BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

CIRCUITS AND ELECTRONICS LABORATORY– ENEE2103

Experiment No. 3 Prelab

First and Second Order Circuit

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Date: 4/3/2024

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Prelab instructions:

1. Simulate the circuits in the procedure section and determine the required values (set the parameters that must be assigned by the instructor in the procedure to proper values).

2. Verify if Simulation Results match the expected results

Procedure and Discussion

Part 1: RC Circuit:

Considering R3=22k, C1=100nF, V1 square wave 5Vp-p and 50Hz with dc offset=2.5V, measure Value of C1using the RLC meter:

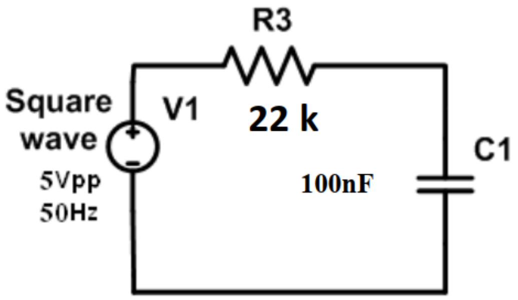

Figure 1 Original circuit

In Pspice circuit:

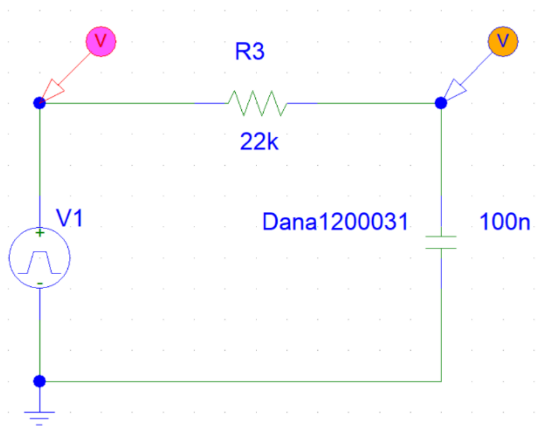

Figure 2 Pspice circuit

Pspice simulation: as purple line is the input and, orange is the output.

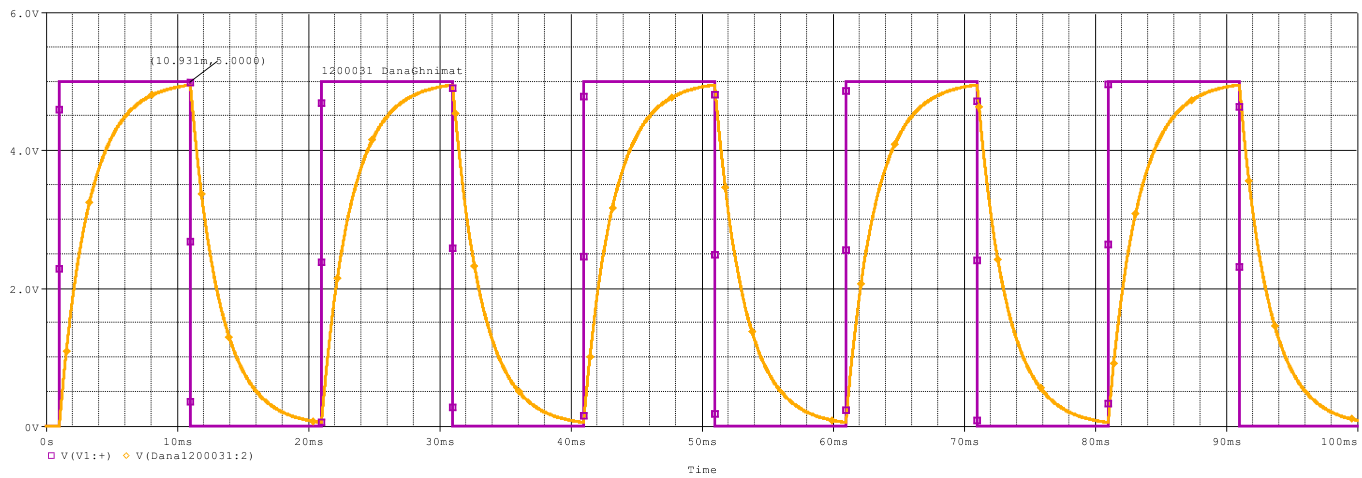

Figure 3 Pspice simulation 1

Value of the system time constant:

