25-1-23.

EECT Lab Practicals.

Experiment - 1

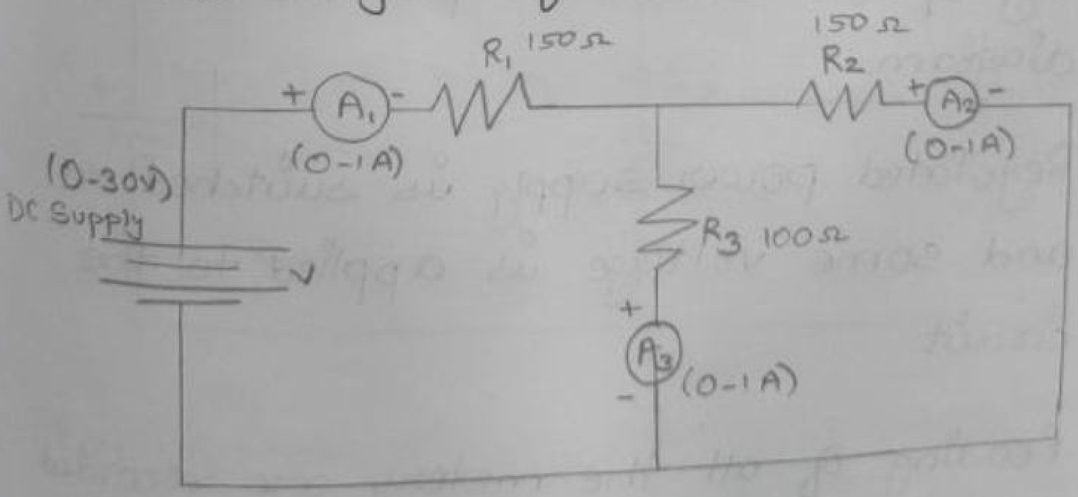
Verification of Kirchoff's Law in D.C. Circuits

Aim - To conduct an experiment on D.C. circuits for verifying KCL

Apparatus Required -

1. Ammeter (0-250mA) MC
2. Voltmeter (0-30 V) MC
3. Resistors (10 Ω ± 10%
   100 Ω ± 10%,
   200 Ω ± 10%)
4. Regulated DC power supply (0-30V)
5. Connecting wires.

Circuit diagram for KCL



Theory - For the analysis of complex electrical networks ohm's law usage takes lot of time. Hence for such purposes Kirchoff's law comes in handy.

"In a linear bilateral network the algebraic sum of currents meeting at a point is zero."

KCL is applied to a node (or junction) and hence verification is to be done at a node. i.e., $\Sigma I = 0$ putting it another way KCL can also be stated as

Algebraic sum of incoming currents = Algebraic sum of outgoing currents

Procedure -

1. Rig up the circuit as per the circuit diagram.

2. Regulated power supply is switched on and some voltage is applied to the circuit.

3. Reading of all the meters are recorded.

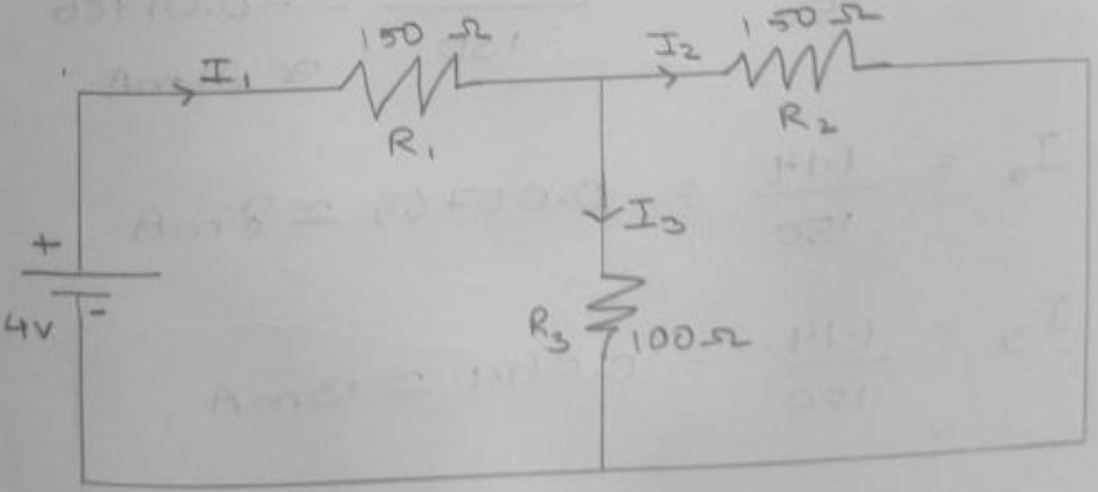
4. Experiment is repeated for different supply voltages and readings are tabulated.

5. Bring back the Regulated power supply output voltage to zero and switch off the supply.

Tabular Column -

S.No.	V	I_1	I_2	I_3
1.	2	11.1	3	8.1
2.	4	24	10	14
3.	6	37.6	18.6	19.1
4.	8	49.8	24.7	25.2

Calculations (Nodal Analysis) -



For $V_1 = 4V$

At node 1,

According to KCL the algebraic sum of currents is equal to zero.

$$\Rightarrow I_1 + I_2 + I_3 = 0$$

Ohm's Law,

$$I = \frac{V}{R}$$

$R_1 = 150\,\Omega$, $R_2 = 150\,\Omega$, $R_3 = 100\,\Omega$

$$\frac{V-4}{150} + \frac{V}{100} + \frac{V}{150} = 0$$

$$\frac{2V - 8 + 3V + 2V}{300} = 0$$

$$7V - 8 = 0$$

$$V = \frac{8}{7} = 1.142$$

$$I_1 = \frac{1.14-4}{150} = \frac{-2.857}{150} = -0.01986$$
$$\approx 21\,mA$$

$$I_2 = \frac{1.14}{150} = 0.00769 \simeq 8\,mA$$

$$I_3 = \frac{1.14}{100} = 0.0114 \simeq 13\,mA$$

Verification

$$I_1 = I_2 + I_3$$

$$I_1 = 8 + 13$$

$$I_1 = 21\,mA$$ Hence proved

Theoretical value = 21 mA

Practical value :

$$I_2 + I_3 = 10 + 14 = 24\,mA = I_1$$

Comparison

	I_1	I_2	I_3	$I_1 = I_2 + I_3$
Practical	24	10	14	$I_1 = 10 + 14 = 24$
Theoretical	21	8	13	$I_1 = 8 + 13 = 21$

Result - Thus Kirchoff's Current Law for DC circuit is verified, both theoretically and practically.

