

# The instructional manual

Updated 24 July 2012

Elsie, the associated support files and this manual Copyright 2012 James L. Tonne This is the instructional manual for Elsie, the program to design and analyze lumped-element electrical filters. Hopefully it will prove helpful to the wide spectrum of users of this program.

It is intended to be more of a teaching tool rather than a reference document and should be gone through from the start with the reader doing the fairly simple exercises as shown. The order and content of those exercises and their entries have been chosen with care. The manual includes reference material at the end.

It would be a good idea to print this manual so that the exercises can be followed more easily. In addition, the quality of the various graphics will be best if the manual is printed on a high-resolution printer such as a laser type. Such a printer typically has much better resolution than a monitor screen.

Please notice that this manual was written when the program was at revision level 2.50 and it will slowly become more and more incomplete as the program is upgraded. Further, the screen appearances will change over time, more and more options and subroutines will become available in the program and so on. When this manual is rewritten these improvements will be included.

Comments and suggestions are welcome. Feel free to contact us at Tonne Software. Use <u>Support@TonneSoftware.com</u> for email.

- James L. Tonne Tonne Software

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Version 2 Licensed Serial nu Copyrigh	2.50 from to Tanul mber 120 t © 2003-	Tonne S kefed Lai 062101 -2012 Ja	Software: nmiyk - Ve mes L. Toi	www.Tor ward, Gu nne	nneSoftw myzk <sup>Get old</sup>	rare.com I design design		Manua Lasi	I parts entry t session

In the lower left corner we see the version number, the licensee and the serial number. The version number is incremented upward in steps of .01 as changes are made.

The licensee is the person responsible for the security of the program. In the case of the Student Edition this will be "Students around the world".

The third line will show the serial number and the fourth line is the copyright notice.

Four options are available on the opening screen.

One is clicked to recall a previously-stored filter design:

Retrieve old design

A second button is clicked to design a new filter:

New design

A third button is clicked to enter an arbitrary collection of components:

Manual parts entry

And a fourth button is clicked to retrieve the last session, saved automatically at program exit:

Last session

If the program cannot find the Last Session file at startup then that button will be replaced by an **Exit** button.

For this startup and walk-through, we will simply retrieve an existing design. That design will then be used to illustrate some of the features of the program. After this has been accomplished then we will move on to more detailed manipulations. Finally a series of real-world design tasks will be shown.

Now recall a previously-designed filter. Pressing the **Retrieve old** button allows us to see the file-selection window:

Cet Liste File	Elsie			•	🗕 🗈 📥	<b>.</b>			
My Recent Documents Desktop My Documents	AMbroadcas CauerBPF3.L CauerBPF4.L Contest20.L Contest80.L Demo1.LCT FMafLPF.LCT FMafLPF.J.CC FMifBPF3.LCC ham20.LCT HamPWM4.L LASTSESSIO	tLowpass.LC .CT .CT CT CT T CT N.LCT isor.LCT	T SCAbpf.LC	л =.LCT .LCT				ıt Ed	ition of ign and
My Computer		5011201							U
My Network Places	File name: Files of type:	Elsie files	s (*.LCT) as read-only		•		Open Cancel		
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This window will show all of the Elsie design files that are available. Mouseover and click on the design to be recovered. For this exercise double-click on **Demo1** or click on it and then click on the **Open** button.

The chosen file is now read into the program and you see the design in the form of a schematic. If it is small enough to fit onto the screen (as is the case shown) it will be centered. If it is too large to fit on the screen then horizontal scroll buttons will appear to allow scrolling as needed. Here is the schematic retrieved:



If a stage (dipole) has an L-C pair, the resonant frequency of that pair will be shown. Design data as available will also be shown beneath the schematic.

The program is now operational to the point where we can go to any of the major operations such as changing the design, editing component values, plotting or tabulating the various responses, sending information to the printer or saving the design to a file and so on.

The major menu items in the bar at the top of the screen (the toolbar) will next be exercised. Each page has that same collection of options although at times one or more of the buttons are dimmed (made inoperative) according to what task is being done and what options have been chosen.

Now explore the top row of buttons at the top of the page. Some pages have a second row of buttons or a set of buttons at the left side of the page; those will be examined later.

## Design

## Clicking on that button takes us to the Design page:

sie 2.50 - De	sign Menu - C	:\Program Files\I	Elsie\Demo1.LCT														
ve design	Get desig	n <mark>Design</mark>	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About		Exit	Restart: Manual			
arest 5%	Specify L	Swap end-end	i Singly-ter	m Cheby	Diplexer	Lumped	to tubular	Z match	Wind L	Find L	Toroid	Bisection	۱				
										Ripple							
Topolo	ogy					-Family-				Bandw	idth (Hz) (F	Fc)					
											3M						
Cap	pacitor-input I	owpass		?		O Butte	rworth	?	•	I							
O Indu	uctor-input lo	vpass		?		Cheb	yshev			Order	(N) [21 max	]					
O Noc	dal capacitor-	coupled bandpa	ss	?		O Caue	er			3							
O Noc	dal inductor-c	oupled bandpas	s	?		O Bess	el										
O Shu	unt-input ban	ipass		?	i I	O Gaus	sian			Input term (Rs)							
O Ser	ies-input ban	dpass		?		C Cons	tant_K			50							
O Mes	Mesh capacitor-coupled bandpass     Cauer-only bandpass					0000				Passha	and ripple (	An)					
Cal	Cauer-only bandpass					C M-de	rived										
O Car	pacitor-input l	highpass				S	ee normalized	values			1 2232	Zeturn: _10	965 dB	1			
O Indu	uctor-input hi	phpass		?						VOVIN	. 1.2202 1	Coturn15	.300 00	,			
						O Manu	al entry			Center	Freq (Fo)						
O Ser	ies-input ban	dstop		?													
C Shu	unt-input ban	istop		?						I							
						Cauer e	ven terms.—										
						Ø Best	selectivity			Stopba	and width (F	Fs)					
						C Equa	l terms.										
Dimen	sions					Cauer B	IPF topology—			Stopba	and Depth (	dB) (As)					
⊖ cm						🙆 Norm	al										
⊙ in						C Zig-za	ag			I							

#### Elsie 2.50 - Design M...

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This page is where a design is entered or modified.

Some options are made operative according to the entries that have been made. For example the **Center Freq** textbox will become active if a bandpass or bandstop topology has been chosen. It has no meaning for a lowpass or highpass topology and so would be dimmed in those cases.

The Design page is where designs are saved (see the **Save design** button at the top of the screen) and where old designs are retrieved (see the **Get design** button at the top of the screen).

We will visit the Design page again later. We have already seen the schematic; now skip on to the Edit page.

# Edit Clicking on that button takes us to the Edit page:



### 🐮 Start 🔹 💀 Jasc Paint Shop Pro

🔇 👿 11:54 AM

On this page there is but one option to choose when the page first opens: mouse-over and then click on a stage in the schematic shown at the top of the page to select it. At that point you can edit its value(s), or change its component type using the library in the lower right corner of the screen, or delete it or insert a stage ahead of the it.

However, if none of those are chosen then you can instead continue on to do other things in the program such as change the analysis entries or plot or tabulate the results. We will revisit the editing routine later.

For this walk-through we are going to continue on to the Analysis page.

# Analysis Clicking on that button takes us to the Analysis page.

🖺 Elsie 2.50 - Analysis Menu - C:\Program F	iles\Elsie\Demo1.LC	Т											. 🕫 🗙	
Save design Get design Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About		Exit			
			Transient	Noise	Phase lin.	Title								
Star	t frequency		Tran	smission b	ottom (dB)		Q of in	ductors	_					
	1MHz			-30				200						
Sto	o frequency		per ir	nterval: 5dl	В									
	20MHz						Q of ca	apacitors						
Spa	n: 19MHz		Dela	y top (secs	)			2k						
				120n	_		,							
Swe	ер		per ir	nterval: 20i	nsecs		Transn	nission						
(°	Log						Ab	solute						
c	Linear		Impe	dance top	(ohms)		C Relative							
				120										
Nr c	f X intervals		per ir	nterval: 20	ohms		Transn	nission m	agnify					
0	Y						No	rmal						
2.33	5MHz per interval		VSW	R top			○ Magnify							
				2.2										
Ana	lysis steps						Deturn	Deferen	o (ohmo)					
	тк		Nr of	Y intervals	;		Ketum	50						
			6	* *										
Wid	th: 3M		,	_										
			Plot I	ine width										
			2	<b>•</b>										
🤧 start 😽 💀 Jasc Paint Shop Pro	📺 Elsie 2.50 - Analysis											<ul> <li></li> </ul>	12:00 PM	

The Analysis page is where the frequency sweep is set and the graph scales are entered, along with other items that enable the analysis to be performed.

A second row of buttons allows transient analysis, noise-bandwidth calculation and phase linearity to be examined, along with an opportunity to add a title to a page (used only in the printouts).

We will look at each of these items in detail later.

# Plot Clicking on that button takes us to the Plot page.



Here the information derived from the frequency sweep is shown as a plot. Transmission is plotted as a default when going to this page unless something besides transmission has been selected, done by clicking on the buttons at the left side of the screen.

The various plotting options available will be looked at later.

## Tabulate

Clicking on that button calls up the **Tabulated** data page:

🏙 Elsie 2.50 - Tal	o1.LCT												
Save design	Get design	Design	Schematic	Edit	Analysi	s Plot	Tabulate	Print	Write	Help	About	Exit	
				_									
Freque	ncy, Transmissi	ion, Phase,	Return,	Delay,	VSWR:	Zin,	Zanqle,						
11	-0.05887	-26.914	-21.368	75.07n	1.1868	46.534	-8.8651	J					
1.003	1 -0.05901 1 -0.05915 4 -0.05929	-25.995	-21.351 -21.335 -21.219	75.02n 75.08n 75.08n	1.1872	46.5	-8.8753						
1.012	LM -0.05942	-27.24	-21.301	75.09n 75.09n	1.1884	46.466	-8.9091						
1.018	LM -0.0597 2M -0.05984	-27.404 -27.487	-21.268 -21.252	75.1n 75.1n	1.1892	46.432 46.415	-8.9305 -8.9411						
1.024 1.027	3M -0.05998 3M -0.06012	-27.57 -27.653	-21.236 -21.219	75.11n 75.12n	1.19 1.1903	46.397 46.38	-8.9516 -8.9619						
1.030	M -0.06026 M -0.0604	-27.736	-21.203 -21.187	75.12n 75.13n	1.1907	46.363	-8.9722 -8.9824						
1.036	M -0.06068 M -0.06068	-27.904 -27.988	-21.171 -21.155 -21.139	75.13n 75.14n 75.14n	1.1915	46.328	-8.9925 -9.0024 -9.0122						
1.0461	4 -0.06095	-28.157	-21.123	75.15n 75.15n	1.1927	46.276	-9.0221						
1.052	2M -0.06123 M -0.06137	-28.327 -28.412	-21.092 -21.076	75.16n 75.17n	1.1934 1.1938	46.24 46.223	-9.0412 -9.0507						
1.058	5M -0.06151 7M -0.06165	-28.498 -28.584	-21.061 -21.045	75.17n 75.18n	1.1942	46.205 46.187	-9.06 -9.0692						
1.064	M -0.06179 M -0.06193	-28.67 -28.757 -28.844	-21.03	75.19n 75.19n 75.2n	1.195	46.17 46.152 46.134	-9.0783						
1.074	5M -0.06221 3M -0.06234	-28.931	-20.984	75.2n 75.21n	1.1961	46.116	-9.1049 -9.1135						
1.0811 1.0843	1 -0.06248 2M -0.06262	-29.105 -29.193	-20.954 -20.939	75.22n 75.22n	1.1968 1.1972	46.08 46.062	-9.122 -9.1304						
1.0879	5M -0.06276 3M -0.0629	-29.281 -29.37	-20.924 -20.909	75.23n 75.24n	1.1976	46.044 46.026	-9.1387 -9.1468						
1.094	1 -0.06303 3M -0.06317 3M -0.06331	-29.458	-20.895	75.24n 75.25n 75.26n	1.1983	45.99	-9.1548						
1.103	9M -0.06345 2M -0.06358	-29.726 -29.816	-20.851 -20.837	75.27n 75.27n	1.1994 1.1998	45.954 45.936	-9.1781 -9.1856						
1.110	5M -0.06372 9M -0.06386	-29.906 -29.996	-20.822 -20.808	75.28n 75.29n	1.2001 1.2005	45.918 45.899	-9.1929 -9.2001						
1.117	2M -0.06399 5M -0.06413	-30.087 -30.178	-20.794 -20.78	75.3n 75.3n	1.2009	45.881 45.863	-9.2072 -9.2142						
1.123	M -0.06427 M -0.0644 M -0.06454	-30.269	-20.752	75.32n 75.32n 75.33n	1.2019	45.826 45.808	-9.221 -9.2276 -9.2342						
1.134	LM -0.06467 5M -0.06481	-30.544 -30.636	-20.725 -20.711	75.33n 75.34n	1.2026	45.79 45.771	-9.2405 -9.2468						
1.140	9M -0.06494 3M -0.06508	-30.729 -30.822	-20.698 -20.684	75.35n 75.36n	1.2033 1.2037	45.753 45.734	-9.2529 -9.2588						
1.14/1	2M -0.06521 2M -0.06534	-30.915	-20.671	75.37n 75.38n 75.38n	1.204	45.698	-9.2646						
1.158	LM -0.06561	-31.102	-20.632	75.39n 75.4n	1.205	45.661	-9.2811						
1.165:	LM -0.06587 5M -0.06601	-31.385 -31.48	-20.606 -20.593	75.41n 75.42n	1.2057 1.206	45.624 45.605	-9.2912 -9.2961						
1.172	LM -0.06614 5M -0.06627	-31.575 -31.67	-20.581 -20.568	75.43n 75.44n	1.2064	45.586 45.568	-9.3008 -9.3053						
1.182	M -0.06653 M -0.06653	-31.862	-20.556 -20.543 -20.531	75.46n 75.46n 75.47n	1.2074	45.531 45.512	-9.3139 -9.3179						
1.189	3M -0.06679 3M -0.06691	-32.055 -32.152	-20.519 -20.507	75.48n 75.49n	1.208 1.2083	45.494 45.475	-9.3218 -9.3255						

