LABORATORY MANUAL

MEASUREMENTS & INSTUMENTATION LABORATORY

II B. Tech II – SEM (EEE)

Prepared by

JAKKULA SURESH

ASSISTANT PROFESSOR

Department of Electrical & Electronics Engineering

MALLA REDDY ENGINEERING COLLEGE & MANAGEMENT SCIENCES

(Approved by the AICTE, New Delhi and affiliated to JNTU, Hyderabad)

Kistapur Hamlet of Medchal, Hyderabad, R.R. Dist. - 501401

VISION OF THE INSTITUTE

The aspiration is to emerge as a premier institution in technical education to produce competent engineers and management professionals contributing to Industry and Society.

MISSION OF THE INSTITUTE (MI)

The aspirations are fulfilled and continue to be fulfilled:
MI-1: By providing the student supporting systems:
To impart updated pedagogical techniques with supportive learning environment and state-of-the-art facilities.
MI-2: By training the students as per the industry needs:
To cultivate a culture of interdisciplinary approach, problem solving, innovative ecosystem, and entrepreneurship by facilitating critical thinking, teamwork, and research-driven activities with hands-on learning.
MI-3: By educating the students about society's needs:
To instill ethical, social, and environmental values through community engagement resulting in sustainable development of society.

VISION OF THE EEE-DEPARTMENT

The aspiration is to produce competent Electrical and Electronics Engineering Graduates capable of making valuable contributions in the field of Electrical and Electronics Engineering.
Mission of the Department:
MD-1:
Student Support Systems:
To equip students with advanced learning skills in Electrical and Electronics Engineering, while providing them with the necessary professional competencies to overcome future challenges.
MD-2:
Training the students as per the industry needs To facilitate the students to acquire interdisciplinary skills in renewable energy, electric vehicles, and power electronics applications through practical knowledge and innovative techniques to meet evolving global challenges.
MD-3:
Educating the students, the needs of society:
To develop professional ethics, self-confidence, and leadership qualities among students.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO 1: MREM B.Tech EEE graduates shall be able to apply technical knowledge in Electrical and Electronics Engineering, empowering them to pursue higher studies or succeed in their professional careers in the electrical Power Industry.

PEO 2: MREM B.Tech EEE graduates shall be able to design and implement complex electrical systems, meeting the electrical and electronics industry demands.

PEO 3: MREM B.Tech EEE graduates shall be able to handle societal and environmental problems with ethical values as demanded by society.

Program Specific Outcomes (PSOs):

PSO1: Provide efficient problem-solving techniques in the areas of Power Electronics, Power Systems, Control systems, and Electrical Machines using MATLAB/MULTISIM.

PSO2: Design and develop a wide range of Electrical and Electronics Systems, specifically emphasizing Electric Drives, Conventional Renewable Energy, and Automation to demonstrate overall knowledge and contribute to the betterment of society.

Course Objective:

This course introduces the basic concepts of measuring instruments and bridges. It also deals with the measurement of RLC parameters voltage, current, power, power factor, energy and magnetic measurements.

Course Outcome:

1. The student will analyze the different types measuring instruments.
2. Prepare theoretically and practically laboratory experiments.
3. Carry out laboratory experiments on instruments, DC and AC bridges.
4. Present experiment results in a written report.
5. Understand the fundamentals of measuring instruments and apply the above conceptual things to real-world electrical and electronics problems applications.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C308.1	3	2	1	2								1	1	2
C308.2	3	2	3	3								1	2	2
C308.3	2	2	2	2								1	2	2
C308.4	2	2	2	2								1	2	2
C308.5	3	1	1	1								1	1	1
Average	2.6	2	2	2								1	1.8	2

CONTENTS

EXPERIMENT-1

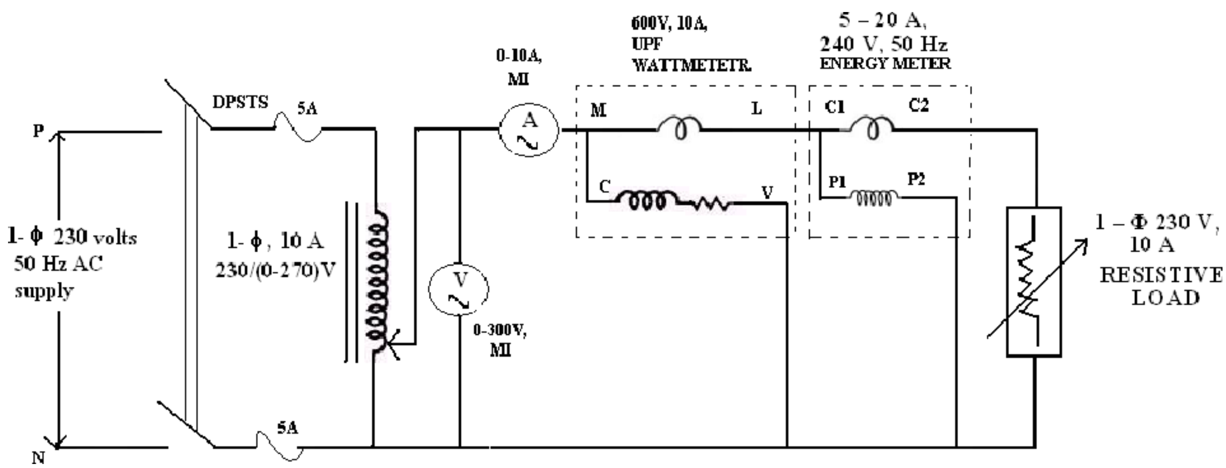
CALIBRATION AND TESTING OF SINGLE PHASE ENERGY METER

Aim: To calibrate the given Energy Meter by Direct Testing.

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Energy Meter	240V,(5-20)A, 50 Hz	1- Φ, MI	01
02	Auto Transformer	230 / (0-270)V, (0-10)A	1- Φ	01
03	U.P.F. Wattmeter	(150/300/600)V, (0-10)A	Dynamometer Type	01
04	Voltmeter	(0-300)V	MI	01
05	Ammeter	(0-10)A	MI	01
06	Resistive Load	230V, (0-10)A	1- Φ	01
07	Stop Watch	------	Digital	01
08	Connecting Wires	------	------	As required

Circuit Diagram:



Theory:

Induction type energy meters are universally used for measurement of energy in domestic and industrial ac circuits. Induction types of meters possess lower friction and higher torque/weight ratio. Also induction type meters are inexpensive and accurate and retain their accuracy over a wide range of loads and temperature conditions.

There are four main parts.

1. Driving System.
2. Moving System.
3. Braking System.

4. Registering System.

The supply voltage is applied across the pressure coil. The pressure coil winding is highly inductive as it has very large number of turns and the reluctance of its magnetic circuit is very small owing to presence of air gaps of very small length. Thus the current I_p through the pressure coil is proportional to the supply voltage and lag it by a few degrees less the 90 degrees. This is because the winding has a small resistance and there are iron losses in the magnetic circuit. Current input produces a flux. This flux divides itself into two pars ϕ_g and ϕ_p. The major portion ϕ_g flows across the side gaps as reluctance of this path is small. The reluctance to the path of flux ϕ_p is large and hence its magnitude is small. This flux ϕ_p goes across aluminum disc and hence is responsible for production of driving torque.

Flux ϕ_p is in phase with current I_p and is proportional to it. Therefore flux ϕp is proportional to voltage V and lags it by an angle a few degrees less than 90 degrees since flux ϕ_p is alternating in nature, it induces an eddy emf in the disc which in turn produces eddy current.

The load current I flow through the current coil and produces a flux ϕg. This flux is proportional to the load current and is in phase with it. This flux produces eddy current is in disc. Now the eddy current is interacts with flux ϕ_p to produce a torques and eddy current is interacts with ϕ_g to produce another torque. Here two torques are in the opposite direction and the net torque is the different of these.

Procedure:

1. Connections are made as per the circuit diagram.
2. Set Auto Transformer at zero voltage position before switching on the supply.
3. Gradually increase the voltage using the auto-transformer till the voltmeter reads 230V.
4. Now apply the Load at certain value (i.e. 2A)
5. Time taken for 25 rev. of the disc of the energy meter in the forward direction is noted
6. Record the Voltmeter, Ammeter, & Wattmeter’s are noted.
7. The experiment is repeated for different values of current (i.e. 4A, 6A,8A) at constant voltage.
8. After noting the values slowly decrease the auto transformer till Voltmeter comes to zero voltage position and switch off the supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Observe the ammeter reading. Apply the voltage slowly so that the current is within the limited range of ammeters, wattmeter and energy meter.
4. If the energy meter rotates in reverse direction, change either its current coil terminals or pressure coil terminal or pressure coil terminal but not both.

Theoretical Calculations:

The energy meter constant = 750 rev/ kWh

i.e. for 750 rev it records 1 unit or 1 kWh

i.e. for 750 rev it records =1 unit

for 25 rev it records = 25/750 = 1/30 kWh

Energy meter reading E_1 = (1000X 60 X 60) /30 = 1, 20,000 W

Actual energy consumed E_2= Wattmeter reading (W) X time (T)

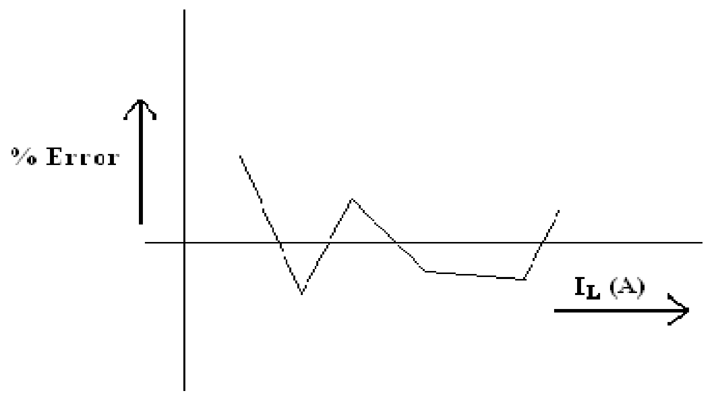
% Error =((E_1-E_2)/ E_2) X 100

Observation Table:

Sl No.	Voltage (V) (Volts)	Load Current (I_L) (Amps)	Wattmeter Reading W (Watts)	Time for 25 rev T(Sec)	Energy meter Reading (E_1)	Actual Energy (E_2) = W X T	% Error = ((E_1-E_2)/E_2)x 100

Model Graph:

A graph is drawn between **% Error Vs Load current**.



Result:

Viva Voce Questions

1. What is a phantom Load?
2. What is creeping?
3. What is Braking?
4. Define meter constant?
5. What is Friction? What are the different types of Friction, explain it?
6. Write short notes on driving system, Moving system, Braking systems, registering systems?
7. What are the errors occurred by the driving system?
8. How do you prevent the creeping?
9. What are the errors occurs in the energy meter?
10. What is the principle of 1-Phase energy meter?

EXPERIMENT-2
CALIBRATION OF DYNAMOMETER TYPE POWER FACTOR METER

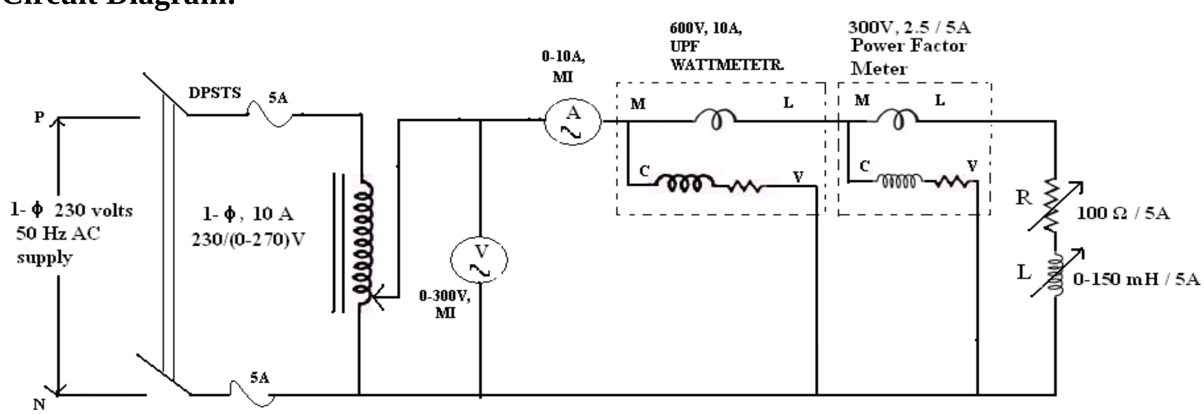
Aim:

To test and calibrate the given 3 phase electro dynamometer type power factor meter.

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Power factor Meter	(75/150/300)V, (2.5/5)A	Dynamometer Type	01
02	Auto Transformer	230/(0-270)V, (0-10)A	1- Φ	01
03	U.P.F. Wattmeter	(150/300/600)V, (0-10)A	Dynamometer Type	01
04	Voltmeter	(0-300)V	MI	01
05	Ammeter	(0-10)A	MI	01
06	Rheostat	100Ω,5A	1- Φ	01
07	Inductive Load	0-150mH, 5A	1- Φ	01
08	Connecting Wires	------	------	As required

Circuit Diagram:



Procedure:

1. Connect the circuit as per circuit diagram.
2. Check meter positions to be at zero.
3. Adjust the Auto Transformer at rated voltage (i.e. 230V)
4. By adjusting the Resistive & Inductive load, adjust the reading of Ammeter to desired value of a 1Amp.
5. Note the readings of Wattmeter, and P.F meter.
6. Repeat 4 & 5 steps for various values of a power factor.
7. Graph is plotted between % Error and Load Current.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

Theoretical Calculations:

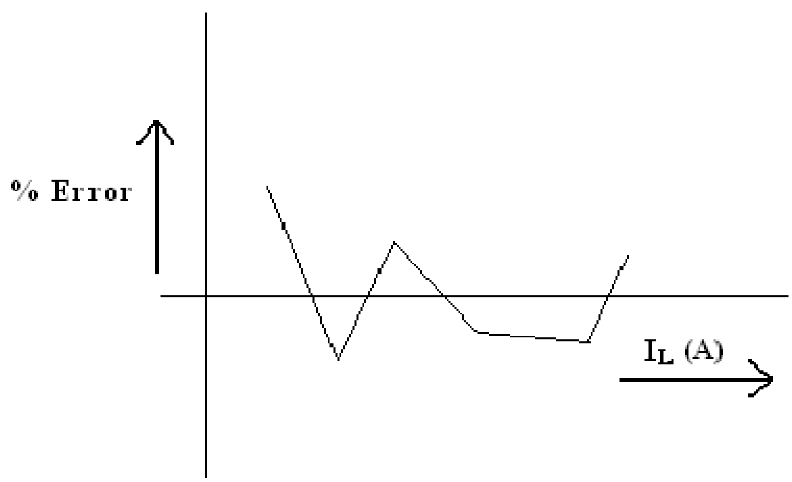
$$\% \text{ Error} = \frac{\text{€alculated Value} - \text{Actual Reading}}{\text{Actual Reading}} \times 100$$

Observation Table:

Sl. No.	Voltage V(Volts)	Load Current I_L (Amps)	Wattmeter (Watts)	P.F = W/VI	P.F Meter Reading	%Error

Model Graph:

A graph is drawn between % Error and Load Current



Result:

Viva Voce Questions

1. What are the different types of Power Factor Meters**?**

2. How is the operating force produced in power factor meter?

3. Why is the controlling force not present in a power factor meter?

4. What is Power factor angle?

5. What is the principle of electrodynamometer wattmeter?

6. What are the various types frequency meter?

7. What are the applications of Induction type instruments?

8. What type of coils are there in a dynamometer type instruments?

9. How many current coils are there in a single phase wattmeter?

10. How many potential coils are in a three phase wattmeter?

EXPERIMENT-3
CROMPTON DC POTENTIOMETER – CALIBRATION OF PMMC AMMETER & PMMC VOLTMETER

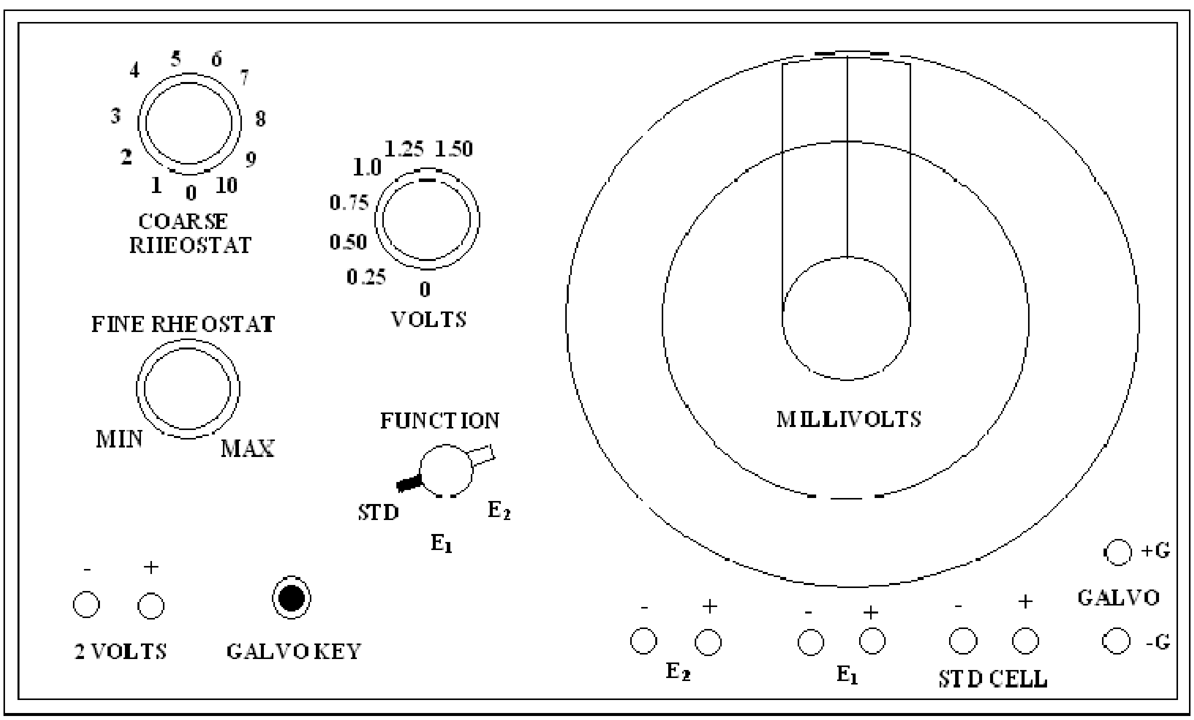
Aim:

To measure the unknown voltage using DC Crompton Potentiometer.