Experiment - 2

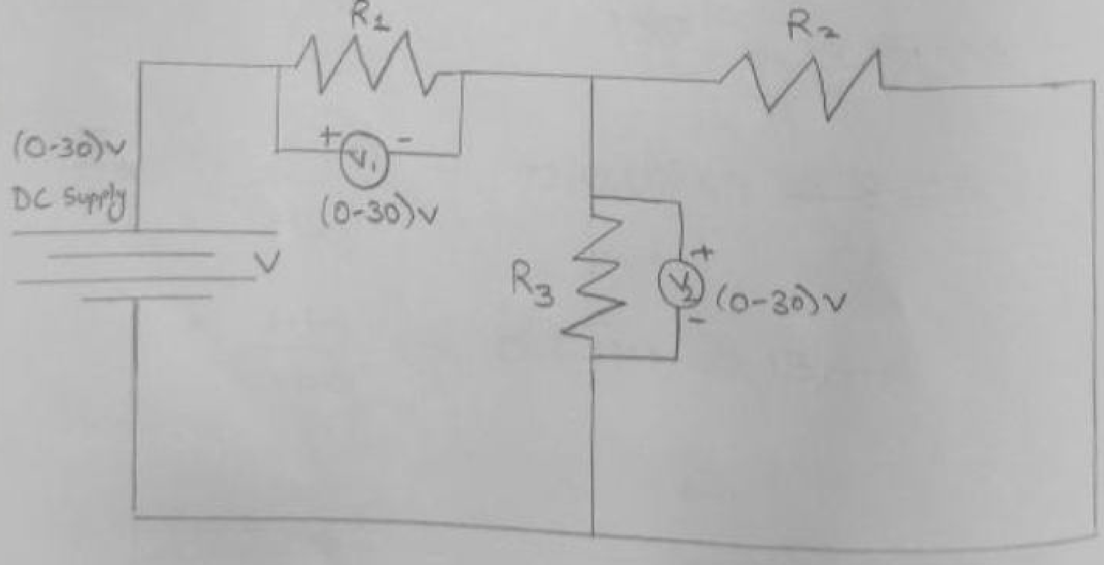
Verification of Kirchoff's Law in D.C. Circuits.

Aim - To conduct an experiment on D.C. circuits for verifying KVL.

Apparatus Required -

1. Ammeter (0 - 250 mA) MC
2. Voltmeter (0 - 30 V) MC
3. Resistors (10 Ω ± 10%,
   100 Ω ± 10%
   200 Ω ± 10%)
4. Regulated DC power supply (0-30V)
5. Connecting wires.

Circuit diagram for KVL



Theory - For the analysis of complex electrical networks ohm's law usage takes lot of time. Hence for such purposes Kirchoff's laws comes in handy.

Kirchoff's Voltage Law (KVL)

"In a linear bilateral network the algebraic sum of emf's of the sources and the voltage drops across the elements around a mesh (or closed path) is zero."

i.e. $\Sigma e + \Sigma IR = 0$ for D.C. circuits

$\Sigma e + \Sigma IZ = 0$ for A.C. circuits

When analyzing a circuit the emf's are taken as voltage rises and voltage across elements as voltage drops. Hence Kirchoff's voltage law can also be stated as

Sum of the voltage rises = Sum of the Voltage drops.

Procedure -

1. Rig up the circuit as per the circuit diagram.
2. Regulated power supply is switched on and some voltage is applied to the circuit.
3. Readings of all the meters are recorded.
4. Experiment is repeated for different

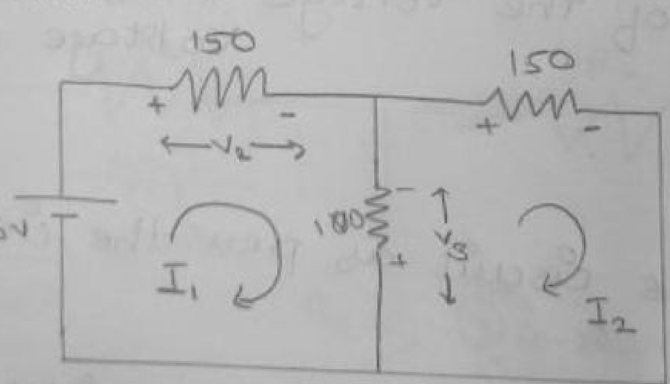
supply voltages and readings are tabulated

5. Bring back the Regulated power supply output voltage to zero and switch off the supply.

Tabular column -

S.No	V_1	V_2	V_3
1.	2.0	1.36	0.7
2	4.0	2.72	1.3
3	6.0	4.0	2.0
4	8.0	5.33	2.7

Calculation -



for $V_1 = 6V$

ⓐ Mesh - ①

According to KVL Sum of the voltages in a mesh is zero.

⇒ According to ohm's Law

$$\boxed{V = IR}$$

$\Rightarrow 250 I_1 - 100 I_2 = 6$ —— ①

@ Mesh 2

$-100 I_1 + 250 I_2 = 0$ —— ②

By solving equations ① & ② we get,

$I_1 = 0.02857$ & $I_2 = 0.01142A$

$\therefore \boxed{I_1 = 0.02857A}$; $\boxed{I_2 = 0.01142A}$

$V_2 = I_1 R_1 = 0.02857 \times 150 = 4.285V$

$\Rightarrow \boxed{V_2 = 4.285V}$

$V_3 = (I_1 - I_2) R_2 = 0.01715 \times 100 = 1.715V$

$\Rightarrow \boxed{V_3 = 1.715V}$

Verification -

$$\boxed{V_1 = V_2 + V_3}$$

Theoretically -

$V_1 = 6V$; $V_2 = 4.285V$; $V_3 = 1.715V$

$V_2 + V_3 = 4.285 + 1.715$
$= 6.00V$

$\therefore \boxed{V_1 = V_2 + V_3}$

Practically -

$V_1 = 6V$, $V_2 = 4V$, $V_3 = 2V$

$V_2 + V_3 = 4 + 2 = 6V$ $\Rightarrow \boxed{V_1 = V_2 + V_3}$

Comparison -

	V_1	V_2	V_3	$V_2 + V_3$
Practical	6	4	2	$4 + 2 = 6V$
Theoritical	6	4.285	1.715	$4.285 + 1.715 = 6.00 = V_1$

Result -

Thus Kirchoff's Voltage Law for DC circuit is verified ~~for~~ both theoretically and practically.

