RLC CIRCUIT

EXPERIMENT NO-6

SUBMITTED BY
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BEE LAB

AIM: To study the behavior of a series **R-L-C** circuit.

APPARATUS REQUIRED:

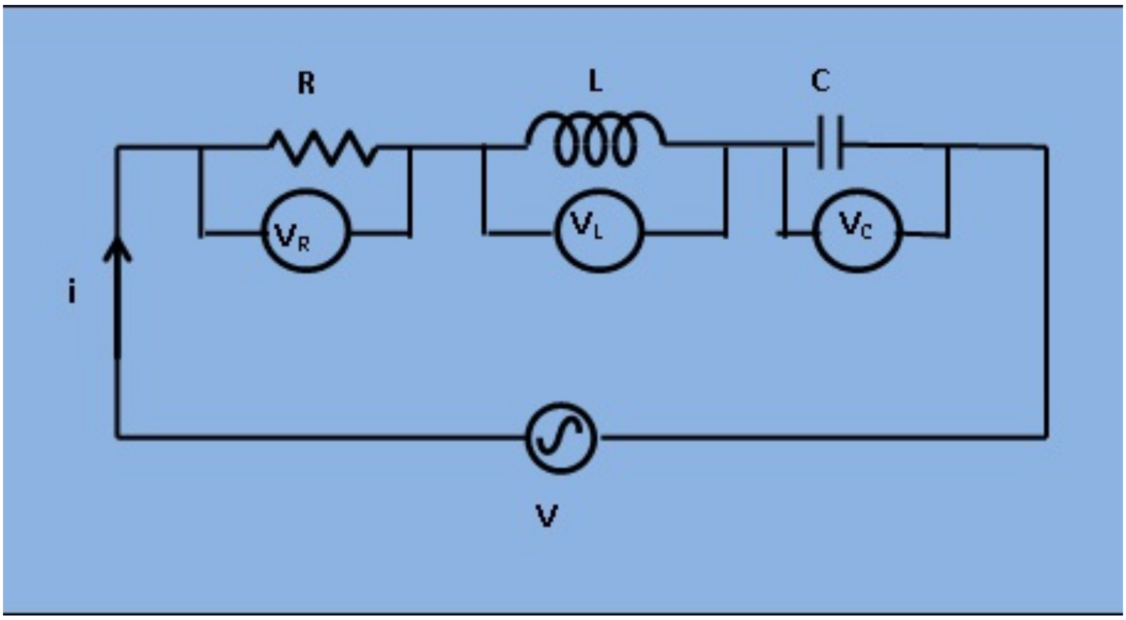
Breadboard, milliammeter, connecting wires, fuse, voltage sources, voltmeter, wattmeter, RLC, switch, auto transformer.

SIMULATOR USED:

VLabs by IITKGP

http://vlabs.iitkgp.ac.in/asnm/exp12/index.html

CIRCUIT DIAGRAM:

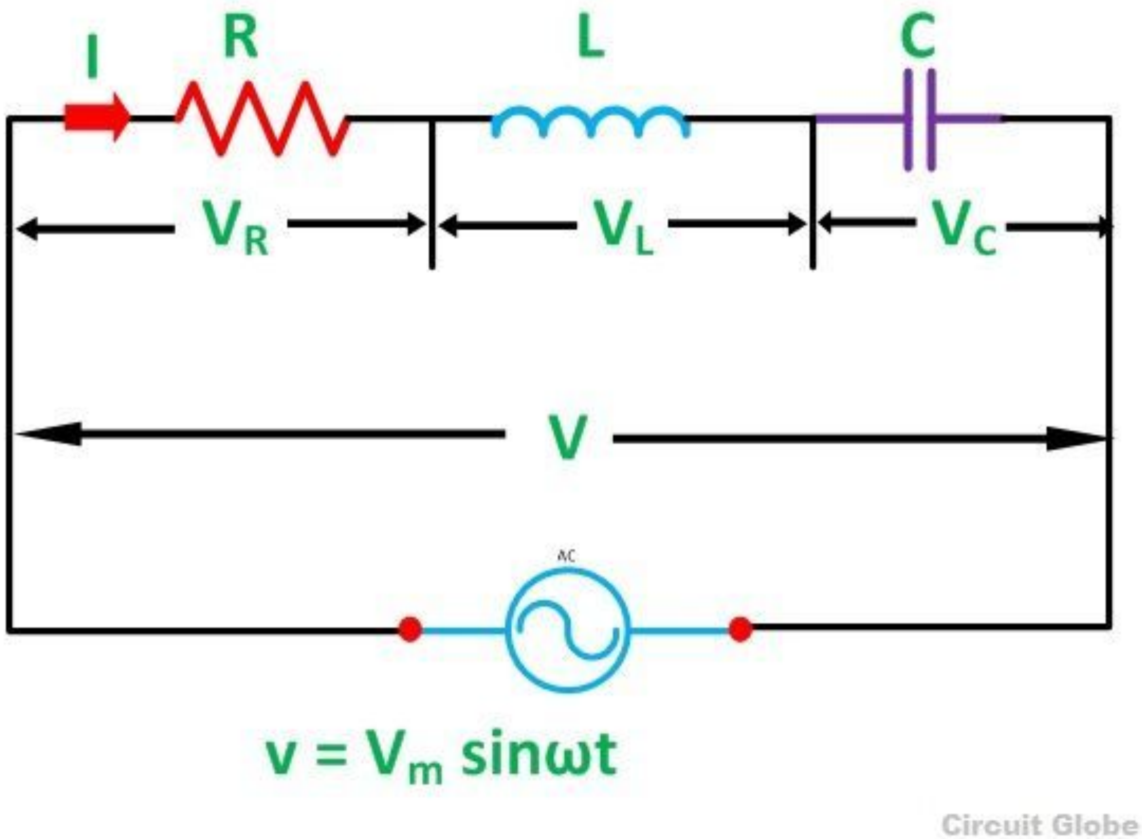


THEORY:

When a pure resistance of R ohms, a pure inductance of L Henry and a pure capacitance of C farads are connected together in series combination with each other then RLC Series Circuit is formed. As all the three elements are connected in series so, the current flowing through each element of the circuit will be the same as the total current I flowing in the circuit.

Impedance Triangle of RLC Series Circuit

The RLC Circuit is shown below:



In the RLC Series circuit

$\mathbf{X_L = 2\pi fL}$ and $\mathbf{X_C = 1/2\pi fC}$

When the AC voltage is applied through the RLC Series circuit the resulting current I flows through the circuit, and thus the voltage across each element will be:

- $V_R = IR$ that is the voltage across the resistance R and is in phase with the current I.

- $V_L = IX_L$ that is the voltage across the inductance L and it leads the current I by an angle of 90 degrees.
- $V_C = IX_C$ that is the voltage across capacitor C and it lags the current I by an angle of 90 degrees.
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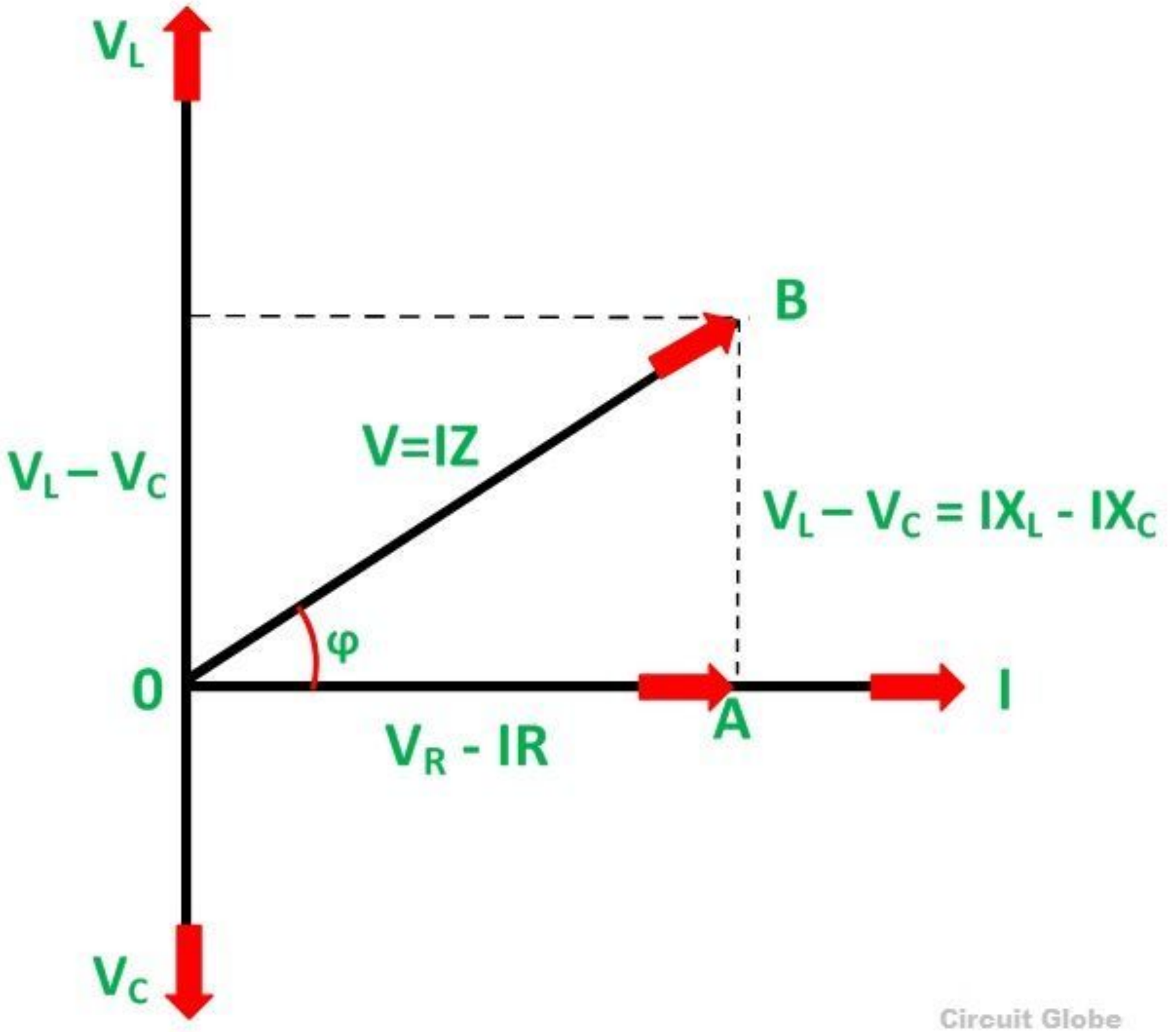
Phasor Diagram of RLC Series Circuit

