Government Polytechnic Vaishali, Bihar

Under Department of Science, Technology and Technical Education, Bihar
Affiliated By State Board of Technical Education

LAB MANUAL

ELECTRICAL MEASUREMENTS

AND INSTRUMENTATION LAB

SUBJECT CODE – P2420302

Government Polytechnic Vaishali

Department of Electrical Engineering

Vision

To nurture industry-ready and ethically responsible diploma engineers in Electrical Engineering, equipped with modern technical skills, digital competence, and adaptability to support evolving industrial, infrastructural, and societal needs.

Mission

M1: To provide a student-centric and outcome-based learning ecosystem that integrates classroom instruction with modern laboratories, simulation software, digital learning platforms, and hands-on practices for effective knowledge acquisition.

M2: To impart application-oriented technical skills in electrical machines, power distribution systems, industrial wiring, control circuits, basic automation, and testing instruments, emphasizing safety standards, quality practices, and the use of contemporary tools and technologies.

M3: To strengthen industry readiness, employability, entrepreneurship, and preparedness for higher education through industry–institute interaction, internships, field exposure, expert lectures, skill development programs, guidance, innovation support, and awareness of emerging trends such as energy efficiency, renewable integration, and smart electrical systems.

M4: To foster professional ethics, teamwork, communication skills, problem-solving ability, environmental consciousness, and lifelong learning attitude, enabling diploma holders to contribute responsibly to industry, society, and national development.

Practical/Lab Session Outcomes (LSOs)

S.NO	Laboratory Experiment	Lab Session Outcomes
1	Identification of Indicating, Recording and Integrating Instruments	Demonstration of the working of Induction type and dynamometer type instrument.
2	Measurement of DC, AC voltage and current.	Measure DC, AC voltage and current using analogue meter.
3	Conversion of a given galvanometer to DC/AC current-meter.	Convert a given galvanometer to DC/AC current- meter.
4	Extension of range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.	Extend the range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.
5	Measurement of high value of current and voltages using Current and Potential Transformer.	Measure high value of current and voltages using Current and Potential Transformer.
6	Calibration of ammeter and voltmeter.	Calibrate the given ammeter and voltmeter with a standard meter.
7	Demonstration of working of Moving Iron and Moving Coil type instruments.	Interpret the working principle of moving iron and moving coil type instruments.
8	Demonstration of the working of Induction type and dynamometer type instrument.	Interpret the working principle of Induction type and dynamometer type instruments.
9	Measurement of voltage, current, resistance using Digital Multimeter.	Measurement of voltage, current, resistance using Digital Multimeter.

10	Continuity test using digital Multimeter.	Perform continuity test using digital Multimeter.
11	Continuity test using digital Multimeter.	Measure single and three phase power using one wattmeter.
12	Measurement of 3 phase power using two and three wattmeter method	Measure 3 phase power using two and three wattmeter method
13	Calibration of wattmeter.	Calibrate the given wattmeter with a standard meter.
14	Calibration of single-phase energy meter.	Calibrate the given single-phase energy meter with a standard meter.
15	Demonstration of the working of a digital energy meter.	Interpret the working of a digital energy meter.
16	Kelvin’s double bridge for measurement of low resistance	Use Kelvin’s double bridge for measurement of low resistance
17	Measurement of medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter.	Measure medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter.
18	Measurement of insulation resistance using Megger.	Us Megger to measure insulation resistance. Measure insulation resistance using Megger.
19	Measurement of earth resistance using Earth tester	Using Earth tester to measure earth resistance. Measure earth resistance using Earth tester.
20	Measurement of unknown inductance using Anderson or Maxwell inductance capacitance bridge	Use Anderson or Maxwell inductance capacitance bridge to measure unknown inductance.

LIST OF EXPERIMENTS

1	Identification of Indicating, Recording and Integrating Instruments
2	Measurement of DC, AC voltage and current
3	Conversion of a given galvanometer to DC/AC current- meter
4	Extension of range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.
5	Measurement of high value of current and voltages using Current and Potential Transformer.
6	Calibration of ammeter and voltmeter
7	Demonstration of working of Moving Iron and Moving Coil type instruments
8	Demonstration of the working of Induction type and dynamometer type instruments
9	Measurement of voltage, current, resistance using Digital Multimeter
10	Continuity test using digital Multimeter
11	Measurement of single and three phase power using one wattmeter
12	Measurement of 3 phase power using two and three wattmeter method

13	Calibration of wattmeter
14	Calibration of single-phase energy meter.
15	Demonstration of the working of a digital energy meter
16	Kelvin's double bridge for measurement of low resistance
17	Measurement of medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter
18	Measurement of insulation resistance using Megger
19	Measurement of earth resistance using Earth tester
20	Measurement of unknown inductance using Anderson or Maxwell inductance capacitance bridge

PRACTICAL OUTCOMES

CO	Statement
1	Interpret the basic concepts of measurement and instrumentation for measuring instruments
2	Measure current and voltage in an electrical system.
3	Measure power and energy in single and three phase systems
4	Measure resistance, inductance, and capacitance using bridges/meters.
5	Use various instruments/meters for measuring electrical parameters such as power factor, Phase sequence, and circuit components.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO No.	Program Educational Objectives Statements
PEO1	To prepare diploma holders with a strong foundation in electrical engineering fundamentals and state-of-the-art technologies, enabling continuous learning, skill upgradation, and adaptability to emerging industrial and technological trends.
PEO2	To develop professionally responsible diploma holders with effective communication skills, leadership qualities, ethical values, and the ability to work efficiently as individuals and as members of multidisciplinary teams.
PEO3	To enhance employability by providing industry-oriented training, hands-on experience, and exposure through industrial visits, internships, seminars, workshops, and interaction with industry professionals and academicians.
PEO4	To enable diploma holders to apply project-based learning, modern tools, and innovative approaches to develop solutions addressing technical, socio-economic, and environmental challenges in a sustainable and socially responsible manner.

PROGRAM SPECIFIC OUTCOMES

PSO1: Design, Install, operate, and troubleshoot electrical systems, machines and power circuits using modern tools while adhering to safety standards and environmental consideration.

PSO2: Work effectively in multidisciplinary teams to solve real-time electrical engineering problems and communicate technical information clearly and professionally.

PROGRAM OUTCOMES (POS)

P01: Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

PO2: Problem analysis: Identify and analyse well-defined engineering problems using codified standard methods.

PO3: Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

P04: Engineering Tools, Experimentation and Testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO5: Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6: Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO7: Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes.

EXPERIMENT NO: 01

Aim:-

To study and identify different types of electrical measuring instruments namely indicating, recording, and integrating instruments, and understand their working principles and applications.

Theory:-

Electrical measuring instruments are classified based on how they display or store measured values. The three major types are:

1. Indicating Instruments

Indicating instruments display the instantaneous value of the electrical quantity being measured. They use a pointer and scale mechanism to indicate values.

Examples: Ammeter, Voltmeter, Wattmeter

Working Principle: These instruments operate on electromagnetic effects such as moving coil or moving iron mechanisms. The deflection of the pointer is proportional to the quantity measured.

2. Recording Instruments

Recording instruments continuously record variations of electrical quantities over a period of time.

Examples: Strip chart recorder, X-Y recorder

Working Principle: These instruments use a moving paper chart and a pen mechanism driven by the measured signal to produce a graphical record.

3. Integrating Instruments

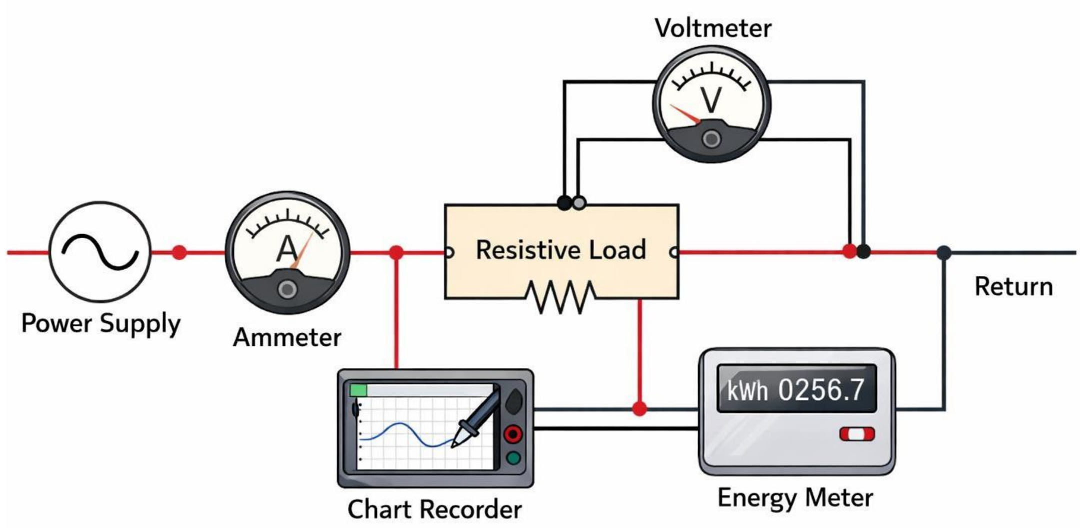
Integrating instruments measure the total quantity of electricity over a period of time.

Examples: Energy meter (kWh meter)

Working Principle: These instruments integrate the measured quantity with respect to time, typically using rotating discs or electronic circuits.

Practical Set-up / Circuit Diagram:-

1. Connect an ammeter in series with the load.
2. Connect a voltmeter in parallel across the load.
3. Use an energy meter to measure total energy consumption.
4. For recording instruments, connect the input signal to the recorder terminals.



Apparatus Required:-

1. Ammeter (Indicating Instrument)
2. Voltmeter (Indicating Instrument)
3. Energy Meter (Integrating Instrument)
4. Recording Instrument (e.g., chart recorder)

5 Resistive Load

6 Power Supply

7 Connecting Wires

Precautions to be Followed:-

1 Ensure proper connections before switching ON the supply.

2 Do not exceed the rated values of instruments.

3 Check zero error before taking readings.

4 Handle instruments carefully to avoid damage.

5 Ensure tight connections to avoid measurement errors.

Procedure:-

1. Identify all instruments provided in the lab.
2. Observe their physical construction and note their scale, pointer, or recording mechanism.
3. Connect the circuit as per the diagram.
4. Switch ON the power supply.
5. Note readings from indicating instruments (ammeter, voltmeter).
6. Observe the recording instrument and its graphical output.
7. Record energy consumption using the energy meter over a fixed time interval.
8. Switch OFF the supply after completion.

Observations and Calculations:-

Observation Table

Instrument Type	Instrument Name	Measured Quantity	Reading
Indicating	Ammeter	Current (A)	
Indicating	Voltmeter	Voltage (V)	
Recording	Chart Recorder	Variation	
Integrating	Energy Meter	Energy (kWh)	

Calculations

- Power, (P = V \times I)
- Energy consumed, (E = P \times t)

Where:

V = Voltage (Volts)

I = Current (Amperes)

t = Time (hours)

Result:-

The different types of electrical measuring instruments indicating, recording, and integrating were successfully identified and studied. Their working principles and practical applications were understood.

Viva book:-

1. Explain main function of a recording instrument?
2. Explain the difference between indicating and recording instruments?.
3. Give an example of an integrating instrument used in electrical systems.
4. Name one commonly used recording instrument..
5. Which instrument is used to measure total energy consumption?

EXPERIMENT NO: 02

Aim:-

To measure DC and AC voltage and current using appropriate measuring instruments and to study their behavior in electrical circuits.

Theory:-

1. DC Measurement

Direct Current (DC) is a unidirectional flow of electric charge.

- DC Voltmeter: Measures voltage across a component and is connected in parallel.
- DC Ammeter: Measures current flowing through a circuit and is connected in series.

Working Principle:

DC instruments typically use Permanent Magnet Moving Coil (PMMC) mechanism, where deflection is proportional to current.

2. AC Measurement

Alternating Current (AC) changes magnitude and direction periodically.

- AC Voltmeter: Measures RMS value of voltage.
- AC Ammeter: Measures RMS value of current.

Working Principle:

AC instruments generally use Moving Iron (MI) mechanism, which works on the principle of magnetic effect of current.

3. Relation Between Voltage, Current and Resistance

According to Ohm's Law:

$V = I \times R$

Where:

V = Voltage (Volts)

I = Current (Amperes)

R = Resistance (Ohms)

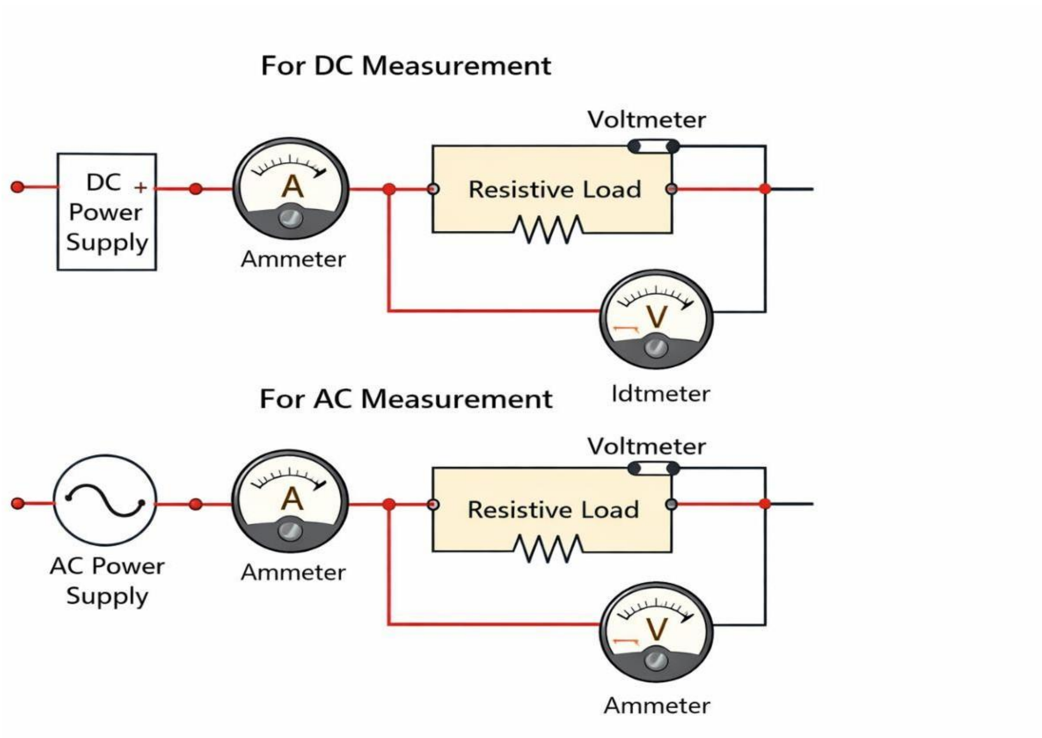
Practical Set-up / Circuit Diagram

For DC Measurement:

- Connect DC power supply.
- Ammeter in series with load.
- Voltmeter in parallel across load.

For AC Measurement:

- Connect AC supply.
- AC ammeter in series with load.
- AC voltmeter in parallel across load.



Apparatus Required:-

1 DC Power Supply

2 AC Power Supply

3 DC Ammeter and Voltmeter

4 AC Ammeter and Voltmeter

5 Resistive Load

6 Connecting Wires

7 Switch

Precautions to be Followed

1 Ensure correct polarity for DC connections.

2 Use appropriate range of instruments before switching ON.

3 Never connect ammeter in parallel.

4 Ensure proper insulation of wires.

5 Switch OFF supply before changing connections.

Procedure:-

A. For DC Measurement

1. Connect the circuit as per diagram.
2. Ensure correct polarity of DC supply.
3. Switch ON the supply.
4. Note the readings of voltmeter and ammeter.
5. Repeat for different load values if required.

B. For AC Measurement

1. Connect the AC circuit as per diagram.
2. Ensure proper connections.
3. Switch ON the AC supply.
4. Record voltmeter and ammeter readings.
5. Repeat observations for different conditions.

Observations and Calculations:-

Observation Table (DC)

S. No.	Voltage (V)	Current (I)	Resistance (R = V/I)

Observation Table (AC)

S. No.	Voltage (V)	Current (I)	Power (P = VI)

Calculations

- Resistance: R = V / I
- Power (AC/DC): P = V × I

Result:-

The DC and AC voltage and current were successfully measured using appropriate instruments. The relationship between voltage and current was verified, and correct usage of ammeter and voltmeter was understood.

Viva book:-

1. Explain the function of an ammeter in electrical circuits.
2. Explain the working principle of voltmeters in electrical circuits.
3. Which instrument is used to measure DC voltage?
4. How is an ammeter connected in a circuit?
5. Explain of the difference between AC and DC supply?

EXPERIMENT NO:03

Aim:-

To convert a given galvanometer into a DC ammeter and AC ammeter and study its working.

Theory:-

A galvanometer is a sensitive instrument used to detect and measure small currents. It can be converted into a current-measuring instrument (ammeter) by modifying its circuit.

1. Conversion to DC Ammeter

To convert a galvanometer into a DC ammeter, a low resistance called shunt resistance (S) is connected in parallel with the galvanometer.

Principle:
Most of the current flows through the shunt, and only a small portion flows through the galvanometer.

Formula:
$S = (I_g \times G) / (I - I_g)$

Where:
S = Shunt resistance

Ig = Galvanometer full-scale deflection current

G = Galvanometer resistance

I = Desired current range

2. Conversion to AC Ammeter

A galvanometer works only for DC. To measure AC current:

- A rectifier (diode) is used to convert AC into DC.
- Then the galvanometer (with shunt) measures the rectified current.

Working Principle:

AC signal is first rectified and then measured as equivalent DC by the galvanometer.