Experiment - 3

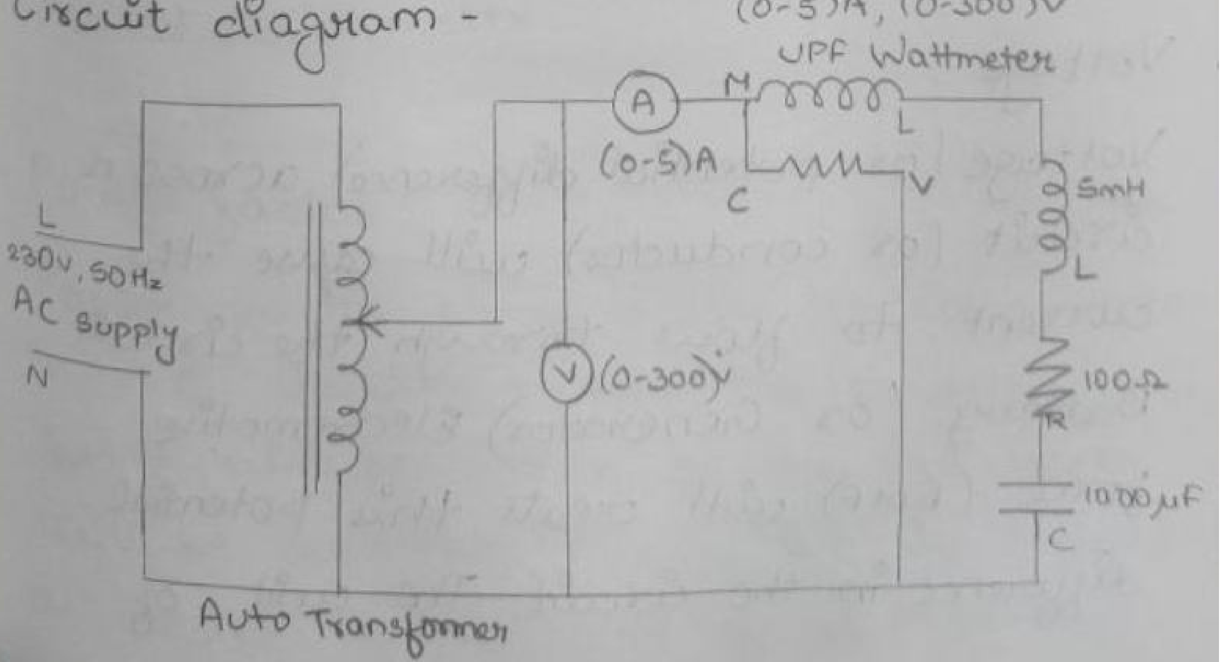
Measurement of Electrical Quantities - Voltage, Current, Power And Power Factor in RLC Circuit.

Aim - To conduct an experiment for measuring electrical quantities - voltage, current, power and power factor in RLC circuit.

Apparatus Required -

1. Ammeter (0-5A) MI
2. Voltmeter (0-300 V) MI
3. Resistor (0-100 Ω)
4. Inductor (0-10mH)
5. Capacitor 1000 μF
6. Single Phase Auto transformer
7. Wattmeter 5A, 300V, UPF
8. Connecting wires.

Circuit diagram -



Theory - In all electrical networks parameters like current, voltage, etc. are frequently measured and calculated for various purposes. Hence knowledge of measurement of such quantities is essential for students of engineering.

Current :

Flow of electrons inside a wire (or device), constitute current "Rate of flow of charge is defined as current".

$I = \frac{dq}{dt}$ coulomb / sec or Ampere

The meter used to record the current is called Ammeter. Moving iron type of ammeter is used for measuring alternating current and moving coil type is used for measuring direct current.

Voltage :

Voltage (or potential difference) across a circuit (or conductor) will cause the current to flow through the circuit. Battery (or Generator) Electromotive force (EMF) will create this potential difference in the circuit. The unit of potiential difference is volts and the meter used to measure voltage is called voltmeter.

Power :

The rate of energy consumed by the circuit (or load) is called power. In D.C. circuits it is given as a product of voltage across the circuit and current in the circuit.

$$\boxed{P_{dc} = \text{Voltage} \times \text{current}}$$

However in alternating current (A.C) circuits it is given by

$P_{ac} = \text{Voltage} \times \text{current} \times \text{Power factor}$

$P_{ac} = VI\cos\phi$

The unit of power is watt.

The meter which measures power is called Wattmeter.

Power factor :

Power factor plays a very important role in A.C. circuits. Higher the power factor better will be active power and lesser will be reactive power. It is defined as cosine of the angle of lead (or lag) between voltage and current. It can be calculated as follows.

a) $\cos\phi = \frac{\text{Resistance of the circuit}}{\text{Impedance of the circuit}} = R/Z$

b) $\cos\phi = \frac{\text{Active power}}{\text{Volt amperes}} = VI\cos\phi / VI$

Procedure -

1. Connect the circuit as per the circuit diagram keeping auto transformer at off position.

2. Switch on the supply and apply some voltage to the circuit by varying the autotransformer.

3. Note down the readings of all meters

4. By varying the autotransformer for different voltages, readings are taken and tabulated.

5. Bring back the autotransformer to zero output position and switch off the supply.

Tabular column -

S.No	V	I	W	P = W * K	cos φ = P/VI
1.	40	0.5	18	18.72	0.936
2.	60	1	40	41.6	0.693
3.	80	1.25	80	83.2	0.832
4.	100	1.6	142	47.6	0.913
5.	120	1.9	210	218.4	0.957

