AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY
(An Constituent College of Vinayaka Mission's Research Foundation)

VINAYAKA MISSION'S RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL MACHINES – I LABORATORY MANUAL

EEE – III SEMESTER

REGULATION – 2017

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PREFACE

This Laboratory manual for Electrical Machines – I Lab has been revised and updated in order to meet the Curriculum changes, laboratory equipment upgrading and the latest circuit simulation.

Every effort has been made to correct all the known errors, but nobody is perfect, if you find any additional errors or anything else you think is an error, Please feel free to inform the HOD / EEE at eeedept@avit.ac.in

The Authors thanked all the staff members from the department for their valuable Suggestions and contributions.

The Authors
Department of EEE

LIST OF EXPERIMENTS:

1. Load test on DC shunt motor.
2. Load test on DC series motor.
3. Speed control of DC shunt motor.
4. Open Circuit and Load Characteristics of DC Generator (Separately Excited)
5. Open Circuit and Load Characteristics of DC Generator (Self Excited)
6. Load test on DC Compound generator.
7. Load test on single phase transformer.
8. Open Circuit & Short Circuit test on single phase transformer.
9. Swinburne's test.
10. Separation of losses in single phase transformer.
11. Hopkinson's test.
12. Sumpner's test on 1-phase transformer.
13. Study of three phase transformer connections.
14. Study of DC starters.

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LABORATORY PRACTICE

SAFETY RULES

1. Safety is of paramount importance in the Electrical Engineering Laboratories.

2. Electricity NEVER EXECUSES careless persons. So, exercise enough care and attention in handling Electrical equipment and follow safety practices in the laboratory. (Electricity is a good servant but a bad master).

3. Avoid direct contact with any voltage source and power line voltages. (Otherwise, any such contact may subject you to electrical shock).

4. Wear rubber-soled shoes. (To insulate you from earth so that even if you accidentally contact a live point, current will not flow through your body to earth and hence you will be protected from electrical shock).

5. Wear laboratory-coat and avoid loose clothing. (Loose clothing may get caught on an equipment/instrument and this may lead to an accident particularly if the equipment happens to be a rotating machine).

6. Girl students should have their hair tucked under their coat or have it in a knot.

7. Do not wear any metallic rings, bangles, bracelets, wristwatches and neck chains. (When you move your hand/body, such conducting items may create a short circuit or may touch a live point and thereby subject you to electrical shock).

8. Be certain that your hands are dry and that you are not standing on wet floor. (Wet parts of the body reduce the contact resistance thereby increasing the severity of the shock)

9. Ensure that the power is OFF before you start connecting up the circuit (Otherwise you will be touching the live parts in the circuit).

10. Get your circuit diagram approved by the staff member and connect up the circuit strictly as per the approved circuit diagram.

11. Check power chords for any sign of damage and be certain that the chords use safety plugs and do not defeat the safety feature of these plugs by using ungrounded plugs.

12. When using connection leads, check for any insulation damage in the leads and avoid such defective leads.

13. Do not defeat any safety devices such as fuse or circuit breaker by shorting across it. Safety devices protect YOU and your equipment.

14. Switch on the power to your circuit and equipment only after getting them checked up and approved by the staff member.

15. Take the measurement with one hand in your pocket. (To avoid shock in case you accidentally touch two points at different potentials with your two hands).

16. Do not make any change in the connection without the approval of the staff member.

17. In case you notice any abnormal condition in your circuit (like insulation heating up, resistor heating up etc), switch off the power to your circuit immediately and inform the staff member.

18. Keep hot soldering iron in the holder when not in use.

19. After completing the experiment show your readings to the staff member and switch off the power to your circuit after getting approval from the staff member.

20. While performing load-tests in the Electrical Machines Laboratory using the brake-drums:

    i. Avoid the brake-drum from getting too hot by putting just enough water into the brake-drum at intervals; use the plastic bottle with a nozzle (available in the laboratory) to pour the water. (When the drum gets too hot, it will burn out the braking belts).

    ii. Do not stand in front of the brake-drum when the supply to the load-test circuit is switched off. (Otherwise, the hot water in the brake-drum will splash out on you).

    iii. After completing the load-test, suck out the water in the brake-drum using the plastic bottle with nozzle and then dry off the drum with a sponge which is available in the laboratory. (The water, if allowed to remain in the brake-drum, will corrode it).

21. Determine the correct rating of the fuse/s to be connected in the circuit after understanding correctly the type of the experiment to be performed: no-load test or full-load test, the maximum current expected in the circuit and accordingly use that fuse-rating. (While an over-rated fuse will damage the equipment and other instruments like ammeters and watt-meters in case of over load, an under-rated fuse may not allow one even to start the experiment).

22. At the time of starting a motor, the ammeter connected in the armature circuit overshoots, as the starting current is around 5 times the full load rating of the motor. Moving coil ammeters being very delicate may get damaged due to high starting current. A switch has been provided on such meters to disconnect the

moving coil of the meter during starting. This switch should be closed after the motor attains full speed. Moving iron ammeters and current coils of wattmeters are not so delicate and hence these can stand short time overload due to high starting current. No such switch is therefore provided on these meters. Moving iron meters are cheaper and more rugged compared to moving coil meters. Moving iron meters can be used for both AC and DC measurement. Moving coil instruments are however more sensitive and more accurate as compared to their moving iron counterparts and these can be used for DC measurements only. Good features of moving coil instruments are not of much consequence for you as other sources of errors in the experiments are many times more than those caused by these meters.

23. Some students have been found to damage meters by mishandling in the following ways:

    i. Keeping unnecessary material like books, lab records, unused meters etc. causing meters to fall down the table.

    ii. Putting pressure on the meter (specially glass) while making connections or while talking or listening somebody.

STUDENTS ARE STRICTLY WARNED THAT FULL COST OF THE METER WILL BE RECOVERED FROM THE INDIVIDUAL WHO HAS DAMAGED IT IN SUCH A MANNER.

I have read and understand these rules and procedures. I agree to abide by these rules and procedures at all times while using these facilities. I understand that failure to follow these rules and procedures will result in my immediate dismissal from the laboratory and additional disciplinary action may be taken.

GUIDELINES FOR LABORATORY NOTEBOOK

The laboratory notebook is a record of all work pertaining to the experiment. This record should be sufficiently complete so that you or anyone else of similar technical background can duplicate the experiment and data by simply following your laboratory notebook. Record everything directly into the notebook during the experiment. Do not use scratch paper for recording data. Do not trust your memory to fill in the details at a later time.

Organization in your notebook is important. Descriptive headings should be used to separate and identify the various parts of the experiment. Record data in chronological order. A neat, organized and complete record of an experiment is just as important as the experimental work.

1. HEADING

The experiment identification (number) should be at the top of each page. Your name and date should be at the top of the first page of each day's experimental work.

2. OBJECT

A brief but complete statement of what you intend to find out or verify in the experiment should be at the beginning of each experiment.

3. DIAGRAM

A circuit diagram should be drawn and labeled so that the actual experiment circuitry could be easily duplicated at any time in the future. Be especially careful to record all circuit changes made during the experiment.

4. EQUIPMENT LIST

List those items of equipment which have a direct effect on the accuracy of the data. It may be necessary later to locate specific items of equipment for rechecks if discrepancies develop in the results.

5. PROCEDURE

In general, lengthy explanations of procedures are unnecessary. Be brief. Short commentaries along side the corresponding data may be used. Keep in mind the fact that the experiment must be reproducible from the information given in your notebook.

6. DATA

Think carefully about what data is required and prepare suitable data tables. Record instrument readings directly. Do not use calculated results in place of direct data; however, calculated results may be recorded in the same table with the direct data. Data tables should be clearly identified and each data column labeled and headed by the proper units of measure.

7. CALCULATIONS

Not always necessary but equations and sample calculations are often given to illustrate the treatment of the experimental data in obtaining the results.

8. GRAPHS

Graphs are used to present large amounts of data in a concise visual form. Data to be presented in graphical form should be plotted in the laboratory so that any questionable data points can be checked while the experiment is still set up. The grid lines in the notebook can be used for most graphs. If special graph paper is required, affix the graph permanently into the notebook. Give all graphs a short descriptive title. Label and scale the axes. Use units of measure. Label each curve if more than one on a graph.

9. RESULTS

The results should be presented in a form which makes the interpretation easy. Large amounts of numerical results are generally presented in graphical form. Tables are generally used for small amounts of results. Theoretical and experimental results should be on the same graph or arrange in the same table in a way for easy correlation of these results.

10. CONCLUSION

This is your interpretation of the results of the experiment as an engineer. Be brief and specific. Give reasons for important discrepancies.

TROUBLE SHOOTING HINTS

1. Be Sure that the power is turned ON.

2. Be sure the ground connections are common.

3. Be sure the circuit you build is identical to your circuit diagram (Do a node by node check).

4. Be sure that the supply voltages are correct.

5. Be sure that the equipment is set up correctly and you are measuring the correct parameters.

6. If steps I through 5 are correct then you probably have used a component with the wrong value or one that doesn’t work. It is also possible that the equipment does not work (although this is not probable) or the protoboard you are using may have some unwanted paths between nodes. To find your problem you must trace through the voltages in your circuit node by node and compare the signal you expect to have. Then if they are different use your engineering judgment to decide what is causing the different or ask your lab assistant.

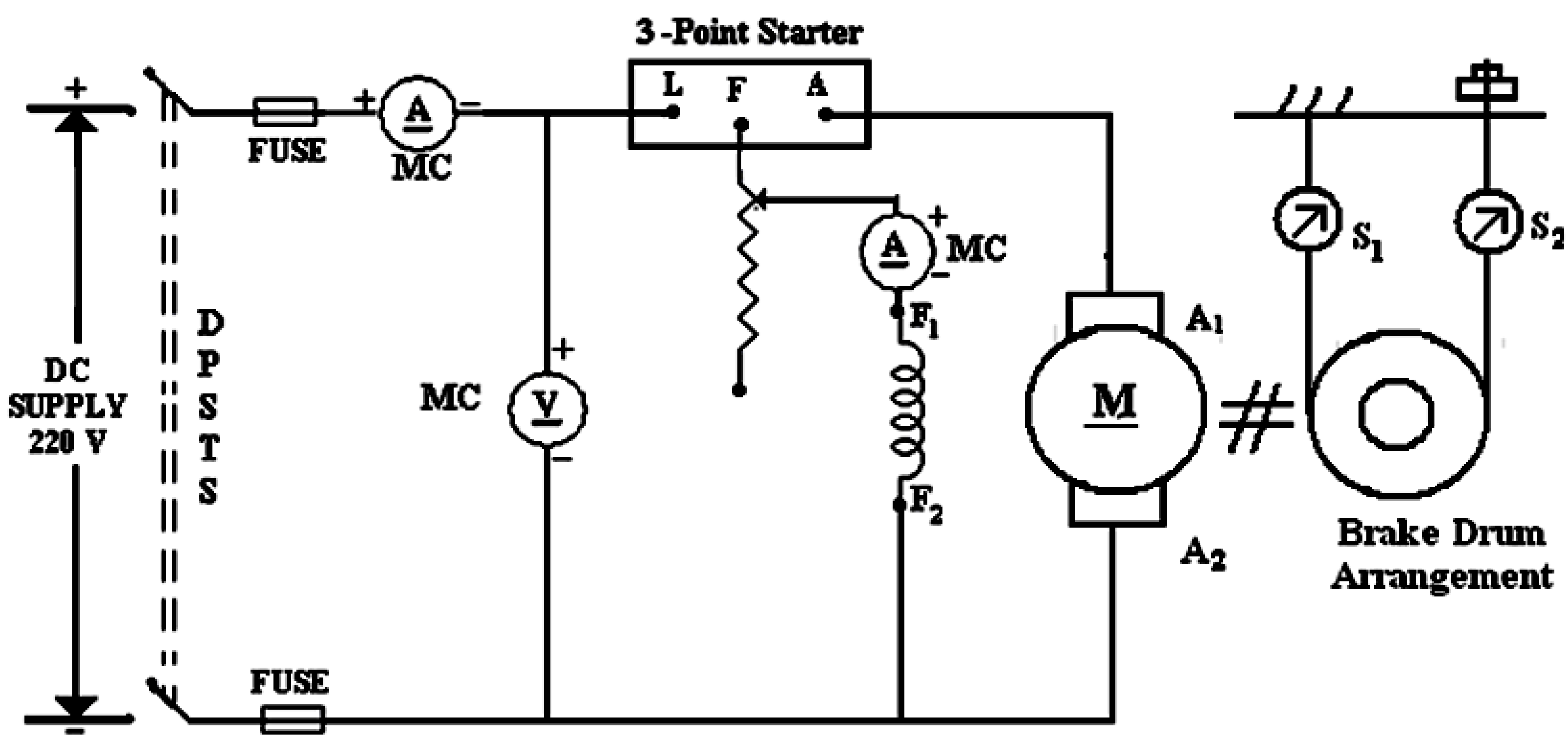
IMPORTANT INSTRUCTIONS TO THE CANDIDATE WHILE ENTERING THE LABORATORY DURING LAB HOURS

- ✓ Wear your lab coat and leather shoe while entering the laboratory
- ✓ Do not touch the apparatus or connection wires when the supply is switched ON.
- ✓ Do not wear long chain, hand rings, bracelets, wrist watches, bangles (gold or gold coated), at the time of lab hours.
- ✓ Girls should plait their hair and should be inserted inside your lab coat during lab hours.
- ✓ Use proper meters and proper fuse rating for that experiment
- ✓ Candidate should come with their own stationeries like pen, pencil, eraser, pro-circle, scale, calculator etc.
- ✓ Do not draw the circuit diagrams, model graphs etc in free hand.
- ✓ Roaming outside the lab during lab hours is totally prohibited. If found severe action will be taken by lab- in charge / HOD/Principal.
- ✓ The number of students per batch to do the experiment in maximum three.
- ✓ Boys students should not wear full sleeve shirts when the come to the lab during lab hours.
- ✓ For load test measure circumference of the brake drum and thickness of the belt before starting the machine.
- ✓ Before entering the laboratory, read the Viva- voce questions and answers given in this manual.

EXPERIMENT – 1

LOAD TEST ON DC SHUNT MOTOR

LOAD TEST ON DC SHUNT MOTOR



Fuse Rating:

Name Plate Details

EXP. NO.: 1 **DATE:**

LOAD TEST ON DC SHUNT MOTOR

AIM:

To conduct load test on D.C motor and to obtain performance characteristics

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Qty
1	Ammeter			
2	Ammeter			
3	Voltmeter			
4	Rheostat			
5	Tachometer			

THEORY:

The shunt motor has a definite no load speed hence it does not run away when load is suddenly thrown off provided the field circuit remains closed. The drop in speed from no-load to full load is small hence this motor is usual referred to a constant speed motor.

The efficiency curve is usually of the same shape for all electric motors and generators. The shape of efficiency curve and the point of maximum efficiency can be varied considerably by the designer, though it is advantageous to have an efficiency curve which is fairly flat. So that there is little change in efficiency between load and 25% overload and to have the maximum efficiency as near to the full load as possible.

From the curves it is observed that is certain value of current is required even when output is zero. The motor input under no-load conditions goes to meet the various losses, occurring within the machine.

PRECAUTIONS:

i. Ensure that there is no load on the brake drum initially.
ii. Check for correct fuse rating.
iii. Ensure that there are no loose connections.
iv. Field rheostat should be kept in minimum resistive position initially.
v. The motor should be cooled by circulating water in the brake drum throughout the experiment.
vi. It is ensured that the MC (Moving Coil) meters are connected with proper polarities.

TABULATION: LOAD TEST ON DC SHUNT MOTOR

Radius of the brake drum (r) :

Thickness of the belt (T) :

S.NO	LINE VOLTAGE	LINE CURRENT	SPEED	SPRING BALANCE READINGS		S1-S2	TORQUE	OUTPUT POWER	INPUT POWER	EFFICIENCY
				S1	S2					
	V	A	RPM	KG	KG	KG	N-M	W_0	W_I	%

PROCEDURE:

1. The connections are made as per the circuit diagram.
2. Ensure that no load is applied to the brake drum and the field rheostat is kept in minimum resistive position initially.
3. Supply is given to the motor by closing the DPST switch, motor is started using a 3 – point starter.
4. The field rheostat is adjusted to make the motor run at the rated speed.
5. At no load, the readings of ammeter, voltmeter, tachometer and spring balance readings are noted.
6. The load is then increased in steps and the readings are noted up to rated current. The load on the brake drum is released fully to no load condition. The field rheostat to original resistive position
7. The supply to the motor is switched off by opening the DPST switch.

MODEL CALCULATION:

FORMULA USED:

Radius $R = r + \frac{T}{2}$ in metre.

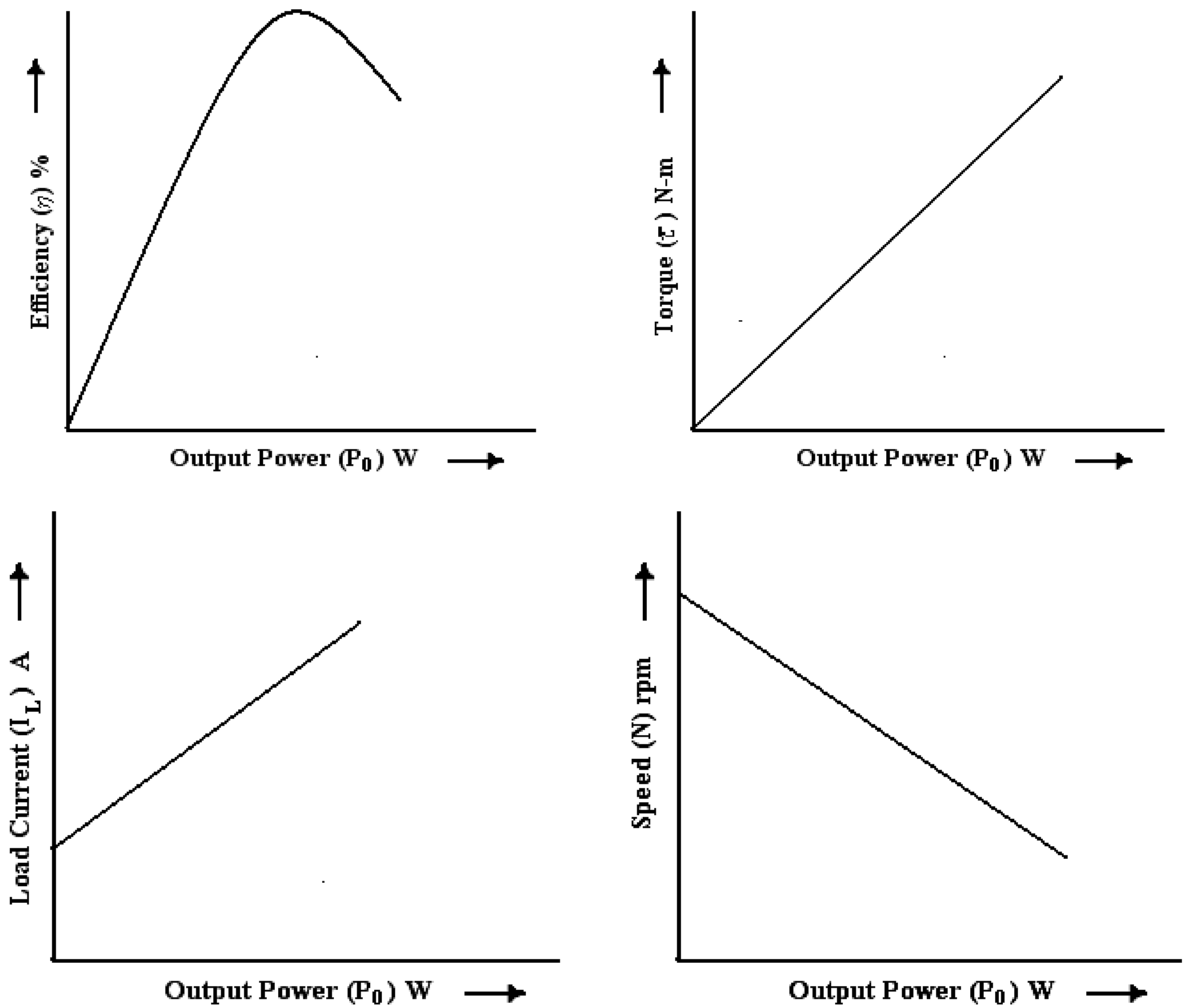
Torque $\tau = 9.81 \times R \times \left(S_1 \sim S_2\right)$ N - m

Input Power $W_i = V_i \ I_i$ Watts

Output Power, $W_o = \frac{2\pi N\tau}{60}$ Watts

$$\text{Percentage Efficiency} = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

MODEL GRAPH


Efficiency (η) %
Output Power (P0) W
Torque (τ) N-m
Output Power (P0) W
Load Current (IL) A
Output Power (P0) W
Speed (N) rpm
Output Power (P0) W

GRAPHS:

1. Output power Vs efficiency
2. Output power Vs current
3. Output power Vs torque
4. Output power Vs speed

RESULT:

Thus the performance and load characteristics of a DC shunt motor are drawn.

