Experiment 1

Experiment Name:

To Study construction of different types of meters & study how to connect them in a circuit.

Objective:

Study of the operation of Moving Coil type, Moving Iron type and Dynamometer type instruments

Apparatus Required:

1. Patch chords of appropriate length
2. One 6V DC bulb as DC load
3. One 100W bulb as AC load
4. Meter demonstrator kit

Theory:

Permanent Magnet Moving Coil (P.M.M.C.) Instruments:

A moving coil instrument consists basically a permanent magnet to provide a magnetic field and a small lightweight coil is wound on a cylindrical soft iron core that is free to rotate around its vertical axis. When a current is passed through the coil windings, a torque is developed on the coil by the interaction of the magnetic field and the field set up by the current in the coil. It has been mentioned that the interaction between the induced field and the field produced by the permanent magnet causes a deflecting torque, which results in rotation of the coil. PMMC instrument are used for DC voltage or current measurement only.

Moving Iron (M.I.) Instruments:

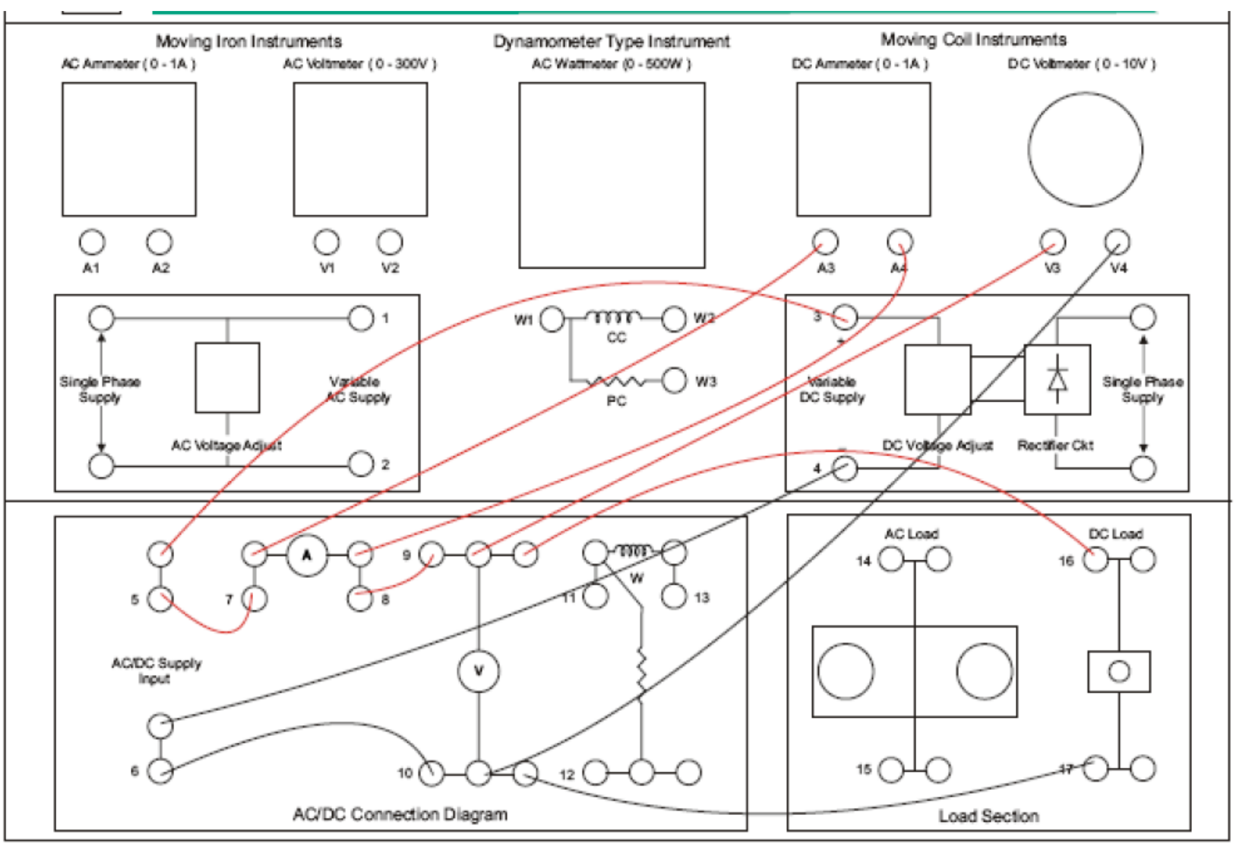
The deflecting torque in any moving iron instrument is due to forces on a small piece of magnetically 'soft' iron that is magnetized by a coil carrying the operating current. Magnet causes a deflecting torque, which results in rotation of the coil. The deflecting torque is proportional to the square of the current in the coil, making the instrument reading true RMS quantity. Rotation is opposed by a hairspring that produces the restoring torque. Only the fixed coil carries load current, and it is constructed so as to withstand high transient current. Moving iron have non-linear scales and somewhat crowded in the lower range of calibration. Two types of Moving Iron instruments are there repulsion type and attraction type. M.I. instruments can also be used for DC and AC current and voltage measurement both.

Dynamometer Type Instrument

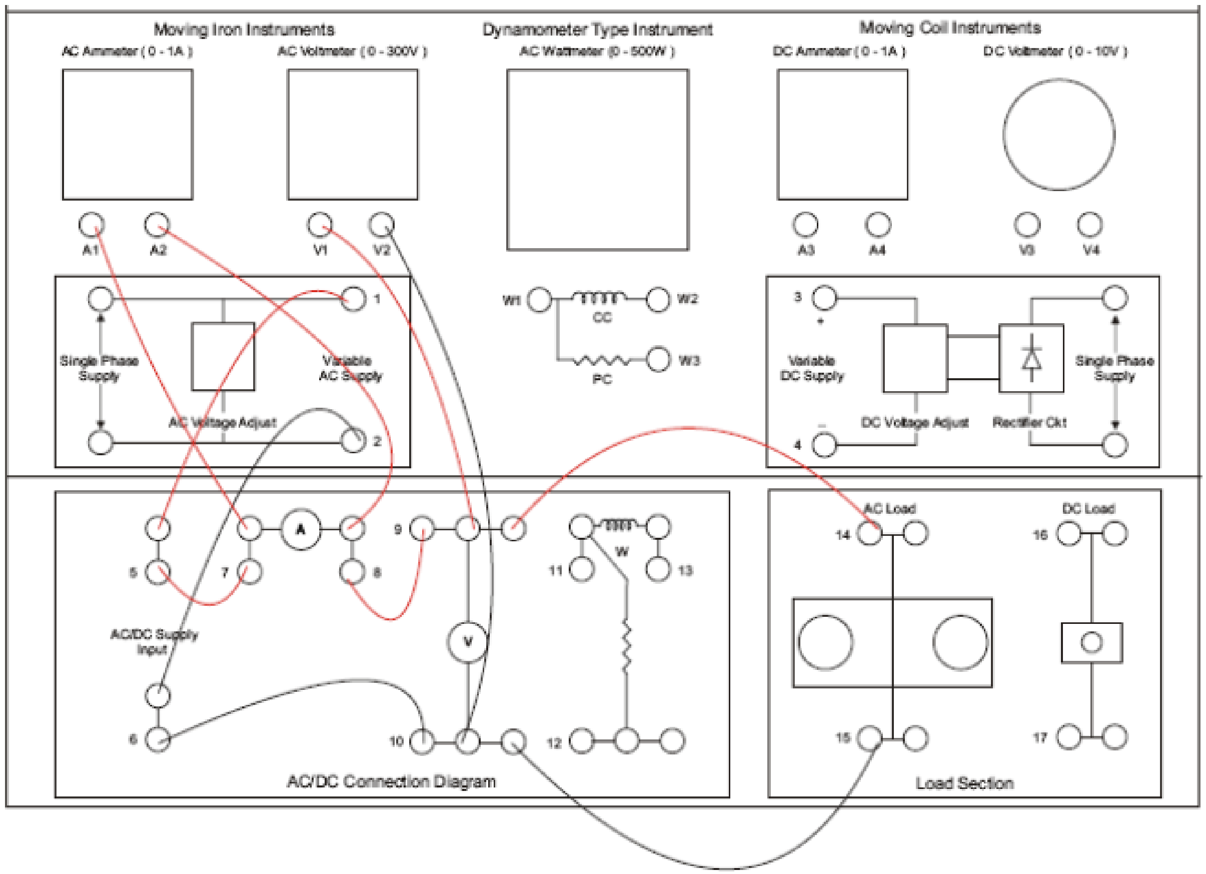
Electrodynamometer type instruments are similar to the P.M.M.C. instruments except the magnet is replaced by two serially connected fixed coils that produce the magnetic field when energized. The fixed coils are spaced far enough apart to allow passage of the shaft of the movable coil. The movable coil carries a pointer, which is balanced by counter weights. Its rotation is controlled by springs. The motor torque is proportional to the product of the currents in the moving and fixed coils. If the current is reversed, the field polarity and the polarity of the moving coil reverse at the same time, and the turning force continues in the original direction. Since reversing the current direction does not reverse turning force, this type of instruments can be used to measure AC or DC current, voltage, or its major application as a wattmeter **(**in our case**)** for power measurement.