#### 🛃 start 📔 🖀 Elsie 2.50 - Tabulated...

1:08 PM

Seen here in tabular form are, for each test frequency, the transmission, phase of transmission, return, group (envelope) delay, VSWR, input impedance and the angle of the input impedance.

Commonly there will enough data points that the user will need to use the vertical scroll bar on the right side of the list.

# Print Clicking on that button calls the printer-selection window:

Elsie 2.50 - Sch	ematic - C:\Prog	ram Files\Els	sie\Demo2.LCT		
Save design	Get design	Design	Schematic	Edit	Analysis
🌢 Print					
General					
Select Prin	nter				2
8		29		^	
Add Pri	nter CutePDF	HP Laser Jet	Microsoft XPS		
	Writer	1200 Series PCL	Document	~	
Status:	Ready		Print to file	Preferences	
Location:				Find Printer	í
Comment.					·   =
Page Ran	ge		Number of conicou	1	
C Select	tion C Current Pag	e	Number of copies.		
C Pages	s:				
			Print	Cance	el

Here you can choose where the printer routine output is to be directed.

What is sent to the printer depends on the page in use when the **Print** button is clicked. For example, if the schematic is showing, then the schematic will be sent to the printer. If a plot is showing then that plot will be sent to the printer.

There may be slight formatting differences between the data as delivered to the screen and that delivered to the printer. The outputs to the printer are not screen dumps but are instead maximum-fidelity versions from separate printer-driver routines, dependent on the set of information being printed. From a practical viewpoint the printer will be the limiting factor in the quality of output. The printer outputs are of presentation quality.

Write Clicking on that button calls the file-writing options page:

Elsie 2.50 - Write files - C:\Program Files\Elsie\Demo1.LCT		
	File-writing routine	
	Write tabulated data file (scientific format)	
	Write tabulated data file (easy-to-read format)	
	Write S-parameter file	
	Write LTspice® schematic file	
	Return to Elsie	

These various buttons take you to routines which allow you to write the analysis data (resulting from the frequency sweep) to files, to write S-parameter files (Touchstone both Type I and Type II), and to write LTspice schematic files. (Tonne Software has no connection with Linear Technology Corporation.)

These routines are separate from the normal Elsie-file read and write routines. Those are accessed from the Design page, using the **Get design** or **Save design** buttons.

## Help

Clicking on that button calls up the context-sensitive Help system.

Information in that system is intended to be of assistance at run-time.

诸 Help system for Elsie		
Hide Back Print		
Contents Index Search		^
Type in the keyword to find:	Plotting	
about Elsie Absolute/relative toggle	From any page, the menu item <b>Plot</b> yields a plot of the current network's various responses. If a particular plot type has been chosen then the plot of transmission is used. If a particular plot has been chosen then going to another screen and returning to the Plot page will return to that same plot type.	
add a part analysis analysis options aspect	On the left side of the plotting page is a series of buttons to select which item (transmission, return, VSWR, etc.) is to be shown. That left-hand set of buttons on the plot page behaves in this manner:	
bandpass bandstop bandwidth = Bessel bisection	Clicking on this button will call up the plot for transmission, called S21 in the RF world.	
Butterworth capacitor input highpass capacitor juput lowpass capacitor qualues	Clicking on this button will call up the plot for return loss or reflected power, usually called S11 in the RF world.	
Cauer Cauer bandpass Cauer minimum-inductor transform Cauer zig-zag transform	Clicking on this button will call up the plot for transmission along with its angle.	
center frequency change bandwidth change center frequency change family	Clicking on this button will call up the plot for group delay (also called envelope delay) along with transmission.	
change order change part type change part value change termination	Clicking on this button will call up the plot for VSWR.	
change topology change width Chebycheff circle termineted	Clicking on this button will call up the plot for VSWR along with transmission.	
circles (vswr) circles (vswr) circuit editor col-saving bandpass	Clicking on this button will call up the plot for input impedance, the impedance seen looking into the filter.	
constant-k dataline delay	Clicking on this button will call up the plot for input impedance along with transmission.	
delate a part design design example	Clicking on this button will call up the plot for input impedance along with its angle.	
design options diplexer editing end	Clicking on this button will call up the plot for input impedance expressed as its real and imaginary parts.	
end sections	Clicking on this button will call up the Smith Chart plot, showing S11.	
Start Elsie Manual - LibreOf	O 19 Help system for Elsie	06 PM

The page that is called up is context-sensitive: it will be a function of which screen in the program you are on when the Help system is requested. You can easily navigate through the help system, use its search feature and so on.

## About

Clicking on this button shows the essential data about the program as seen here:

About Elsie												
<u>iii</u>		Els	ie									
	An uncommo	only easy-to-us	se electrical	filter o	lesign							
	and analysis program written by engineers for											
	engineers											
	Professional edition											
	Version 2.50											
	Serial number 12062101											
	Licensed to Tanukefed Lanmiyk - Veward, Gumyzk											
	by Tonne	Software - ww	w.TonneSof	ftware.	com							
	Copyri	ght © 2003-20	12 James L.	Tonn	е							
			<b>E</b> 1 - 1									
		Return to	) Elsie									
		Go to Tonne	Software									
		See License	agreement									
		System Info	ormation									
									$  \rangle$			
									$ \rangle$			
21	M		5M					1	OM			

The buttons allow a choice of visiting the Tonne Software site homepage, or to see the licensing agreement that was agreed-to at the time of installation, or to see detailed information about your computer.

Click on the Return to Elsie button to close this window.

Exit

Clicking on that button opens a window to allow exiting the program:



If this windows was opened in error you can click on the **Cancel / Continue** button to simply close this window.

The Save then exit button allows you to save your work prior to exit if you have not done so.

Or you can simply end the program: click on End / Quit.

Even if you have not already saved your work, or if you choose not to save your work at this point, it will nevertheless be saved automatically to a file named LASTSESSION, along with various operational parameters to allow a smooth program restart.

This exit options window also once again shows the name of the licensee.

Restart: Manual

The **Restart: Manual** button is only available from the Design page and clicking on it will take you to a manual-entry page where you can manually enter all new components. If you go on to that manual-entry page, the analysis items current in memory will be retained but all of the components will be discarded.

This is the window you will see when clicking on the **Restart: manual** button:



If you arrived at this window in error simply click on the **Return to Design screen button** to go back to the design screen; no changes will have been made.

But if you in fact want to go on to the manual entry routine then click on the **Continue to Manual Entry routine** button. That routine has an option to allow you to completely restart the program.

# **Numeric entries**

This program accepts a variety of numerical input formats.

Frequency entries are always in Hz. A frequency of 3.3 MHz may be entered as 3.3M, or as 3.3e6, 3300k or even 3300000. The program accepts them all. The "Hz" is not needed.

The letter "M" in this program is case-sensitive. By this we mean that upper-case "M" is interpreted as "mega" while lower-case "m" is interpreted as "milli". Only the letter M is case-sensitive for numeric entry.

Capacitor values are always entered in farads. A capacitance of 33 pF may be entered as 33p, or 33e-12. A capacitor with a value of .01 uF would be entered as .01u but it could be entered as .01e-6 or even 1e-8 (rather awkward and complicated by comparison). The letter "F" is not needed.

Inductors are entered in henries. An inductance of 33 millihenries may be entered as 33m or .033 An inductor of 33 uH may be entered as 33u, or 33e-6. The letter "H" is not needed.

Resistors are entered in ohms. A resistor of 33 ohms is simply entered as 33. 33 kilohms may be entered as 33k or 33e3 (or even .033M).

Time entries are in seconds. A plotting envelope delay plot upper value might be 120 nanoseconds. That would be entered as 120n. The letter "s" is not needed.

Some entries inherently have no suffix or extension. Number of steps in the frequency sweep used for analysis is an example. Enter 1000 or 1k; either way is satisfactory.

The letter sufix if used can be upper or lower case except for "M" as described above.

Only one letter is needed; the commonly-used second letter (for example "p**F**") is not needed (nor is it even read by the parser).

It may be of interest to see that the entries are generally "echoed back" using the full suffix. You can, for example, enter a frequency of "3500k" and the next time you see that box it will be "3.5MHz" or at least "3.5M". The program may add on appropriate letters to more clearly define the value; in this case it may have added "Hz". All of the entries and readouts behave in this manner.

# Analyzing the design

The Analysis page has three groups. The left-hand group specifies the frequency sweep entries for the analysis. On the plots these are the X-axis items.

Elsie 2.50 - An	alysis Menu - C:\	Program File	s\Microsoft Visua	I Studio\VE	398\ElsieSource	LASTSESSIC	N.LCT						▁
Save design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	
					Transient	Noise	Phase lin.	Title					
		_											
		Start fi	coguopau		Trop	amingion b	offerm (dR)		Oofi	aduatora			
		Start I	200Hz		Tran	-60				10M	_		
		Stop fr	equency.		per i	nterval: 100	βB						
			5kHz						Opfo	anacitors			
		Span:	4 8kHz		Dela	w ton (sers	<b>`</b>			10M	_		
		opun.	4.01112			1.2m	<u>,                                    </u>		I				
		Sweep	,		l per i	nterval: 200	Ousecs		Trans	mission			
		⊙ Lo	g						At	osolute			
		O Lir	near		Impe	edance top	(ohms)		O Re	elative			
		1				120							
		Nr of X	Intervals		per i	nterval: 200	ohms		Trans	mission m	agnify		
									⊙ No	ormal			
		600Hz	per interval		VSW	/R top	_		СM	agnify			
		Analys	is stens			2.2							
		- Finally S	2k		Nr. o	f V intervals			Retur	n Referen	ce (ohms)		
					6					50			
					0	•							
		Width:	1k		Plot	line width							
		_			2	<b></b>							
					,								
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A closer look - the first group:

Start frequency
1MHz
Stop frequency
20MHz
Span: 19MHz
Sweep
● Log
C Linear
Nr of X intervals
2.375MHz per interval
Analysis steps
1k
Width: 3M

In this group we set the analysis frequency sweep starting and stopping frequencies along with the number of points and whether it is a logarithmic or linear sweep. If the sweep is set to be linear, then you can also set the number of vertical lines – the number of X-axis intervals – that will show on the plots. Narrowband filters should use a linear sweep.

