LABORATORY MANUAL
BASIC ELECTRICAL ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Jorhat Engineering College

Jorhat, Assam – 785007

STUDENT PROFILE
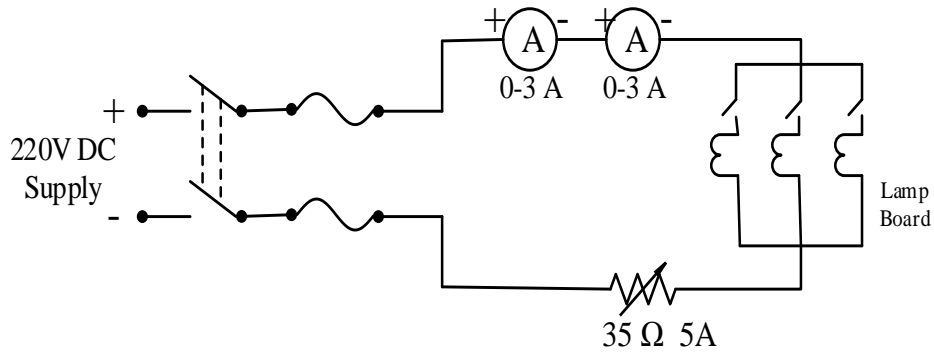
NAME	
ROLL NUMBER	
SECTION	
SEMESTER	
YEAR	

PERFORMANCE RECORD

Sl. No.	EXP. NO	TITLE OF THE EXPERIMENT	DATE	REMARKS/ GRADE

FOR OFFICE USE ONLY

Checked By:	
Overall Grade/ Marks	
Signature of the Teacher	

Title: Calibration of Ammeter

Objective: To compare the readings of an ammeter (M.C. or M.I.) with those of a substandard one and hence to draw the, (a) calibration curve and, (b) correction curve.

Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation:

Sl. No.	Readings of		Error ($A_T - A_s$)	Correction = - Error
	Ammeter under test (A_T)	Substandard Ammeter (A_s)		
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Theory: Calibration of Voltmeter, Ammeter and Wattmeter is the process of checking the accuracy of the reading of the ammeter under test (A_T) by comparing it with the standard (A_S) one. In other words, calibration checks the correctness of the instrument by comparing it with the reference standard. The various types measuring standards available are given as below.

International Standards: These standards are defined by an international agreement. These standards are accurate to the extent the production and measurement technology of the time allow. These are periodically evaluated by absolute measurement in terms of fundamental units. These international standards are kept and maintained at International Bureau of Weights and Measures at Paris. These are not available to ordinary users even for the purpose of calibration.

Primary/Basic Standards: National standards laboratories are responsible for keeping in maintaining the primary standards. The primary standards are independently measured by absolute measurements of the national laboratories. The result of measurements at various national laboratories are compared amongst themselves. This brings out an average figure for primary standards all over the world. These are available for calibration purpose outside the national laboratories. However the basic purpose of maintaining the primary standards remains the verification/calibration of secondary standards.

Secondary Standards: These are calibrated with the primary standards. They are maintained by involved industries. They are sent to national laboratories for calibration and certify periodically.

Working Standards: These are used to further calibrate the instruments which are made for the users. These type of standards can be named as sub-standards.

The need for calibration arises out of two reasons. First, because of continuous use of laboratories/industries, any instrument may develop some fault/ detect due to which it starts giving wrong results. Second, the instrument is tested for its quality at the time of procurement. By calibration, we mean to record the actual value of the quantity under measurement (by sub-standard meter) and the value given by the meter under test. If the two readings are same to the accuracy desired, then the meter under test can be taken is correct, otherwise, calibration and correction curve are plotted as an outcome calibration.

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the lamp load in off position and also keep the rheostat to its maximum position.
3. Both the meters should be zero initially and then switch-on the supply.
4. Switch on the lamps in steps till the end scale of the ammeter. If full scale is not covered, then adjust the rheostat.
5. Note down readings in both the meters by switching off the lamps in different steps upto zero reading.
6. Switch-off the supply.