Practical Set-up / Circuit Diagram

For DC Ammeter Conversion:

- Connect shunt resistance in parallel with galvanometer.
- Apply DC supply through load.

Circuit:

Supply → Load → (Galvanometer || Shunt) → Return

For AC Ammeter Conversion:

- Connect rectifier in series with galvanometer.
- Shunt may also be used for range extension.

Circuit:

AC Supply → Rectifier → (Galvanometer || Shunt) → Load

Apparatus Required

1. Galvanometer
2. Known Resistance (Shunt)
3. DC Power Supply
4. AC Power Supply
5. Rectifier (Diode)
6. Rheostat (Variable Resistance)
7. Ammeter (for comparison)
8. Connecting Wires

Precautions to be Followed:-

1. Do not pass high current directly through galvanometer.

2 Ensure correct calculation of shunt resistance.

3 Check polarity in DC circuit.

4 Ensure proper connection of rectifier in AC circuit.

5 Avoid loose connections.

Procedure:-

A. For DC Ammeter Conversion

1. Note the resistance (G) and full-scale current (Ig) of galvanometer.
2. Calculate shunt resistance (S).
3. Connect shunt in parallel with galvanometer.
4. Connect the circuit with DC supply and load.
5. Pass current and note readings.
6. Compare with standard ammeter.

B. For AC Ammeter Conversion

1. Connect rectifier in series with galvanometer.
2. Add shunt resistance if required.
3. Connect AC supply and load.
4. Switch ON supply.
5. Note readings of converted ammeter.
6. Compare with standard AC ammeter.

Observations and Calculations:-

Observation Table (DC)

S. No.	Applied Current (I)	Galvanometer Reading	Calculated Current

Observation Table (AC)

S. No.	Applied Current (I)	Rectified Reading	Actual Current

Calculations

- Shunt Resistance: $S = (I_g \times G) / (I - I_g)$
- Error % = [(Measured − Actual) / Actual] × 100

Result:-

The given galvanometer was successfully converted into a DC ammeter using a shunt resistance and into an AC ammeter using a rectifier. The readings were found to be in close agreement with standard instruments.

Viva book:-

1. Explain the function of a rectifier in AC measurement?
2. Why is a galvanometer sensitive?
3. What is a shunt resistance?
4. Explain the type of rectifier is commonly used in AC ammeters?
5. What is a galvanometer?

EXPERIMENT NO:04

Aim:-

To extend the range of a given ammeter and voltmeter to measure high values of current and voltage using shunt and multiplier resistances respectively.

Theory:-

A measuring instrument like an ammeter or voltmeter has a limited range. To measure larger currents or voltages, external resistances are connected.

Extension of Ammeter Range (Using Shunt)

An ammeter is connected in series and has low resistance. To measure high current, a low resistance called shunt (S) is connected in parallel with the galvanometer. Most of the current flows through the shunt.

Let:

- G = galvanometer resistance
- Ig = full scale deflection current of galvanometer
- I = desired current range

Then shunt resistance is given by:

$S = (I_g \times G) / (I - I_g)$

Extension of Voltmeter Range (Using Multiplier)

A voltmeter is connected in parallel and has high resistance. To measure high voltage, a high resistance called multiplier (R) is connected in series with the galvanometer.

Let:

- G = galvanometer resistance
- Ig = full scale deflection current
- V = desired voltage range

Then multiplier resistance is given by:

$R = (V / Ig) - G$

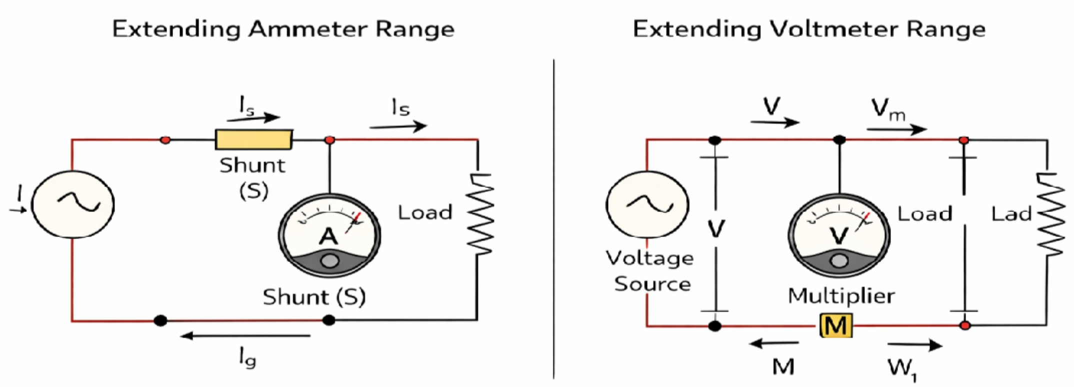
Practical Set-up / Circuit Diagram

For Ammeter (Shunt Connection):

- Galvanometer connected in parallel with shunt
- Combination connected in series with circuit

For Voltmeter (Multiplier Connection):

- Multiplier connected in series with galvanometer
- Entire setup connected across load



Apparatus Required:-

1. Galvanometer
2. Resistance box
3. Ammeter (standard)
4. Voltmeter (standard)

5 Battery / DC power supply

6 Rheostat

7 Plug key

8 Connecting wires

Precautions to be Followed:-

1 Ensure tight and correct connections.

2 Use proper range instruments to avoid damage.

3 Do not exceed galvanometer current rating.

4 Keep key open when not taking readings.

5 Avoid parallax error while noting readings.

6 Check zero error before starting.

Procedure:-

For Ammeter Range Extension

1. Note the galvanometer resistance (G) and full-scale current (Ig).
2. Calculate required shunt resistance (S).
3. Connect shunt in parallel with galvanometer.
4. Connect the setup in series with circuit.
5. Pass current and note readings of standard ammeter and modified ammeter.
6. Compare values.

For Voltmeter Range Extension

1. Note galvanometer resistance (G) and Ig.
2. Calculate multiplier resistance (R).
3. Connect multiplier in series with galvanometer.

4. Connect the setup across voltage source.
5. Measure voltage using standard voltmeter and modified voltmeter.
6. Compare readings.

Observations and Calculations

Ammeter Table

S.No	Standard Ammeter (A)	Extended Ammeter (A)	Error
1			
2			
3			

Voltmeter Table

S.No	Standard Voltmeter (V)	Extended Voltmeter (V)	Error
1			
2			
3			

Sample Calculations

- Shunt Resistance: S = (Ig × G) / (I − Ig)
- Multiplier Resistance: R = (V / Ig) − G
- Error = Standard Reading − Measured Reading

Result:-

The range of the given ammeter and voltmeter was successfully extended using shunt and multiplier respectively, and the readings were found to be in close agreement with standard instruments.

Viva book:-

1. Explain the possible errors in this experiment?

2. Explain the difference between shunt and multiplier resistances.

3. What is meant by full-scale deflection (FSD)?

4. Explain the internal resistance of a voltmeter?

5. What is he internal resistance of an ammeter?

EXPERIMENT NO:5

Aim:-

To measure high values of current and voltage using Current Transformer (CT) and Potential Transformer (PT) safely and accurately.

Theory:-

In high voltage and high current systems, direct measurement is not practical due to safety and instrument limitations. Therefore, instrument transformers such as CT and PT are used.

1. Current Transformer (CT)

A Current Transformer is used to measure high current by stepping it down to a lower value suitable for measuring instruments.

Working Principle:

It works on the principle of electromagnetic induction. The primary winding carries the high current, and the secondary winding provides a reduced current proportional to the primary current.

Formula:
$I_p / I_s = N_s / N_p$

Where:
I_p = Primary current

I_s = Secondary current

N_p = Number of primary turn

N_s = Number of secondary turns

2. Potential Transformer (PT)

A Potential Transformer is used to measure high voltage by stepping it down to a lower value.

Working Principle:

It also works on electromagnetic induction. The secondary voltage is proportional to the primary voltage.

Formula:
$V_p / V_s = N_p / N_s$

Where:
V_p = Primary voltage

V_s = Secondary voltage

3. Transformation Ratio

- CT Ratio = Primary Current / Secondary Current
- PT Ratio = Primary Voltage / Secondary Voltage

These ratios are used to calculate actual high values from measured low values.

Practical Set-up / Circuit Diagram

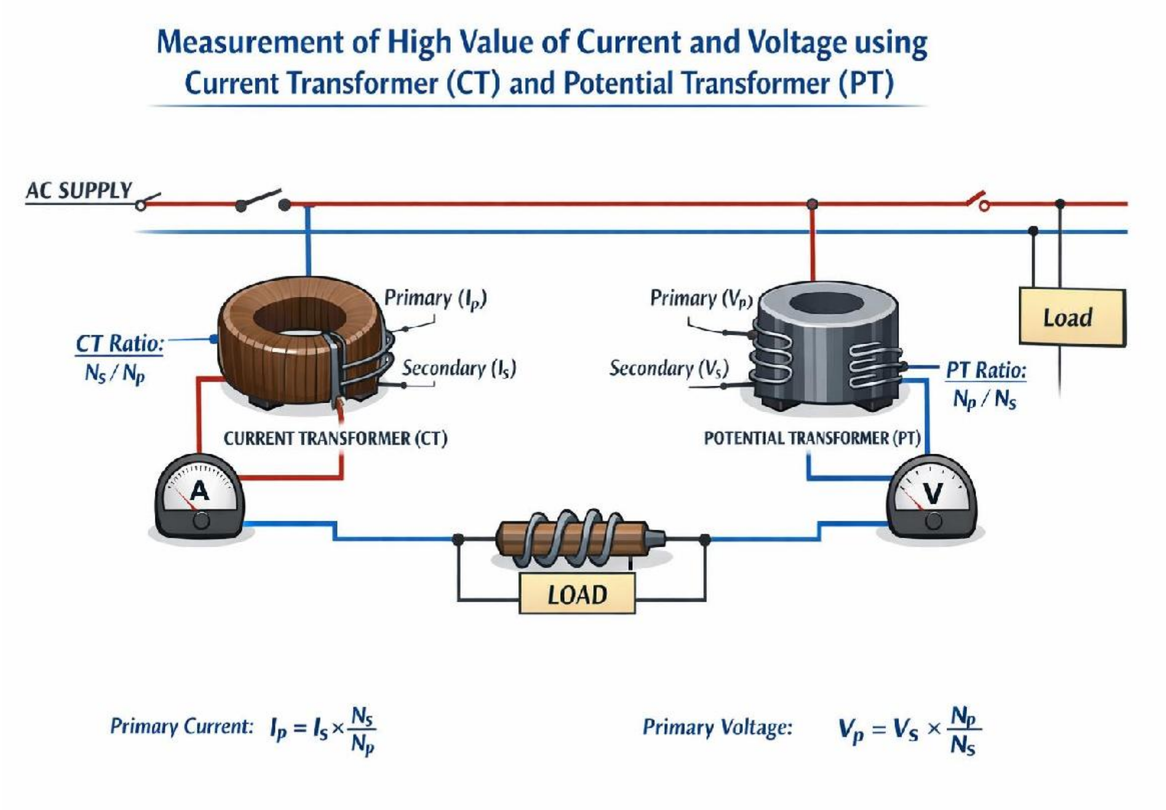
For Current Measurement using CT:

- Connect CT primary in series with the load carrying high current.
- Connect an ammeter to the CT secondary.

For Voltage Measurement using PT:

- Connect PT primary across high voltage supply.

- Connect voltmeter across PT secondary.



Apparatus Required:-

1. Current Transformer (CT)
2. Potential Transformer (PT)
3. Ammeter (low range)
4. Voltmeter (low range)
5. Load (Resistive/Inductive)
6. AC Power Supply
7. Connecting Wires

Precautions to be Followed:-

1 Never keep CT secondary open while primary is energized.

2 Ensure proper earthing of transformer.

3 Use correct ratio CT and PT.

4 Do not exceed rated values.

5 Check connections before switching ON supply.

Procedure:-

A. Measurement of Current using CT

1. Connect CT primary in series with load.
2. Connect ammeter to CT secondary.
3. Switch ON supply.
4. Note ammeter reading (secondary current).
5. Calculate primary current using CT ratio.

B. Measurement of Voltage using PT

1. Connect PT primary across supply.
2. Connect voltmeter across PT secondary.
3. Switch ON supply.
4. Note voltmeter reading (secondary voltage).

5. Calculate primary voltage using PT ratio.

Observations and Calculations:-

Observation Table (CT)

S. No.	Secondary Current (Is)	CT Ratio	Primary Current (Ip = Is × Ratio)

Observation Table (PT)

S. No.	Secondary Voltage (Vs)	PT Ratio	Primary Voltage (Vp = Vs × Ratio)

Calculations

- Primary Current: Ip = Is × CT Ratio
- Primary Voltage: Vp = Vs × PT Ratio

Result:-

High values of current and voltage were successfully measured using Current Transformer (CT) and Potential Transformer (PT). The calculated values were found accurate and within acceptable limits.

Viva book:-

1. What is a Current Transformer (CT)?
2. Explain the transformation ratio of a CT?
3. What is a Potential Transformer (PT)?
4. Why should the secondary of a CT never be kept open?
5. Explain the importance of safety precautions while using CT and PT.

EXPERIMENT NO:6

Aim:-

To calibrate the given ammeter and voltmeter with the help of standard instruments and to find out the error and correction in the readings.

Theory:-

In electrical measurements, instruments like ammeter and voltmeter may not always give exact readings due to internal errors. So, calibration is necessary to check their accuracy.

An **ammeter** is used to measure current and is always connected in series in the circuit. During calibration, its reading is compared with a standard ammeter, which is assumed to give the correct value.

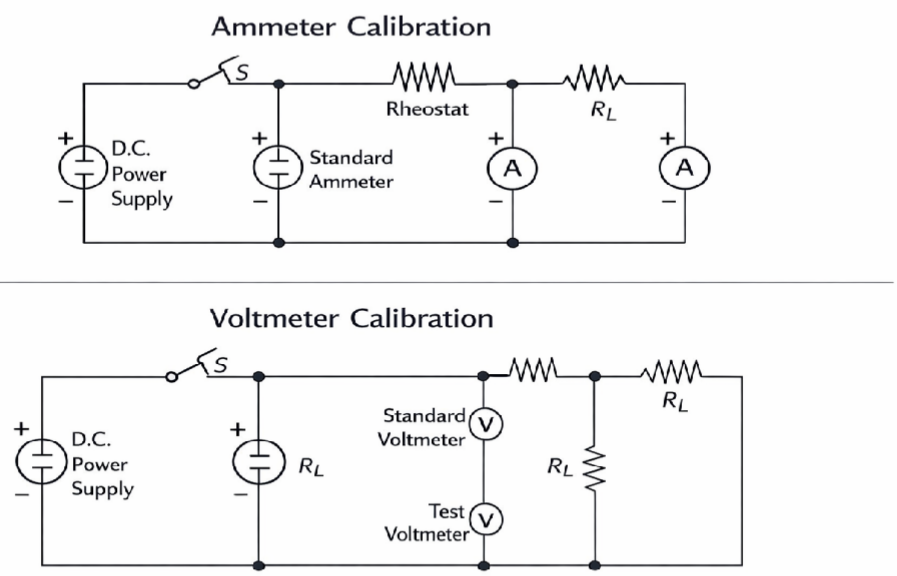
A **voltmeter** is used to measure voltage and is connected in parallel across the circuit. Its reading is compared with a standard voltmeter.

If there is any difference between the observed value and the true value, it is called **error**. The negative of this error is called **correction**, which helps in improving measurement accuracy.

Practical Set-up / Circuit Diagram

For ammeter calibration, both the standard and test ammeters are connected in **series** with a DC supply, rheostat, and load.

For voltmeter calibration, both the standard and test voltmeters are connected in **parallel** across the supply.



Voltmeter Calibration

(Draw neat circuit diagrams in your notebook: series connection for ammeter.

Apparatus Required:-

1 Standard ammeter

2 Test ammeter

3 Standard voltmeter

4 Test voltmeter

5 Rheostat

6 DC power supply

7 Resistance/load

8 Connecting wires

9 Plug key (switch)

Precautions to be Followed:-

1. All connections should be tight and correct
2. The instruments must be connected with proper polarity
3. Do not exceed the rated values of instruments
4. Avoid parallax error while taking readings
5. The rheostat should be adjusted slowly
6. Switch off the supply after completing the experiment

Procedure:-

For Ammeter Calibration

First, the circuit is connected in series as per the diagram. Then the supply is switched ON. The rheostat is adjusted to allow different values of current to flow through the circuit. The readings of both the standard ammeter and the given ammeter are noted. This process is repeated for different current values.

For Voltmeter Calibration

The circuit is connected such that both voltmeters are in parallel across the supply. After switching ON the supply, the rheostat is adjusted to vary the voltage. The readings of both voltmeters are recorded for different values of voltage.

Observations and Calculations

Ammeter Calibration Table

S. No.	True Current (Standard)	Observed Current (Test)	Error	Correction
1				
2				
3				

Voltmeter Calibration Table

S. No.	True Voltage (Standard)	Observed Voltage (Test)	Error	Correction
1				
2				
3				

Calculations

Error = Observed Value – True Value

Correction = – Error

These calculations are done for each reading.

Result:-

The given ammeter and voltmeter were calibrated successfully by comparing them with standard instruments. The errors and corrections were calculated, and it was found that the instruments show slight deviation but are within acceptable limits.

Viva Book:-

1. Explain calibration of an ammeter and voltmeter?
2. What is absolute error?
3. What is meant by standard instrument?
4. Explain correction factor?
5. Explain true value and indicated value??

EXPERIMENT NO:7

Aim:-

To study and demonstrate the working principle of Moving Iron (MI) and Moving Coil (MC) type instruments and compare their performance.