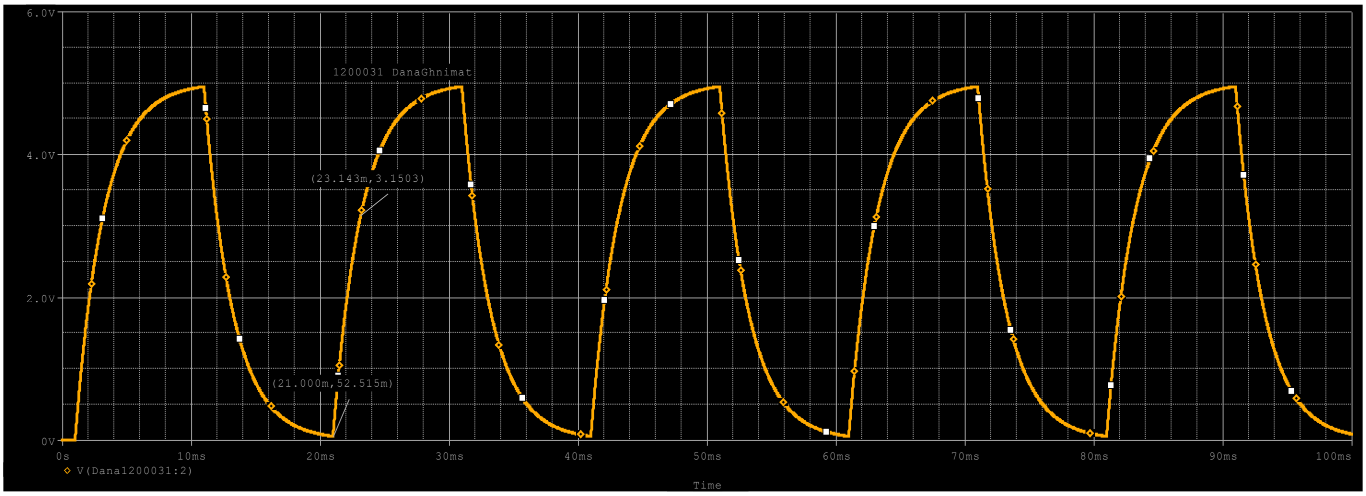

Figure 4 Calculating the time constant

As shown in figure 4, by taking the charging mode, we can calculate time constant using cursors simulation, from the beginning of charging until the voltage is around 0.63 from Vinput, which is at V= 3.15V, T= 23.143- 21.000 = 2.143 msec. which acceptable since the theoretical value is

$\tau = RC$

$= 22k\Omega * 100nF$

$= 2.2msec$

Calculating the value of Vc:

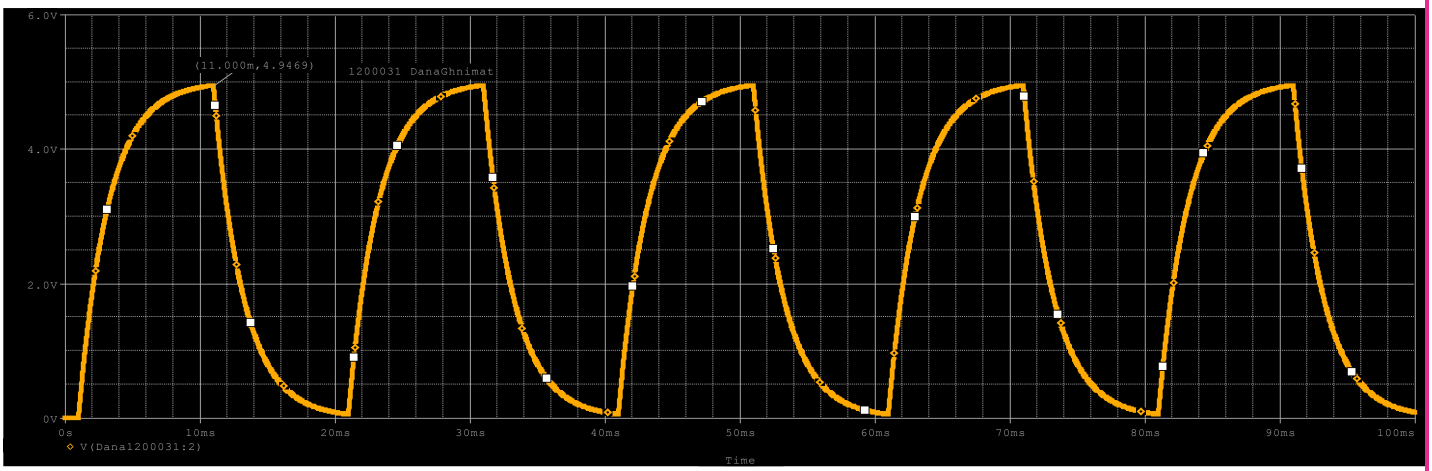

Figure 5 Finding Vc

we can conclude that Vc = 4.9469V. Which acceptable since Vc theoretically can be given as

$Vc= V_{p\text{-}p}*[1- e^{(-t/\tau)}]$

$= 5*(1- e^{(-0.01 / 2.2ms)})$

$Vc \approx 4.9469$ which is the same as the simulator.

Since both values are close and similar to simulation, then our simulation is correct.

Part2: RL Circuit:

Set the signal generator to generate a periodic square waveform with 10Vp-p and frequency=500Hz , dc offset=5V.

Circuit:

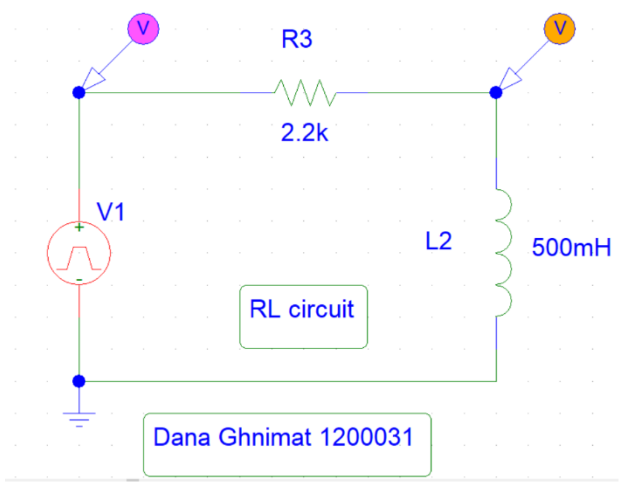

Figure 6 RL circuit

Used parameters in the Voltage:

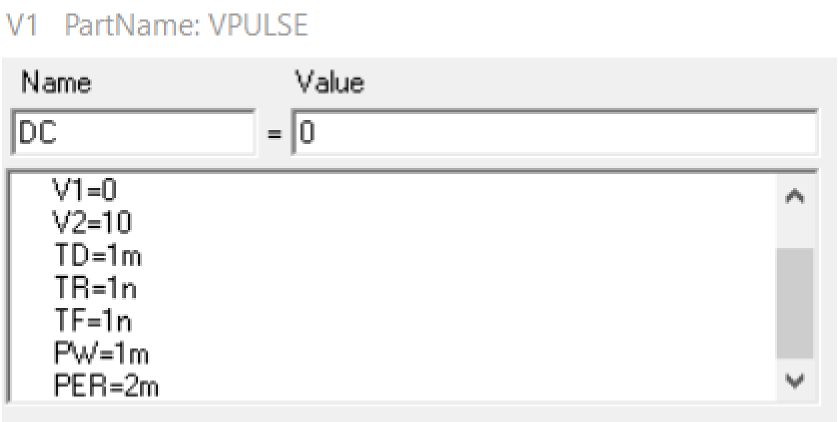

Figure 7 Rl Circuit parameters

Simulation:

▫ Purple detects the input voltage, and ▫ orange the inductor voltage.