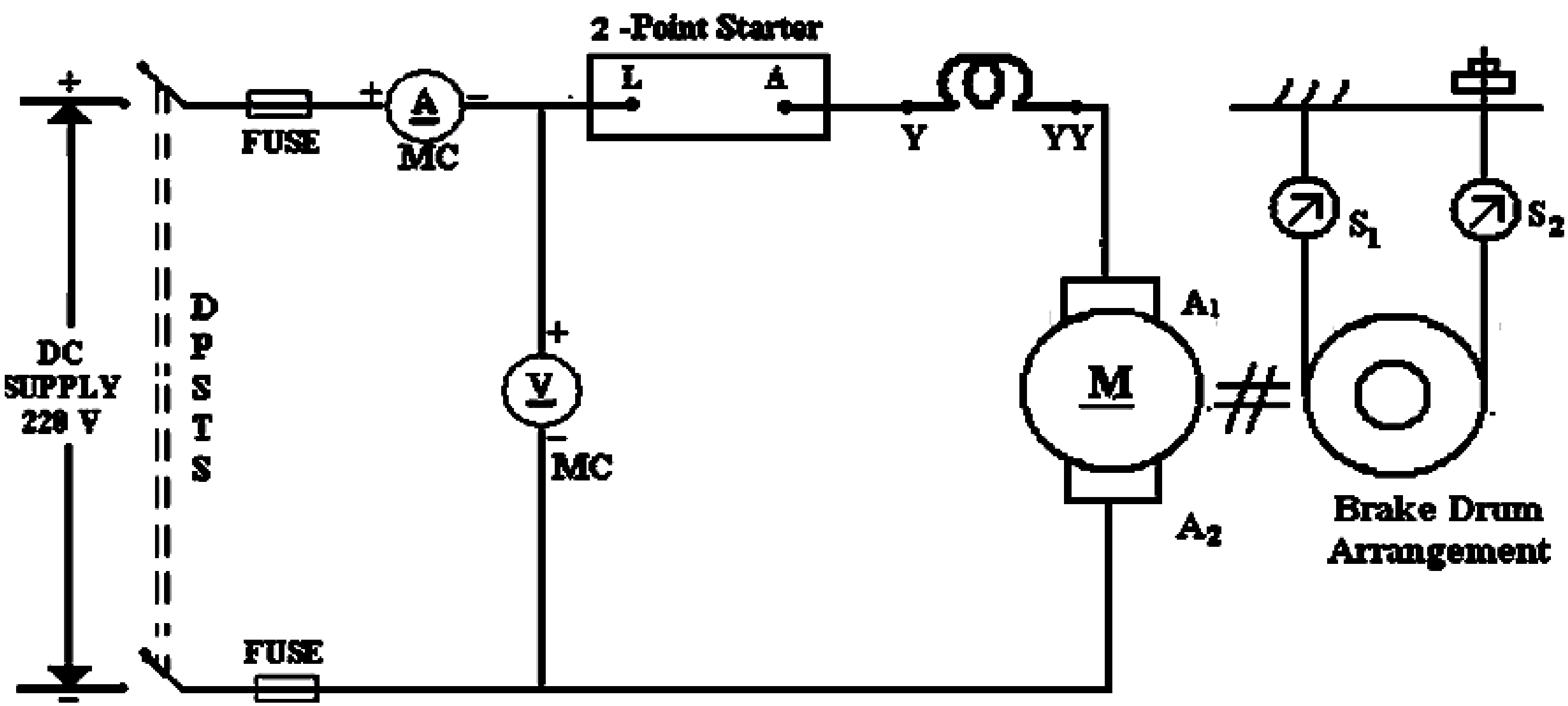
VIVA QUESTIONS:

1. Why should the field rheostat be kept in the position of minimum resistance?
2. What is the loading arrangement used in a DC motor?
3. How can the direction of rotation of a DC shunt motor be reversed?
4. What are the mechanical and electrical characteristics of a DC shunt motor?
5. What are the applications of a DC shunt motor?
6. What is the type of voltmeter and ammeter used in this experiment?
7. If the pointer of the voltmeter or ammeter reverses, what corrective action will you take?
8. What will happen if the field circuit of the DC shunt motor is open?
9. Comment on the shape of the Speed VS Torque curve.
10. What percentage of the full load rated current is the no load current?

EXPERIMENT – 2

LOAD TEST ON DC SERIES MOTOR

LOAD TEST ON DC SERIES MOTOR



Fuse Rating:

Name Plate Details

EXP. NO.: 2 **DATE:**

LOAD TEST ON DC SERIES MOTOR

AIM:

To conduct load test on DC series motor and to obtain performance characteristics

APPARATUS REQUIRRED:

S.No.	Apparatus	Range	Type	Qty
1	Ammeter			
2	Voltmeter			
3	Tachometer			

THEORY:

The drop in speed with increased load is much prominent in series motor than in a shunt motor hence a series motor is not suitable for application requiring a substantially constant speed.

For a given current input a starting torque developed by a series motor is greater than that developed by a shunt motor. Hence series motors are used where huge starting torques is necessary that means for cranes and traction purpose. In addition to huge starting torque there is another unique characteristic of series motor which makes this especially desirable for traction work that means when a load comes on a series motor it response by decreasing its speed and supplies the increased torque with a small increase in current.

On the other hand a shunt motor under the same condition would hold its speed nearly constant and would supply the required increased torque with a large increase of input current.

PRECAUTIONS:

i. Ensure that some load is applied to the brake drum initially (S_1=S_2=5kg).
ii. Check the correct fuse ratings.
iii. Ensure that there are no loose connections.
iv. Under no circumstances, the motor should be unloaded fully during operation.
v. The motor should be cooled by circulating water in the brake drum throughout the experiment.
vi. It is ensured that the MC (Moving Coil) meters are connected with proper polarities.

<u>TABULATION</u>: LOAD TEST ON DC SHUNT MOTOR

Radius of the brake drum (r) :

Thickness of the belt (T) :

S.NO	LINE VOLTAGE	LINE CURRENT	SPEED	SPRING BALANCE READINGS		S1-S2	TORQUE	OUTPUT POWER	INPUT POWER	EFFICIENCY
				S1	S2					
	V	A	RPM	KG	KG	KG	N-M	W_0	W_I	%

PROCEDURE:

1. The connections are given as per the circuit diagram.
2. Ensure that some load is applied to the brake drum initially (S_1=S_2=5Kg).
3. Supply is given to the motor by closing the DPST Switch.
4. Motor is started using the two point starter.
5. The readings of ammeter, voltmeter, tachometer and spring balance are noted.
6. The load is then gradually increased in steps and the readings are noted up to rated load.
7. Decrease the load on the brake drum (until S_1=S_2=5Kg).
8. The motor is switched off using the DPST switch.

MODEL CALCULATION:

FORMULA USED:

Radius $R = r + \frac{T}{2}$ in metre.

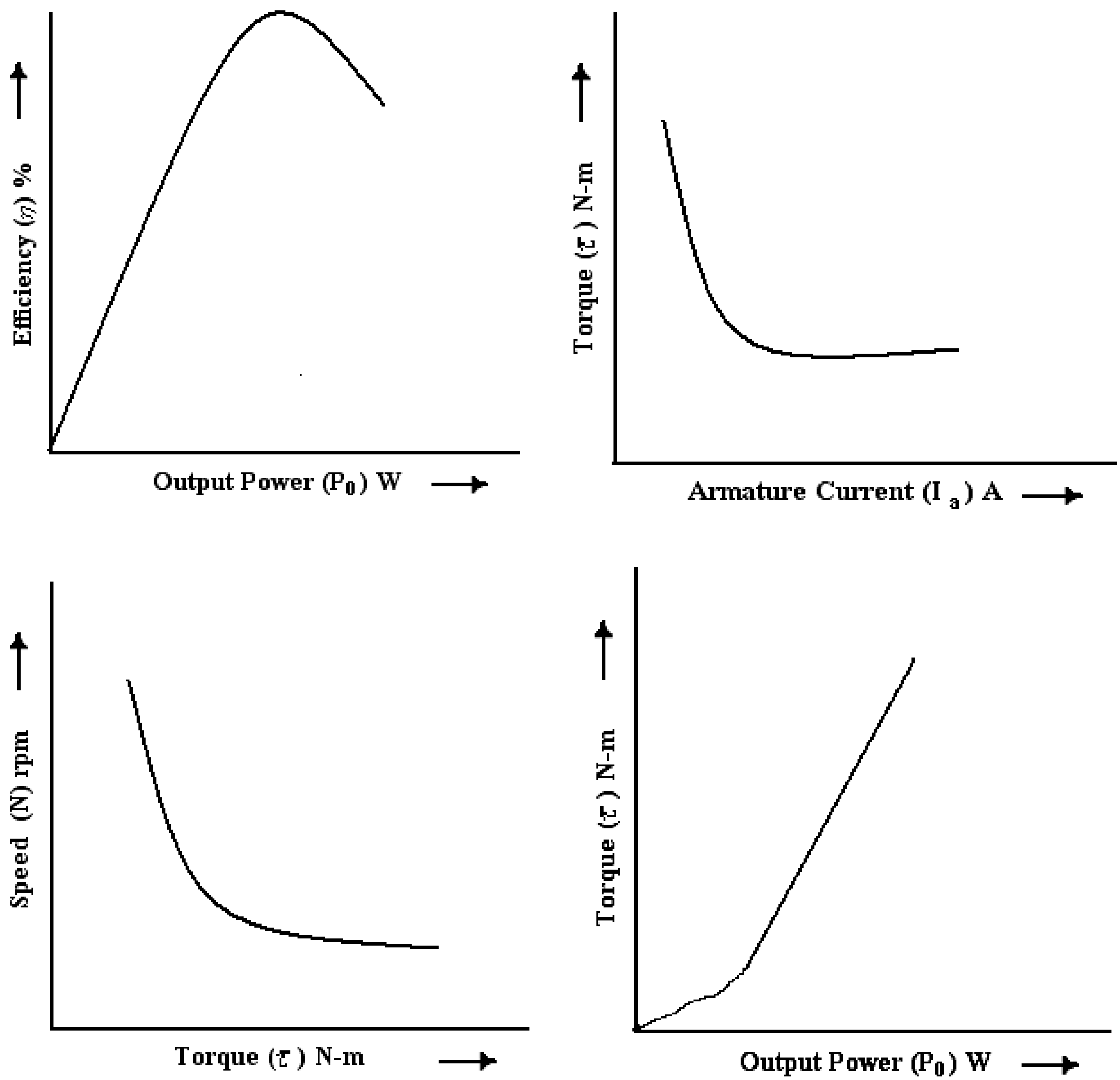
Torque $\tau = 9.81 \times R \times (S_1 - S_2)$ N-m

Input Power $W_i = V_i I_i$ Watts

Output Power, $W_o = \frac{2\pi N\tau}{60}$ Watts

$$\text{Percentage Efficiency} = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

MODEL GRAPH


Efficiency (η) %
Output Power (P_0) W
Torque (τ) N-m
Armature Current (I_a) A
Speed (N) rpm
Torque (τ) N-m
Torque (τ) N-m
Output Power (P_0) W

GRAPHS:

1. Output power Vs efficiency
2. Armature current Vs torque
3. Output power Vs torque
4. Speed Vs Torque

RESULT:

Thus the performance and load characteristics of a DC series motor are drawn.

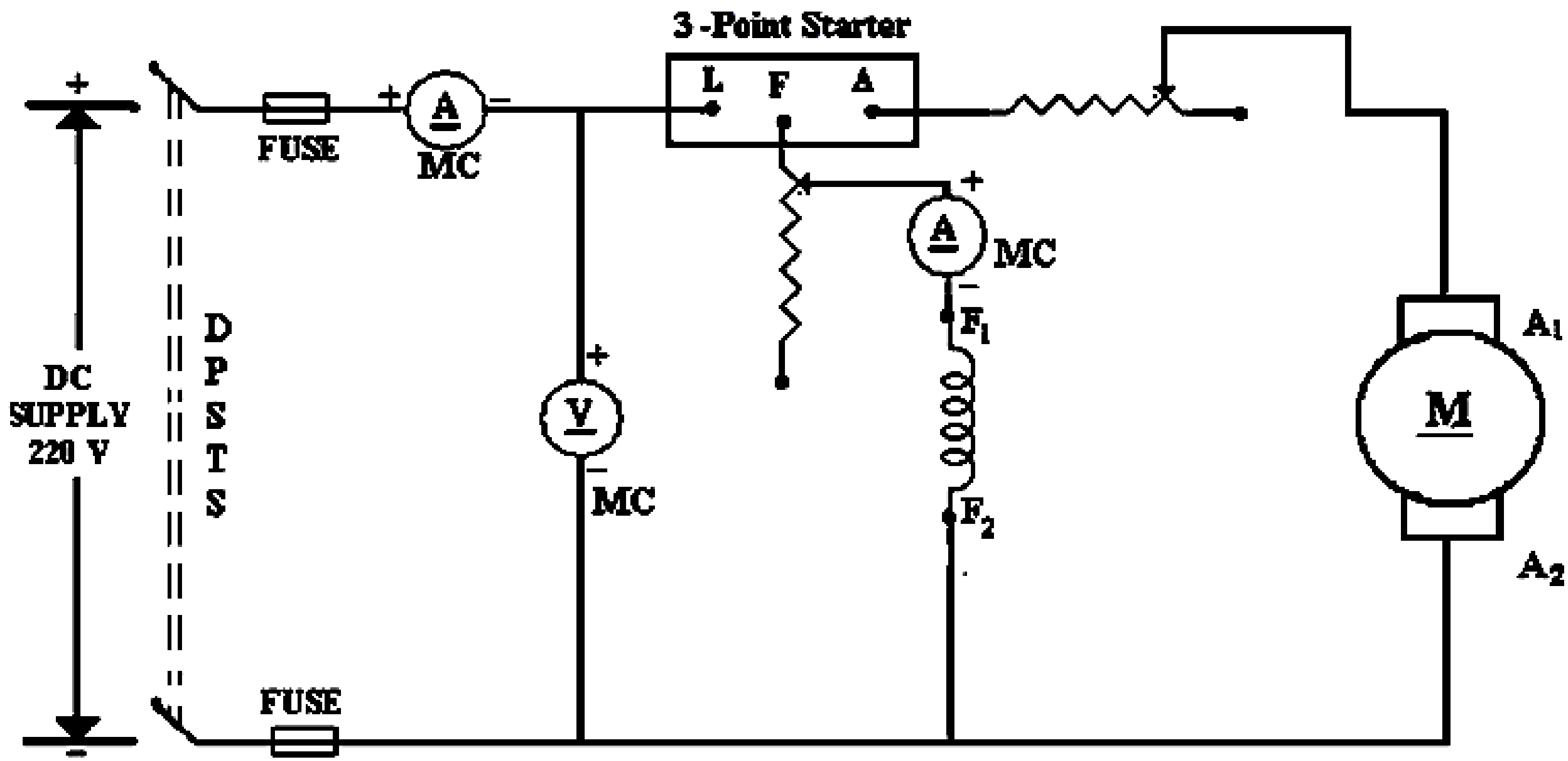
VIVA QUESTIONS

1. Why a DC series motor should not be stared without load?
2. Why a DC series motor has a high starting torque?
3. Compare the resistances of the field windings of DC shunt and series motor?
4. What are the applications of DC series motor?
5. Comment on the Speed – Torque characteristics of a DC series motor.
6. If a graph is drawn by taking armature current (Ia) on the X-axis and Torque (T) on the Y-axis, what will be the shape of the graph?
7. Why is the DC series motor suitable for use in electric traction?
8. At what percentage of full load does the maximum efficiency occur? Mark the point on the graph.
9. Compare the resistances of the series field winding and shunt field winding.
10. Can AC supply be given to DC series motor? If so, what will happen?

EXPERIMENT – 3

SPEED CONTROL OF DC SHUNT MOTOR

SPEED CONTROL OF DC SHUNT MOTOR



Fuse Rating:

Name Plate Details

EXP. NO.: 3 **DATE:**

SPEED CONTROL OF DC SHUNT MOTOR

AIM:

To control the speed of DC shunt motor by

1. Armature control method
2. Field control method

APPARATUS REQUIRRED:

S.No.	Apparatus	Range	Type	Qty
1	Ammeter			
2	Ammeter			
3	Voltmeter			
4	Rheostat			
5	Tachometer			

THEORY:

FLUX CONTROL METHOD

The speed of the DC motor is inversely propositional to the flux per pole, when the armature voltage is kept constant. By decreasing the flux the speed can be increased and vice –versa. Hence the main flux of field control method the flux of a DC motor can be changed by changing field current with help of a shunt field rheostat. Since shunt field current is respectively small shunt field rheostat has to carry only a small amount of current which means I^2R losses is small so that rheostat is small in size .This method is very efficient.

ARMATURE CONTROL METHOD

This method is used when speed below the no load speed are required. As the supply voltage is normally constant the voltage across the armature is varied by inserting a variable rheostat in series with the armature circuit. As conductor resistance is increased potential difference across the armature is decreased, herby decreasing the armature speed. For a load of constant torque speed is approximately propositional to the potential difference across the armature.

<u>TABULATION</u>: SPEED CONTROL OF DC SHUNT MOTOR

ARMATURE CONTROL METHOD

SL. NO.	FIELD CURRENT I_f = _____		FIELD CURRENT I_f = ____	
	ARMATURE VOLTAGE V_a (VOLTS)	SPEED N (RPM)	ARMATURE VOLTAGE V_a (VOLTS)	SPEED N (RPM)

FIELD CONTROL METHOD

SL.NO.	ARMATURE VOLTAGE Va = ____		ARMATURE VOLTAGE Va = ___	
	FIELD CURRENT I_f (AMPS)	SPEED N (RPM)	FIELD CURRENT I_f (AMPS)	SPEED N (RPM)

PRECAUTIONS:

1. Check for the correct fuse ratings.
2. Ensure there are no loose connections.
3. Field rheostat should be kept in minimum resistive position initially.
4. Armature resistance rheostat is kept initially at maximum resistive position**.**

PROCEDURE:

1. The connections are made as per the circuit diagram.
2. Field rheostat is initially kept in the minimum resistive position and the armature rheostat is in the maximum resistive position.
3. Supply is given to the motor by closing the DPST switch.
4. Motor is started using a three point starter.
5. Adjust the armature rheostat to get rated voltage.
6. In actual case adjust to about 200 V, beyond this speed will be more than 1500 rpm.
7. The field rheostat is adjusted to make the motor run at the rated speed.

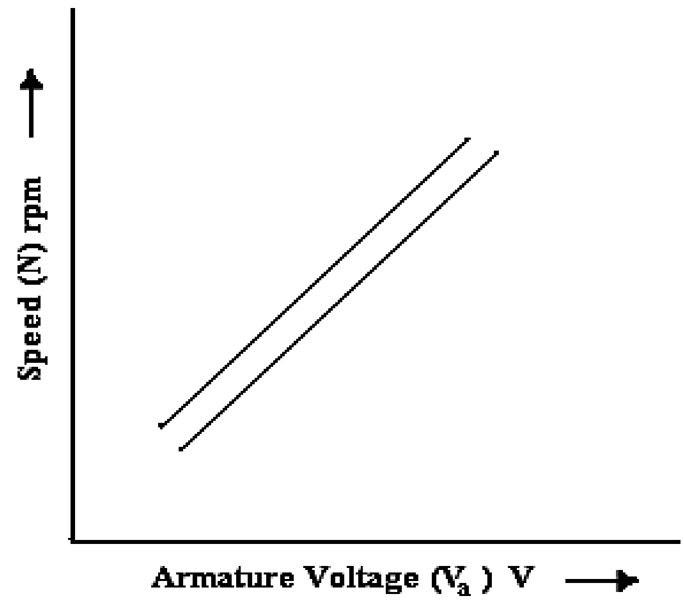
ARMATURE CONTROL METHOD:

1. By varying the field rheostat, set the value of field current to a particular value say I_f = ____ A
2. Now, by varying the armature rheostat, for various values of armature voltages, find the values of speed and armature voltage, repeat this procedure for various values of field current.
3. Bring back the armature rheostat and field rheostat to initial resistive position.

