



THE ISLAMIC UNIVERSITY OF GAZA

FACULTY OF ENGINEERING

Electrical Circuits Lab 2

Report for the Fourth laboratory

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Major	Electrical Engineering
Course Name	Electrical Circuits Lab 2
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Experiment 4: RLC Series and Parallel AC Circuits

1. Objectives

- To investigate RLC circuits and determine the relationships between frequency, impedance, voltage, and current.
- To study the resonance phenomenon in series and parallel RLC circuits under frequency variations.

2. Theory

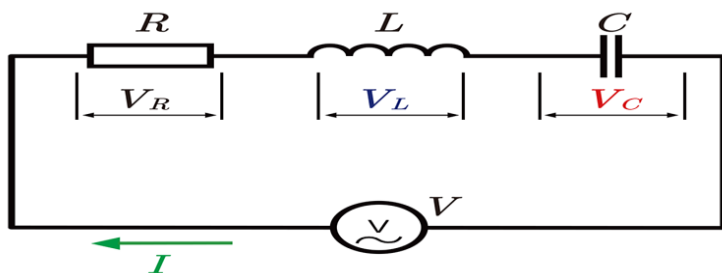
General Introduction to RLC Circuits

An RLC circuit is an electrical circuit containing a resistor **R** an inductor **L**, and a capacitor **C** connected together, which stores energy and responds differently based on the AC source frequency.

Types of RLC Circuits:

1. Series RLC AC Circuits

In a series RLC circuit, all components are connected in a single line, meaning the **same current flows through them**, while the total input voltage **divides across each element** according to its impedance.



$$V_R = I \times R$$

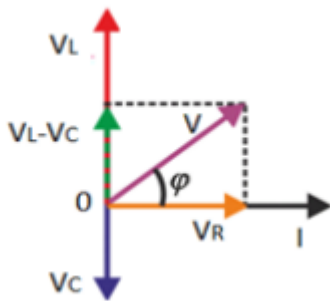
$$V_L = I \times \omega L$$

$$V_C = \frac{I}{\omega C}$$

Depending on the frequency, the circuit has **three cases**:

- **Case 1: Inductive Circuit ($X_L > X_C$)**

- **Condition:** Occurs at high frequencies where $V_L > V_C$
- **Result:** The circuit acts like an **RL** circuit; total voltage V_{in} **leads** the current **I**, and the phase angle is **positive**.



$$|V_{in}| = \sqrt{(V_R)^2 + (V_L - V_C)^2}$$

$$|V_{in}| = I \sqrt{(R)^2 + (X_L - X_C)^2} = IZ$$

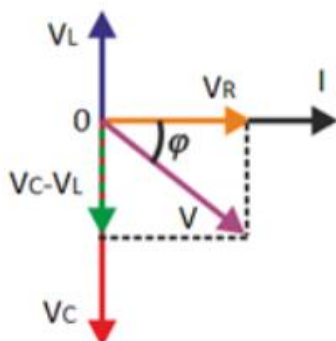
$$Z = R + j(X_L - X_C)$$

From the phasor diagram, the value of phase angle will be:

$$\tan(\phi) = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R} \quad \therefore \quad \phi = \tan^{-1} \frac{X_L - X_C}{R}$$

- **Case 2: Capacitive Circuit ($X_C > X_L$)**

- **Condition:** Occurs at low frequencies where $V_C > V_L$
- **Result:** The circuit acts like an **RC** circuit; total voltage V_{in} **lags** behind the current **I** and the phase angle is **negative**.



