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Acknowledgement

Mona uses software from the book "Tempra Graphica, A Generic Graphical Editor for the Macintosh" by Sharam Hekmatpour, Prentice Hall.

About this document...

Getting Started with Mona is an example based tutorial designed to get you up and running on Mona in a minimum amount of time. It is not a user's guide, and does not describe all features of the Mona software.

This tutorial uses a simple RLC circuit to demonstrate how to:

- Launch the Mona application.
- Create a new circuit using the schematic editor.
- Obtain node voltages and branch currents in symbolic or numeric form.
- Obtain and manipulate a circuit's frequency response.
- Plot a circuit's output response over time.

The estimated time required to complete this tutorial is **30 minutes.**

Getting Started

1. Insert the Mona Demo disk in your disk drive and launch the Mona application by double clicking on the Mona icon. (For better performance, you may wish to copy the entire disk to a new folder on your hard drive before launching the application.)

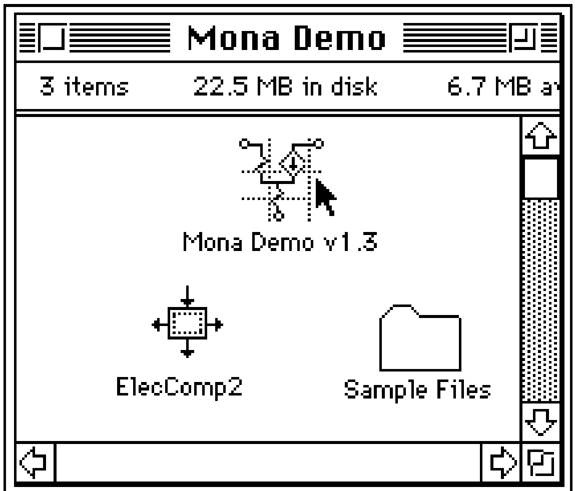


Figure 1: Launching Mona

2. A dialog box will appear such as that shown below. Select "ElecComp2" by double clicking on that choice.

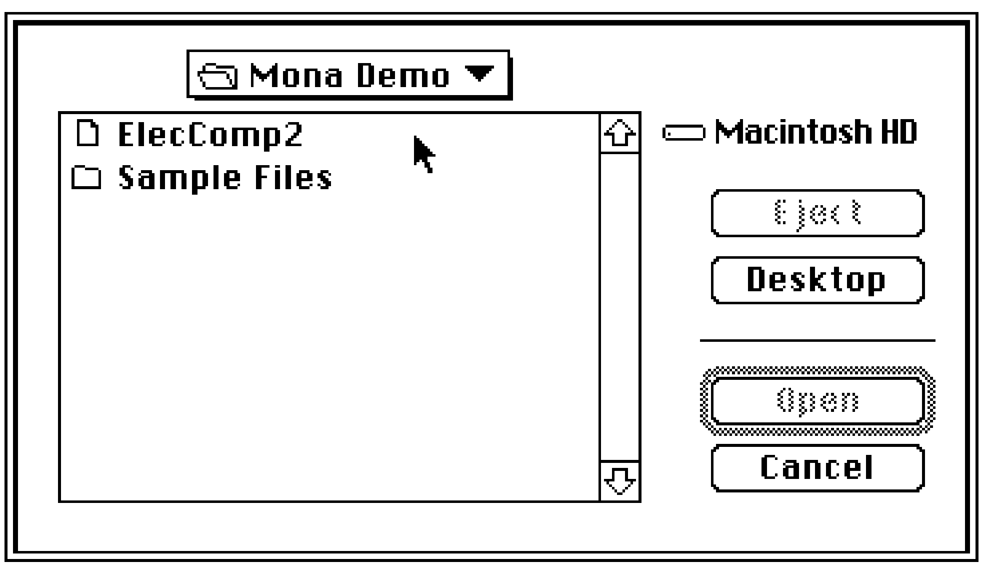


Figure 2: Selecting a component template.

> *Mona is a powerful tool with applicability to a wide range of engineering fields. The component template file provides the means to customize Mona with symbols and terms suitable to different environments.*

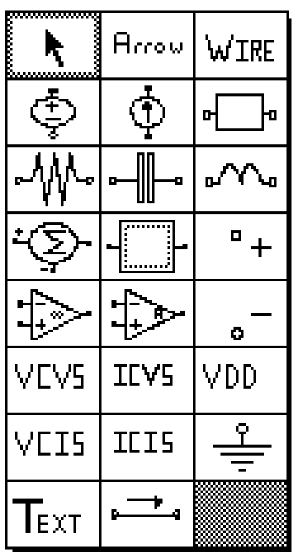
3. Wait a moment and a new window will appear.

Using the Schematic Editor

In Mona, you specify circuits the same way you normally visualize them: using a schematic diagram. In this section, we create a series RLC circuit using the schematic editor.

☞ **Component Placement**

4. Position the mouse anywhere in the new window (we will refer to this window as the *drawing area*). While holding down the ⌘ key, press and hold the mouse button. A palette of circuit components will appear under the current mouse position (see Figure 3). Once the palette appears, release the ⌘ key.



Selection Tool, Directed wiring Tool, Wiring tool

Voltage source, Current source, Impedance

Resistor, Capacitor, Inductor

Adder, Multiplier, Positive terminal

Opamp - infinite gain, Opamp - finite gain, Negative terminal

Voltage controlled voltage source, Current controlled voltage source, Voltage source

Voltage controlled current source, Current controlled current source, Ground

Text annotation tool, Short circuit

Figure 3: The component palette

5. Without releasing the mouse button, select the **voltage source** by moving the mouse pointer over that symbol. Once the mouse pointer is positioned over the voltage source symbol, release the mouse button. Note that the palette will disappear and the appearance of the mouse pointer will change to indicate that an element is selected.

6. Now place the voltage source in the drawing area by holding down the mouse button and dragging the mouse pointer downwards and to the left. An outline box will "rubber-band" with the pointer. Once this box is visible, release the mouse button. An independent voltage source will appear in the drawing area.

7. Repeat steps 4-6 to place a **resistor**, an **inductor**, a **capacitor**, and a **ground symbol** in the drawing area. Lay out these components as shown in Figure 4 below.

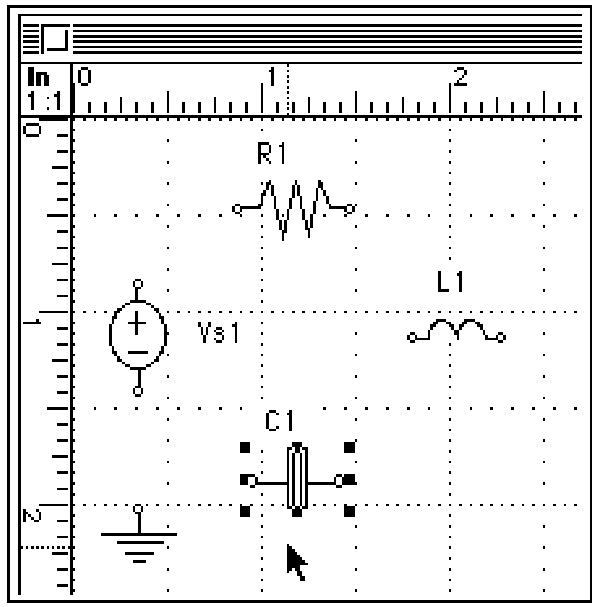


Figure 4: Placing components in the drawing area.

Tips from the pros...

• for dependent sources, a short circuit or positive and negative terminals must be drawn before the source.

• To reposition the label of a component, select the component first, then press the Option key and click and drag the label to its new position.

• To edit a label, first select the component then click on the label to edit it.

☞ **Component Rotation**

8. Your circuit will look better if you rotate the inductor by 90 degrees. To do this, follow these steps:

   • Click on the inductor; a selection box will appear around the inductor.
   • Under the **Misc** menu, select the **Transform** sub-menu. Select **Rotate 90˚**.

Your circuit diagram should now appear as shown in Figure 5.