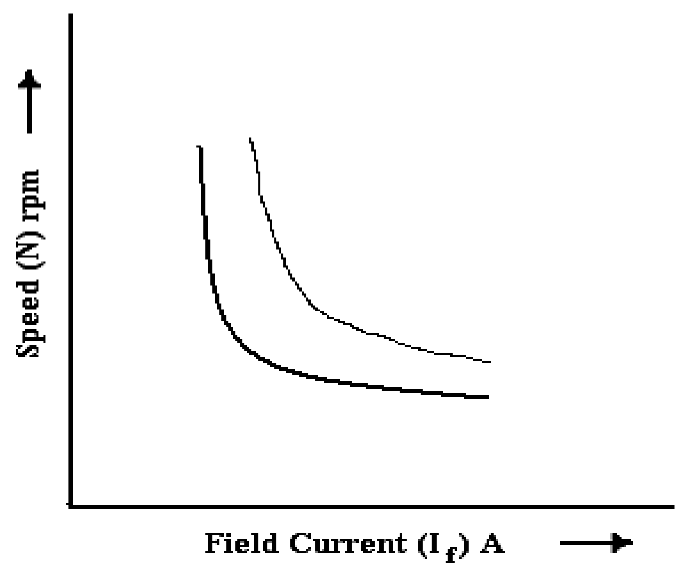
FIELD CONTROL METHOD:

1. By varying the armature rheostat, set the value of armature voltage to a particular value say Va = ____ V.
2. Now, by varying the field rheostat, for various values of filed currents, find the values of speed and filed current, repeat this procedure for various values of armature voltage.
3. Bring back the armature rheostat and field rheostat to the initial resistive position.
4. Switch off the DPST switch.

MODEL GRAPH



Armature Control Method



Field Control Method

GRAPHS:

1.Field current Vs speed

2.Armature voltage Vs speed

RESULT:

Thus the speed control characteristics of DC shunt motor by (i) Armature control method (ii) Field control method are done.

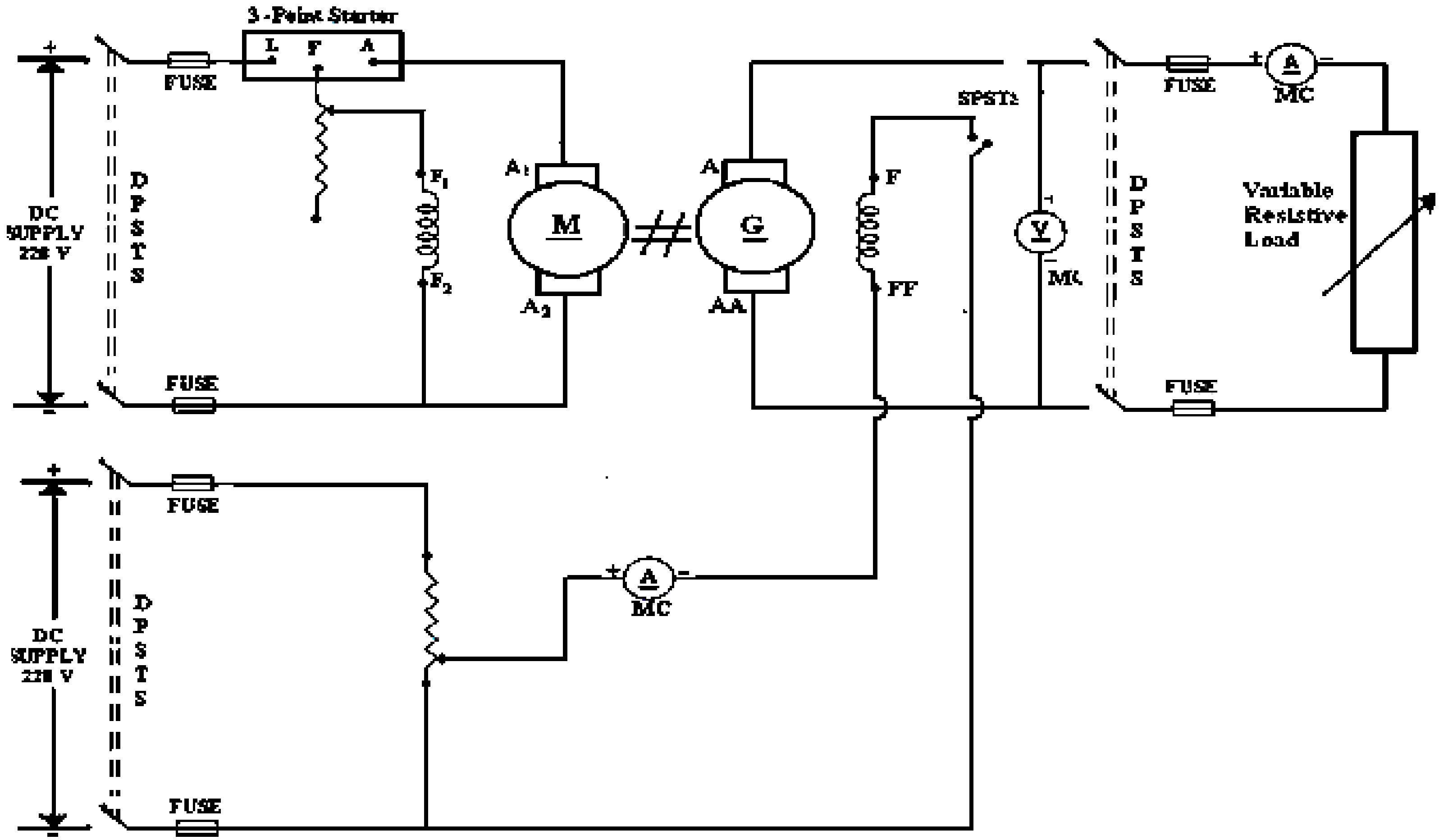
VIVA QUESTIONS:

1. How does the speed of a DC shunt motor vary with armature voltage and field current?
2. Compare the resistance of the armature and field winding.
3. What is the importance of speed control of DC motor in industrial application?
4. Which is of the two method of speed control is better and why?
5. Why is the speed of DC shunt motor practically constant under normal load condition?

EXPERIMENT – 4

OPEN CIRCUIT
AND
LOAD CHARACTERISTICS
OF DC GENERATOR
(SEPARATELY EXCITED)

OCC & LOAD TEST ON DC SEPARATELY EXCITED GENERATOR



FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 4 **DATE:**

OPEN CIRCUIT AND LOAD CHARACTERISTICS OF DC GENERATOR (SEPARATELY EXCITED)

AIM:

To draw the OCC and load characteristics of separately excited DC Generator.

APPARATUS REQUIRRED:

S.No.	Apparatus	Range	Type	Qty
1	Voltmeter			
2	Ammeter			
3	Ammeter			
4	Rheostat			
5	Rheostat			
6	Tachometer			

THEORY:

Due to residual magnetism in the poles some EMF is generated even when If = 0. Hence the curve starts a little way up. The slight curvature at the lower end is due to magnetic inertia. It is seen that in the first part of the curve is practically straight. Hence the flux and the consequently the generated EMF is directly proportional to the exciting current. However at the higher flux densities where it is small iron path reluctance becomes appreciable and straight.

Field windings are connected parallel to the armature and it is called dc shunt generator. Due to residual magnetism some initial emf and hence some current will be generated. This current while passing into the field coils will strengthen the magnetism of poles. This will increase pole flux which will further increase the generated emf. Increased emf and flux proceeds till equilibrium reached. This reinforcement of emf and flux proceeds till equilibrium reached at some point.

PRECAUTIONS:

1. Check for Correct Fuse Ratings.
2. Avoid loose connections.
3. The generator field rheostat is kept in maximum voltage position and motor field rheostat is minimum resistive position.
4. Initially all switches kept at open condition and the variable resistive load should be no load condition.

TABULATION: OCC & LOAD TEST ON SEPERATELY EXCITED DC GENERATOR

OPEN CIRCUIT CHARACTERISTICS:

SL.NO.	Field Current (I_f) Amps	Generated Voltage (E_g) Volts

LOAD CHARACTERISTICS:

SL.NO.	Load Current I_L Amps	Load Voltage V_L Volts	Armature Current $I_a = I_L$ Amps	$I_a R_a$ Volts	Generated Voltage $E_g = V_L + I_a R_a$ Volts

TABULATION FOR R_a:

SL.NO.	Armature Current Ia (Amps)	Armature Voltage Va (Volts)	Armature Resistance Ra = Va/Ia (Ohms)
		Average Ra	

PROCEDURE:

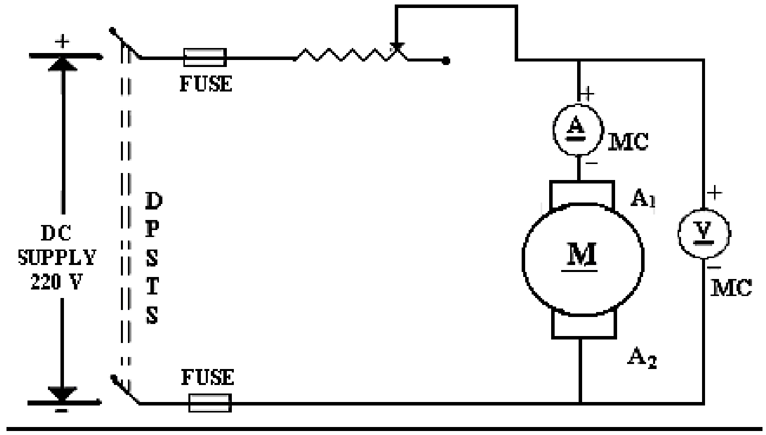
OPEN CIRCUIT CHARACTERISTICS

1. The connections are given as per the circuit diagram.
2. Supply is given to motor by enclosing DPSTS 1.
3. Motor is started using Three point Starter.
4. The field Rheostat of motor is varied to make the motor run at rated speed of the generator.
5. The voltmeter and ammeter readings are noted.
6. The field rheostat of generator is varied gradually and the readings of ammeter and volt meter are noted in steps.
7. Bring the generator field rheostat and motor field rheostat to the original position and open the DPSTS 1.

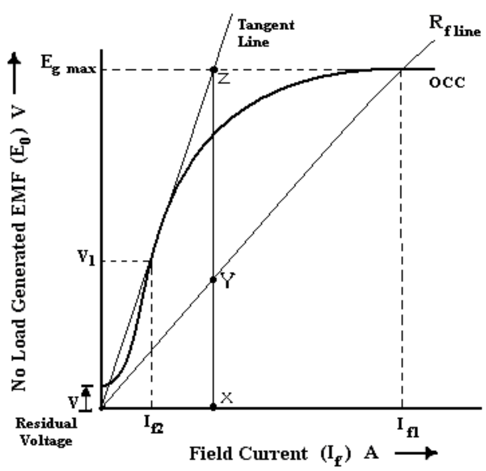
LOAD CHARACTERISTICS:

1. The connections are given as per the circuit diagram.
2. Supply is given to motor by enclosing DPSTS 1.
3. Motor is started using Three point Starter.
4. The field Rheostat of motor is varied to make the motor run at rated speed of the generator.
5. By adjusting the field rheostat of the generator, the generator voltage is brought to the rated voltage.
6. Now the load side DPST2 is closed and load is applied gradually upto rated current.
7. The speed is maintained constant at each load.
8. The readings of ammeter and voltmeter are noted at each load.
9. Remove the load completely.
10. Open the load side DPST2.
11. Bring the field rheostat of generator and motor to its original position and open the DPST1.

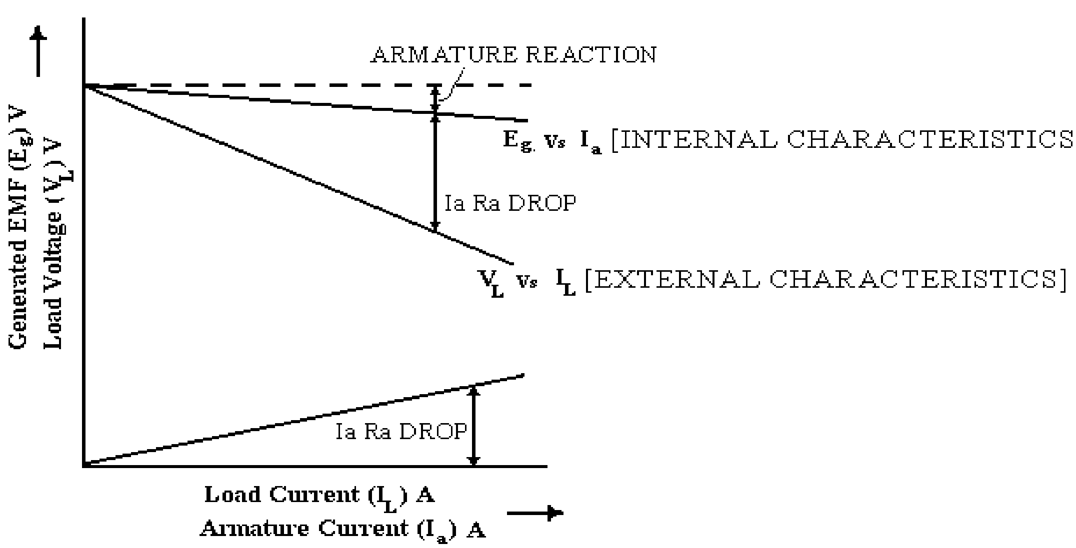
CIRCUIT DIAGRAM TO MEASURE R_a



MODEL GRAPH:



$$\text{Critical Resistance } R_C = \frac{V_1}{I_{f2}}\,\Omega, \text{ Critical Speed } N_C = \frac{XY}{YZ} \times \text{rated speed}$$



GRAPHS:

1.Field current Vs Generated voltage
2.Load current Vs Load voltage

RESULT:

Thus the OCC and load characteristics of DC shunt generator when it is separately excited are determined.

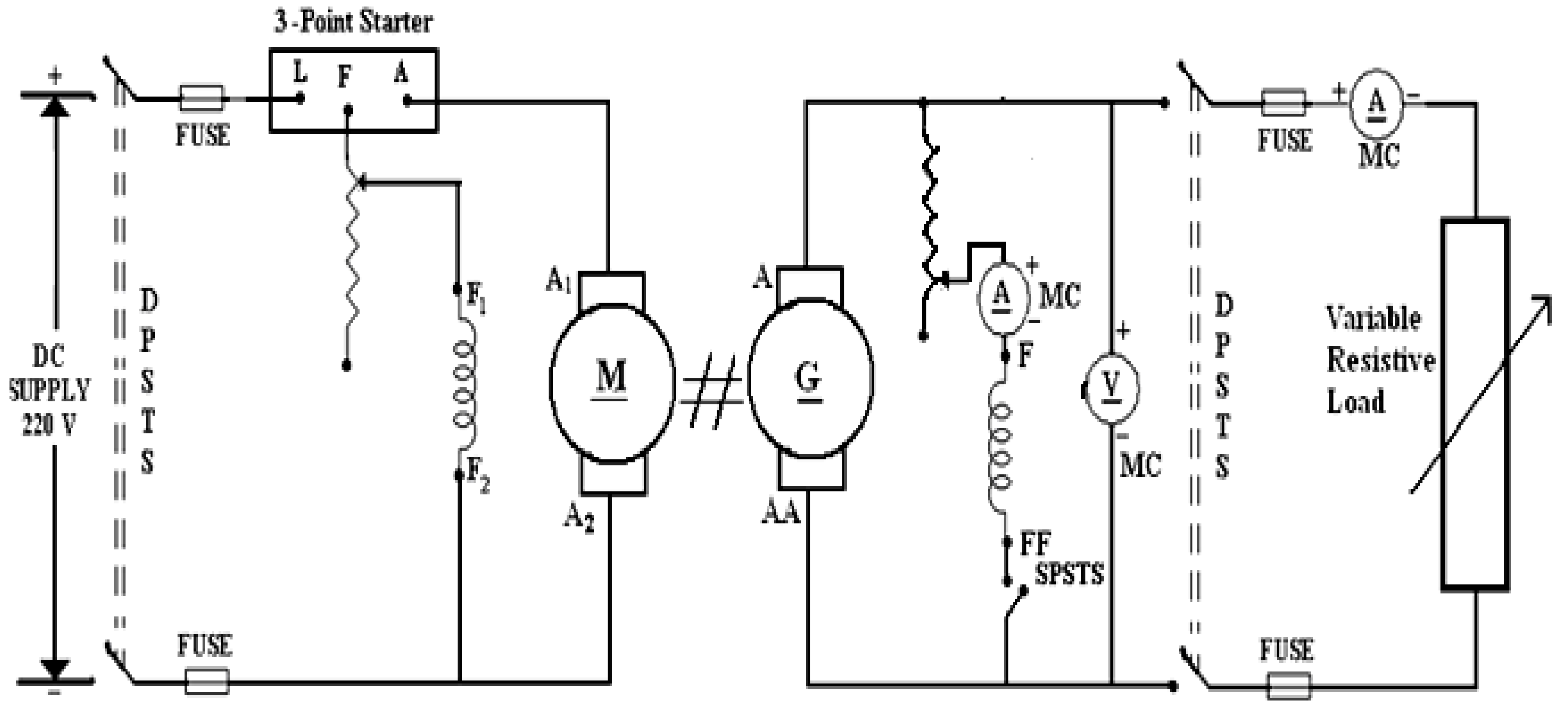
VIVA QUESTIONS:

1. What is the principle of generator?
2. What is meant by separately excited dc generator?
3. What is the function of brushes in dc generator?
4. Tell the function of commutator in DC generator?
5. Why the armature core is laminated in dc machine?
6. What are the conditions for a dc generator to build up voltage?
7. What is meant by saturation?
8. Comment on the shapes of the OCC and load characteristics of a dc separately excited generator.

EXPERIMENT – 5

OPEN CIRCUIT
AND
LOAD CHARACTERISTICS
OF DC GENERATOR
(SELF EXCITED)

OCC & LOAD TEST ON DC SHUNT GENERATOR



FUSE RATING

NAME PLATE DETAILS

EXP.NO. 5 **DATE:**

OPEN CIRCUIT AND LOAD CHARACTERISTICS OF DC GENERATOR (SELF EXCITED)

AIM:

To draw the OCC and load characteristics of Self Excited DC shunt Generator.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Qty
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			
5	Resistive Load			

THEORY:

A DC generator requires an excitation circuit to generate an induce voltage depending on whether excitation circuit consumes power for the armature of the machine or from separately require power supply. Generators may be classified as self excited or separately excited generators respectively.

The induced emf in DC generators is given by the equation PϕZN/60A volts. State P, Z, A are constants the above equation are written as Eg= KϕN. I f the speed of the generator also maintained constant then Eg = Kϕ but the flux is directly proportional to the current Hence Eg =K2If.From the above equation it is clear that the induced emf is directly propositional to the field current when speed maintained constant,. The plot between the induced emf and the field current is known as open circuit characteristics of the DC generator.

The induced emf when the field current is zero is known as residual voltage. This emf is due to the presence of a small amount of flux detained. In the field poles of the generator called residual flux. Once the OCC is obtained parameters such as critical field resistance, critical speed and the maximum voltage to which the machine can build up can be determined. If required the OCC at a different speeds can also be obtained. Critical speed is minimum speed below which the generator shunt fails to excite.

A DC generator works on the principle of Faraday’s Law of Electromagnetic induction, which says that, “Whenever a conductor is moved in magnetic field, an EMF is generated in it”.

TABULATION:

TO DRAW OCC:

S.No.	Open Circuit Voltage (V_0)	Field Current (I_f)
	Volts	Amps

TO DRAW LOAD CHARACTERISTICS:

S.No.	Load Current (I_L)	Terminal Voltage (v)	Field Current (I_f)	Armature Current (I_a)	Induced Voltage E_g=V+IaRa
	Amps	Volts	Amps	Amps	Volts

TO FIND R_a:

S.No.	Armature Voltage (V_a)	Armature Current (I_a)	Armature Resistance (R_a)
	Volts	Amps	Ω

“The magnitude of induction EMF is directly proportional to the rate of change of flux”. The voltage equation for a DC shunt generator is given; by VL = Eg – IaRa; Under No Load Condition; Since Ia, Is negligibly small, From the above equation, the terminal voltage (VL), Is the no; load induced EMF (Eg), as the load on the generator increases, the load current and hence the armature current increases due to armature reaction the induced EMF in the armature decreases.