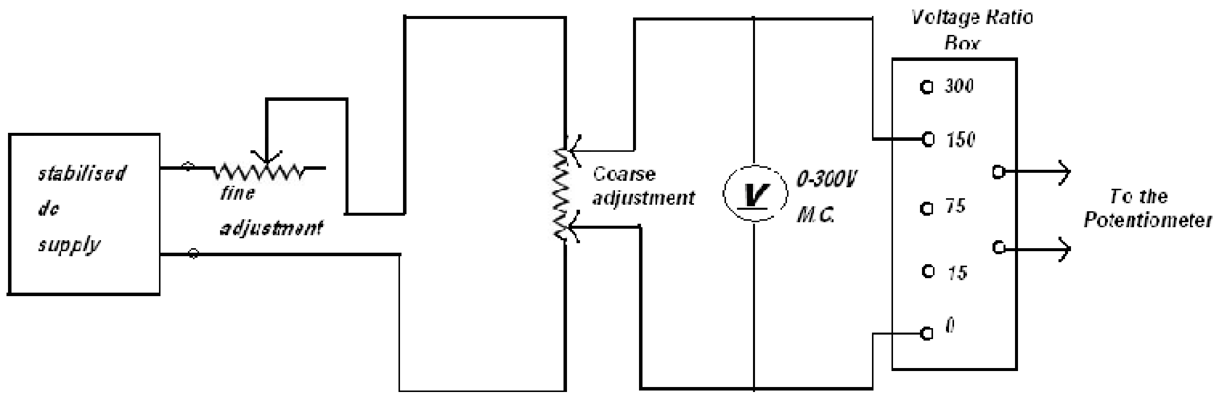
Apparatus required:

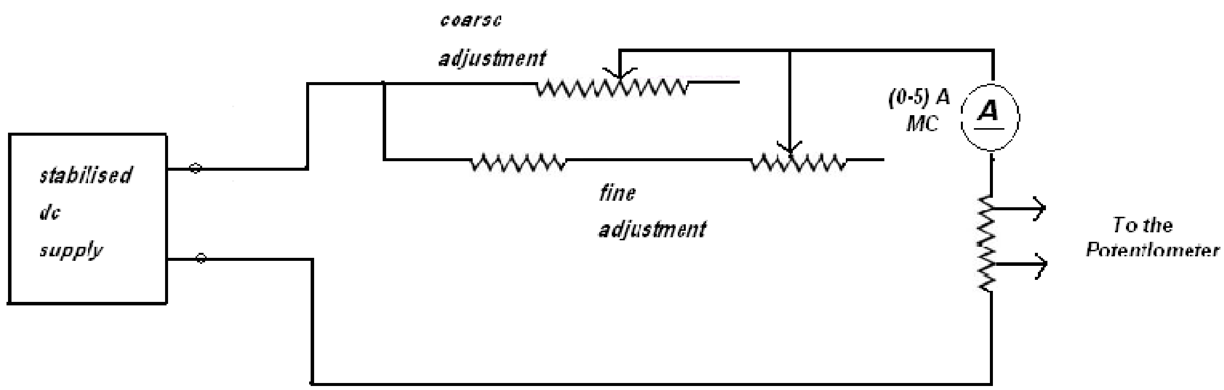
Sl. No.	Specification	Quantity
1	D.C Potentiometer	01
2	Standard cell{ 1.018 v}	01
3	Sensitive Galvanometer	01
4	RPS {0-30V} or unknown emf {say dry cell}	01
5	Standard Resistance	01
6	D.C Ammeter - (0-5)A	01
7	D.C Voltmeter - (0-300)V	01
8	Rheostat - 5A,50Ω	01
9	Connecting Wires	As required

Kit Diagram:



Circuit Diagram:





Procedure:

Initial calibrations (Fixing working current)

1. Connect the battery, galvanometer in the kit as shown in the circuit diagram.
2. Put the switch 'S' in the standard cell position and connect the standard cell to the standard knob.
3. Rotate the main dial and slide wire in order to get the same voltage of the standard emf.
4. Now press the key and observe the galvanometer deflection.
5. If the galvanometer does not show the balance position, adjust the rheostat and make it to read zero.

To find unknown emf:

1. Connect the unknown battery across the knob marked 'X'
2. Put the switch 'S' in the unknown emf position.
3. Adjust the main dial slide wire to get the null position in the galvanometer.
4. The reading in the main dial and slide wire gives the voltage of the unknown cell.

CALIBRATION OF AMMETER:

1. Made the connections as per the circuit diagram.
2. A standard resistance of suitable value and sufficient current carrying capacity is placed in series with the Ammeter under calibration.

3. The voltage across the standard resistance is measured with the help of potentiometer and the current through the standard resistance can be compound current I= Vs / S amps.
4. Since the resistance of standard resistor is accurately known and the voltage across the standard resistor is measured by a potentiometer, this method of calibrating an Ammeter is very accurate.
5. A calibration curve indicating the errors at various scale reading of the ammeter may be plotted.

CALIBRATION OF VOLTMETER:

1. Made the connections as per the circuit diagram.
2. The first and foremost requirement in this calibration is that a suitable stable DC voltage supply is available since any changes in the supply voltage will cause a corresponding change in the voltmeter calibration.
3. The figure given is a potential divides, consisting of two rheostats, one or course and the other for fine control of calibrating voltage.
4. These controls are connected to the supply source and with the help of these controls it is possible to adjust the voltage so that the pointer coincides exactly with a major division of the voltmeter.
5. The voltage across the voltmeter is stepped down to a value suitable for application to a potentiometer with the help of a volt-Ratio Box for accuracy of measurement, it is necessary to measure voltages near the maximum range of the potentiometer, as for as possible.
6. Thus the potentiometer has a maximum range of 1.6V. To achieve high accuracy we will have to use low voltage ranges for voltages less than 1.6V and use appropriate tapping's on volts ratio box for voltages higher than 1.6V.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings.
3. Observe the ammeter reading. Apply the voltage slowly So that the current is within the limited range of ammeters.
4. Handle the Bridge carefully.

Observation Table:

S.No.	True Value of Unknown EMF (Volts)	Measured Value of Unknown EMF (Volts)	% Error

MALLA REDDY ENGINEERING

CALIBRAION OF AMMETER:

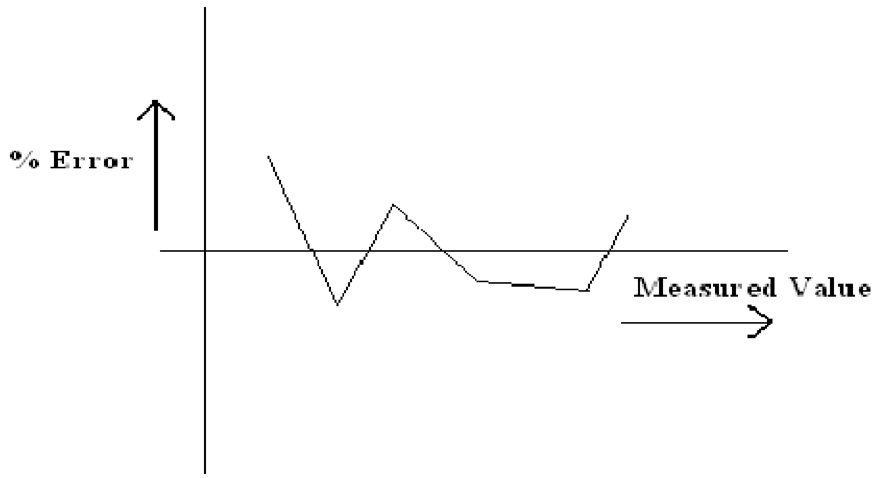
Sl. No.	Current (I_{in}) Amps	Current (I_{out}) Amps	% Error ((I_{out} - I_{in}) / I_{out}) x 100

CALIBRATION OF VOLTMETER:

Sl. No.	Voltage (V_{in}) Volts	Voltage (V_{out}) Volts	% Error ((V_{out} - V_{in}) / V_{out}) x 100

Model Graph:

A graph is drawn between **% Error and measured Value**



Result:

Viva Voce Questions

1. Explain Standardization

2. What precautions have to be followed in the case of Standard cell

3. What is the application of D.C Potentiometer

4. What are the precautions to be observed in connecting and using the Galvanometer

5. Is it absolutely necessary to standardize the potentiometers for resistance measurements.

6. How do you choose the standard resistance to be connected in series with the Ammeter to be calibrated

7. What is the potentiometer?

8. Can a potentiometer be used on A.C?

9. What are applications of A.C potentiometer?

10. What are the errors and precautions for the potentiometer?

EXPERIMENT-4
KELVIN'S DOUBLE BRIDGE

Aim:

To measure the low value of unknown resistance and resistance of connecting leads using a Kelvin's double bridge.

7Apparatus Required:

Sl.No.	Name of the Equipment	Quantity
01	Portable Kelvin's double bridge Kit	01
02	Dry Cells -- (1.5Volts)	02
03	Unknown Resistance	01
04	Connecting wires	As required

Theory:

This is a portable bridge with built in taut suspension galvanometer and a 1.5 Volts dry battery (3 cells of 1.5 V each in parallels) This bridge is useful for the measurement of low resistance.

Main dial – There are 10 coils of 0.1 ohm each.

Slide wire - 100 divisions of slide wire are equal to 0.1 ohm, Each main division is to ohm. Each sub – division is to 0.0005 ohm. The reading to the left of zero is to be subtracted from main dial reading and that to the right of zero is to be added to main dial reading. Rang switch:- A range multiplier switch furnishers 5 range of X100, X10, x1, x0.1,x0.01. The value of unknown resistance is given by sum of main dial and slide wire reading multiplied by range used.

Method for Measurement of low resistance:-

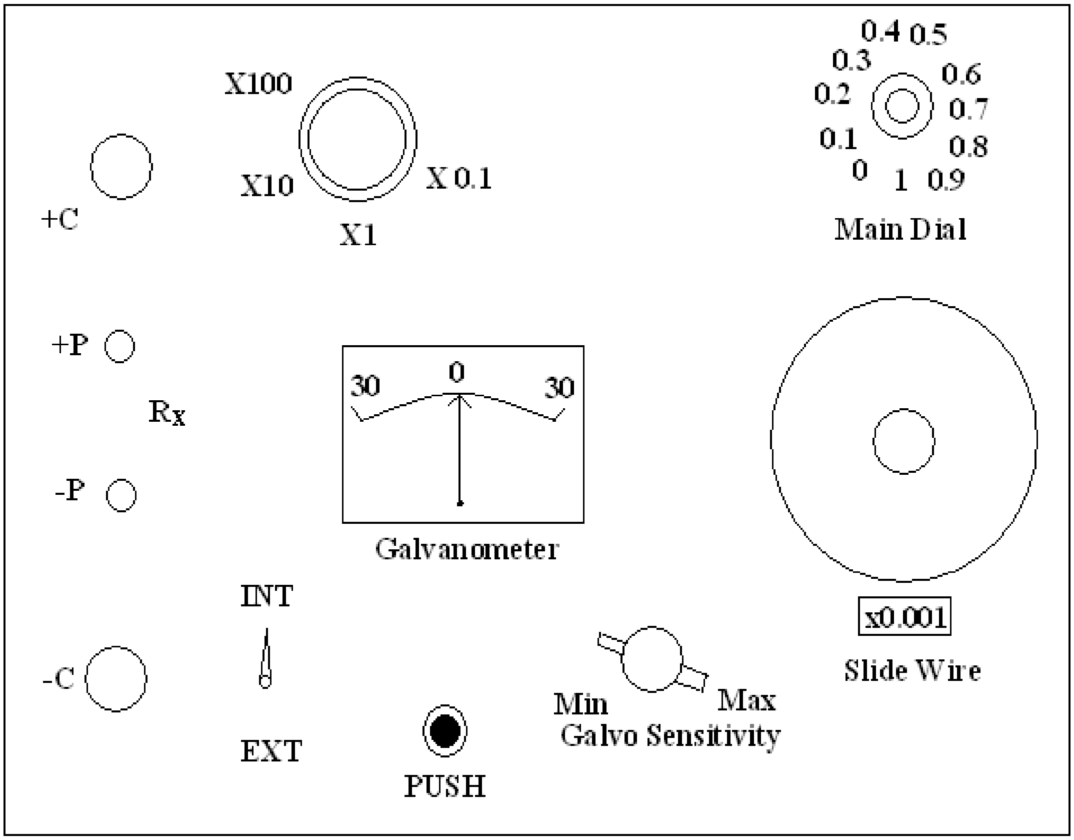
The methods for measurement of low resistance are:-

1. Ammeter Voltmeter method.
2. Kelvin's Double bridge method.
3. Potentiometer method.
4. Ducter.

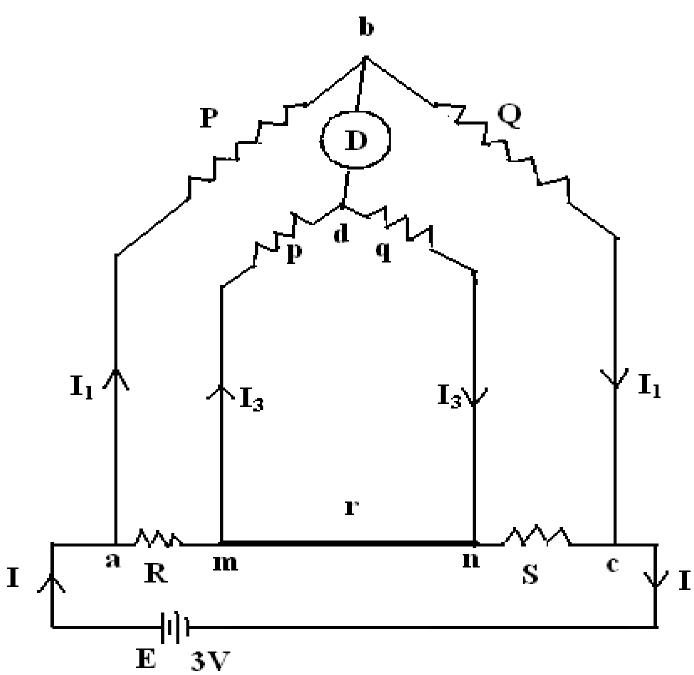
Kelvin's Double Bridge

This bridge is a modification of the Wheatstone bridge and provides greatly increased accuracy in measurement of low value resistance an understanding of the Kelvin's bridge arrangement may be obtained by a study of the difficulties that arise in a Wheatstone bridge on accoure of the leads and the contact resistances while measuring low valued resistors. Two actual resistance units of correct ratio be connected between points m and n in the Galvanometer be connected to the function of the resistors. This is the actual Kelvin bridge arrangement. The Kelvin double bridge incorporates the idea of a second set of ratio arms-hence the name double bridge and the use of four terminals resistors for the low resistance arms. The first of ratio arms. P and Q is used to connect the galvanometer to a point C at the appropriate potential between points M and N to eliminate the effect of connecting lead of resistance R between the known resistance, R and the standard resistance, S as shown.

Kit Diagram:



Circuit Diagram:



MALLA REDDY ENGINEERING

Procedure:

1. The connections are made as shown in fig.
2. Across the terminals X meant for the unknown resistance, Connected whose shunt resistance can be measured
3. The ratio (P/Q) is adjusted to a particular value.
4. For the ratio, balancing resistance is varied until Galvanometer shows null deflection.
5. The balance is similarly obtained for different ratios of (P/Q)
6. The resistance since it includes the resistance of the leads.
7. The lead resistance is measured by shorting the leads.
8. To obtain ammeter shunt resistance, the resistance of the leads is subtracted from the total resistance.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their Ratings
3. Handle the Bridge very carefully

Theoretical Calculations;

$R = (P/Q) \times S$

Where R= Unknown Resistance

P= Variable resistance

Q= Variable resistance

S= Standard resistance

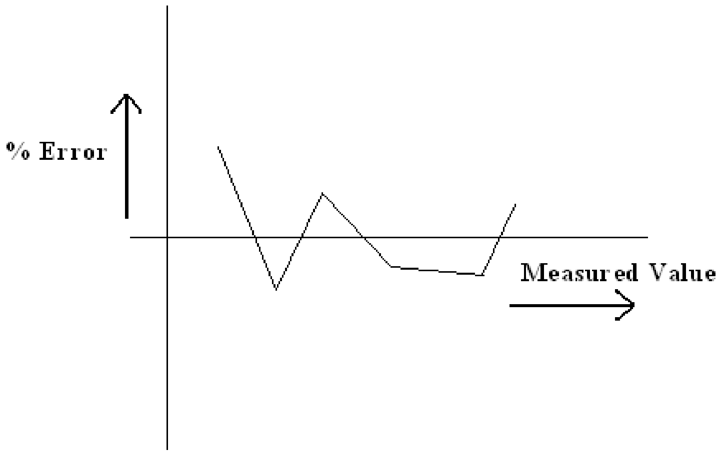
Observation Table:

Resistance of the given connecting wire:

Sl. No.	Observed Resistance in Ohms	Calculated resistance in Ohms	% Error	Standard Deviation

$$\textbf{\% Error} = \frac{\text{Observed Resistance - Calculated resistance}}{\text{Calculated resistance}}$$

Model Graph:
A graph is drawn between **% Error Vs Measured Value**



Result:

Viva- Voce Questions

1. Why it is called as double bridge.
2. What are the ranges of resistance that can be measured using The bridge.
3. What are the ranges of resistances for low, medium and high resistances.
4. What is sensitivity of bridge?
5. What are the detectors used for DC Bridge.
6. Why the low resistances are four terminal resistances.
7. Why the methods used for medium resistances are not suitable for measurement of low resistances.
8. What are the other instruments to measure the resistance?
9. What is a megger?
10. How megger is work?

EXPERIMENT – 5
DIELECTRIC OIL TESTING USING H.T TESTING KIT

Aim:

To conduct test on dielectric oil using H.T oil testing Kit.

