ATME College of Engineering

Department of Electrical and Electronics Engineering

Laboratory Manual

Electrical Hardware Laboratory

BEEL358D

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Semester: III

Compiled by   Verified by   Approved by

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Cycle of Experiments

Cycle - I	
Sl. No.	**Experiment**
1	Verification of KCL and KVL for DC Circuits.
2	Measurement of Current, Power and Power Factor of Incandescent Lamp, Fluorescent Lamp and LED Lamp.
3	Evaluate the loading effect of Voltmeter of electric circuits.
4	Measurement of Resistance using V-I method.
5	Measurement of Resistance and Inductance of a Choke coil using three voltmeter method.
Cycle - II	
6	Verification of KCL and KVL for AC Circuits.
7	Determination of Phase and Line quantities in three-phase star and delta connected loads.
8	Two-Way and Three-Way Control of Lamp and Formation of Truth Table.
9	Measurement of Earth Resistance using fall of potential method.
10	Determination of fuse characteristics.

EXPERIMENT No. 1

VERIFICATION OF KVL AND KCL FOR DC CIRCUITS

Objectives:

1. To find the relation between the currents flowing in different branches meeting at a node or a junction in an electrical circuit
2. To verify that in a closed electrical circuit the algebraic sum of the emfs and the voltage drop in the resistance is equal to zero

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Apparatus:

Sl. No.	Apparatus	Range	Quantity
1	Regulated Power Supply (RPS)	0-30V	1
2	Resistors	-	4
3	Ammeter	0-500mA	3
4	Voltmeter	0-30V MC	4

Kirchhoff Law Statement:

Kirchhoff's Current Law (KCL) states that at any junction (node) of a circuit, the algebraic sum of all the currents is zero (sum of the currents entering the junction equals the sum of the currents leaving the junction).

Kirchhoff's Voltage Law(KVL)states that around any closed loop or path in a circuit, the algebraic sum of all electric potential differences is equal to zero**.**

Precautions:

1. Voltage control knob of RPS should be kept at minimum position.

2. Current control knob should be kept at maximum position.

Procedure:

1. Make the connections as shown in the circuit diagram.
2. Set Source Voltage 'E' value in Regulated Power Supply.
3. Note down the corresponding ammeter reading and voltage drop across each rheostat
4. Repeat the same for different Source voltages and note down the readings of meters
5. Check and verify the KCL& KVL with the obtained readings

Circuit Diagram

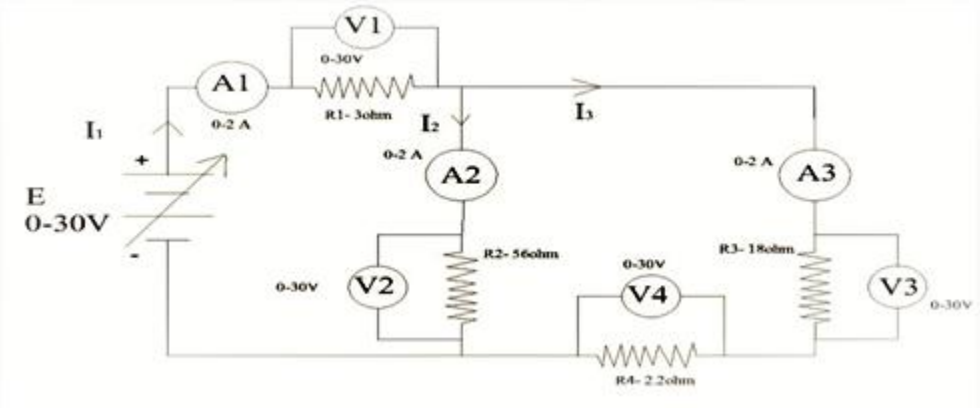

Fig-1.1: Circuit Diagram

Experimental Values:

Sl. No.	**Source Voltage E in Volts**	**Current in mA**				**Voltage Drop across Resistances in Volts**					
		I_1	**I_2**	**I_3**	**I_1= (I_2+I_3)**	**V_1**	**V_2**	**V_3**	**V_4**	**V_2=V_3+V_4**	**E=(V_1+ V_2)**
1	10										
2	15										
3	20										
4	25										

Theoretical Values:

Sl. No.	**Source Voltage E in Volts**	**Current in mA**				**Voltage Drop across Resistances in Volts**					
		I_1	**I_2**	**I_3**	**I_1= (I_2+I_3)**	**V_1**	**V_2**	**V_3**	**V_4**	**V_2=V_3+V_4**	**E=(V_1 + V_2)**
1	10										
2	15										
3	20										
4	25										

Calculations:

Results:

Inference:

Experiment No.2

MEASUREMENT OF CURRENT, POWER AND POWER FACTOR OF INCANDESCENT LAMP, FLUORESCENT LAMP, CFL AND LED LAMP

Objective:

To conduct an experiment to measure current, power and power factor for different lighting lamps.

Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1.	Single Phase Electronic Energy Meter	230V, 50Hz	1 No
2.	Incandescent bulb	40W	1 No
3.	Fluorescent Lamp (Electrical Type)	40W	1 No
4.	Compact Fluorescent Lamp (CFL)	40W	1 No
5.	Light-emitting diodes (LED) Lamp	40W	1 No
6.	Connecting wires	----	

Method 1: Using Single Phase Electronic Energy Meter

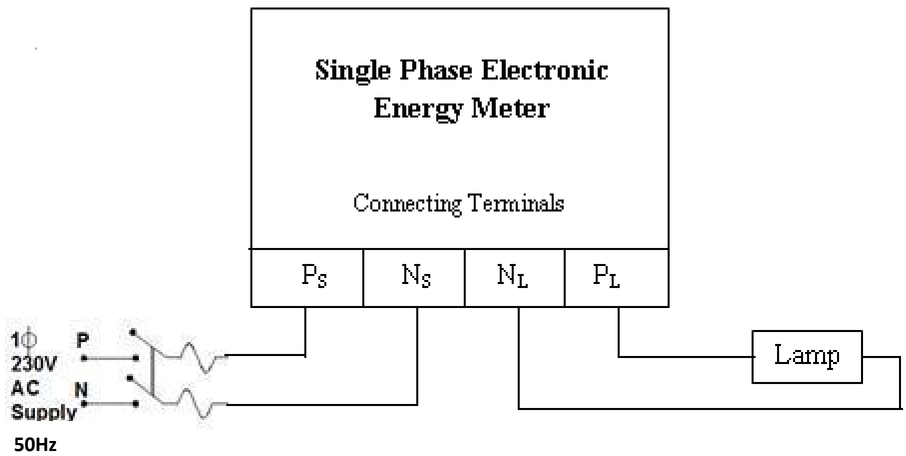

Fig. 2.1: Circuit Diagram

Procedure:

1. Make the connections as shown in the circuit diagram.
2. Connect the lamp load, close the supply switch and note down the readings (Current, Voltage, Power consumption, Power factor) by pressing push button in electronic energy meter.
3. Similarly note down the reading for different lamp load.

Experimental Values

Tabular Column:

Sl. No.	Load	Vin Volts	I in Amps	Power Consumption W in Watts	Power Factor Cos Ø
1	Incandescent Lamp				
2	Fluorescent Lamp				
3	Compact Fluorescent Lamp				
4	Light-emitting diodes (LED) Lamp				

Calculation:

Power Factor, $\mathbf{Cos}\ \emptyset = \frac{\mathbf{W}}{\mathbf{V * I}}$

Results:

Inference:

Experiment No.3

EVALUATE THE LOADING EFFECT OF VOLTMETER OF ELECTRIC CIRCUITS

Objective: To understand and analyze the loading effect of voltmeters on DC circuits.

Apparatus Required:

Sl. No.	Particulars	Range	Quantity
1	Regulated Power Supply (0 to 30V)	(0 to 30V)	1
2	Decade Resistance Box (DRB)	----	2
3	DC Voltmeter (0 to 300V)	(0 to 300V)	1
4	Multimeter	----	1
5	Connecting Wires		

Circuit Diagram:

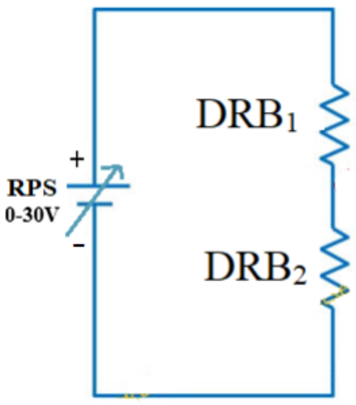

Figure- 3.1: Electrical DC Circuit

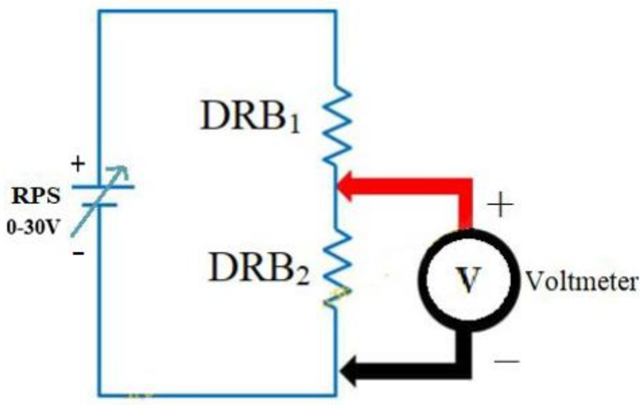

Figure 3.2: Electrical DC Circuit with Voltmeter

Theory:

The loading effect of the voltmeter is the difference between actual voltage that exists in the circuit without connecting the voltmeter and the voltage that appears after connecting voltmeter.

A voltmeter is placed across a resistor to measure its voltage. When a voltmeter connects across any resistance its internal resistance impacts the overall resistance of the circuit. This effect of change in overall resistance is known as the loading effect of the voltmeter.

Procedure:

1. Measure the resistance of the voltmeter across the terminals and make connections as shown in the circuit diagram as indicated in figure-1
2. Set the value in DRB_1 corresponding to the voltmeter resistance reading and set the twice the voltmeter resistance value in DRB_2.
3. Turn on the RPS and record the voltage values across R_2 using a Multimeter.
4. Now connect Voltmeter as shown in figure-2 across R_2 and record the values tabular column.
5. Repeat the step 2 to 4 for different range of Voltmeter to understand the loading effect.

Experimental Values:

Tabular column:

Sl. No.	RPS	Resistance in Ω		Voltage across R_1		Voltage across R_2	
	Voltage	R1	R2	Case-1:	Case-2: Voltmeter	Case-1:	Case-2: Voltmeter
1							
2							
3							
4							
5							

Calculation:

Results:

Inference:

Experiment No.4

MEASUREMENT OF RESISTANCE USING V-I METHOD.

Objective: To measure the resistance using V-I Method

Apparatus Required:

Sl.No.	Apparatus	Range	Quantity
1	DC Power supply	0-30 V	1
2	DC Ammeter	0-2 A	1
3	Rheostat	18Ω, 100Ω	Each 1no.
4	Digital multi-meter	-	1