Also increased armature current causes increase in IaR_a drop. Hence the terminal voltage decreases with increase load. The plot between the terminal voltage (VL) and load current (IL) is known as the external of load characteristics. The plot between the induced EMF (Eg) and the armature current (Ia) is known as the internal or total characteristics. The type of graph of internal and external characteristics is shown in model graph.

PRECAUTIONS:

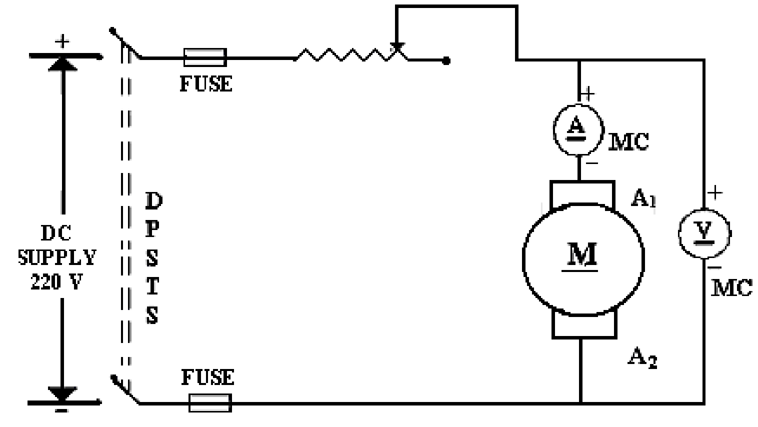
1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Keep the motor field rheostat at minimum resistance position and generator field rheostat at maximum resistive position.
3. The SPST switch is kept open at the time of starting the experiment.
4. As the no-load test is conducting the required fuse ratings are 20% of motor rated current.
5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge.

PROCEDURE:

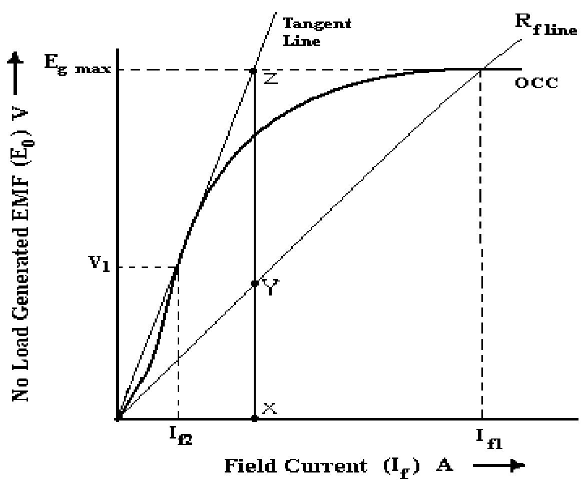
OPEN CIRCUIT CHARACTERISTICS

1. The connections are given as per the circuit diagram.
2. Supply is given to motor by enclosing DPSTS 1.
3. Motor is started using Three point Starter.
4. The field Rheostat of motor is varied to make the motor run at rated speed of the generator.
5. Note residual voltage before closing the SPST switch.
6. The voltmeter and ammeter readings are noted.
7. The field rheostat of generator is varied gradually and the readings of ammeter and volt meter are noted in steps.
8. Bring the generator field rheostat and motor field rheostat to the original position and open the DPSTS 1.

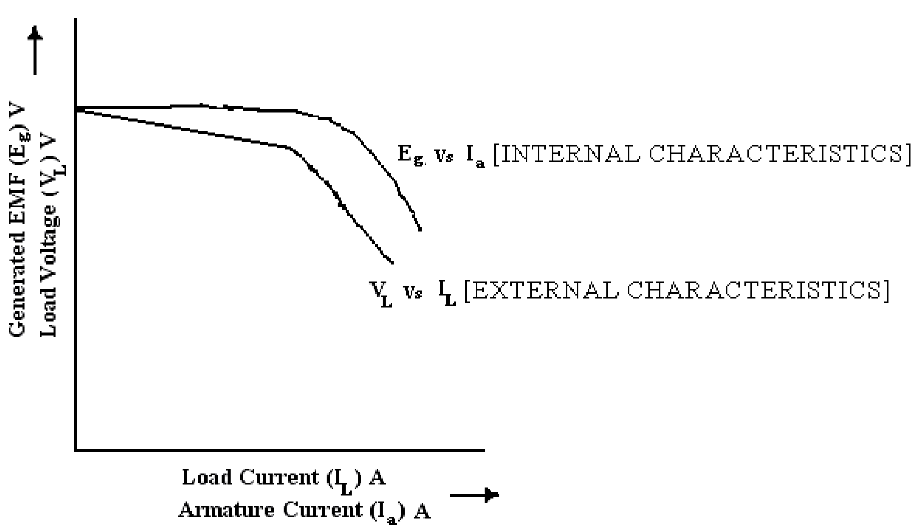
CIRCUIT DIAGRAM TO MEASURE R_a



MODEL GRAPH:



Critical Resistance $R_C = \frac{V_1}{I_{f2}}\ \Omega$, Critical Speed $N_C = \frac{XY}{YZ} \times$ rated speed



LOAD CHARACTERISTICS:

1. The connections are given as per the circuit diagram.
2. Supply is given to motor by enclosing DPSTS 1.
3. Motor is started using Three point Starter.
4. The field Rheostat of motor is varied to make the motor run at rated speed of the generator.
5. By adjusting the field rheostat of the generator, the generator voltage is brought to the rated voltage.
6. Now the load side DPST2 is closed and load is applied gradually upto rated current.
7. The speed is maintained constant at each load.
8. The readings of ammeter and voltmeter are noted at each load.
9. Remove the load completely.
10. Open the load side DPST2.
11. Bring the field rheostat of generator and motor to its original position and open the DPST1.

GRAPHS:

1.Field current Vs Generated voltage
2.Load current Vs Load voltage

RESULT:

Thus the OCC and load characteristics of DC shunt generator when it is separately excited are determined.

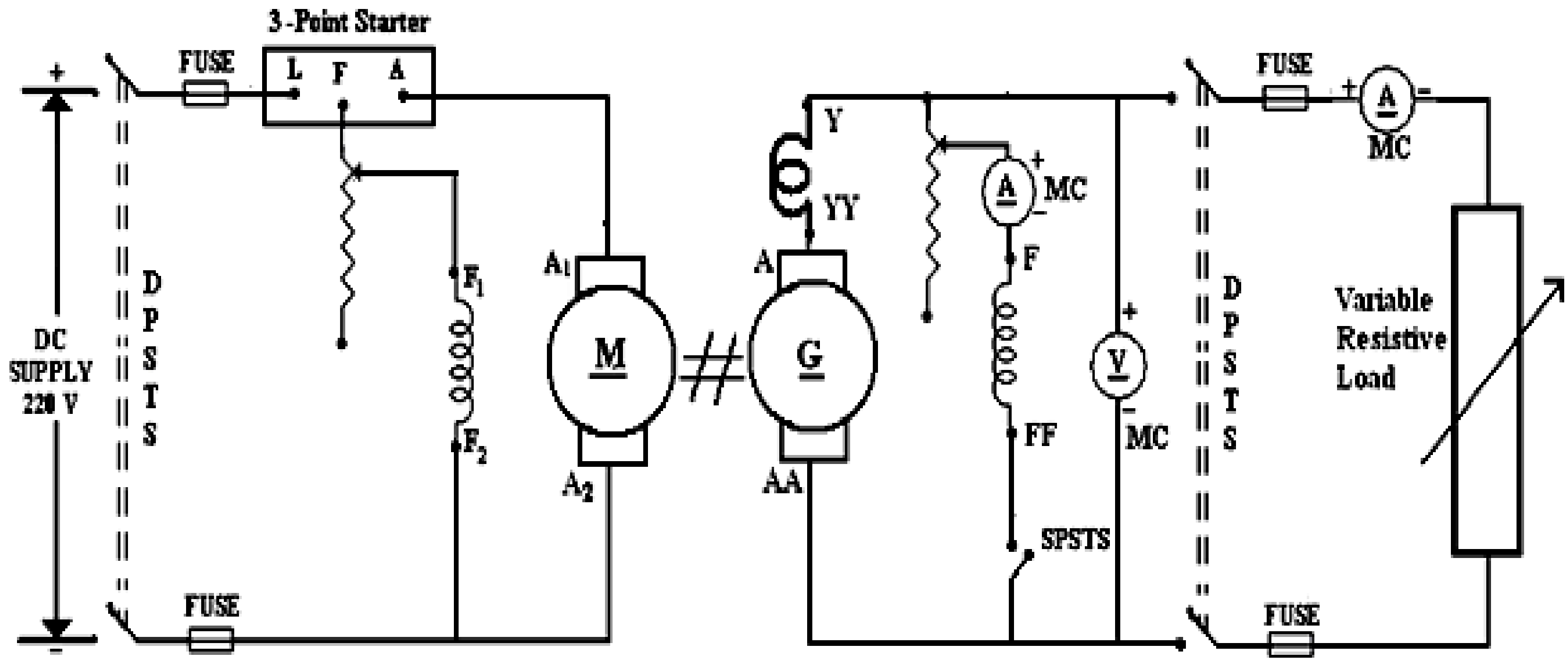
VIVA QUESTIONS:

1. Tell the function of commutator in DC generator?
2. Why the armature core is laminated in dc machine?
3. Define eddy current loss and hysterisis loss
4. What is the function of brushes in dc generator?
5. Define critical speed and critical resistance?

EXPERIMENT – 6

LOAD TEST ON DC COMPOUND GENERATOR

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR WITH DIFFERENTIAL AND CUMULATIVE CONNECTION



FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 6 **DATE:**

LOAD TEST ON DC COMPOUND GENERATOR

AIM:

To determine the load characteristics of given self excited dc compound generator.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Qty
1	Ammeter			
2	Voltmeter			
3	Rheostat			
4	Tachometer			
5	Resistive Load			

THEORY:

A shunt generator may be made to supply substantially constant voltage or even rise in voltage as the load increases, by adding to it a few turns joined in series with armature. These turns are so connected as to hide the shunt turns when the generator supplies the load. As the load current is increases, the current through the series winding also increases there by increasing the flux. Due to the increasing the flux, induced emf also increase. By adjusting the number of series turns, this increase emf can be load to be balance the combine voltage drop in the generator due to armature reaction and armature drop. Hence the voltage remains practically constant.

The cumulatively – compound generators are used for motor driving which required DC supply constant voltage, for lamp loads and for heavy power service. The differential – compound generator is widely use in arc welding were larger voltage drop is desirable with increasing current.

PRECAUTIONS:

1. All switches kept initially.
2. The motor field rheostat, R_1 is at minimum resistance initially and the generator field rheostat R_2 is at maximum resistance position initially.
3. The speed of the machine is maintained constant for the whole experiment.

TABULATION:

CUMULATIVELY COMPOUNDED GENERATOR

S.No.	I_L	I_F	V_L	I_a	$I_a(R_a+R_{se})$	$E_g=V_L+I_a(R_a+R_{se})$	Speed
	A	A	V	A	V	V	Rpm

DIFFERENTIALLY COMPOUNDED GENERATOR

S.No.	I_L	I_F	V_L	Ia	$Ia(Ra+R_{se})$	$Eg=V_L+Ia(Ra+R_{se})$	Speed
	A	A	V	A	V	V	Rpm

MEASUREMENT OF Ra:

S.No	Armature Voltage (Va)	Armature Current (Ia)	Armature Resistance (Ra)
	V	A	Ω

MEASUREMENT OF Rse:

S.No	Voltage (Vse)	Current (Ise)	Resistance (Rse)
	V	A	Ω

PROCEDURE:

LOAD TEST

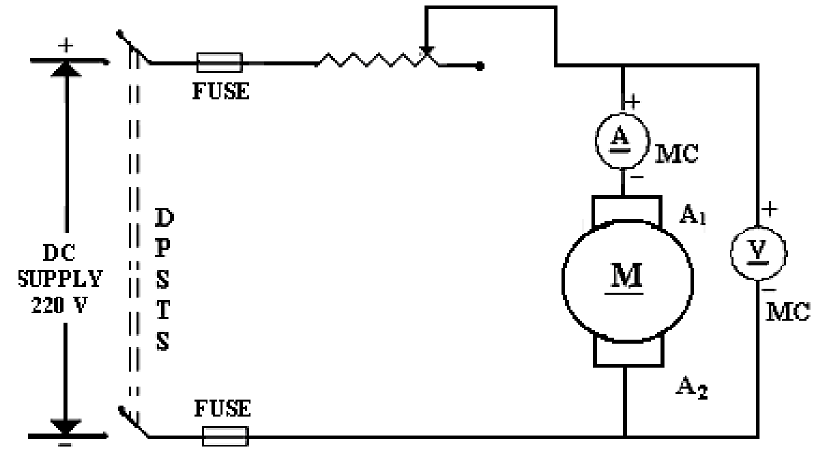
(Procedure same for cumulative compound generator and differential compound generator. Interchange series coil connections for the later)

1. The DPST switch S_1 is closed and the starter handle is moved from OFF position to ON position. Motor picks up speed. Adjust the motor field rheostat so that it runs at rated speed. Maintain the speed constant for the rest of the experiment.
2. Adjust the generator field rheostat so that the generator terminal voltage is the rated voltage. After this the generator field rheostat is not altered for the rest of the experiment.
3. The no load terminal voltage and field current is noted.
4. The DPST switch S_2 is closed and the load is applied in steps from no load to full load. In each load the speed is maintained constant by adjusting motor field rheostat R_1.
5. The terminal voltage V field current if and load current I_L are noted for every load. The readings are tabulated.
6. After completion of the test, load is removed in steps, S_2 is opened and motor supply is switch off by opening S_1.
7. Induced EMF E_g is calculated, along with I_a, armature current. Here induced EMF E_g is the EMF after allowing for armature reaction.
8. Repeat procedure a to g for differentially compounded generator.

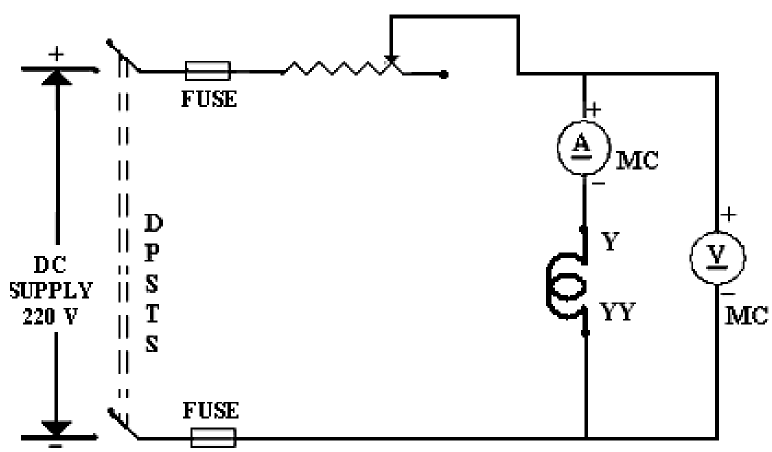
MEASUREMENT OF ARMATURE RESISTANCE AND SERIES COIL RESISTANCE:

1. The circuit is as shown in figure 2.
2. Keeping the rheostat at maximum resistance position, close S_3 (or) S_4.
3. Keep various voltmeter or ammeter readings by varying the rheostat. Meter readings are noted.
4. The ratio of voltage and current gives the required resistance.

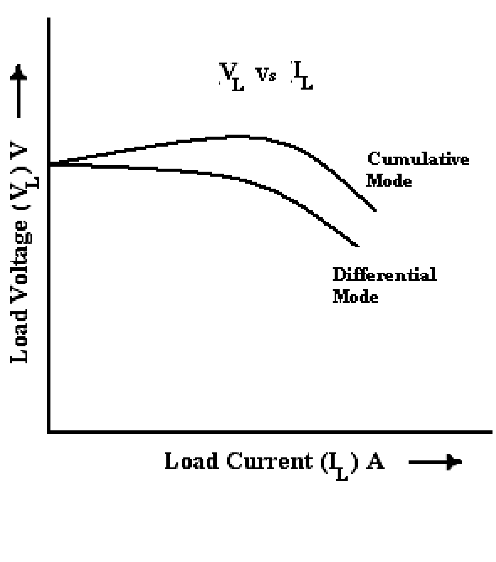
CIRCUIT DIAGRAM TO MEASURE R_a



CIRCUIT DIAGRAM TO MEASURE R_{se}



MODEL GRAPH:



GRAPHS:

The following characteristics curves are drawn,

1. External characteristics (V Vs I)
2. Internal characteristics (E_g Vs I_a)

For both differential compounding and cumulative compounding of the generator.

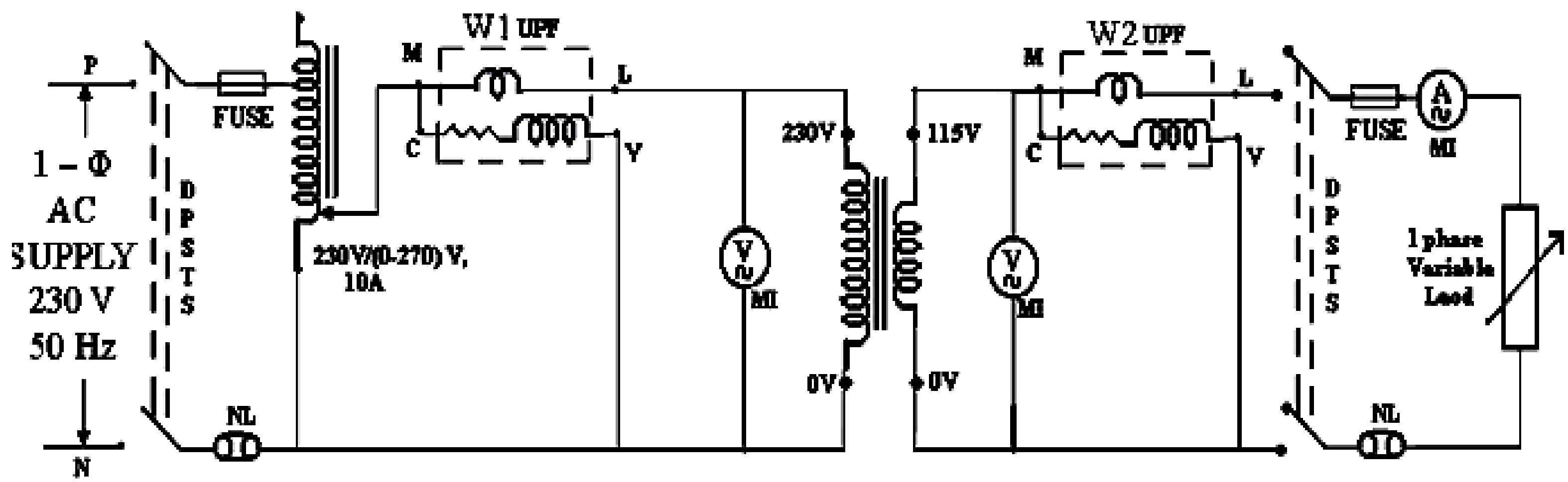
RESULT:

The load test on a DC compound generator was conducted and characteristics curves drawn.

EXPERIMENT – 7

LOAD TEST ON SINGLE PHASE TRANSFORMER

LOAD TEST ON SINGLE PHASE TRANSFORMER



FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 7 **DATE:**

LOAD TEST ON SINGLE PHASE TRANSFORMER

AIM:

To conduct load test on single phase transformer and to obtain percentage efficiency & regulation.

APPARATUS REQUIRRED:

Sl.No	Apparatus	Type	Range	Quantity
1	Voltmeter			
2	Ammeter			
3	Lamp load			
4	1ф Transformer			
5	Wattmeter			
6	Auto Transformer			

THEORY:

When the secondary is loaded the secondary current I_2 is setup. The magnitude and phase of I_2 with respect to V_2 is determined by the characteristics of the load. The secondary current sets up its own mmf and hence its own flux ф2 which is in opposition to main primary flux ф which is due to I0 the secondary ampere turns N_2*I_2 are known as demagnetizing ampere turns .The opposing secondary flux I2 weakens the primary flux ф momentary. Hence primary back Emf E1 tends to be reduced. For a moment V1 gain the upper handover E1 and hence causes more current to flow in primary.

