Steady-State Response Of RLC Circuits
ELP100
LAB REPORT 4

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Contents

1 Steady-State Response Of RLC Circuits

1.1 Aim

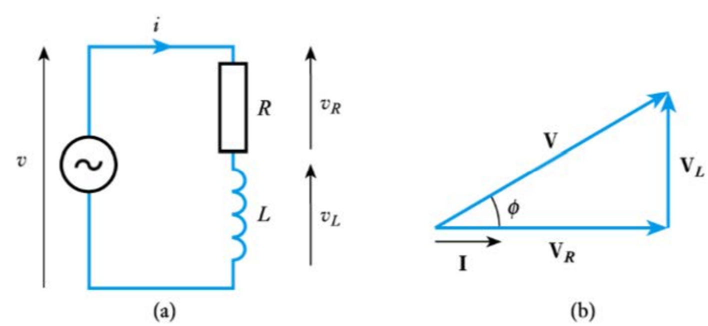
To draw the phasor diagram of series RLC circuit and compare the experimental and theoretical results.

1.2 Apparatus

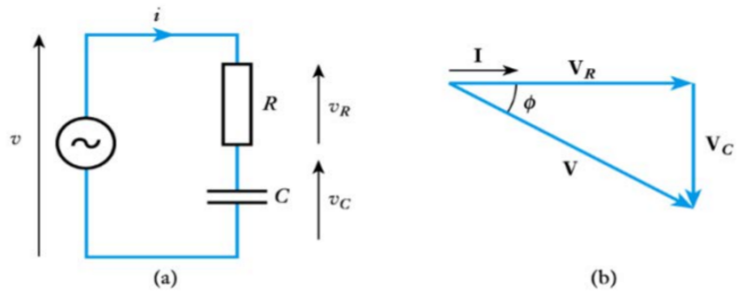
1. Signal Generator
2. Components
3. Bread board
4. Multimeter
5. Digital Storage Oscilloscope (DSO1052B)
6. Jumpers

1.3 Theory

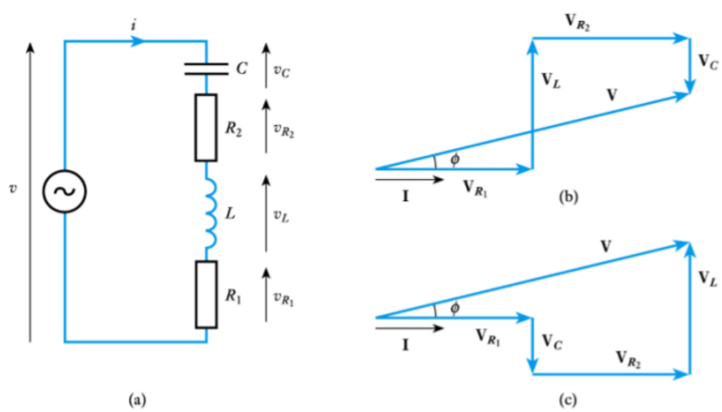
The amplitude, frequency, and phase of sinusoidal signals are defining characteristics.
In many circuits, the frequency is fixed (possibly at the frequency of the AC supply), and we are only concerned with the amplitude and phase.
In such situations, phasor diagrams are frequently used to represent amplitude and phase in a single diagram.
The addition of signals can be depicted by phasor diagrams. This provides the amplitude and phase of the final signal.



Phasor Diagram for RL



Phasor Diagram for RC Circuit



Phasor Diagram for RLC Circuit

For R,L and C, the current at any time t is given by:

$$I(t) = I_{max} sin(\omega t) \tag{1}$$

The inductive reactance(X_L) and capacitive reactance(X_C) of and inductor and capacitor are defined respectively as follows:

