ELECTRICAL ENGINEERING LABORATORY LAB MANUAL

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VELAMMAL INSTITUTE OF TECHNOLOGY
(Affiliated to Anna university-Chennai)

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VELAMMAL INSTITUTE OF TECHNOLOGY

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Name of the Student	**:**	
Register No.	**:**	
Department	**:**	**Electrical and Electronics Engineering**
Name of Laboratory	**:**	**Electrical Engineering Laboratory**
Lab Code	**:**	**ME2209**
Year / Semester	**:**	**II MECH / III**

PREFACE

This Laboratory book in Electrical Engineering Laboratory is intended specifically to meet the needs of basic courses in electrical machines. It is used at undergraduate level for studying the characteristics and operation of DC and AC machines using state of the art teaching modules. This Laboratory book has been revised in order to make up to date with curriculum changes & laboratory equipment upgrading. All effort has been made to correct all the acknowledged errors, but nobody is picture-perfect, if you find any other errors or any updating, please contact VIVEK.P/AP-EEE at vit.eepvk@gmail.com . The Authors thanked all the staff members from the department for their valuable suggestion and contribution.

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11.		Study of DC & AC Starters	

CYCLE - 1

LIST OF EXPERIMENTS

1. Load test on DC Shunt motor
2. Load test on DC Series motor
3. O.C.C & Load characteristics of DC Shunt generator
4. Speed control of DC shunt motor
5. Load test on single-phase transformer
6. O.C & S.C Test on a single-phase transformer

CYCLE - 2

LIST OF EXPERIMENTS

1. Regulation of an alternator by EMF & MMF methods
2. V curves and inverted V curves of synchronous Motor
3. Load test on three-phase squirrel cage Induction motor
4. Speed control of three phase slip ring Induction Motor
5. Load test on single phase Induction Motor
6. Study of DC & AC Starter

LABORATORY PRACTICE

SAFETY RULES

1. SAFETY is of extreme importance in the Electrical Engineering Laboratories.
2. Electricity NEVER EXECUSES careless persons. So, practice with 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. 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.
19. 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)
20. 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)
21. 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.

22. 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 (especially 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.

Observe these safety rules yourself and help your friends to observe.

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.

Signature of Student **Date** **Lab in charge**

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 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.

1. **Heading:**

   The experiment identification (number) should be at the top of each page.

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 labelled 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 alongside 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 labelled 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. Tables are generally used for small amounts of results.

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 1 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 proto board 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