Let the additional primary current be $I2^1$ .It is known as load component of primary current. This current is antiphase with $I2^1$ the additional primary mmf N1*I2 sets up its own flux $ф2^1$ which is in opposite to ф2 and is equal to its magnitude. Hence the two cancel each other out. So the magnetic effects of secondary current I2 are immediately neutralized by the additional primary current $I2^1$.Hence whatever the load conditions be, the net flux passing through core is approximately the same as no-load.

PRECAUTIONS:

1. The autotransformer should be kept at minimum voltage position.
2. Before switching off the supply the variac should be brought back to 0 minimum voltage positions.
3. Initially load should off condition.

TABULATION: LOAD TEST ON SINGLE PHASE TRANSFORMER

mf_1 = mf_2 =

SL.NO.	Primary Voltage V_1 Volts	Primary Current I_1 Amps	W_1 Watts	Sec. Voltage V_2 Volts	Sec. Current I_2 Amps	W_2 Watts	Input Power $W_1 \times mf_1$ Watts	Output Power $W_2 \times mf_2$ Watts	Efficiency η %	Regulation %

PROCEDURE:

1. Connect as per the circuit diagram
2. Close the DPST switch
3. Adjust the Auto transformer till the rated voltage is reached
4. Note down the readings of primary voltmeter, ammeter and wattmeter& secondary voltmeter, ammeter and wattmeter
5. Apply load in steps and note down the corresponding reading till the rated current is reached.

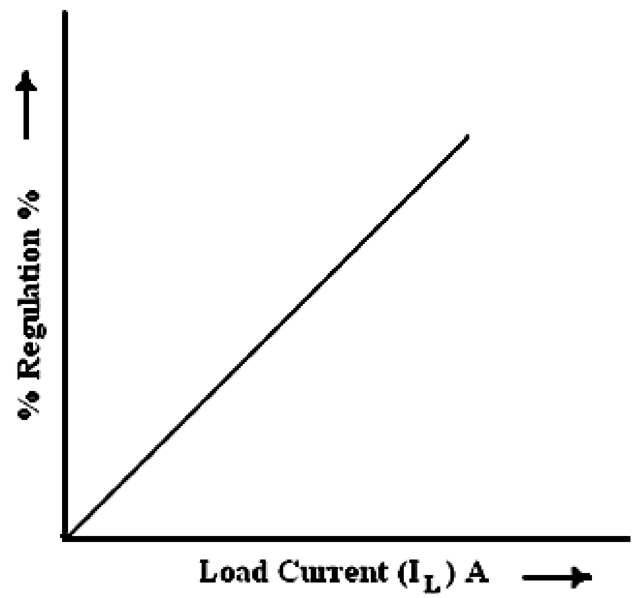
FORMULA USED:

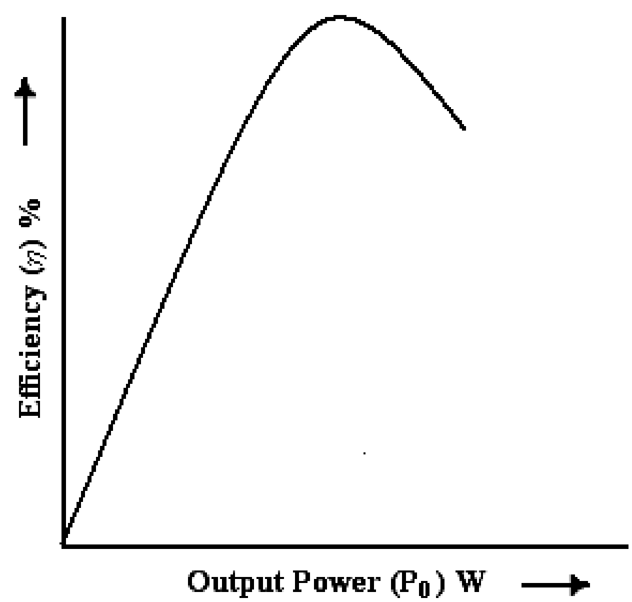
$$\% \text{ Efficiency } \eta = \frac{\text{Output power}}{\text{Input power}} \times 100$$

$$\% \text{ Regulation } = \frac{E0 - V}{V} \times 100$$

MODEL CALCULATION:

MODEL GRAPH:





GRAPHS:

1. Output power Vs efficiency

2. Output power Vs % regulation

RESULT:

Thus the load test on single phase transformer was performed and the respective graphs were plotted.

VIVA QUESTIONS:

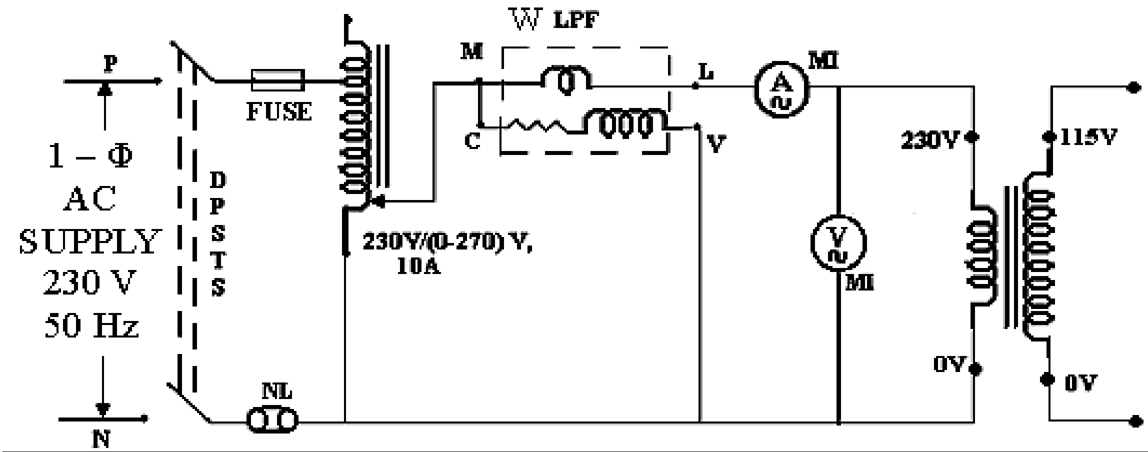
1. What is the principle of a transformer?
2. What are the types of transformer?
3. What are the applications of transformer?
4. Why is the capacity of a transformer specified as KVA and not as KW?
5. What is the condition for maximum efficiency of a transformer and at which load does it occur?
6. Why is the efficiency of a transformer higher than that of motors?

EXPERIMENT – 8

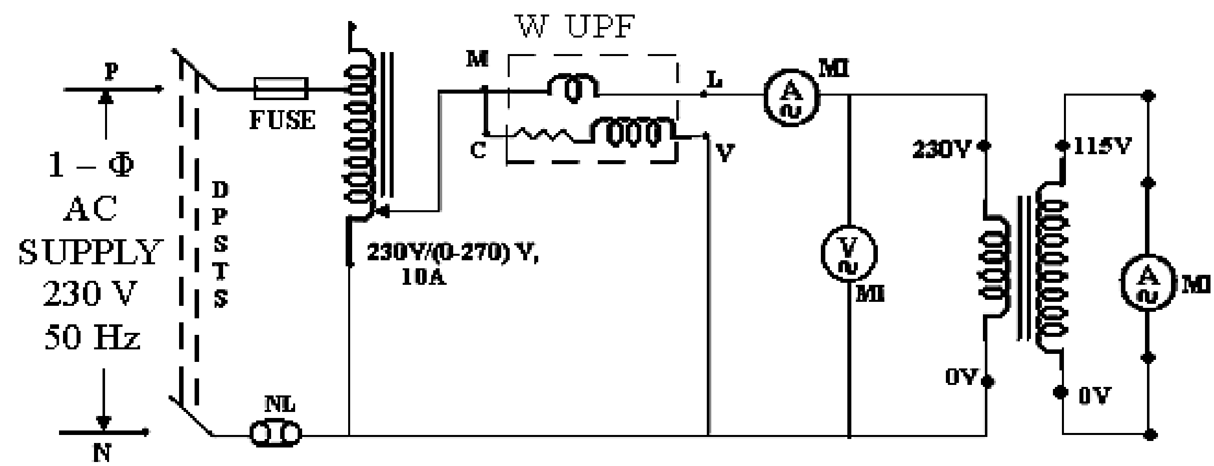
OC & SC TEST ON SINGLE PHASE TRANSFORMER

OC & SC TEST ON SINGLE PHASE TRANSFORMER

OPEN CIRCUIT TEST



SHORT CIRCUIT TEST



FUSE RATING **NAME PLATE DETAILS**

EXP. NO.: 8 **DATE:**

OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON SINGLE PHASE TRANSFORMER

AIM:

To conduct OC and SC tests on single phase transformer and to draw the equivalent circuit and obtain percentage efficiency & regulation at UPF &0.8 PF (lag & lead).

APPARATUS REQUIRED:

SL.NO	APPARATUS	TYPE	RANGE	QUANTITY
1.	Voltmeter			
2.	Voltmeter			
3.	Ammeter			
4.	Ammeter			
5.	Wattmeter			
5.	1ϕ Transformer			
6.	Wattmeter			
7.	Auto Transformer			

THEORY:

The purpose of this test is to determine no load loss or core loss and no load current I_0. This is helpful in finding X0 and R0.

One winding of the transformer whichever is convenient but usually HV winding is kept open and the other is connected to its supply of normal voltage and frequency. A wattmeter W, voltmeter and ammeter A are connected in the present case. With normal voltage applied to the primary normal flux will be set up in the cores hence normal iron losses will occur which are recorded by the wattmeter. As the primary no load current Io is small. Cu loss is negligibly small in primary. Hence the wattmeter reading represents the core loss under no load conditions.

It should be noted that since I_0 is very small, the pressure coils of wattmeter and the voltmeter are connected such that the current in these do not pass through the current coil of wattmeter.

PRECAUTIONS:

1. The autotransformer should be kept at minimum voltage position.
2. Before switching off the supply the variac should be brought back to minimum voltage position.

TABULATION: OPEN CIRCUIT TEST:

V_O Volts	I_O Amps	Wattmeter Reading (mf =)	
		Observed W_O	Actual W_O x mf Watts

SHORT CIRCUIT TEST:

V_{SC} Volts	I_{SC} Amps	Wattmeter Reading (mf =)	
		Observed W_{SC}	Actual W_{SC} x mf Watts

MODEL CALCULATION:

PROCEDURE:

OC TEST:

1. Connect as per the circuit diagram
2. Close the DPST switch
3. .Adjust the Auto transformer till the rated voltage is reached
4. Note down the readings of primary voltmeter, ammeter and wattmeter.
5. Adjust the Auto transformer till the ZERO voltage is reached
6. Open the DPST switch

SC TEST:

1. Connect as per the circuit diagram
2. Close the DPST switch
3. Adjust the Auto transformer till the rated CURRENT is reached
4. Note down the readings of primary voltmeter, ammeter and wattmeter.
5. Adjust the Auto transformer till the ZERO voltage is reached
6. Open the DPST switch

FORMULAE:

$R_0 = V_1/I_W$

$X_0 = V_1 / I\mu$

$I_W = I_0 \cos \phi_0$

$I\mu = I_0 \sin\phi_0$

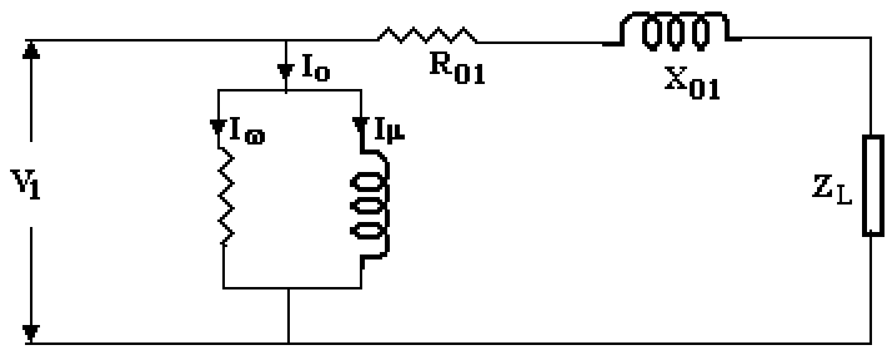
$Z_{01} = V_{SC}/I_{SC}$

$R_{O1} = W_{SC}/I_{SC}^2$

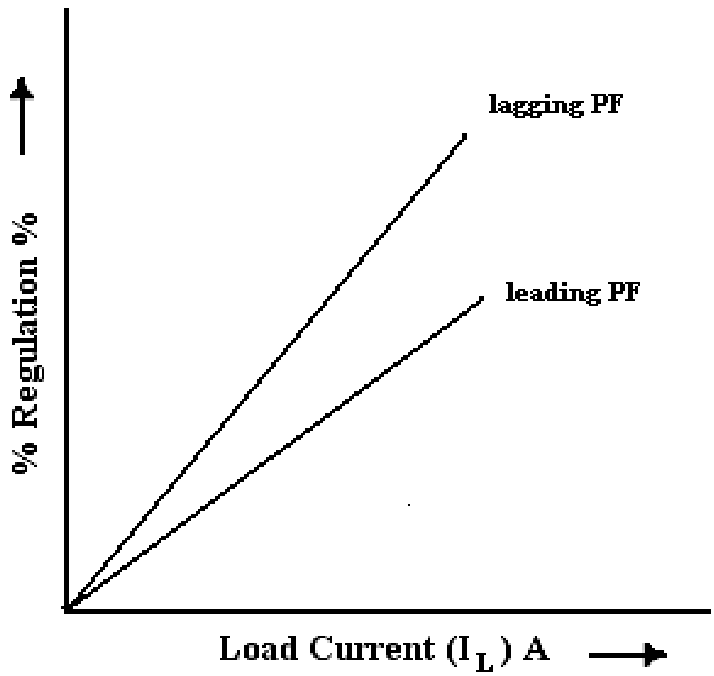
$XO1 = \sqrt{Z_{01}^2 - R_{01}^2}$

$$\% \text{ Regulation at lead} = \frac{I_{SC}(R_{O1} \cos\phi_0 - X_{O1} \sin \phi_0)}{V1} \times 100$$

EQUIVALENT CIRCUIT OF SINGLE PHASE TRANSFORMER



MODEL GRAPH



$$\%\ \text{Regulation at lag} = \frac{I_{SC}\,(R_{O1}\text{COS}\phi_0 + X_{O1}\,\text{Sin}\,\phi_0\ )}{V1} \quad X \quad 100$$

CU Losses = $W_{SC} * X^2$ Where X = Load

Output power = KVA*1000*X *PF watts

Input power = Output power + Losses

$$\text{Efficiency} = \frac{\text{Output power}}{\text{Input power}} \quad X \quad 100$$

GRAPHS:

% Regulation Vs power factor

RESULT:

Thus the OC & SC tests on single phase transformer were performed and the respective graphs were drawn.

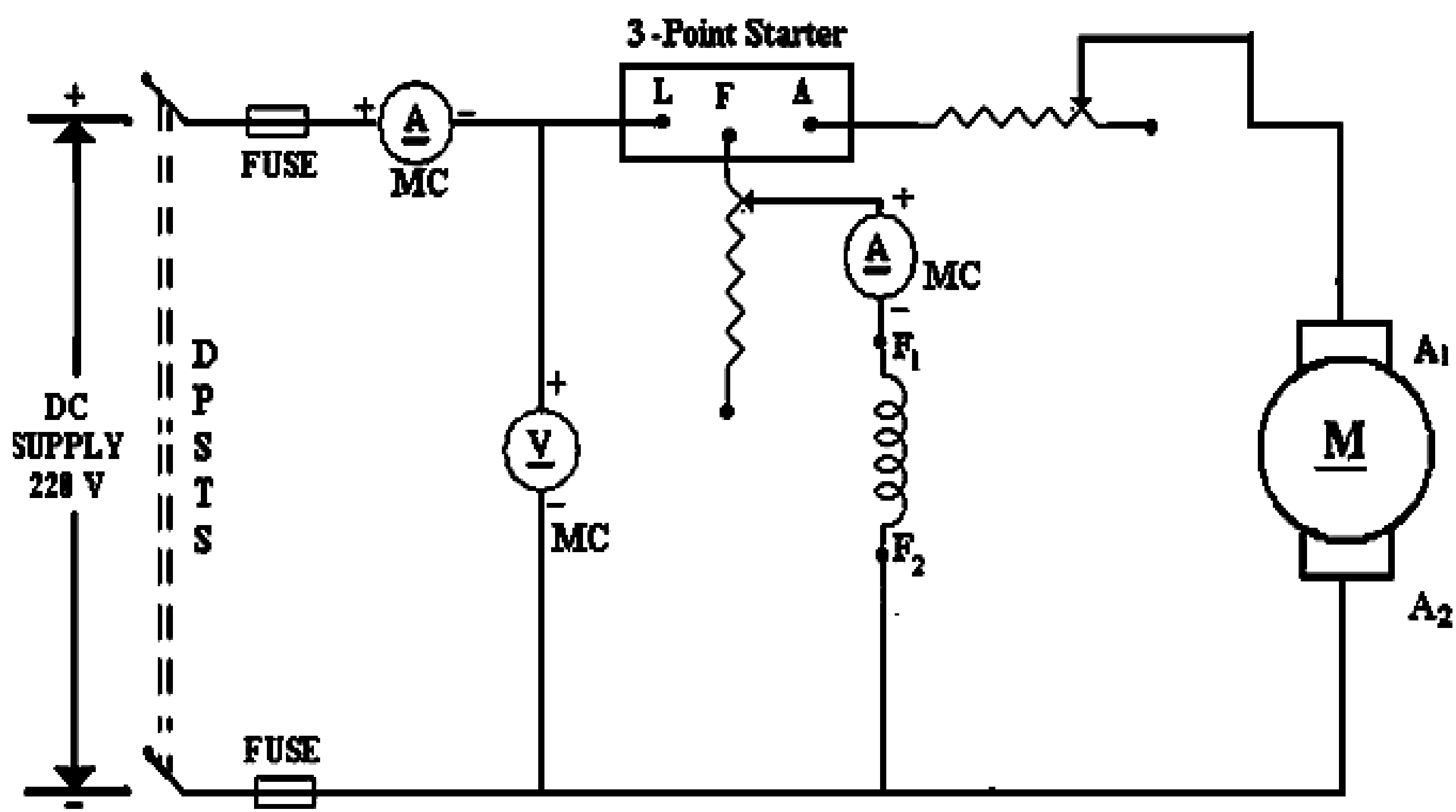
VIVA QUESTIONS:

1. What is the purpose of OC and SC tests?
2. Why the core is laminated?
3. What is meant by regulation?
4. Define the term transformation ratio?
5. What are the components of no load current?

EXPERIMENT – 9

SWINBURNE'S TEST

SWINBURNE'S TEST



FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 9 **DATE:**

SWINBURNE'S TEST

AIM:

To predetermine the efficiency of a DC shunt machine by conducting the Swinburne's Test

1. as a motor
2. as a generator

APPARATUS REQUIRED:

SL.NO.	APPARATUS	RANGE	TYPE	QUANTITY
1	Ammeter			
2	Ammeter			
3	Voltmeter			
4	Voltmeter			
5	Rheostat			
6	Rheostat			
7	Tachometer			

THEORY:

In this method the losses are measured separately and from their knowledge efficiency at any desired load can be predetermined. Hence the only running test needed is the no load test. This test is applicable to the machine in which flux is practically constant i.e shunt wound and compound wound machines. The machine is to run as a motor at its rated voltage. The speed is adjusted to rated speed with help of shunt field regulator. The no load current and field current are measured using ammeters.

This test is convenient and economical because power required to test a large machine is small i.e. only input power is required. The efficiency can be predetermined at any load because constant losses are known. In this test we are not taking into account the change in iron loss from no-load to full load. In this test it is impossible to know that whether commutation would be satisfactory at full load and whether temperature rise would be within specified limits.