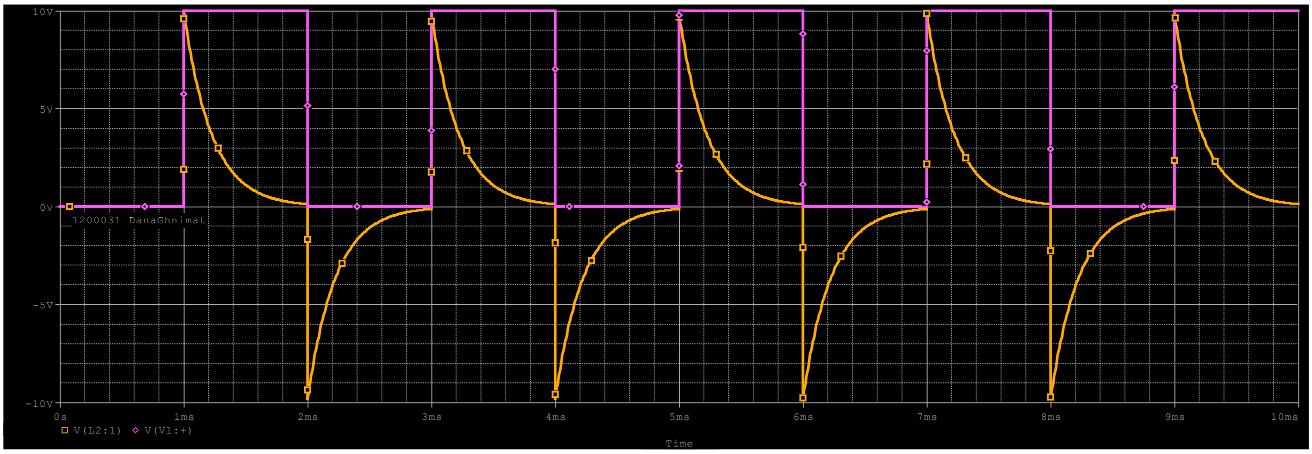

Figure 8 RL Circuit Voltage simulation

Measure the time constant

The voltage responses

Using V discharge, as Vd = 0.37 * Vp-p = 3.7V

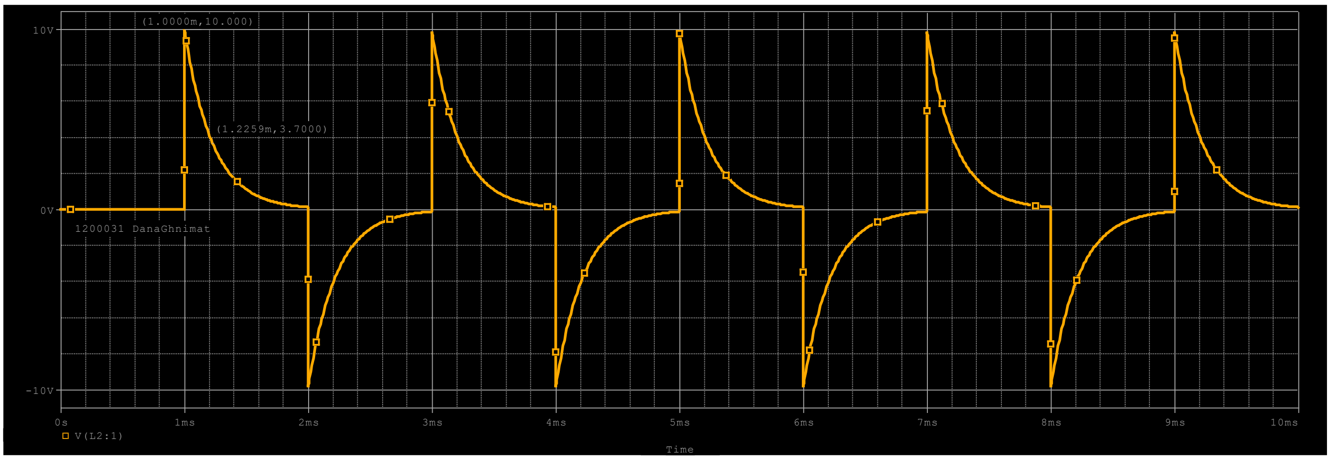

Figure 9 RL Circuit Measure time using voltage.

Using the first point of discharging at 10V with the point of 0.37 of discharge:

T = 1.2259m - 1.0000m = 0.2259m which is acceptable since T theoretically can be given as

$\tau = L/R$

$= 500mH/2.2k\Omega$

$= 0.227msec$

And both Values are closely similar.