Note :- $\cos\phi \le 1$

Calculations -

$$\boxed{P = W \times K}$$

$$\boxed{\cos\phi = P/VI}$$

$$\boxed{K = \frac{\text{Voltage Range} \times \text{Current Range} \times \text{Power Factor}}{\text{Wattmeter Range}}}$$

Active power (Q) = $VI\cos\phi$

Reactive power (Q) = $VI\sin\phi$

Apparent power (S) = $V \cdot I$

Volt range = 250 ; Current range = 5 ;
power factor = 1 ; wattmeter range = 1200

$$\Rightarrow K = \frac{250 \times 5 \times 1}{1200} = 1.04$$

$$\therefore \boxed{K = 1.04}$$

i) $I = 0.5A$; $V = 40V$; $W = 18$

$P = W \times K$

$= 18 \times 1.04 = 18.72$

$$\therefore \boxed{P = 18.72}$$

$$\cos\phi = \frac{P}{VI} = \frac{18.72}{40 \times 0.5} = 0.936$$

$$\therefore \boxed{\cos\phi = 0.936}$$

Active power $= VI\cos\phi$

$P = 40 \times 0.5 \times 0.936 = 18.72$

Reactive power $= VI\sin\phi$

$Q = 40 \times 0.5 \times 0.351 = 7.02$

$$\therefore \boxed{Q = 7.02}$$

Apparent power $= VI$

$S = 40 \times 0.5 = 20$

$$\boxed{S = 20}$$

2) $I = 1.0A$; $V = 60V$; $W = 40$

$P = W \times K$

$= \cancel{41.6}\ 40 \times 1.04 = 41.6$

$\therefore \boxed{P = 41.6}$

$\cos\phi = \frac{P}{VI} = \frac{41.6}{60 \times 1} = 0.693$

$\boxed{\cos\phi = 0.693}$

Active power = $VI\cos\phi$

$P = 60 \times 1 \times 0.693$

$\boxed{P = 41.6}$

Reactive power = $VI\sin\phi$

$Q = 60 \times 1 \times 0.72 = 43.2$

$\therefore \boxed{Q = 43.2}$

Apparent power = VI

$S = 60 \times 1 = 60$

$\therefore \boxed{S = 60}$

3) $I = 1.25A$; $V = 80V$; $W = 80$

$P = W \times K$

$= 80 \times 1.04 = 83.2.$

$\cos\phi = \frac{P}{VI} = \frac{83.2}{80 \times 1.25} = 0.832$

$\boxed{\cos\phi = 0.832}$

Active power = $VI\cos\phi$

$\therefore \boxed{P = 83.2}$

Reactive power = $VI\sin\phi$

$Q = 80 \times 1.25 \times 0.554 = 55.$

$\therefore \boxed{Q = 55.4}$

Apparent power = VI

$S = 80 \times 1.25 = 100$

$\therefore \boxed{S = 100}$

4) $I = 1.6A$; $V = 100V$; $W = 142$

$P = W \times K$

$= 142 \times 1.04 = 147.68$

$\cos\phi = \frac{P}{VI} = \frac{147.68}{100 \times 1.6} = 0.923$

$\therefore \boxed{\cos\phi = 0.923}$

Active power = $VI\cos\phi$

$\therefore \boxed{P = 147.68}$

Reactive power = $VI\sin\phi$

$= 100 \times 1.6 \times 0.384 = 61.44$

$\therefore \boxed{Q = 61.44}$

Apparent power = VI

$S = 100 \times 1.6$

$\therefore \boxed{S = 160}$

5) $I = 1.9\ A$; $V = 120\ V$; $W = 210$

$P = W \times K$

$= 210 \times 1.04 = 218.4$

$\cos\phi = \frac{P}{VI} = \frac{218.4}{120 \times 1.9} = 0.957$

$\therefore \boxed{\cos\phi = 0.957}$

Active power $= VI\cos\phi$

$= 120 \times 1.9 \times 0.957$

$\boxed{P = 218.4}$

Reactive power $= VI\sin\phi$

$Q = 120 \times 1.9 \times 0.29 = 66.12$

$\therefore \boxed{Q = 66.12}$

Apparent power $= VI$

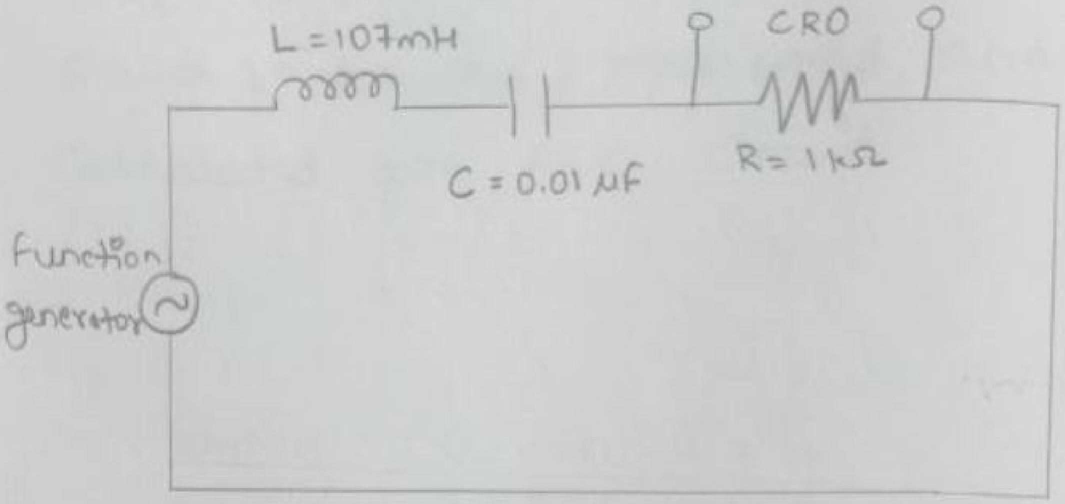
$S = 120 \times 1.9 = 228$

$\therefore \boxed{S = 228}$

S.No.	I	V	W	P	Q	S
1.	0.5	40	18	18.72	7.02	20
2.	1.0	60	40	41.6	43.2	60
3.	1.25	80	80	83.2	55.4	100
4.	1.6	100	142	~~2~~ 147.68	61.44	160
5.	1.9	120	210	218.4	66.12	228

Result - Thus the electrical quantities like voltage, current, power and power factor are measured and calculated for RLC circuit

Circuit diagram -



Circuit diagram for series resonance.