Report:

1. Draw the Calibration curve (A_T vs. A_S) and Correction curve (A_T vs. Correction).

2. What are the various errors in the moving coil and moving iron instruments?
3. What does calibration mean? What is standard calibration curve?
4. What does variable resistor mean?
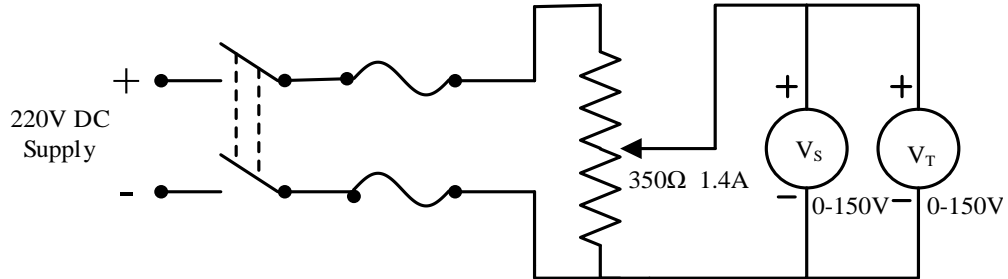5. What do you mean by substandard instrument?

Signature of the Class Teacher

Title: Calibration of Voltmeter

Objective: To compare the readings of a Voltmeter (M.C. or M.I.) with those of a substandard one and hence to draw the, (a) Calibration curve and, (b) Correction curve.

Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation:

Sl. No.	Readings of		Error $(V_T - V_s)$	Correction = - Error
	Voltmeter under test (V_T)	Substandard Voltmeter (V_s)		
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Theory: **As same as 1(a)**

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the potential difference in its minimum potential position.
3. Both the meters should be zero initially and then switch-on the supply.
4. Increase the potential difference gradually till the end of the scale of the voltmeter.
5. Note down readings in both the meters now by decreasing the potential difference upto zero value.
6. Switch-off the supply.

Report:

1. Draw the Calibration or Characteristic or Standard curve (V_T vs. V_S)
2. Draw the Correction curve (V_T vs. Correction).
3. What is meant by voltmeter?
4. How the voltmeter be calibrated with DC potentiometer?
5. What is the principle of potentiometer?

Signature of the Class Teacher

Title: Calibration of milli-ammeter as Voltmeter

Objective: To calibrate the milli-ammeter as an voltmeter with the help of a substandard voltmeter and hence to draw the,

a) Calibration Curve
b) Correction Curve
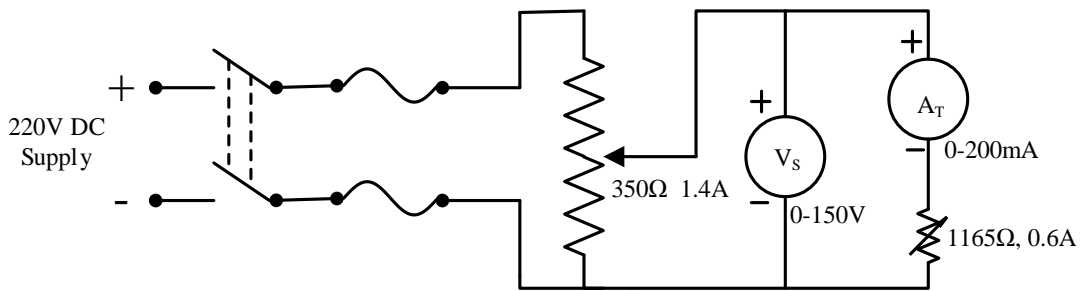
Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation:

Equivalent Constant or Multiplying Factor   : $k = \dfrac{I_n}{V_n}$

Sl. No.	Substandard Voltmeter Reading, V (Volts)	Milliammeter Reading, I (mA)	Equivalent Voltage, $V_{eq} = k.\,I_{eq}$ (Volts)	Error in Voltage, $(V_{eq} - V)$ (Volts)	Correction in Current = - (Error) (Volts)
1					
2					
3					
4					
5					
6					

7				
8				
9				
10				
11				
12				
13				
14				
15				

Theory: Ohm's law enables us to use a milli-ammeter as a voltmeter. Ohm's law states that the ratio of potential difference (V) between any two points on a conductor to the current (I) flowing between them, is, constant, provided the temperature of the conductor does not change. In other words, $\frac{V}{I} = \boldsymbol{Constant\ or}\ \frac{V}{I} = \boldsymbol{R}$, where R is the resistance of the conductor between the two points considered.