Unless a slow computer is being used, the number of analysis steps should be at least 1000; the upper limit is 2049.

👫 Elsie 2.50 - Ani	alysis Menu - C:\P	Program Files	s\Microsoft Visua	l Studio\VB	98\ElsieSource\	LASTSESSIC	N.LCT							- 7 🗙
Save design		Design	Schematic	Edit	Analysis	Plot	Tabulate	Print		Help	About	Exit		
					Transient	Noise	Phase lin.	Title						
		Start fr	equency		Tran	smission b	ottom (dB)		Q of ir	nductors	_			
		2	200HZ			-60				TOM				
		Stop fr	equency		per i	nterval: 100	lВ							
			SKHZ						Q of c	apacitors	_			
		Span: 4	4.8kHz		Dela	y top (secs	)			10M				
						1.2m								
		Sweep			per i	nterval: 200	)usecs		Trans	mission				
		⊙ Lo	g		lmne	dance ten	(ahma)		• Al	osolute				
		O Lin	iear		impe	120	(onms)		C Re	elative				
		Nr of X	intervals		per ii	nterval: 20r	ohms							
		8 4	-						Trans	mission m	agnify			
									• No	ormal				
		600Hz	per interval		VSW	2.2	- 1		ΟM	agnify				
		Analys	is steps											
			2k		Nr of	Y intervals			Retur	n Referen	ce (ohms)			
		1			6					50				
		145.00				•								
		width:	тк		Plot	line width								
					2	-								
						<u> </u>								
							-							
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The middle group sets the plotting scales:

Closer look at the middle group:

Transmission bottom (dB)
-30
per interval: 5dB
Delay top (secs)
120n
per interval: 20nsecs
Impedance top (ohms)
120
per interval: 20ohms
VSWR top
2.2
Nr of Y intervals
6
Plot line width
2

The middle group is where scales for the plots - the Y-axis items - are entered.

The transmission plot bottom in decibels can be set here; the top is always zero dB. For the group (time) delay, we can set delay top; the bottom is always zero seconds. The impedance plots top can be set; the bottom is always zero ohms. The VSWR plot top can be set; the bottom is always unity (1.00). The number of horizontal lines (Y-axis divisions) can be set here. And, especially useful for high-pixel-count screens, the plot line width can be adjusted.

🎬 Elsie 2.50 - Ana	alysis Menu - C:\f	Program Files	s\Microsoft Visua	l Studio\VB	98\ElsieSource\	LASTSESSIC	N.LCT							
Save design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About		Exit	
					Transient	Noise	Phase lin.	Title				_		
	Start frequency				Tran	Q of inductors								
200Hz Stop frequency 5kHz Span: 4.8kHz						10M								
				per i										
					Q of capacitors									
				Dela		10M								
Sweep														
					per i		Transmission							
	C Linear				lure e		Absolute							
					impe		C Relative							
					per i									
8						Transi	mission m	agnify						
				1/014		• No	ormal							
600Hz per interval			VSW		C Magnify									
	Analysis steps			]										
				Nr of		Return Reference (ohms)								
, Width: 1k				6		50								
				<u> </u>										
				Plot										
					2	•								
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The third group on the Analysis page sets the remaining items needed for analysis:

A closer look at the third group:



Return Reference (ohms)

50

The Analysis page is where we set the Q values for the inductors and for the capacitors.

Q values have no effect on the design process. They are used only during the frequency sweep - analysis - to get the various responses. By taking Q values into account, remarkable agreement is achieved when the computed data is compared with actually-measured "real world" data.

Here is the magnitude response for a bandpass filter using all ideal components:



This filter is a 7-pole bandpass designed to pass 3500 kHz to 4000 kHz with 0.5 dB of passband ripple, using ideal components.

Here is the response using real components (with the overlay showing the original):



The overlay is from a response run using the original high-Q components. Here we have put that overlay on top of the plot using low-Q components.

There are two observations that can be made here. One is that at the center frequency there is a loss, about 2 or so dB in this case. This is the insertion loss; use the mouseover to get the figure.

The other is that especially at the band edges the loss increases. To support higher passband ripple designs requires higher-Q components. The higher the design value for ripple the higher will be the required Q values.

Now we are going to look at the **Absolute** and **Relative** buttons.

 Transmission, dB

 0

 -5

 -5

 -10

 -10

 -10

 -11

 -12

 -15

 -20

Here is a plot of a bandpass filter with ideal components:

With those ideal components we have no insertion loss, certainly not a real-world design. Here is that ideal-components filter (as the overlay) and a real filter with lossy components:



Again we have called on the overlay routine to do the comparison. Note the **Absolute** and **Relative** buttons:

Transmission

- O Absolute
- Relative

We have clicked on **Relative** which will make the plot relative, not absolute. The transmission will be relative to the point of maximum transmission in the sweep-frequency range. The default method of plotting transmission in Elsie is absolute.

When we click on **Relative** we see the plot with the point of maximum transmission moved to the top of the screen:



This duplicates the typical measurement of a filter when the "frequency response" is being plotted in that the usual method of showing the response of a filter - especially a bandpass filter as is shown here - is to find the point of maximum transmission and then plot the magnitude response relative to that point.

Now look at the Normal and Magnify buttons; default is Normal.

Transmission magnify

Normal

O Magnify

We want to examine the top of the response plot of a filter, this time being a modest-ripple bandpass. This would be a typical plot:



Resolution is poor in this plot; we can't see details of the passband ripple or loss.

To resolve this issue for the transmission plot, on the Analysis page click on the **Magnify** button:

Transmission magnify

- O Normal
- Magnify

This will add a second plot to the original transmission plot. This added plot has been magnified by a factor of ten; if the original plot had 5 dB per vertical interval then the magnified plot will have 0.5 dB per interval.

The result of adding the magnified plot is seen here:



The details of transmission can be more easily seen.

This magnification is available only on the transmssion-only plot.

# **Plotting the responses**

We have called up a simple lowpass design - Demo1 - and will now use that design for illustrating some plotting options on the Plot page. The buttons on the left side of the page are used to select which of the available plots is called up; they are miniaturized versions of plots for a lowpass filter.



Clicking on this button on the Plot page calls up a plot showing transmission.



Here transmission is shown by itself, probably the most commonly invoked plot.

The button for the current plot is highlighted by a bright cyan background as a reminder of which aspect of the analysis is being shown.



Clicking this button calls a plot showing both transmission (forward) and reflection (return).



When two items are being plotted on one screen they are shown in different colors as can be seen here.

The start of one plot is identified by a colored dot at the beginning of the plot. The end of the other plot is identified by a colored dot at the end of that plot.



Clicking this button calls up a plot showing transmission and its angle.



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Clicking on this button calls a plot showing transmission and associated group (envelope) delay.



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Clicking on that button will show a plot of input VSWR (only).



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Clicking on that button will show a plot of input VSWR along with transmission.



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Clicking on this button calls a plot of input impedance magnitude (only).



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Clicking on this button calls up a plot of input impedance along with transmission.



#### 🔠 start 🕴 🕞 Jasc Paint Shop Pro 🛛 🔛 Elsie 2.50 - Plotted O..



Clicking on this button calls up a plot of input impedance and its angle.



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Clicking on this button calls a plot of input impedance, real and imaginary.



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Clicking on this button calls on a plot showing the Smith Chart, S11



Notice the buttons in the lower-left corner. Clicking the **In** or **Out** buttons allows zooming in (or out) on the chart to allow examining, for example, low-ripple filters. The magnification is done in 2x steps, up to a magnification factor of 16.

Clicking the **VSWR** button places a circle on the chart corresponding to whatever entry is in the associated box. That button toggles the circle on and off.

Clicking on the < or > buttons adjusts the aspect ratio (width) of the chart. This allows correction for various monitor screen aspect ratios. Once adjusted, it is automatically stored to the hard drive for use next time the program is started. This correction is not applied to the plot as sent to the printer because it is not needed.



Clicking on this button calls up a chart showing transmission, S21, in polar form.



Elsie 2.50 - Plotted O...

This plot also has the aspect-ratio correction feature.

### **Transient response**

Elsie has three transient response routines. One is the usual squarewave analysis wherein a squarewave of a specified frequency is applied to the network and the program shows the waveform of the signal exiting from the network.

The second and third routines use a "carrier" of a specified frequency which is keyed on and off at a specified rate. The program shows the waveform exiting from the network for the second routine and it shows the *demodulated* waveform for the third routine.

On the Analysis page click on the **Transient** button to go to that routine. We will then see this window for entry of the various items:

Elsie 2.50- transient analysis setup	Tra	ansient Analysis Set	up	
	Waveform type  Squarewave  Burst  Envelope of burst	Squarewave (Hz): 500 Carrier (Hz):	Analysis type Normal Delay equalized Normal and equalized	
		Plot waveform Return to Analysis page		

Set the waveform type to be Squarewave and enter 500 into the squarewave textbox. Set the analysis type to Normal.

Click on the **Plot waveform** button.

 Tanient Analysis

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 International descent desc

We will see the waveform of the signal exiting from the network:

Filter which have a sharp cutoff, such as this one, generally have the "ringing" as seen on this graphic. The frequency of the ringing is approximately the cutoff frequency of the filter.

Now look at a burst. It is best for this exercise to import a bandpass filter.

On the Design page click on **Get design** and then select CauerBPF4. This is a sharp bandpass filter for use with a carrier frequency of 20 kHz and a bandwidth of 3 kHz, used to generate a single-sideband signal for communications. It has a center frequency of 21500 Hz.

We see this:

Elsie 2.50- transient analysis setup				
	Т	ransient Analysis Setu	p	
	-Waveform type	Modulation Squarewave (Hz):	Analysis type	
	C Squarewave	150	• Normal	
	<ul> <li>Burst</li> <li>Envelope of burst</li> </ul>	Carrier (Hz): 21500	<ul> <li>Delay equalized</li> <li>Normal and equalized</li> </ul>	
				1
	ſ	Plot waveform		
		Return to Analysis page		

This time set the **Waveform type** to **Burst**. Set **Modulation squarewave (Hz)** to 150 and **Carrier (Hz)** to 21500. Leave the **Analysis type** at **Normal**. Click on **Plot waveform** to see this:



### Noise bandwidth

While on the Analysis page and with CauerBPF4 as the chosen network, click on the **Noise** button to see the noise-bandwidth entry screen:

Elsie 2.50 - Noise Bandwidth Routine	
	Noise Bandwidth Routine
Starting frequency (Hz):	18k
Stopping frequency (Hz):	26k
Number of steps:	1k
This network appears to be a	Lowpass networks should be swept from 1 Hz to above the upper 0.1%
bandpass of highpass type.	Requency. Bandpass networks should be swept from below the lower 0.1% frequency to above the upper 0.1% frequency.
Compute Noise	Bandwidth
Return to Anal	ysis page

We are still using "CauerBPF4" for our network. That file has an analysis frequency sweep from 18 kHz to 26 kHz and those frequencies have been entered into the Starting and Stopping frequency textboxes by the program. The number of test-frequency steps has been set to a default number of 1000.

To see the noise bandwidth, click on the **Compute Noise Bandwidth** button.

That screen remains in place but additional information is now available:

Elsie 2,50 - Noise Bandwidth Routine	
Noise	e Bandwidth Routine
Starting frequency (Hz): 18k	Lower frequency for 0.1% power: 19.62k
Stopping frequency (Hz): 26k	Lower frequency for 1% power: 19.836k
Number of steps: 1k	Frequency of maximum transmission: 22.012k
I	Upper frequency for 1% power: 23.3k
	Upper frequency for 0.1% power: 23.564k
This network appears to be a bandpass or highpass type.	Lowpass networks should be swept from 1 Hz to above the upper 0.1% frequency.
	Bandpass networks should be swept from below the lower 0.1% frequency to above the upper 0.1% frequency.
Compute Noise Bandwid	th Noise bandwidth: 2.5857k
Return to Analysis page	

The noise bandwidth of a network is measured here by a process of integration.

