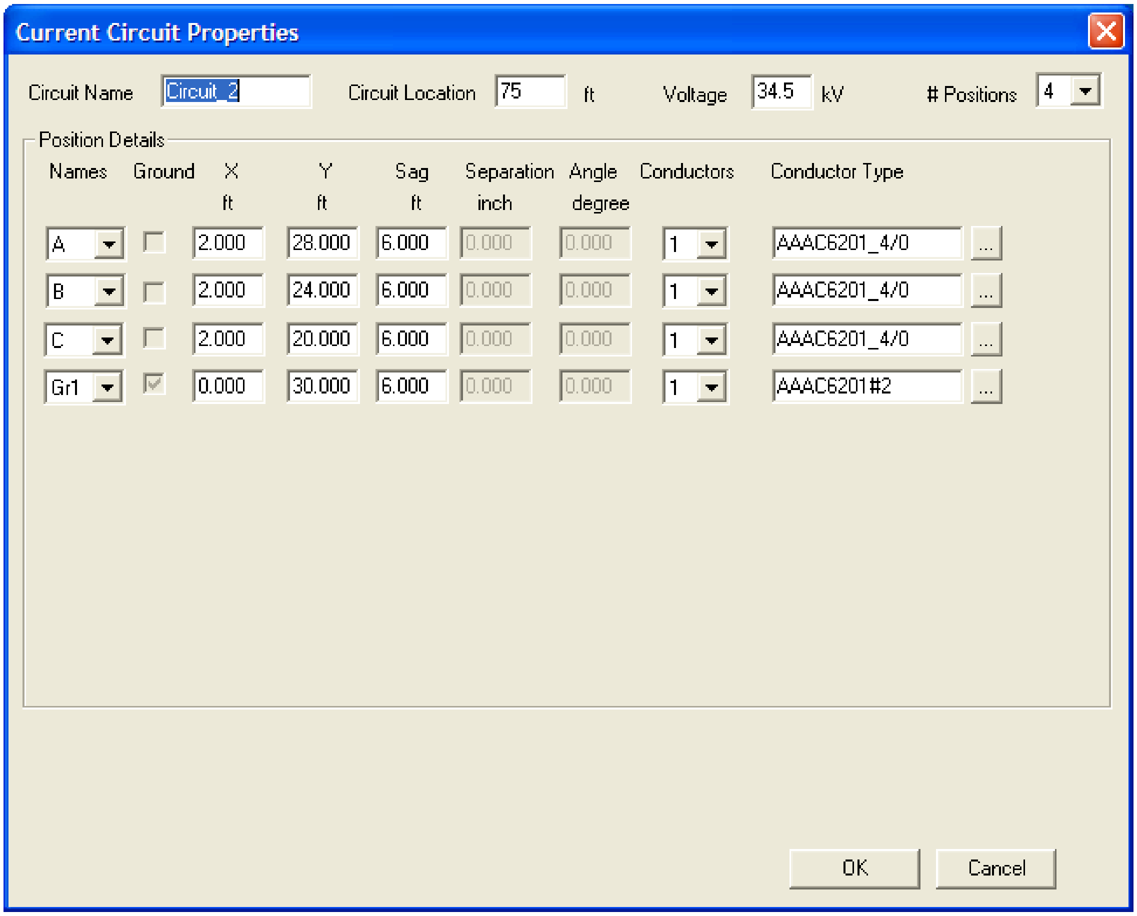



**Figure 1-29. Corridor Circuit Data for Circuit #2**

## Calculation Results

The results of the calculations are:

- **Zero and Positive Sequence Impedances for Each Circuit** ("Z0,Z1 (Per Circuit)" Tab). As shown in Figure 1-30 each circuit in the corridor is listed, along with the calculated positive and zero sequence resistance and reactance values.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then resistance and reactance are in ohms. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section  Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

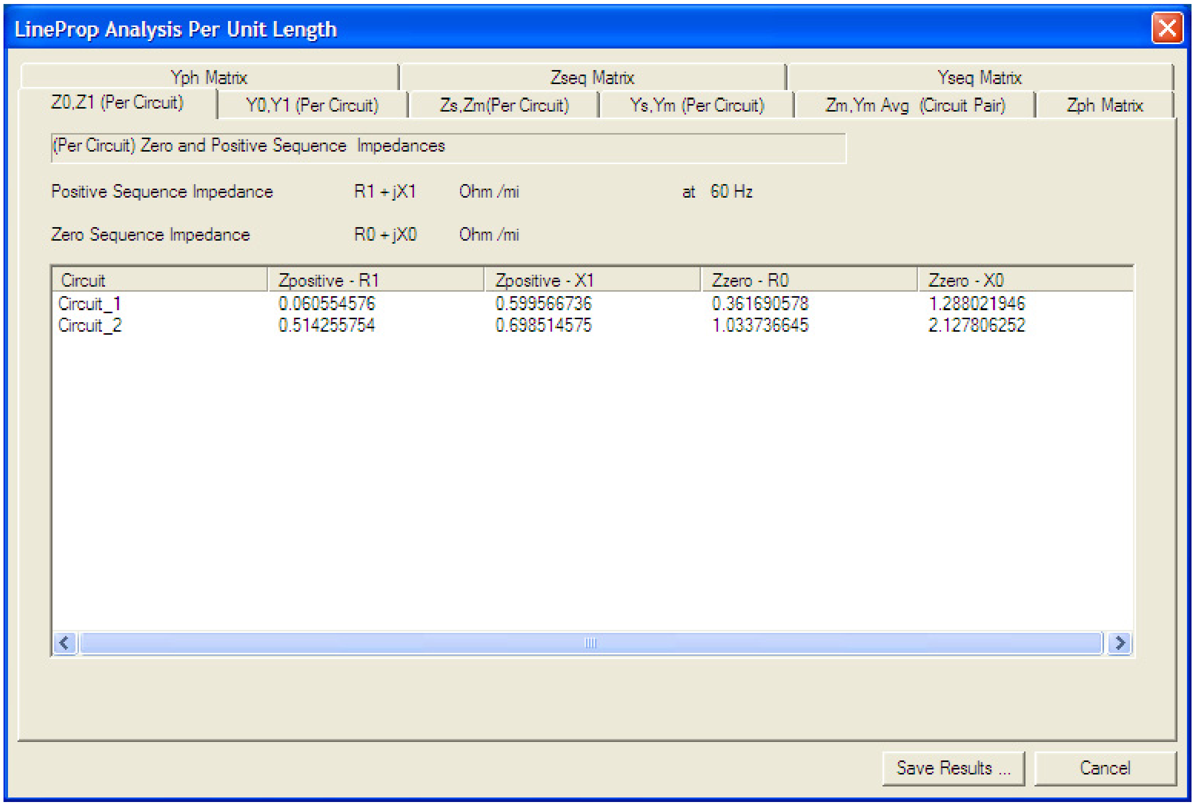



**Figure 1-30. Sample Zero and Positive Sequence Impedances Report**

- **Zero and Positive Sequence Admittances for Each Circuit** ("Y0,Y1 (Per Circuit)" Tab). As shown in Figure 1-31 each circuit in the corridor is listed, along with the calculated positive and zero sequence admittance values.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then conductance and susceptance values are in micro-Siemens. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

