MULTISIM DEMO 12.2*: AN OVER, UNDER, AND CRITICALLY DAMPED CIRCUIT

The Parameter Sweep Analysis in Multisim allows us to sweep across specific values of components in order to display widely varying behavior.

In this Demo, we'll investigate and compare the response of the circuit shown in Fig. 12.2.1 using three different values for *R* to over-, under-, and critically damp the circuit. We will measure the voltage v_C.

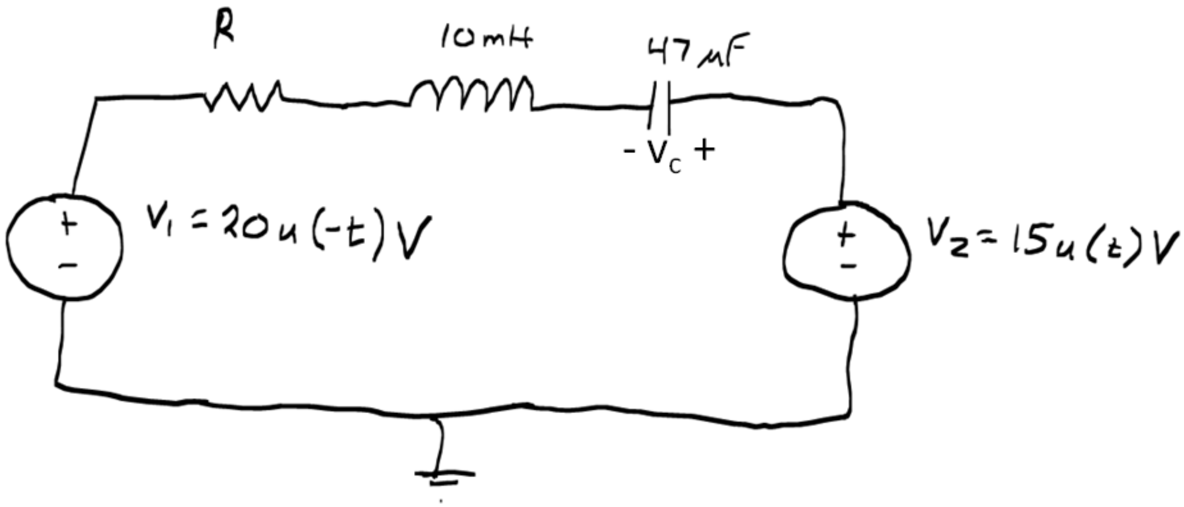


Figure 12.2.1 Simple series RLC circuit.

Because the two sources use *u(t)* and *u(-t)* functions, ABM_VOLTAGE sources are needed. Once everything is assembled, the circuit should resemble 12.2.2 below.

