SimSmith Primer
(12/14/2016)

Acknowledgements:

This primer is written for the experienced Smith Chart user. If you are new to Smith charts you would be well advised to watch the tutorials provided at www.ae6ty.com/Smith_Charts.html.

Let me emphasize this a bit. This primer is really a set of notes. It is not an introductory tutorial. Basic operation of SimSmith is best learned by watching the videos. These notes explain some things in detail not covered by the tutorials.

Reading the QRP Quarterly article is probably worthwhile. It is available on my web site or in the 'help' menu if you are running SimSmith.

Let me start out by pointing out a few important aspects of SimSmith.
- Signal flow is "right to left". Yes, this bugs the engineer in me. Still, all of Smith chart software that I have used before work this way so, I decided not to break with tradition.
- (Almost) Everything you might want to update is visible on the screen all the time. I've tried really hard not to have difficult to find information. Version 7 introduced a 'preferences' menu under the 'file'. The preferences menu allows you to specify seldom (if ever) changed items such as 'units' for length.
- Creating a schematic is done using drag and drop. Click on the component you want and drag it to the place you want it. Components can be rearranged in the schematic in the same way.

- As of version 11p4, you can 'cut', 'copy', and 'paste' an item. See 'Editing' below.
- There is no limit on the number of components. As you add components, SimSmith will endeavor to resize them to fit the window.
- The window can be resized to just about anything and SimSmith will attempt to resize everything accordingly. I have relatively poor eyesight so I tend to set the window very large. SimSmith always tries to maximize the font within the area provided. Thus, not all text is the same size but it is maximally readable.
- Values for each element can be set directly by clicking on the field below the component.
- Values for each element can be 'tuned' using the buttons labeled "<<< << < > >> >>>". Left being reduce, right being increase.
- Values for each element can be tuning using the arrow keys as well. Nominally, Left and down are like '<<', right and up are like '>>'. Holding the shift key makes increases the scale by a factor of ten (making it like '<<<' or '>>>'.) Holding control decreases it to '<' and '>'. Holding down both keys decreases it to $1/10^{th}$ of '>'.
- The mouse wheel can also be used to tune parameter values. This feature must be enabled in file/preferences. One click of the mouse wheel is like one click of the arrow key. Shift and control work the same as with arrows.
- Standard values for things like resistors can be forced using the "next", "closest", and "previous" tune buttons. The values may be specified using files. See "standard values" below.
- In SimSmith, every component you add will, by default, have at least SOME loss (except transformers which are non-ideal enough). You can set the losses to zero manually if you like. I consider this a major feature of SimSmith, all devices have some loss, especially transmission lines when used as reactances. *Smith chart software which does not model transmission line losses mislead you and can waste your time.*
- SimSmith provides two basic graphs: the traditional Smith chart and an SWR (or Scattering Parameter) charts. If you use
- Transformers: PLEASE READ THE UPDATED SECTION ON TRANSFORMERs.
- IN GENERAL… SimSmith circuits are NOT BACKWARD COMPATIBLE. It is simply too time consuming to ensure. Make

sure and save any circuit files in a safe place before invoking the newest version of SimSimth.

Most parameters can have certain default properties overridden. Right clicking on a parameter will bring up a menu of the form:
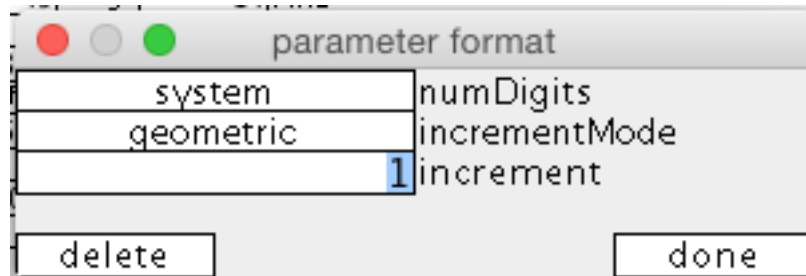
The 'numDigits' field can be left as 'system'. When left as 'system', the file/preferences/numParamDigits value will control. Otherwise the number of digits can be set to 3,4,5,6,7, or 8.

The increment mode can be either 'geometric' (the normal thing) or 'linear'. When 'linear' is selected, the arrow keys will advance the value of the field by the specified increment. In geometric mode, the increment is ignored.

Formatting information for a parameter can be deleted which makes the parameter operate as if no format was ever specified.

This whole thing is useful when you need lots of digits OR you want a parameter to swing positive to negative which cannot happen in 'geometric' mode.

REMEMBER: SimSmith does not always display all the digits it is carrying around. It truncates trailing 0s from nearly all displays so as to make the text as large as possible.

The remainder of this primer discusses important features of the various components and menus.

THE MENU BAR (new in version 4.1) contains several pull down menus. The most important ones are 'file' and 'help'.

Seldom used functions are generally put in the toolbar at the top of the screen. These include a variety of functions including reading and writing of files, capturing images, selection of references, control of what can be viewed, and control of a notes block. References are discussed in detail below.

The circuit is generally constructed by dragging components from the menu on the lower left hand corner to the appropriate place in the circuit. Items can be re-arranged in the circuit in the same way. Components can be selected from the library by clicking on the library icon next to the garbage can at the bottom of the screen.

Items can be deleted from the circuit by dragging them to the garbage can. Items can be removed from the library in the same way. See 'Editing' below for more details.

SimSmith has essentially two modes of operation: 'single frequency' and 'sweep'. An example of a 'single frequency' is:


Nov 30. 2016 11:58:18 AM
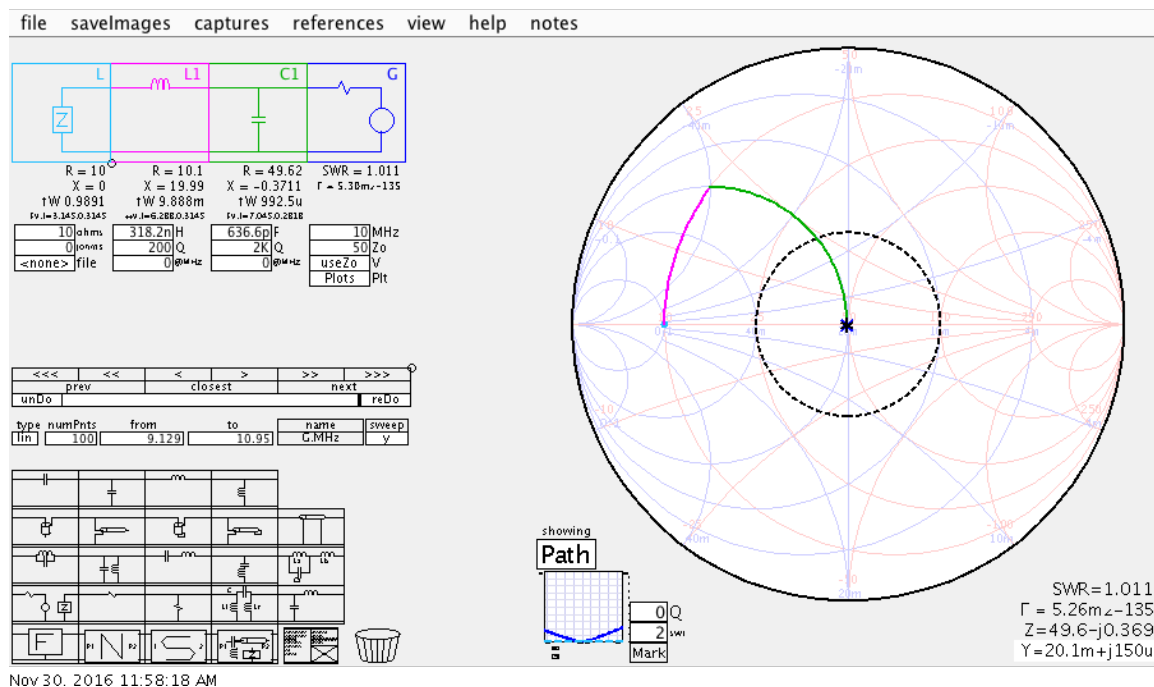
Notice that SimSmith traces the path of the impedance as it progresses from the load (at 10 ohms), through the series inductor (in magenta) and past the capacitor (green). The 'showing' field indicates the display

mode. Clicking on the 'Path' above will change to 'Sweep'. Clicking on 'Sweep' will change the mode to 'Both'; both the Path and Sweep traces will be displayed.

The scale of the Smith chart is controlled by the mouse wheel. Moving the mouse when will zoom in or out around the mouse location. The chart can be repositioned with the mouse by clicking and dragging the chart well away from any trace.

Clicking on the Smith chart will generate a report in the lower right hand corner of the screen. Clicking on a sweep line will generate a report of the frequency (or other swept variable values) at that point AND highlight the associated component.

The Smith chart can display SWR circles and Q curves. The values of these curves are controlled by the parameters in the lower left hand side of the Smith Chart. Multiple SWR circles or Q curves can be displayed by specifying multiple values in the provided fields separated by whitespace. For example, to display the SWR=2 curve:
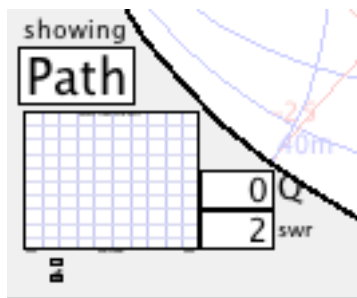
To display SWR=2 and SWR=3:
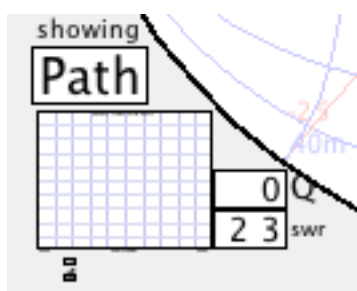
DRAG TUNING:

You can adjust the value of a component parameter simply by 'right clicking' the mouse on the associated arc of the Path display. Simply 'right click' and drag. By default, SimSmith will adjust the value of the arc selected and the arc immediately 'before' the arc selected.

Mouse right clicking on a 'Sweep' arc will change the value of the sweep variables to those necessary to reach that point in the sweep. Please see the video "IntroToSimSmithV7" parts 1 and 2 from at www.ae6ty.com/Smith_Charts.html.

NOTES BOX:
   The 'file' pull down menu contains an entry called "show Notes Box". Clicking on this option will display a box. You can move this box by dragging the upper left hand corner. You can resize the box by dragging any of the other corners. For some silly reason I've been unable to deduce, if a corner falls within a parameter field you won't be able to selected it. To recover from this go to 'help' and click on:
 "recover Notes Box".
    The box can contain multiple lines. The first list is replicated in the title bar.