Apparatus:

1. H.T testing Kit
2. Dielectric oil

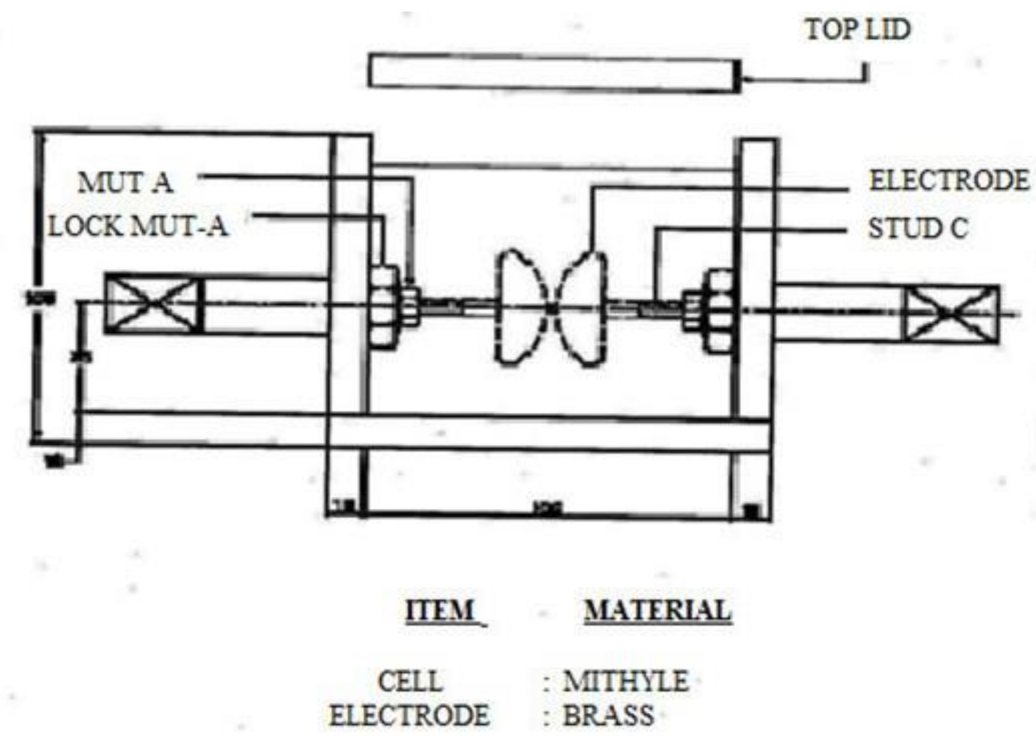
Specifications:

1. Input Voltage : 240 Volts, 50Hz, Single Phase, AC mains.

2. Electrodes : 36 mm of diameter, mushroom.

3. Spacing guage : 2.5 mm.

"Circuit Diagram:



Procedure:

BREAK DOWN TEST:

1. Connect the unit to a properly earthed single phase mains supply.
2. Adjust the gap between the electrodes in the test cell using correct clearance.
3. Adjust the electrode gap as follows

   a) Loosen the knurled thumb screws (A) by turning them anticlockwise.
   b) Move spindle (B) by turning and set the gap between the electrodes according to the GO guage.
   c) Tighten the knurled knobs(A) by turning them clockwise. This will fix the electrode spacing and eliminate frequent checking of the gap size.

4. Open the lid and ensure proper placement of test. Close the lid.
5. Press the H.V ON button and move output control knob in full anticlockwise direction till the ‘H.V OFF’ lamp goes off.’HV ON’ lamp lights up. The action is simultaneous. HT is now switched.
6. Advance the output control knob in the clockwise direction. The pointer of KV meter reads the voltage applied to the test cell. Advance the output control till breakdown occurs and overload trips cutting off the supply of HV transformer
7. The HV ON lamp goes off HV ON lamp lights up. Do not advance the voltage control any further. Breakdown voltage can be read from the meter.

WITHSTAND TEST:

1. Put the mains rocker switch in the ‘ON’ position. The ‘MAINS ON’ lamp lights up and the ‘HV OFF’ lamp also lights up.
2. Press ‘HV ON’ button and move output control knob in full anti clockwise direction till the ‘HV OFF’ lamp goes off and the ‘HV ON’ lamp lights up.
3. Advance the output control knob in the clock wise direction.
4. The pointer of KV meter reads the voltage applied to the oil test cell.
5. When the meter indicates the voltage at which the withstand test is to be carried out, stop moving the voltage regulator. Now watch the time and after the desired time, shut off HV by pressing HV OFF switch.

6. If there is a breakdown in the sample oil, the overload relay will trip. The high voltage supply will be cut off and the ‘HV ON’ lamp will go off. The voltmeter will continue to indicate the voltage applied when the oil sample failed, thus recording its break down voltage.
7. The voltage regulator can be returned to zero by manually turning the regulator knob fully anti-clockwise.
8. Switch the main supply to the ‘OFF’ position before lifting the hood to gain access to the test cell.

Observation Table:

SI.No	Spacing between electrodes in (mm)	With stand KVA Rating

Result:

MALLA REDDY ENGINEERING COLLEGE & MANAGEMENT SCIENCES

EXPERIMENT - 6
SCHERING BRIDGE & ANDERSON BRIDGE

a) SCHERING BRIDGE

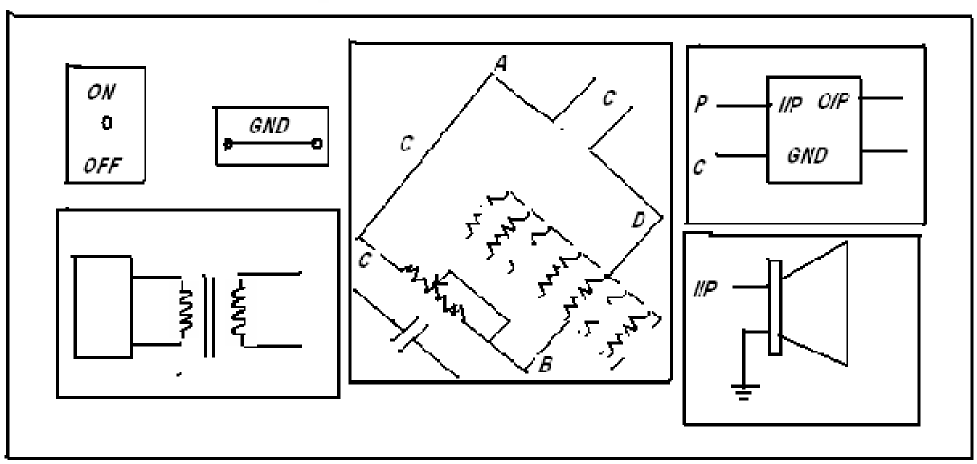
Aim:

To find the capacitance of the unknown capacitor and it's dissipation factor**.**

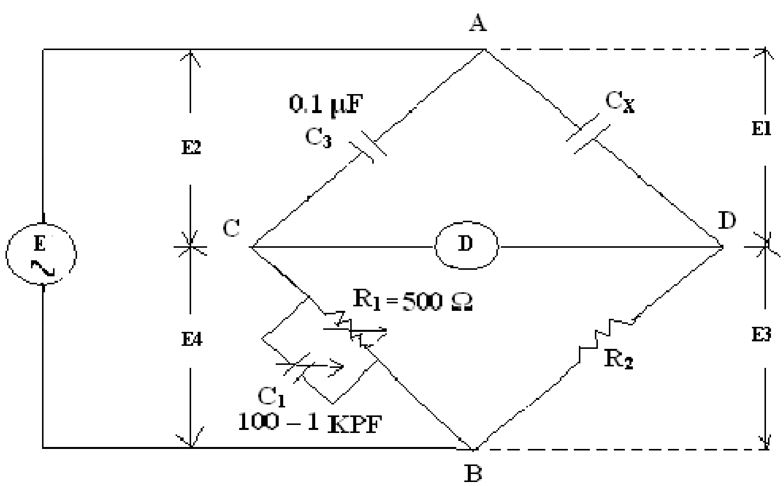
Apparatus Required:

Sl.No.	Specification	Quantity
1	Schering bridge kit	01
2	LCR meter	01
3	Dual trace CRO	01
4	Decade Capacitance Box or Unknown Capacitance	01
5	Connecting wires	As required

Kit Diagram:



Circuit Diagram:



Procedure:

1. Connect the circuit as shown in the circuit diagram.
2. Switch on the trainer kit and connect the unknown capacitance in the arm marked.
3. Observe the sine wave at the output of 1KHz oscillator and patch circuit using the wiring diagram.
4. Select some value of R2.
5. Vary R1 from minimum position in a clockwise direction.
6. If the selection of R2 is correct balancing point {DC line} can be observed on the oscilloscope. Else vary R2 and repeat step 5.
7. Capacitor C1 is varied for fine adjustment from minimum position in the clock direction.
8. The balance is also indicated by the minimum sound in the loud speaker. The unknown capacitance and it's dissipation factor is calculated.

Precautions:

1. There should not be any loose connections.
2. Handle the Bridge very carefully.

Theoretical Calculations

Unknown Capacitance Cx = C3R1/R2

Resistance Rx = C1R2/C

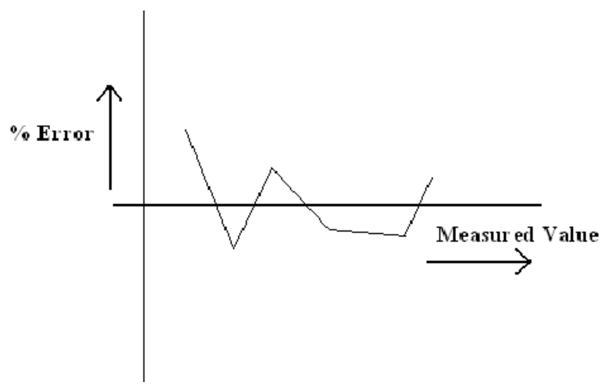
Dissipation factor Tan = Cx Rx

Observation Table;

Sl.No	R1 (Ohms)	R2 (Ohms)	C3 (μ farads)	Observed Value =	Calculated Value =	%Error

Model Graph:

A graph is drawn between % Error and Measured Value



Result:

Viva Voce Questions

1. What is the other name of this Bridge
2. What are the types of capacitances which can be measured using. Schering Bridge.
3. What are the other bridges are used to find the capacitance.
4. What are the different types of D.C Bridges.
5. What are the different types of A.C Bridges.
6. Upto what value of capacitance this schering bridge is used?

(b) ANDERSON BRIDGE

Aim:

To measure the self-inductance of the given coil using Anderson’s bridge.

Apparatus Required:

Sl. No	Specification	Quantity
1	Anderson’s Bridge kit	01
2	LCR meter	01
3	Dual trace CRO	01
4	Decade Inductance Box or Unknown Coil	01
5	Head Phones	01
5	Connecting wires	As required
6	Bridge Oscillator	01

Theory:

This bridge is a modification of Maxwell Wein Bridge. In this method, the unknown inductance is measured in terms of a known capacitance and resistance as shown. Tha equation at balance is,

L= Rc(Q+m+Qm/P), where ‘L’is the unknown inductance which can be determined by substituting the values of other quantities in the above balance equation. The advantage of the Anderson bridge is it is capable of precise measurements of inductance over a wide range of values from a few micro henrys to several henrys & is one of the commonest and the best bridge methods.

This bridge is very common for measurement of self-inductance in terms of standard capacitance and non-inductive resistances. An audio-frequency oscillator of, say. 1000 CPS and a variable output of 10 volts is used as a source of supply.

A pair of headphones of good sensitivity is used as a detector in the bridge network.

BRIDGE ARMS

P = Non-inductive resistance of 1000 ohms

Q = Non-inductive resistance of 1000 ohms

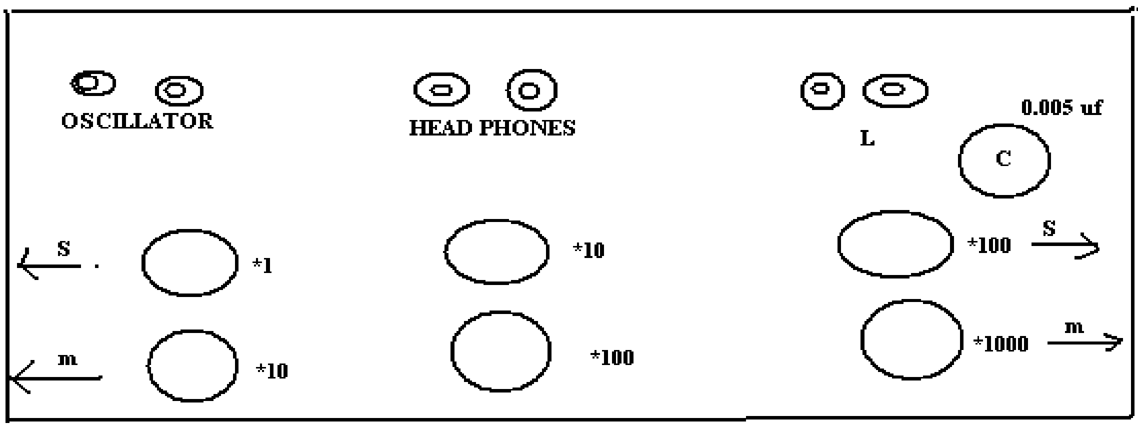
R = Non-inductive resistance of 1000 ohms

S = A variable non-inductive resistance in the form of 3 decades of 10X1, 10X10,10X100 ohms. This resistance also includes the resistance of self-inductance L which is also connected in the same arm.

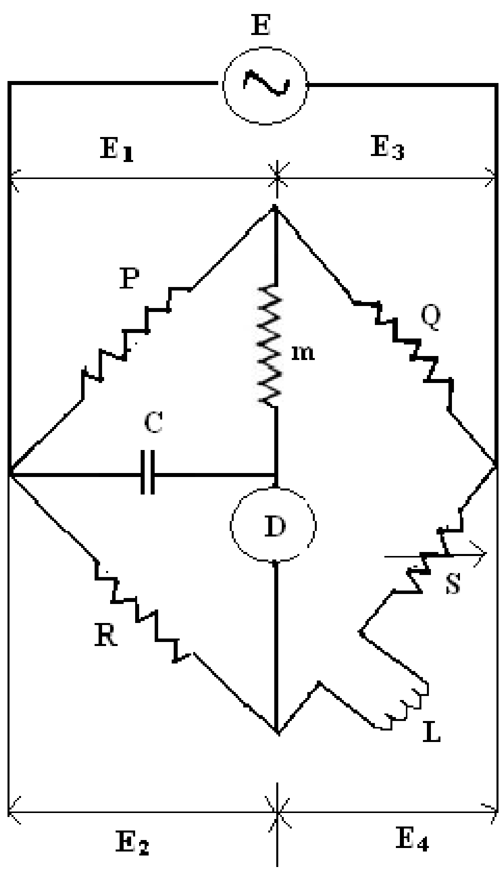
m = A non-inductive variable resistance of 3 decades of 10X10, 10X1000,10X1000 ohm.

C = A standard capacitance in the form of a values of .005. 0.01, 0.02, 0.05 mfd selected by a selector switch.

Kit Diagram:



Circuit Diagram:



Procedure:

1. Connect the circuit as shown in the diagram.
2. Initially when bridge is not balanced an amplitude proportional to the potential difference is indicated on the CRO screen.
3. Connect the oscillator and headphones at the places marked in the circuit diagram..
4. Keeping **m** = o vary **'s'** to get null deflection in the galvanometer.

5. Choose appropriate value of capacitance {say 0.01 Farads)
6. Further balance is obtained by varying **m** so as to give minimum sound in the headphone.

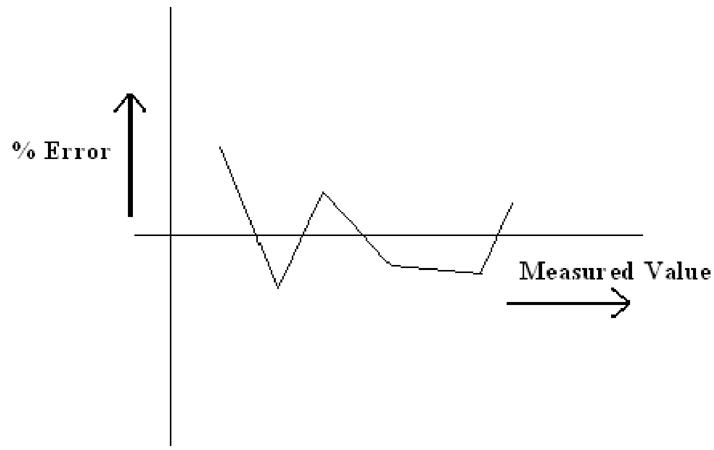
Precautions:
1. There should not be any loose connections.
2. Handle the Bridge very carefully.

Theoretical Calculations
L= C{RQ+{R+S}m} henries
P= Q=R=1000 ohms
%Error = {{True Value- Measured Value/True Value * 100

Observation Table;

Sl. No.	S Ώ	P Ώ	Q Ώ	R Ώ	QR/P Ώ	m Ώ	L=RC (Q+m+Qm/P) mH

Model Graph:
A graph is drawn between % Error and Measured Value



Result:

Viva Vice Questions

1. Can Anderson Bridge be used for frequencies higher then normal frequencies.

2 .What is the other name of this Bridge.

3. This Bridge is A.C or D.C?

4. What are the other bridges to be find the unknown inductance.

5. What is the range of Maxwell Bridge.

6. What is the difference between Maxwell bridge & Anderson Bridge.

EXPERIMENT - 7
MEASUREMENT OF 3- PHASE REACTIVE POWER WITH SINGLE PHASE WATTMETER

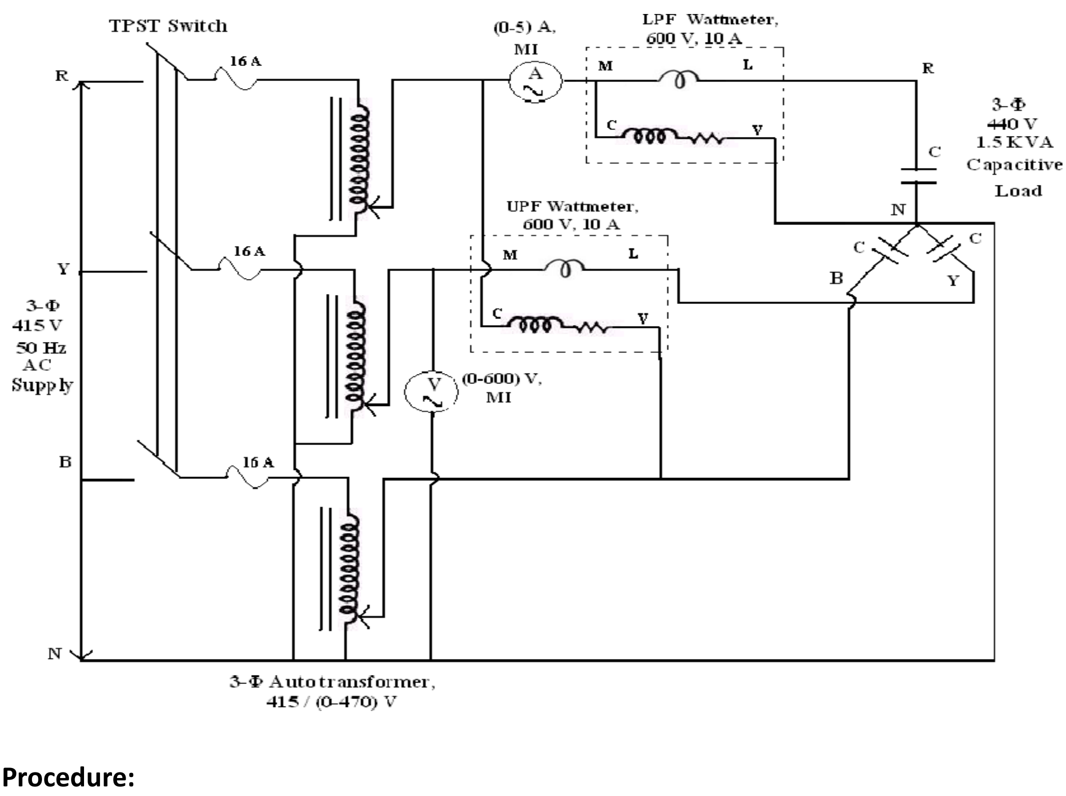
Aim:

To measure the total reactive power of a three phase balanced load using single phase wattmeter method.