Theory:-

Moving Iron (MI) Instrument

A Moving Iron instrument works on the principle that a soft iron piece gets magnetized when placed in a magnetic field. Due to this, it experiences a force and moves.

There are two types:

- Attraction type
- Repulsion type

When current flows through the coil, a magnetic field is produced which moves the iron piece, and hence the pointer deflects.

Key Points:

- Can measure both AC and DC
- Scale is non-linear
- Less accurate compared to MC

Moving Coil (MC) Instrument

A Moving Coil instrument works on the principle that a current-carrying conductor placed in a magnetic field experiences a force.

When current flows through the coil placed in a magnetic field, it rotates and causes pointer deflection.

Key Points:

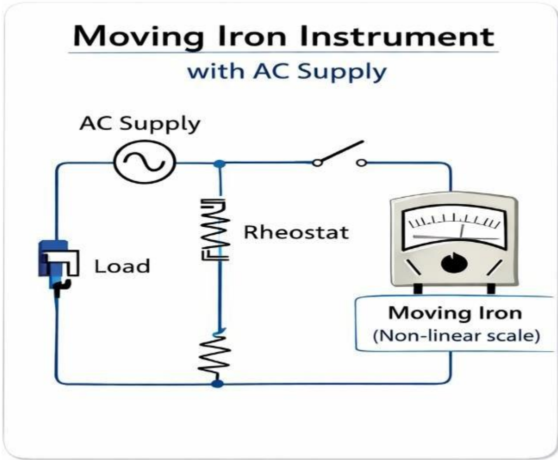
- Works only on DC
- Scale is linear
- More accurate and sensitive

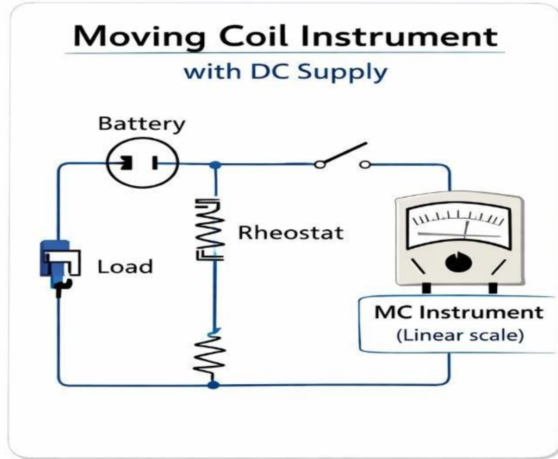
Comparison

- MI works on magnetization of iron, MC works on electromagnetic force
- MI can measure AC & DC, MC measures only DC
- MC is more accurate than MI

Practical Set-up / Circuit Diagram

- For **Moving Iron Instrument**:
- Connect MI ammeter/voltmeter in the circuit with AC supply and load.
- For **Moving Coil Instrument**:
- Connect MC instrument in a DC circuit with a battery, rheostat, and load.





Apparatus Required:-

1 Moving Iron ammeter/voltmeter

2 Moving Coil ammeter/voltmeter

3 AC supply

4 DC supply (battery)

5 Rheostat

6 Load resistance

7 Connecting wires

8 Switch

Precautions to be Followed:-

1 Ensure proper connections before switching ON

2 Do not exceed the rated values of instruments

3 Handle instruments carefully (they are sensitive)

4 Avoid parallax error while taking readings

5 Use correct type of supply (AC for MI, DC for MC)

6 Switch OFF supply after experiment

Procedure:-

For Moving Iron Instrument

First, the MI instrument is connected in the AC circuit as per the diagram. Then the supply is switched ON. The rheostat is adjusted to vary the current or voltage. The readings are observed and noted.

For Moving Coil Instrument

The MC instrument is connected in a DC circuit. After switching ON the supply, the rheostat is adjusted to change the current. The deflection of the pointer is observed and readings are recorded.

Observations and Calculations:-

Observation Table

S. No.	Supply Type	Instrument Type	Applied Value	Deflection
1	AC	MI		
2	DC	MI		
3	DC	MC		

Calculations

- Observe nature of scale (linear/non-linear)

- Compare deflections for same input
- Note accuracy and sensitivity

Result:-

The working of Moving Iron and Moving Coil instruments was successfully demonstrated. It was observed that MI instruments work on both AC and DC with non-linear scale, while MC instruments work only on DC and provide linear and more accurate readings.

Viva Book:-

1. What is controlling torque?
2. Explain Permanent Magnet Moving Coil (PMMC) instrument?
3. Why is the scale of PMMC instrument uniform?
4. Explain Why can PMMC instruments measure only DC?.
5. What is damping torque?

EXPERIMENT NO:8

Aim:-

To study and demonstrate the working principle of Induction type and Dynamometer type instruments and compare their characteristics.

Theory:-

Induction Type Instrument

Induction type instruments work on the principle of **electromagnetic induction**. When an alternating current flows through the coil, it produces a changing magnetic field which induces eddy currents in a metallic disc. The interaction between these currents and magnetic field produces torque, causing the pointer to move.

Key Points:

- Works only on AC supply
- Used in energy meters and AC measuring instruments
- Scale is generally non-linear
- Based on eddy current principle

Dynamometer Type Instrument

Dynamometer type instruments work on the principle of **force between two current-carrying coils**. One coil is fixed and the other is movable.

When current flows through both coils, a magnetic field is produced and interaction between them causes deflection of the pointer.

Key Points:

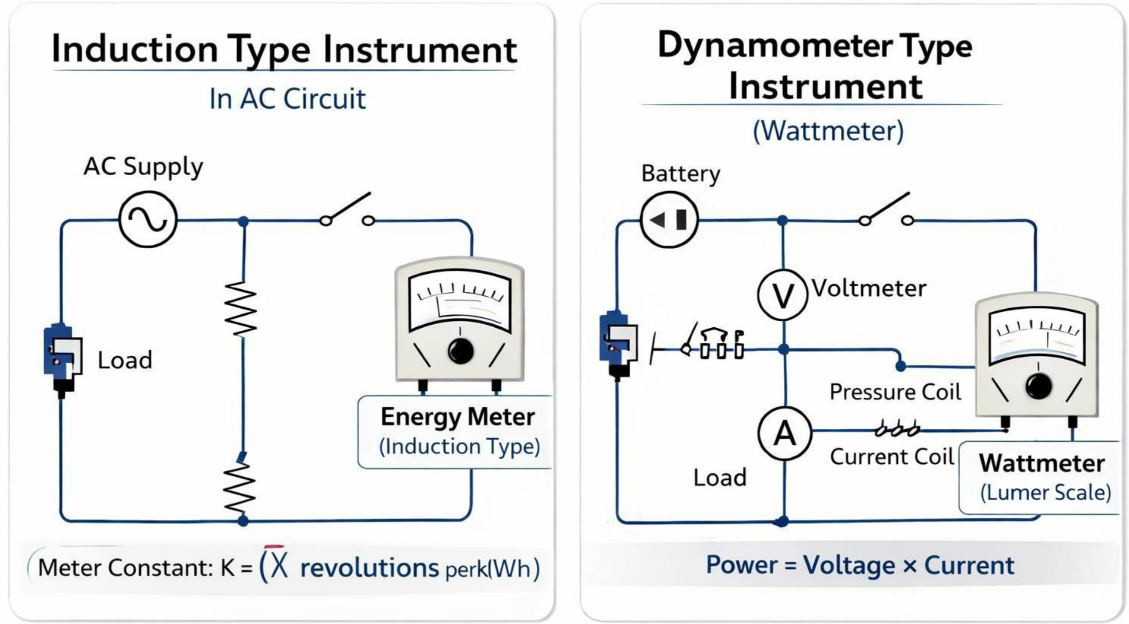
- Can measure both AC and DC
- Used as wattmeter
- Scale is uniform (linear)
- More accurate than induction type

Comparison

- Induction type works only on AC, dynamometer works on both AC & DC
- Induction type uses eddy currents, dynamometer uses electromagnetic force
- Dynamometer instruments are more accurate

Practical Set-up / Circuit Diagram

- **Induction Type Instrument:**
- Connect the induction type instrument (like energy meter) in an AC circuit with load.
- **Dynamometer Type Instrument:**
- Connect the dynamometer instrument (wattmeter) in a circuit where current coil is in series and pressure coil is in parallel with load.



Apparatus Required:-

1 Induction type instrument (energy meter)

2 Dynamometer type instrument (wattmeter)

3 AC power supply

4 Load (resistive/inductive)

5 Rheostat

6 Voltmeter

7 Ammeter

8 Connecting wires

9 Switch

Precautions to be Followed:-

1. Ensure proper connections before switching ON
2. Do not exceed rated values of instruments
3. Use AC supply only for induction type instrument
4. Avoid loose connections
5. Take readings carefully to avoid parallax error
6. Switch OFF supply after experiment

Procedure:-

For Induction Type Instrument

First, the circuit is connected with the induction type instrument in an AC supply. Then the load is connected and supply is switched ON. The meter disc rotation is observed and readings are noted for different loads.

For Dynamometer Type Instrument

The dynamometer instrument (wattmeter) is connected properly with current coil in series and pressure coil in parallel. After switching ON the supply, load is varied using rheostat and readings are observed.

Observations and Calculations:-

Observation Table

S. No.	Instrument Type	Supply	Load	Reading/Deflection
1	Induction	AC		
2	Dynamometer	AC/DC		

Calculations

For Dynamometer (Wattmeter):

$$Power = Voltage \times Current$$

Compare calculated power with wattmeter reading.

For Induction Type:

Observe number of disc rotations and relate with energy consumption**.**

Result:-

The working of Induction type and Dynamometer type instruments was successfully demonstrated. It was observed that induction type instruments operate only on AC and are commonly used in energy meters, whereas dynamometer type instruments can be used for both AC and DC and provide more accurate measurements.

Viva Book:-

1. What is a dynamometer type instrument?
2. Explain induction type instrument?
3. Where are induction and dynamometer instruments commonly used?
4. Explain eddy current in induction instruments?.
5. Explain the advantages of induction type instruments?

EXPERIMENT NO:9

Aim

To measure voltage, current, and resistance using a Digital Multimeter (DMM) and understand its proper operation.

Theory

A **Digital Multimeter (DMM)** is an electronic instrument used to measure electrical quantities such as voltage, current, and resistance. It provides readings in digital form, which increases accuracy and reduces reading errors.

Voltage Measurement

Voltage is the potential difference between two points. It is measured by connecting the multimeter in **parallel** with the circuit element.

Current Measurement

Current is the flow of electric charge. It is measured by connecting the multimeter in **series** with the circuit so that current flows through the meter.

Resistance Measurement

Resistance is the opposition offered by a material to the flow of current. It is measured by connecting the multimeter across the resistor after disconnecting it from the circuit.

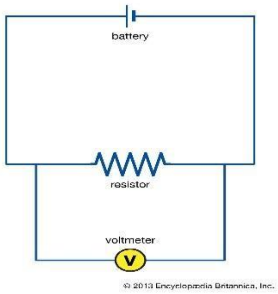
Ohm's Law

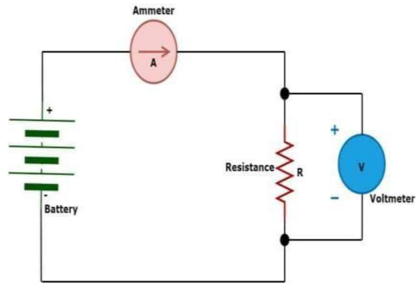
[V = I \times R]

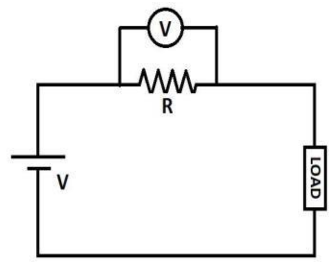
This relation is used to verify measured values.

Practical Set-up / Circuit Diagram

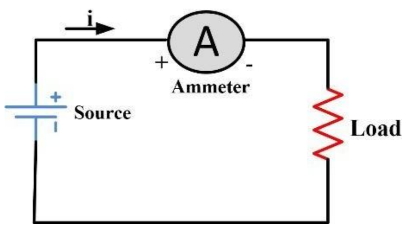
- Voltage Measurement**:** Multimeter connected in parallel across the load

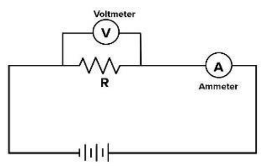


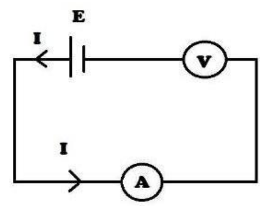




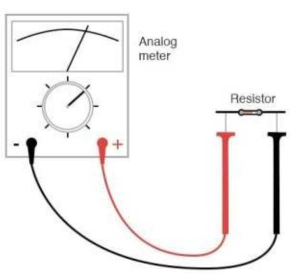
- **Current Measurement:** Multimeter connected in series with the circuit

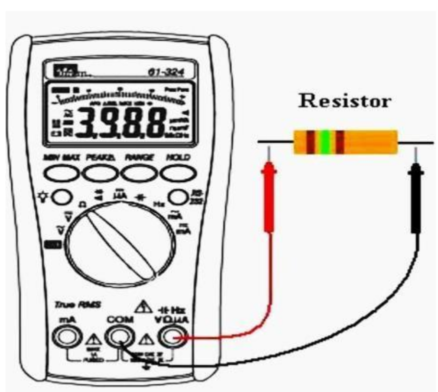






- **Resistance Measurement:** Multimeter connected across the resistor (no supply)





Apparatus Required

1 Digital Multimeter

2 DC power supply / Battery

3 Resistor (known/unknown)

4 Connecting wires

5 Switch

Precautions to be Followed

1 Select correct measurement mode (V, A, Ω)

2 Choose proper range before measurement

3 Do not measure resistance in live circuit

4 Ensure correct polarity while measuring DC

5 Avoid loose connections

6 Do not exceed meter limits

Procedure:-

Voltage Measurement

First, the multimeter is set to voltage mode (DC/AC as required). Then it is connected in parallel across the load. The supply is switched ON and the voltage reading is noted.

Current Measurement

The multimeter is set to current mode. The circuit is opened and the meter is connected in series. The supply is switched ON and the current reading is recorded.

Resistance Measurement

The multimeter is set to resistance mode. The resistor is disconnected from the circuit and the probes are connected across it. The resistance value is directly displayed on the screen.

Observations and Calculations

Observation Table

S. No.	Voltage (V)	Current (A)	Resistance (Ω)
1			
2			
3			

Calculations

Using Ohm’s Law:

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The value of resistance can also be calculated as:

[R = \frac{V}{I}]

First, the measured values of voltage and current are noted. Then resistance is calculated using the above formula. This calculated value is compared with the resistance measured directly using the multimeter.

If both values are nearly equal, it confirms the accuracy of the multimeter.

Result:-

The voltage, current, and resistance were successfully measured using the Digital Multimeter. The calculated and measured values were found to be nearly equal, verifying Ohm’s Law and proper working of the instrument.

Viva Book:-

1. What is a Digital Multimeter (DMM)?
2. Explain the basic functions of a DMM?.
3. What happens if the wrong range is selected?
4. How is resistance measured using a DMM?.

5 Where are DMMs commonly used?

EXPERIMENT NO:10

Aim:-

To perform a continuity test using a Digital Multimeter (DMM) and identify whether a circuit path is open or closed.

Theory:-

A continuity test is used to check whether an electrical path is complete (closed) or broken (open). It helps in detecting faults like broken wires, damaged components, or loose connections.

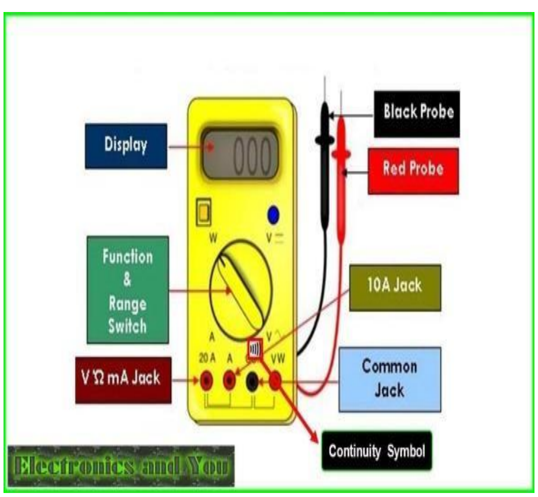
A Digital Multimeter (DMM) has a continuity mode, usually indicated by a buzzer symbol. When the probes are connected across a closed circuit, the multimeter produces a beep sound, indicating continuity. If the circuit is open, no sound is produced.