$$|V_{in}| = \sqrt{(V_R)^2 + (V_C - V_L)^2}$$

$$|V_{in}| = I \sqrt{(R)^2 + (X_C - X_L)^2} = IZ$$

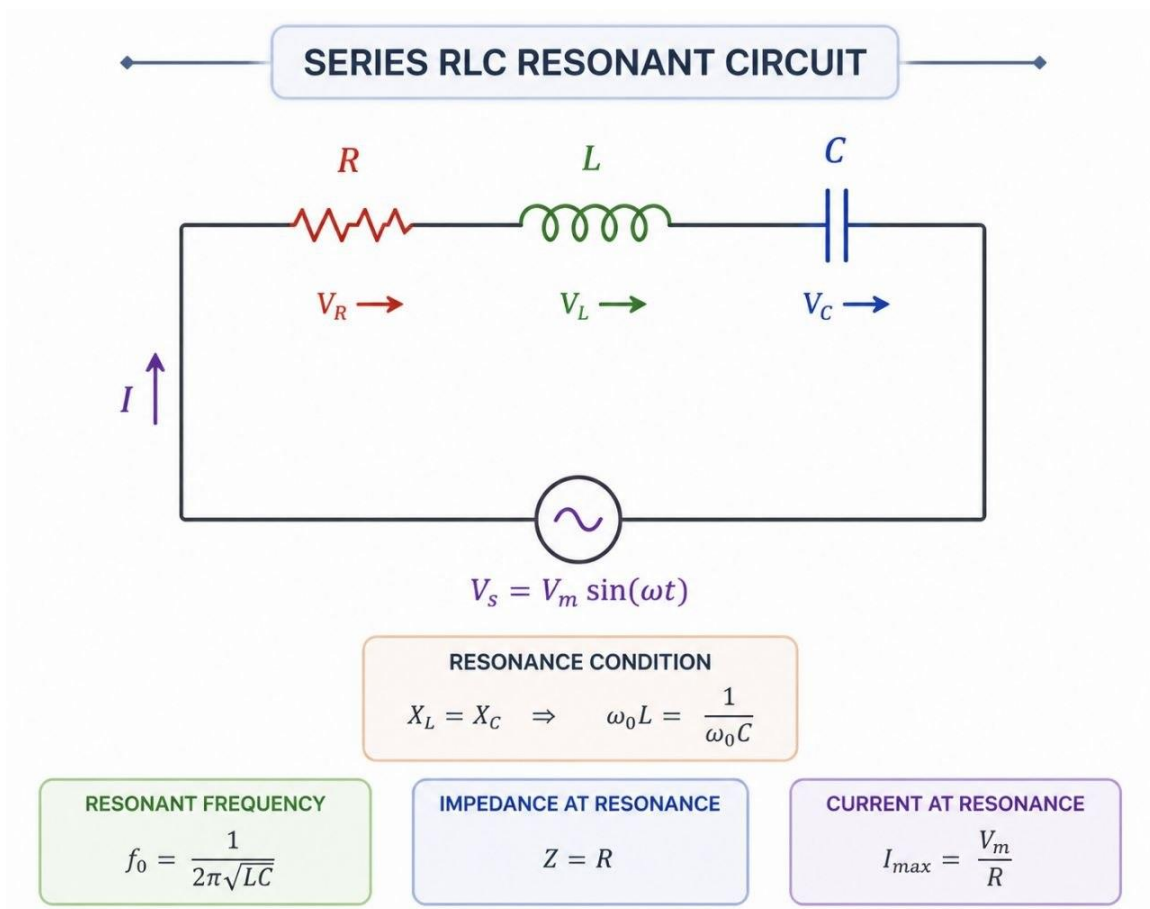
$$Z = R + j(X_C - X_L)$$

From the phasor diagram, the value of phase angle will be:

$$\tan(\phi) = \frac{V_C - V_L}{V_R} = \frac{X_C - X_L}{R} \quad \therefore \quad \phi = \tan^{-1} \frac{X_C - X_L}{R}$$

- **Case 3: Resonance Condition ($X_L = X_C$)**

- **Condition:** Occurs at the resonant frequency (f_0) where $V_L = V_C$ and they cancel each other.
- **Result:** The circuit becomes **purely resistive** ($Z = R$); impedance is at its **minimum**, current reaches its **maximum** I_{max} and the phase angle is **zero**



2. Parallel RLC AC Circuits

In a parallel RLC circuit, all components are connected across the same voltage source, meaning the **voltage (V_{in}) is identical across all elements $V = V_R = V_L = V_C$** , while the total input current **divides into three branch currents** based on their impedances.

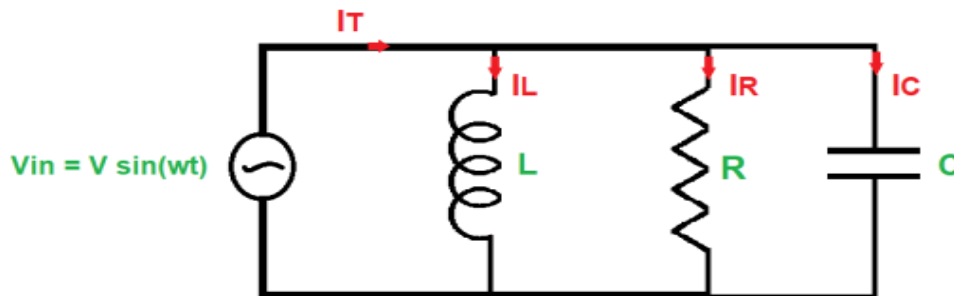


Figure 18: Parallel RLC Circuit and its Phasor diagram

$$\vec{I_{in}} = \vec{I_L} + \vec{I_C} + \vec{I_R}$$
$$\vec{V_{in}} = \vec{V_L} = \vec{V_C} = \vec{V_R}$$

Depending on the frequency, the circuit has **three cases**:

- **Case 1: Capacitive Circuit ($I_C > I_L = X_L > X_C$)**
 - **Condition:** Occurs at high frequencies where $I_C > I_L$.
 - **Result:** The circuit acts like an $\$RC\$$ circuit; total current **I leads** the voltage **V_{in}** and the phase angle is **positive**.