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Capacitive Load	440V, 1.5KVA	3–Φ	01
02	Auto Transformer	415V/(0-440), (0-20)A	3–Φ	01
03	U.P.F. Wattmeter	(150/300/600) (0-5/10)A	Dynamometer Type	01
04	L.P.F. Wattmeter	(150/300/600)V(0-5/10)A	Dynamometer Type	01
05	Ammeter	(0-10)A	MI	01
06	Voltmeter	(0-600)V	MI	01
07	Connecting Wires	------	------	As required

Circuit diagram:



Procedure:

1. Make the Connections as per circuit diagram.
2. Keep the 3-Phase Autotransformer is in minimum output position.

3. Switch on the supply and by slowly varying the autotransformer, rated value is applied to motor.
4. Note down the readings of Ammeter, Voltmeter, Wattmeter's readings (Wr & Wa)
5. After noting the values slowly decrease the Auto Transformer till Volt meter comes to zero voltage position, and switch of the supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

Theoretical Calculations:

Ammeter reading = I_{ph} =

Voltmeter reading = V_{ph} =

Wattmeter reading (W_a) = Active power / Phase

Wattmeter reading (W_a) =

i.e. total active power = 3×Wa Total active power = 3VIcosϕ = $3W_a$

Cosϕ = W_a / VI

$Sin^2ϕ = 1- Cos2ϕ$

Total calculated reactive power = W_{RC} = 3VISin ϕ

Total measured reactive power = 3Wr

%Error = $\frac{3W_r - W_{RC}}{W_R} \times 100$

Observation Table:

S.No	Voltage V (Volts)	Line Current I_L (Amps) I	W_r (Watts)	W_a (Watts)	%Error

Result:

Viva Voce Questions

1. How do you define reactive power?
2. Distinguish between Leading VAR’s and Lagging VAR’s.
3. How many methods are represent to calculate 3-phase reactive power
4. What are the advantages of measuring 3-phase reactive power using single wattmeter?
5. What is the disadvantage of this test?
6. In this method is applicable to Unbalance loads.
7. What is method to be calculating reactive power in unbalanced loads?
8. Is it beneficial to have high reactive power?
9. What are the different types of Wattmeter’s are available.
10. What is the principle used in measurement of Reactive power.

EXPERIMENT - 8
LINEAR VARIABLE DISPLACEMENT TRANSDUCER

Aim:

To measure output voltage due to small change in displacement.

Apparatus Required:

L V D T Trainer Kit.

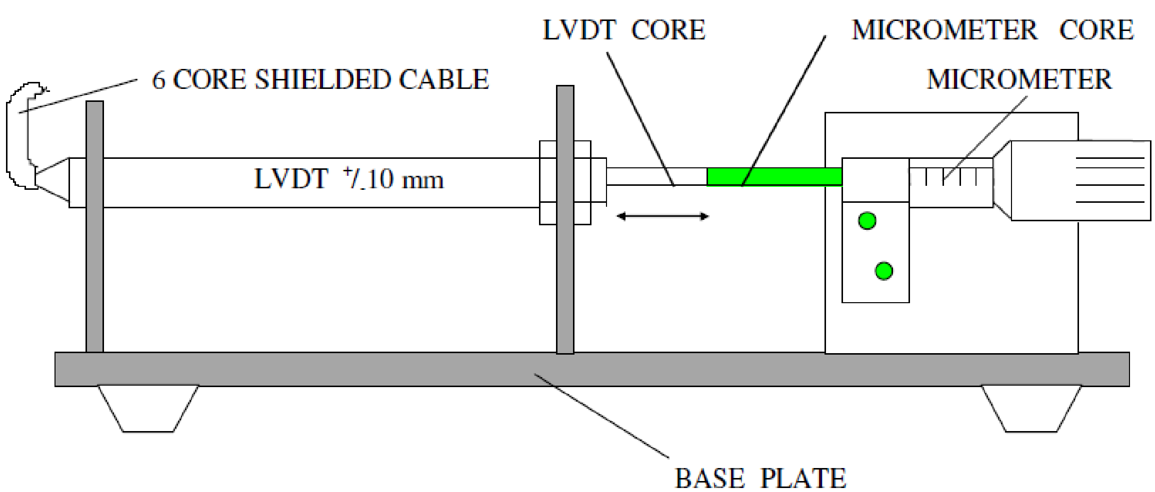
Theory:

MEASUREMENT OF DISPLACEMENT

Differential transformers, based on a variable Inductance principle, are also used to measure displacement. The most popular variable-inductance transducer for linear displacement measurement is the Linear Variable Differential Transformer (LVDT). The LVDT illustrated in the fig. consists of three symmetrically spaced coils wound onto an insulated bobbin. A magnetic core, which moves through thee bobbin without contact, provides a path for magnetic flux linkage between coils. The position of the magnetic core controls the mutual between the center or primary coil and with the two outside or secondary coils.

When an AC carrier excitation is applied to the primary coil, voltages are induced in the two secondary coils that are wires in a series-opposing circuit. When the core is centered between the two secondary coils, the voltage induces between the secondary coils are equal but out of phase by 1800. The voltage in the two coils cancels and the output voltage will be zero. When the core is moves from the center position, an imbalance in mutual inductance between the primary coil and the secondary coil occurs and an output voltage develops. The output voltage is a linear function of the core position as long as the motion of the core is within the operating range of the LVDT.

Circuit Diagram:



Connection Procedure:

CONNECTING INSTRUMENT TO MAINS

1. 3 Pin power chord is provided, attached to the instrument. Connect the 3pin plug to 230V 50Hz socket.
2. Before connecting ensure that the power On switch is in OFF position.

SENSOR CONNECTION

1. 6 core shielded cable is connected to the LVDT with male connectors of different colors are fixed to each wire.
2. Connect the male pins to the socket matching the color correctly.
3.

Procedure:

1. Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on the instrument by pressing down the toggle switch. The display glows to indicate the instrument is ON.
2. Allow the instrument in ON position for 10 minutes for initial warm-up.
3. Rotate the micrometer till it reads “20.0”
4. Adjust the CAL potentiometer at the front panel so that the display reads “10.0”.
5.Rotate the core of micrometer till the micrometer reads “10.0” and adjust the ZERO potentiometer till the display reads “00.0”
6. Rotate back the micrometer core upto 20.0 and adjust once again CAL Potentiometer till the display read 10.0. Now the instrument is calibrated for +/-10.0mm range. As the core of LVDT moves the display reads the displacement in mm.
7. Rotate the core of the micrometer in steps of 1 or 2 mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core the display will read the displacement sensed by the LVDT. Tabulate the readings and Plot the graph Actual V/s indicator reading.

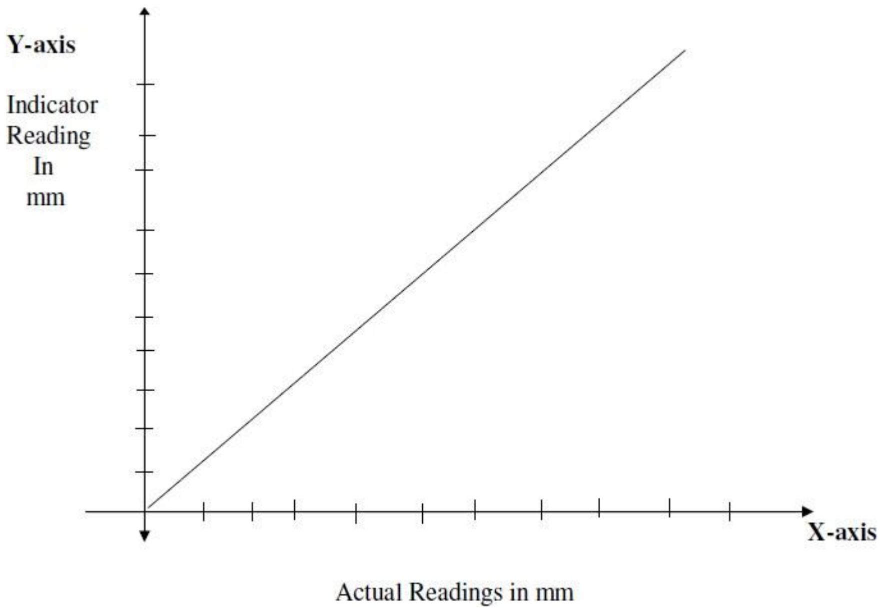
Observation Table:

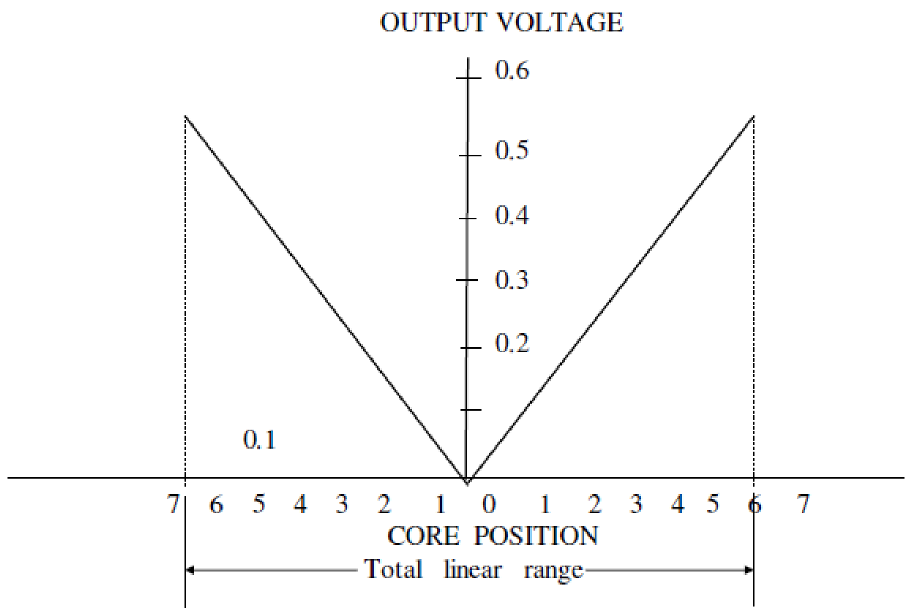
SI.NO	Actual Micrometer Reading (mm)	Indicator Reading LVDT (mm)	%Error

Model Calculation:

$$\%\text{Error} = \frac{\text{Actual micrometer reading} - \text{indicator reading}}{\text{Actual micrometer reading}} \times 100$$

Model Graphs:





Result:

Viva Voce Questions:

1. What is LVDT?
2. LVDT is which type of transducer?
3. Draw the output characteristics of LVDT
4. What is sensitivity of LVDT
5. What are the applications of LVDT
6. What is RVDT
7. What is difference between LVDT and RVDT
8. The principle of LVDT is similar to _____________

EXPERIMENT - 9
CALIBRATION OF LPF WATTMETER - BY PHANTOM TESTING

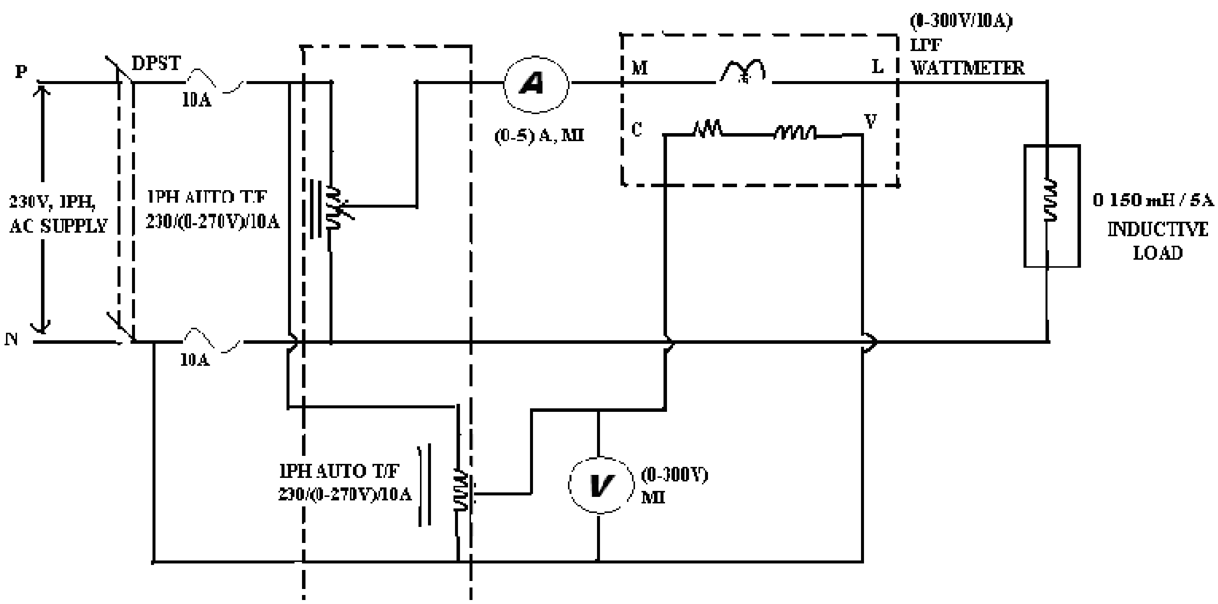
Aim:

To Calibrate a given LPF Wattmeter by phantom testing Method.

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Auto Transformer	230/(0-270)V, (0-5)A	1- Φ	02
02	L.P.F. Wattmeter	(150/300/600)V (2.5/5)A	Dynamometer Type	01
03	Voltmeter	(0-300)V	MI	01
04	Ammeter	(0-5)A	MI	01
05	Inductive Load	0-150mH, 5A	1- Φ	01
06	Connecting Wires	------	------	As required

Circuit Diagram:



Procedure:

1. Connections are made as per circuit diagram.
2. Kept the Auto Transformer (1 & 2) in minimum position.
3. The Auto Transformer 2 is varied in pressure circuit the voltmeter reading is adjusted to rated value i.e 150V.
4. Slowly the Auto Transformer 1 is varied in current coil circuit the Ammeter reading is adjusted at different valued in steps from 0-5Amps.

5. The experiment is repeated for different values of current at constant voltage.
6. After noting the values slowly decrease the auto transformers till Ammeter and Voltmeter comes to zero position and switch off the supply.

Precautions:
1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings.
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

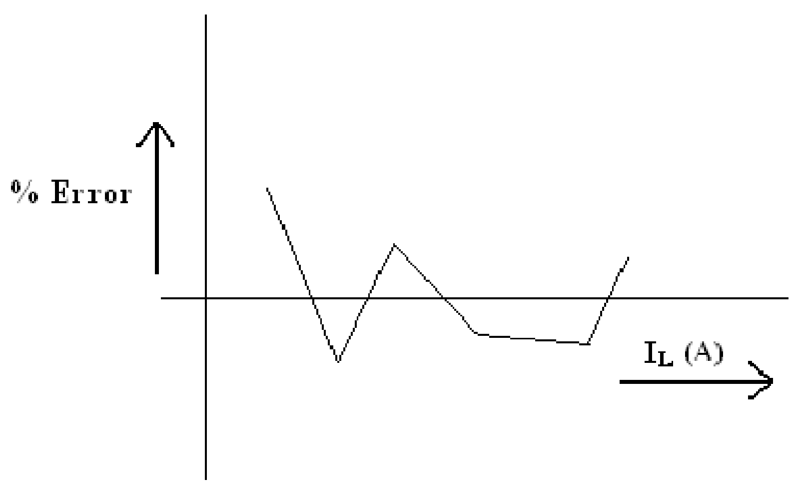
Theoretical Calculations

$$\% \text{ Error} = \frac{\text{Wattmeter Reading} - \text{Actual Power}}{\text{Actual Power}} X100$$

Observation Table:

Sl. No.	Voltage V(Volts)	Load Current I_L (Amps)	Wattmeter (Watts)	True Power (Wt) = VI Cosϕ	%Error

Model Graph: A graph is drawn between % Error and Load Current



Result:

Viva Voce Questions

1. What is the difference between moving coil & Fixed coil.

2. What type of control is used for electrodynamometer? Type wattmeter.

3. What is damping.

4. What type of scales & pointers used for electro Dynamometer wattmeter.

5. What are the different types of errors occur as the Wattmeter.

6. What is the power factor?

7. Explain the shape scale.

8. How the current is related with the voltage in current coil?

9. On What principle does the power factor meter work?

10. How the torque is developed in case of power factor meter?

EXPERIMENT – 10
MEASUREMENT OF 3- ϕ POWER USING SINGLE WATTMETER AND 2 NO'S OF CT'S

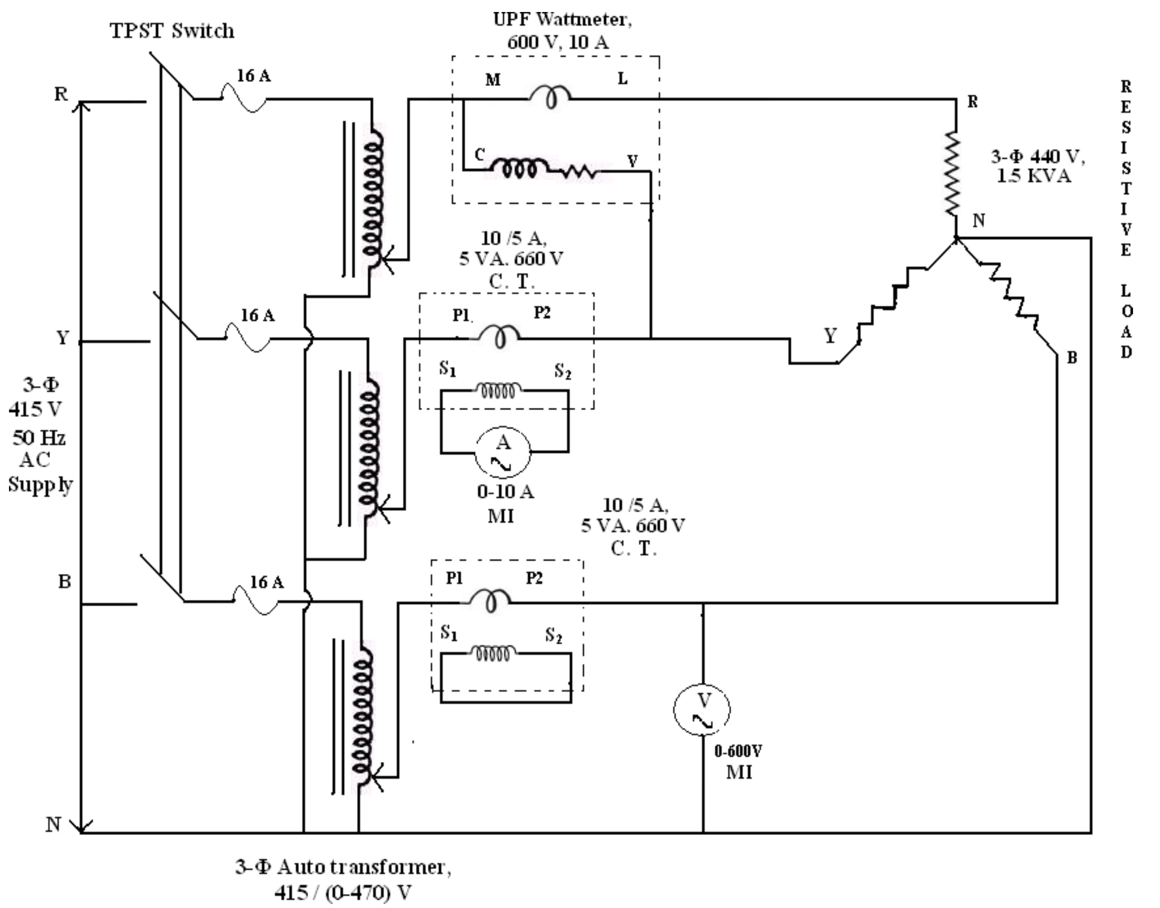
Aim:

Measurement of a 3-phase active power and also power factor using 2 CT's and one wattmeter.

