Faculty of Engineering and Technology
Department of Electrical and Computer Engineering

ENEE 2103

CIRCUITS AND ELECTRONICS LABORATORY

Experiment #3, Pre-Lab #8

First and Second Order Circuit

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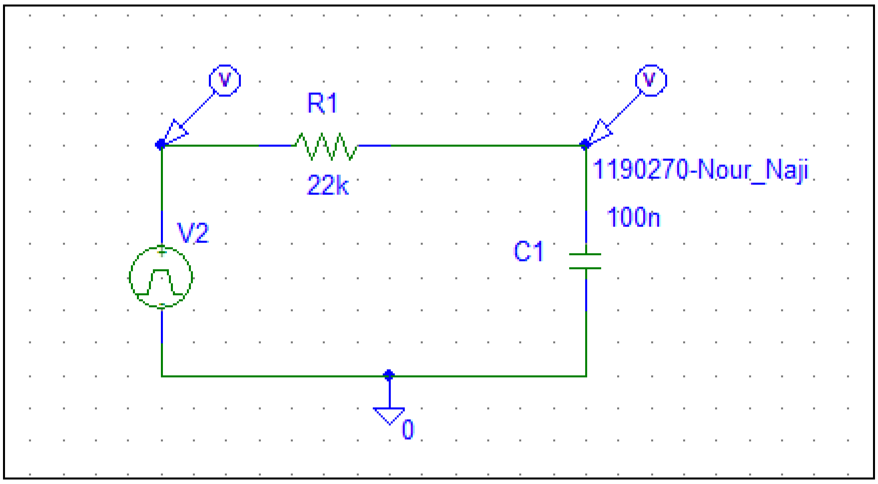
Date: 22/11/2020

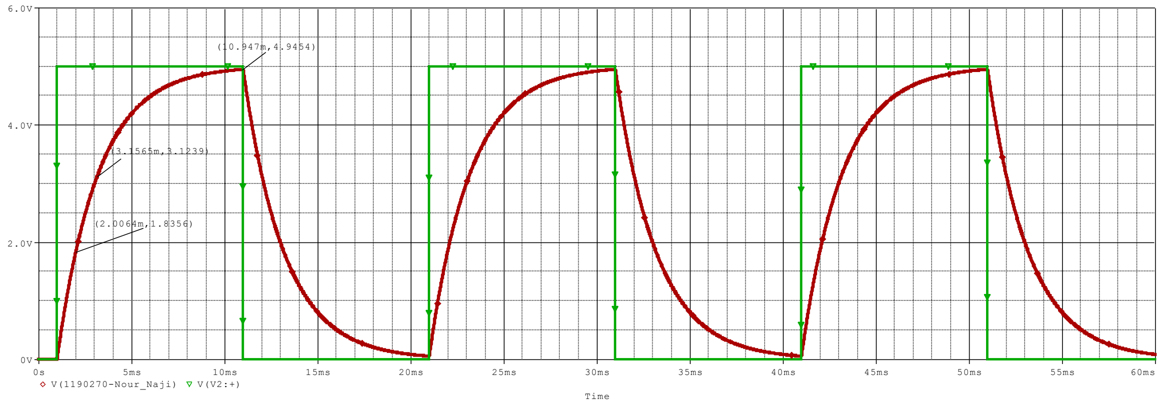
Table of Contents

1. RC Circuit:

➔ Circuit using PSpice:



⇨ Voltage on capacitor



Vmax (experimentally) = 4.9454 v

Vmax (theoretically) = $V_P (1- e^{-T/RC}) = 5(1- e^{-0.01/2.2m}) = 4.946$ v.

- Time constant:
  - To find the time constant <u>experimentally</u>, we find the time at both charging and discharging voltages:

    V(t)charging = 0.63 Vmax ➔ V(t) = 0.63 ∗ 4.9454= 3.115602 v

    t (at v = 3.115602) =3.1565 ms

    V(t) discharging = 0.37 Vmax ➔ V(t) = 0.37 ∗ 4.9454= 1.829798 v

    t (at v = 1.830353) = 2.0064 ms

    so T (experimentally) = $t_{avg} = \frac{2.0064+3.1565}{2}$ = 2.5814 ms.
  - To find the time constant <u>theoretically</u>, we have R=22kΩ, and C=100nF :

    so ➔ T (theoretically) = RC = $22 * 10^3 * 100 * 10^{-9}$ = 2.2 ms
- Steady state voltage value on the capacitor:

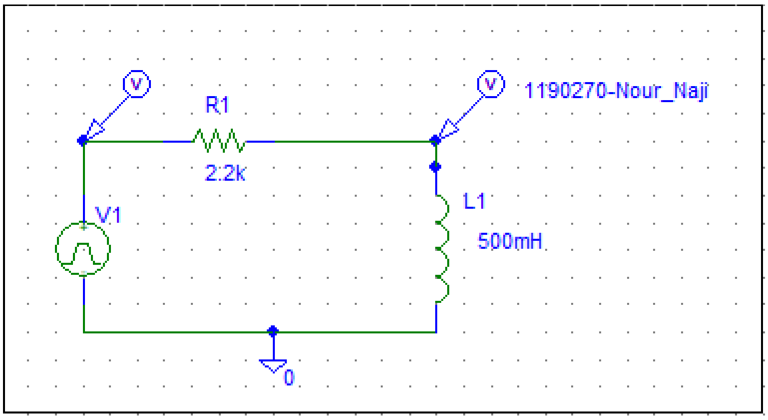
  The capacitor voltage reaches its steady state value at Vc(0), C appears as an open circuit.

  ➔ Vc steady state = 5 v
- The value of the capacitor:
  - C(experimentally) = $\frac{T(experimentally)}{\text{R}} = \frac{2.5814\text{ ms}}{22\text{K}}$ = 117.3nF
  - C(theoretically) = 100nF

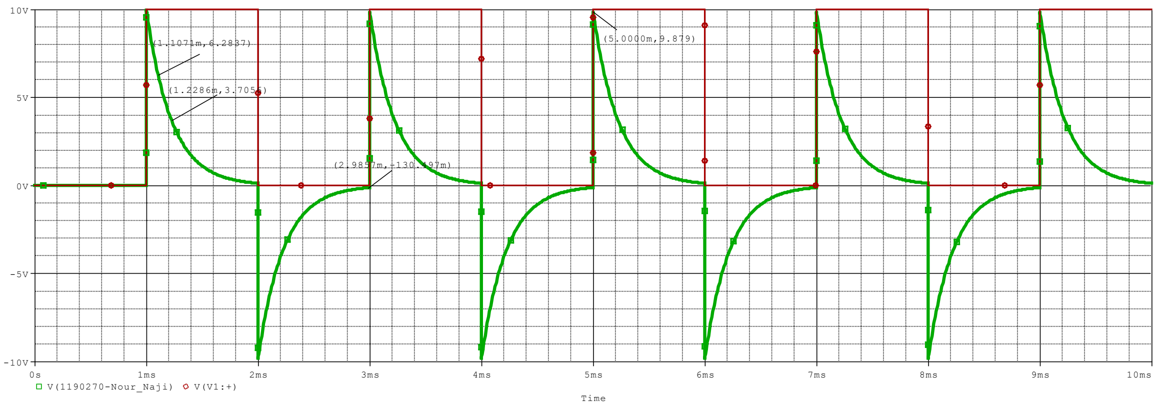
✓ The practical results are too close from the theoretical results

2. RL Circuit:

➔ Circuit using PSpice:



⇨ Voltage on inductor:



Vmax (experimentally) = 9.879v

Vmax (theoretically) = V_P (1- $e^{-t/T}$) = 10(1- $e^{-1m/0.227m}$) = 9.87v.

- Time constant:

  - To find the time constant experimentally, we find the time at discharging voltages(Since it's discharging in the voltage) :

    V(t) discharging = 0.37 Vmax ➔ V(t) = 0.37 ∗ 9.87= 3.5619v

    t (at v =3.6519) = 1.2268ms

    so ,T (experimentally) = 1.2268ms -1ms = 0.2268ms
  - To find the time constant theoretically, we have R=2.2kΩ, and L=500mH:

    so ➔ T (theoretically) $= \frac{L}{R} = \frac{500m}{2.2k}$ = 0.227ms

    Steady state voltage value on the inductor:

  The capacitor voltage reaches its steady state value VL(0), C appears as a short circuit.

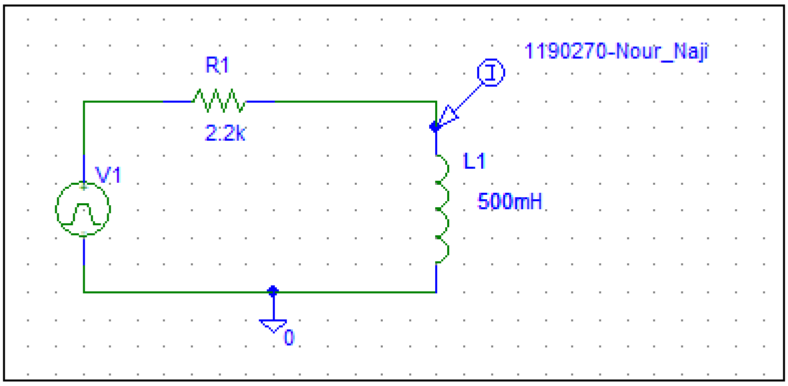
  ➔ V_L steady state = 10 v

- The value of the inductor:
  - L(experimentally) = T (experimentally) * R = 0.2268ms *2.2K =498.96 mH
  - L(theoretically) = 500mH

