Santa Clara University	ELEN 115 Spring 2023	Dr. Shoba Krishnan
Laboratory #2: Single time constant circuits		

I. Objectives

- To construct a simple RC single time constant circuit and do transient analysis in LTSpice.
- To understand frequency behavior and do ac analysis for simple RC circuits.

II. Laboratory Procedure:

Part 1: Schematic Capture

For this part of the lab, please create the single time constant circuit shown in Figure 1 in LTSpice.

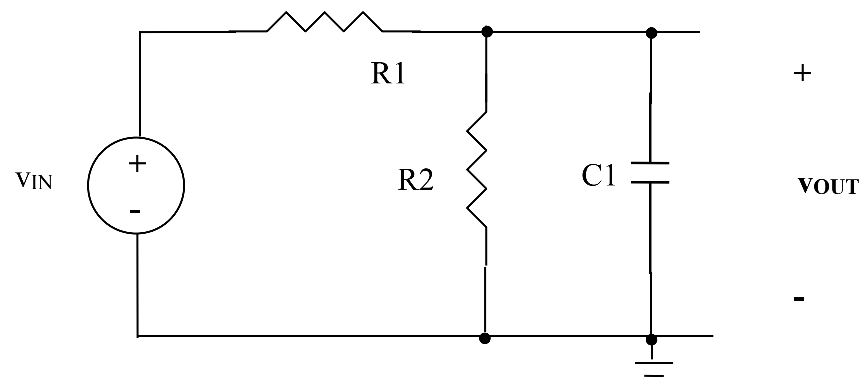

Figure 1. Single time constant circuit

Part 2: Transient Analysis- Pulse Input

(1) Assign component value for R1 = 20kΩ, R2 = 20kΩ and C1 = 0.1µF.

(2) Make v_{IN} a pulse input that goes from 0V to 10V and has a pulse width of 10msec and period of 20msec. The rise and fall times should both be 1nsec. Set v_{IN} pulse delay time = 0.

(3) Set the initial condition on the capacitor to be 0V.
To do this, make a SPICE directive with the following text: ".ic V(Vout)=0" where Vout is the name of the output node.

(4) Run a Transient Analysis for 50ms, using a 10us time step.

(5) Plot v_{IN} and v_{OUT} as a function of time on the same plot.
Do the results look as expected? Why or why not?
Make sure to take a screen capture of the simulation waveforms.

(6) Change the v_{IN} pulse width and period (and transient runtime) to produce a full charge/discharge Vout wave. How many time constants does it take to reach steady state.

(7) Plot C*dVout/dt (use: 1e-6*D(V(Vout)).

(8) Plot current i_{OUT} as a function of time.
What does the plot show? Explain its shape. Verify if i_{OUT} is the same as your plot in (6)
Make sure to take a screen capture of the simulation waveforms.

(9) Modify the initial condition on the capacitor C1 to 1V. Rerun the simulations and replot.
How did the waveforms change? Explain why?
Make sure to take a screen capture of the simulation waveforms.

(10) Modify the value of C1 = 10uF. Rerun the transient simulations and replot the signals.
How did the waveforms change? Explain why?

Make sure to take a screen capture of the simulation waveforms.
TA Check Point: Complete Part 1 and Part 2 and demo the results to your TA.

Part 3: AC analysis

(1) Assign component value for R1 = 20kΩ, R2 = 20kΩ and C1 = 0.1µF. Initial condition of 0V on the capacitor.
(2) V_{IN} is a sinusoidal source. Set the small signal AC analysis amplitude to 1.
(3) Simulate using AC Analysis. Sweep type: Decade.
Number of Points per decade: at least 5. Start frequency: 1Hz. Stop Frequency 100kHz.
Use cursors to measure the slope of the line to verify -20dB/decade
Measure the -3dB frequency to verify the time constant and cutoff frequency.
Screen Capture the Bode plot of magnitude and phase of vout/vin.

TA Check Point: Complete Part 4 and demo the results to your TA.

Physical Circuit Build

Build the circuit in Figure 1 with components R1 = 20kΩ, R2 = 20kΩ and C1 = 0.11µF. For the circuit build of Figure 1 we would like to observe its output to input of various frequencies and understand its frequency behavior. The following parts helps us make observations regarding this passive filter.

Part 4: Transient input

(1) Build the circuit in Figure 1 with components R1 = 20kΩ, R2 = 20kΩ and C1 = 0.1µF.
(2) Connect the signal generator as the voltage source v_{IN} with a sinusoidal input with 1V amplitude and 1Hz frequency. Connect an oscilloscope at the output to monitor the voltage.
(3) Observe v_{IN} and v_{OUT} on the oscilloscope. Zoom in to see two to three time periods.
Do the results look as expected? Why or why not?
Make sure to take a screen capture of the measured waveforms.
(5) Make v_{IN} a sinusoidal input with 1V amplitude and 10Hz frequency. Repeat step 3.
(6) Make v_{IN} a sinusoidal input with with 1V amplitude and 100Hz frequency. Change the transient duration to 10msec. Repeat step 3.
(7) Make v_{IN} a sinusoidal input with with 1V amplitude and 1kHz frequency. Change the transient duration to 1msec. Repeat step 3.
(8) What have you observed while doing steps (2) through (7)? What behavior does this RC circuit show?

TA Check Point: Complete Part 3 and demo the results to your TA.

III. REPORT

Write a short laboratory report that details all the work done **and** answer the following questions:

- What is the RC time constant when R1 = 20kΩ, R2 = 20kΩ and C1 = 0.1µF?
- From part 2, what did you understand is the relationship between i_{OUT} (current in capacitor) and v_{OUT} (voltage across the capacitor)
- Draw the schematic of a single time constant high pass filter. What will be the value of the R and

C to obtain a cutoff frequency 1/10th of the low pass filter you created in the lab.

- If we took the output of the high-pass-filter you just designed and made that the input of the low-pass filter of the lab, what sort of behavior do we expect at the output of the combined circuit? Draw a rough bode plot sketch of this behavior.