Faculty of engineering and Technology

Department of electrical and computer Engineering

Basic Electrical Engineering Lab [ENEE2101]

Report of Experiment 6

First order Circuits

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1. Abstract

This experiment focused on examining the behavior of first-order circuits, specifically those with resistor-capacitor (RC) or resistor-inductor (RL) combinations, in response to various inputs. Voltages and currents were measured using a digital multimeter and oscilloscope to analyze the transient response, as the circuits reacted over time, and the steady-state response, once they reached equilibrium.

2. Theory

First-Order Circuits with DC sources (Step Response):

The unit step function is a mathematical tool used to represent switching actions in circuits. It allows us to model how circuits respond over time(transient response) by "activating" a DC source at a specific point in time. This is particularly useful in analyzing RC and RL circuits where the current or voltage changes over time due to the presence of capacitors or inductors.

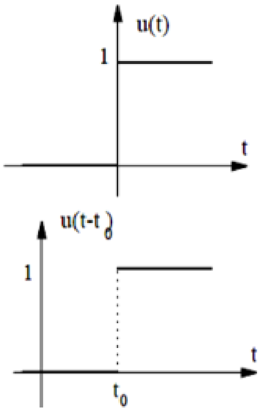

Figure 1

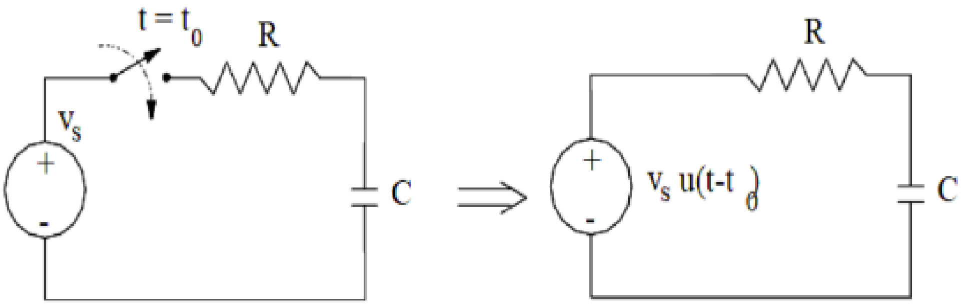

Figure 2

CH 7 : First order RL + RC circuits

[1] First order RL circuit.

$i = I_f + (I_o - I_f)e^{-t/\tau}$ $\quad t \geq 0$

when $V_s \neq 0$ or $I_f \neq 0$ → step response.

when $V_s = 0$ or $I_f = 0$ → Natural response

. Note : At $t \to \infty$ → $I_f = \frac{V_s}{R}$, L is short circuit.

. $\tau = L/R_{Th}$ $\quad$. $V_L = L\frac{di}{dt}$

[2] First order RC circuit.

$v_c = RI_s + (V_0 - RI_s)e^{-t/\tau}$; $\tau = RC$ $\quad t \geq 0$

when $I_s \neq 0$ → step response → $V_c = RI_s + (V_0 - RI_s)e^{-t/\tau}$

when $I_s = 0$ → Natural response → $V_c = V_0 e^{-t/\tau}$

$\underset{initial}{V_c(0)} = V_0 = V_c(0^-) = V_c(0^+)$

$v_c(\infty) = RI_s$ → The capacitor appear as an open circuit.

. $i_c = C\frac{dv}{dt}$

3. Procedure

Part A: Step response of First-order RC circuit

The circuit in the figure 4 was conected

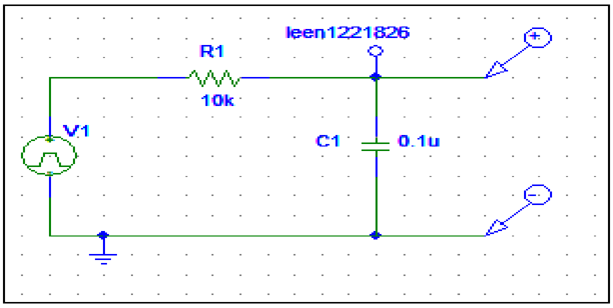

Figure 4

the function generator and set to produce a square wave of: Vin= 6 VPP , f = 50 Hz The actual value of the resistor was measured using Digital Multimeter (DMM) and results were recorded in Table 1 The oscilloscope was used to view $VC(t)$ waveform By connect CH1 of the oscilloscope on the function generator and CH2 across the capacitor and by using cursors in the oscilloscope to take point on the wave of $VC(t)$ to find the value of τc and a picture of the waveform was taken and it will be attached down below in the data section.