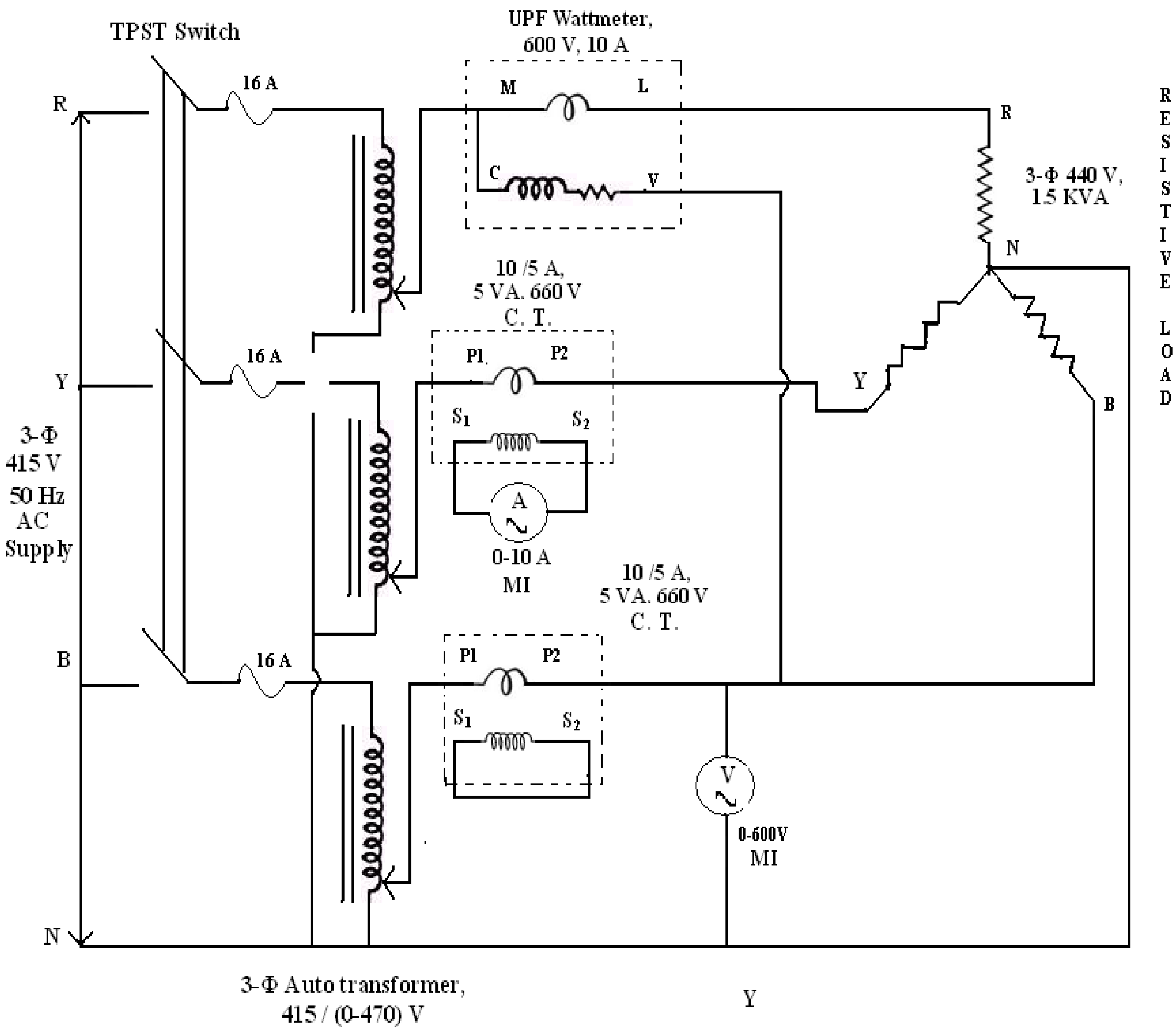
Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Resistive Load	440V, 1,5KVA	3-Φ	01
02	Current Transformer	5/10A, 660V	50Hz	01
03	U.P.F. Wattmeter	(150/300/600)V(0-5/10)A	Dynamometer Type	01
04	Auto Transformer	415V/(0-440)V (0-20)A	3-Φ	01
05	Ammeter	(0-10)A	MI	02
06	Voltmeter	(0-600)V	MI	01
07	Connecting Wires	------	------	As required

CIRCUIT DIAGRAM:
Between R and Y Phases:



Between R and B Phases:



Theory:

For very high voltage circuits, the high rating wattmeters are not available to measure the power. The range of wattmeters can be extended using instruments transformers, in search high voltage circuits.

The primary winding of current transformers are connected in series with load and secondary is connected series with an ammeter and current coil of a wattmeter.

The primary winding of potential transformers are connected across the supply and secondary is connected across voltmeter and the pressure coil of a wattmeter. One secondary terminal of each transformers and casing are granted.

Now, both C.T's & P.T's are have a errors like a ratio error and phase angle error.
For precise measurements, these errors must be co insider. If not coin sided these errors may cause in accurate measurements the corrections must be applied to such errors to get a accurate results.

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Switch on the supply and set the autotransformer upto rated voltage.
3. Connect the current coil of the wattmeter in R-phase and pressure coil across R and Y Phases or R and B for active power.
4. The values of voltage, current and wattmeter readings are noted down.,
5. The value of W_1 is noted by connecting pressure col between R and Y and W_2 is noted by connecting pressure coil between R and B.
6. The total power is calculated as $W_1 + W_2$.

$\phi = \tan^{-1}((\sqrt{3}(W_1 - W_2) / (W_1 + W_2))$

Precautions:

1. Loose connections are to be avoided.
2. Circuit connections should not be make while power is on.
3. Reading of the meters must be taking without parallax error..
4. Voltage is to be varied gradually till rated current flows.
5. Ensure that the setting of the variac is at zero output voltage during starting

Observation Table:

For Resistive Load:

R and Y Phases

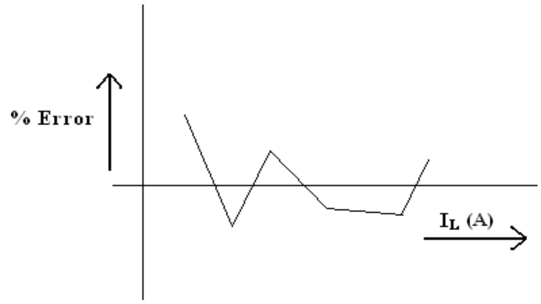
Sl. No.	Voltage (volts)	Current (Amps)	Wattmeter (watts)

R and B Phases

Sl. No.	Voltage (volts)	Current (Amps)	Wattmeter (watts)

Model Graph:

A Graph between %Error Vs load current



Result:

Viva Voce Questions:

1. What is a C.T?
2. Explain the working principle of C.T?
3. What is a P.T?
4. Explain the working principle of P.T?
5. What is the difference between C.T & P.T?
6. Where we use the C.T's & P.T's

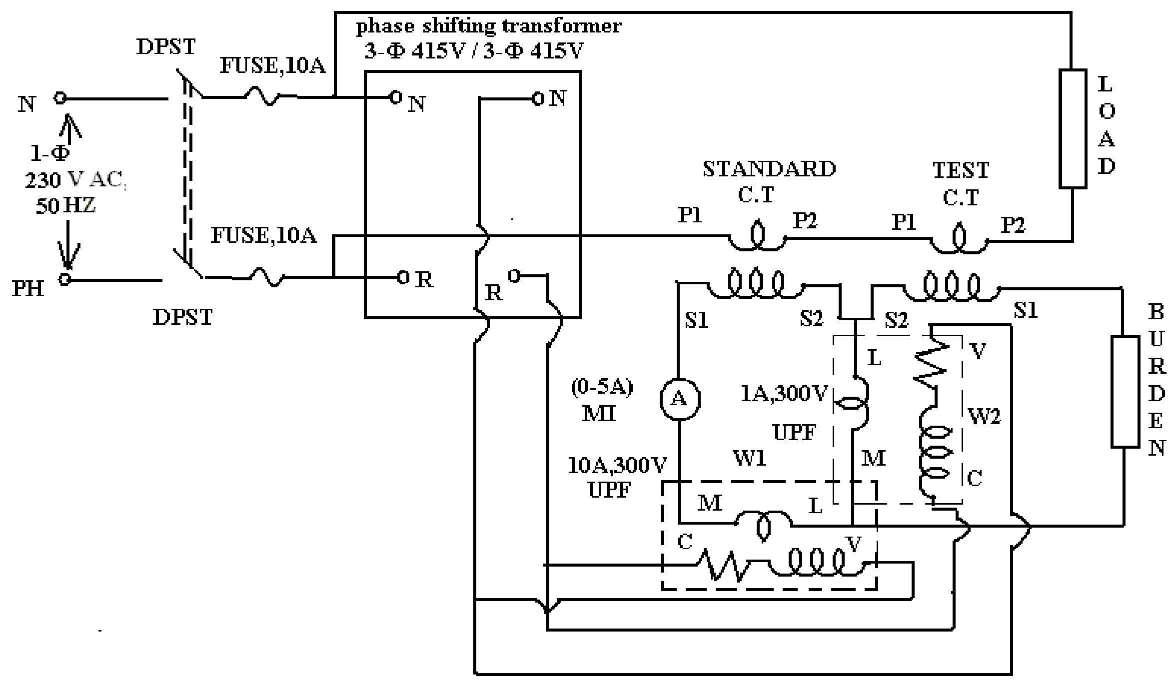
EXPERIMENT – 11

C.T TESTING USING MUTUAL INDUCTOR - MEASUREMENT OF % RATIO ERROR AND PHASE ANGLE OF GIVEN C.T BY NULL METHOD

AIM: To determine % ratio error an phase angle error of a given current transformer using Silsbee's method.

APPARATUS: Phase shifting Transformer 3-phase, 415 V.
Two current Transformers (i) Standard C.T 10A /5A.
Burden 2.5, 7.5, 10, 15,, 30,VA
Wattmeter -5A, 300V, UPF
1A, 300V, UPF.
Ammeter -0-5A

CIRCUIT DIAGRAM:



THEORY:

Here the ratio and phase angle of the transformer are determined.. In terms of that of a standard transformer having the same nominal ratio.

The two transformers are connected with their primary in series. An adjustable burden is put in the secondary circuit of the transformer r under test. An ammeter is included in the secondary circuit of the standard transformer so that the current may be set to the desired vaslue.W1 is wattmeter whose current coil is connected to carry the secondary current of the standard transformer.' the current coil do the wattmeter W2 carries a differential current I which is the difference between a secondary current s of the standard and test transformers. The voltage circuits of the wattmeters are supplied from a phase shifting transformer voltage

PROCEDURE:

1. Connections are made as per the figure
2. Adjust the supply voltage to 230 V
3. Vary the load current and at each current read the wattmeter W1 & W2 by keeping the phase angle.
4. Note down the readings

TABULAR COLUMN:

S.No	Current (A)	W1		W2		% ratio error= W2p/W1pX100	Φ angle error Φx= Φs = W2q/W1q radiances

RESULT:

EXPERIMENT – 12

P.T.TESTING BY COMPARISION METHOD MEASUREMENT OF % RATIO ERROR AND PHASE ANGLE OF GIVEN P.T. BY COMPARISON

Aim:

To determine the percentage ratio error and the phase angle error of the given potential transformer by comparison with another potential transformer whose error is known.

Apparatus:

1. Standard PT (one for which the error are know)
2. Testing PT
3. Wattmeter, UPF – 2 Nos.
4. Ammeter (MI type) - 1 Nos.
5. Voltmeter (MI type)-2 No
6. Rheostat
7. Phase shifting transformer.

Theory:

This is a comparison type of test employing deflectional methods. Here the ratio and phase angle of the test transformer **x** are determined in terms of that of a standard transformer **s** having same nominal ratio.

The errors are as follows say:

PT \ Error	Ratio Error	Phase Angle Error
S	RS =	θs =
X	RX =	θX =

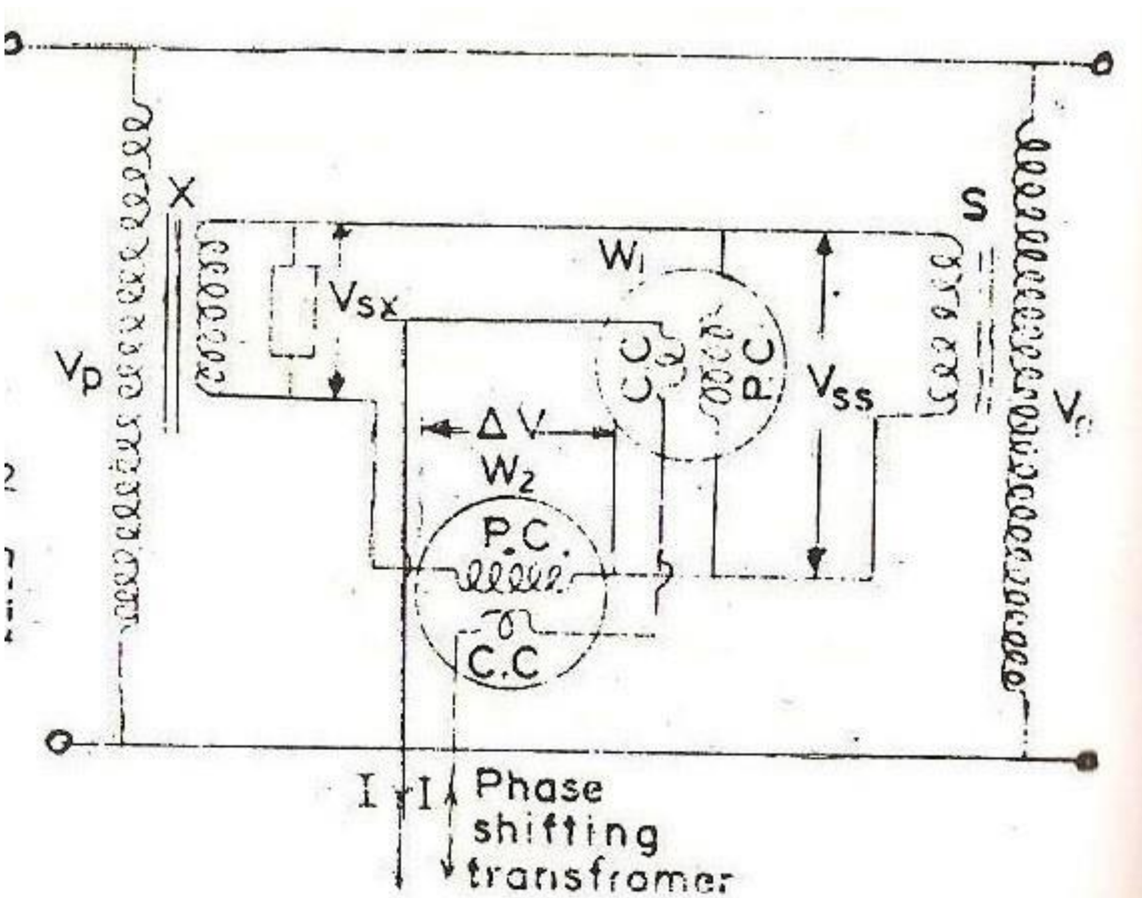
The two transformers are connected with their primaries in parallel. A burden is put in the secondary circuit of test transformers.

W1 is a wattmeter whose potential coil is connected across the secondary of standard transformer.

The pressure coil of wattmeter W2 is so connected that a voltage ΔV which is the difference between the secondary voltages of standard and test transformer.

The current coil of two watt meters is connected in series and is supplied from phase shifting transformer. They carry a constant current I.

Circuit Diagram:



Proceudre:
1. The connections are made as shown in the circuit diagram.
2. Switch on the main supply, apply 200 volts to primaries of potential transformers.
3. Noted down the voltages across the burden(Vsx),pressure coil of W2(Δv) and secondary of standard PT(Vss)
4. Adjust the phase shifting transformer until W1 reads zero.at this condition note down the reading of wattmeter W2(W2q).
5. Now apply 90° of phase shift and noted down the readings of W1 and W2 (W1p & W2p).
6. Apply different voltages to the primaries of potential transformers and repeat the same procedure.

