Circuit Diagram

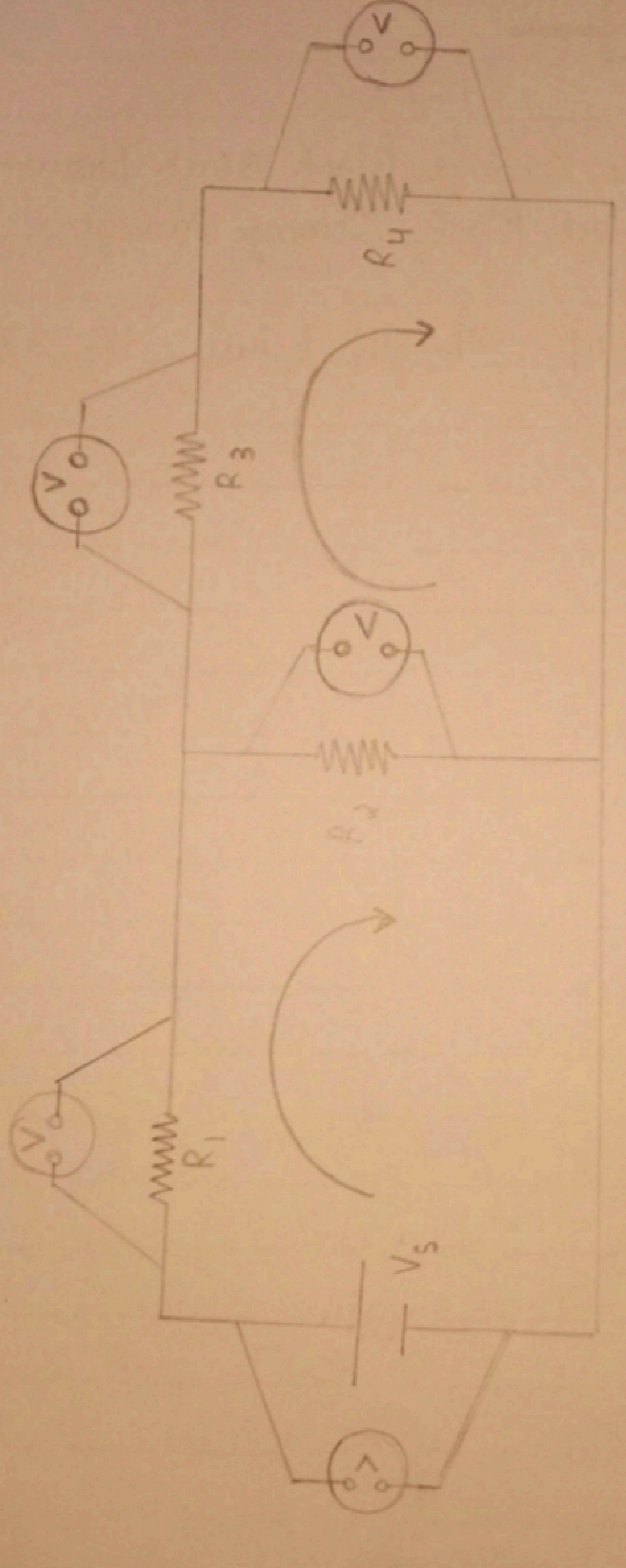

Fig. 1.1. Circuit diagram for verification of KVL

Experiment No. 1

Objective: To verify Kirchoff's voltage law (KVL) in D.C. circuits.

Apparatus Required: Breadboard, connecting wires, voltmeter and carbon resistors.

Theory:

Kirchoff's Voltage law (KVL): This law states that at any instant (time), the algebraic sum of the voltages taken in the same direction around a loop (closed path) is zero. In other words, the net voltage around a closed circuit is zero. Mathematically it can be expressed as:

$$\Sigma V_k = 0$$

This law is valid regardless of the direction in which loop is considered. It should also be noted that in a circuit, the direction of a loop does not have to be the same as the direction of current. However, the sign convention is very important.

Equations:

According to KVL, for the given circuit in loop 1:

$$V - I_1 R_1 - I_2 R_2 = 0$$

$$\text{or } V = I_1 R_1 + I_2 R_2$$

$$\text{or } V = V_1 + V_2$$

Similarily, for loop 2 :

$$I_2 R_2 = I_3 R_3 + I_3 R_4$$

Or $V_2 = V_3 + V_4$

Procedure:

1.) Connect the circuit as shown in circuit diagram.
2.) Switch on the power supply.
3.) Note the reading of Voltmeter

Observation Table:

S.No.	V_S (V)	V_1 (V)	V_2 (V)	V_3 (V)	V_4 (V)	$V_S = V_1 + V_2$	$V_2 = 3_4 + V_4$
1.	6V	1.69V	4.33V	2.25 V	2.06V	6.02V	4.31V

Result: The KVL is verified

Precaution:

1) All connection should be tight.
2) Before connecting the instruments check their zero reading
3) The terminals of the resistance should be properly connected.

Circuit Diagram

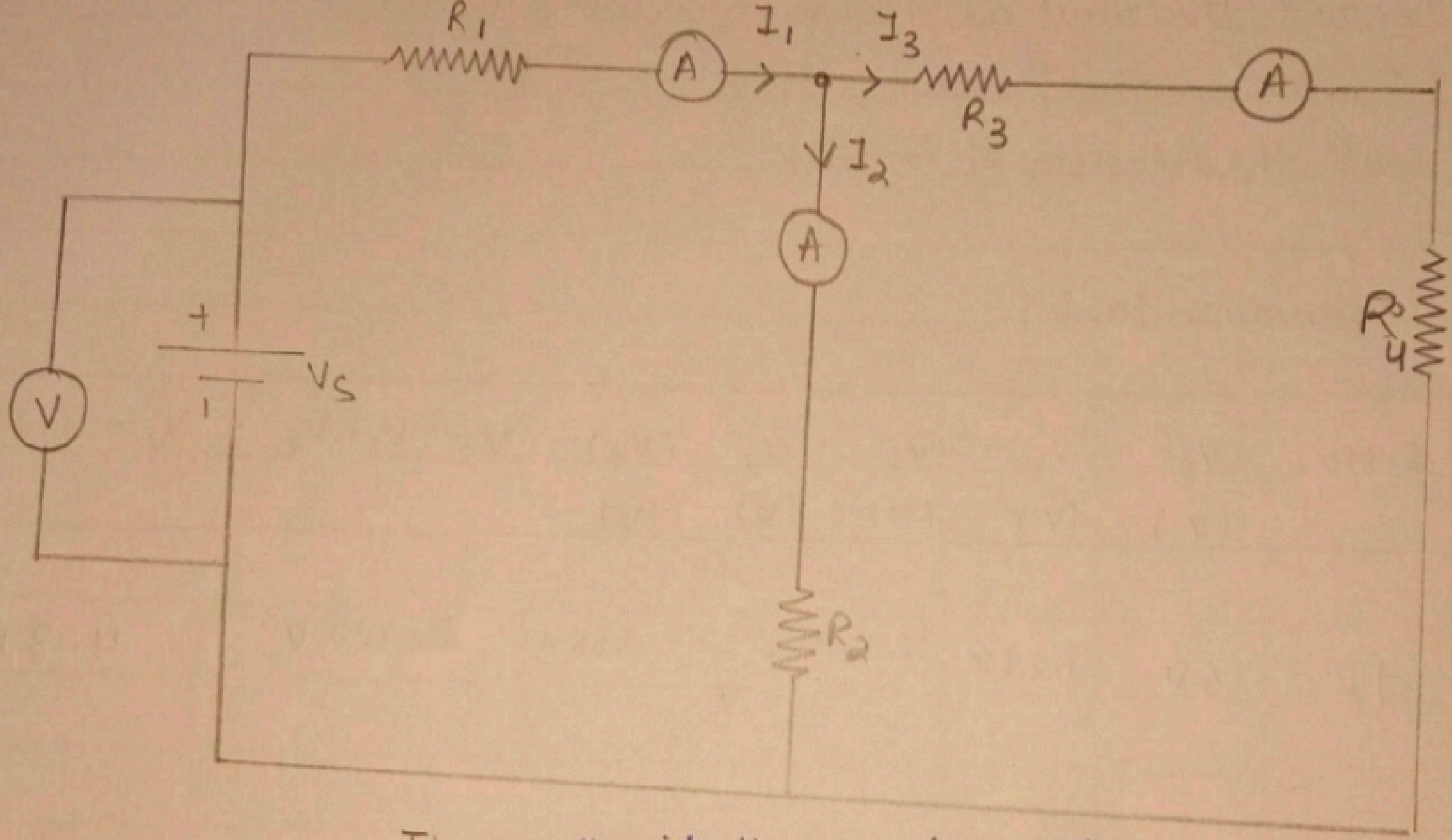

Fig. 2.1. Circuit diagram for verification of KCL

Experiment No. 2

Objective: To verify Kirchoff's Current law (KCL) in D.C. circuits.