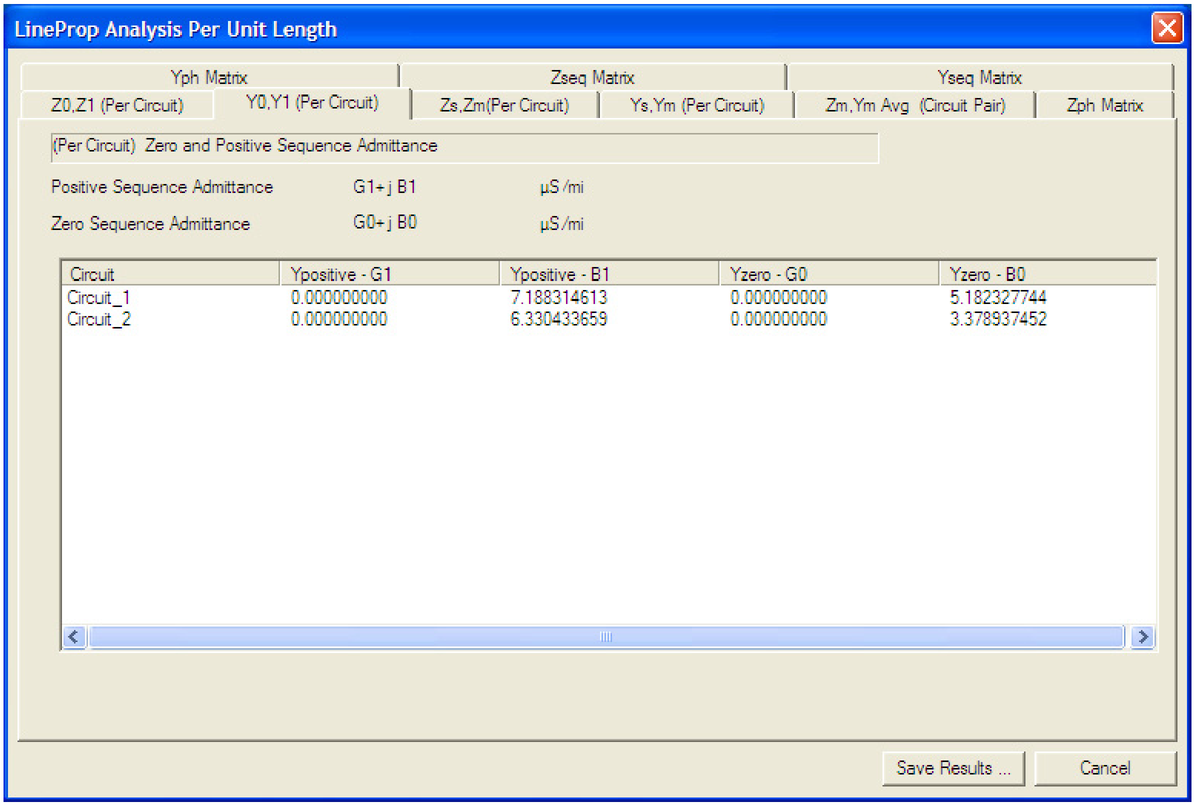



**Figure 1-31. Sample Zero and Positive Sequence Admittance Report**

- **Self and Mutual Impedances for Each Circuit** ("Zs,Zm (Per Circuit)" Tab). As shown in Figure 1-32, the average self and mutual impedances are shown for each circuit in the corridor.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then resistance and reactance values are in ohms. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

