PHYSICS LAB MANUAL

2nd Semester

MIDNAPORE CITY COLLEGE

Course No: C3P: Electricity and Magnetism (Lab)

Credit: 2.

Experiment No. 1

Title: . To study the characteristics of a series RC and RL Circuit.

Introduction:

The RC & RL circuit is used to determine the input and output relationship of voltage and current for different frequencies. In RC series circuit the voltage lags the current by $90^0$and in RL series circuit the voltage leads the current by90^0.

Theory and Methodology:

RC Series Circuit:

A resistor–capacitor circuit (RC circuit), or RC network, is an electric circuit composed of resistors and capacitor is in series driven by a voltage or current source (See the figure-1). A first order RC circuit is composed of one resistor and one capacitor and is the simplest type of RC circuit.

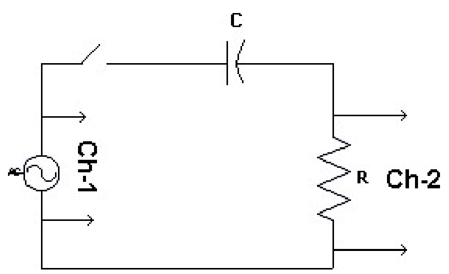

Figure-1

Analysis of a Series RC Circuit

For doing a complete analysis of a series RC circuit, given the values of R, C, f, and V_T.

Step 1: Calculate the value of X_C:

$X_C = 1 / (2\pi fC)$

Step 2: Calculate the total impedance Z:

$$Z = \sqrt{X_C^2 + R^2}$$

Step 3: Use Ohm's Law to calculate the total current I_T:

$I_T = V_T / Z$

1

Difference between Rectangular & Polar representation of Impedance:

- In Rectangular form:

  $Z_T = R - j\,X_C$

- In Polar form:

  $Z_T = \sqrt{\square 2 + (X\square)2}$

  $\theta = \tan^{-1}(-X_C/R) = \tan^{-1}(-1/\omega RC)$

Impact of frequency on the value of capacitance:

Figure 2 will show the impact of frequency by varying the value of Capacitance inseries resonance.

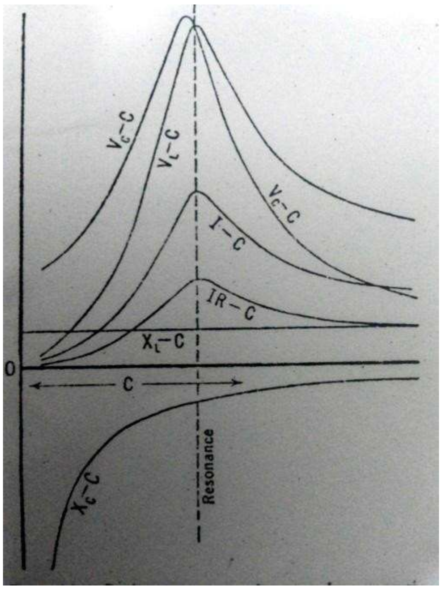

Figure-2

RL Series Circuit:

A resistor–inductor circuit (RL circuit), or RL network, is an electric circuit composed of resistors and inductor is in series driven by a voltage or current source (See the figure-3). A first order RL circuit is composed of one resistor and one inductor and is the simplest type of RL circuit.

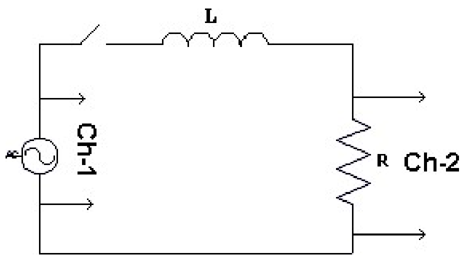

Figure-3

Analysis of a Series RL Circuit

For doing a complete analysis of a series RL circuit, given the values of R, L, f, and V_T.

Step 1:. Calculate the value of X_L:

$X_L = 2\pi fL$

Step 2: Calculate the total impedance Z:

$$Z = \sqrt{X_L^2 + R^2}$$

Step 3: Use Ohm's Law to calculate the total current I_T:

$I_T = V_T / Z$

Difference between Rectangular & Polar representation of Impedance:

- In Rectangular form:

  $Z_T = R + j X_L$

- In Polarform:

  $Z_T = \sqrt{\square 2 + (X\square)2}$

  $\theta = \tan^{-1}(X_L / R) = \tan^{-1}(\omega L / R)$

Impact of frequency on the value of inductance:

Figure 4 will show the impact of frequency by varying the value of Inductance in series resonance.

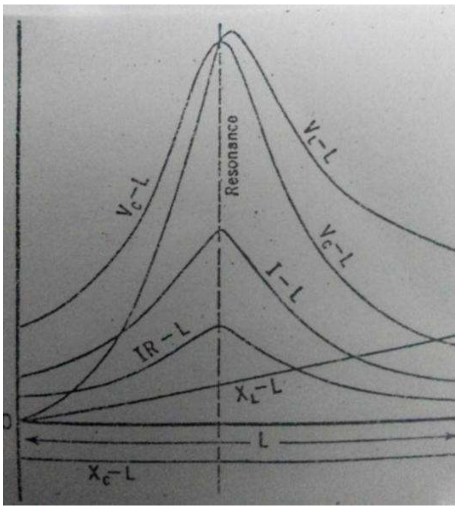

Figure-4

Pre-Lab Homework:

Read about the characteristics of RC and RL series circuit from "Alternating Current Circuit" by George F Corcoran and use NI Multisim to generate the output of the circuits provided in this lab sheet. Compare the wave shapes given in the textbook with your results. Save the simulation results and bring it to the lab.

Apparatus:

- Oscilloscope
- Function generator
- Resistor: 100Ω
- Inductor:2.4mH
- Capacitor: 1 μF/ 10μF
- SPST switch
- Connecting wire.
- Bread board

Precautions:

Connection of circuit should be done carefully, and oscilloscopes should be properly calibrated using the information provided at the calibration port before obtaining the wave shapes using the experimental set up.

Experimental Procedure:

1. Construct the circuit as shown in the fig.1. Connect channel 1 of the oscilloscope across function generator and channel 2 of the oscilloscope acrossR.
2. Set the amplitude of the input signal 10V peak to peak and the frequency at 1 kHz. Select sinusoidal wave shape.

3. Measure peak value of both wave shapes.
4. Determine phase relationship between the waves.
5. Write down the wave equations for I and E.
6. Calculate resistance and reactance from the relevant data.
7. Do the same experiment setting input frequency 5kHz and10kHz.
8. Complete the following table.

Table 1

f	E	I	$Z = E/I$ (Polar form)	Z (Rectangular form)	R	X_L	$V_R=IR$	$V_L=IX_L$
1KHz								
5KHz								
10KHz								

9. Now construct the circuit as shown in fig.3. Connect channel 1 of the oscilloscope across function generator and channel 2 of the oscilloscope acrossR.
10. Do the same procedure stated in 2 to 7. Complete the followingtable.

Table 2

f	E	I	$Z = E/I$ (Polar form)	Z (Rectangular form)	R	X_C	$V_R=IR$	$V_C=IX_C$
1KHz								
5KHz								
10KHz								

Simulation and Measurement:

Compare the simulation results with your experimental data/ wave shapes and comment on the differences (if any).

Questions for report writing:

1. Complete Table 1 and Table2.
2. Calculate the value of X_C, X_L, Z,I.
3. Draw the complete vector diagram for the RL and RCcircuit.
4. Comment on the role of frequency to inductive reactance and capacitivereactance.

