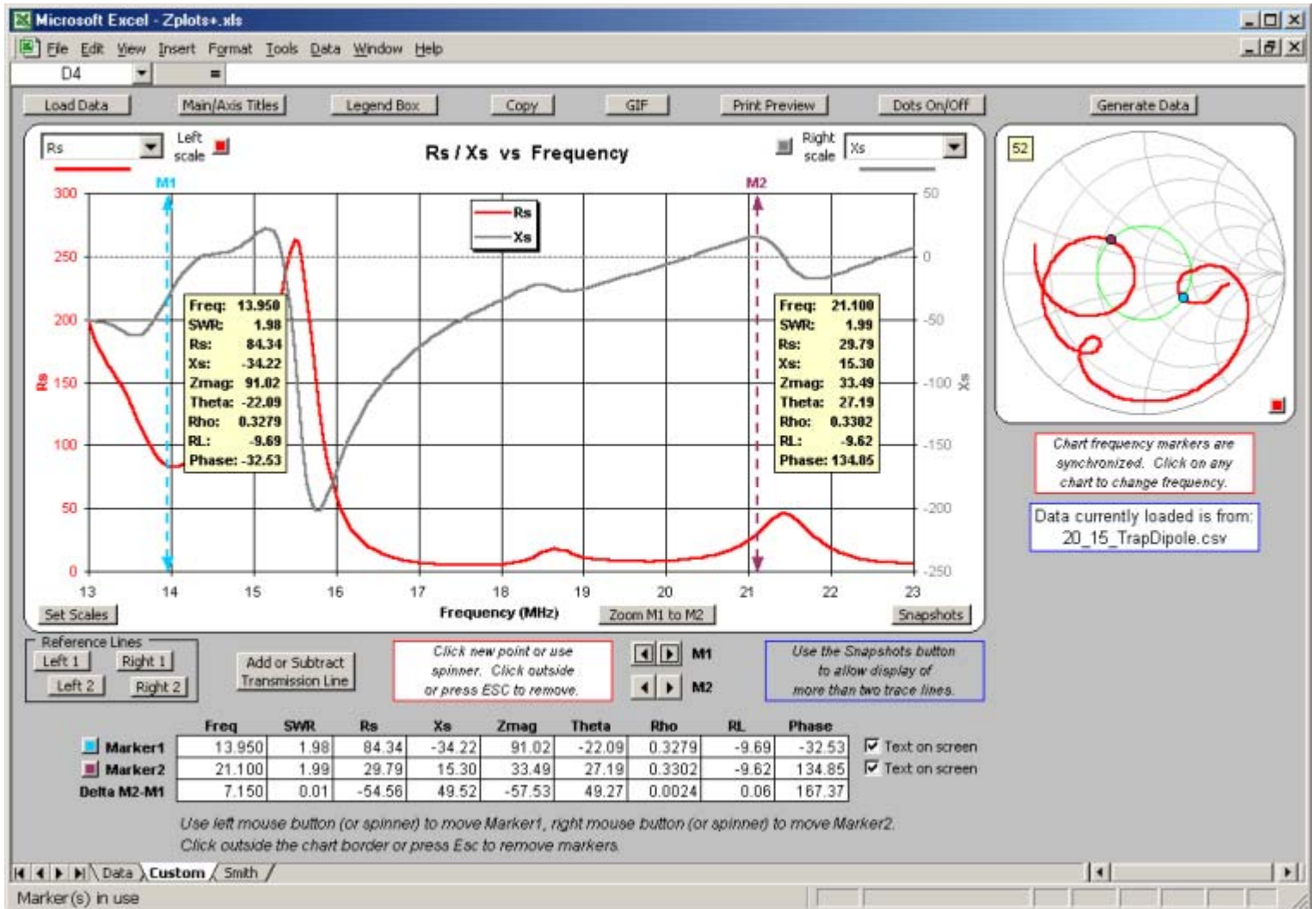


Zplots

Impedance Plots using Excel Charts



Zplots is an Excel application that allows you to plot impedance and related data obtained from a variety of sources. You can plot on both an XY chart and a Smith chart as well as view the data in tabular format.

The XY chart can be customized with your choice of trace lines. Frequency (in MHz) is always shown on the X axis. On the primary (left side) or secondary (right side) Y axis you can plot:

- SWR - Standing Wave Ratio
- Rs - Resistance, series form
- Xs - Reactance, series form
- Zmag - Impedance magnitude
- Theta (deg) - Impedance angle
- Rho - Reflection coefficient magnitude
- RL (dB) - Return Loss, plotted as a negative number to simulate "reverse scale"
- % Reflected Power
- Phase (deg) - Reflection coefficient angle
- Q - Quality factor, $|Xs| / Rs$

- Rp - Resistance, parallel form
- Xp - Reactance, parallel form
- Ls (μH) - Equivalent inductance for series Xs, both positive and negative
- Cs (pF) - Equivalent capacitance for series Xs, both positive and negative
- Lp (μH) - Equivalent inductance for parallel Xp, both positive and negative
- Cp (pF) - Equivalent capacitance for parallel Xp, both positive and negative

Negative values for Ls, Cs, Lp, and Cp may be interpreted to mean the amount of inductance or capacitance which must be added, in series or parallel respectively, to "cancel out" the corresponding reactance.

The order of the items in the above list has no special significance other than that the items most likely to be chosen for plotting are near the top. On the secondary (right side) Y axis you can also choose "(none)" to indicate no secondary plot line.

A Mini-Smith chart is shown on the same sheet with the XY chart. To see both the XY chart and the Mini-Smith at the same time you must have your screen resolution set to 1024x768 or higher and you must maximize both the Excel window and the workbook sub-window (using the lower set of size buttons). Alternatively, on the Excel menu you can select View | Zoom and choose a magnification level less than 100%.

Zplots can read impedance data from:

- **AIM** - Antenna Analyzer AIM430 / AIM4160 / AIM4170 by W5BIG [\(more info\)](#)

On the AIM menu bar select File | Save Graph. The current scan will be saved in two formats. The *.scn file is used by AIM if you want to reload the scan data at a future time. AIM also saves the scan data in *.csv format that can be read by *Zplots*.

Your AIM software must be version 547 or later.

- **VNA4Win** - Windows software for the N2PK VNA by GM4PMK and GM3SEK [\(more info\)](#)

After at least one sweep has been completed, the Save Data button will appear when the sweep is stopped. Clicking Save Data opens a dialog box to allow you to save the measurement results as a *.csv file. *Zplots* can read this file.

- **Exeter** - VNA Control Software by W8WWV [\(more info\)](#)

An Exeter data set is created whenever a data capture finishes without error. You may then use the Save As button (or File | Save Data Set As on the menu bar) to save the data in *.csv format. *Zplots* can read this file. Note that *Zplots* makes use of only the default fields in the file. The file may contain other fields as well; these are ignored by *Zplots*.

- **Refl.exe/Trans.exe/GrpDel.exe** - DOS store data programs by N2PK [\(more info\)](#)

These programs can create various .DAT files and *Zplots* can read these files. If the file contains multiple DUT data sets you will be asked which one you wish to show. Note that it is not necessary to change the file extension to something other than .DAT, although you may do so for other reasons.

- **VNA1/miniVNA** - Antenna Analyzer and miniVNA by IW3HEV, et al. [\(more info\)](#)

These programs can save sweep data in *.csv format via File | Save As on the menu bar. *Zplots* can read these files.

VNA1 software must be version 1.1.8 or later, miniVNA software must be version 2.2.8 or later.

- **TAPR VNA** - TAPR Vector Network Analyzer ([more info](#))

Use File | Export on the TAPR software menu bar and then choose Rectangular or Polar format (but not csv format). *Zplots* can read these files and will ask if you want to use the S11 (reflection) or S21 (transmission) data.

- **EZNEC** - EZNEC Antenna Software by W7EL ([more info](#))

Every time you run either an SWR sweep using the SWR button, or a Frequency Sweep via Setups | Frequency Sweep on the menu bar, EZNEC will automatically write a file named LastZ.txt to the EZNEC home folder, typically C:\Program Files\EZW. *Zplots* can read the LastZ.txt file.

Because EZNEC overwrites this file every time a sweep is done you may have decided to make a copy under a different name. You may also have changed the file extension from .txt to .csv to allow more convenient use with a spreadsheet program. *Zplots* can read the file no matter what name or extension it may have.