The current responses

Using Current simulation instead of voltage:

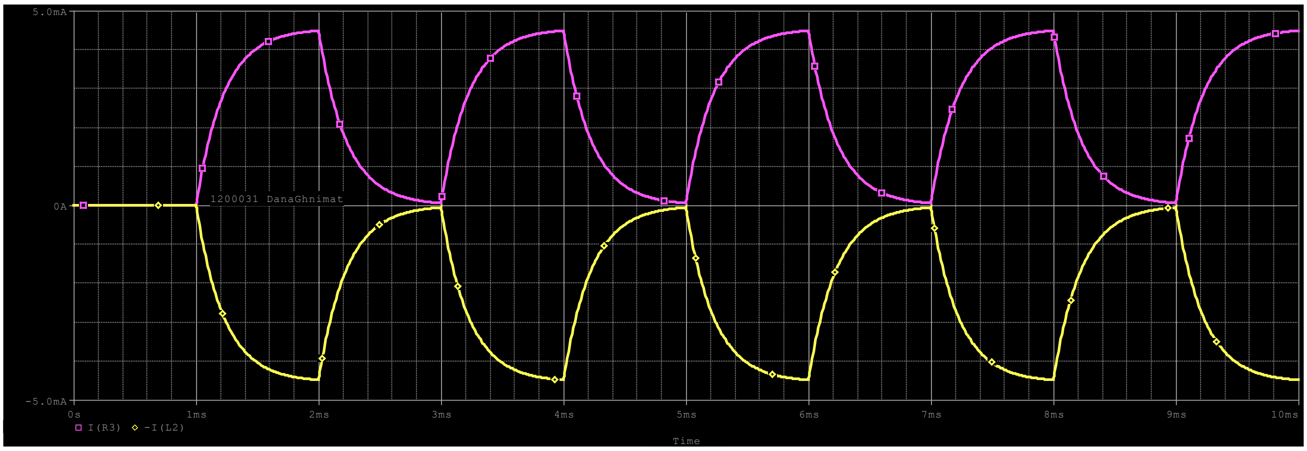

Figure 10 RL circuit current simulation

From $I_{p\text{-}p}$ = 4.4897mA

taking 0.37 Ip-p since its discharge giving us the value of 1.6611mA.

Using the curser to determine the value of which is 2.2260m

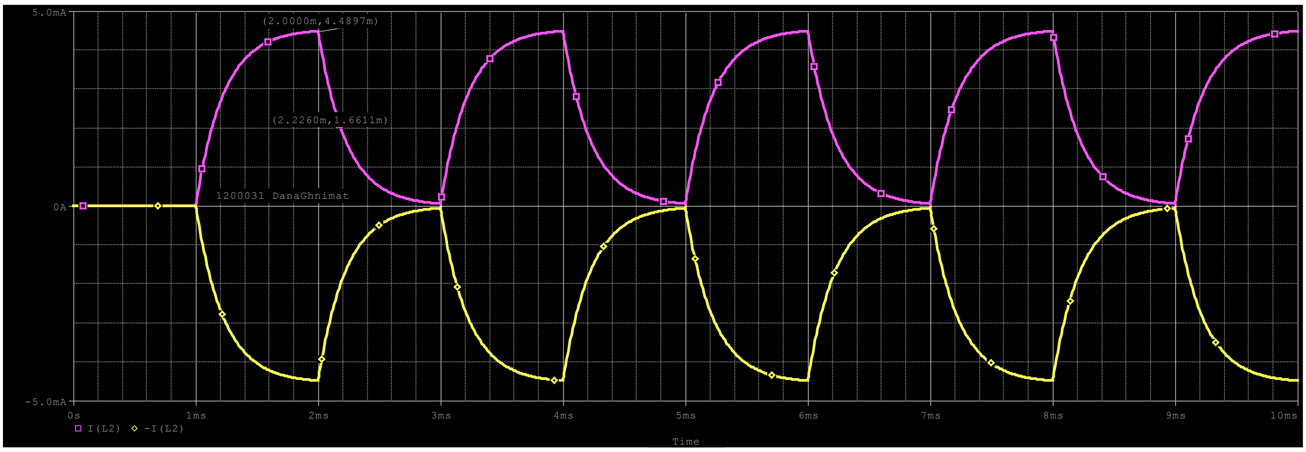

Figure 11 RL Circuit Measure time using current

Calculating T from first point of discharge 2ms to 2.2260ms = 0.226ms Which is close value to the one given theoretically, meaning our simulation is correct.

RL circuit after the period have been changed to $T=2\tau_L$ (time constant of inductor): (By theoretical)

$T = 2 *L/R=500mH/2.2K = 0.454ms$

$F = 1/T= 2.2$ kHz.

Meanwhile the current using this formula will be $I = Vin/R *[1-e^{(-t/T)}] = 4.5mA$.

Current simulation after changing the period:

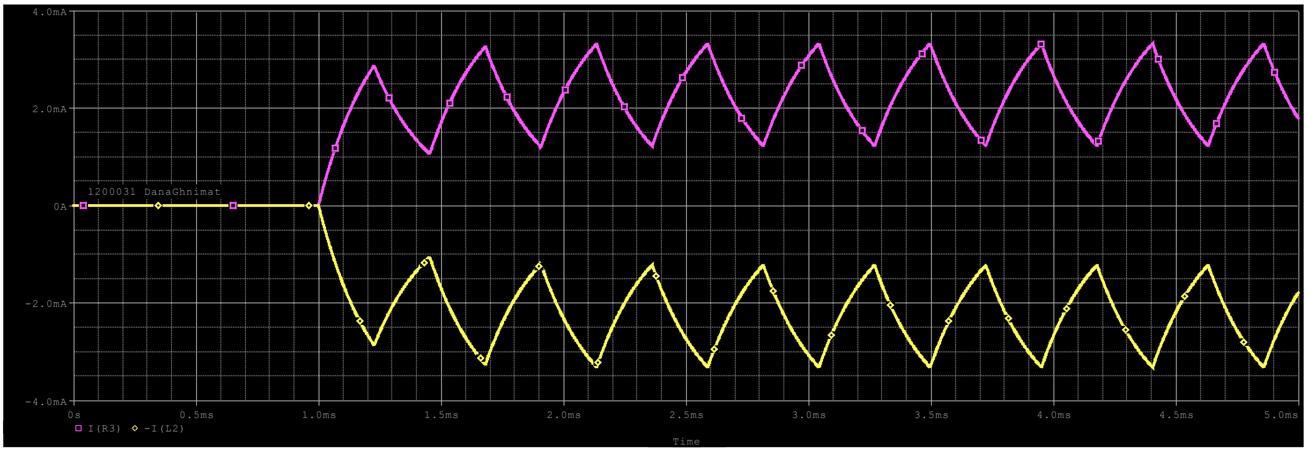

Figure 12 RL Circuit after current after changing the period

Voltage simulation:

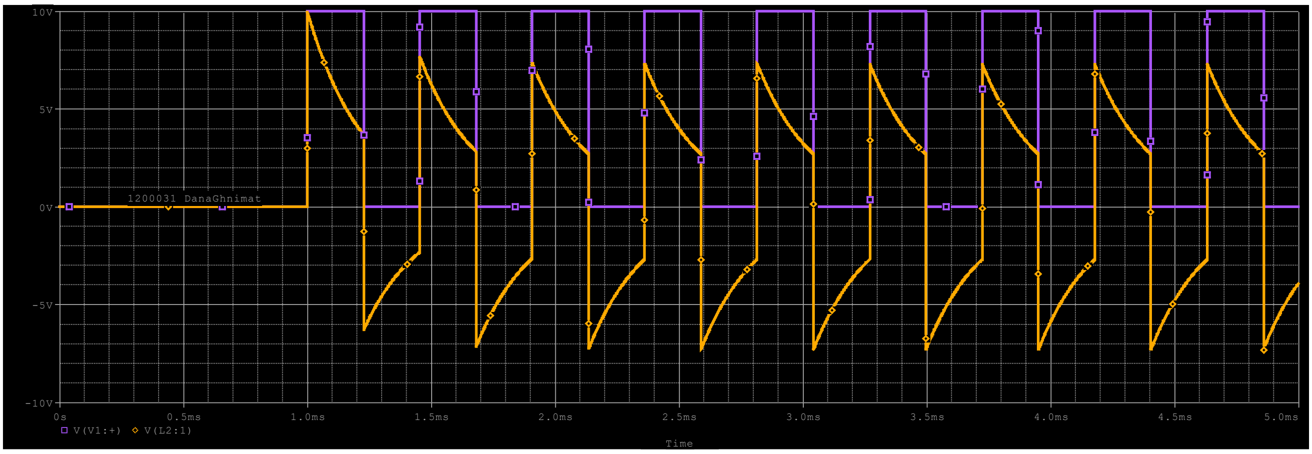

Figure 13 RL Circuit after voltage after changing the period

The period is too small which is not enough to charge and discharge completely, hence the change seems unstable.

Part 3: RLC Circuit:

I. Response types

Considering R3=22k, L=500mH, V1 square wave 5Vp-p and 30Hz with dc offset=2.5V.

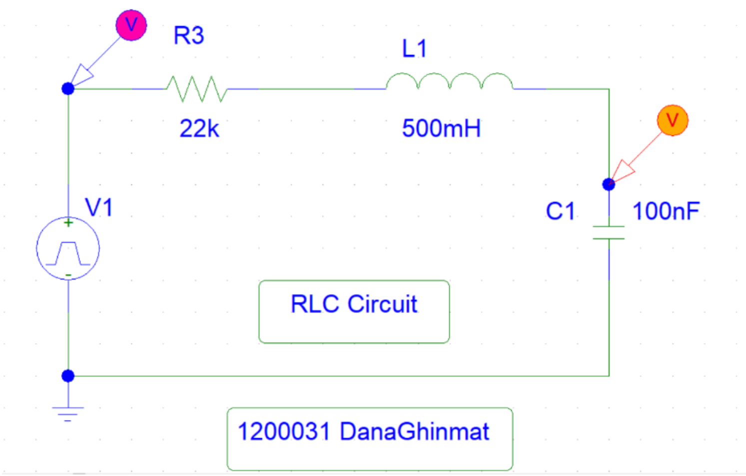

Figure 14 RLC circuit

measure the voltage in the capacitor.