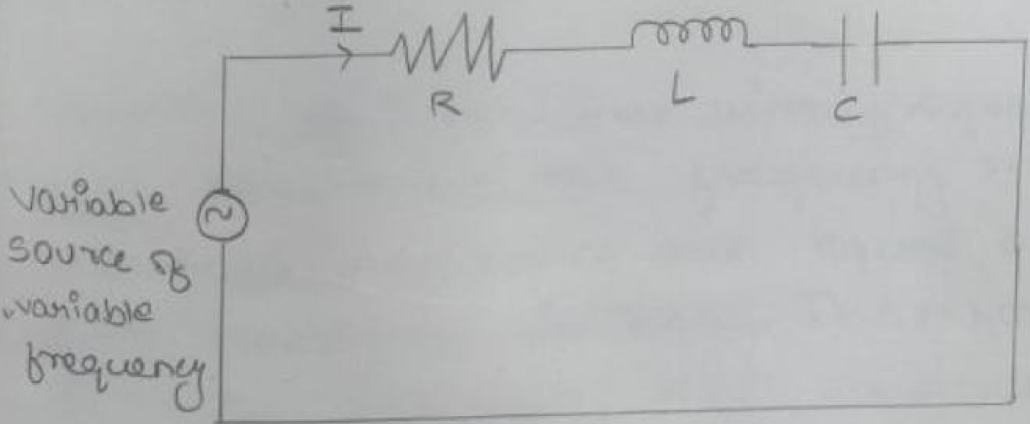
Experiment - 4

Series resonance for a RLC Circuit.

Aim - To verify the voltages and currents of each element by using series and parallel in the following circuit under series resonance.

Apparatus - 1. Function Generator
2. Resonance trainer kit
3. Cathode Ray Oscilloscope
CRO probe
Connecting wires

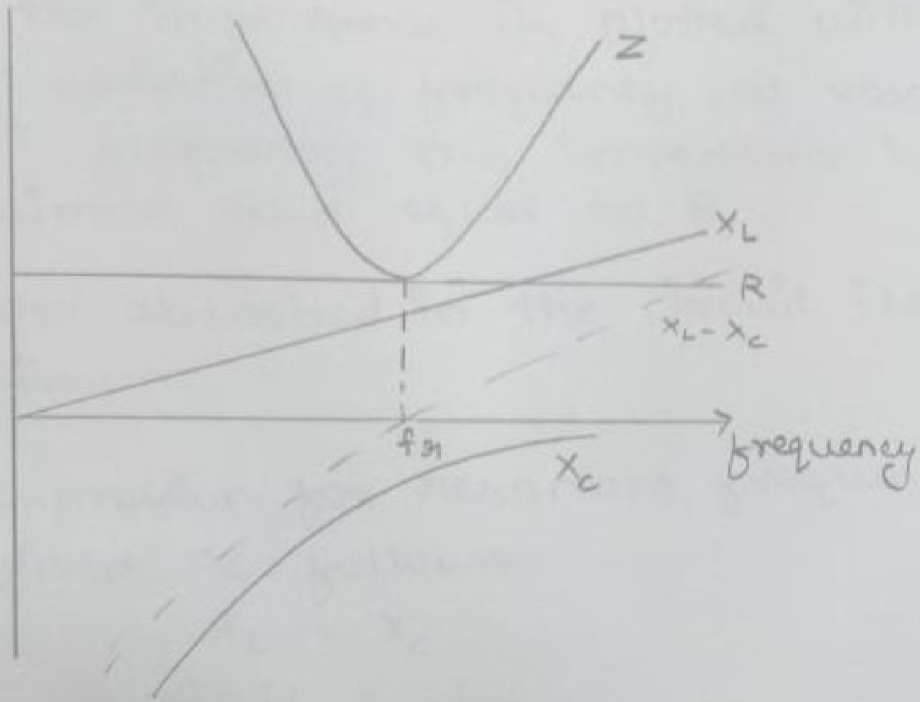
Theory - A circuit is said to be in resonance when the applied voltage and the current are in same phase. Consider a series RLC circuit as shown below.



Current drawn by the above circuit is given by, $I = \dfrac{V}{R + j\left(\omega L - \frac{1}{\omega C}\right)}$

Evidently, in the above circuit, the current and voltage in the same phase, if inductive reactance and capacitance reactance are numerically equal.

As the frequency is varied, the inductive reactance increases and capacitive reactance decreases a shown in figure.



Variation of R, X_L, X_C, $(X_L - X_C)$ and Z with frequency.

Variation of impedance with frequency is also shown. At the frequency "f_r", the two reactance are equal and net reactance is zero. Therefore, at this frequency "f_r", resonance occurs. At resonance following is the behaviour of the electrical circuit.

1. Voltage and current in the circuit are in phase. Power factor of the circuit is unity.

2. Voltage across the inductance is equal to the voltage across the capacitance. The entire applied voltage appears across the resistance.

3. If the impedance is plotted with the variation of frequency, at resonant frequency the impedance is minimum and equal to R.

4. Power absorbed in the circuit its maximum.

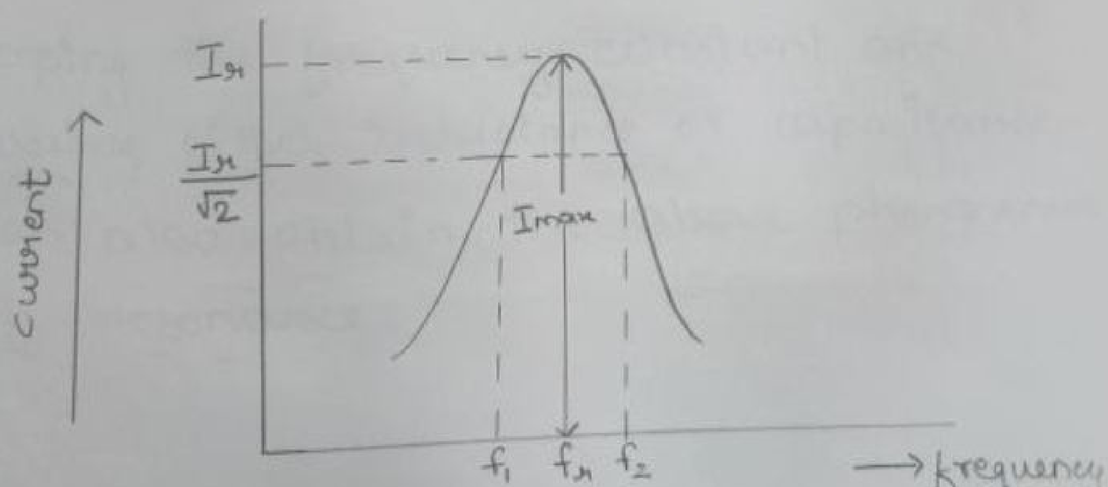
The expression for resonant frequency is derived as follows