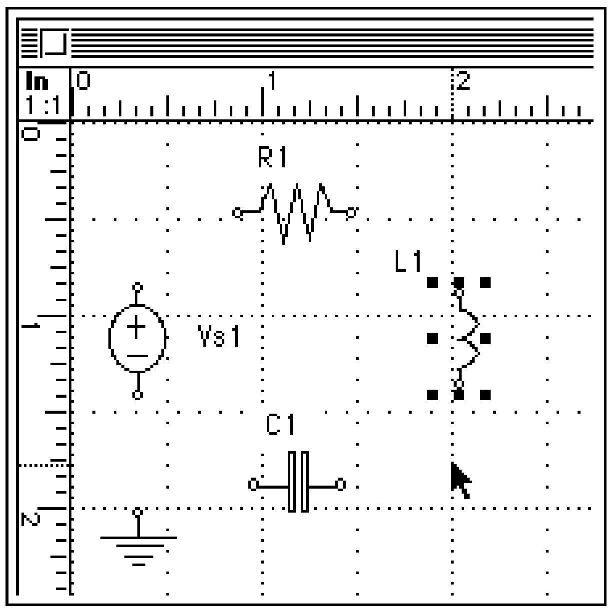


Figure 5: Circuit elements with inductor rotated.

Tips from the pros...

Mona has many other useful features for making your circuit schematics look just right. You can drag and drop elements, cut and paste, annotate your diagram with text, align elements relative to one another, and much more. Many of these features are quite intuitive. Others you'll find by browsing through the menu items. And of course, there are a few that you won't discover until you read the user's guide! You might want to take a moment to experiment with some of these now - the Edit menu is a good place to start.

☞ **Wiring**

9. Select the WIRE element from the component palette just as you selected the voltage source and other elements in steps 4 and 5.

10. Position the mouse pointer over the small circle on the positive terminal of the voltage source.

11. Press and hold the mouse button and move the mouse pointer upwards. Note that wire now trails the mouse pointer.

12. When the mouse pointer is roughly horizontal with the resistor, release the mouse button. A fixed segment of wire should extend from the voltage source to the position at which the mouse button was released and wire should still trail the mouse pointer.

13. Position the pointer over the small circle on the near terminal of the resistor. Single click the mouse button. Wire should now extend from the voltage source to the resistor. Wire should no longer trail the mouse pointer. (If it does, try clicking again on the resistor terminal.)

Repeat steps 9 through 13 - summarized in Figure 6 - to connect the remaining elements in series. Don't forget to connect the ground symbol to the negative terminal of the voltage source. Your completed circuit should look similar to that shown in Figure 7.

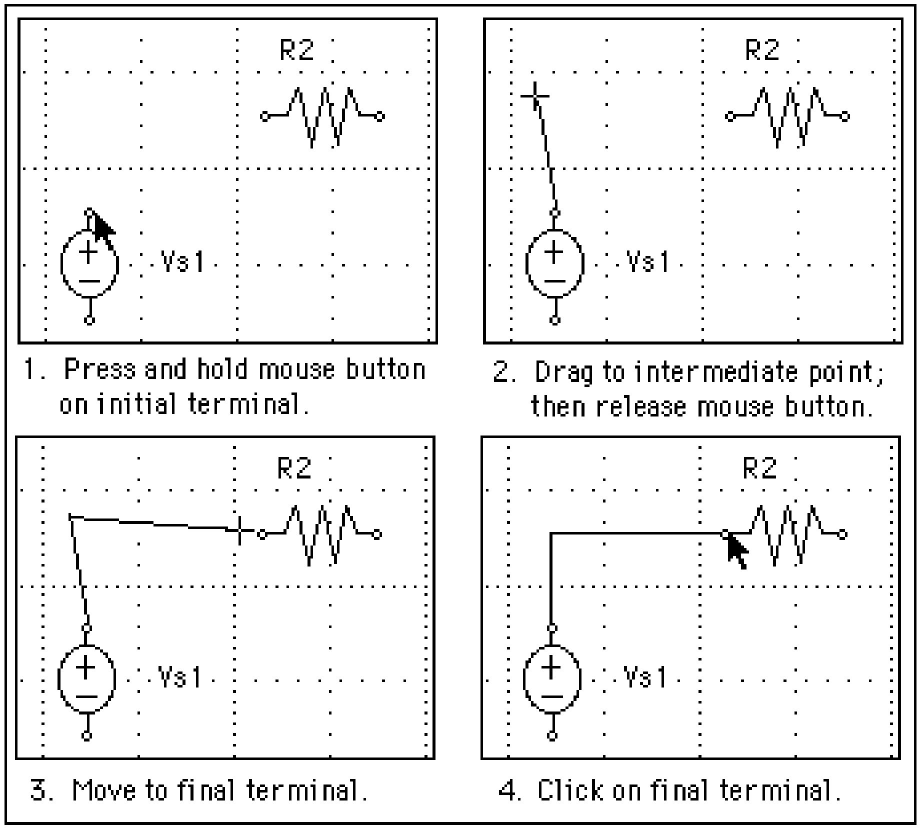


Figure 6: Wiring components.

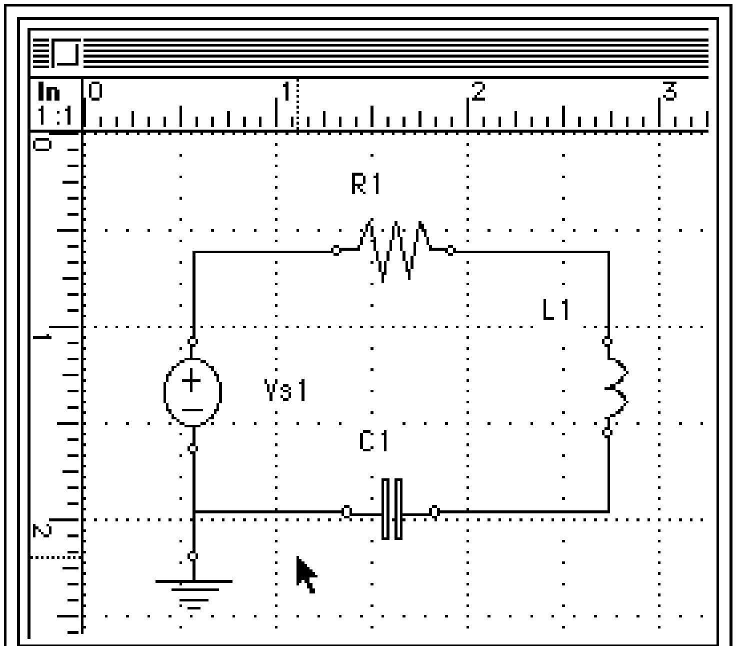


Figure 7: Completed series RLC circuit.

Tips from the pros...

• *Remember: Wire from terminal to terminal. Wire is used to connect circuit elements, so each segment of wire must begin and end on element terminals.*

• *If you need to put more than one "bend" in a wire, just single click at each point where you want a bend.*

• *Make sure you connect a ground symbol to your circuit. Mona will need it to provide a voltage reference.*

Circuit Analysis

Rather than providing a lot of fancy analysis tools that perform specific tasks "automatically", Mona concentrates on the fundamentals: determining node voltages and branch currents.

Using these tools, ordinary circuit components, and a little thought, practically all other circuit parameters can be determined. For instance, to find the input impedance, you can change the input to a 1 A current source and measure the voltage across the input terminals (setting all independent sources to zero).

☞ **Preparations**

15. Select **Analyze Circuit** from the **Mona** menu. This updates the circuit node voltages and branch currents and must be repeated whenever the circuit schematic is modified.

☞ **Symbolic Node Voltage**

16. Using the mouse, click on the wire between the resistor and inductor, as shown in Figure 8. Note that selection corners will appear on the ends and corners of the wire once it is properly selected.

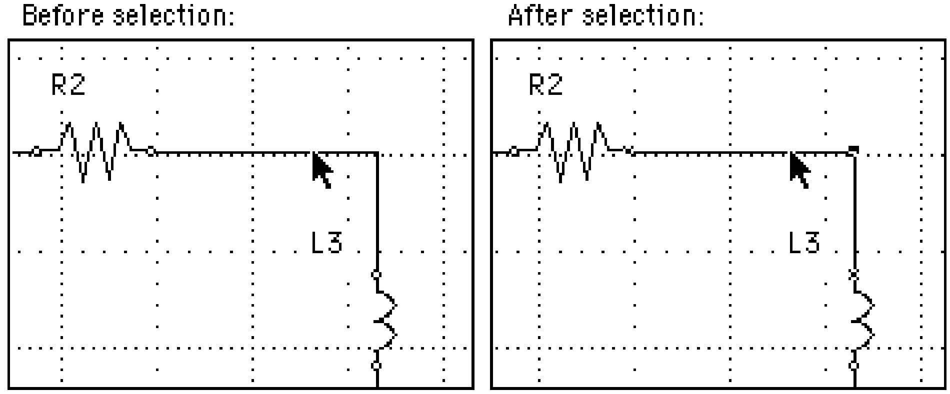


Figure 8: Selecting a node.