Apparatus Required: Breadboard, connecting wires, ammeter and Carbon resistors.

Theory:

Kirchoff's current law (KCL): This law states that the algebraic sum of the currents into a node or a junction at any instant is zero. In other words, the sum of currents entering the node is equal to the sum of currents leaving the node. Mathematically, it can be expressed as

$$\Sigma I_k = 0$$

If the current leaving the node is taken as positive (+ve), then the current entering the node should be taken as negative (-ve) or vice versa.

Equations:

According to KCL, for the given circuit at node a:

$$I_1 = I_2 + I_3$$

Procedure:

1.) Connect the circuit as shown in circuit diagram.

2.) Switch on power supply

3.) Note the reading of ammeter.

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Observation Table

S. No.	V_S (V)	I_1 (mA)	I_2 (mA)	I_3 (mA)	$I_1 = I_2 + I_3$
1.	10 V	28.1 mA	15.5 mA	12.7 mA	28.2 mA

Result: The KCL is verified

Precautions:

1.) All connections should be tight.
2.) Before connecting the instruments check their zero reading
3.) The terminal's of the resistance should be properly connected.

Circuit Diagram

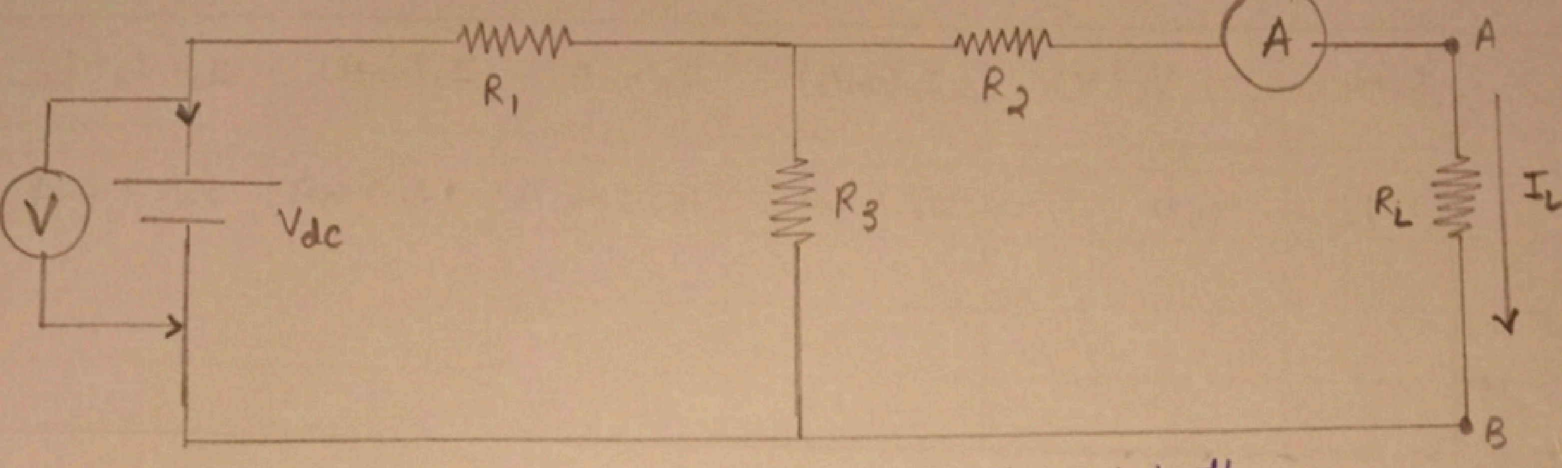

Fig. 3.1. Connection Diagram of Thevenin's theorem

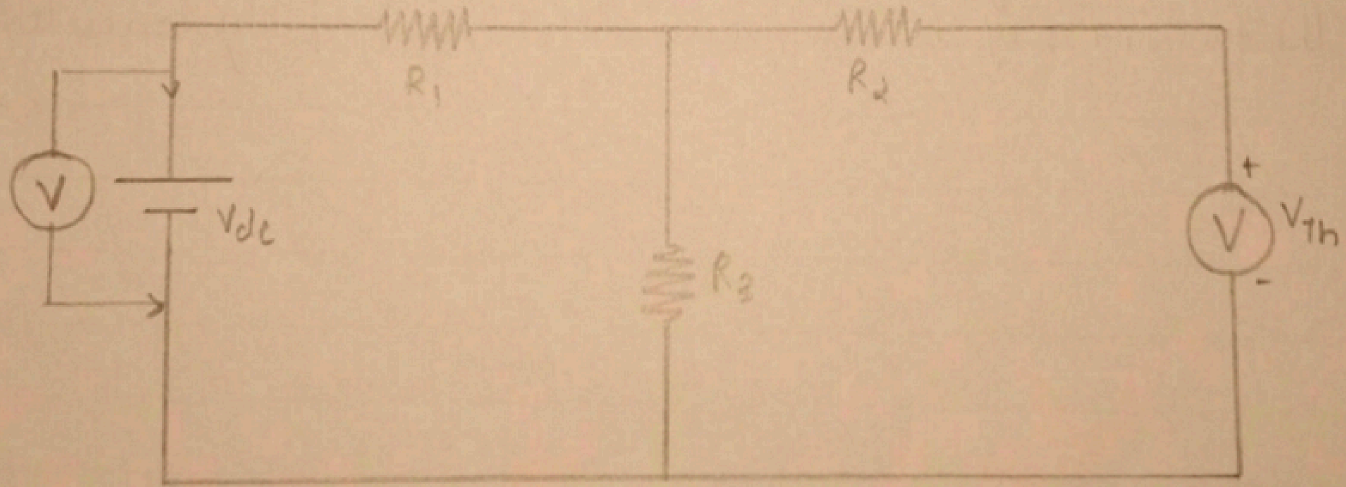

Fig. 3.2. Measurement of V_{Th}

Experiment No. 3

Aim: To verify Thevenin's theorem for DC circuits.

Theory: It states that, any two terminal, linear, bilateral network can be replaced by an equivalent circuit consisting of a voltage source in series with the resistance (impedance) seen from that terminals. The equivalent voltage source, V_{Th}, is the open circuit voltage between the terminals and equivalent resistance R_{Th}, ratio of the open circuit voltage to the short circuit current of these terminals. R_{Th} is also the resistance to measured by looking back into the network from the open circuit terminals by replacing all the sources by their internal resistances.

Formula: load current $I_L = V_{Th} / R_{Th} + R_L$

V_{Th} = Thevenin Voltage

R_{Th} = Thevenin resistance

R_L = load resistance

Apparatus Required:

S.No.	Name	Range / Value	Quantity
1.	D.C. Voltmeter	0-20V	1
2.	D.C. Ammeter	0-20mA	1
3.	Breadboard	–	1
4.	Connecting wires	–	