Since the coil obeys Ohm's law, the current through it is proportional to the potential difference across it and since the deflection of the pointer is proportional to the current, it is therefore also proportional to the potential difference. Thus the instrument can be used as a voltmeter giving full-scale deflection. The resistance R is also called as a multiplier. Many voltmeters contains a series of multipliers of different resistances, which can be chosen by a switch or plus-and-socket arrangement.

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the potential divider in its minimum potential position and adjust the rheostat in series with the milli ammeter in its maximum position.
3. Both the meters should be zero initially and then switch-on the supply.
4. Increase the potential difference gradually and at the same time adjust the series rheostat carefully such that both the meters show maximum deflection as desired.
5. Note down the readings in both the meters by gradually decreasing the potential difference upto zero value.
6. Switch-off the supply.

Report:

1. Draw the Calibration curve (mA vs. V).
2. Draw the Correction curve (V_{eq} vs. Correction).
3. How do you convert milli-ammeter to voltmeter?
4. How do you convert ammeter to Milli ammeter?
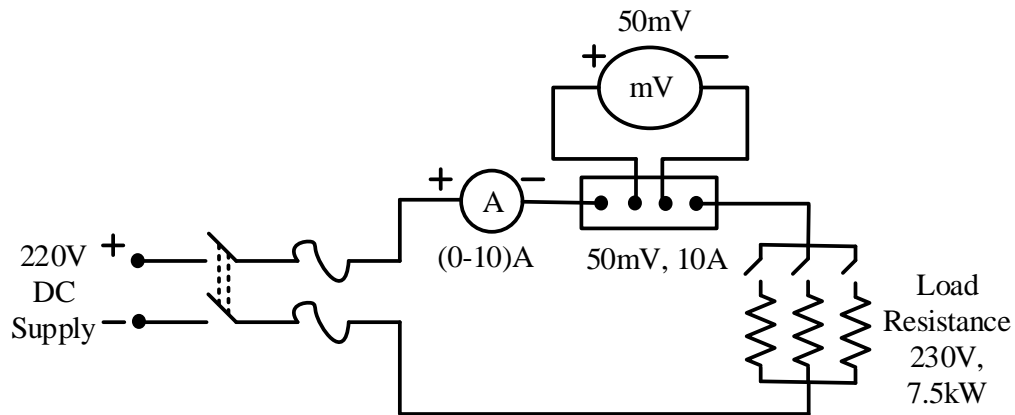
Signature of the Class Teacher

Experiment No: 3

Title: Calibration of milli-voltmeter as Ammeter

Objective: To calibrate the milli-voltmeter as an ammeter with the help of a substandard ammeter and hence to draw the,

   c) Calibration Curve
   d) Correction Curve

Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation:

Equivalent Constant   : $k = \dfrac{I_n}{V_n}$

Sl. No.	Substandard Ammeter Reading, I (A)	Millivoltmeter Reading, V (mV)	Equivalent Current, $I_{eq} = k.V_{eq}$ (A)	Error in Current, $(I_{eq} - I)$ (A)	Correction in Current = - (Error) (A)
1					
2					
3					
4					

5					
6					
7					
8					
9					
10					
11					
12					

Theory: Voltmeter measures voltage drop across resistance by putting it in parallel to the resistance. The internal resistance of a voltmeter is quite high and, therefore, when connected in parallel the current through the voltmeter is quite small. This keeps the current flowing through the resistance R almost the same as when the voltmeter was not connected. Hence, the voltage drop measured across the resistance by a voltmeter is also almost the same as the voltage drop without the voltmeter across the resistance

On the other hand, ammeter measures current through resistance by connecting it in series with the resistance. An ammeter has very low resistance and changes the effective resistance of the circuit only by a tiny amount, not altering the original current by too much. Therefore, the current measured by the ammeter is about the same as without the ammeter in the circuit.

The internal resistance of a voltmeter is much greater than ammeter, for conversion to ammeter we need to decrease the voltmeter's internal resistance by adding appropriate shunt i.e. resistance in parallel to the meter.