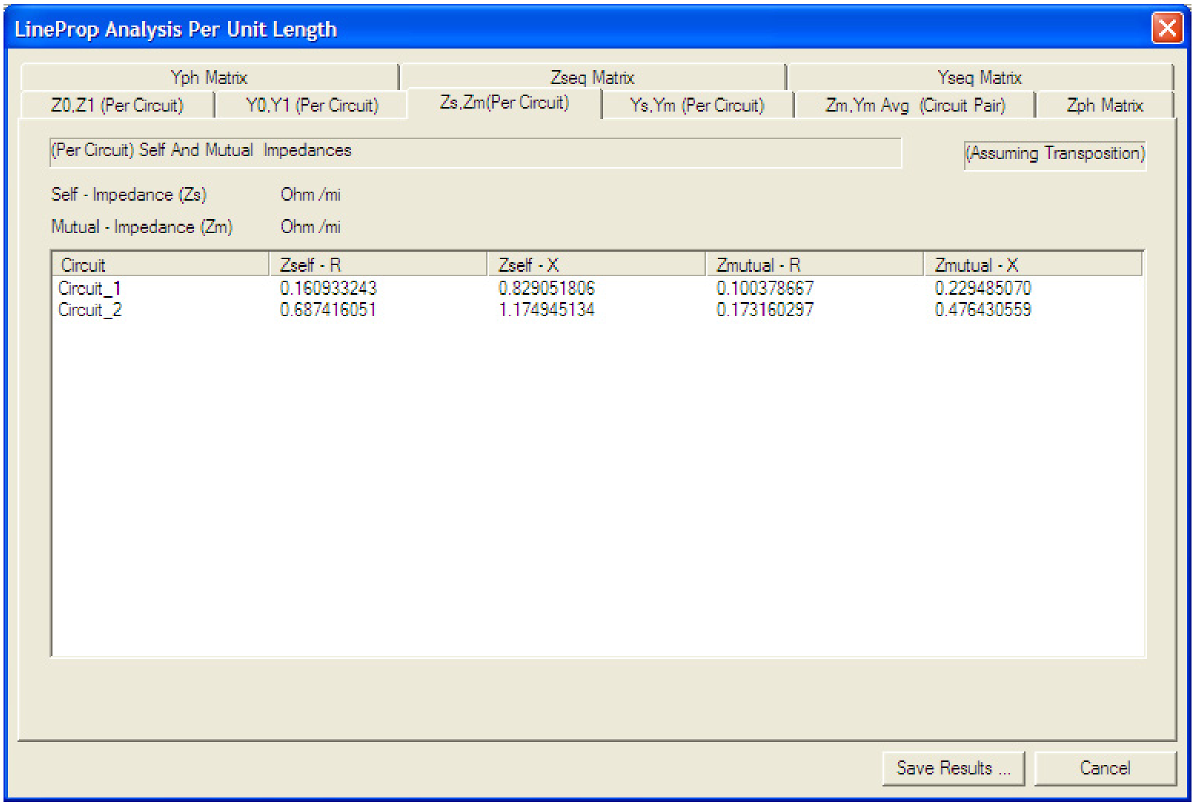



**Figure 1-32. Sample Self and Mutual Impedances Report**

- **Self and Mutual Admittances for Each Circuit** ("Ys,Ym (Per Circuit)" Tab). As shown in Figure 1-33, the average self and mutual admittances are shown for each circuit in the corridor.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then conductance and susceptance values are in micro-Siemens. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

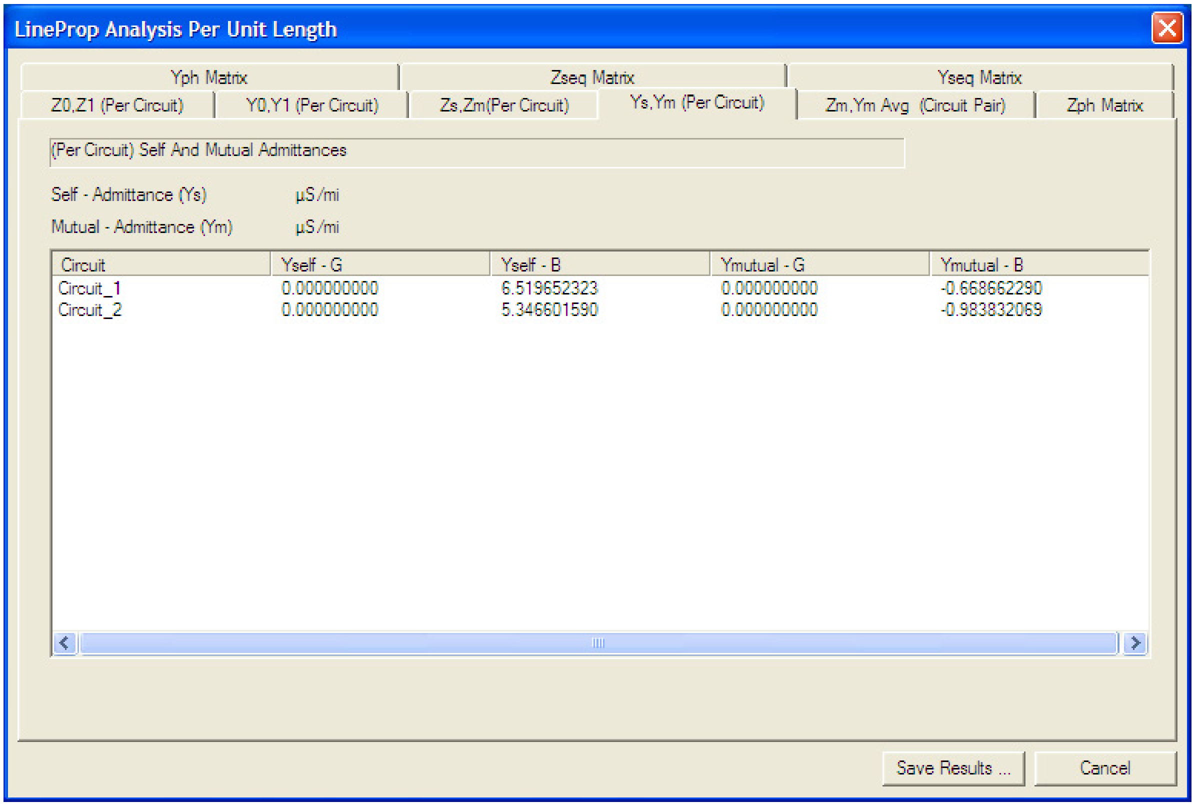



**Figure 1-33. Sample Self and Mutual Admittances Report**

- **Average Mutual Impedance and Admittance for Each Circuit** ("Zm,Ym Avg (Per Circuit)" Tab), also called zero sequence coupling. The report requires that two or more circuits exist in the corridor and shows the calculated average mutual impedance and admittance between the circuits.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then the average mutual impedance (ZmAvg-R and ZmAvg-X) values are in ohms and the average mutual admittance (YmAvg-G and YmAvg-B) values are in micro-Siemens. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section  Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