Circuit diagram

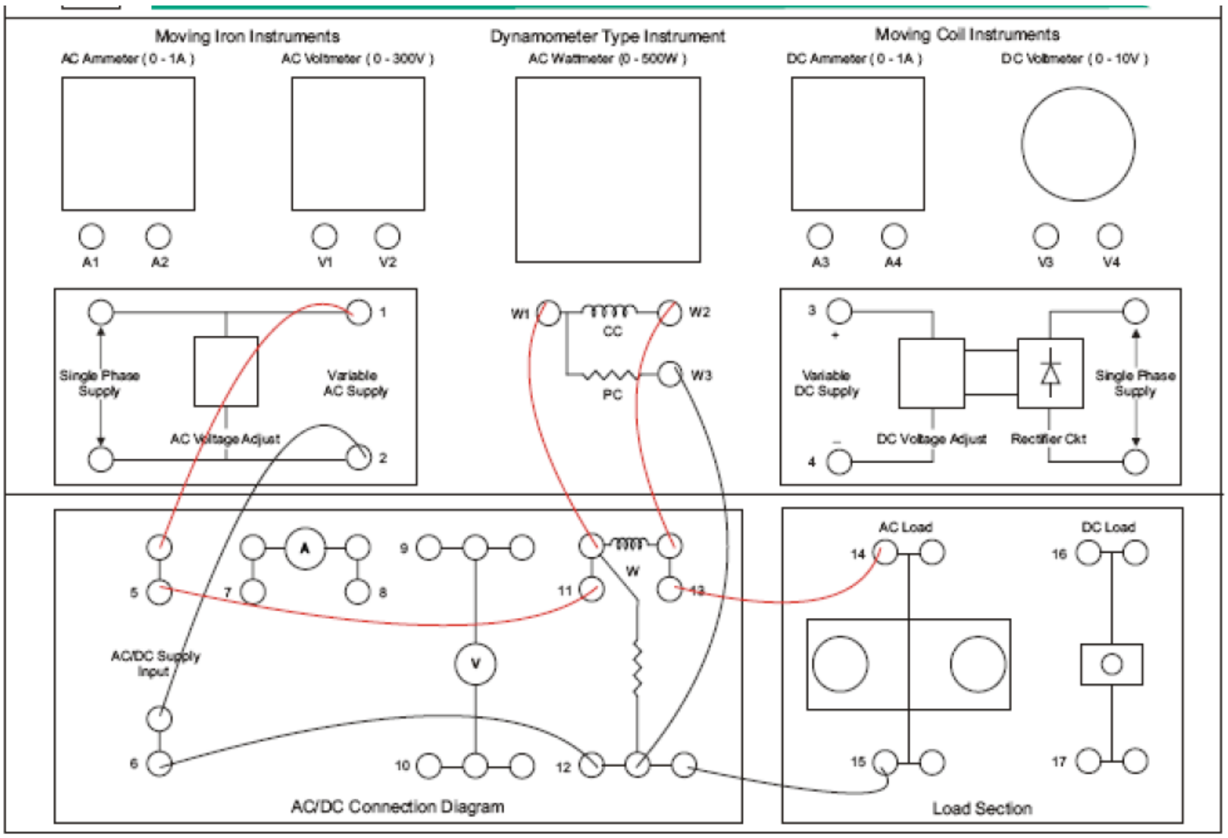
For Moving Coil Type Instrument



For Moving Iron Type Instrument



For Dynamometer Type Instrument



Procedure

1. Connect 230V AC supply to the Meter Demonstrator.
2. Now connect Variable AC or DC supply according to the requirement of the circuit to AC/DC supply input.
3. Connect Ammeter in series to the load & connect voltmeter and wattmeter across the load
4. Connect a 6V bulb to the DC load section or a 100W bulb to the AC load section according to the instrument.
5. Connect the circuit according to the given circuit diagram
6. Compare these connections with the connections given in the circuit diagram.
7. Switch ON the mains Supply.
8. Now slightly move the DC or AC voltage adjust knob and observe the motion in meters.
9. Now note down the reading of the pointer with the changing of input supply.
10. Switch Off the mains Supply.

Result:

In case of Moving Coil the coil wounded to the soft iron deflects with respect to the torque produced due to the voltage (or current)

In case of Moving Iron the soft iron would deflect with respect to the torque produced due to the voltage (or current), while the coil remain stationary.

In case of dynamometer the pressure coil (inner) deflects with respect to the torque produced due to the voltage & current, while two current coils remain stationary.

Precaution:

1. Handle all the equipments with care.

2. Make connections according to circuit diagram.

3. Take the readings carefully & the connections should be tight.

Experiment 2

Experiment Name:

To calibrate a voltmeter & an ammeter using a potentiometer.

Objective:

- Calibration of voltmeter using DC potentiometer
- Calibration of Ammeter using DC potentiometer

Apparatus Required:

1. Calibration of voltmeters and ammeter by Potentiometer
2. Potentiometer
3. Sliding jockey
4. Mains cord
5. Patch cords

Theory:

A potentiometer instrument for measuring the potential (or voltage) in a circuit taps off a fraction of a known voltage from a resistive slide wire and compares it with the unknown voltage by means of a galvanometer. The potentiometer method is the usual basis for the calibration of voltmeters, ammeters, and wattmeters. Since the potentiometer is a DC measurement device, the instrument to be calibrated must be of the DC or electrodynamometer type. One of the first requirements in this calibration procedure is that a suitable, stable DC supply be available, since any variation in the supply voltage causes a corresponding change in the voltmeter calibration voltage.

Diagram of Callibration of Voltmeter:

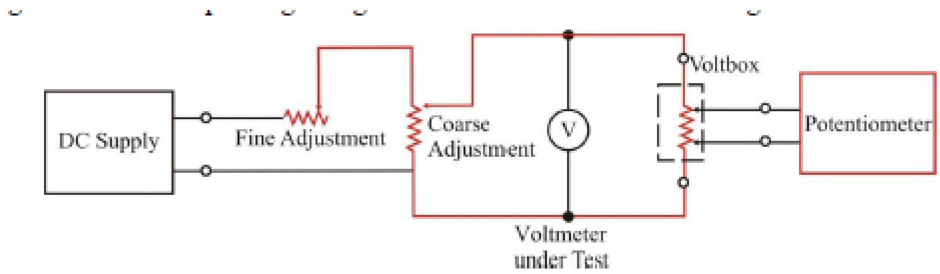
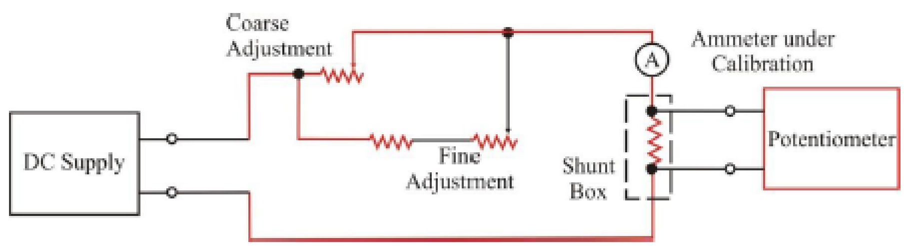


Diagram of Callibration of Ammeter:



Procedure:

1. Connect the mains cord to the Trainer kit and switch On Mains Supply.

3. Note the output of standard DC supply (Vdc) by connecting terminal 32 to digital voltmeter V1's positive terminal and ground terminal 6 to negative of V1.

4. Once voltage is noted from V1, disconnect them and connect the negative terminal of galvanometer G1 to positive terminal 32 of DC supply.

5. Connect positive terminal of G1 to jokey.

6. Connect terminal 3 and 4 to digital ammeter A1 polarity wise.

7. Connect DC potentiometer between terminal 5 and 6. Connect 5 to X and 6 to Z terminal.

8. Vary VR2 knob to set the current in A1 (say 30 mA).

9. Touch jokey to X and then to Z terminals of potentiometer and see the reading of galvanometer. Compare both reading of galvanometer.

10. Now slide the jokey on potentiometer wire and the find null point i.e., the point where galvanometer G1 shows zero reading.

11Connect the circuit according to the provided circuit Diagram.

12. Set the voltage in analog DC Voltmeter (V) to some value (say 1 V) with the help of VR1 knob.

13. Touch jokey to X and then to Z terminals of potentiometer and see the reading of galvanometer. Compare both reading of galvanometer.14. Now slide the jokey on potentiometer wire and the find null point.

15. Now measure distance D (in cm) moved from terminal Z to null point.

Observation Table:

For Voltmeter Calibration

Observation Table-1:

Value of standard DC Suppy V_{dc} = ...

Value of Calibration constant C = V_{dc}/L = ...

S. No	DC Voltmeter Reading V (Volt)	Null point position D (cm)	Voltage Ratio (M)	Voltage across potentiometer Vp =C×D×M (Calibrated Voltage)	percentage error = $\frac{V - V_p}{V_p} \times 100$
1	1 V				
2	2 V				
3	3 V				
4	4 V				
5	5 V				
6	6 V				
7	7 V				
8	8 V				
9	9 V				

For Ammeter Calibration

Observation Table-2:

Value of Calibration constant C = …….., Value of Standard Resistance R = 10 Ω

S. No	DC Ammeter Reading I (Ampere)	Null point position D (cm)	Voltage Ratio (M)	Voltage across potentiometer Vp=C×D×M	Current in standard resistance $I_p = \frac{V_p}{R}$	percentage error = $\frac{I - I_p}{I_p} \times 100$
1	0.1 A					
2	0.2 A					
3	0.3 A					
4	0.4 A					
5	0.5 A					
6	0.6 A					
7	0.7 A					

Calculations:

Distance L (in cm) moved from terminal Z to null point is

L = [(n-1)*100 + r] cm.

n= number of wire from the Z terminal, for odd line of wire take reading from lower scale and for even line wire take reading from upper scale.