LIST OF EXPERIMENTS

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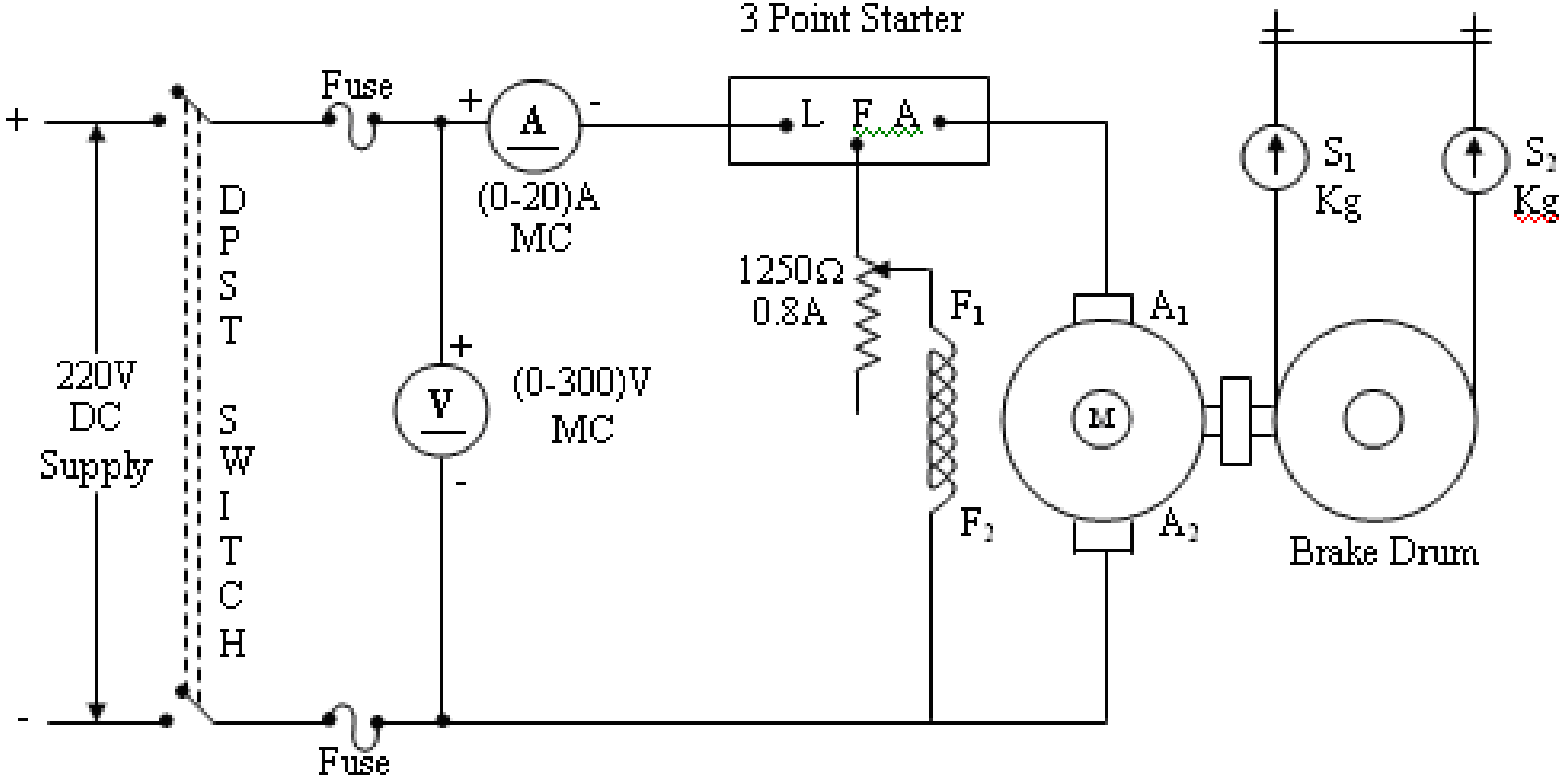
CIRCUIT DIAGRAM

LOAD TEST ON DC SHUNT MOTOR



FUSE RATING:

125% of rated current

NAME PLATE DETAILS:

Rated Voltage :
Rated Current :
Rated Power :
Rated Speed :

Ex.No.1

LOAD TEST ON DC SHUNT MOTOR

AIM:

To obtain the performance characteristics of DC shunt motor by using load test.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	1250Ω, 0.8A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE:

$$R = \frac{\text{Circumference}}{100 \times 2\pi} \text{ m}$$

Torque $T = (S_1 \sim S_2) \times R \times 9.81$ Nm

Input Power $P_i = VI$ Watts

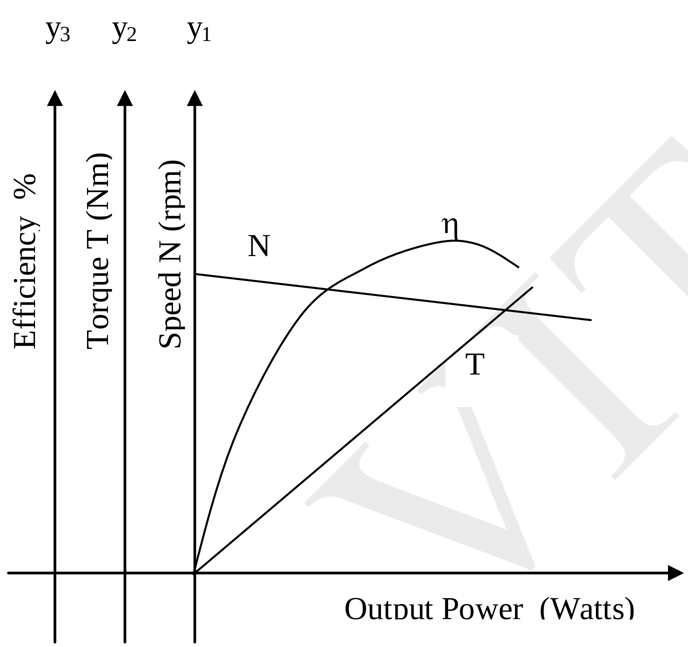
$$\text{Output Power } P_m = \frac{2\pi NT}{60} \text{ Watts}$$