17. To determine the voltage at this node, select **Node Voltage** from the **Mona** menu. A new window - the **Console** window - will appear. The requested voltage will be displayed in the **Console** window.

Note that the mathematical expression for the voltage is entirely *symbolic. Practically all other commercial circuit analysis programs force the user to associate fixed numeric values with each component before performing any analysis. Mona provides the general solution in terms of the names assigned to the circuit components.*

☞ Symbolic Branch Current

18. Using the mouse, click on a circuit element such as the resistor. A selection box will surround the element as shown in Figure 9.

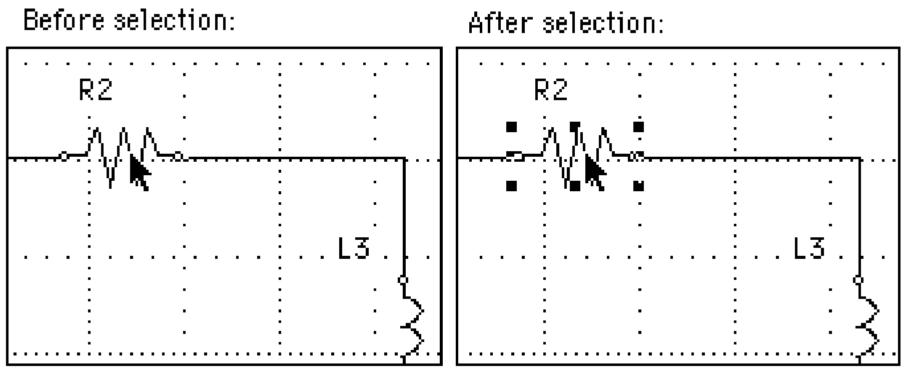


Figure 9: Selecting an element.

19. Select **Branch Current** from the **Mona** menu. Another result will be displayed in the **Console** window, as shown in Figure 10.

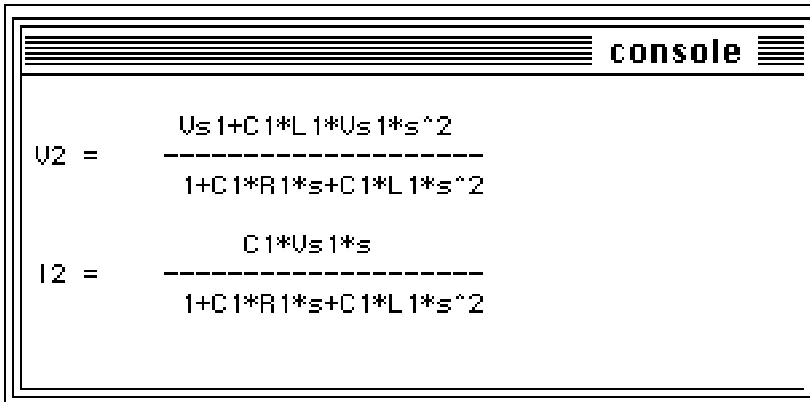


Figure 10: Symbolic expressions in the Console window.

Frequency Domain Analysis

20. Under the **Window** menu, select **Graph & Bode Window**. A new window will appear on top of your circuit diagram window such as that shown in Figure 11. We will use this window to obtain a frequency domain plot of **V2**.

☞ **Setting Variables**

Note that the variables queried earlier - **V2** and **I2** - have been automatically added to the **Variables** list, along with all of the variables that they reference: **Vs1**, **R1**, **L1**, **C1**, and **s**. In order to graph **V2** over a range of frequencies (a range of **s=jw**), we will need to assign fixed numeric values to **Vs1**, **R1**, **L1**, and **C1**.

To assign a value to a variable, follow these steps, as indicated in Figure 12:

- Select the variable to be modified by clicking on its name in the **Variables** list.
- Enter the new value for the variable - units are not required - in the input box.
- Click on the **Set Var** button in the main command bar.

Tips from the pros:

• *Instead of clicking on the* **Set Var** *button, you can simply hit the* **RETURN** *key once the value is entered. This is usually faster.*

• *You can use the standard metric prefixes and exponential notation when specifying values. For instance, all of the following are equivalent:*