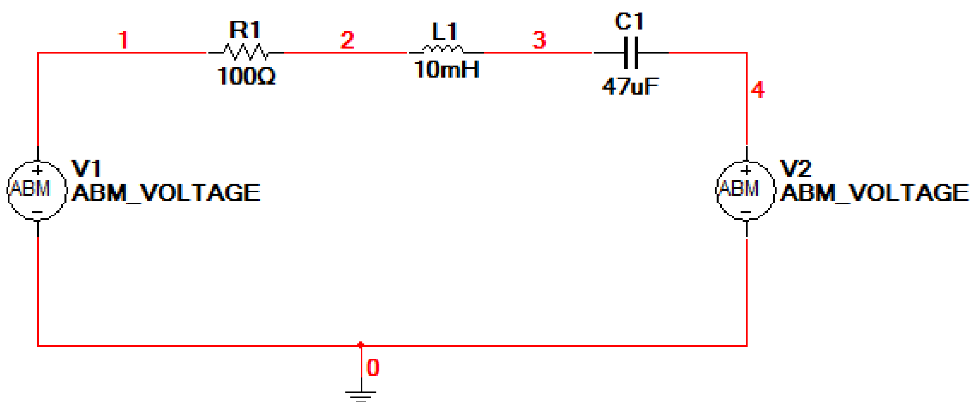
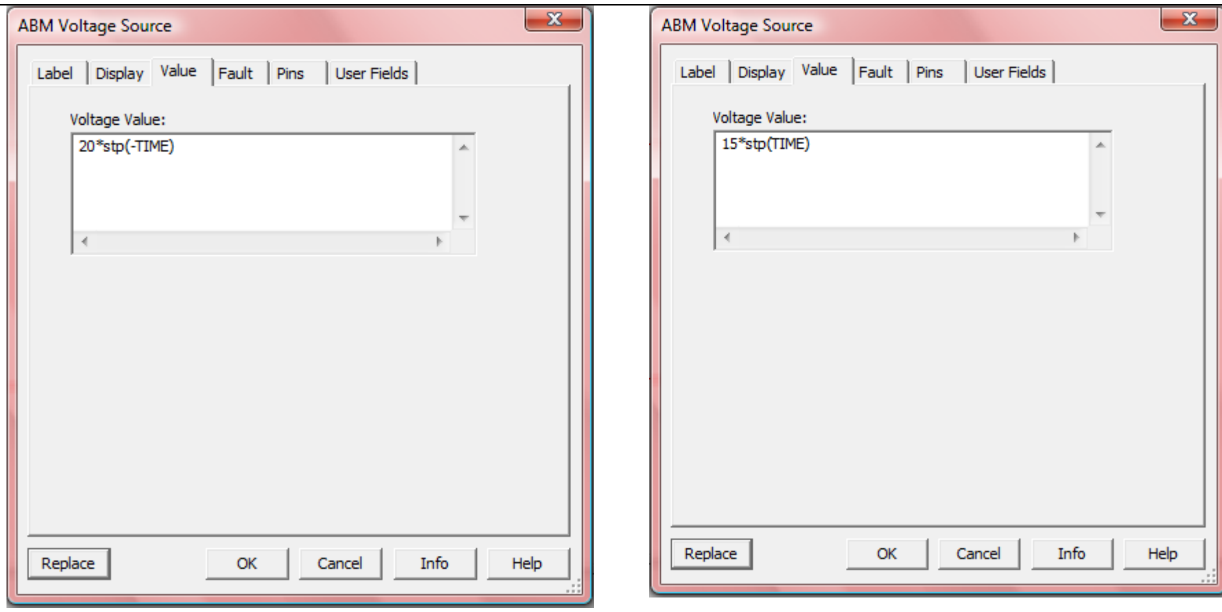


Figure 12.2.2 Circuit implemented in Multisim.

Set the Voltage Value equation for the V1 source to be: 20*stp(-TIME).
Set the Voltage Value equation for the V2 source to be: 15*stp(TIME).
(See Fig. 12.2.3(a) and (b) for reference).



(a) (b)

Figure 12.2.3 ABM_VOLTAGE Source Settings

What should the values for the resistor R in the Parameter Sweep Analysis? We need to figure that out. One value needs to make the circuit under-damped, the second value needs to critically damp the circuit, and the third value needs to over-damp the circuit. Therefore an efficient way to figure this out would be to find the value of the resistor which would critically damp the circuit (R_{CRIT}) first (obviously), and then make that the middle value of the parameter sweep. Then, set the Parameter Sweep Start point to a value R_{CRIT} – X and set the Stop point to R_{CRIT} + X, where X is some arbitrary value which we choose. Finally, set the # of points to 3. This will cause the Parameter sweep to start at R_{CRIT} – X first, then run R_{CRIT}, and then end on R_{CRIT} + X.