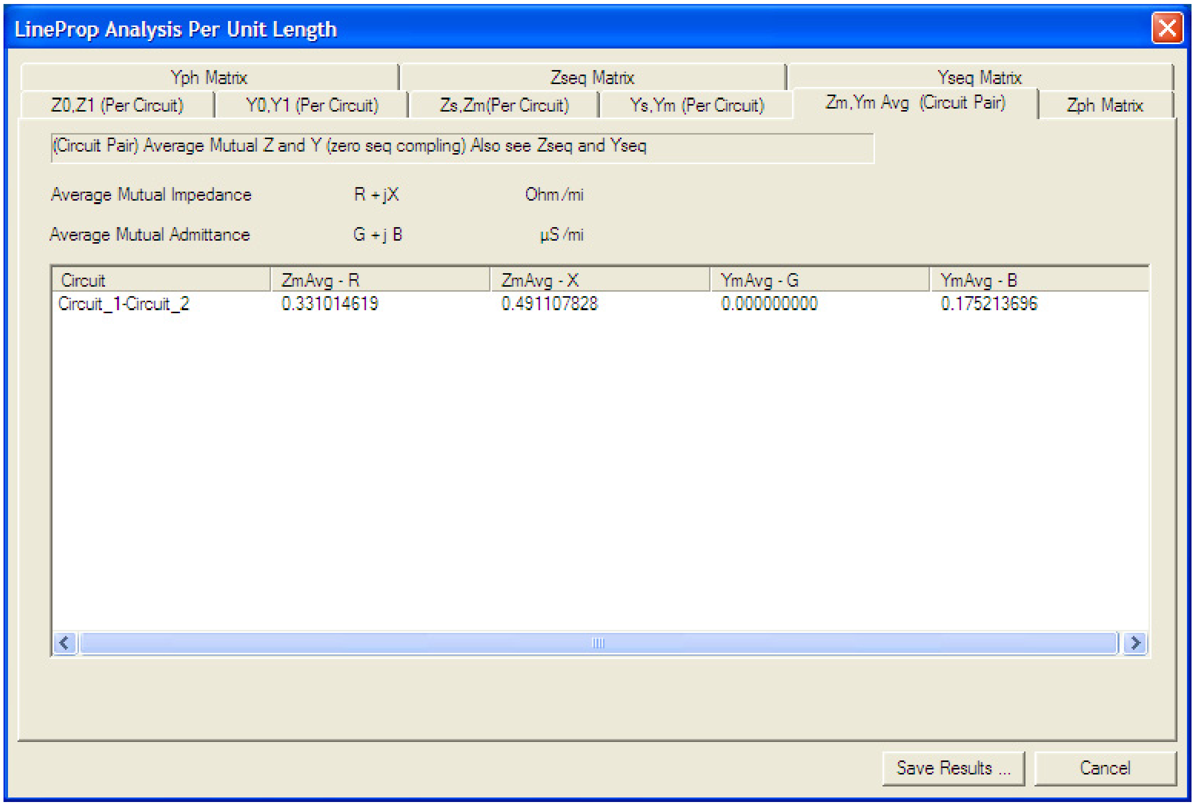


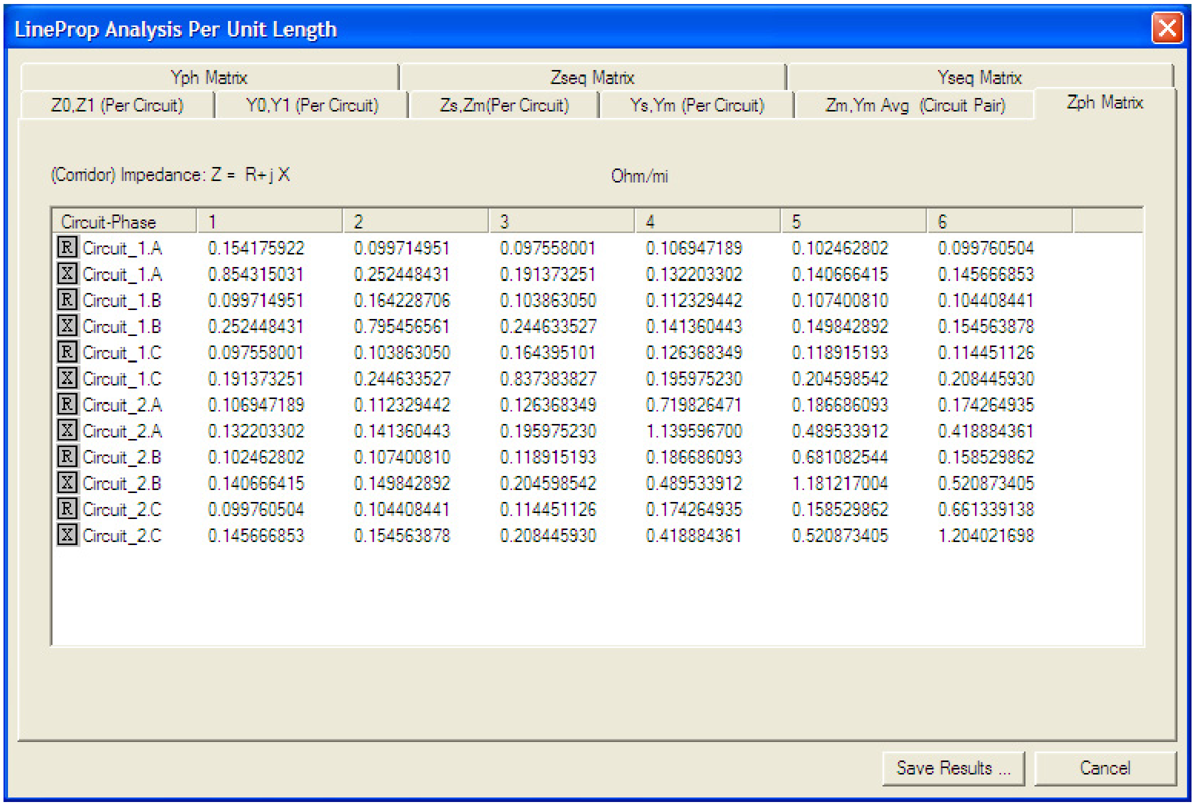

**Figure 1-34. Sample Average Mutual Impedance and Admittance Report**

- **Impedance for the Corridor** ("Zph Matrix" Tab). This report shows the impedance matrix for the corridor. The numbers listed across the top of the report correspond to the circuit phases. Thus, 1 corresponds to Circuit_1.A, 2 corresponds to Circuit_1.B, etc. The off-diagonal terms are for the coupling of the phases.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then impedance values are shown in ohms. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.