4700
4.7k
4.7E3

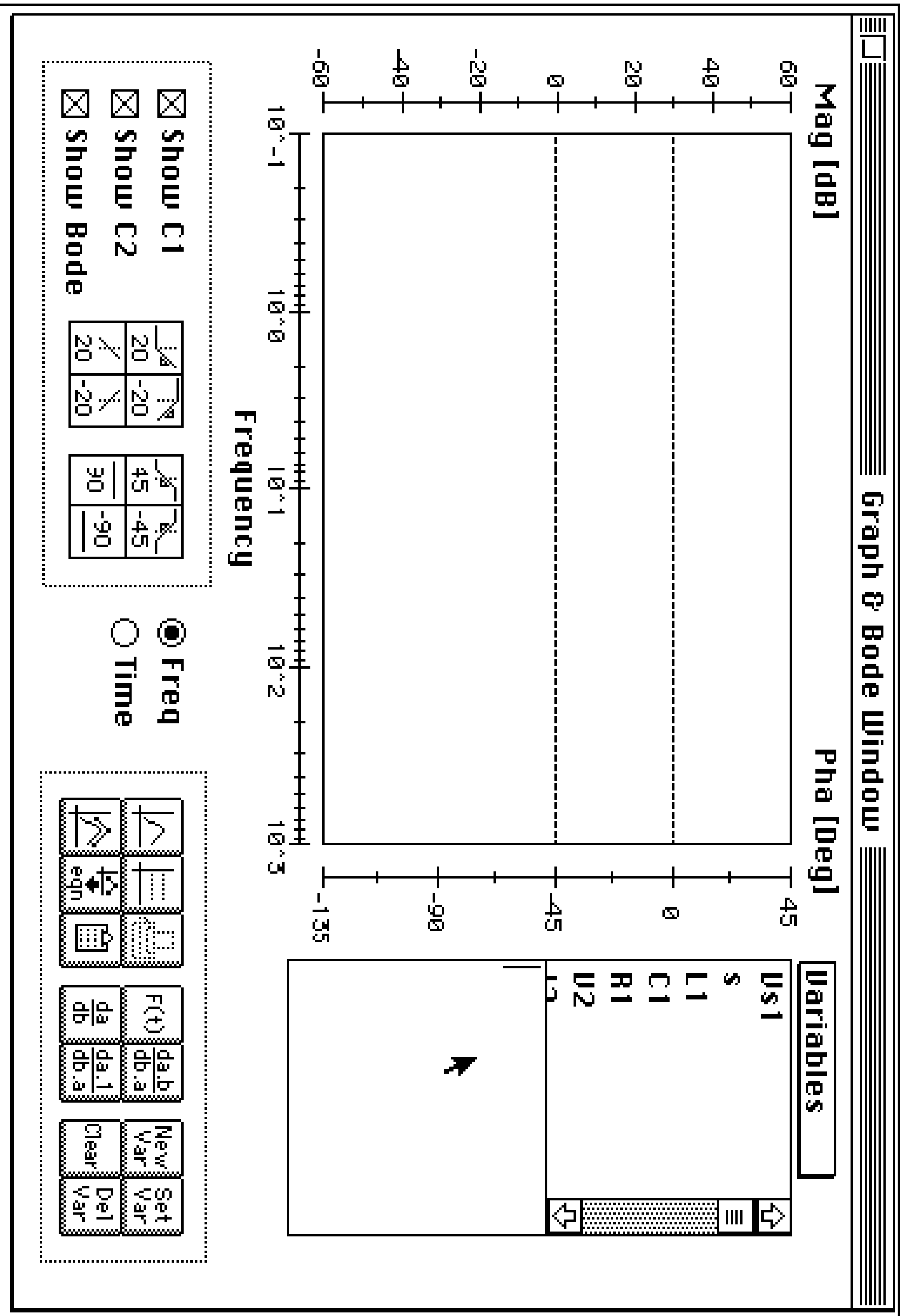


Figure 11: Bode and Graph Window

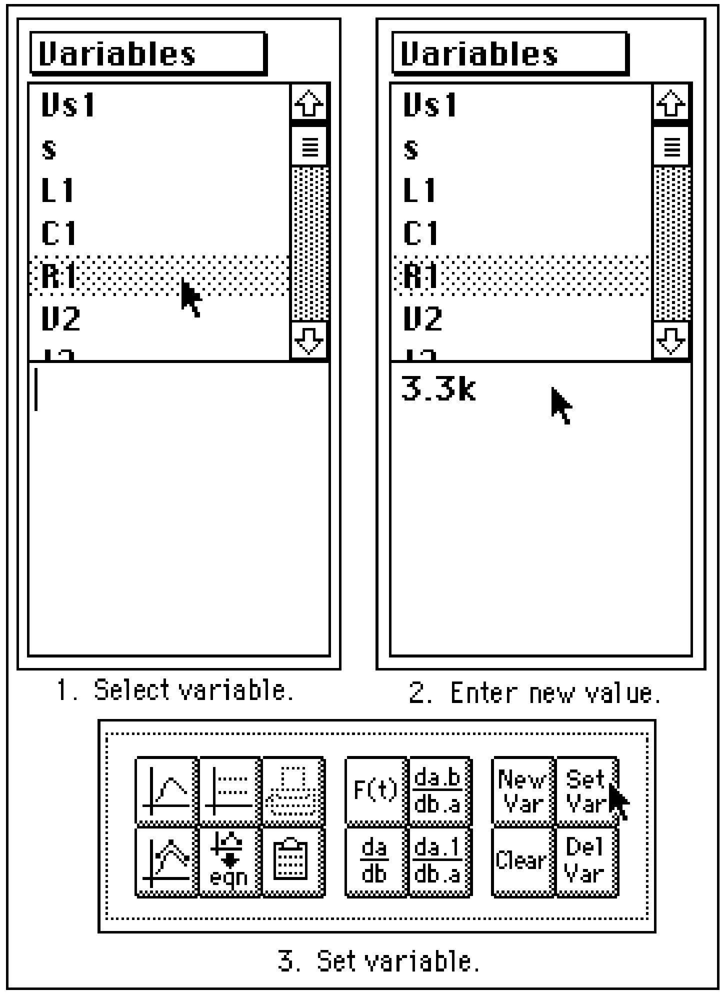


Figure 12: Setting the value of a variable.

21. Set **Vs1**, **R1**, **L1**, and **C1** to the values shown below:

   - Vs1 = 1 V
   - R1 = 3.3 kΩ
   - L1 = 3000 H
   - C1 = 1μF

22. To see the value associated with a variable, simply double-click on that variable in the **Variables** list. For example, to examine**V2**, double click on the **V2** choice in the **Variables** list, as shown in Figure 13. Note that Mona has substituted the values for **Vs1**, **R1**, **L1**, and **C1** into the expression associated with **V2**. If your **V2** is different from that shown in Figure 13, make sure that you have set **Vs1**, **R1**, **L1**, and **C1** correctly as indicated above.

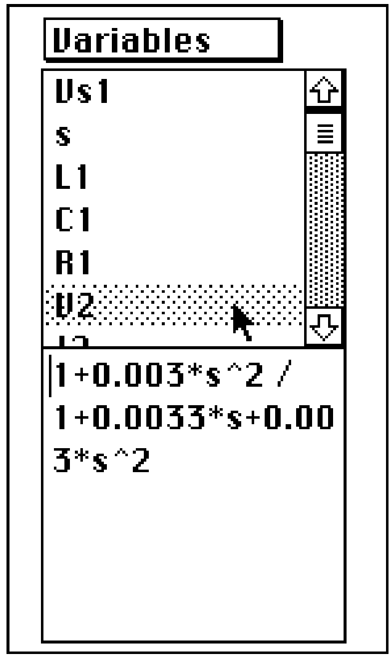


Figure 13: New value of V2.

☞ Plotting a Graph

23. To plot a graph of **V2** over the current frequency range, ensure that **V2** is the currently selected variable in the **Variables** list, and click on the graph button, as shown in Figure 14. A frequency response graph similar to that of Figure 15 will be plotted.

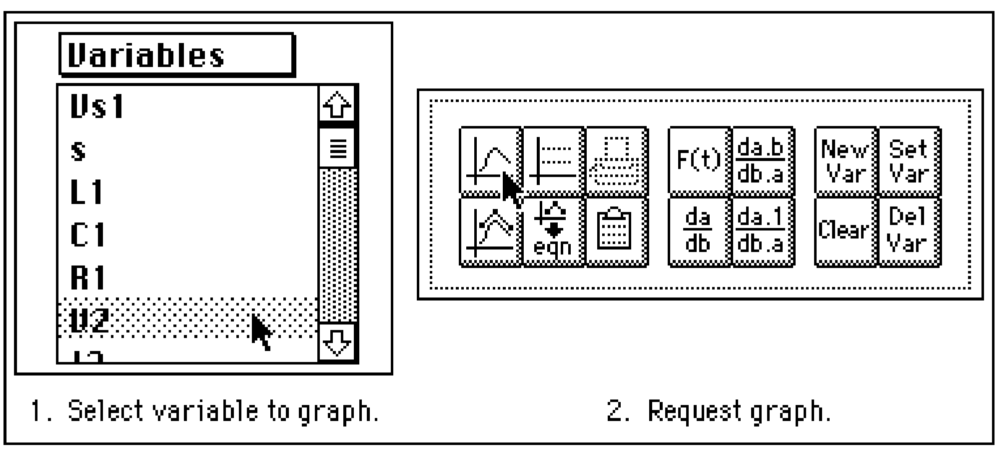


Figure 14: Obtaining a graph.

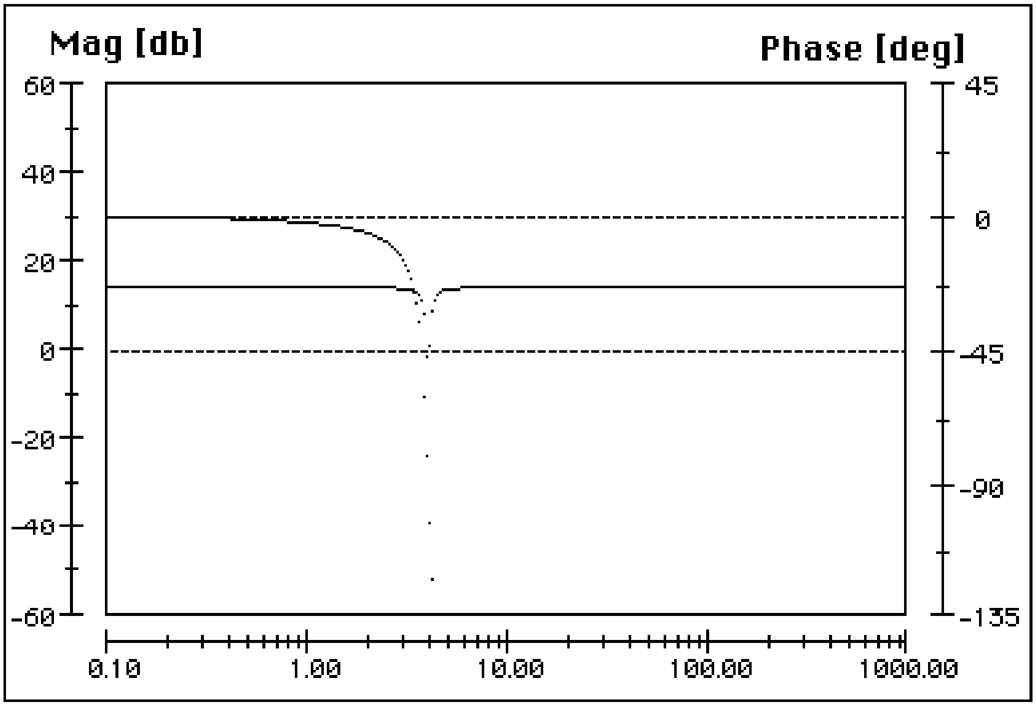


Figure 15: Frequency response of V2.

Tips from the pros...

