MULTISIM DEMO 5.4*: TIME CONSTANTS IN RC CIRCUITS

While we know numerically that in an RC circuit the value of the resistance affects the time constant, how does variation of the resistor affect the response graphically?

For this Demo, we will feed a square wave into a standard RC circuit, shown in Fig. 5.4.1 below, vary the value of the resistance from 100 Ω to 3 kΩ, and plot the variation in the value of $v_c(t)$.

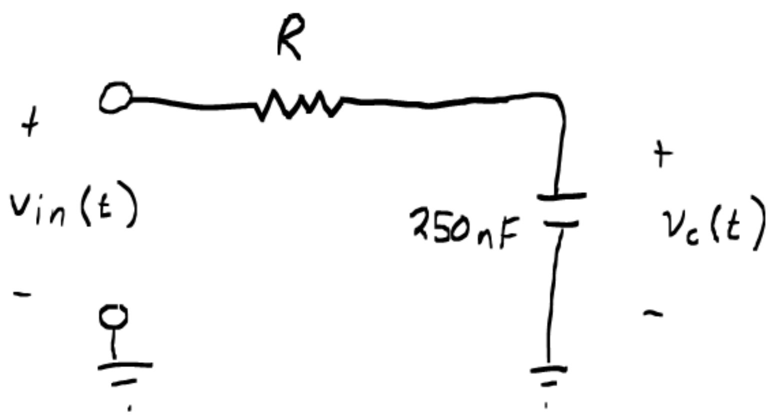

Figure 5.4.1 Simple RC circuit.

In building the circuit, use the PULSE_VOLTAGE component found under Sources and SIGNAL_VOLTAGE_ SOURCES in the Select a Component window. Set the Initial value of the PULSE_VOLTAGE source to 0 V, set its pulsed value to 1 V, and leave the period and pulse width to the default values of 1 ms and 0.5 ms, respectively. When completed, your circuit should resemble Fig. 5.4.1.

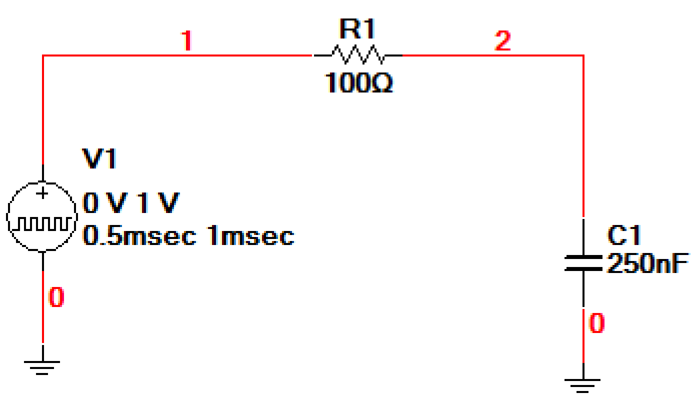

Figure 5.4.2 Simple RC circuit implemented in Multisim.

So in order to watch the response of the circuit to different resistor values we will run a Parameter Sweep Analysis with a Transient Analysis. Set the Analysis Parameters of the Parameter Sweep to those shown in Fig. 5.4.3 on the next page.

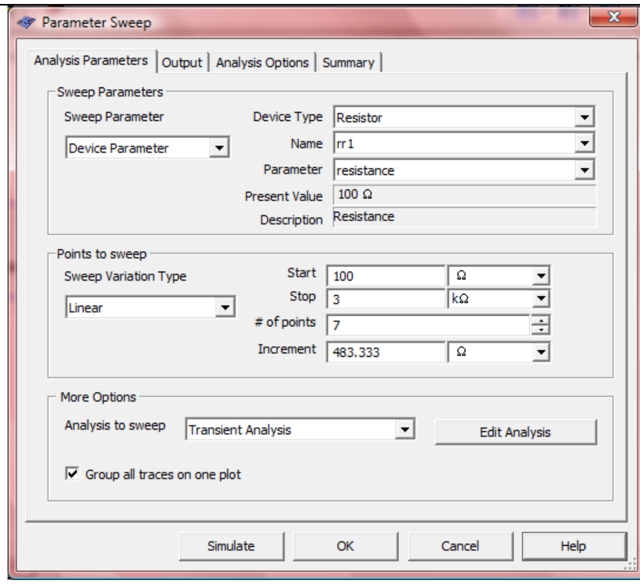

Figure 5.4.3 Parameter Sweep Values.

Make sure you select to run a Transient Analysis; set the parameters and values of that simulation to what is shown in Fig. 5.4.4 below. The variable we want to measure is the voltage across the capacitor which can be represented by the simple variable V(2) (using the notation of the circuit in Fig. 5.4.2).