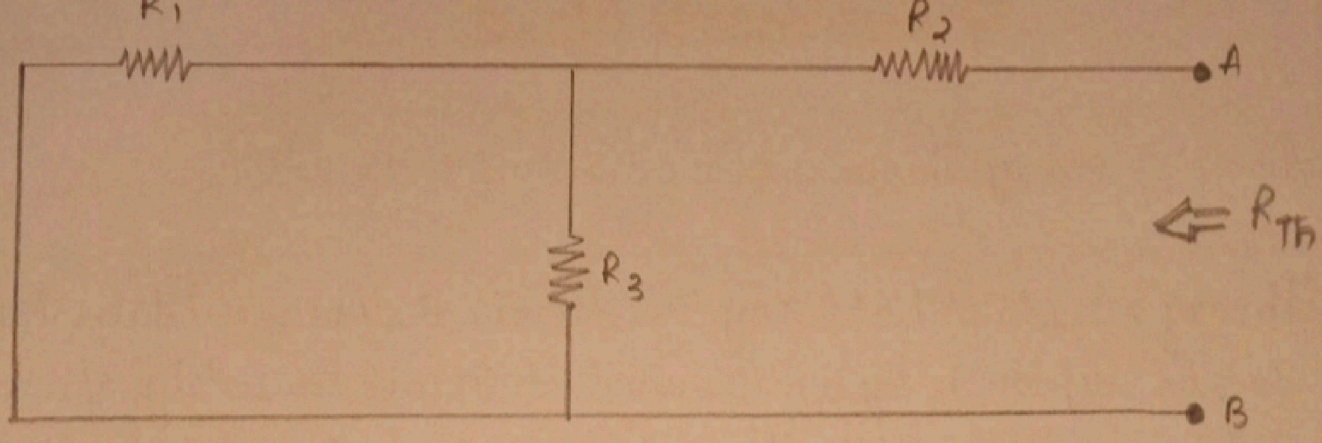

Fig. 3. 3. Measurement of R_{Th}

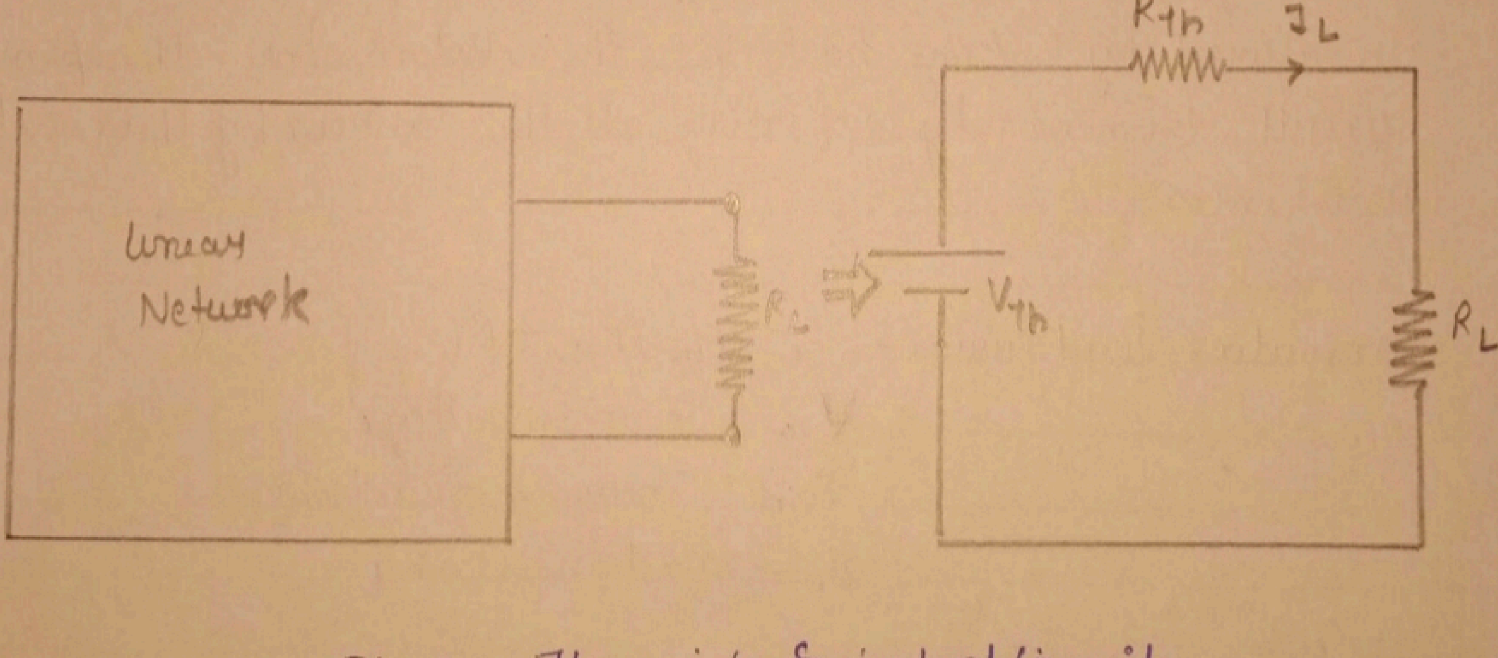

Fig. 3.4. Thevenin's Equivalent Circuit

5.	Carbon resisters	

Procedure:

1. The circuit is connected as shown in (Fig. 3.1).
2. Note the reading of ammeter which is load current in the circuit.
3. Find the open circuit voltage across the terminal AB when the load resistance is removed (Fig. 3.2)
4. Measure Thevenin's resistance by using (Fig. 3.2)
5. Compute the current flowing through R_L (Fig. 3.4) using the equation.

$$I_L = V_{th} / (R_{th} + R_L)$$

And compare the first reading.

Observation Table:

S.No.	Vdc (Volts)	I_L (mA)	R_L (Ω)	V_{th} (Volts)	R_{Th} (Ω)	$I_L = V_{th} / (R_{Th} + R_L)$ (mA)
1.	10V	3.60mA	217Ω	2.11V	355.79Ω ≈ 355Ω	2.11/(355+217) = 3.68mA

Conclusion: Hence, Thevenin's theorem is verified for DC circuits

Precautions:

1. As the input is on DC supply, use only the DC meters

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2.) Connet the D.C. meters with proper polarity.
3.) Complete the circuit as per the diagram.
4.) All connections must be tight and proper.