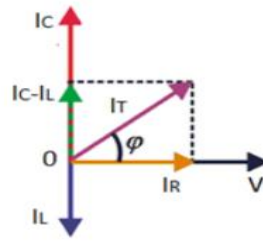


Figure 19: Phasor diagram for parallel RLC Circuit($I_C > I_L$)

$$|I| = \sqrt{(I_R)^2 + (I_C - I_L)^2}$$

From the phasor diagram, the value of phase angle will be:

$$\tan(\varphi) = \frac{I_C - I_L}{I_R} = \frac{R(X_L - X_C)}{X_C * X_L} \quad , , , , \quad \varphi = \tan^{-1} \frac{R(X_L - X_C)}{X_C * X_L}$$

- **Case 2: Inductive Circuit ($I_L > I_C = X_C > X_L$)**
 - **Condition:** Occurs at low frequencies where $I_L > I_C$.
 - **Result:** The circuit acts like an **RL** circuit; total current **I** lags voltage **Vin** and the phase angle is **negative**.

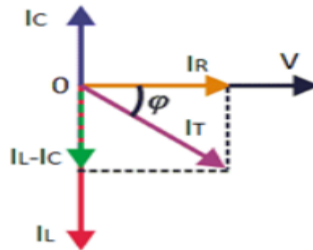


Figure 20: Phasor diagram for parallel RLC Circuit($I_C < I_L$)

$$|I| = \sqrt{(I_R)^2 + (I_L - I_C)^2}$$

From the phasor diagram, the value of phase angle will be:

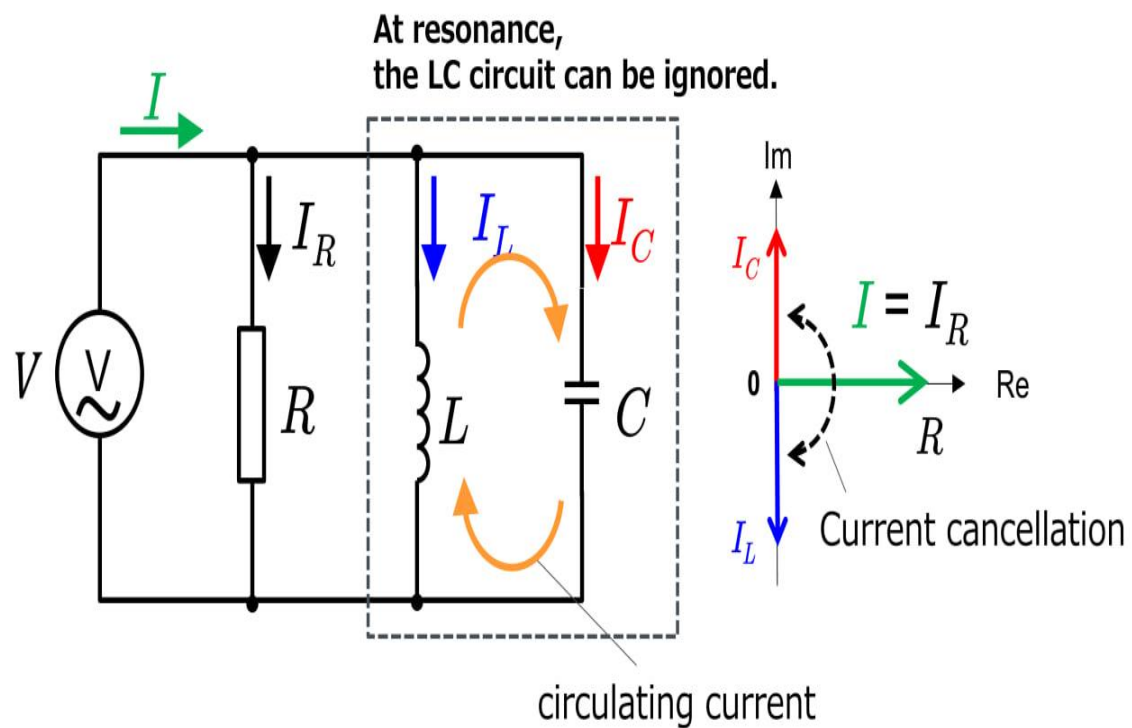
$$\tan(\varphi) = \frac{I_L - I_C}{I_R} = \frac{R(X_C - X_L)}{X_C * X_L} \quad , , , , \quad \varphi = \tan^{-1} \frac{R(X_C - X_L)}{X_C * X_L}$$

- **Case 3: Resonance Condition ($I_L = I_C$, $X_L = X_C$)**

- **Condition:** Occurs at the resonant frequency (f_0) where branch currents are equal and cancel each other.