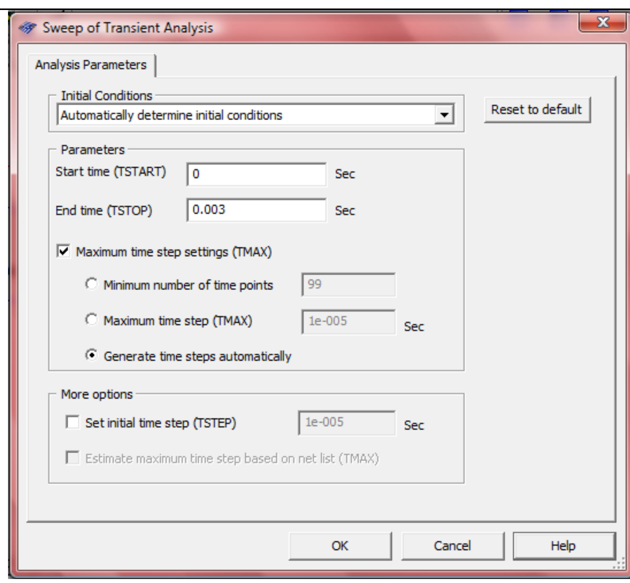

Figure 5.4.4 Transient Analysis Values.

When you are ready, Simulate. The plot generated should resemble that shown on the next page.

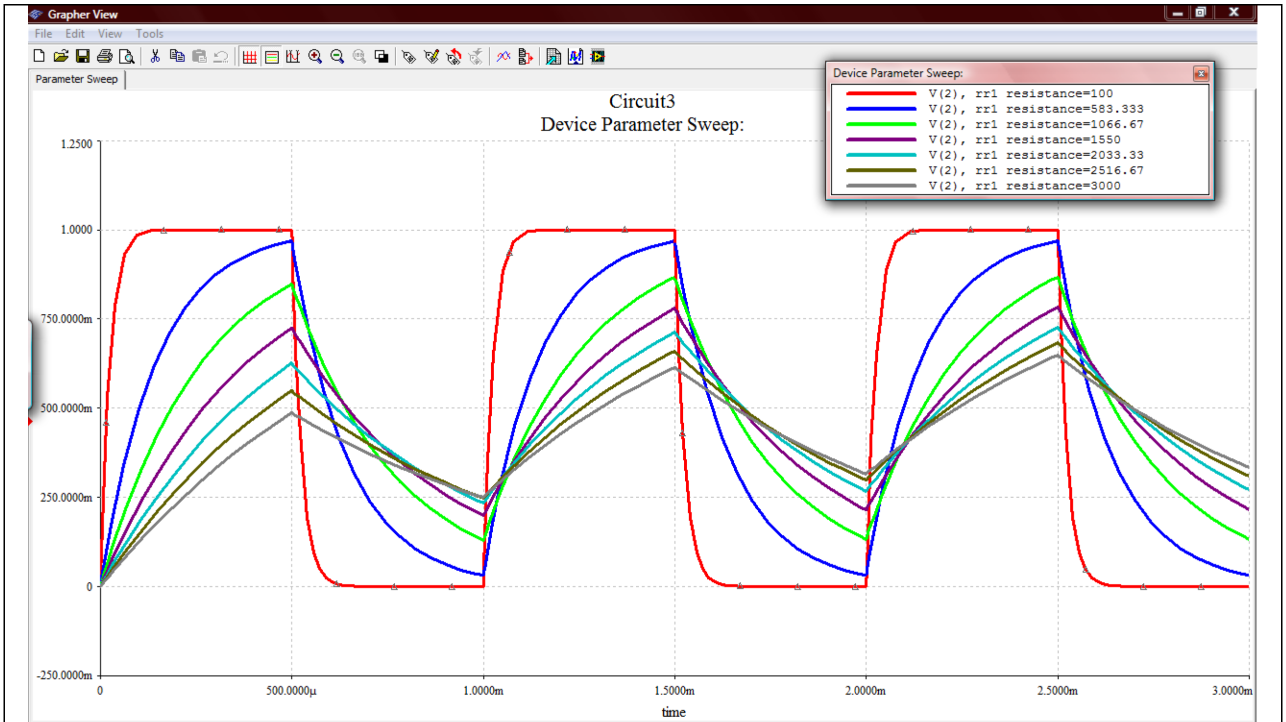

Figure 5.4.5 RC charge/discharge curves for varying resistance values.

From basic theory ($\tau = RC$) we know that for this circuit when:

R = 100 Ω, τ = 25 µs
R = 583.3 Ω, τ = 145.83 µs
R = 1066.7 Ω, τ = 266.93 µs
R = 1550 Ω, τ = 387.5 µs
R = 2033.3 Ω, τ = 508.33 µs
R = 2516.7 Ω, τ = 629.18 µs
R = 3000 Ω, τ = 750.0 µs

If we compare these values to their corresponding plots, things start to make sense. The circuit with the lowest time constant quickly reaches the input voltage values (it is the only circuit with a response that looks similar to the square wave input signal). As we keep increasing the time constant, the capacitor charges up less and takes longer to decay.