TABULATION: SWINBURNE'S TEST

Motor on No Load

V_O Volts	I_O Amps	I_f Amps	$I_a = I_O - I_f$ Amps	Speed (N) RPM

PREDETERMINATION OF LOSSES AND EFFICEINCY AT DIFFERENT LOADS:

AS A MOTOR:

SL. NO	Load Voltage V_L Volts	Load Current I_L Amps	Armature Current Ia Amps	Copper losses $Ia^2 Ra$ Watts	Total losses Wi + Wc Watts	Input Power $V_L I_L$ Watts	Output Power I/P - losses Watts	Efficiency η %

AS A GENERATOR:

SL. NO	Load Voltage V_L Volts	Load Current I_L Amps	Armature Current Ia Amps	Copper losses $Ia^2 Ra$ Watts	Total losses Wi + Wc Watts	Output Power $V_L I_L$ Watts	Input Power O/p+losses Watts	Efficiency η %

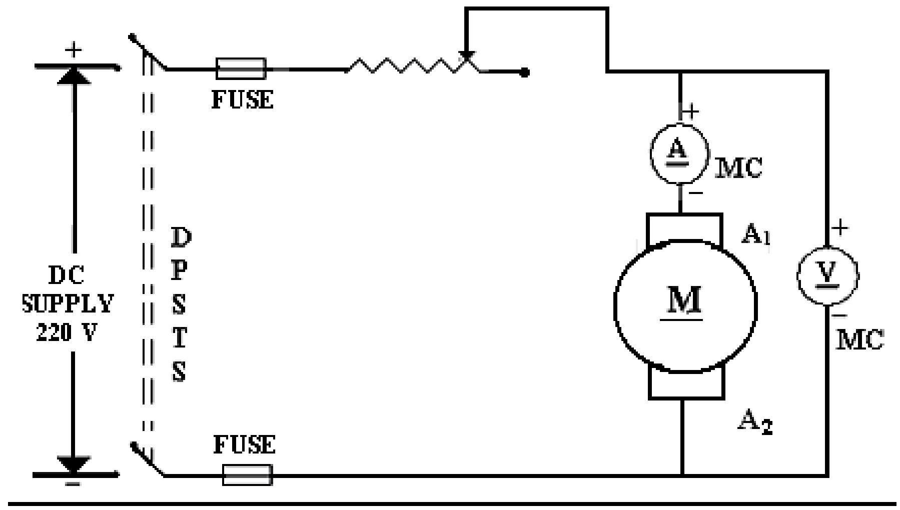
PRECAUTIONS:

1. The field rheostat must be kept in minimum resistance position.
2. The starter handle must be kept in OFF position before switching ON the supply.
3. The motor must be started at no load condition.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. The supply is switched ON by closing the DPST switch.
3. The field rheostat is adjusted till the motor attains its rated speed.
4. The readings of the ammeters and voltmeter are noted under no load conditions.
5. The rheostat is brought back to the minimum resistive position and the supply is switched OFF.
6. The DC resistance of the armature is determined using a voltmeter and an ammeter.

CIRCUIT DIAGRAM TO MEASURE R_a



SL.NO.	Armature Current Ia (Amps)	Armature Voltage Va (Volts)	Armature Resistance Ra = Va/Ia (Ohms)
		Average Ra	

MODEL CALCULATION:

FORMULA USED:

Constant Losses Wc = VIo – (Io – Ish)^2 Ra Watts

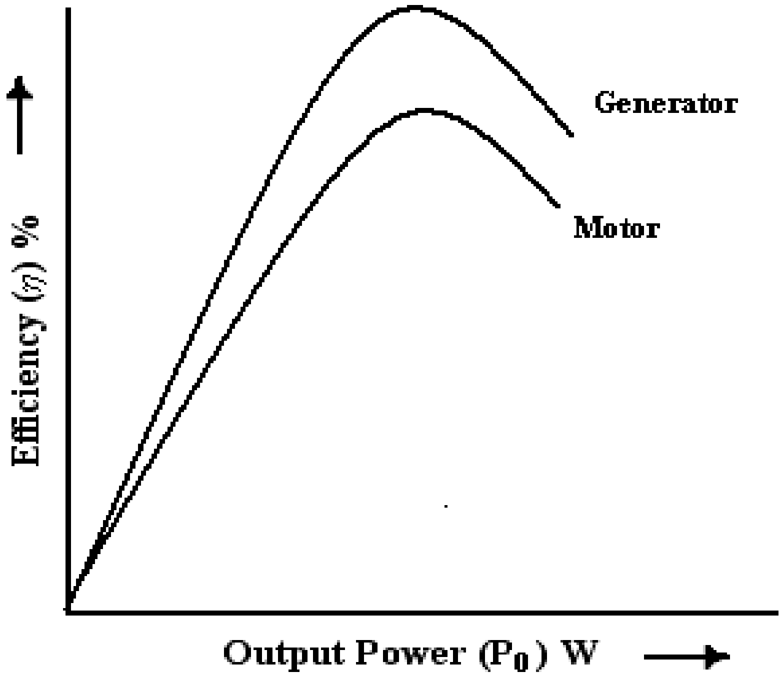
As a Motor:

Input power = V_LI_L Watts
Ia =I_L – If Amps
Armature Cu loss = Ia^2 Ra Watts
Total Loss = Wc + Cu loss Watts
Output power = Input – Total loss Watts
% Efficiency = Output/Input * 100

As a Generator:

Ia =I_L + If Amps
Armature Cu loss = Ia^2 Ra Watts
Total Loss = Wc + Cu loss Watts
Output power = V_LI_L Watts
Input power = Output + Total loss Watts
% Efficiency = Output/Input * 100

MODEL GRAPH:



GRAPHS:

1. Output power Vs efficiency (as a motor)
2. Output power Vs efficiency (as a generator)

RESULT:

Thus the Swinburne's test (no load test) was conducted and the following efficiency was predetermined at different loads:

1. Efficiency as motor
2. Efficiency as generator.

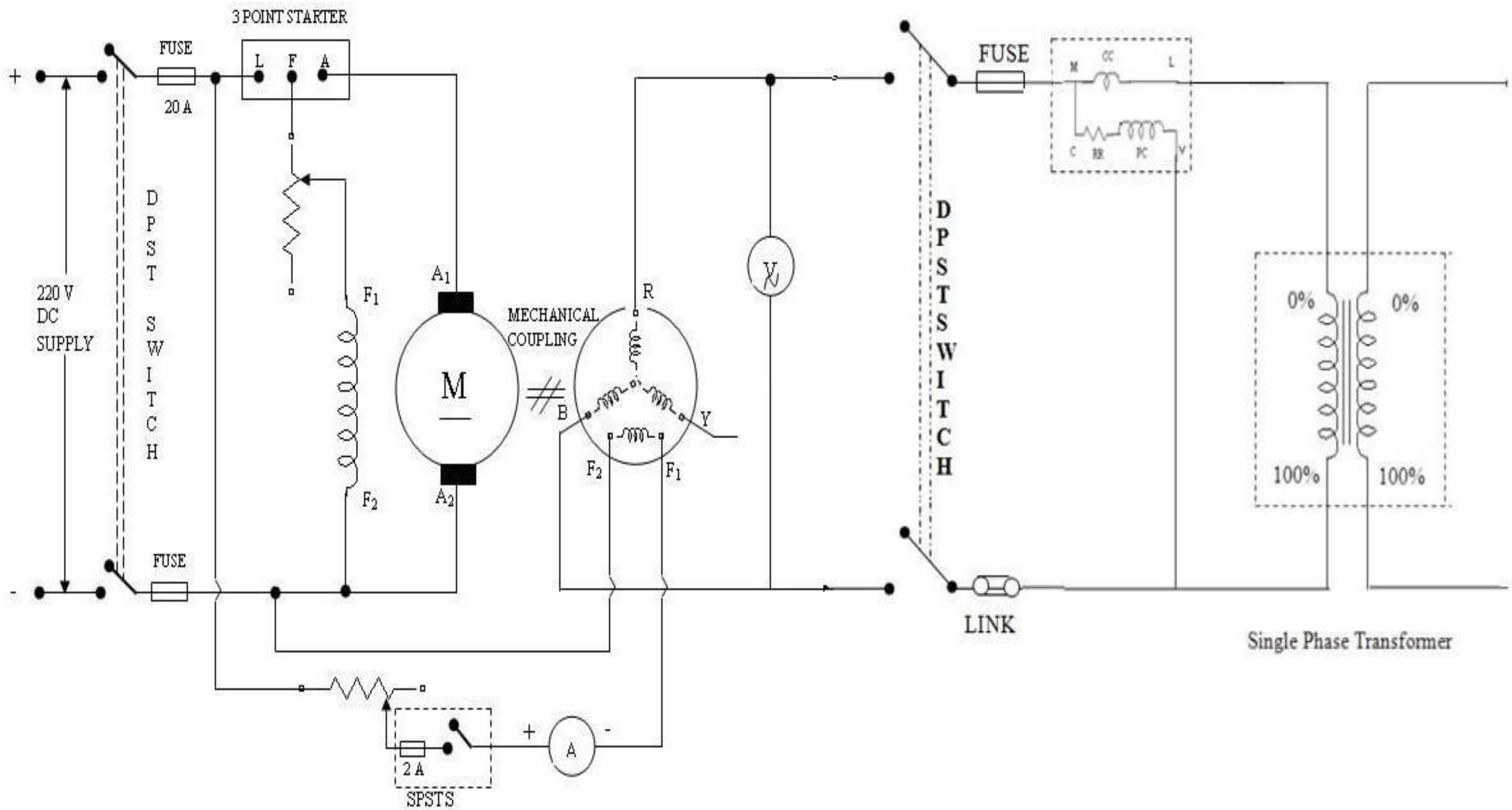
VIVA QUESTIONS:

1. What is the purpose of Swinburne's test?
2. What are the constant losses in a DC machine?
3. What are the assumptions made in Swinburne's test?
4. Why is the indirect method preferred to the direct loading test?
5. The efficiency of DC machine is generally higher when it works as a generator than when it works as a motor. Is this statement true or false? Justify your answer with proper reasons.

EXPERIMENT – 10

SEPARATION OF LOSSES IN SINGLE PHASE TRANSFORMER

SEPARATION OF LOSSES IN SINGLE PHASE TRANSFORMER



FUSE RATING

NAME PLATE DETAILS

EXP. NO.:10 **DATE:**

SEPARATION OF LOSSES IN SINGLE PHASE TRANSFORMER

AIM:

To separate the eddy current loss and hysteresis loss from the iron loss of single phase transformer

APPARATUS REQUIRED:

SL.NO	APPARATUS	RANGE	TYPE	QTY
1	Voltmeter			
2	Ammeter			
3	Wattmeter			
4	Voltmeter			
5	Rheostat			
6	Single Phase Transformer			

THEORY:

PRECAUTIONS:

1. The motor field rheostat should be kept at minimum resistance position.
2. The alternator field rheostat should be kept at maximum resistance position

TABULATION: SEPARATION OF LOSSES IN SINGLE PHASE TRANSFORMER

S.No	Speed (RPM)	Frequency f (Hz)	Voltage V (Volts)	Wattmeter reading Watts	Iron loss Wi (Watts)	Wi / f Joules

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. The DC motor is started by using the 3 point starter and brought to rated speed by adjusting its field rheostat.
4. By varying the alternator filed rheostat gradually the rated primary voltage is applied to the transformer.
5. The frequency is varied by varying the motor field rheostat and the readings of frequency are noted and the speed is also measured by using the tachometer.
6. The above procedure is repeated for different frequencies and the readings are tabulated.
7. The motor is switched off by opening the DPST switch after bringing all the rheostats to the initial position

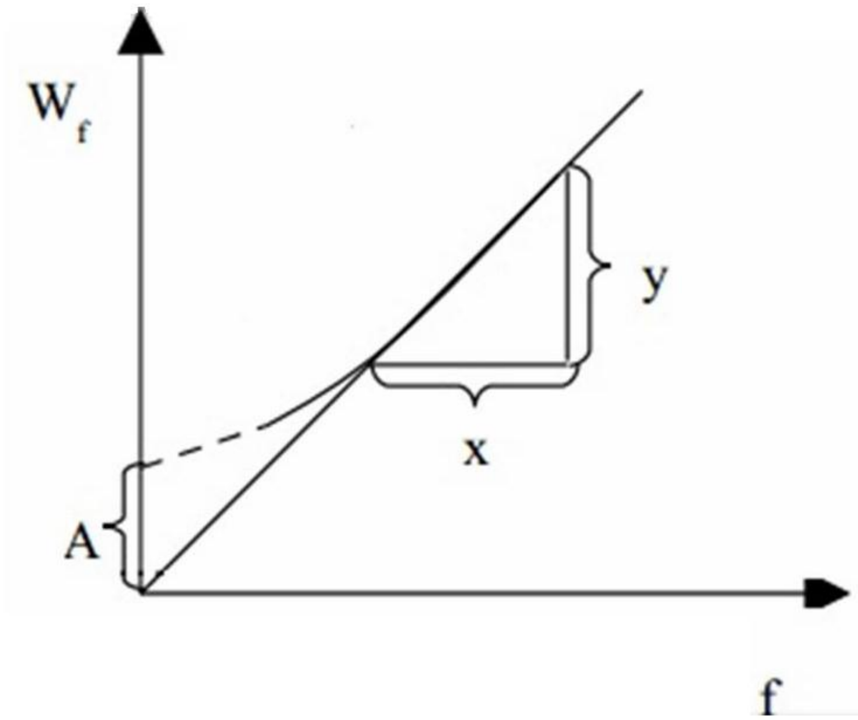
FORMULAE USED:

1. Frequency, f =(P*NS) / 120 in Hz P = No.of Poles & Ns = Synchronous speed in rpm.
2. Hysteresis Loss W_h= A * f in Watts A = Constant (obtained from graph)
3. Eddy Current Loss We= B * f^2 in Watts B = Constant (slope of the tangent drawn to the curve)
4. Iron Loss Wi= Wh+ Wein Watts

$$Wi / f = A + (B * f)$$

Here the Constant A is distance from the origin to the point where the line cuts the Y-axis in the graph between Wi / f and frequency f. The Constant B is $\Delta(Wi/ f) / \Delta f$

MODEL GRAPH:



MODEL CALCULATION:

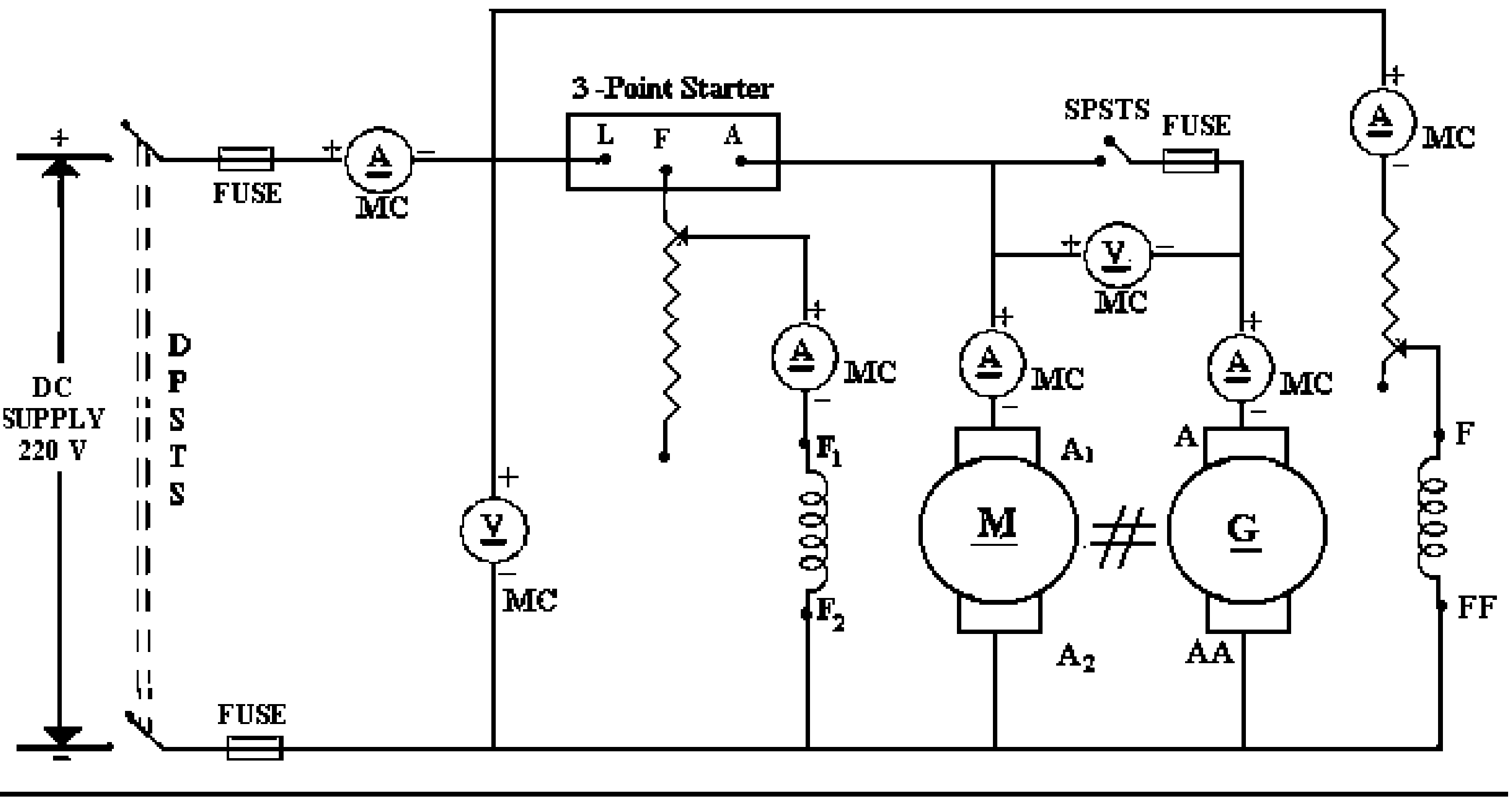
RESULT:

Thus the eddy current loss and hysteresis loss from the iron loss of single phase transformer have been separated.

EXPERIMENT – 11

HOPKINSON'S TEST

HOPKINSON'S TEST



FUSE RATING

NAME PLATE DETAILS

EXP. NO.: 11 **DATE:**

HOPKINSON'S TEST

AIM:

To conduct the Hopkinson's test on the given pair of DC machines and to obtain the performance curve.

APPARATUS REQUUIRED:

SL.NO	APPARATUS	RANGE	TYPE	QTY
1	Voltmeter			
2	Voltmeter			
3	Ammeter			
4	Ammeter			
5	Tachometer			
6	SPST knife switch			

THEORY:

In this method full load test can be carried out on two shunt machines without wasting their outputs. The two machines are mechanically coupled and adjusted so that one of them runs as a motor and the other runs as a generator. The mechanical output of the motor drives the generator and the electrical output of the generator drives the motor. Due to losses the generator output is not sufficient to drive the motor and vice versa. The motor is started with no load. Then the field of one is weakened and the other is strengthened so that the former runs as motor and the latter as generator.

Initially the SPST switch is kept open. The field is adjusted so that the motor runs at rated speed. The voltage is adjusted by the field regulator until the voltmeter reads zero indicating that the voltage is same in polarity and magnitude as that of main supply. Then the switch is closed to parallel the machines. By adjusting the respective field regulators any load can be thrown on the machine. Generator current I_1 can be adjusted to any desired value by increasing the excitation of generator or by reducing the excitation of motor.

The power required for this test is very small when compared to the full load power of two machines. As machines are tested under full load conditions the temperature rise and commutation quantities are observed.

TABULATION: HOPKINSON'S TEST

I_L	Terminal Voltage V_L	Field Current motor Ifm	Field Current Generator I_{FG}	Armatu re current Generat or I_{AG}	Armat ure curre nt motor I_{AM}	Wconst.m	Armat ure cu loss of motor	Armatu re cu loss of Gen	Total loss	Stra y loss	Wsm = Wsg	Shun t cu loss of gen Wcug	Shunt cu loss of motor Wcu m	Wconst. g
A	V	A	A	A	A	W	W	W	W	W	W	W	W	W

PRECAUTIONS:

1. The SPST is closed only when the voltmeter across it reads zero.
2. The motor field rheostat & generator field rheostat should be kept in minimum resistive & maximum voltage position.

PROCEDURE:

1. Connectional are given as per the circuit diagram.
2. Initially all switches are kept open.
3. The motor field rheostat is kept at minimum resistive position & generator field rheostat is kept at maximum voltage position.
4. The motor is brought to rated speed by varying the motor field resistance.
5. The generator terminal voltage is increased using the generator field rheostat till the voltmeter across the SPST switch reads 0.
6. Interchange generator arm connections if the voltmeter V2 reads double the rated voltage.
7. Close the SPST switch. When the voltmeter across it reads zero.
8. Now the motor & generator are paralleled.
9. Note down the voltage V1 of the motor, field current and armature current.
10. The armature resistance of both machines is determined separately.