Clicking on the "PATH" button will change the display of the Smith chart and show how the final impedance changes as a variable is swept. Which variable is swept is controlled by the sweep menu.   Here is an example of the sweep menu:

type	numPnts	from	to	name	sweep
lin	25	1	100	G.MHz	y

In this example, there is only one sweep variable which is the "MHz" parameter of the "G" or generator circuit element. This entry indicates that the G.MHz parameter will be swept from 1 to 10 MHz and plot 25 points. The 'lin' means 'linear spacing'. You can also request 'logarithmic' steps by clicking on the 'lin' button.

More parameters may be added by clicking on the 'name' button in the sweep menu. When you click on the 'name' button, a menu of possible sweep parameters will appear. Below is an example screen shot.

<<<	<<	<	>	>>	>>>	L.ohms
	prev		closest		next	L.johms
						L.file
unDo					reDo	G.Zo
						G.a
						G.b
type numPnts		from	to	name	sweep	G.c
lin 100		90	110	G.MHz	y	G.d

You can 'click and drag' a parameter do the sweep menu. Here is the menu after the addition of two items:

type	numPnts	from	to	name	sweep
lin	100	90	110	G.MHz	y
lin	100	45	55	G.Zo	n
lin	100	45	55	L.ohms	n

In this example there are three sweep parameters listed. However, only one is being used: G.MHz. The G.Zo and L.ohms parameters are NOT being swept as indicated by the 'n' next to their names.

Clicking on the 'y' or 'n' in the sweep column toggles the sense. Here is the menu after having clicked on the 'A.H', then the 'B.F' and then the 'G.MHz', y/n buttons:

type	numPnts	from	to	name	sweep
lin	25	10	30	G.MHz	n
lin	25	139.8n	552.2n	A.H	y
lin	25	22.43p	374.4p	B.F	y

Here is a complete picture of the screen after showing the "PATH" but having the two sweep variables set:
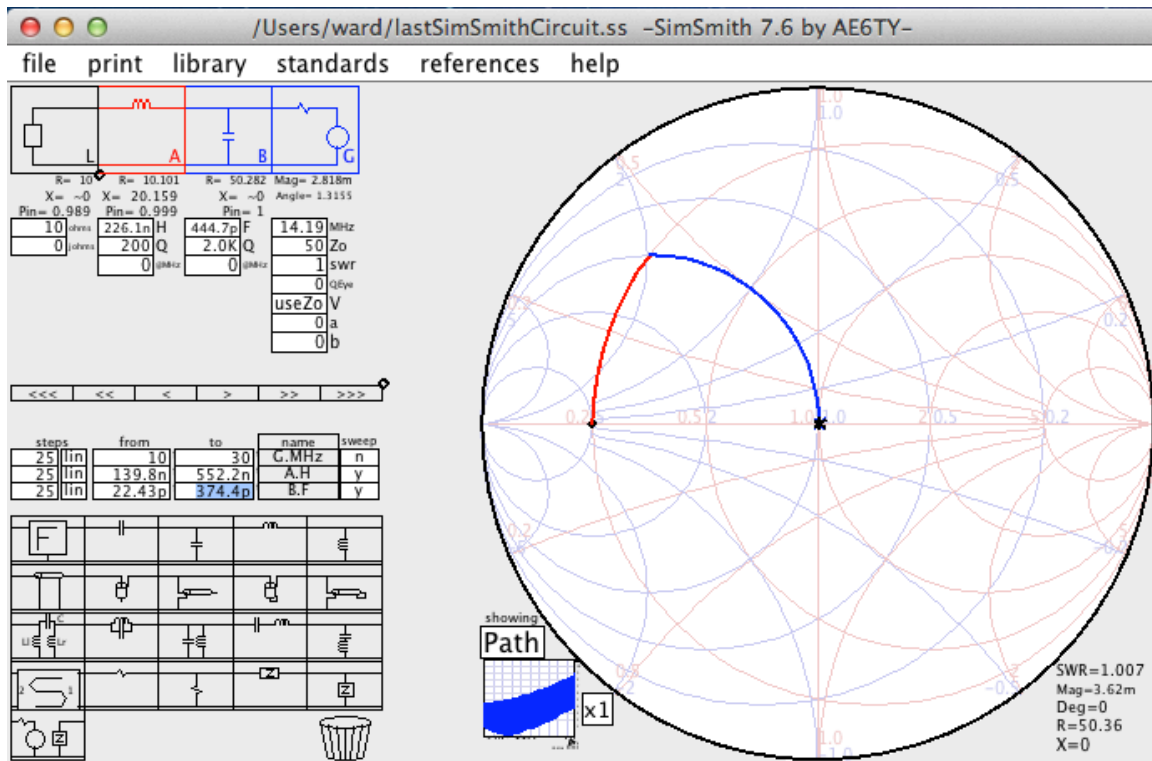
The Smith chart display can be switched to sweep mode by clicking on the 'Path' button:
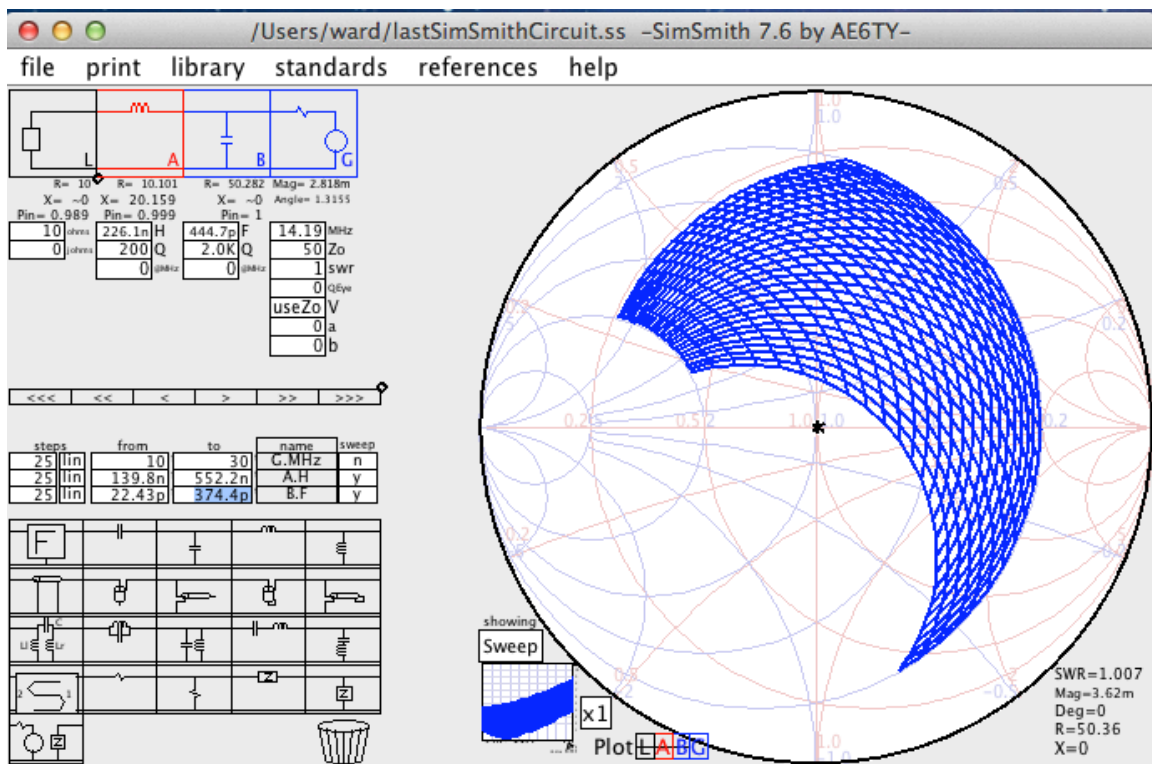
During a sweep, the steps can be equally spaced (lin) or logarithmically spaced (log). You can select which is being used by clicking on the button in the 'steps' column. Of course, you can change the lower and upper bounds of the scan and the number of steps to take. You can even reverse the direction of the scan if you wish.

When displaying the Smith Chart a menu at the bottom called "plot" lists which signals can be displayed on the chart. A letter with a line through it means the signal is not being displayed. Clicking on the letter will add or remove the line thereby displaying or not displaying the signal.

IMPORTANT: when doing multivariable sweeping it is easy to ask for tens or even hundreds of thousands of points. This can cause SimSmith to 'hang' for a very long time. To avoid this, SimSmith limits the maximum number of points it will plot. The size of a sweep is controlled by two parameters maintained in 'file/preferences': ExtendedSweepSize and NormalSweepSize. As might be expected, normally SimSmith will limit the number of points to "NormalSweepSize" by scaling each swept parameter proportionately. An extended sweep can be requested by clicking on the 'sweep' button next to the 'name' button in the sweep parameter menu.

It is the author's intent to have the size revert to 'normal' when any parameter is edited. It may revert unexpectedly. When the extended sweep is performed, the 'sweep' button will turn green. Clicking on the green button will turn the button gray and will cause a sweep 'normalSweepSize' to take place.

It is highly recommended that the 'normalSweepSize' be kept small as it directly affects responsiveness during editing. Reasonable values for the 'extendedSweepSize' are machine dependent. SimSmith uses massive amounts of memory when you set the 'extendedSweepSize' large.

FILES AS SWEEP PARAMS
   Load and Scattering parameter files can be used as sweep controllers. Simply click on the 'name' button of the sweep menu, select the

appropriate parameter and drag it to the sweep menu. If the sweep is enabled the frequencies specified in the file will be used for a sweep. Only one 'frequency' parameter may be enabled at a time. Thus, if you enable the "L.file" sweep parameter, SimSmith will disable the "G.MHz". If you then enable "G.MHz" then the "L.file" will be disabled.

For 'Load' files, the Sweep menu provides a secondary function. Consider the following sweep menu:

steps		from	to	name	sweep
386.93	lin	12	18	G.MHz	y
25	lin	139.8n	552.2n	B.H	n
25	lin	22.43p	374.4p	A.F	n
vertical.txt			clr	L.file	n

Here the 'L.file' parameter has been added to the sweep menu. This means that the impedance of the 'L' circuit element is being specified by the file 'vertical.txt'. This is true EVEN IN THE SWEEP IS NOT ENABLED. To stop using the file you can remove then 'L.file' parameter from the sweep menu by dragging it to the trash can.

If you enable the sweep of the 'L.file' parameter, SimSmith will sweep the frequency based on the contents of the 'vertical.txt' file.