Discussion and Conclusion:

Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set. Discuss any mistake you might have made while conducting the investigation and describe ways the study could have been improved.

References:

[1] “FundamentalofElectricCircuit”byAlekzendreSadiku
[2] “AlternatingCurrentCircuit”byGeorgeFCorcoran
[3] http://physics.bu.edu/~duffy/py106/ACcircuits.html

Experiment No. 2

Title: To determine an unknown Low Resistance using CROMPTON Potentiometer

OBJECTIVE:

To measure low resistance by Crompton Potentiometer.

APPARATUS:

Crompton potentiometer New Tech Type NTI – 501, two battery eliminators, two rheostats, two one way keys, one two way key, One Galvanometer, one known resistance of comparatively higher value and given small resistance.

THEORY:

Let *I* current is passing through known resistance R of comparatively higher value R and small unknown resistance r. The balancing length corresponding to potential drop on R is l_1.

$$\therefore IR = \sigma l_1 \text{.......................................} (1)$$

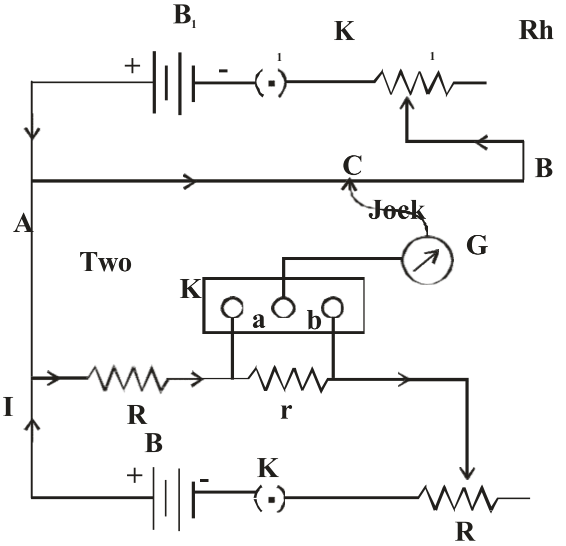

Fig. 1

Where σ is potential gradient.

Ifbalancinglengthcorrespondingtopotentialdroponn(R+r)resistanceisl_2. Then I

(R + r) =σl_2 (2)

(2) / (1)

$$\frac{R + r}{R} = \frac{l_2}{l_1}$$

$$\text{or} \quad 1 + \frac{r}{R} = \frac{l_2}{l_1}$$

$$\text{or} \quad \frac{r}{R} = \frac{l_2 - l_1}{l_1}$$

$$\text{or} \quad r = \frac{l_2 - l_1}{l_1} R \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

OBSERVATIONS:

Sr. No.	Balancinglength l_1 for P.D. on R Cm	Balancing length l_2 for P.D. on R Cm	r (Ohm)
1. 2. 3. 4. 5.			

CALCULATIONS:

Putting values of l_1, $l_2$and R in the formula the value of unknown small resistance r is calculated in each set of observations. Then mean value of r is determined.

RESULT:

The value of given small resistance as determined using Crompton potentiometer is = ... Ohm.

PRECAUTIONS:

1. The E.M.F. of the cell used in primary circuit should be kept morethan E.M.F. of the cell in secondary circuit.
2. All the positive terminals should be connected to the same point (A) of the potentiometer.
3. Jokeyshouldnotbemovedalongthepotentiometerwire.
4. Electricalconnectionsshouldbetight.

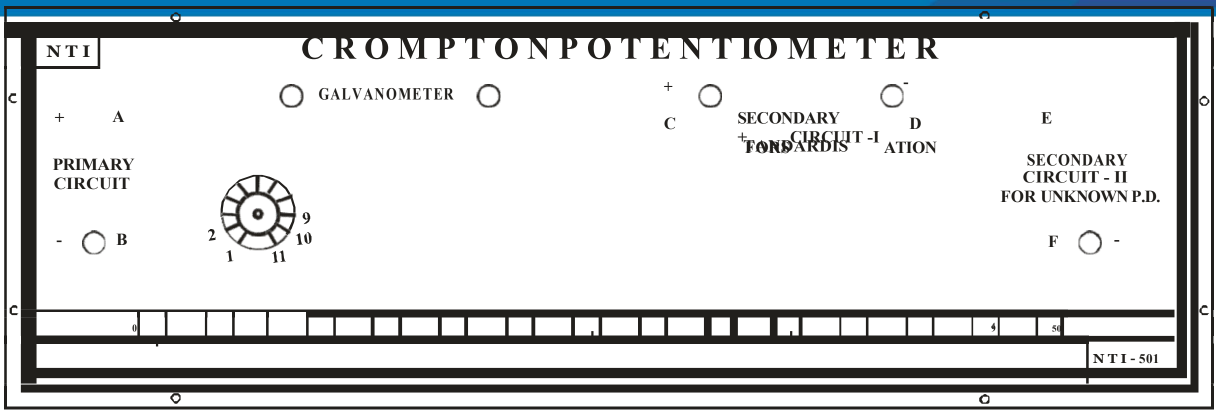

Fig. (2) Panel Diagram

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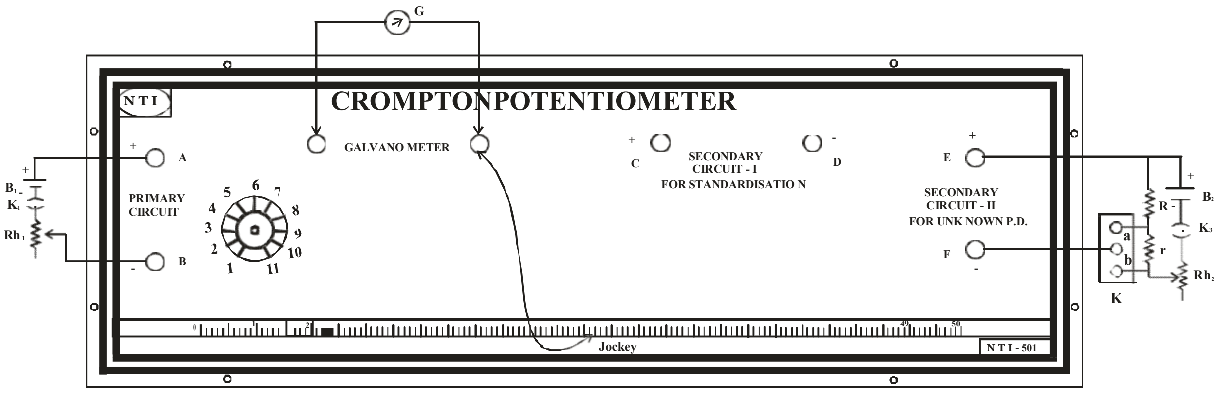