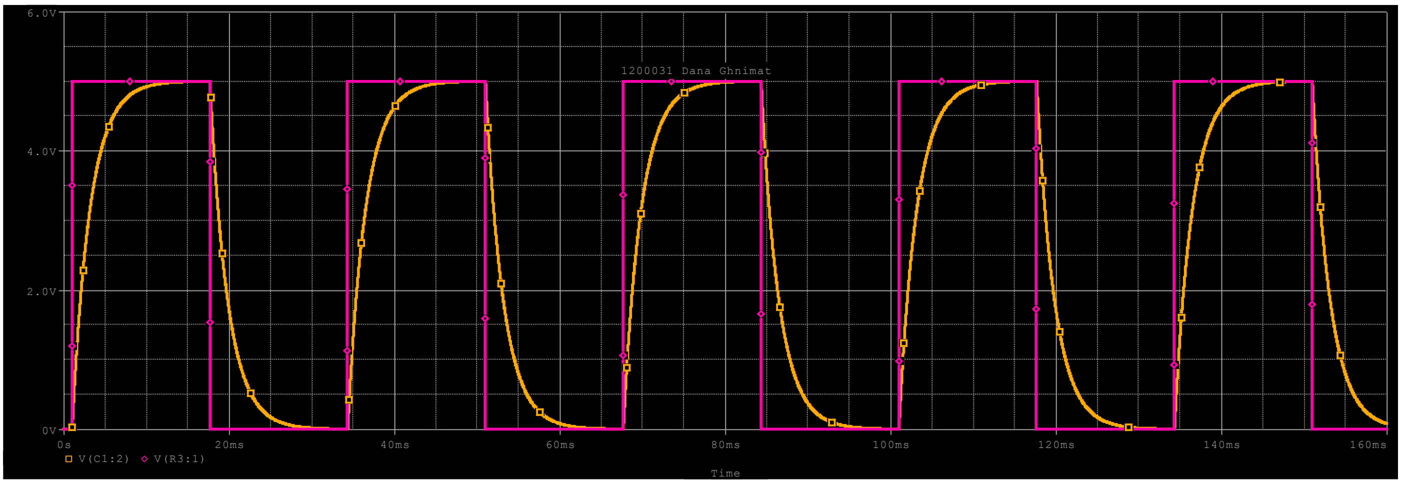

Figure 15 RLC circuit simulation

we can determine type of response we have according to damping ratio (ζ), into three main types: overdamped, critically damped, and underdamped.

$\zeta = R / [2 * \sqrt{(L / C)}] = 22k\Omega / [2 * \sqrt{(500\ mH / 100\ nF)}] = 4.9193$

since our result is greater than 1, we are in overdamping region.

We need to fine R critical:

$R\ critical = 2 * \sqrt{(L / C)} = 4472.1\ \Omega = 4.472k\Omega$

Critical damping:

When R3=4.472kΩ.

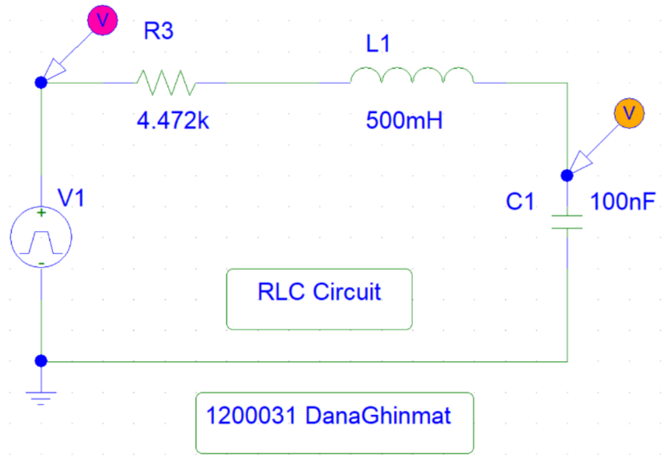

Figure 16 RLC critical damping circuit

Simulation:

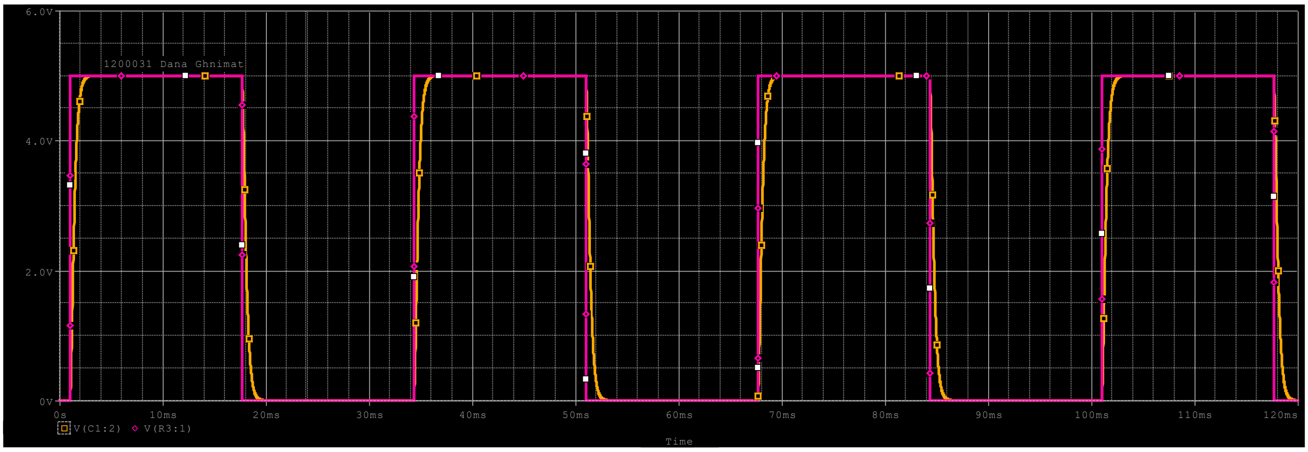

Figure 17 RLC critical damping circuit simulation

Under damping:

when R3 <4.472kΩ

For example, 500 Ω.