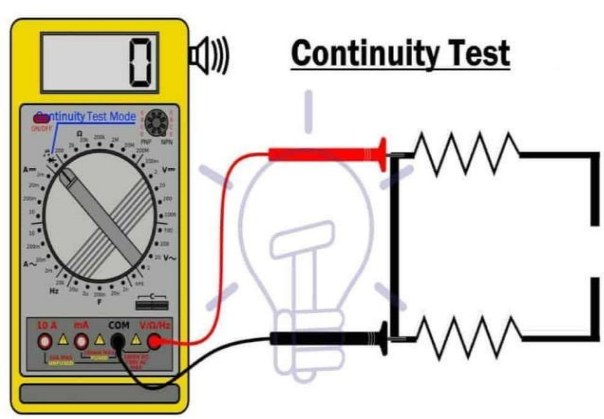
Continuity testing is essentially a simple resistance check:

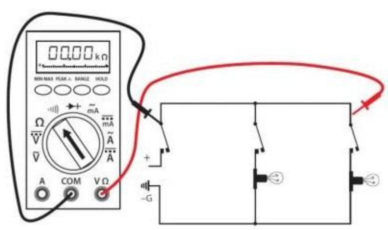
- Very low resistance → Continuity present (closed circuit)
- Very high/infinite resistance → No continuity (open circuit)

Practical Set-up / Circuit Diagram

Continuity Test Diagram








Multimeter probes are connected across the component/wire being tested
No external power supply is required

Apparatus Required:-

1 Digital Multimeter
2 Connecting wires
3 Switch
4 Resistor or test wire
5 Breadboard (optional)

Precautions to be Followed:-

1 Ensure circuit is not connected to power supply
2 Select correct continuity mode on DMM
3 Check multimeter battery before use
4 Ensure proper contact of probes
5 Do not touch probe tips with fingers while testing
6 Avoid testing live circuits

Procedure;-

1. Set the multimeter to continuity mode (buzzer symbol)
2. Insert probes into correct terminals (COM and V/Ω)

3. Touch both probes together to check beep sound (test meter)
4. Connect probes across the wire/component to be tested
5. Observe whether the multimeter beeps or not
6. Repeat for different components or connections

Observations and Calculations:-

Observation Table

S. No.	Component Tested	Multimeter Reading	Beep Sound	Continuity
1			Yes/No	Present/Absent
2			Yes/No	Present/Absent
3			Yes/No	Present/Absent

Calculations (Human Written Style)

In this experiment, no complex calculations are required. The continuity is checked based on the resistance value shown by the multimeter.

If the resistance is very low (close to zero), it indicates that the circuit is complete and current can flow easily. In this case, the multimeter gives a beep sound.

If the resistance is very high or infinite, it means the circuit is open and there is no continuity.

Thus, the presence or absence of continuity is determined directly from the multimeter reading and beep indication.

Result:-

The continuity test was successfully performed using the Digital Multimeter. It was observed that the multimeter gives a beep sound for closed circuits and no sound for open circuits, thereby confirming the presence or absence of continuity.

Viva Book:-

1. What is a continuity test in an electrical circuit?
2. Explain the role of the buzzer in continuity mode?
3. What is considered a good continuity reading?
4. Can continuity testing damage components?.
5. Which mode is used in DMM for continuity testing?

EXPERIMENT NO:11

Aim

To measure the power in single-phase and three-phase circuits using one wattmeter and study the method of measurement.

Theory

Single Phase Power Measurement

In a single-phase circuit, power is measured directly using a wattmeter. The wattmeter has two coils:

- Current coil (CC) – connected in series
- Pressure coil (PC**)** – connected in parallel

The wattmeter directly indicates power consumed in the circuit.

Formula**:**

$$P = V \times I \times \cos\, \phi$$

Three Phase Power Measurement (One Wattmeter Method)

For a three-phase balanced load, power can be measured using a single wattmeter by taking two readings with different connections.

The total power is calculated as:

$$P_{total} = W_1 + W_2$$

Where:

- W_1= First wattmeter reading
- W_2= Second wattmeter reading

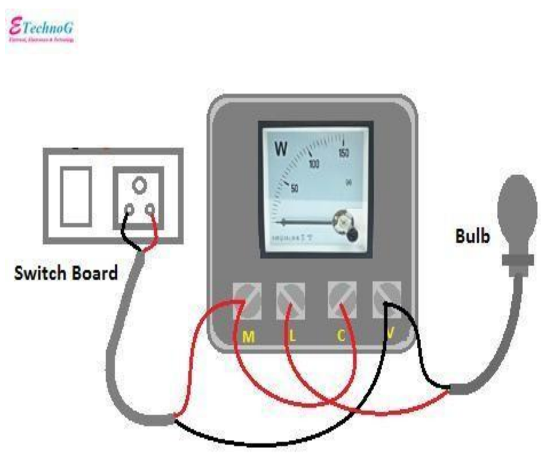
This method is suitable for balanced loads only.

Working Principle of Wattmeter

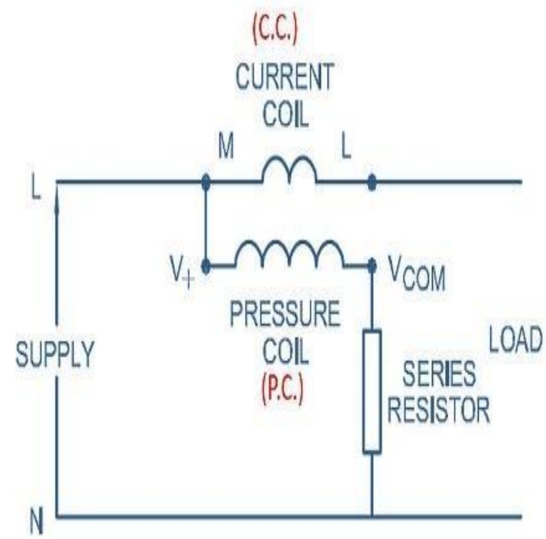
A wattmeter works on the principle of interaction between magnetic fields produced by current coil and pressure coil, resulting in deflection proportional to power.

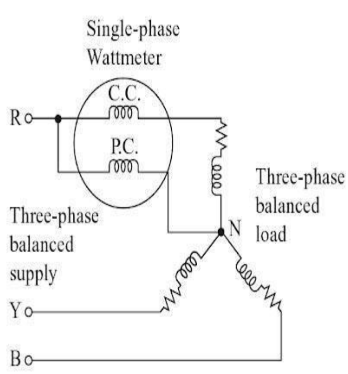
Practical Set-up / Circuit Diagram

Single Phase Measurement

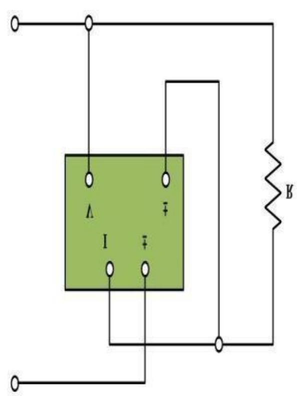


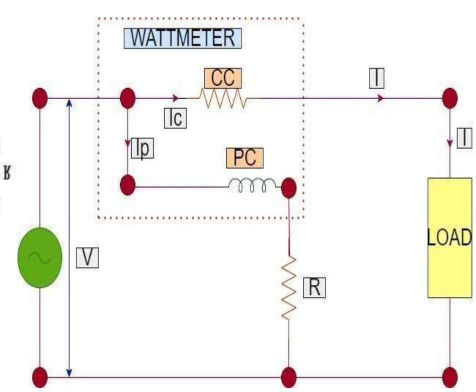
Connection Diagram of Wattmeter





One-wattmeter method





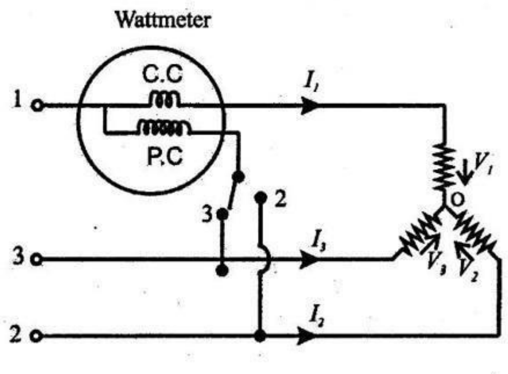


Fig. 5.15 One wattmeter method

Current coil in series, pressure coil in parallel

Three Phase Measurement (One Wattmeter Method)

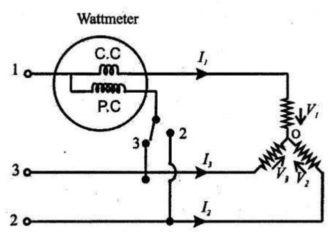
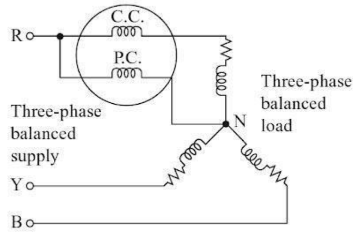
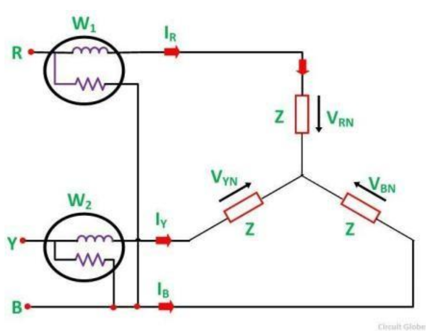


Fig. 5.15 One wattmeter method



One-wattmeter method



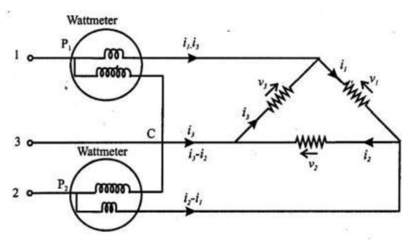
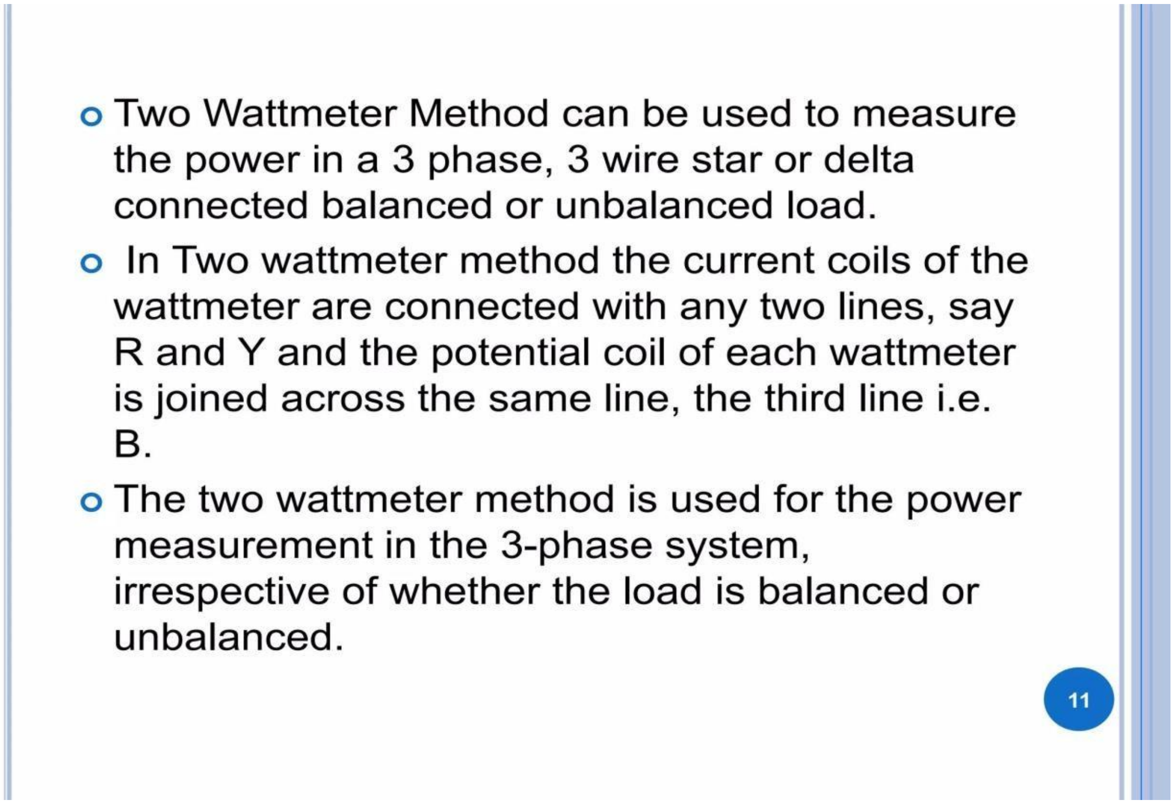


Fig. 5.13 Two wattmeter method (Delta connection)



Two readings are taken by changing connections

Apparatus Required

1. Wattmeter
2. Voltmeter
3. Ammeter
4. Three-phase AC supply
5. Single-phase AC supply
6. Load (resistive/inductive)
7. Connecting wires
8. Switch

Precautions to be Followed:-

1 Ensure proper connection of current and pressure coils

2 Do not exceed rated values of instruments

3 Check polarity of wattmeter connections

4 Tighten all connections properly

5 Avoid loose wiring

6 Switch OFF supply before changing connections

Procedure:-

For Single Phase

1. Connect the circuit as per diagram
2. Switch ON the supply
3. Note wattmeter reading
4. Record voltage and current readings
5. Repeat for different loads

For Three Phase (One Wattmeter Method)

1. Connect wattmeter in first position and take reading (W_1)
2. Change connection as per method and take second reading (W_2)
3. Note both readings carefully
4. Repeat for different load conditions

Observations and Calculations:

Observation Table (Single Phase)

S. No.	Voltage (V)	Current (A)	Wattmeter Reading (W)
1			
2			

Observation Table (Three Phase)

S. No.	W_1 (W)	W_2 (W)	Total Power (W)
1			
2			

Calculations

For the single-phase circuit, the power is calculated using the formula:

$$P = V \times I \times \cos\,\phi$$

The values of voltage and current are taken from the voltmeter and ammeter. The calculated power is compared with the wattmeter reading.

For the three-phase circuit, two readings are taken using one wattmeter. The total power is calculated as:

$$P_{total} = W_1 + W_2$$

Result:-

The power in single-phase and three-phase circuits was successfully measured using one wattmeter. The results were found to be satisfactory and within acceptable limits.

Viva Book:-

1. Explain the connection of a wattmeter in a circuit.
2. Explain the working principle of a wattmeter..
3. Explain how three-phase power is measured using one wattmeter method.
4. Define power factor.
5. What is the Differentiate between current coil and pressure coil.

EXPERIMENT NO:12

Aim:-

To measure the total power in a three-phase circuit using two wattmeter method and three wattmeter method and compare the results.

Theory:-

Three Phase Power

In a three-phase system, total power is the sum of power consumed in all three phases. It depends on voltage, current, and power factor of the load.

Two Wattmeter Method

In this method, two wattmeters are used to measure power in a three-phase system (3-wire system).

The current coils are connected in two lines

The pressure coils are connected between those lines and the third line

Total Power:

$$P_{total} = W_1 + W_2$$

Power Factor:

$$\cos \phi = \frac{W_1+W_2}{\sqrt{3}(W_1-W_2)}$$

This method can be used for both balanced and unbalanced loads

Three Wattmeter Method

In this method, three wattmeters are used, one for each phase.

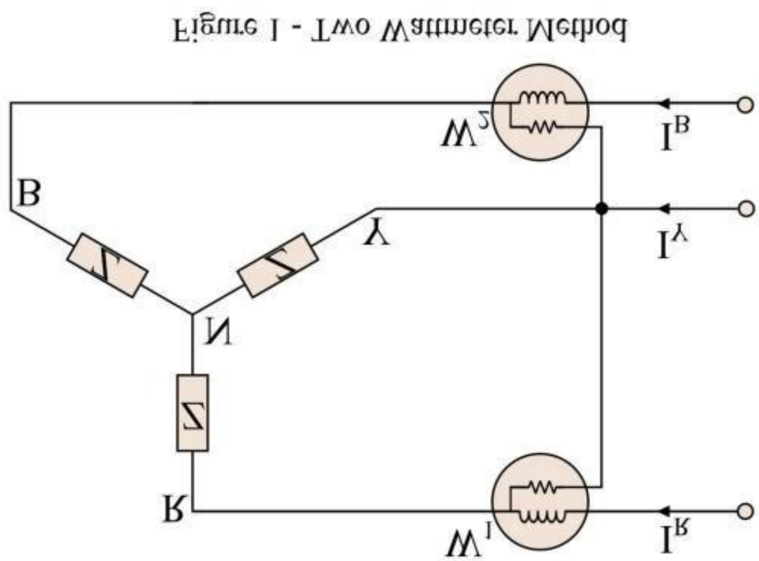
- Each wattmeter measures power in one phase
- The total power is the sum of all three readings

Comparison

- Two wattmeter method uses only 2 wattmeters
- Three wattmeter method uses 3 wattmeters
- Both methods give total power of the system

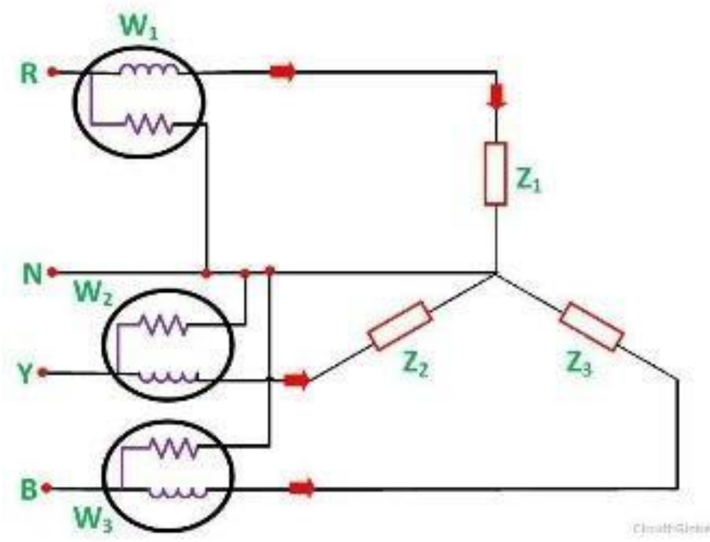
Practical Set-up / Circuit Diagram

Two Wattmeter Method



Two wattmeters connected in two lines

Three Wattmeter Method



One wattmeter per phase

Apparatus Required:-

1 Wattmeters (2 or 3)

2 Three-phase AC supply

3 Load (balanced/unbalanced)

4 Voltmeter

5 Ammeter

6 Connecting wires

7 Switch

Precautions to be Followed:-

1 Ensure correct connection of current and pressure coils

2 Check polarity of wattmeter terminals

3 Do not exceed rated values

4 Tighten all connections properly

5 Avoid loose wiring

6 Switch OFF supply before making changes

Procedure:-

Two Wattmeter Method

1. Connect the circuit as per diagram
2. Switch ON the supply
3. Note readings of both wattmeters (W_1) and (W_2)
4. Repeat for different load conditions

Three Wattmeter Method

1. Connect three wattmeters, one in each phase
2. Switch ON the supply
3. Record readings (W_1), (W_2), and (W_3)
4. Repeat for different loads

Observations and Calculations:-

Observation Table (Two Wattmeter Method)

S. No.	W_1 (W)	W_2 (W)	Total Power (W)
1			
2			

Observation Table (Three Wattmeter Method)

S. No.	W_1 (W)	W_2 (W)	W_3 (W)	Total Power (W)
1				
2				

Calculations

For the two wattmeter method, the readings of both wattmeters are taken. The total power is calculated by adding both readings:

$$P_{total} = W_1 + W_2$$

If required, the power factor is calculated using the given formula.