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the lamp load in off position.
3. Both the meters should be zero initially and then switch-on the supply.
4. Switch on the lamps in steps till the end of the scale of the milli voltmeter. The ammeter in series may not show the full scale deflection.
5. Switch off the lamps in different steps and note the readings in both the meters upto zero value.
6. Switch off the supply.

Report:

1. Draw the Calibration curve (mV vs. I).
2. Draw the Correction curve (I_{eq} vs. Correction)
3. How do you convert milli-voltmeter into ammeter?
4. Does ammeter have high resistance?
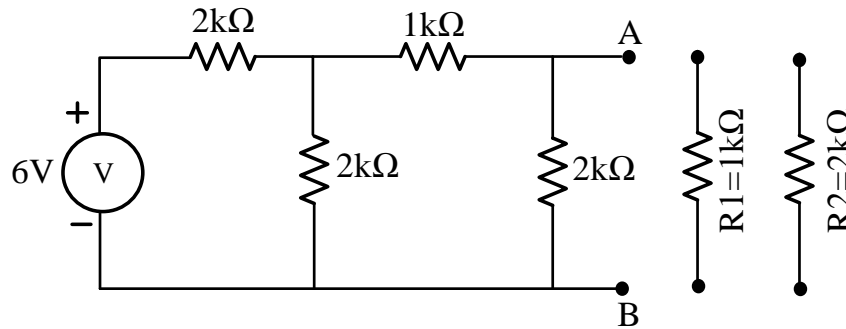5. What is a DC shunt?

Signature of the Class Teacher

Title: Verification of Thevenin's Theorem

Objective: To verify the Thevenin's Theorem with the help of an electronic trainer.

**Circuit Diagram**: Draw the circuit diagram from the apparatus supplied.

Experimental Observation:

      OC voltage (Thevenin's Voltage, V_{th})   :
      Thevenin's Resistance (R_{th})   :

Sl. No.	Load Resistance (kΩ)	Measured Current (mA)	Calculated Current (mA)	Remarks
1	R_{L1}			
2	R_{L2}			
3	$R_{L1} + R_{L2}$			
4	$R_{L1} \parallel R_{L2}$			

Theory: It provides a mathematical technique for replacing a given network, as viewed from two output terminals, by **a single voltage source with a series resistance**. Thevenin's theorem as applicable to D.C. circuits, may be stated as below. The current flowing through a load resistance R_L connected across any two terminals A and B of a linear, active bilateral network is given by $V_{OC} \parallel (R_i + R_L)$ where V_{OC} is the open circuit voltage (i.e. voltage across the two terminals where R_L is removed) and R_i is the internal resistance of the network as viewed back into the open-circuited network from terminals A and B with all voltage sources replaced by their internal resistance (if any) and current sources by infinite resistance.
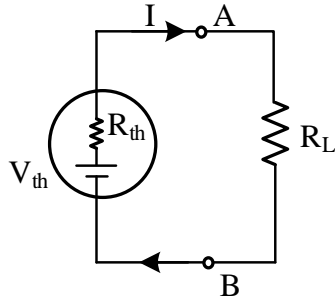
$$I = \frac{V_{th}}{R_{th} + R_L}$$

Procedure: (Refer to the network trainer)

1. Connect the voltage source to A and B.
2. Measure the OC voltage between A & B.
3. Calculate the Thevenin's equivalent resistance, R_{th}.
4. Connect R_{L1} to AB and measure the current through it.
5. Repeat step 4 with R_{L2}.
6. Repeat step 4 with R_{L1} and R_{L2} in series and parallel.