$C=V_{dc}/L$

V_{DC} = DC Supply Voltage.
L= Distance
C= Voltage drop per cm.

Precaution:

1. Handle all the equipments with care

2. Make connections according to circuit diagram

3. Take the readings carefully& the connections should be tight

Experiment 3

Objective:

Determination of unknown inductance and Q factor using Hay's bridge method

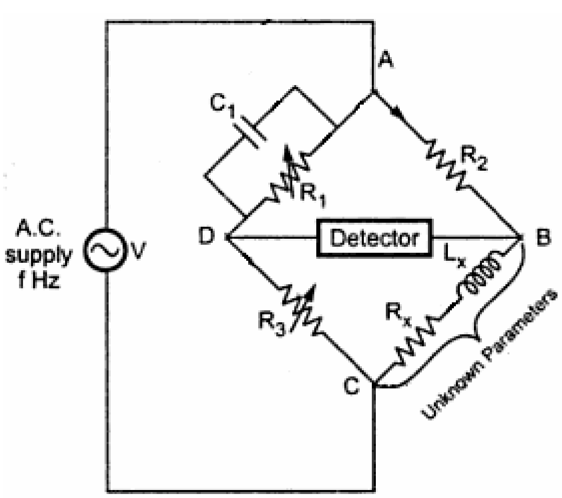
Apparatus Required:

1. Hays Bridge trainer kit
2. Patch cords
3. CRO
4. Digital multimeter

Theory:

These bridges work by balancing the inductive phase shift of unknown inductor against a capacitive phase shift of the same magnitude in the diametrically opposite arm of the bridge. As shown in figure 1, one arm of the Hay's bridge consists of a capacitor in series with a resistor C1 and R2) and another arm consists of an inductor L1 in series with a resistor (L1 and R4). The other two arms simply contain a resistor each (R1 and R3). The value of R3 is known, and R1, R2 and C1 are all adjustable. The unknown values are those of L1 and like other bridge circuits, the measuring ability of hay's bridge depends on 'balancing' the circuit. Balancing the circuit means adjusting R2 and C1 in figure until the current through the null detector between points A and B becomes zero.

Circuit diagram:



Procedure:

1. Connect mains cord to the Trainer.
2. Connect terminal 1 to 4(for evaluating unknown capacitance Cx1).
3. Rotate variable resistance R1 towards anti clockwise direction.
4. Connect null detect or (i.e. terminal 5 to 10 and 8 to 9).
5. Keep toggle of Null Detect or towards 'off' condition.
6. Select Frequency Selector f or any desired range of frequency.

· 100 Hz to 1 kHz

· 1 kHz to 10 kHz

· 10 kHz to 60 kHz

7. For example 2 kHz frequency, select frequency in between the ranges 1 kHz-10 kHz
8. Use Frequency Variable knob to set 2 kHz frequency on display screen.
9. Connect terminal 19 to 6 and 20 to 7.
10. Now switch 'On' the power supply.
11. Set toggle of null detector towards 'on' condition.
12. Vary Amplitude Variable f or enough sound of speaker.
13. Vary resistance R1 towards clockwise direction slowly. (Sound diminishes).
14. Keep varying R1 until you get very low sound or null sound (null condition). Further varying R1 in same direction speaker starts sounding.
15. Finally adjust the value of R1 to get null point. (Where sound completely diminishes)
16. Now remove the patch cord between terminal 1 & 4 and record the value of R1 in the observation table using multimeter.
17. Repeat above procedure f or different value of frequency and different value of unknown capacitors (i.e. Cx2 and Cx3).
18. Tabulate all the retrieved data in observation table below.

Observation Table:

Observation Table 1

Lx1 & Rx1 using:	R3 Ω	R1x Ω	Cx nF	R2 Ω	Lx1 mH	Rx1 Ω	Q1
C1 and R11	500	28	220				
C2 and R12	500	20	330				
C3 and R13	500	13	470				
Average of all readings							

Observation Table 2

Lx2 & Rx2 using:	R3 Ω	R1x Ω	Cx nF	R2 Ω	Lx2 mH	Rx2 Ω	Q2
C1 and R11	500	28	220				
C2 and R12	500	20	330				
C3 and R13	500	13	470				
Average of all readings							

Observation Table 3

Lx3 & Rx3 using:	R3 Ω	R1x Ω	Cx nF	R2 Ω	Lx3 mH	Rx3 Ω	Q3
C1 and R11	500	28	220				
C2 and R12	500	20	330				
C3 and R13	500	13	470				
Average of all readings							

Calculation:

This happens when the voltages at points A and B are equal. When the hay's bridge is balanced, then

Z1/ R1 = R3/ Z2 ……………….. ..(1)
Where, Z1 is the impedance of the arm containing C1 and R2
While, Z2 is the impedance of the arm containing L1 and R4.

Thus,
Z1 = R2 + 1/ (2.Π.f.C1) ………………… (2)
And, *Z2 = R4 + (2. Π.f.L1)* ………………… (3)
Mathematically, when the bridge is balanced,
[R2 + 1/ (2.Π .f.C1)] / R1 = R3 / [R4 + 2. Π .f.L1]

Thus, the equations for L1 and R4 for the hay's bridge when it is balanced are:
L1 = R3.R1.C1 / [1 + (2.Π.f.R2.C1)2] ……………….(4)
R4 = (2.Π.f.C1)2.R2.R3.R1 / [1 + (2.Π.f.R2.C1)2] ………………..(5)

Note that the balancing of hay's bridge is frequency-dependent. Another important parameter
of this bridge is Q factor of the inductor used.
Q = 1/ (2.Π.f.C1.R2) = (2.Π.f.L1)/R4 ………………. .(6)

L1 = R3.R1.C1 /[1+ (1/Q)2] ………………. .(7)
And *R4 = R3.R1/ [R2 (Q2+1)]* ………………. .(8)

For large values of Q factors (or Q>10),

L1 = R3.R1.C1 ………………. .(9)
And, **R1 = R3.R1/ (R2.Q2)** ……………….. (10)

Result:

1. The unknown values of Inductor Lx1, Resistance Rx1 and Q1 factor are-

   Lx1 = …………….mH,

   Rx1 = …………….Ω,

   Q1 = ……………

2. The unknown values of Inductor Lx2, Resistance Rx2 and Q2 factor are-

   Lx2 = …………….mH,

   Rx2 = …………….Ω,

   Q2 = ………………

3. The unknown values of Inductor Lx3, Resistance Rx3 and Q3 factor are -

   Lx3 = …………….mH,

   Rx3 = …………….Ω,

   Q3 = ……………

Precaution:

1. Handle all the equipments with care

2. Make connections according to circuit diagram

3. Take the readings carefully& the connections should be tight

Experiment 4

Experiment Name: High Resistance Measurement by Leakage Method

Objective: To determine the value of High Resistance by Leakage Method.

Apparatus Required

1. NV6061 Trainer
2. Mains cord
3. Ballistic galvanometer
4. Lamp & Scale arrangement
5. Connecting wires

Theory:

High Resistance Measurement by Leakage Method is very useful for measuring very high value of Resistance. DMM or LCR meters are suitable to measure the normal value of resistance (generally .1 Ω – 20MΩ) but in the case of very high value of resistance they are unable to measure with high accuracy. Leakage method is very accurate to measure the high resistance because of very sensitive ballistic galvanometer and very low value of capacitances are used in the trainer.

Resistance: Resistance refers to the property of a substance that impedes the flow of electric current. Some substances resist current flow more than others. If a substance offers very high resistance to current flow i t is called an insulator. If its resistance to current flow is very low, it is called a conductor. Resistivity refers to the ability of substances to resist current flow. Good conductors have low resistivity and insulator have high resistivity.

Ballistic Galvanometer:

A ballistic galvanometer is used to measure the total quantity of electrical charge that passes through it as a sudden discharge. The moment of inertia of the moving system is very large and hence it is slow to begin its motion under the impulse of the charge so that the whole of the charge passes through the galvanometer before the moving system has appreciably moved from its position of rest.

Voltage sensitivity of galvanometer:

It is defined as the deflection of the meter per unit voltage, a / v

Now, a / V = a / RI or a / V = (NBA / k) R

Experimental theory:

If a capacitor C after being charged to a potential difference V_0 is instantaneously discharged throw a ballistic galvanometer giving a rise to a first throw θ_0 then the charge on the capacitor

$$q_0 = CV_0 = K\theta_0 \left|1 + \frac{\lambda}{2}\right|$$

Where K is the constant of the ballistic galvanometer

λ is the logarithmic decrement.

The capacitor is again charged to the same potent i al and the charge is all owed to leak through a high resistance R for a known time t so that the potential falls from V0 to Vt. If the remaining charges q on the capacitor i s allowed to pass through the galvanometer so that a first throw θ1 i s produced, then

$$q_0 = CV_1 = K\theta_1 \left|1 + \frac{\lambda}{2}\right|$$

$$\frac{q_0}{q_1} = \frac{V_0}{V_1} = \frac{\theta_0}{\theta_1}$$

Procedure:

Setting of ballistic galvanometer and lamp & scale arrangement:

1. Place ballistic galvanometer at plane surface.
2. Look at coil of ballistic galvanometer at the middle of core and moves freely.
3. If coil does not centered properly, than use leveling screw.
4. Place lamp and scale arrangement at a distance of one meter from the mirror of galvanometer.
5. Incident laser light at the mirror of ballistic galvanometer.
6. Adjust lamp and scale arrangement so that spot of light moves freely on scale.
7. Set rest position of spot at zero division of scale.
8. Give slight rotation to the coil and see reflecting spot moves freely straight on full scale.
9. If reflecting spot does not move freely straight- wise than again use leveling screw or change a bit position of scale vertically.
10. When spot move freely straight wise on full scale than galvanometer is prepare for experimental procedure.