Circuit Diagram

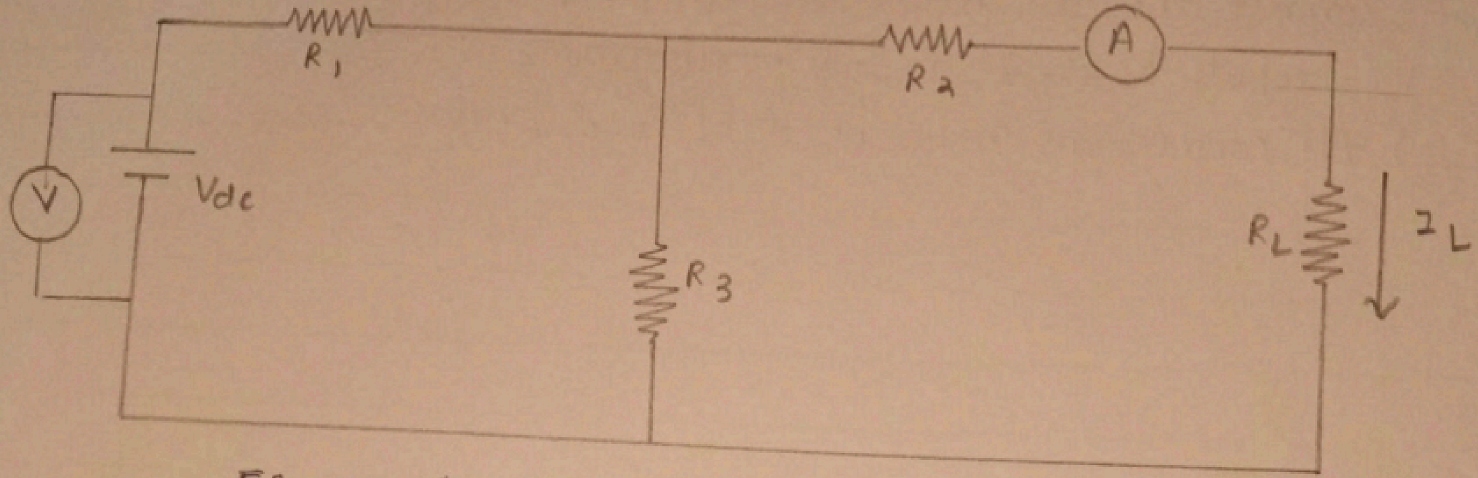

Fig. 4.1. Connection Diagram of Norton Theorem

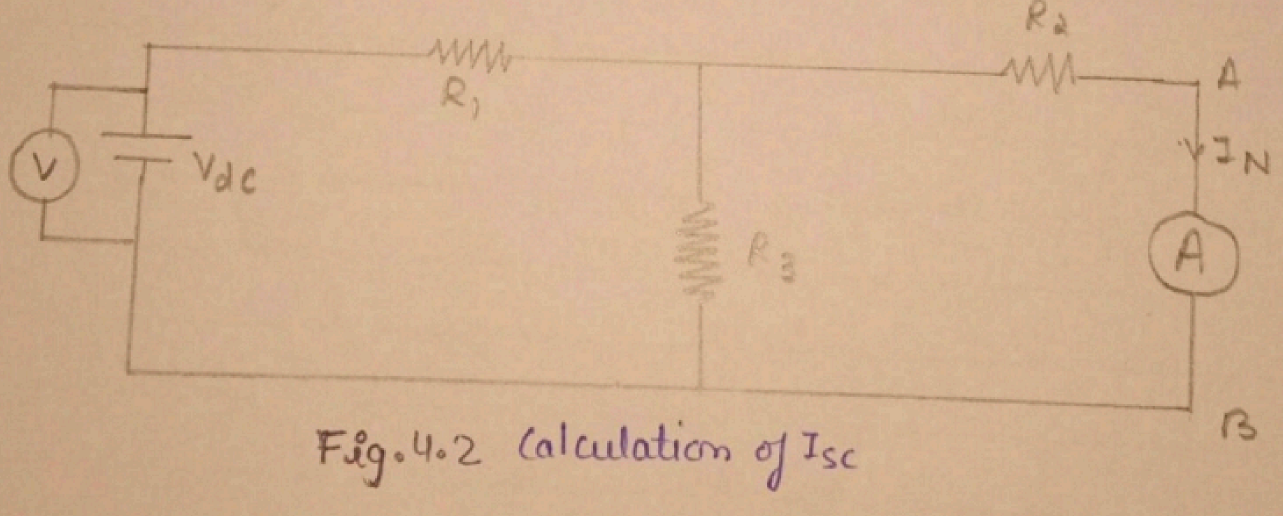

Fig. 4.2 Calculation of I_{sc}

Experiment No. 14

Aim : To verify Norton's theorem for DC circuits

Theory: It states that, in any linear, bilateral network consisting of many sources and impedances, current in any branch AB, is equal to current due to a single current source connected in parallel with a resistance/ impedance where, the single current source is the short circuit current flowing through in the branch AB, and the parallel resistance is the total resistance measured by looking back into the network from the terminals AB. While measuring all the sources are to be replaced by their internal resistances.

Formula :

$$I_L = I_{SC} \cdot R_N / (R_N + R_L)$$

where I_{SC} = Short circuit current

R_N = Norton Resistance

R_L = Load Resistance

Apparatus Required:

S. No.	Name	Range	Quantity
1	DC Voltmeter	0-20V	1
2	DC Ammeter	0-20mA	1
3	Breadboard	—	1

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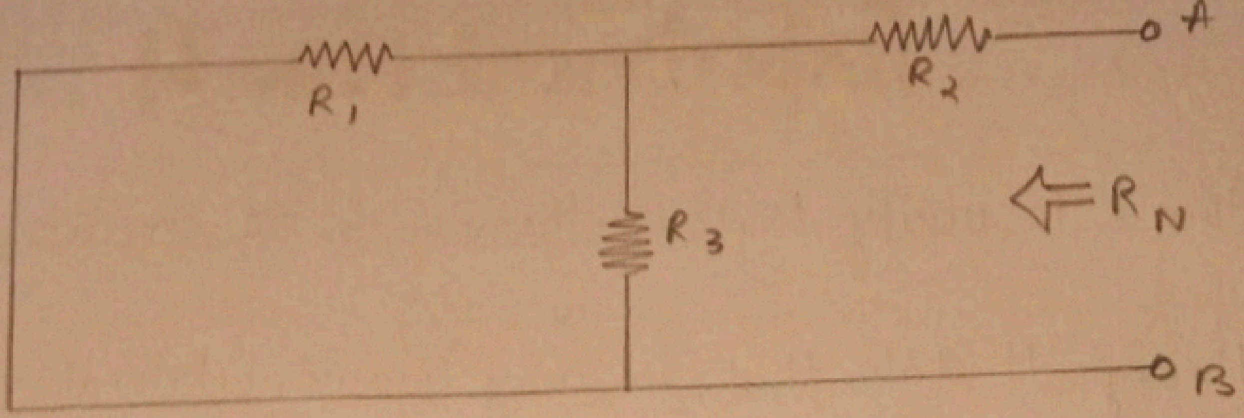

Fig. 4.3 Measurement of R_N

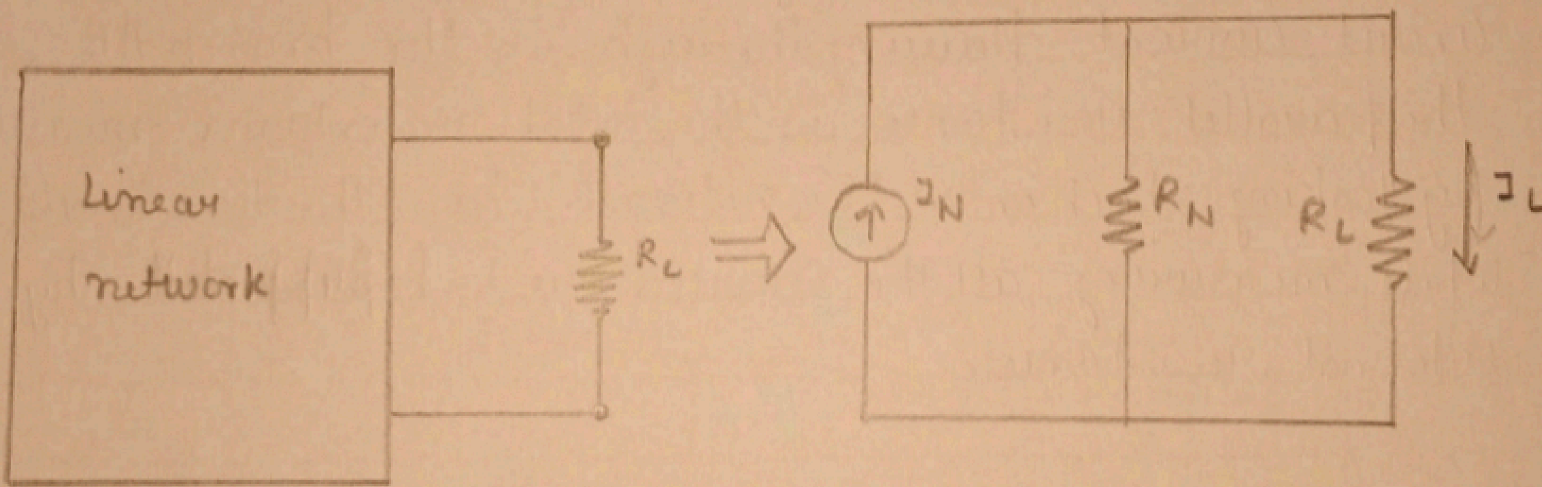

Fig. 4.4. Norton's Equivalent Circuit

4	Connecting wires	-
5	Carbon resistors	-

Procedure:

1) The circuit is connected as shown in fig. 4.1.
2) Note the reading of ammeter which is load current in the circuit.
3) Find the short circuit current through the terminal AB when load resistance is short circuited (fig 4.2).
4) Measure the Norton's resistance by using (fig. 4.3)
5) Compute the current flowing through R_L (fig. 4.4) using the equation.

$$I_L = I_{SC} . R_N / (R_N + R_L)$$

And compare with first reading

Observation Table:

S.No.	V_{dc} (volts)	I_L (mA)	R_L (Ω)	I_{SC} (mA)	R_N (Ω)	$I_L = I_{SC} . R_N / (R_N+R_L)$
1	10.11V	4.48 mA	235 Ω	8.33 mA	263 Ω	4.39 mA
2						
3						
4						

Conclusion: Hence, Norton theorem is verified for DC circuits te

Precaution:

(i) As the input is an DC supply, use only the DC meters

(ii) Connect the DC meters with proper polarity

(iii) Complete the circuit as per the diagram

(iv) All connections must be tight and proper

Circuit Diagram:

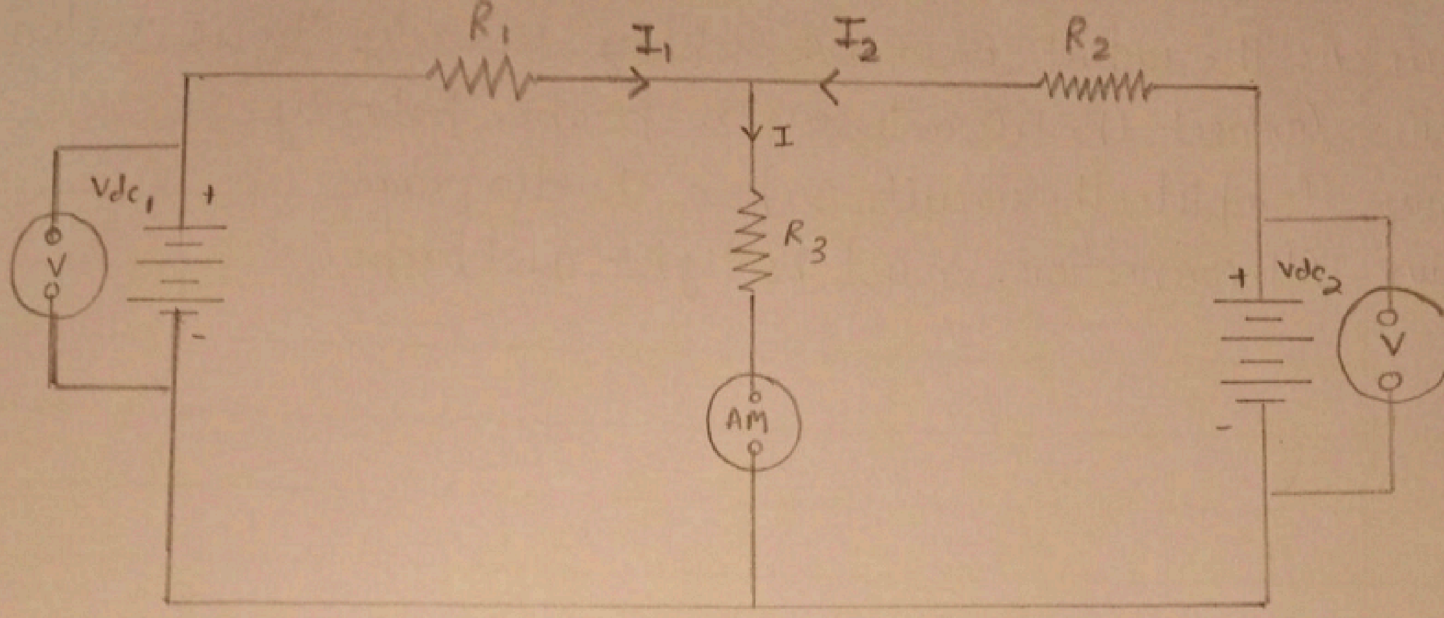

Fig. 5.1. Connection diagram of superposition theorem

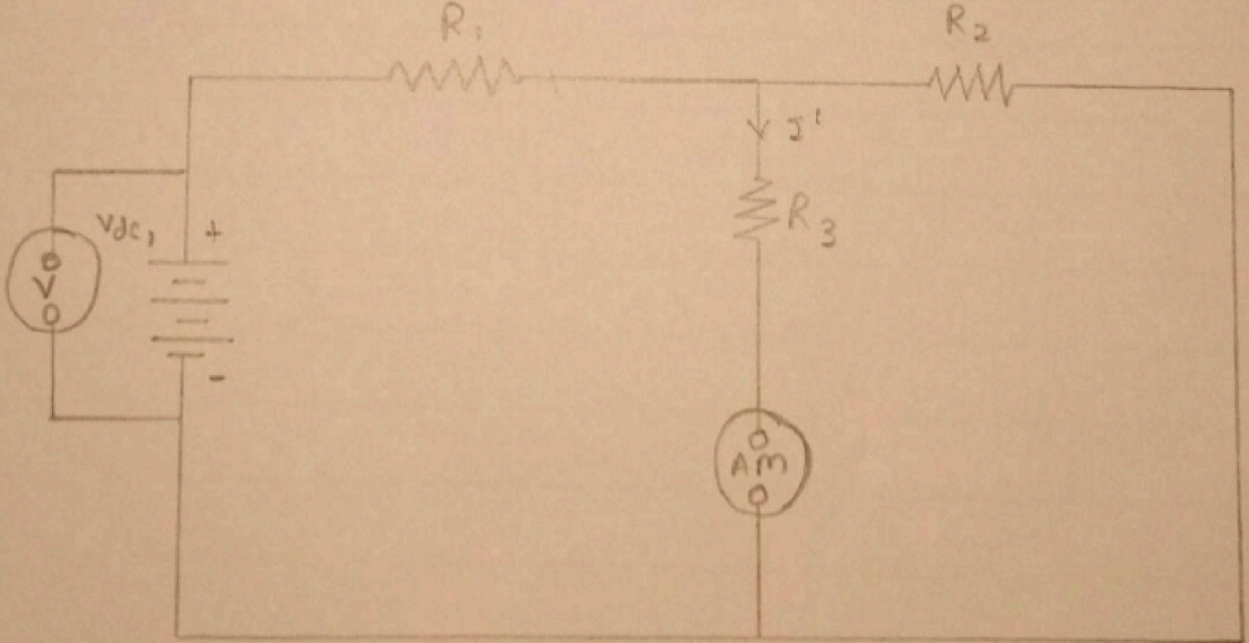

Fig. 5.2. Circuit diagram when V_1 source considered

Experiment No: 05

Aim:- To verify superposition theorem for D.C. Circuits.

Theory: In a linear bilateral network containing more than one source, the current flowing through any branch is the algebraic sum of the current flowing through that branch by considering one source at a time and replacing the other sources by their internal resistance.

Apparatus Required:

S. No.	Name	Range	Quantity
1	DC Voltmeter	0-20 V	1
2	DC Ammeter	0 - 20mA	1
3	Breadboard	-	1
4	Connecting wires	-	6
5	Carbon Resistors		

Procedure:

i) Connect the circuit as per the circuit diagram shown in (Fig. 5.1)

ii) Switch on the DC power supplies (V_1) and (V_2) say 5V and 10V and note down the corresponding ammeter reading I_0

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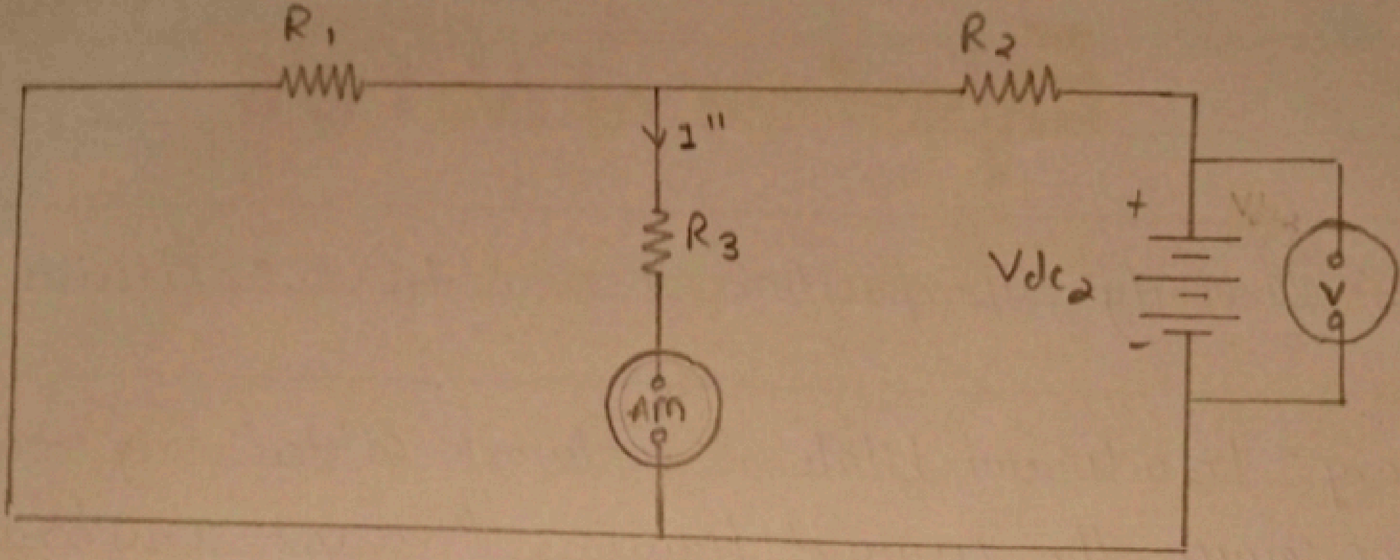

Fig. 5.3. Circuit diagram when V_2 source considered

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(iii) Replace the second power supply V_2 by short circuit (Fig. 5.2).

(iv) Switch on the power supply V_1 and note down the corresponding ammeter reading I_1.

(v) Connect the second power supply V_2 and replace V_1 power supply by short circuit (Fig. 5.3)

(vi) Switch on the power supply V_2 and note down the corresponding ammeter reading I_2.

(vii) Verify the following condition:

$$I = I_1 + I_2$$

Observation Table:

S.No.	V_1 (V)	V_2 (V)	I_1 (mA)	I_2 (mA)	Measured Value $I = I_1 + I_2$ (mA)	Calculated Value I (mA)
1.	4.97	10.18V	9.5mA	22.1mA	22.2 mA	22.2 mA

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Conclusion: Hence, Superposition theorem for given circuit is verified.