Fig. (3) Connections for Crompton Potentiometer

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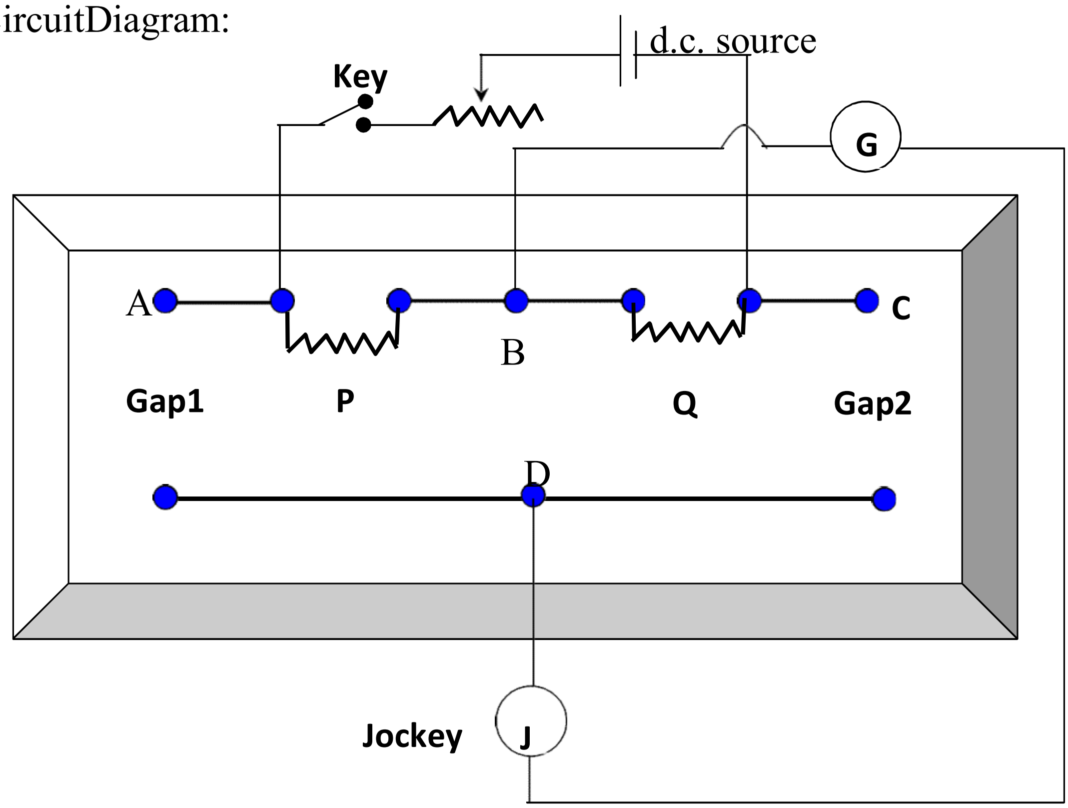
Experiment No. 3

Aim: To find low resistance by Carey Fosters bridge

1. **Apparatus required:** Given low resistance, dc power supply (2 V), Carey Foster'sbridge, galvanometer, one waykey.
2. Formula used: $X = \frac{d_2Y_1 - d_1Y_2}{d_2 - d_1}$
3. CircuitDiagram:



4. Theory: Carey Foster's bridge is a modified Wheatstone bridge. Here a potentiometer wire MN is inserted between the R and S arms of the Wheatstone bridge as shown in Fig. below. The ratio arms P & Q are made equal. Gap 1 carries a small resistance (known) and the Gap 2 (fourth arm) carries the unknown resistance. If ρ be the resistance per unit length of wire, r_1& r_2 be the end resistances at M & N, MD = l_1 is balancing length a shown inFig.,

then, $\frac{P}{Q} = \frac{X + l_1\rho + r_1}{Y + (100 - l_1)\rho + r_2}$ .. (1) When, X & Y are interchanged, the balance point shifts to a lengthl$_2$,then,

$$\frac{P}{Q} = \frac{Y + l_2\rho + r_1}{X + (100 - l_2)\rho + r_2} \quad \text{....... (2)}$$

Comparing (1) & (2) and adding 1 to both sides, we get,

$$\frac{X + Y + 100\rho + r_1 + r_2}{Y + (100 - l_1)\rho + r_2} = \frac{X + Y + 100\rho + r_1 + r_2}{X + (100 - l_2)\rho + r_2}$$

$$\Rightarrow X + (100 - l_2)\rho + r_2 = Y + (100 - l_1)\rho + r_2 \Rightarrow Y - X = (l_1 - l_2)\rho$$

Where X is unknown resistance, $(l_1 - l_2)$ is shift in balance point when the positions of X & Y are interchanged. Let d_1& d_2 are the shifts corresponding to resistances Y_1& Y_2, then,

$$X - Y_1 = d_1\rho, \text{ and, } X - Y_2 = d_2\rho, \text{ so, } \frac{X - Y_1}{X - Y_2} = \frac{d_1}{d_2} \Rightarrow X = \frac{d_2 Y_1 - d_1 Y_2}{d_2 - d_1}$$

5. Procedure:

(i). Make connection as shown inFig.
(ii). Fix P = Q = 1 Ω throughout theexperiment.
(iii). Keep X = Y = 0 by short circuiting by copper plates to get balancepoint.
(iv). Repeat step (iii) by interchanging the position of copper plates and determinex_0.
(v). ReplacetripofgapIbyunknownresistanceXandgap2byknownresistanceY.Findbalance point for 0.1 Ω, and, then interchange X & Y, and again find balance point.
(vi). Repeat this step for Y = 0.2, 0.3, 0.4, 0.5 Ω.

6. Observations: Determination of electricalzero:

Sr. No.	Resistance introduced in between		Position of Null point(cm)	Value of electrical zero, x_0 (cm) ($x_0 = a - b$)
	Gap-1	Gap-2		
1	Copper plate	Copper plate (a)		
2	Cu plates interchanged (b)			

(b). Determination of unknown resistance:

Sr. No.	Y (Ω)	Position of balance point with unknown resistance in		Shift $l_1 - l_2$ (cm)	Corrected shift $d = (l_1 - l_2) - x_0$ (cm)	Unknown resistance $X = \frac{d_2 Y_1 - d_1 Y_2}{d_2 - d_1}$ (Ω)	Mean X (Ω)
		Left gap l_1 (cm)	Right gap l_2 (cm)				
1							
2							
3							
4							
5							
6							

7. Results: The value of unknownresistanceis......................Ω.

8. Precautions:

(i). All terminals should be tight.

(ii). The connecting wires and the copper strip should be thoroughly cleaned with sandpaper.
(iii). The connection should be tight, and the plugs of the resistance box should be given twist so that they are tight.
(iv). The battery key should be taken out when the readings is not being taken in order to avoid heating and thewire.

Experiment No. 4

Aim: To determine the resistance of Weston type galvanometer by Kelvin's method using Post Office box.

1. **Apparatus required:** Post Office box, galvanometer, power supply (2v), Resistance box, connectingwires.

2. Theory: A post office box is a compact form of the Wheatstone's bridge. In the instrument each of the arms AB &BC contains three of 10, 100 and 1000 Ω respectively as shown in Fig.1. These are called ratio arms. The arm AD is the other ratio arm R. The key K1 is connected tothe point A and the key K2 to the point B internally as shown by the lines drawn on the ebonite plate. The unknown, S, is connected between C & D, the battery, E, between C & A through the key K1 and the galvanometer, G, between D & B through the key K2. The circuit is now the same as shown in Fig.2. Hence,

$$\frac{P}{Q} = \frac{R}{G} \Rightarrow G = R.\frac{Q}{P}$$

IntheKelvin"smethodthesame galvanometer whose has to be measured, is also used as an indicator for obtaining the balance point. The galvanometer acts as itsown indicator for obtaining the balance point a shown inFig.3.

