Faculty of Engineering and Technology

Electrical and Computer Engineering Department

ENEE2103

Circuits and Electronics Lab

Experiment No.4 - Pre Lab No.3

Sinusoidal Steady State Circuit Analysis

Student's Name: Lojain Abdalrazaq. **ID Number:** 1190707.

Instructor's Name: Dr. Ali Abdo.

Teaching assistant: Eng. Ismail Abualia.

Section: 5.

Apr 1, 2022

Table of Content:

1. Impedance:

✓ **Connecting the first circuit using PSpice:**

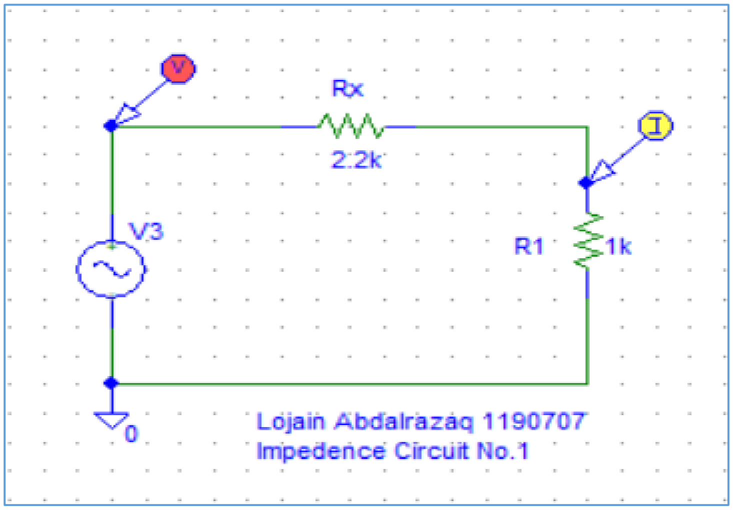


Fig1.1: Connecting the circuit using PSpice.

✓ **Calculating the total impedance using the total voltage and current:**

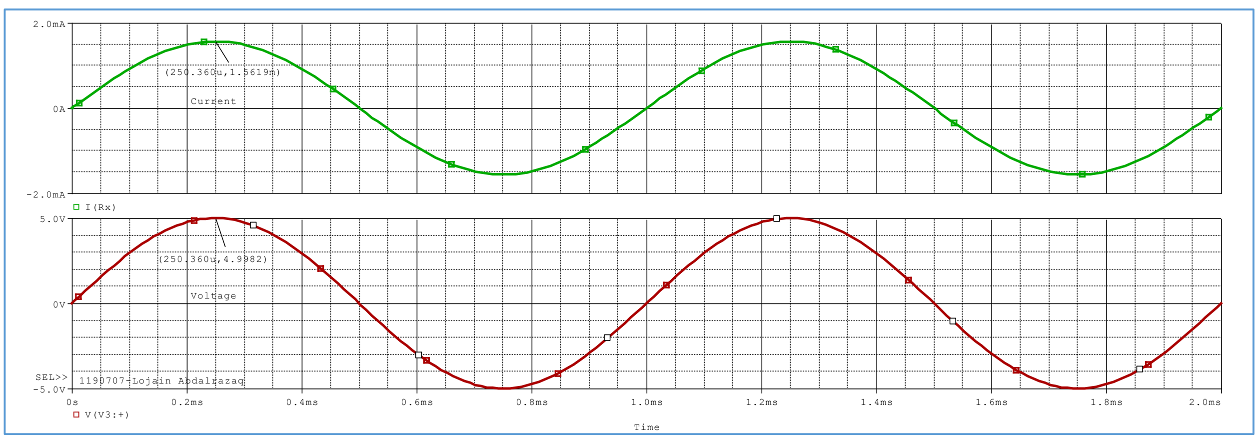


Fig1.2: Current and voltage through the circuit(Freq =1kHz).

In the first circuit, $\boxed{Z = R}$ becuse the circuit has resistors only.

from $V = RI \Rightarrow V = ZI \quad \therefore Z = \frac{V}{I} = \frac{4.998}{1.5619m} = \boxed{3.1999\ k\Omega}$

And theoritacly :- $Z = R_{eq} = 1k + 2.2k = \boxed{3.2\ k\Omega}$, too close!!

Fig1.3: Calculating the total impedance.

- ✓ **Repeating the previous steps with 500 Hz , 1500 Hz:**

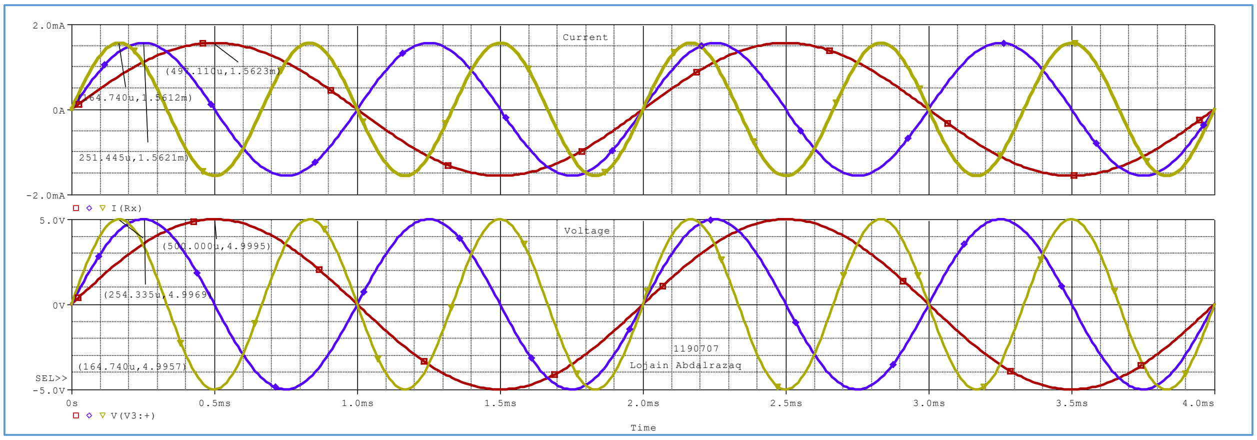


Fig1.4: Current and voltage through the circuit when Freq=1kHz,1.5kHz and 0.5kHz.

Note:
From the previous figure, we notice that the total impedance will be almost equal 3.199K, and 3.2K theoretically and there is no phase shift (Equals to 0).