For a lowpass filter it should be swept from as close to DC as we can get (1 Hz should work in most cases) to above the 0.1% power point.

For a bandpass filter the sweep should be from below the lower 0.1% power level to above the upper 0.1% power level.

It should be evident that a highpass filter has infinite noise bandwidth.

The computed noise bandwidth is shown highlighted.

## **Phase linearity**

To look at the phase-linearity routine, call up the file FMifBPF3. This would be a design to be in an FM broadcast receiver I.F. amplifier.



The display showing magnitude and delay would appear like this:

The signal passing through this filter would be centered at 10.7 MHz, in the middle of the plot.

The region we are interested in for phase-linearity analysis would be in the middle of the passband, from 10.6 MHz to 10.8 MHz.

To invoke the phase-linearity routine click on Analysis and then on Phase lin.

This will call up the phase-linearity entry window.

By default the starting frequency and stopping frequency are those used for analysis in the main part of the program. Here we have changed those entries to 10.6M and 10.8M.

After changing the starting and stopping frequencies we see this:

Elsie 2.50 - Phase Linearity setup		
	Phase Linearity Setup	
	Starting frequency (Hz): 10.6M	
	Stopping frequency (Hz): 10.8M	
	Number of steps: 1k	
	Show phase Linearity and best-fit line	
	Show deviation from best-fit line	

Return to Analysis page

Now click on the Show phase linearity and best-fit line button.

We see those two items plotted as shown here:



The buttons Decrease stepsize and Increase stepsize may have to be clicked on to adjust the vertical scaling.

The graphic shown is typical of a filter with fairly good phase linearity in that the straight best-fit line is nearly coincident with the phase linearity line.

Click on the **Back to setup** button to change the plot type.





Again the **Decrease stepsize** and **Increase stepsize** buttons may have to be click on to adjust the vertical scale. (Think of those two buttons as a vertical gain control on an oscilloscope.)

This plot is the deviation from the best-fit straight line over the specified frequency range.

### Mousedown

Click on the Plot button to see the plot; then for this exercise click on the second button from the top on the left side of the page. This will cause both transmission and reflection to be shown in one plot.

Now place your mouse anywhere on the plot and press and hold down the mouse button. You will see two things: one is one a marker (or two, in this case) on the plot showing you where Elsie finds your frequency (by reading the X-axis pixel number) and the other is a data readout at the bottom of the screen. You will see this:



In this graphic the screen has been dimmed down in intensity but the items under discussion remain highlighted. As the mouse is moved the dot(s) on the plot will follow and the readout below the plot will be updated. Only the X-axis is being read. Release the mouse button to stop this activity.

### Saving an overlay plot

Now we will save all the data to the hard drive for the current sweep by using a particular filename. These will be retrieved later and can then be plotted on top of the plot that is currently on the computer screen.

While on the Plot screen click on the Save overlay button to see this screen:



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At the left is a small window with ten buttons. For this demo click on the **Save as 1** button.

A set of files will now be written to the hard drive for recall later. Each of the plots is saved with the complete sweep data for replotting. These files have no headers or footers and so could be used by other programs for some kind of further analysis. In about a second the small window will close itself but if you came to this option in error you can simply close it yourself by clicking on the **Exit** button.

# **Tuning width**

With the transmission plot in place, click on the **Tune width** button to see this small window at the lower-left part of the screen:

Elsie - Tune width/center
Width: 3M Center:
Clear plot
Wider
Lower center Raise center
Narrower
Stepsize, %: 1
End tuning routine

Clicking on the **Wider** button will redesign the curent filter to a newer width by whatever the stepsize is (defaulting to 1%). Cliding on the **Narrower** button will make the design width shrink by the stepsize. If the filter is a bandpass or bandstop then the center frequency can be changed in a similar manner.

If the topology is neither bandpass nor bandstop then the **Lower center** and **Raise center** buttons will be dimmed. If the design *is* a bandpass or bandstop, then the **Lower center** and also the **Raise center** buttons will be enabled. These then will tune the center frequency down or up.

With the transmission plot in place click on **Wider** several times and see the bandwidth increase:



Each time the button is clicked the filter is redesigned, reswept and replotted with the new component values. The new plots are overlaid on top of the older ones. If the stepsize is small (such as the default value of 1%) then the individual plots may be indiscernible one from the other.

Elsie 2.50 - Plotted Output - C:\Program Files\Elsie\LASTSESSION.LCT Design Schematic Edit Analysis Plot Tabulate Print Write Help About Exit Transmission, dB -5 -10 Elsie - Tune width/center Width: 3.3139M Center:

5 M

10M

Click on the **Clear plot** button to show only the new-values plot:

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Clear plot Wider

Narrower

End tuning routine

1

Stepsize, %:

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20M

Click on the End tuning routine button to remove the small window.

2M

The next exercise will let us recall that old data plot we saved earlier.

## Getting an overlay plot

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While on the Plot window click on the Get overlay button.

We see the small window allowing us to retrieve the earlier-saved data file.

Elsie 2.50 - Ple	otted Output - C	:\Program File	s\Elsie\LASTSES	SION.L	ст	()		1		- 1			
Save design	Get design	Design	Schematic	E	dit Analysis	Plot	Tabulate	Print	t V	Vrite	Help	About	Exit
Tune width	Tune part	Save overlag	y Get ove	rlay	Stepsize %	Monte Carlo	End	Optimize	L	imits	Mark	ers	
	Transmis	ssion, dB											
Get	-												
7													
Get 1	Delete 1							$ \setminus $					
Get 2	Delete 2							$\square$					
Get 3													
Get 4	Delete 4								$\langle \rangle$				
Get 5													
Get 6	Delete 6									$  \rangle$			
Get 7	Delete 7	1								$  \rangle$			
0	Delete 0										$\mathbf{n}$		
Get 8	D/elete 8												
Get 9	Delete 9												
Get 10	Delete 10											$\mathbf{X}$	
Hide all	overlays												
													$\setminus$
E	xit												$\left  \right\rangle$
				21	ſ		5	M				10M	

When this small window is showing you can click on one of the **Get** buttons to retrieve a stored overlay data file.

For this exercise click on **Get 1** and see the retrieved overlay on top of the existing file:



These "Get" and "Save" buttons apply to each of the plots, not just magnitude as seen here. When you save a set of the data, you can recall (get) that data for any of the plots.

Buttons that are dimmed are simply not available because there is no data for them.

To erase any of the previously-saved datafile sets, click on the appropriate **Delete** button(s).

To close the small options window click on its **Exit** button.

After that is done we see the plot with current data and also the just-retrieved overlay:



At intervals the overlay number will be written on top of the line of data. In this case we recalled number one and so the digit "1" will appear.

Using overlays will prove quite useful when comparing two or more different designs. Up to ten sets of data can be saved this way. Data for all of the plots is saved, not just transmission as we used here.

You can save the responses using any of the numbered buttons. To retrieve a given set of responses that were saved just use that same number for retrieval as was used for saving.

To get rid of a set of data - the overlay - click on the **Delete** button for that data.

## **Tuning a part**

With the transmission plot in place, click on the **Tune part** button to see this small window at the lower-left part of the screen:

By default you will see in this window the first component, in this case a shunt capacitor, with its part value. Clicking on the **Increase value** button will incease the value of that part by the percentage as entered in the **Stepsize** box, then resweep the filter and show the resultant plot. Conversely, clicking on the **Decrease value** button will reduce the value of that part, resweep the filter and plot the resultant.

To navigate to another part to tune it, click on the Next part or the Previous part button.

To exit this routine click on the **End tuning routine** button.

Next we will exercise the part-tuning routine.

Here is the appearance of the screen after clicking on the **Tune part** button: Elsie 2.50 - Plotted Output - C:\Program Files\Elsie\Demo1.LCT 
Save design Get design Design Schematic Edit Analysis Plot Tabulate Print Write Help About Exit



Each time we click on the **Increase value** button (and conversely the **Decrease value** button) the part value will be stepped up (or down) and the new value will be used for the filter. Then the filter will be reswept and the resulting plot shown.

The value of the selected part will be changed according to the entry in the **Stepsize** textbox.

The small tuning window shows the first element in the network, in this case a shunt capacitor.

Set the **Stepsize** to 10.

Then click on the **Increase value** button five times; see the plot change.

Click on the **Clear plot** button. Now only the final plot is seen.

Click on the **Next part** button. See the second element, in this case a series inductor.

Set the Stepsize to 15.

Click on the **Decrease value** button four times and see the plot change.

Click on the **Clear plot** button to again clarify the screen.

Click on the **Next part** button. See the third element, in this case a shunt capacitor.

Set the Stepsize to 20.

Click on the **Increase value** button three times and see the plot change.

Click on the **Clear plot** button.

Click on the **End tuning routine** button to leave this procedure.

Click on Get overlay.

Click on the Get 1 button. This will call up the plot you saved earlier.

Click on **Exit** in the small Get overlay window.

Now you have a plot showing the manually-adjusted values along with the original values.



Those percentage values that were entered during the adjustment process are saved as part of the parts list. They become part of the Elsie file when the file is saved.

They also show on the schematic.

Here is the schematic of the manually-adjusted network:



Beneath each component is the stepsize that was assigned to it.

Those percentage values will be used if the part-tuning routine is used again, and they are also used in the Monte Carlo sweep.

Click on the **Plot** button to see the plot again.

### **Monte Carlo**

While a plot is on the screen, click on the **Monte Carlo** button. This starts the Monte Carlo routine (randomly-changing parts values to see the spread in production) using the percentages that have been assigned to each part. If a particular part has no percentage assigned to it then that part will not be altered during the routine.



Here we see the plot while the Monte Carlo routine is running:

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Each plotted line has a different color, rotating through a series. This somewhat clarifies how the individual sweeps are behaving.

Rather quickly the maximum and minimum responses will be seen.

The parts values in this routine are of a uniform random distribution. For each sweep all parts

values are simultaneously altered in that manner and then the data is collected and plotted. When the decision is made to stop the routine, then click on the **End** button to stop it with a screen appearing as shown, or click on the **End / show extremes** button to see the result as shown here. Each of these two methods of ending the routine has it own merits.

When the Monte Carlo routine is ended using the **End / show extremes** button we have this result:



#### Elsie 2.50 - Plotted O...

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During the run, the program keeps track in memory of the maximum and the minimum values for each test frequency during the sweep. When the routine is ended, the maximum values alone are used to make a plot. Then the minimum values are used to make a second plot. Finally the target values are used to make a third plot. The maximums and minimums are plotted in one color and the plot using the target values - typically right down the middle of the extremes - is in a second color.

After the Monte Carlo routine is finished the components are returned to their original (target) values.

# Limits

Typically a filter is designed to pass some range of frequencies with some kinds of restraints and to reject some other range or ranges, perhaps with other restraints. It is helpful during this design process to show visually any "out of bounds" areas. The same routine for defining these areas is also used in the optimizer. First we have to install the limits areas.

Call up the Demo1 file, click on **Plot** to see transmission and then click on **Limits**. We see this after the cursor is over the **Enter** button:

![](_page_66_Figure_3.jpeg)

Click on that Enter button.

🖺 Elsie 2.50 - Plo	tted Output - C:\	Program File	s\Elsie\Demo1.LC	T									
	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	
E	nter transmis	sion limit	s				End						
	Transmissi	ion, dB											
M	Ů Î												]
$\overline{\mathcal{N}}$	-5												
								$\setminus$					
$\overline{\mathbf{N}}$													
F.V.	-10												
									$\mathbf{N}$				
A	-15												

After clicking on the Enter button we see this:

We see a series of buttons illustrating the variety of "out of bounds" areas.

The first button allows placement of a limit in which all of the area beneath and to the left of the chosen point is out of bounds.

The second button allows placement of a limit in which all of the area to the right and above the chosen point is out of bounds.

The other buttons have the remaining possible traits.

For this exercise, click on that first button, at the far left.