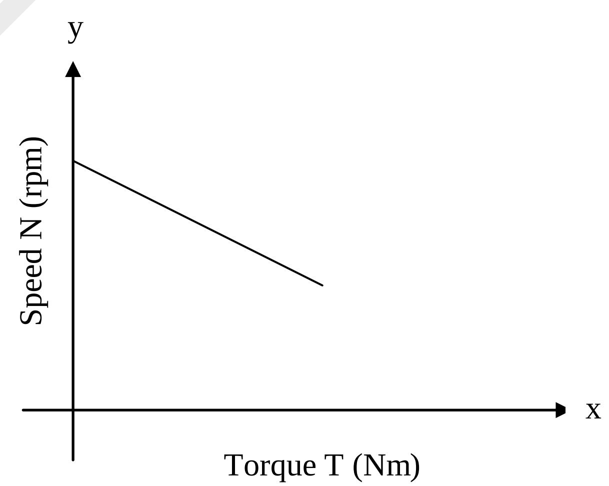
$$\text{Efficiency } \eta\ \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

TABULAR COLUMN: **Circumference of the Brake drum = cm.**

S.No.	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1(Kg)	S_2(Kg)						

MODEL GRAPHS:





PRECAUTIONS:

1. DC shunt motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, and minimum field rheostat position, DPST switch is closed and starter resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat.
4. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.
5. The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.
6. The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

RESULT:

The load test on the given D.C shunt motor was conducted and its performance characteristics were drawn and the following conclusion can be given based on the performance curves.

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?

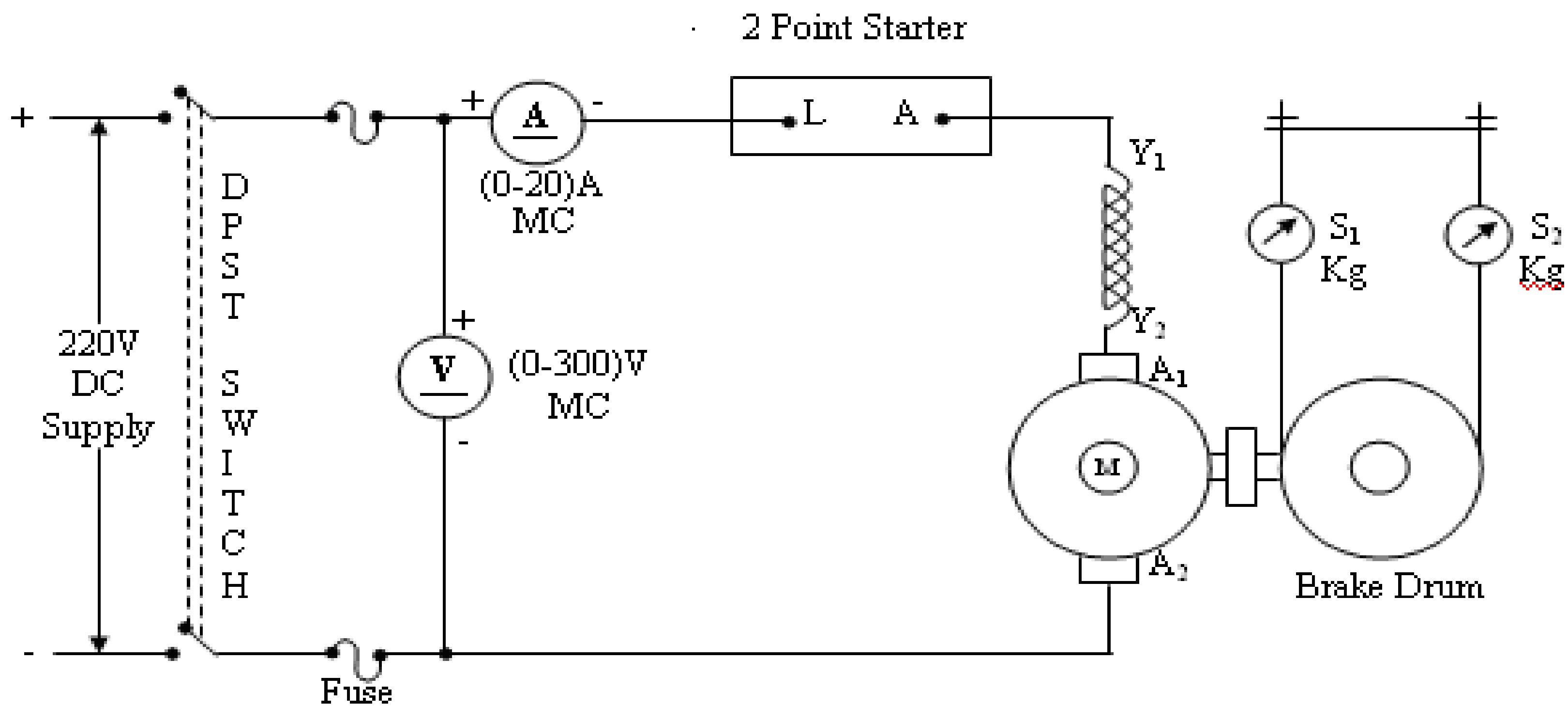
3. How can the direction of rotation of a DC shunt motor be reversed?