Circuit diagram

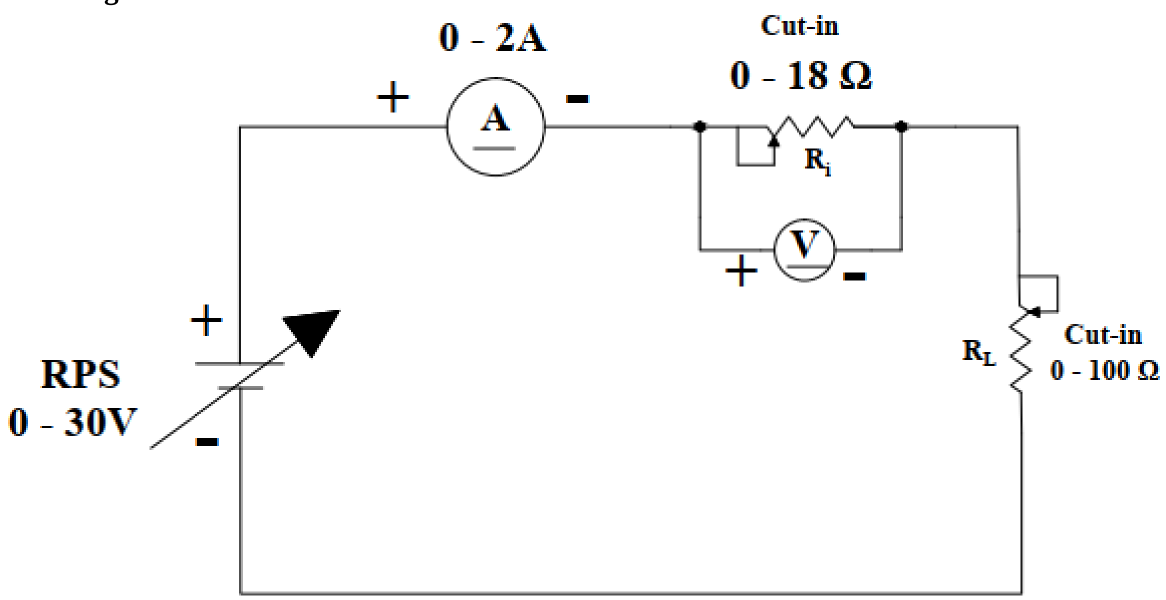

Fig-4.1: Circuit diagram

Theory

The V-I (voltage-current) method can be utilized to measure the resistance of a component. This method involves applying a known voltage across the component and measuring the resulting current.

Procedure:

1. The circuit connection is made as shown in the circuit diagram.
2. Switch on the supply and set source voltage value in Regulated Power Supply.
3. Keep the constant internal resistance and vary the load resistance.
4. Tabulate the readings of voltage of internal resistance and current for different load values of resistance.
5. Switch off the supply.
6. Calculate the Average value of internal resistance.

Tabular Column:

Sl. No	**V**(V)	**I(A)**	**R (Ω)**

1. Average of Resistance**=**

Calculations:

Results:

Inference:

Experiment No.5

MEASUREMENT OF RESISTANCE AND INDUCTANCE OF A CHOKE COIL USING 3 VOLTMETER METHODS

Objective: Measurement of Resistance and Inductance of a choke coil using 3 voltmeter methods

Apparatus Required:

Sl. No	Apparatus	Range	Quantity
1	Rheostat	1.5K, 2Amps	1
2	A.C. Voltmeter	0-300V	3
3	A.C. Ammeter	0-2A	1
4	Choke coil	0.41A, 50Hz, 230V	1

Circuit Diagram:

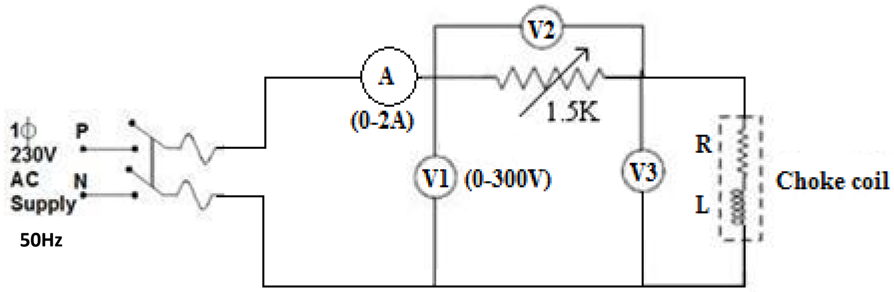

Fig- 5.1: Circuit Diagram

Theory:

Three Voltmeter methods: In this method, three voltmeters and a known non inductive resistance is used (Rheostat). This resistance is connected in series with the load (choke coil). As shown in the circuit voltmeters are used to measure the supply voltage 'V_1', Voltage 'V_2' across the Rheostat and voltage 'V_3' across the choke coil.

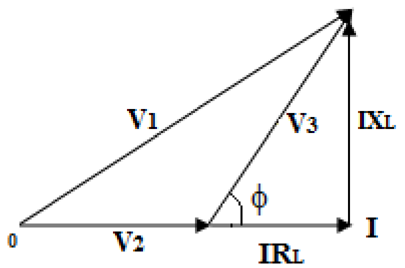

Fig-5.2: Phasor Diagram

From the above Phasor diagram $V_1^2 = V_2^2 + V_3^2 + 2V_2V_3 \cos \emptyset$

Neglecting the current taken by the voltmeters V_2 and V_3, the current in R is same as load Current I. thus V_2=IR.

,Power factor, $\cos\emptyset = \frac{V_1^2 - V_2^2 - V_3^2}{2V_2V_3}$

Procedure:

1. Make the connections as shown in the circuit diagram.
2. Give the supply of 230V, 50 Hz A.C. and note down the value of V_1, V_2, V_3& I by varying the rheostat.
3. Now change the current through choke coil by varying the rheostat in steps, for each step note down the Voltmeters and Ammeter readings.
4. Switch off the supply
5. Calculate the parameters of choke coil for each current.
6. Calculate the Average internal resistance and inductance of the choke coil.

Experimental Values:

Tabular column:

SL. No.	R (Ω)	V_1 (V)	V_2 (V)	V_3 (V)	I (A)	COS φ	P_L(W)	Z_L (Ω)	X_L (Ω)	R_L (Ω)	L (H)
1											
2											
3											
	Average internal resistance and inductance of the choke coil										

Calculations:

Power factor, $\cos\emptyset = \frac{V_1^2 - V_2^2 - V_3^2}{2V_2V_3}$ =.......................................

The Power consumed by the Load (choke coil) $P_L = V_3 I \cos\emptyset$ =............................

Where Load Impedance $Z_L = V_3 / I$ =............................... Ohms

Resistance of a choke coil $R_L = P_L / I^2$=..............................Ohms

Inductive Reactance$X_L = \sqrt{Z_L^2 - R_L^2}$=...................... Ohms

Inductive Reactance $X_L = \omega L = 2\pi fL$ in ohms,

Inductance of the choke coil $L = X_L / 2\pi f$ =.......................... Henry

Average Inductance of the choke coil L =.................................Henry

Average Resistance of a choke coil R_L=................................ Ohms

Results:

Inference:

Experiment No.6

VERIFICATION OF KCL AND KVL FOR AC CIRCUITS.