🎬 Elsie 2.50 - Plo	tted Output - C:\l	Program File	s\Elsie\Demo1.LC	т									
Save design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	
E	nter transmis	sion limit	s				End						
	Transmissi u	ion, dB											_
M	I						$\langle \rangle$						
$\sim$	-5												-
								$\left  \right\rangle$					
								$  \setminus$					
	-10								$\setminus$				-
									$\mathbb{N}$				
-	-15												

That button is then highlighted as a reminder of the shape that has been chosen.

Move the cursor to (for this exercise) a point on the plot corresponding to a frequency of 4 MHz and a magnitude of -1 dB and then click on that point.

![](_page_68_Figure_0.jpeg)

The out-of-limits area is immediately highlighted and so we see this display:

We are going to continue on and add a second limit. The shape we want is that shown by the second button; mouseover and click on it.

We see this display:

🎬 Elsie 2.50 - Pla	tted Output - C:\\	Program File	s\Elsie\Demo1.L	ст									
Save design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	
							End						
	Transmissi U	ion, dB										]	_
M	F			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~									
	-5												1
								$\left  \right\rangle$					
								$  \setminus$					
	-10								$\leftarrow$				-
									$\mathbf{N}$				
-1	-15								$\setminus$				

After you chose that button it is then highlighted as a reminder of the shape chosen.

Move the cursor to a point on the plot corresponding to a frequency of 8 MHz and a magnitude of -20 dB and then click on that point.

### We see this display:

![](_page_70_Figure_1.jpeg)

Again the out-of-limits area is highlighted.

When finished with selecting and then entering the limits, click on the **End** button located right above the limits buttons.

The final display is as shown here:

![](_page_71_Figure_1.jpeg)

When a file is saved after the limits-entry process, all of the limits information is saved along with the other design data. When a plot is called up, those limits areas are shown by default, the assumption being made that if they were important enough to enter they should be shown by default.

The limits can be hidden (but are still available for showing if desired) by using the **Hide** button. They can be erased completely by using the **Erase local** button to delete all limits for the plot being seen. Or by using the **Erase all** button to delete all limits for all plots.

The entry process described is not precise. Using the mouse to read pixels and translating that to meaningful numbers (kilohertz, decibels and so on) is at best an approximation. Now we will set the entries to exact values. In general this is not needed if care was used in the
entry process using the mouse. We will edit the entries here as an exercise. With the plot as shown click again on the **Limits** button. Then mouseover the **Edit** button in the small window.



Click on that Edit button to see the next screen.

Here we see the editing screen as it first appears. The icons near the top of the page will be illustrative of each of the limits that were previously entered. Beneath that is a table (listbox) which shows the limits that were entered.

0 Limits Show / Edit - C:\Program Files\Elsie\LASTSESSION.LCT	-4
lick on a limit to edit it	
ansmission Shape: 1 DC up to to 4.0029M top: -1.056 bottom: -300 ansmission Shape: 2 from 8.0208M to 10G top: 0 bottom: -19.92	
Edit this one	
Starting frequency:	
Stopping frequency:	
Upper limit:	
Accept values Return to Plot page	

The values that were entered using the mouse are typically only approximate. To edit a line of data in the list to clearly define its numbers, click on that line.

The line will then be highlighted and the data in that line is shown in the set of four text entry boxes below the table. Those values show starting frequency, stopping frequency, upper magnitude limit and lower magnitude limit, as applicable, as you entered them into the plot, prior to any editing.

After a line of data is clicked on it is highlighted. In addition the data for that line appears in the set of textboxes below the listbox.

Elsie 2.50 Limits Show / Edit - C:\Program Files\Elsie\LASTSESSION.LCT	
Click on a limit to edit it	
Transmission Shape: 1 DC up to to 4.0029H top: -1.056 bottom: -300 Transmission Shape: 2 from 8.0208H to 10G top: 0 bottom: -19.92	
Edit this one	
Starting frequency: 10m	
Stopping frequency: 4.0029M	
Upper limit: -1.056	
Lower limit: -300	
Accept values Return to Plot page	

An informative notice in green notice tells you that you can "Edit this one".

To edit the values, simple alter the values as seen in the textboxes. Here we have an odd value for frequency; change it to the exact value you want, in this case 4 MHz.

The upper limit is also not exact; change it here to an exact value of -1.

When done with an edit operation, click on the **Accept values** button beneath the textboxes. The values will then be placed back into the list box just beneath the icons.

When all of the limits values are satisfactory, click on the **Return to Plot page** button. You will see the plot as it was before you refined the limits-entry values.

# Limits entry options

In the limits entry and editing exercise we used only two of the available options.

Limits options					
Enter					
Edit					
Erase local					
Erase all					
Hide					
Show					

Clicking on the **Limits** button while a plot is showing calls up this small options window.

Here we can click on the **Enter** button to call up the routine to enter the limits using the mouse.

We can click on the **Edit** button to go to the routine to set the limits more precisely by entering exact values for frequency and magnitude.

By clicking on the **Erase local** button we delete all limits for the current plot. As an example, if the plot for transmission is the current display then all limits for that plot will be deleted. Any limits entered for other plots will be left intact.

By clicking on the **Erase all** button, all limits for all plots will be deleted.

By clicking on the **Hide** button, the limits are removed from the display but they still reside in memory.

By clicking on the **Show** button, any limits for the currently-displayed plot will be shown.

### Limits shape options

In the limits-entry exercise only two of the available shapes were utilized. Here is more information on each of those shapes.



This shape is used to require the response in question to be at least some magnitude below the chosen frequency. There is no restriction above that frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.



This shape is used when the response in question must not exceed some magnitude above the chosen frequency. There is no restriction below that frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.



This shape is used to require the response to be at least some magnitude above the chosen frequency. There is no restriction below that frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.



This shape is used to require the response to be no more than some magnitude below the chosen frequency. There is no restriction above that frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.



This shape is used to require the response to be at least some magitude between two frrquencies. There are no restrictions below the lower or above the upper frequency.

To enter this shape, mouseover and click on the point corresponding to one of the chosen frequencies. Magnitude at that first frequency is ignored. Then click on the frequency point and magnitude of the second frequency.

	-		
-		_	

This shape is used to require the response to be no more than some magnitude between two frequencies. There are no restrictions below the lower or above the upper frequency.

To enter this shape, mouseover and click on the point corresponding to one of the chosen frequencies. Magnitude at that first frequency is ignored. Then click on the frequency point and magnitude of the second frequency.

1		_	
	1	r I	

This shape is used to illustrate that the response is to be at least some minimum value at a specified frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.

This shape is used to illustrate that the response is to be no more than some maximum value at a specified frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.



This shape is used to illustrate that the response is to be a particular magnitude at a specified frequency.

To enter this shape, mouseover and click on the point corresponding to the chosen frequeny and magnitude.

### Stepsize

Two routines in this program utilize component tolerances or step sizes. These are the Monte Carlo, previously explored, and the optimizer.

The Monte Carlo can use any percentage to vary the components during the routine. That includes a value of 0% if a component is to be held at a constant value, with no variation during the routine.

The optimizer is best operated using a small value for adjusting the component values. Suggested is a value of 1 to 5 percent.

To enter that step size for the optimizer, click on the **Stepsize%** button while a plot is showing.

A small window will show in the center of the screen:

Stepsize entry							
	Previous item Next item						
Stage: 1	C1: 907.131pF						
	Step size %: 5						
	Enter						
S	elect all items to have same stepsize						
	Evit						
	EXIL						

Here is where the items' stepsizes are entered. Each item can be selected one at a time by using the **Previous item** and **Next item** buttons.

Alternatively, and typically quite satisfactory - and definitely faster - is to enter a step size in the text box and then click on the **Select all items to have same stepsize** button.

After doing that the window appears as this:

Stepsize entry						
Previous item Next item						
Stage: 1 C1: 907.131pF						
Step size %						
Enter						
Stepsize for all items has been set to 5%						
Select all items to have same stepsize						
· · · · · · · · · · · · · · · · · · ·						
Exit						

After clicking on that button a confirmation notice appears indicating that all items will have the same size, and indicating the size.

Using the **Select all items to have same stepsize** button does *not* preclude selecting some items to have a different stepsize. Simply click on the **Next item** button to go one and select the item, enter the differing stepsize into the textbox and click on the **Enter** button. Do this for each of the items that are to be re-specified.

## Optimizer

If the limits have been set correctly, and if the stepsizes have been entered, then the optimizer can be invoked. This is a great tool to use to design networks that might be considered special in some way. Here we will go through another simple exercise. Later in the manual this tool will be invoked in a more meaningful manner.



Here is the plot we had at the end of the limits-entry routine:



The limits that were entered in the limits-entry exercise were deliberately chosen so that the plot would not quite "meet specifications." It would be quite possible to use the Tune part button to adjust the component values until the specifications were met but there is a much better way to do this: use the optimizer.

With the system primed per the previous exercises, click on the **Optimize** button. The optimizer routine will then start. It will vary the component values in an attempt to minimize the plot area that is inside of the out-of-bounds (limits) areas, and then immediately replot the result. We will see this display:



As with the Monte Carlo, we can see the plot resulting from each frequency sweep. These plots are colored with a series of colors that appear in rotation.

In the upper-left corner is information about the optimizer progress.

Immediately above the plot is a bar showing the error term that the routine has found. This bar uses a logarithmic scale and is updated every time an improvement is made, i.e., the error is reduced.

When the error term is reduced to less than 0.01 (nothing, in practical terms), the routine will stop and we will see the plot of the resultant:



We can see that the data plot clears - avoids - the limits areas. We have a satisfactory design.

The optimizer adjusts the component values using a uniform-distribution random number generator with the specified constraints on component stepsizes.

It is possible that the routine will stop without reaching a satisfactory design. Either the specifications simply can't be met or the optimizer has tried for 2000 times and automatically stops. Or else a "local minimum" has been reached. The routine can't do any better but has come up with a non-optimum answer: a different combination of components might be better: it has failed to find that global minimum. Some manual component adjustment, augmented by operator common sense, may solve the problem.

### Markers

Several markers can be shown on a plot to reveal precise data about each of a set of specified frequencies.

To enter the marker frequencies while a plot is showing click on the **Markers** button. In the middle of the screen we will see this small window:

Marker entry						
Frequence	:y 1:	1M				
Frequence	; <b>y 2</b> :	2M				
Frequence	: <b>y 3</b> :	ЗM				
Frequenc	:y 4:	4M				
Frequenc	: <b>y 5</b> :	8M				
Frequenc	<b>:y 6</b> :	0.0	)			
Frequenc	;y 7:	0.0	)			
Frequenc	: <b>y 8</b> :	0.0	)			
	Sho	w				
	Hide					
	Erase all					
	Exit					
	Show Hide Erase all Exit					

Into each textbox enter the frequencies of special interest. Here we have already entered a set of frequencies.

To show the markers on a plot simply click on the **Show** button.

🖺 Elsie 2.50 - Plotted Output - C:\Program Files\Elsie\LASTSESSION.LCT Design Schematic Edit Analysis Plot Tabulate Print Write Help About Exit Tune width Tune part Save overlay Get overlay Stepsize % Monte Carlo Optimize Limits Markers Transmission, dB U (4) M -5 -10 -15 0 C -20-25 -30 2M 5M 10M 20M 1M VSWR: Zmag.: Zangle: Real: Freq.: Trans.: Angle: Return: Delay: Imag. 34.563 24 31.107 80.315 0.16202 -16.497 -9.484 3.5856 -34.651 -18.579 -11.626 -8.6135 -12.51 -9.3338 -0.04946 38.298 25.806 31.313 87.471 18.58 -25.515 -21.562 6.5752 -23.338 -89.5 1 1M 2 2M 3 3M 4 4M 5 8M -0.33175 -0.67701 -0.30387 -0.62168 -31.16 -59.437 -90.895 -138.84 128.61 82.11n 77.79n 104.3n 154.5n 17.79n 1.7109 2.1795 1.6208 2.0369 351.21 -20.013

- 7 🗙

🔇 👁 💁 🖾 📿 🧟 👿 5:39 PM

We will then see the markers on the display:

#### Elsie 2.50 - Plotted O...

On the plot we will see the marker number inside of a small circle. The center of each of the circles is placed at the point corresponding to its magnitude for that plot. At the bottom of the page we see all of the data for each marker frequency.