$$X_L = X_C$$

$$2\pi f L = \frac{1}{2\pi f C}$$

Therefore,

$$f = \frac{1}{2\pi\sqrt{LC}}$$: This frequency f is called the resonant frequency "f_r".



Variation of current with frequency.

Variation of current through the series circuit as the frequency is increased as shown in figure. Half power frequency of the circuit are f_1 and f_2 at which the power absorbed by the circuit is half the maximum power absorbed.

Bandwidth, selectivity and quality factor are the terms used for describing the behaviour of the circuit. They are defined as,

Quality factor $= Q_r = \frac{2\pi f_r L}{R}$, where f_r is the resonant frequency and L is the inductance of the coil.

Bandwidth $= (f_2 - f_1)$

Selectivity $=$ Bandwidth / f_r

$= 1/Q_r$

$Q_r =$ Quality factor $= \frac{1}{R}\sqrt{\frac{L}{C}}$

Keeping the frequency constant and varying either inductance or capacitance can also obtain the above phenomenon of resonance.

Tabular column -

S.No.	Voltage (v)	RMS voltage (V)	RMS current (mA)
1	4	2.82	2.82
2	8	5.05	5.05
3	12	8.48	8.48
4	16	11.31	11.31
5	20	14.14	14.14.

Fu
gen

S.No.	Frequency (Hz)	Irms (mA)
1.	500	0.63
2.	1000	1.13
3.	1500	1.23
4.	2000	1.35
5.	2500	1.47
6.	3000	1.55
7.	3500	2.20
8.	4000	2.69
9.	4500	3.12
10.	5000	2.33
11.	5500	1.95
12	6000	1.13
13	6500	1.11
14	7000	0.90
15	7500	0.80
16	8000	0.44

Procedure -

1. Make connections as per the circuit dia

2. Switch "ON" the experimental board by connecting the power card to the AC mains.

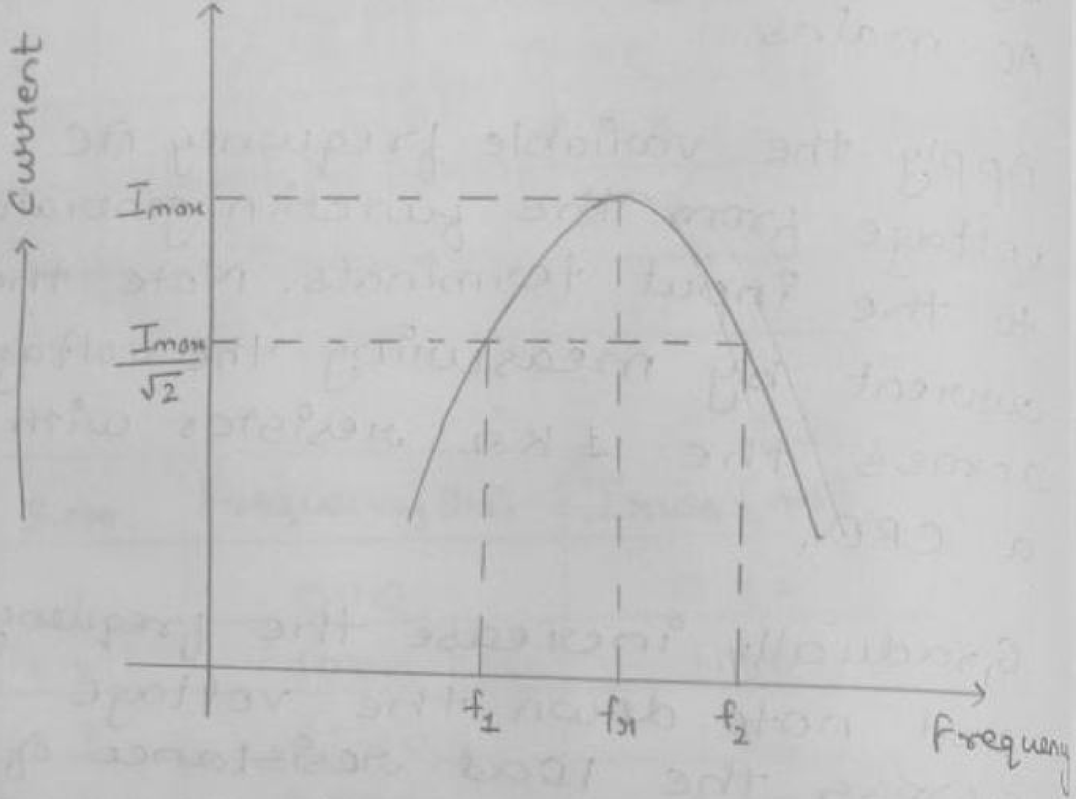
3. Apply the variable frequency AC voltage from the function generator to the input terminals. Note the current by measuring the voltage across the 1 KΩ resistor with a CRO.

4. Gradually increase the frequency and note down the voltage across the load resistance of 1 KΩ "V_0" with the help of CRO.

5. Calculate the current values from Vo.

6. Tabulate the results.

MODEL Graphs -



Current response of series resonance circuit.