- **Result:** The circuit becomes **purely resistive**

($Z_{\max} = R$); impedance is at its **maximum**, total current drops to its **minimum** and the phase angle is **zero**.

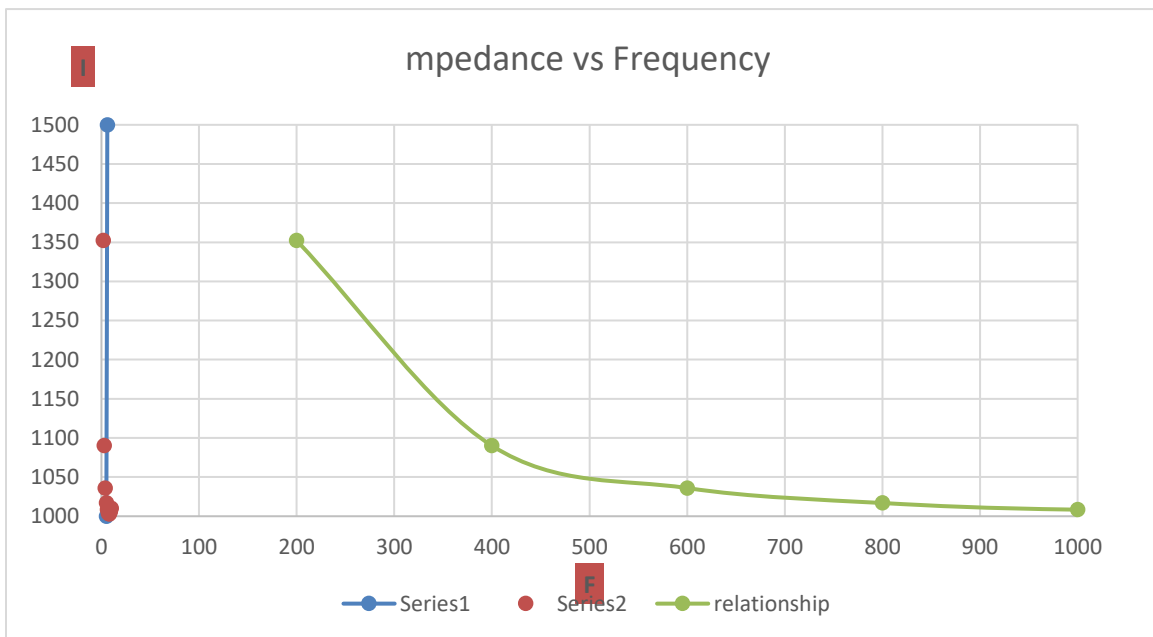


At resonance, $I = I_R$

Simulation:

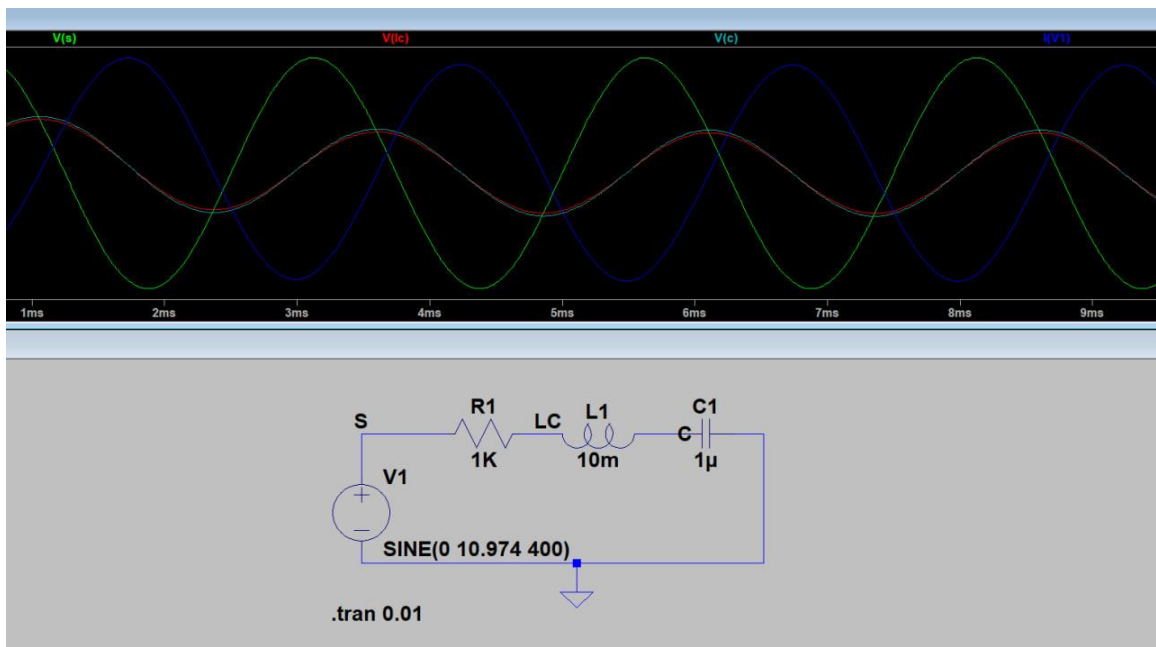
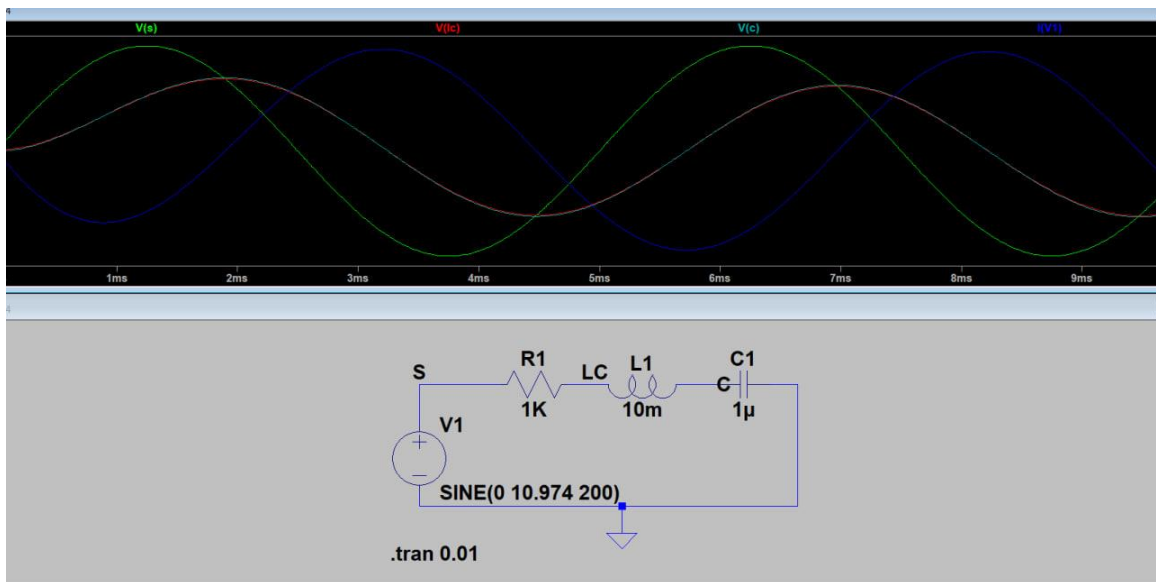
Question1 : Series circuit.