- **Antenna Model** - Software for the Analysis of Wire Antennas by Teri Software ([more info](#))

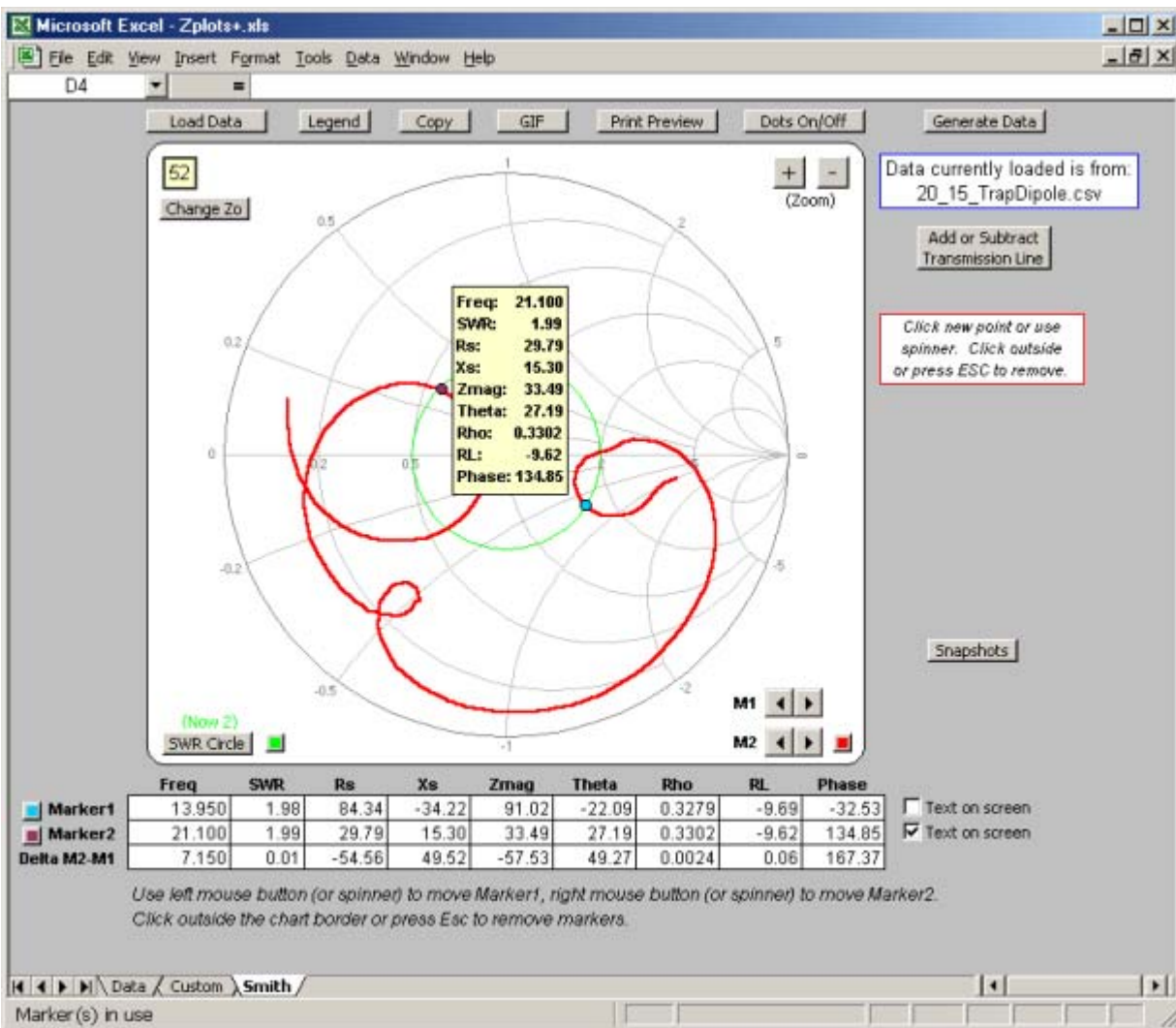
After you have done a scan via Calculate | Frequency Scan on the menu bar you will have the option to save the impedance data (and other data) for the model. On the menu bar choose File | Export Impedance Data Points, or press Ctrl-M. A file named [model]Impedances.csv will be written to the Archive folder. (If you want the file to go someplace else press Shift-Ctrl-M instead of Ctrl-M and you will get a Save As dialog box.) *Zplots* can read this file.

Your Antenna Model software must be version 635 or later.

The VNA4Win, Exeter, N2PK DOS, and miniVNA programs mentioned above can create "Transmission" and/or "Group Delay" type files as well as "Reflection" files. *Zplots* can read these files and show an XY plot for:

- |TL| - Transmission loss (also called insertion loss) expressed as a ratio
- TL (dB) - Transmission loss in dB, plotted as a negative number to simulate "reverse scale"
- Phase (deg) or Grp Delay (μ sec) - Phase shift or Group delay, depending on file contents

When a "Transmission" or "Group Delay" type file is used as input to *Zplots* the Smith charts and certain other program functions will be disabled.



Zplots shows a large Smith chart on a separate sheet, as pictured in the above screen shot. Note that the marker line / marker dot frequency markers are synchronized on all three charts.

Buttons available on the various sheets are:

Load Data: Read a data file from one of the above-mentioned sources.

Note: You do **not** use File | Open on the Excel menu bar to read a data file. You would only use File | Open if you wanted Excel to open a different spreadsheet program (also known as a different workbook), such as one you might have created to track the family budget. Although Zplots has the "look and feel" of a normal application program it is important to remember that it is merely a very refined spreadsheet. The operation of Zplots is controlled by the buttons on the various sheets, not by the Excel menu bar.

If you do use File | Open to read a data file, Excel will open that file in a separate workbook window. Excel can have multiple workbooks open at one time, such as one for your family budget and another to track your investments. This can be confusing to new users of Excel because typically one workbook window completely hides any others. Zplots is still there, except it is "underneath" the data file window you just opened. Just switch back to the Zplots window, using the Excel menu bar 'Window' selection (just to the left of 'Help') or by pressing Ctrl-Tab, and Zplots will ask you if you want to load the data from the "other" window.

As an additional reminder, anytime *Zplots* is active you will see a new first entry in the list of choices under the Excel File menu. The new choice is 'Zplots: Load Data...' and selecting that item is exactly the same as clicking the "Load Data" button.

Generate Data: Use this button to create and then automatically load a frequency sweep data file independent of any other program. (More details below.)

Change Zo: Some data sources include the reference Zo value that was used to compute Rho (and hence SWR, Return Loss, % Reflected Power, and Phase). Others do not, in which case Zo will default to 50. You can use this button to change Zo at any time. You may also click directly on the text box in the upper left corner of either Smith chart to change Zo. You may find this convenient when viewing the Mini-Smith.

Main/Axis Titles: (Custom XY chart only) Change the text shown for the main chart title, the X axis title (normally "Frequency"), the primary (left side) Y axis title, and the secondary (right side) Y axis title.

Legend Box: Add or delete the legend box and change the text shown in the box. You can move the position of the legend box by dragging with the mouse. When you are done click anywhere outside the chart.

Copy: Copy the chart (main chart only on the Custom sheet) to the clipboard, with optional resizing. The chart can then be pasted into another application such as Word or Paint.

GIF: Create a GIF file of the chart (main chart only on the Custom sheet), with optional resizing. The GIF file can then be used with email and web pages.

Print Preview: This shows what the chart will look like if printed. You can of course then print the chart, but you might also want to use this button just to see a magnified version of the chart which may help in picking out fine details.

Dots On/Off: When "On" you can see a round dot for each data point on the chart traces. When "Off" the traces are just lines.

Set Scales: (Custom XY chart only) The min and max settings for the primary and secondary Y axis scales are normally set automatically by Excel. You can use this button to "freeze" the min and max at values of your choice. You can also set the min and max of the X axis in order to "zoom in" on a frequency subset of interest.

Warning: The scales will stay locked until you manually reset them. Suppose you are plotting SWR and you set the Y axis min to 1 because you know that the SWR value will never fall below 1. Then you decide to plot Rho. Since Rho values are (almost) always less than 1, the trace line for Rho will be entirely "clipped" and will appear as just a flat line along the bottom of the chart.

Zoom M1 to M2: This button offers a more convenient way to zoom in on a frequency range of interest. Set Marker1 with the left mouse button and Marker2 with the right mouse button. Press "Zoom M1 to M2" and the frequency range of the X axis will be changed to match the range between the two markers. When you use this button (or if you do the same thing manually using "Set Scales"), an additional **Full Freq Range** button will appear allowing you to return to showing the entire set of frequencies available in the data file.

Snapshots: This button has two uses. On the Custom XY chart you can use snapshots to plot more than two trace lines at the same time. For example, you could plot Xs on the primary (left) axis and take a snapshot. Then plot Rs (again on the left axis) and take another snapshot. Then plot Zmag. While you are doing this you can be showing Theta (for example) on the secondary (right) axis. When you are done you will have four trace lines: Zmag, Rs, and Xs using the left scale and Theta using the right scale.