4. What are the mechanical and electrical characteristics of a DC shunt motor?

5. What are the applications of a DC shunt motor.

CIRCUIT DIAGRAM

LOAD TEST ON DC SERIES MOTOR



FUSE RATING:

125% of rated current

NAME PLATE DETAILS:

Rated Voltage :
Rated Current :
Rated Power :
Rated Speed :

Ex.No.2

LOAD TEST ON DC SERIES MOTOR

AIM:

To obtain the performance characteristics of DC Series motor by using load test.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Tachometer	(0-3000) rpm	Digital	1
4	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE:

$$R = \frac{\text{Circumference of the Brake Drum in cm}}{100 \times 2\pi} \quad \text{(metre).}$$

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

Input Power $P_i = VI$ Watts

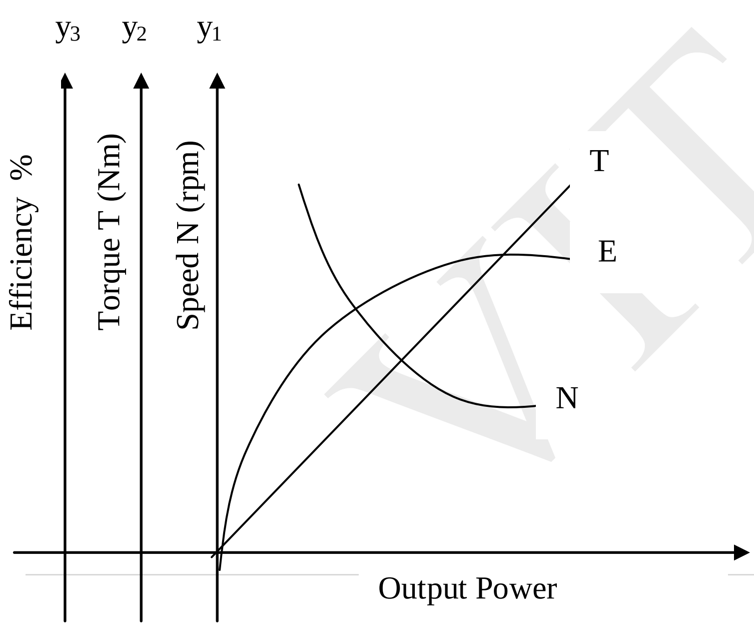
$$\text{Output Power } P_m = \frac{2\pi NT}{60} \text{ Watts}$$

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

TABULAR COLUMN:

S.No.	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1(Kg)	S_2(Kg)						

MODEL GRAPH:



PRECAUTIONS:

1. The motor should be started and stopped with 25% of rated load.
2. Brake drum should be cooled with water when it is under load.