• The default style for this graph is that of a Bode diagram: magnitude in dB (20log(V2)), phase in degrees, and frequency in radians/s on a logarithmic scale. You can reconfigure many of these parameters with a little experimentation, if you wish.

• The plotting functions are quite generic and may be used to plot any univariate function. For example, if you developed an equation for the voltage characteristics of a capacitor, C = f(V), you could plot the C-V characteristics.

26. You can make this plot look better by changing the axes to "zoom in" on the interesting part. Single clicking with the mouse pointer over any axis will bring up a dialog box which will allow you to change the range of that axis (see Figure 16). For this plot, you might want to try the following settings:

    • Magnitude: -60 dB to 30 dB
    • Phase: -180 degrees to 180 degrees
    • Frequency: 1 rad/s to 10 rad/s

Note that you'll have to click on the graph button to replot the graph after you have changed the frequency range. The resulting graph should look similar to that shown in Figure 17.

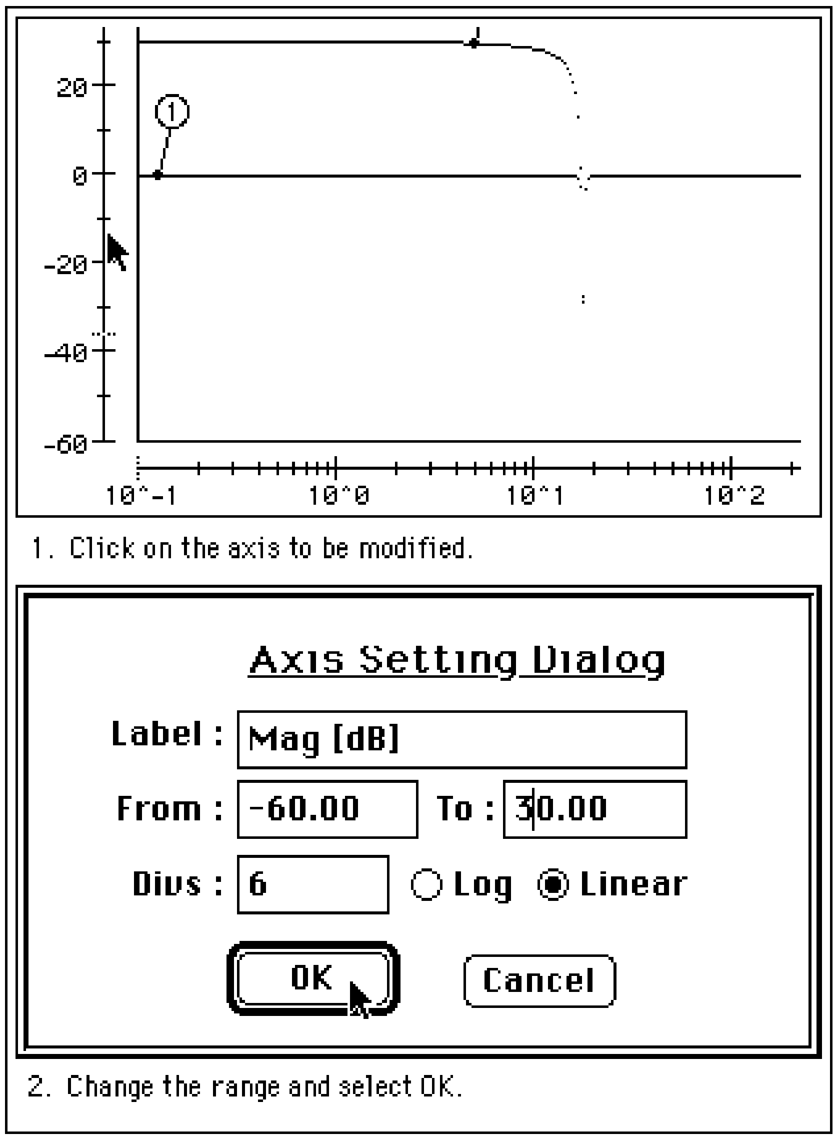


Figure 16: Changing the graphing range.

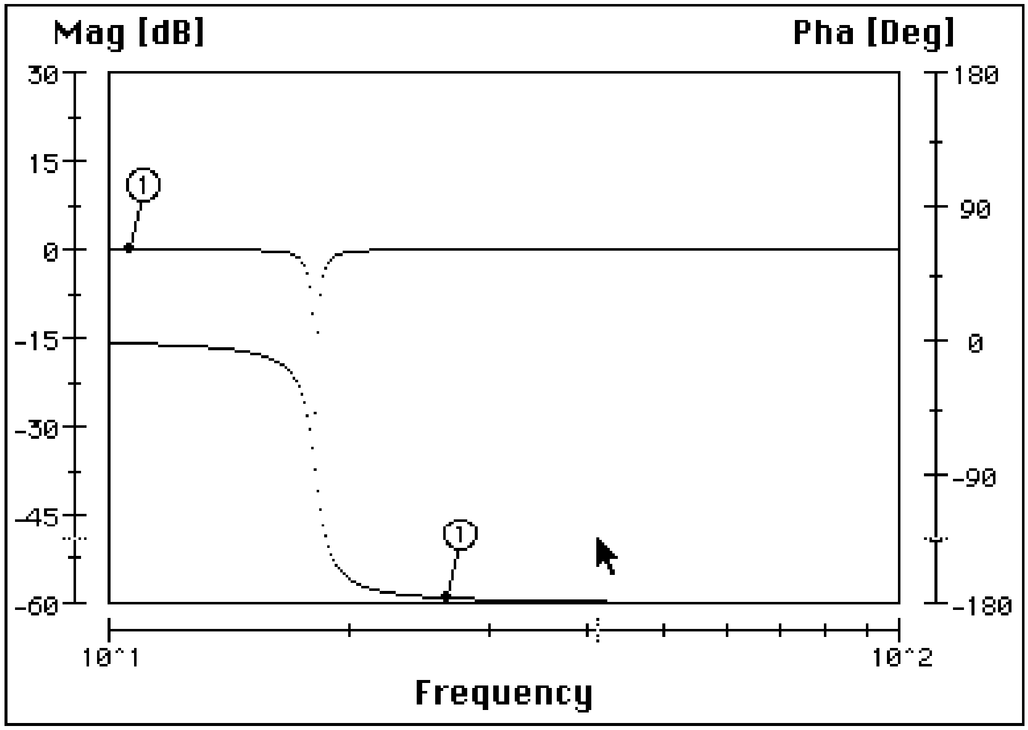


Figure 17: Frequency response of V2 with axes adjusted.

☞ **Parameter Variation**

27. Double click on the **R1** variable and note its current value (3.3K). Change the value to 33K using the same procedure you used in step 21 above.

28. Double click on the **V2** variable and note that the new value of **R1** has been substituted into **V2**. Plot this new expression for **V2** by clicking on the graph button. Your plot should look similar to that shown in Figure 18. Feel free to experiment with other values for **R1** and the other circuit components.

This "graphical equation manipulation" environment is one of Mona's greatest strengths. It encourages "what if" analysis and shows the relationship between parameter values, transfer function expressions, and the resulting graphs. Up to four functions can be plotted on the same graph.