Actual ratio of standard transformer Rs=Vp/Vsx………1
Actual ratio of test transformer Rx=Vp/Vsx 2
The actual ratio of transformer under test Rx=Rs(1+W2p/W1p)
The phase angle of test transformer ϴx=(W2q/W1p)+ϴs

Tabular Column:

S.No	**Vsx**	**W1q**	**W2q**	**W1p**	**W2p**	**Rx**	Θx

Precautions:

1. W2 is sensitive instrument. Its current coil may be defined for small values. It is normally designed to carry about 0.25 A

Result:

EXPERIMENT – 13
STRAIN MEASUREMENT AND CALIBRATION USING STRAIN GUAGE

Aim:

Calibration and strain measurement using Resistance strain guage.

Apparatus Required:

Sl.No.	Name of the Equipment	Range	Quantity
1	Strain guage Trainer Kit	-	1
2	Weights	100 gms	10
3	9 pin connector	-	1

Theory:

When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain in the material or the material get strained. So the material is mechanically strained, this strain is defined as ' The ratio between change in the mechanical property to the original property'.

Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of l So according to the definition strain S is given by

$$S = l / L$$

Since the change in the length of the material is very small it is difficult to measurel. So the

strain is always read in terms of micro strain. Since it is difficult to measure the length Resistance strain gauges are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesives. As the material gets strained due to load applied, the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property in to electrical signal which can be easily measured and stored for analysis.

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge. The sensitivity of strain gauges is usually expressed in terms of a gauge factor S_g where Sg is given as

$$R / R = Sg$$

Where is Strain in the direction of the gauge length

The output R / R of a strain gauge is usually converter in to voltage signal with a Whetstones bridge, If a single gauge is used in one arm of whetstones bridge and equal but fixed resistors is used

in the other arms, the output voltage is

$$Eo = Ei / 4 (Rg / Rg)$$

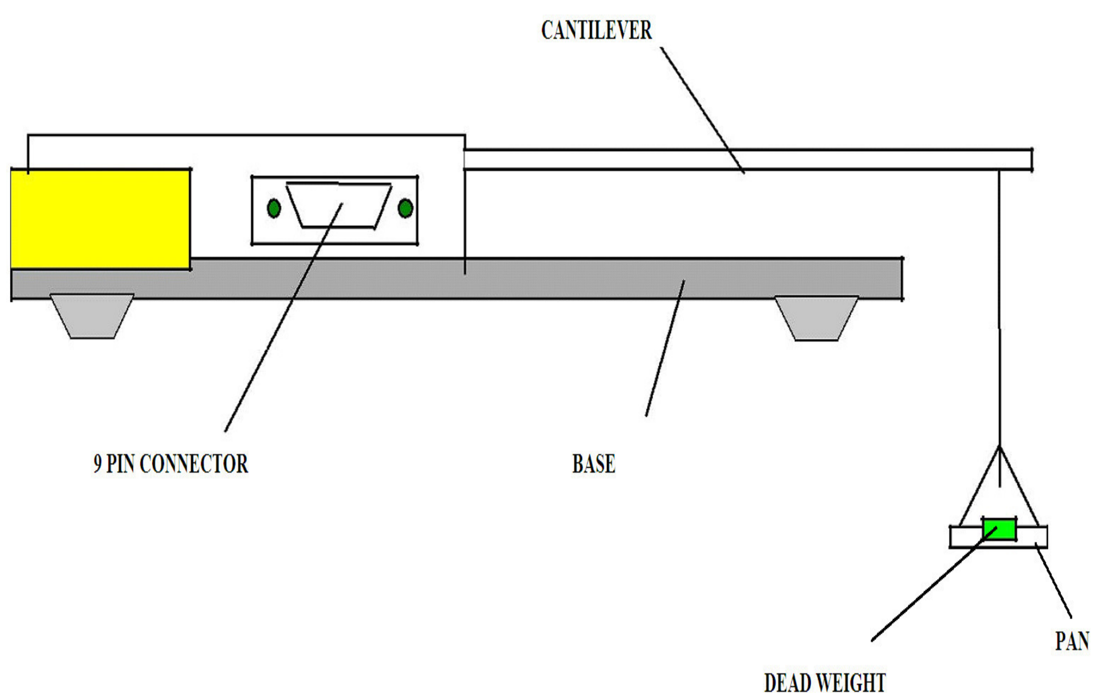
Substituting Eq 2 into Eq 3 gives

$$Eo = 1/4 (Ei Sg)$$

The input voltage is controlled by the gauge size (the power it can dissipate) and the initial resistance of the gauge. As a result, the output voltage Eo usually ranges between 1 to 10 V / microunits of strain.

Circuit Diagram:

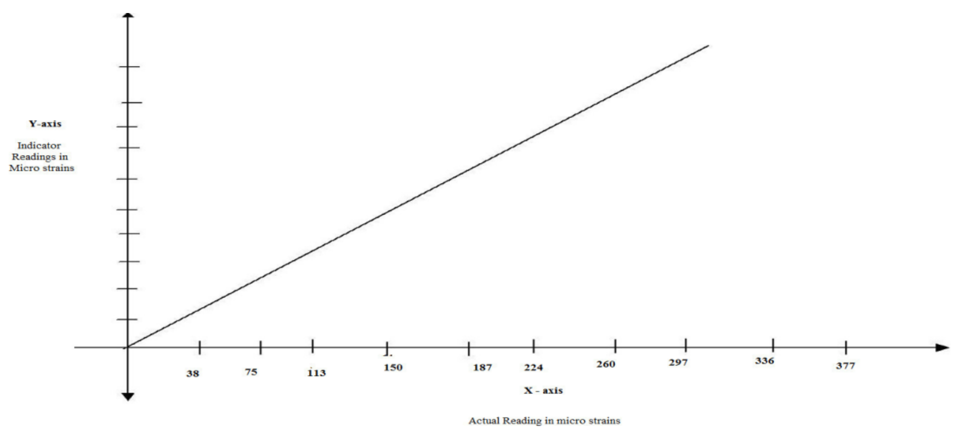
CANTILEVER BEAM SETUP



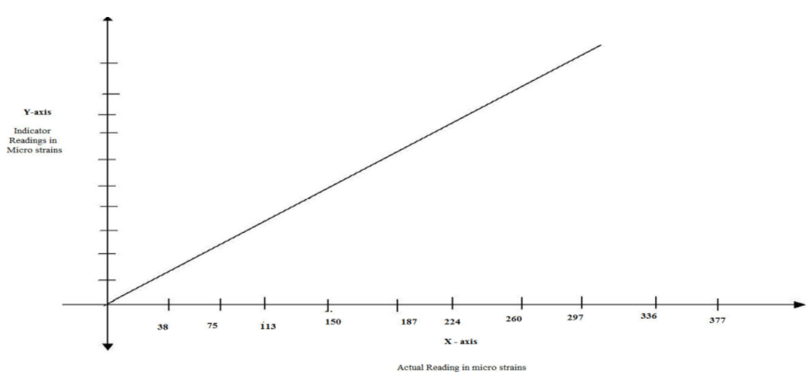
Procedure:

1. Check the connection made and Switch ON the instrument by toggle switch at the back of the box. The display glows to indicate the instrument is ON.
2. Allow the instrument in position for initial warmup.
3. Adjust the ZERO potentiometer on the panel till the display reads '000'.
4. Apply 1kg load on the cantilever beam and adjust the CAL potentiometer till the display reads 377 micro strain.(as per calculations given below)
5. Remove the weigts, the display should come to ZERO incase of any variation adjust the ZERO pot again and repeat the procedure again.Now the instrument is calibrated to read micro-strain.
6. Apply load on the sensor using the loading arrangement provided in steps of 100g to 1kg.
7. The instrument displays exact microstrainstrained by the cantilever beam.
8. Note down the readings in the tabular column. Percentage error in the readings, Hysteresis and Accuracy of the instrument can be calculated by comparing with the theoretical value.

Model Graphs:



Load Vs Strain



Model calculations:

$S = (6PL)/BT^2E$

P = Load applied in Kg. (1kg)

L = Effective length of the beam in Cms. (22Cms)

B = Width of the beam(2.8 Cms)

T = Thickness of the beam ($2X10^6$)

S = Micro strain

Then the micro strain for the above can be calculated as follows

$$S = \frac{6 X 1 X 22}{2.8X\ 0.25^2 X(2X10^6)} = \text{Power factor of the load}$$

S= 377 microstrain

Observation Table:

A	B	C	D	E
SL.No.	**Weight (in grams)**	**Actual readings (using formulae) S = (6 P L) / BT2E (in micro strains)**	**Indicator readings (in micro strains)**	**Error in %**

$$\% \text{ ERROR} = \frac{\text{Actual Reading (C) - Indicator Readings (D)] x 100}}{\text{Max. Weight in gms}}$$

Result:

EXPERIMENT – 14
TRANSFORMER TURNS RATIO MEASUREMENT USING A.C. BRIDGE

Aim:

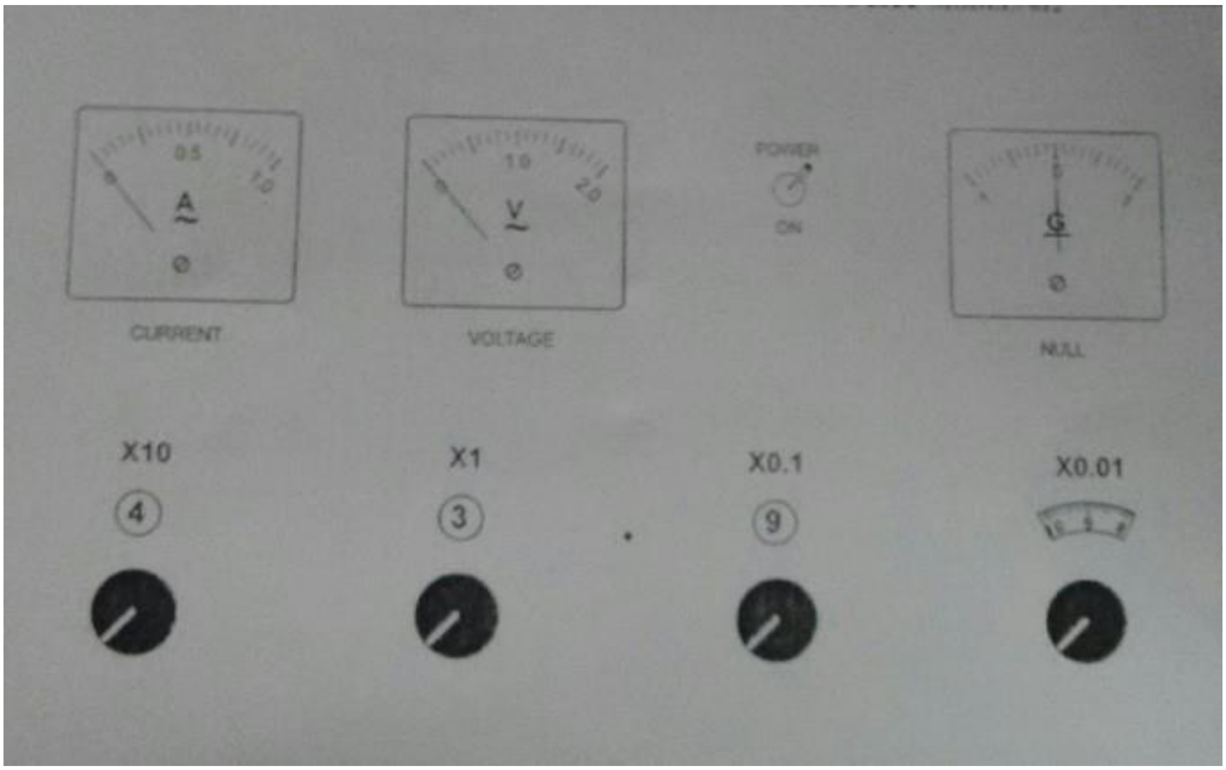
To measure actual turns ratio of a transformer.

Apparatus:

Transformer Turns Ratio Meter, Model 612

Ciruit Diagram:

Transformer turn Ratio meter:



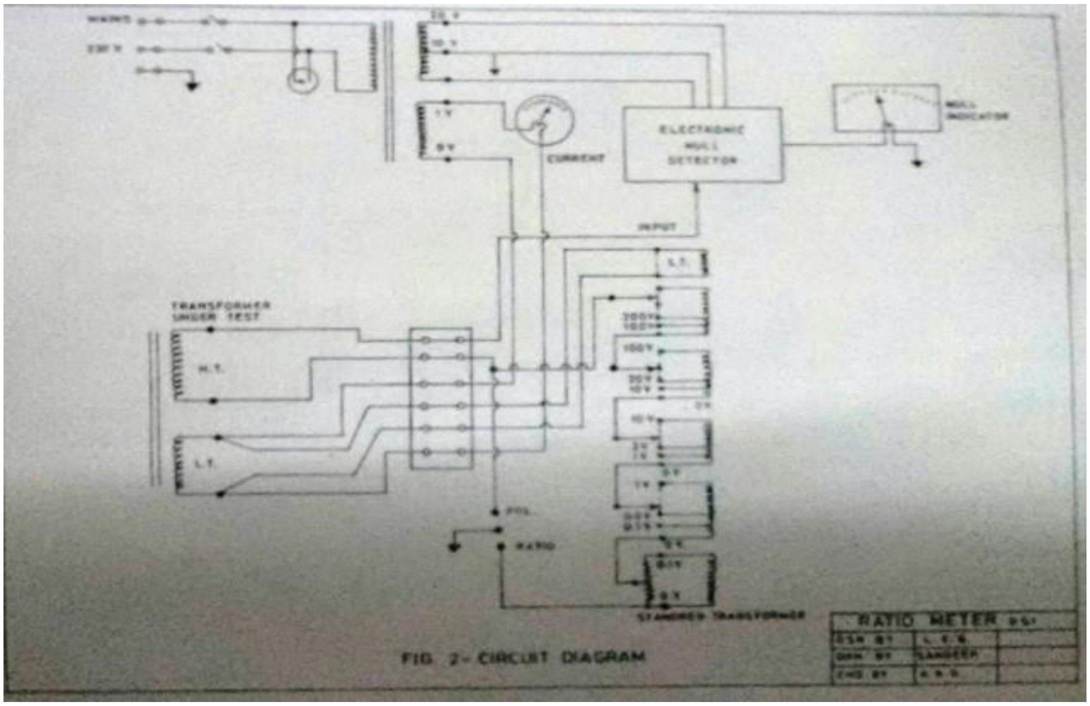


FIG 2- CIRCUIT DIAGRAM

Procedure:

1. Connect 'Transformer Under Test'. L.T. Winding through L.T. terminals (7) by help of supplied L.T. cable leads and H.T. winding by supplied flexible wire leads toH.T. Terminals (8) on test set. The care should be taken about perfect gripping ofL.T. leads massive clips at L.T. Winding of "Transformer Under Test".

2. Set the ratio (approximately) of "transformer under test" by help of Ratio decade switches (6).

3. Feed the unit by 240V. 50Hz. 1ph. a.c. supply having proper earthing. The electronic null detector circuit needs proper earthing.

4. Switch on the unit by main switch (1) and pilot lamp (3) will glow to indicate the condition. Keep the polarity/Detector Function switch (10) at 'POLARITY'position. Toggle the "Test ON" switch (5) to 'ON' position and turn the sensitivity control knob (11) at 'MIN' position whereby interlocking switch (MS) will operate and energise the contactor (CON). The 'Test ON' pilot lamp (4) will glow to indicate that contactor (CON) is energised. The null indicator meter (9) will act as polarity meter at this juncture. If the pointer of this meter swings in direction of

"REVERSE" Zone then it indicates that polarity is wrong and 'transformer under test' must be de-energised by toggling 'Test ON' Switch (5) to OFF position immediately. After switching off the "Test" circuit, the polarity at H.T. terminals (8) can be corrected. After the polarity correction is done once again switch on the test circuit by toggling switch (5) . The pointer of meter (9) will now swing in "CORRECT" zone which concludes that polarity of transformer under test is correct. Now toggle the Polarity/Detector switch (10) in "DETECTOR" position and observe the meter (9). Balance the bridge by Ratio switches (6) suitably. Increase the sensitivity by turning the knob (11) in clockwise direction i.e. towards max. Position and at 'Max' position balance the bridge. Note the readings. Switch off the test circuit by switch (5). and change the tap position of 'transformer under test', or connect the next job under test.The test circuit can be switched ON only with 'MIN' position of sensitivity knob (11) and polarity/Detector switch (10) at 'POLARITY' position.

Precautions:

1. Ensure about proper connections of transformer under test especially connections of L.T. Leads.

2. Set the Ratio decade switches (6) to approximate value of "Ratio" before switching ON the "Test Circuit". Avoid the adjusting of decade switches (6) in large variations.

3. Do not switch off main switch often but switch off the test circuit, while changing the job, or selecting next tap of transformer under test.

Result:

EXPERIMENT – 15
MEASUREMENT OF % RATIO ERROR AND PHASE ANGLE OF GIVEN C.T. BY COMPARISON

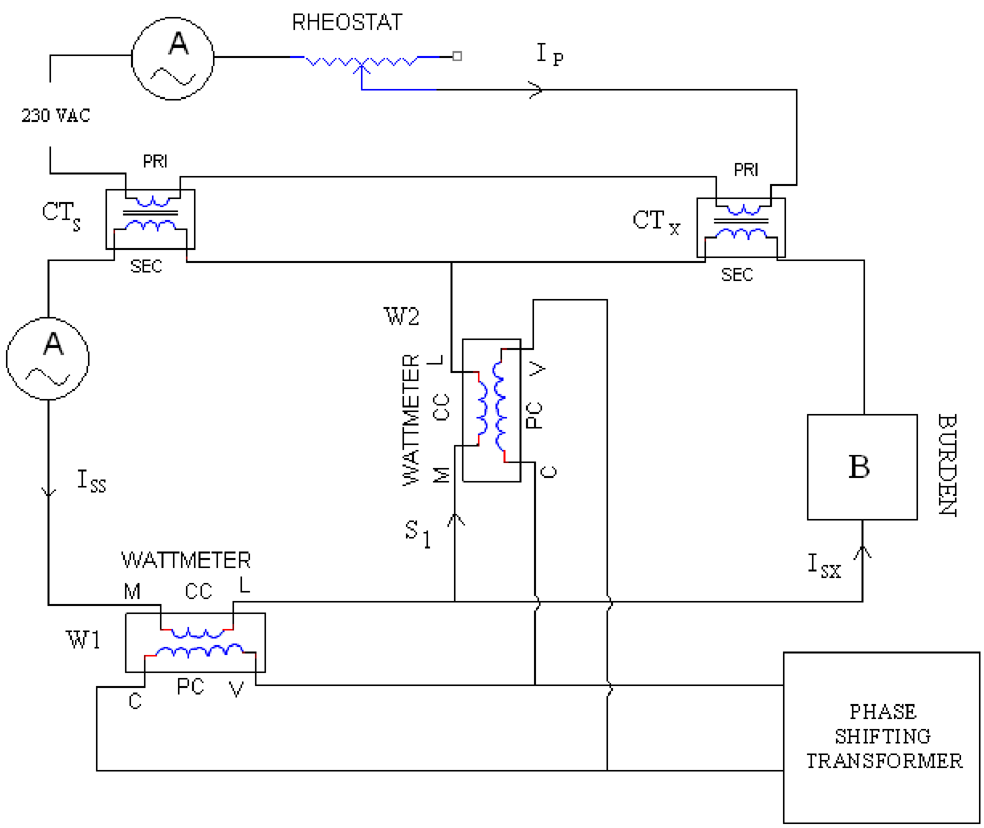
Aim:

To determine the percentage ratio error and the phase angle error of the given current transformer by comparison with another current transformer whose error are known.