After the plot is finished then each of the marker frequencies is run through the analysis routine and data for that exact frequency is shown. Marker data frequencies are totally independent of the various frequencies used for the main sweep.

Write

Here is additional information for the **Write** button. That buttons calls on one of four routines to write data resulting from analysis of the network. Those routines are independent of the routines used to write Elsie circuit files.

After clicking on the **Write** button and then clicking on the **Write data file (scientific format)** we see this:

Elsie - write tal	oulated data file	;			? 🗙	
Save in:	Elsie		- te e	· 🎫 -		
My Recent Documents	Default.DAT  EasyToReadExa	ample.DAT				e-writing routine
Desktop						
My Documents						ated data file (scientific format)
My Computer						ed data file (easy-to-read format)
Mv Network	File name: Save as type:	ScientificExample.DAT	•	Si Si	ave Incel	
Places		, , , , , , , , , , , , , , , , , , , ,				/rite S-parameter file



This filenaming window shows by default all of the files with an extension of .DAT Entering a root name in the file name box would result in an extension of .DAT

Clicking on the down-arrow in the Save as type box reveals that files with extensions of .TXT can be seen (and written with that extension). Or a third option will show all files in the directory.

The files written by this routine are in fact simple text files. The formatting is all that changes according to the format button selected.

Here is how the "scientific format" file would appear using a text editor to view it:

Freq, Hz:	Trans, dB:	Phase, degrees:	Return, dB:	Delay, secs:	VSWR, v/v:	Zin, ohms:	Zangle, degrees:
1000000	-5.886845E-02	-26.9142	-21.36806	7.506927E-08	1.186814	46.53429	-8.86514
1003000	-5.900714E-02	-26.99528	-21.35127	7.50742E-08	1.187209	46.51733	-8.876269
1006009	-5.914591E-02	-27.07662	-21.33455	7.507912E-08	1.187603	46.50033	-8.887307
1009028	-5.928475E-02	-27.1582	-21.3179	7.508411E-08	1.187997	46.48328	-8.898254
1012055	-5.942367E-02	-27.24003	-21.30131	7.508916E-08	1.188391	46.46619	-8.909109
1015091	-5.956266E-02	-27.32212	-21.28478	7.509427E-08	1.188783	46.44906	-8.91987
1018137	0597017	-27.40446	-21.26833	7.509944E-08	1.189175	46.43189	-8.930537
1021192	-5.984079E-02	-27.48705	-21.25193	7.510467E-08	1.189566	46.41468	-8.941107
1024255	-5.997993E-02	-27.56989	-21.23561	7.510997E-08	1.189957	46.39742	-8.95158
1027328	0601191	-27.65299	-21.21935	7.511533E-08	1.190347	46.38013	-8.961954
1030411	0602583	-27.73635	-21.20317	7.512076E-08	1.190736	46.36279	-8.97223
1033502	-6.039751E-02	-27.81995	-21.18705	7.512625E-08	1.191124	46.34542	-8.982404
1036603	-6.053673E-02	-27.90382	-21.171	7.513182E-08	1.191511	46.328	-8.992476
1039713	-6.067596E-02	-27.98795	-21.15502	7.513744E-08	1.191898	46.31055	-9.002443
1042832	-6.081519E-02	-28.07233	-21.13911	7.514314E-08	1.192283	46.29306	-9.012307
1045961	-6.095439E-02	-28.15697	-21.12327	7.51489E-08	1.192668	46.27553	-9.022064
1049099	-6.109358E-02	-28.24188	-21.1075	7.515474E-08	1.193052	46.25796	-9.031714
1052247	-6.123273E-02	-28.32704	-21.09181	7.516065E-08	1.193435	46.24035	-9.041257
1055404	-6.137185E-02	-28.41247	-21.07619	7.516662E-08	1.193817	46.22271	-9.050689
1058570	-6.151091E-02	-28.49816	-21.06064	7.517268E-08	1.194198	46.20503	-9.060009
1061746	-6.164992E-02	-28.58412	-21.04517	7.51788E-08	1.194577	46.18732	-9.069218
1064931	-6.178886E-02	-28.67034	-21.02977	7.5185E-08	1.194956	46.16957	-9.078312

For this manual the image has been trimmed. Scroll bars would appear if the file is viewed using an ordinary text editor, this generally being the case if the recommended hundreds of lines of data are in the file.

If this information is to be read by a machine it should be quite satisfactory. It is not quite optimum from a human viewpoint. Hence Elsie also has a file-writing routine that is oriented toward being read by humans. The information delivered by that routine is the same but it may very not be optimum from a machine's viewpoint.

Clicking on the **Write** button and then clicking on the **Write data file (easy-to-read format)** we see this:

Elsie - write ta	bulated data fil	e		? 🗙	
Save in:	🚞 Elsie	•	← 🗈 💣 🎟-		
	Default.DAT				e-writing routine
My Recent Documents					
6					
Desktop					
<b>&gt;</b>					ated data file (scientific format)
My Documents					aled data me (scientine format)
Mv Computer					ed data file (easy-to-read format)
	File name:	EasyToReadExample.DAT	•	Save	
My Network Places	Save as type:	Tabulated-data files (*.DAT)		Cancel	
					/rite S-parameter file

Write LTspice® schematic file

Tonne Software has no connection with LTspice

As with the scientific-format entry, this filenaming window shows by default all of the files with an extension of .DAT Entering a root name in the file name box would result in an extension of .DAT

Clicking on the down-arrow in the Save as type box reveals that files with extensions of .TXT can be seen (and written with that extension). Or a third option will show all files in the directory.

Again, the files written by this routine are simple text files. The formatting is all that changes according to the format button selected.

Here is how the "easy-to-read" format appears using the text editor to view it:

Freq,	Trans,	Phase,	Return,	Delay,	VSWR,	Zin,	Zangle,
Hz:	dB:	degrees:	dB:	secs:	v/v:	ohms:	degrees:
1M	-0.05887	-26.914	-21.368	75.07n	1.1868	46.534	-8.8651
1.003M	-0.05901	-26.995	-21.351	75.07n	1.1872	46.517	-8.8763
1.006M	-0.05915	-27.077	-21.335	75.08n	1.1876	46.5	-8.8873
1.009M	-0.05928	-27.158	-21.318	75.08n	1.188	46.483	-8.8983
1.0121M	-0.05942	-27.24	-21.301	75.09n	1.1884	46.466	-8.9091
1.0151M	-0.05956	-27.322	-21.285	75.09n	1.1888	46.449	-8.9199
1.0181M	-0.0597	-27.404	-21.268	75.1n	1.1892	46.432	-8.9305
1.0212M	-0.05984	-27.487	-21.252	75.1n	1.1896	46.415	-8.9411
1.0243M	-0.05998	-27.57	-21.236	75.11n	1.19	46.397	-8.9516
1.0273M	-0.06012	-27.653	-21.219	75.12n	1.1903	46.38	-8.962
1.0304M	-0.06026	-27.736	-21.203	75.12n	1.1907	46.363	-8.9722
1.0335M	-0.0604	-27.82	-21.187	75.13n	1.1911	46.345	-8.9824
1.0366M	-0.06054	-27.904	-21.171	75.13n	1.1915	46.328	-8.9925
1.0397M	-0.06068	-27.988	-21.155	75.14n	1.1919	46.311	-9.0024
1.0428M	-0.06082	-28.072	-21.139	75.14n	1.1923	46.293	-9.0123
1.046M	-0.06095	-28.157	-21.123	75.15n	1.1927	46.276	-9.0221
1.0491M	-0.06109	-28.242	-21.108	75.15n	1.1931	46.258	-9.0317
1.0522M	-0.06123	-28.327	-21.092	75.16n	1.1934	46.24	-9.0413
1.0554M	-0.06137	-28.412	-21.076	75.17n	1.1938	46.223	-9.0507
1.0586M	-0.06151	-28.498	-21.061	75.17n	1.1942	46.205	-9.06
1.0617M	-0.06165	-28.584	-21.045	75.18n	1.1946	46.187	-9.0692
1.0649M	-0.06179	-28.67	-21.03	75.19n	1.195	46.17	-9.0783

As might be surmised this information is formatted using the same formatting subroutines that are used in Elsie for delivering data to the screen. Machines or programs may or may not accept these lines of data.

Clicking on the **Write** button and then clicking on the **Write S-parameter file** button we see this:

Elsie 2.50 - Get SnP options - C:\Program Files\Elsie\LASTSESSION.LCT	
C	hoose SnP File Options
<ul> <li>ତ S2P [2-port]</li> <li>○ S1P [1-port]</li> </ul>	
୍ତ Hz ୁ KHz ୁ MHz	GHz     Starting frequency: 1M
<ul> <li>♥ Version 1.0</li> <li>♥ Version 2.0</li> </ul>	Number of frequencies: 1001
Continue with SnP operati	ion
Return to Elsie	

Here several options for the Touchstone SnP files are chosen. These include one-port or twoport files, magnitude in dB or volts/volt, the frequency definition and Version 1 or 2.

To the right of the options buttons is information that may prove helpful.

Here is how the first few lines of such a file appear if viewed using an ordinary text editor:

: 2-port 2	-parameter file	version 1.0 by	/ EISIE //4/2012	12:15:22 PM				
# Hz S DB	R 50							
! Fstart:	1000000 Fstop:	2E+07 Freqs:	1001					
! Freq:	S11 mag:	S11 angle:	S21 mag:	S21 angle:	S12 mag:	S12 angle:	S22 mag:	S22 angle:
1000000	-21.36806	-8.865137	-5.886843E-02	-26.9142	-5.886843E-02	-26.9142	-21.36806	-8.865137
1003000	-21.35128	-8.876266	-5.900712E-02	-26.99528	-5.900712E-02	-26.99528	-21.35128	-8.876266
1006009	-21.33456	-8.887304	-5.914589E-02	-27.07662	-5.914589E-02	-27.07662	-21.33456	-8.887304
1009028	-21.3179	-8.898252	-5.928473E-02	-27.1582	-5.928473E-02	-27.1582	-21.3179	-8.898252
1012055	-21.30131	-8.909106	-5.942366E-02	-27.24004	-5.942366E-02	-27.24004	-21.30131	-8.909106
1015091	-21.28479	-8.919868	-5.956264E-02	-27.32212	-5.956264E-02	-27.32212	-21.28479	-8.919868
1018137	-21.26833	-8.930533	-5.970168E-02	-27.40446	-5.970168E-02	-27.40446	-21.26833	-8.930533
1021192	-21.25194	-8.941104	-5.984078E-02	-27.48705	-5.984078E-02	-27.48705	-21.25194	-8.941104
1024255	-21.23561	-8.951577	-5.997991E-02	-27.56989	-5.997991E-02	-27.56989	-21.23561	-8.951577
1027328	-21.21936	-8.961951	-6.011908E-02	-27.65299	-6.011908E-02	-27.65299	-21.21936	-8.961951
1030411	-21.20317	-8.972226	-6.025827E-02	-27.73635	-6.025827E-02	-27.73635	-21.20317	-8.972226
1033502	-21.18705	-8.9824	-6.039749E-02	-27.81996	-6.039749E-02	-27.81996	-21.18705	-8.9824
1036603	-21.171	-8.992472	-6.053671E-02	-27.90382	-6.053671E-02	-27.90382	-21.171	-8.992472
1039713	-21.15502	-9.00244	-6.067594E-02	-27.98795	-6.067594E-02	-27.98795	-21.15502	-9.00244
1042832	-21.13911	-9.012303	-6.081517E-02	-28.07233	-6.081517E-02	-28.07233	-21.13911	-9.012303
1045961	-21.12327	-9.022061	-6.095437E-02	-28.15697	-6.095437E-02	-28.15697	-21.12327	-9.022061
1049099	-21.10751	-9.031712	-6.109356E-02	-28.24188	-6.109356E-02	-28.24188	-21.10751	-9.031712
1052247	-21.09181	-9.041253	-6.123271E-02	-28.32704	-6.123271E-02	-28.32704	-21.09181	-9.041253
1055404	-21.07619	-9.050685	-6.137183E-02	-28.41247	-6.137183E-02	-28.41247	-21.07619	-9.050685
1058570	-21.06064	-9.060006	-6.151089E-02	-28.49817	-6.151089E-02	-28.49817	-21.06064	-9.060006
1061746	-21.04517	-9.069214	0616499	-28.58412	0616499	-28.58412	-21.04517	-9.069214
1064931	-21.02977	-9.078308	-6.178884E-02	-28.67034	-6.178884E-02	-28.67034	-21.02977	-9.078308

Clicking on the **Write** button and then clicking on the **Write LTspice schematic file** button we see this:

Elsie - write L	Tspice schemat	ic			? 🗙	
Save in	: 🔁 Elsie		• <del>•</del> •	r 🗐 🕂		
My Recent Documents	🏌 LTspiceExamp	le.ASC				e-writing routine
Desktop						
My Documents						ated data file (scientific format)
My Computer						ed data file (easy-to-read format)
My Network Places	File name: Save as type:	LTspiceExample.ASC LTspice files (*.ASC)		•	Save Cancel	
						/rite S-parameter file

Write LTspice® schematic file

Tonne Software has no connection with LTspice

Return to Elsie

Although the file is a simple text file the extension must be .ASC for LTspice to accept it.