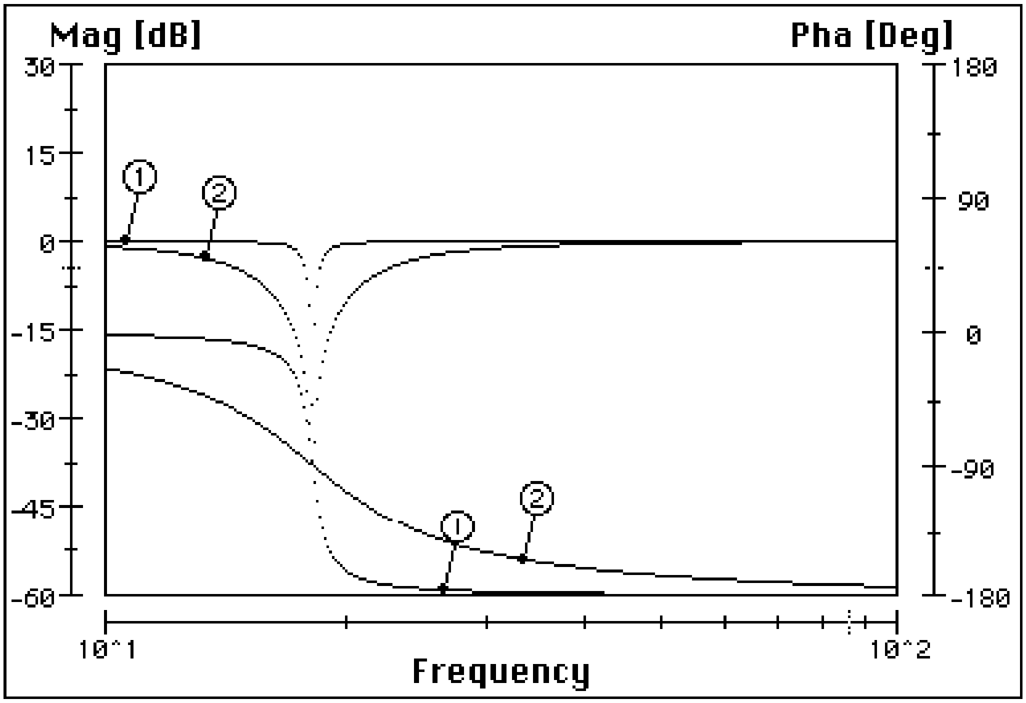


Figure 18: Comparing V2 with R = 3.3K vs. R = 33K

The numbers in the graph can be dragged around, just click and drag on the solid dot.

Time Domain Analysis

To obtain a graph of the time domain response of a variable, you first create a new time domain variable, and then plot a graph of that variable.

Important note: The remainder of this tutorial uses the original component values:

- Vs1 = 1 V
- R1 = 3.3 kΩ
- L1 = 3000 H
- C1 = 1μF

If you've changed some of these values (such as **R1**), you should change them back now.

☞ **Generating a Time Domain Function**

29. Ensure that **V2** is the current variable and select the **F(t)** button from the main command bar, as shown in Figure 19. This will create a new variable, **V2_t**, corresponding to the Inverse Laplace transform of **V2** (see Figure 20).

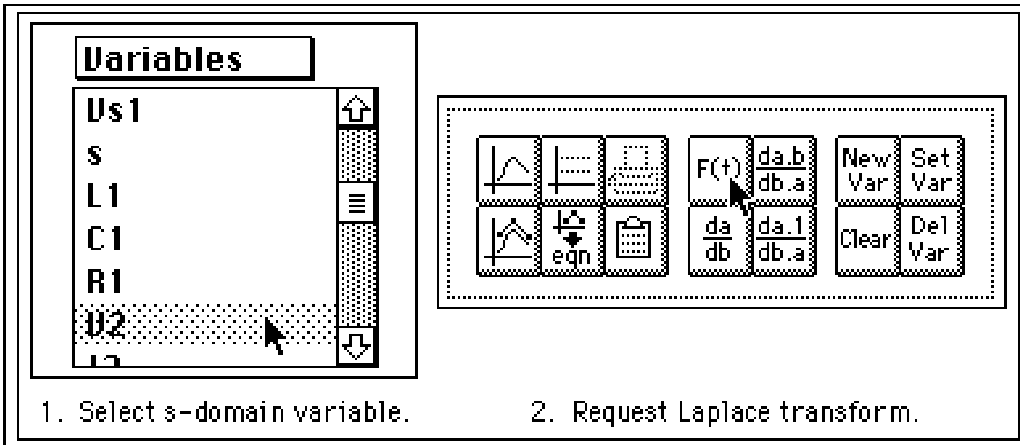


Figure 19: Obtaining a time-domain function.

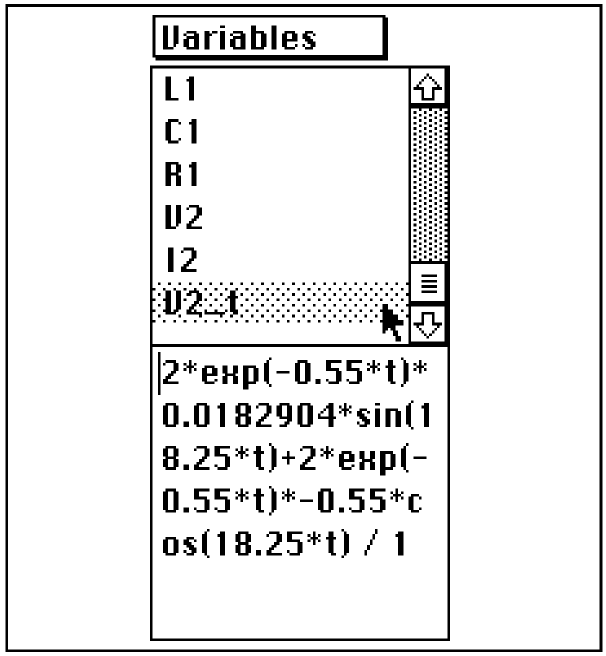


Figure 20: Time domain representation of V2.

☞ Preparing to Plot

Mona maintains two independent graphing windows, each with its own domain, range, and other preferences. This allows you to keep two different "sets" of graphs. Usually, this feature is used to separate frequency domain plots from time domain plots, and the default preferences for each have been set accordingly.

30. Change to the time domain graph set by clicking on the Time toggle switch, as indicated in Figure 21.

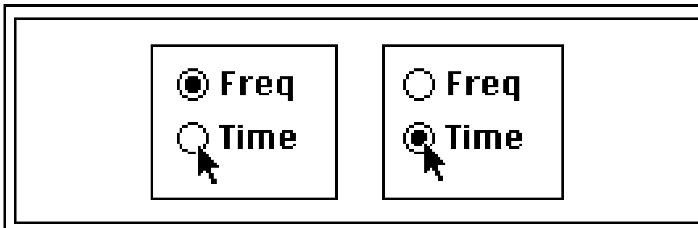


Figure 21: Changing to time domain graph settings.

31. Click on the vertical axis. A dialog box will appear, allowing you to modify the range of the graph. Change the range to {-2 V to +2 V} and click on **OK**.

☞ Plotting a Graph

32. Ensure that **V2_t** is the current variable and click on the graph button. The time response will be plotted as shown in Figure 22.

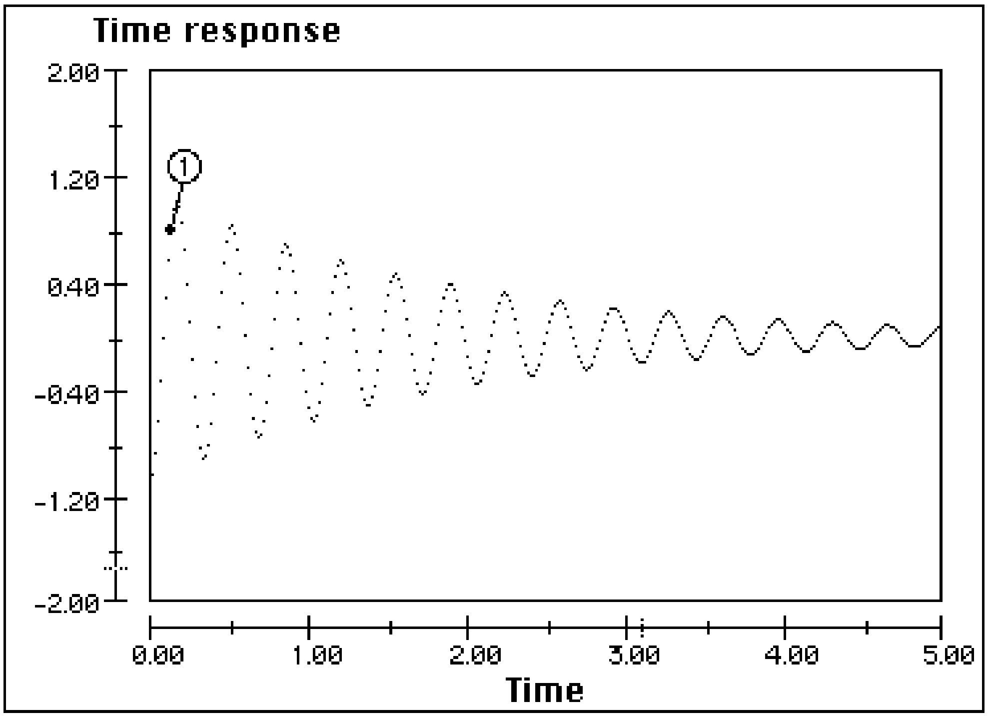


Figure 22: Time domain plot of V2.

