BIRZEIT UNIVERSITY

Faculty of Engineering & Technology
Electrical & Computer Engineering Department

CIRCUITS AND ELECTRONICS LABORATORY

ENEE2103

Pre-Experiment No.3

Prepared by: Faten Sultan

ID Number: 1202750

Instructor: Dr. Mohammad Jehad Al Ju'Beh

Teaching Assistant: Eng.Bilal Ismail

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RC Circuit

We connect the circuit with 5V peak-peak, 50Hz which result in Period “PER”=1/f=1/50=20m. Beside to pulse width=0.5T=10m.

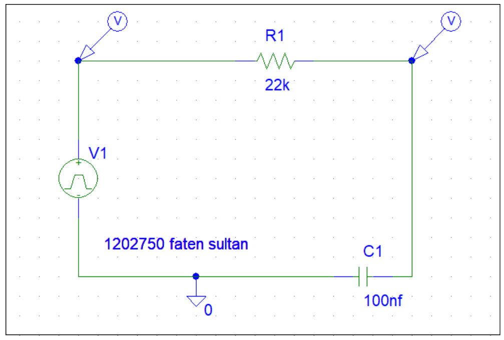

Figure 1 Rc Circuit

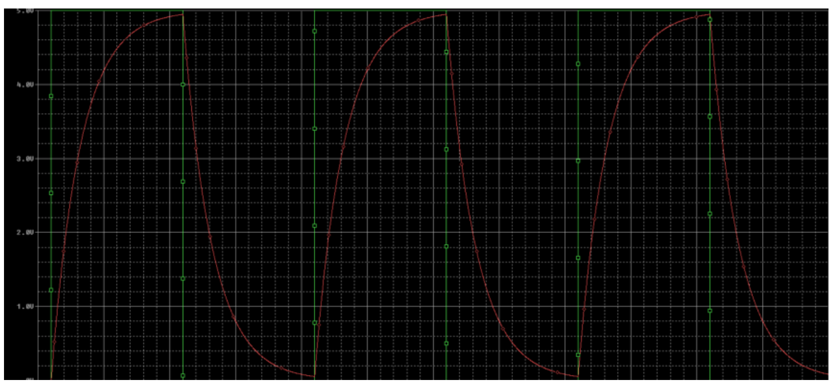

Figure 2 Voltage Vs Time

**Note that the red one is the output

- As shown in the figure 2 simulation, **Vp Max= 4.9460V** “ I used the cursor to indicate that”
- While, If we calculate $\mathbf{V_{charge}}$ using theoretical formulas:

$Vc = VP(1 - e^{-t}/RC)$ From the circuit, R =22k, Vp = 5V , C =100nF, t = 0.01:

$Vc = 5 * (1 - e^{-0.01}/2.2*10^{-3})$

$Vc = 4.9469V$

Time constant theoretically

As $\tau = R*C \rightarrow 22k* 100n$

$\tau = 2.2msec$

Time Constant from Simulation:

As the peak voltage equals 4.9466v, and V charge = 0.63 V peak =3.1182v at time 3.149ms, therefore the time constant that starts at the beginning is (1.0079ms) equals to 3.1459 – 1.0079 = 2.1380ms.

We can conclude that 0.63Vm from the charging and 0.37Vm from the discharging that the time constant in simulation and time constant theoretically are approximate equal to each other

RL – Circuit:

We connect the following circuit with a square waveform 10V and a frequency=500Hz

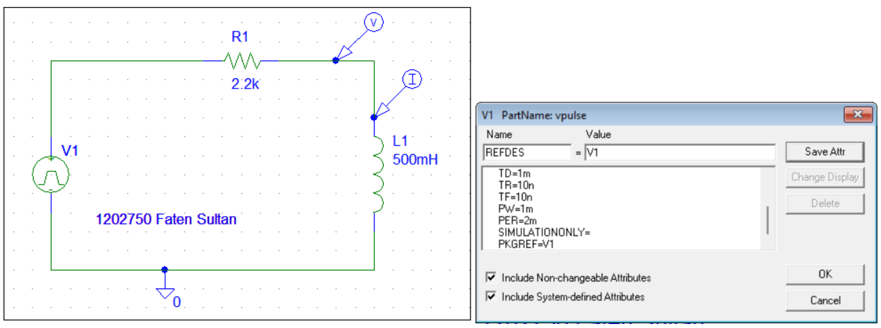

Figure 3 RL Circuit

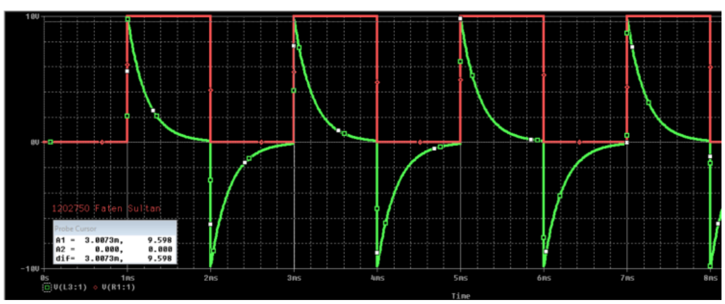

Figure 4 voltage response

The idea of connecting the circuit in figure 3 is to measure the time constant of the circuit and the steady state values of the voltage and current responses. Therefore As shown in figure 4 the steady state is 9.598v.