Table1

R actual	9.946k

The circuit in the figure was connected

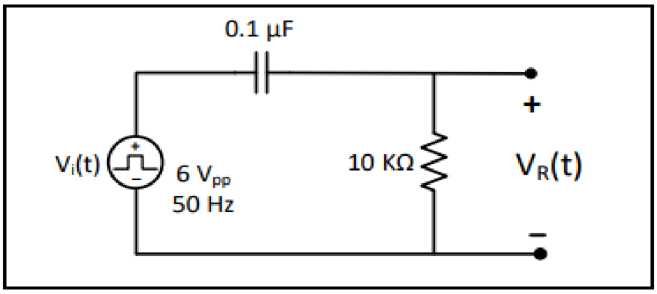

Figure 5

The previous steps were repeated after switching the resistor and the capacitor places, such in Figure 5 The oscilloscope was used to view $VR(t)$ waveform and by using the cursors in the oscilloscope to take point on the wave of $VR(t)$ to find the value of τR and a picture of the waveform was taken and will be attached down below in the data section.

Part B: Step response of first-order RL circuit

The circuit in the figure 7 related to the function generator and it was set to produce a square wave of: Vin= 6 VPP, f = 50 Hz the DC resistance of the inductor and the actual value of the resistor was measured using Digital Multimeter (DMM) and results were recorded in Table 2 The oscilloscope was used to view $VL(t)$ waveform. By connect CH1 of the oscilloscope on the function generator and CH2 across the inductor and busing cursors in the oscilloscope to take point on the wave of $VL(t)$ to find the value ofτL and a picture of the waveform was taken and will be attached down bellow in the data section.

The circuit in the figure 6 was connected

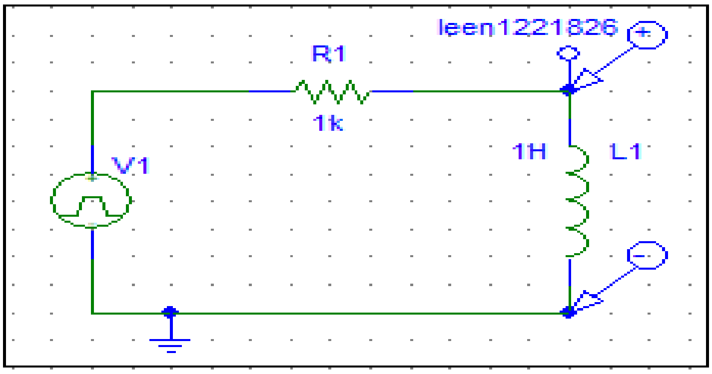

Figure 5

The previous steps were repeated after switching the resistor and the inductor places, such in Figure 1 The oscilloscope was used to view $VR(t)$ waveform by using the cursors in the oscilloscope to take point on the wave of $VR(t)$ to find the value of τR and a picture of the waveform was taken and will be attached down below in the data section.