FORMULA USED:

1) Motor armature copper loss = I2AM RAM
2) Generator armature copper loss - I2AG RAG
3) Total losses = V * IL
4) Stray loss = V * IL
5) Wsm = WSG = stray loss / 2

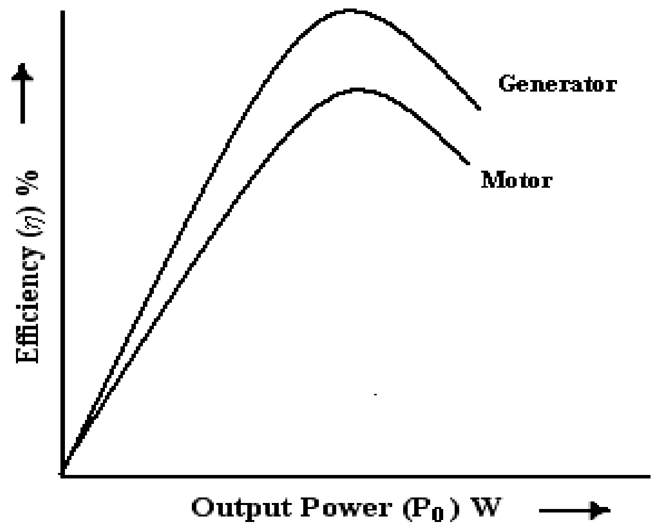
The shunt copper loss in generator

1) $W_{cug} = V_1 * I_{fg}$
2) $W_{cum} = V_1 * I_{fm}$
3) Constant loss (m)=$W_{const.m} = W_{sm} + W_{cum}$
4) $W_{const.G} = W_{s\ G} + W_{cu.G}$
5) To determine the efficiency of generator
6) Output.Power =V_L*Ia.G
7) Input Power = $W_{const.gm} + W_{cu.g}$ + Output Power
8) η = output / input X 100%

To determine the η for motor:

1) Input power = $V_L(I_{am} + I_L)$
2) Output Power = Input Power – losses
3) Output = Input – $W_{constm} - W_{cum}$
4) η= output / input * 100%

MODEL GRAPH:



MODEL CALCULATION:

GRAPHS:

1. Output VS Efficiency (of generator)
2. Output VS Efficiency (of motor)

RESULT:

Thus the Hopkinson's test was conducted and the performance curve drawn.

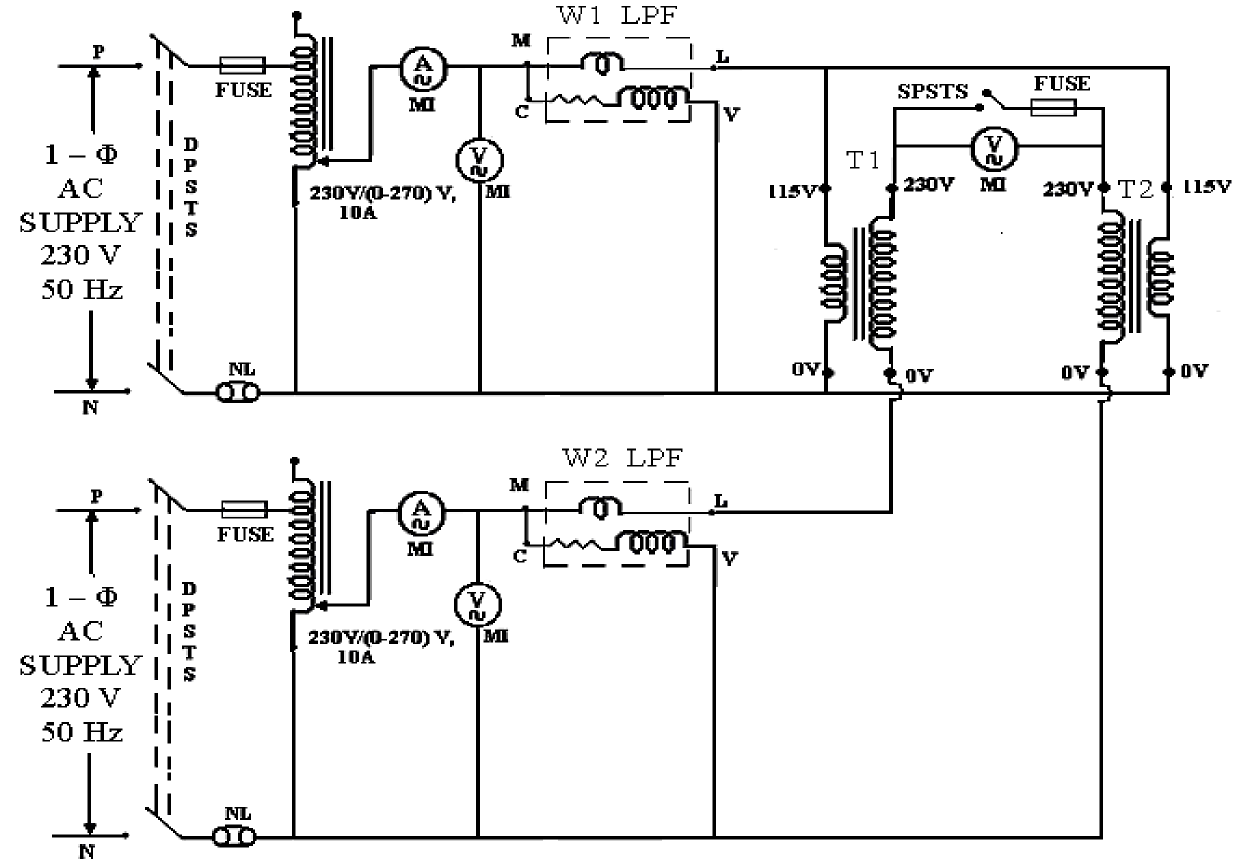
VIVA QUESTIONS:

1. What is the purpose of Hopkinson's test?
2. What are the advantages of Hopkinson's test?
3. What are the conditions for conducting the test?
4. Why the adjustments are done in the field rheostat of generator and motor?
5. If the voltmeter across the SPST switch reads zero what does it indicate?

EXPERIMENT – 12

SUMPNER'S TEST ON 1-PHASE TRANSFORMER

SUMPNER'S TEST ON 1-PHASE TRANSFORMER



FUSE RATING **NAME PLATE DETAILS**

EXP. NO.: 12 **DATE:**

SUMPNER'S TEST ON 1-PHASE TRANSFORMER

AIM:

To predetermine the efficiency of the transformer at any desired load and power factor by conducting the Sumpner's test.

APPARATUS REQUIRED:

SL.NO.	APPARATUS	TYPE	RANGE	QUANTITY
1	Ammeter			
2	Voltmeter			
3	Wattmeter			
4	Transformer			
5	Autotransformer			
6	SPST knife switch			

THEORY:

This test provides data for finding the regulation, efficiency and heating under load condition and is employed only when two similar transformers are available. One transformer is loaded on the other and both are connected to the supply. The power taken from the supply is that necessary for supplying the losses of both transformers.

Primaries of the two transformers are connected in parallel across the same AC supply, with switch S open and the wattmeter W1 reads the core losses for the two transformers.

The secondary are connected that their potentials are in opposition to each other. This would be $V_{AB} = V_{CD}$ and A is joined to C with B is joined to D in this case there would be no secondary current flowing around the loop formed by the two secondary.

PRECAUTIONS:

1. All the switches are kept open initially
2. The variac is initially at zero output voltage position.
3. There should not be any loose connections.

TABULATION: **SUMPNER'S TEST**

TFR.1 Current I_1 Amps	TFR.2 Current I_2 Amps	TFR.1 Voltage V_1 Volts	TFR.2 Voltage V_2 Volts	TFR.1 W_1 Watts	TFR.2 W_2 Watts

PREDETERMINATION OF EFFICIENCY AT DIFFERENT LOADS AT UNITY AND 0.8 POWER FACTOR

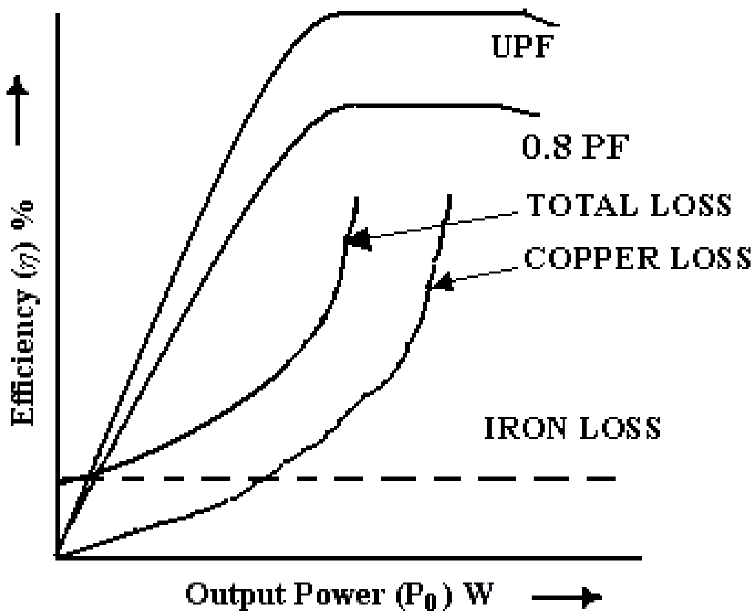
Load Current I_L Amps	% of full load X (as decimal fraction)	Core Losses $W_i = W_1 / 2$ Watts	Copper losses $W_C = W_2 / 2 * X^2$ Watts	Total Losses $W_i + W_C$ Watts	Output Power Watts	Input Power Watts	Efficiency η %
	¼ (0.25)						
	½ (0.5)						
	¾ (0.75)						
	1(full load)						

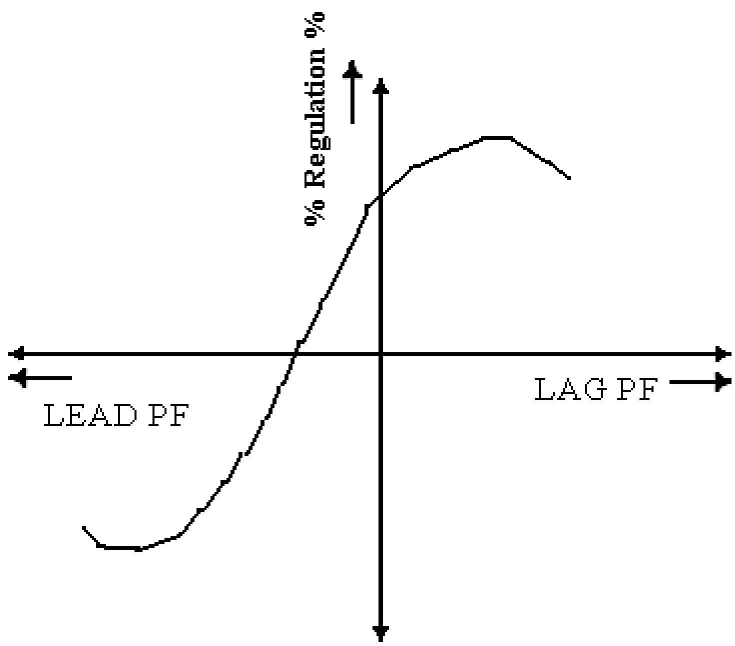
MODEL CALCULATION:

PROCEDURE:

1. Connectional are given as per the circuit diagram
2. All switches are initially opened.
3. Variac is at minimum voltage position.
4. DPST switch 1 is closed and rated primary voltage is applied by varying the output of the variac.
5. The voltmeter V_0 should almost read zero, if not the connections of any one of the transformer is reversed.
6. Close the SPST switch so that both transformers are connected back to back.
7. The DPST's & S_2 are closed and the variac 2 current is increased in steps till rated secondary current is obtained in ammeter A_2.
8. The primary voltage is kept at rated voltage always in each step readings of all wattmeter & ammeters are taken.
9. W_1 gives the core loss of each transformer and W_2 gives the copper loss of both transformers.

MODEL GRAPH:


UPF
0.8 PF
TOTAL LOSS
COPPER LOSS
IRON LOSS
Efficiency (η) %
Output Power (P_0) W


% Regulation %
LEAD PF
LAG PF

FORMULA USED:

1) Output power = X * rated KVA * Cosϕ
2) Total losses = iron loss / 2 + X^2 copper loss / 2
3) Input power = output power + toal losses
4) η= output / input * 100%

GRAPHS:

1. Output power Vs efficiency

2. Output power Vs % regulation

RESULT:

Thus the Sumpner's test on a given two single phase transformer is conducted and its efficiency is predetermined.

VIVA QUESTIONS:-

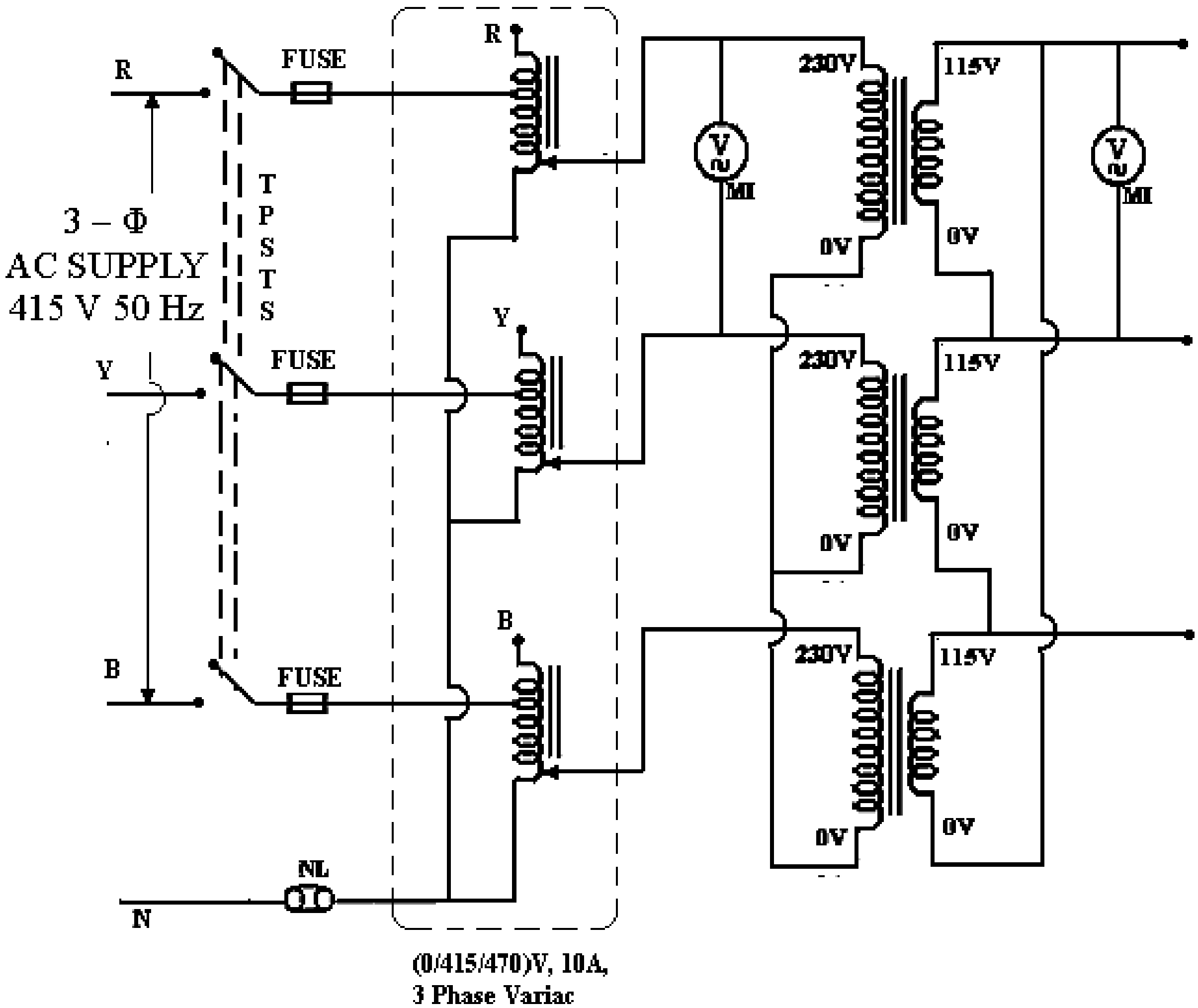
1. What is the purpose of conducting the Sumpner's test?
2. What are the losses in a transformer?
3. Why LPF wattmeter is used in OC test?
4. Why UPF wattmeter is used in SC test?
5. What is meant by predetermination of efficiency?

EXPERIMENT – 13

STUDY OF THREE PHASE TRANSFORMER CONNECTIONS

STUDY OF THREE PHASE TRANSFORMER CONNECTIONS

1. STAR TO DELTA CONNECTION



EXP. NO.: 13 **DATE:**

STUDY OF THREE PHASE TRANSFORMER CONNECTIONS

AIM:

To find the voltage of primary and secondary winding of transformer for different connections.

APPARATUS REQUIRED:

S.NO.	APPARATUS	TYPE	RANGE	QUANTITY
1	Voltmeter			
2	3 Phase Transformer			

THEORY:

1. STAT – STAR CONNECTION:

This connection is most economical for small high voltage transformers because the number of turns / phase and the amount of insulation required is minimum. This connection works satisfactorily only if the load is balanced. The main advantage of this connection is that insulation is stressed only to the extent of line to neutral voltage.

2. DELTA – DELTA CONNECTION:

This connection is most economical for large, low voltage transformers. The advantages of this connection are;

a) The third harmonic component of the magnetizing component can flow in the delta connected transformer primaries without flowing in the line wires.

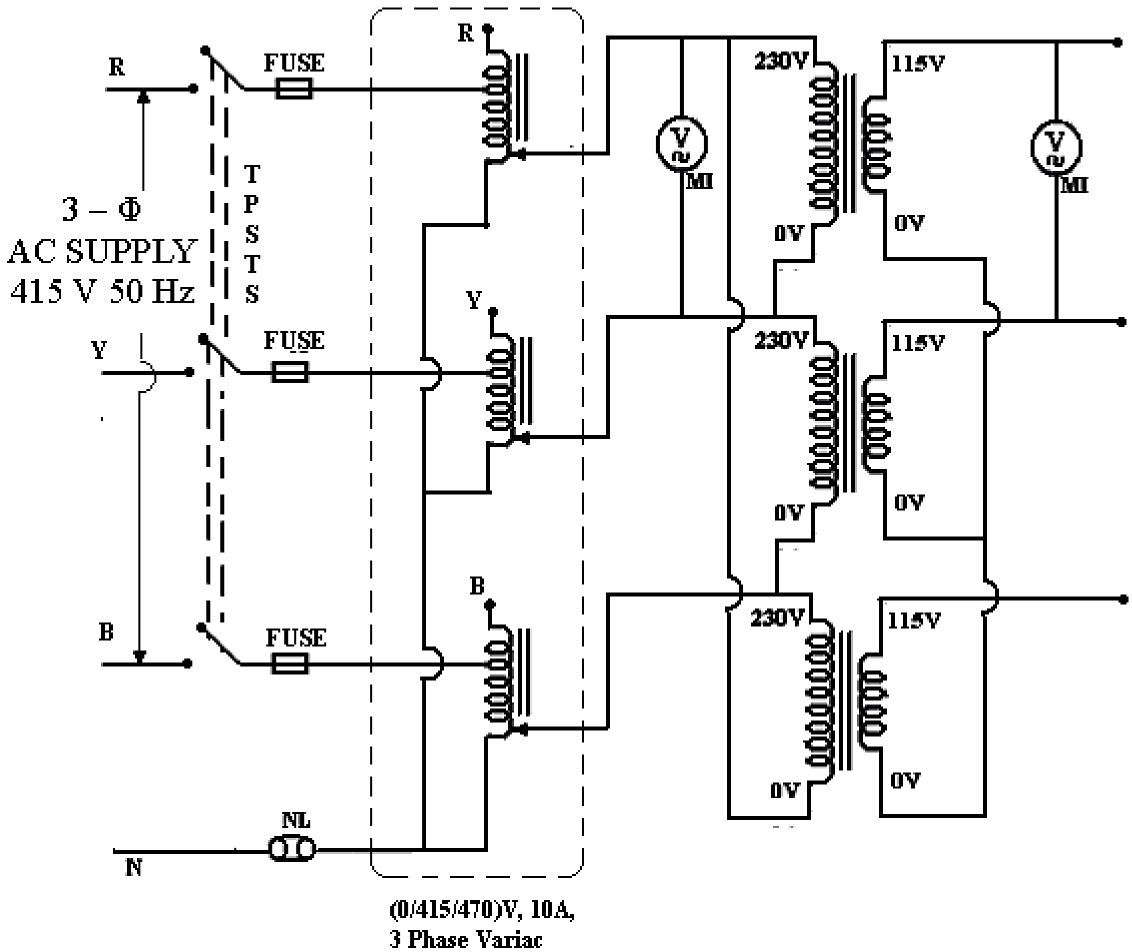
b) No difficulty is experienced from unbalanced loading.

c) If one transformer becomes disabled, the system can continue to operate in open – delta connection.