Calculations -

Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$

$L = 107 mH$; $C = 0.01\mu F$

$\Rightarrow f_r = \frac{1}{2\pi\sqrt{LC}}$

$\Rightarrow L = 107 \times 10^{-3} H \qquad C = 0.01 \times 10^{-6} f$

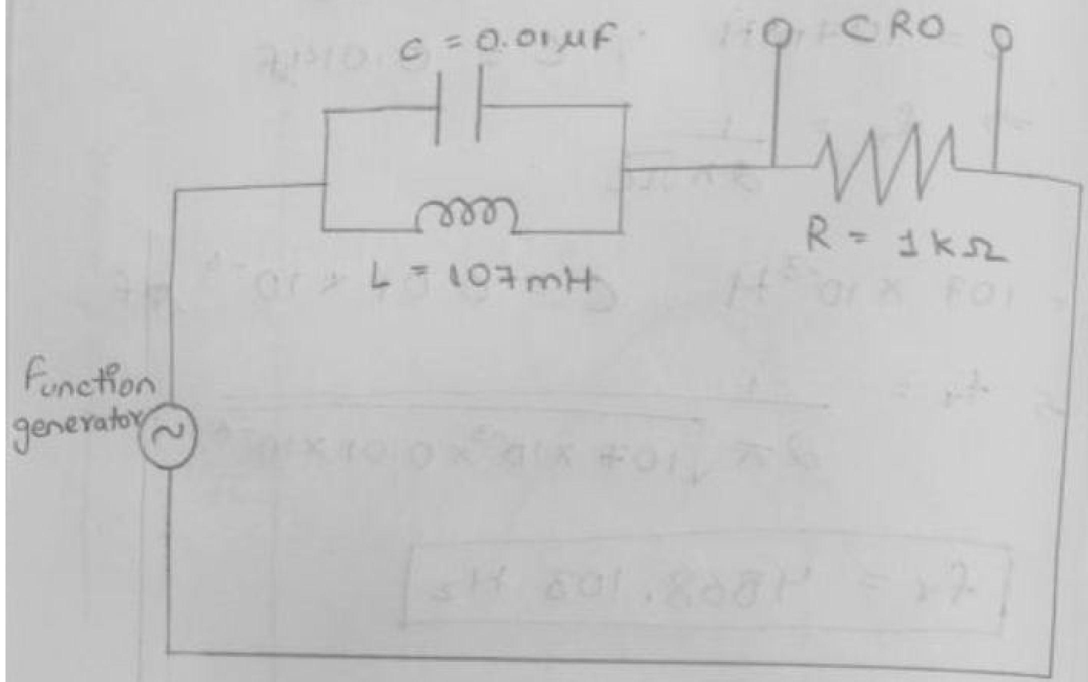
$\Rightarrow f_r = \frac{1}{2\pi\sqrt{107 \times 10^{-3} \times 0.01 \times 10^{-6}}}$

$$\boxed{f_r = 4868.103 \text{ Hz}}$$

Result -

The series resonance occurs at a resonance frequency of 4868 Hz and the peak value of the current is 3.12 A.

Circuit diagram



Circuit diagram for parallel resonance.

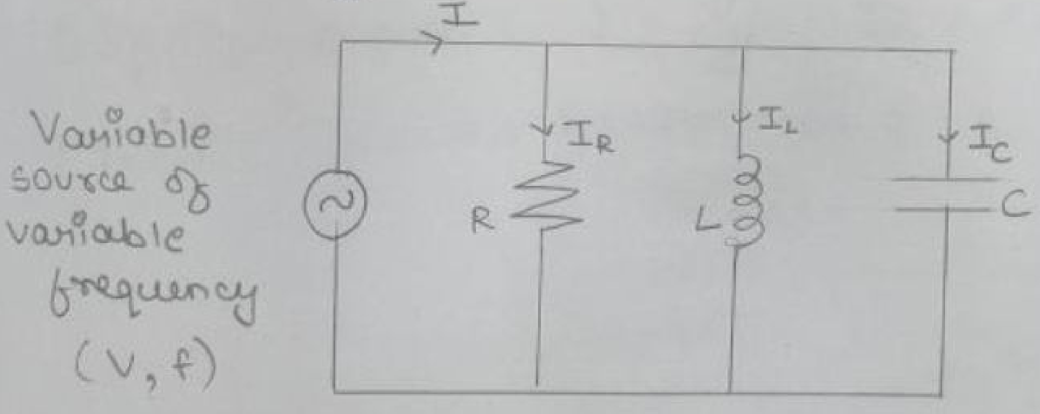
Experiment - 5

Parallel resonance for a RLC circuit.

Aim - To verify the voltages and currents of each element by using series and parallel in the following circuit under parallel resonance.

Apparatus - 1. Function Generator
2. Resonance trainer kit
3. Cathode Ray
4. Oscilloscope
5. CRO probe
6. Connecting wires.

Theory - Consider the parallel circuit given below.



$$Y = G + jB = G + j(B_C - B_L)$$

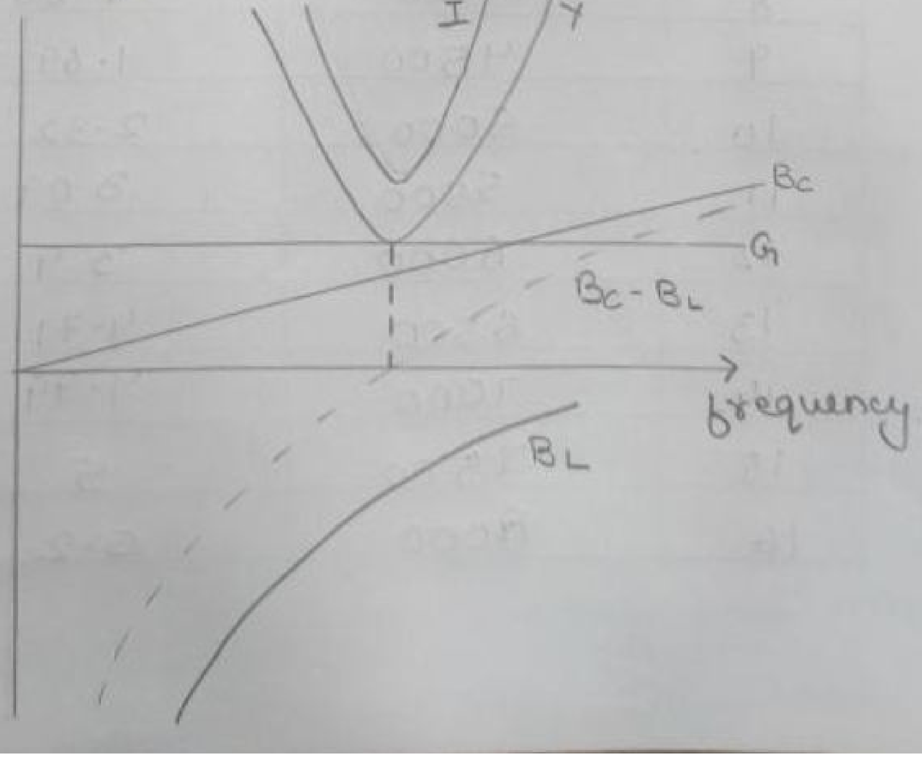
$$Y = \frac{1}{R} + j\left(\omega C - \frac{1}{\omega L}\right)$$