Precautions :-

(i) All connection should be tight and perfect.

(ii) Connect the DC meters with proper polarity.

(iii) Reading must be well within the range of the meters

Circuit Diagram :

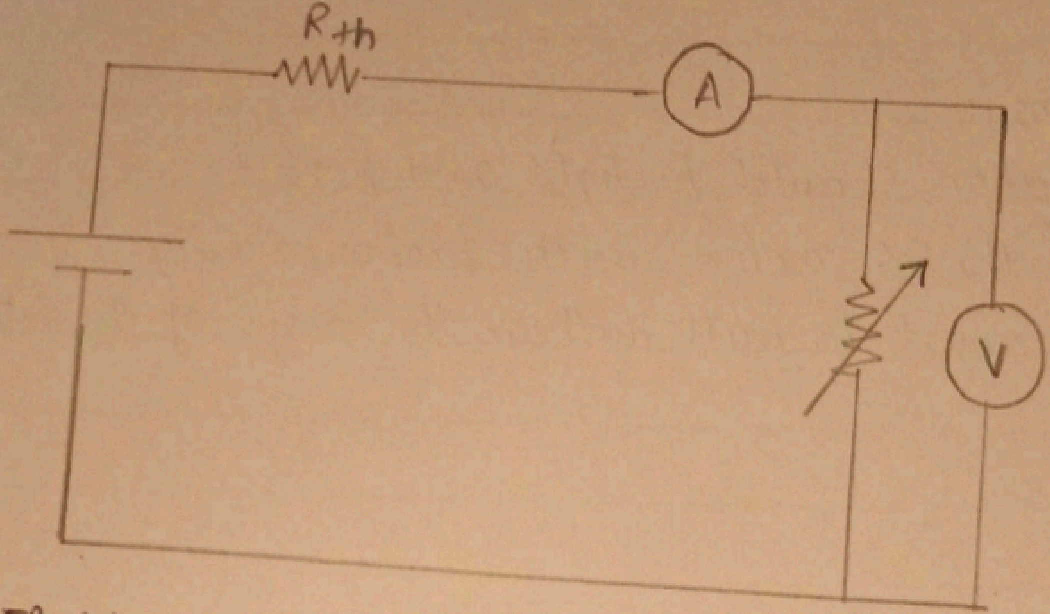

Fig.6.1. Connection Diagram of Maximum Power Theorem

Experiment No. : 6

Objective:- To verify maximum power transfer theorem in DC circuits.

Apparatus Required: Battery (dc Source), carbon (non-inductive) resistors, voltmeter, mili-ammeter, variable load resistor, and connecting wires.

Theory: Maximum power transfer theorem states that the load draws maximum power from the source, when the load resistance is equal to the internal resistance of the source.

At $R_L = R_{th}$, the power consumed by the load is maximum

The power in the load is given by

$$P = I_L^2 R_L = V_L^2 / R_L$$
$$= V_L I_L$$

Formula: Power $P = I_L^2 R_L = V_L^2 / R_L$ watt

where I_L = load current

R_L = load resistance

V_L = Voltage across the load

Procedure:

i) The circuit is connected as shown in fig. 6.1

(ii) R_{th} is fixed at some suitable value, for a particular value of R_L the ammeter (A) and voltmeter (V) reading are noted.

(iii) By varying the value of R_L from $R_L < R_{th}$ to $R_L > R_{th}$, the voltage across the load and current through the load are noted.

(iv) Now the power is calculated by using the formula

$$P = I_L^2 R_L = V_L^2 / R_L = V_L I_L$$

(v) for each value of current I_L or V_L take the value of R_L at the maximum power. If R_L value is equal to the internal resistance of source R_{th}, then the theorem is proved

Observation Table:

S. No.	Load Resistance (R_L) (Ω)	Voltage across load (V_L) Volts	Current through load (I_L) (mA)	$P_L = V_L I_L$ (watt)	R_{th} (Ω)
1.	100 Ω	1.98 V	15.02 mA	22.22	220Ω
	200 Ω	2.42 V	10.97 mA	26.54	220 Ω
	330 Ω	2.89 V	8.98 mA	25.95	220Ω

Result: It is found that power consumed is maximum when R_L becomes equal to R_{th}.
This verifies the maximum power transfer theorem

Precaution:
(i) The load resistance R_L is varied from $< R_{th}$ to $> R_{th}$.
(ii) Internal resistance of the source should be measured before going to the experiment.
(iii) All connections should be tight.

Circuit Diagram:

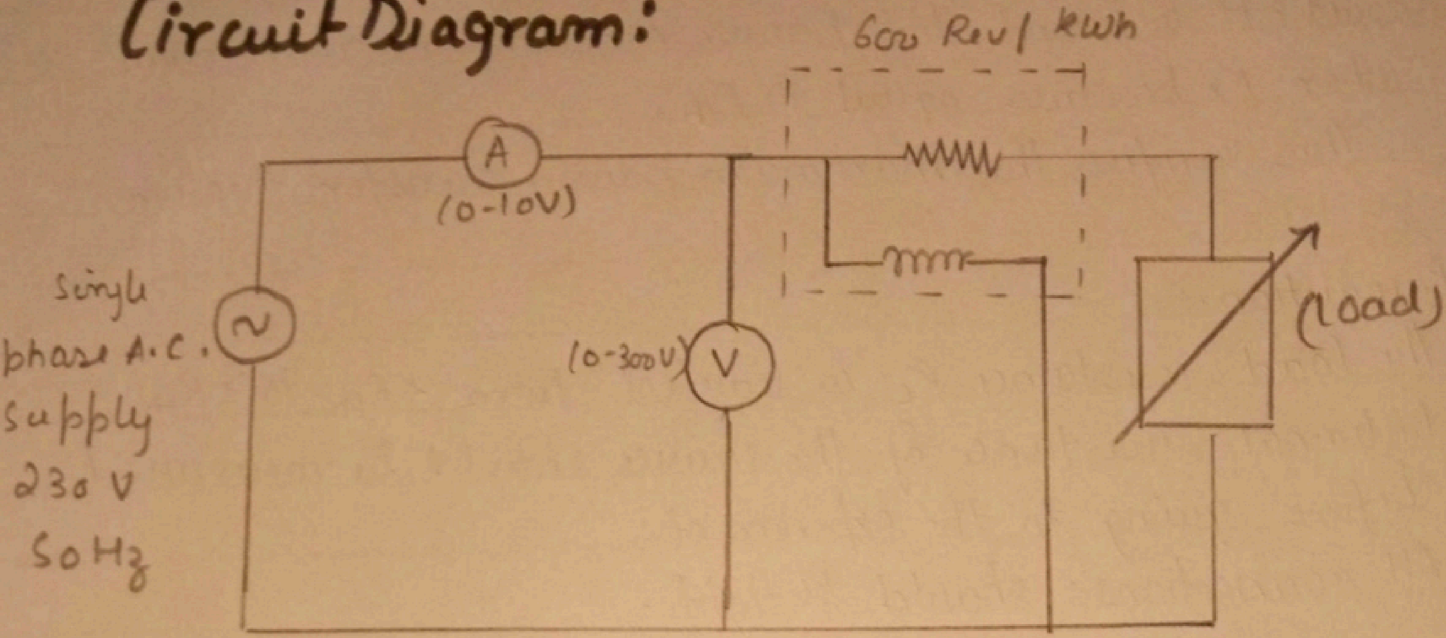

Fig. 7.1 Connection Diagram of ~~to~~ 1-ϕ Energy meter

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Experiment No.: 7

Aim: To find out the meter constant of a single phase energy meter.

Theory: "Energy meter is an integrating instrument which is used to record the energy consumed by the load during a given time period". The data mentioned on the name plate of the meter are as follows:

Number of phase - Single
Volts - 230/240/250 V
Frequency - 50 Hz
Current rating - 5/10/25 A
Energy meter constant - 600 Rev./kWh

Apparatus Required:

S.No.	Name	Range	Quantity
1.	DPIC (Double Pole Iron Clad) Switch	230V, 16A	1
2.	AC Voltmeter	0-300V	1
3.	AC Ammeter	0-10A	1
4.	Resistive Load (Bulbs)	100W	7
		200W	3
5.	Single Phase Energy Meter	240V, 10A, 50Hz 600 Rev/kWh	1

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Formula: Energy Meter Constant = (Number of revolutions made by disc) / (Energy Consumed)

Procedure:

(i) Note down the initial energy meter reading

(ii) Now switch on the lamp load.