Objectives:

1. To find the relation between the currents flowing in different branches meeting at a node or a junction in an electrical circuit
2. To verify that in a closed electrical circuit the algebraic sum of the emfs and the voltage drop in the resistance is equal to zero

Apparatus:

SL. No	Apparatus	Range	Quantity
1	Energy meter	1ϕ	2
2	Rheostat	600Ω, 100 Ω	Each 1No.
3	AC Ammeter	0-2A	1
4	Choke coil	40w, 0.43A, 230V	1

Circuit Diagram:

Kirchoff's Current Law

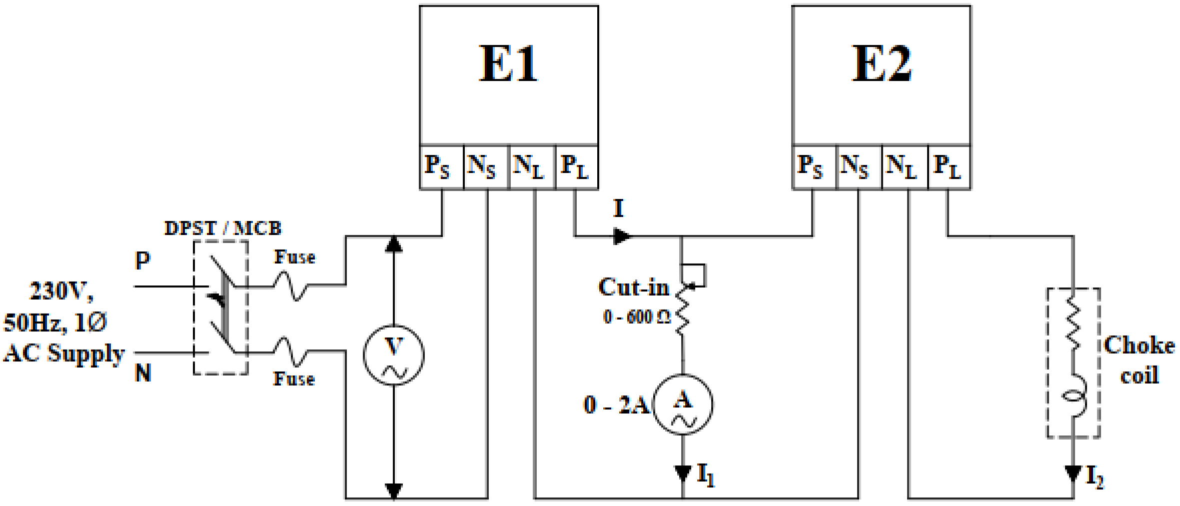

Fig-6.1: Circuit Diagram of KCL

Procedure:

1. Make the connections as shown in the circuit diagram.
2. Ensure the rheostat is in cut-in position and switch ON the power supply.
3. Note down the readings of all meters.
4. Slowly cut-out the rheostat and set the current value close to 0.75A and repeat step no.3.
5. Set the ammeter reading not to exceed 1.25Aand repeat step no.3.
6. Bring back the rheostat to cut in position and switch off the supply.

Tabular column:

Practical Values :

Sl. No.	|I|	$\|I_1\|$	$\|I_2\|$	P_1	P_2
1					
2					
3					

Calculations

Sl. No.	|I|	$\|I_1\|$	$\|I_2\|$	Φ_1	Φ_2	$\vec{I_1}$	$\vec{I_1}$	$\vec{I_2}$
1								
2								
3								

Circuit Diagram:

Kirchoff's Voltage Law

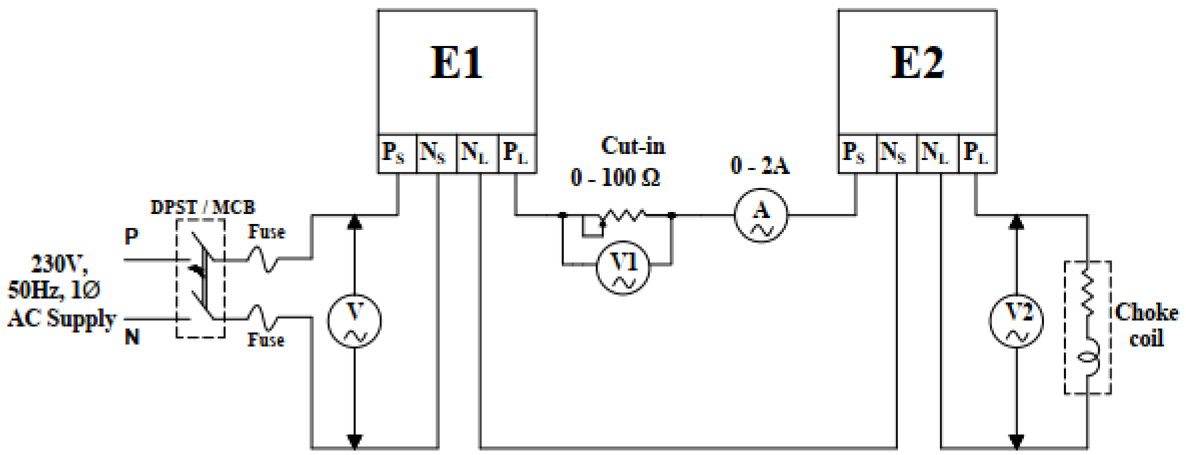

Fig-6.2: Circuit Diagram of KVL

Procedure:

1. Make the connections as shown in the circuit diagram.
2. Ensure the rheostat is in cut-in position and switch ON the power supply.
3. Note down the readings of all meters.
4. By cutting out the rheostat and set the current value to 0.45A and note down the meter readings.
5. Repeat step no.4for 0.55A.
6. Bring back the rheostat to cut-in position and switch off the supply.