To measure unknown High Resistance:

11. Connect main cord to the trainer.
12. Take two patch cords and connect them between 5&6 point of the trainer and ballistic galvanometer.
13. Select toggle switch S1 at off position and S2 at Open position.
14. Select toggle switch S3 and S4 on position 1.
15. Select unknown resistance at R4 position and capacitance at .47μF by given rotary switches.
16. Now switch ON the trainer then DC supply switch S1, so that the supply-capacitor circuit will be complete and capacitor will be charge with same voltage.

17. After 20-25 seconds suddenly select switch S4 at position 2, so that the galvanometer circuit will be complete and capacitor will discharge through galvanometer. Carefully note the first throw θ0 corresponding to the chargeq0.

18. Wait till position of the spot of light on the scale set on zero position.

19. Now select S4 back on position 1, so that capacitor will charge again with same potential.

20. Select toggle switch S3 on position 2 and immediately start the stop-watch. Now capacitor has leaked for a known time t, say 5 seconds, then immediately select toggle switch S4 on position 2 so capacitor will discharge throw galvanometer and observe the first throw θ'.

21. Repeat this self -leakage experiment for different values of leakage time i .e.15, 20, 25 sec noting the value of the throw θ' for each time of t.

22. Again set toggles S3 and S4 on position 1 so capacitor will be charge.

23. Select toggle S2 on Short position.

24. Wait till position of the spot of light on the scale set on zero position.

25. Select toggle switch S3 on position 2 and immediately start the stop-watch. Now capacitor has leaked throw resistance R for a known time t, say 5 seconds, then immediately select toggle switch S4 on position 2 now capacitor will discharge throw galvanometer and observe the first throw θ1.

26. Repeat this experiment for different values of leakage time i .e.15, 20, 25 Sec. noting the value of the throw θ1 for each time of t.

27. Repeat all experiment for different combination of R and C.

Observation Table:

Capacitance of the capacitor C = ...μF =..................... F

Initial position of the spot on the scale =.......................

First throw due to charge q0, θ0 =........................

S.No.	Leakage Time t seconds	First throw after the charge had leaked						$\log_{10}\left(\frac{\theta_0}{\theta'}\right)$	$\log_{10}\left(\frac{\theta_0}{\theta_1}\right)$
		Self-leakage			Leakage throw R				
		Initial	final	θ'	Initial	final	θ_1		
1.	15								
2.	20								
3.	25								
4.	30								
5.	35								
6.	40								

Precaution:

1. Handle all the equipments with care

2. Make connections according to circuit diagram

3. Take the readings carefully& the connections should be tight

Experiment 5

Experiment Name: Determination of unknown resistance using Kelvin's Bridge method

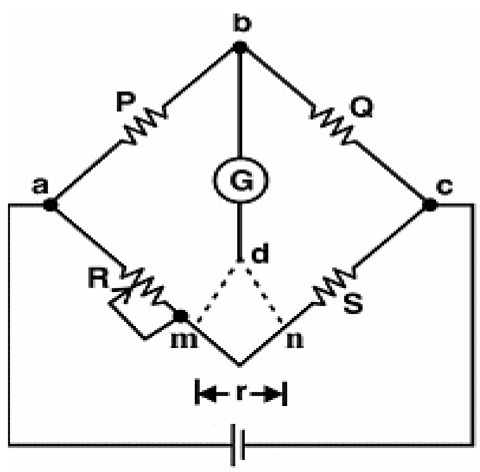
Apparatus Required:

1. NV6534trainer board

2. Digital Multimeter

3. 2 mm patch chords

Circuit Diagram:



Kelvin's bridge

Theory:

Kelvin's double bridge or simply Kelvin's bridge (as it is commonly known as) is employed when a very low value of resistance is to be measured. Consider the value of resistance is in the magnitude of contact leads. For low resistance measurement, the resistance of lead and contacts becomes significant and can introduce an error; this can be eliminated using Kelvin's bridge. This bridge is a modification over other DC bridges and provides greatly increased accuracy in measurement of low resistance.

Procedure:

1. Connect a patch cords between sockets '1' and '2 ', and in between sockets '9' and '6' to maintain the 100:1 ratio of bridge.

2. Rotate the Potentiometer R2 in fully counter clockwise direction.

3. Connect the patch cords according to the provided circuit diagram.

6. Switch 'ON' the power supply.

7. Rotate the potentiometer R2 towards clockwise direction till the galvanometer gives the null deflection.

8. Switch 'OFF' the power supply and disconnect the patch cords between sockets '10' and '11'.

9. Take reading of potentiometer R2 between test-points '16' and '15' using digital multimeter.

10. You can verify the calculated value by measuring the value of Rx in between socket '11' and test-point '14' using digital multimeter.

Observation Table:

SERIAL NO	R_X	R_1	R_2	R_3

Calculations:

Unknown Resistance

Rx = (R2. R3) / R1

Where,

R3 = 1KΩ, R1 = 100KΩ.

Precaution:

1. Handle all the equipments with care
2. Make connections according to circuit diagram
3. Take the readings carefully& the connections should be tight

Experiment 6

Experiment Name: To measure inductance by Maxwell's bridge.

Objective:

Determination of unknown inductance using Maxwell's inductance bridge method

Equipment Needed:

1. NV6533 Trainer Board

2. 2 mm patch cords

3. Digital multimeter

Theory:

This bridge is the simplest method of comparing two inductance values and to determine the values of unknown inductance. Its first arm consists of a non-inductive resistance R1, second arm consists of a standard inductor L3 in series with the non-inductive resistance R3 used for resistance balance control, third arm consisting of variable resistance R2 used for inductive balance control and fourth arm consists of unknown inductor Lx with internal resistance Rx. The balance can be obtained by varying the Its first arm consists of a non-inductive resistance R1, second arm consists of a standard inductor L3 in series with the non-inductive resistance R3 used for resistance balance control, third arm consisting of variable resistance R2 used for inductive balance control and fourth arm consists of unknown inductor Lx with internal resistance Rx. The balance can be obtained by varying the resistance R2of third arm.

Lx= inductor with unknown inductance

Rx= internal resistance

L3= standard inductor

R1, R2= non-inductive resistance.

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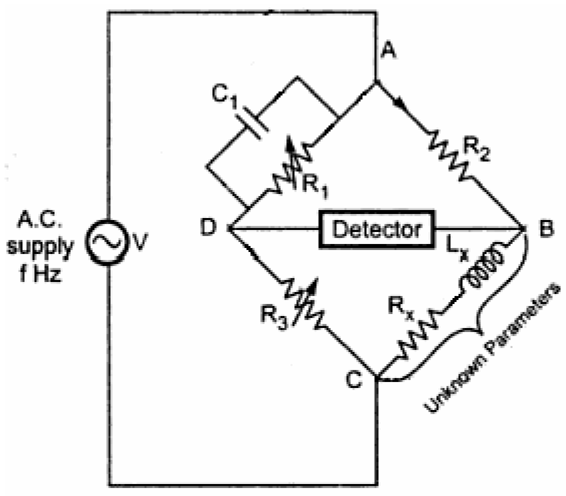
Maxwell's Inductance Capacitance Bridge:

In this bridge, an inductance is measured by comparison with a standard or variable capacitance.



L_x = unknown inductance

R_x = effective resistance of inductor L_x

R_2, R_3, R_1 = unknown non-inductive resistances

C_1 = standard capacitor

And writing the equation for balance,

$$(R_x + j\omega L_x)(R_1 / 1 + j\omega C_1 R_1) = R_2 R_3$$

Or, $RxR1 + j\omega L_x R1 = R_2 R_3 + j\omega R_2 R_3 C_1 R_1$

Separating the real and imaginary terms, we have

$$\mathbf{Lx = R_2 R_3 C_1}$$

And, $\mathbf{Rx = R_2 R_3 / R_1}$

The expression for Q factor

$$\mathbf{Q = \omega Lx / Rx = \omega C_1 R_1}$$

Procedure:

1. Connect a patch cord between socket '13' of Vin terminals of Maxwell's inductance bridge and socket '29' of Vout terminals of the 1 KHz sine wave generator.
2. Connect a patch cord between socket '14' of Vin terminals of Maxwell's inductance bridge and socket '30' of Vout of the 1 KHz sine wave generator.

