Name:	Lab Session:	TA:
Score:	/ 10	

Online Lab 2: Transient Response

Objectives

- Simulate transient responses of RC and RL circuits
- Determine the time constant of a first-order circuit analytically and through simulations
- Simulate how the output performance is affected by frequency and the time constant

LAB TASK 1: RC CIRCUIT SIMULATION WITH LTSPICE

LTSpice is a circuit schematic editor and simulator. The circuit can be simulated after the schematic is drawn. Build the RC circuit shown in Fig. 1 in LTSpice. u(t) is the unit step function.

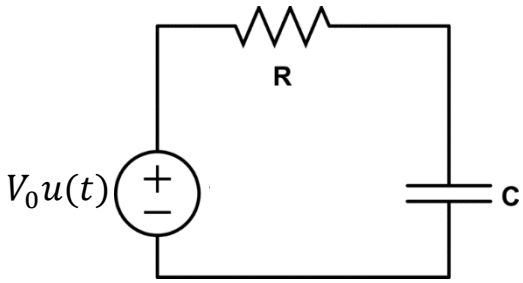

Fig. 1

TA will announce the voltage, resistance value and capacitance value at the beginning of the lab.

V_0 = _____ V

R = _____ kΩ

C = _____ μF

Calculate the time constant $\boldsymbol{\tau}$ of the circuit.

$\boldsymbol{\tau}$ = RC = _____ s

In LTSpice, select the voltage source with DC value V_0. When you are editing the analysis command, select the "Transient" tab, use 10τ as the stop time, and make sure that "Start external supply voltages at 0V" is checked. Plot the simulated current and the simulated voltage across the capacitor.

Find the voltage across the capacitor v_c at the time *t*.

t (s)	$\boldsymbol{v_c}$ **(V)**	$\boldsymbol{v_c/V_0}$
0		
τ		
3τ		
5τ		

If the input voltage is 9V instead after 0s, pick any resistor and capacitor so that the time constant remain the same and find the new voltage across the capacitor at time *t*.

t (s)	$\boldsymbol{v_c}$ **(V)**	$\boldsymbol{v_c/9V}$
0		
τ		
3τ		
5τ		

How are the voltage and current affected by the resistance and capacitance values of the RC circuit?

_____ / 3

LAB TASK 2: RC CIRCUIT RESPONSE TO A PERIODIC STEP-VOLTAGE INPUT

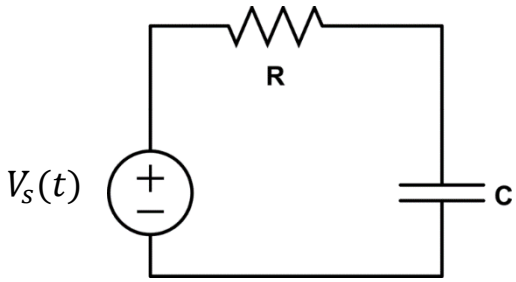

Fig. 2

In Fig. 2, $V_s(t)$ is a square wave from -10V to 10V with period *T*. Build the RC circuit shown in Fig. 2 in LTSpice, where R and C are the same as those picked by the TA in Task 1. Edit voltage source and select "Advanced". Select "PULSE" in the style menu of "Time Domain Function" and parameters are summarized in Table 1. Different period *T* will be investigated in this task.

Parameters	**Values**
Vinitial[V]	-10
Von[V]	10
Trise[s]	1e-6
Tfall[s]	1e-6
Ton[s]	*T*
Tperiod[s]	*2T*

Table 1

a) $\boldsymbol{T = 10\tau}$**.** Editing the analysis command and select the "Transient" tab, use 50τ as the stop time. Simulate $\mathbf{v_c(t)}$ and plot with $V_s(t)$.

a) $\boldsymbol{T = 10\tau}$**.** Keep 50τ as the stop time in "Transient" tab of the analysis command. Simulate $\mathbf{i_R(t)}$ and plot with $V_s(t)$**.**

c) $\boldsymbol{T = 0.1\tau}$**.** Editing the analysis command and select the "Transient" tab, use 5τ as the stop time. Simulate $\mathbf{v_c(t)}$ and plot with $V_s(t)$.

d) Comment on the results in Task 2.

_____ / 4

LAB TASK 3: RL CIRCUIT SIMULATION WITH LTSPICE

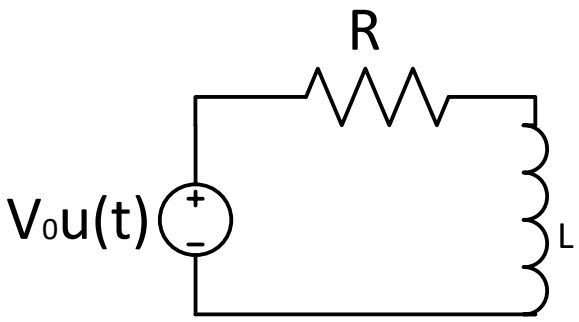

Fig. 3

For the RL circuit in Fig. 3, R is the same resistor from task 1. Inductance L is 100 mH. u(t) is the unit step function. Calculate the time constant of RL circuit:

τ_0 = L/R = _____s.

Build the circuit in Fig. 3 via LTSpice. Add the line ".ic i(L1)=0" in the analysis command. Simulate v_c and i_R from t = 0s to t = $10\tau_0$.

Find v_L and i_R at time t and complete the following table

t (s)	$\boldsymbol{v_L}$ **(V)**	$\boldsymbol{i_R}$ **(A)**	**Calculated** $\boldsymbol{v_R}$ **(V)**	$\boldsymbol{v_L + v_R}$ **(V)**
0				
$\boldsymbol{\tau_0}$				
$\boldsymbol{3\tau_0}$				
$\boldsymbol{5\tau_0}$				

Is KVL satisfied in this circuit at all time?

_____ / 3