The phasor diagram of the RLC series circuit when the circuit is acting as an inductive circuit that means ($V_L > V_C$) is shown below and if ($V_L < V_C$) the circuit will behave as a capacitive circuit.



To draw the **Phasor Diagram** of the RLC Series Circuit

- Take current I as the reference as shown in the figure above
- The voltage across the inductor L that is V_L is drawn leads the current I by a 90-degree angle.
- The voltage across the capacitor c that is V_c is drawn lagging the current I by a 90-degree angle because in capacitive load the current leads the voltage by an angle of 90 degrees.
- The two vector V_L and V_C are opposite to each other.

$$V = \sqrt{(V_R)^2 + (V_L - V_C)^2} = \sqrt{(IR)^2 + (IX_L - IX_C)^2} \quad \text{or}$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2} \quad \text{or}$$

$$I = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{V}{Z}$$

-

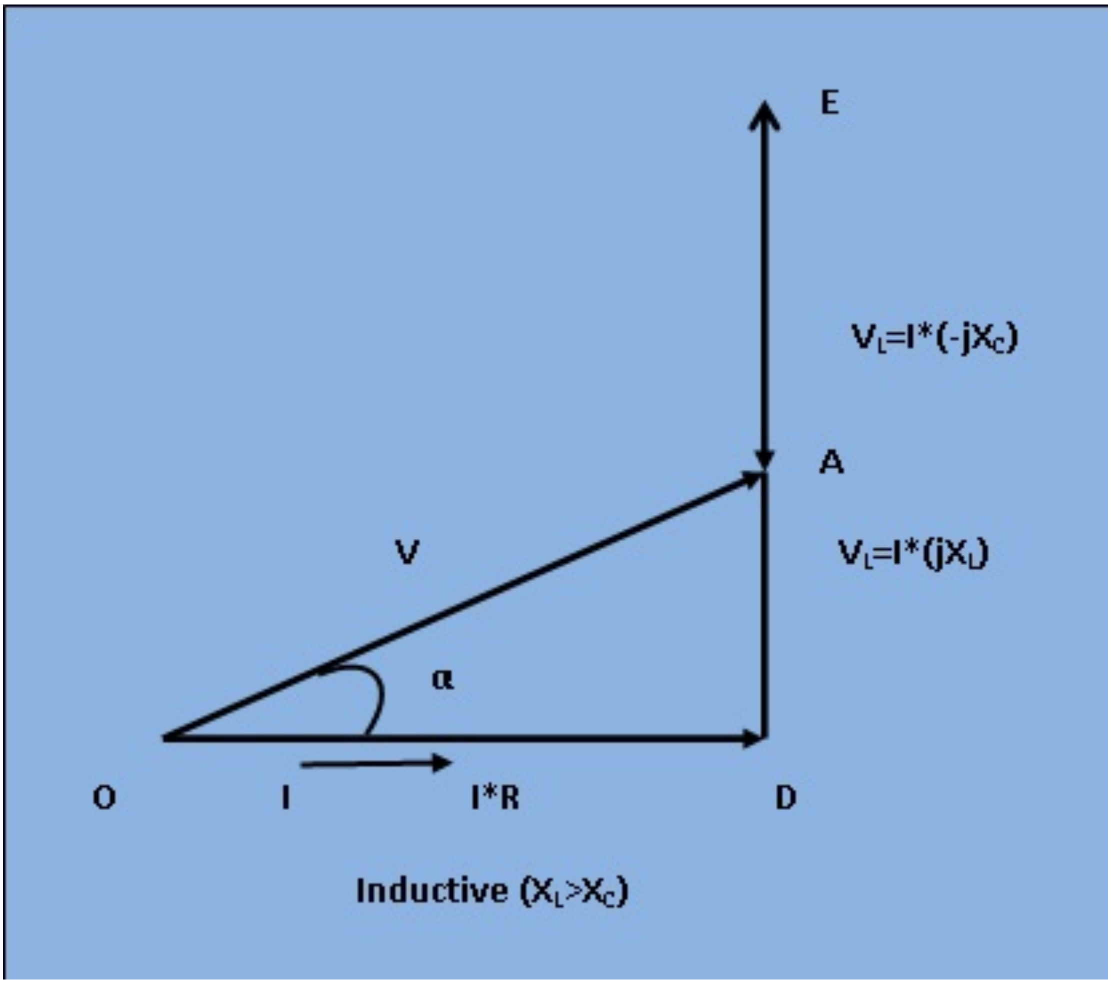
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Where