Practical Values:

Sl. No.	|V|	V_1	V_2	|I|	P_1	P_2
1						
2						
3						

Calculations:

Sl. No.	$\|V\|$	$\|V_1\|$	$\|V_2\|$	I	Φ_1	Φ_2	$\vec{V}$	$\overrightarrow{V_1}$	$\overrightarrow{V_2}$
1									
2									
3									

Results:

Inference:

Experiment No.7

DETERMINATION OF PHASE AND LINE QUANTITIES IN THREE-PHASE STAR AND DELTA CONNECTED LOADS

Objectives:

1. **To determine the relations between Phase voltage and Line voltage, and Phase currents and Line currentsin a three-phase star and delta connected load.**

Star Connection:

Apparatus Required:

Sl. No	Particulars	Range	Quantity
1	AC Ammeter	0-5 A	1
2	AC Ammeter	0-2A	1
3	AC Voltmeter	0-600V	2
4	3 Phase Resistive load (Balanced)-Star Connected		
6	3 Phase Inductive load (Balanced)-Star Connected		

Theory:

A three-phase ac system consists of three voltage sources that supply power to loads connected to the supply lines, which can be connected to either delta (Δ) or star (Y) configurations. In three-phase systems, the voltages differ in phase by 120° and their frequency and Magnitude are equal.

The 3-phase loads that have the same impedance and power factor in each phase are called balanced loads. The problems on balanced loads can be solved by considering one phase only: the conditions in the other two phases being similar. However, we may come across a situation when loads are unbalanced *i.e.* each load phase has different impedance and/or power factor. In that case, current and power in each phase will be different.

The voltage induced in each winding is called the phase voltage ($V_{p)}$ and current in each winding is likewise known as phase current ($I_{p)}$. However, the voltage available between any pair of terminals (or outers) is called line voltage (V_L) and the current flowing in each line is called line current (I_L)

A balanced system is one in which (*i*) the voltages in all phases are equal in magnitude and differ in phase from one another by equal angles, in this case, the angle = 360/3 = 120°, (*ii*) the currents in the three phases are equal in magnitude and also differ in phase from one another by equal angles.

Star Connection:

A star connection is formed, when the similar ends of the three coils are joined together at neutral point N, the other three ends being free as shown in Fig 7.1. The three conductors meeting at point Nare replaced by a single conductor known as neutral conductor as shown in fig. Suchan interconnected system is known as four-wire, 3-phase system. If this three-phase voltage system is applied across a balanced symmetrical load, the neutral wire will be carrying three current switch are exactly equal in magnitude but are 120° out of phase with each other. Hence, their vector sum is zero.i.e.$I_R + I_Y + I_B = 0$... vectorially.

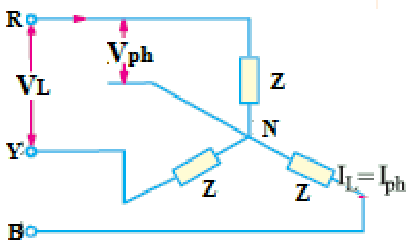

Fig-7.1: Star Connection

Voltages and Currents in Y-Connection

When a balanced system has been assumed. It means that $V_R = V_Y = V_B = V_{ph}$ (Phase voltage).

Line Voltages and Phase Voltages

In star connection $V_L = \sqrt{3} * V_{ph}$

It will be noted that
1. Line voltages are 120° apart.
2. Line voltages are 30° ahead of their respective phase voltages.
3. The angle between the line currents and the corresponding line voltages is (30 + ϕ) with current lagging

It should be particularly noted that ϕ is the angle between phase voltage and phase current and not between the line voltage and line current

Line Currents and Phase Currents
It is seen from Fig.4.2 that each line is in series with its individual phase winding, hence the line current in each line is the same as the current in the phase winding to which the line is connected.

Current in line 1 = I_R; Current in line 2 = I_Y; Current in line 3 = I_B

Since $I_R = I_Y = I_B =$ say, I_{ph}– the phase current
Therefore, line current $I_L = I_{ph}$

Circuit Diagram: Three Phase Star Connected Resistive load (Balanced)

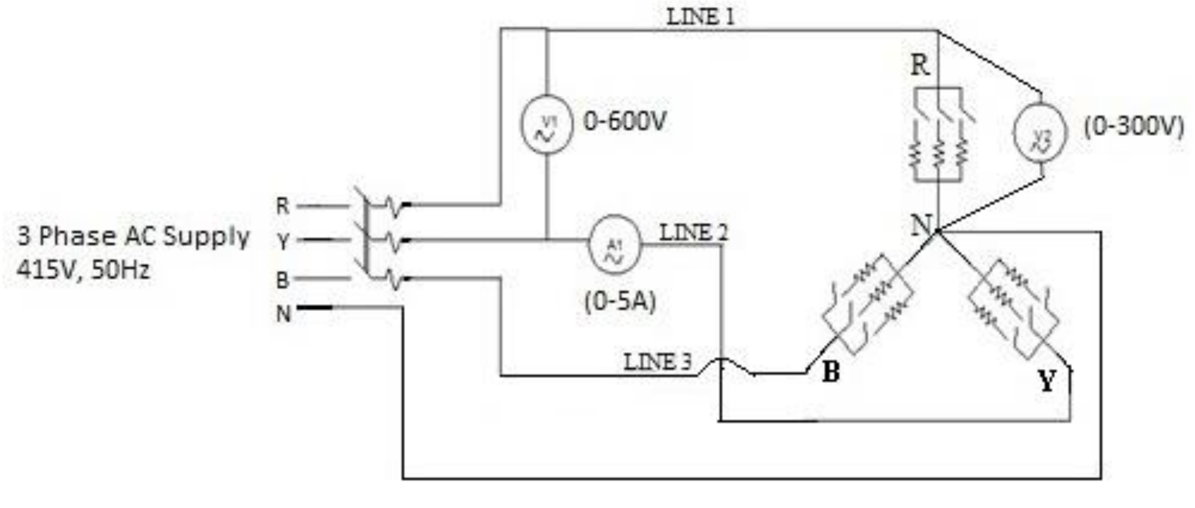

Fig.7.2: Three Phase Star Connected Resistive load (Balanced)

Procedure:
Star Connected: - 3 Phase Resistive load /Inductive Load
1. Make the connections as shown in the circuit diagram.
2. By closing TPST switch, apply a line voltage of 415V to the load
3. By closing the switches, apply the load in steps and note down the reading V_L, V_{Ph}, I_L and I_{Ph} in corresponding meters and verify the same with the Table 1.