3. Connect a patch cord between sockets '1' and '2' and connect another patch cord between sockets '8' and '11' to determine the value of Lx1 and Rx1.
4. Connect patch cords between sockets '15' and '17' and sockets '16' and '18'for the purpose of null detection.
5. Set the potentiometer R2 in counter clockwise direction.
6. Switch 'On' the power supply and the Null Detector.
7. Set the amplitude or loudness of the audio detector as per your requirement by rotating amplitude control knob of 1 KHz sine wave generator.
8. Rotate the potentiometer R2 towards clockwise direction very precisely to find a condition where null (or a minimum sound) is generated.
9. Switch 'Off' the power supply and the Null Detector.
10. Remove the patch cords between sockets '1' and '2'.
11. Take the reading of resistance R2 between test-points '5' and '6' using a digital multimeter.
12. Calculate the value of inductance Lx1 and resistance Rx using the formula

    $$Lx = L1.R2/ R4$$

    Where, Lx=Lx1, L1= 12μH, R4=100Ω
13. Calculate the value of unknown resistance using the formula

    $$Rx = R2.R3 /R4.$$

    Where, R3=470Ω, R4=100Ω
14. Connect a patch cord between sockets '1' and '3' and another patch cord between sockets '10' and '8' to determine the value of Lx2 and Rx2.
15. Repeat the above steps from 5 to 9.
16. Remove the patch cords between sockets '1' and '3'.
17. Take the reading of resistance R2 between test-points '5' and '6' using a digital multimeter.
18. Calculate the value of inductance Lx2 and resistance Rx using the formula

    $$Lx = L1.R2/ R4$$

    Where, Lx=Lx2, L1= 12μH, R4=100Ω
19. Calculate the value of unknown resistance using the formula

    $$Rx = R2.R3/ R4.$$

    Where, R3=4.7KΩ, R4=100Ω
20. Now connect a patch cord between sockets '1' and '4' and another patch cord between sockets '9' and '8' to determine the value of Lx2 and Rx2.

21. Repeat the above steps from 5 to 9.

22. Remove the patch cords between sockets '1' and '4'.

23. Take the reading of resistance R2 between test-points '5' and '6' using a digital multimeter.

24. Calculate the value of inductance Lx2 and resistance Rx using the formula

Lx = L1.R2/ R4

Where, Lx=Lx3, L1= 12µH, R4=100Ω

25. Calculate the value of unknown resistance using the formula

Rx = R2.R3/ R4

Where, R3=1.2KΩ, R4=100Ω

Observation Table:

S. No.	R2 Ω	R4 Ω	R3 Ω	L1 µH	Lx =L1.R2/R4 µH	Rx = R2.R3/R4 Ω
1.						
2.						
3.						

Calculation:

Measured value of R2 is. ………..........Ω.

Now measure the value of Lx by the formula

Lx =L1.R2/R4

Measured value of resistance Rx by multimeter between sockets ………Ω.

Now measure the values of Rx by the formula

Rx =R2.R3/R4

Result:

The unknown value of inductance Lx1 = ………µH.

The unknown value of inductance Lx2 = ………µH.

The unknown value of inductance Lx3 = ………µH.

The unknown value of resistance Rx = ….………Ω.

Note:

1. The actual values of inductors Lx1, Lx2 and Lx3 are12µH, 1.2µH and 4.7µH.
2. The actual value of resistor Rx is 470 Ω.
3. Small amount of error would be there due to component variations and also due to human error.

Precaution:

1. Handle all the equipments with care

2. Make connections according to circuit diagram

3. Take the readings carefully & the connections should be tight

Experiment 7

Experiment Name: To measure power & p.f. by 3-ammeter & 3 Voltmeter methods.

Objective: To calculate the power and power factor in a single-phase circuit using three Voltmeters.

Apparatus Required:

1. Single phase variac 230V, 5Amp

2. Connecting leads

3. Rheostat 45 Ohm, 5Amp

4. Power Measurement kit.

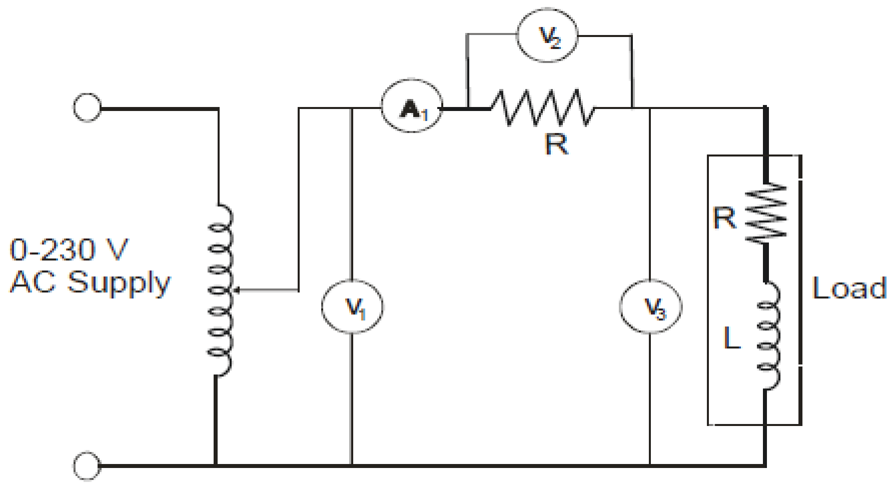
Theory:

Electric power is defined as the rate at which electrical energy is transferred by an electric circuit. P = VI Where, P is the power (watt or W) V is the potential difference (volt or V) I is the current (ampere or A) Alternate forms of the basic definition can be obtained by using Ohm's law, which states that the voltage across a pure resistance is proportional to the current through the element. Where, R is the resistance of the element, and I and V are the current through and voltage across the resistive element.

In electrical engineering, **single-phase electric power** refers to the distribution of alternating current electric power using a system in which all the voltages of the supply vary in unison. Single-phase distribution is used when loads are mostly lighting and heating, with few large electric motors. A single-phase supply connected to an alternating current electric motor does not produce a revolving magnetic field; single-phase motors need additional circuits for starting, and such motors are uncommon above 10 or 20 kW in rating.
Power Factor The ratio of real power to apparent power is called Power Factor and is a number always between 0 and 1.

Three voltmeter method

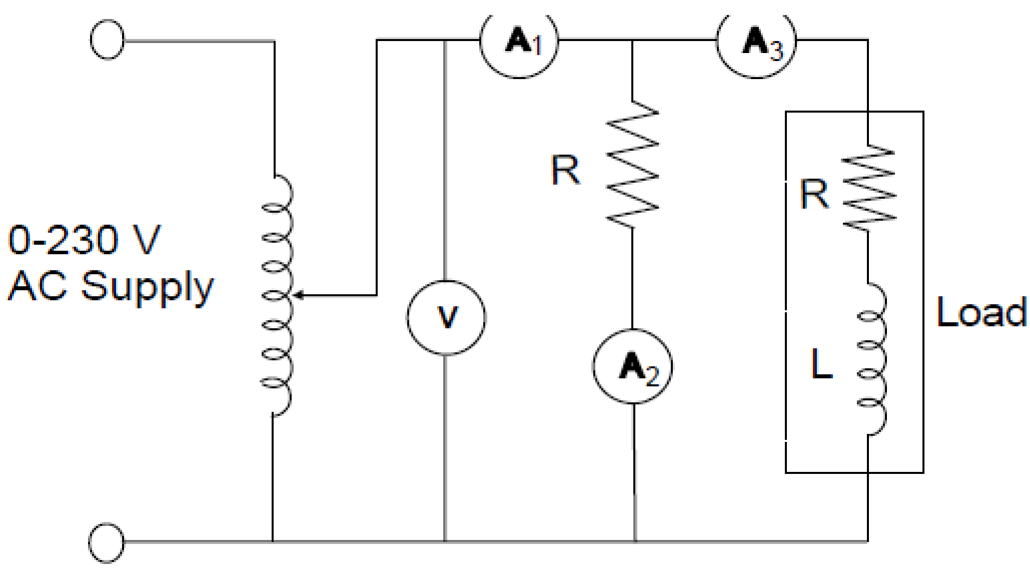
The connections are made as shown in fig. Where V_1, V_2 and V_3 are thee voltmeters and R is a non-inductive resistance which is connected in series with the load.