$$X_L = \omega L \; and \; X_C = \frac{1}{\omega C} \tag{2}$$

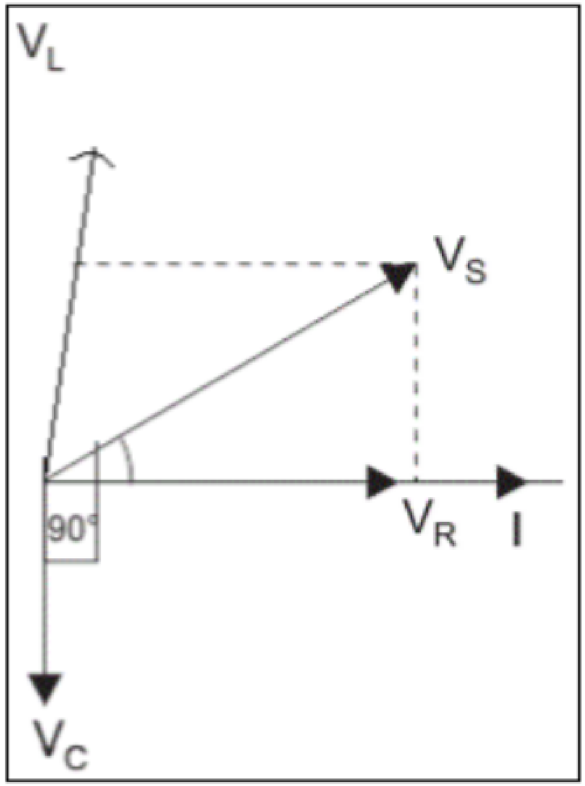
For an AC Circuit:

1. The instantaneous voltage across a pure resistor, V_R is "in-phase" with the current.

2. The instantaneous voltage across a pure inductor, V_L "leads" the current by 90°.

3. The instantaneous voltage across a pure capacitor, V_C "lags" the current by 90°.

In actual practice, the inductors have finite internal resistance and hence are not 90°out of phase, instead the phase difference is slightly less than 90°.



Real Phasor Diagram for RLC Circuit

To get the actual phase angle of inductor, measure the dc resistance of the inductance coil separately.
Therefore we will have to find the supply voltage, V_S as the phasor Sum of the three component voltages combined together vectorially. So, finally impedance of
Resistor=Z_R=R
Capacitor=Z_C=$\frac{1}{\omega C}$
Inductor=Z_L=ω L

$$V_R = I_{max}R, V_C = I_{max}X_C, V_L = I_{max}X_L \tag{3}$$

Therefore, the net impedance of the circuit is:

$$Z = \sqrt{R^2 + (X_L - XC)^2} \tag{4}$$

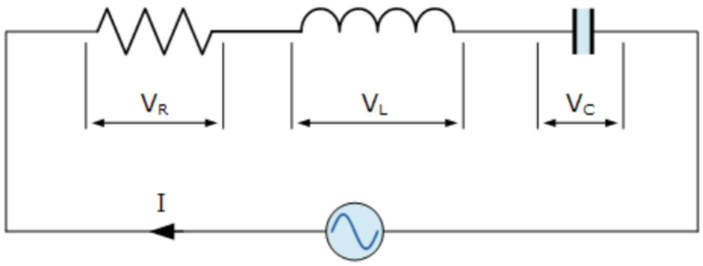
$$Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2} \tag{5}$$

The phase angle of impedance is given by:

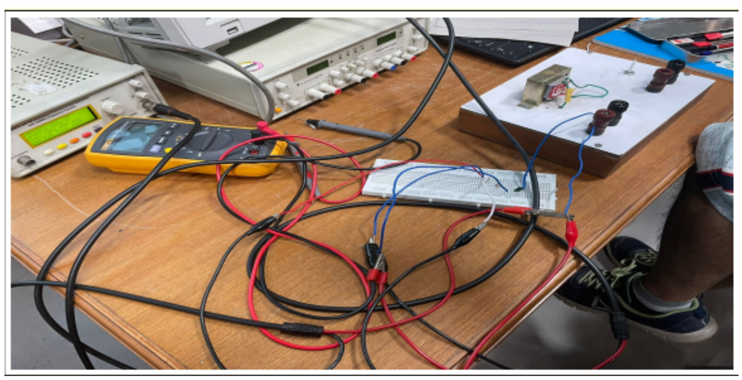
$$\phi = tan^{-1}(\frac{X_L - X_C}{R}) \tag{6}$$

The final expression for source voltage V_S is given by:

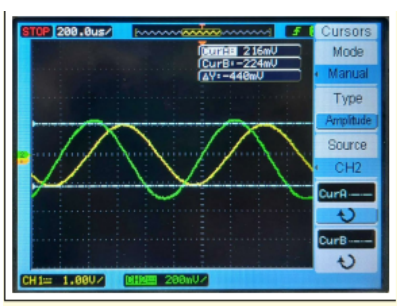
$$V_S = I_{max} Z sin(\omega t + \phi) \tag{7}$$