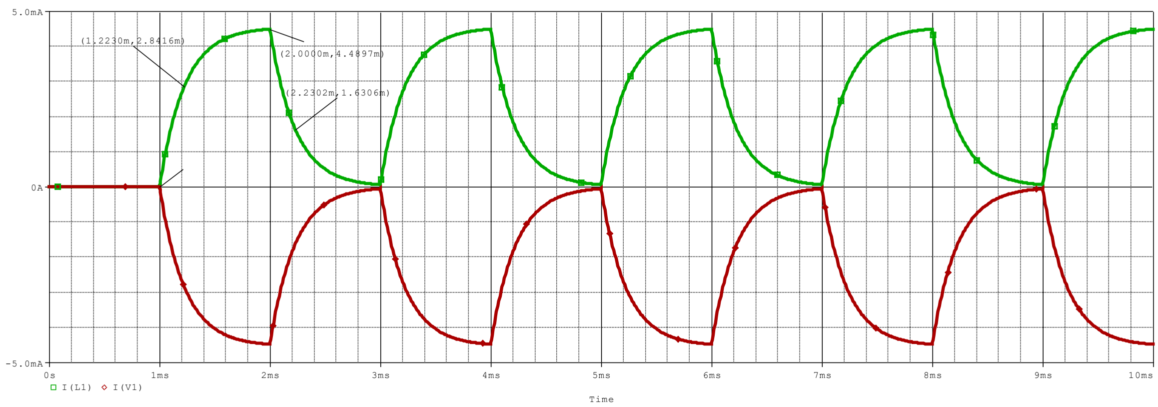
✓ The practical results are too close from the theoretical results

Current response:

➔ Circuit using PSpice:



⇨ Current on inductor:



Imax (experimentally) = 4.4897A

- Time constant:

  - To find the time constant experimentally, we find the time at charging (Since it's charging in the current response) :
    I(t)charging = 0.63 Imax ➔ I(t) = 0.63 ∗ 4.4897= 2.8285mA
    t (at I = 2.8285mA) =1.2230ms
    so , T (experimentally) = 1.2230ms -1ms = 0.2230ms

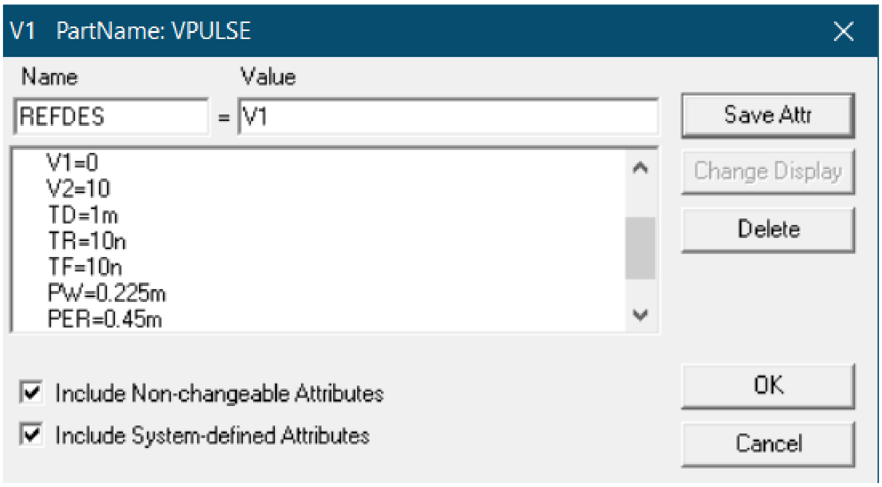
- Steady state current value on the inductor:
  The inductor current reaches its steady state value at $V_L(0)$, L appears as a short circuit..