- ✓ **Connecting the RC using PSpice and measuring the total Impedance:**

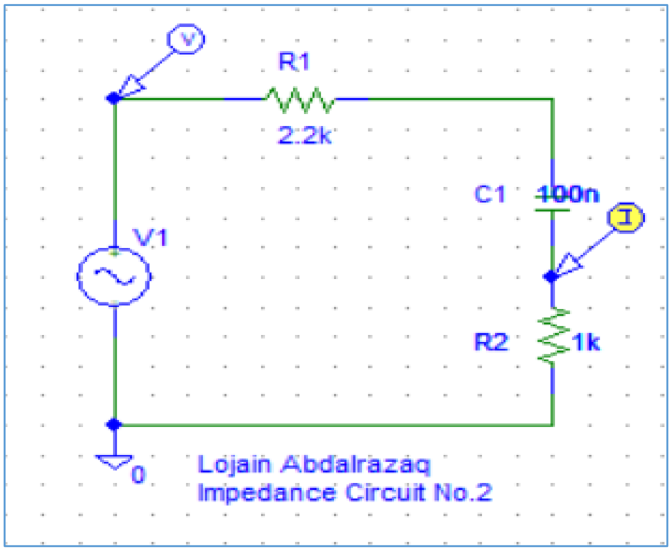


Fig1.5: Connecting the RC circuit using PSpice.

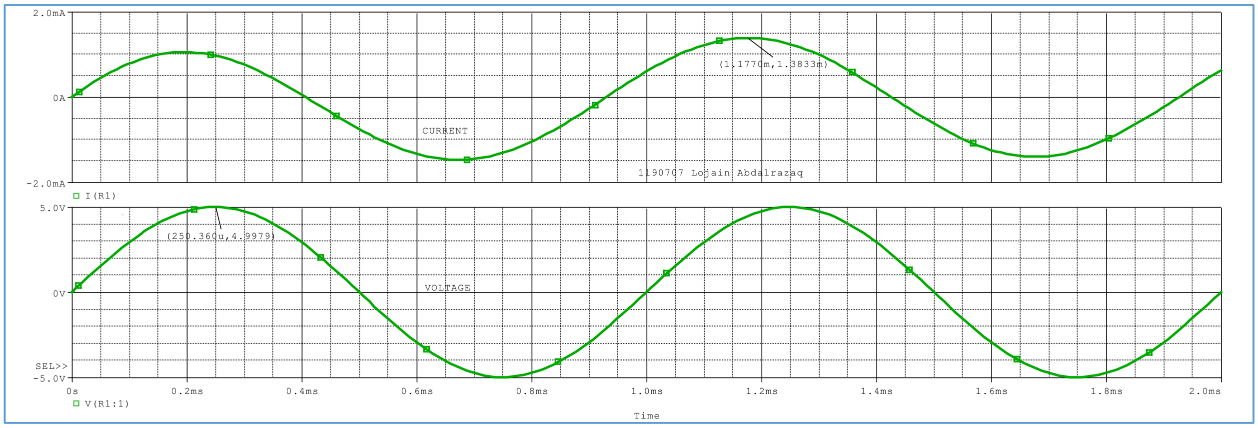


Fig1.6: Voltage and current through the RC circuit when Freq=1kHz.

⇒ RC Circuit :-

From the graph, we can find that $\boxed{V_{max} = 4.997\,V}$ and $\boxed{I_{max} = 1.383\,mA}$

∴ $Z = \frac{V_{max}}{I_{max}} = \frac{4.997}{1.383\,mA} = \boxed{3.613\,k\Omega}$

∴ Phase-shift $= \frac{(1.1770m - 1.2504m)}{\text{Period} \Rightarrow 1ms} * 360 = \boxed{-26.424\,deg.}$

Theoritically :- $Z = R_{eq} + \frac{1}{j\omega C} = 2.2k + 1k + \frac{1}{j(2\pi 1k)(100n)} = \boxed{3.2k + 1.59(-j)k}$

Z as magnitude ∴ $|Z| = \sqrt{(3.2)^2 + (1.59)^2} = \boxed{3.573\,k\Omega}$

phase $= \tan^{-1}\frac{y}{x} = \tan^{-1}\left(\frac{-1.59\cancel{k}}{3.2\cancel{k}}\right) = \boxed{-26.4216\,deg}$

Note: the results are too close!!

Fig1.7: Calculating the total impedance for the RC circuit.

✓ **Repeating the previous steps with signal frequencies: 500Hz , 1500 Hz:**

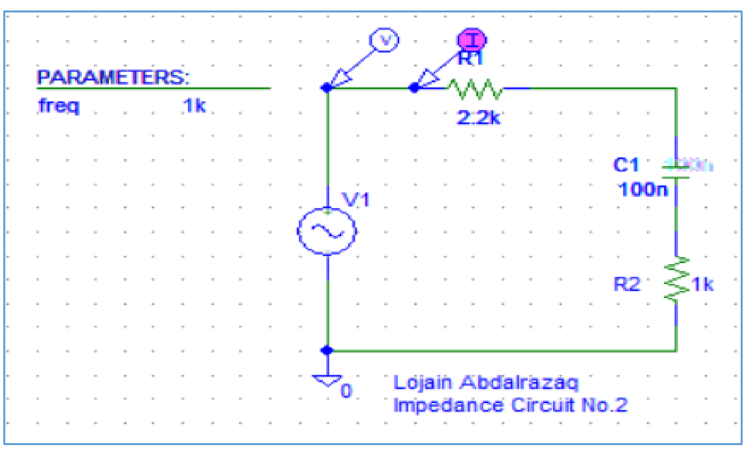


Fig1.8: Connecting the RC circuit with different frequencies.