PROCEDURE:

1. Connections are given as per the circuit diagram
2. Observing the precautions the DPST switch is closed.
3. The motor is started with the help of two-point dc starter slowly.
4. Load on the motor is varied with the help of pony brake arrangement.
5. Spring balance, ammeter, voltmeter and speed readings are noted down for various line currents as the load is applied. Care must be taken to avoid the speed reaching dangerously high values while reducing the load.
6. At a minimum safe load the DPST switch is opened.
7. Disconnect and return the apparatus.

RESULT:

The load test on the given D.C series motor was conducted and its performance characteristics were drawn and the following conclusion can be given based on the performance curves

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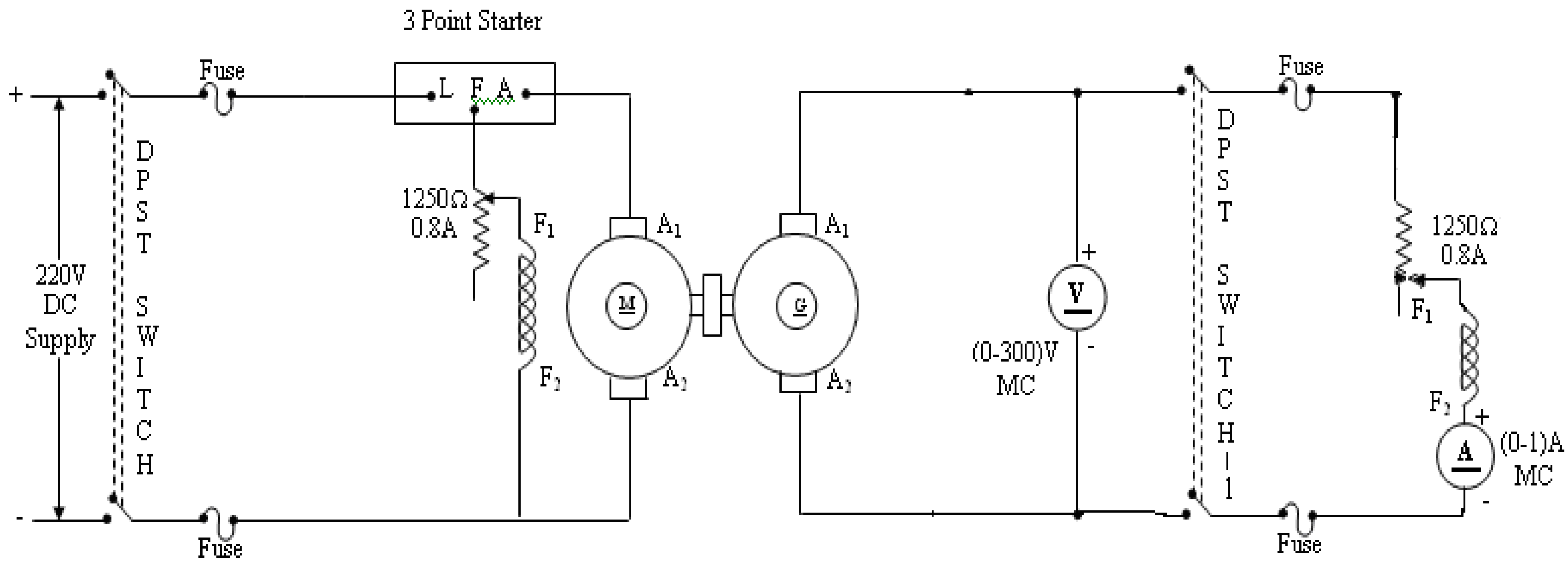
VIVA QUESTIONS

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. What is the precaution to be taken when working with a D.C series motor?
7. What is the need for starter with a D.C motor?
8. How does a 2-point starter function?
9. Explain the shape of the electrical and mechanical characteristics.
10. What is the condition for maximum efficiency in a D.C motor?
11. What are the different losses occurring in a D.C machine?
12. How are the meter ratings selected for this experiment?
13. Give some applications of D.C series motor.