Three Voltmeter Method

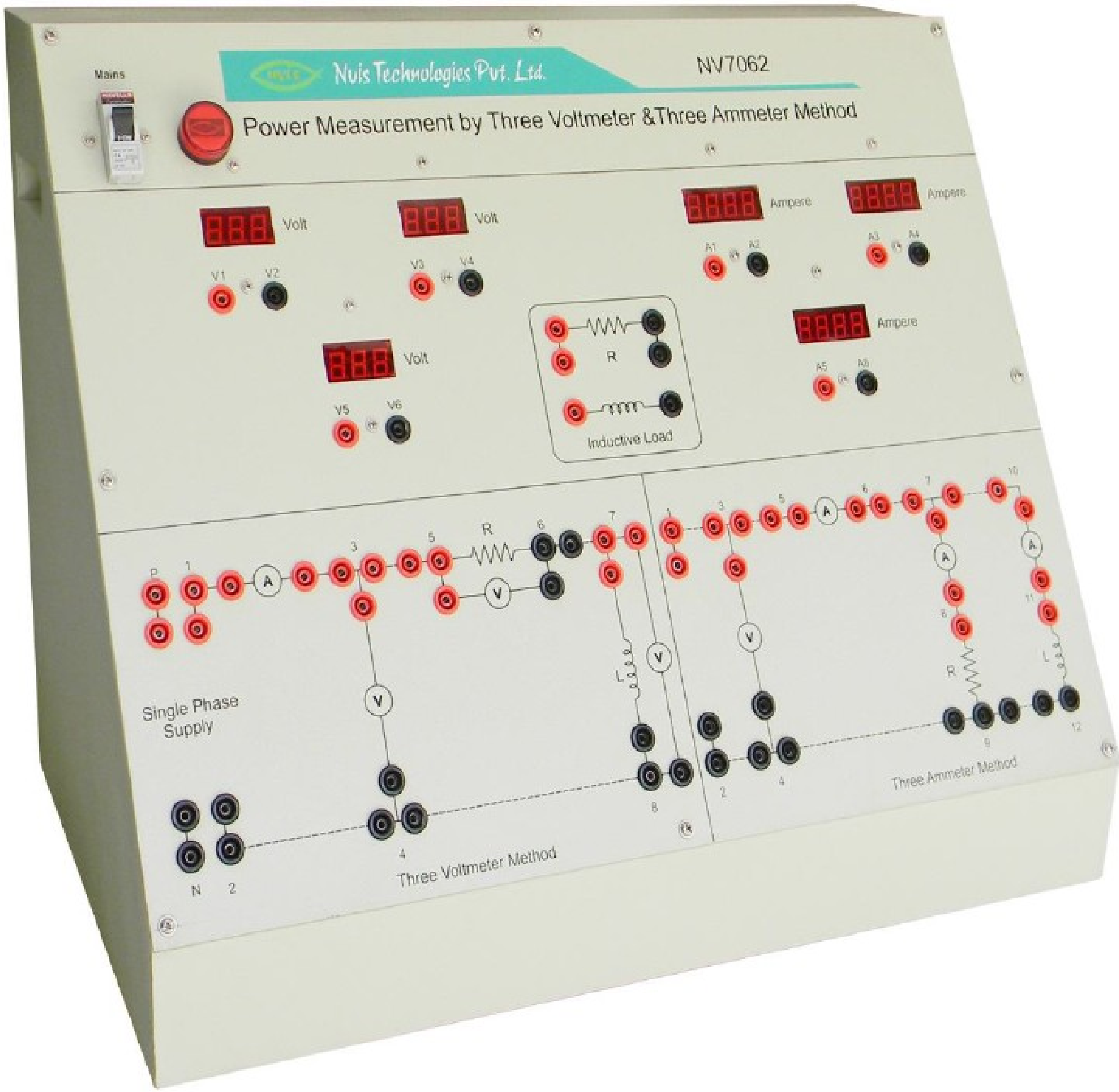
Three Ammeter Method

This method is somewhat similar to the previous one. The connections are shown in fig. the current measured by ammeter A_1 is the phasor sum of the load current and that taken by the non-inductive resistance R which is in phase with the voltage V



Three Ammeter Method

Circuit diagram:



Procedure:

1. First check the earthing of the laboratory properly and it is connected to the terminal provided to back side of panel.

2. Connect single phase supply through a single phase variac to main supply (back side of Trainer) with knob of variac at zero position and also connect the 230AC mains directly to the auxiliary supply.

3. Make sure that the AC Mains and MCB of your trainer is at off position.

4. Now connect the circuit according to the provided circuit diagram.

5. Now set the value of rheostat at 45 Ohms and insert rheostat, across R terminal.

6. Compare these connections with the connections given in Figure.

7. If all the connections are right then switch on the single phase mains supply as well as the MCB of panel.

8. Apply certain voltage to the circuit through the variac.

9. Observe the readings of voltmeters and ammeter.

10. Record readings of voltmeters and the reading of ammeter in observation table.

11. Switch off mains supply as well as MCB of panel.

Observation Table:

For Voltmeter:

S.No.	Current (I_{12}) in Amp	Voltage (V_{12}) in Volts	Voltage (V_{34}) in Volts	Voltage (V_{56}) in Volts
1				
2				
3				
4				
5				
6				
7				
8				
Mean Value				

For Ammeter:

S.No.	Voltage (V_{12}) in Volts	Current (I_{12}) in Amp	Current (I_{34}) in Amp	Current (I_{56}) in Amp
1				
2				
3				
4				
5				
6				
7				
8				
Mean value				

Calculations:

For Voltmeter:

Power factor Power factor would be $\cos \Phi = (V_{12}^2 - V_{34}^2 - V_{56}^2) / (2 V_{34} V_{56})$

Where $\cos \Phi$ = Power factor of the circuit

I_{12} = Total current drawn from supply

V_{12} = Mean voltage applied to the circuit through variac

V_{34} = Mean voltage across non- inductive resistor R.

V_{56} = Mean voltage across inductive load.

Power factor = Cos Φ = ……….

Power

Power consumed by inductive load **$P = (V_{12}^2 - V_{34}^2 - V_{56}^2) / 2R$**

Where, P = Power in Watts

V_{12} = Mean voltage applied to the circuit through variac

V_{34} = Mean voltage across non- inductive resistor R

V_{56} = Mean voltage across inductive load.

Measured Power = ………..Watts

For Ammeter:

Power factor Power factor would be Cos Φ = $(I_{12}^2 - I_{34}^2 - I_{56}^2) / (2\, I_{34}\, I_{56})$

Where Cos Φ = Power factor of the circuit

V_{12} = Voltage applied to the circuit through variac

I_{12} = Mean current drawn from the main supply

I_{34} = Mean current drawn by non-inductive resistor R.

I_{56} = Mean current across inductive load.

Power factor = Cos Φ = ……….

Power

Power consumed by inductive load **P = R $(I_{12}^2 - I_{34}^2 - I_{56}^2) / 2$**

Where, P = Power in Watts

I_{12} = Mean current drawn from the main supply

I_{34} = Mean current drawn by non- inductive resistor R.

I_{56} = Mean current across inductive load.

Measured Power = ………..Watts

Precaution:

1. Handle all the equipments with care

2. Make connections according to circuit diagram

3. Take the readings carefully & the connections should be tight

Experiment 8

Experiment Name:

To Measure resistance using Wheatstone bridge /Post office box

Apparatus Required

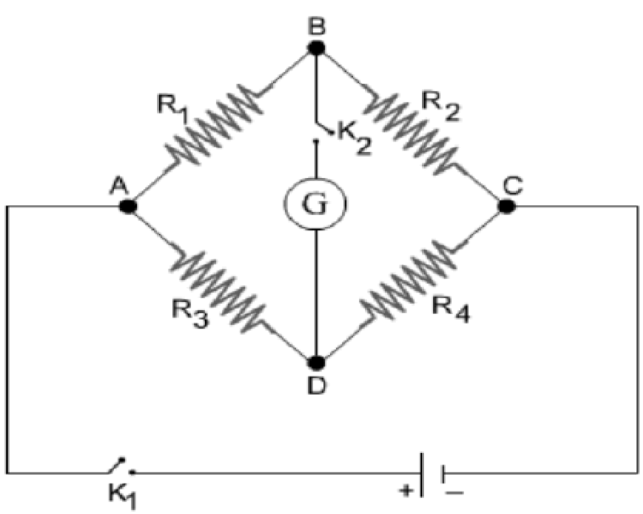
1. Patch Cord
2. 100Ω Resistances
3. Unknown wire
4. Post office box kit

Theory:

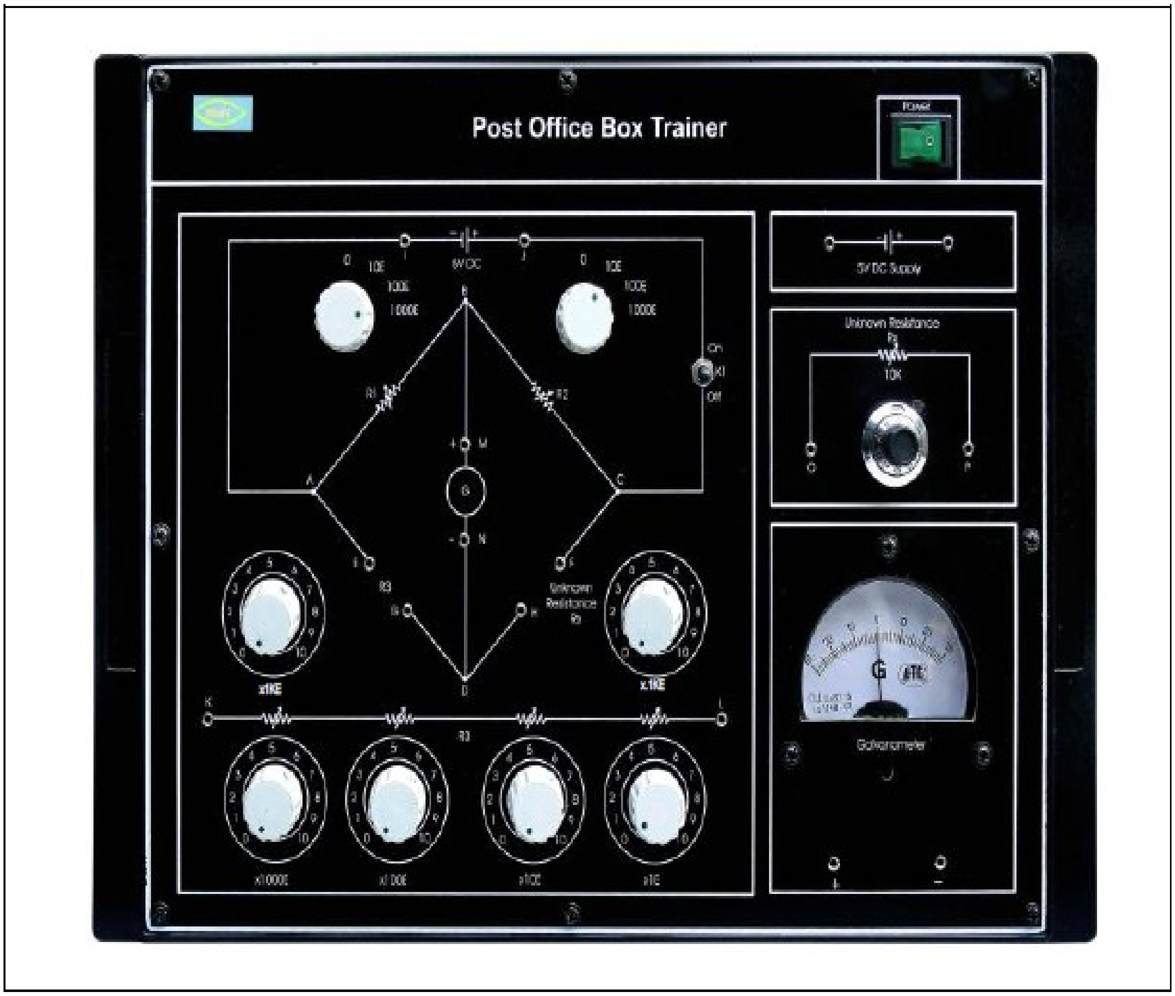
Resistance is a ratio of the degree to which an object opposes an electric current through it, measured in ohms. Post Office Box refers to a box containing a combination of ten resistors of 1 Ω, 10 Ω, 100 Ω and 1000 Ω. They are so connected that when Post Office Box is connected in series in a circuit, it is possible to introduce any resistance of integer value from 1 Ω to 10000 Ω by pulling out appropriate keys of the resistors. Post Office Box arranged in the form of a Wheatstone bridge which is used to find the value of an unknown resistance.