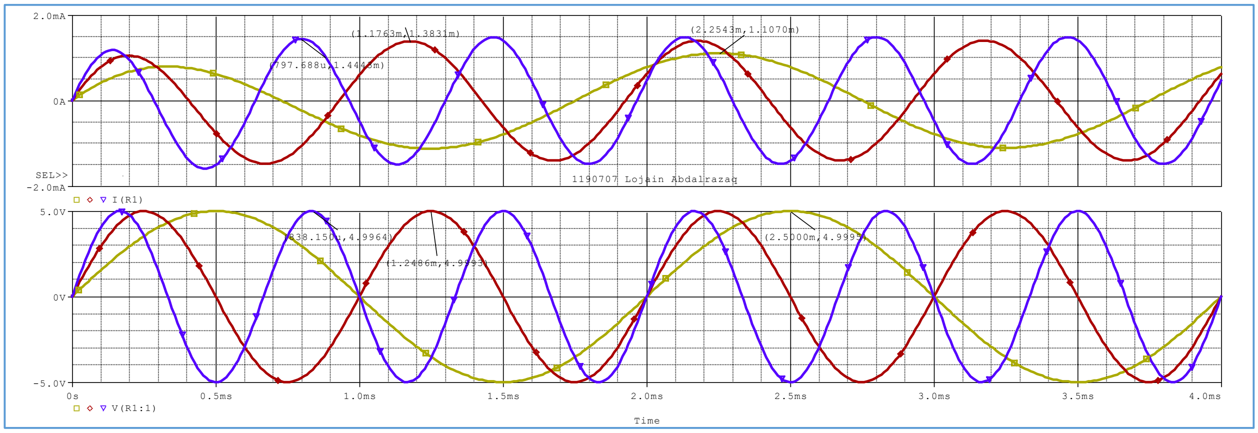


Fig1.8: Current and voltage through the RC circuit when Freq=1kHz,1.5kHz and 0.5kHz.

$\Rightarrow$ When Frequency = 1.5kHz :-

From the graph, we can notice that $\boxed{V_{max} = 4.9964\,V}$, $\boxed{I_{max} = 1.4443\,mA}$

* $Z_{max} = \dfrac{V_{max}}{I_{max}} = \dfrac{4.9964}{1.4443mA} = \boxed{3.459\,k\Omega}$

* Phase $= \dfrac{(0.797688m - 0.83815m) \times 360}{0.6666m} = \boxed{-21.849\ deg}$

Theor. : $Z = R_{eq} + \dfrac{1}{j\omega C} = 3.2k + \dfrac{1}{j(2\pi 1.5k)C} = \boxed{3.2 - j1.06\,k\Omega}$

Z as magnitude $\Rightarrow \sqrt{3.2^2 + 1.06^2} = \boxed{3.37099\,k\Omega}$

Z as phase $\Rightarrow \tan^{-1}\dfrac{y}{x} = \tan^{-1}\left(\dfrac{-1.06}{3.2}\right) = \boxed{-18.327\ deg}$

$\Rightarrow$ When Frequency = 0.5kHz :-

From the graph, we can find that $\boxed{V_{max} = 4.9995\,V}$ and $\boxed{I_{max} = 1.1070\,m}$

* $Z = \dfrac{V_{max}}{I_{max}} = \dfrac{4.9995}{1.1070m} = \boxed{4.5162\,k\Omega}$

* Phase shift $= \dfrac{(2.2543m - 2.5m) \times 360}{2m} = \boxed{44.226\ deg}$

Theoriticlly :- $Z = R_{eq} + \dfrac{1}{j\omega C} = \boxed{3.2k - j(3.183)\,k\Omega}$

Z as magnitude : $|Z| = \sqrt{(3.2)^2 + (3.18)^2} = \boxed{4.5113\,k\Omega}$

phase $= \tan^{-1}\dfrac{y}{x} = \tan^{-1}\left(\dfrac{-3.183\,k}{3.2\,k}\right) = \boxed{-44.847^\circ}$

✓ **Connecting the RL using PSpice and measuring the total Impedance:**

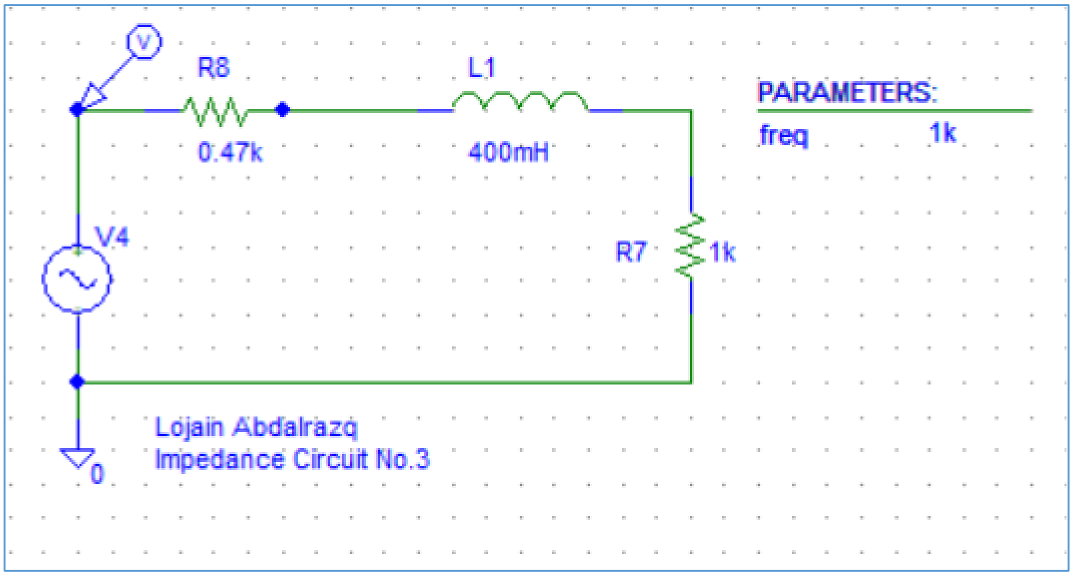


Fig1.9: Connecting the RL circuit using PSpice.

✓ **Calculating the total impedance using the total voltage and current:**

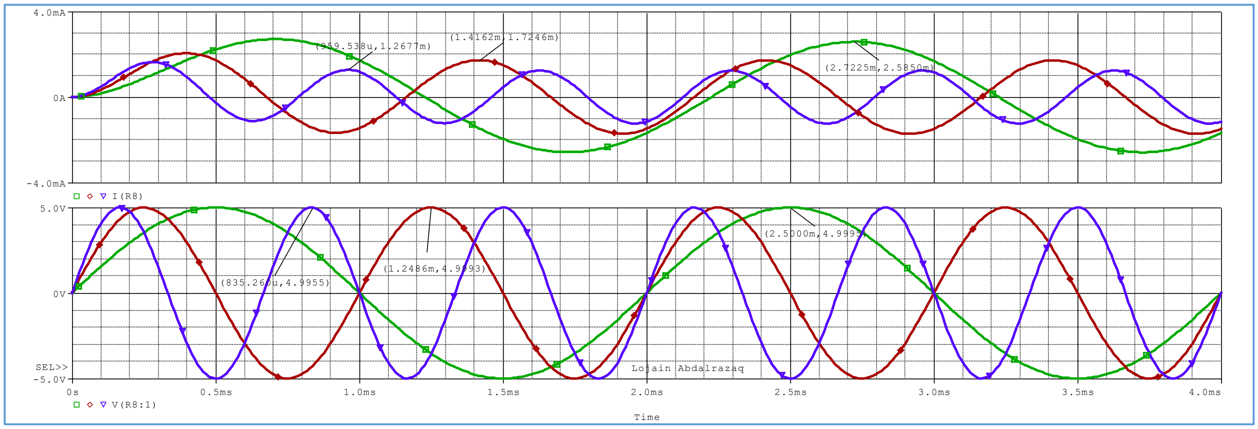
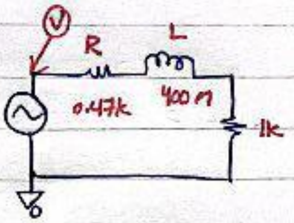


Fig1.10: Current and voltage through the RL circuit when Freq=1kHz,1.5kHz and 0.5kHz.