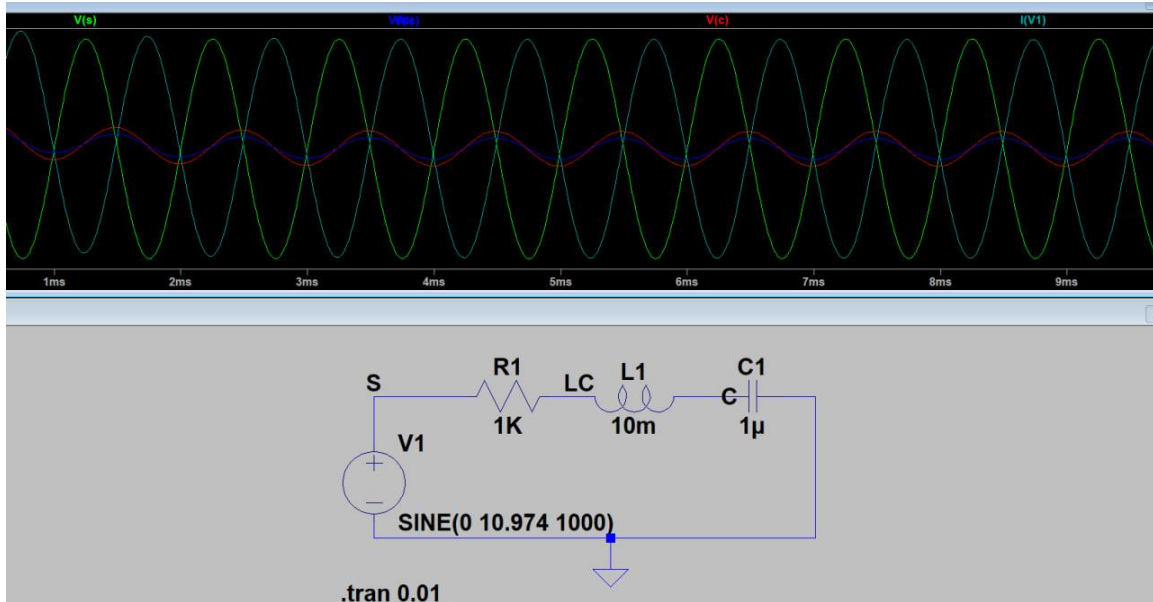
Frequency (Hz)	Vs (V)	VR (V)	VL (V)	VC (V)	Is (mA)	Z (Ω)	Phase Angle (φ)
200	7.7593	5.99	0.07	5	5.7389	1352.1	-39.5°
400	7.7581	7.22	0.17	3.01	7.1166	1090.1	-21.5°
600	7.7496	7.53	0.27	2.09	7.4804	1036	-13.6°
800	7.7456	7.65	0.36	1.59	7.6167	1016.9	-9.2°
1000	7.7435	7.7	0.45	1.28	7.6788	1008.4	-6.2°
1500	7.7466	7.74	1.28	0.9	7.7196	1003.5	+2.8°
2000	7.7451	7.73	1.12	0.67	7.7223	1002.9	+3.3°
2500	7.7446	7.7	1.29	0.54	7.7016	1005.6	+5.6°
3000	7.7379	7.67	1.5	0.45	7.6615	1010	+7.8°



➤ From the experimental data and the impedance plot, the resonance frequency (f_0) is:

F=1500KHZ





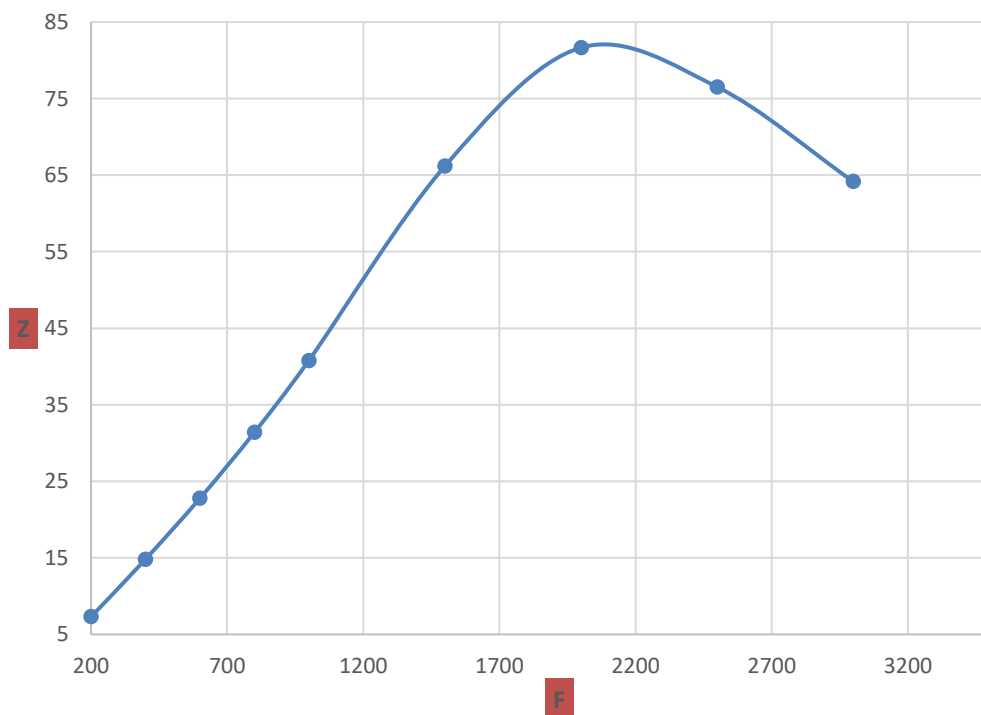
Conclusion

- **Before Resonance:** The circuit has capacitive properties, and the phase angle is **negative**.
- **At Resonance (1591.5 Hz):** Inductive and capacitive reactances cancel out. Impedance drops to its minimum, current reaches its maximum, and the phase angle becomes **zero**.
- **After Resonance:** The circuit has inductive properties, and the phase angle turns **positive**.
- **Phasor Addition:** The experiment proves that AC voltages add vectorially, shown by V_{LC} dropping near zero at resonance due to the 180-degree phase opposition.