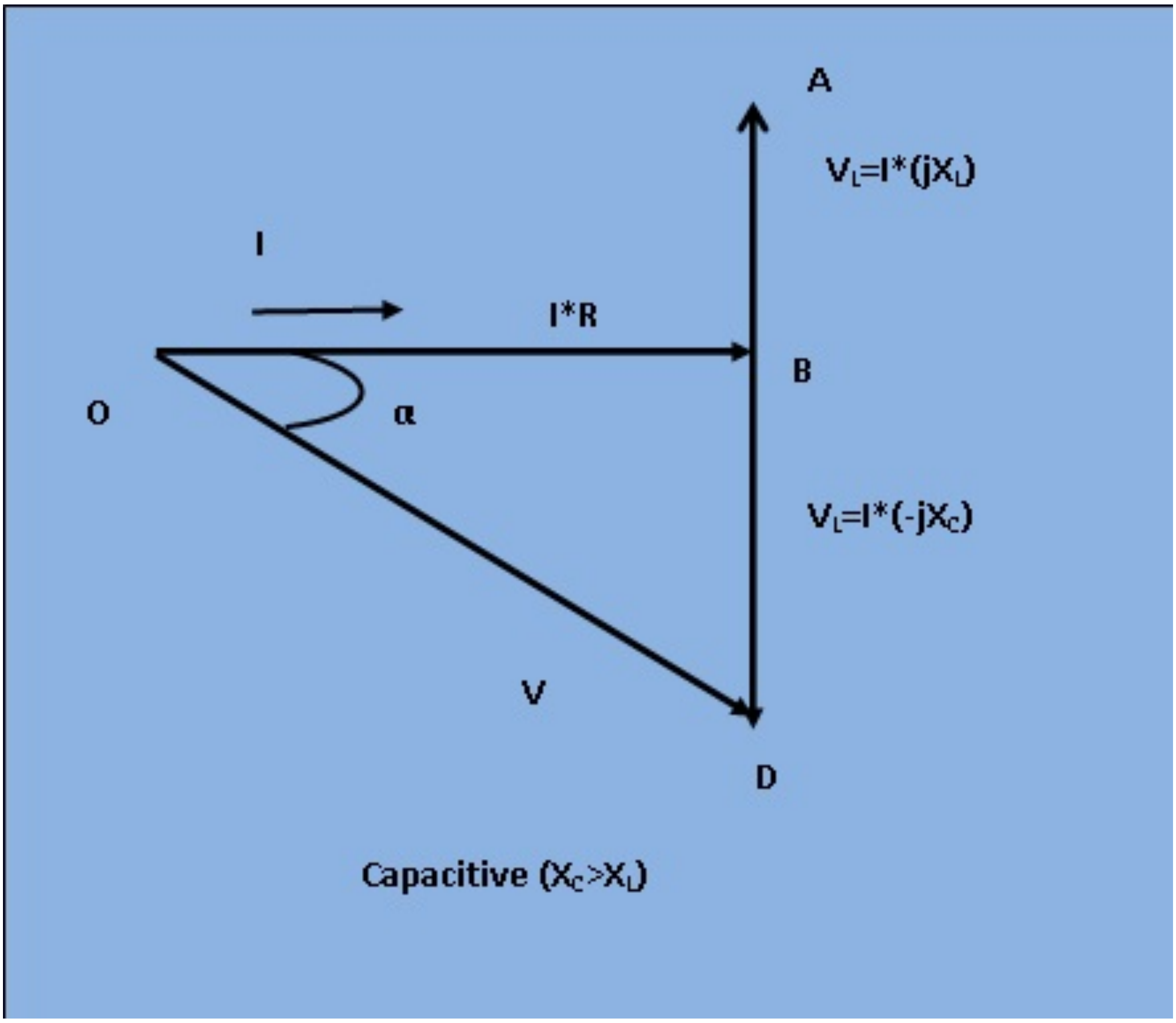
It is the **total opposition** offered to the flow of current by an **RLC** Circuit and is known as **Impedance of the circuit**.