On both the Custom XY chart and the Smith chart you can also use snapshots in order to compare data from one sweep against that from another. *Snapshot traces persist when you load*

new data. Hence you can, for example, load data from a particular *.csv file, take a snapshot, load data from a different file, and see how the two compare. If you are using one of the N2PK VNA control software programs or the miniVNA program you could even load a "Reflection" type file, take a snapshot, then load a "Transmission" type file and see the S11 and S21 traces overlaid.

You can also compare data from completely different sources. For example, suppose you modeled an antenna with EZNEC, constructed a "real-world" version of the model, and took some impedance measurements when you were done. You could load the EZNEC SWR sweep data (from LastZ.txt) into *Zplots* and take one or more snapshots. Then load the data file produced by your AIM or VNA software. Now you can see the difference, hopefully small, between the "as modeled" as "as measured" data. (See below for more on the *Zplots* 'Add or Subtract Transmission Line' feature which allows you to account for the fact that your modeled impedance [probably] represents the antenna feed point while your measured impedance was [probably] taken at the input end of a feedline.)

Reference Lines: (Custom XY chart only) Use these buttons to add horizontal marker lines to the chart, perhaps to aid in analysis or presentation. You can show up to two reference lines associated with the left scale and up to two reference lines associated with the right scale.

Zplots also has a fifth reference line not under direct user control. Whenever you plot any item on the RIGHT (secondary) axis that is likely to have both positive and negative values, such as Xs or Theta, *Zplots* will show a dotted line which corresponds to zero on that axis. This may be helpful in situations where there is not a normal gridline at the zero value. Note that when plotting items on the LEFT (primary) scale it is usually possible to set the scale min and max values such that a gridline will show at the zero value, hence there is no need for a "program-controlled" zero line for the LEFT axis.

Zoom In/Out: (Smith chart only) In some but not all cases it is useful to be able to zoom in on the center portion of the Smith chart. The zoom steps correspond to: Full size > SWR 5:1 > SWR 3:1 > SWR 2:1, with some overshoot in the corners at anything other than full size. When you zoom the main Smith the Mini-Smith will follow.

SWR Circle: (Smith chart only) You can choose to show a constant SWR circle at a specified size, hide (not show) the circle, or have the circle auto-size to match the frequency marker. (More on frequency markers below.)

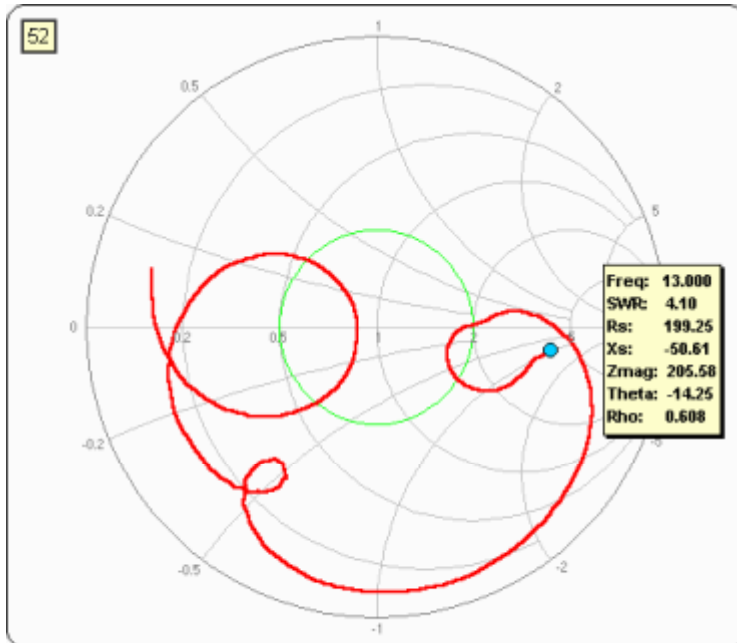
Add or Subtract Transmission Line: For *modeled* data you may wish to "Add" a transmission line to the results to see what the impedance or SWR would be at the transmitter (or tuner) end of the line. *Zplots* lets you do that without making any changes to the model itself, such as adding a NEC TL card and an extra wire. On the other hand, for *measured* data you may wish to transpose the measurements to the antenna feedpoint. In that case you can "Subtract" a transmission line. Either way, you can choose from several dozen line types or you can specify your own line characteristics such as Ro and VF. Line loss is included in the calculations. You can 'Apply' the transformation without closing the dialog box, perhaps to see the results as you are viewing one of the charts. It may be helpful, although not required, for you to take a snapshot of the original trace before doing the transformation. This will allow you to visually compare the "before" and "after" impedance values.

Important: The "start point" for the impedance transformation will ALWAYS be the impedance as contained in the source data file that is currently loaded into *Zplots*. So, for example, if you "Add" a transmission line of length 50 feet and then "Add" 55 feet, the length of the simulated line will be 55 feet, not 105 feet. Similarly, if you "Add" 100 feet and then "Subtract" 100 feet you will **not** be back to where you started, you will see the results of subtracting 100 feet. To return to the original values use the 'Undo' button.

For users familiar with AIM, the "Subtract Transmission Line" feature is conceptually identical to the AIM "Refer to Antenna" feature. Using AIM to do the transformation will be more accurate since AIM accounts for the small changes in line Ro and VF as the frequency changes. Remember, you must first use AIM to calibrate the line in question and that requires access to the far end so you can terminate the line with two different resistors. But if you have an AIM device and you can access the far end of the line you should definitely use the "Refer to Antenna" feature.

For users familiar with Exeter, "Subtract Transmission Line" is conceptually identical to the Exeter "Feed System" feature. And of course when using the N2PK VNA with any software you can always do an Open-Short-Load calibration at the far end of the feedline, assuming you have access to that point. This will have the effect of "subtracting out" the feedline at the time the measurements are taken.

Example of using the "Add Transmission Line" feature:



Here are the results of a frequency scan from 13 to 23 MHz on an indoor 20M/15M trap dipole, tacked up to the ceiling about 8 feet off the ground. The *measurements* were taken at the end of a 23 foot length of RG-58 transmission line using an AIM4160 device.

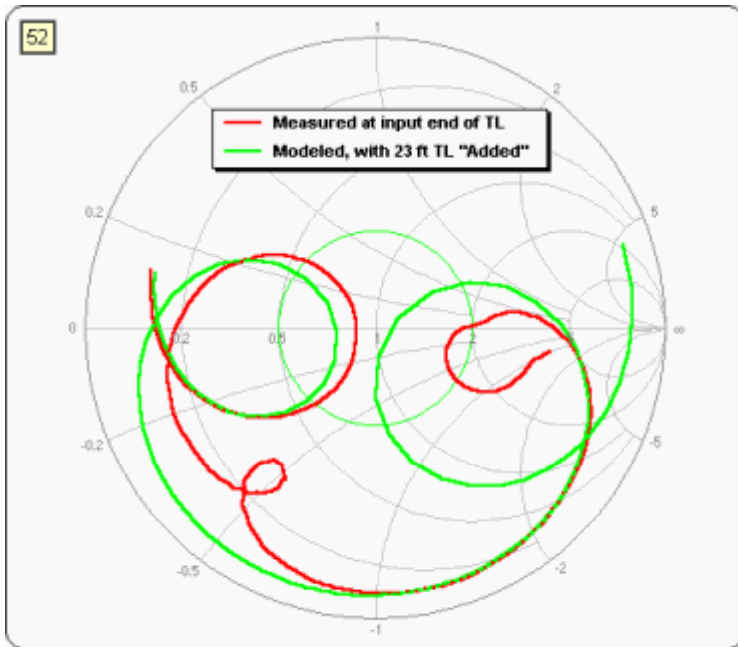
The frequency progression follows a clockwise path on the trace. The blue dot marker and the associated text box show the 13 MHz scan point.

(This is the same Smith chart as is shown in the above screen shot, except this image was made using the **GIF** button with optional resizing. Notice that when you use the **Copy** or **GIF** buttons only the chart itself is captured, not including all the various control buttons that are normally shown.)



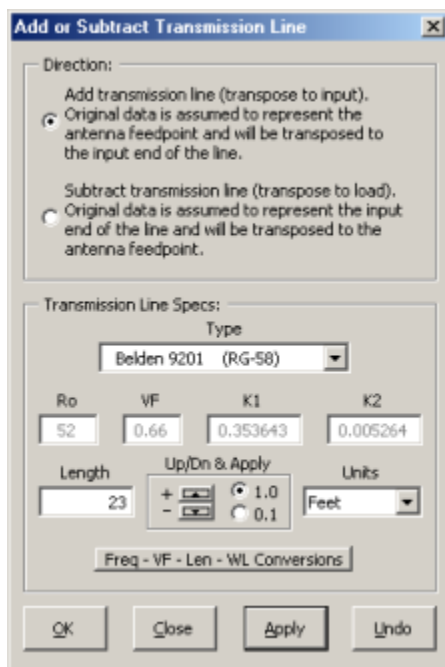
Here are the results of an EZNEC SWR sweep for a *model* of a 20M/15M trap dipole over the same frequency range. The data is from the EZNEC LastZ.txt file and represents the impedance as seen at the feedpoint of the antenna.