⇒ RL Circuit:



When $\boxed{\text{Frequency} = 1000\,\text{Hz}}$

$* \; Z = \dfrac{V_{max}}{I_{max}} = \dfrac{4.9993\,V}{1.7246m} = \boxed{2.8988\,k\Omega}$

$* \; \text{Phase-shift} = \dfrac{T \times 360}{(1/f)} = \dfrac{(1.4162m - 1.2486m)\,360}{1 * 10^{3}} = \boxed{60.336\ \text{deg}}$

By theoritically: $* \; Z = R_{eq} + jwL = \boxed{1.47 + j(\cancel{2.48}\;2.512)\,k\Omega}$

$|Z| = \sqrt{1.47^2 + 2.512^2} = \boxed{2.905\,k\Omega}$

$\measuredangle\theta = \tan^{-1}\left(\dfrac{2.512}{1.47}\right) = \boxed{59.66\ \text{deg}}$

When $\boxed{\text{Frequency} = 500\,\text{Hz}}$

$* \; Z = \dfrac{V_{max}}{I_{max}} = \dfrac{4.9995}{2.585m} = \boxed{1.93\,k\Omega}$

$* \; \text{Phase-shift} = \dfrac{T \times 360}{per} = \dfrac{(2.7225m - 2.5m) \times 360}{2\,ms} = \boxed{40.05}$

By theoritically: $* \; Z = R_{eq} + jwL = 1.47 + j(2\pi\,0.5k)L = \boxed{1.47 + j1.257}$

$|Z| = \sqrt{1.47^2 + 1.257^2} = \boxed{1.934\,k\Omega}$

$\measuredangle\theta = \tan^{-1}\left(\dfrac{1.257}{1.47}\right) = \boxed{40.5\ \text{deg}}$

When $\boxed{\text{Frequency} = 1500\,\text{Hz}}$

$* \; Z = \dfrac{V_{max}}{I_{max}} = \dfrac{4.9955\,V}{1.2677m} = \boxed{3.9406\,k\Omega}$

$* \; \text{Phase-shift} = \dfrac{T \times 360}{per} = \dfrac{(0.9595m - 0.8352m) \times 360}{0.666667} = \boxed{67.122\ \text{dge.}}$

By theoritically: $* \; Z = R_{eq} + jwL = \boxed{1.47k + j3.77\,k\Omega}$

$|Z| = \sqrt{1.47^2 + 3.77^2} = \boxed{4.04\,k\Omega}$

$\measuredangle\theta = \tan^{-1}\left(\dfrac{3.77}{1.47}\right) = \boxed{68.9\ \text{dge}}$

2. Capacitive and inductive behavior:

✓ Connecting the RLC using PSpice:

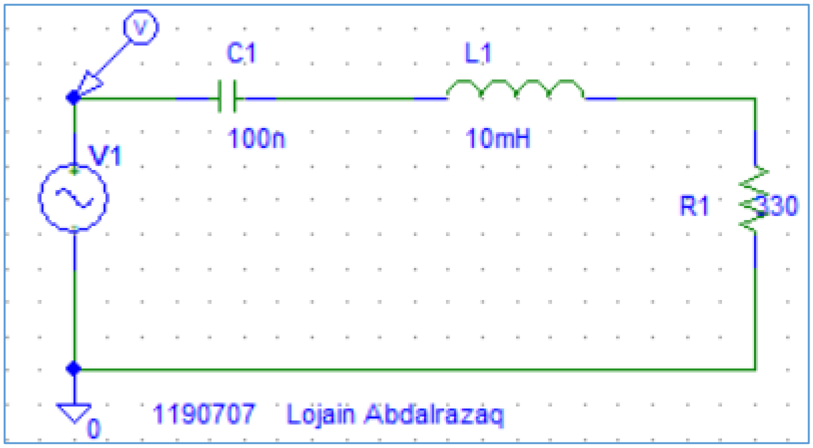


Fig1.11: Connecting the RCL circuit using PSpice.

✓ Measuring the phase shift between the total current and the source voltage:

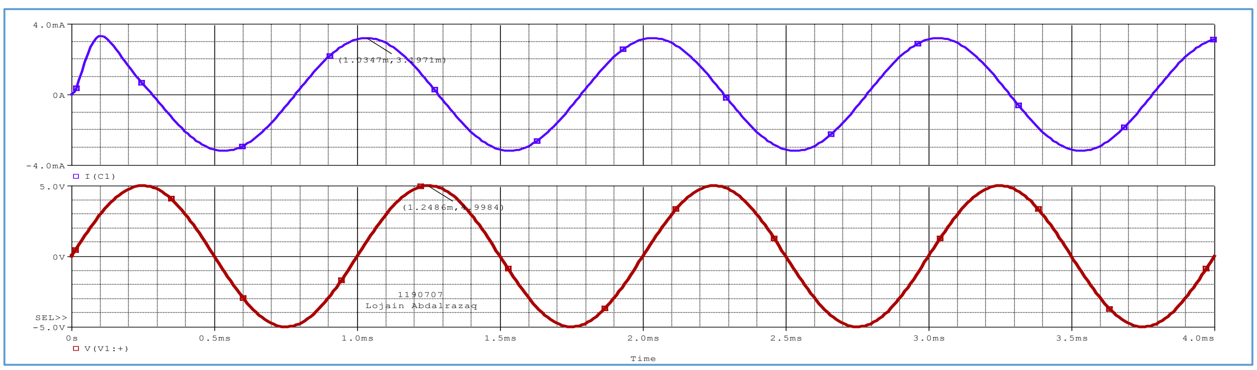


Fig1.12: Total voltage and current in RLC circuit when Freq=1000 Hz.