Report:

1. Show the calculations (add extra pages if needed).
2. What is a network theorem?
3. What is difference between circuit and network?
4. What are the application of Thevenin's theorem?
5. What are the limitations of Thevenin's theorem?
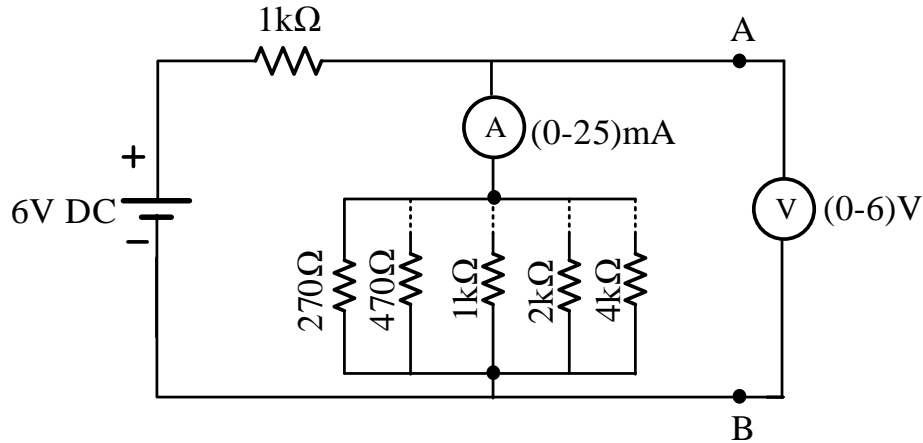
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Signature of the Class Teacher

Title: Verification of Maximum Power Transfer Theorem

Objective: To verify the Maximum Power Transfer Theorem with the help of an electronic trainer.

Circuit Diagram: Draw the circuit diagram from the apparatus supplied.

1kΩ
A

A (0-25)mA

6V DC +
−

270Ω 470Ω 1kΩ 2kΩ 4kΩ

V (0-6)V

B

Experimental Observation:

OC voltage (Thevenin's Voltage, V_{th})   :
Thevenin's Resistance (R_{th})   :

| Sl. No.	Load Resistance (Ω)	Voltmeter reading, V (Volts)	Ammeter Reading, I (mA)	Power dissipated, P=V*I	Remarks
1					
2					
3					
4					
5					

Theory: As applied to D.C. networks, this theorem may be stated as below,

A resistive load will abstract maximum power from a network when the load resistance is equal to the resistance of the network as viewed from the output terminals, with all energy sources removed leaving behind their internal resistance.

In the Fig. shown below, a load resistance R_L is connected across the terminals A and B of the network which consists of a generator of e.m.f. E and internal resistance of R_g and, a series resistance of R which, in fact, represents the lumped resistance of the connecting wires. Let, $R_i =$

(R_g+R) = internal resistance of the network as viewed from A and B. According to the theorem, R_L will abstract maximum power from the network when $R_L=R_i$

$$P_{max} = \frac{E^2}{4R_{th}} = \frac{E^2}{4R_L}$$
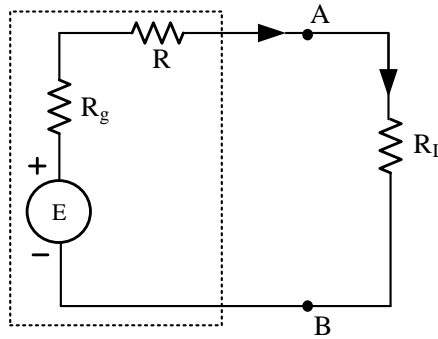
Procedure: (Refer to the network trainer)

1. Connect the voltage source to A and B.
2. Measure the OC voltage between A & B.
3. Calculate the Thevenin's equivalent resistance, R_{th}.
4. Connect R_{L1} to AB and measure the current through it.
5. Calculate $P_{L\,(max)} = V_{th}^2 / R_{L1}$
6. Calculate $P_{L\,(max)} = I_L^2 . R_{L1}$

Report:

1. Show the calculations (add extra pages if needed).
2. What is the condition for maximum power transfer theorem?
3. What is the load resistance?
4. Is load the same as resistance?
5. Is maximum power transfer theorem applicable to AC circuits?
6. What is the efficiency of transmitting power when the power transferred is at maximum?
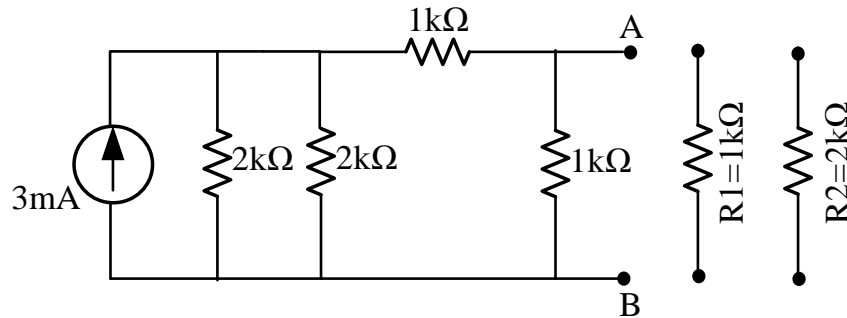
Signature of the Class Teacher