| | Circuit-Phase | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| R | Circuit_1.A | 0.154175922 | 0.099714951 | 0.097558001 | 0.106947189 | 0.102462802 | 0.099760504 |
| X | Circuit_1.A | 0.854315031 | 0.252448431 | 0.191373251 | 0.132203302 | 0.140666415 | 0.145666853 |
| R | Circuit_1.B | 0.099714951 | 0.164228706 | 0.103863050 | 0.112329442 | 0.107400810 | 0.104408441 |
| X | Circuit_1.B | 0.252448431 | 0.795456561 | 0.244633527 | 0.141360443 | 0.149842892 | 0.154563878 |
| R | Circuit_1.C | 0.097558001 | 0.103863050 | 0.164395101 | 0.126368349 | 0.118915193 | 0.114451126 |
| X | Circuit_1.C | 0.191373251 | 0.244633527 | 0.837383827 | 0.195975230 | 0.204598542 | 0.208445930 |
| R | Circuit_2.A | 0.106947189 | 0.112329442 | 0.126368349 | 0.719826471 | 0.186686093 | 0.174264935 |
| X | Circuit_2.A | 0.132203302 | 0.141360443 | 0.195975230 | 1.139596700 | 0.489533912 | 0.418884361 |
| R | Circuit_2.B | 0.102462802 | 0.107400810 | 0.118915193 | 0.186686093 | 0.681082544 | 0.158529862 |
| X | Circuit_2.B | 0.140666415 | 0.149842892 | 0.204598542 | 0.489533912 | 1.181217004 | 0.520873405 |
| R | Circuit_2.C | 0.099760504 | 0.104408441 | 0.114451126 | 0.174264935 | 0.158529862 | 0.661339138 |
| X | Circuit_2.C | 0.145666853 | 0.154563878 | 0.208445930 | 0.418884361 | 0.520873405 | 1.204021698 |

**Figure 1-35. Sample Corridor Phase Impedance Report**

- **Admittance for the Corridor** ("Yph Matrix" Tab). This report shows the admittance matrix. The numbers listed across the top of the report correspond to the circuit phase. Thus, 1 corresponds to Circuit_1 Phase A, 2 corresponds to Circuit_1 Phase B, etc.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then admittance values are shown in micro-Siemens. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

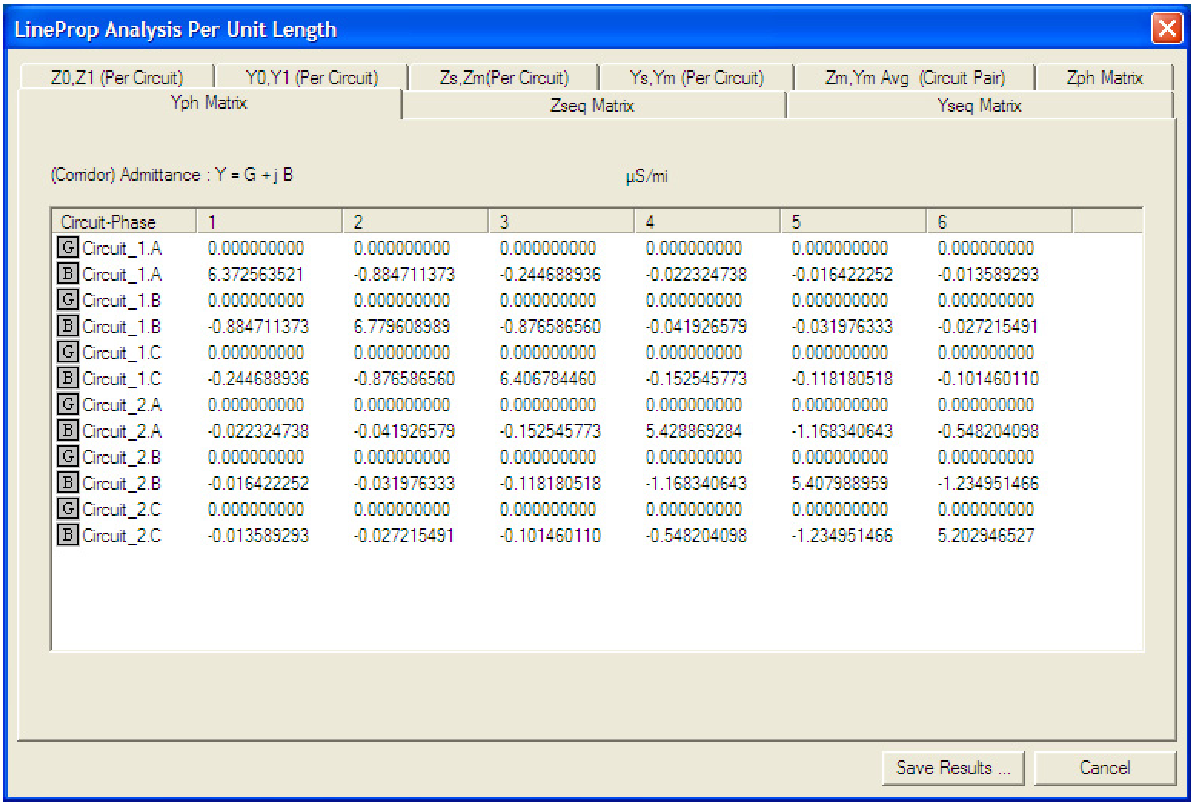



**Figure 1-36. Sample Corridor Phase Admittance Report**

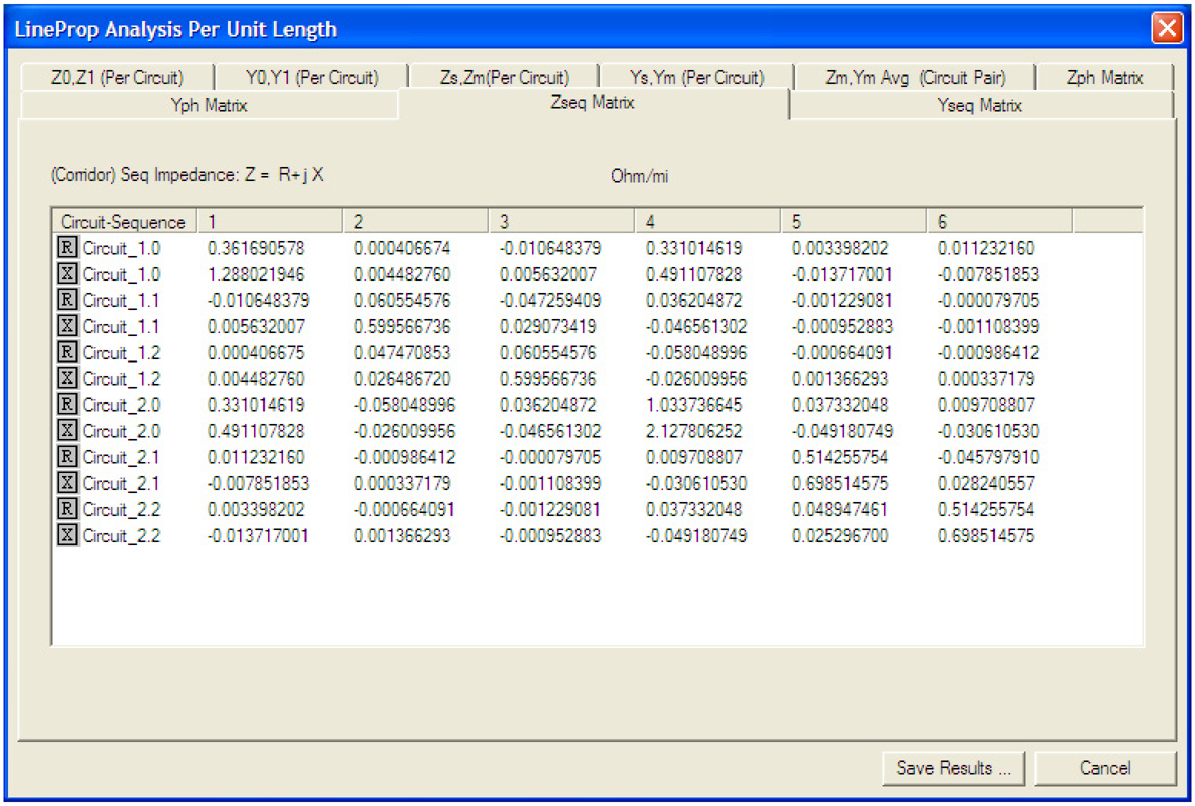
- **Sequence Impedance for the Corridor** ("Zseq Matrix" Tab). This report shows the sequence information for the full impedance matrix. The numbers listed across the top of the report correspond to the circuit sequence.