(iii) Count the revolution of the energy meter disc from starting and continued for 5-10 minutes

(iv) Switch off the lamp load and note down the meter reading.

Observation Table:

Meter reading before switching on Load (kWh_1)	Meter reading after switching off load (kWh_2)	Number of revolution made by the disc N	Energy Consumed	Practical value	Error
515.19 kwh	515.25 kwh	25	0.04	625	

Calculation:

Energy Consumed = $kWh_1 - kWh_2$

Practical value = $N / (kWh_1 - kWh_2)$

Error = $\frac{(\text{Meter constant} - \text{Practical value}) \times 100}{\text{meter Constant}}$

Result: The calculated meter constant is ....

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Precautions:

(i) Take the readings carefully and accurately

(ii) Do not touch the live terminal during the experiment

(iii) Switch off the power supply after completing the experiment.

Circuit Diagram:

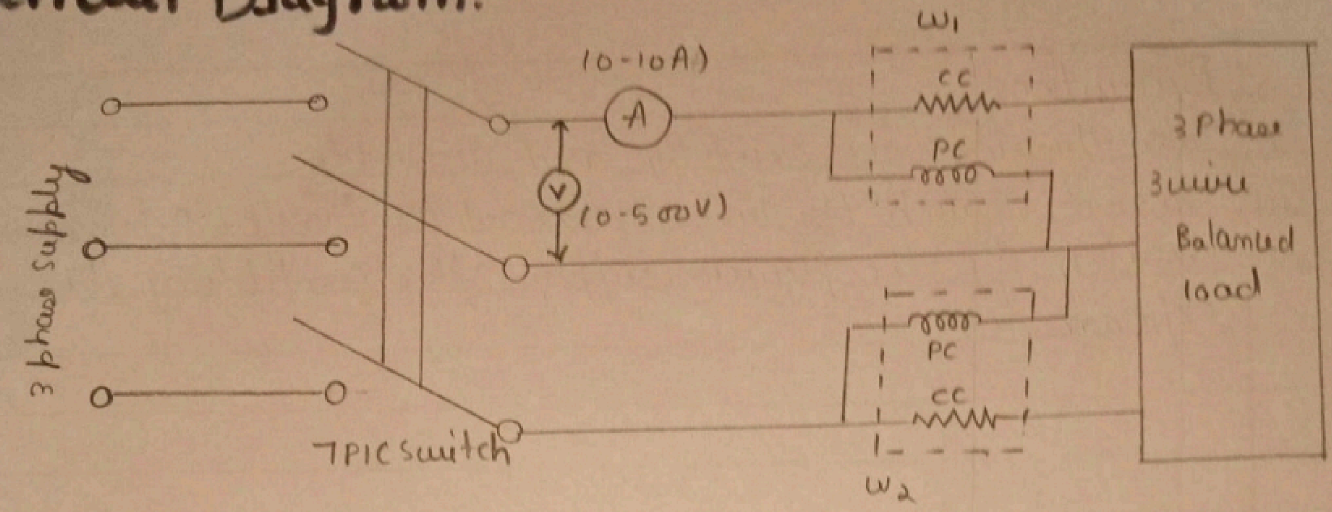

fig. connection diagram for two wattmeter method

Apparatus Required :

S.No.	Name	Range	Quantity
1	3 Phase MCB	230 V, 16 A	1
2	AC Voltmeter	0 - 500 V	1
3	AC Ammeter	0-10 A	1
4	Dynamometer type wattmeter	0-750 W, 5/10 A, 300/600 V	1
5	3 Phase Autotransformer	50/60 Hz, 415 V, 0 - 8 A	1
6	3 Phase Induction motor	1.5 kW / 2 hp, 415 V 3.6 A, 1410 rpm	1
7	Connecting Wires	—	12

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Experiment No. : 08

Aim : To measure the power and power factor of a three phase balanced circuit by two wattmeter methods.

Theory: Two wattmeter method is used to measure power of a three phase balanced or unbalanced system. Each wattmeter consists of two coils named as current coil (CC) and potential coil (PC). Current coil is used to measure line current whereas potential coil is used to measure line voltage. In this method we have two types of connection named as star connection of loads and Delta connection of loads

Formula: Power consumed by the load is given by $P = W_1 + W_2$

Power factor of load $\cos\phi = \cos[\tan^{-1}\{\sqrt{3}(W_1 - W_2)/(W_1 + W_2)\}]$

Procedure:

(i) Connect the load, wattmeter W_1 and W_2, ammeter (A) and voltmeter (V) to the 3-phase ac supply through a TPIC switch.

(ii) Note down the readings of wattmeters W_1 and W_2, ammeter (A) and voltmeter (V) for the different load

(iii) If the scale reading of any wattmeter becomes down then switch off the supply and reverse the connections of current coil (CC) or potential coil (PC) and now the reading is considered as negative

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Observation Table:

S.No.	Ammeter Reading (A)	Voltmeter Reading (volts)	Wattmeter Reading (watt)		Total Power $= W_1 + W_2$	Power Factor $\cos\phi$
			W_1	W_2		
1.	1.88 A	400 V	5x8 =400W	-30x8 -240W	400 - 240 160 W	0.1433

Result: The total power calculated is 160W
The total power factor calculated is 0.1433

Precautions:

(i) Take the readings carefully and accurately
(ii) Do not touch the live terminal during the experiment
(iii) Switch off the power supply while reversing the connections

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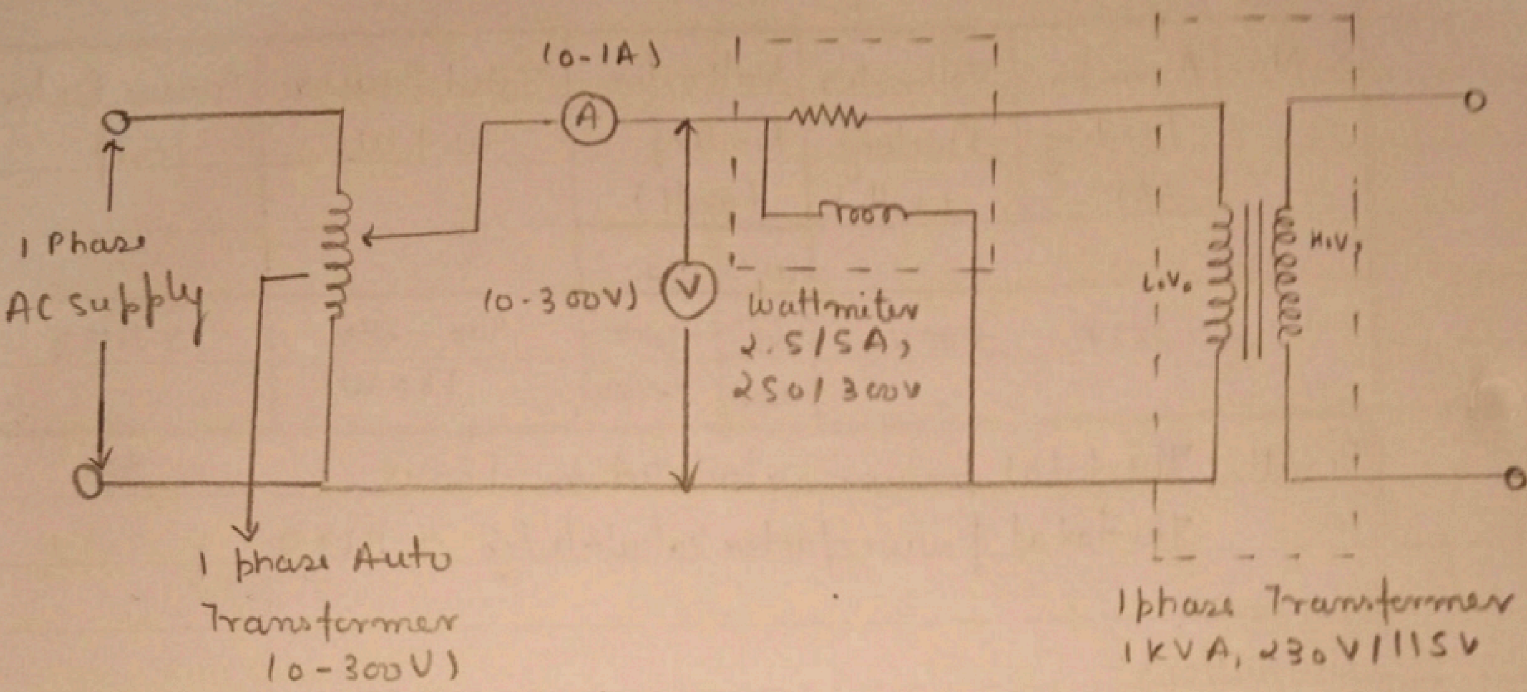
Circuit Diagram:



Apparatus Required:

S.NO.	Name	Range	Quantity
1	Double Pole MCB	415V, 16A	1
2	AC Voltmeter	0-300 V	2
3	AC Ammeter	0-500mA	1
		0-5A	1
4	Wattmeter	50 Hz, 1.5A, 150/300V	1
5	Single phase Autotransformer	50/60 Hz, 0-240V, 0-6A	1
6	Single phase Transformer	1KVA, 230/230V (1:1, 4.3 A, 50 Hz	1
7	Connecting wires	—	12

Experiment No. : 09

Aim: To perform Open circuit Test on single phase transformer to find out core loss.