As you can see, it is not very obvious that these two Smith chart traces have anything to do with each other.



Finally, here is the original *measurement* data (red) compared with the *modeled* data (green), except that a 23 foot length of RG-58 has been "Added" to the modeled results.

The traces match fairly well at the higher frequencies of the 15M band. For the lower frequency 20M band it is obvious that the model has some shortcomings, perhaps related to all the interactions with house wiring and roof gutters. (Or perhaps I just didn't do a very good job of creating the model!) But at least now it is apparent that there is some kind of correlation between the measured and modeled data.



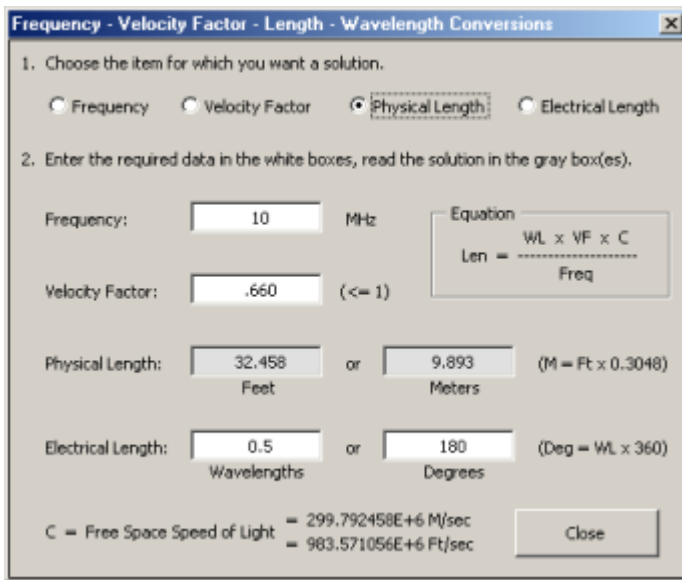
Add or Subtract
Transmission Line
(23 Feet Added)

This is the dialog (reduced-size image) that controls transmission lines. Choose Add or Subtract, select a line type, enter a length and select the length units. If you click 'OK' the transformation will be applied and the dialog window will close. If you click 'Apply' the dialog window will stay open after the calculations are complete. 'Undo' is used to remove any previous-applied transformations.

The spin button changes the length of the line by +/- 1 or +/- 0.1 (in the current units) and then does an 'Apply' operation. Hence the spinner may be used to make adjustments interactively while you watch the results change on the charts.

To use custom values for the transmission line parameters select the last entry in the 'Type' drop down box. Doing so will allow you to set the Ro, VF, K1, and K2 boxes. (If you are not familiar with K1 and K2 just leave the values the same as for a similar line type.)

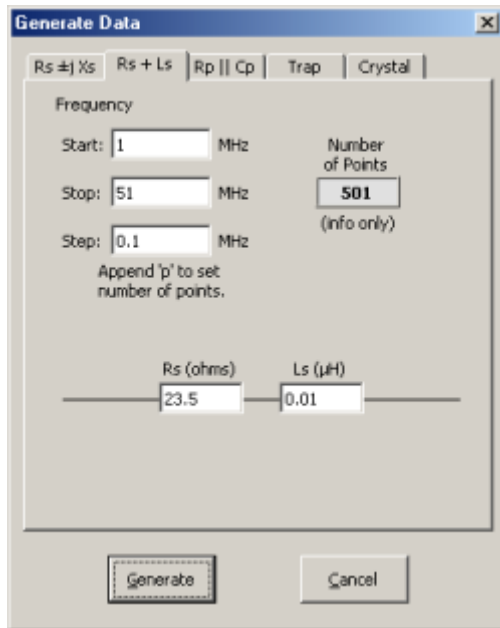
Anytime a transformation has been applied a small reminder will appear underneath the "Add or Subtract" button.



This is a sub-dialog of "Add or Subtract" that you may find useful to help in determining particular line lengths to use. It is basically a calculator for the velocity factor equation in different forms. Choose which item you want to solve for and the results will be computed automatically as you change the input fields.

You can also use this calculator to determine physical line lengths from measurements. Terminate the line with either an open or short and run a frequency sweep with your analyzer. Display the results with *Zplots*, select *Zmag* (impedance magnitude) as the parameter to be plotted, place Marker1 on one *Zmag* peak and Marker2 on the next peak. The frequency difference between the two, available in the lower row of the marker value table, is the half wavelength frequency for the line. Enter that frequency in the calculator, set the velocity factor to match the line in question, make sure the electrical length is a half wavelength, and read the physical length in feet or meters.

Example of using the "Generate Data" feature:

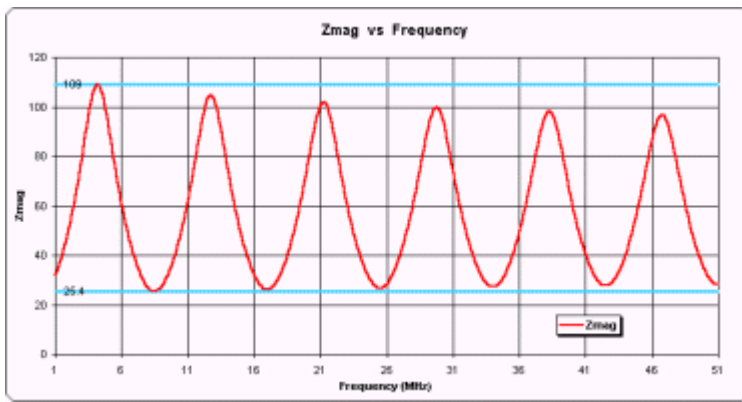


This is the dialog (reduced-size image) that controls the generation of frequency sweep data internal to *Zplots*. Specify the desired start, stop, and step values for frequency. The *Number of Points* box will be recalculated automatically as you are making changes to the frequency range or step size.

The *Number of Points* box is read-only, but if you don't care about the frequency step size in MHz you can specify the number of points to be generated by putting a 'p' after the number in the "Step" box. That is, if you want 100 data points enter "100p" (no quotes) in the box. Note that using the 'p' option may result in some very odd frequency steps between the Start and Stop frequencies.

For the type of data to generate you can choose a simple R and X combination (which will not vary as the frequency changes), a series combination of R and L, a parallel combination of R and C, R-L-C components arranged in a trap configuration, or a model of a quartz crystal with Rs, Ls, Cs, and Co.

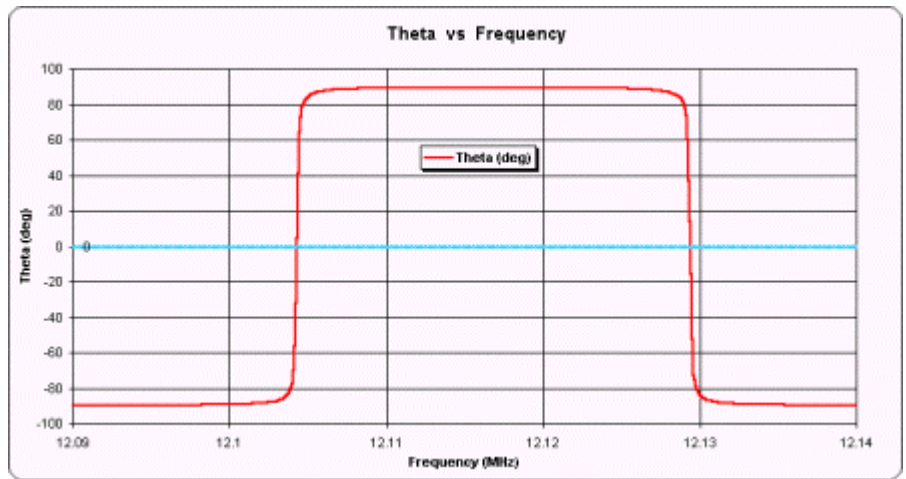
Zplots will create a file named '\$Zplots\$Generated.csv' in the same folder that contains the *Zplots.xls* workbook. This file is then automatically loaded. The file is not erased when the operation is complete. You are free to modify the contents of this file if you wish, perhaps cutting and pasting from another application. (Don't change the first two lines. And note that the file contains columns for only Frequency in MHz, series form R, and series form X no matter what type of data was specified in the dialog window.) You can then load the modified data into *Zplots* just like any other data file. The file name will be reused the next time you use the "Generate Data" feature, so if you modify the contents you may wish to also rename the file.