ONE OF TWO TYPES OF CHARTS:

The CHART section of the SimSmith window can display either the Smith chart or one of two Square charts. If the Smith chart is being displayed, a small copy of the Square chart is shown. Clicking on this small Square chart will change SimSmith from 'Smith' to 'Square' mode.

There are two types of square charts. The type of square chart being displayed is controlled by clicking on the button below the 'showing' label. The most commonly used chart is the 'SWR' chart. When the SWR chart is showing there are two menus at the bottom of the chart, one called "Pwr" and one called "SWR". Which signals traces are displayed is controlled with these menus.

The "Pwr" trace shows the power being dissipated by that component. The "SWR" trace shows just that.

The scale of an axis may be changed using the mouse wheel. Simply move the mouse pointer over the axis of interest and move the mouse wheel. The amount of gain is controlled by the 'help/preferences/wheelGain' parameter. The scale will move up and down accordingly. The chart is zoomed around a 'pivot line' which is selected as described below.

Occasionally, there is a desire to adjust the scale to an arbitrary increment. This can be done by holding down the control key while zooming.

Zooming all the way out will reset the pivot line.

The 'pivot line' is set when you press a button on the vertical axis. The 'pivot line' will snap to a grid point. If you do not want it to snap to a grid point you may hold down the control key when you click on the axis.

You can move the axis up and down using the familiar click/drag motion. When the mouse button is released the axis will 'snap to' the closest grid point (if appropriate).
Occasionally there is a desire to suppress the 'snap to' at the end of a axis move. The snap will NOT occur if the control key is depressed when the mouse button is released at the end of the drag.

The horizontal axis if the Square chart can be either "linear" or "logarithmic". The mode is selected by clicking on the button. The label of the button indicates what is being displayed (rather than what will be displayed). Usually, if you are displaying things with a logarithmic scale you'll want your sweep to be logarithmic as well. It is not automatic, though, because this is not ALWAYS the case.

In the logarithmic scale with a descending scan range (say 10u to 10n), the logarithmic scale is 'reversed'. It can look strange and so I mention it here.

Clicking on the square chart near a line will generate a report about that point on the line. If the mouse is not close enough to a computed point, the report will not be generated; no interpolation is provided.

When displaying the Square chart you can switch to the Smith chart by click on the small Smith chart at the lower left hand corner.

Component specific notes:

TRANSMISSION LINES:
Transmission lines have 7 parameters: length in degrees at a given frequency, the given frequency, the length in feet (or meters), the velocity factor, the character impedance (only real right now), the loss in db at a given frequency and that given frequency. The formula "sqrt(f/fo)" is used to calculate the loss at other frequencies.
Changing one value of a transmission line can cause others to change so that things remain consistent. For example, if you change the velocity factor, SimSmith will change the length to keep the 'degrees' constant. When you change the length, the degrees will change. When you change the degrees, the length will change, etc.
Special note should be made of the '~deg' parameter. The '~' is significant as it indicates that the parameter is an approximation. Because it is a function of the 'velocity factor' and the 'velocity factor' can change by small amounts (see below), the '~deg' report can change unexpectedly. Indeed, it is possible to edit the value directly but after having completed the edit the '~deg' will be rewritten. To avoid this, when fine tuning the length of a line, it is best to adjust the 'len' field rather than the '~deg' field.

TRANSMISSION LINE MODELS
While we are here, a few notes about transmission line models are in order.
Transmission lines in SimSmith are modeled using the familiar 'k0,k1,k2' model. The algorithms used were graciously provided by Dan Maguire, AC6LA. In this model, k0 is used to describe the DC resistance of the line. It rarely comes into play in SimSmith but it is there. The k1 parameter represents losses do to skin effect. These losses dominate at HF frequencies and grow with the square root of frequency. Finally, the k2 parameter represents dielectric losses and grow linearly with

frequency. These losses become progressively more important as the frequency increases and start to make a significant difference well above HF.

Dan was kind enough to provide his database of commercial transmission line parameters. A specific product can be selected by clicking on the 'Mdl' parameter.

In addition to resistive losses, Dan's model also refines the 'velocity factor', making it lower at low frequencies. This becomes progressively more important below 1 MHz. His model also refines the Zo creating a Zeff (effective). The result of this is that Zeff can have a significant 'imaginary' part. There is no magic here: any transmission line with losses will necessarily have a characteristic impedance with an imaginary component. The imaginary part tends to disappear at higher frequencies.

Under most circumstances, a simplified model of a generic transmission line is adequate. In this case, the 'simplified' model can be used. The simplified model takes a pair of parameters called '/100f' (where 'f' for feet, 'm' for meters, etc.) and @frq which specifies the frequency at which this loss was specified. SimSmith uses these parameters to compute a 'k1' for handing off to Dan's model. K0 and K2 are assumed 0.

It may appear that assuming K2 is zero will cause problems at higher frequencies. To reduce the errors, it is best to set '/100f' and '@frq' close to the frequencies of interest. For example, if one is working on 2m, use the vendors '100 MHz' or '200 MHz' loss data. The manufacturer's data contains within it a part of k2. Only if you are working well away from the '@frq' frequency will k2 issues become a problem.

In the event one is uncomfortable with this approximation the 'k0k1k2' model can be used. Start with a commercial model from Dan's database. Select it and then change the model to 'k0k1k2' model. The k0k1k2 parameters from the commercial model will be preserved. Then, adjust the parameters as necessary to achieve correct predictions.

It is important to note that any transmission line model is exactly that, a model. Ultimately, you'll need to build, measure, and adjust to achieve model/reality parity.

CAPACITORS:

Capacitors have three parameters: value, Q at a given frequency and the given frequency. The losses associated with Q do change as a function of frequency. Setting the Q frequency to zero means the Q is constant independent of frequency. The losses associated with Q go up with the square root of frequency: $Q = Qo/sqrt(Foperating/Fo)$. Specifying a Q of zero is really setting it to infinity.

INDUCTORS:

Inductors have three parameters: value, Q at a given frequency and the given frequency. Setting the Q frequency to zero means the Q is constant independent of frequency. The losses associated with Q go up with the square root of frequency: $Q = Qo/sqrt(Foperating/Fo)$. Specifying a Q of zero is really setting it to infinity.

RESISTORS:

Nothing special about resistors.

GENERATOR:

The generator is always present and is always at the right hand side of the schematic. The generator has many parameters. The Zo specifies the impedance of the center of the Smith chart and "SWR=1" for the SWR chart.

The MHz indicates the frequency for "PATH" displays and for the frequency at which all component impedances are presently reported on the circuit elements.

The V parameter is an equation that controls the voltage delivered by the generator. The equation can have up to four arguments whose values are controlled by the 'a' through 'd' parameters.

LOAD:

The load is always present and is always at the left hand side of the schematic. It always has two parameters showing, the 'R' and the 'X'. If the 'L.file' parameter has been added to the sweep menu then the 'R' and 'X' fields will be grey and cannot be changed since they are being derived from the provided file.

The load file can be provided in several formats and SimSmith uses heuristics to figure out what the file format must be. These formats and the heuristics are:

- EZNEC: the EZNEC file format is recognized by observing the string "Freq MHz", quotes included. The remainder of the file has lines of the form: srcNumber,R,X,SWR,altSWR. SimSmith pays attention to the R and X fields which are floating point numbers.
- EZNEC: SimSmith also recognizes the 'GAM' files produced by EZNEC. I've been told that the GAM file will be deprecated in the next release of EZNEC but I've no idea when that will be.
- miniVNA and miniVNApro: the miniVNA file format is recognized by observing a line of the form Freq,R,X. Subsequent lines are of the form F,R,X and SimSmith pays attention to all fields which are, of course, floating point numbers.
- AIM4170: the AIM4170 file format is recognized by observing a line of the form: Freq(MHz). Subsequent lines are of the form: Freq,SWR,Rs,Xs,Zmag,Theta,Rho,ReturnLoss,%ReflectedPower. SimSmith pays attention to Freq, Rx and Rx fields which are floating point numbers.
- CocoaNEC: cocoaNet files are recognized by observing the words: NUMERICAL ELECTROMAGNETICS CODE (nec2d). The file format is verbose and I won't try to say how SimSmith extracts the Frequency, Resistance and Reactance values. Sorry.
- Kok Chen (W7AY) provides some support for the Rig Expert antenna analyzer. His '.aaplot' file format is supported by SimSmith.
- Support for "Touchstone S1P" files is provided. SimSmith looks at the extension ("s1p") to determine that it should expect a touchstone one port file.
- When an S2P file is being used to describe al load impedance, SimSmith examines the file name further. If the file name contains the string "shunt" or "shnt" or "snt" then SimSmith assumes the component was characterized in 'shunt'. Otherwise, it is assumed to have been measured in 'series'.
- MMANA impedances files can be used as well.
- Generic CSV file. See below.
- Any file whose title matches (case independent) "mhz*db*deg".

The easiest format to make by hand is the generic CSV file. The generic CSV file must start with a line of the form "Generic fCol fScale rCol xCol". Subsequent lines are parsed for numeric values. The 'fCol' line indicates which column contains the frequency info with '1' being the first

column. The 'fScale' field is a double indicating the scale of the frequency column. As an example:

    Generic 1 1e6 2 3
    1,50,0
    2,100,0

specifies a load file with frequency ranges of 1 Mhz to 2 Mhz with the first point at 50 ohms and the second at 100.

SimSmith will parse lines ignoring extra columns until it comes to a line that it can't parse into the necessary number of numbers. No warnings are given concerning malformed lines. 'Generic' allows great flexibility in the file format but is quiet concerning problems. Users of 'Generic' will need to make sure all the appropriate data is being read from their file.

SimSmith does a linear interpolation to compute the load for frequencies not explicitly described. Thus, in the above example, at 1.5 MHz SimSmith would compute the load to be 75 ohms, real.

F BLOCK:
    The F Block allows you to write equations rather than use the components. See the "F Block Syntax" button on the 'help' menu for details.

N BLOCK
    The N Block allows you to enter an arbitrary netlist of RLC components. It uses numerical methods to analyze the circuit. See the "N Block Syntax" entry in the 'help' menu for details.

STANDARD VALUES:
    The standard values for resistors, capacitors and inductors can be overridden by loading from files. The file contains comments and numbers. Comments start with "//" and continue to the end of the line. Numbers can be simple floating point numbers or engineering numbers like:

            // comment.
            10p // another comment.
            20p 1u
            8M 2k

The numbers need not be in any particular order.

SimSmith tries to warn you if it can't make sense of the line but it is assumed the file is well formed.