Apparatus:

1. Standard CT (one for which the error are know)
2. Testing CT
3. Wattmeter, LPF – 2 Nos.
4. Ammeter (MI type) - 2 Nos.
5. Phase shifting transformer.

Circuit Diagram:



Theory:

This is a comparison type of test employing deflectional methods. Here the ratio and phase angle of the test transformer **x** are determined in terms of that of a standard transformer **s** having same nominal ratio.

The errors are as follows say:

Error / CT	Ratio Error	Phase Angle Error
S	RS =	θs =
X	RX =	θX =

The primaries of the two CTs are connected in series and the current through them is say IP. The pressure coils of two watt meters are supplied with constant voltage V from a phase shifting transformer.

The current coil of wattmeter W1 is connected to **S** through an ammeter. The current coil of wattmeter W2 is connected as shown in fig and carriers a current SI.

SI = Iss - Isx (Victorian difference)

Where **Iss** is the current in the current coil of W1 and Isx is the current flowing through the burden. The phase shifting transformer is adjusted so that the wattmeter W1 reads zero.

$$W\ 1q = Vpcq\ Iss \cos 90 = \theta$$

$$W2q = Vpcq\ SI \cos (\theta X - \theta s)$$

$$= V\ Isx \sin (\theta X - \theta s)$$

Where Vpcq is the voltage from the phase shifting transformer, which is in quadrature with the Iss in is current coil of W1.

Then the phase of the voltage from to phase shifting transformer is shifted through 90^o.

Therefore, now V is in phase with the current Iss.

$$W1p = V\ Iss$$

$$W2p = VSI \sin (\theta X - \theta s)$$

$$= V\ [Iss - isx \cos (\theta X - \theta s)$$

$$= W1p - VISX \cos (\theta X - \theta s)$$

As $(\theta X - \theta s) \sim 0$

Therefore $VIsx = W1p - W2p$

$$RX = \frac{Ip}{ISX}$$

$$RS = \frac{Ip}{ISS}$$

$$\frac{RX}{RS} = \frac{ISS}{ISX} = \frac{V\ Iss}{V\ Isx} = \frac{W1p}{W1p\ W2p}$$

$$RX = RS\,(1 + W2p / W1p)$$

Now to obtain the Phase Angle Errors

$\sin(\theta X - \theta s) = W2q / V\ Isx$

$$\cos(\theta X - \theta s) = \frac{W1p - W2p}{V\ Isx}$$

$$\tan(\theta X - \theta s) = \frac{W2Q}{W1p - W2p}$$

OR

$$\theta X = \frac{W2\theta}{W1p - W2} + \theta s \text{ radius}$$

procedure:

1. the connections are made as per the circuit diagram. The burden is adjusted to have a suitable current In. the phase angle is adjusted using the phase shifting transformer will wattmeter W1 reads zero. Reading of the other wattmeter (W2q) is noted.
2. A phase shift of 90 is obtained by the phase sulfating transformer. The two wattmeter readings W Ip and W 2p are then observed

3. The ratio error is calculated using the formula Rx = Rs
4. The phase angle error is calculated using the formula
5. The experiment is repeated by varying the burden and setting different values for Iss.
6. The average values of Rs and are then obtained.

Tabular Column:

S.No	**Iss**	**Wiq**	**W2q**	**W1p**	**W2p**	**Rx**	Θx

Precautions:

1. W2 is sensitive instrument. Its current coil may be defined for small values. It is normally designed to carry about 0.25 A for testing CTs having a secondary current of 5 Amps.

Result:

EXPERIMENT – 16

MEASUREMENT OF PARAMETERS OF A CHOKE COILS USING 3-VOLTMETER AND 3-AMMETER METHODS

Aim:

To calculate the resistance and inductance of the given choke coil by using (a) 3 Ammeters (b) 3 Voltmeters methods

(b) Three voltmeter method

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Choke coil	0.41A, 40W, 230V	50 Hz	01
02	Auto Transformer	230/(0-270)V, (0-10)A	1- Φ	01
03	Rheostat	50/100Ω, 5A	1- Φ	01
04	Voltmeter	(0-300)V	MI	03
05	Ammeter	(0-5)A	MI	01
06	Connecting Wires	------	------	As required

Theory:

The parameters of a choke coil (L & R) can be measured using 3 Voltmeters. Out of 3-Voltmeter is connected across supply, second voltmeter across a series known resistance and third is connected across choke coil as shown in figure. The phasor diagram of the circuit is shown below.

From the phasor diagram,

$V_1^2 = V_2^2 + V_3^2 + 2\,V_2V_3\,\mathrm{Cos}\Theta$

$2\,V_2V_3\mathrm{Cos}\Theta = V_1^2 - V_2^2 - V_3^2$

$\mathrm{Cos}\Theta = \frac{V_1^2 - V_2^2 - V_3^2}{2V_2V_3}$ = Power factor of the load

And also the current flowing through the choke coil is

$I = \frac{V_2}{R}$ = or $V_2 = IR$

By substituting V_2 in the equation

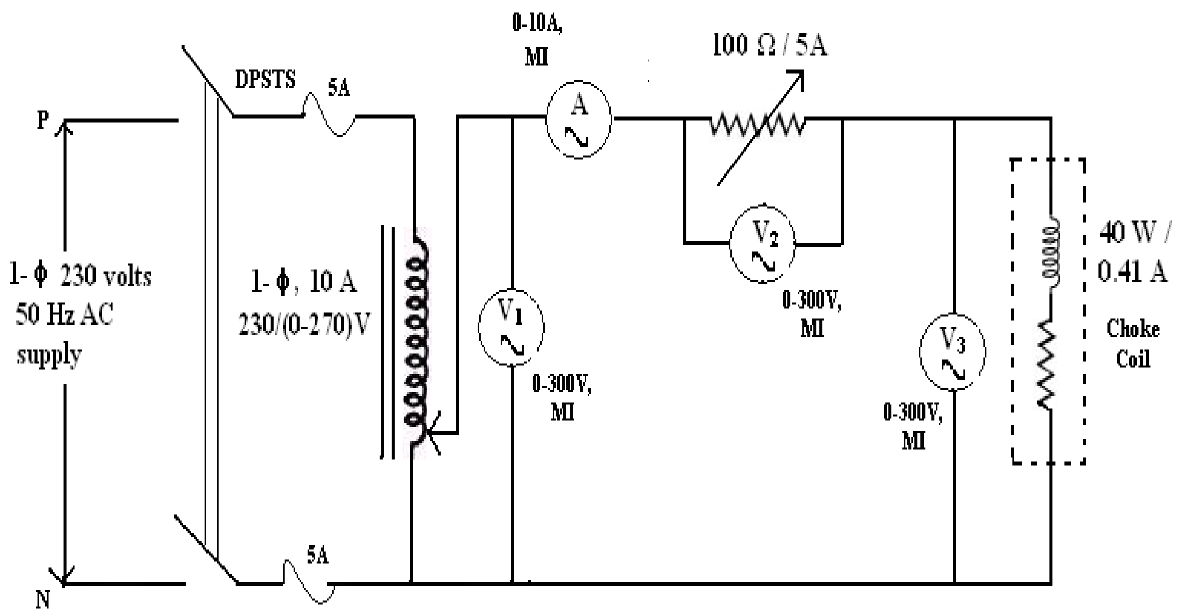
$2IR\, V_3 \cos\Theta = V_1^2 - V_2^2 - V_3^2$

$2RP = V_1^2 - V_2^2 - V_3^2$

$P = \frac{V_1^2 - V_2^2 - V_3^2}{2R}$ = Power consumed by choke coil

Circuit Diagram:

(Three voltmeter method)



Procedure:
3- Voltmeters method:

1. Connect as per the circuit diagram.
2. Initially the Auto Transformer should be in minimum output position.
3. By slowly varying the Auto Transformer the Voltmeter V_1 is adjusted at different values
4. Note down the corresponding readings of V_2 & V_3
5. After noting the values slowly decrease the auto-transformer till the Voltmeter comes to zero position, and Switch off the Supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

Theoretical Calculations:

$P = (V_1^2 - V_2^2 - V_3^2) / 2R$

$\cos\Phi = (V_1^2 - V_2^2 - V_3^2) / 2V_2V_3$

$I = V_2/R$

$Z = V_3/I$

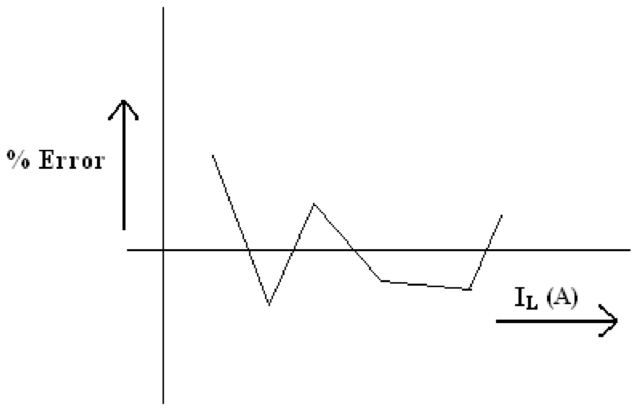
$R = Z \cos\Phi$
$X_2 = Z \sin\Phi$
$L = X_L / 2\pi f$

Observation Table:

Sl.No.	V_1	V_2	V_3	P	cosΦ	sinΦ	I	Z	R	X_L	L

Average Inductance =
Average Resistance =

Model Graph:
A graph is drawn between **% Error Vs Line current**.



Result:

Viva Voce Questions

1. What are the disadvantages of 3-Voltmeter & 3- Ammeter Method? in measuring the parameters of choke coil..

2. What are main parts of a moving coil instrument?

3. What is known as M.I instrument?

4. What are the types M.I type instruments?

5. Which meter, the ammeter or voltmeter has high resistance?

6. Why a shunt is provided with an ammeter

7 . Name the device used for extension of voltmeter range.

8. If you connect the voltmeter in series with the load what will happen?

9. Can you use the M.C.type meter on A.C?

10. If an ammeter is connected across the A.C line what will happen?

(b) Three Ammeter method
Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Choke coil	0.41A, 40W, 230)V	50 Hz	01
02	Auto Transformer	230/(0-270)V, (0-10)A	1- Φ	01
03	Rheostat	50/100Ω, 5A	1- Φ	01
04	Voltmeter	(0-300)V	MI	01
05	Ammeter	(0-5)A	MI	02
06	Ammeter	(0-1)A	MI	01
07	Connecting Wires	------	------	As required

Theory:

The parameters of a choke coil (R & L) can also be measured using 3-Ammeters, out of 3-Ammeters one is connected in series with the supply, second one is connected in series with Standard resistance & third is in series with choke coil the phasor diagram of the circuit is shown in the figure.

$I_1^2 = I_2^2 + I_3^2 + 2\ I_2I_3\text{Cos}\Theta$

$2\ I_2I_3\text{Cos}\Theta = I_1^2 - I_2^2 - I_3^2$

$\text{Cos}\Theta = \frac{I_1^2 - I_2^2 - I_3^2}{2I_2I_3}$ = Power factor of the load

And also the current flowing through the choke coil is

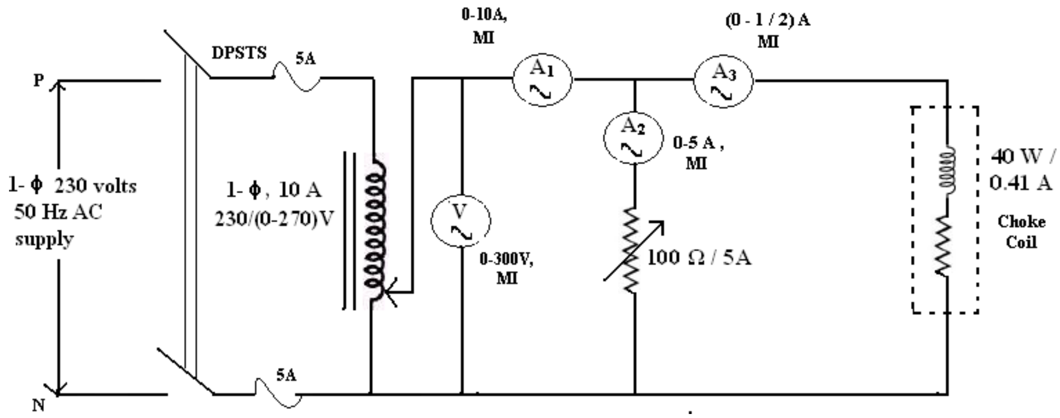
$I = \frac{V_2}{R}$ = or $V_2 = IR$

By substituting V_2 in the equation

$2\ I_3X\text{Cos}\Theta = = \frac{I_1^2 - I_2^2 - I_3^2}{2I_1I_2}$

$P = \frac{I_1^2 - I_2^2 - I_3^2}{2R}$ = Power consumed by choke coil

Circuit diagram:



Procedure:

1. Connections are made as per the circuit diagram
2. Initially the Auto Transformer should be in minimum output position.
3. By slowly varying the Auto Transformer, the Ammeter A_1 is adjusted at different values from 0 to 5A.
4. Note the corresponding readings of A_2 & A_3.
5. After noting the values slowly decrease the auto-transformer till the Voltmeter comes to zero position, and Switch off the Supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage During starting.

Calculations:

$P = (I_1^2 - I_2^2 - I_3^2) \times R$

$\cos\Phi = (I_1^2 - I_2^2 - I_3^2) / 2I_2I_3$

$V = I_2R$

$Z = V/I$

$R = Z \cos\Phi$

$X_L = Z \sin\Phi$

$L = XL / 2\pi f$

Observation Table:

Sl.No.	I_1	I_2	I_3	P	cosΦ	sinΦ	V	Z	R	X_L	L

Average Resistance:
Average Inductance:

Result:

Viva Voce Questions

1. What are the disadvantages of 3-Voltmeter & 3- Ammeter Method? in measuring the parameters of choke coil..
2. What are main parts of a moving coil instrument?
3. What is known as M.I instrument?
4. What are the types M.I type instruments?
5. Which meter, the ammeter or voltmeter has high resistance?
6. Why a shunt is provided with an ammeter
7. Name the device used for extension of voltmeter range.
8. If you connect the voltmeter in series with the load what will happen?
9. Can you use the M.C.type meter on A.C?
10. If an ammeter is connected across the A.C line what will happen?

EXPERIMENT – 17
MEASUREMENT OF ACTIVE POWER FOR STAR AND DELTA CONNECTED BALANCED LOADS

Aim:

To measure the active power for the given star and delta network.

Apparatus:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Auto Transformer	415V/(0-440), (0-20)A	3–Φ	01
02	U.P.F. Wattmeter	(150/300/600) (0-5/10)A	Dynamometer Type	01
03	L.P.F. Wattmeter	(150/300/600)V(0-5/10)A	Dynamometer Type	01
04	Ammeter	(0-10)A	MI	01
05	Voltmeter	(0-600)V	MI	01
06	Connecting Wires	------	------	As required

Theory:

A three phase balanced voltage is applied on a balanced three phase load when the current in each of the phase lags by an angle Φ behind corresponding phase voltages. Current through current coil of $w_1=I_r$, current through current coil of $W_2=I_B$, while potential difference across voltage coil of $W_1=V_{RN}-V_{YN}=V_{RY}$(line voltage), and the potential difference across voltage coilof $W_2= V_{RN}-V_{YN}=V_{BY}$.Also, phase difference between I_R and V_{RY} is (300+ Φ).While that between I_B and V_{BY} is (300- Φ).Thus reading on wattmeter W_1 is given by $W_1=V_{RY} I_Y Cos(300+ \Phi)$While reading on wattmeter W_2 is given by $W_2=V_{BY}I_B Cos(300- \Phi)$Since the load is balanced, $|I_R|=|I_Y|=|I_B|=I$ and $|V_{RY}|=|V_{BY}|=V_L W_1=V_L I Cos(300+ \Phi) W_2=V_L I Cos(300- \Phi)$.