⇒ Using the graph, $\text{phase-shift} = \frac{(1.0347m - 1.2486m)}{1m} \times 360 = \boxed{-77.004}$

⇒ Theoritcally: $Z = R_{eq} + j(2\pi f L) + \frac{-j}{2\pi f c} = \boxed{330 + -j\,1528.7}$

$\therefore \text{Phase-Shift} = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{-1528.7}{330}\right) = \boxed{-77.82^\circ}$

∴ Becuse the shift is negative, that means the current leads the voltage by 77.82°,

∴ the circuit $\boxed{\text{copasitive}}$

- ✓ **Calculating the resonance frequency and measuring the phase shift(F=Fres):**

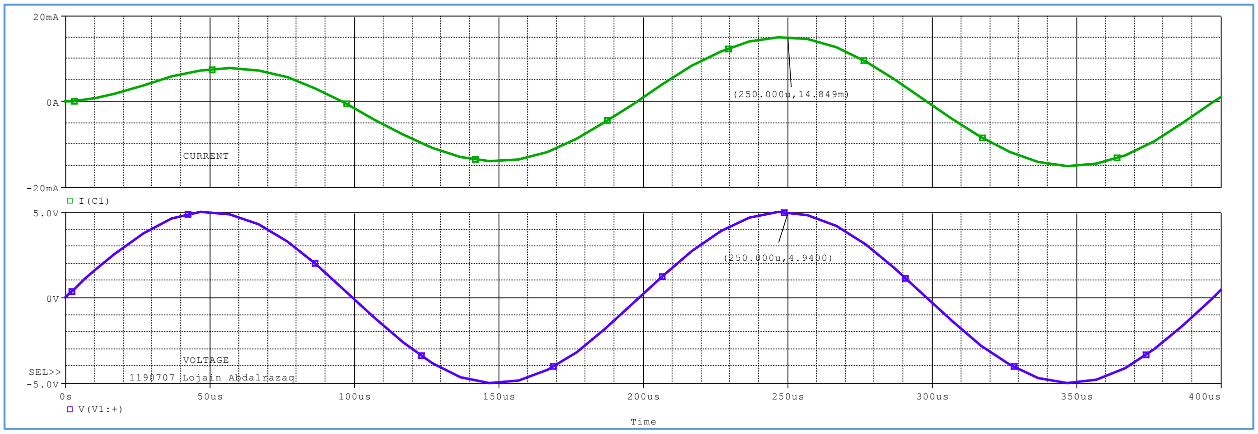


Fig1.13: Current and voltage through the RLC circuit when Freq=resonance=5033Hz.

=> When $F = f_o$

* $f_o = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(10m)(100n)}} = \boxed{5033\ HZ}$

* Phase-shift: using graph: $\frac{T\Delta \times 360}{Per} = \boxed{0\ \text{degree}}$

$\therefore$! calculation => $Z = j\omega L + \frac{1}{j\omega C} = \frac{1}{2\pi(5033)(100n)} + j(2\pi 5033)\,10m$

$\therefore \tan^{-1}\left(\frac{0}{330}\right) = \boxed{0\ deg}$ $= 0$

- ✓ **Changing the source frequency to 2fo and calculating the phase shift:**

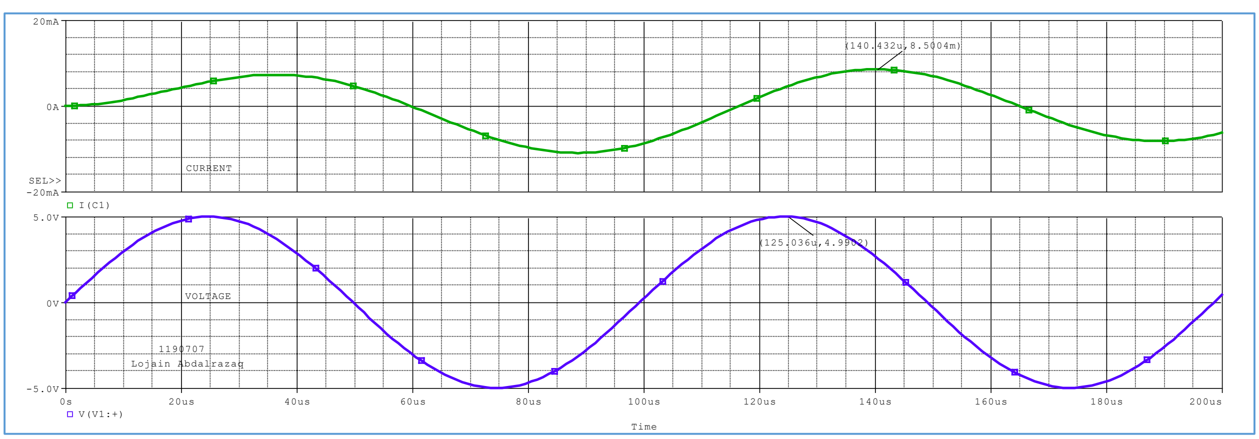


*Fig1.13: Current and voltage through the RLC circuit when Freq=2*resonance=10066Hz.*

According to the calculation, its inductive circuit:

⇒ When $F = 2F_{sen}$:

* From graph ⇒ Phase-shift $= \dfrac{(140.432u - 125.036u)\,360}{99.344u} = \boxed{55.79\ deg}$

* From calculation ⇒ $Z = R_{eq} + X \rightarrow \frac{1}{j\omega C} + j\omega L = \boxed{j\,474.35}$ complex

∴ Phase-shift ⇒ $\tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{474.35}{330\Omega}\right) = \boxed{55.17\ deg}$

- ✓ **Doubling the value of capacitor:**

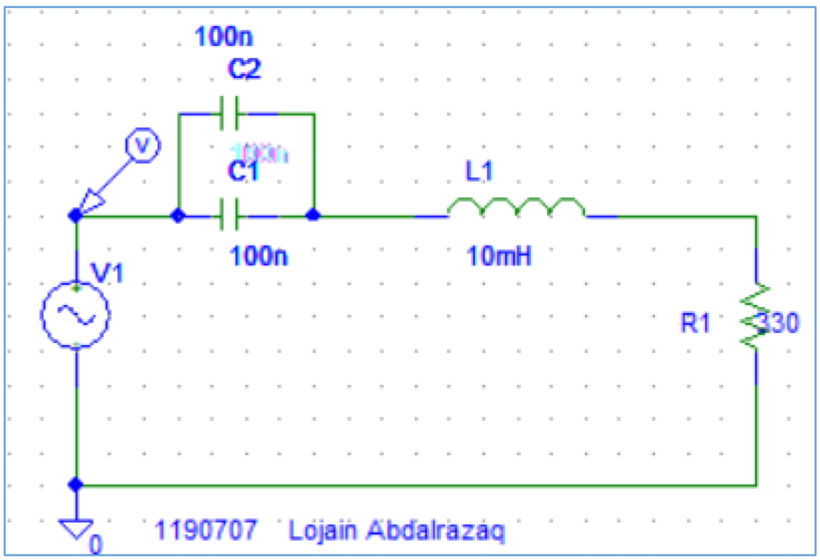


Fig1.14: Connecting the RCL circuit with doubling the capacitor.