Transformers as of 12/14/2016:
Transformers are notoriously non-ideal devices. Transformers in SimSmith are specified much the same was as is done in PSpice. You specify the inductance of the two inductors (call Ll and Lr) and the coupling coefficient 'k'. The transformer symbol is:
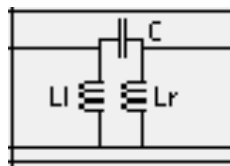
Ignoring the capacitor, the internal model for the transformer is a T network of inductors.
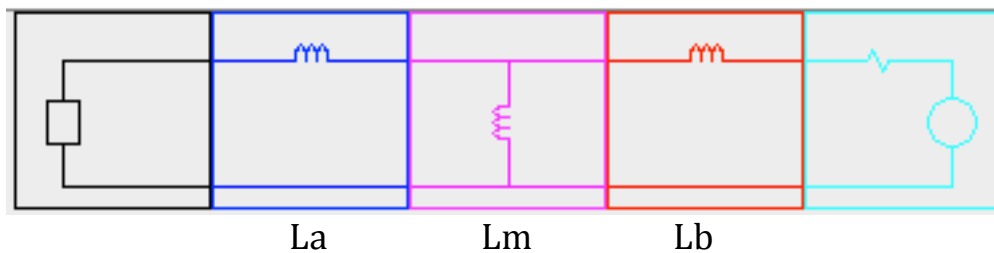
Where:

$$Lm = k \; Sqrt(Ll \; Lr)$$
$$La = Ll - Lm$$
$$Lb = Lr - Lm$$

SimSmith's transformer is 'lossless' but distinctly NOT ideal. Ideal transformers are those in which Lm is infinite. You can, of course, set Ll and Lr so high as to make Lm essentially infinite.

This model of a transformer is unfamiliar to many folks who prefer to think of transformers as more simplified devices. Specifically, if one is willing to assume k is equal to 1, then a simpler model can be used.

Here, you need only specify the primary magnetizing inductance and the turns ratio.

To use this model you need only click on the 'mdl' property of the transformer circuit element. When you click on 'mdl', SimSmith will change the available parameters to 'Hr' and "n". 'n' is the turns ratio so, for example, if you have a 4->1 impedance transform the turns ratio will be 2 OR, if the transformer must be reversed, ".5". For Example:
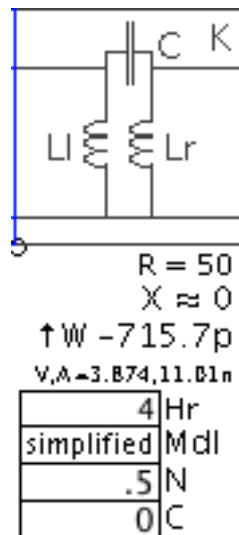
If you don't know the primary magnetizing inductance simply set it to a big number. For example, '1' which would be one Henry... a truly large inductance.

SimSmith version 11.10 introduced an 'auto transformer' model. Clicking on the 'mdl' property of the transformer will offer the option of 'auto'. As of 14.3 it looks like this:
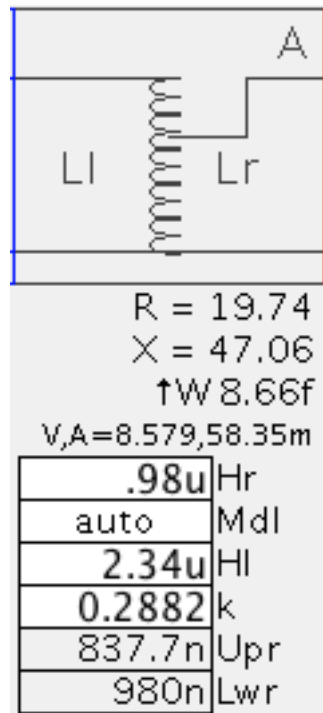
When using the 'auto 'model, the transformer consists of a single coil with two taps. As with the isolation transformer, the auto transformer requires the specification of the inductance of the two taps and the coupling coefficient 'k'. SimSmith requires that the k be >= 0. It is allowed to be larger than 1 but that makes the transformer 'non-physical'.

The autotransformer has two 'reported' parameters: "Upr" and "Lwr". These are the inductances, in heneries, of the 'upper' and 'lower' inductors. As one might expect, 'Lwr' is the smaller of Hr and Hl. 'Upr' is computed taking Hr, Hl, and k into account.

It is often tempting to model transformers as having coupling close to 1. This can be true for transmission line and ferrite core transformers. However, it is distinctly NOT true for powdered iron core transformers. Considerable care must be taken to get a k better than .8 using typical powdered iron cores.

One final note: as one might expect, the transformer also represents a difficult component to 'trace' on the smith chart. To keep things simple,

SimSmith draws an arc from the input impedance to the output impedance. The arc is drawn as though the transformer were a shunt device.

S Block:

   Version 4.9 adds the S block. S blocks require a TouchStone two port, S parameter file. SimSmith excepts the file name extension to be "s2p". The touchstone file format allows the specification of a wide range of data and formats. The frequency units may be "HZ KH MH GH" and the data format can be "RI" "DA" and "MA".
   SimSmith does a linear interpolation between provided data points.
   The default S block has port 1 on the right. This can be a bit disturbing but is a result of SimSmith's power flow being right to left. You can reverse the direction by clicking on the 'dir' parameter.

Z Block:

   The Z block allows you to read in any 'load' file and place it anywhere in the circuit.

LIBRARY:

   There are times when you develop a component (say in an F block) and you would like to save a copy of it. SimSmith allows you to save a circuit element by simply click/dragging it. You can drag it to your desktop or to your system file handler OR to the SimSmith file chooser.
   The SimSmith file chooser becomes visible when you drag a component and hover over the icon show below:
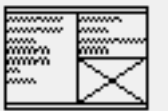
   The SimSmith file chooser can be used to navagate to any directory in which you might want to save files.

SESSION AUTO SAVE AND RESTORE

   Under normal circumstances, SimSmith keeps a copy of your last circuit in a file called "lastSimSmithCircuit???.ss" which is stored in your home directory. The ??? can change depending on the version of

SimSmith you are using. If you exit a session and then restart it, SimSmith will attempt to read in this file to restore your session.

REFERENCES

You can write out trace files and read them back in as references. You can also read in a load file of any of the supported formats including EZNEC, COCOANEC, AIM4170, miniVNA FRX files, and touchstone S1P files. Others are occasionally added. Please check the web site for a complete list.

These load files can be displayed as a 'reference' on the Smith and SWR charts. You can add a reference file by clicking on the 'reference' button of the tool bar, selecting 'add' and then selecting a file in a supported format. To remove the reference file, simply drag it to the trashcan.

On the Smith chart, all the data of the reference chart are drawn. The lower frequency end is marked with a small dot and the upper frequency end is shown with an x. When the 'generator frequency' is within the range of the reference trace a small circle will be drawn on the reference at that frequency. If the frequency is out of range no circle will be drawn.

When displaying things on the SWR chart, the references are only shown when the horizontal axis is frequency. The reference trace may not cover the entire swept frequency. Only ranges where the data is valid are displayed. For example, below you'll see a reference that covers 10 to 20 MHz while the scan covers 5 to 30.
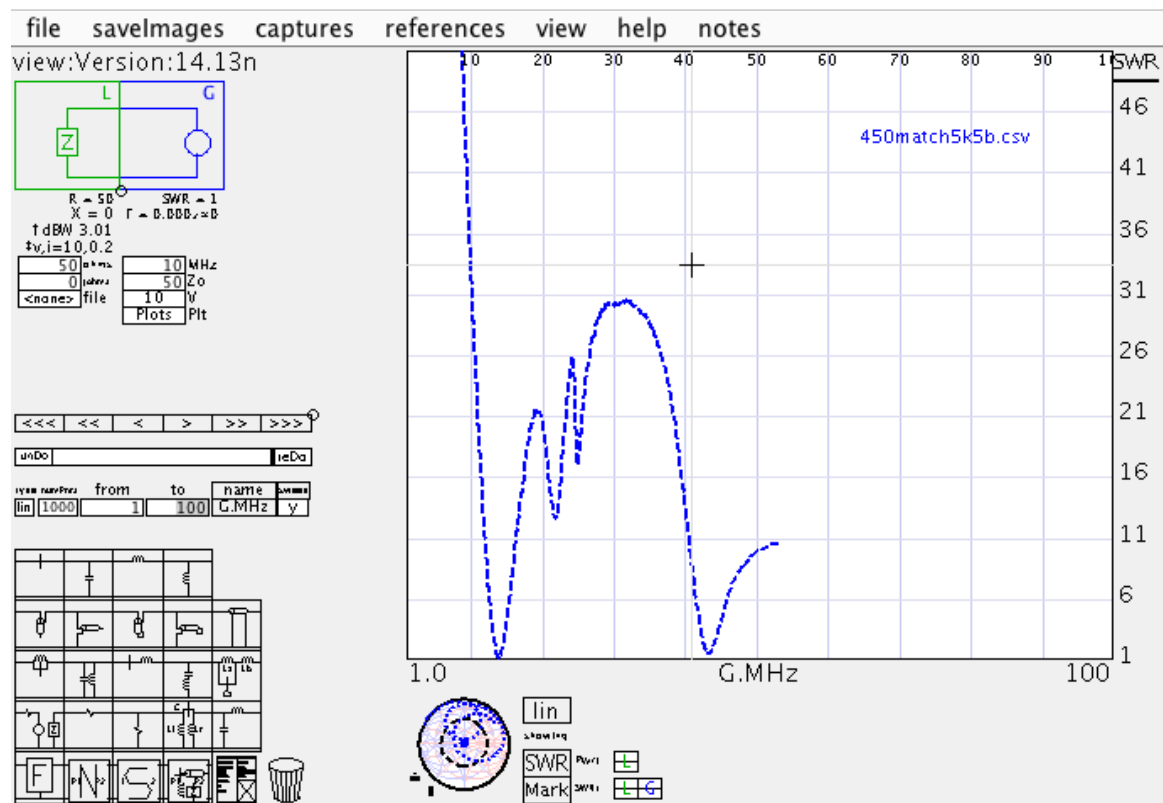
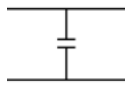Please see my tutorial video "SmithTutorial7" for more details.

CIRCIUT ELEMENTS:
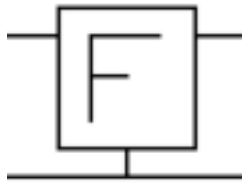
The F block is provided as an escape hatch. It allows you to write an equation for the impedance transformation. The equation syntax is described in "help/F block syntax".
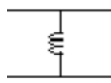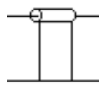
Series Capacitor.