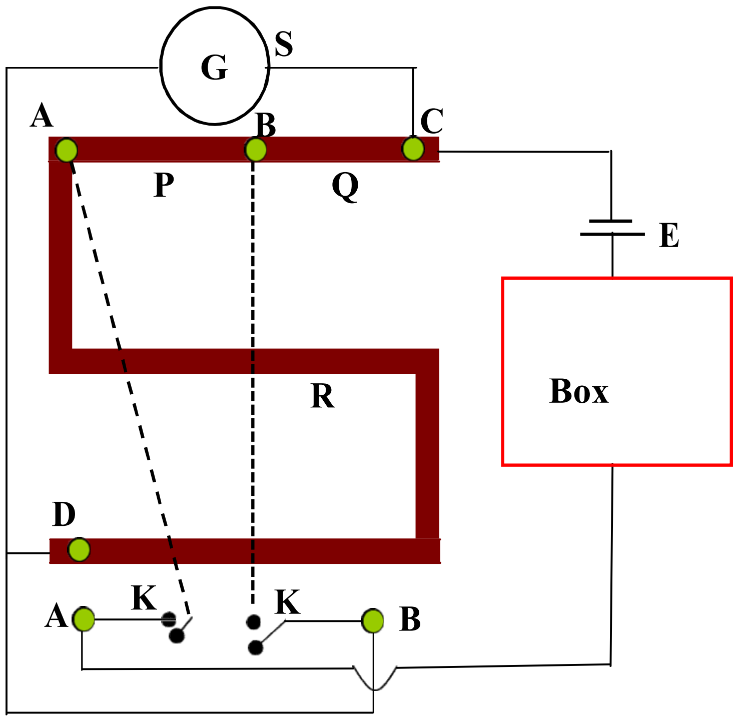


Fig.1

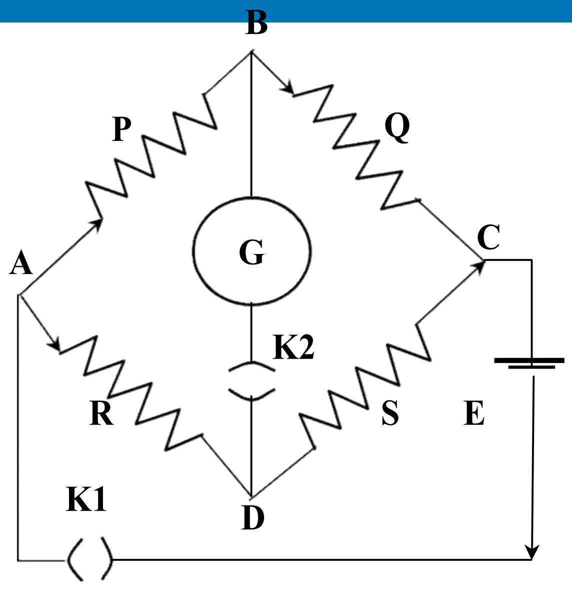


Fig.2

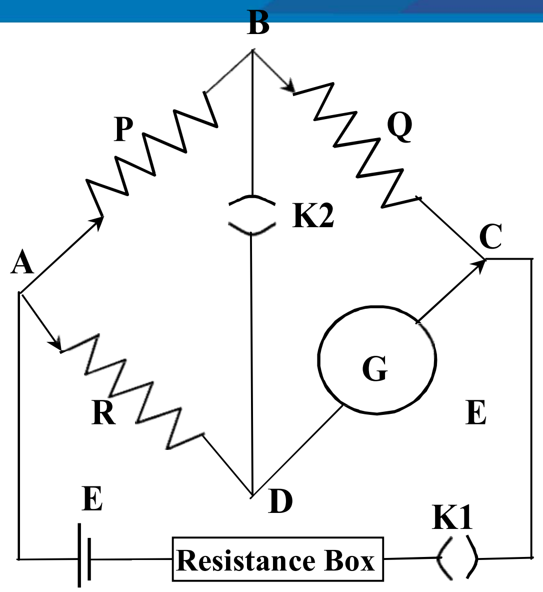


Fig.3.

3. Procedure:

(i). Make connections as in Fig.1.
(ii). Take resistance from box and keep other plugstight.
(iii). Keeping R = 0, insert 10 Ω s in arms P & Q. Press tappingkey K1 and adjust from resistance box so that deflection is between 10 &30.
(iv). Insert 10 Ω in R, press tapping K1 and note deflection in galvanometer. If deflection decreases on tapping key K2, go on repeating the observation byincreasing R in steps so that on pressing K1 first and then tapping K2, the deflection increases. The value of galvanometer lies between last two valuesof R.
(v). Keeping Q = 10 Ω make P = 100 Ω. Starts with 10 times the lower value of R obtained in earlier step and increase it in steps, so that on pressing K1 first and then K2, the deflection increases instead of decreasing. Note last two values ofR.
(vi). Keeping Q = 10 Ω make P = 1000 Ω. Starts with 10 times the lower value of R obtained in earlier step and increase it in steps, so that on pressing K1 first and then K2, the deflection increases instead of decreasing. Note last two values ofR.

4. Observations:

Sr. No.	Ratio arms		Values of R (Ω) for which deflection increases instead of decreasing	G (Ω) lies between $G = R.\frac{Q}{P}$
	P (Ω)	Q (Ω)		

5. Result: TheresistanceoftheGalvanometeris ....Ω.

6. Precautions:

(i). The ends of the connecting wires should be clean.
(ii). All the plugs should be properly tight.
(iii). K1 should be pressed first and thereafter K2.

Experiment No. 5

VERIFICATION OF THEVENIN'S AND NORTON'S THEOREMS

AIM: To Verify Thevenin's Norton's and Maximum power transfer theorems.

APPARATUS:

S.No	Equipment	Range	Type	Quantity
1.	Ammeter	0-200mA	MC	
2.	Voltmeter	0-20V	MC	
3.	Bread Board	-	-	1
4.	R.P.S	0-30V/0-1A	Dual channel	1
5.	Resistors			As required
6.	Connecting Wires			As required

THEVENIN'S THEOREM

STATEMENT: - Any two terminal, linear, bilateral network having a number of voltage, current sources and resistances can be replaced by a simple equivalent circuit consisting of a single voltage source in series with a resistance, where the value of the voltage source is equal to the open circuit voltage across the two terminals of the network, and the resistance is the equivalent resistance measured between the terminals with all energy sources replaced by their internalresistances.

CIRCUIT DIAGRAM:

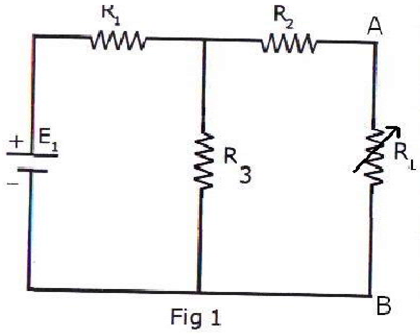


Fig 1

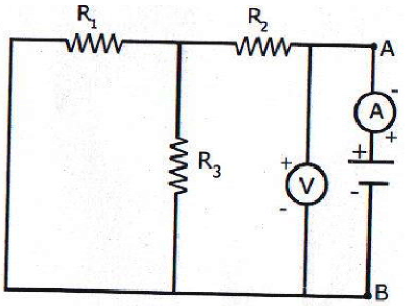


Fig 2

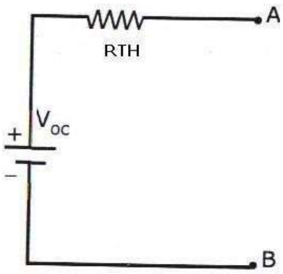


Fig3

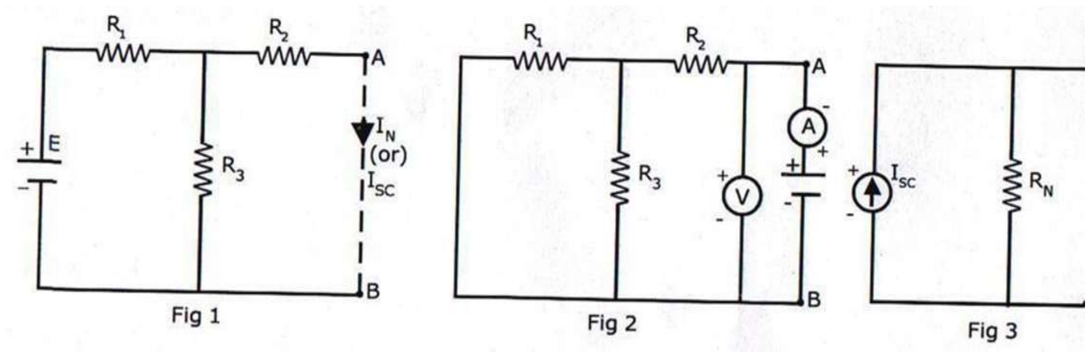
PROCEDURE:

1. Connect the circuit diagram as shown infigl.
2. MeasureVocbetweenAandBterminals,byopencircuitingABterminals.
3. Connect the circuit as shown infig2.
4. The resistance between A and B is obtained by using voltmeter, ammeter method, and the ratio of V & I givesRTh
5. Draw the Thevenin‟s equivalent circuit as shown infig.3

NORTON’S THEOREM

STATEMENT: Any two terminals, linear, bilateral network with current sources, voltagesources and resistances can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance. The value of the current source is the short circuit current between the two terminals of the network and the resistance is the equivalent resistance measured between the terminals of the network with all the energy sources replaced by their internalresistances.

Circuit Diagram:



PROCEDURE:

1. Connect the circuit diagram as shown infig1.
2. Measure the current I_{sc} (or) I_N through 'AB' by short-circuiting the resistance between A andB.
3. Connect the circuit diagram as shown infig2.
4. TheresistancebetweenAandBisobtainedbyusing.voltmeter,ammetermethodandthe ratio of V & I givesR_N.
5. Draw Norton's equivalent circuit by connecting IN & RN in parallel as shown infig3.

TABULAR COLUMN:

Parameters	Theoretical Values	Practical Values
Voc		
Isc		
R_{TH}		

5

Experiment No. 6

SUPERPOSITION THEOREM AND RECIPROCITY THEOREM

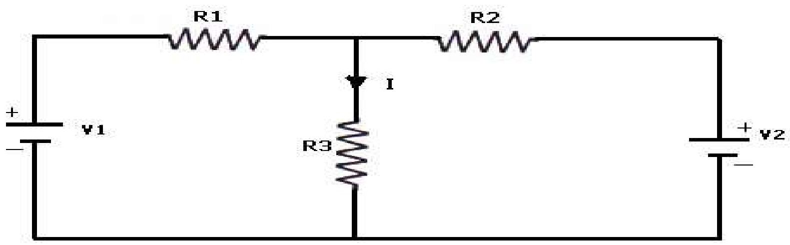
AIM:

To Verify Superposition Theorem and to find the RMS value of complex wave form

APPARATUS:

S.No.	Equipment	Range	Type	Quantity
1.	Resistors	-	-	As required
2.	Multi-meter			1
3.	R.P.S	0-30V/0-1A	Dual channel	1
4.	Bread Board	-	-	1
5.	Connecting Wires			As required

CIRCUIT DIAGRAM:



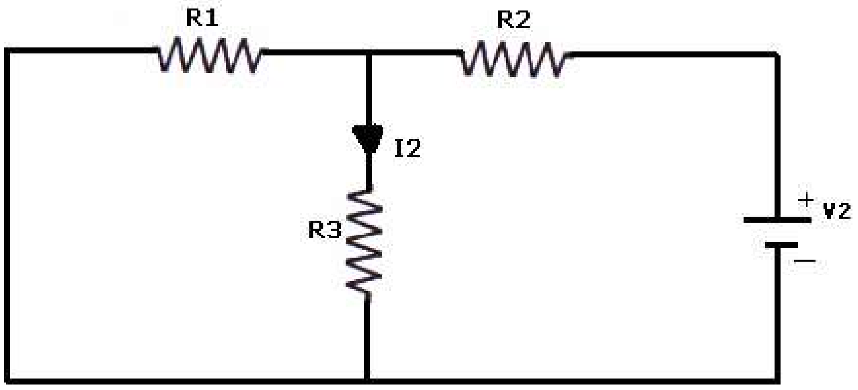


Fig3

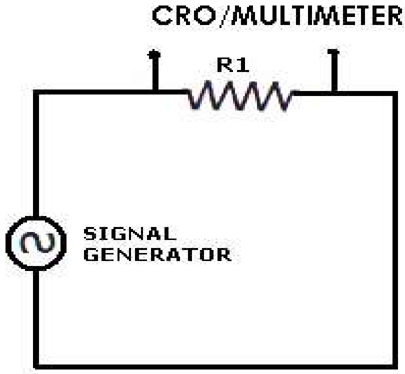


Fig4

PROCEDURE:

1. Connect the circuit as shown in figure (1) and note down the current flowing through R_3. and let it beI.
2. Connect the circuit as shown in figure (2) and note down the ammeter Reading,and let it be I_1.
3. Connect the circuit as shown in figure (3) and note down the ammeter reading, and let it beI_2.
4. Verify for $I=I_1+I_2$.
5. Compare the practical & theoreticalcurrents.

RESULT:

VERIFICATION OF RECIPROCITY THEOREM

AIM:

To verify Reciprocity theorem both analytically and experimentally.

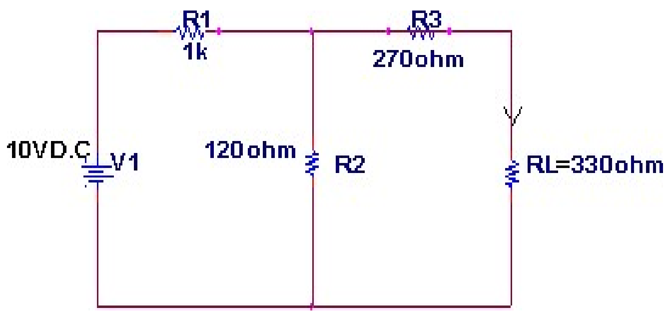
APPARATUS REQUIRED:

S.No.	Equipment	Range	Type	Quantity
1.	Resistors	-	-	As required
2.	Multi-meter			1
3.	R.P.S	0-30V/0-1A	Dual channel	1
4.	Bread Board	-	-	1
5.	Ammeter	0-200mA	MC	1
6.	Connecting Wires			As required

THEORY:

STATEMENT: **"**In a linear bi-lateral single source network ,the ratio of excitation to the response is constant when the position of excitation and response are interchanged".

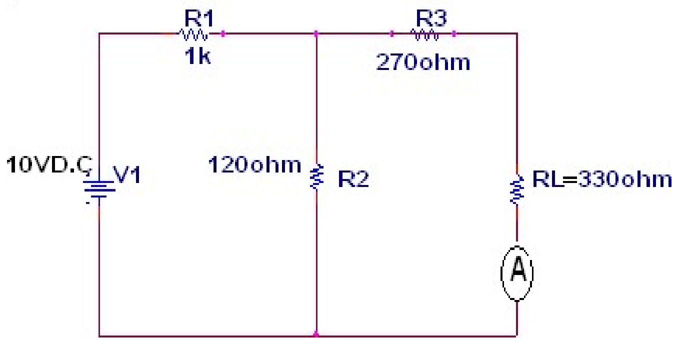
CIRCUIT DIAGRAM:



CALCULATION:

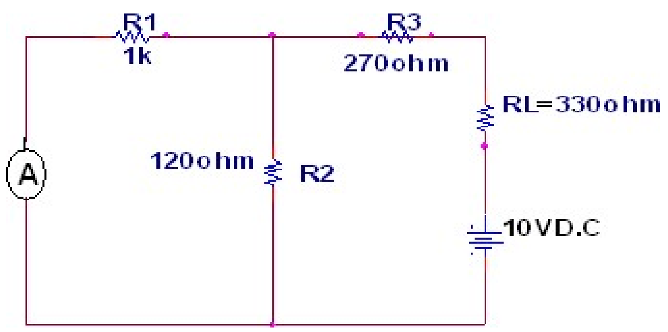
Step i) Calculation of I_L before interchanging the power supply,

$I_L = I_2 = 1.5mA$



Stepii)CalculationofI_L''afterinterchangingthepowersupply,$I_L'' = I_2'' =$

1.5mA



PROCEDURE:

1. Forthegivencircuitdiagram,theoremmustbeverifiedtheoretically.
2. Theranges ofthemetersareselectedaccordingto thetheoreticalcalculations.