The circuit in Fig. 12.2.1 is a series RLC circuit (effectively), so:

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10\times10^{-3}\cdot 47\times10^{-6}}} = 1.459\times10^{3}\,\text{rad}\cdot\text{s}^{-1}$$

In order for the circuit to be critically damped, α has to equal ω_0. For a series RLC circuit:

$$\alpha = \frac{R}{2L}$$

Therefore setting α has to equal ω_0:

$$\frac{R_{CRIT}}{2L} = \omega_0 \qquad R_{CRIT} = 1.459\times10^{3}\cdot 2\cdot 10\times10^{-3} = 29.175\ \Omega$$

Now let’s pick a X value of 19.175 Ω. This will give us a nice round Start value of 10 Ω and Stop value of 48.35 Ω. Insert these values into the Parameter Sweep, and don’t forget to set the # of points to 3 as shown in Fig. 12.2.4 on the next page.

We will be running a Transient Analysis in this Parameter Sweep so use the option selections and values shown in Fig. 12.2.5 on the next page.

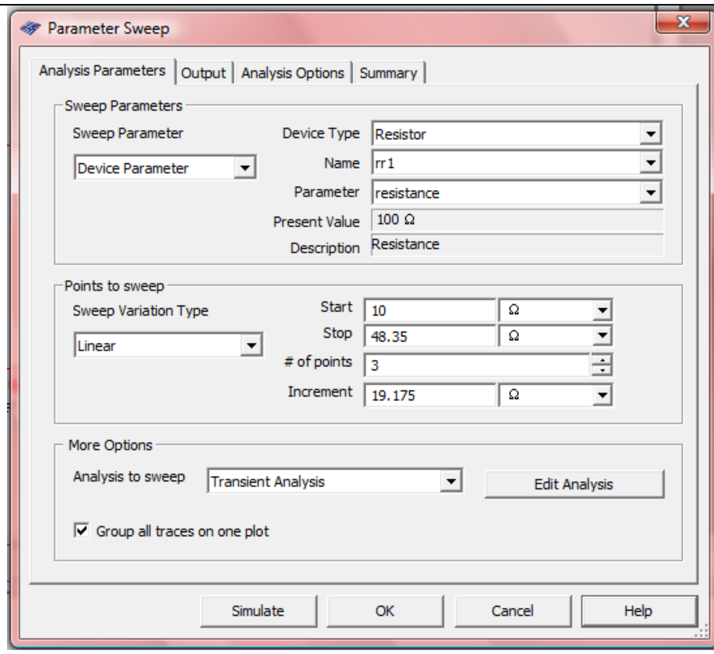


Figure 12.2.4 Settings for the Parameter Sweep.

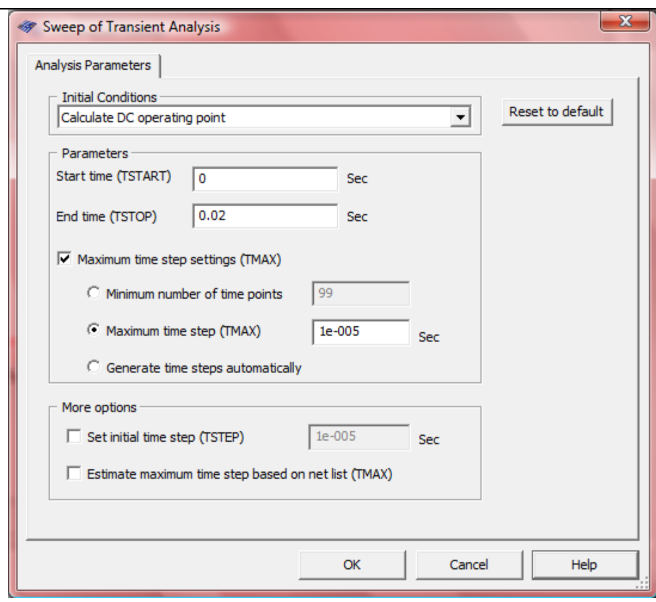


Figure 12.2.5 Settings for the Transient Analysis.

Since we want to plot the voltage v_C , we need to plot the equation V(4) – V(3). Make sure you enter this equation into the Selected Variables for Analysis field under the Output tab in the Parameter Analysis setup window.

