

Lance's Smith Chart Program Introduction (see <http://tools.rfdude.com>)

Or

"All the help you're going to get until Lance figures out how to generate Windows Help"

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Changes 3/16/2003

- Changed the location of the install slightly
- Moved some features from a more advanced version I was working on (and gave up on certain features such as scalable fonts, variable trace widths, etc.). Only major feature added was a fix to the print preview, that should now work.

Changes on this edit (4/6/2002)

- Cleaned up more dialog boxes
- May have fixed a bug in the trajectory plotting (surprised it didn't stand out before)
- Added "adaptive" VSWR circle, text display of VSWR, Mismatch Loss, /Return loss
- Added "flip" network around command (not sure if it works perfectly) CTRL-F
- Added "simple filter synthesis" wizard – for lumped LPF and HPF's.

Changes on this edit (10/28/2001)

- Cleaned up some dialog boxes
- Mainly a "safety" release as I went through and put some headers in all the source files
- Added new "check boxes" to the setup dialog that pretty much makes it so that anything that is a setup parameter is handled in the setup dialog. Specific additions were
 - Q arc button
 - Admittance circle button
 - Text marker button
 - Gamma mode button

Changes on this edit (8/24/2001)

- MatchMe now makes a lame attempt at compensating for the complex source (starting impedance) and load (Goal impedance) by matching the reactive parts (or duplicating them)
- Overall MatchMe got some redo – still quite crude and not optimal, but it probably will never be – it's just to get you started.
- **Added a title option which gets saved and displayed at the top of the chart. This causes old files saved to be incompatible, sorry ☹**

Changes on this edit (8/23/2001)

- MatchMe can now start at the higher or lower impedance (needs testing, any feedback welcomed)
- Added Edit-> options to bring chart setup dialog
- Added a "setup" button on the toolbar to bring up chart setup dialog

Changes on this edit (8/20/2001)

- Added the "MatchMe" wizard. This is a quick (very quick) and dirty implementation of something I did in mathcad a few years ago. It computes N-section matching networks to transform one real impedance to another. The options are lumped-LP, lumped-HP, and series QW transformers. The transformation is "constant Q" at least with the lumped stuff, and only works between two real impedances. I figured it's a good place to start anyway...

Changes on this edit (8/19/2001)

- Added magnitude/angle format to impedance popup dialog
- I think I finally fixed the Q plotting problems!!!!
- Trajectory plotting "settings" changed slightly
- The Q of the starting impedance is accounted for, i.e. if that's the highest Q of the network, that is what is shown

Changes on this edit (8/18/2001)

- Added mucho rodent support – try left clicking or right clicking in the chart.
- Fixed the File->New behavior
- Added an "impedance" popup box for mouse-probing the chart and looking what impedance was at the probed point
- More single-valued parameters can now be edited with the shortcut keys rather than pulling up the monster setup dialog box (freq, precent tuning, Z0, etc).

- When a component is added, it can now be inserted. Previously it was always added after the last element in the network. Now it is always added to the "right" (i.e. after) the "selected" component.
- **Please read the other stuff below to understand better how the rodent support is supposed to work**

Changes on this edit (8/16/2001)

- Added complex elements, parallel /series RLC networks (us x key to add). This is a very nice feature that turned out to take a little less work than I expected. The series RLC in a shunt configuration is very nice for simulating real capacitors in low-Z matching networks. At high frequencies it also helps. The parallel RLC was included for completeness, and also for the purposes of modeling coils with known parasitics.
- Changed file format to include new element types (two types, series/parallel RLC, two configurations, Series, Shunt)
- Added a button (with the clean "x" in it) for adding the complex element, also setup "e" edit function to handle the complex elements appropriately.
- **This version could use some serious testing, so I would appreciate anyone's help who is willing to try it.**
- Cut down some of the fat in this document

Changes on this edit (8/15/2001)

- Added (C,R,L,T) keystrokes for quickly adding parts with keyboard (bye bye mouse!)
- Added new dialog boxes for R,C,L,TRL, so only the necessary parameters can be edited

Changes on this edit (8/13/2001)

- Fixed the plotting of the Q curve so any dependence on Z0 is removed (gosh that was annoying).
- There is still a Q quirk or two, hopefully you don't notice it ☹

Changes on this edit (8/12/2001):

- Save As now works (got bungled before)
- File-New (CTRL-N is shortcut) works
- Added a "delete" button to the toolbar (looks like a sloppy X), acts just like the delete key
- Fixed the coloring on some of the buttons that are on the toolbar so they don't look so goofy (yes, they still are sloppy)
- Printing seems to work with limited testing, print PREVIEW does **not** seem to work properly for me.
- Mouse left/right button "increment/decrement active component" functionality removed for now, someday this will hopefully evolve into a real "click nearest the given trajectory" and select function but no work has been done on this yet.
- Q curve plotting is still messed up at Z0 extremes.

Changes on this edit (8/7/2001):

- File saving/loading now is included, seems to work. File menu re-enabled, as well as save icon and "CTRL-S". should be pretty self explanatory.
- Q curve plotting has been changed slightly, but there are still some bugs. TBD.

Changes on this edit (5/30/2001):

- Trajectory plotting continues to get a little work here and there... there are now a couple of annoying warning messages (which are better than the program hanging). The two main sources of error are:
 - When a series transmission line is added to a point where it won't cause any movement on the chart (i.e. start at 50 ohms and add a 50 ohm transmission line). This sucks, but I have to think about what to do about this case...
 - When an **extremely** low/high reactance is plotted, this causes a similar problem... as my new adaptive plotting routines try to show the movement as the element is added, it either doesn't move far enough with each impedance step, or it moves too far.
- Maybe I can come up with easy solutions to these problems... not sure.
- Added Q curve to display (toggle on /off with the "q" key)... the Q plotted is the maximum Q of the network

Changes on this edit (5/28/2001):

- Trajectory plotting has been entirely redone. In most cases this is good, some it wigs out (for very extreme impedances). If this gives you grief, please let me know. The new trajectory plotting may significantly slow down the response, let me know what you find... I will try to improve this.
- New command: holding shift and using the up/down arrows will move Z0 of the chart up and down. Shift and rolling the mouse wheel does the same thing (for now)
-

Reactances of L/C are plotted next to text description

Changes on this edit (5/23/2001):

- Starting and Goal impedance available in the Setup menu ("s" on the keyboard) (goal impedance just for display)
- Reactances of L/C are plotted next to text description
- Admittance circles are shown toggle on/off with "a"
- Mouse buttons (left and right) when in the window (not on the toolbar where the parts are), with a single click, act like the left and right arrow keys. The Mouse wheel (if present) acts like the up/down arrow (you can tweak and select parts by just using the mouse). This feature may go away... but I thought I would give it a try

Changes on this edit (5/18/2001):

- Flicker is GONE! Thanks to www.codeguru.com and Paul Ruhland's help....
- Some dialog box edit fields were made wider until I can get a better handle on the text field widths (i.e. not show a billion decimal places).
- This version is larger because it's statically linked with the DLLs... this might help on the one case where the program didn't work for somebody.

Changes on this edit (5/17/2001):

- Added magnitude/angle entry into the chart setup box for the starting impedance (either format you enter is ok. If you make entries into the real/imag and mag/angle fields both, it will use the mag/angle and tell you so...)
- Added magnitude/angle display of markers. I call this "gamma mode", you toggle between R+/-jX and Mag/angle by hitting the **g** key. Markers are now on again by default, so to turn them off you have to hit **m**
- Note, I've seen a couple quirks with the program... and fixed a couple bugs. One had to do with ridiculously low shunt impedances. With all the additions in the last couple days, I would appreciate any bug reports! (send to lance_lascari@ieee.org)
- Added the Freq "tuning".... If you hold the CTRL key while pressing the up/down arrows, the frequency will be tuned just like a component value (using the percentage tune multiplier).

Here's a very quick introduction to Lance's Smith Chart program

While this has been and will continue to be a fun exercise for me, I hope others can use this and find it handy. Please let me know what you think, and I especially want to know if you find errors/crashes. I apologize for any trouble this might cause you. It is free, and I plan it to always be free, **so use it at your own risk...**

Note: this is the first windows program Lance has tried to write, so please be gentle! The initial release was written in spare time over the course of about 1.5 weeks (after taking about 1.5 weeks of spare time to "cram" visual C++). Note: Once I have things cleaned up and in a more readable state, I plan on making the source code available. I also have other features planned as well as a ton of other things to do unrelated to this program...., which may delay things. The way certain portions of the program are structured internal are really nasty, which would be embarrassing to reveal ☹.

Feedback is welcomed.

It probably makes sense to first make a list of what DOESN'T work:

Things that don't work / don't really do anything/ is annoying:

1. There is no help to speak of (my goal is to eventually make it intuitive enough that you don't need it....)
2. The shunt shorted transmission line case is a little funny when the angle is quite low (i.e. the case of a short)

3. extremely high reactances cause some grief. I need to revisit my scaling algorithm (too few lines along the trajectory get drawn so it looks screwy).
4. the text can and will overlap the chart (maybe I'll get fancy with fonts someday)

Keystroke (lowercase if letters)	Action	Description/notes
w	MatchMe wizard is started	A simple matching network synthesis routine, for limited cases (resistive to resistive)
c, r, l, t	Add component with keystroke	Cap, Resistor, Inductor, Transmission line A dialog box will pop up to ask for the device configuration (series, shunt, shunt (open or shorted for trl))
x	Add "complex" component	Pops up a dialog box where you can configure the many parameters of the "complex" component. A "complex" component is a series or parallel combination of a resistor, inductor, and capacitor. See the Dialog box screen shot below for a better understanding
a	Toggle admittance curves	Turns on and off the admittance curves
e	Edit component	Pops up Edit Component Dialog with parameters of the currently selected component when pressed
f	Set frequency for analysis	Brings up a simple dialog box for editing the chart frequency.
m	Toggle text labels	This turns on and off the impedance labels (text) that appear at the endpoint of each trajectory
g	Toggle Gamma display	Default display is in R+/-jX format, this turns on magnitude and angle.
s	Chart setup	Brings up chart setup dialog when pressed

Keystroke (lowercase if letters)	Action	Description/notes
p	Set tuning percentage	Brings up a simple dialog box for setting the amount that elements are tuned for each "kick"
z	Set characteristic impedance of chart (Z0)	Brings up a simple dialog box for editing the chart characteristic impedance
q	Toggle Q curve	Toggles the Q curve on and off, the Q displayed is the maximum Q of the network This is a little quirky, and will be refined.
Delete key	Delete selected component	Obvious
Left arrow/right arrow	Select component	Moves back and forth through the "ladder" network selecting components
Up arrow/down arrow	Tune component	Increases/decreases component value. For R, L, C this is obvious. For transmission lines, the only "tuned" item is the electrical length. Z0 and frequency must be set using the Edit Component dialog
CTRL - Up arrow/down arrow	Tune Frequency	Increases/decreases frequency value.
SHIFT-Up arrow/down arrow	Tune Z0 of chart	Increases/decreases Z0 value for zooming in and out on a section of the chart
CTRL-F	Flip Network	Conjugates the starting and goal impedances, and swaps them. Swaps the components around in the network so that the source/load ends are swapped (kind of like reversing a two port)

Keystroke (lowercase if letters)	Action	Description/notes
v	Display VSWR circle	Circle will be centered around the “goal” load impedance, the radius will touch the “ending”/load impedance of the network. Hence, the circle will shrink as you approach the goal
CTRL-W	Simple Filter Wizard is started	Allows synthesis of simple chebychev filters

How to use the program to create a simple matching network:

1. type “f”, “s”, or “z” in the program window to setup the frequency, Starting Impedance, Percentage tuning, or characteristic impedance of the chart. All can be set at once by filling all the field of the dialog box that pops up, then hitting ENTER
2. Then, click (with the mouse) on whichever elements you wish to add. As can be seen in the table above, all elements can be added without touching the mouse, by merely typing the appropriate shortcut key. By default all reactances/resistances are set to the characteristic impedance of the chart. One exception to this is that the “complex” elements are set to default values rather than calculated reactances. Transmission lines have several parameters and they are defaulted as follows: $Z_0=Z_0$ of chart, Angle (electrical length) = 45 degrees and frequency = current chart frequency (The frequency is stored so that the element has meaning when you change the frequency on the chart setup). If you want to type an exact value, just hit the “e” key to edit the selected component (which will be the last component added if you didn’t change anything).
3. if you’re content to just manually tune the value around, then just use the up and down arrow keys to tweak the value into place. The mouse-wheel will perform the same function, and this is my favorite for tweaking a network once the topology is in place.
4. At any time you can use the left and right arrow keys to select a different component to edit it (the blue component is the one to be edited). Type “e” to get the edit dialog. Now you can also select the component with the mouse in two ways, after selecting it you can double-left click and edit the part:
 - a. Left-click on the point that is in the center of the “trajectory” of the component. You don’t have to hit this exactly, you just have to be

closer to this point than the equivalent point of any other element. Note, the “midpoint” will NOT usually be on the actual trajectory, but on the center of the line that goes between the endpoints. I know this may seem odd, but it is probably the simplest way to implement such a function.

- b. Left click on the text that is on the left half of the screen (this may be helpful in very dense smith-chart-situations).
5. At any time you can also delete a component from the “ladder” network by selecting it (left right arrow keys) and hitting your delete key.

That’s really about it. I’m looking forward to hearing the positive and negative feedback on the chart.

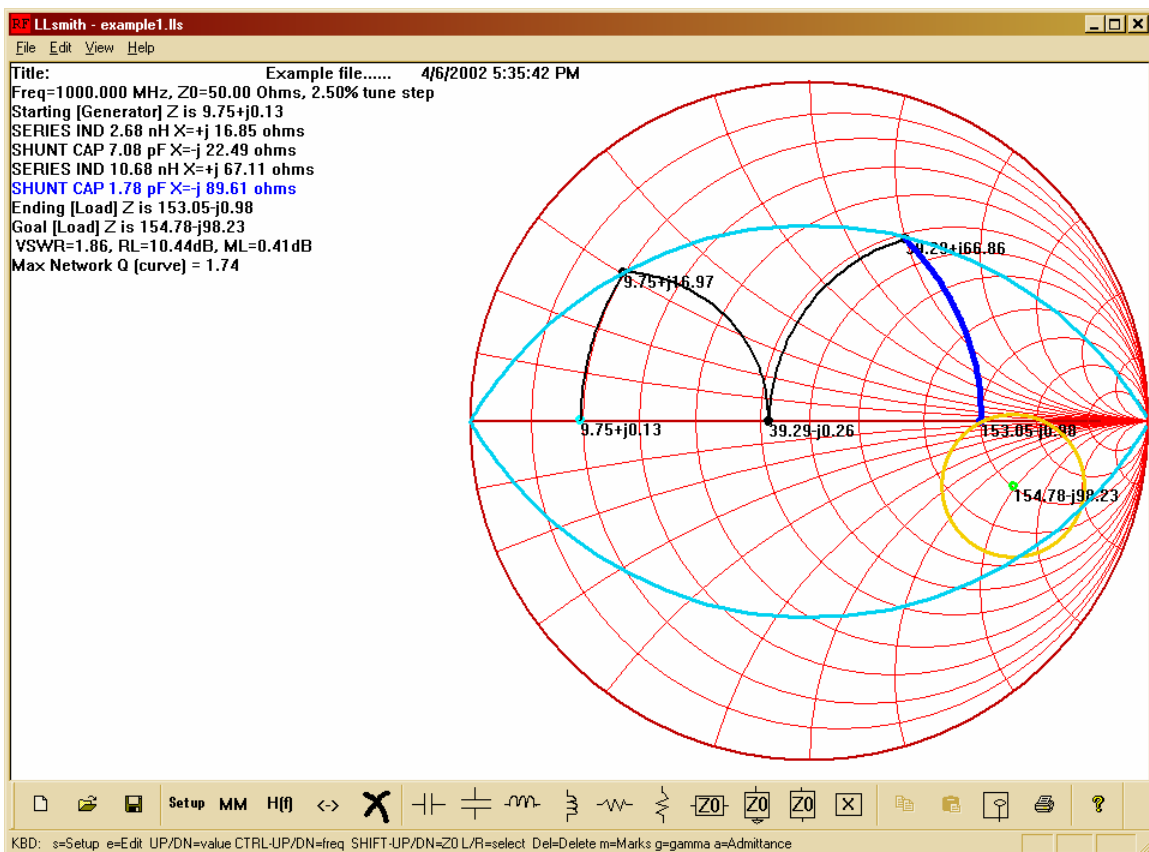


Figure 1: Main Program Window

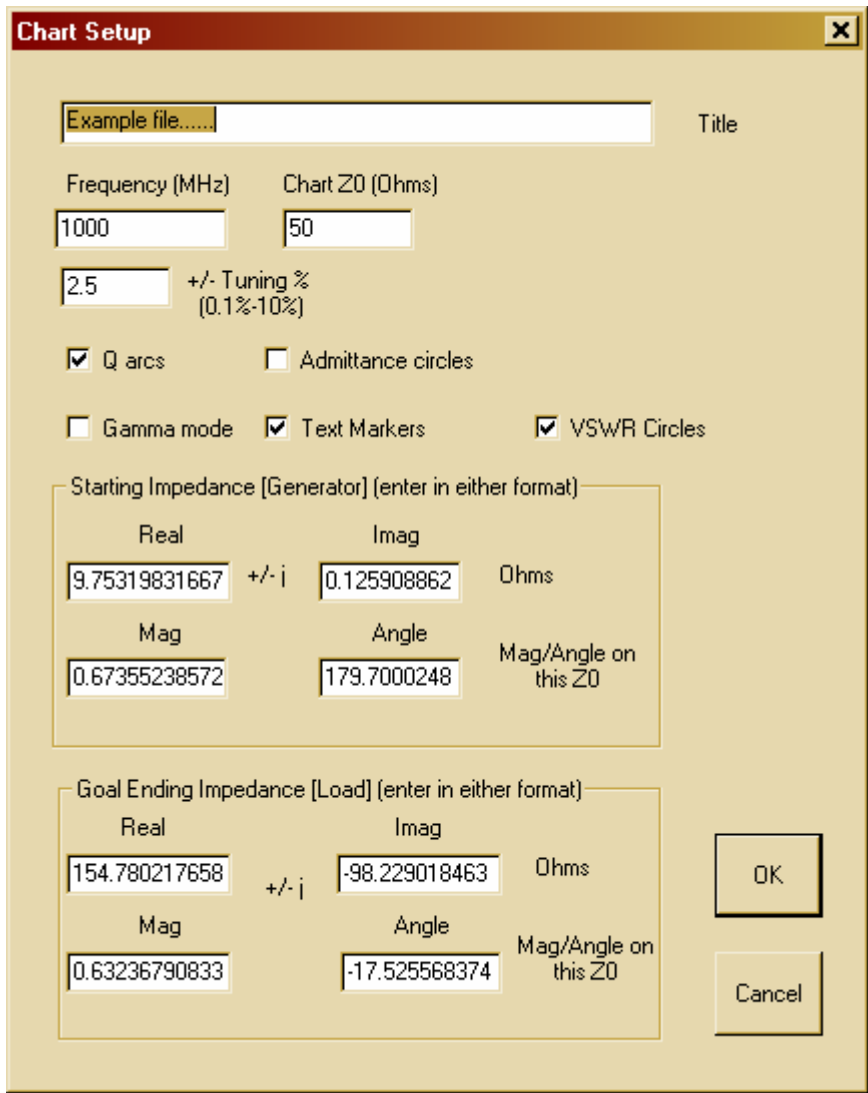


Figure 2: Chart Setup Dialog

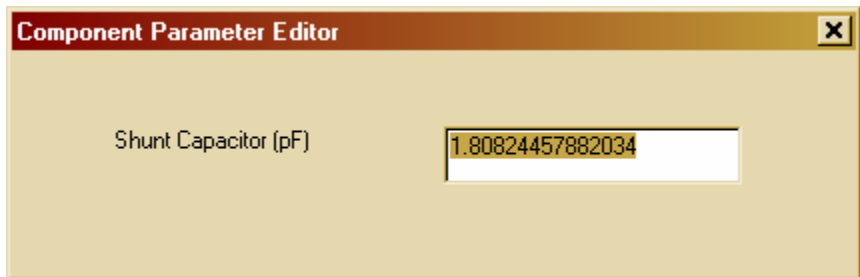


Figure 3: Component Edit Dialog (when capacitor is selected)

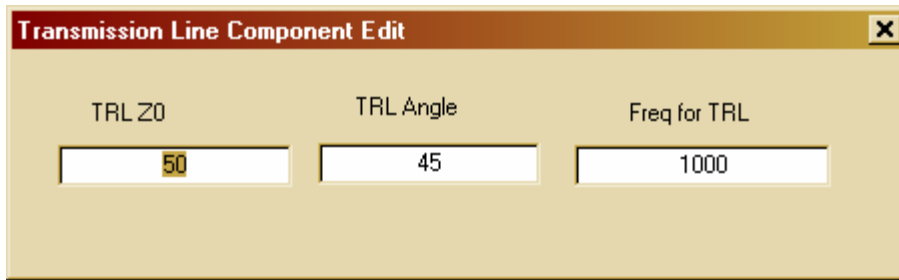


Figure 4: Component Edit Dialog (when transmission line is selected)

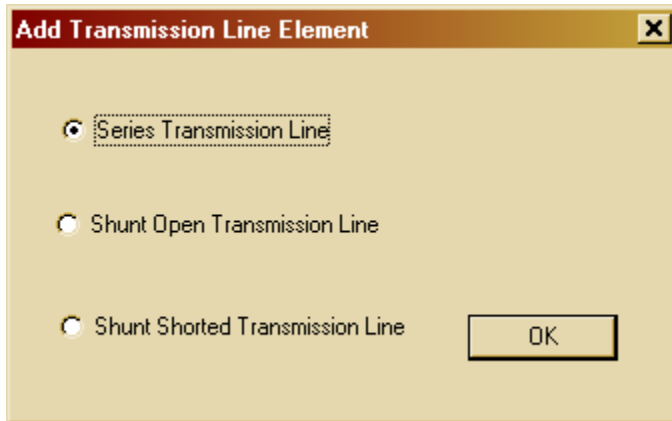


Figure 5: Dialog for setting transmission line mode (after hitting "t")

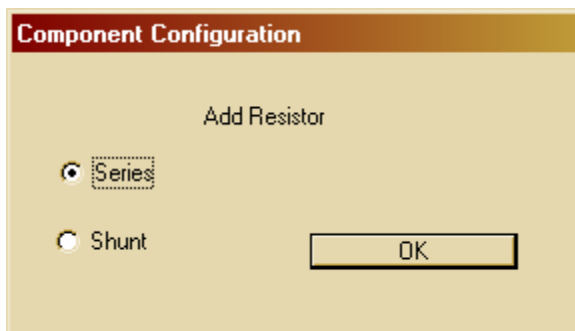
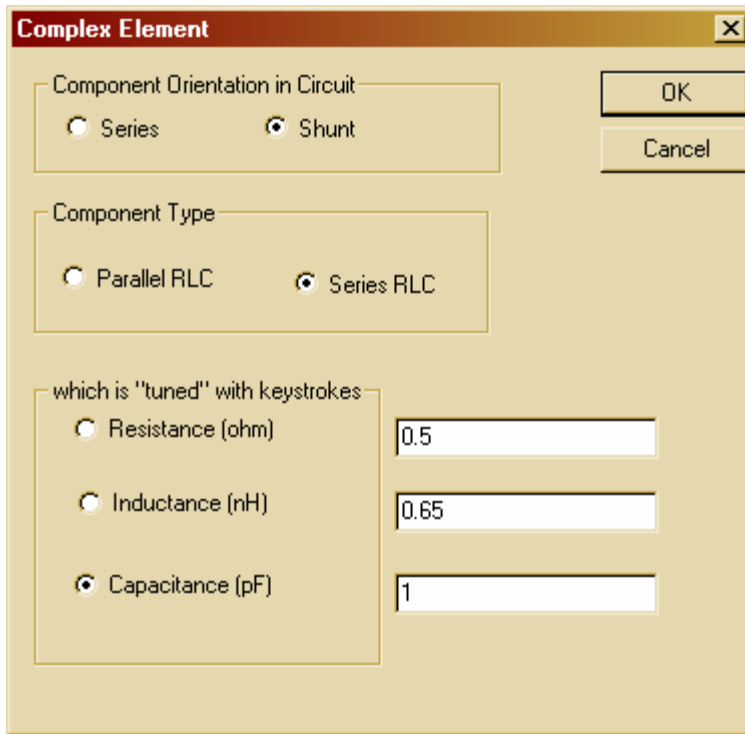


Figure 6: Dialog for setting lumped element configuration (after hitting "c, r, or l")



The image shows a dialog box titled "Complex Element" with a close button (X) in the top right corner. The dialog is divided into three main sections:

- Component Orientation in Circuit:** Contains two radio buttons: "Series" (unselected) and "Shunt" (selected).
- Component Type:** Contains two radio buttons: "Parallel RLC" (unselected) and "Series RLC" (selected).
- which is "tuned" with keystrokes:** Contains three radio buttons and three text input fields:
 - "Resistance (ohm)" (unselected) with a text field containing "0.5".
 - "Inductance (nH)" (unselected) with a text field containing "0.65".
 - "Capacitance (pF)" (selected) with a text field containing "1".

At the top right of the dialog, there are two buttons: "OK" and "Cancel".

Figure 7: "Complex" element Editor. This is for editing compound elements such as Series RLC and Parallel RLC components. Both types can be placed in series or shunt with the circuit.

Impedance Display

Magnitude	Angle	
<input type="text" value="0.42513097740829"/>	<input type="text" value="148.425809253957"/>	deg
R	JX	
<input type="text" value="21.5015385846493"/>	<input type="text" value="11.684228712074"/>	ohm

Do Nothing

Make Starting Impedance

Make Goal Impedance

Figure 8: "Impedance Popup". This is found when you right-click anywhere in the smith chart. I think it's operation is fairly straightforward. In case it isn't: the impedance that is displayed is that which is found where you clicked the mouse. You can for

Simple MatchMe Wizard ✕

Starting Impedance

+/- J Ohms

Goal Impedance

+/- J Ohms

*** this is not meant to replace a real synthesis program!!! ***
It is very crude and simplistic -- you might be able to do better manually!!!

Number of Sections (10 Max)

Lumped Low-pass

Lumped High-pass

Quarter Wave Transformer

!!Note, this will blow away anything on the chart that you've manually added!! Cancel now if you don't want to do this!!

Figure 9: The simple “MatchMe” wizard

Simple HPF/LPF Synthesis wizard ✕

Topology

Lowpass
 Highpass

First Element is....

Shunt
 Series

Fc (MHz, Ripple Cutoff frequency)

Passband Ripple (dB)
(ripple will be the loss at cutoff)

N ($3 \leq N \leq 15$), if not odd , it will be rounded up

Ro (Ohms, characteristic resistance for filter design)

Note: this will blow away anything you have on the chart (replace your circuit)

Figure 10: Simple Filter Synthesis Dialog



Figure 11: And of course, the "About" box