Bode Diagram Approximation and Design

Bode diagram approximation is an important concept often taught in electrical engineering undergraduate courses. Frequency domain design is performed using standard piecewise linear "building blocks" which approximate the contribution of particular poles and zeros in the s-domain function.

☞ Preparations

33. Return to the frequency domain graph set, as shown in Figure 23.

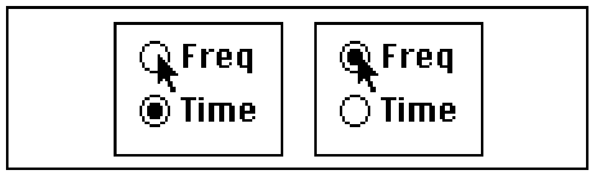


Figure 23: Returning to the frequency domain.

34. Remove any existing plots using the **Clear Graph** button, as shown in Figure 24.

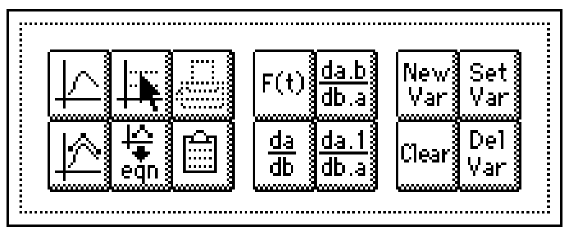


Figure 24: Clearing old graphs.

35. Since this section of the tutorial isn't concerned with the RLC circuit we looked at earlier, you should delete those old variables. Simply select **V2** from the variables list and click on **Del var**. **V2** should be removed from the list of variables, along with any variables that it references (unless another variable also references those variables). Repeat this procedure for **I2** and **V2_t**. Nothing should remain in the list of variables.

Tips from the pros...

A faster way of deleting all variables is to select **Init variables** *from the* **Variables** *pop-up menu (above the list of variables).*

36. We will need some room for our design, so change the magnitude range to { -60 dB to 60 dB } and the frequency range to { 1E-1 to 1E6 }.

37. Although it is important to recognize that each building block has both a characteristic magnitude and a characteristic phase response, we have chosen to suppress the phase information in the screen shots that follow, to simplify the presentation. In order to obtain the same graphs, you will need to click on the **Show C2** check box. When you do this, the phase axis should disappear.

☞ Bode Diagram Design

There are four building blocks, corresponding to: a pole at the origin, a zero at the origin, a pole away from the origin, and a zero away from the origin. The corresponding piecewise linear effect on the magnitude and phase plots is depicted by the buttons in the Bode diagram design palette located below the graph window.

38. Select the "zero away from the origin" button, as shown in Figure 25.

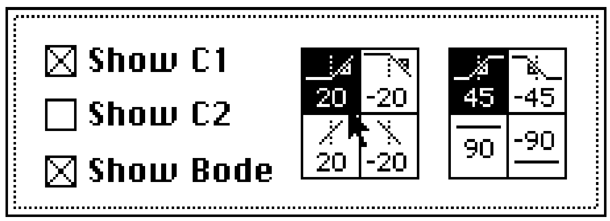


Figure 25: Selecting a Bode design tool.

39. Move the mouse pointer into the graph window, approximately over the 10^2 frequency, and single click the mouse button. This should introduce a magnitude increase of 20 dB/decade, beginning at the frequency where the mouse was clicked, as shown in Figure 26.

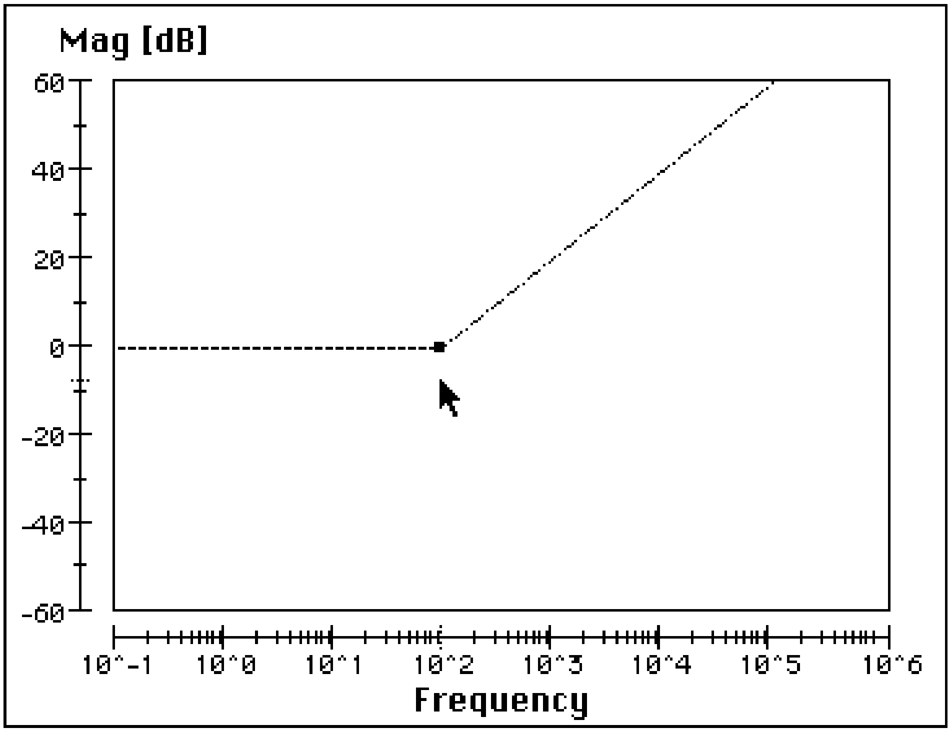


Figure 26: Inserting a zero point.

40. Select the "pole away from the origin" button, as shown in Figure 27.

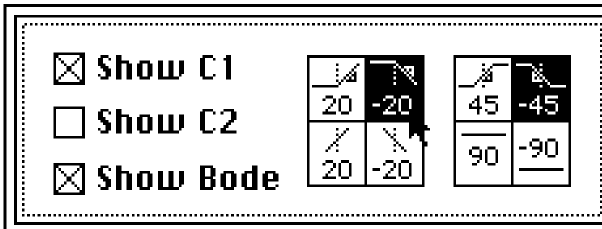


Figure 27: Selecting a different Bode tool.

41. Move the mouse pointer into the graph window, approximately over the 10^3 frequency, and single click the mouse button. This should introduce a magnitude decrease of 20 dB/decade, beginning at the frequency where the mouse was clicked, as shown in Figure 28.

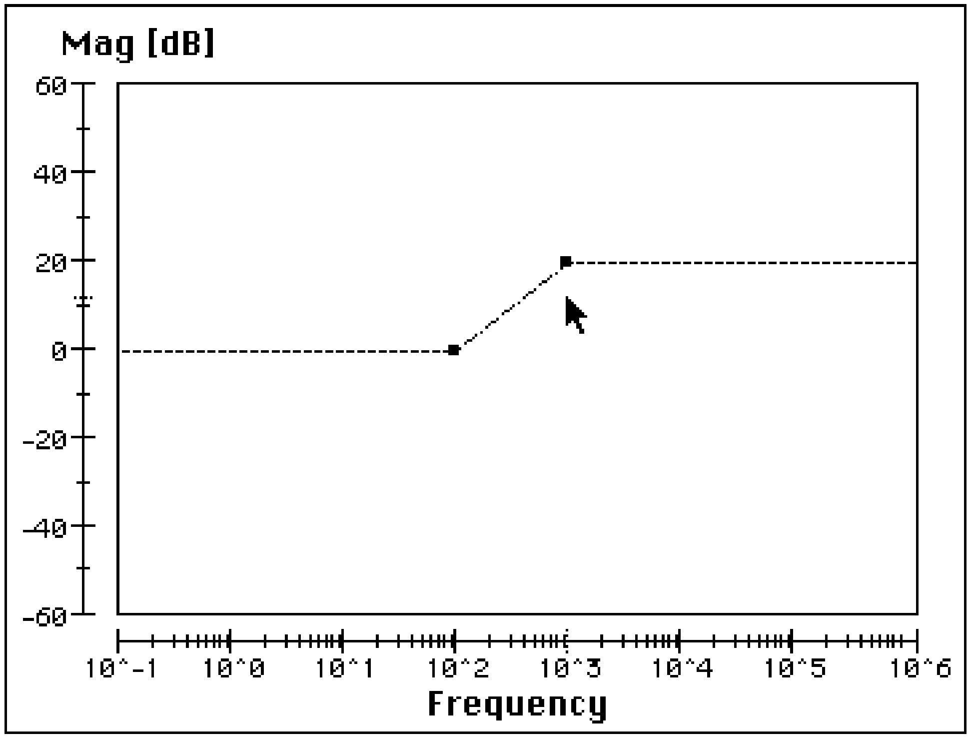


Figure 28: Introducing a pole.