If the corridor contains only a single three phase line, then the sequence matrix would be 3x3. The diagonal terms are: $Z_0$, the zero sequence impedance; $Z_1$, the positive sequence impedance; and $Z_2$, the negative sequence impedance. The off-diagonal terms show the coupling between the sequences. For a perfectly transposed line the off diagonal terms would be zero (the impedance matrix would be symmetric). Many power flow computer programs consider transmission and distribution lines to be completely transposed, so the off diagonal terms are not used.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then impedance values are shown in ohms. If pu output is selected, then output is in pu based on circuit voltage and base power.

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.



LineProp Analysis Per Unit Length

Z0,Z1 (Per Circuit) | Y0,Y1 (Per Circuit) | Zs,Zm(Per Circuit) | Ys,Ym (Per Circuit) | Zm,Ym Avg (Circuit Pair) | Zph Matrix | Yph Matrix | Zseq Matrix | Yseq Matrix

(Corridor) Seq Impedance: Z = R+j X    Ohm/mi

| Circuit-Sequence | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| R Circuit_1.0 | 0.361690578 | 0.000406674 | -0.010648379 | 0.331014619 | 0.003398202 | 0.011232160 |
| X Circuit_1.0 | 1.288021946 | 0.004482760 | 0.005632007 | 0.491107828 | -0.013717001 | -0.007851853 |
| R Circuit_1.1 | -0.010648379 | 0.060554576 | -0.047259409 | 0.036204872 | -0.001229081 | -0.000079705 |
| X Circuit_1.1 | 0.005632007 | 0.599566736 | 0.029073419 | -0.046561302 | -0.000952883 | -0.001108399 |
| R Circuit_1.2 | 0.000406675 | 0.047470853 | 0.060554576 | -0.058048996 | -0.000664091 | -0.000986412 |
| X Circuit_1.2 | 0.004482760 | 0.026486720 | 0.599566736 | -0.026009956 | 0.001366293 | 0.000337179 |
| R Circuit_2.0 | 0.331014619 | -0.058048996 | 0.036204872 | 1.033736645 | 0.037332048 | 0.009708807 |
| X Circuit_2.0 | 0.491107828 | -0.026009956 | -0.046561302 | 2.127806252 | -0.049180749 | -0.030610530 |
| R Circuit_2.1 | 0.011232160 | -0.000986412 | -0.000079705 | 0.009708807 | 0.514255754 | -0.045797910 |
| X Circuit_2.1 | -0.007851853 | 0.000337179 | -0.001108399 | -0.030610530 | 0.698514575 | 0.028240557 |
| R Circuit_2.2 | 0.003398202 | -0.000664091 | -0.001229081 | 0.037332048 | 0.048947461 | 0.514255754 |
| X Circuit_2.2 | -0.013717001 | 0.001366293 | -0.000952883 | -0.049180749 | 0.025296700 | 0.698514575 |

Save Results ... | Cancel

**Figure 1-37. Sample Corridor Sequence Impedance Report**

If the corridor has two 3-phase circuits (for example "Circuit_1" and "Circuit_2"), then the sequence matrices would be 6x6, as seen in Figure 1-37. The upper left 3x3 part of the matrix would be for Circuit_1 and the lower right for Circuit_2. The upper right and lower left 3x3 sections show the intercircuit sequence coupling. For example, the term $Zseq_{1,4}$ (1st row, 4th column), shows how a zero sequence current in Circuit_1 would induce zero sequence voltage in Circuit_2. This value is used in some computer programs. For example, PSS®E considers the zero sequence coupling between parallel circuits. In LineProp, the zero sequence coupling is also displayed in the "Zm,Ym Avg (Circuit Pair)" tab. In general, as you will notice, for two 3-phase circuits, the sequence matrices are not symmetric.

What if the circuits are not three phase? LineProp allows phase labels of A, B, C, D, E and F, so it can calculate parameters for circuits from one to six phases. Symmetrical components, developed by C.L. Fortescue in 1918, are actually defined for a circuit of any number of phases. A good reference is "Analysis of Faulted Power Systems" by Paul M. Anderson. His discussion begins on page 19 of the 1978 printing of the book. As it turns out, a single phase circuit has only one component, while a six phase circuit has six components. LineProp uses this general definition of symmetrical components. If you build a four phase circuit, the Zseq matrix will be 4x4.