Theory: In this test low voltage (primary) is connected to a ~~sup~~ supply of normal voltage and frequency and the high voltage winding is left open. The primary winding draws very low current hardly 3 to 5 percentage of full load current under this condition. As such copper loss in the primary winding will be negligible. Thus mainly iron losses occur in the transformer under no load or open circuit condition, which are indicated by the wattmeter connected in the circuit.

Hence total iron losses = W_0 (Reading of Wattmeter)

From the observation of this test, the parameters R_0 and X_m of the parallel branch of the equivalent circuit can also be calculated, following the steps given below:

Power drawn, $W_0 = V_0 I_0 \cos\phi_0$

Thus, no load power factor, $\cos\phi_0 = \dfrac{W_0}{V_0 I_0}$

Core loss component of no load current, $I_w = I_0 \cos\phi_0$

And magnetising component of no load current, $I_m = I_0 \sin\phi_0$

Equivalent resistance representing the core loss, $R_0 = \dfrac{V_0}{I_w}$

Magnetising reactance representing the magnetising current, $X_0 = \dfrac{V_0}{I_m}$

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Procedure:

(i) Connect the circuit

(ii) Ensure that the setting of the variac is at low output voltage.

(iii) Switch on the supply and adjust rated voltage across the transformer circuit.

(iv) Record no load current, voltage applied and no load power, corresponding to the rated voltage of the transformer winding.

(v) Switch-off the AC supply.

Observations:

S.NO.	Open Circuit		
	No load Voltage (V_0)	No load Current (I_0)	Iron loss (Core loss W_0)
1.	230 V	0.1 A	0.7 × 8 = 5.6 W

Conclusion: Hence, we find out the core loss with the help of open circuit test on single phase transformer.

Procedure:

(i) Take the readings carefully and accurately.

(ii) Do not touch the live terminal during the experiment.

(iii) Switch off the power supply after completing the experiment.

Circuit Diagram:

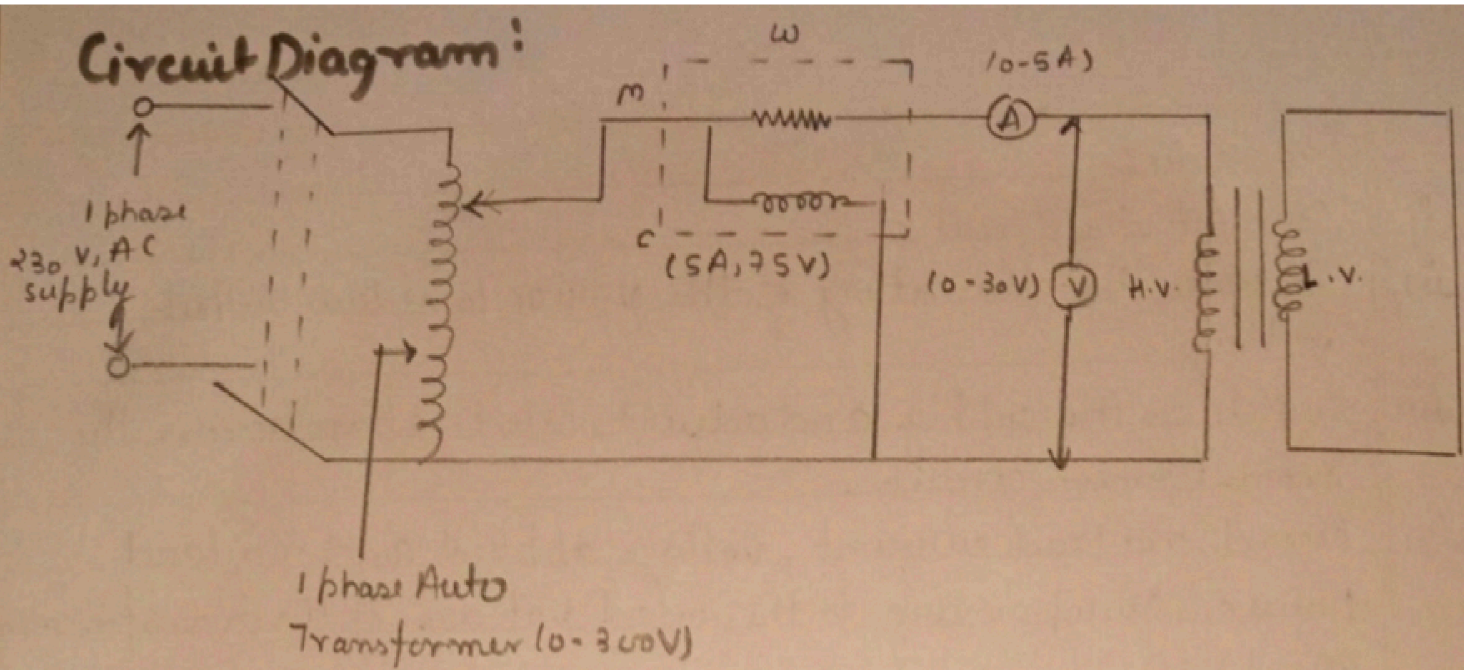

Figure Connection diagram for short Circuit (SC) test of transformer

Apparatus Required:

S. No.	Name	Range	Quantity
1	Double Pole MCB	415 V, 16 A	1
2	AC Voltmeter	0 - 30 V	1
		0 - 300 V	1
3	AC Ammeter	0 - 5 A	2
4	wattmeter	50 Hz, 0-5A, 150/300 V	1
5	Single Phase Auto Transformer	50/60 Hz, 0-240 V, 0-6 A	1
6	single phase Transformer	1KVA, 230/230V (1:1), 4.3 A, 50 Hz	1
7	Connecting wires	—	12

Date

Experiment No.: 10

Aim: To perform short circuit test on single phase transformer to find out copper loss.

Theory: In this test, low voltage winding is short circuited and a low voltage hardly 5 to 8 percent of the rated voltage of the high voltage winding is applied to this winding. This test is performed at rated current flowing in both the windings. Iron losses occurring in the transformer under this condition is negligible, because of very low applied voltage. Hence the total losses occurring under short circuit are mainly the copper losses of the both the winding, which are indicated by the wattmeter connected in the circuit.

Thus total full load copper losses = W_{sc} (reading of wattmeter)

The equivalent resistance R_{eq} and reactance X_{eq} referred to a particular winding can also be calculated from the observation of this test, following the steps given below.

Equivalent resistance referred to H.V. winding, $R_{eq} = \frac{W_{sc}}{I^2_{sc}}$

Also, equivalent impedance referred to H.V. winding, $Z_{eq} = \frac{V_{sc}}{I_{sc}}$

Thus the equivalent reactance referred to H.V. winding

$$X_{eq} = \sqrt{Z^2_{eq} - R^2_{eq}}$$

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Date: / /

Procedure!

(i) Connect the circuit

(ii) Adjust the setting of the variac, so that the output voltage is zero.

(iii) Switch on the AC supply to the circuit.

(iv) Increase the voltage applied slowly, till the current in the windings of the transformer is full load rated value.

(v) Record short circuit current, corresponding applied voltage and power with full load current flowing under short circuit conditions.

(vi) Switch off the AC supply.

Observation Table!

S.No.	Short Circuit Test		
	Short circuit voltage (V_{sc})	Short Circuit current (I_{sc})	Copper loss W_{sc}
1.	15 V	4.3 A	2.5 × 2 = 50 W

Precaution:

(i) Take the readings carefully and accurately

(ii) Do not touch the live terminal during experiment

Conclusion!

Hence, we find out the copper loss with the help of short circuit test on single phase transformer.