In wheat-stone bridge four resistances R_1, R_2, R_3 and R_4 are connected end to end with each other to form a closed loop. A sensitive galvanometer "G" is connected between their junctions as shown. The circuit is provided with two keys „K_1" and „K_2". Generally wheat-stone bridge is used to determine unknown resistances.

Expression for balanced bridge: $R_1/R_2 = R_3/R_4$



Circuit diagram:



Procedure:

1. Connect the -ve terminal of DC Supply to I and +ve terminal to J terminal of the bridge.
2. Connect Galvanometer’s +ve and -ve terminals to M and N terminals respectively.
3. Connect K & L terminals of variable resistance to E & G (R3) terminals of bridge.
4. Connect O & P terminals of unknown resistance to H & F (Rx) terminals of bridge.
5. Keep the key K_1 in 'Off ' position.
6. Switch '**On**' the trainer.
7. Set the resistance R_x at any unknown resistance by rotating its dial Knob.
8. Then set resistance R_1 and R_2 at 10Ω.

9. Switch 'On' the key K_1 and observe the deflection on galvanometer.

10. Then adjust the value of R_3 in step of .1Ω, 1Ω, 10Ω, 100Ω, 1000Ω, 10KΩ as per the requirement beginning from zero, till the null point is not obtained in the galvanometer.

11. Note the value of R_3 in the given Observation table.

12. Repeat the same procedure for 1/10 and 1/100 ratio by taking out R_1 = 10Ω and R_2 = 100Ω and adjust the resistance R_3 till the null point is not obtained.

13. Unknown resistance R_x can be determined by using Wheatstone Bridge relation

$R_1/R_2 = R_3/R_x$

Where R_1 & R_2 are the resistances of arm AB and BC respectively, R_3 is variable resistance at which point we determined null point.

14. Tabulate all the readings of R_x in the given Observation table and the mean of Rx.

15. Compare experimental and actual values of unknown resistance.

Observation Table:

S No.	Resistance R_1 (in Ω)	Resistance R_2 (in Ω)	Resistance R_3 (in Ω)	Resistance $R_x = R_3R_2/R_1$ (in Ω)
1.	10	10		
2.	100	10		
3.	1000	10		

Precaution:

1. Handle all the equipments with care

2. Make connections according to circuit diagram.

3. Take the readings carefully & the connections should be tight

Experiment 9

Experiment Name: To measure capacitance by Desauty's bridge.

Apparatus Required:

1. Desauty`s Bridge Trainer
2. Multi meter
3. 2mm Patch cords

Theory:

Capacitor:

A capacitor is a passive electronic component that stores energy in the form of an electrostatic field.

In its simplest form, a capacitor consists of two conducting plates separated by an insulating material called the dielectric. The capacitance is directly proportional to the surface areas of the plates, and is inversely proportional to the separation between the plates.

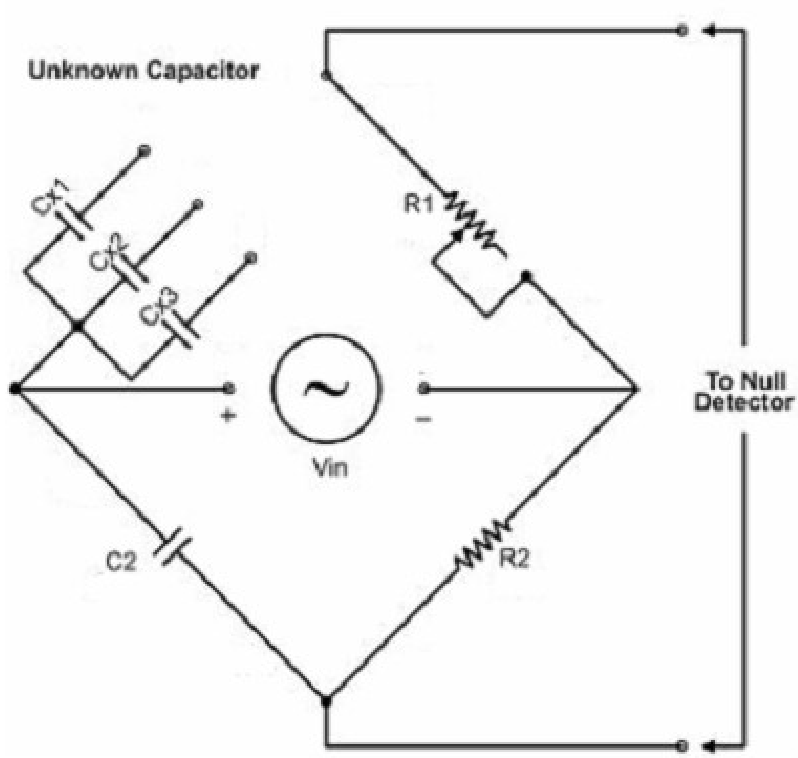
Capacitance also depends on the dielectric constant of the substance separating the plates.

Desauty's bridge**:**

The Desauty's bridge is a direct carryover of the Wheatstone bridge with the DC Source replaced by an AC source.

The null detector we will be using also has an amplifier where the gain can be adjust ed. This is connected to Null detector which is used for getting the null point.

$$Cx = R_2 \times \frac{C_2}{R_1}$$



Procedure:

1. Connect mains cord to the Trainer.
2. Connect terminal 1 to 4(for evaluating unknown capacitance Cx1).
3. Rotate variable resistance R1 towards anti clockwise direction.
4. Select Frequency Selector f or any desired range of frequency.

· 100 Hz to 1 kHz

· 1 kHz to 10 kHz

· 10 kHz to 60 kHz

7. For example 2 kHz frequency, select frequency select or between the ranges1 kHz-10 kHz.

8. Use Frequency Variable knob to set 2 kHz frequency on display screen.

9. Connect terminal 19 to 6 and 20 to 7.

10. Now switch ‘On’ the power supply.

11. Set toggle of null detector towards ‘on’ condition.

12. Vary Amplitude Variable f or enough sound of speaker.

13. Vary resistance R1 towards clockwise direction slowly. (Sound diminishes). Keep varying R1 until you get very low sound or null sound (null condition).

16. Now remove the patch cord between terminal 1 & 4 and record the value of R1 in the observation table using multimeter.

Observation Table:

S.No.	Unknown capacitor	Frequency		Resistance R_1 ohm	Resistance R_2 ohm	Capacitor C_2 µF
1.	Cx1	f_1				
		f_2				
		f_3				
2.	Cx2	f_1				
		f_2				
		f_3				
3.	Cx3	f_1				
		f_2				
		f_3				

Calculations:

1. **For unknown Capacitance Cx1 on frequency f_1:**

$$C_{x1} = R_2 \times \frac{C_2}{R_1}$$

=...............μF

Similarly calculate Capacitance Cx1 on frequency *f2 and f3*.and take the mean value.

2. **For unknown Capacitance Cx2 on frequency f_1:**

$$C_{x2} = R_2 \times \frac{C_2}{R_1}$$

=...............μF

Similarly calculate Capacitance Cx2 on frequency *f2 and f3* and take the mean value.