Title: Verification of Norton's Theorem

Objective: To verify the Norton's theorem with the help of and electronic trainer.

Circuit Diagram: Draw the circuit diagram from the apparatus supplied.


Experimental Observation:

S.C. Current   :   Thevenin's Resistance (R_{th})   :

Sl. No.	Load Resistance (kΩ)	Measured Current (mA)	Calculated Current (mA)	Remarks
1	R_{L1}			
2	R_{L2}			
3	$R_{L1} + R_{L2}$			
4	$R_{L1} \parallel R_{L2}$			

Theory: It is an alternative to Thevenin's theorem. Norton's theorem replaces the network by an equivalent constant-current source and a parallel resistance. This theorem stated that,

Any two terminal active network containing voltage sources and resistance when viewed from its output terminals, is equivalent to a constant-current source (I_{sc}) and a parallel resistance (R_N). The constant current is equal to the current which would flow in a short-circuit placed across the terminals and parallel resistance is the resistance of the network when viewed from these open circuited terminals after all voltage and current sources have been removed and replaced by their internal resistances.
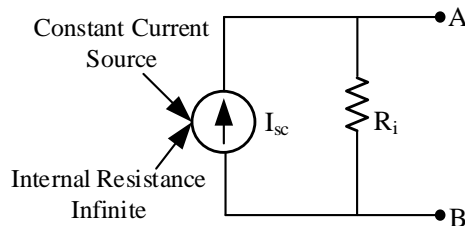
Procedure: (Refer to the network trainer)

1. Connect the current source to A and B.
2. Measure the short circuit current between A and B.
3. Calculate the Thevenin's equivalent resistance.
4. Connect R_{L1} to AB and measure the current through it.
5. Repeat step 4 with R_{L2}.
6. Repeat Step 4 with R_{L1} and R_{L2} in series and parallel.

Report:

1. Show the calculations for I_N, R_N, I_L.
2. What are the uses and limitations of Norton's theorem?
3. How do you verify Norton's Theorem?
4. What are the three main components in a circuit to be conducting?

$$\overline{\qquad\qquad\qquad\qquad\qquad\qquad}$$
Signature of the Class Teacher

Experiment No: 7

Roll No. of the Student:
Date of Experiment:

Title: Measurement of Power and Power Factor($Cos\ \Phi$) in a single phase R-L series circuit. (Three voltmeter method)

Objective: To measure the power dissipated in a single phase R-L series circuit and to calculate power factor of the circuit by voltmeter method. Also to draw phasor diagram for each reading and to find the value of power factors from it.

Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation:

Sl. No	Ammeter reading, I_1 (A)	Voltmeter reading, V_1 (Volts)	Voltmeter reading, V_2 (Volts)	Voltmeter reading, V_3 (Volts)	Power dissipated, $P = V_3 I_1 Cos\Phi$	Power Factor from		$Cos\theta$
						Calcul -ation	Vector diagram	

Theory: There is a very simple trick to measure CosΦ called *the **three voltmeters method***. We just need three AC voltmeters and a resistor. But in practice, we don't really need three voltmeter, we can get it by one only, and very often it's better to use one only. The three voltmeters method of determining the power factor is an attractive alternative to the home experimenter with limited equipment. Although, it is not easy to use as a true power analyzer and not as precise as an oscilloscope (properly equipped for high voltage measurements), but requires only a multimeter and a resistor.
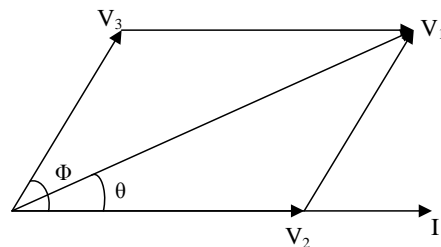
Since it is a series circuit, the current *I* should be taken as reference phasor. From the phasor diagram shown below, we can write, $V_1{}^2 = V_2{}^2 + V_3{}^2 + 2V_2V_3Cos\Phi$