Tonne Software has no connection with LTspice or Linear Technology Corporation.

Here are the first few lines of the LTspice schematic file as examined with an ordinary text editor:

Version 4 SHEET 1 800 600 SYMBOL voltage 0 144 R0 WINDOW 123 24 132 Left 0 SYMATTR InstName Vgen SYMATTR Value AC 2 WIRE 0 80 48 80 WIRE 0 160 0 80 WIRE 0 240 0 336 FLAG 0 336 0 TEXT 0 464 Left 0 !.AC DEC 1000 1000000 2E+07 TEXT 0 496 Left 0 ;Schematic drawn by Elsie SYMBOL res 192 64 R90 WINDOW 0 0 56 Vbottom 0 WINDOW 3 32 56 Vtop 0 SYMATTR InstName RS SYMATTR Value 50 WIRE 48 80 96 80 WIRE 176 80 224 80 SYMBOL cap 272 160 R0 SYMATTR InstName C1 SYMATTR Value 907.131pF SYMATTR SpiceLine Rpar=116.966k WIRE 224 80 384 80 WIRE 288 80 288 160 WIRE 288 224 288 336 FLAG 288 336 0 TEXT 288 400 Center 0 ; 1 SYMBOL ind 400 96 R270 WINDOW 0 32 56 Vtop 0 WINDOW 3 5 56 Vbottom 0 SYMATTR InstName L2 SYMATTR Value 2.92962uH SYMATTR SpiceLine Rser=0.2761102

(This is only a partial listing of the file.)

# Editing

Here is more detail for the **Edit** button. Clicking on that button calls up the circuit editor. Here is the screen at that point.



Other than leaving this routine - by using one of the buttons at the top of the screen - the only option is to select a component in the schematic near the top of the screen by clicking on it.

After a part has been chosen the screen appears like this:



The selected component is highlighted and is also shown again in the lower-left corner of the screen. Four options are now available. The component can be edited (changed in value) or its type changed or a part can be inserted into the network just ahead of that component, or the component can be deleted.

#### Edit values of this stage

Clicking on this button allows the value of the component to be changed (edited).



The highlighted component now has its value shown in a small window, labeled here as "L value". Enter the new value for the component in that window and then click on the **Accept** button.

After acceptance we see this:



We see here the schematic with the newly-entered value.

Continuing this exercise, change the topology (the type of component) of that stage.

### Change topology of this stage

Clicking on this button allows that component to be changed to a different type as seen in the library at the lower-right corner of the screen.

This is the appearance of the screen after clicking on that button:



Note the prompt to "Click on an element to select it" immediately above the library.

Mouseover and click on a a component in the library; for this exercise choose the series parallel-tuned trap.



This is the screen appearance after choosing that component:

Note the cursor at the selected component along with the textboxes showing the current parts values.

Since this component consists of an existing item (an inductor) along with a new item (a capacitor), the current inductor value will be shown in its textbox but there is no value for the capacitor and so its textbox is empty.

Enter new values for both the capacitor and the inductor and then click on the **Accept** button. For this exercise we entered 3.1u into the inductor textbox (wose label is "L value") and 33p into the capacitor textbox (whose label is "C value").

Here is the appearance of the screen after acceptance:



We see the updated schematic with the newly-entered values.

### Insert part prior to this stage

Clicking on this button allows insertion of a component **prior** to the chosen one.

Immediately after clicking on that button and then after having chosen the first stage, this is the screen appearance:



#### Elsie 2.50 - Circuit Edi...

We have chosen to insert a part prior to the first stage.

See the prompt "Click on an element to select it".

We are going to add a series inductor so click on that part in the library.

Here can be seen the cursor in the library, pointing at the part just selected, a series inductor. A textbox has opened for value entry.



In the textbox, enter a value of 2 microhenries; use 2u in the "L value" textbox.

After clicking on the **Accept** button we see this screen:



The value in the textbox was accepted and we have the updated schematic with the 2 microhenry component added ahead of the original selected part.

To add a component at the end of the network, select the output termination (load) and then add the part ahead of the load.

If the input termination (source) is selected the **Insert part priot to this stage** will be inoperative; you cannot add a part ahead of the input termination.

Next in this exercise we will delete a component.

Delete this stage

Clicking on this button causes the chosen component to be removed from the network.

For this exercise we will remove the just-added component.

Select the stage to delete (the first stage):



### Elsie 2.50 - Circuit Edi...

The first stage has just been selected; see the cursor pointing to the series inductor in the schematic.

That component is also echoed in the window at the lower-left.

To delete that component, click on the **Delete this stage** button.

The component is removed and we see the updated schematic:



This is a very fast operation; no entries had to be made.

## **Design entry**

If you have been working your way through this manual from the start you will have noticed that we have shown some of the various circuit manipulation and analysis options but have not done any real design work. Now we will open the door to design.

Design entries or changes are logically done on the Design page. It has been divided into blocks. The left group is highlighted here:

🎬 Elsie 2.50 - De	sign Menu - C:\P	Program Files\M	icrosoft Visual	Studio\VB98	\ElsieSource\	LASTSESSIO	N.LCT						- 7 🛛		
Save design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	Restart: Manual		
Nearest 5% Specify L Swap end-end Singly-term Cheby		m Cheby	Diplexer	Lumpe	d to tubular	Z match	Wind L	Find L	Toroid	Bisection					
	I		_			,	I.				_				
										3 dB					
Topol	ogy					Family				Bandwi	idth (Hz) (F	-c)			
🧿 Ca	pacitor-input low	pass		2		<ul> <li>Butt</li> </ul>	erworth	2			31k				
O Ind	uctor-input lowp	ass		1											
				_ f		C Che	byshev			Order (	(N) [21 max	]			
C No	dal capacitor-co	upled bandpas	3	2		O Cau	er			11					
C No	dal inductor-cou	pled bandpass		. 2		C Bes	sel								
C Sh	unt-input bandpa	ass				0.00				Input te	Input term (Rs)				
O Ser	ries-input bandp	ass				C Gau	issian				1k				
O Me	sh capacitor-cou	upled bandpass	5			C Con	stant-K			1					
🧿 Ca	uer-only bandpa	ISS		2		⊂ M-d	erived			Passba	and ripple (	Ap)			
				_	·				_						
C Ca	pacitor-input hig	hpass		?			See normalized	values		VSWR:	1.3554	 Return: -16.428 dB	3		
O Ind	uctor-input high	pass		?	i										
				_	- III	C Man	ual entry			Center	Freq (Fo)				
C Ser	ries-input bands	top		?							34.9k				
C Sh	unt-input bandst	ор		?	i										
					- III	Г <sup>Cauer</sup>	even terms.—								
						6 Bes	t selectivity			Stopba	ind width (I	Fs)			
					- 1	C Equ	al terms.								
Dimer	isions					Г <sup>Cauer</sup>	BPF topology—			Stopba	ind Depth (	dB) (As)			
O cm						Norr	mal								
⊙ in						C Zig-:	zag								
🦺 start	🔐 Elsie 2.50 - D	esign M										• • • • • • • • • • • • • • • • • • •	💽 🙅 🧖 😋 🔍 6:13 PM		

This group is used to select the topology – how the components are connected together.

Looking closer we see this:



If perchance no topology is chosen then the program uses the capacitor-input lowpass.

The buttons with ? offer instant help for that particular selection in the form of a small window that pops up with explanatory text. We will look at what each of those buttons do later.

The Cauer-only bandpass is not enabled unless the Cauer family has been chosen.

To the right of each topology option is an instant-help button which will call up the appropriate topology-help window. These are all similar in nature in that they all show three-pole filters with a schematic on the left and the corresponding magnitude response on the right. The response plots show a typical magnitude plot for the selected topology. To close the instant-help window click on the **Return** button.



Click on the button to the right of **Capacitor input lowpass** and see this instant help window:

Here we see a lowpass filter whose first component is a shunt capacitor to ground, a capacitor-input lowpass. A conventional topology and the Cauer equivalent are shown.

The Cauer family is used when the best shape factor, the highest efficiency in terms of descent into the stopband, is required.


Now click on the button to the right of **Inductor input lowpass** to see this window:

Here we see a lowpass filter whose first component is a series inductor. A conventional topology and the Cauer equivalent are shown.

Note that the magnitude response for this topology is the same as that for the capacitor-input lowpass. Other responses, such as input impedance, may be different.

Now click on the button to the right of **Nodal capacitor-coupled bandpass** to see this window:



Here we have parallel-tuned L-C pairs in shunt to ground, with the high sides – the nodes – being connected via coupling capacitors. The internode coupling capacitors have small value and so high reactance.

When a relatively wide percentage bandwidth is used the magnitude response will be asymmetric about the center frequency as shown. There will be a slower descent into the stopband on the high-frequency side compared with the descent into the stopband on the lowfrequency side. As the bandwidth is narrowed the various will become more and more symmetrical.

This topology is very popular for narrowband bandpass filters such as might be used in the Intermediate Frequency bandpass filter for a radio receiver.

The resonant frequencies of the L-C pairs is critical; the values of the coupling capacitors are less so.

Now click on the button to the right of **Nodal inductor-coupled bandpass** to see this window:



As with the previous example we have parallel-tuned L-C pairs in shunt to ground but this time we have the high sides being connected via coupling *inductors* from node to node. The coupling inductors have high value and so high reactance.

When a relatively wide percentage bandwidth is used the magnitude response will be asymmetric about the center frequency as shown but with a slower descent into the stopband on the low-frequency side compared with the descent into the stopband on the high-frequency side. As the bandwidth is narrowed the various will become more and more symmetrical.

The resonant frequencies of the L-C pairs is critical; the values of the coupling inductors are less so.



Click on the button to the right of **Shunt-input bandpass** to see this window:

Here we see a conversion of a lowpass filter to a bandpass. The earlier "prototype" lowpass has its parts resonated to a specified center frequency. The shunt capacitors are resonated by having placed in parallel with them a shunt inductor. The series inductors are resonated by having placed in series with them a series capacitor.

The result is a bandpass filter which is geometrically-symmetrical about the center frequency. When plotted using a logarithmic X-axis (frequency sweep) scale the magnitude response will appear symmetrical as shown in this plot.

This is a fine topology for a wideband bandpass filter. The parts values become awkward in practice if a narrowband design is attempted.

This topology is commonly used to illustrate the conversion from lowpass to bandpass in an academic environment. But it should never be used to make a narrowband filter in a manufacturing environment.



Click on the button to the right of **Series-input bandpass** to see this window:

Again we have a conversion from a lowpass filter to a bandpass. The earlier "prototype" lowpass has its parts resonated to a center frequency. The shunt capacitors are resonated by having placed in parallel with them a shunt inductor. The series inductors are resonated by having placed in series with them a series capacitor.

As with the shunt-input bandpass, the result is a filter which is geometrically-symmetrical about the center frequency. When plotted using a logarithmic X-axis (frequency sweep) scale the magnitude response will appear symmetrical as shown in the graph.