This shows what the above R-L combination looks like after being transformed via 38 feet of RG-58 transmission line. In this particular case I had soldered two 47 ohm resistors in parallel between the braid and center conductor at the far end of a length of coax. The small value for L is used to account for the inductance of the short length of wire on either side of the resistor bodies. I then simulated what the impedance would be at the input end of the line so that I could compare it with measurement readings over a frequency range from 1 to 51 MHz.

Below is another example of using the "Generate Data" feature, this time for a quartz crystal. The parameter values are shown in the dialog box on the left. Note that when you model a crystal *Zplots* will automatically calculate the series and parallel resonant frequencies as you change the values for Ls, Cs, and Co.

The results of the simulation are shown on the right. The resonant frequencies are the points where Theta (impedance angle) crosses the zero line.



Getting more information for each plotted point:

Series "Zmag"
(16.450, 111.82) When you hover the mouse pointer over any data point on the Custom XY chart a small "Chart Tips" box will appear. The first line in the box will show the name of the item being plotted, such as Zmag or Theta. (Different versions of Excel may show additional information.) The second line will be in the form (xx,yy) where xx is the frequency at that point and yy is the data value. On the Smith chart a similar box will appear but the information shown is actually the real and imaginary parts of Gamma (complex Rho).

To see more information for a given point, click the point with your mouse. On the Custom XY chart a vertical line frequency marker will appear. On the Smith charts the frequency marker will be a large dot. In both cases a large text box (optional) will show other data values for that particular frequency. (The same information is also shown in the marker table below the chart.) To move to a different frequency click on a new data point, use the spinner button, or use the keyboard arrow keys. (Up and Right increase the frequency, Down and Left decrease the frequency. The keyboard arrows control Marker1 only.) All three charts are synchronized, so

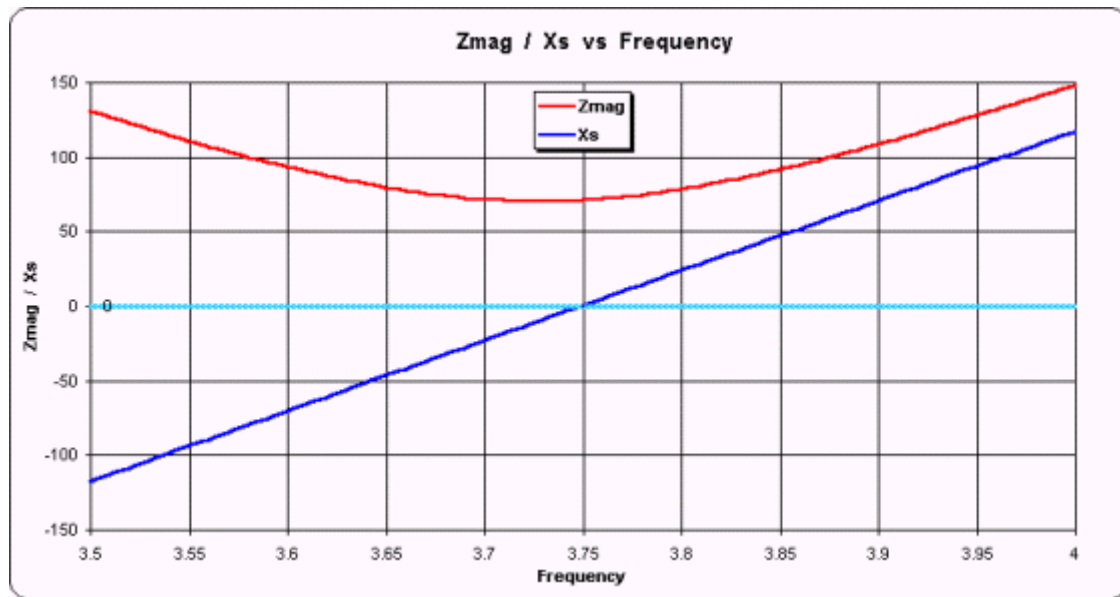
when you click on a new point (or use the spinner or arrow keys) to change the frequency marker on one chart it will be changed on the other two charts as well. To see a second marker use the right mouse button. To remove the frequency marker(s) and associated text box(es) click anywhere outside the chart boundary or press the Esc key.

For users familiar with AIM, please note that the vertical line is **not** a cursor. You don't drag it to a new position on the chart. Instead, use the arrow keys or click a new point. Also note that *Zplots* does not do any interpolation of the data points. The vertical line will move from one scanned frequency to the next, not from one chart pixel to the next as with AIM.

Resolving the sign of X:

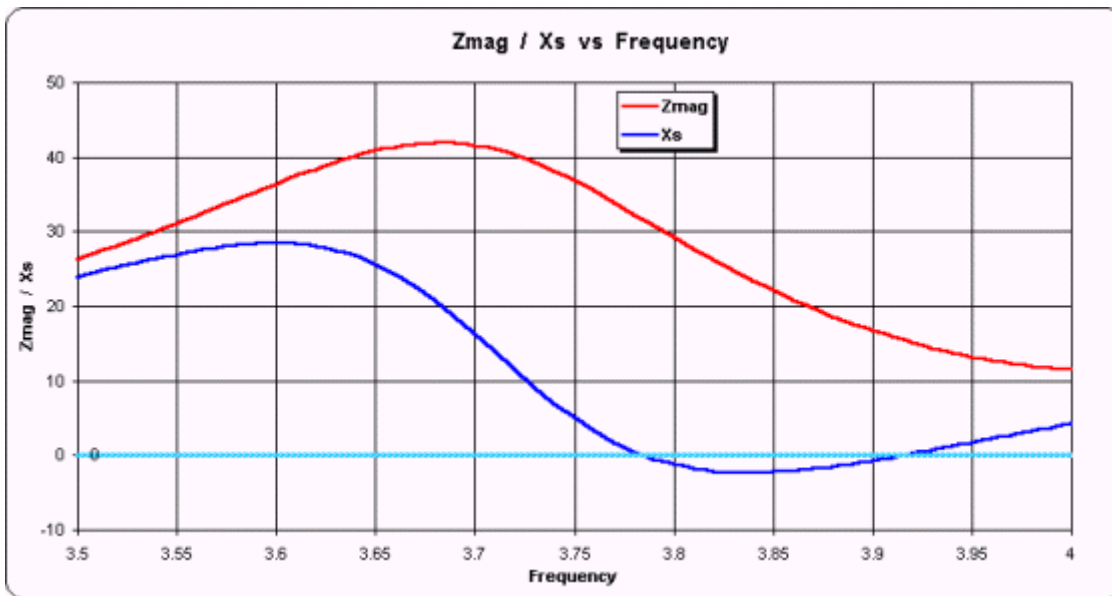
This section applies only to users of the VNA1 and miniVNA analyzers. These devices do not show the sign (positive or negative) of the reactance value X. One method that is often cited to determine the sign of X involves noting the change in the impedance magnitude (Zmag) between a lower frequency and a higher frequency. If the Z magnitude increases the sign of X is assumed to be positive and if the Z magnitude decreases the sign of X is assumed to be negative.

This method works for relatively simple configurations of discrete components when connected directly to the analyzer and for simple antennas when measured at the antenna feedpoint. For example, the following figure shows the Z and X values for an 80 meter dipole antenna that is resonant at 3.75 MHz.



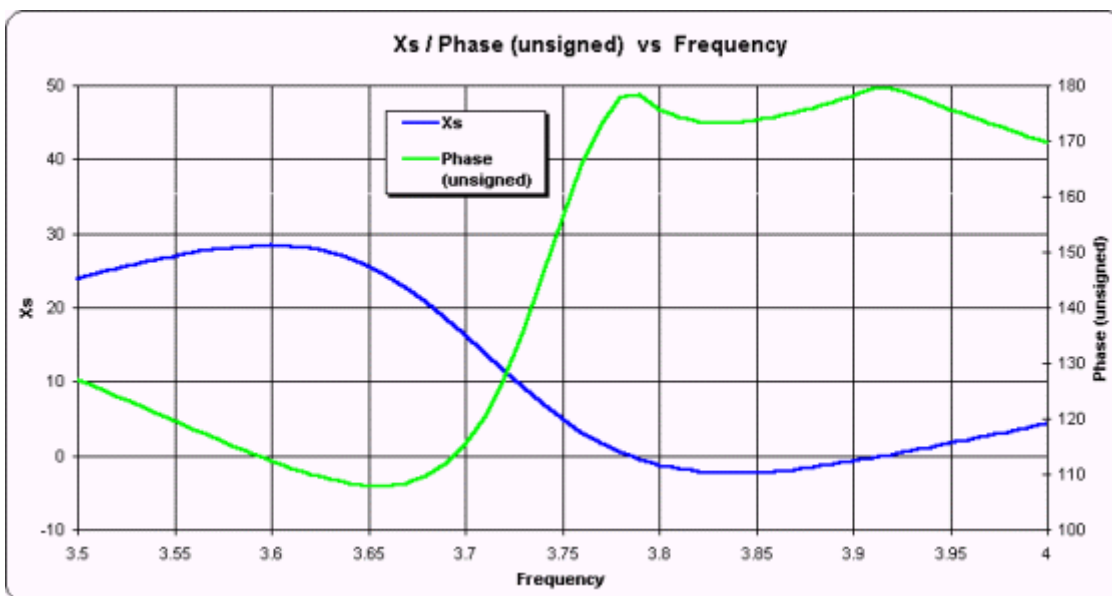
The red line is the Z magnitude and the dark blue line is the reactance X. (The light blue horizontal line merely highlights 0 on the scale.) As can be seen, above 3.75 MHz where the Z magnitude is increasing the sign of X is positive and below 3.75 MHz where the Z magnitude is decreasing the sign of X is negative. On the VNA1 and miniVNA displays the trace line for X would always be positive, with a "V" in the middle, but this illustrates that the technique sometimes holds true.

However, if the same antenna were to be measured at the input end of 50 feet of RG-213 (chosen just as an example) the situation is not so clear. (On the following plot note that the scale has changed but the 0 value is still highlighted.)



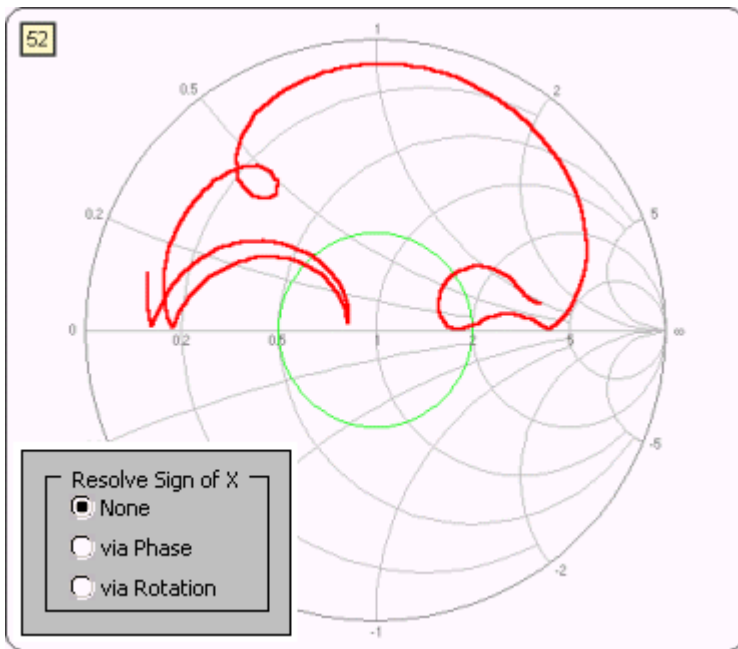
Here the magnitude of Z is increasing in the frequency range from 3.5 to just less than 3.7 MHz. In that range the sign of X is positive, as expected when Z magnitude increases. But the Z magnitude is decreasing from there until 4 MHz and in that span the sign of X is still positive for a while, then goes negative, then goes positive again. So if you did not know the sign of X and you used the simple "Z mag goes down means X is negative" you would be wrong over much of the frequency range.

Another technique for resolving the sign of X involves looking at the slope of the reflection coefficient phase angle. This also works in simple cases, but not for this example of taking measurements at the input end of a feedline.



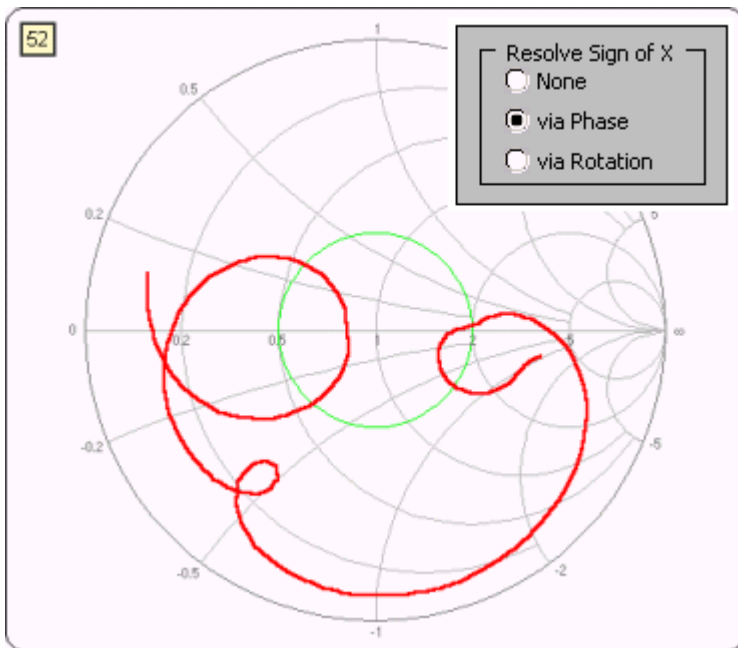
This plot shows X, both positive and negative, referenced to the left scale as before. The green line shows Phase, referenced to the right scale. The Phase values have been artificially altered to be unsigned, the same as would be shown on the VNA1 and miniVNA displays, except for clarity the scale range has been limited to 100-180 degrees instead of 0-180 degrees. As you can see, there is no correlation between the slope of the Phase trace line and the sign of X.

Below is a slightly more complicated measurement example, shown on Smith charts instead of XY charts.



Here is what the Smith chart looks like when the sign of X is always positive. This is the 20M/15M trap dipole measured via 23 feet of RG-58 used in previous illustrations.

It is possible to make some "educated guesses" about the sign of X and *Zplots* has logic to do that. When you display VNA1 and miniVNA data with *Zplots* you will have three options for how you want to resolve the sign of X. The "None" option (at left) means to show the sign of X as always positive, the same as it is displayed on the VNA1 or miniVNA software.



Here is exactly the same data as reported by the VNA1 or miniVNA device, except that one of two possible *Zplots* algorithms has been applied to determine the sign of X.


The "Phase" option looks for places where the Phase angle approaches 0 or 180 degrees and then does further processing to determine the correct sign for X. This option works in most cases and is the one you should try first.

The "Rotation" option works on the principal that the Smith chart trace should always rotate in a clockwise direction as the frequency increases. This option works even if the Phase angle does not approach 0 or 180 degrees but does not handle cases where the Smith trace has "closed loops" that are not centered on the middle of the chart, as at left.

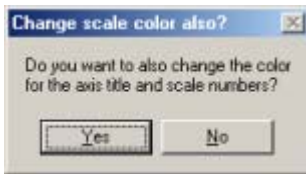
For relatively simple cases either method will work. For extremely complex cases, such as measuring a multi-band antenna over a very wide frequency range, neither method may work. If you see "up-down jumps" on the Smith chart, where the sign of X swings rapidly between positive and negative values, it means that the sign of X was not determined correctly. It is amazingly easy for the human eye to see these shifts, and surprising difficult for a "blind" computer program to do the same.

You will see the three option buttons only when the input data to *Zplots* comes from either the VNA1 or miniVNA analyzer. If you choose one of the correction algorithms the corrected sign will also be shown on the various traces of the Custom XY chart that are dependent on the correct sign of the reflection coefficient angle, including Xs, Theta, Phase, and others.

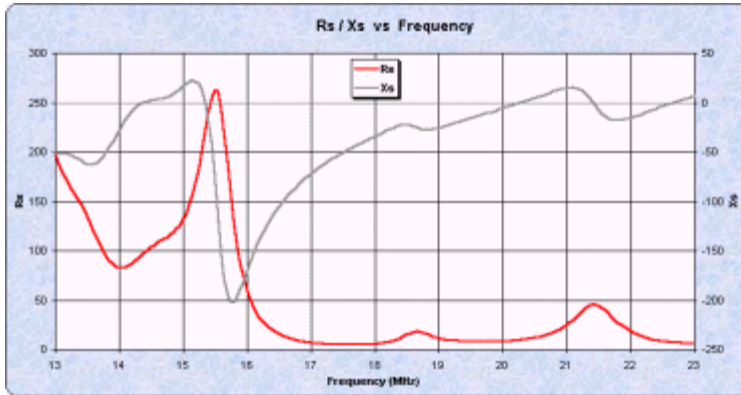
Changing trace line colors and other visual aspects of the charts:

Left scale  *Zplots* has built-in "Color Dot" buttons that allow you to easily change the colors for the chart trace lines, the frequency marker line/dot, the SWR circle on the Smith charts, and the

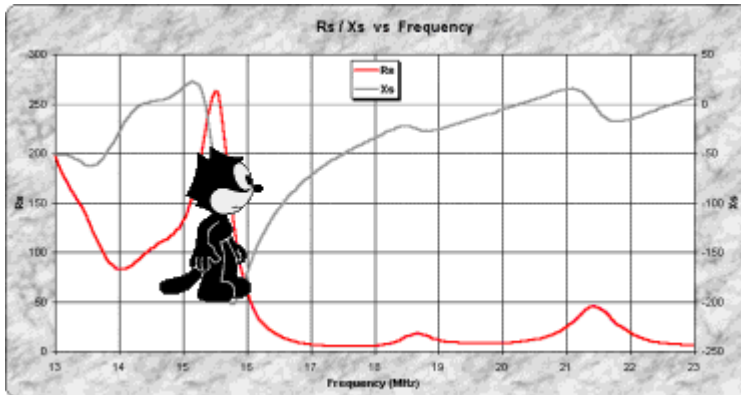
horizontal reference lines on the Custom XY chart. These buttons are visible only when the associated item is being displayed. For example, if you are not currently plotting anything on the XY secondary (right) axis then the color button for that trace line is not shown.



When you change the color for either the left or right axis trace line on the Custom XY chart you will also be given a choice to change the color of the scale numbers and axis title. Choose "Yes" and the text color will match the trace color. Choose "No" and the text will be standard black.



To change things like the background fill color of the charts you can use the standard Excel user interface. In most cases the easiest way to do that is to hover your mouse pointer over the item to be changed and verify that the "Chart Tips" box shows what you intend to change, such as "Chart Area" for the outer area of the chart or "Plot Area" for the inner area. Then hold down the Alt key, RIGHT click the mouse, and choose "Format ..." from the context menu that will appear. Usually 'Patterns' is the tab you will want to select in the dialog box that will follow. Make changes as desired. When you are done just click outside the chart boundary to return to a normal state. (Holding down the Alt key when you click on a chart signals *Zplots* that you do not want to show or change the frequency marker.)



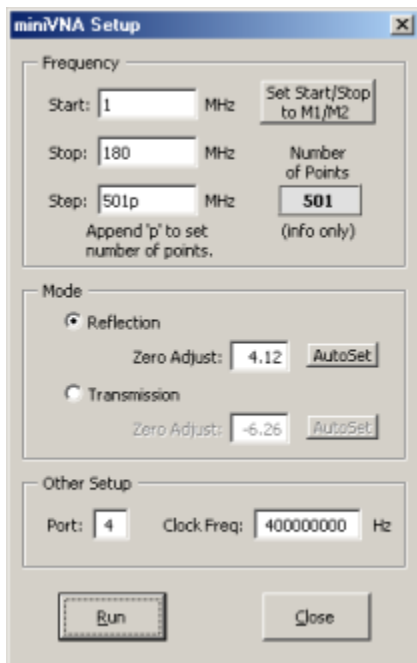
Of course, once you start playing around with the visual aspects of the charts you may get carried away. (Press Esc to calm the nervous cat.)

Important: You may wish to keep a backup copy of *Zplots* if you intend to experiment with various format changes. If you are not very familiar with Excel it is possible that you may make changes from which you don't know how to recover, or which cause *Zplots* to fail. If that happens just close the *Zplots* workbook (File | Close, without saving) and you will be back to where you started. If you have already saved your changes and get into trouble, you can always start fresh with the backup copy that you made.

Optional - Using 'Zplots+' to control the miniVNA hardware:



An enhanced version of *Zplots* called *Zplots+* can be used to control the operation of the miniVNA device. Begin by clicking the "Setup" button.



Start at the bottom of the dialog window, in the "Other Setup" area. Enter the port number that corresponds to the USB-COM port used for your miniVNA, the same as is found in your miniVNA analyz.ini file. Leave the setting for clock frequency at the default value except in special circumstances.

Next move up to the "Mode" area. You will probably want to use a different Zero Adjust value than the default of 0. *Zplots+* can set both the Reflection and Transmission mode zero adjust values for you automatically if you so choose. Just click the small "AutoSet" button and follow the instructions. For Reflection mode you will be asked to place a short on the DUT port. A resistor wire lead, held in place with your finger, will do fine. *Zplots+* will take a single-point reading and calculate what the zero adjust value should be. The procedure for Transmission mode is similar except that you have to place a short jumper between the DUT and DET ports.

When finished you are free to manually change the zero adjust value and/or have *Zplots+* set it at a different frequency. When you close and save the *Zplots+* workbook your zero adjust and port number settings will be saved.

Finally, move up to the "Frequency" area and enter desired values for frequency start, stop, and step size. The *Number of Points* box will be recalculated automatically as you are making changes to the frequency range or step size. If you don't care about the frequency step size in MHz you can specify the number of points in the scan by putting a 'p' after the number in the "Step" box. That is, if you want 100 data points enter "100p" (no quotes) in the box. Note that using the 'p' option may result in some very odd frequency steps between the Start and Stop frequencies.

If you want to duplicate the default miniVNA scan conditions use Start: 1, Stop: 180, and Step 501p. Use 501p, not 500p, because *Zplots+* includes the start frequency in the scan. *Zplots+* will allow up to 2047 points in a scan, so you can (for example) enter values of 1, 180, and 0.1 for 1791 points. You are not limited to 500 points and the number of points is dynamic.

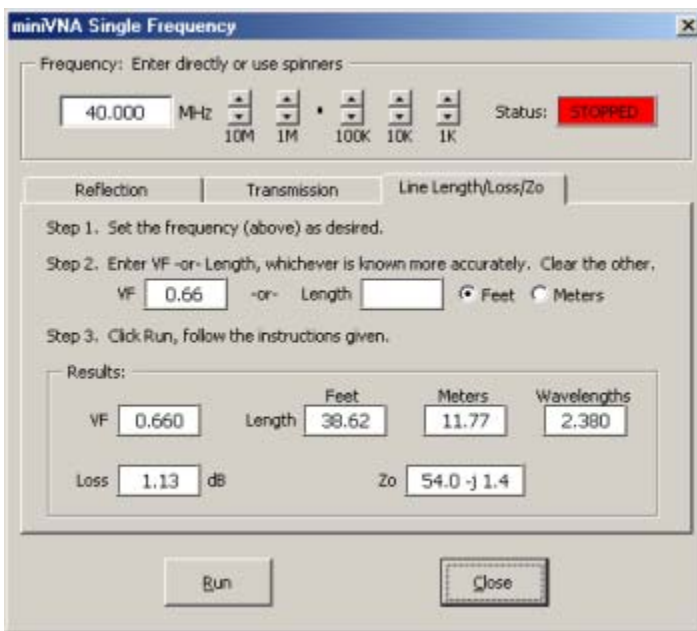
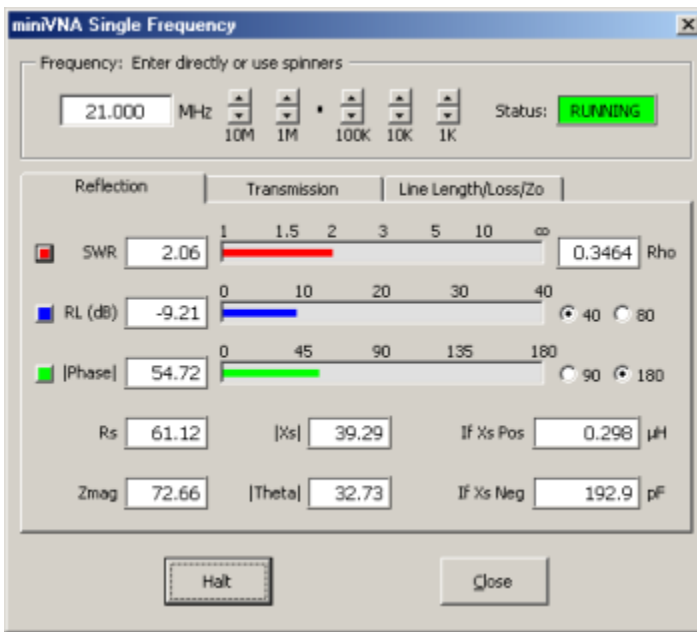
Note that there is a speed versus accuracy trade-off when setting the step size (or number of points). Smaller step sizes (greater number of points) will produce more accurate results but the processing will take a little longer. In general you should use a step size of 0.5 MHz or less.

The "Set Start/Stop to M1/M2" button can be used as a convenient way to scan just in the frequency range between the current marker positions. The button will be enabled only when both markers are present.

When you click "Run" *Zplots+* will send the appropriate commands to the miniVNA, read the results, write the data to a temporary file named '\$Zplots\$Scan.csv', then automatically load that file just like any other data file. If you want to save the scan data click on the Excel File menu and choose the "Zplots: Save Scan As..." entry.