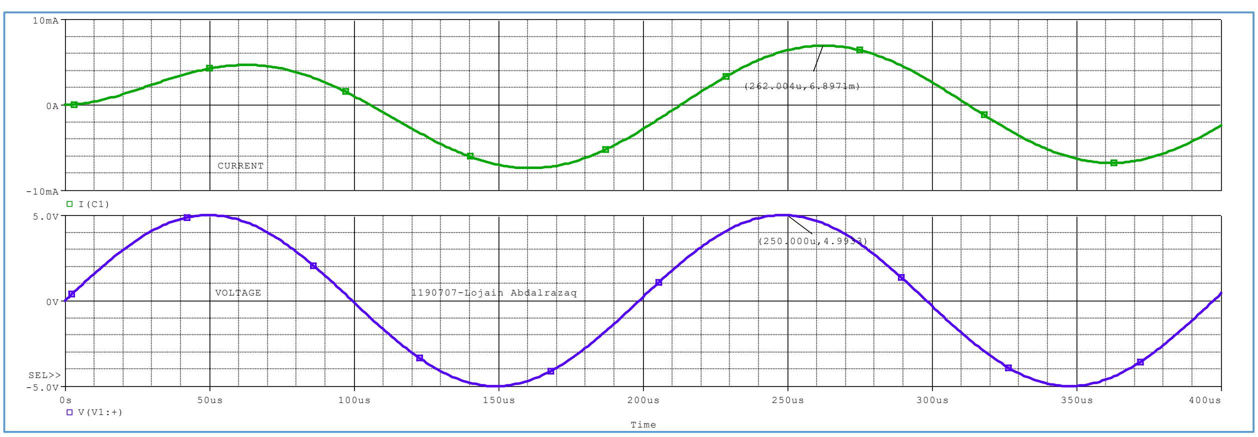


Fig1.15: Current and voltage through the RLC circuit when DOUBLING the capacitor.

✓ **Doubling the value of inductor:**

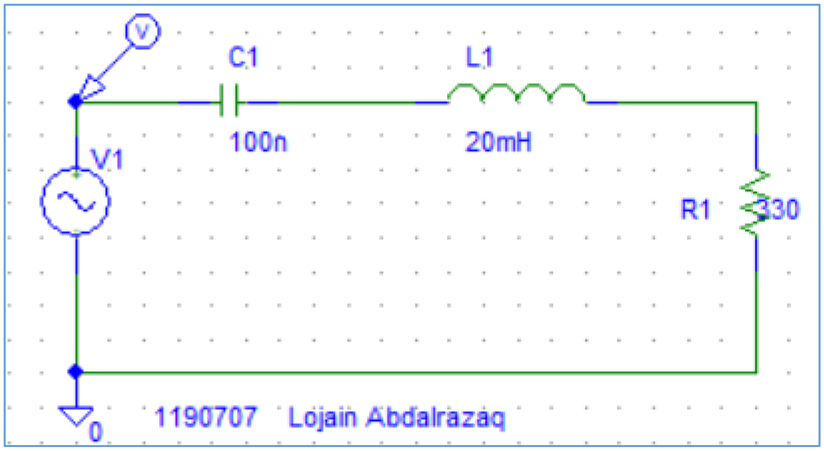


Fig1.16: Connecting the RCL circuit with doubling the inductor.

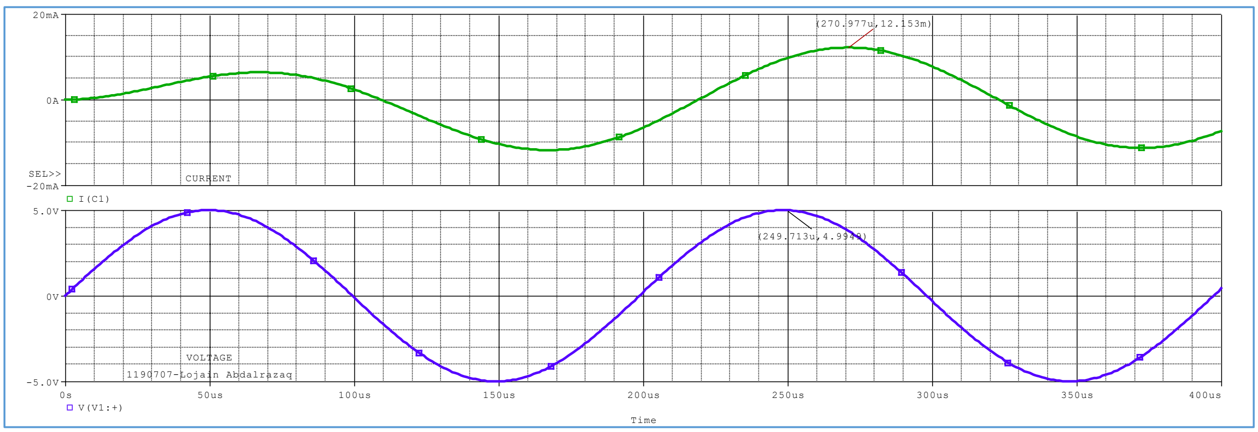


Fig1.17: Current and voltage through the RLC circuit when DOUBLING the inductor.