Phasor Diagram:

The phasor diagram for Inductive and capacitive series R-L-C circuit is given in figure 2 and 3 respectively.



[Fig 2: Phasor diagram for inductive circuit]



[Fig 3: Phasor diagram for capacitive circuit]

Phase Angle

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

$$\tan\varphi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R} \quad \text{or}$$

$$\varphi = \tan^{-1}\frac{X_L - X_C}{R}$$

Power in RLC Series Circuit

The product of voltage and current is defined as power.

$$P = VI\cos\varphi = I^2R$$

Where **cosɸ** is the power factor of the circuit and is expressed as:

$$\cos\varphi = \frac{V_R}{V} = \frac{R}{Z}$$

The three cases of RLC Series Circuit

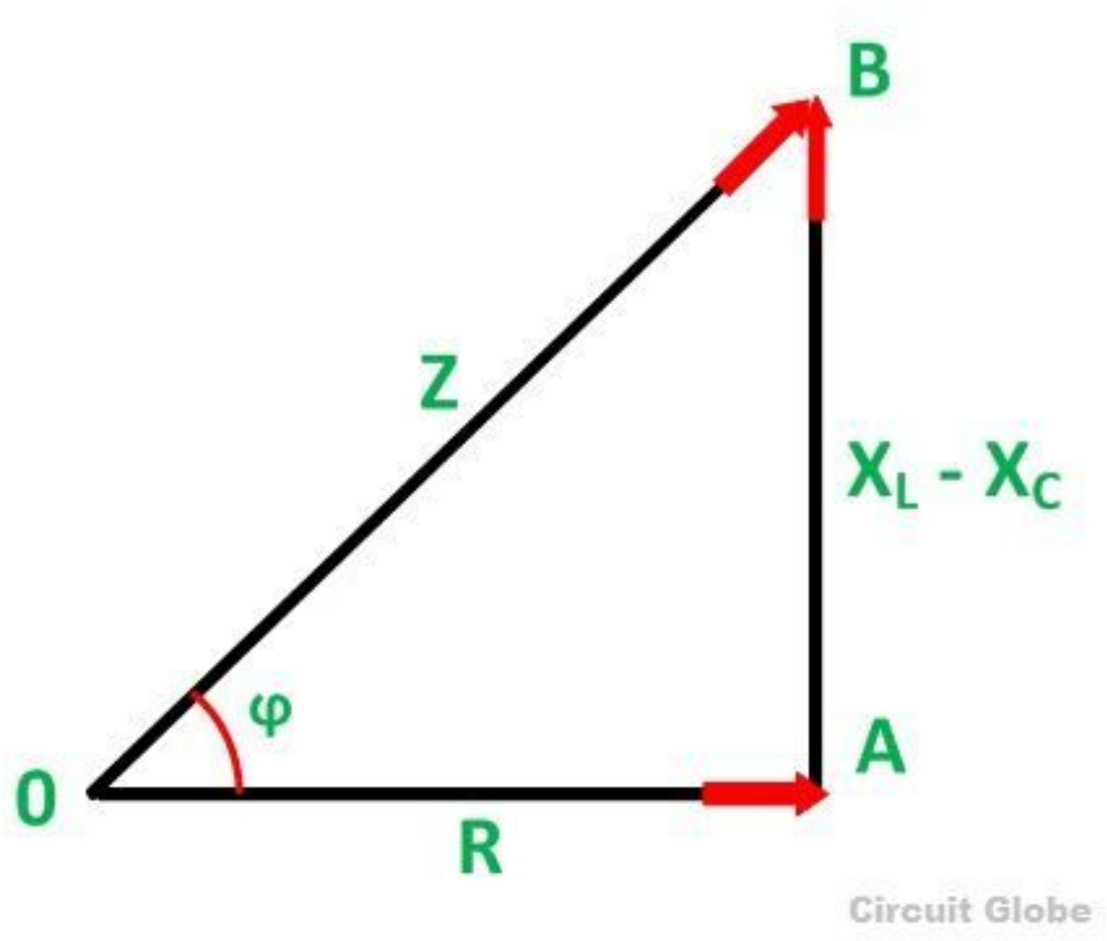
I. When $X_L > X_C$, the phase angle ϕ is positive. The circuit behaves as RL series circuit in which the current lags behind the applied voltage and the power factor is lagging.