Shunt Capacitor

Series Inductor

Shunt Inductor

Series Transmission line. Two models are provide. The 'Simplified' model which takes a single loss parameter (dB/foot or dB/meter) and decomposes that loss into K0/K1/K2 as defined by Dan Maguire AC6LA. The other the K0/K1/K2 model as provided by Dan. He uses manufacturer's data. Click on the 'mdl' to change models.
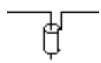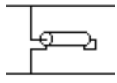
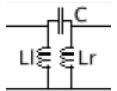Series Open transmission line stub.
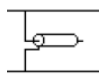
Shunt, Open transmission line stub.
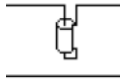
Series, Shorted transmission line stub.

Shunt, Shorted transmission line stub.

Transformer with winding/winding capacitance C. The transformer is modeled as two 'coupled' inductors. Two models are provided. The first, called 'coupled' specifies the winding inductances Lr and Ll and the coupling coefficient 'k'. The second, called 'simplified' specifies the Lr and the winding ratio. The winding ratio can be any positive number.

Series, Parallel LC. Commonly called a 'trap'. At resonance the impedance is very high. Losses can be important to consider.
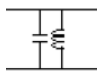
Shunt, parallel LC. This can be modeled as two independent elements. The combination is provided to simplify the circuit description and to allow for coupled 'tuning' of the LC pair.
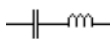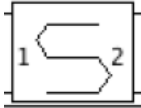
Series, Series LC. This can be modeled as two independent elements. The combination is provided to simplify the circuit description and to allow for coupled 'turning' of the LC pair.
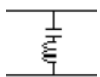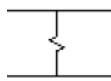
Shunt, Series LC. Sometimes called a 'trap' or a 'tuned shunt'. This circuit has very low impedance at resonance. Can be used as part of a filter circuit.
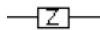
S Block. This block allows you to describe a circuit element using 'Scattering parameters'. The parameters may be specified on the element or using a 'touchstone s2p' file.
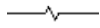
———— Series Resistor.

———— Shunt Resistor.

———— Series impedance. This allows you to specify a complete impedance. It is essentially a resistor except that you can specify a reactance as well. The impedance can be specified on the component or using a 'load file'. Many load file formats are supported. The best specified would be the 'touchstone s1p' file format.
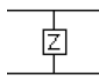
———— Shunt impedance. This allows you to specify a complete impedance. It is essentially a resistor except that you can specify a reactance as well. The impedance can be specified on the component or using a 'load file'. Many load file formats are supported. The best specified would be the 'touchstone s1p' file format.
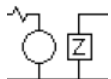
———— Generator/Load block. This block is generator to the left and a load on the right. Using this block allows you to evaluate two circuits at the same time.

   When you use this block and are displaying the 'path' on the Smith chart, an additional menu is provided. This menu allows you to choose which of the independent paths you want to see. The entire path leading up to a selected item is displayed.

Generator. This block creates the signal entering the circuit being analyzed. You can write an equation for the voltage using the same syntax as the F block's. Five 'predefined' options are provided:

'useZo' which provides a Thevenin equivalent with Vthev = 2Sqrt(Zo) and RThev = Zo. Thus, the equation is V = 2*Sqrt(z)*I/(I+z).

'cloneGen' which allows the Isolate block to mimic the behavior of the Generator equation. This can be used only in isolation blocks.

'xMtch' which adjusts V so that 1 watt enters the circuit. The equation is, therefore, V = Sqrt(1/Real(1/I)). There may be an easier equation...

'fixedV' which sets V = Sqrt(Zo);

'forXfer' for scattering parameter transfer measurements which sets V = 2 I/(I+Zo)

These three 'useZo', 'xMtch', and 'fixedV' take a single optional argument which scales the power. For example, 'xMtch' is the same as 'xMtch(1)' which delivers 1 watt. 'xMtch(10)' delivers 10 watts.

The final 'predefined' generator equation is 'outpuZ(val)'. This form is used when you want to model the generator as having some internal impedance. For example, if you measurement indicates an impedance of 10-4j ohms then you would use "outputZ(10-4j)" as the generator. The Thevenin voltage is set to that necessary to deliver 1 watt to Zo ohm.

outputZ takes an optional second arg which specifies the power to be delivered to a load of Zo. For example, outputZ(a+jb,c) will deliver c watts to a load of Zo ohms.

Note that 'outputZ(z)' is equivalent to useZo.

As of 14p10, these predefined functions are 'special' in that their returned value is 'preferred' over other values computed in 'V' expressions.   The following are now equivalent:

>   useZo ; a=23;
>   a=23; useZo

(Prior to 14p10 the first equation would have set a to 23 and returned 23.)
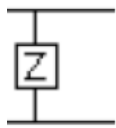
Load. Essentially a Z with nothing connected to the left.
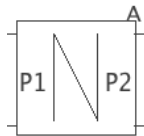
Network block. Enter an arbitrary netlist of RLC, independent and controlled voltage and current sources.
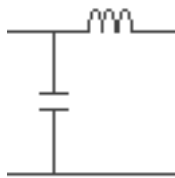
XMatch. This circuit element is designed to provide an automatic tuning element. It can be either 'low pass' (as shown here) or 'high pass' and can have the first element be 'shunt' or 'series'.
It can run either 'automatic' or 'manual'.

When running in manual mode the L and C values can be set. Manual mode is provided as a way to 'freeze' the values of L and C but is not intended as the normal operating mode.

When running in 'automatic' mode, the element will automatically set the 'shunt', 'L', and 'C' values so as to effect a match to the impedance specified by R+jX at the frequency specified by MHz. If R+jX is absolutely zero, the match impedance is specified by G.Zo. If the MHz parameter is zero, the element is adjusted to provide a match at all frequencies.

The mathematics for this element are, well, extensive and this element has not been extensively debugged. Use caution.
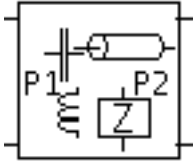
RUSE Block: this block is a 'front end' to the 'N' block. It allows you to draw simple schematics which are translated into 'N' block equations for you.

Touchstone S2P Files as loads

Touchstone S2P files can be used as load files which include the 'Z' files. If the file name has the letters 'shnt', 'shunt', or 'snt' then the SimSmith assumes the device was measured in a 'shunt' configuration. Otherwise, it is assumed to have been measured in 'series'.

Voltages, Currents, and Power

Internally, SimSmith does not actually compute impedances. Rather, it computes the voltage and current flowing into each electrical node of the circuit. As might be expected, these voltages and currents are complex values; they have a magnitude and phase. SimSmith, however, reports voltages and currents as an RMS magnitude and does not report phase.

SimSmith displays the voltage and current on the circuit diagram immediately above the circuit elements' parameters, just to the right of the 'V,A=' label. Again, the voltages and currents are RMS values.

For most circuit elements, the reported voltage is 'across' the circuit element and the current is 'through' the element. Thus, for a series resistor the voltage reported will be the difference between the 'voltage on the left' and the 'voltage on the right'. (NOTE: since there is no 'angle' information, there can never be a negative voltage....)

For a 'shunt' resistor, the voltage reported will be the 'voltage on the right' which is, of course, the same as the 'voltage on the left'.

Again, for most circuit elements, the reported current is that current flowing THROUGH the element.

There are several circuit elements which are somewhat more complex than simple RLCs: the F,N, and S blocks as well as the series transmission line. These elements are more complicated because the

can be both 'shunt' and 'series' devices at the same time. For no particular reason, the following is true for version 9.9:

NBlock: Voltage reported is the voltage on the right hand side.
            Current reported is that 'through' the N block.
FBlock: Voltage and current are NOT reported at all.
SBlock: Voltage an current are NOT reported at all.

Series Transmission line:
            Voltage is the voltage on the right hand side.
            Current is the current flowing INTO the right hand side.

Please note that these reports may well change with future releases as things evolve. (Specifically: I would like to report the PEAK voltage and current in a transmission line.)

Closely related to voltages and currents is 'power'. SimSmith reports the power being dissipated by each element. As of version 10.1, the user may select the units used (dBW or watts) using the 'preferences' menu.

SimSmith reports the power being dissipated by all circuit elements (expect the generator). If the power is very low, SimSmith will report "~0" watts.

In addition to reporting the power dissipated by each circuit elemnt, SimSmith can also plot the power being dissipated by each element in the 'Square' chart. The 'Pwr' selection menu is used to select which elements should be plotted. The units used are the same as for the circuit elements.

With version 11.4, the 'power entering the right' of each circuit element can be plotted as well. There are now four ways power can be plotted:

Label	Description
↑W	Power dissipated by each element
↑dBW	Same but in dBW
←W	Power entering a circuit element from the right
←dBW	Same but in dBW

NOTE: it is sometimes confusing that the power being reported is NOT the arithmetic 'product' of the voltage and current being reported. This is because the voltage and current are not exactly in phase. For example, for a perfect capacitor, the voltage and current are 90 degrees out of phase and so no power is being dissipated. For lossy devices, the voltage and current are not exactly 90 degrees out of phase and, so, some power will be dissipated.

Power and the Generator

Of course, the power being dissipated by any given component is directly related to how much power is entering the circuit from the generator. SimSmith allows the user to specify the voltage being delivered by the generator using an equation. Several 'predefined' equations are available and described above. What follows is a bit of explanation.

When exploring and manipulating impedances, most users really don't care about the Generator characteristics. However, when exploring power related issues, the Generator characteristics become paramount. SimSmith has a very primitive view of Generator characteristics: it allows the user to specify only the Generator output voltage. Thus, for the simplest cases, the user can just put in a number. For example: here is a circuit with a 1 volt (RMS) generator feeding a resistive divider:

R = 50	R = 200	SWR = 4
X = 0	X = 0	Γ = 0.6∠≈0
1.25m W	3.75m W	
V,A=0.25,5m	V,A=0.75,5m	

50	ohms
0	ohms
<none>	file

150	ohms

10	MHz
50	Zo
1	V
0	a
0	b
0	c
0	d
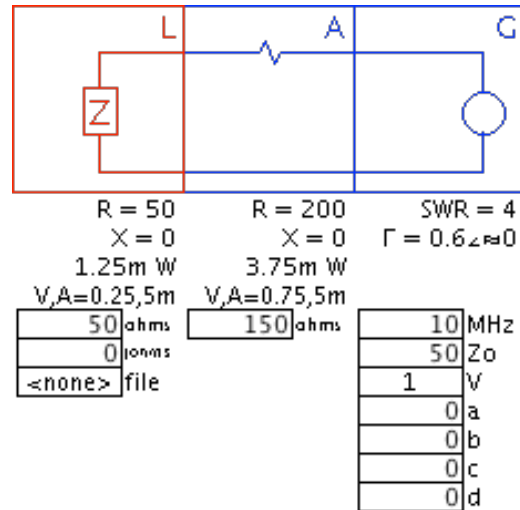
Notice that the voltage of L is .25 volts and the voltage across A is .75 as expected. Note that the current through both resisters is the same. This is, by far, the easiest use of the generator equation and is generally adequate for most situations. There are, however, times when the generator voltage must vary.