where B_C is capacitive susceptance is directly proportional to frequency, whereas inductive susceptance is inversely proportional to frequency. If the supply voltage is maintained constant and frequency is gradually increased from zero to some high value, the capacitive susceptance increases while the inductive susceptance decreases. Hence at some frequency, the two susceptance become numerically equal and net susceptance reduces to zero causing $Y = 1/R$. Note that the admittance becomes minimum, i.e., the impedance becomes maximum at resonance, which results in minimum current.

When $B_C = B_L$, $B_C - B_L = 0$ & $Y = \frac{1}{R}$

Supply current $I = \frac{V}{Z} = I_R$ (minimum)

Circuit power factor $\cos\phi = 1$.



Tabular column -

S.No.	Voltage (v)	RMS Voltage (V)	RMS Current (mA)
1.	4	2.02	2.82
2.	8	5.05	5.05
3.	12	8.48	8.48
4.	16	11.31	11.31
5.	20	14.14	14.14

S.NO.	Frequency (Hz)	Irms (mA)
1.	500	4.11
2.	1000	3.60
3.	1500	3.12
4	2000	2.80
5	2500	2.70
6	3000	2.23
7	3500	2.01
8	4000	1.85
9	4500	1.69
10	5000	2.32
11	5500	3.09
12	6000	3.9
13	6500	4.71
14	7000	4.99
15	7500	5
16	8000	5.2

Variation of circuit parameters and current response with frequency.

for resonance $B = 0$. That is $B_L = B_C$. where B_L is the susceptance of inductor L and B_C is the susceptance of capacitor C. That is

$$\frac{1}{\omega L} = \omega C \quad (\text{or}) \quad \omega_r = \frac{1}{\sqrt{LC}} \; ; \; f_r = \frac{1}{2\pi\sqrt{LC}}$$

The bandwidth, selectivity and quality factor are obtained as below.

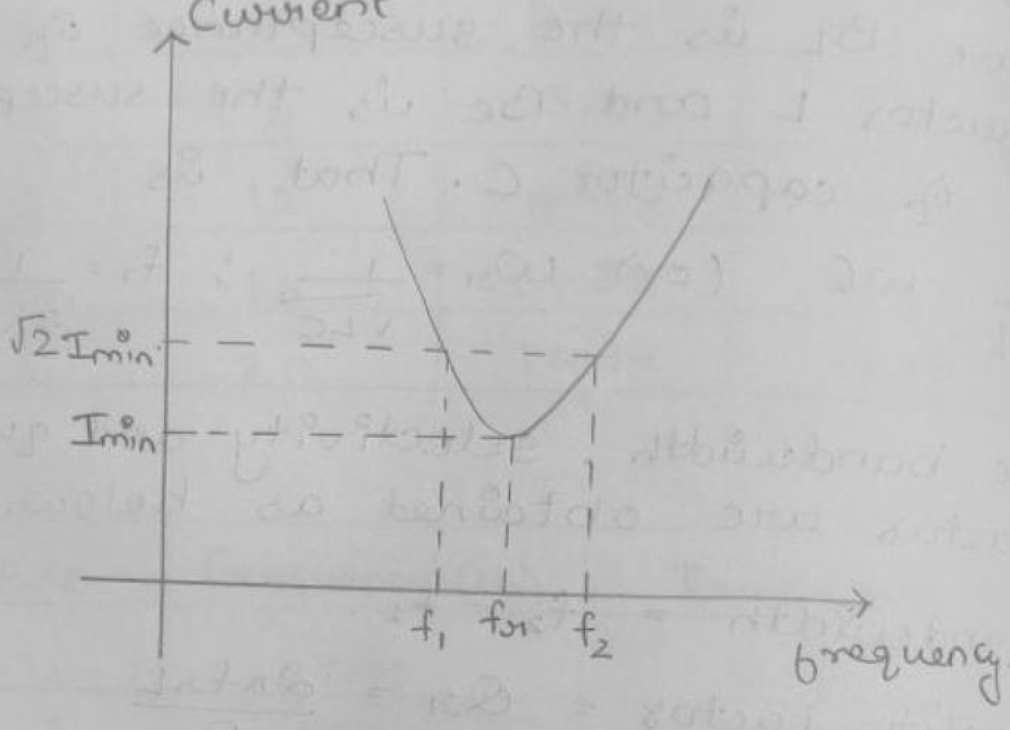
Bandwidth $= f_2 - f_1$.

Quality factor $= Q_r = \frac{2\pi f_r L}{R}$.

Procedure -

1. Make connections as per the circuit dia
2. Switch "ON" the experimental board by connecting the power card to the AC mains.
3. Apply the variable frequency AC voltages from the function generator to the input terminals. Note the current by measuring the voltage across the 1KΩ resistor with a CRO.
4. Gradually increase the frequency and note down the voltage across the load

Model Graphs -



Current response of parallel resonance circuit.

resistance of 4.7 KΩ "Vo" with the help of CRO.

5. Calculate the current values from Vo.

6. Tabulate the results.

Calculations -

Resonance frequency, $f_r = \frac{1}{2\pi\sqrt{LC}}$

$L = 107\ mH = 107 \times 10^{-3} H$

$C = 0.01\ \mu f = 0.01 \times 10^{-6} F$

$\therefore f_r = \frac{1}{2\pi\sqrt{107 \times 10^{-3} \times 0.01 \times 10^{-6}}}$

$\boxed{f_r = 4868.103\ Hz}$

Result -

The parallel resonance occurs at a resonance frequency of 4868 Hz and the ~~are~~ minimum value of current is 1.69 A.