II. When $X_L < X_C$, the phase angle ϕ is negative, and the circuit acts as a series RC circuit in which the current leads the voltage by 90 degrees.

III. When $X_L = X_C$, the phase angle ϕ is zero, as a result, the circuit behaves like a purely resistive circuit. In this type of circuit, the current and voltage are in phase with each other. The value of the power factor is unity.

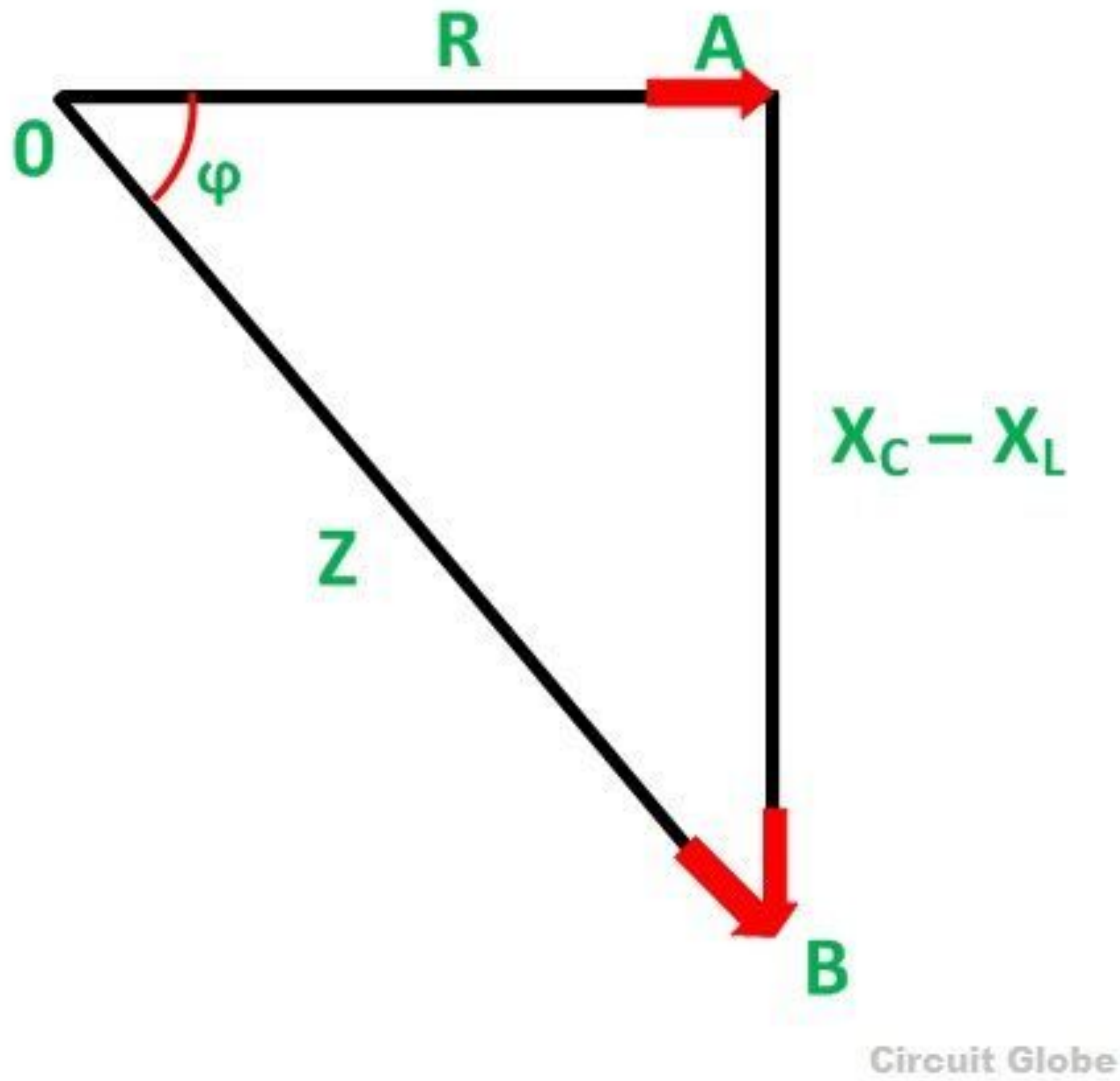
Impedance Triangle of RLC Series Circuit