  ➔ I_L steady state = $\frac{10}{2.2k}$ = 4.545 mA

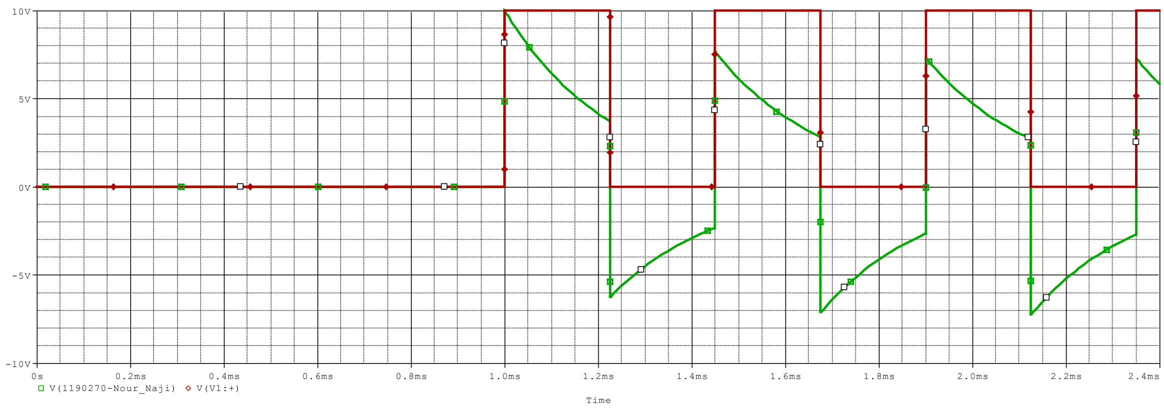
✓ The practical results are too close from the theoretical results

RL circuit after change the period of the periodic square wave to T=2* time constant of inductor:

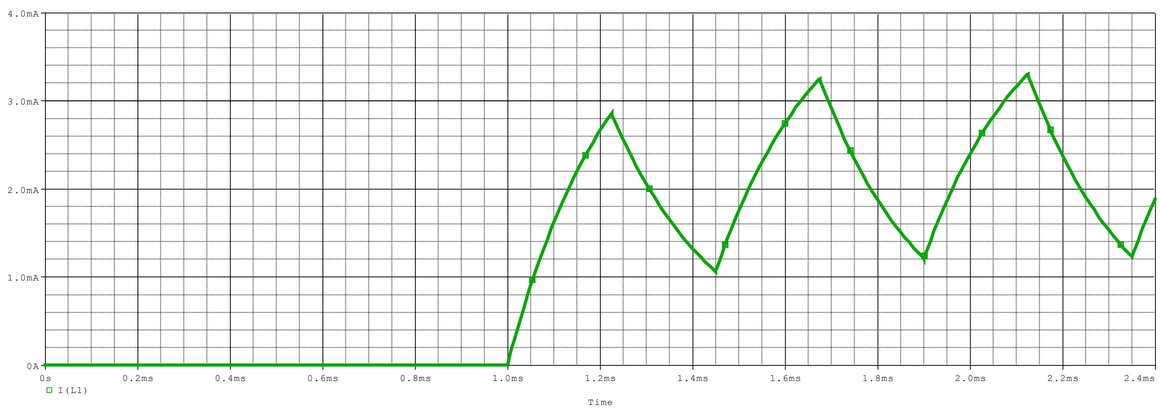
- ⇨ $T = 2 * \frac{L}{R} = \frac{500m}{2.2k} = 0.454ms$
- ⇨ $F = \frac{1}{T} = 2.2\ KHz.$



⇨ voltage response:



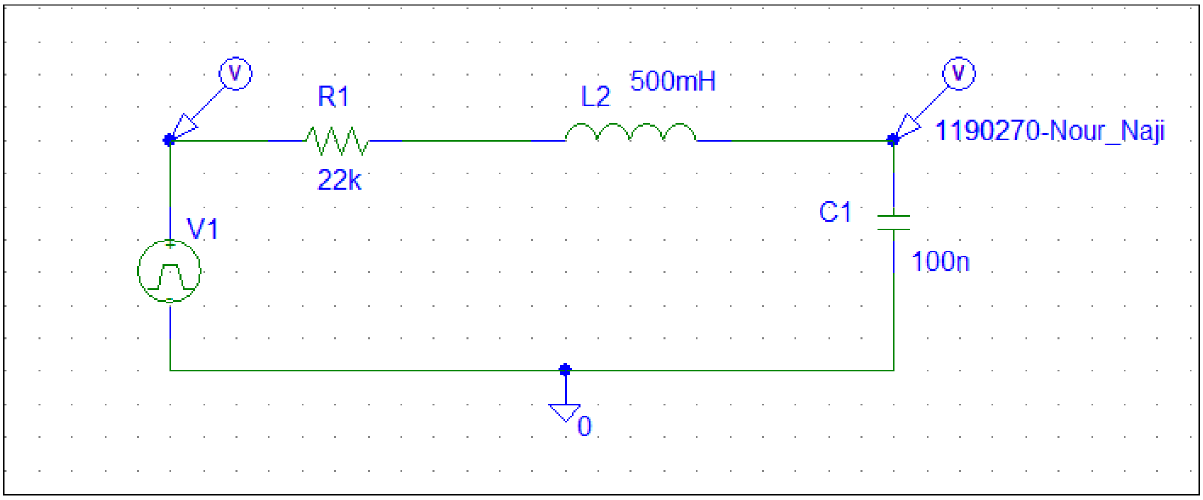
⇨ Current response:

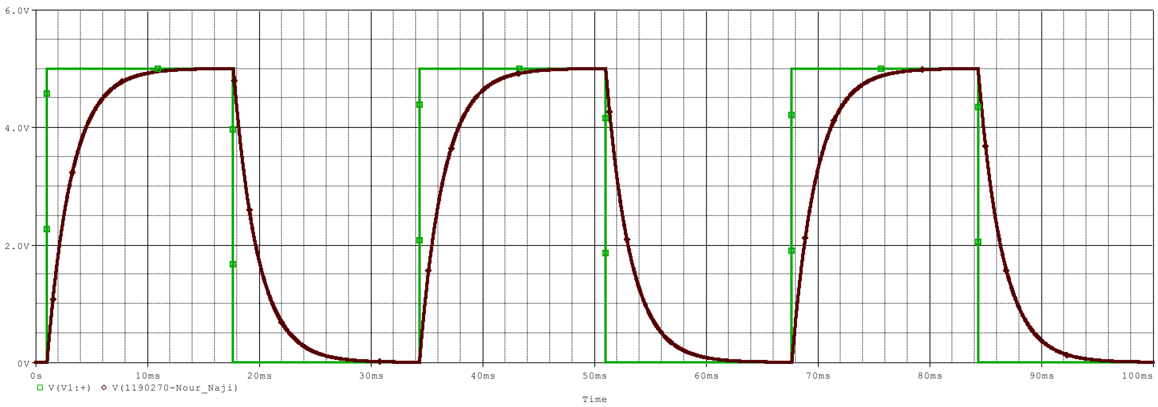


RLC Circuit:

1. over damped response

➔ Circuit using PSpice:





⇨ The response is over damped since we have α > w

$$\alpha = \frac{R}{2L} = \frac{22K}{2*500m} = 22000 \text{ rad/s}$$

$$w = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{500m*100n}} = 4472.13 \text{ rad/s}$$

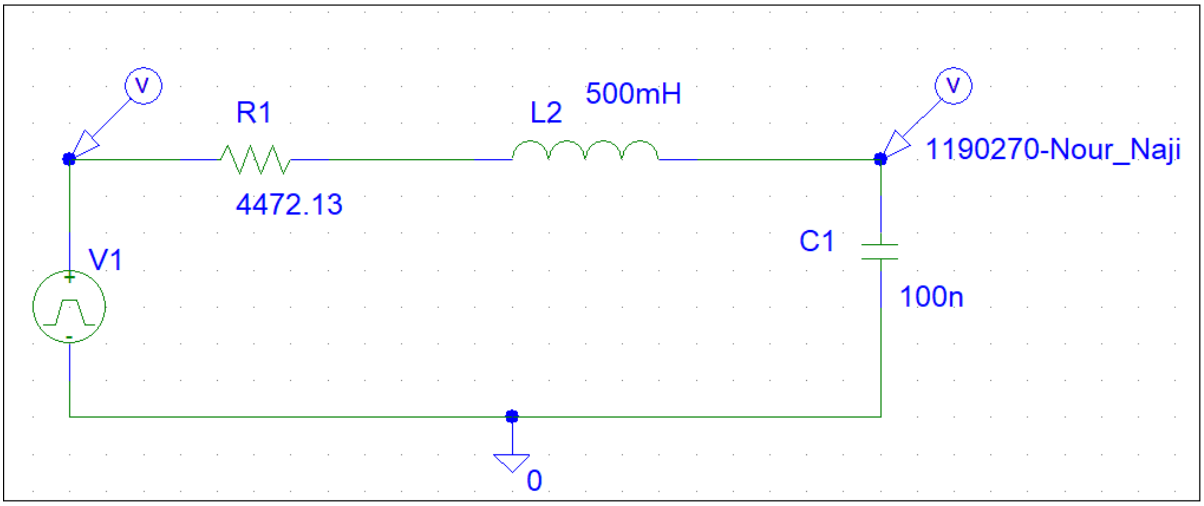
2. critical damped response:

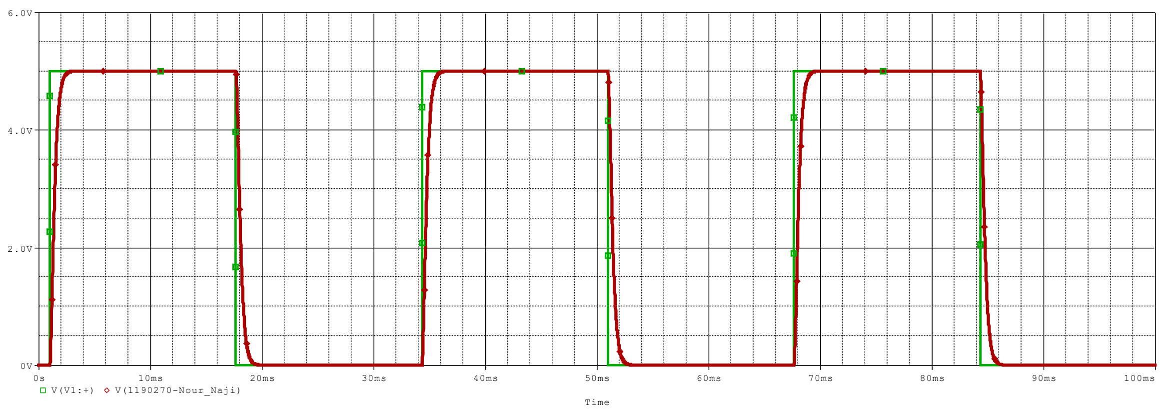
⇨ To get critically damped response we have α = w.

Therefore, the value of the resistance to give critically damped response will be:

$\frac{R}{2L} = \frac{1}{\sqrt{LC}}$ ➔ $\frac{R}{2*500m} = \frac{1}{\sqrt{500m*100n}}$ ➔ R= 4472.13

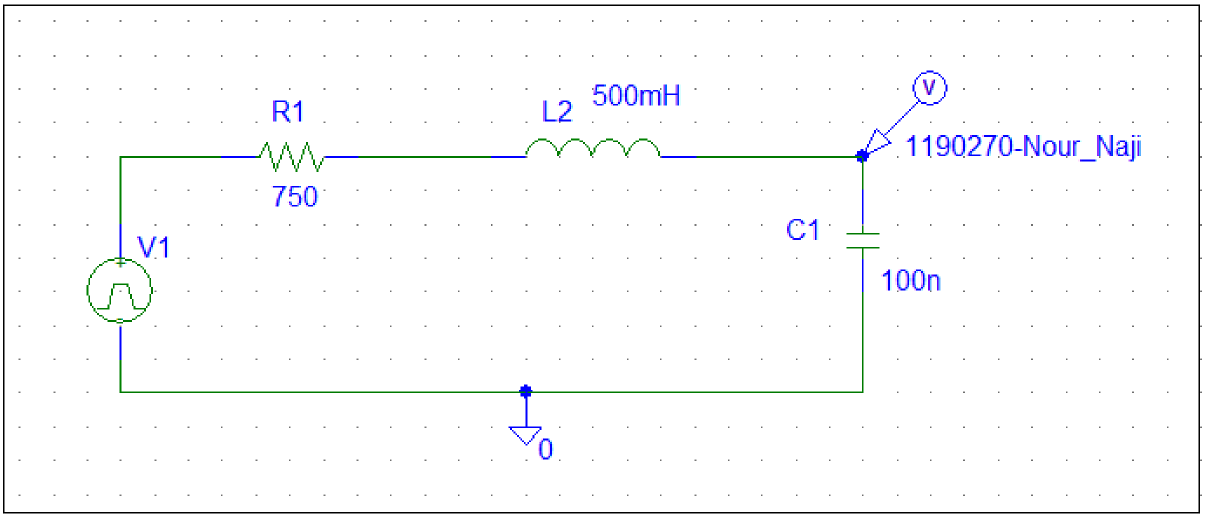
➔ Circuit using PSpice:

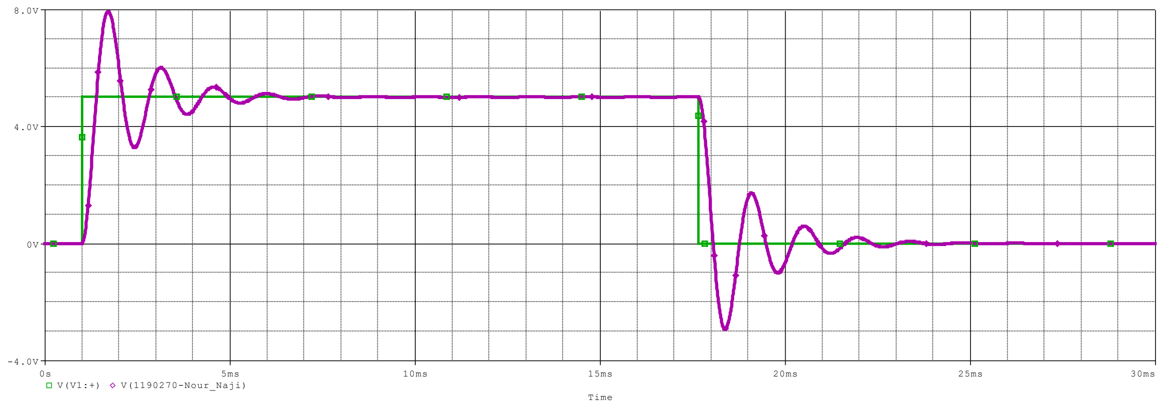




3. under damped response:

➔ Circuit using PSpice:





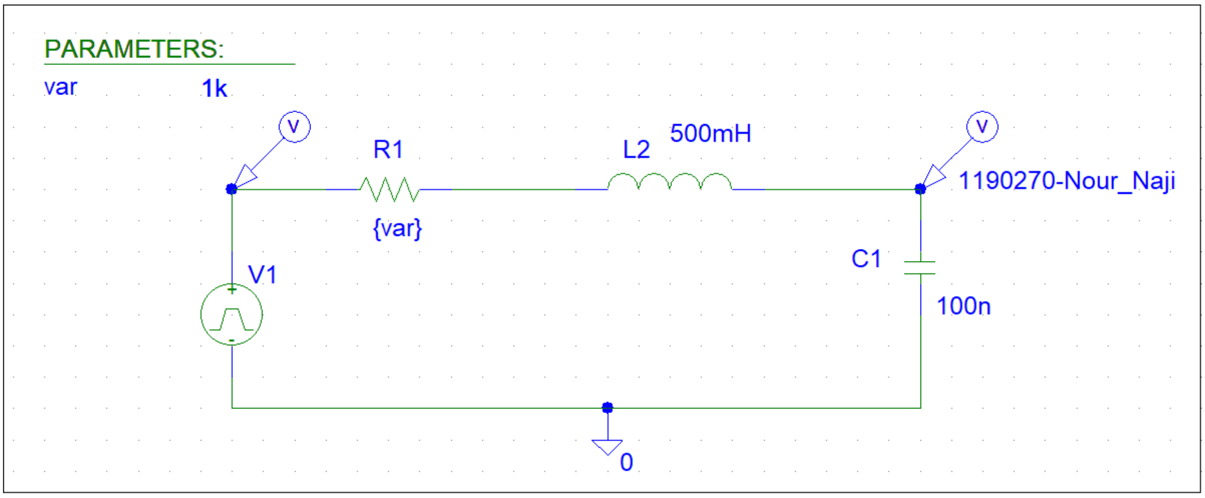
⇨ The response is under damped since we have $\alpha < w$

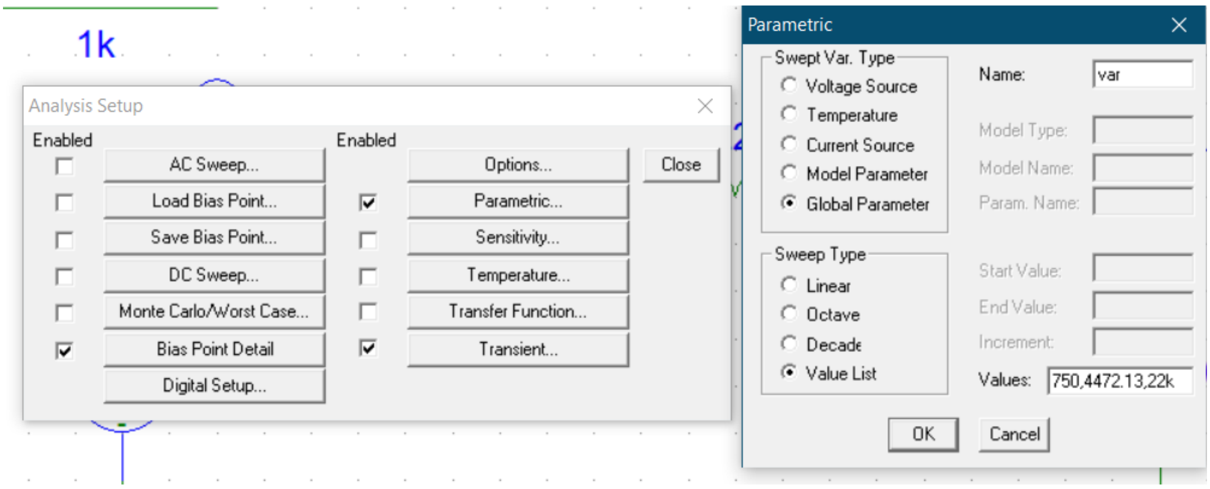
$$\alpha = \frac{R}{2L} = \frac{750\Omega}{2*500m} = 750 \text{ rad/s}$$