CIRCUIT DIAGRAM:

OPEN CIRCUIT CHARACTERISTICS OF DC SHUNT GENERATOR



FUSE RATING:

DC Motor

125% of rated current

DC Shunt Generator

10% of rated current

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :		
Rated Current :		
Rated Power :		
Rated Speed :		

Ex.No.3(a)

OPEN CIRCUIT CHARACTERISTICS OF DC SHUNT GENERATOR

AIM:

To obtain the open circuit characteristics of DC shunt generator and find It's critical resistance.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	1250Ω, 0.8A	Wire Wound	2
4	SPST Switch	-	-	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

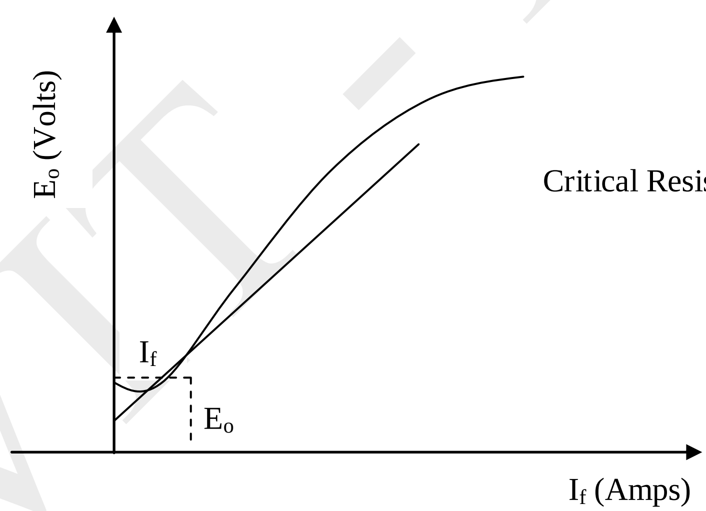
PRECAUTIONS:

1. The field rheostat of motor should be in minimum resistance position at the time of starting and stopping of the machine.
2. The field rheostat of generator should be in maximum resistance position at the time of starting and stopping of the machine.
3. DPST-1 should be kept open during starting and stopping of the machine

TABULAR COLUMN:

S.No.	Field Current I_f (Amps)	Armature Voltage E_o (Volts)

MODEL GRAPH:



Critical Resistance = E_o / I_f Ohms

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking minimum position of motor field rheostat, maximum position of generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. By adjusting the field rheostat, the motor is brought to its rated speed.
4. Voltmeter and ammeter readings are taken when the SPST switch is kept open.
5. After closing the DSPST switch, by varying the generator field rheostat, voltmeter and ammeter readings are taken.
6. After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, both DPST-1 and DPST switch is opened.

VIVA QUESTIONS:

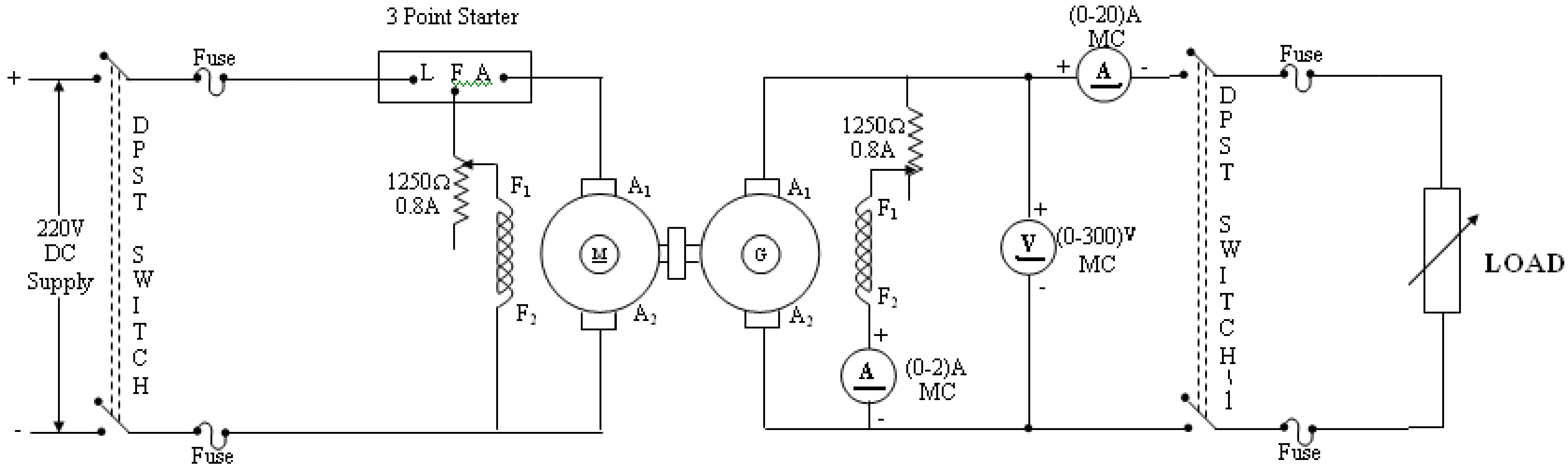
1. What is the difference between a separately excited dc generator and shunt generator?
2. If a DC shunt generator fails to build up voltage, what may be the probable reasons?
3. What is SPST? What is its use in this experiment?
4. What is the reason the presence of residual magnetism in the field poles?
5. Why does the terminal voltage decrease as the load current increases?
6. What is the need for starter in a d.c motor?
7. How does a 3-point starter function?
8. Why is motor rheostat kept in minimum position at starting?
9. Why is generator rheostat kept in maximum position at start up?
10. What is residual voltage? How is it measured?
11. What is critical resistance? How can it be determined?
12. What are the conditions necessary for voltage build up in a d.c shunt generator?
13. What is critical speed?
14. Explain the shape of the O.C.C.

RESULT:

Thus open circuit characteristics of DC shunt generator are obtained and its critical resistance is determined.

CIRCUIT DIAGRAM

LOAD CHARACTERISTICS OF DC SHUNT GENERATOR



FUSE RATING:

Both motor and Generator

125% of rated current

NAME PLATE DETAILS:

	Motor	**Generator**
Rated Voltage :		
Rated Current :		
Rated Power :		
Rated Speed :		

Ex.No.3(b)

LOAD CHARACTERISTICS OF DC SHUNT GENERATOR

AIM:

To obtain the internal and external characteristics of DC shunt generator.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A (0-20) A	MC MC	1 1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	1200Ω, 0.8A	Wire Wound	2
4	Loading Rheostat	5KW, 230V	-	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE:

$E_g = V + I_a R_a$ (Volts)

$I_a = I_L + I_f$ (Amps)