For example, suppose the goal is to measure the losses of a matching circuit. The easiest way to determine this loss is to 'deliver 1 watt' into the circuit and examine the 'power dissipated' by the L element. Here is an example circuit:

R = 25	R = 25.127	R = 50.736	SWR = 1.017
X ≈ 0	X = 25.381	X = 0.4049	Γ = 8.3m∠28.6
−24.2m dBW	−22.97 dBW	−33 dBW	
V,A=4.986,0.199	V,A=5.062,0.199	V,A=7.123,0.141	

25	ohms
0	johms
<none>	file

377.1n	H
200	Q
0	@MHz

293.3p	F
2K	Q
0	@MHz

10.712	MHz
50	Zo
xMtch	V
0	a
0	b
0	c
0	d
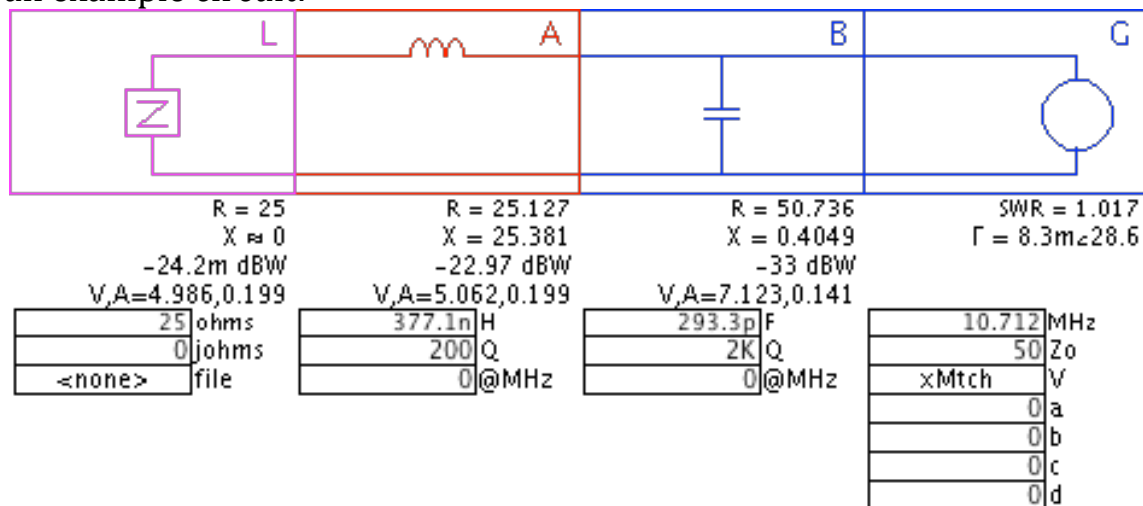
This is a simple LC impedance match from 25 ohms to 50 ohms at 10 MHz. The generator V equation is using the 'xMtch' builtin which ensures that, regardless of the circuit impedance, 1 watt will be

delivered to the circuit. In the above, 1 watt is being delivered by the generator and the load is dissipating -.0242 dbW watts so the LC network must be dissipating .0242 dbW.

In version 10.1 you can choose to see power in watts and the circuit would be:
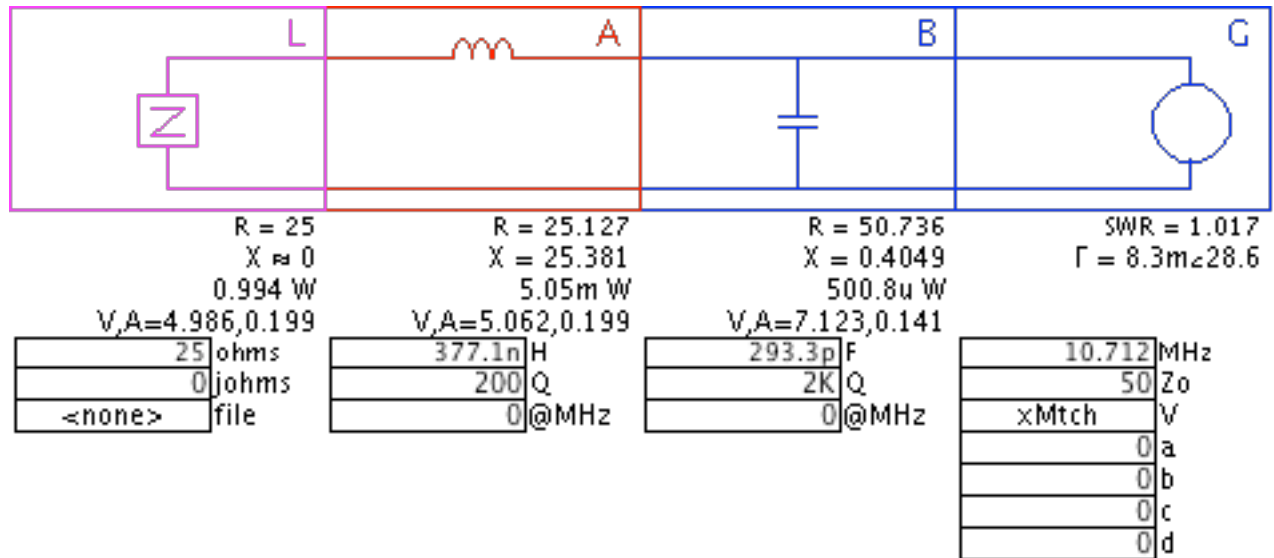
 Thus, 'xMtch' is delivering 1 watt and .994 is going to the load and .00505 + .0005 watts is being dissipated by the LC match.

However, now look at what happens when the match is not correct because the frequency is not 10 MHz:

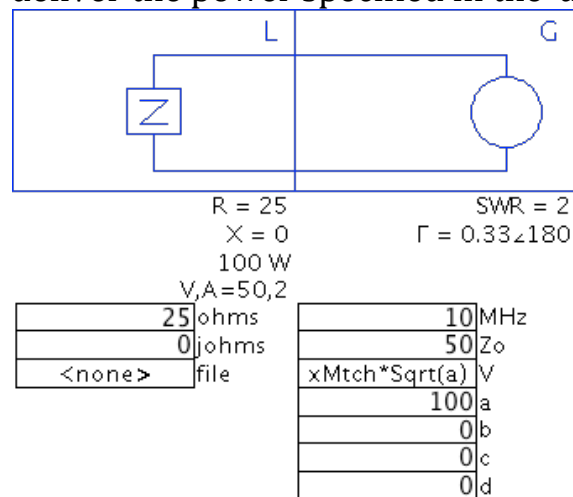|	R = 25		R = 25.592		R = 0.2528		SWR = 208.9	
	X ≈ 0		X = 118.47		X = -11.888		Γ = 0.99∠-153.3	
	0.952 W		22.5m W		25.8m W			
	V,A=4.878,0.195		V,A=23.11,0.195		V,A=23.65,2.179			
25	ohms	377.1n	H	293.3p	F		50	MHz
0	johms	200	Q	2K	Q		50	Zo
<none>	file	0	@MHz	0	@MHz	xMtch		V
							0	a
							0	b
							0	c
							0	d
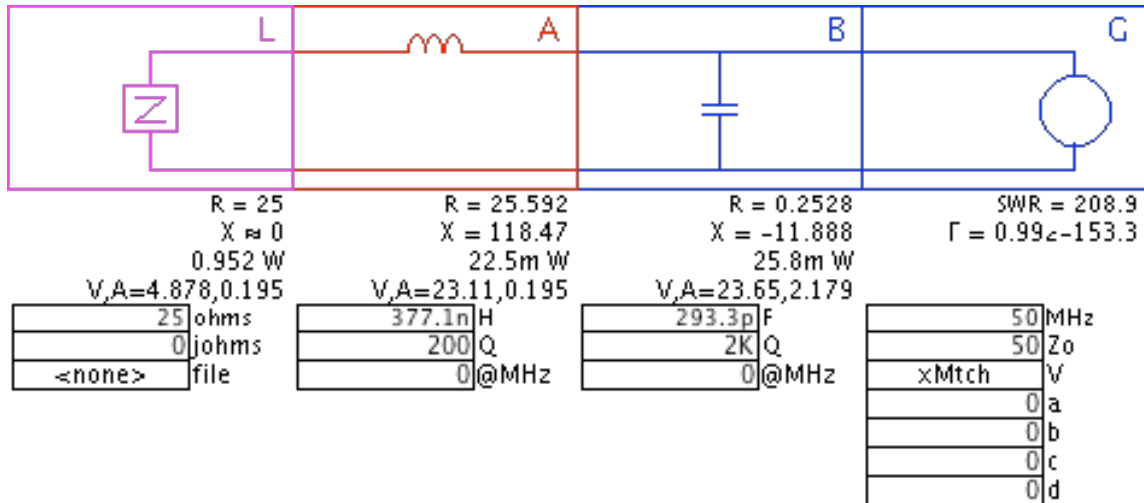
Here, the 'xMtch' must adjust the voltage upward significantly in order to deliver 1 watt to the circuit: now 23.6 volts instead of only 7.07. The load gets .952 watts and the LC circuit dissipates 50 milliwatts. The components are not very lossy so the majority of power still gets to the load but the generator must (and does) compensate for the large impedance mismatch.

Of course, 1 watt is not always what is required; sometimes 10 watts or 1000 watts is desired. Because generator V is specified using an equation, the xMtch can be scaled. For example, here is a generator which will always deliver the power specified in the 'a' parameter:

	R = 25		SWR = 2	
	X = 0		Γ = 0.33∠180	
	100 W			
	V,A=50,2			
25	ohms	10	MHz
0	johms	50	Zo
<none>	file	xMtch*Sqrt(a)	V
		100	a
		0	b
		0	c
		0	d

Another builtin for generator V is the 'useZo'. (The name of this builtin was poorly chosen but is pretty much set in stone after so many years of use). (The equation for 'useZo' is provided in the section on the 'generator' element above.)

The purpose of the 'useZo' builtin is to deliver 1 watt to a perfectly matched circuit. It is used when exploring the 'maximum power transfer' of a circuit. A little background is probably in order.