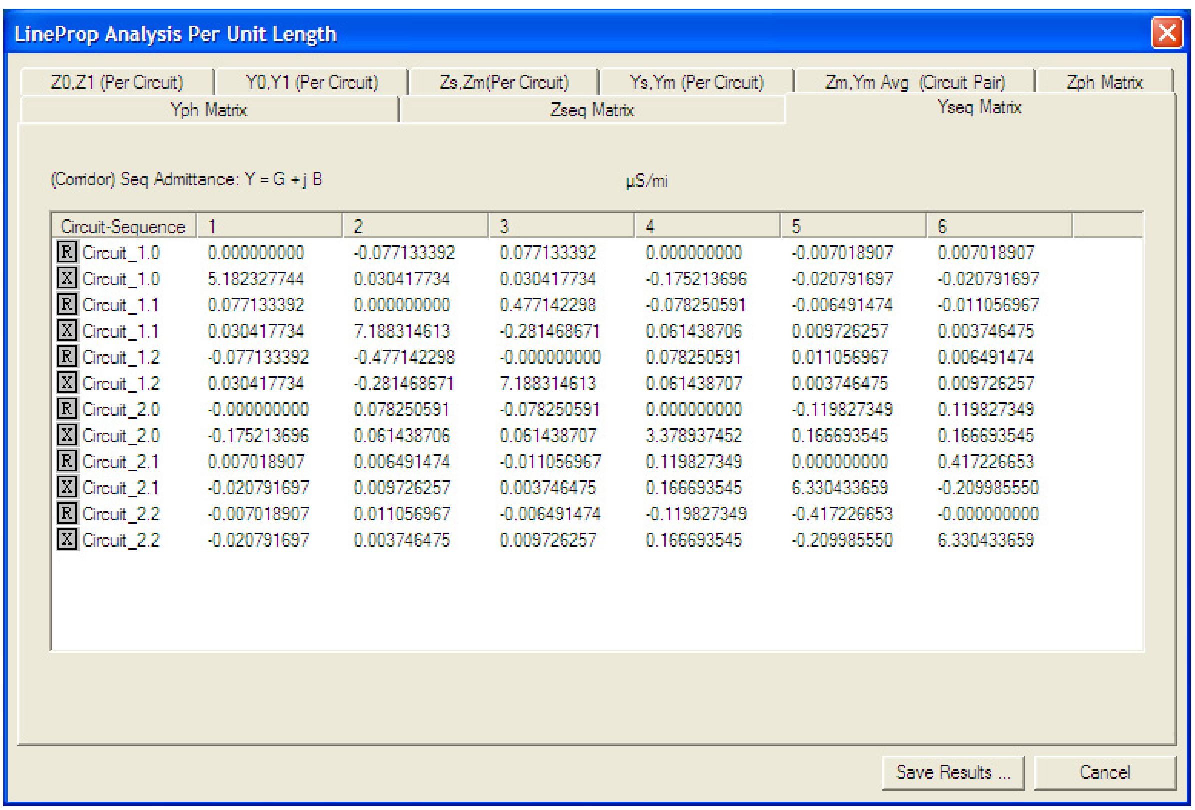
In actual power systems there are many one, two and three phase circuits, but not many with four or five. However, six phase circuits have been proposed and tested. They have the ability to transmit a lot of power in a small space. They are also easy to construct; all you need are a pair of transformers with 30 degree phase shifts. Six phase circuits have the interesting property that the line-to-line voltage is the same as the line-to-ground value. In LineProp, if the corridor has a three phase circuit and a six phase circuit, then the sequence matrices will show the coupling between any of the three components of the three phase circuits and the six components of the six phase circuit. The matrix size will be 9x9.

- **Sequence Admittance for the Corridor** ("Yseq Matrix" Tab). This report shows the sequence information for the full admittance matrix. The numbers listed across the top of the report correspond to the circuit sequence.

If the corridor contains only a single three phase line, then the sequence matrix would be 3x3. The diagonal terms are: $Y_0$, the zero sequence admittance; $Y_1$, the positive sequence admittance; and $Y_2$, the negative sequence admittance. The off-diagonal terms show the coupling between the sequences. For a perfectly transposed line the off diagonal terms would be zero (the admittance matrix would be symmetric). Many power flow computer programs consider transmission and distribution lines to be completely transposed, so the off diagonal terms are not used.

If the corridor has two three phase circuits (for example "Circuit_1" and "Circuit_2"), then the sequence matrices would be 6x6, as seen in Figure 1-38. The upper left 3x3 part of the matrix would be for Circuit_1 and the lower right for Circuit_2. The upper right and lower left 3x3 sections show the intercircuit sequence coupling. In LineProp, the zero sequence coupling is also displayed in the "Zm,Ym Avg (Circuit Pair)" tab.

The units used depend on the options set by the user on the Corridor tab of the LineProp Options window (***Options>Setup...***). If physical units are selected, then admittance is in micro-Siemens. If pu output is selected, then output is in pu based on circuit voltage and base power.




| Circuit-Sequence | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| R Circuit_1.0 | 0.000000000 | -0.077133392 | 0.077133392 | 0.000000000 | -0.007018907 | 0.007018907 |
| X Circuit_1.0 | 5.182327744 | 0.030417734 | 0.030417734 | -0.175213696 | -0.020791697 | -0.020791697 |
| R Circuit_1.1 | 0.077133392 | 0.000000000 | 0.477142298 | -0.078250591 | -0.006491474 | -0.011056967 |
| X Circuit_1.1 | 0.030417734 | 7.188314613 | -0.281468671 | 0.061438706 | 0.009726257 | 0.003746475 |
| R Circuit_1.2 | -0.077133392 | -0.477142298 | -0.000000000 | 0.078250591 | 0.011056967 | 0.006491474 |
| X Circuit_1.2 | 0.030417734 | -0.281468671 | 7.188314613 | 0.061438707 | 0.003746475 | 0.009726257 |
| R Circuit_2.0 | -0.000000000 | 0.078250591 | -0.078250591 | 0.000000000 | -0.119827349 | 0.119827349 |
| X Circuit_2.0 | -0.175213696 | 0.061438706 | 0.061438707 | 3.378937452 | 0.166693545 | 0.166693545 |
| R Circuit_2.1 | 0.007018907 | 0.006491474 | -0.011056967 | 0.119827349 | 0.000000000 | 0.417226653 |
| X Circuit_2.1 | -0.020791697 | 0.009726257 | 0.003746475 | 0.166693545 | 6.330433659 | -0.209985550 |
| R Circuit_2.2 | -0.007018907 | 0.011056967 | -0.006491474 | -0.119827349 | -0.417226653 | -0.000000000 |
| X Circuit_2.2 | -0.020791697 | 0.003746475 | 0.009726257 | 0.166693545 | -0.209985550 | 6.330433659 |

**Figure 1-38. Sample Corridor Sequence Admittance Report**

Output is per unit length (1 mi or 1 km) if **Use Length** is not selected on the Corridor tab under ***Options>Setup...***. If **Use Length** has been selected, the value is for the specified corridor Length.