When the quantities of the phasor diagram are divided by the common factor I then the right angle triangle is obtained known as impedance triangle. The impedance triangle of the RL series circuit, when ($X_L > X_C$) is shown below:



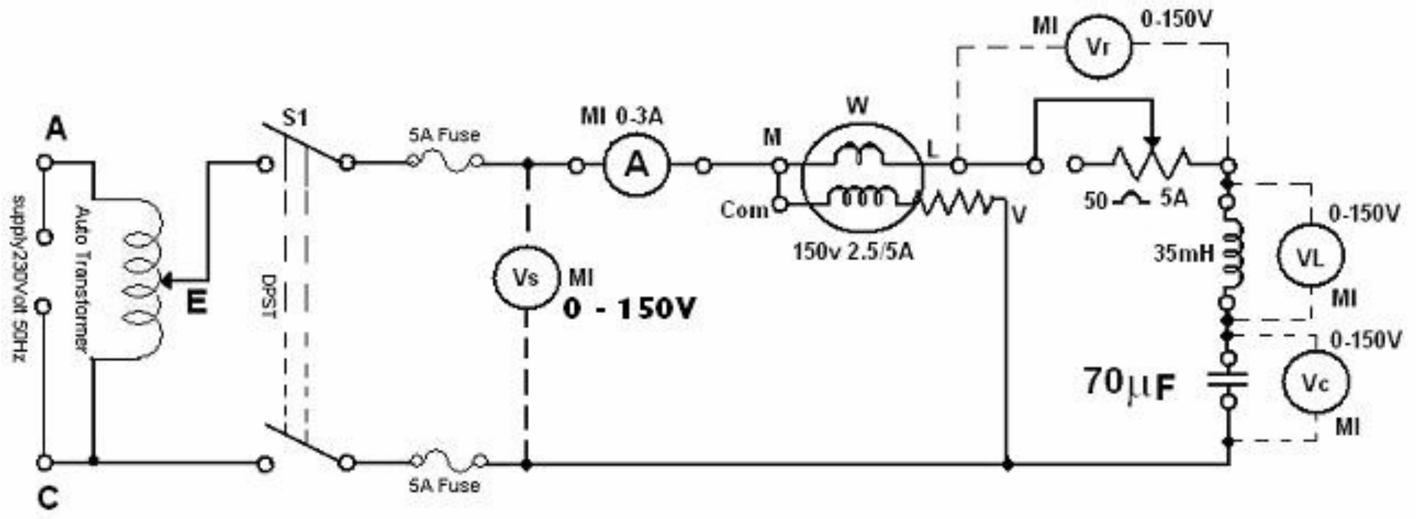
If the inductive reactance is greater than the capacitive reactance than the circuit reactance is inductive giving a lagging phase angle.

Impedance triangle is shown below when the circuit acts as an RC series circuit ($X_L < X_C$)



When the capacitive reactance is greater than the inductive reactance the overall circuit reactance acts as capacitive and the phase angle will be leading.

Procedure
Circuit Diagram



[Fig 1: Circuit Diagram for experimental set-up of R-L-C circuit analysis]

1. Connect the circuit as shown in the diagram in figure 1.

2. Adjust the rheostat for maximum resistance and the auto transformer to the position of zero-output voltage and switch on the supply.