For the three wattmeter method, the readings of all three wattmeters are noted. The total power is calculated as:

$$P_{total} = W_1 + W_2 + W_3$$

Result:=

The total power of the three-phase system was successfully measured using both two wattmeter and three wattmeter methods. The results obtained were found to be satisfactory and nearly equal.

Viva Book:-

1. What happens when the power factor is zero?
2. Define balanced load..
3. Differentiate between line current and phase current.
4. Explain the three wattmeter method for power measurement.
5. Explain the condition when one wattmeter shows negative reading.

EXPERIMENT NO:13

Aim:-

To calibrate the given wattmeter by comparing its readings with the standard values and to determine the error and correction.

Theory:-

A wattmeter is an instrument used to measure electrical power in a circuit. It works on the principle of interaction between the magnetic fields produced by the current coil (CC) and pressure coil (PC).

In practical conditions, the wattmeter may show slight errors due to:

- Mechanical friction
- Temperature effects
- Improper calibration

Hence, calibration is necessary to ensure accurate measurement.

During calibration, the wattmeter reading is compared with the true power, calculated using measured values of voltage and current.

True Power:

$$P = V \times I$$

Error:

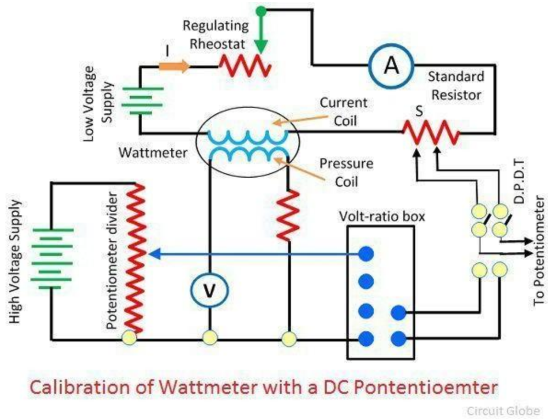
$$\text{Error} = W_{observed} - W_{true}$$

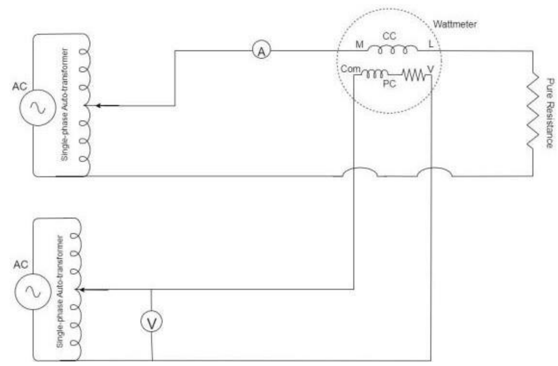
Correction:

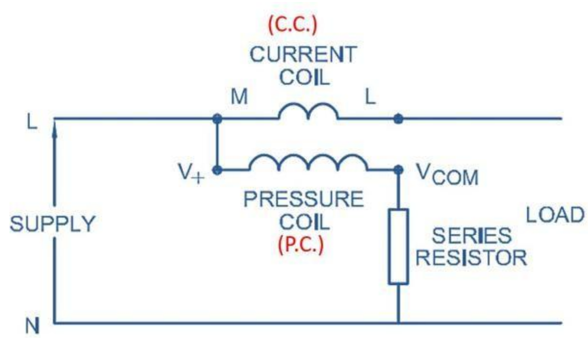
$$\text{Correction} = -(\text{Error})$$

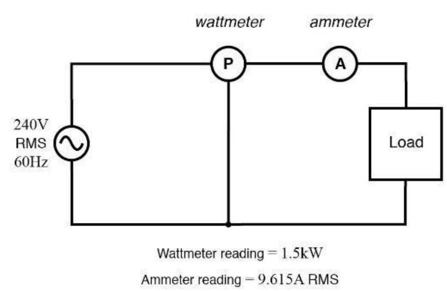
Practical Set-up / Circuit Diagram

Wattmeter Calibration Circuit









Current coil is connected in series with load

Pressure coil is connected in parallel across supply

Apparatus Required:-

1. Wattmeter
2. Voltmeter
3. Ammeter

4 Rheostat

5 Load (resistive)

6 AC/DC power supply

7 Connecting wires

8 Switch

Precautions to be Followed:-

1 Ensure correct connection of current and pressure coils

2 Check polarity of wattmeter terminals

3 Do not exceed rated values

4 Make tight and proper connections

5 Avoid parallax error while reading instruments

6 Switch OFF supply before changing connections

Procedure:-

1. Connect the circuit as per the diagram
2. Switch ON the power supply
3. Adjust the rheostat to set different load conditions
4. Note readings of voltmeter, ammeter, and wattmeter
5. Take multiple readings for different loads
6. Switch OFF the supply after completion

Observations and Calculations:-

Observation Table

S. No.	Voltage (V)	Current (A)	Wattmeter Reading (W)	True Power (W)	Error	Correction
1						
2						
3						

Calculations (Human Written Style)

First, the values of voltage and current are noted from the voltmeter and ammeter. Then the true power is calculated using the formula:

$$P = V \times I$$

After that, the wattmeter reading is compared with the calculated power.

The error is calculated as:

Error = Observed Reading – True Power

Then, the correction is calculated as:

Correction = – Error

These calculations are repeated for all observations to check the accuracy of the wattmeter.

Result:-

The given wattmeter was calibrated successfully by comparing its readings with the calculated true power. The error and correction were determined, and the instrument was found to be working within acceptable limits**.**

Viva Book:-

1. What is calibration of a wattmeter?
2. Explain the Differentiate between accuracy and precision.
3. Define calibration.
4. Explain Differentiate between absolute error and relative error.
5. What is a standard wattmeter?

EXPERIMENT NO:14

Aim:-

To calibrate the given single-phase energy meter and determine its accuracy by comparing actual energy consumed with measured energy.

Theory:-

An energy meter is used to measure electrical energy consumed in a circuit, usually in kilowatt-hour (kWh). It works on the principle of electromagnetic induction.

In a single-phase energy meter:

- A current coil carries load current
- A pressure coil is connected across supply
- These produce a rotating magnetic field
- This causes an aluminium disc to rotate

The speed of rotation is proportional to power, and total number of rotations is proportional to energy consumed.

Each meter has a meter constant (K), expressed as:

$$K = \text{revolutions per kWh}$$

Actual Energy

$$E_{actual} = \frac{V \times I \times t}{1000}$$

Measured Energy

$$E_{measured} = \frac{N}{K}$$

Where:

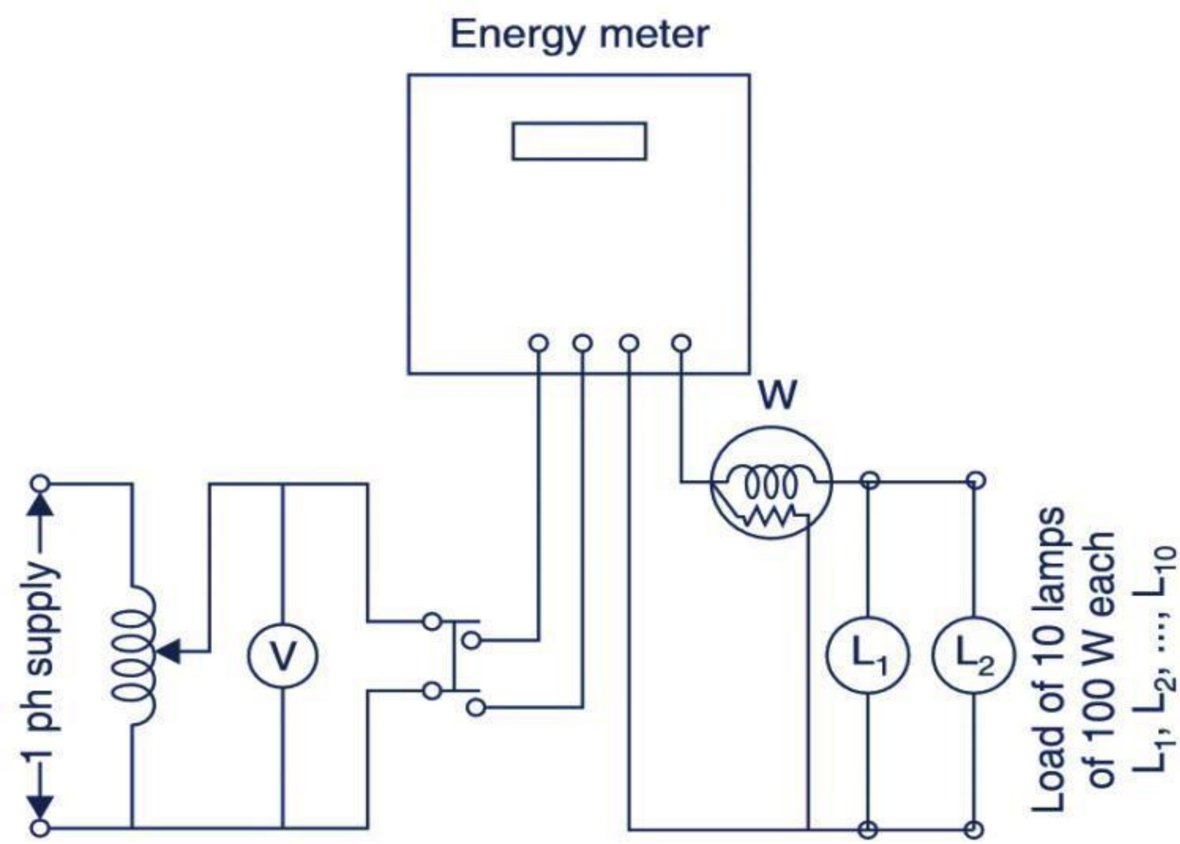
- N= Number of disc revolutions
- K= Meter constant

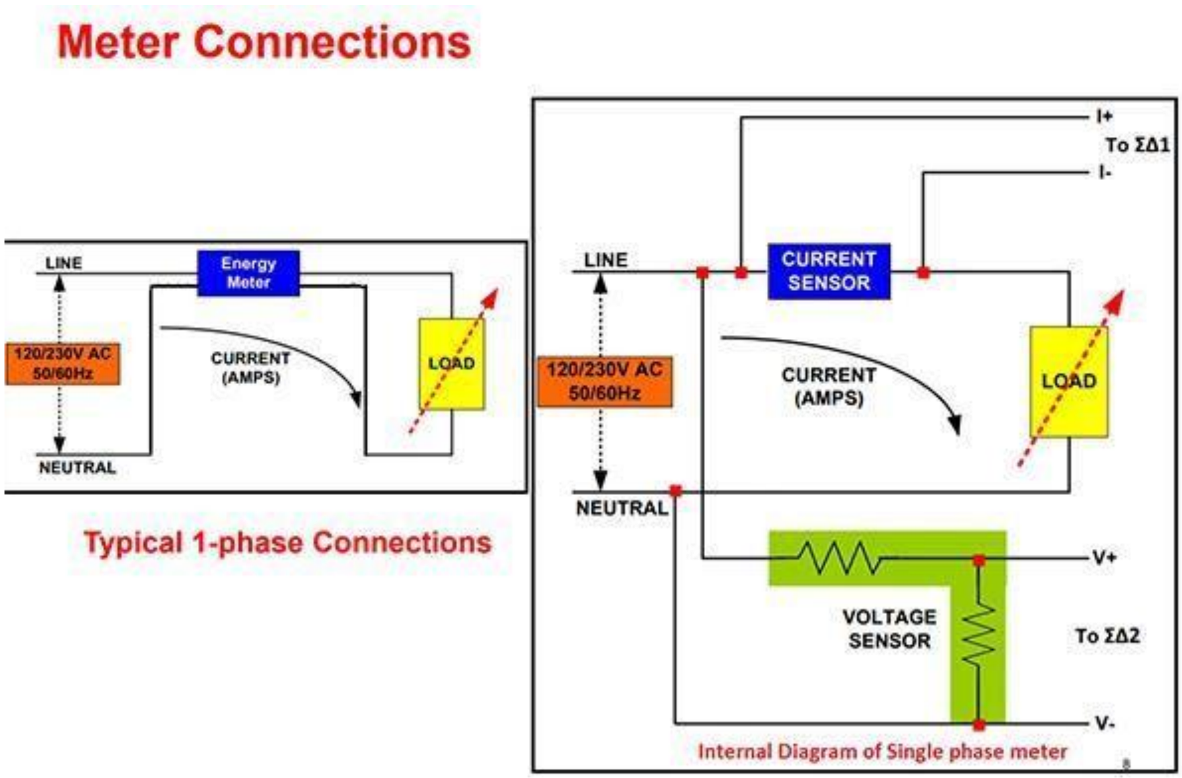
Percentage Error

$$\%\text{Error} = \frac{E_{measured} - E_{actual}}{E_{actual}} \times 100$$

Practical Set-up / Circuit Diagram

Energy Meter Calibration Setup





Energy meter connected in series with load

Voltmeter in parallel, ammeter in series

Apparatus Required:-

1. Single-phase energy meter
2. Voltmeter
3. Ammeter
4. Stop watch
5. Rheostat
6. Load (lamp/resistor)
7. AC power supply

8 Connecting wires

9 Switch

Precautions to be Followed:-

1 Ensure proper and tight connections

2 Check meter constant before experiment

3 Do not exceed rated current and voltage

4 Start stopwatch accurately

5 Count disc revolutions carefully

6 Avoid parallax error while reading meters

7 Switch OFF supply after experiment

Procedure:-

1. Connect the circuit as per the diagram
2. Switch ON the supply
3. Adjust load using rheostat
4. Note voltage and current readings
5. Count number of disc revolutions (N)
6. Measure time taken (t) using stopwatch
7. Repeat for different loads
8. Switch OFF the supply

Observations and Calculations:-

Observation Table

S. No.	Voltage (V)	Current (A)	Time (t) sec	Revolutions (N)	Actual Energy (kWh)	Measured Energy (kWh)	% Error
1							
2							

Calculations (Human Written Style)

First, the values of voltage and current are noted from the meters. The time for a certain number of disc revolutions is also recorded.

The actual energy consumed is calculated using the formula:

$$E_{actual} = \frac{V \times I \times t}{1000}$$

Then, the measured energy is calculated using the meter constant:

$$E_{measured} = \frac{N}{K}$$

After that, the percentage error is calculated using:

$$\%\text{Error} = \frac{E_{measured} - E_{actual}}{E_{actual}} \times 100$$

These calculations are repeated for all readings to check the accuracy of the energy meter.

Result:-

The given single-phase energy meter was calibrated successfully. The actual and measured energy values were compared, and the percentage error was found to be within acceptable limits.

Viva Book:-

1. Differentiate between true energy and recorded energy.
2. Explain the working principle of an energy meter.
3. Define meter constant.
4. Explain how accuracy of an energy meter is determined.
5. Explain the role of load in energy meter calibration.

EXPERIMENT NO:15

Aim:-

To study and demonstrate the working of a digital energy meter and understand how electrical energy consumption is measured.

Theory:-

A digital energy meter is an electronic device used to measure electrical energy consumed in a circuit in terms of kilowatt-hour (kWh).

Unlike analog meters, digital energy meters do not have a rotating disc. Instead, they use electronic circuits to measure voltage and current.