Table 1: - Phase and Line quantities in Three Phase star connected loads

3ϕLoad Connection	Phase Voltage	Line Voltage	Phase Current	Line Current
Star connected	$V_{Ph}=V_L/\sqrt{3}$	$V_L=\sqrt{3}*V_{Ph}$	$I_{Ph}=I_L$	$I_L=I_{Ph}$

V_P= Phase Voltage, V_L=Line Voltage, I_P=Phase Current, I_L=Line Current

Tabular column:

(a) Star Connected - 3 Phase Resistive load (Balanced)

Sl. No.	Line Voltage(V_L) in Volts	Phase Voltage(V_{Ph}) in Volts	Line current(I_L) in Amps	Phase current(I_{Ph}) in Amps	Remarks
1					
2					
3					

Delta Connection:

Theory:

A three-phase ac system consists of three voltage sources that supply power to loads connected to the supply lines, which can be connected to either delta (Δ) or star (Y) configurations. In three-phase systems, the voltages differ in phase by 120° and their frequency and Magnitude are equal.

The 3-phase loads that have the same impedance and power factor in each phase are called balanced loads. The problems on balanced loads can be solved by considering one phase only: the conditions in the other two phases being similar. However, we may come across a situation when loads are unbalanced *i.e.* each load phase has different impedance and/or power factor. In that case, current and power in each phase will be different.

The voltage induced in each winding is called the phase voltage (V_p) and current in each winding is likewise known as phase current (I_p). However, the voltage available between any pair of terminals (or outers) is called line voltage (V_L) and the current flowing in each line is called line current (I_L)
A balanced system is one in which (*i*) the voltages in all phases are equal in magnitude and differ in phase from one another by equal angles, in this case, the angle = 360/3 = 120°, (*ii*) the currents in the three phases are equal in magnitude and also differ in phase from one another by equal angles.

Delta (Δ) or Mesh Connection:
In this form, of interconnection the dissimilar ends of the three phase winding are joined together i.e. the 'starting' end of one phase is joined to the 'finishing' end of the other phase and so on . In other words, the three windings are joined in series to form a closed mesh as shown in Fig. 4.2.For forming a delta connection, three coils are connected, end to end as shown in below Fig 4.2

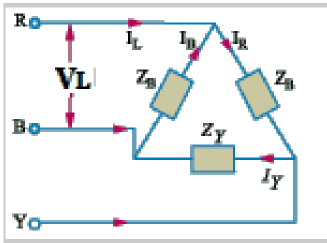

Fig-7.3: Delta Connection

It might look as if this sort of interconnection results in short circuiting the three windings. However, if the system is balanced then sum of the three voltages round the closed mesh is zero, hence no current of fundamental frequency can flow around the mesh when the terminals are open. It should be clearly understood that at any instant, the e.m.f. in one phase is equal and opposite to the resultant of those in the other two phases
This type of connection is also referred to as 3-phase, 3-wire system.

Line Voltages and Phase Voltages
It is seen from Fig. (b) that there is only one phase winding completely included between any pair of terminals. Hence, in Δ-connection, the voltage between any pair of lines is equal to the phase voltage of the phase winding connected between the two lines considered. Let $V_{RY}= V_{YB} = V_{BR}=$ Line voltage V_L. Then, it is seen that $V_L = V_{ph}$.
Therefore, Line Voltage (V_L) = Phase Voltage (V_{Ph})

Line Currents and Phase Currents
It will be seen from Fig. 7.2 that current in each line is the vector difference of the two-phase currents flowing through that lineFor example
Current in line 1 is $I_1= I_R-I_B$
Current in line 2 is $I_2= I_B-I_Y$
Current in line 3 is $I_3= I_Y-I_R$, If $I_R= I_Y=I_B$ phase current I_{ph}(say), then in delta connection $I_L = \sqrt{3}\, I_{ph}$
i.e. Line current (I_L) = $\sqrt{3}$ * Phase current (I_{Ph})

Circuit Diagram: Three Phase Delta Connected Resistive load (Balanced)

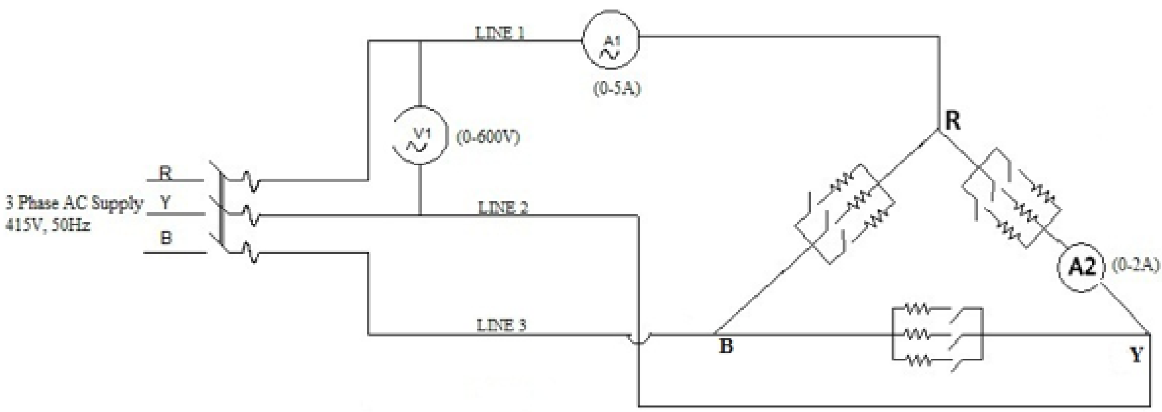

Fig.7.4: Three Phase Delta Connected Resistive load (Balanced)

Procedure:

Delta Connected:-3 Phase Resistive load

1. Make the connections as shown in the circuit diagram.
2. Close TPST Switch and apply a line voltage of 440V to the load
4. Apply the load in steps and note down the reading V_L, V_{Ph}, I_L and I_{Ph} in corresponding meters and verify the same with the Table 1.