Hence the power factor of the coil is, $Cos\Phi = (V_1{}^2 - V_2{}^2 - V_3{}^2)/ (2V_2V_3)$

The power consumed by the coil is, $P = V_3ICos\Phi$

Again, Cos θ is the power factor of the total circuit. It can be calculated as, $V_1 Cos\,\theta = V_2 + V_3Cos\Phi$

Hence, $Cos\,\theta = (V_2 + V_3Cos\Phi)/V_1$

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the rheostat at its maximum potential position and lamp load in off position.
3. All the meters should be zero initially and then switch-on the supply.
4. Decrease the resistance of rheostat so that voltmeter V_2 gives suitable reading as desired.
5. Switch on the loads at different steps and note the readings of all the instruments.
6. Change the position of the rheostat slightly and repeat the step 5 again.

7. Switch-off the supply.

Report:

1. Show the calculations for Cos Φ, Cos **θ** and P for each reading.
2. Draw the corresponding vector diagrams.

Signature of the Class Teacher

Title: Measurement of Power and Power Factor($Cos\, \Phi$) in a single phase R-L parallel circuit.

Objective: To measure the power dissipated in a single phase R-L parallel circuit and to calculate power factor of the circuit by ammeter method. Also to draw phasor diagram for each reading and to find the value of power factors from it.

Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation:

Sl. No	Ammeter reading, I_1 (A)	Ammeter reading, I_2 (A)	Ammeter reading, I_3 (A)	Voltmeter reading, V_1 (Volts)	Power dissipated, $P = V_1 I_3\, Cos\Phi$	Power Factor from Calcul-ation	Power Factor from Vector diagram	$Cos\theta$

Theory: In d.c. circuit power is given by the product of voltage and current, whereas, in a.c. circuit, it is given by the product of voltage, current and power factor. For this reason, power in an a.c. circuit is normally measured by wattmeter. However, this method demonstrates that the power in a single-phase a.c. circuit can be measured by using three ammeters.

Power consumed by the load, $P = VI_3 cos\Phi$. The phasor diagram of this circuit is given below. Since it is a parallel circuit, the voltage V is considered as reference phasor. From phasor diagram shown below, we can write, $I_1^2 = I_2^2 + I_3^2 + 2I_2I_3 cos\Phi$

Hence, power factor, $cos\Phi = (I_1^2 - I_2^2 - I_3^2)/2I_2I_3$

Power factor of the total circuit is, $cos\theta$. It is given as, $I_1 cos\theta = I_2 + I_3 cos\Phi$
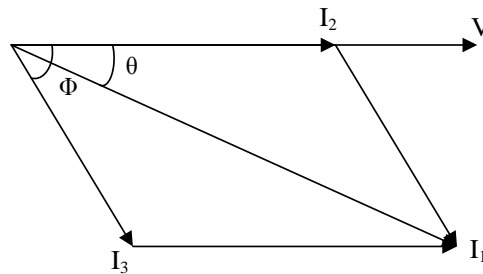
Hence, $cos\theta = (I_2 + I_3 cos\Phi)/I_1$

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the rheostat at its maximum potential position and lamp load in off position.
3. All the meters should be zero initially and then switch-on the supply.
4. Decrease the resistance of rheostat so that ammeter A₂ gives suitable reading as desired.
5. Switch on the loads at different steps and note the readings of all the instruments.
6. Change the position of the rheostat slightly and repeat the step 5 again.
7. Switch-off the supply.

Report:

1. Draw the vector diagram for each set of reading and find the power factor.

2. What is Henry? Two solenoids are kept co-axially at a little distance apart and current is sent through them. What will be the effect of changing the direction in (a) one of the coil, (b) both the coil.