3. STAR – DELTA CONNECTION:

The main use of this connection is at the substation end of the transmission line where the voltage is to be stepped down. The primary winding is star connected and secondary winding is delta connected.

2. DELTA TO STAR CONNECTION



4. DELTA – STAR CONNECTION:

This connection is generally employed where it is necessary to step up the voltage. This connection is not open to the objection of a floating neutral and voltage distortion because the existence of a delta connection allows a path for the third harmonic currents.

5. OPEN – DELTA CONNECTION:

The method of transforming 3 phase power by means of only two transformer is called open – delta connection. It is employed.

a) When the three phase load is too small to warrant the installation of full three phase transformer bank.

b) When one of the transformers is disabled, service is continued at reduced capacity.

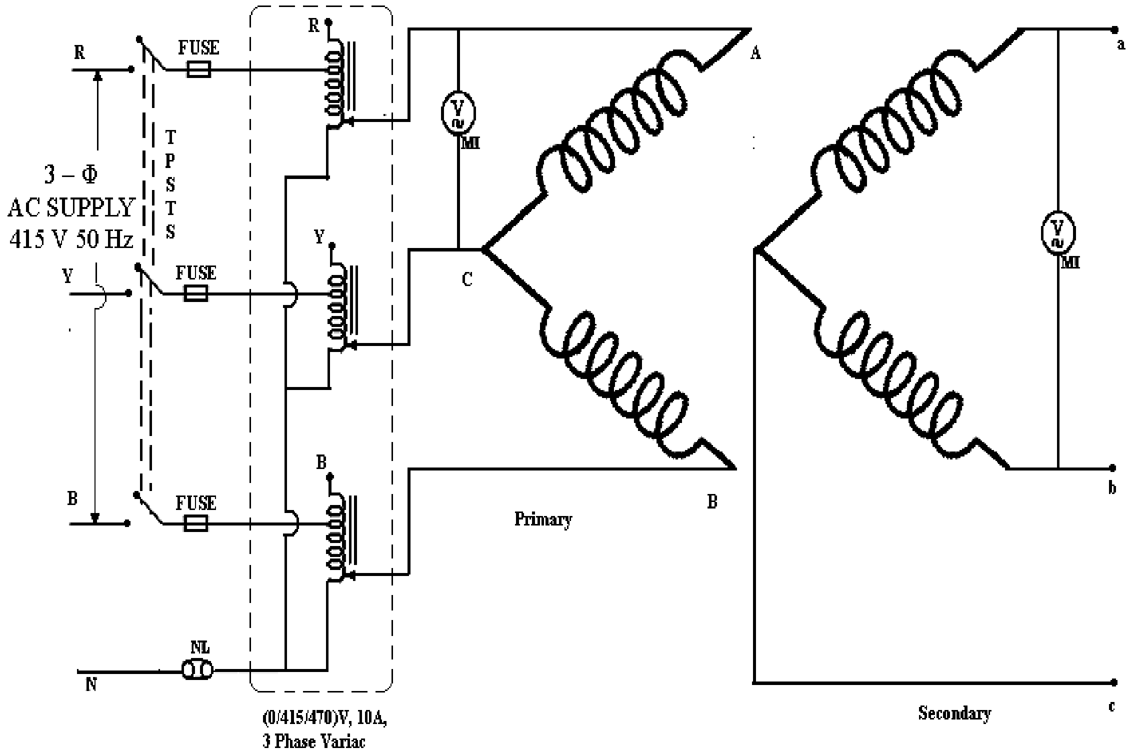
PRECAUTIONS

1. Fuse of correct rating should be used.
2. There should be no loose connections.
3. Three phase auto transformer initially should kept at minimum voltage position.

PROCEDURES:

1. Connections are made as per the circuit diagram.
2. Now apply the voltage with the help of auto transformer.
3. Observe the voltmeter reading
4. Repeat the same procedure and make positive and negative windings correctly.

3. OPEN DELTA CONNECTION



TABULAR COLUMN:

Type of connection	Primary line voltage (V_{pl})	Secondary line voltage (V_{sl})
	V	V

MODEL CALCULATION:

RESULT:

Thus the transformer ratio for different types of three phase transformer was studied.

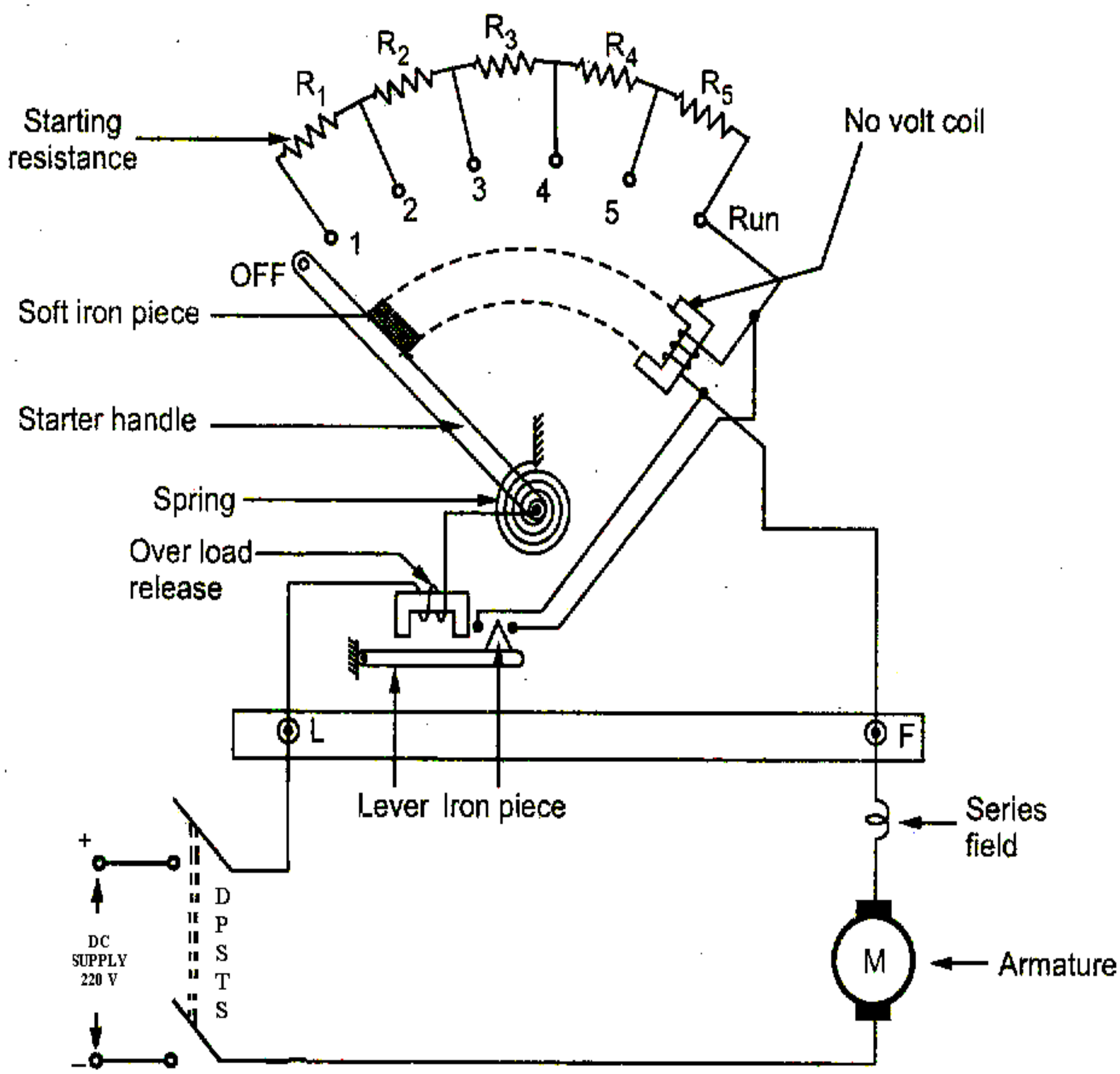
VIVA QUESTIONS:

1. What are the various types of three phase transformer connections?
2. What is meant by vector grouping?
3. State the relationship line voltage and phase voltage in star connection.
4. What are the different types of three phase transformers?
5. What are the applications of the different types of three phase transformers?

EXPERIMENT – 14

STUDY OF DC STARTERS

1. TWO POINT STARTER



EXP. NO.: 14 **DATE:**

STUDY OF DC STARTERS

AIM:

To study the construction and working of DC starters.

NECESSITIES OF A STARTER:

Since dc motor is directly connected to the main, a heavy current may flow through the armature at the instance of starting; due to this the following may take place.

- Heavy sparking at the commutator.
- Damage to armature winding either by heat developed or due to such forces set up by electromagnetic induction.
- Large dip in supply voltage.
- For protection of armature winding, a high resistance is connected in series with the armature.

TYPES OF STARTERS

The different types of starters are,

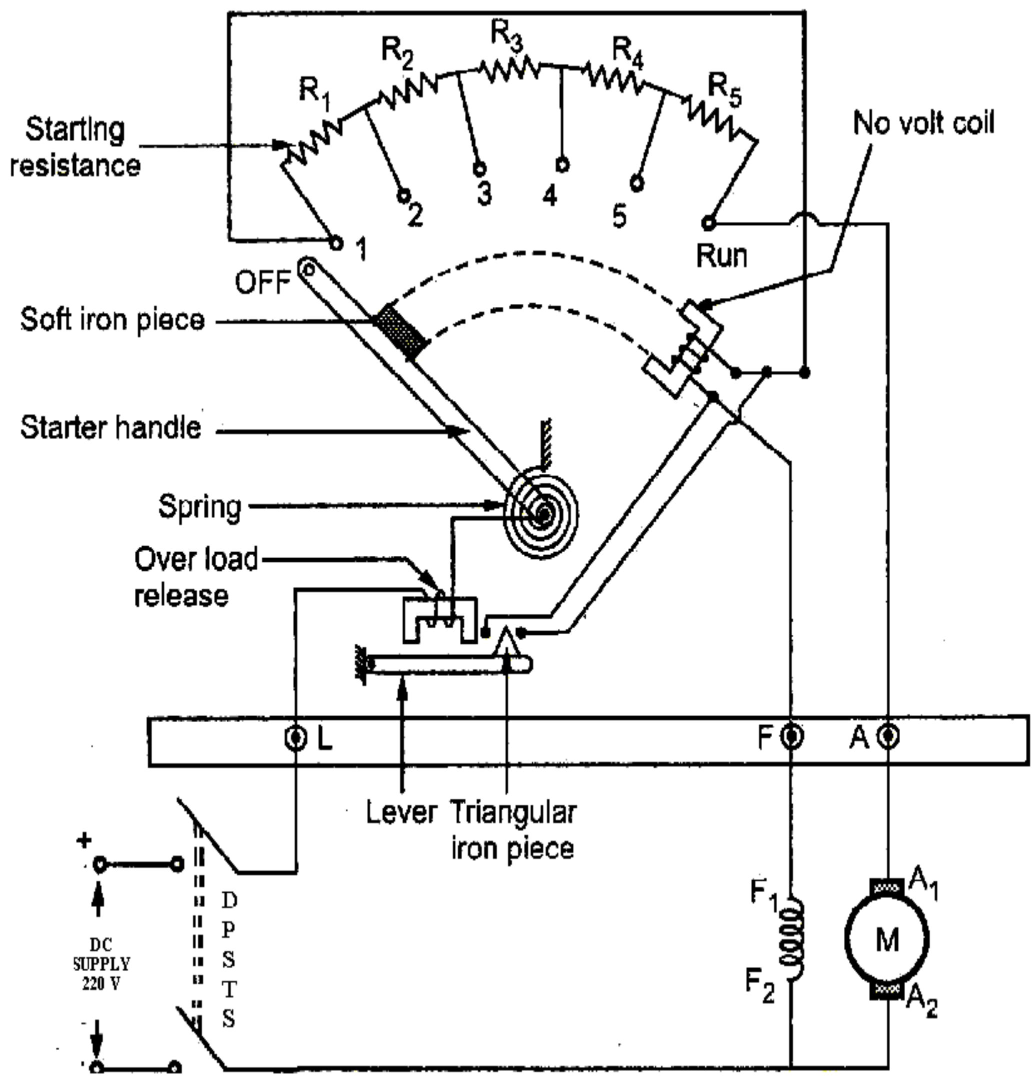
i. Two point starter
ii. Three point starter
iii. Four point starter

TWO POINT STARTER

Three point and four point starters are used for dc shunt motors. In case of series motors, the field and armature are in series and hence starting resistance is inserted in series with the field and armature. Such a starter used to limit the starting current in case of dc series motors is called two point starter. The basic construction of two point starter is similar to that of three point starter except the fact that it has only two terminals namely Line (L) and Field (F). The F terminal is one end of the series combination of field and the armature winding.

The handle of the starter is in OFF position. When it is moved to ON, motor gets the supply and the entire starting resistance is in series with the armature and field. It limits the starting current. The current through no volt coil energizes it and when handle reaches to RUN position, the no volt coil holds the handle by attracting the soft iron piece on the handle. Hence the no volt coil is also called hold on coil.

2. THREE POINT STARTER



The main problem in case of dc series motor is it's over speeding action when the load is less. This can be prevented using two point starter. The no volt coil is designed in such a way that it holds the handle in RUN position only when it carries sufficient current, for which motor can run safely. If there is loss of load then current the current drawn by the motor decreases, due to which no volt coil looses its required magnetism and releases the handle. Under spring force, handle comes back to OFF position, protecting the motor from over speeding. Similarly if there is any supply problem such that the voltage decreases suddenly then also no volt coil releases the handle and protects the motor from adverse supply conditions.

The overload condition can be prevented using overload release. When motor draws excessively high current due to overload, then current through overload magnet increases. This energizes the magnet upto such an extent that it attracts the lever below it. When lever is lifted upwards, the triangular piece attached to it touches the two points, which are the two ends of no volt coil. Thus no volt coil gets shorted, loosing its magnetism and releasing the handle back to OFF position. This protects the motor from overloading conditions.

THREE POINT STARTER

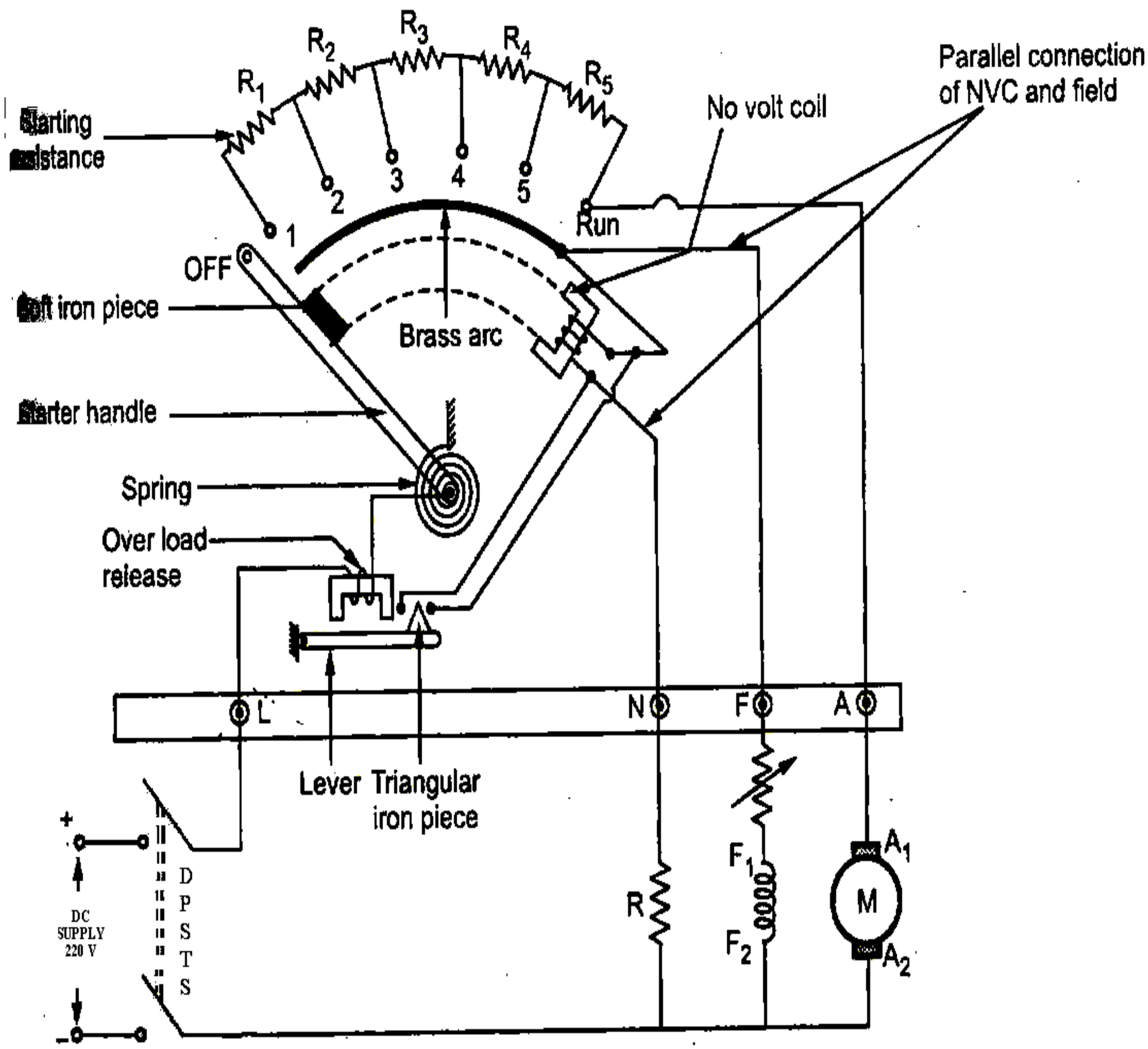
The starter is basically a variable resistance, divided into number of sections. The contact points of these sections are called studs and brought out separately shown as OFF, 1, 2 … upto RUN. There are three main points of this starter:

1. L – Line terminal to be connected to positive of supply.
2. A – To be connected to the armature winding.
3. F – To be connected to the field winding.

Point 'L' is further connected to an electromagnet called overload release (OLR). The second end of 'OLR' is connected to a point where handle of the starter is pivoted. This handle is free to move from its other side against the force of the spring. This spring brings back the handle to the OFF position under the influence of its own force. Another parallel path is derived from the stud '1', given to another electromagnet called No Volt Coil (NVC). The NVC is further connected to terminal 'F'. The starting resistance is entirely in series with the armature. The OLR and NVC are the two protecting devices of the starter.

Initially the handle is in OFF position. The dc supply to the motor is switched on. Then handle is slowly moved against the spring force to make a contact with stud No. 1. At this point, field winding gets supply through the parallel path provided to starting resistance, through NVC. While entire starting resistance comes in series with the armature and armature current which is high at start, gets limited. As the handle is moved further, it goes on making contact with studs 2, 3, 4 etc., cutting out the starting resistance gradually from the armature circuit.

3. FOUR POINT STARTER



Finally when the starter handle is in RUN position, the entire starting resistance gets removed from the armature circuit and motor starts operating with normal speed.

FOUR POINT STARTER:

The basic difference between three point starter is in the connection of NVC. In three point, NVC is in series with the field winding while in four point starter NVC is connected independently across the supply through the fourth terminal called ‘N’ in addition to the ‘L’,’F’ and ’A’.

Hence any change in the field current does not affect the performance of the NVC. Thus it is ensured that NVC always produce a force which is enough to hold the handle in RUN position, against force of the spring, under all the operating conditions. Such a current is adjusted through; NVC with the help of fixed resistance R connected in series with the NVC using fourth point ‘N’.

RESULT

Thus the construction and working of DC starters are studied.