Now we have to repeat the steps above with Changing the period of the periodic square wave to $T=2\tau_L$

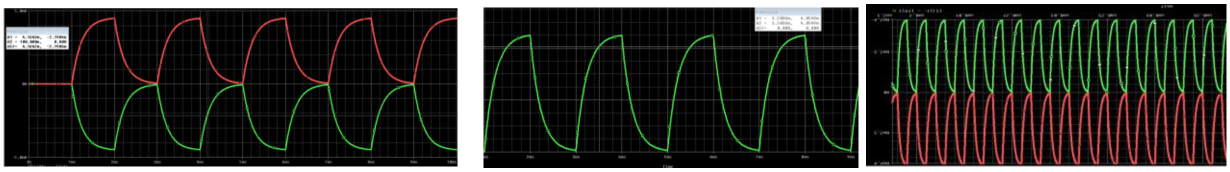

Figure 5 Current across Inductor

As Steady State of the current is when the current at each point in the circuit is constant (does not change with time). Therefore steady state is equal to 4.0549 mA .

From figure 4&5 we can conclude the following:

- Vp= 9.598V
- The period is τ = 0.22ms in figure 4 and the 2τ = 0.44ms is the new period for figure 5
- Time Constant theoretically:

  τ =L/R=500m/2.2k τ = 0.227ms
- Current Calculations:
  - Io max from the simulation is = 4. 4897mA

RL circuit after the period have been changed to T=2* time constant of inductor:

T = 2 ∗L/R=500mH/2.2K = 0.454 ms

F= 1/T= 2.2 kHz.

Therefore τ = 0.22ms, then T =2τ =0.44ms.

PER = 0.44ms

PW = 0.22 ms

The following figures shows the voltage and the current responses of the inductor with T= 2τ.

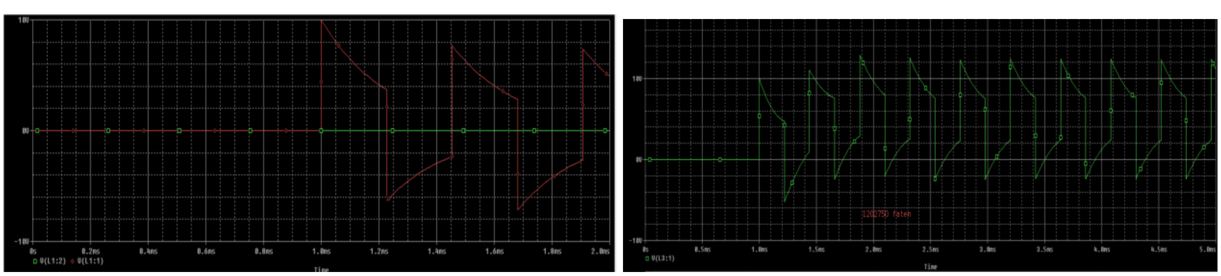

Figure 6 voltage response

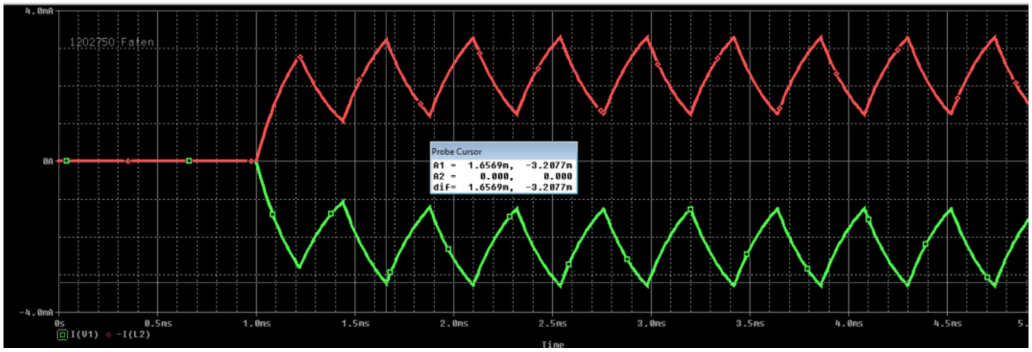

Figure 7 current response

The steady state voltage =9.915v, and the steady state current =3.207m.