☞ Equation Manipulation

Approximations are useful tools, but it is always important to keep in mind their limitations. What is the actual s-domain expression ? Mona will provide you with the actual expression and even plot the approximation and real functions side by side.

42. You will need to create a new variable to associate with the new expression you are about to retrieve. Enter a new variable name in the variable input area, and click on the **New var** button, as shown in Figure 29.

Tips from the pros...

• *corner points can be moved by clicking and dragging.*

• *corner points can be deleted by shift clicking.*

• *graphs can be dragged vertically by clicking and dragging on a line segment.*

• *graphs can be dragged horizontallu by shift clicking and dragging on a line segment.*

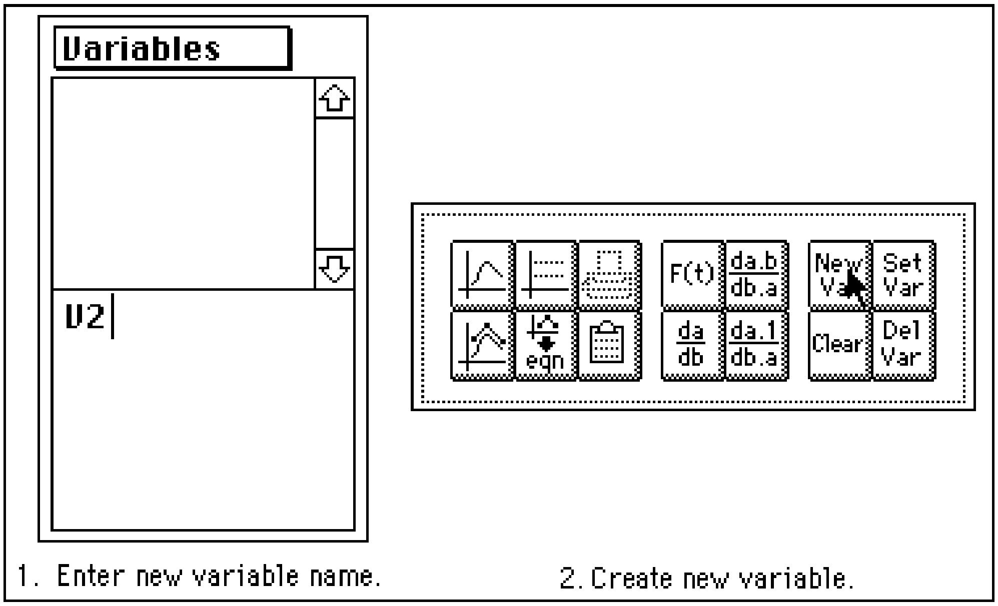


Figure 29: Creating a new variable

43. Click on the **Get eqn** button, as shown in Figure 30. This copies the expression corresponding to the Bode diagram approximation into the input area.

44. Ensure that your new variable name is selected, and click on **Set Var**. This associates the expression with a particular variable.

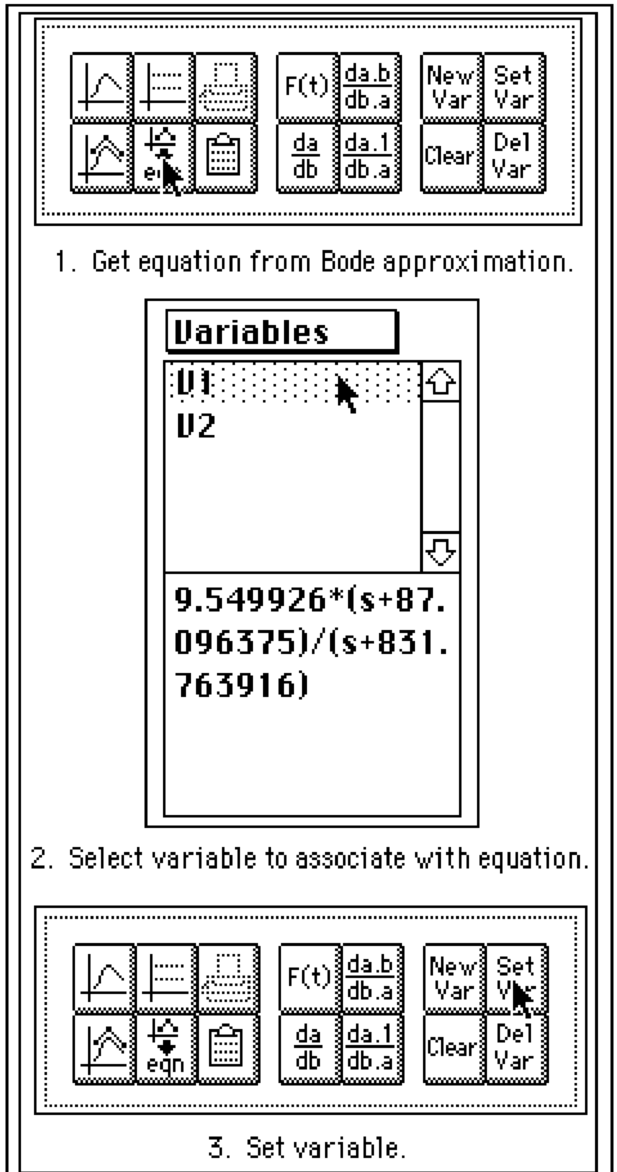


Figure 30: Associating the approximation expression with a variable.

45. Plot the new variable by clicking on the graph button. Results are shown in Figure 31.

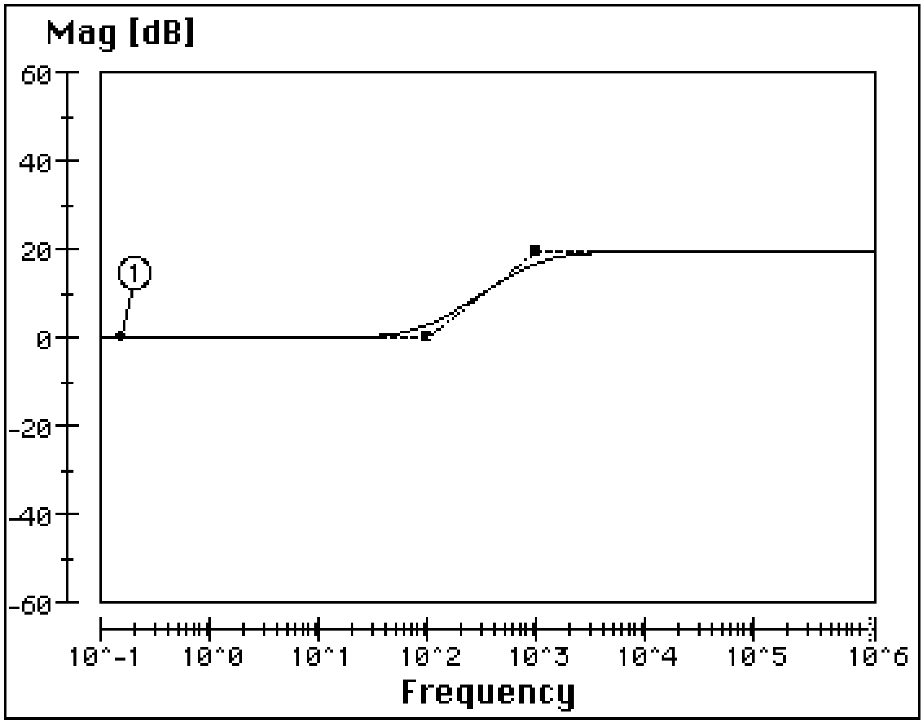


Figure 31: Comparing actual and approximate plots.

This completes the *Getting Started With Mona* tutorial. Feel free to continue to experiment with this demonstration copy of Mona, using your own circuits or those provided in the **Sample Files** folder. When you are finished, select **Quit** from the **File** menu.