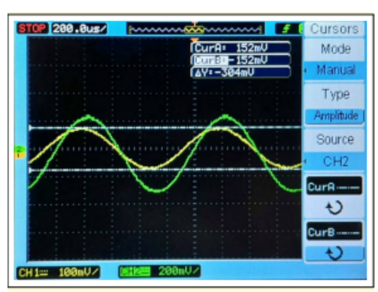
1.4 Breadboard Setup



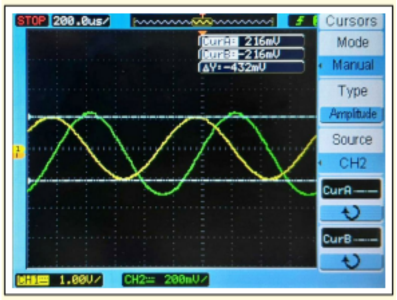
1.5 DSO Images



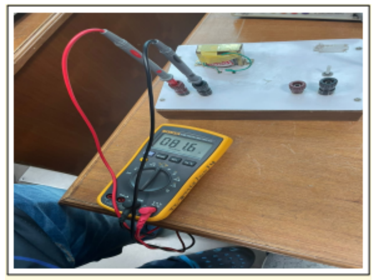
Voltage across Capacitor



Voltage across Resistor



Voltage across Real Inductor



Measurement of Resistance of Inductor

1.6 Observation

R= 1kΩ , L= 2H , C= 0.01µF and V_{PP}=2V

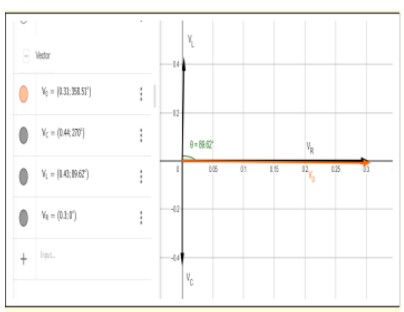
Frequency(kHz)	V_0(v)	V_R(V)	V_L(V)	V_C(V)	I=$\frac{V_R}{R}$(mA)
1	2	0.304	0.44	0.432	0.304
2	2.1	0.205	1.47	3.22	0.207

1.7 Calculations

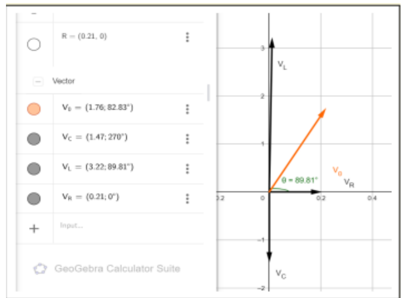
Frequency(kHz)	V_L(V)	X_L(Ω)	Phase Difference
1	0.432	12566.37	89.62°
2	3.22	25132.74	89.61°

V_L(V)	I(mA)	Phase Difference	r(Ω)
0.432	0.304	89.62°	74.37
3.22	0.207	89.81	58.32

1.8 Phasor Diagrams



Phasor for 2^{nd} Observation



Phasor for 1^{st} Observation

1.9 Conclusion

The difference in reading may be attributable to some resistance in the connecting wires. In addition, due to deflection in the reading of the multimeter, the obtained values may not be precise, as the error in the values is acceptable as long as it does not exceed the Least Count.

2 Sources Of Error

1. Resistance of wires not taken into account, and also giving rise to inconsistency due to increase in resistance due to heating.
2. Loose Connections
3. Scale of multi-meter not appropriate for measurements
4. Change in the connections while circuit is closed.

3 Precautions

1. Make the connections neat and tight
2. Don't leave the switch on for long continuous periods of time.
3. Wear proper shoes and use insulated tools.

4 Concluding Remarks

In the above experiment, we analysed the steady state response of a series RLC circuit to an ac input by producing phasor diagrams and validating the impedance relationships with the measured values. We also confirmed that the phase difference between voltage signals across a resistor and a capacitor is a right angle, as is the phase difference between an inductor and a resistor (since the inductor coil is not ideal and has a nonzero resistance).