3. Adjust the voltage across the circuit to about 70 V and note I,Vs,VL,VC,VRI,Vs,VL,VC,VR and WW.

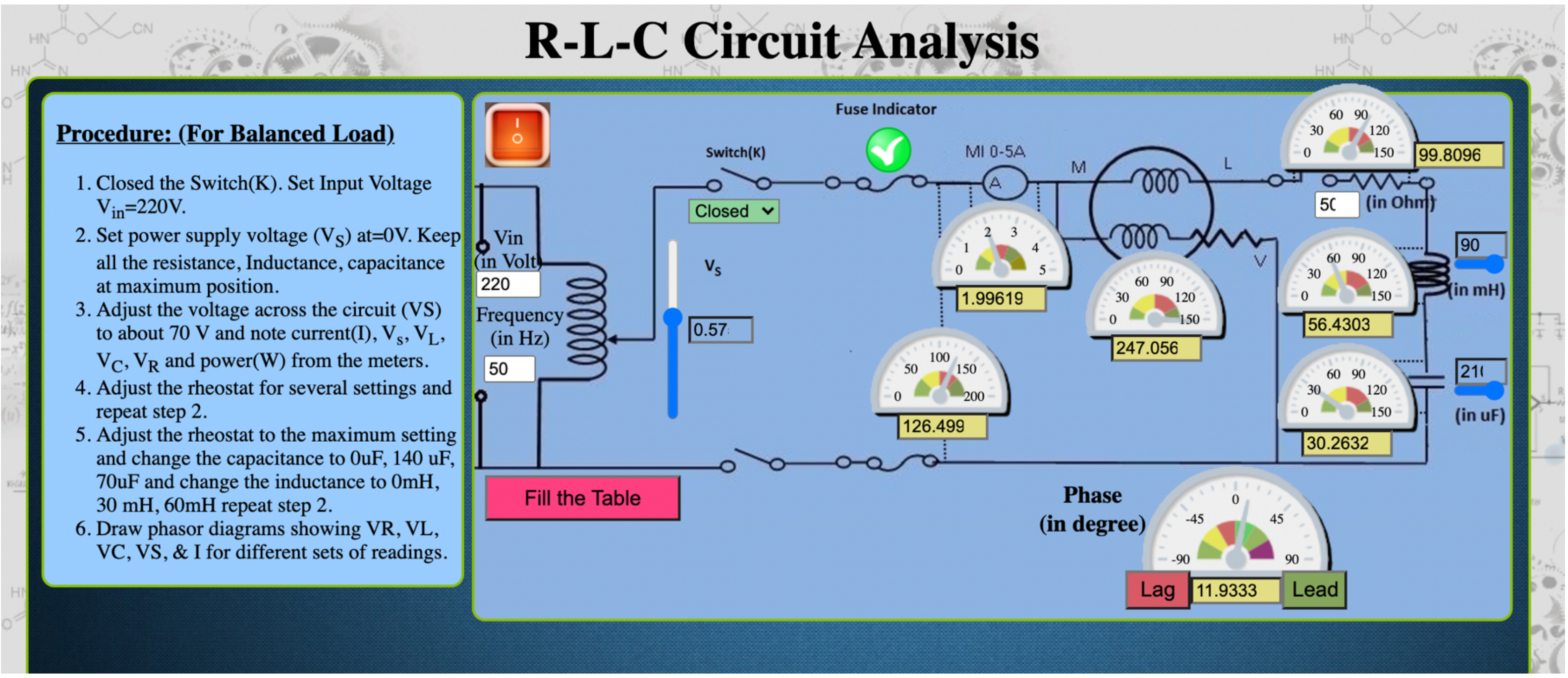
4. Adjust the rheostat for several settings and repeat step 3.

5. Adjust the rheostat to the maximum setting and change the capacitance to 140 μF and repeat step 4.

6. Compare the values of phase angle as obtained from the meter readings and from the phasor diagrams. (From the phasor diagrams compute cosθ and θ). Draw phasor diagrams showing I,Vs,VL,VC,I,Vs,VL,VC, and VRVR for different sets of readings.

OBSERVATIONS

THE ABOVE SS IS OF THE VIRTUAL LAB



OBSERVATION TABLE

Observation Table

Serial no. of Observation	Power Supply Vs (in Volt)	Current I (in Amp)	Power (in Watt)	VR (in Volt)	VL (in Volt)	VC (in Volt)	Theta (in degree)	Power factor (in degree)
1	126.499999	3.80691163	362.314404	95.1727908	71.7450566	86.5718750	-6.7282903	6.72829034
2	126.499999	3.46430870	360.043043	103.929261	32.6441808	78.7808409	-21.381541	21.3815417
3	126.499999	2.50093513	218.913679	87.5327298	47.1326236	113.746083	-31.762465	31.7624653
4	126.499999	2.35889526	222.575475	94.3558106	66.6836103	35.7619694	14.1430403	14.1430403
5	126.499999	1.99619368	199.239462	99.8096844	56.4303994	30.2632417	11.9333075	11.9333075

CONCLUSION/RESULT

WE STUDIED THE BEHAVIOUR OF **R-L-C** CIRCUIT THROUGH THIS EXPERIMENT