The **Save Results** button allows you to save the results in a spreadsheet format (see Section  Saving Output to a File). A click on the **Cancel** button returns you to the main LineProp window.

## Saving Output to a File

The results of the analysis may be saved to a spreadsheet. To perform the save:

1. Click on the ***Save Results*** button at the bottom of the Analysis Window.
2. The window illustrated in Figure 1-39 appears on the screen.
3. Select the directory and filename where the data are to be stored.
4. Click on the ***Save*** button to save the data are return to the output window.

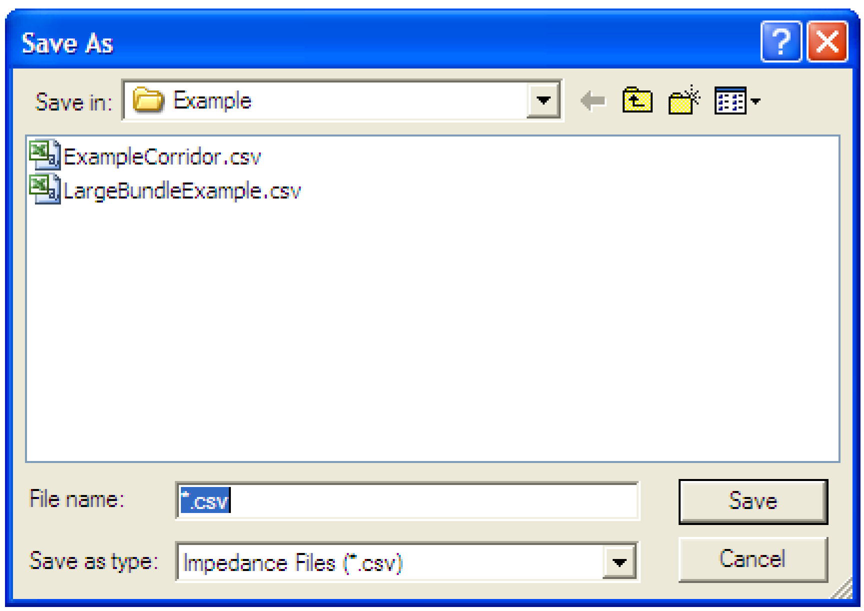



**Figure 1-39.  Save Results Dialog**

SIEMENS

# Chapter 2

# Conductor Database

| Column Heading | Description |
|---|---|
| NAME<br>!'--<br>!'-- | Conductor Name. |
| TYPE<br>--<br>-- | Conductor Type. |
| R_DC<br>--<br>(ohm/mi) | dc resistance in ohm/mi at 25$^{O}$ C. |
| R_DC<br>--<br>(ohm/km) | dc resistance in ohm/km at 25$^{O}$ C. |
| R_AC60<br>60 Hz<br>(ohm/mi) | ac resistance at 60 Hz in ohm/mi at 25$^{O}$ C. |
| R_AC60<br>60 Hz<br>(ohm/km) | ac resistance at 60 Hz in ohm/km at 25$^{O}$ C. |
| R_AC50<br>50 Hz<br>(ohm/mi) | ac resistance at 50 Hz in ohm/mi at 25$^{O}$ C. |
| R_AC50<br>50 Hz<br>(ohm/km) | ac resistance at 50 Hz in ohm/km at 25$^{O}$ C. |
| XL_60<br>60 Hz<br>(ohm/mi) | Inductive reactance at 1-ft spacing at 60 Hz in ohm/mi. |
| XL_60<br>60 Hz<br>(ohm/km) | Inductive reactance at 1-ft spacing at 60 Hz in ohm/km. |
| XL_50<br>50 Hz<br>(ohm/mi) | Inductive reactance at 1-ft spacing at 50 Hz in ohm/mi. |

| Column Heading | Description |
|---|---|
| XL_50<br>50 Hz<br>(ohm/km) | Inductive reactance at 1-ft spacing at 50 Hz in ohm/km. |
| XC_60<br>60 Hz<br>(mohm-mi) | Capacitive reactance at 1-ft spacing at 60 Hz in mohm-mi. |
| XC_60<br>60 Hz<br>(mohm-km) | Capacitive reactance at 1-ft spacing at 60 Hz in mohm-km. |
| XC_50<br>50 Hz<br>(mohm-mi) | Capacitive reactance at 1-ft spacing at 50 Hz in mohm-mi. |
| XC_50<br>50 Hz<br>(mohm-km) | Capacitive reactance at 1-ft spacing at 50 Hz in mohm-km. |
| AREA<br>Aluminum<br>(kcmil) | Aluminum cross-sectional area in thousands of circular mils. |
| AREA<br>Total<br>(sq-in.) | Total cross-sectional area of the conductor in $in.^2$ (includes core area). |
| AREA<br>Total<br>(sq-mm) | Total cross-sectional area of the conductor in $mm^2$ (includes core area). |
| OD<br>--<br>(in.) | Conductor diameter (in.). |
| OD<br>--<br>(mm) | Conductor diameter (mm). |
| STRAND<br>outer/core<br>-- | Stranding coefficient defined as the number of aluminum strands per number of core strands. |
| #STD-OL<br>outer<br>-- | Number of aluminum strands in outer layer. |
| STR-DIA<br>outer<br>(in.) | Diameter of outer stands (in.). |
| STR-DIA<br>outer<br>(mm) | Diameter of outer stands (mm). |
| STR-DIA<br>core<br>(in.) | Diameter of core stands (in.). |

| Column Heading | Description |
|---|---|
| STR-DIA<br>core<br>(mm) | Diameter of core stands (mm). |
| UTS<br>--<br>(lb) | Rated breaking strength of the conductor (lb). |
| UTS<br>--<br>(kg) | Rated breaking strength of the conductor (kg). |
| WGT<br>--<br>(lb/1000 ft) | Total conductor weight (lb/1000 ft). |
| WGT<br>--<br>(kg/km) | Total conductor weight (kg/km). |
| Amps<br>--<br>(A) | Ampacity based on 40$^{o}$C conductor temperature rise over a 40$^{o}$C ambient temperature with a 2ft/sec crosswind, 0.5 emissivity and no sun. |