Thus total power P is given by

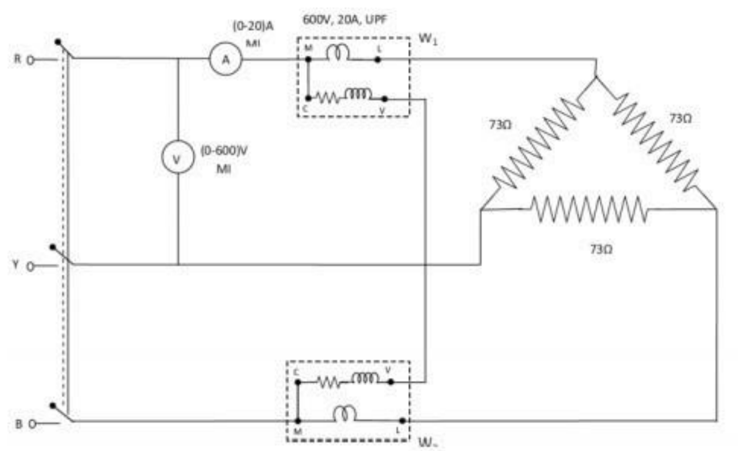
$$W= W_1 +W_2 = V_L I Cos(300+ \Phi) + V_L I Cos(300- \Phi)$$

$$= V_L I[Cos(300+ \Phi) + Cos(300- \Phi)]$$

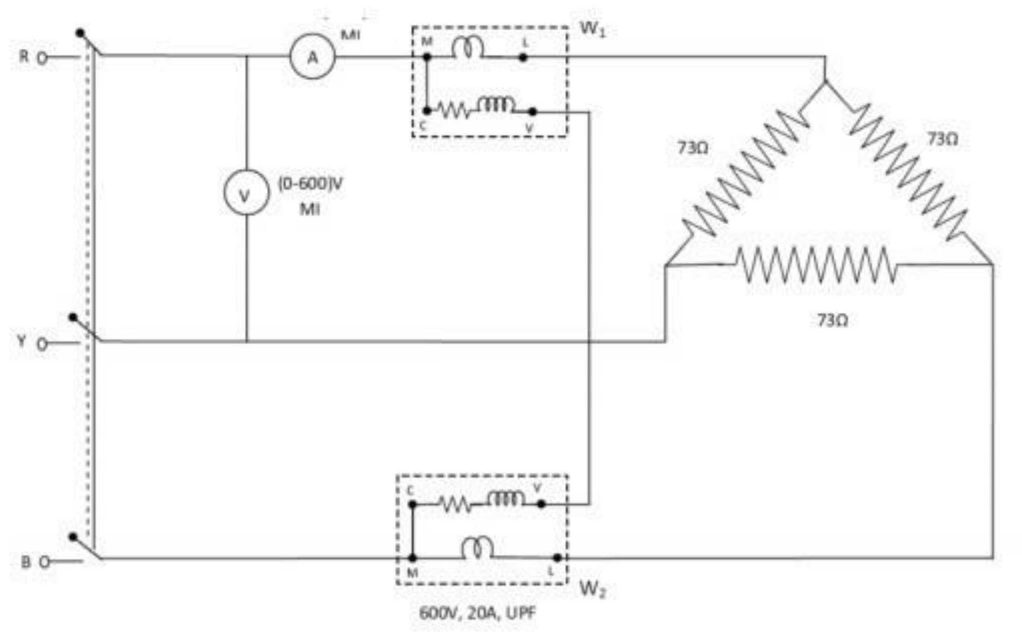
$$= [\sqrt{3}/2 *2Cos \Phi]V_L I = \sqrt{3} V_L I Cos \Phi$$

Circuit diagram:

Star connected load:



Delta connected load:



Procedure:

(Star connection):

1) Connect the circuit as shown in the figure.

2) Ammeter is connected in series with wattmeter whose other end is connected to one of the loads of the balanced loads.

3) The Y-phase is directly connected to one of the nodes of the 3-ph supply.

4) A wattmeter is connected across R-phase & Y-phase as shown in fig. The extreme of Bphase is connected to the third terminal of the balanced 3-ph load.

5) Another wattmeter is connected across Y & B phase, the extreme of B-phase is connected to the third terminal of the balanced three phases load.

6) Verify the connections before switching on the 3-ph power supply.

(Delta connection):

1) Connect the circuit as shown in the figure.

2) Ammeter is connected in series with wattmeter whose other end is connected to one of the loads of the balanced loads.

3) The Y-phase is directly connected to one of the nodes of the 3-ph supply.

4) A wattmeter is connected across Y & B phase, the extreme of B-phase is connected to the third terminal of the balanced 3-ph load.

5) Another wattmeter is connected across R & Yphase, the extreme of R-phase is connected to the third terminal of the balanced three phases load.

6) Verify the connections before switching on the 3-ph power supply.

Tabular Column:

S.No	Voltage V (Volts)	Line Current I_L (Amps) I	W_1 (Watts)	W_2 (Watts)	$W = W_1 + W_2$

Calculations:

For a star connected load

Line voltage(V_L) = VL/$\mathbf{3^{1/2}}$

Line current(I_L) = I_L

$$\mathbf{Ø = tan\text{-}1\ 3^{1/2}(W_1 - W_2)/(W_1 + W_2)}$$

$$\mathbf{P = 3^{1/2} V_L\, I_L\, COSØ}$$

$$\mathbf{P = W_1 + W_2}$$

For a delta connected load

Line voltage(VL) = VL

Line current(IL) = I_L/$\mathbf{3^{1/2}}$

$$\mathbf{Ø = tan\text{-}1\ 3^{1/2}\ (W1 - W2)/(W1 + W2)}$$

$$\mathbf{P = 3^{1/2} V_L\, I_L\, COSØ}$$

$$\mathbf{P = W_1 + W_2}$$

Precautions:

1. Avoid making loose connections.

2. Readings should be taken carefully without parallax error.

Result:

Viva-Voice:

1. Define active power, reactive power & apparent power.
2. Define power factor?
3. What are the different types of loads?
4. Write the equations of active power, reactive power & apparent power.

EXPERIMENT – 18
MEASUREMENT OF 3-PHASE POWER BY TWO – WATTMETER METHOD FOR UNBALANCED LOADS.

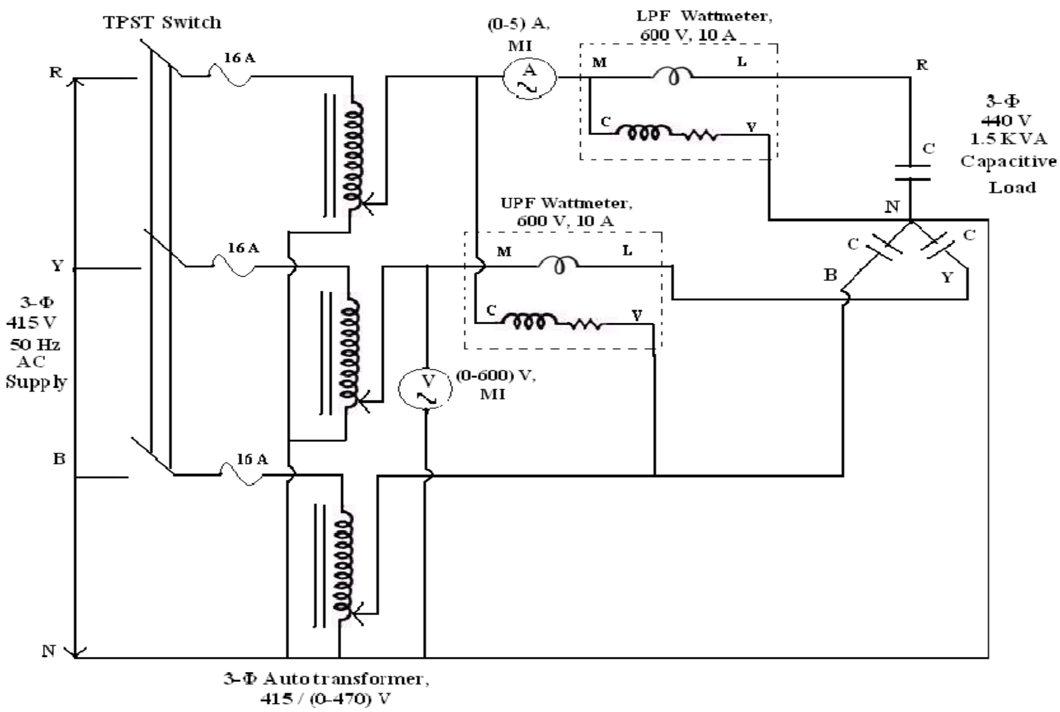
Aim:

To measure the 3-phase power by two wattmeter method unbalanced load

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Capacitive Load	440V, 1.5KVA	3–Φ	01
02	Auto Transformer	415V/(0-440), (0-20)A	3–Φ	01
03	U.P.F. Wattmeter	(150/300/600) (0-5/10)A	Dynamometer Type	01
04	L.P.F. Wattmeter	(150/300/600)V(0-5/10)A	Dynamometer Type	01
05	Ammeter	(0-10)A	MI	01
06	Voltmeter	(0-600)V	MI	01
07	Connecting Wires	------	------	As required

Circuit diagram:



Procedure:

1. Make the Connections as per circuit diagram.
2. Keep the 3-Phase Autotransformer is in minimum output position.
3. Switch on the supply and by slowly varying the autotransformer, rated value is applied to motor.
4. Note down the readings of Ammeter, Voltmeter, Wattmeter's readings (Wr & Wa)
5. After noting the values slowly decrease the Auto Transformer till Volt meter comes to zero voltage position, and switch of the supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

Theoretical Calculations:

Ammeter reading = I_{ph} =

Voltmeter reading = V_{ph} =

Wattmeter reading (W_a) = Active power / Phase

Wattmeter reading (W_a) =

total active power = 3×Wa Total active power = 3VIcosϕ = $3W_a$

Cosϕ = W_a / VI

$Sin^2\phi = 1- Cos2\phi$

Total calculated reactive power = W_{RC} = 3VISin ϕ

Total measured reactive power = 3Wr

Observation Table:

S.No	Voltage V (Volts)	Line Current I_L (Amps) I	W_1 (Watts)	W_2 (Watts)	$W= W_1 + W_2$

Result:

Viva-Voice:

1. Define active power, reactive power & apparent power.
2. Define power factor?
3. What are the different types of loads?
4. Write the equations of active power, reactive power & apparent power.

PROJECT
BUILD YOUR OWN LOW-RESISTANCE METER

Aim: This project will show you how to make your own low-resistance meter; it uses only a handful of components and can measure resistances as low as 0.1Ω.

Apparatus:

Component Indent	Value
U1, U2	LM358 – DIP 8
R1, R4, R5, R6, R7	100K resistor
R2, R10	10K resistor
R3, R8	1R 1W metal film resistor, 1% tolerance
RV1, RV2, RV3	100K linear potentiometer
Q1	2N3055 BJT, TO-3
C1, C2	100nF decoupling capacitors

Theory:

Measuring resistances can be done using a variety of methods (Wheatstone bridge, RC calculation), but in this project, the chosen method is to use the most fundamental equation in electronics:

V=IR

A constant-current source will establish the current through the resistance under test and measure the voltage drop that the resistance produces. This voltage drop will then be amplified and fed into a standard multimeter. The magnitude of the voltage will be equal to the resistance in ohms (e.g., 1V = 1Ω). We will need to select a current that produces reasonable voltages for the amplifier stages that follow the constant-current stage, and we can do this by using the above equation and inserting expected values for R (i.e., less than a few ohms).

One important consideration is the op-amp's input offset voltage, which is modeled as a voltage source in series with the op-amp's inverting or noninverting input terminal. This voltage is multiplied by the op-amp's noninverting gain, and it is a source of error because it can make the output voltage lower or higher than what we would expect from an ideal circuit. So we want to design our circuit such that the effect of this offset voltage will be minor. If your op-amp has offset-null functionality, you can use that to reduce the amplitude of the offset voltage, but we're using the LM358, which does not include offset-null pins. Instead, we can easily reduce the influence of the offset voltage by ensuring that the signal of interest is much larger than the offset voltage, which is ±2mV for the LM358.

Our goal is to measure resistance as low as 0.1Ω. This means that we have to choose a constant-current source that creates a voltage significantly larger than 2mV when the current is passing through a resistance of 0.1Ω. This is a trade-off, because higher currents have disadvantages and lower currents reduce the voltage drop across the resistance under test. The problems with higher current are the following:

- Higher power consumption, whereas lower power consumption helps with portability.
- Lower currents result in less heat generated by the constant current source circuit.
- Lower currents reduce the power dissipation and hence temperature increase of the resistance under test; with lower current, we can measure the resistance of circuit elements that are more susceptible to heat damage (thin wires, for example).

The current chosen for this circuit is 100 mA. This amount of current is not too high yet it generates 10mV across a 0.1Ω resistor, and 10 mV is adequate considering our ±2mV offset voltage.

With a constant current of 100mA through the 1Ω sense resistor, the power dissipation is 0.1W (hence the choice of 1W). Q1 will conduct 100mA as long as a resistance is connected to P2, and I chose the TO-3 package to ensure that the transistor does not overheat. The specific part used for Q1 is not that important as long as the transistor can handle 100mA of collector current and is NPN.

The next stage after the constant-current source is a differential amplifier with a gain of 1 and an offset voltage adjust. We are using a "differential" amplifier here because we want to detect the voltage drop across the resistance under test, i.e., the *difference* between the voltage on one side of the resistance and the voltage on the other side of the resistance.

The differential amplifier consists of

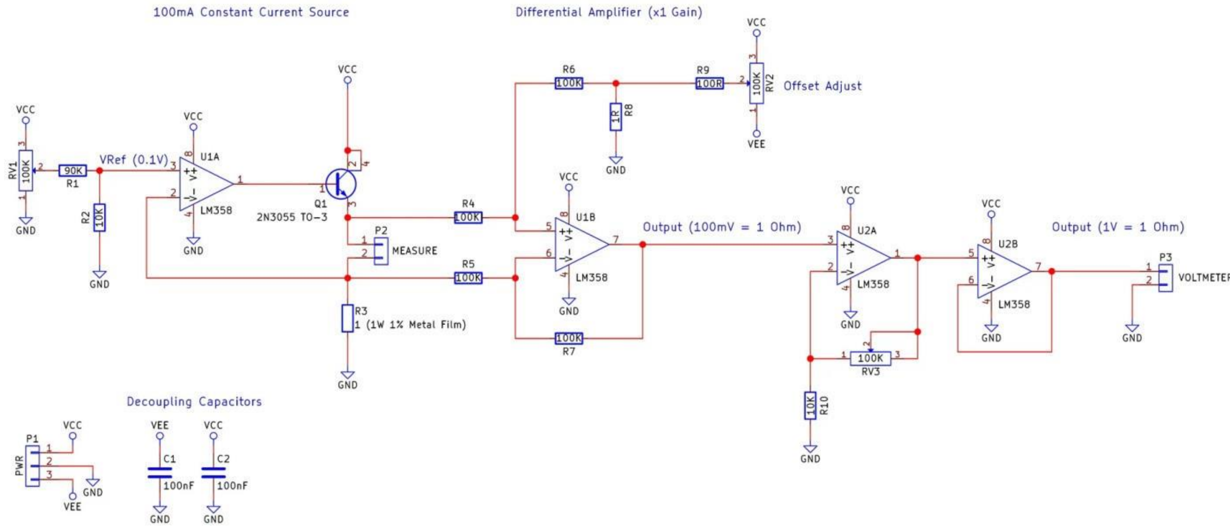
- U1B – the op-amp
- R4, R5, R6, and R7 – these resistors configure U1B as a differential amplifier
- R8, R9, and RV2 – offset adjust

The circuit consisting of R8, R9, and RV2 allows us to add an adjustable offset voltage to the output of the differential amplifier. This feature can be used to compensate for the op-amp's input offset voltage or other error sources. Please refer to the calibration section (below) for details on how to implement this compensation circuit.

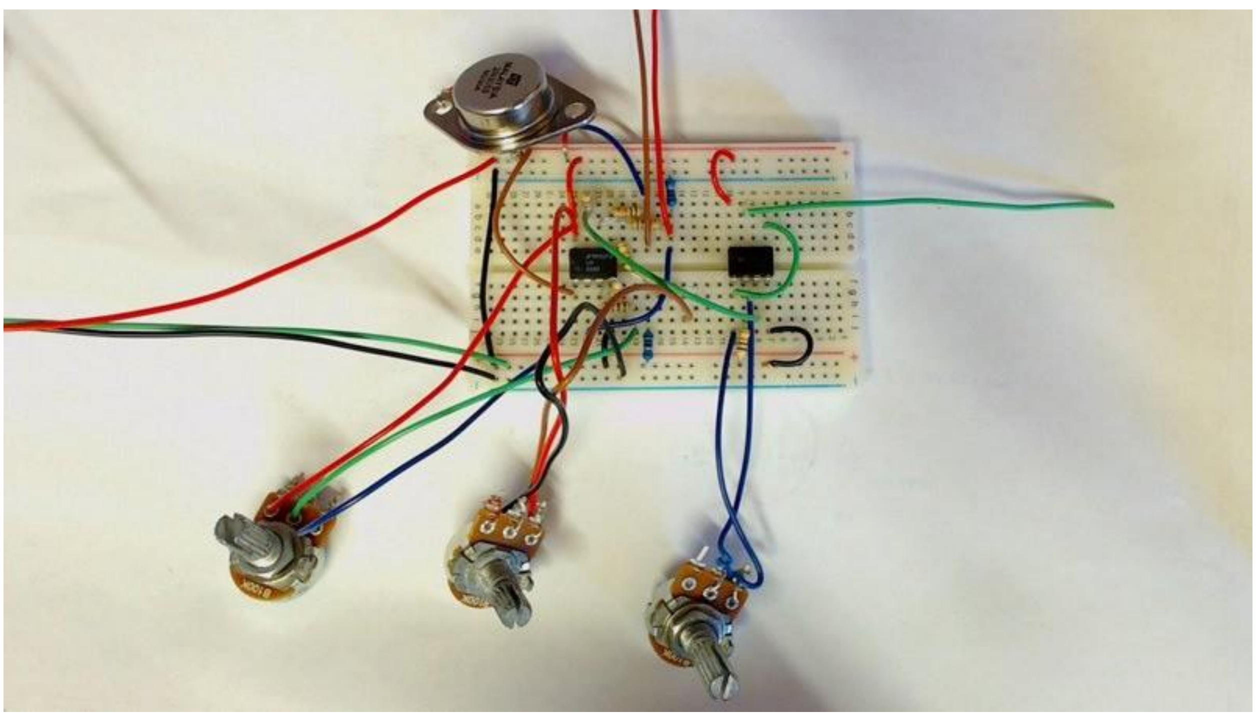
The last stage is an amplifier with gain of 10. This additional gain sets the overall measurement ratio to the convenient value of 1:1, i.e., 1Ω of resistance produces 1V at the output.

- U2A, RV3, and R10 – non inverting amplifier with gain of 10 (RV3 set to 90K)
- U2B – output buffer

Circuit Diagram:



Hardware Circuit:



Description:

- Project box – Use an internal 9V battery and external connectors to keep the circuit in one small box.

- Multimeter attachment – Using a few banana plugs, you could create a circuit that fits directly onto a multi-meter.
- A meter – Going all the way, you could purchase a small voltage meter and house the whole project in its own package to make your own measurement device!

The photo above shows the three potentiometers:

- the one on the left controls the constant-current source
- the one in the middle controls the differential amplifier offset
- the one on the right controls the gain of the output stage

The red, green, and black wires leaving the breadboard are for +5V, 0V, and -5V, respectively. The brown and red wires that go off toward the top of the image are for the resistance under test, and the green wire going to the right is for connecting the low-resistance meter's output to the input of a multimeter.

Note: You will need to ensure that the multimeter's common input is connected to the ground of the low-resistance meter.

Result:

Hence the low-resistance meter (0.1Ω) is designed using simple hardware.