3. **For unknown Capacitance Cx3 on frequency f_1:**

$$C_{x3} = R_2 \times \frac{C_2}{R_1}$$

=.................μF

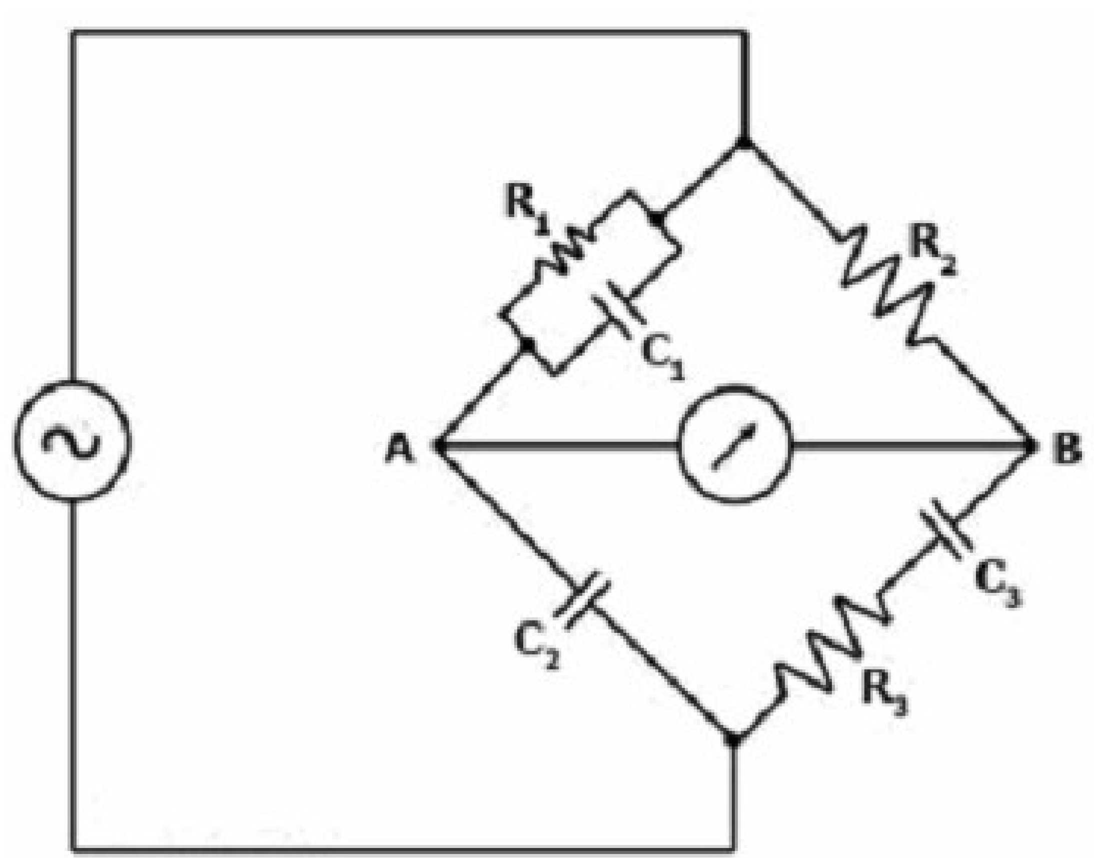
Objective:

Determination of unknown capacitance using Schearing Bridge method.

Apparatus required:

1. Schearing Bridge Trainer
2. Multimeter
3. Patch cords

Circuit Diagram:



Theory:

A Schering Bridge is a bridge circuit used for measuring an unknown electrical capacitance and its dissipation factor. The dissipation factor of a capacitor is the ratio of its resistance t o its capacitive reactance. The Schering Bridge is basically a four-arm alternating-current (AC) bridge circuit whose measurement depends on balancing the loads on its arms. In the Schering Bridge above, the resistance values of resistors R1 and R2 are known, while the resistance value of resist or R3 is unknown. The capacitance values ofC1 andC2 are also known, while the capacitance of C3 is the value being measured. To measure R3 and C3, the values ofC2 and R2 are fixed, while the values of R1 and C1 are adjusted until the current through the ammeter between point s A and B becomes zero. This happens when the voltages at points A and B are equal, in which case the bridge is said to be 'balanced '.When the bridge is balanced, WhereZ1 is the impedance of R1 in parallel with C1 and Z3 is the impedance of R3 in series with C3 .

Procedure:

1. Connect mains cord to the Trainer.
2. Connect terminal 15 to 12 (for evaluating unknown capacitance Cx4).
3. Rotate Variable Resistance **R3** towards anticlockwise direction.
4. Connect Null Detector (terminal 9 to 11 and 10 to 18)
5. Keep toggle of **Null Detector** towards ‘off ‘condition.

6. Select **Frequency Selector** for any desired range of frequency.
    - **100 Hz to 1 kHz**
    - **1 kHz to 10 kHz**
    - **10 kHz to 60 kHz**
7. For example 2 kHz frequency, select frequency selector between the ranges 1kHz-10 kHz.

    Note: Chose any ambient frequency (let it be 500Hz)
8. Use **Frequency Variable** knob to set 2 kHz frequency on display screen.
9. Connect terminal 19 to 16 and 20 to17.
10. Now switch 'On' the power supply.
11. Turn toggle of null detector towards 'on' condition.
12. Vary **Amplitude Variable** for enough sound of speaker.
13. Vary resistance **R3** towards clockwise direction slowly. (Sound diminishes).
14. Keep varying **R3** until you get very low sound or null sound (null condition). Further varying **R3** in same direction speaker starts sounding.
15. Finally adjust the value of **R3** to get null point. (Where sound completely diminishes)
16. Now remove the patch cord between terminal 12 &15 and record the value of **R3** in the observation table using multimeter.
17. Repeat above procedure for different value of frequency and different value of unknown capacitors (i.e. Cx5 and Cx6).
18. Tabulate all the retrieved data in observation table below.

Observation Table:

S. No.	Unknown Capacitor	Frequency		Resistance R_3 ohm	Resistance R_4 ohm	Capacitor C_3 μF
1.	Cx4	f_1				
		f_2				
		f_3				
2.	Cx5	f_1				
		f_2				
		f_3				
3.	Cx6	f_1				
		f_2				
		f_3				

Calculations:

1. **For unknown Capacitance Cx4 on frequency $f1$:**

$$CX4 = R4 \times \frac{C3}{R3}$$

=…………...μF

Similarly calculate Capacitance Cx4 on frequency $f2$ *and* $f3$ and take the mean value.

2. **For unknown Capacitance Cx5 on frequency $f1$:**

$$CX5 = R4 \times \frac{C3}{R3}$$

=…………...μF

Similarly calculate Capacitance Cx5 on frequency $f2$ *and* $f3$ and take the mean value.

3. **For unknown Capacitance Cx6 on frequency $f1$:**

$$CX6 = R4 \times \frac{C3}{R3}$$

=…………...μF

Similarly calculate Capacitance Cx6 on frequency $f2$ *and* $f3$ and take the mean value.

Precaution:

1. Handle all the equipments with care
2. Make connections according to circuit diagram
3. Take the readings carefully& the connections should be tight

Experiment 10

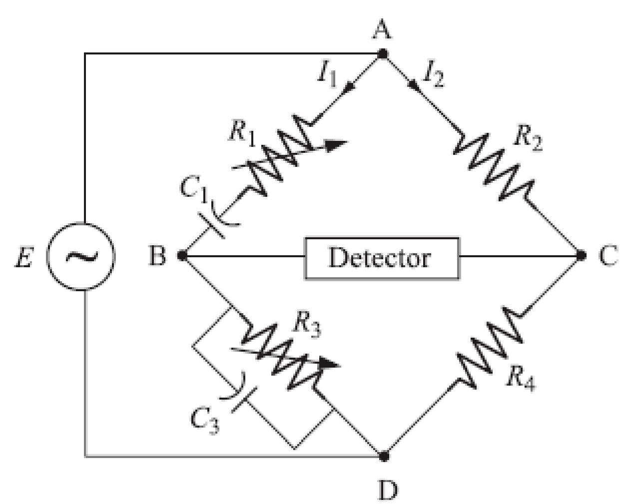
Experiment Name: To measure frequency by Wien's bridge

Apparatus Required:

1. Wien`s Bridge Trainer
2. Multi meter
3. 2mm Patch cords

Theory:

In this bridge circuit, there is a lead-lag network. Balancing of the bridge is easier because satisfying the phase angle equality condition can be achieved. This bridge can also be used to determine the frequency of the AC input in terms of the component values of the bridge circuit. In this AC bridge, there is no inductor. Inductive losses because of stray fields cause problems in balancing of the bridge. Owing to the absence of *L* in the circuit, this can be effectively used for determining the frequency *f* of the AC input..



Procedure:

1. Connect mains cord to the Trainer.

2. Connect terminal 1 to 4(for evaluating unknown capacitance Cx1).

3. Rotate variable resistance R1 towards anti clockwise direction.

4. Select Frequency Selector f or any desired range of frequency.

· 100 Hz to 1 kHz

· 1 kHz to 10 kHz

· 10 kHz to 60 kHz

7. For example 2 kHz frequency, select frequency select or between the ranges1 kHz-10 kHz.

8. Use Frequency Variable knob to set 2 kHz frequency on display screen.

9. Connect terminal 19 to 6 and 20 to 7.

10. Now switch 'On' the power supply.

11. Set toggle of null detector towards 'on' condition.

12. Vary Amplitude Variable f or enough sound of speaker.

13. Vary resistance R1 towards clockwise direction slowly. (Sound diminishes). Keep varying R1 until you get very low sound or null sound (null condition).

16. Now remove the patch cord between terminal 1 & 4 and record the value of R1 in the observation table using multimeter.

Observation Table:

S No.	R1	R2	C1	C2	f
1					
2					
3					
4					
5					

Calculations:

$$f = \frac{1}{2\pi\sqrt{R_1 R_3 C_1 C_3}}$$

Precaution:

1. Handle all the equipments with care
2. Make connections according to circuit diagram
3. Take the readings carefully& the connections should be tight