Working Principle

1. The meter senses voltage and current using sensors
2. These signals are processed using electronic circuits
3. Instantaneous power is calculated as:

$$P = V \times I$$

The energy consumed is obtained by integrating power over time

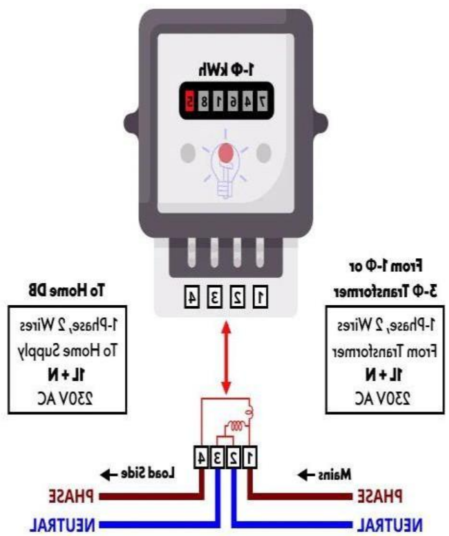
4. The result is displayed digitally in kWh

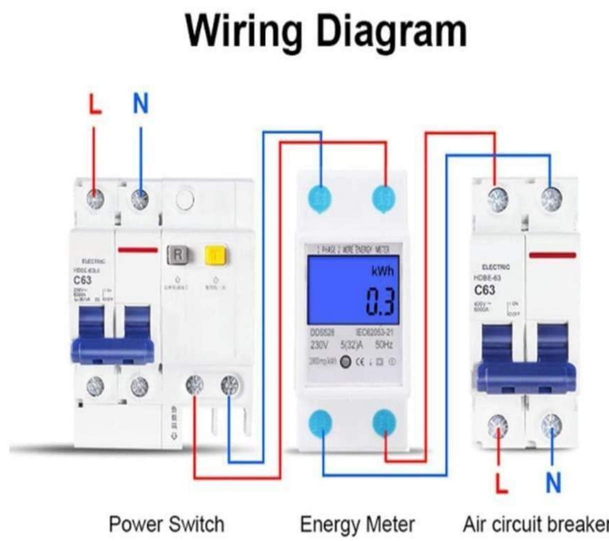
Advantages

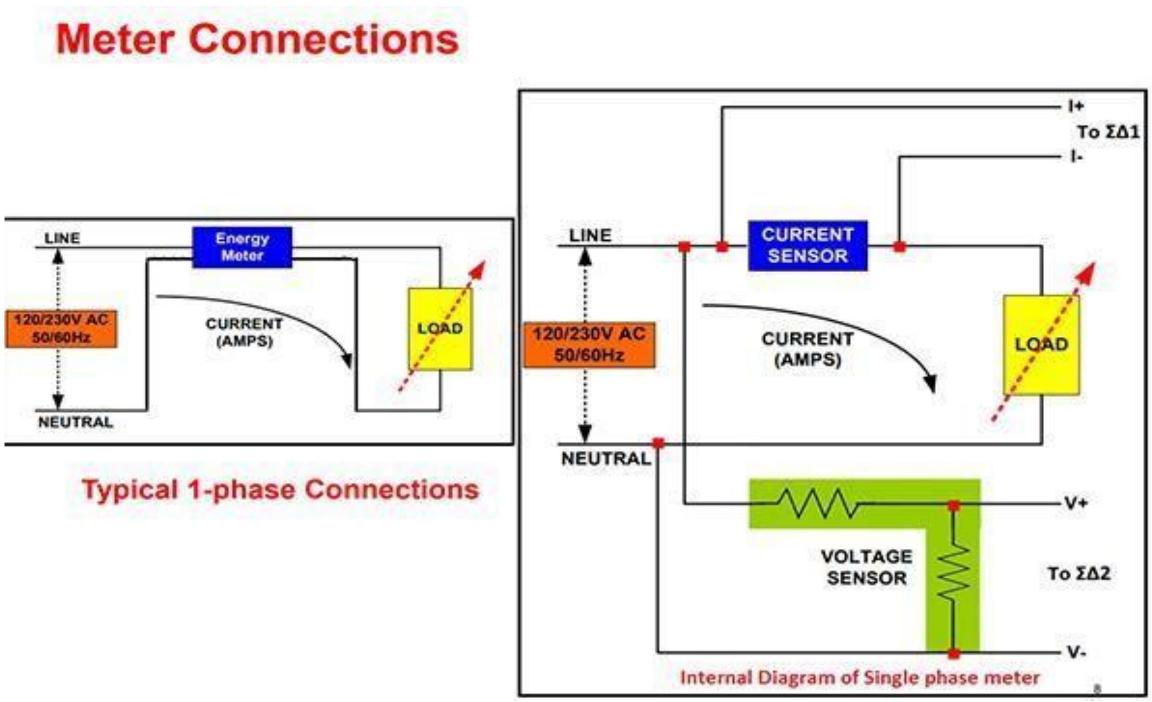
1. Higher accuracy
2. No mechanical losses
3. Direct digital display
4. Low maintenance

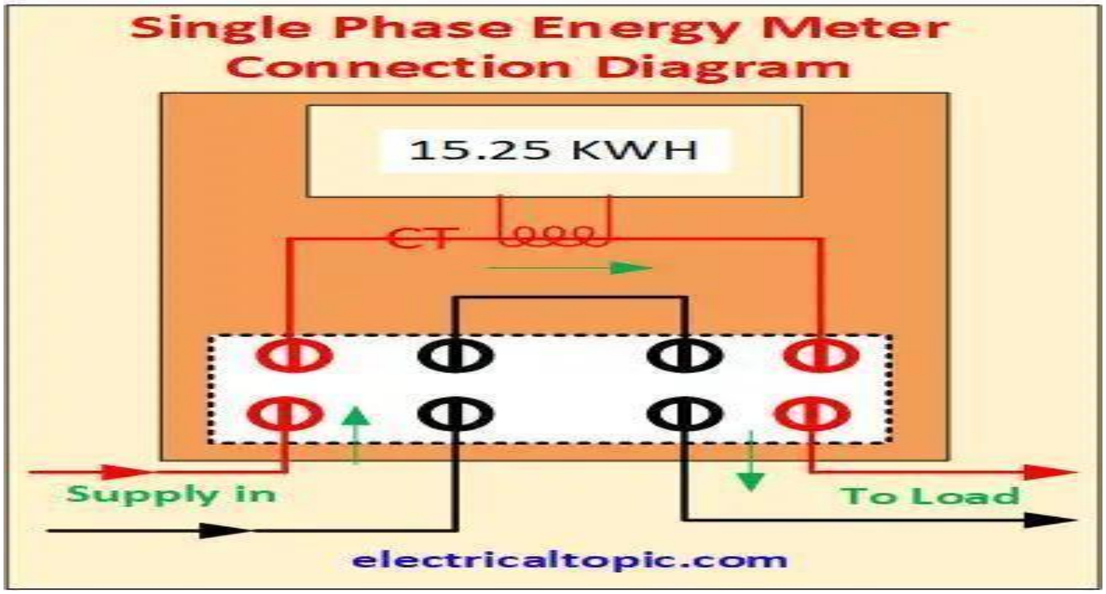
Practical Set-up / Circuit Diagram

Digital Energy Meter Setup









Energy meter connected in series with load

Supply given to meter input terminals

Apparatus Required:-

1. Digital energy meter
2. AC power supply
3. Load (lamp/heater/resistor)
4. Voltmeter
5. Ammeter
6. Stop watch (optional)
7. Connecting wires
8. Switch

Precautions to be Followed:-

1 Ensure correct wiring of input and output terminals

2 Do not exceed rated voltage and current

3 Avoid loose connections

4 Switch OFF supply before making changes

5 Handle meter carefully

6 Check proper functioning before experiment

Procedure:-

1. Connect the digital energy meter as per the circuit diagram
2. Connect the load to the output of the meter
3. Switch ON the power supply
4. Observe the digital display reading (kWh)
5. Note initial reading
6. Allow load to run for some time
7. Note final reading
8. Calculate energy consumed
9. Repeat for different loads

Observations and Calculations:-

Observation Table

S. No.	Voltage (V)	Current (A)	Initial Reading (kWh)	Final Reading (kWh)	Energy Consumed (kWh)
1					
2					

Calculations

First, the initial reading of the energy meter is noted. Then the load is switched ON and allowed to run for some time.

After that, the final reading is recorded. The energy consumed is calculated as:

Energy Consumed = Final Reading – Initial Reading

This value represents the electrical energy used by the load in kWh.

The readings can also be verified using the relation:

$$Energy = Power \times Time$$

Thus, the measured energy is compared with calculated energy to verify accuracy.

Result:-

The working of the digital energy meter was successfully demonstrated. The energy consumed by the load was measured directly from the meter, and the readings were found to be accurate and reliable.

Viva Book:-

1. What is a digital energy meter?
2. Explain the working principle of a digital energy meter.
3. Explain the role of microcontroller in a digital energy meter.
4. Differentiate between power and energy.
5. What is meant by energy consumption?

EXPERIMENT NO:16

Aim:-

To measure very low resistance accurately using Kelvin's Double Bridge method.

Theory:-

Kelvin's Double Bridge is a modified form of the Wheatstone bridge, specially designed to measure very low resistances (in milliohms). It eliminates errors due to contact resistance and lead resistance.

In low resistance measurement, the resistance of connecting wires and contacts affects accuracy. Kelvin's bridge overcomes this by using two sets of ratio arms.

Working Principle

The bridge works on the principle of null deflection. When the bridge is balanced, no current flows through the galvanometer.

At balance condition:

$$\frac{R_x}{R_s} = \frac{P}{Q}$$

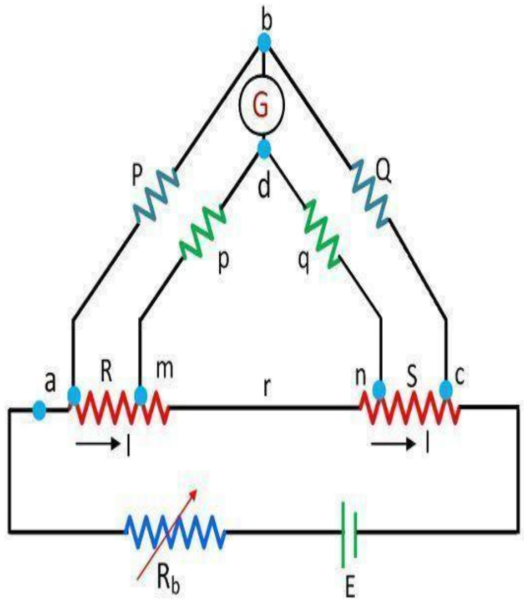
Where:

- R_x= Unknown resistance
- R_s= Standard known resistance
- P, Q= Ratio arms

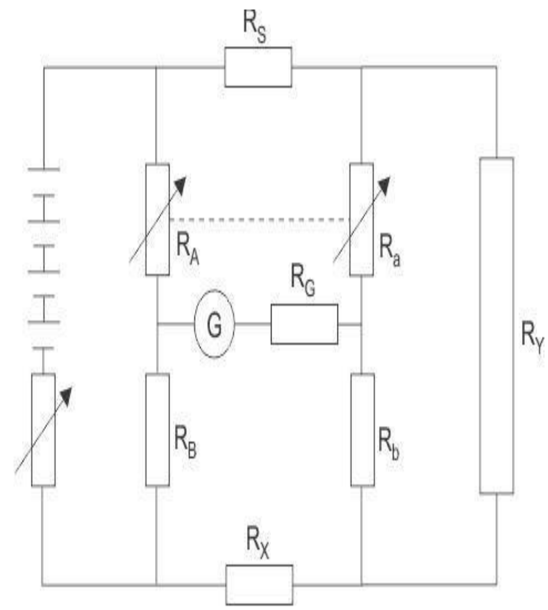
The bridge also includes additional resistors to compensate for lead resistance.

Practical Set-up / Circuit Diagram

Kelvin's Double Bridge Circuit



Kelvin Double Bridge



Kelvin Bridge to Measure low resistance

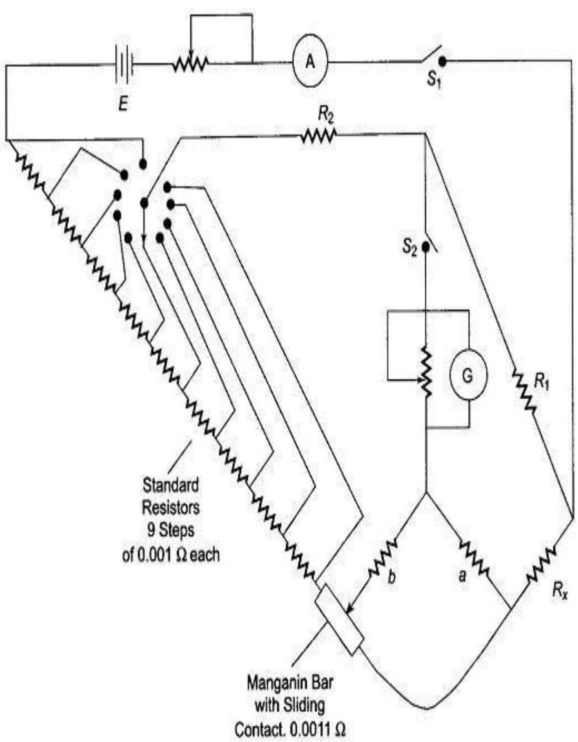
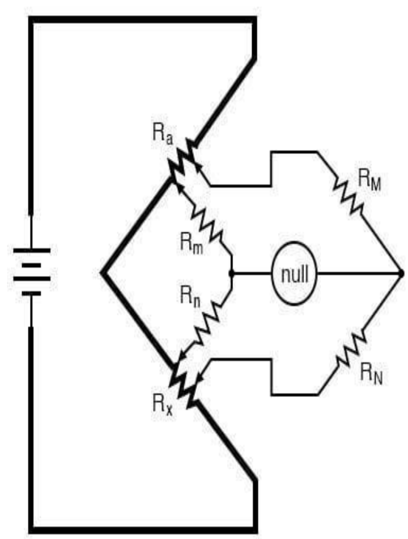
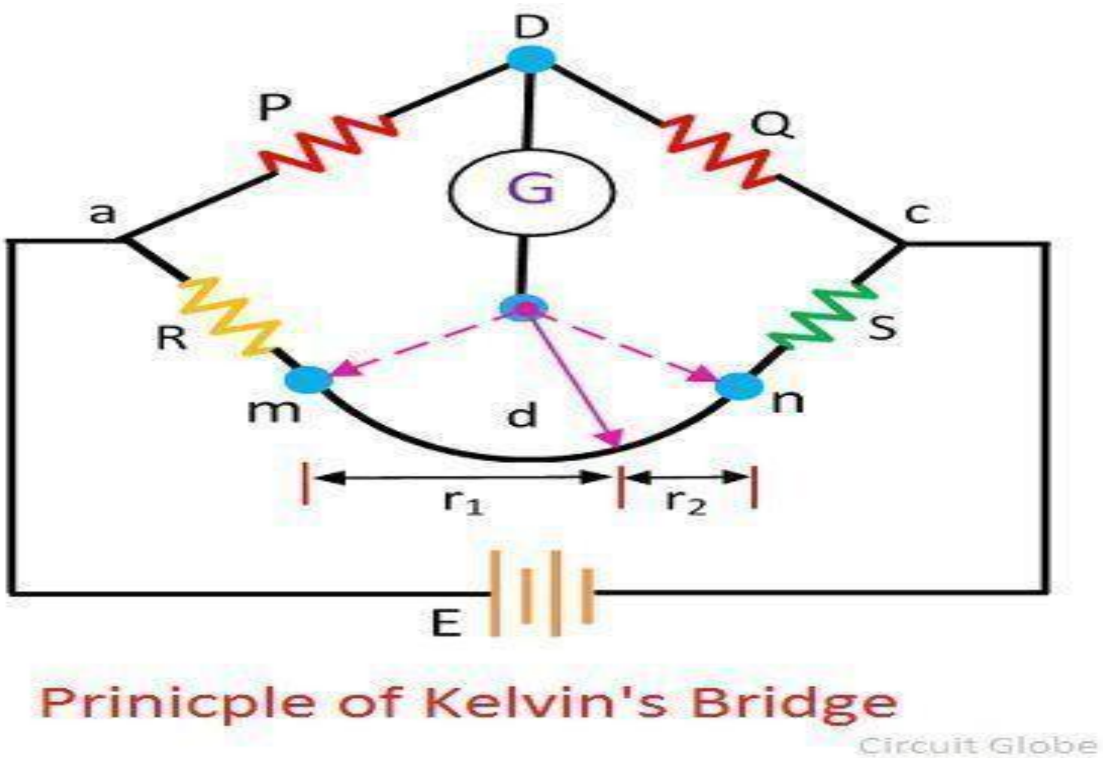


Fig. 11.13 Practical Kelvin's Bridge

Kelvin Double Bridge



R_a and R_x are low-value resistances



Galvanometer shows null at balance

Battery provides supply

Apparatus Required:-

1. Kelvin's Double Bridge setup
2. Galvanometer
3. Battery (DC supply)
4. Standard resistance
5. Unknown low resistance
6. Connecting wires
7. Key/switch

Precautions to be Followed:-

1 Ensure tight and clean connections

2 Avoid contact resistance errors

3 Do not disturb the setup during measurement

4 Adjust bridge carefully for null condition

5 Use sensitive galvanometer

6 Avoid heating of resistors

Procedure:=

1. Connect the circuit as per the diagram
2. Close the key to allow current flow
3. Adjust the ratio arms (P and Q)
4. Observe galvanometer deflection
5. Adjust until null deflection is obtained
6. Note values of resistances
7. Repeat readings for accuracy

Observations and Calculations:-

Observation Table

S. No.	Standard Resistance (R_s)	Ratio Arms (P/Q)	Unknown Resistance (R_x)
1			
2			

Calculations

First, the values of standard resistance and ratio arms are noted. The bridge is balanced by adjusting the resistances until the galvanometer shows zero deflection.

At this balanced condition, the unknown resistance is calculated using the formula:

$$R_x = R_s \times \frac{P}{Q}$$

The values are substituted in the formula to obtain the unknown low resistance.

The experiment is repeated for different values to ensure accuracy, and the average value is taken.

Result:-

The low resistance was measured successfully using Kelvin's Double Bridge. The result obtained was accurate and free from errors due to contact and lead resistance.

Viva Book:-

1. Explain the working principle of Kelvin's double bridge.
2. Explain the role of ratio arms in Kelvin's double bridge.
3. Differentiate between Wheatstone bridge and Kelvin's double bridge.

4. What is the function of a galvanometer in the bridge?
5. Define contact resistance.

EXPERIMENT NO:17

Aim:-

To measure the value of a medium resistance using Wheatstone Bridge, Voltmeter-Ammeter method, and Ohmmeter, and compare the results.

Theory:-

1. Wheatstone Bridge Method

The Wheatstone bridge is used for accurate measurement of unknown resistance by balancing two legs of a bridge circuit.

At balance condition:

$$\frac{R_1}{R_2} = \frac{R_x}{R_3}$$

Where:

- R_x= Unknown resistance
- R_1, R_2, R_3= Known resistances

At balance, no current flows through the galvanometer.

2. Voltmeter-Ammeter Method

In this method, resistance is calculated using Ohm's law.

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

$$V = IR = 12$$

Voltage is measured across the resistor and current through it.

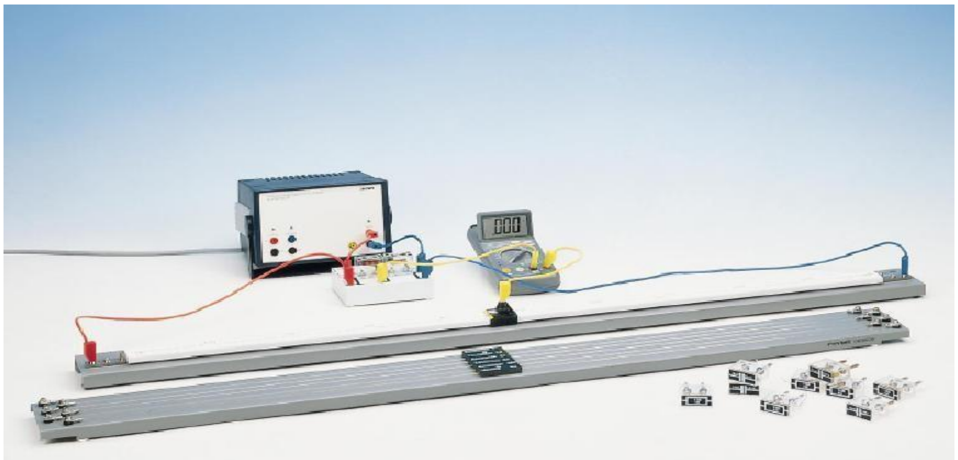
3. Ohmmeter Method

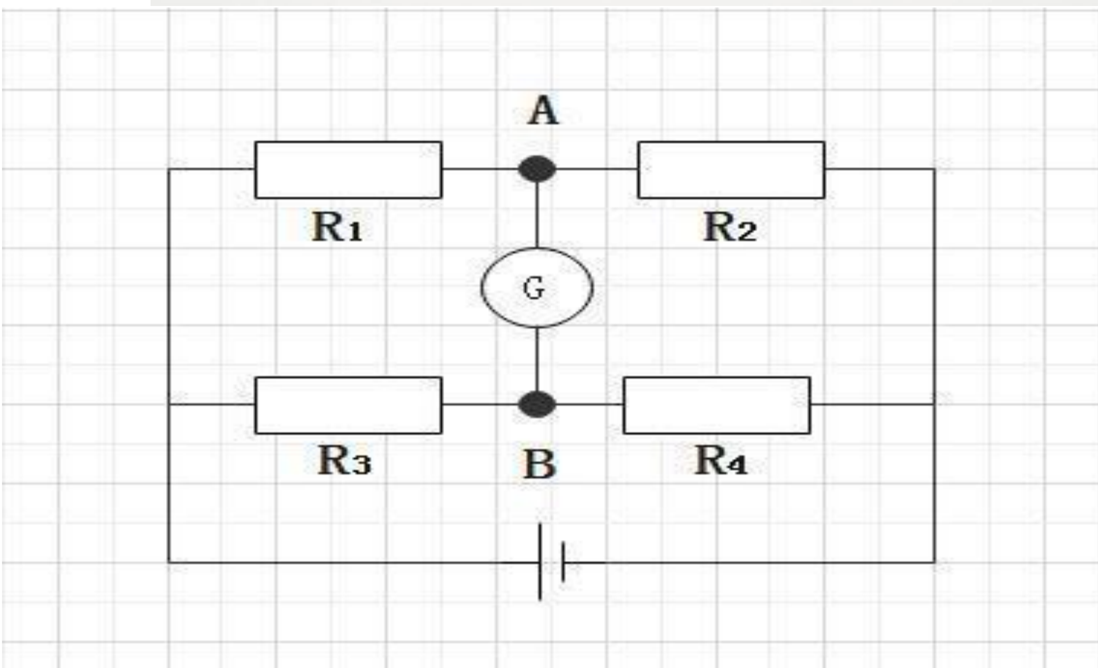
An ohmmeter directly measures resistance by passing a small current through the resistor and displaying the value.

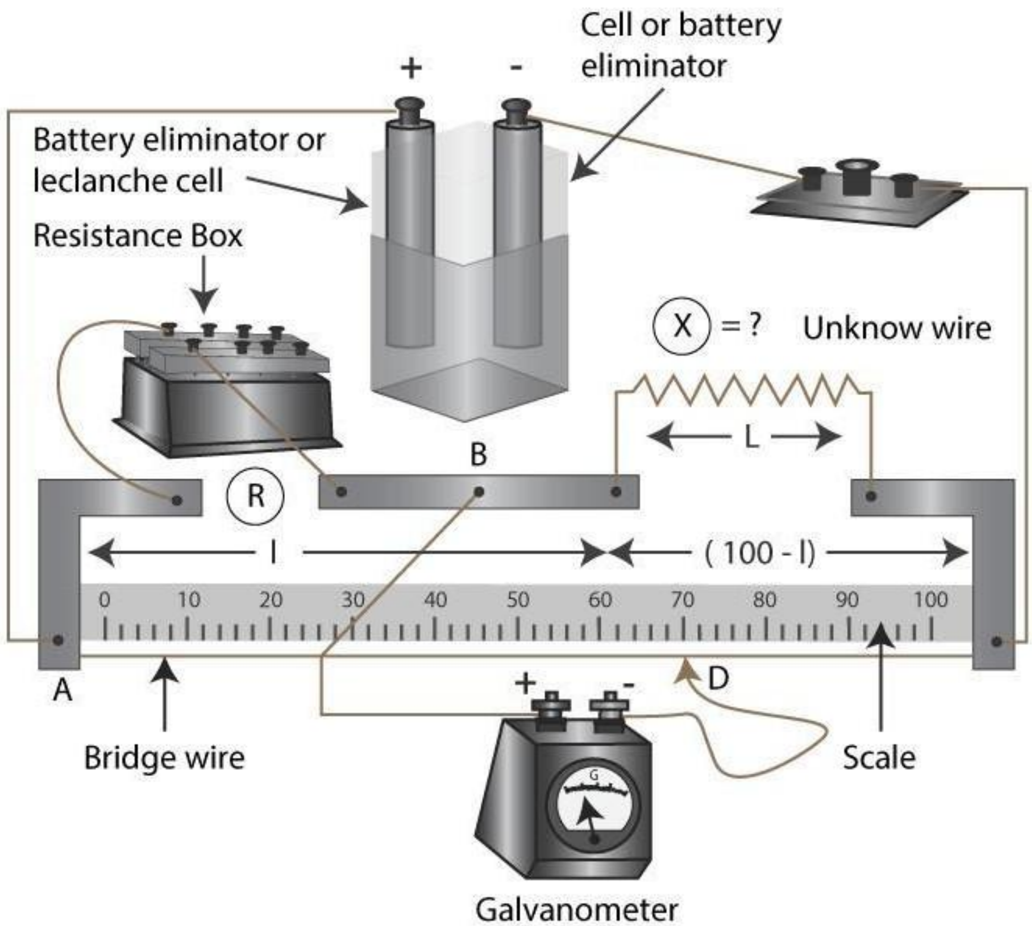
Simple and quick method, but less accurate compared to Wheatstone bridge.

Practical Set-up / Circuit Diagram

Wheatstone Bridge

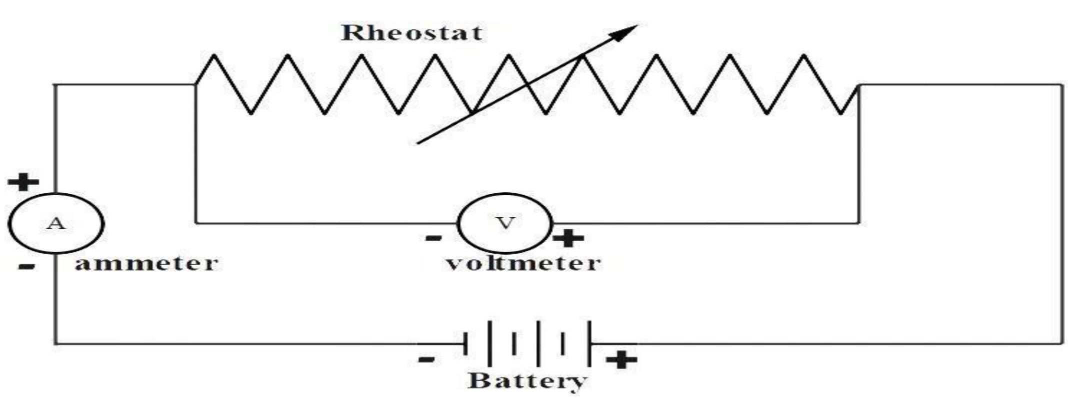


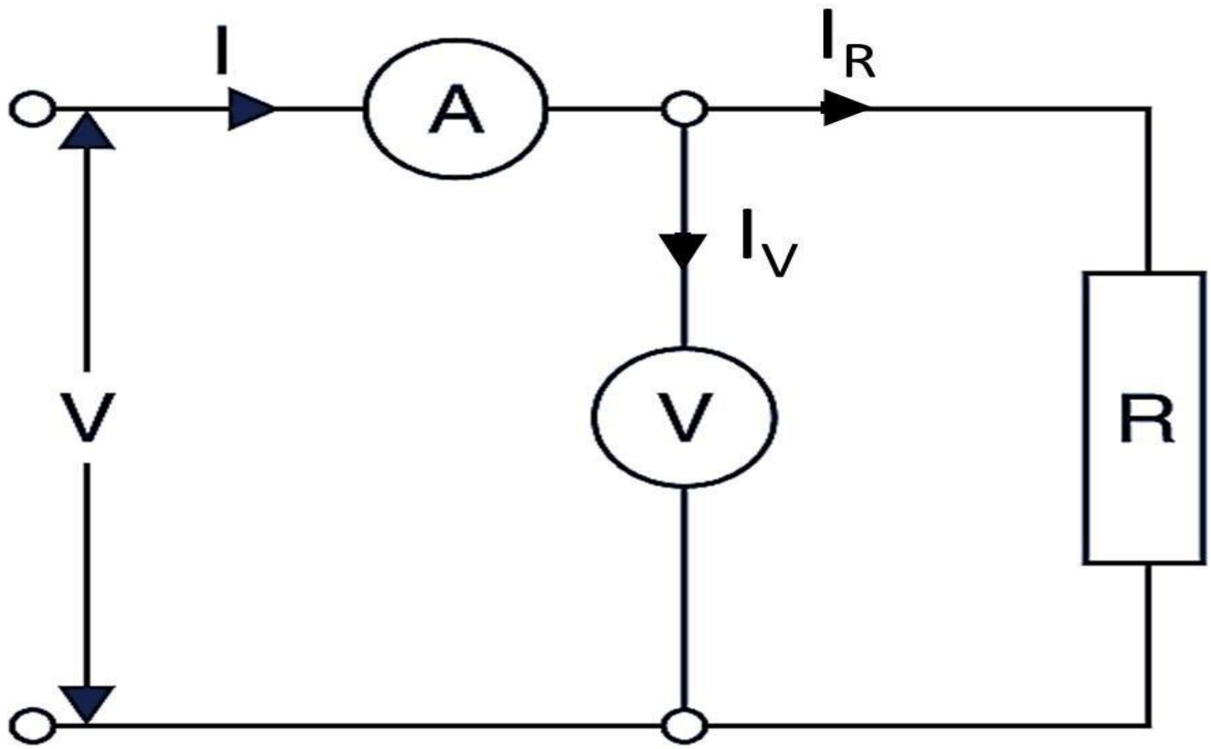




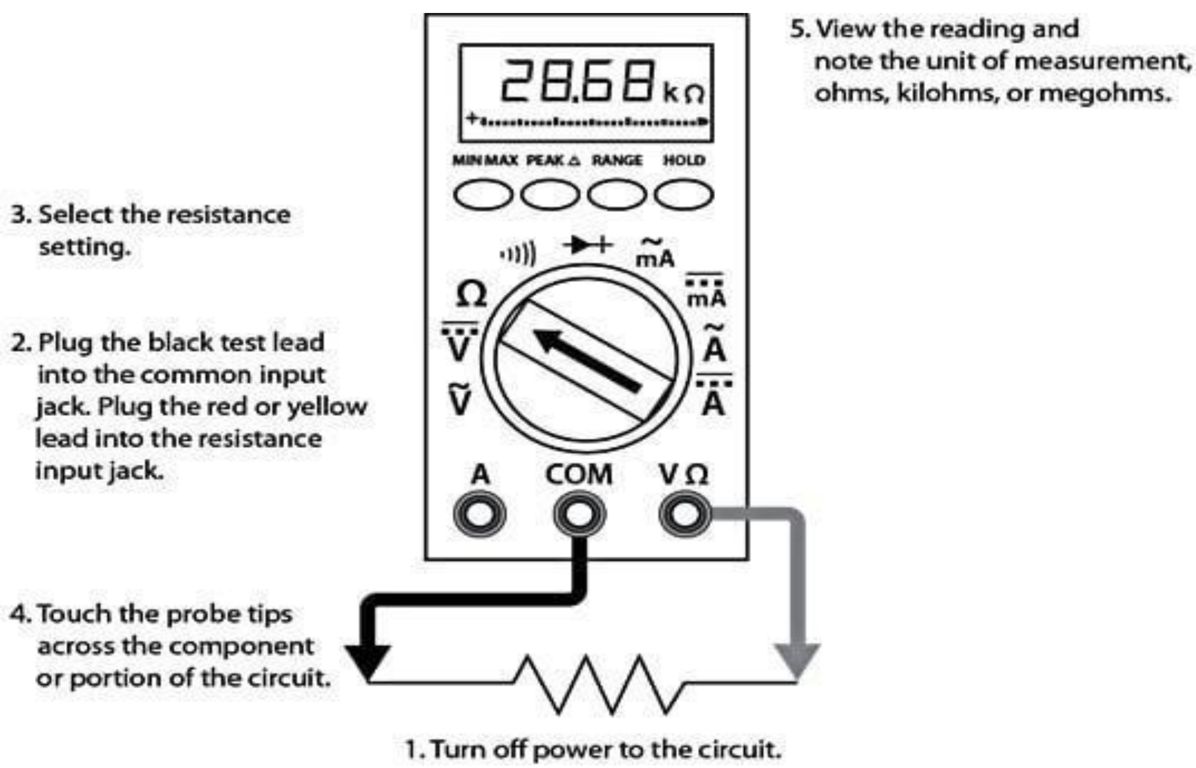
Arrangement diagram

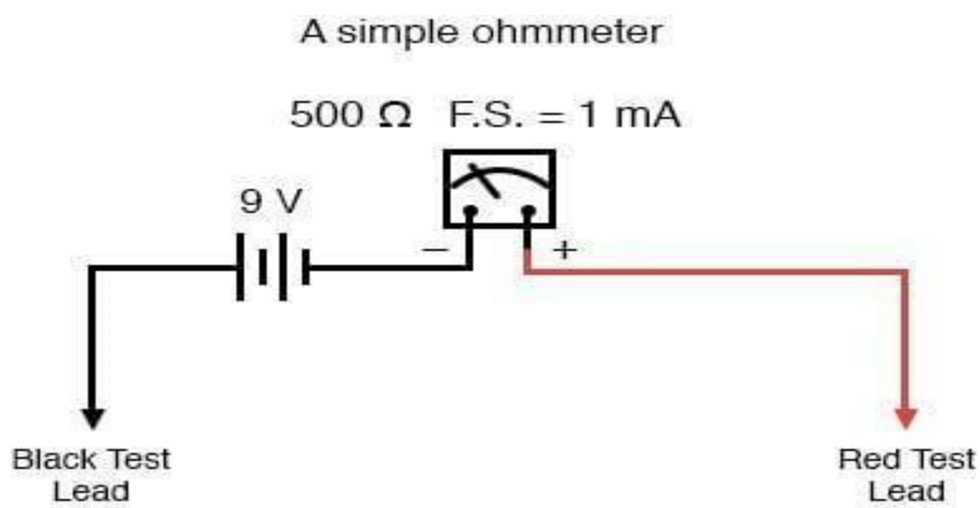
Voltmeter-Ammeter Method





Ohmmeter Method





Apparatus Required:-

1 Wheatstone bridge setup

2 Galvanometer

3 Battery

4 Known resistors

5 Unknown resistor

6 Voltmeter

7 Ammeter

8 Digital multimeter (ohmmeter)

9 Connecting wires

10 Switch

Precautions to be Followed:-

1 Ensure tight and proper connections

2 Avoid parallax error while reading instruments

3 Do not exceed instrument limits

4 Ensure galvanometer shows null condition accurately

5 Disconnect supply while changing connections

6 Use correct polarity in DC circuits

Procedure:-

Wheatstone Bridge Method

1. Connect the circuit as per diagram
2. Adjust known resistances
3. Observe galvanometer deflection
4. Adjust until null deflection is obtained
5. Note resistance values

Voltmeter-Ammeter Method

1. Connect ammeter in series and voltmeter in parallel
2. Switch ON supply
3. Note voltage and current readings
4. Repeat for different values

Ohmmeter Method

1. Set multimeter to resistance mode
2. Disconnect resistor from circuit
3. Connect probes across resistor
4. Note resistance reading

Observations and Calculations:-

Observation Table

Method	Voltage (V)	Current (A)	Resistance (Ω)
V-I			
Bridge			
Ohmmeter			

Calculations (Human Written Style)

In the Wheatstone bridge method, the unknown resistance is calculated using the balance condition formula by substituting known resistance values.

In the voltmeter-ammeter method, the resistance is calculated by dividing the measured voltage by current using Ohm’s law.

In the ohmmeter method, the resistance is directly obtained from the multimeter reading.

All three values are compared to check accuracy. The Wheatstone bridge method gives the most accurate result

Result:-

The medium resistance was measured successfully using Wheatstone bridge, voltmeter-ammeter method, and ohmmeter. The values obtained were found to be close, and the Wheatstone bridge method gave the most accurate result.

Viva Book:-

1. Explain the working principle of the Wheatstone bridge.
2. Explain the working of an ohmmeter.
3. Differentiate between analog ohmmeter and digital ohmmeter.
4. What is the voltmeter-ammeter method?.
5. Differentiate between series and parallel connection in measurement circuits.

EXPERIMENT NO:18

Aim:-

To measure the insulation resistance of an electrical circuit or equipment using a Megger (Insulation Tester).

Theory:-

Insulation resistance is the resistance offered by insulating materials to the flow of leakage current. It is an important parameter to ensure the safety and proper functioning of electrical equipment. A high insulation resistance indicates good insulation, whereas a low value indicates deterioration or fault in insulation.

A Megger is a portable instrument used to measure high resistance values, typically in megaohms. It works on the principle of a moving coil instrument and uses a built-in DC generator (manual or electronic) to apply a high voltage (usually 250V, 500V, or 1000V) across the insulation.

The Megger consists of two coils:

1. Deflecting coil (current coil)
2. Control coil (voltage coil)

When the handle is rotated (in manual Megger), it generates voltage and current flows through the insulation under test. The deflection of the pointer depends on the ratio of currents in the coils, giving a direct reading of insulation resistance.

The insulation resistance is given by

$$R = V / I$$

where V is the applied voltage and I is the leakage current.

Practical Set-up / Circuit Diagram

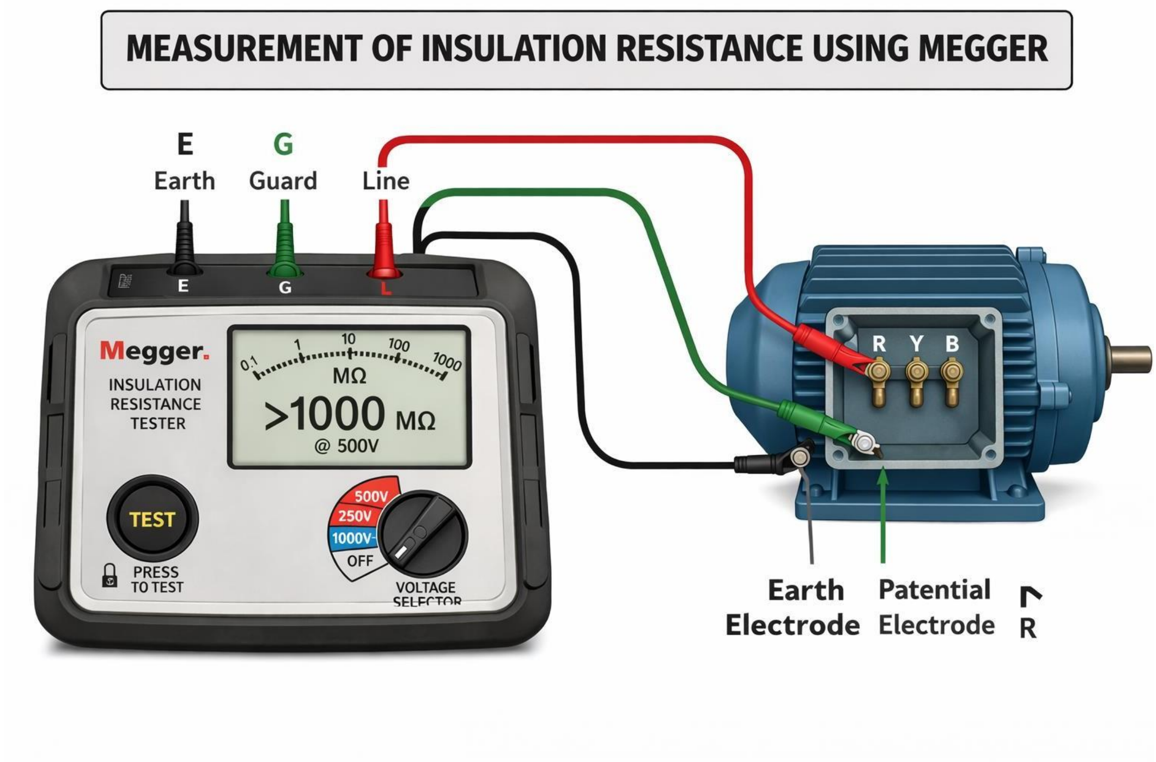
The Megger has two terminals:

• Line (L) terminal

• Earth (E) terminal

The equipment under test is connected between these two terminals. One terminal is connected to the conductor and the other to the earth or body of the equipment. The Megger applies voltage across these terminals and measures insulation resistance.

(Connect the phase wire to L terminal and earth/body to E terminal.)



Apparatus Required:-

1. Megger (Insulation Resistance Tester)

2. Electrical equipment/cable under test

3. Connecting wires

4. Safety gloves

Precautions to be Followed:-

1. Ensure the circuit is completely de-energized before testing.

2. Discharge the equipment before and after measurement.

3. Do not touch the terminals while operating the Megger.

4. Maintain proper speed while rotating the handle (for manual Megger).

5. Ensure proper connections to avoid incorrect readings.

6. Use appropriate voltage rating of Megger for the equipment under test.

Procedure:-

1. Disconnect the equipment from the power supply.
2. Connect the Megger terminals:
3. • Line terminal to conductor
4. • Earth terminal to body/ground
5. Ensure all connections are tight and correct.
6. Rotate the Megger handle at a constant speed (or press test button for digital Megger).
7. Note the reading shown on the scale.
8. Repeat the measurement for accuracy.
9. Discharge the equipment after testing.

Observations and Calculations:-

Observation Table

S. No.	Applied Voltage (V)	Insulation Resistance (MΩ)
1		
2		
3		

Calculation

Insulation Resistance (R) = V / I

(Direct reading is usually obtained from the Megger scale in megaohms, so calculation may not be required.)

Result:-

The insulation resistance of the given electrical equipment was measured using a Megger and found to be MΩ.

(Conclusion: If the value is high, insulation is good; if low, insulation is faulty.)

Viva Book:-

1. Explain the working principle of a Megger.
2. Explain why high voltage is required for insulation testing..
3. Differentiate between Megger and ohmmeter.
4. What is insulation resistance?
5. Define leakage current.

EXPERIMENT NO:19

Aim:-

To measure the earth resistance of a grounding system using an earth tester.

Theory:-

Earth resistance is the resistance offered by the earth electrode to the flow of electric current into the ground. A good grounding system ensures safety by preventing electric shock and protecting equipment from faults.

The earth tester works on the principle of the fall-of-potential method. In this method, current is passed through the earth electrode, and the potential difference is measured between two auxiliary electrodes placed in the soil. Using Ohm's law, the resistance of the earth electrode is calculated.

The formula used is:

$R = V / I$

Where:

- R = Earth resistance (Ohms)
- V = Voltage measured
- I = Current flowing

Lower earth resistance indicates a better grounding system.

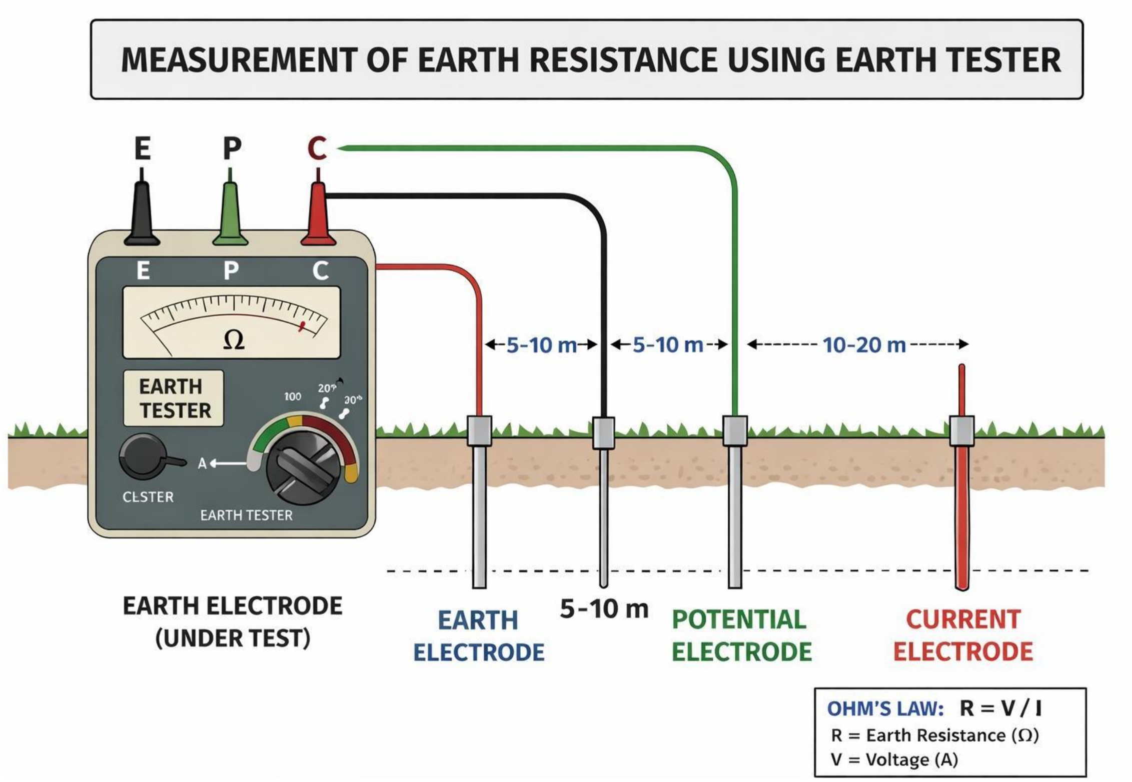
Practical Set-up / Circuit Diagram

You can draw this in your notebook based on the description:

- Three electrodes are used:

1. Earth Electrode (E) – Under test
2. Potential Electrode (P) – Placed at some distance
3. Current Electrode (C) – Placed farther away

- Connections:
  - Earth tester terminal **E** → Earth electrode
  - Terminal **P** → Potential electrode
  - Terminal **C** → Current electrode



Apparatus Required:-

1 Earth tester (Megger type)

2 Earth electrodes (rod or plate)

3 Connecting wires

4 Hammer (to fix electrodes)

5 Measuring tape

6 Water (optional, for better soil conductivity)

Precautions to be Followed:-

1 Ensure proper and tight connections.

2 Electrodes should be placed at proper distance to avoid overlapping resistance zones.

3 Avoid testing during dry soil conditions unless necessary.

4 Keep electrodes firmly fixed in the ground.

5 Do not touch terminals while taking readings.

6 Ensure the tester is properly calibrated before use.

Procedure:-

1. Insert the earth electrode (E) into the ground.
2. Place the potential electrode (P) at a suitable distance (usually 5–10 m).
3. Place the current electrode (C) farther away (10–20 m).
4. Connect the electrodes to the earth tester terminals E, P, and C.
5. Rotate the handle of the earth tester (for manual type) to generate current.
6. Note the reading shown on the scale.

7. Repeat the measurement by slightly changing the position of the potential electrode.

8. Take the average of readings for accuracy.

Observations and Calculations:-

S. No.	Voltage (V)	Current (I)	Resistance R = V/I (Ω)
1			
2			
3			

Average Earth Resistance:

$R = (R1 + R2 + R3) / 3$

Result:-

The earth resistance of the given grounding system is found to be:

R = Ω

Viva Book:-

1. Explain the working principle of an earth tester.

2. Explain the role of auxiliary electrodes in earth resistance measurement.

3. Differentiate between earthing and grounding.

4. What is the function of current and potential electrodes?

5. Define electrical safety.

EXPERIMENT NO:20

Aim:-

To determine the value of unknown inductance using a Maxwell inductance-capacitance bridge.

Theory:-

Maxwell's bridge is an AC bridge used to measure unknown inductance by comparing it with a known capacitance and resistances. It is based on the principle of balance condition of a bridge circuit, where no current flows through the detector.

The bridge consists of four arms:

- One arm contains the unknown inductance (Lx) with resistance (Rx)
- One arm contains a standard capacitor (C)
- The other two arms contain known resistances

At balance condition:

Lx = R2 × R3 × C

Rx = R1 × (R3 / R4) *(depending on configuration)*

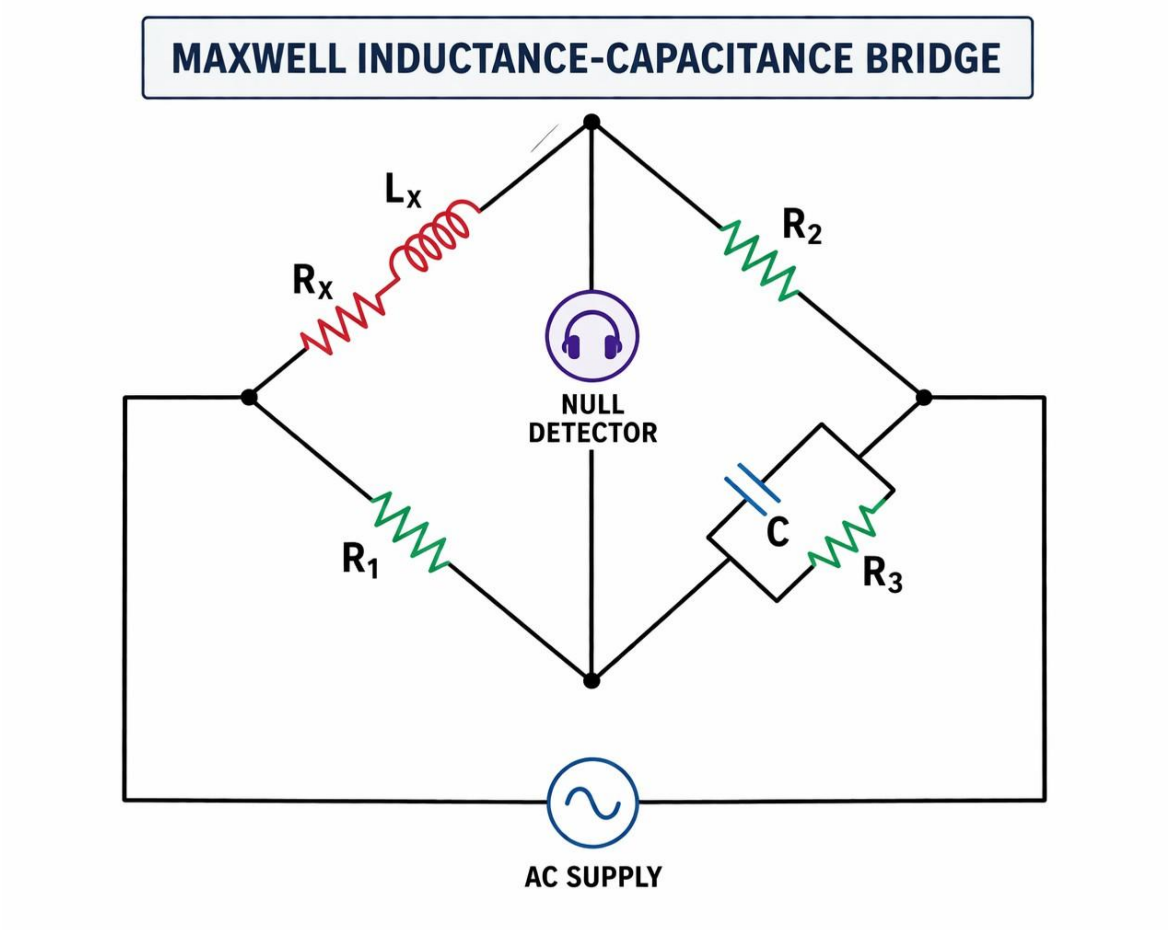
The advantage of this bridge is that it does not require a standard inductor, making it practical and accurate.

Practical Set-up / Circuit Diagram ***(14 px)***

Draw the circuit with:

- Four arms of the bridge
- Unknown inductance (Lx, Rx) in one arm

- Standard capacitor (C) in parallel with resistor (R3)
- Ratio arms with resistors R1 and R2
- AC supply connected across opposite corners
- Headphones or galvanometer connected across the other two corners



Apparatus Required;-

1. Maxwell inductance-capacitance bridge
2. Standard capacitor
3. Known resistors (R1, R2, R3, R4)

4 AC supply

5 Null detector (headphones/galvanometer)

6 Connecting wires

Precautions to be Followed:-

1 Ensure all connections are tight and correct.

2 Use a stable AC supply.

3 Avoid stray magnetic fields near the circuit.

4 Keep the capacitor leakage minimal.

5 Take readings only after achieving perfect balance.

6 Do not disturb the circuit once balanced condition is reached.

Procedure:-

1. Connect the circuit as per the Maxwell bridge diagram.
2. Switch on the AC supply.
3. Adjust the resistances (R2, R3, R4) to obtain null deflection in the detector.
4. Achieve balance condition where no sound/current is detected.
5. Note the values of resistances and capacitance at balance.
6. Repeat the experiment for different values to ensure accuracy.

Observations and Calculations:-

S. No.	R2 (Ω)	R3 (Ω)	C (μF)	Lx = R2×R3×C (H)
1				
2				
3				

Average Inductance:

Lx = (L1 + L2 + L3) / 3

Result:-

The value of the unknown inductance is found to be:

Lx = H

Viva Book:-

1. Differentiate between inductance and capacitance.
2. Define impedance.
3. Explain how unknown inductance is measured using Maxwell bridge.
4. What is meant by balance condition in AC bridges?
5. Explain the working principle of Anderson bridge.