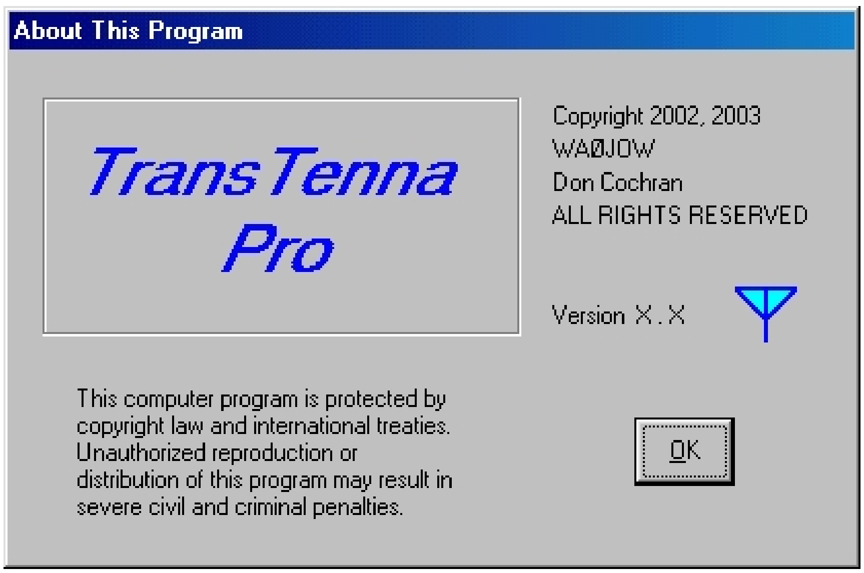
Impedance Transformation
with
Transmission Lines



Software Installation
and
Operation Manual

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Manual Revision 1

TransTenna Pro

Table of Contents

1. Introduction

This manual provides instructions for the installation of the TransTenna Pro program, a description of the operation of the program and an explanation of the tools and other features provided.

TransTenna Pro is impedance transformation software for use with transmission lines. It may be used in conjunction with an impedance measuring instrument such as an SWR analyzer, RF bridge, network analyzer or vector voltmeter. The program performs impedance transformation calculations on a transmission line and this allows the operator to measure the impedance at one end of a transmission line and then calculate the impedance at the other end of the transmission line. It can transform the measured impedance in either direction, that is, from the antenna/load end of the transmission line to the receiver/transmitter end of the transmission line or vice versa.

The calculated results data is provided in both series and parallel formats and takes into account the transmission line characteristics including length, velocity factor, characteristic impedance and cable loss. Other data is also supplied and includes SWR, return loss, transmission line loss and transmission line length in lambda.

TransTenna Pro is not limited in use to any specific instrument and may be used with any type of equipment capable of providing the series equivalent resistance and reactance (R and X) measurement data. A calculator is also provided for use with instruments which give only Impedance and SWR measurement data and the program supports selected RF bridges and vector voltmeter input.

A cable data base is provided which allows the operator to retrieve data for a specific transmission line and automatically enter that data into the main worksheet. An additional feature provides automatic calculation of transmission line loss at the operating frequency. The data base can be edited to add, change or remove transmission line entries.

A series of specialized tools are provided to enhance the usefulness of the program and to make other calculations for the operator.

The program supports printing of the main worksheet to provide a permanent record of the data entry and calculated results. The Windows system printer is used and both graphics and textual printing are supported.

TransTenna Pro uses the general transmission line equations and its accuracy is limited only by the accuracy of the data entered by the operator. In effect, TransTenna Pro provides an easy to use alternative to the Smith Chart for transmission line analysis.

2. System Requirements

PC with a 486 processor or better.

Microsoft Windows 95 or latter operating system or
Microsoft Windows NT version 4.0 or latter operating system.

8 MB of RAM.

Hard disk space required: 3 MB.

CD ROM or 3.5 inch floppy disk, determined by supplied TransTenna Pro media.

VGA or higher resolution monitor.
640 by 480 pixels minimum resolution.

Mouse or compatible pointing device.

3. Program Installation

Installation of TransTenna Pro is performed using a setup wizard very similar to other Windows based programs. As newer operating systems are released, the exact installation details and terminology can vary slightly. The following details apply to Windows 95/98. Other operating systems are similar.

TransTenna Pro can be supplied on 3.5 inch floppy disks or a single CD ROM.

For 3.5 inch floppy disks:
Insert Disk 1 in the floppy disk drive.
Click on Start in the lower left of the screen.
Click on Run.
Type in A:\Setup.exe. (Where A is the floppy disk drive letter.)
Click OK
Follow the instructions in the setup wizard.

For CD ROM:

Insert the CD in the CD ROM drive.

If autorun is enabled, the setup wizard will start automatically.
Follow the instructions in the setup wizard.

If autorun is not enabled:
Click on Start in the lower left of the screen.
Click on Run.
Type in D:\Setup.exe. (Where D is the CD ROM drive letter.)
Click OK
Follow the instructions in the setup wizard.

The setup wizard will guide you through the installation. You may choose the directory where TransTenna Pro will be installed or let the setup wizard install it in the default directory.

4. Program Removal

Removal of TransTenna Pro is performed in a similar way to any Windows program. For Windows 95/98, click on Start in the lower left of the screen, click on Settings and then click on Control Panel. Select Add/Remove Programs by double clicking on the icon. This will display a panel listing the software installed on the computer. Scroll down if necessary and click on TransTenna Pro. Next click on the Add/Remove button and follow the instructions.

Other operating systems will be similar.

5. Program Operation

Launch the TransTenna Pro program as you would any other Windows program on your computer. An opening panel, Figure 1, will appear.

This panel is the start up and welcome screen and allows the operator to select which direction on the transmission line to make the impedance transformation, toward the generator or toward the load. Use the mouse to click on the desired button and this panel will close and the main worksheet will be presented ready for data entry.

You may also click on the Continue button and make the choice later from the main worksheet. The operator may also continue without making a choice or may exit the program.

The main worksheet also allows you to select the direction on the transmission line to make the impedance transformation at any time.

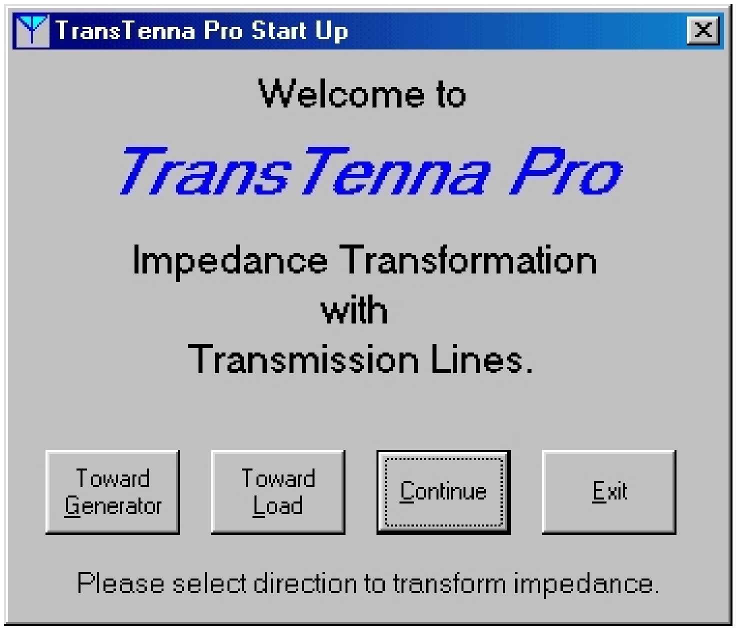

Figure 1
Opening Panel

The next panel is the main worksheet, Figure 2, and provides for data entry by the operator. This main worksheet is divided into three areas:

1. Impedance Data Entry
2. Transmission Line Data Entry
3. Rotate Toward Selection

The impedance entry format can be selected. The default is rectangular format, series impedance (R and X). The impedance may also be entered in other forms by clicking on the Bridge selection on the menu bar and selecting the desired data entry format or bridge to be used. After the data has been entered, click on the Enter or Use button to automatically calculate the equivalent series impedance (R and X). The results will automatically be entered into the main worksheet for the Real Part and Imaginary Part data entries.

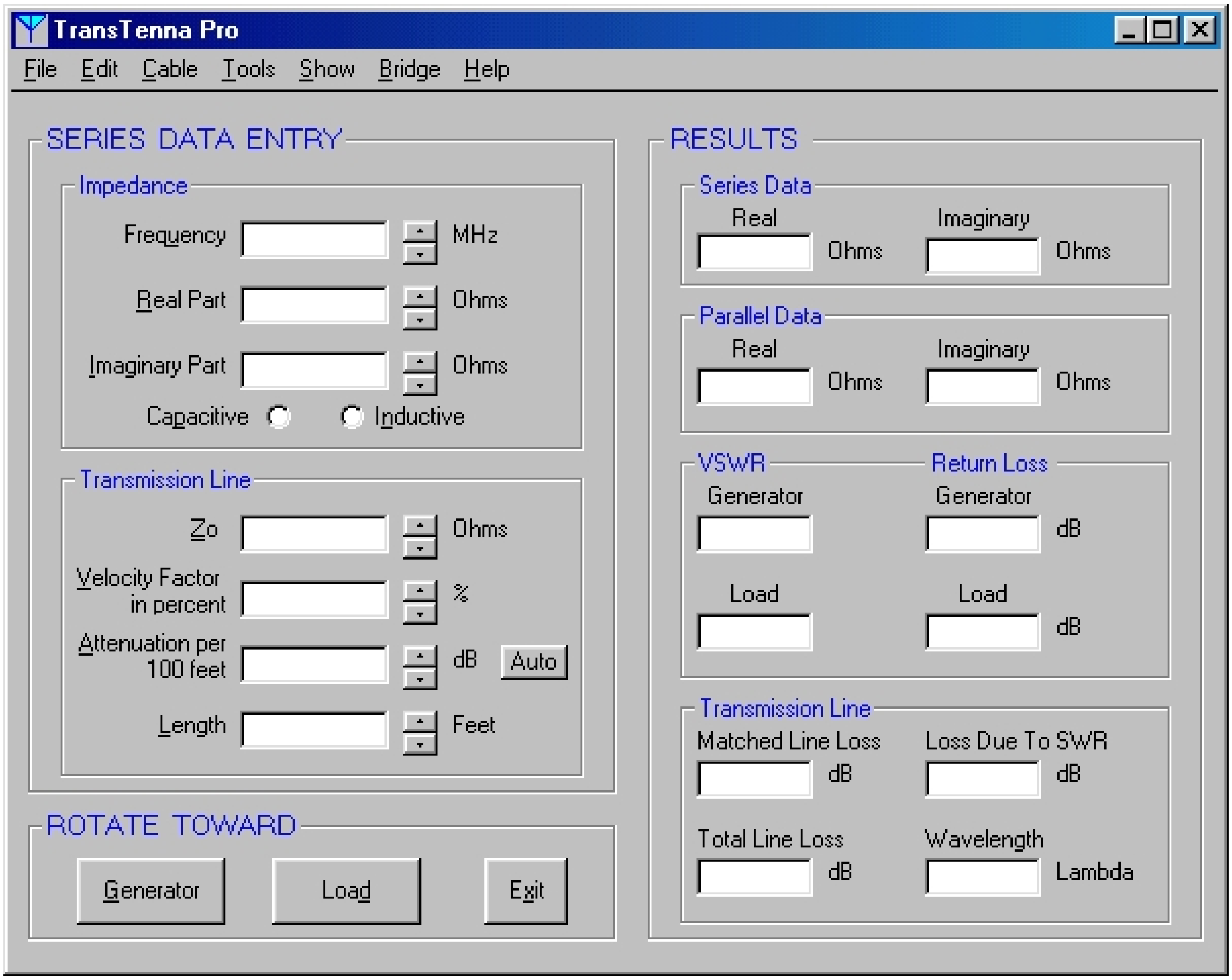

Figure 2
Main Work Sheet

The Impedance entry fields provide entry of the measured Frequency, Resistance and Reactance data.

The Transmission Line entry fields provide entry of the transmission line parameters. This includes Zo (Cable Impedance), Velocity Factor in percent, Attenuation per 100 feet (meters) and Length in feet (meters).

When the Generator or Load button is selected, the program calculates and fills in the Results fields. This displays the calculated Series Resistance (R), Series Reactance (X), Parallel Resistance (R), Parallel Reactance (X), VSWR and Return Loss for both the Generator and Load, Transmission Line Loss in dB and Transmission Line Length in lambda.

Use the TAB key, the Return key or the Mouse left button to move between data entry fields. You may also use the ALT key with the underscored letter key to move directly to a selected field.

Data entered into each field is error checked for a valid range of numbers for that specific field. This check is performed when the field is exited, that is when you move to the next field. If you exit a field without entering data, a default value will be entered automatically. The valid entry ranges for each field may be viewed by placing the mouse pointer over that entry field and waiting for a moment. The valid entry ranges for that field will then be displayed as a small pop up panel until you move the mouse pointer off the field.

When all entry fields have been completed, select the Generator or Load button. The program will then perform the mathematical calculations required to transform the entered data to the opposite end of the transmission line. It will display the results of the calculations in the Results section of the work sheet.

If a required data entry field was left blank when you selected the Generator or Load button, an error message will pop up in a small panel to alert you, see Figure 3. When you close that error message panel, the cursor will automatically be placed in the field that is missing an entry.

Figure 3
Data Entry Error

A menu bar appears at the top of the main worksheet. These items provide additional features and tools to enhance and expand the usefulness of the TransTenna Pro program. Each of the menu bar items is discussed in detail later in this manual.

A detailed discussion of each part of the main worksheet follows this section of the operators manual.

6. Impedance Entry Format

The default entry of impedance is in Rectangular Format and the Real and Imaginary parts of the impedance will be entered separately as series R and X. The R will be the real part of the impedance measured in ohms. The X will be the imaginary part of the impedance measured in ohms and may be either inductive or capacitive.

Other choices for impedance data entry may be made from the Bridge selection on the menu bar. These selections will pop up a special window for the selected data format or bridge that was selected. The required data can then be entered and the Enter button or Use Button will calculate the series R and X based upon the data entered and automatically enter the results into the main worksheet Real Part and Imaginary Part entry fields. The pop up panel will close automatically. You may also click on the Cancel button to close a pop up panel without making entries on the main worksheet. Refer to Section 15. Bridge Menu Selection for details of the other impedance entry formats and selected bridges that are supported.

7. Impedance Fields

Frequency. --- Enter the operating frequency in MHz. The range of accepted values is from 0.01 to 999.999 MHz. If no entry is made, a default value of 10 MHz is entered automatically when the cursor is moved to the next data entry field.

Real Part. -– This is the real part of the impedance. Enter the measured series resistance from the measuring instrument. The range of accepted values is from 0 to 999,999.999 ohms.

Imaginary Part. --- This is the imaginary part of the impedance. Enter the measured series reactance from the measuring instrument. The range of accepted values is from -999,999.999 to 999,999.999 ohms. Inductive reactance is represented by a positive number while capacitive reactance is represented by a negative number. If the entry is capacitive reactance use a minus sign preceding the number entered or simply click on the Capacitive Xc button and the minus sign will be entered automatically. If the value is inductive reactance do not include a plus sign as it is implied to be a positive value.

If you are unsure of the sign of the Imaginary Part value, i.e. capacitive or inductive, refer to a later section of this manual titled Determining the Sign of X for additional information.

Note that up and down scroll bars are provided at the right of each of the data entry fields. These may be used to change the values by clicking on them with the mouse pointer. Resolution may be changed from the Edit selection on the menu bar. Discussion of this feature is discussed in the Edit Menu Selections section of this manual.

8. Transmission Line Fields

Zo. --- This is the transmission line characteristic impedance. The range of accepted values is from 1 to 999.999 Ohms. If no entry is made, a default value of 50 ohms is entered automatically when the cursor is moved to the next data entry field.

Example: RG-8/U has a nominal characteristic impedance of 52 ohms.

Velocity Factor. --- Enter the transmission line velocity factor in percent. The range of accepted values is from 1 to 100 %. If no entry is made, a default value of 66 % is entered automatically when the cursor is moved to the next data entry field.

Example: RG-8/U has a nominal velocity factor of 66%.

Attenuation per 100 Feet. --- Enter the cable loss in decibels. The range of accepted values is from 0 to 99.999 dB. If no entry is made, a default value of 0 dB is entered automatically when the cursor is moved to the next data entry field. This value can be estimated with some reduction in accuracy of the antenna data calculations. If you are completely unsure of the cable loss, leave the field at the default value of 0.

This data field can also support entry in meters. Feet or meters selection is made from the Edit selection on the menu bar. Discussion of this feature is discussed in the Edit Menu Selections section of this manual.

Auto Button. --- This button will calculate the approximate cable attenuation per 100 feet if you have selected a coax cable from the Cable menu selection. It uses the Resistive Loss Constant, k1, and the Dielectric Loss Constant, k2, for the coax cable you have selected from the cable data file, CoaxList.txt, installed as part of the TransTenna Pro program. It makes the calculation using the frequency entered in the work sheet. The calculation provides an approximate value which is automatically entered into the Cable Loss per 100 feet entry of the work sheet.

This automatic attenuation calculation provides improved accuracy for the calculated Results data over leaving the entry at 0 dB. However, better accuracy may be achieved by using loss data supplied by the coax manufacturer. For the best accuracy, an actual measurement of cable loss per 100 feet(meters) at the operating frequency should be made.

Length. --- Enter the length of the transmission line. The range of accepted values is from 0 to 999,999.999. If no entry is made, a default value of 0 is entered automatically. This entry is critical to getting accurate data calculated at the antenna. When ever possible make as accurate measurement as practical. The higher the operating frequency, the more critical this factor becomes due to the shorter wavelengths. You can experiment with this entry by changing the cable length entry field and observing the effects on the antenna resistance and reactance data.

Note that up and down scroll bars are provided at the right of each of the data entry fields. These may be used to change the values by clicking on them with the mouse pointer. Resolution may be changed from the Edit selection on the menu bar. Discussion of this feature is discussed in the Edit Menu Selections section of this manual.

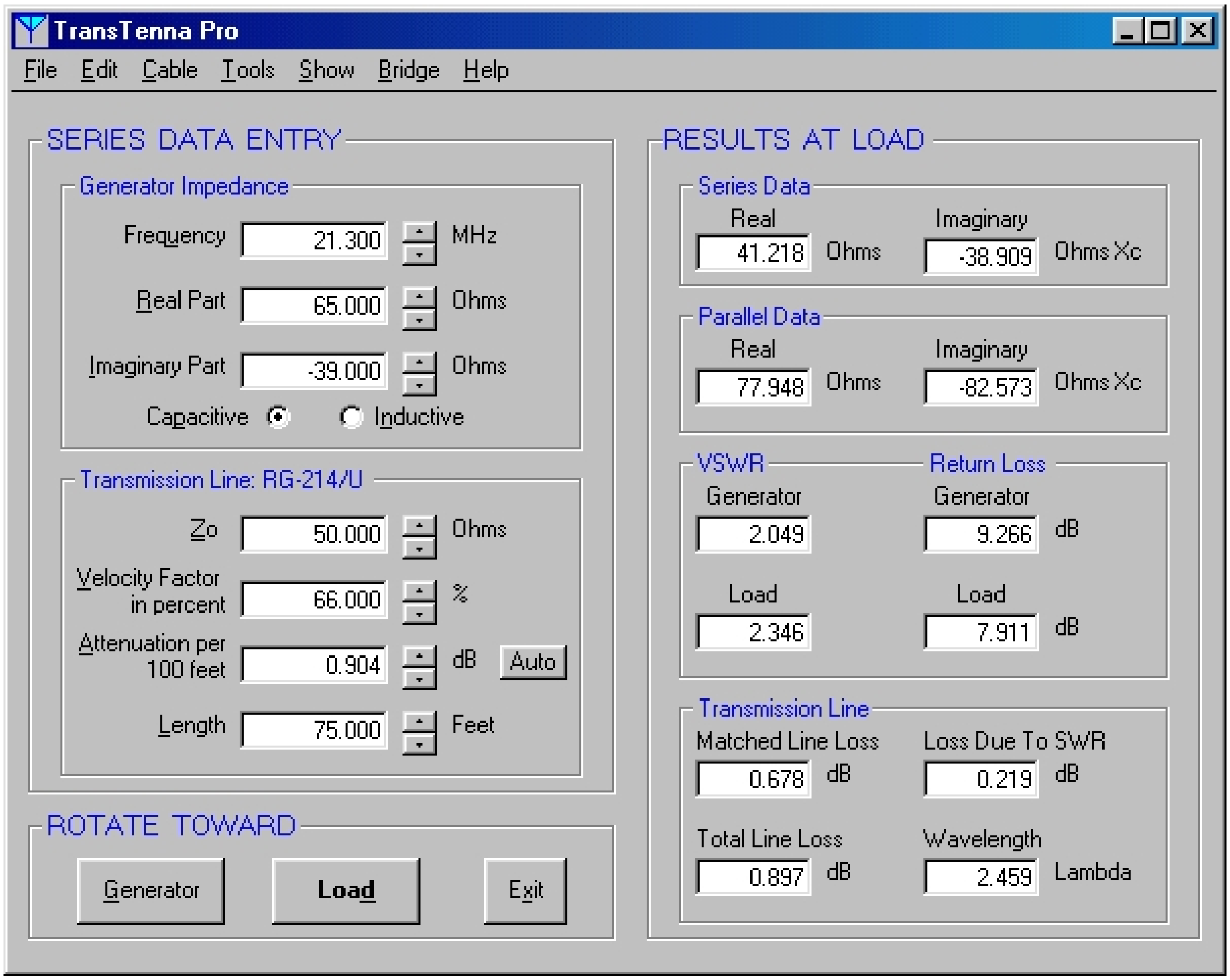

Figure 4
Completed Work Sheet

9. Results Fields

Series Data Real. --- Displays the calculated series resistance in ohms at the end of the transmission line opposite the impedance measurement end.

Series Data Imaginary. --- Displays the calculated series reactance in ohms at the end of the transmission line opposite the impedance measurement end. A positive value indicates inductive reactance, Xl, and a negative value indicates capacitive reactance, Xc.

Parallel Data Real. --- Displays the calculated parallel resistance in ohms at the end of the transmission line opposite the impedance measurement end.

Parallel Data Imaginary. --- Displays the calculated parallel reactance in ohms at the end of the transmission line opposite the impedance measurement end. A positive value indicates inductive reactance, Xl, and a negative value indicates capacitive reactance, Xc.

VSWR at Generator. --- Displays the calculated VSWR at the generator end of the transmission line. This calculated value is based on the measurement data you have entered on the work sheet.

VSWR at Load. --- Displays the calculated VSWR at the load end of the transmission line. This calculated value is based on the measurement data you have entered on the work sheet.

Return Loss at Generator. --- Displays the calculated return loss at the generator end of the transmission line in dB. This calculated value is based on the measurement data you have entered on the work sheet.

Return Loss at Load. --- Displays the calculated return loss at the load end of the transmission line. This calculated value is based on the measurement data you have entered on the work sheet.

Matched Line Loss. --- Displays the total cable loss in dB. This calculation is based on the length of the transmission line in feet(meters) and the cable loss in dB per 100 feet(meters). Matched Line loss is the total loss if the transmission line is terminated in its characteristic impedance.

Loss Due To SWR. --- Displays the loss caused by the SWR and is displayed in dB. The Loss Due To SWR takes into account the Matched Line Loss and the SWR presented to the transmission line by a mismatched load. It represents additional lost power as a result of transmission line loss when the SWR is not 1:1.

Total Line Loss. --- This is the sum of the Matched Line Loss and the Loss Due To SWR. It is displayed in dB.

Transmission Line Wavelength --- This is the length of the transmission line in lambda. One lambda is the length of one wavelength in the transmission line. It takes into account the velocity factor of the transmission line and the frequency.

10. File Menu Selections

Load. --- Loads a set of data entry values from a file on the computers hard disk drive. The file name is Default.txt and is located in the directory where TransTenna Pro was installed. This is a text file and can be edited by using Notepad or any similar text editor that does not embed formatting data in the file. This file is overwritten each time the Save selection is made. See discussion in the next paragraph.

Save. --- Saves the current set of data entry values to a file on the computers hard disk drive. The file name is Default.txt and is located in the directory where TransTenna Pro was installed. The file Default.txt is overwritten each time this selection is made. This file is a text file and can be edited by using Notepad or any similar text editor that does not embed formatting data in the file.

Print Graphic. --- Uses the current system printer to print a graphical copy of the screen. No provision is provided to select a printer. If a printer other than the current system printer is required, it must be selected prior to making this selection. This is typically done by selecting Printers from the Control Panel.

Print Text. --- Uses the current system printer to print the screen data in a text format. Use with dot matrix printers or with any printer when you want to conserve or toner compared to the Print Graphic selection.

Exit. --- Close the program and end this session of TransTenna Pro. The program can also be closed by clicking on or selecting the Exit button at the lower right of the opening panel used as the work sheet.

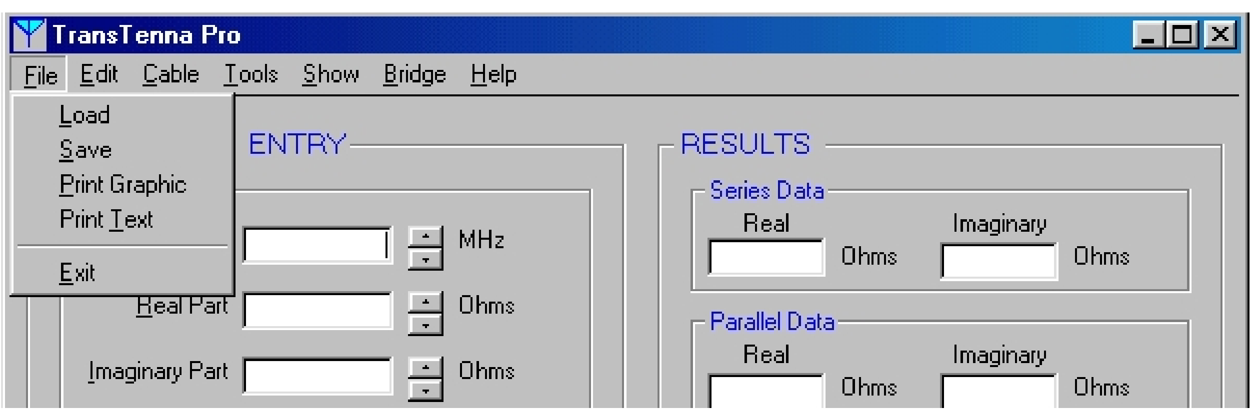

Figure 5
File Menu Selection

11. Edit Menu Selections

Clear Results. --- Clear all of the Results fields.

Clear All. --- Clear all fields; Impedance Entry, Transmission Line Entry and Results fields.

Set Scroll Bar Resolution. --- This allows you to set the scroll bar resolution for all scroll bars on the main worksheet. The default resolution is 0.100. Other choices are 1.000, 0.010 and 0.001.

Attenuation per 100 feet/meters. --- This sets the units of measure to either feet or meters for the Transmission Line Attenuation data entry field on the main worksheet. It defaults to feet at program start up.

Length feet/meters. --- This sets the units of measure to either feet or meters for the Transmission Line Length data entry field on the main worksheet. It defaults to feet at program start up.

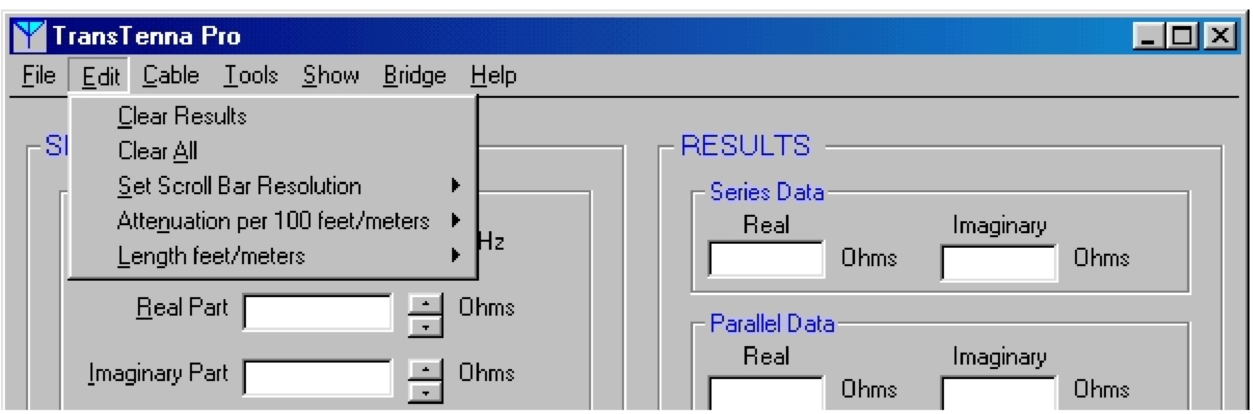

Figure 6
Edit Menu Selection

12. Cable Menu Selection

This selection opens a window and allows the operator to select a cable type from the list. By highlighting a cable from the list and clicking on the Select button, the Cable Impedance and Velocity Factor for the selected cable will be automatically entered into their respective fields of the main work sheet. The selection may also be made by double clicking on the desired selection of cable. The cable type selected will appear at the top of the Transmission Line entry section on the worksheet.

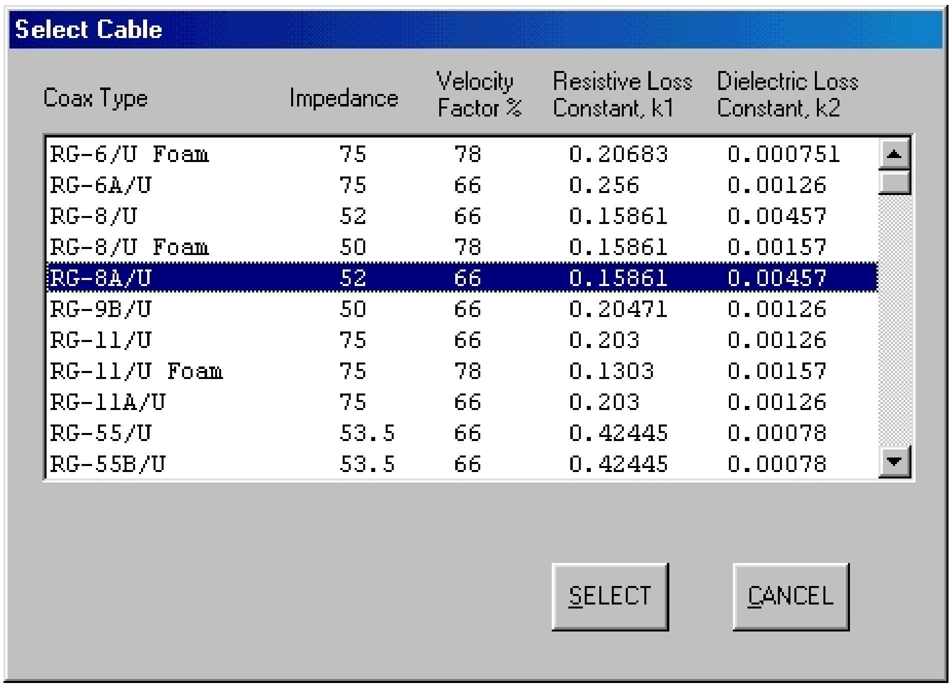

Figure 7
Cable Menu Selection

As shown in Figure 7, the Cable Menu Selection lists numerous popular coax types. For each Coax Type, the nominal Impedance, Velocity Factor %, Resistive Loss Constant, k1 and the Dielectric Loss Constant, k2 are listed. As discussed in the previously, Impedance (Zo) and Velocity Factor are used in the main worksheet. Resistive Loss Constant, k1 and the Dielectric Loss Constant, k2 are used to calculate the approximate transmission line attenuation per 100 feet(meters) for entry into the worksheet.

For further discussion of the Attenuation per 100 feet(meters) entry on the worksheet, refer to the Auto button discussion in section 8 of this manual.

The cable data is contained in a file called CoaxList.txt located in the directory where TransTenna Pro was installed. This file is a text file and can be edited to change, add or remove cable types by opening it with a text editor. A preferred editor is Notepad or Wordpad or any similar text editor that does not save embedded format information in the file. If you use a word processor, be sure to save the file as an ASCII DOS TEXT file. Do not save any format characters in the file.

It is recommended that you make a backup copy of the file before opening it.

The following instructions for editing this file also appear in the file itself.

```
; This file is the list of coax types to be displayed in the
; program when the "Cable" menu is selected on the main
; window of the program.
;
; This file can be edited using WordPad or a similar text
; editor. If you use a word processor, you must save the
; file as an ASCII text file (no embedded formatting
; characters).
;
; Each comment line must begin with a ";" (semicolon)
; character in the first character position on the line. The
; program will ignore lines beginning with a semicolon.
;
; You may add additional coax data to this file. The maximum
; number of entries is 300.
;
; Use a semicolon to separate each field. Each line
; must contain five fields.
;
; Field 1 is the coax type and is 19 characters max.
; Field 2 is the cable impedance and is 7 characters max.
; Field 3 is the velocity factor and is 7 characters max.
; Field 4 is the resistive loss constant, k1, and is 9 characters max.
;         Enter 0 if the resistive loss constant is unknown.
; Field 5 is the dielectric loss constant, k2, and is 8 characters max.
;         Enter 0 if the dielectric loss constant is unknown.
;
;
; Each entry must have 5 fields or the line will
;    not be displayed in the list.
;
```

RG-6/U Foam;75;78;0.20683;0.000751
RG-6A/U;75;66;0.256;0.00126
RG-8/U;52;66;0.15861;0.00457
RG-8/U Foam;50;78;0.15861;0.00157
RG-8A/U;52;66;0.15861;0.00457
RG-9B/U;50;66;0.20471;0.00126
RG-11/U;75;66;0.203;0.00126
RG-11/U Foam;75;78;0.1303;0.00157
RG-11A/U;75;66;0.203;0.00126
RG-55/U;53.5;66;0.42445;0.00078
RG-55B/U;53.5;66;0.42445;0.00078
RG-58/U;53.5;66;0.444;0.00126
Etc.

Note that each field on a line is separated with a semicolon.

13. Tools Menu Selection

Metric Conversion. --- This tool will allow you to easily convert measurements between meters and feet. Conversions can be made from feet to meters or from meters to feet by clicking on the appropriate button, Feet or Meters.

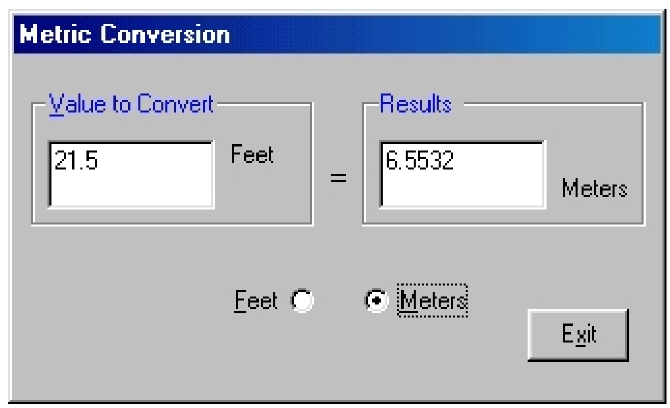

Figure 8
Metric Conversion

Wavelength Calculator. --- This tool will allow you to calculate the wavelength in both feet and meters for a frequency. It takes into account velocity factor and calculates 1, ½ and ¼ wavelengths.

For wavelength in a transmission line, use the velocity factor for that line. This tool makes determining the length of baluns and stubs much easier by doing the math for you and also allowing you to quickly analyze changes in length.

If calculating an antenna length, use a velocity factor of 100 %. This may result in an antenna that is slightly long (it is easier to shorten an antenna than it is to lengthen it). For better accuracy you may consult one of the many antenna books to get the value to use. One popular publication uses a value of 0.95 (95 %) for making a HF dipole antenna with wire. In this case the velocity factor would be 95 %.

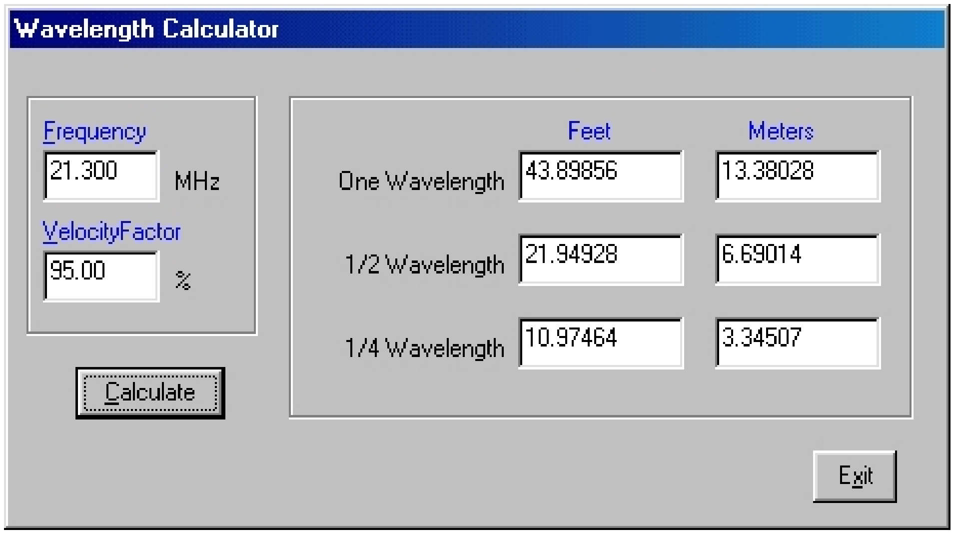

Figure 9
Wavelength Calculator

SWR to Return Loss. --- This tool will allow you to convert a SWR value into return loss in dB. Return loss is equal to the difference in dB between the forward power and the reflected power.

The percent of reflected power is also given.

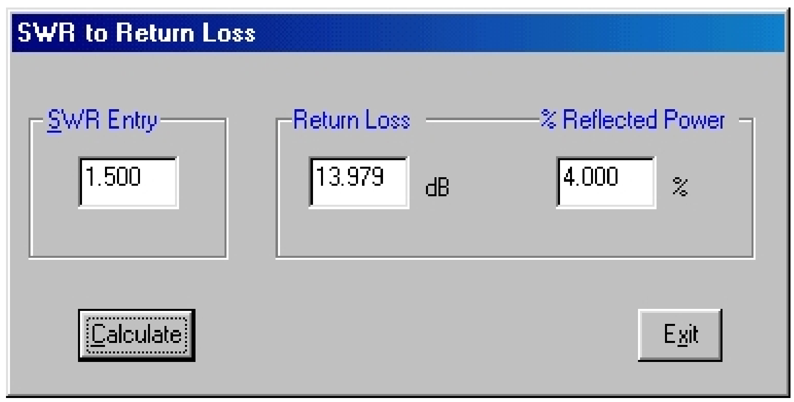

Figure 10
SWR to Return Loss

Return Loss to SWR. --- This tool will allow you to convert a return loss in dB to SWR. Return loss is equal to the difference in dB between the forward power and the reflected power.

The percent of reflected power is also given.

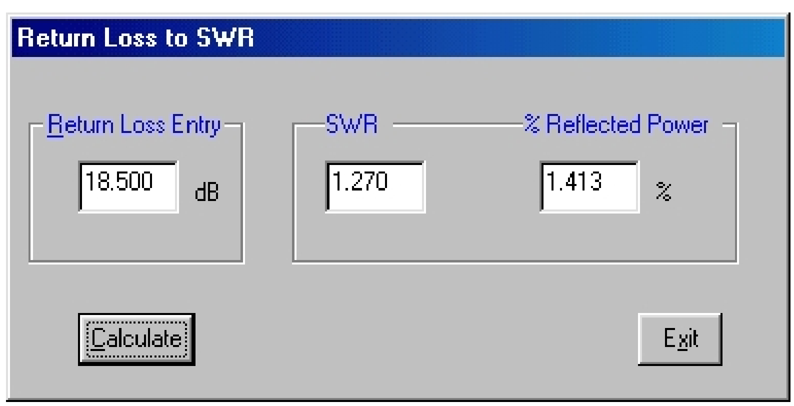

Figure 11
Return Loss to SWR

Power to SWR. --- This tool will allow you to convert measured forward and reflected power readings to SWR.

This tool is especially useful if you use a power meter which reads both forward and reflected power.

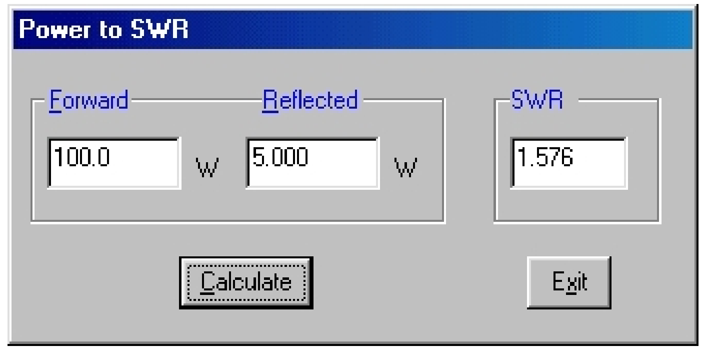

Figure 12
Power to SWR

Attenuation. --- This tool will allow you to calculate cable attenuation in dB when the power at the source and load ends of the transmission line is known.

Use this tool with a transmitter, wattmeter and dummy load to get accurate cable loss data at the precise frequency you need. It is also useful to evaluate a length of coax, if its history may be questionable, before you commit to using it.

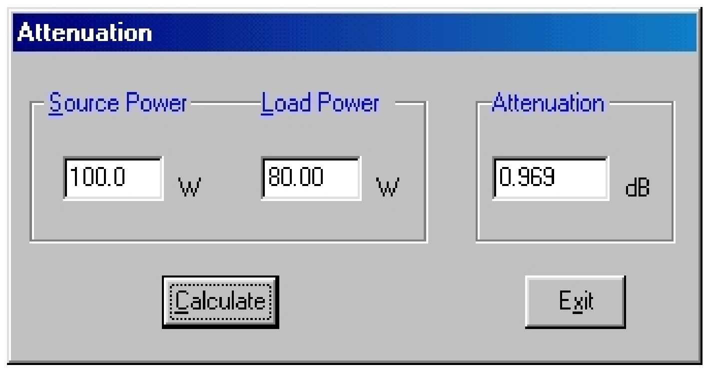

Figure 13
Attenuation

Calculate k1 and k2 -– This work sheet can be used to calculate the approximate values for Resistive Loss Constant k1 and Dielectric Loss Constant k2. These constants are used by the Auto calculation feature found on the main work sheet to calculate the approximate cable loss per 100 feet. The constants k1 and k2 are read from the cable data file, CoaxList.txt, installed as part of the TransTenna Pro program. This file is read when a cable is selected by using the Cable menu feature of the program as discussed in section 12, Cable Menu Selection, of this manual.

If you add a cable to the CoaxList.txt file, use this calculator to determine values for k1 and k2. Two sets of data must be entered. These are the loss in dB per 100 feet (meters) at two frequencies. The lower of two frequencies will be Frequency 1 and the higher of the two frequencies will be Frequency 2. Obtain this data from the cable manufacturers data for the cable you are adding or make actual cable loss measurements on the cable.

Note that using k1 and k2 to calculate the loss per 100 feet is subject to some accuracy limitations. These include accuracy of the manufactures data, age of the cable, deterioration of the cable, effects of connectors, accuracy of measurements, etc. Best accuracy for determining the cable loss is from actual measurements on the cable at the operating frequency.

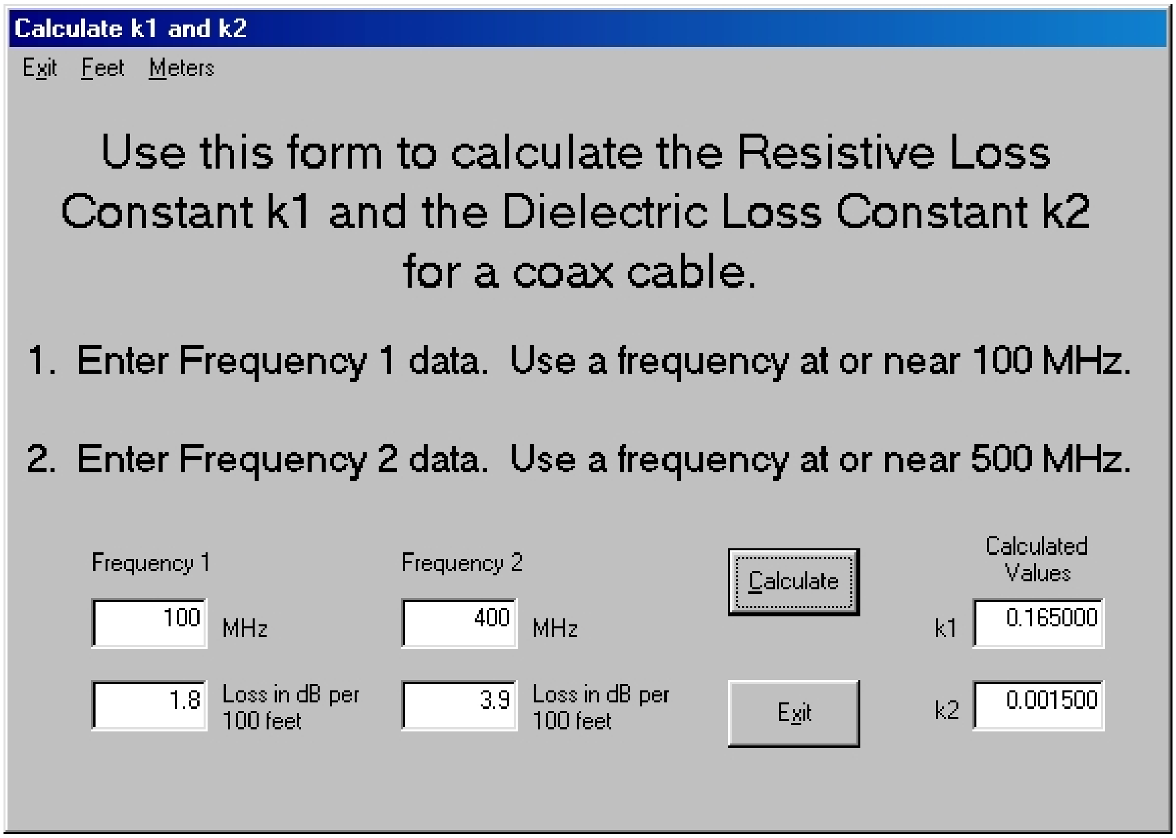

Figure 14
Calculate k1 and k2

14. Show Menu Selection

The following Show menu selections provide alternate display of data.

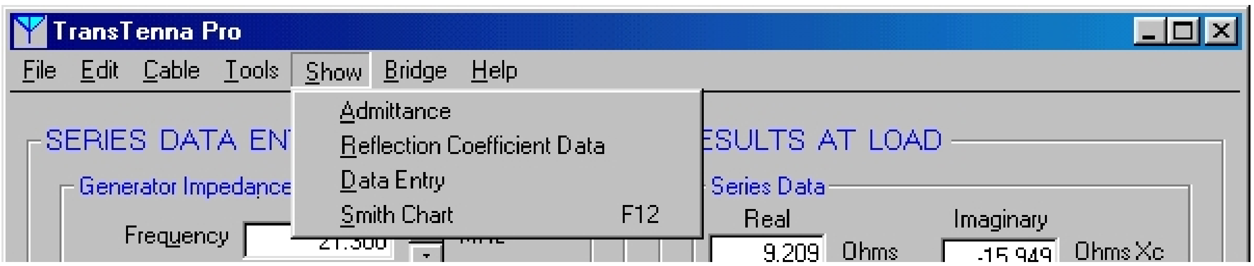

Figure 15
Show Menu Selection

Admittance --- See Figure 16. This panel shows the calculated admittance values of conductance and susceptance for both the generator and load. Values normalized to the transmission line Zo are also given. These values are calculated from data on the main work sheet.

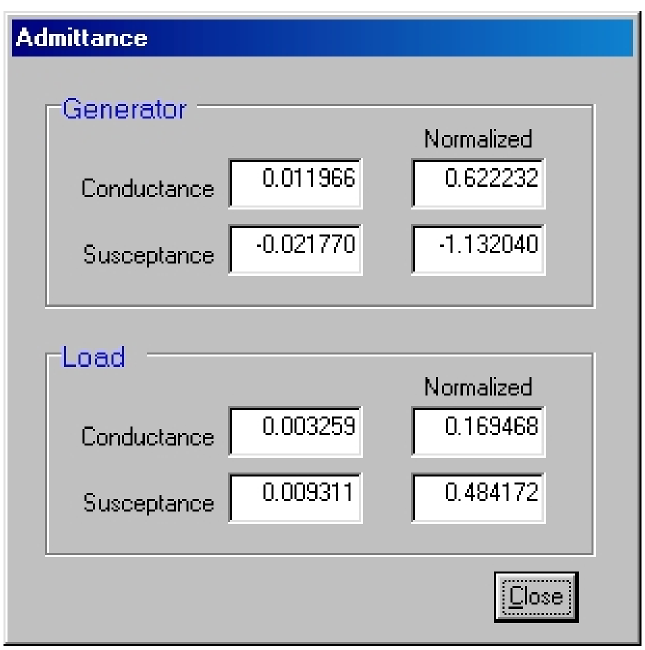

Figure 16
Admittance Data Display

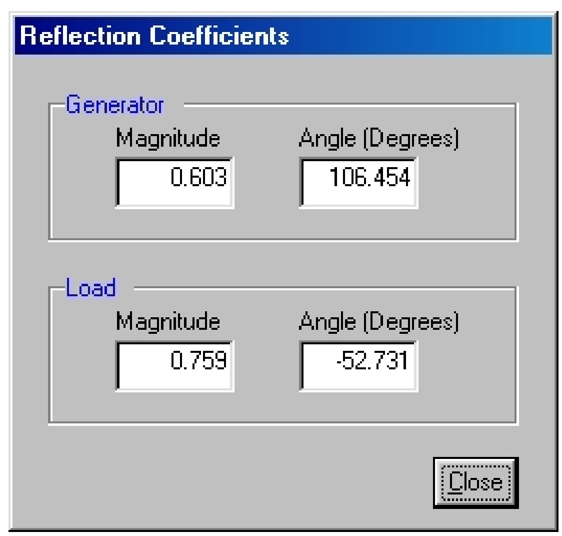

Figure 17
Reflection Coefficients

Reflection Coefficients--- See Figure 17. This panel shows the calculated reflection coefficients for both the generator and load. Magnitude and angle in degrees are displayed. These values are calculated from data on the main work sheet.

Data Entry--- See Figure 18. This panel shows the series and parallel values for the measurement impedance entry. These values are calculated from data on the main work sheet.

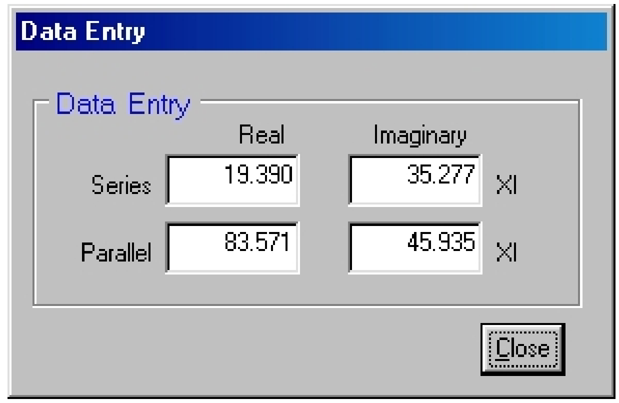

Figure 18
Data Entry

Smith Chart --- See Figure 19. This panel provides a graphical display of the generator impedance and load impedance on a Smith Chart. A shortcut key, F12, is provided for this worksheet.

SWR circles are displayed for both the generator and the load. This information is calculated from data on the main work sheet.

The Smith Chart may be printed to the Windows system printer by clicking on the Print button.

The Close button will close this panel and return to the Main Work Sheet.

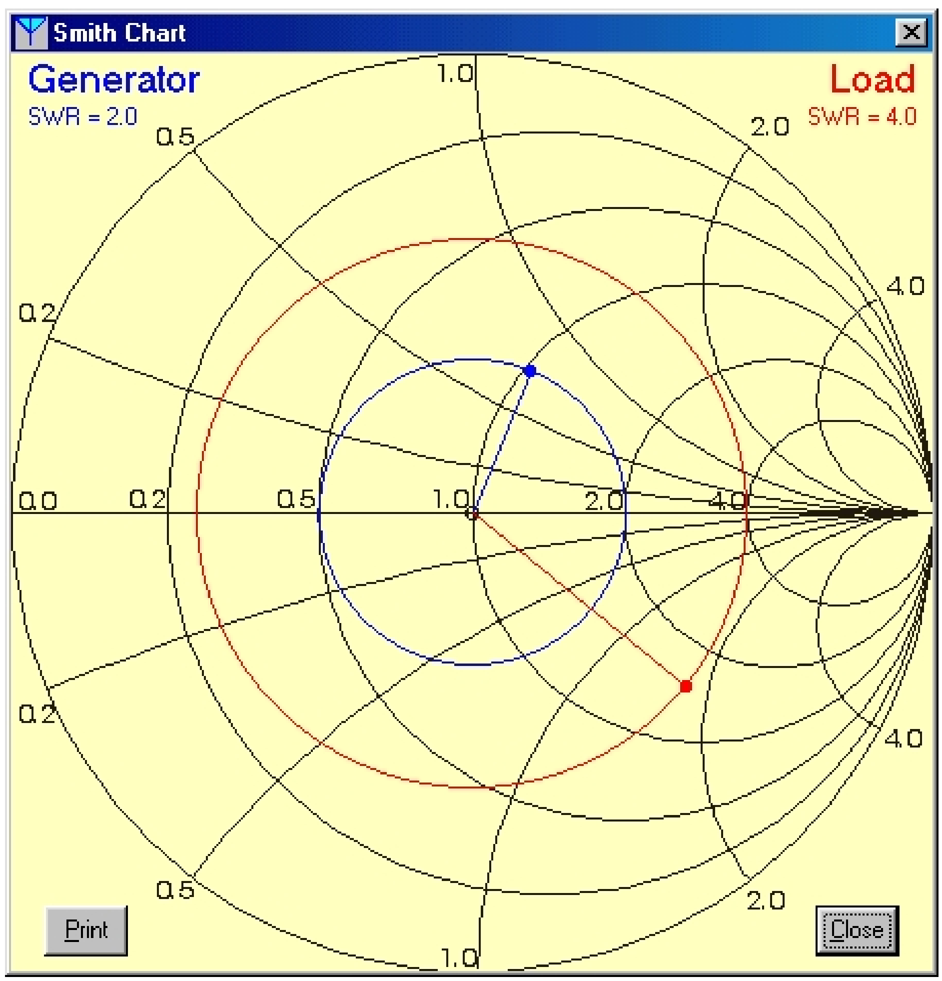

Figure 19
Smith Chart

15. Bridge Menu Selection

The following Bridge menu selections provide alternate data entry to accommodate various types of impedance measuring instruments. Each selection will open a pop up panel unique to that selection. A short cut key is provided for each selection.

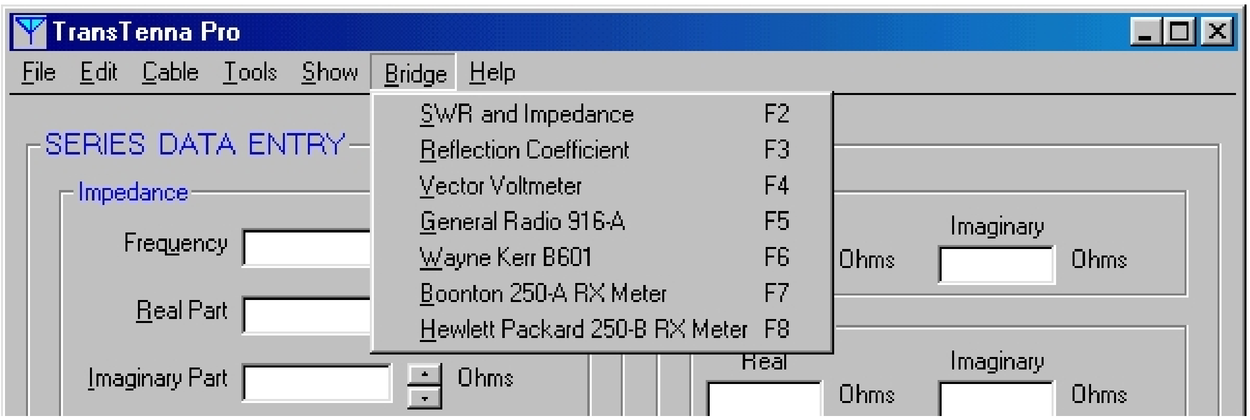

Figure 20
Bridge Menu Selection

SWR and Impedance Entry --- This work sheet provides a special calculator to determine series R and X values when the impedance and SWR are known. The shortcut key for this worksheet is F2.

Enter the Measured Impedance value and the SWR value into their respective data fields. Then click on the Calculate button to calculate the Series Resistance and Series Reactance which equates to the data entry values. By clicking on the Use button, the calculated Series Resistance and Series Reactance values will automatically be entered into the main work sheet.

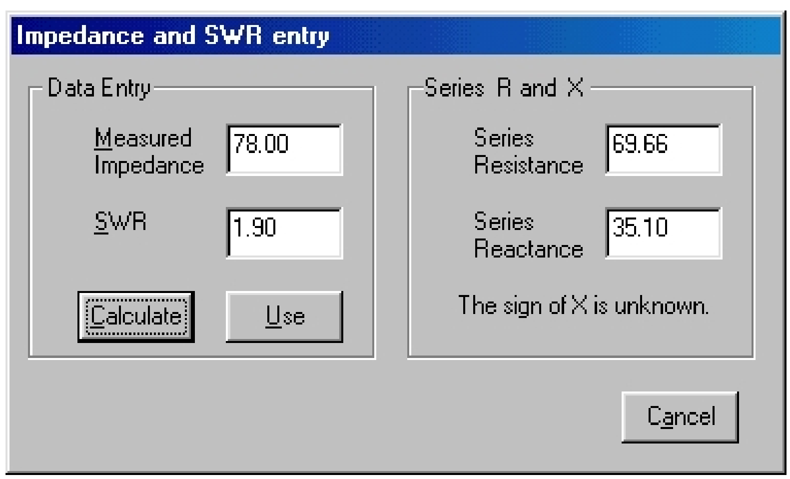

Figure 21
Impedance and SWR Conversion
to R + j X

Note that the sign of the Series Reactance, i.e. capacitive or inductive, cannot be determined when only the impedance and SWR are known. Also, the cable impedance must be entered before using this calculator.

Reflection Coefficient Entry --- This work sheet provides data entry in terms of transmission line characteristic impedance, magnitude and phase angle. The shortcut key for this worksheet is F3.

This data may be taken directly from a Smith Chart. The Enter button will calculate the series R and X based upon the data entered and automatically enter the results into the main worksheet Real Part and Imaginary Part entry fields.

The pop up panel will close automatically. You may also click on the Cancel button to close this pop up panel without making entries on the main worksheet.

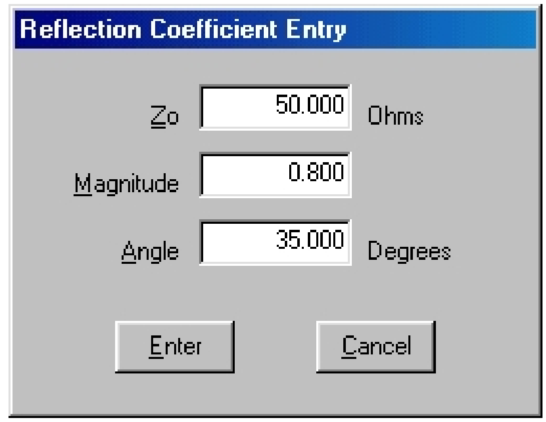

Figure 22
Reflection Coefficient Entry

Vector Voltmeter Entry -- This work sheet provides a special calculator to determine series R and X values when using a vector voltmeter to measure the unknown impedance. The shortcut key for this worksheet is F4.

Enter the transmission line Zo, the reference magnitude, the device under test magnitude and the phase angle into their respective data fields. Then click on the Enter button to calculate the Series Resistance and Series Reactance which equates to the data entry values. The calculated Series Resistance and Series Reactance values will automatically be entered into the main work sheet.

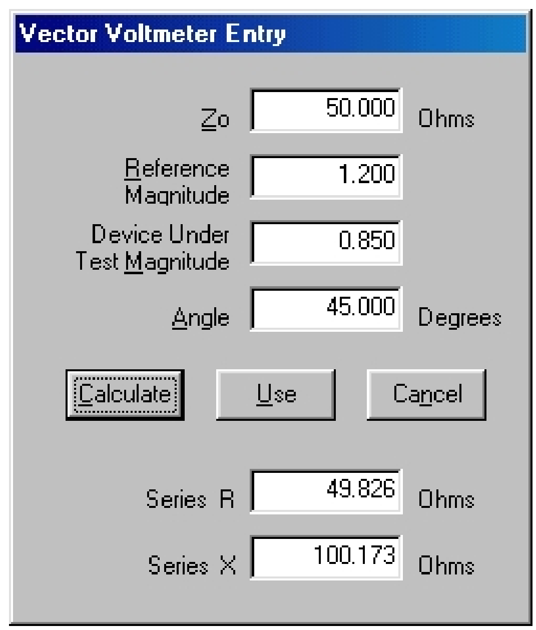

Figure 23
Vector Voltmeter Entry

General Radio 916-A Entry --- This work sheet provides a special calculator to determine the series R and X values when using a General Radio 916-A RF Bridge to measure the unknown impedance. The shortcut key for this worksheet is F5.

Enter the data for the Initial Balance Settings if they are not the default settings. The Resistance and Reactance dial settings will default to the correct values for standard usage of the bridge if no entries are made.

Enter the operating frequency. It is important to make as accurate of a frequency entry as is practical because it directly affects the accuracy of the final impedance measurement.

Enter the UUT Measurement readings from the bridge dials.

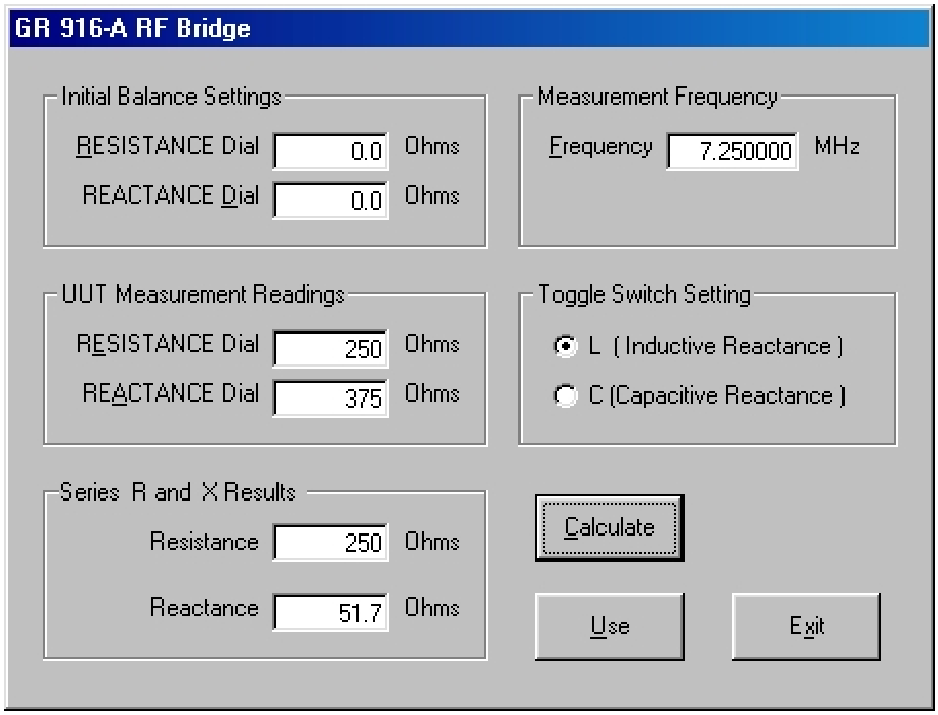

Figure 24
General Radio 916-A RF Bridge

Click the button for the correct Toggle Switch Setting to select either an inductance or capacitance measurement.

Next, click on the Calculate button to get the calculated series resistance and reactance values. The polarity of the Reactance will indicate whether it is inductive reactance (positive value) or capacitive reactance (negative value). Clicking on the Use button will automatically enter the series resistance and reactance values into the main work sheet for the Real Part and Imaginary Part entries. This bridge panel will then automatically close.

Refer to the bridge operating instructions for additional operating information.

Wayne Kerr B601 Entry --- This work sheet provides a special calculator to determine the series and parallel R and X values when using a Wayne Kerr B601 RF Bridge to measure the unknown impedance. The shortcut key for this worksheet is F6.

Click on the appropriate buttons to make selections for the Terminal Used, R Window Multiplier C - L Window Multiplier.

Enter the operating frequency. It is important to make as accurate of a frequency entry as is practical because it directly affects the accuracy of the final impedance results.

Enter the UUT Measurement readings from the bridge for the KILOHMS dial and the PICOFARADS dial.

Next, click on the Calculate button to get the calculated parallel and series resistance and reactance values. The polarity of the Reactance will indicate whether it is inductive reactance (positive value) or capacitive reactance (negative value).

Clicking on the Use button will automatically enter the series resistance and reactance values into the main work sheet for the Real Part and Imaginary Part entries. This bridge panel will then automatically close.

Refer to the bridge operating instructions for operating information.

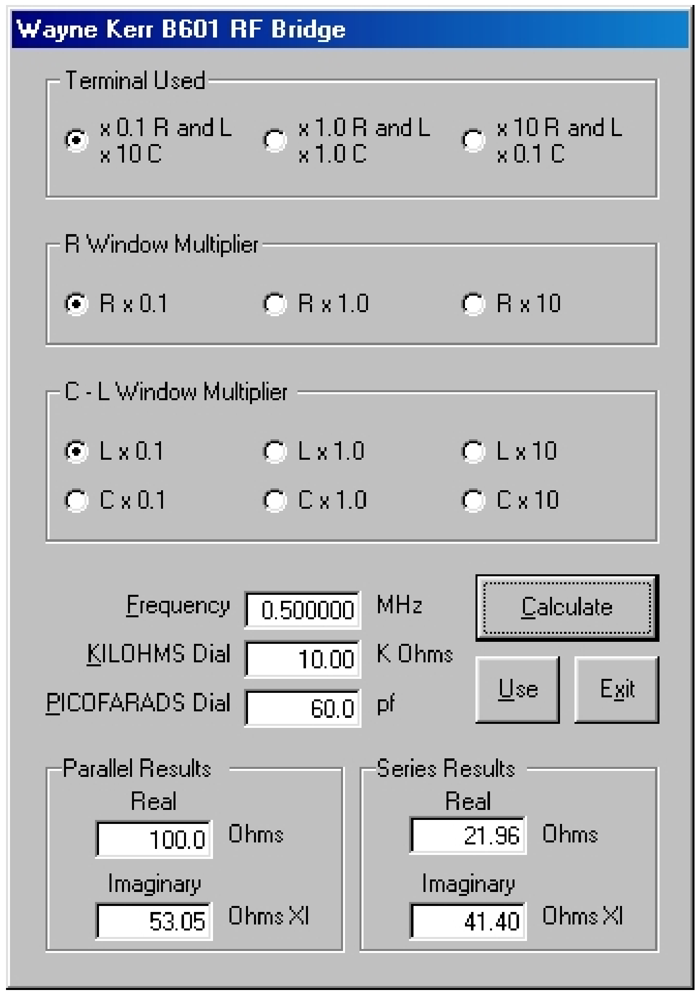

Figure 25
Wayne Kerr B601 RF Bridge

Boonton 250-A RX Meter Entry — This work sheet provides a special calculator to determine the series and parallel R and X values when using a Boonton 250-A RX Meter to measure the unknown impedance. The shortcut key for this worksheet is F7.

Enter the operating frequency. It is important to make as accurate of a frequency entry as is practical because it directly affects the accuracy of the final impedance results.

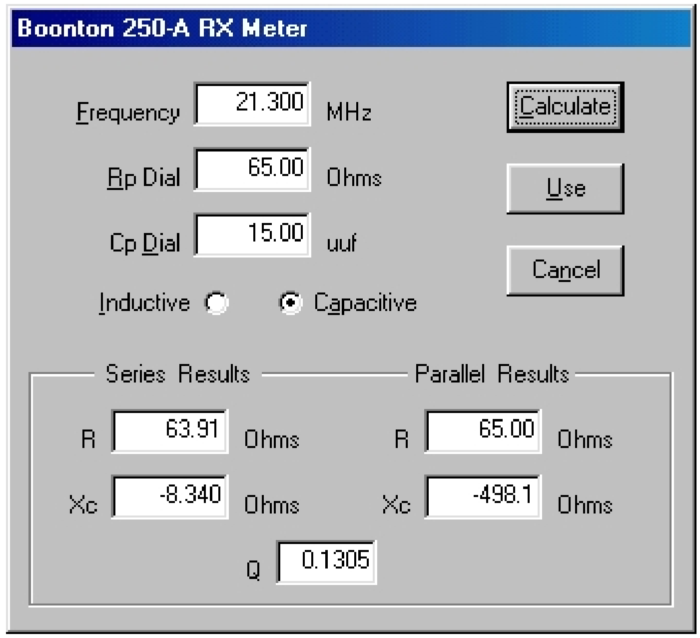

Figure 26
Boonton 250-A RX Meter

Enter the UUT Measurement readings from the RX Meter for the Rp Dial and the Cp Dial. Note that the Cp Dial readings are positive values for capacitance and negative values for inductance. You may also click on the Inductive or Capacitive option buttons to make the selection.

Next, click on the Calculate button to get the calculated parallel and series resistance and reactance values. The polarity of the Reactance will indicate whether it is inductive reactance (positive value) or capacitive reactance (negative value).

Clicking on the Use button will automatically enter the series resistance and reactance values into the main work sheet for the Real Part and Imaginary Part entries. This bridge panel will then automatically close.

Refer to the bridge operating instructions for operating information.

Hewlett Packard 250-B RX Meter Entry — This work sheet provides a special calculator to determine the series and parallel R and X values when using a Hewlett Packard 250-B RX Meter to measure the unknown impedance. The shortcut key for this worksheet is F8.

Operation is the same as the Boonton 250-A RX Meter described above.

16. Help Menu Selection

About Program. --- This selection will display a screen showing program version and copyright notice.

Operation. --- This selection will load and display the instruction manual for the TransTenna Pro program. This file is named Operators Manual.pdf and is located in the same directory where TransTenna Pro is installed. It is the full version of the operator manual and is intended to provide the operator with complete access to program operation and assistance. This file is in pdf format and will be opened by the program associated with pdf files.

17. Invalid Data Entered

TransTenna Pro calculates values using the general transmission line equations. It is possible under some circumstances to enter data which cannot be realistically achieved in a conventional transmission line and antenna/load scenario.

For example, if you have a 50 ohm transmission line of infinite length connected to a transmitter with a 50 ohm output, there can be no reflected power coming back to the transmitter since the power never reaches the load to be reflected. In this case a perfect match exists between the transmitter and the transmission line. The resistance and reactance measured at the transmitter end of the transmission line will be 50 + j 0 ohms (series resistance and reactance).

Just because you can enter a different value such as 25 + j 30, does not mean that this is a valid measured value. Error checking is used to avoid most problems of this nature. If an invalid scenario is entered, the program will prompt you to check your data entry, see Figure 26. As with any calculation, the accuracy of the data you enter affects the accuracy of the results. Have you heard the phrase “Garbage in, garbage out”? Well, it applies to impedance transformation along a transmission line also.

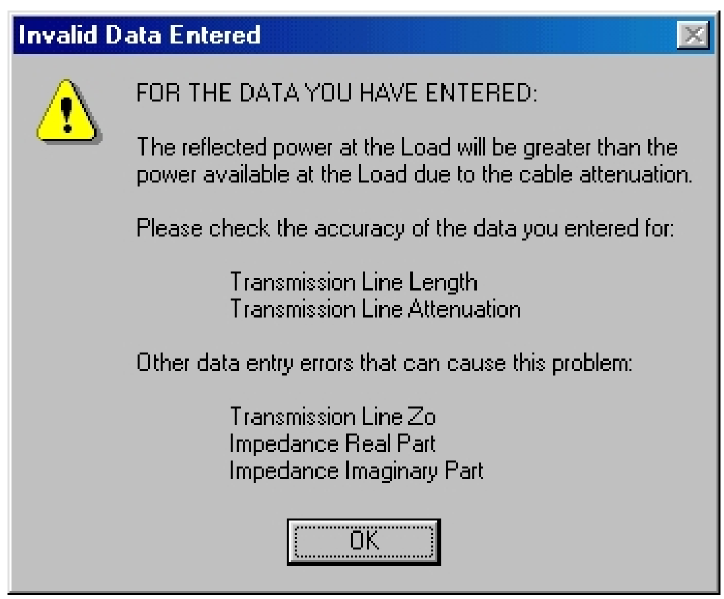

Figure 27
Invalid Scenario Message

18. Determining the Sign of X

When we use the term X or j X, we are referring to the reactive part of the complex impedance. This reactive part can be either a negative value (- j X) which indicates capacitive reactance or a positive value (j X or + j X) which indicates an inductive reactance. If you do not know the sign of j X or can not read it from the test instrument you are using, getting accurate results will require a little extra work. Lets look at some examples.

1. We may not care about the sign of j X if the value of j X is small compared to the resistance desired. For example lets assume the calculated antenna impedance is 46 + j 3 ohms and the SWR is 1.12:1. In this case we may be quite satisfied with the 1.12:1 SWR and no further analysis is required. Does it matter whether it was a + j 3 ohms or a - j 3 ohms if we are not going to do anything about it?

2. We can solve for two results at the antenna end of the transmission line by using a positive value entry for Series Reactance in the Data Entry field and then calculate again using a negative value for the entry. This gives two solutions and the ambiguity must be resolved by some other method such as trial and error in making an antenna adjustment.

3. In some antenna systems such as simple dipoles and verticals that are intended to be resonant at the operating frequency, the sign of j X can be determined by changing the test frequency. Find the resonant frequency where the reactance (j X) is smallest. As you move slightly below the resonant frequency of the antenna, it becomes capacitive and the X term is - j ohms. As you move slightly above the resonant frequency of the antenna, it becomes inductive and the X term is + j ohms. Remember that we are talking about the calculated antenna resistance and reactance not the values measured on the test instrument.

4. Another method involves adding a small length of transmission line to the antenna feed line and observing the change in the measured resistance reading on the test instrument.

When measuring at the **Generator end of the transmission line**, adding transmission line will rotate the impedance point plotted on a Smith Chart clockwise, in the direction of the Generator. By adding a small length such as 0.01 wavelength, the resistance will change and the direction of change will tell you if the reactance is inductive or capacitive i.e. in which half of the Smith Chart the impedance is located.

If the resistance goes down, the impedance is in the lower half of the Smith Chart and therefore the reactance is capacitive and the X term is - j ohms.

If the resistance goes up, the impedance is in the upper half of the Smith Chart and therefore the reactance is inductive and the X term is + j ohms.

When measuring at the **Load end of the transmission line**, adding transmission line will rotate the impedance point plotted on a Smith Chart counter clockwise, in the direction of the Load. By adding a small length such as 0.01 wavelength, the resistance will change and the direction of change will tell you if the reactance is inductive or capacitive i.e. in which half of the Smith Chart the impedance is located.

If the resistance goes down, the impedance is in the upper half of the Smith Chart and therefore the reactance is inductive and the X term is + j ohms.

If the resistance goes down, the impedance is in the lower half of the Smith Chart and therefore the reactance is capacitive and the X term is - j ohms.

This method does have an ambiguity when the X term is very low compared to the characteristic impedance of the transmission line. In this case it is possible to add a small length of transmission line and have the resistance value as read from the test instrument read the same value. This can occur when the impedance is nearly purely resistive and the added transmission line moves the impedance point on the Smith Chart from the lower half to the upper half, or vice versa, an equal distance relative to the horizontal axis of the chart. In this case the addition of a second short length of transmission line will provide the desired results and the resistance reading will change as discussed above.