Question2: Prallel Circuit

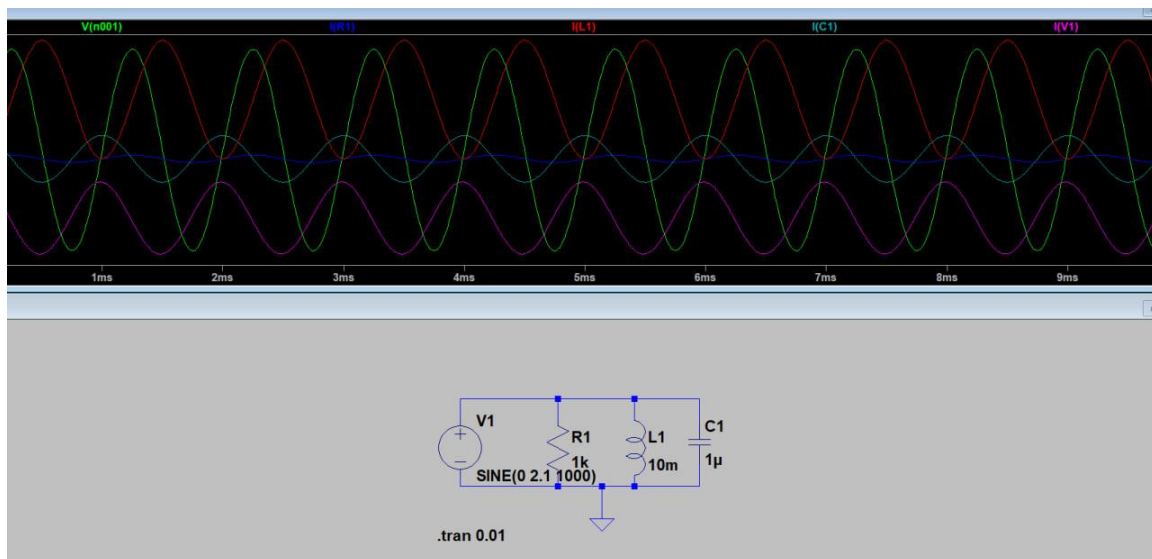
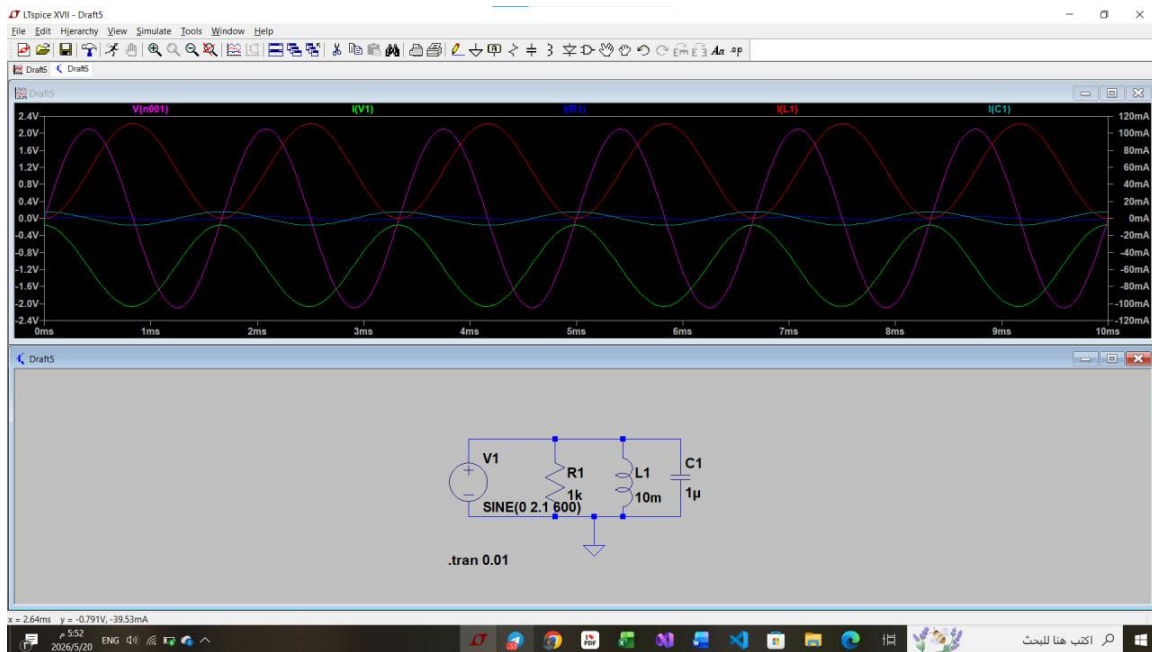
Frequency (Hz)	IS (mA)	IR (mA)	IL (mA)	IC (mA)	VS (V)	Z = V/I (Ω)	Phase Angle (ϕ)
200	mA202.34	mA1.4777	mA203.4	mA1.859	V1.4777	7.3	◦89.58-
400	mA100.19	mA1.4846	mA102.29	mA3.7311	V1.4846	14.82	◦89.14-
600	mA65.112	mA1.4831	mA68.162	mA5.5932	V1.4831	22.78	◦88.64-
800	mA47.224	mA1.4825	mA51.106	mA7.4549	V1.4825	31.39	◦88.05-
1000	mA36.341	mA1.4819	mA40.877	mA9.3164	V1.4819	40.78	◦87.31-
1500	mA22.371	mA1.4807	mA27.236	mA13.99	V1.4807	66.19	◦83.63-
2000	mA18.095	mA1.4777	mA20.402	mA18.59	V1.4777	81.66	◦31.51-
2500	mA19.267	mA1.4741	mA16.295	mA23.19	V1.4741	76.51	◦77.82+
3000	mA22.923	mA1.4706	mA13.558	mA27.768	V1.4706	64.15	◦84.02+