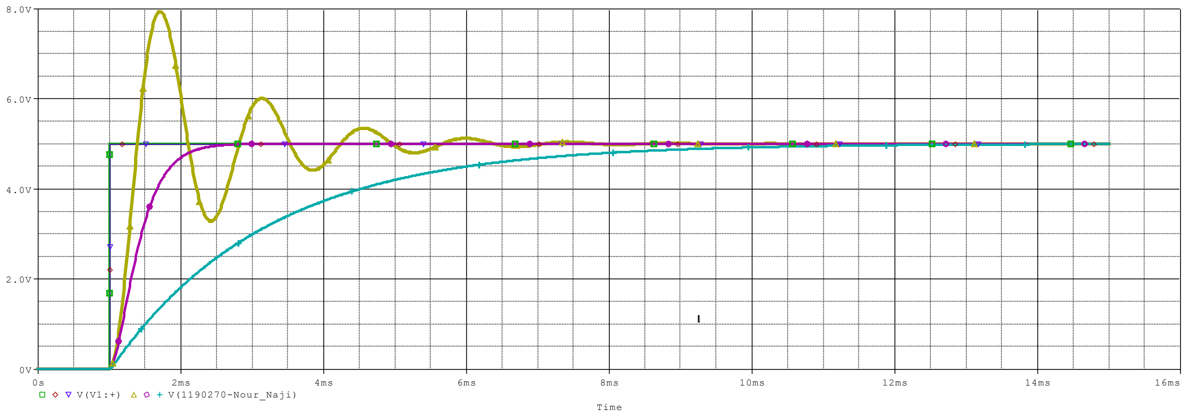
$$w = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{500m*100n}} = 4472.13 \text{ rad/s}$$

Using PARAM Element

➔ Circuit using PSpice:

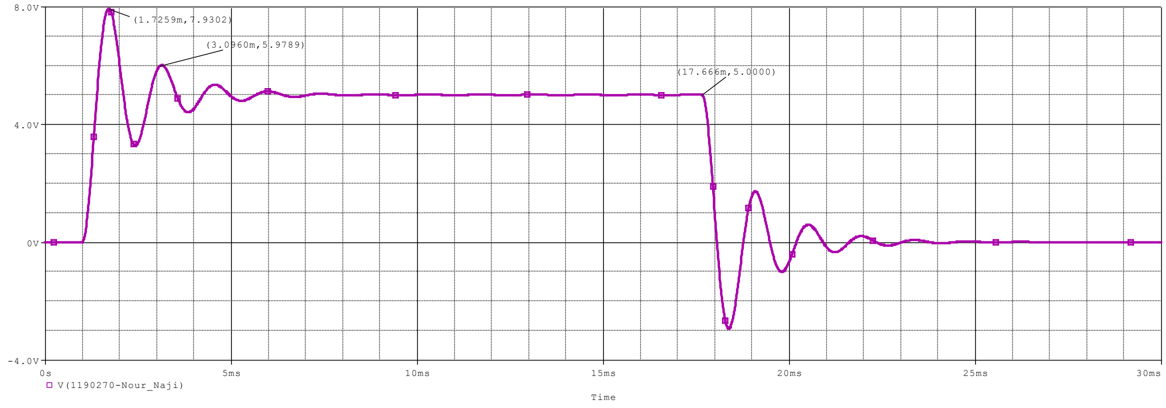






We can notice that when R=4472.13Ω (Critical Damping –purple curve), the output voltage is near from the input voltage.

Response parameters:



- ta = 1.7259ms
- tb = 3.0960 ms
- Va = 7.9302 v
- Vb = 5.9789 v
- V0(∞) = 5.0000 v

$$\tau = \frac{t_b - t_a}{ln\left(\frac{V_a - V_{o(\infty)}}{V_b - V_{o(\infty)}}\right)} = \frac{3.0960 - 1.7259}{ln\left(\frac{7.9302 - 5}{5.9789 - 5}\right)} = 1.2496 \text{ ms}$$

damping coefficient $\alpha = \frac{1}{\tau}$ = 0.8 krad/sec

Damped radian frequency $\omega_d = \frac{2\pi}{t_b - t_a} = \frac{2\pi}{3.096 - 1.7259}$ = 4.5836 krad/sec

Damped radian frequency(theoretically) $\omega_d = \frac{1}{\sqrt{LC}}$ $\frac{1}{\sqrt{500m * 100n}}$ = 4.47213 Krad/s

We can clearly see that the damping radio frequency experimentally and theoretically Values matched.