Table 1: - Phase and Line quantities in Three Phase delta connected loads

3ϕLoad Connection	Phase Voltage	Line Voltage	Phase Current	Line Current
Delta connected	$V_{Ph}=V_L$	$V_L=V_{Ph}$	$I_{Ph}=I_L/\sqrt{3}$	$I_L=\sqrt{3}*I_{Ph}$

V_P= Phase Voltage, V_L=Line Voltage, I_P=Phase Current, I_L=Line Current

Tabular column:

Delta Connected:-3 Phase Resistive load (Balanced)

Sl. No.	Line Voltage(V_L) in Volts	Phase Voltage(V_{Ph}) in Volts	Line current(I_L) in Amps	Phase current(I_{Ph}) in Amps	Remarks
1					
2					
3					

Results:

Inference:

Experiment No.8

TWO WAY AND THREE-WAY CONTROL OF LAMP AND FORMATION OF TRUTH TABLE

Objectives: To explain methods of controlling lamp from different place.

Apparatus Required:

Sl. No.	Particulars	Quantity
1	Two-way switches	2
2	Intermediate switch	1
3	Bulb holders	1
4	Bulb	1
5	Connecting Wires	

Circuit Diagram: Two way control of Lamp

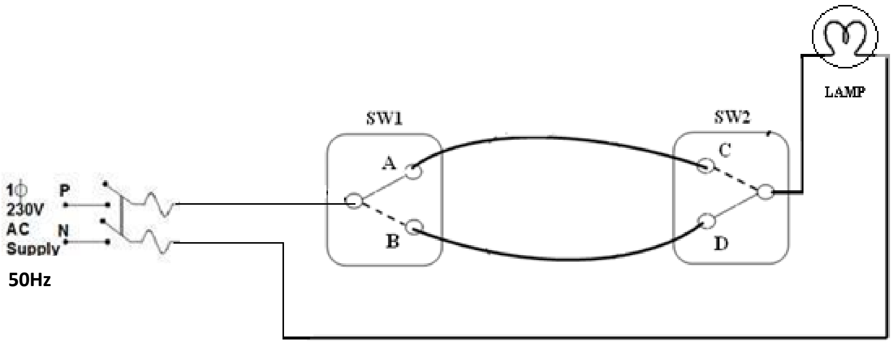

Fig. 8.1: Two-way control of bulb by two wire control

Position of Switch 1	Position of Switch 2	Lamp state
A	C	
A	D	
B	C	
B	D	

Table 4.1 Truth table for two-way control of bulb two wire control

Theory: A Two-way switching connection is used to control an electrical equipment like bulb by Two switches placed at different places. Generally used in the staircase. Two-way switch can be operated from any of the switch independently, means whatever be the position of other switch (ON/OFF), you can control the light with other switch.

Three-way control of lamp

Theory: A Three-way switching connection is used to control an electrical equipment like bulb by three switches placed at different places. This type of switching will be usually used in big corridors and workshops. In this lamp control along with two, two-way switches, an intermediate switch is used. The lamp can be controlled from any of the three switches.

Circuit Diagram: Three-way control of bulb

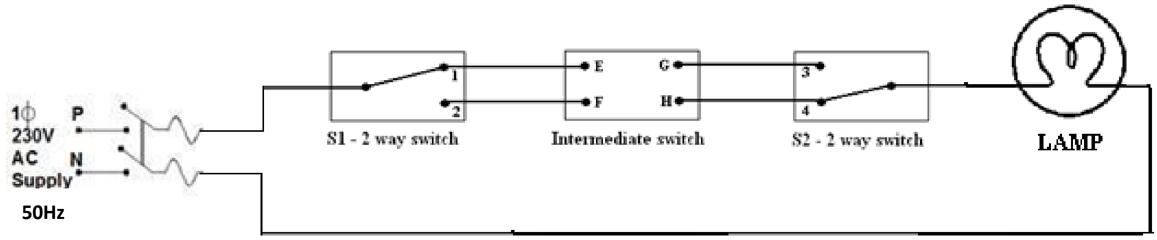

Fig. 8.2: Three-way control of bulb

Position of Switch 1	Position of Switch 2	Intermediate Switch Position		Lamp state
1	3	Straight Connection	E-G, F-H	
1	4		E-G, F-H	
2	3		E-G, F-H	
2	4		E-G, F-H	
1	3	Cross Connection	E-H, F-G	
1	4		E-H, F-G	
2	3		E-H, F-G	
2	4		E-H, F-G	

Table 4.2: Truth table for three-way control of bulb

Procedure:

1. Make the circuit as shown in the circuit diagram.
2. Switch on the power supply and check for the Lamp state for various combinations of the switches state given in the truth table for two-way control and three-way control of lamp respectively.
3. Switch off the power supply and remove the connections

Conclusion:

Inference:

Experiment No. 9

MEASUREMENT OF EARTH RESISTANCE USING FALL OF POTENTIAL METHOD

Objective: To measure the earth resistivity and earth resistance using digital earth resistance tester.

Apparatus Required:

Apparatus	Range	Quantity
Earth Resistance Tester – 4terminals	Range 10 ohm- 200ohm-1000ohm	01
Electrodes (Metal Spikes)	40cm length(1ft 3.7in) , 18mmdiameter	04
Connecting wires	2.5 sq mm multistrand, copper , PVC insulated cable	40meters
Hammer,	-----	01
Tape & measuring equipment		