Important: You cannot have the miniVNA software running at the same time as *Zplots+*. The miniVNA software will keep the USB-COM port busy and *Zplots+* will not be able to access it.

If you want to repeat a scan using the same frequency settings you can bypass the "Setup" step and just click the large "Run" button that is present on both the Custom and Smith sheets. And if you want to have the scanning repeated, perhaps while you make adjustments to the DUT such as changing a wire position or a tuner setting, check the "Continuous" box. The scans will be repeated until you uncheck the box or click the "Halt" (was "Run") button. While in continuous scan mode you can still interact with the charts, changing the drop down selections or placing and moving markers, although the response will be delayed.



Zplots+ also has a "Single Frequency" function for the miniVNA, controlled by the dialog window shown here. When you click "Run" the program will continuously poll a single frequency and post the results, mostly as numbers but in a few cases augmented with bar graphs. For the RL/TL and Phase bars you can choose between two different full-scale levels.

The polling will continue until you click "Halt" (was "Run") or close the window, so you can use both hands to make adjustments to the DUT if desired. Under Excel 97, because of a limitation in that version of Excel, the polling is done about once per second. Under Excel 2000 and higher the rate is about 4 times per second. There is no screen flicker although you may see the various values change in small amounts even for the same frequency. The red/green status indicator tells you whether or not polling is taking place.

A specialized application of the "Single Frequency" function lets you easily determine the characteristics of a transmission line. After setting the desired frequency and entering either the velocity factor or physical length for the line, click the "Run" button. You will be asked to first terminate the line with a short circuit, then an open circuit. *Zplots+* will make a series of measurements and report the results. The algorithm used to determine line loss is not dependent on the impedance of the line (50 ohms, 75 ohms, etc.) so you may measure lines of any impedance.

Keep in mind that the velocity factor for any line is not a constant but in fact increases by a small amount as the frequency increases. Because of small inaccuracies in determining the line length you may or may not be able to see this trend when you measure the same line at increasingly higher frequencies, but you probably will notice that, for example, the length of the line in wavelengths is not exactly doubled when you double the measurement frequency.

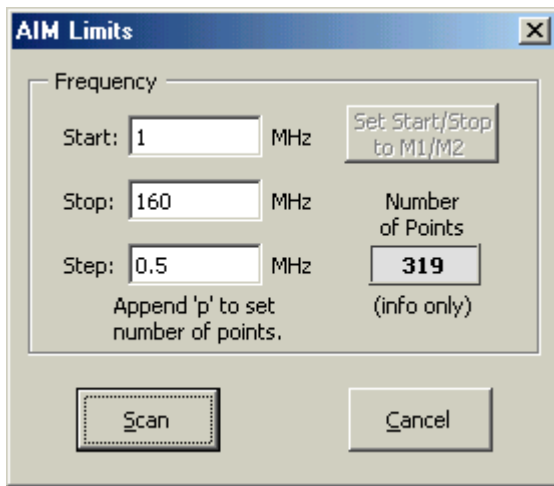
Zplots+ works only with hardware that is controlled via the USB-COM port, not the LPT port. That means that it works only with the miniVNA device unless you have done the "SP3SWJ modification" to your older VNA1 hardware to control it via the USB-COM port. *Zplots+* will not control the (unmodified) original VNA1.

For details on modifying the original VNA1 see the (Polish language) [SP3SWJ web page](#).

Optional - Using 'Zplots-AIM' to control the AIM hardware:



An enhanced version of *Zplots* called *Zplots-AIM* can be used to control the operation of the AIM device.



You'll see two buttons in the "AIM" frame: "Limits" is pretty much the same as the AIM Limits window and "Scan" does a scan using the whatever the current limits are just like the AIM Scan button.

To use the Zplots-AIM interface:

1. Start the AIM software (version 561 or higher) in a separate window. Leave that window up and then switch back to the Excel window with Zplots.
2. Set the scan limits as desired, using the *Zplots-AIM* "Limits" button. The *Number of Points* box will be recalculated automatically as you are making changes to the frequency range or step size. If you don't care about the frequency step size in MHz you can specify the number of points in the scan by putting a 'p' after the number in the "Step" box. That is, if you want 100 data points enter "100p" (no quotes) in the box. Note that using the 'p' option may result in some very odd frequency steps between the Start and Stop frequencies.
3. Click the "Scan" button.
4. The first time you use the Zplots-AIM automated interface you'll be prompted to navigate to the AIM folder and double-click on any file in that folder. Zplots will then keep track of the folder name for future use.
5. Zplots will check to make sure that the AIM program is running and that the version is 561 or higher. If AIM is not currently running you'll get a gentle reminder.
6. Zplots will make AIM the active window, send keystrokes to set the AIM scan limits to match whatever you set in Zplots, then send a special hot-key command. AIM will do a scan and write a temporary file named '\$AutoScan\$.csv' to the AIM home folder. (That's why Zplots needs to know what the folder is.) **Important:** If you are using *Zplots-AIM* under the Windows Vista operating system you must disable User Account Control or else you will get run-time errors (Error 90) at this point.
7. Zplots will read the temporary '\$AutoScan\$.csv' file and plot the data.
8. If you want to repeat the scan using the same Start/Stop/Step just click the large "Scan" button in the "AIM" frame. No need to bring up the "Limits" window again.
9. If you want to permanently save the scan data just switch back to the AIM window and select File | Save Graph from the AIM menu bar, as you would normally do to save a scan. AIM will then save the data in both *.scn and *.csv formats using whatever file name you specify.

There's an additional button, disabled by default, in the Zplots "Limits" dialog window. The button is named "Set Start/Stop to M1/M2". M1 and M2 refer to Marker 1 and Marker 2. If desired, set Marker 1 by left clicking on the trace and set Marker 2 by right clicking. When/if both markers are set the new button will be enabled. If you click the button the Start/Stop will be set to whatever frequencies the markers are set to. So you can do a broad scan, see the big picture, put the markers around a frequency range of interest, click "Limits" and then click "Set Start/Stop ...", do a new scan, and the new scan will be just at the narrower frequency range.

Download:

Download one of the following. Free. All require Excel 97 or later.

- [Zplots](#) standard version.

- [Zplots+](#) for use only with the miniVNA device (and includes all the features of the standard version). Note that *Zplots+* assumes that you have already installed the miniVNA software, including the necessary USB-COM port device drivers and other required components that are included in the [miniVNA Windows software](#) package.
- [Zplots-AIM](#) for use only with the AIM device (and includes all the features of the standard version). Note that *Zplots-AIM* requires that your AIM software be version 561 or later.

You can also download this web page in [PDF format](#) to serve as a basic user guide.

Bodo, DC1DV, has very kindly provided a [German language translation](#) of the user guide. Thank you, Bodo!

Important: You must allow Excel macros to be enabled or none of the *Zplots* buttons will work. Please see [Understanding Excel Macro Virus Warnings](#) for more details.

Note to international users: You need not make any changes to your Control Panel Regional Settings for language or number format in order to use *Zplots* with the comma-separated-values (*.csv) files from the programs mentioned above. *Zplots* will read these files correctly even though they are formatted with a period as the decimal point and commas as field separators.

Change history:

- Version 1.2, uploaded 3 Sep 2007.
 - Support for the s2p format files produced by the TAPR VNA software.
 - Fixed bug related to saving Snapshot data in an external file.
 - Fixed bug related to recognizing the AIM software version number. (Applies to *Zplots-AIM* only.)
- Version 1.1a, uploaded 25 Feb 2007.
 - This is the *Zplots-AIM* package. No other functional changes.
- Version 1.1, uploaded 11 Jan 2007.
 - Version number shown on the Data sheet along with web page and email links.
 - Both the Excel window and the workbook window are maximized on start-up.
 - Phase (reflection coefficient angle) and Q (quality factor) added to list of available XY plot items.
 - For the "Add or Subtract Transmission Line" feature: The dialog window is initially positioned to the right of the chart, if possible. The spinner can now change the line length by +/- 1 or +/- 0.1 in the current units. Less screen flashing when using the spinner. The amount of line added or subtracted (if any) is shown below the "Add or Subtract" button.
 - File name shown on print preview and on printed charts.
 - "Color Dot" buttons added for convenient color changes.
 - Two frequency markers. Marker1 is controlled by the left mouse button, Marker2 is controlled by the right mouse button.
 - "Zoom M1 to M2" and "Full Freq Range" buttons added as a convenient way to zoom in on a frequency range of interest.
 - Units (MHz, dB, deg, etc.) automatically removed from the default title on the XY chart.
 - "Generate Data" button added.
 - Support for the csv files produced by the VNA1 and miniVNA software.
 - Using *Zplots+*, control of the miniVNA hardware.
- Version 1.0, initial release, 10 Nov 2006.