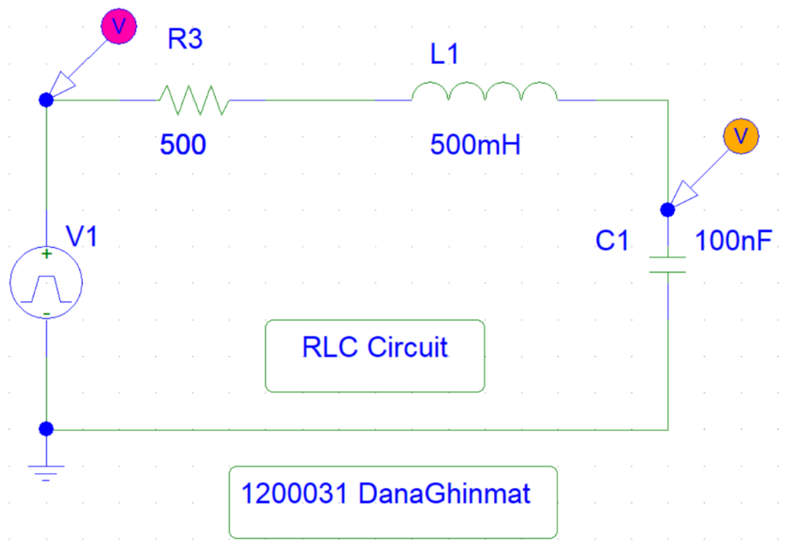

Figure 18 RLC Underdamping circuit

Simulation:

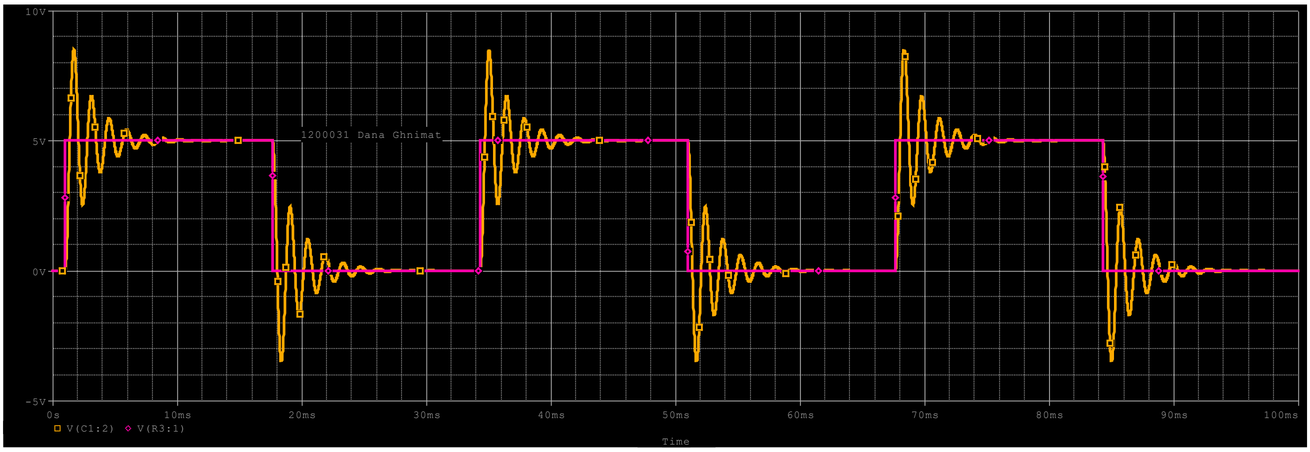

Figure 19 RLC Underdamping circuit simulation

In a critically damped region, the damping of an oscillator results in it returning as quickly as possible to its equilibrium position which was seen in our simulations. Which is why our simulation is valid, while in an overdamped system, the oscillations are so slow that they might as well not be oscillating at all in some cases.

Over Damping:

Same as the original circuit. Hence R3 > 4.472kΩ.

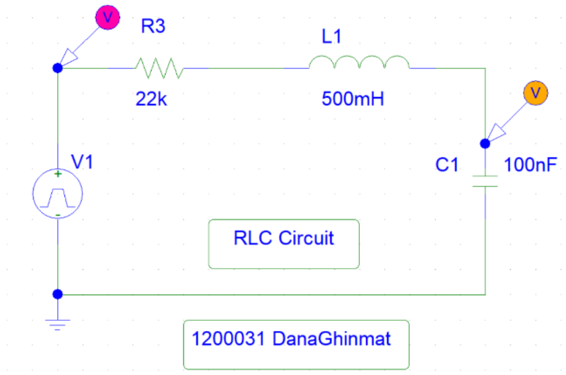

Figure 20 RLC over damping circuit

Simulation:

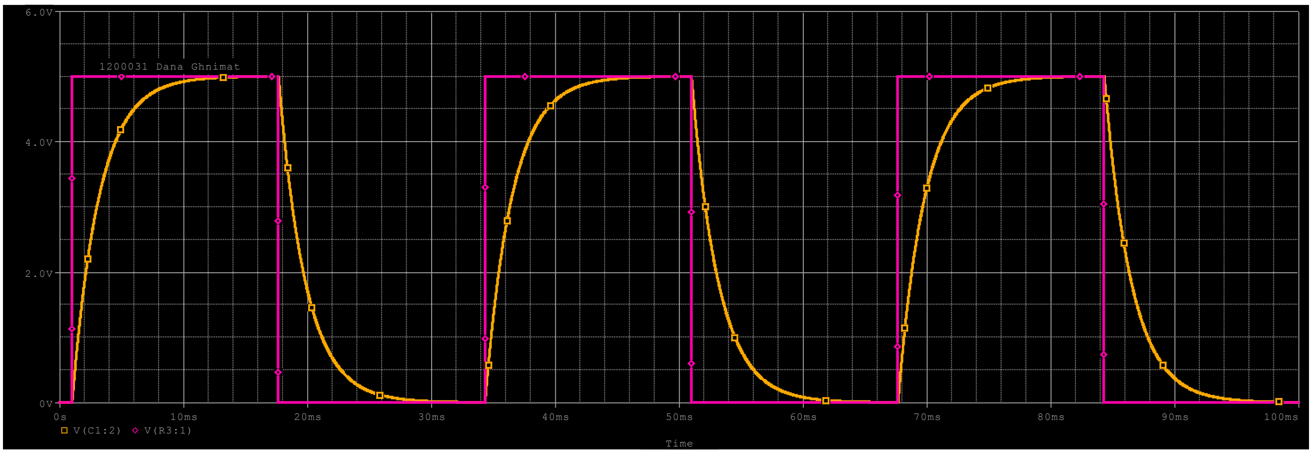

Figure 21 RLC over damping circuit simulation

Parameters:

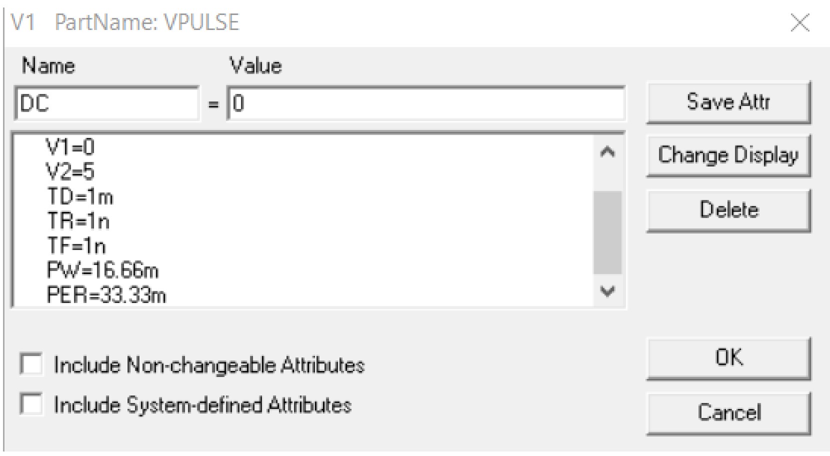

Figure 22 RCL circuit voltage parameter.

II. Response parameters

Circuit:

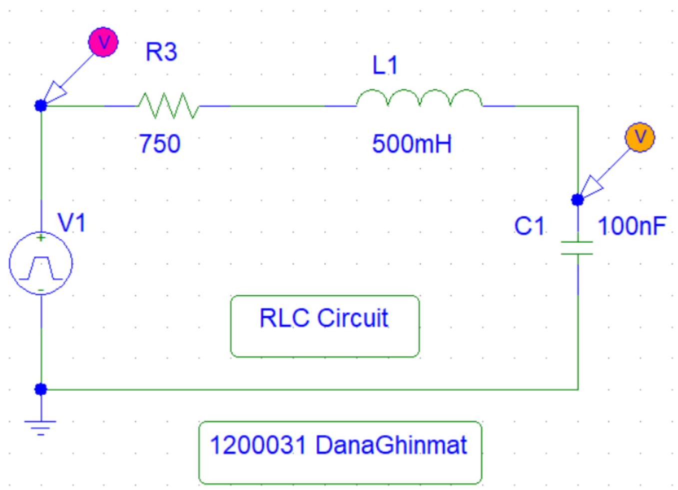

Figure 23 RLC response parameters circuit

Simulation:

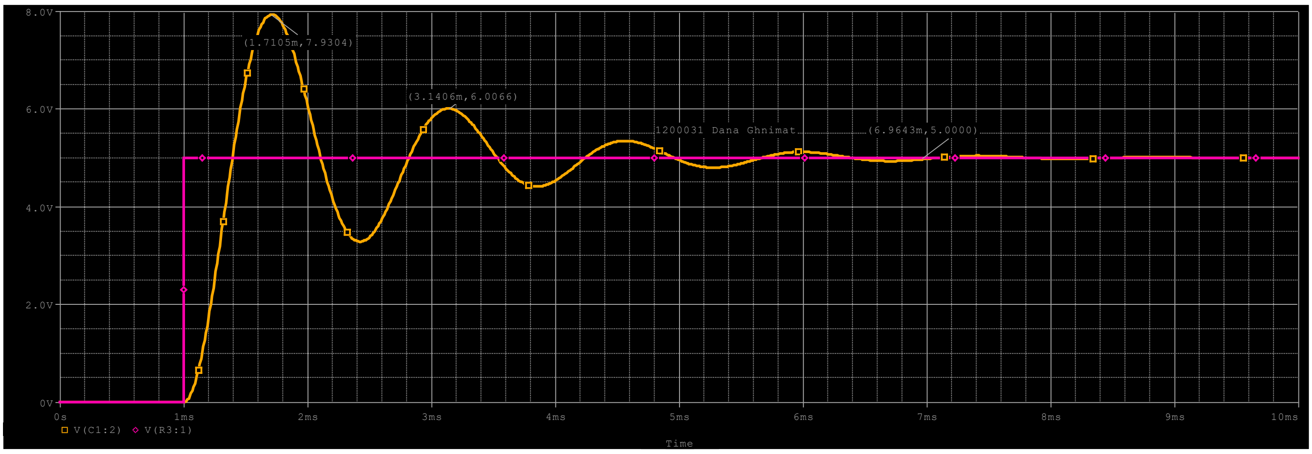

Figure 24 RLC response parameters circuit simulator

From figure above:

ta = 1.71ms , tb = 3.14ms , Va = 7.93v , Vb =6v , Vin = 5 v.

decay-envelope time constant $\tau = \dfrac{tb-ta}{ln(\frac{Va-Vin}{Vb-Vin})}$ = 1.330 m sec

Damping Coefficient α = 1/ τ = 751.8 rad/sec
Damped radian frequency ωd(from above figure) = 2π/(tb−ta) = 4.393 krad/sec.
Damped radian frequency ωd (theoretically) = 1/√LC= 4.5 krad/sec
The theoretical and the experimental values are close, then they are valid.

Conclusion

Simulation is a great way to detect and analysis the circuits and find errors before applying them into real circuits, this will make us avoid damaging real circuits, as well electrical hazards.

Capacitors and inductors work well in filtering and changing the input of the voltage.