Signature of the Class Teacher

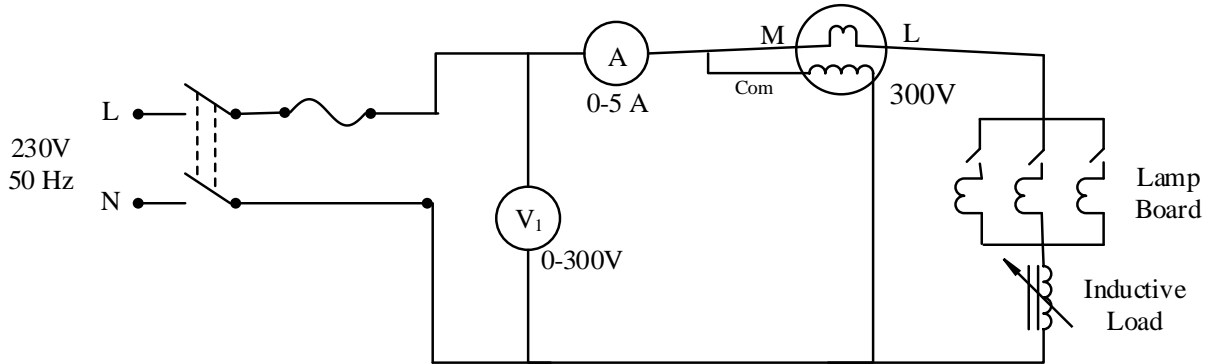**Title: Measurement of Power and Power Factor by Wattmeter.**

Objective: To measure the power dissipated in a single phase R-L circuit with the help of a wattmeter and find the power factor by measuring the voltage and current in the circuit.

Circuit Diagram:

List of Apparatus:

Sl. No	Apparatus Name	Range	Make	Maker's Name

Experimental Observation: Multiplying Factor of the Wattmeter = (Current coil rating X Voltage coil rating) / No. of scale division in Wattmeter, i.e. $k = \frac{I_n}{V_n}$

	Sl. No.	Voltage across the Load, V_L	Current through the Loads, I_L	Reading of Wattmeter, (div)	Power Dissipated, P (Watt)	Power Factor, $Cos\Phi = \frac{P}{V_L \cdot I_L}$
With Core	1					
	2					
	3					
	4					
	5					
Without Core	1					
	2					
	3					

| | 4 | | | | | |
| | 5 | | | | | |

Theory: A series R-L circuit will draw a current I when an alternating voltage of r.m.s. value V is applied to it. Suppose the current lags behind the voltage by Φ. The three powers drawn by the circuit are as under:

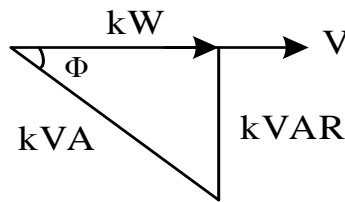a. **Active Power (P):** It is the power which is actually dissipated in the circuit resistance.
$$P = I^2.R = VIcos\Phi \text{ Watts.}$$

b. **Reactive Power (R):** It is the power developed in the inductive resistance of the circuit.
$$Q = I^2.X_L = VIsin\Phi \qquad VAR$$

c. **Apparent Power (S):** It is the product of r.m.s. value of applied voltage and circuit current.
$$S = VI = I^2.Z \qquad VA$$

Power Factor: It is defined as,

a. Cosine of the angle of lead or lag,

b. The ratio, $\dfrac{R}{Z} = \dfrac{RESISTANCE}{IMPEDANCE}$

c. The ratio, $\dfrac{TRUE\ POWER\ (P)}{APPARENT\ POWER\ (S)} = \dfrac{Watts}{Volt\ Ampere} = \dfrac{W}{VA}$

Procedure:

1. Connect the circuit as shown in the Figure.
2. Keep the lamp load in off position and rotate the wheel of the variable inductor to get with Core condition.
3. All the meters should be zero initially and then switch on the supply.
4. Switch on the loads at different steps and note the readings of all the instruments.
5. Switch off the loads and now rotate the wheel again to get without Core position.
6. Switch on the lamps at different steps again and note down the readings.
7. Switch-off the supply.

Report:

1. Show the calculations for P and $Cos\Phi$ for each reading.
2. Draw the vector diagrams for each set of readings.

Signature of the Class Teacher