RLC Circuit:

Response type:

I. Overdamped voltage Response

We connect the following circuit with PER=period=1/f=1/30=33.33m, PW= pulse width=0.5T=16.67m.

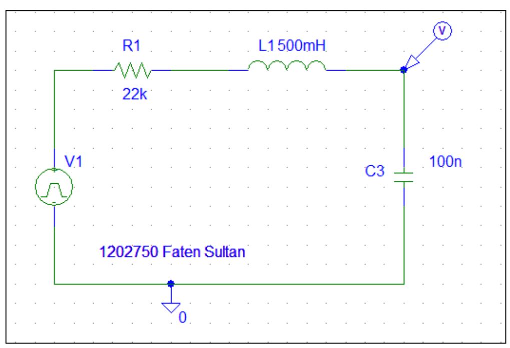

Figure 8 RLC Circuit with R=22kohm

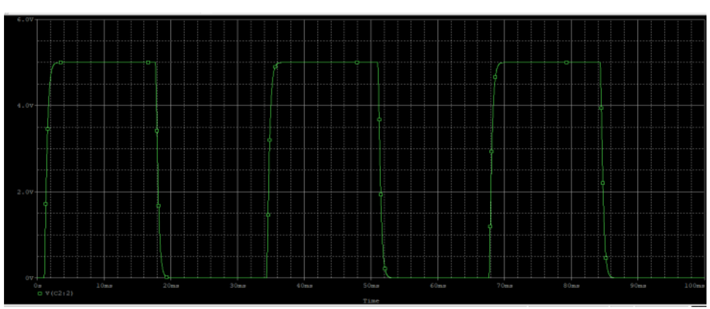

Figure 9 Overdamped voltage response with R=22kohm

II. critically damped response

Calculate R3 to give critically damped response:

Setting $\alpha = w_o$ ➔ Critically damped response means .

the value of R of the critically damped response will be:

$\alpha = w_o$ where $\alpha = R/2L$, $w_o = 1/\sqrt{LC}$

$R/2L=1/\sqrt{LC}$

$R = 2L/\sqrt{LC}$

$R= 1/\sqrt{(500*10^{-3} * 100 * 10^{-9})}$

$R= 1/\sqrt{(500*10^{-12})}$

R=474ohm

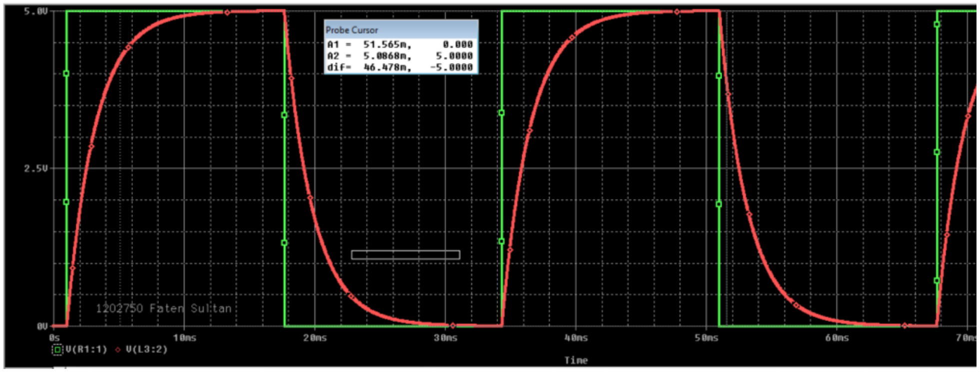

Figure 10 Critical voltage response with R=4.47kohm

III. underdamped response

R3 for underdamped response =600ohm

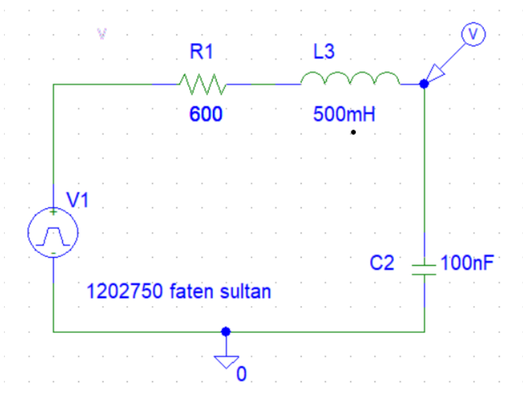

Figure 11 RLC circuit with R=600ohm

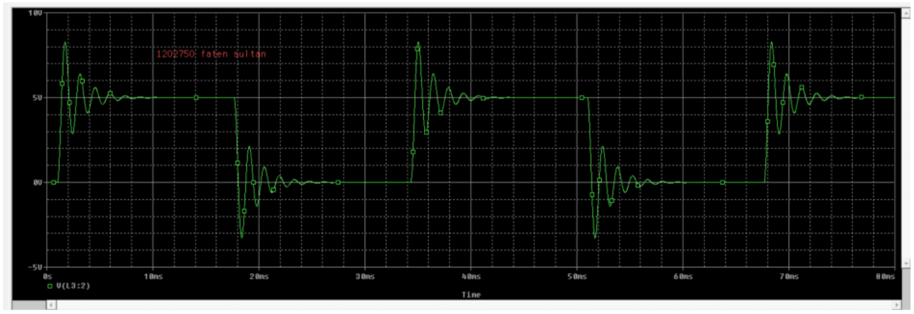

Figure 12 underdamped voltage response with R=4.47kohm

II. Response Parameters

R3 is set to 750Ω, which is an underdamped response case.

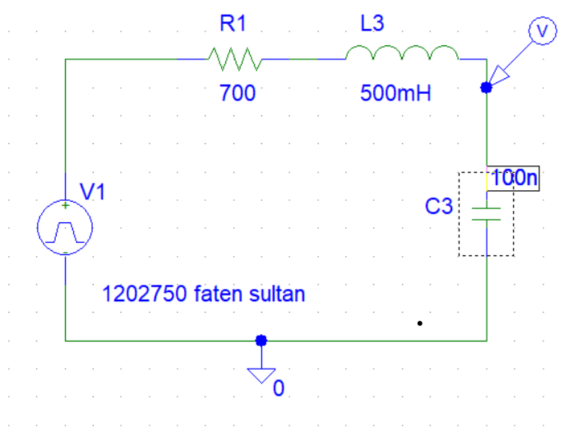

Figure 13RLC circuit with R3=750ohm

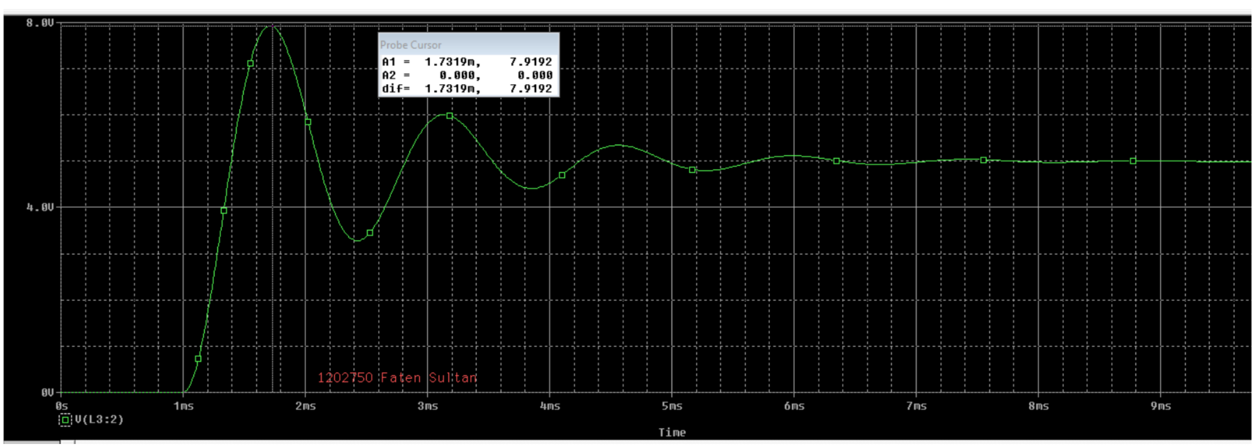

Figure 14 voltage response for R=750ohm

As shown in figure 14: -

T_a =1.71ms, V_a=7.93v , T_b=3.15ms, V_b=6.006v , V_o = 5v (‘note that these values are from the graph I have used the cursor to indicate these values ‘)

Now we can obtain these values τ, α, ω_d.

- τ = (Tb- Ta) / ln ((Va-Vo) ÷ (Vb –Vo)) = 1.321ms
- α = 1/ t

  = 1/1.321 = 757 (1/sec)

- ω_d = 2pi ÷ (t_b - t_a)

  = 4.4278 KHz

At the end we can conclude the following:

Critical Damping → R3 = 4.742kΩ as shown in figure 10, underdamped → R3 = 600Ω as shown in figure 12, overdamped → 22kΩ as shown previously in figure 9

In addition to that our theoretical values matches with our experimental values.