✓ **Calculations when doubling the capacitor and the inductor:**

=> When doubling the capacitor and Inductor:

[1] Doubling the capacitor:

* From graph: Phase-shift $= \dfrac{(262.004u - 250u) \times 360}{198.68u} = \boxed{21.74 \text{ deg}}$

* From calculation: $X = jwL + \dfrac{1}{jwC} = \boxed{j(158.122)}$

$\therefore$ Phase-shift $= \tan^{-1}\left(\dfrac{158.122}{330}\right) = \boxed{25.6 \text{ deg}}$

[2] Doubling the inductor:

* From graph: Phase-shift $= \dfrac{(270.977u - 249.713u)\ 360}{198.689u} = \boxed{38.527 \text{ deg}}$

* From calculation: $X = jwL + \dfrac{1}{jwC} = \boxed{j(316.233)}$

$\therefore$ Phase-shift $= \tan^{-1}\left(\dfrac{316.233}{330}\right) = \boxed{43.78^\circ}$

3. Sinosoidal steady state power:

✓ **Connecting the circuit using PSpice:**

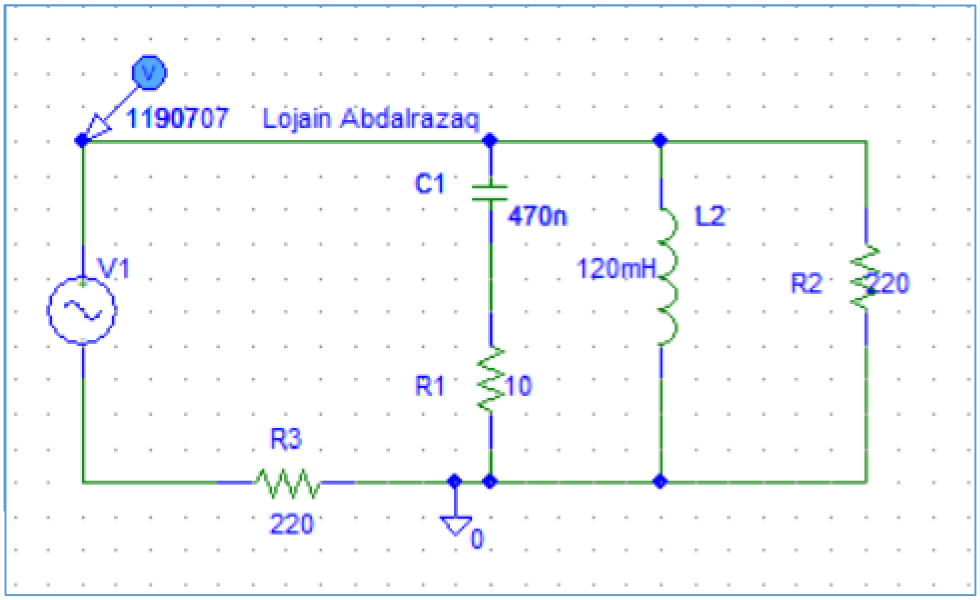


Fig1.18: Connecting the circuit using PSpice.

✓ **Plotting current and voltage across R1:**

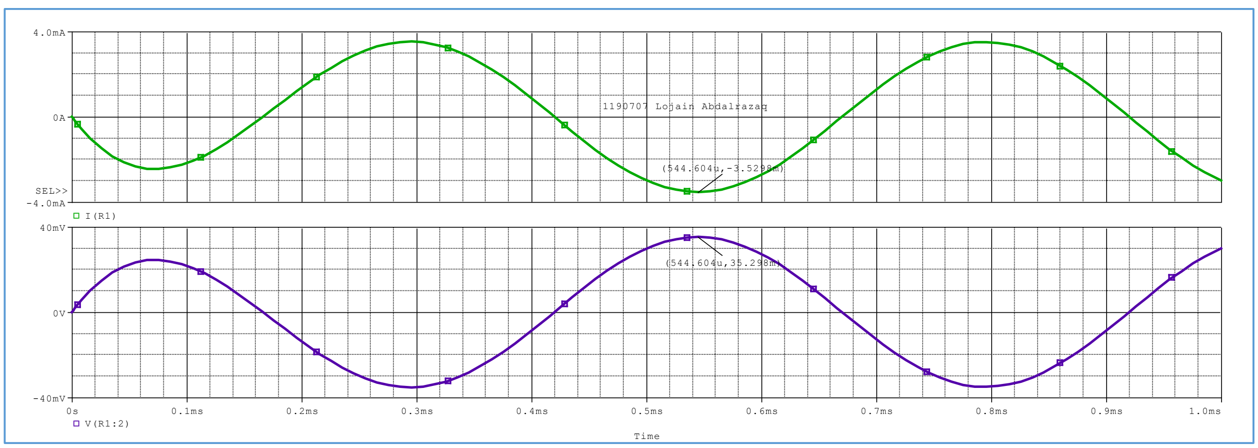


Fig1.19: Current and voltage across R1.

✓ Plotting Vs and Is:

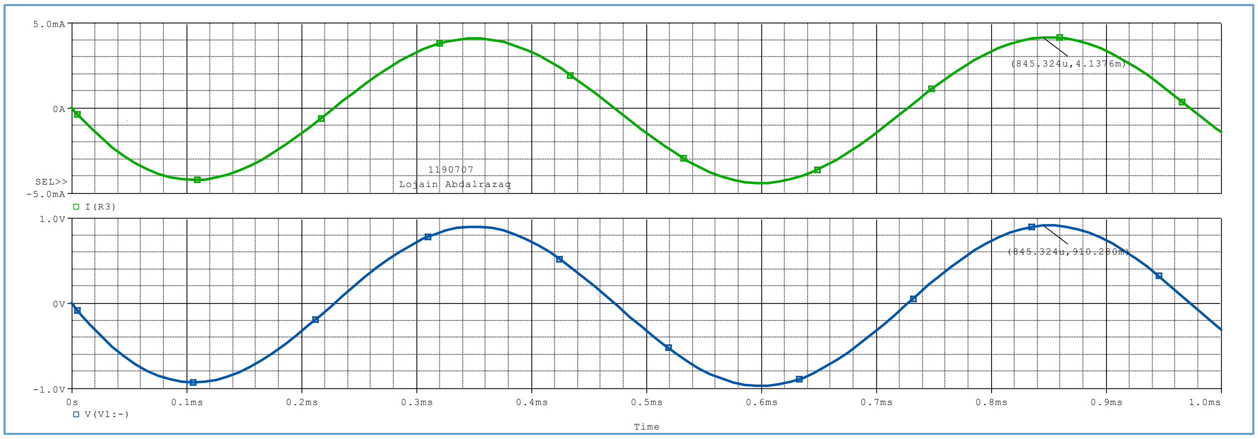


Fig1.19: plot of Vs and Is.