Once you are ready, press Simulate. The plot which comes up should exhibit the same behavior as that shown in Fig. 12.2.6 on the next page.

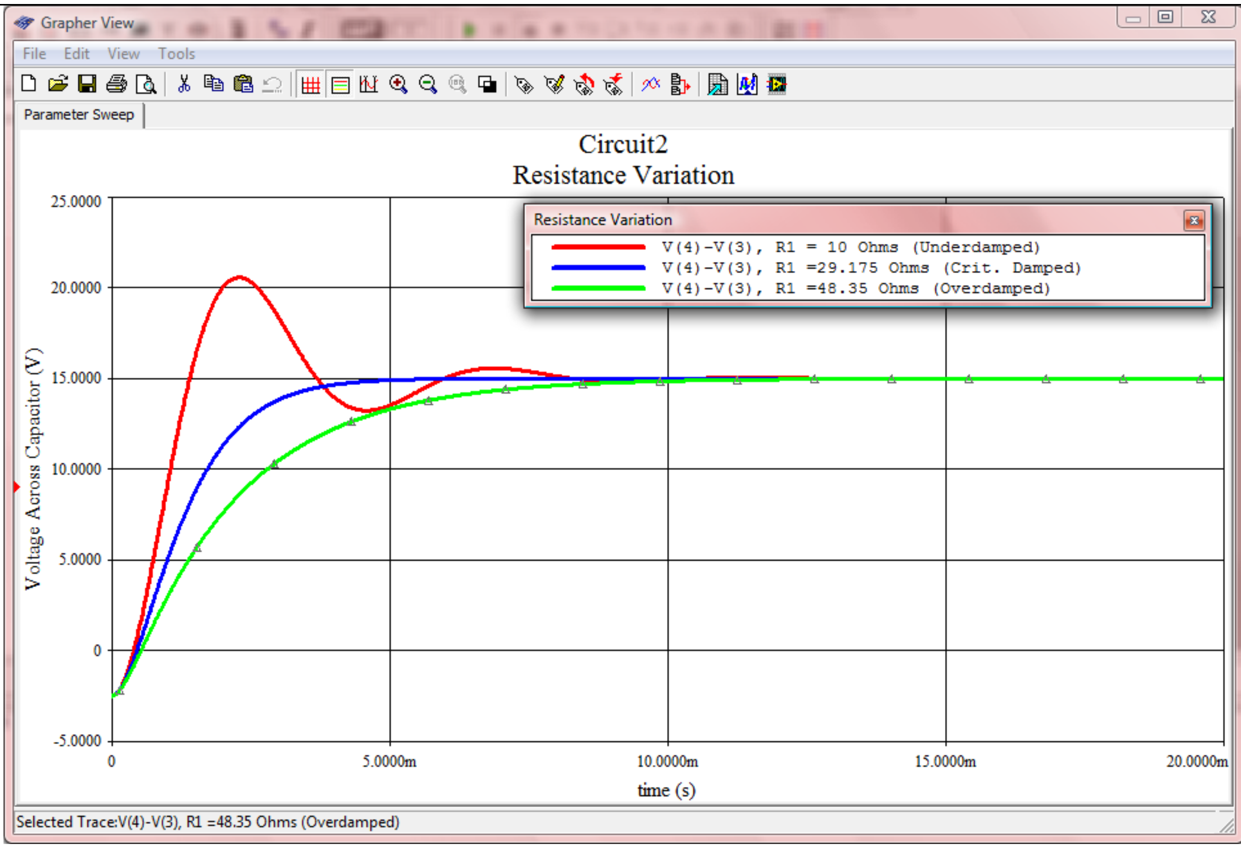


Figure 12.2.6 Plot of the three general types of response for the circuit in Fig. 12.2.1.

You can use the cursors to investigate in more detail, but as we can clearly see, the critically damped response (in blue) reaches 15 V the quickest by far. The under-damped response (red) oscillates as expected, and the over-damped response rises to 15.00 V smoothly but at a much slower rate than the crucially damped response.