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 .



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.



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).

ABM Voltage Source	ABM Voltage Source
Label Display Value Fault Pins User Fields	Label Display Value Fault Pins User Fields
Voltage Value:	Voltage Value:
20*stp(-TIME)	15*stp(TIME)
▼ 	· · · · · · · · · · · · · · · · · · ·
,	
Replace OK Cancel Info	Help Replace OK Cancel Info Help
(a)	(b)
Figure 12.2.3	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:

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

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 :

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

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.

Parameter Sweep Analysis Parameters Output Analysis Options Summary
Sweep Parameters Sweep Parameter Device Type Resistor ▼ Device Parameter Name rr 1 ▼ Parameter resistance ▼ Present Value 100 Ω
Description Resistance Points to sweep Start 10 Ω Sweep Variation Type Start 10 ✓ Linear ✓ Stop 48.35 Ω # of points 3
More Options Analysis to sweep Transient Analysis Image: Group all traces on one plot
Simulate OK Cancel Help

Sweep of Transient Analysis	
Analysis Parameters	
Initial Conditions Calculate DC operating point Parameters	
Start time (TSTART) 0 Sec	
End time (TSTOP) 0.02 Sec	
Minimum number of time points 99 Aximum time step (TMAX) Ie-005 Sec	
C Generate time steps automatically	
Set initial time step (TSTEP) Ie-005 Sec Estimate maximum time step based on net list (TMAX)	
Sumate maximum ume step based on net list (TMAX)	
OK Cancel Help	

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.



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.