This is another fine topology for a wideband bandpass filter. As with the shunt-input bandpass, the parts values become quite difficult to achieve in practice if a narrowband (percentage-wise) design is attempted. This topology is never used to make a narrowband filter in a manufacturing environment.

Now click on the button to the right of **Mesh capacitor-coupled bandpass** to see this window:



Here we have series-tuned L-C pairs with each stage being connected by a shunt capacitor to ground. The individual stages – dipoles – with the shunt coupling capacitors form a mesh network hence the name. The shunt coupling capacitors are of high value and so low reactance.

When a relatively wide percentage bandwidth is used the magnitude response will be asymmetric about the center frequency as shown but with a slower descent into the stopband on the low-frequency side compared with the descent into the stopband on the high-frequency side. As the bandwidth is narrowed the various responses will become more and more symmetrical. Click on the button to the right of **Cauer-only bandpass** to see this window:



This topology is only available if the Cauer family is selected. It is a conversion of a Cauer lowpass to a bandpass. The responses are symmetrical about the center on a geometric basis as shown in the plot. The Cauer family is used when the best shape factor, the highest efficiency in terms of descent into the stopband, is required.

The series-connected "traps" provide notches or transmission zeros as can be seen in the plot. These yield a better shape factor, a sharper descent into the stopband, than the other topologies, at the expense of more components and more adjustments.

This is a fine topology for a wideband bandpass filter. The parts values become quite difficult to achieve in practice if a narrowband design is attempted.

If the order is even then Elsie allows the conversion to a topology called the *coil-saving* or *zig-zag*. This reduces the number of inductors needed but this comes at the expense of interaction between various component values when adjusted.



Click on the help button for Capacitor-input highpass to see this window:



Now click on the button to the right of **Inductor-input highpass** to see this window:

Instant Help - Topology Series-input bandstop uico dB Tenner ġ -5 ЦЦ ┉ -10 -10 -15 -15 -20 -20 -25 -25 -30 50Ez -30 208z 582 1082 Non-Cauer Return

Click on the button to the right of **Series-input bandstop** to see this window:

The bandstop designs are in fact conversions from a highpass by the simple process of resonating the highpass components to a specified center frequency, in a manner similar to that which was done for the shunt- and series-input bandpass filters.

Click on the button to the right of **Shunt-input bandstop** to see this window:



ie 2.50 - Desi	ign Menu - C:\\	Program Files\Mi	icrosoft Visual S	Studio\VB98	ElsieSource\L	ASTSESSIO	N.LCT						
e design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	Restart: Manu
rest 5%	Specify L	Swap end-end	Singly-terr	m Cheby	Diplexer	Lumpe	d to tubular	Z match	Wind L	Find L	Toroid	Bisection	
Topolog C Capa C Induc C Noda C Noda C Noda C Shur C Serie C Capa C Capa C Induc C Serie C Serie C Serie	gy acitor-input low ctor-input low al capacitor-co al inductor-cou nt-input bandp es-input bandp acitor-input high es-input bands	wpass pupled bandpass upled bandpass pass pass upled bandpass ass stop top	5	7 ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?		Family- © Butto C Chell C Cau C Bess C Gau C Con: C M-de	enworth oyshev er sel ssian stant-K erived See normalized ual entry	? values		3 dB Bandwi Order ( 11 2 Input te Passba VSWR:	dth (Hz) (f 31k (N) [21 max erm (Rs) 1k 1.3554   Freq (Fo) 34.9k	<b> </b>	dB
Dimensi C cm c in	ions				1	Cauer ( Best Equa Cauer I Norm Zig-z	even terms. — selectivity al terms. 3PF topology — nal rag			Stopba Stopba	nd width (	Fs) dB) (As)	
tart	🕌 Elsie 2.50 - D	Design M											X 🕈 🖓 C O 🔍 6:1

The middle group on the Design page allows selection of a family.

Those families with a proper name are named after the mathematician who developed that particular algorithm.

We can select one of a number of family options:





The single ? button allows a brief explanation of each family.



## After clicking on that ? button we see a menu screen:

You now have the option to see instant help for each of the available families by clicking on the buttons on this small window.

Associated with each button is an illustrative graphic (a plot of transmission in blue and group delay in red) and associated explanatory text, all for a lowpass version of a filter in that family.

The family currently in use is selected as a default. In this case, Demo1 has been called up and its family is Chebyshev so the Chebyshev button has already been selected.

Now we'll go through each of the families on this small window.



Clicking on the **Butterworth** option button to see information about that family:

Here the transmission plot (the top one, in blue) shows a fairly smooth corner and a smooth descent into the stopband.

The group delay (bottom, in red) has a modest peak near cutoff.

A Butterworth lowpass filter is defined by specifying its 3 dB bandwidth, the order and the input termination.



Click on the Chebyshev option button to get information about the Chebyshev family:

The main thing to observe here is that the Chebyshev family will yield a slightly sharper cutoff as you start the descent into the stopband area, at the expense of ripples in the passband.

The amount of ripple can be specified; it is called **passband ripple** in the entry group. As the ripple is increased the group delay will also show increased ripples.

In this plot, with the ripple value being set to 0.06 dB, and deliberately using the same scale factors as we did for the Butterworth, the passband ripples are not apparent. But the group delay is not as smooth and has a higher peak near cutoff.

Common values for passband ripple range from 0.01 dB for precision radio-frequency work, through 0.044 dB for RF applications with modest (practical) return loss figures, on up to perhaps 0.5 dB for non-critical audio-frequency designs.

It should be considered ill-advised to go over 1 dB for the passband ripple entry for any reason except curiosity; Elsie allows an upper limit of 10 dB.

A Chebyshev lowpass filter is defined by spedifying its ripple bandwidth, its passband ripple, its order and its input termination.



Click on the **Cauer** option button to see a summary of data for the Cauer family:

The Cauer family has a trait similar to the Chebyshev family: it has ripples in the passband to assist in achieving a better shape factor (faster descent into the stopband).

But this improved rate of descent into the stopband comes at the expense of a finite stopband minimum attenuation.

The Cauer family needs for its definition – in addition to specification of bandwidth and of the passband ripple – the stopband frequency and the stopband depth. These items interact to some extent and so they are not all independently specifiable.

A Cauer filter is defined by specifying its ripple bandwidth, its order, its input termination, its stopband frequency and stopband depth. Some orders require the passband ripple as an entry while others require a stopband frequency entry.



Now click on the **Bessel** option button to see information on the Bessel family:

A very important attribute for the Bessel family is a constant group (time) delay in the passband, shown here in the red plot. Higher orders extend this trait partway into the stopband.

That trait of constant time delay in the lowpass topology holds true for bandpass filters only if the design is narrowband. As the percentage bandwidth increases this item deteriorates.

It is not advisable to use this family if the input impedance is to remain constant in the passband (i.e., has poor return loss figures, poor VSWR, in the passband).

Square waves applied to a Bessel lowpass will exit with their spectrum defined and will have a small amount of overshoot on their leading edges.

Bessel lowpass filters are defined by specifying the 3 dB bandwidth, the order and the input termination.



Clicking on the Gaussian option shows us data for that family:

The major trait for the Gaussian family is a lack of overshoot seen on a squarewave exiting from a lowpass filter.

This filter has an not-quite-constant time delay in the passband, having a slight droop as seen here.

As with the Bessel, it is not advisable to use this filter if the input impedance is to remain constant in the passband (i.e., has low VSWR in the passband).

Square waves applied to a Gaussian *lowpass* will exit with their spectrum defined and with no overshoot on their leading edges. Gaussian *bandpass* filters have no ringing on the envelope of a pulsed burst.

Gaussian lowpass filters are defined by specifying the 3 dB bandwidth, the order and the input termination.



Click on the Constant-K family to see a summary for it:

This is not a "precise" family. For the third order it is identical to the Butterworth but as the order is increased it will be seen that ripples will appear in the various responses, particularly at the band edge. These become greater in amplitude as the order is increased.

An interesting thing about this filter is that it uses repetitive component values; except for the first and last elements, all of the inductors have the same value and all of the capacitors have the same value. This can be quite useful in a manufacturing arena.

The ripples at band edges are reduced as component Q values are reduced.

It is simple to design even without a computer but should not be used if precision in the various responses is an object.

The Constant-K family lowpass is defined by specifying the bandwidth (approximately 3 dB), the order and the input termination.



Click on the **M-derived** option button see this plot:

Historically the M-derived family followed in the the footsteps of the Constant-K. It was developed to improve the selectivity in a filter, to get a better shape factor. The zeros ("notches") in the response can be adjusted in frequency. As this is done the flareups in the stopband will change in magnitude but the passband retains a relatively flat response and good return loss / VSWR.

This family was later replaced by the Cauer family which has better performance with fewer components. The reason for using the M-derived family in the first place was that it could be designed using ordinary arithmetic; the Cauer did not become practical until computers were available.

The filter shown here has but one zero in the response; several zeros can be specified, each have a specified frequency.

The M-derived filter is defined by specifying the bandwidth (approximately 3 dB), the order, the input termination and the frequencies of the stopband zeros ("notches").

The third group on the Design page allows selection of those remaining items needed to complete a design:

Elsie 2.50 - De	sign Menu - C:\P	Program Files\M	icrosoft Visual S	studio\VB98	\ElsieSource\L	ASTSESSIO	N.LCT							
Save design	Get design	Design	Schematic	Edit	Analysis	Plot	Tabulate	Print	Write	Help	About	Exit	Restart: Manual	
Nearest 5%	Specify L	Swap end-end	Singly-ter	m Cheby	Diplexer	Lumpe	ed to tubular	Z match	Wind L	Find L	Toroid	Bisection		
													_	
										3 dB				
	ogy			Family				Bandwidth (Hz) (Fc)						
Capacitor-input lowpass							terworth	2		31k				
C Inductor-input lowpass														
	?						ebysnev			Order (N) [21 max]				
C Not	C Nodal capacitor-coupled bandpass						ier							
C Not	Nodal inductor-coupled bandpass						sel							
C Shi	C Shunt-input bandpass									Input term (Rs)				
C Ser	C Series-input bandpass										1k			
O Me	sh capacitor-cou	upled bandpass	;			C Cor	istant-K							
Ca	uer-only bandpa	iss				О М-о	erived			Passba	and ripple (	Ap)		
					-				_					
O Ca	C Capacitor-input highpass						See normalized	values		VSWR: 1.3554 Return: -16.428 dB				
C Ind	uctor-input high	pass												
				<u> </u>	-	O Mar	nual entry			Center	Freq (Fo)			
C Series-input bandstop										34.9k				
O Shi	unt-input bandst	ор		2										
					-	г <sup>Cauer</sup>	even terms.—							
					G Bes	t selectivity			Stopband width (Fs)					
						C Equ	ial terms.							
Dimen	isions					⊢ Cauer	BPF topology-			Stopba	ind Depth (	dB) (As)		
O cm						@ Nor	mal							
© in						C Zig-	zaq							
													_	
start	🕰 Elsie 2.50 - De	esign M										( )	🛯 💁 😭 📿 🔍 🐨 6:13 PM	

This is where the filter bandwidth is entered, along with its order (complexity) and the input termination. The bandwidth entry is for the 3-dB point for Butterworth, Bessel or Cauer. It will be ripple bandwidth for Chebyshev and Cauer. It is an approximation for Constant-K and M-derived.

Pointed out at this time is that Elsie will compute the output termination; it will commonly - but not always - be the same as the input termination.

When a value of passband ripple is entered for those families needing that entry, the program immediately shows you the associated VSWR and return loss.

Next we see a closeup of those entries:

Ripple
Bandwidth (Hz) (Fc)
ЗМ
Order (N) [21 max]
3
Input term (Rs)
50
Passband ripple (Ap)
0.044
VSWR: 1.2232 Return: -19.965 dB
Center Freq (Fo)
Stopband width (Fs)
Stopband Depth (dB) (As)

Cauer-family filters will need some additional entries (for the stopband). These will change according to whether the order is even or odd.

As refinements are made to the program the various screen appearances will doubtless change and so the operation of the program will change as well.

Comments about the manual will be welcomed.

24JUL12