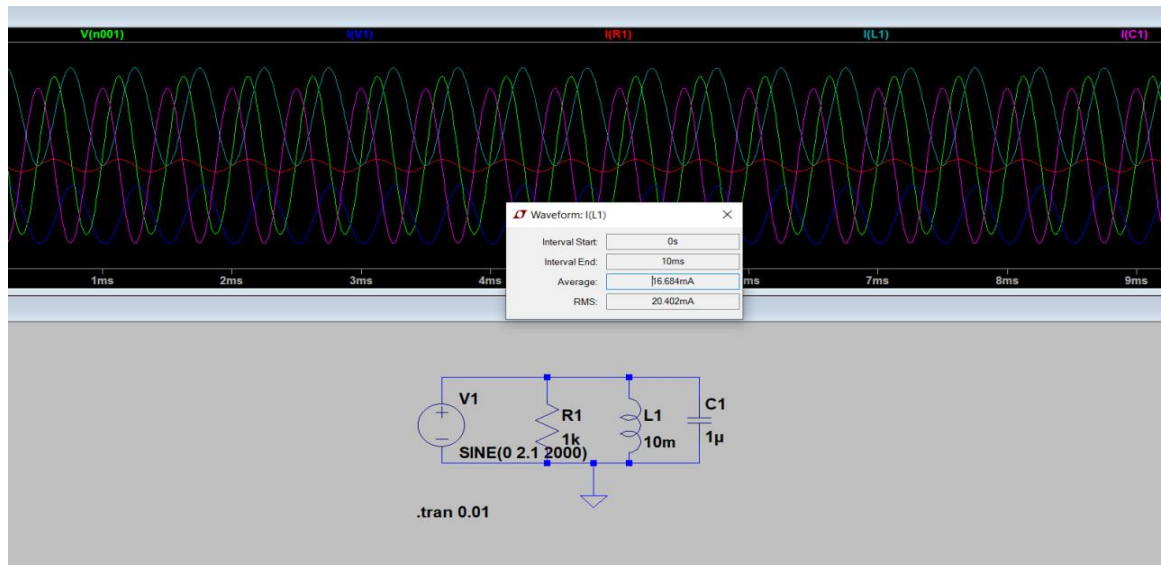
Impedance vs. Frequency Curve



- From the experimental data and the impedance plot, the resonance frequency (f_0) is:

$$F=2000\text{KHZ}$$





Conclusion (Parallel RLC)

- **Before Resonance:** The circuit is **inductive**, and the phase angle is **negative** because the inductor draws most of the current.
- **At Resonance (2000 Hz):** Inductive and capacitive currents cancel out ($I_L = I_C$). Impedance reaches its **maximum**, source current drops to its **minimum**, and the phase angle becomes **zero**.
- **After Resonance:** The circuit becomes **capacitive**, and the phase angle turns **positive** because the capacitor dominates the current.
- **Phasor Addition:** The experiment proves that AC currents add vectorially, where I_L and I_C oppose each other by 180 degrees, minimizing the total source current (I_S) at resonance