Case 1: Measurement of Earth Resistivity

Circuit diagram

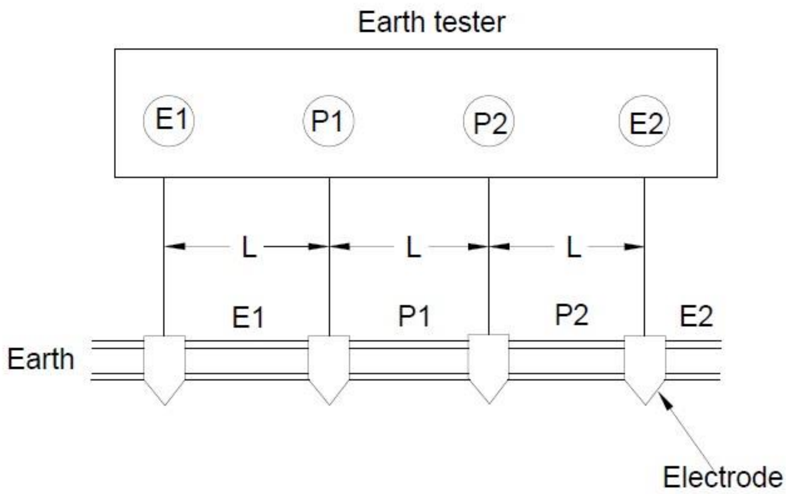

Fig: 9.1: schematic for 4-terminal resistivity measurement

Principle of operation (four-terminal resistivity measurement) the soil resistivity measurement works on a similar principle to the other measurements which use stakes: a current is injected around an outer loop and a voltage measured, shown in Figure 10.1. In this case, however, the measurement made by the instrument requires further conversion using a formula to derive the volumetric soil resistivity from the resistance value display

PROCEDURE:

1. Four earth ground stakes/spikes are positioned in the soil in a straight line, equidistant from one another as shown in Figure 7.1
2. The value of 'L' may be kept between 50 feet to 70 feet and the reading is observed by pressing the tester switch.
3. The value of earth resistivity may be obtained from the formulae
   $\rho=2\pi LR$ in ohm-cm. Where R= Earth resistance in Ω, δ =Earth resistivity in Ω-cm, L= Distance between the electrode, π =3.14
4. Change the distance & note down the value of resistance of various value of distance 'L' and note down corresponding length.

Note: To avoid error due to wire resistance, 1st short the wire &Note down the meter reading. Then connect the wire to different electrode as explained above. This reading minus the reading with wire shorted will give the actual value of resistance.

Tabular Column

SL. No.	**Length in cm**	**Resistance in ohms**	**Resistivity in** Ω-cm
1.			
2.			

Typical Value of Earth Resistivity (in Ohm-meter)

Sea Water	Swampy Ground	Dry Earth	Pure Slate	Sand	Sandstone	Dry Concrete
0.01-1.0	10-100	1000	$100\text{-}10^7$	500-5,000	$1\text{-}10^8$	2,000-10,000

Type of Soil	Earth resistivity in Ω-M	Ground Electrode Depth in meters		
		3m	6m	10m
Moist Soil	30 Ω-m	10 Ω	5 Ω	3 Ω
Sandy Clay Soil	150 Ω-m	50 Ω	25 Ω	15 Ω

Results:

Inference:

Experiment No. 10

DETERMINATION OF FUSE CHARACTERISTICS.

Objective: To study the Current-time characteristics of fuse

Apparatus Required:

Sl. No	Particulars	Range	Quantity
1	AC Ammeter	0-10A	1
2	Fuse element	5A	1
3	SPST	0-10A	1
4	1KVATransformer	230V , 50Hz	1
5	Auto transformer	230V , 50Hz	1

Circuit Diagram :

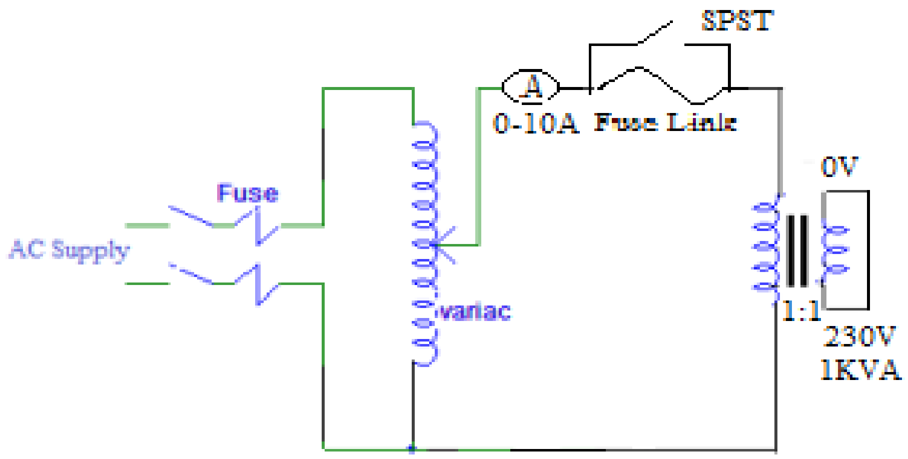

Fig-10.1: Circuit Diagram of Fuse Characteristics

Theory:

Fuse is a Cheapest, simplest current interrupting device for protection from excessive currents. As such, it is used for overload and/or short circuit protection in medium voltage (up to 33 kV) and low voltage (up to 400 V) installations, which opens the circuit (in which it is inserted) by fusing (melting) the element when the current in the circuit exceeds a certain value.

Recently, HRC fuses have been developed for applications up to 66 kV for distribution systems

It is designed so that it carries the working current safely without over heating under normal condition and melts due to sufficient I^2R heating when current exceeds certain predetermine value in abnormal condition

Procedure:

1. Connection are made as per the circuit diagram
2. Switch on the system with SPST switch in the closed position
3. Set the current loading (say 5.5 amp) using the above circuit.
4. Open the SPST switch and at the same time switch on the timer. Note the time taken to melt or blow-off the fuse link. Then tabulate the load current and time taken to low off the fuse.
5. Now switch off the load and supply
6. Rewind the fuse link to fuse unit
7. Repeat the above steps by increasing the load current in steps of 0.5 amps
8. Plot a graph of time Vs Current

Fusing Factor = Minimum Fusing current / Current rating of Fuse.

The current-time Characteristics of fuse is Inverse Characteristics as current increases the time reduces.

Tabular Colum:

Fuse rating (Rated Current of Fuse) = _______Amps

SL No.	Load Current in Amps	Melting Time in sec
1		
2		
3		
4		

Results:

Inference: