NØAX

HANDS-ON RADIO

Experiment #87 — *ELSIE* Filter Design — *Part 1*

After four consecutive columns about the *LTspice* circuit simulator software, it's time to move on — but not totally away from the world of virtual circuits. Your experience with *LTspice* has given you the opportunity to rapidly test circuit performance, but a simulator will not design the circuit for you. You are still responsible for selecting a circuit and determining a set of values for every component. That's where another class of software called *design tools* comes in.

A design tool helps you select the type of circuit and develop a set of values for the individual components. That circuit can then be simulated with a program such as *LTspice* and the result turned into a working prototype. If the design software is properly used, the prototype's behavior on the workbench will correspond closely to its behavior on the computer screen. That's where this month's column begins. As promised, we'll explore one of the terrific design tools available to hams — *ELSIE*, by Jim Tonne, W4ENE. *ELSIE* is a design tool for passive LC filters, thus the name.

The student version of *ELSIE* is included in recent editions of *The ARRL Handbook*.[1] The 2010 edition also includes seven other W4ENE design tools for diplexers, Pi-L networks, Class E amplifiers, meter faces and more. Assuming you have your *Handbook* CD ready, let's get started!

Installing and Running *ELSIE*

Load the *Handbook* CD ROM on your computer. (I assume the reader is using a *Windows* based computer.) Your computer may be configured to *Autorun* the installation software to install the complete *Handbook* document set onto your computer. If you want to install the complete set of documents, proceed as directed by the installer software. If the installation process did not begin automatically, run *Setup* in the top level or root directory of the CD ROM.

To install the *ELSIE* software, open MY COMPUTER or run *Windows Explorer*. Open the README file in the top level CD ROM folder and make sure your computer is suitable for installing the software. Open the folder PROGRAM FILES then ARRL 2010 HANDBOOK then COMPANION SOFTWARE and finally TONNE SOFTWARE (or the appropriate folders on the CD ROM for your edition).

Run *LCinstall* — the program name concludes with a number representing the program version; version 2.32 is shipped with the 2010 edition and so the program name is *LCinstall232*. Follow the program's installation directions: I recommend using the default folder names.

To run *ELSIE*, use the START button, select ALL PROGRAMS and navigate to the folder ELSIE. In that folder double click the ELSIE icon and off you go! The opening screen will display the version and note that you have the student version of the program. Take a look at the schematics on the screen and note all the different configurations of inductors, capacitors, transmission lines and even numeric values of reactance. All of these can be used to design filters in the *ELSIE* software.

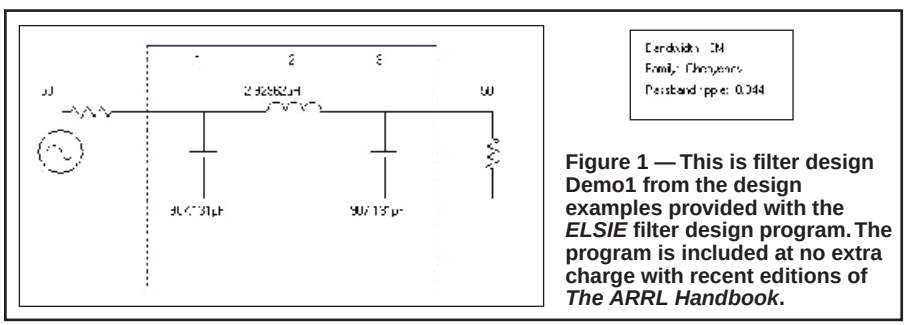

Figure 1 — This is filter design Demo1 from the design examples provided with the *ELSIE* filter design program. The program is included at no extra charge with recent editions of *The ARRL Handbook*.

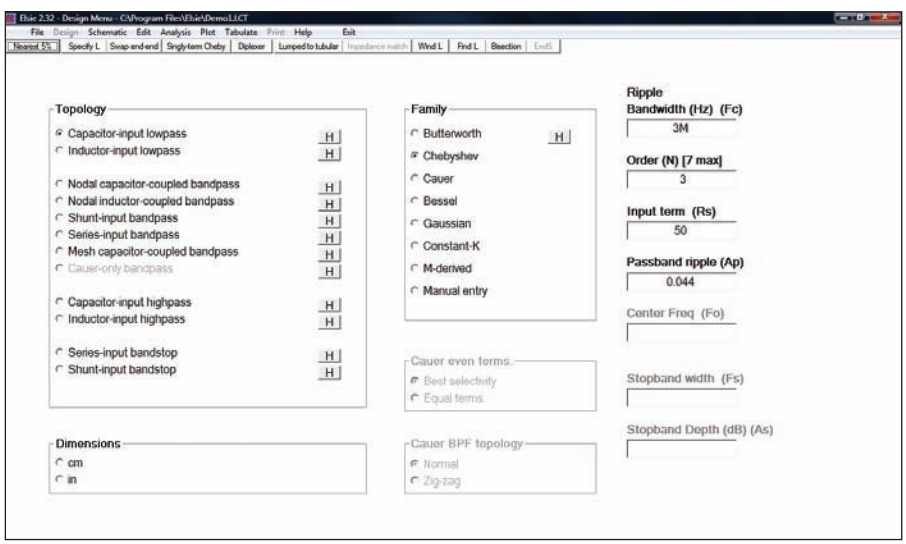

Figure 2 — The DESIGN window is used to select a filter's design parameters, such as the filter topology, the family of design equations that will be used and several performance requirements.

[1]*The ARRL Handbook for Radio Communications,* 2010 Edition. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 1448 (Hardcover 1462). Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop**; **pubsales@arrl.org**.

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Conventions and Controls

ELSIE uses the same number entry conventions as *LTspice*. For very large and very small numbers, use scientific notation, such as 1E6 for 1,000,000 or 1E–11 for ten pico somethings. Upper or lower case k represents kilo. Capital M represents mega and lower case m represents milli — don't get them mixed up!

Frequency values are always entered in hertz — use scientific notation or prefixes such as k, M or G. Capacitance values are always in farads, so use scientific notation or prefixes such as u for micro (1u is 1 µF), n for nano and p for pico. Similarly, inductor values are always in henrys; m for millihenrys, u for µH and n for nH. Resistance values are always in ohms and the same prefix conventions are used. Ripple and attenuation values are in dB.

ELSIE has seven different windows that display information or collect design information to operate the program. The different window choices are listed along the top of the screen: Design, Schematic, Edit, Analysis, Plot, Tabulate and Help. File is a menu for saving or loading a filter design or for exporting a *netlist* or schematic of the filter in a format that can be read by *SPICE* simulators (including *LTspice*). A netlist is a list of connections between the filter components and can be read by many simulation and circuit-board layout programs.

In addition, *ELSIE* includes an extensive "walk-through" under the HELP menu. Click on HELP, make sure the CONTENTS tab is selected, then click WALKTHROUGH. Once you're beginning to use *ELSIE*, the information in each section of Help will explain the design process and how to interpret the program's results.

Driving Miss *ELSIE*

Click the OPEN OLD button and from the list of designs (the software includes dozens of sample designs) select *Demo1.LCT*. The software will load the filter design named Demo1 and you'll see the screen shown in Figure 1. This is the program's *schematic view*. Filter input is on the left and the output is on the right. The section of the schematic in green is the part that *ELSIE* designs.

At the bottom left of the schematic are three lines of text — these describe the filter's design parameters. The bandwidth of the filter is 3 MHz, the filter's design is from the Chebyshev family and the maximum ripple in the filter's passband is 0.044 dB.