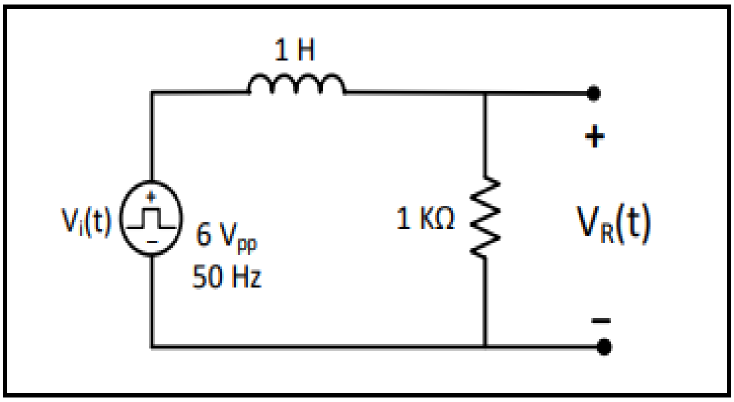

Figure 6

Table2

R actual	R inductor
0.985k	52.39Ω

4. Calculation, and Analysis of results

Figure 7

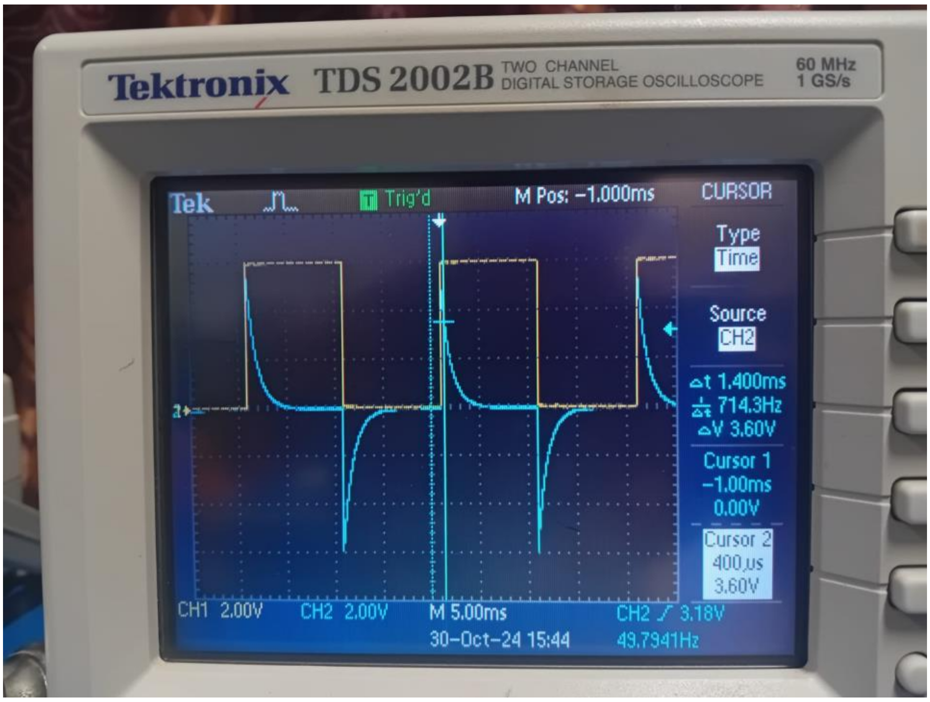

Figure 8

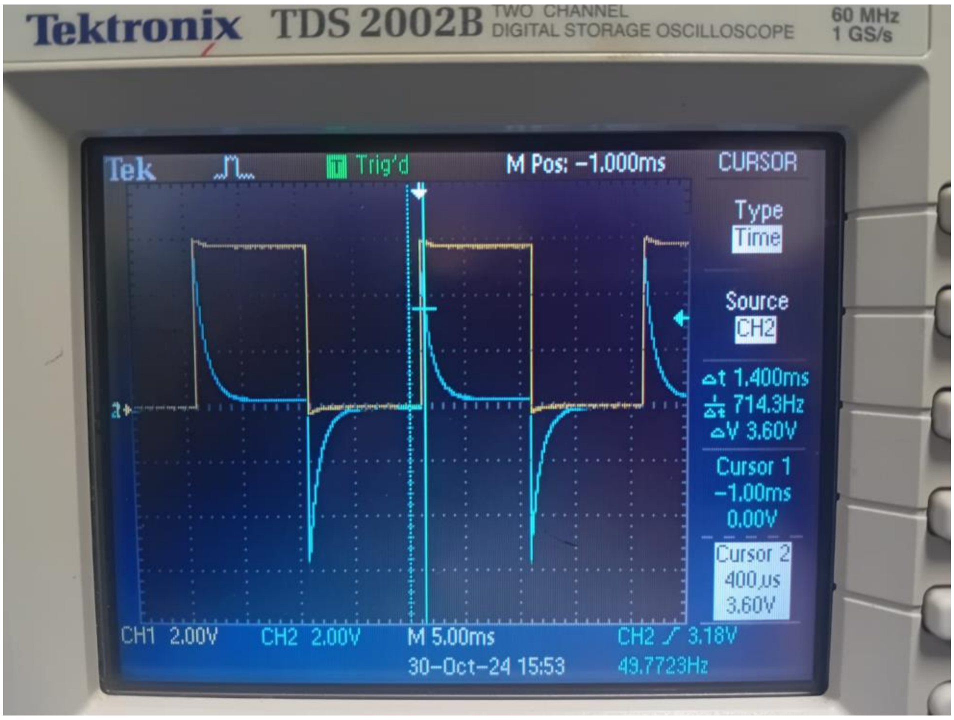

Figure 9

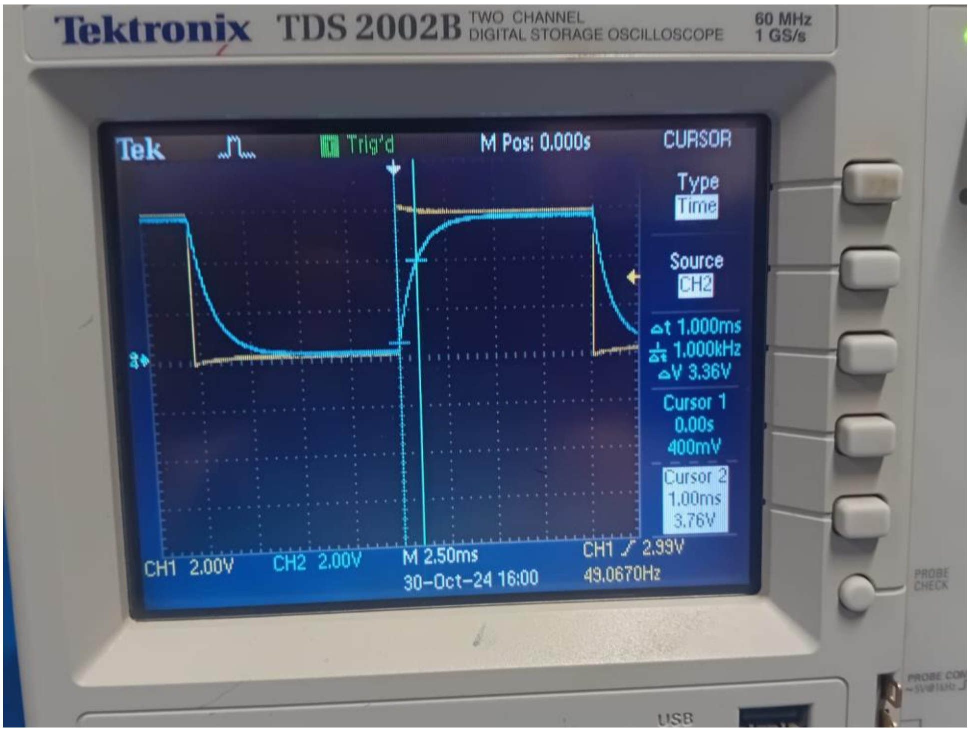

Figure 10

Question 1: τ = RC, almost identical and equal 1ms.

Question 2:

Vc [charging capacitor]

Vr [discharging capacitor]

τ → the same time constant.

Question 3:

τ =L/R

τ =1ms, L=50 H →R=50Ω

The result of the measurement was 52.39Ω

Question 4:

Vc [charging capacitor]

Vr [discharging capacitor]

τ → the same time constant.

5. Conclusion

in conclusion, we examined first-order RC and RL circuits, with an emphasis on their transient and steady-state responses. Our experiments demonstrated the expected exponential behavior of these circuits when exposed to step inputs. The measured time constants aligned with theoretical predictions, confirming our understanding of these essential circuits. This practical experience strengthened our grasp of key principles and underscored the importance of first-order circuits in electronic design and analysis.

6. References

[1] Electrical and Computer Engineering Department, circuit lab manual, 2022, pp.42-48