3. Circuit connections are made as shown infigure.
4. Required supply is given to the circuit and the corresponding readings ofammeter and voltmeter are noteddown.
5. Theoretical values are compared with practicalvalues.

TABULATION:

Parameters	Analytically	Experimentally
I_L	**1.5mA**	
I_{L} ,,	**1.5mA**	
V/I_L	**6.66KΩ**	
V/I_{L} ,,	**6.66KΩ**	

RESULT:

VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM

AIM: - To Verify Maximum power transfer theorem.

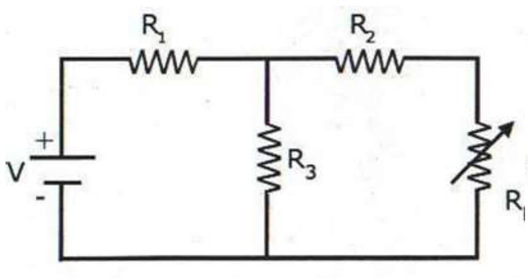
APPARATUS:

S.No.	Equipment	Range	Type	Quantity
1.	Resistors	-	-	As required
2.	Multi-meter			1
3.	R.P.S	0-30V/0-1A	Dual channel	1
4.	Bread Board	-	-	1
5.	Ammeter	0-200mA	MC	1
6.	Voltmeter	0-20V	MC	1
7.	Connecting Wires			As required

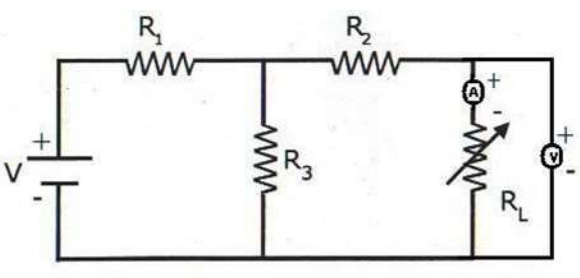
STATEMENT:

The maximum power transfer theorem states that maximum power is delivered from a source resistance to a load resistance when the load resistance is equal to source resistance. $R_s = R_L$ is the condition required for maximum power transfer.

Circuit Diagram:



DC CIRCUIT



DC CIRCUIT

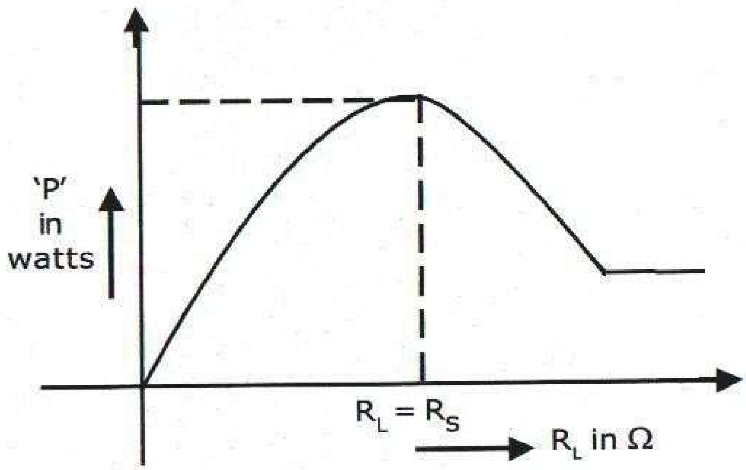
PROCEDURE:

1. Connect the circuit as shown infig.
2. Vary the load resistance in steps and note down voltage across the load and current flowing through thecircuit.
3. Calculate power delivered to the load by using formulaP=V*I.
4. Draw the graph between resistance and power (resistance on X- axis and power on Y- axis).
5. Verify the maximum power is delivered to the load when $R_L = R_s$ forDC.

TABULAR COLUMN:

R_L	V_L	I_L	P=VI

MODEL GRAPH:



RESULT:

Experiment No. 7

OPERATING INSTRUCTIONS FOR ANDERSON'S BRIDGE

OBJECT:

To measureself-inductance ofacoilusingAnderson"sBridge.

APPARATUS:

Anderson"s Bridge has been designed on a training board New Tech Type NTI – 117. It consists three fixed resistances R1, R2, R3. R1 is connected in between A and B. R2 is connected in between B and C. Thus R1 and R2 form two ratio arms, R3 is connected in between A and D and a variable resistance R4 is connected in unknown arm C and D. The inductance (L) to be measured is also connected in the samearm. Thus, R4and L are in series. A set of seven capacitors C = C1, C2, C3, C4, C5, C6, C7 andresistance r in two steps of (i) X 100Ω upto 1KΩ (ii) X 1KΩ upto 10 KΩ are provided on the board. Fixed frequency oscillator is connected in the bridge two terminal provided for this. A headphone or galvanometer fitted with diode is joined in between two terminals marked for this purpose. Three inductances L1, L2 andL3 are also provided on the board. L1is between first and second terminal, L2 is between second and third terminal, L3 is in between third and fourthterminal.

THEORY:

When Anderson Bridge is balanced in the sound in headphone or deflection in galvanometer fitted with diode is minimum. The potential at E & F is samethen:

$$\therefore \frac{P}{Q} = \frac{R}{S}$$

$$\therefore \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

And if P = Q or $R_1 = R_2$

$$\boxed{L = CR_3(R_2 + 2r)}$$ .... (1)

PROCEDURE:

(1) Connect oneself inductance say L2 (second and third terminals) to the sockets provided across the symbol of the Coil in the bridge circuit.

(2) Connect a leclanche cell or lead accumulator in place of oscillator and Galvanometer at place of headphone. Adjust R4 so that Zero deflectionisobtainedinGalvanometerkeepingrat0resistance.

(3) Now disconnect leclanche cell and at itsplace connect fixed frequency oscillator. Headphoneor Galvanometer fitted with diode is connected at its properplace.

(4) Set suitable value of C and by changing r obtain minimum sound in headphone or minimum deflection in Galvanometer. Record the value of C and r inO.T.

(5) Changing value of C repeat step (4) several times. Record the value of C and r inO.T.

(6) CalculateLusingformula(1)givenintheory.

OBSERVATIONS : Given Values :

$R_1 = R_2 = R_3 = 1K\Omega$

C_1 = …… μF, C_2 = ….. μF, C_3 = …… μF

C_4=……μF,C_5=…..μF,C_6=……μFandC_7=…….μF L_1=
…… mH, L_2= ….. mH, L_3= …..mH

S. No.	Value of C μF	Resistance r Ohms	Inductance L mH
1			
2			
3			

Mean Value of L = ……. mH

CALCULATIONS:

$L = CR_3 (R_2 + 2r)$ Henry

$= CR_3 (R_2 + 2r) \times 10^3$ mH

RESULT:

Inductance of the given:

Coil = …. mH

Standardvalue = ….mH

PRECAUTIONS:

(1) Initially the output of frequency oscillator should be kept low and near null point it should beincreased.