Click on the DESIGN menu label (next to FILE at the top of the screen) and the screen in Figure 2 will appear. The buttons labeled H indicate that "instant help" is available to explain that function or selection. Click on them and see! This screen is used to define the requirements for a filter and here you can see more information about filter Demo1. In addition to the information on the schematic view the *topology* is "Capacitor-Input low-pass." A filter's topology describes how the components are arranged. Since the filter is a low-pass type from the Chebyshev family, the Ripple Bandwidth (Fc) means that the filter's transmission will be no lower than twice the maximum ripple (–0.088 dB) at 3 MHz. The order of the filter is 3, meaning that it consists of three individual energy-storing reactances. The filter's input termination impedance has been set to 50 Ω. Select the TABULATE window and browse through the list of values to determine the frequency at which the response is closest to –0.088 dB (between 2.9935 and 3.0025 MHz).

Now open the PLOT window using the list of windows across the top of the screen. This window can display many different types of useful graphs. The default is the TRANSMISSION PLOT showing filter response versus frequency. (Click the top plot selection button at the upper left of the screen if some other graph is displayed.) Response in dB is shown on the Y axis with larger negative values meaning more attenuation of the input signal and frequency is on the X axis.

Switch between the different types of plots by clicking on the different plot selection buttons. Holding the cursor over the button without clicking (called "mousing over" a control) will display a label describing what data the plot contains. For example, the second button (TRANSMISSION AND RETURN) adds return loss to the graph. The third button (TRANSMISSION AND ITS ANGLE) shows the familiar Bode style plot of both amplitude and phase response as seen in Figure 3. The graph scales are determined automatically by the program, although some graph parameters can be adjusted by selecting the Analysis window.

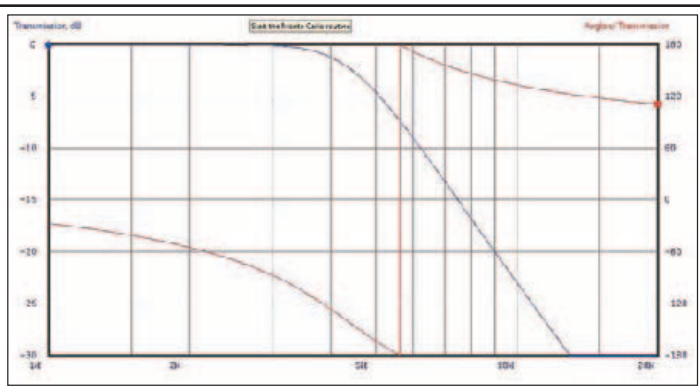

Figure 3 — The filter's response can be displayed in a number of different ways, from the familiar transmission and phase response plot shown here to a Smith chart view of return loss.

Editing and Adjusting

You can adjust the component values, too. You can do this manually or use some of the program's design options. For example, return to the SCHEMATIC window — the component values of 907.131 pF and 2.92962 µH aren't exactly common in vendor catalogs! *ELSIE* allows you to change the values to the nearest standard value in the 5% series for capacitors and inductors.

Select the DESIGN window and click the 5% VALUES button underneath the FILE menu label at the upper left-hand part of the screen. The NEAREST VALUES ROUTINE window will open showing the closest standard values; in this case 910 pF and 3 µH. Select the TRANSFER ALL NEAREST-VALUE PARTS… option then click END NEAREST-VALUE ROUTINE. We could just as easily elect to only modify the capacitors or inductors. If only one type of component is changed to a standard value, the program can also recalculate ("retune") the remaining components so that the filter meets the original design requirements.

Return to the SCHEMATIC window and confirm that the parts values are now standardized. What effect has this had on filter performance? Checking the PLOT window doesn't show a lot of change, but if you look for Fc in the TABULATE window, you'll see that Fc is now between 2.9226 and 2.9314 MHz — a shift of about 70 kHz or 2.3%. Feel free to experiment with the design, changing the component values and getting comfortable with some of the controls.

Further Reading

Filter design involves knowing some terminology. You can catch up on most of *ELSIE*'s terms by doing a little reading. Hands-On Radio experiments #50 and #51 on Filter Design define a lot of the terms and processes used to design filters.[2]

Next Month

Let's build a filter or two next month, shall we? The goal will be to design something useful for your shack!

[2]All previous Hands-On Radio experiments are available to ARRL members as downloadable PDF files at **www.arrl.org/hands-on-radio-experiments-resources-and-faq**.