✓ Plotting Vc and Ic:

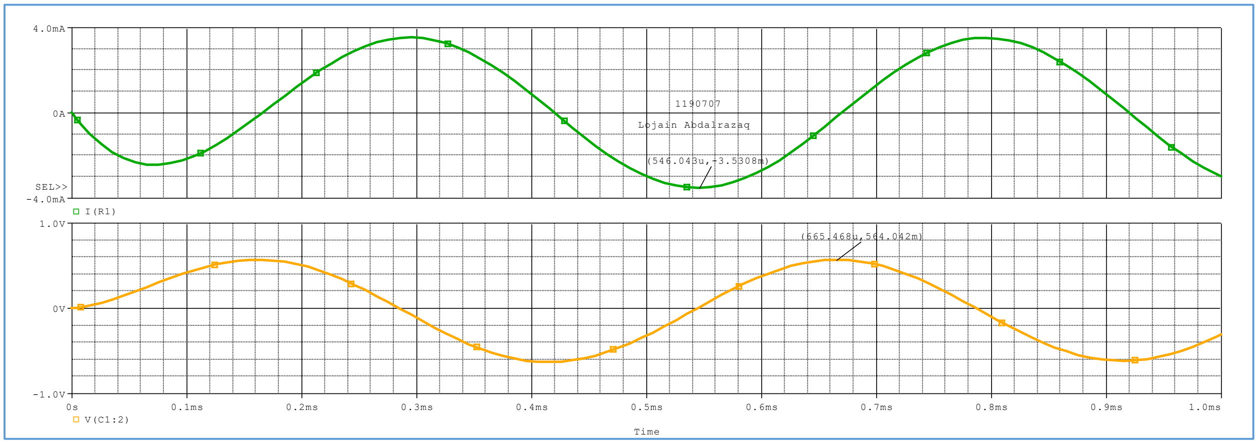


Fig1.20: plot of Vc and Ic.

✓ Plotting VL and IL:

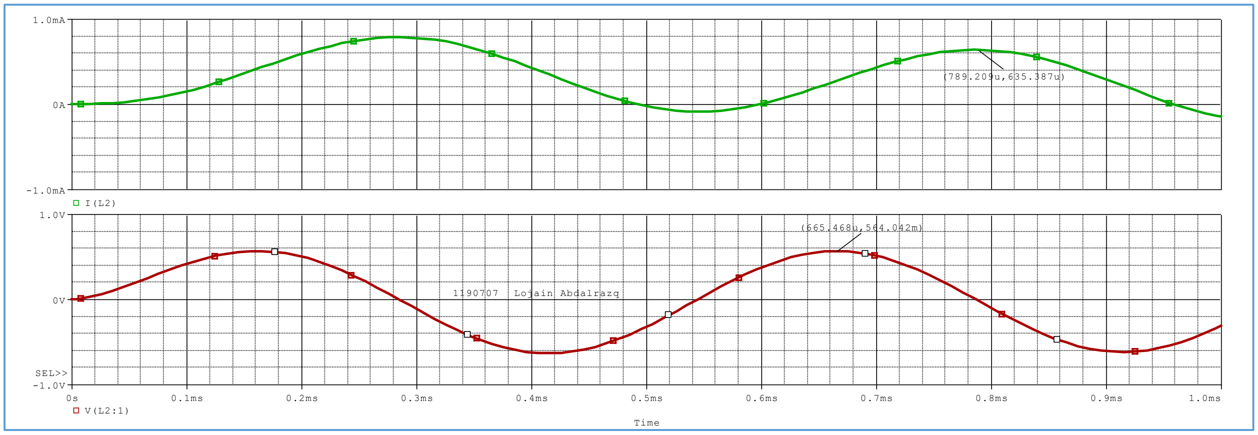
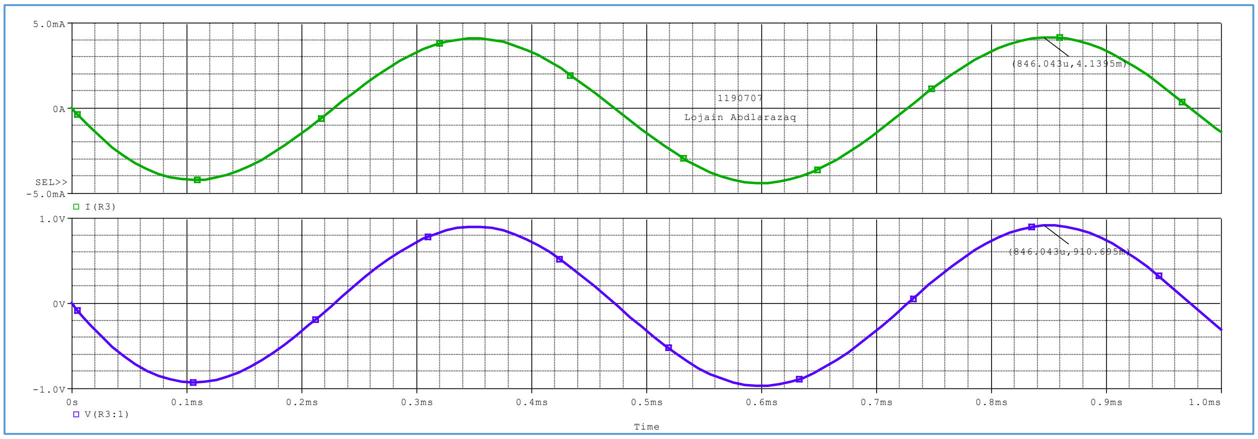


Fig1.21: plot of VL and IL.

- ✓ **Plotting voltage across R3=220 ohm and Is:**



- ✓ **Phase Shift calculations:**

* Phase-shift of Vs and Is:- Note: $V_{rms} = V_P/\sqrt{2} \Rightarrow \therefore \boxed{V_P = 1.4142\,V}$

using the graph $\Rightarrow \left(\frac{845.324u - 845.324u}{0.5m}\right) * 360 \Rightarrow \boxed{\text{zero}}$

* Phase-Shift of V_c and I_c:-

using the graph $\Rightarrow \left(\frac{546.043u - 665.468u}{\text{Period}}\right) * 360 = \boxed{-85.96}$

* Phase-Shift of V_L and I_L:-

using the graph $\Rightarrow \left(\frac{789.209u - 665.468u}{0.5m}\right) * 360 = \boxed{87.1°}$

* Phase-Shift of $V_{R=220}$ and I_S:- $\left(\frac{846.043u - 846.043u}{0.5m}\right) * 360 = \boxed{\text{zero}}$