(2) Ifheadphoneisusedtheseshouldbesilenceintheneighboring.

(3) For greater sensitivity of the bridge resistances in the four arms should be nearlysame.

(4) Plugtype ResistanceboxorP.O.boxshouldnotbeused.

(5) For obtaining balance point $L > CR_2R_3$.

(6) For inductance L_1 is of low value C_1, C_2, C_3 capacitors should be used. For inductance $L_2$is medium value C_3, C_4, C_5. Capacitors should be used and for L_3 Capacitors C_5, C_6, C_7 should be used to get null point and better results.

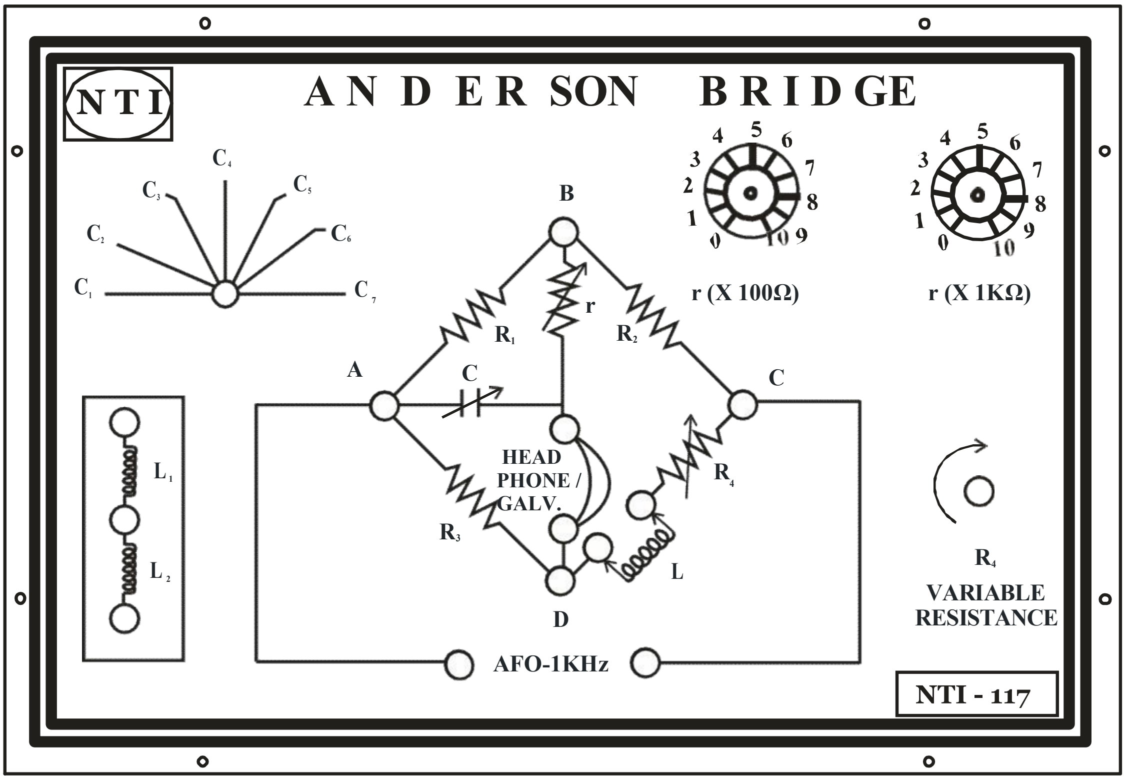


Fig. (1) PanelDiagram

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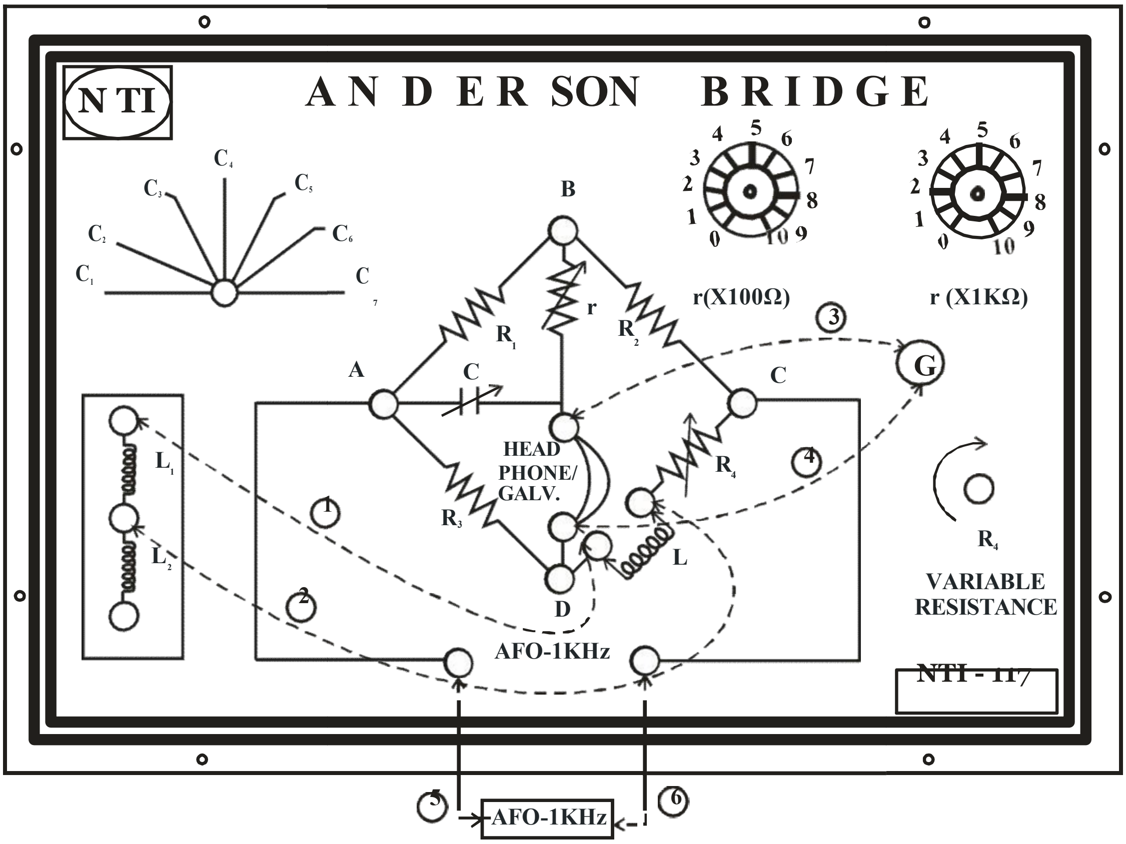

Fig. (2) Connections for ANDERSON BRIDGE

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Experiment No. 8

L-C-R Series and parallel Resonance

Aim :- To study the frequency response and to find resonant frequencies of L-C-R series and parallel circuits. Also to find the quality factor and band width in L-C-R series circuit.

Apparatus :- A variablenon-inductiveresistor,avariablecapacitor,avariable inductor, a signal generator, an a.c. milli- ammeter and the connecting wires.

Formula :- Theresonancefrequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$ Hz

Where L = Self inductance (mH)

C = Capacity of the capacitor (μF)

Quality factor $Q = \frac{2\pi f_0 L}{R}$

Where R = Resistance (Ω)

Band width = ($f_2 - f_1$) (Hz)

AlsoQualityfactor $Q = \frac{f_0}{f_2 - f_1}$

Where f_1 and f_2 are the frequencies at the half power points.