The 'maximum power transfer theorem' says that, if the generator has an internal impedance of Zthev then maximum power will be delivered to the load when the load is also Zthev when Zthev is purely resistive. Consider the simple circuit below. It contains a generator which is output 2 volts, a resistance 'A' of 1 ohm and a load of 1 ohm.
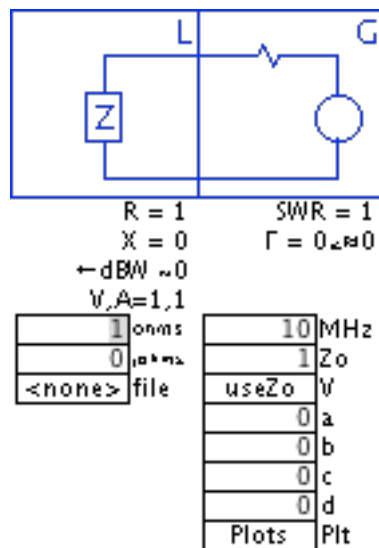
If the 'maximum power transfer theorem' is true, we should get maximum power when the load 'L' is 1 ohm as well. SimSmith can be used to verify this by scanning over a range of values for L. Here is a plot of the power being dissipated by L:
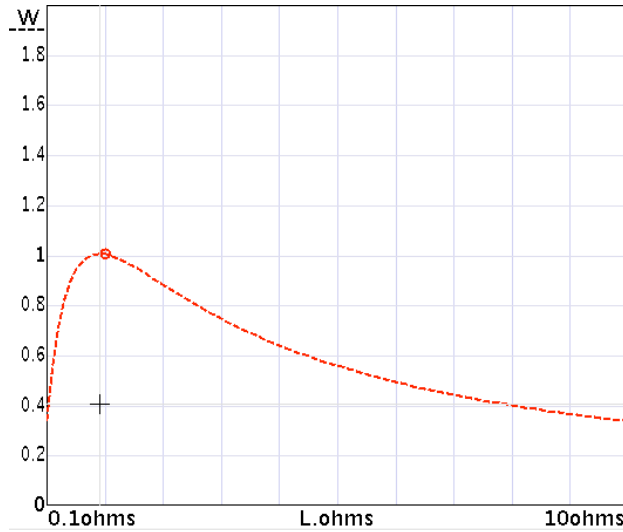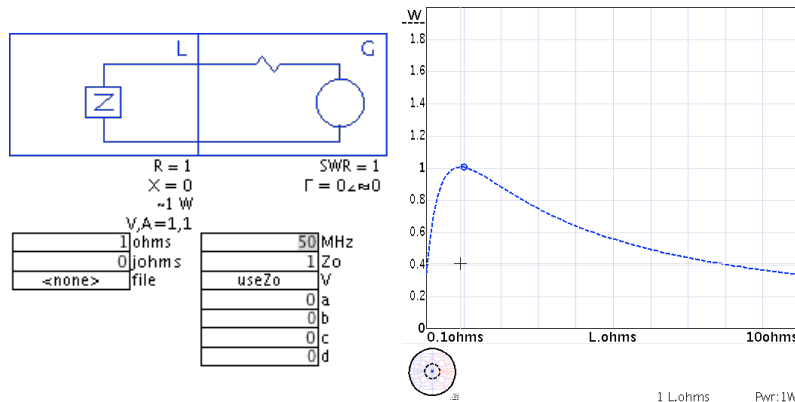
1 L.ohms   Pwr:1W

As can readily be seen, the peak power in L occurs when L is 1 ohm. (Note that the generator voltage '2' was chosen so that when the two resistances were equal to 1 the power delivered would be 1 watt.)

In the vast majority of cases, the 'A' resistor has a value of 'Zo'. In this case, the voltage chosen would need to be "2*Sqrt(Zo)" in order to deliver 1 watt to the load when load and 'A' were Zo.

This configuration is so common that SimSmith provides a builtin which computes the voltage assuming an 'internal' resistance of Zo and a 'internal voltage' of 2*Sqrt(Zo). It is called 'useZo'. Below see how the above circuit would appear using 'useZo'. Note that 1 watt is delivered when the load is 'Zo'.

Now, understanding the 'maximum power transfer theorem' we can see how it might be used. Suppose we have a generator with a 50 ohm internal impedance and a load of 25 ohms. What is the total power delivered to the load in this mismatched case?
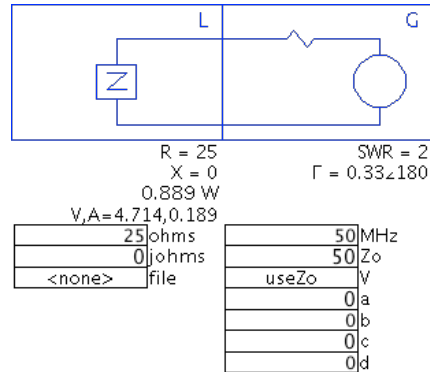
As it turns out, the 25 ohm load will receive .889 watts in this case; only about 10% down from the theoretical maximum of 1 watt.

It is important to note that there are times when the internal generator impedance Zthev is not equal to Zo and may even be complex. While there is no builtin for this case, it is possible to write an equation for the generator V which takes this into account. Without showing the messy details, here's an example of a Zthev = a+jb and a 'sweep' to find the maximum power transfer:
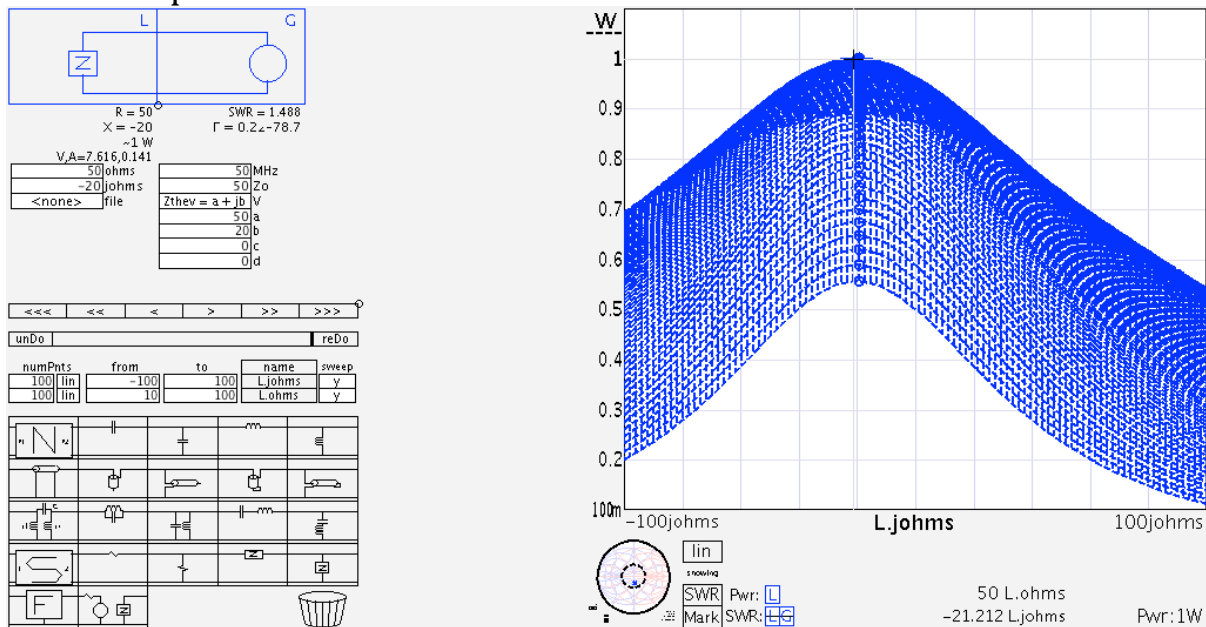
Note that the maximum occurs when the 'Load' is the "complex conjugate" of the generator internal impedance.

A third builtin is 'fixedV'. This is simply 'Sqrt(Zo)'. It is useful when the generator is designed to deliver 1 watt into Zo ohms. This, like all builtins, can be scaled using an equation such as "fixedV*Sqrt(a)" to deliver 'a' watts into a load of Zo ohms.

What Happened to Scattering Parameters?

Some versions of SimSmith provided for the display of Scattering parameters. As of 10.1, this capability was removed. This was done because the scattering parameter support was undergoing significant revamping and has several, well, 'shortcomings'. Rather than delay the release of 10.1 indefinitely, it was decided to remove the scattering parameter support for the time being. So far as I know, it is rarely used by the existing user community. Please let me know if you are one of the few and 'we can talk'.

EXTRA INFORMATION REPORTS

There are times when SimSmith would like to tell you a bit more information that can fit easily on the screen. In order to see this information the 'view/show extra info' needs to be enabled.

When enabled, the extra information is displayed between the element menu and the chart. There is not always information to be shown in which case the area will be blank.

Here is an example of it showing:
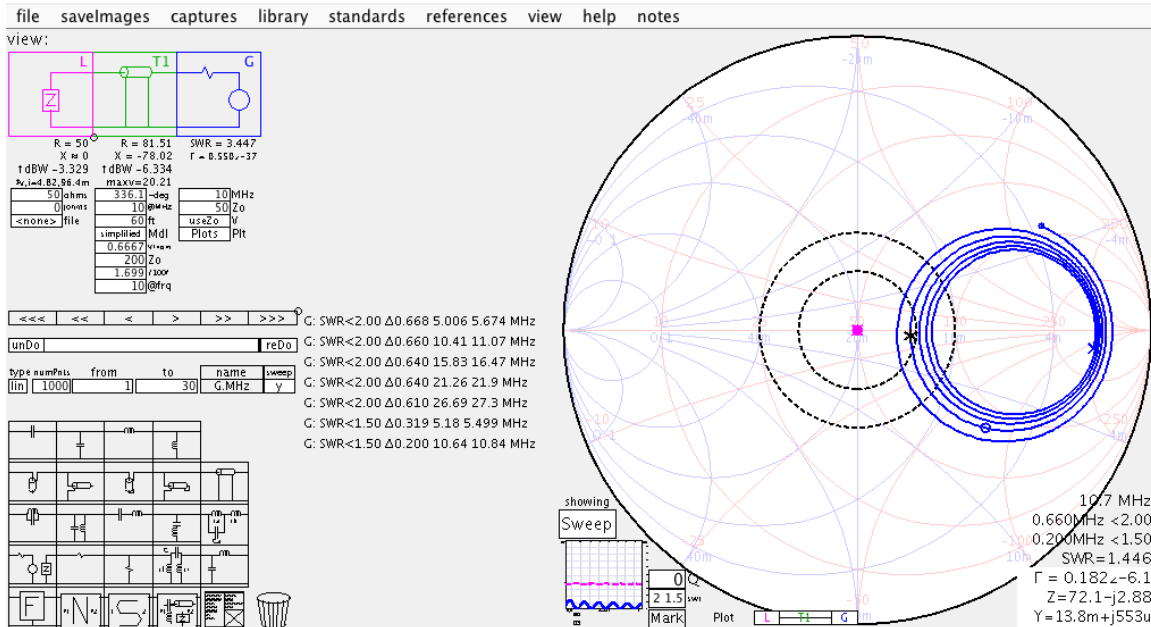
In the above, the extra information offered up is the frequency ranges which fall below the SWR circles specified on the Smith chart. This is the only information presently displayed automatically.

The extra information block is auto-sized and the lines respond to mouse hovers if the text is too small to read.

ERROR REPORTS

Version 11 introduces a new Window for warnings and error reports. The frame can be moved and resized but is always 'on top'. Occasionally, a warning will 'persist' even though you have corrected the problem. In essence, SimSmith forgets that it even produced the error message. Often, you can clear out inappropriate error message simply by closing the error window.

If an error message persists even when you close the window (i.e. the window pops back up). In this case, the error condition is real and is being detected during the sweeps or scans.

Editing

There are three basic categories of editing in SimSmith: editing the circuit, editing the analysis, and editing the view.

There are a few general 'characteristics' throughout SimSmith. First, if some piece of text is white you can edit it in some way. If it has a box around it some action will be taken when you click it. If there is some text which has no box or white background, it is derived information.

Generally, numeric values can be editing in two ways: you can select the value by clicking on it and editing the value using the keyboard. You can also click on it and use the tuning buttons labeled <<< << < > >> >>>.

SimSmith provides an undo. Generally, anything you do can be 'undone'. Undo is invoked by typing 'control z' and 'redo' can be invoked by typing an 'control y'. The 'undo' ring is only about 50 actions.

Circuit Editing:

Editing of the circuit is fairly straightforward. You add components using 'click/drag' from the circuit element menu to the circuit. (You can also click/drag a component from the library.) You move components within the circuit using click/drag. You can delete circuit elements in several ways:

  Click/drag the component to the trash can.
  Hold the down the control key and click on the component.
  Click on the component and type 'control d'.
  Click on the component and type 'control x' (see 'cut' below)
  Click/drag the component to the library.

Version 11.4 adds an internal 'clipboard'. This is NOT the system clipboard. You add items to the clipboard by clicking on a component and typing 'control c' to put a copy on the clipboard or 'control x' to remove the item from the circuit and add it to the clipboard.

Items from the clipboard can be added back to the circuit using paste. To do a paste you type 'control v'. This will copy the element on the clipboard to the 'cursor' and you can place the element in the circuit by moving to the desired position in the circuit and clicking the left mouse button.

The clipboard is implemented as a stack. Each time you 'cut' or 'copy' the stack is pushed. The stack is 10 items deep.
If you type 'control v' to get the clipboard item and then type 'control v' again before placing the item you get progressively lower items on the stack.

Circuit element parameters can be changed using the general methods described above. Additionally, they can be set by clicking the right mouse button on a trace in the Smith or Square charts. This right click will set all circuit element parameters to the values necessary to generate that point on the chart.

Analysis Editing:

Circuit analysis is controlled using the sweep menu along with the Generator frequency. The 'Generator Frequency' is specified using the MHz parameter of the generator (circuit element G). This parameter specifies the 'single frequency analysis' of the circuit. It is the frequency used when showing the 'Path' on the Smith chart. On the charts, the single frequency operating point is displayed as circle.

The Generator frequency can be set using the general methods described above. Additionally, the G.MHz parameter can be set by 'right clicking' the mouse on a trace on the Smith or Square chart.

Generally, analysis will include one or more sweep parameters. The sweep parameters are selected by clicking on the 'name' field and adding parameters. Parameters can be deleted by moving them to the trashcan or by holding the control button and clicking on them. They cannot be added to the clipboard.

View Editing:

While analysis is the primary goal of SimSmith, being able to see the results in a useful way is equally important. The primary choice to be made is which chart to use the Smith chart or the Square chart.

Smith Chart Viewing:

While analysis is the primary goal of SimSmith, being able to see the results in a useful way is equally important. The primary choice to be made is which chart to use the Smith chart or the Square chart.

The Smith chart displays two different forms of lines. The first is the 'PATH'. When showing 'PATH' the chart shows how the impedance is transformed from the load (represented by a circle) to the generator (represented by an 'x').

The second form of line is a 'sweep' line. Switching to the 'Sweep' mode is done by clicking on the 'showing PATH' button. In this mode, the Smith chart shows the swept values of the circuit elements. The 'sweep menu' selects which variables are swept. When showing 'sweep's, the 'Plot' menu at the bottom of the Smith chart selects which circuit element values are displayed.

Clicking on the 'showing Sweep' will enter the 'Both' mode. Unsurprisingly, 'Both' means the Smith chart shows both the 'PATH' and the 'Sweep' information. NOTE: in the 'BOTH' mode, not all the 'PATH' will be shown. Only those PATHs which lead to a sweep trace will be shown.

The Smith chart can be panned by clicking on the chart well away from any trace and 'dragging' the chart to a new position. The Smith chart can be zoomed in/out using the mouse wheel. The zooming takes place around the mouse pointer.

Square Chart Viewing:

While in the Smith chart there is a small square chart in the lower left hand corner. Clicking on that small square chart changes the view to the Square chart.

As with the Smith chart, the Square chart shows sweeps of the various circuit elements. Which sweeps are shown is selected using the small menus at the bottom of the screen.

The 'SWR' menu selects which SWR traces are shown on the Square chart. The 'PWR' menu selects which element's power will be displayed.

The vertical axes of the Square chart can be modified somewhat. The scale can be changed by moving the mouse pointer over the axis and using the mouse wheel. The zooming takes place around the up&down arrow. The up&down arrow can be moved by clicking on the vertical axis itself. The axis can be panned up/down by clicking on the axis and dragging it to a new position.

Axis scaling and positioning 'snaps' to appropriate lines on the chart. This snapping can be disabled by holding down the control key before clicking the button.

The horizontal axis of the Square Chart can be zoomed and panned as well. No snapping is provided. The zoom takes place around where the mouse is pointing. To pan, click and hold well away from any trace and drag the image as desired. It is not possible to zoom both horizontally and vertically at the same time.

Transmission Line Losses:

   As one might expect, a great deal of SimSmith is concerned with modeling transmission lines. It is important to remember that simulation should be considered an APPROXIMATION of the real world. To be certain your circuit works as expected one must actually build it and tune it accordingly. Simulation will get close but tuning of critical parameters will be necessary.

   That having been said, there are a variety of ways to model transmission lines. The exact method depends on which characteristics

are important to the application. Without judgment, SimSmith provides the following possibilities:

   The most basic transmission line is expressed using the basic circuit elements from the element menu. This is called the 'simple' model. It allows the user to specify the length, characteristic impedance, velocity factor, loss, and a loss frequency. Setting the loss frequency to 0 means the loss will be constant regardless of frequency.   If the loss is not zero, SimSmith will add a reactance to the characteristic impedance approximated from that loss. The approximated Zo is not reported.
   An enhancement to this basic model is called the 'k0k1k2' model. Here, the user specifies loss using three parameters K0, K1, and K2 instead of loss & frequency. K0 corresponds to dc losses in the copper. These losses grow only with the length of the line. K1 corresponds to skin effect of the internal conductor and affects both resistive losses AND changes in internal inductance. These effects grow like the square root of frequency. Finally, K2 corresponds to dielectric losses which grow like frequency.
   K0, K1, & K2 can be determined through measurement. Additionally, Dan Maguire (AC6LA) has put considerable effort into determining these parameters for a wide variety of commonly used media. He has been kind enough to provide that data and it has been imported into SimSmith.

   Transmission lines can also be described inside the Function (F) block and the Network (N) block (and by implication a RUSE block). For the F block the simplest line would be: "T(I,len)". In this form the line is assumed to be lossless and have a characteristic impedance of G.Zo. The 'len' parameter may be followed by 'feet', 'meters', 'inches', or 'cms'.
   The basic function can be expanded by adding parameters. The first additional parameter is taken to be the characteristic impedance: "T(I,len,Zo)". The next parameter is taken to be the velocity factor: "T(I,len,Zo,vf)". If Zo is purely real then up to two more parameters are allowed, first 'lossPer100' in dB and then the frequency of that loss specification. If the frequency is missing or 0 then the loss is assumed constant regardless of frequency. If Zo is not purely real, the losses are computed from the imaginary part of Zo.

It is also possible to specify the loss information using the k0,k1,k2 parameters. In this case, all parameters must be provided. The syntax is "T(I,len,{vf,zo,k0,k1,k2})".

The N block can also be used to describe a transmission line. Here the syntax is "transN w1 w2 w3 w4 len;". The transmission line is 'ideal' in that there is no common mode conduction. Additional arguments can be added in the same order as the F block: Zo vf lossPer lossFreq or {vf,zo,k0,k1,k2}. Again, Zo with a reactive component cannot have a lossPer or use K0,K1,K2.

In the F and N blocks, the AC6LA database can be accessed using the syntax {"key[key[key]]"} where 'key' are strings.   SimSmith scans the database and looks for descriptions that have the 'key'. Examples might be {"RG-58/U"} or {"Belden 9269"}. No attempt is made to ensure the pattern matches a unique element. Thus, {"52"} might work and it might not. Check your results.

In summary, different models often reveal different results and can provide insight to different transmission line phenomena. For most purposes, the simple model is sufficient when the lossPer100 and lossFrequenty are taken from the manuals. Increased accuracy can be obtained through measurement of these parameters near the operating point of interest AND with the specific manufacturer's product in hand.

Using the K0K1K2 model has the advantage of importing manufacturer's data BUT it is still necessary to measure and tune as product variation is a real concern. The K0K1K2 approach has the added advantage of predicting behavior at lower frequencies where the velocity factor changes with frequency.

Using a complex Zo is more of a learning exercise than a real world technique. This is because the true characteristic impedance varies with frequency. Still, there are academic applications and it is provided.

As a final note, it often happens that users will point out that simulation does not match "this piece of RG-58/U". That is to be expected. At best, simulation will provide guidelines and lend insight to circuit sensitivies. Simulate… cut long.. tune… measure… feedback… repeat… oh.. .and enjoy! And if you got here, drop me a note at ae6ty@arrl.net.