Description and theory :- (Series L-C-R) When the resistor R, inductor L and capacitor C are connected in series with a source of emf E , the circuit is called as the series resonant or series tuned circuit (figure-1). This is an acceptor circuit, that means it allowsmaximumcurrenttoflow throughitataparticular(resonant)frequencyandatall other frequencies it allows less current.

In A.C. circuits the voltage and the current are usually out of phase. Across the inductor, the current lags behind the voltage by 90^0, where as across the capacitor, the current leads the voltage by 90^0. But across the resistor the voltage and current both are in phase. Under certain conditions, the voltage and current are in phase, even though the circuit consists of L , C and R and the circuit behaves as a pure resistor. This phenomenon is called resonance. This occurs at a single frequency known as resonant frequency. At this frequency the capacitive reactance ($X_C = 1/\omega C$) and the inductive reactance ($X_L = \omega L$) are equal and opposite in direction. So they get cancelled eachother and only resistance acts.

The impedance of the circuit is given by $Z = R + j(\omega L - 1/\omega C)$

At resonance the reactivetermdisappears $\omega L - 1/\omega C = 0$

The impedance is minimum i.e. $Z = R$

The current is maximum $I = E/R$

So $\omega L = 1/\omega C$

$\omega_0 = \omega = 2\pi f_0$ 1

At this frequency the current ismaximum and thisfrequency f_0 is calledresonant frequency. The circuit has selective properties. To compare selectivity or sharpness of resonance, a band of frequencies is chosen at which the current falls to times (half power points) of its maximum value. The frequency difference ($f_2 - f_1$) between the half power points are called the bandwidth.

<u>L-C-R parallel</u>:- Parallel resonant circuit (figure-2) is one in which one branch consists of an inductor L with associated resistor R and the other branch consists of a capacitor C. Thisisarejectorcircuit,thatmeansitrejectsthecurrentorallowsminimumcurrentto flow through it, at a particular (anti- resonant) frequency and it allows more current at

all other frequencies. So the circuit is not selective. But it is highly selective when energized from a high impedance generator.

The impedance of the circuit is given by

$$\frac{1}{Z} = \frac{1}{R + j\omega L} + \frac{1}{\frac{1}{j\omega C}}$$

At resonance the impedance is maximum.

The impedance at resonance $Z = \frac{L}{CR}$

The anti-resonance frequency $f_o = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$ Hz

If R-value is small, then $f_0 = \frac{1}{2\pi\sqrt{LC}}$ Hz

Procedure :- For L-C-R series, the circuit is connected as shown in the figure-1.The source resistance and the series resistance should be small. The output voltage of the signalgenerator is adjusted to be around 5V. The frequency of the signal generator is changed in steps and the corresponding current values are noted from the a.c. milli-ammeter. The readings are tabulated. The current values increase with the increase of frequency, up to the resonant frequency, further increase of frequency causes the decrease of current. The L, C and R values are noted to calculate the resonant frequency f_0 andQ-factor, using the above formulae.

Note :- The experiment may be repeated with a different values of „R‟ . Here the f_o value is unchanged, but Q- factor value is changed.

Graph :- A graph is drawn for current against frequency. The frequency corresponding to maximum current is noted and it is the resonant frequency f_0. The frequencies f_1 and f_2 corresponding to half power points is noted and from it the bandwidth, $(f_1 - f_2)$ is noted. From the values of f_0, f_1 and f_2, the quality factor, Q iscalculated.

For L-C-R parallel, the circuit is connected as shown in the figure-2. The frequency of the signal generator is changed in steps and the corresponding current values are noted from the a.c. milli- ammeter. The readings are tabulated. But here, the current values decrease with the increase of frequency up to the anti- resonant frequency, furtherincrease of frequency causes the increase of current. The anti- resonant frequency f_o is noted corresponding to the minimum current in thecircuit.

Graph :- A graph is drawn for current against frequency. The frequency corresponding to minimum current is noted and it is the anti- resonant frequency f_0.

Precautions :- 1) The internal resistance of the source and series resistance should be small.

2)Before going to the experiment the resonant frequency should be calculated from L and C values so that to select the range of frequencies forobservation.

Results:-

Table-1

L-C-RSeries

S.No.	Frequency (Hz)	Current (mA)
1.		
2.		
3.		
20.		

Table-2

L-C-RParallel

S.No.	Frequency (Hz)	Current (mA)
1.		
2.		
3.		
20.		

Fig-1

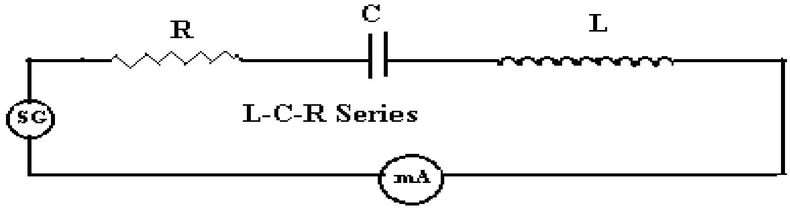
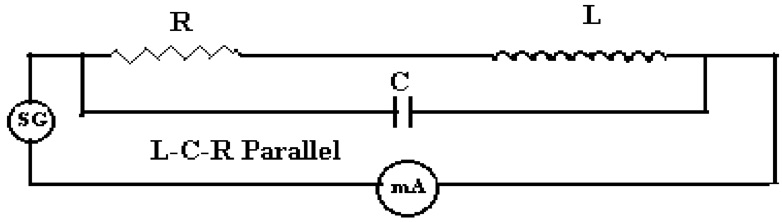
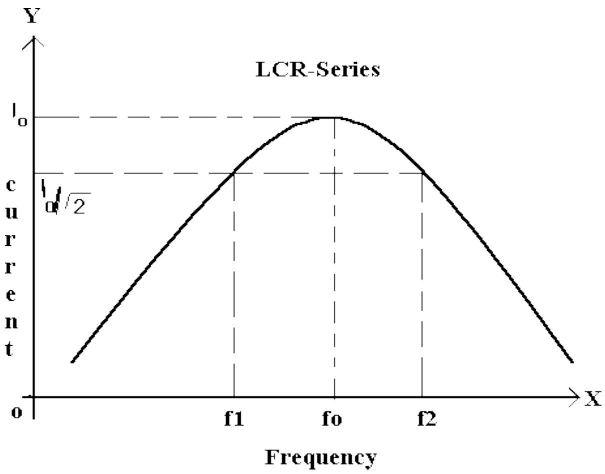
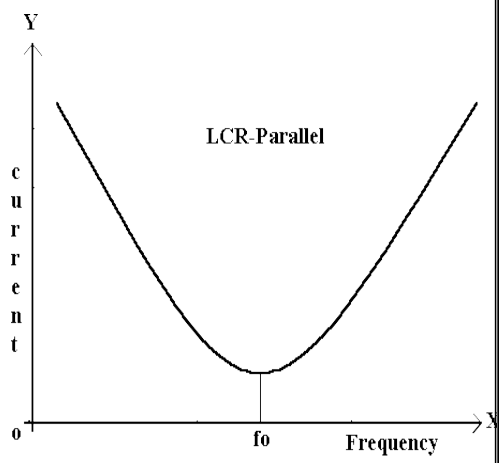


Fig-2




LCR-Series
Y
current
o
f1
fo
f2
X
Frequency


LCR-Parallel
Y
current
0
fo
Frequency
X

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