E_g : Generated emf in Volts

V : Terminal Voltage in Volts

I_a : Armature Current in Amps

I_L : Line Current in Amps

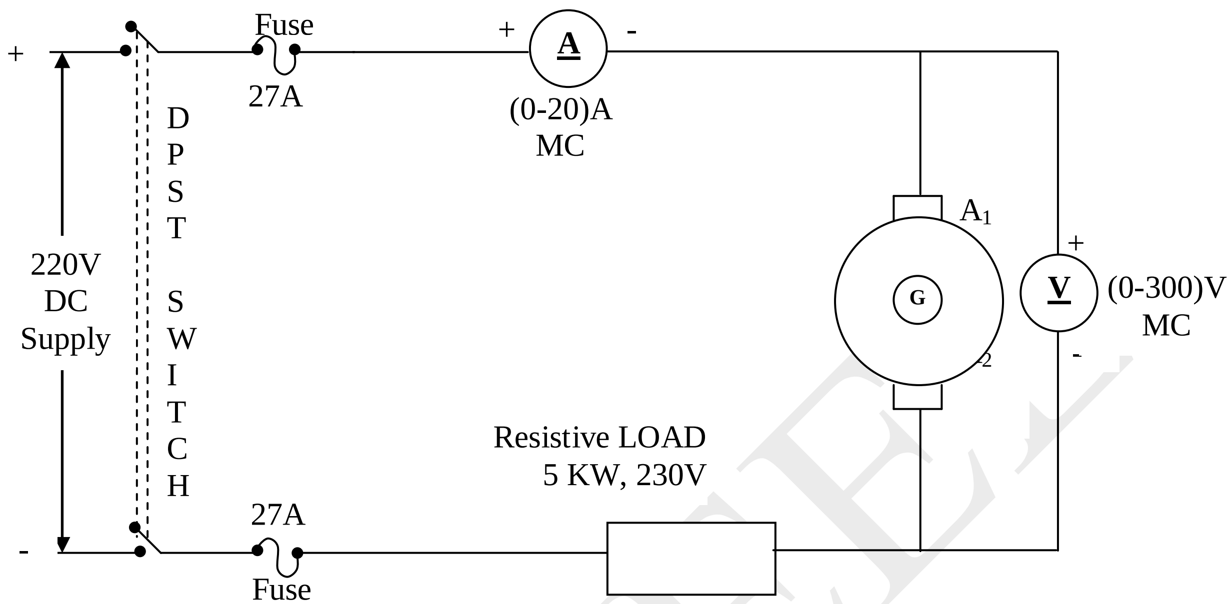
I_f : Field Current in Amps

R_a : Armature Resistance in Ohms

PRECAUTIONS:

1. The field rheostat of motor should be at minimum position.
2. The field rheostat of generator should be at maximum position.
3. No load should be connected to generator at the time of starting and stopping.

DETERMINATION OF ARMATURE RESISTANCE:



TABULAR COLUMN:

S.No.	Voltage V (Volts)	Current I (Amps)	Armature Resistance R_a (Ohms)

PROCEDURE (To find Ra):

1. Connections are made as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. Readings of Ammeter and Voltmeter are noted.
4. Armature resistance in Ohms is calculated as R_a = (Vx1.5) /I

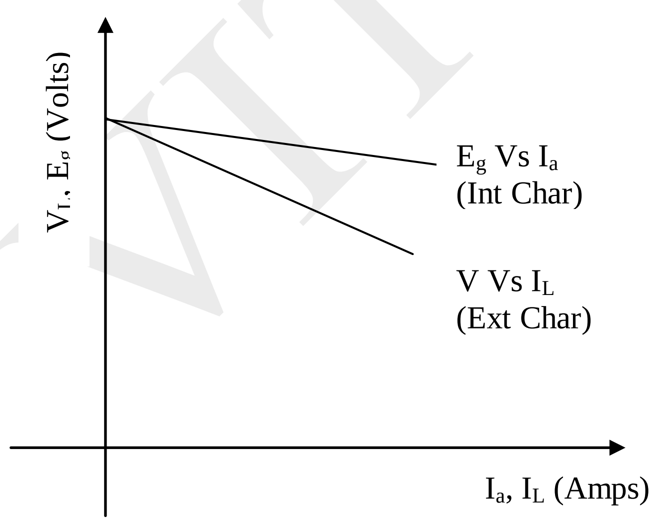
PROCEDURE (obtain load characteristic):

1. Connections are made as per the circuit diagram.
2. After checking minimum position of DC shunt motor field rheostat and maximum position of DC shunt generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the voltage to rated voltage by adjusting the field rheostat of generator.
4. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
5. Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximum position and the field rheostat of DC shunt motor to minimum position, DPST switch is opened.

TABULAR COLUMN:

S.No.	Field Current I_f (Amps)	Load Current I_L (Amps)	Terminal Voltage (V) Volts	$I_a = I_L + I_f$ (Amps)	$E_g = V + I_a R_a$ (Volts)

MODEL GRAPH:

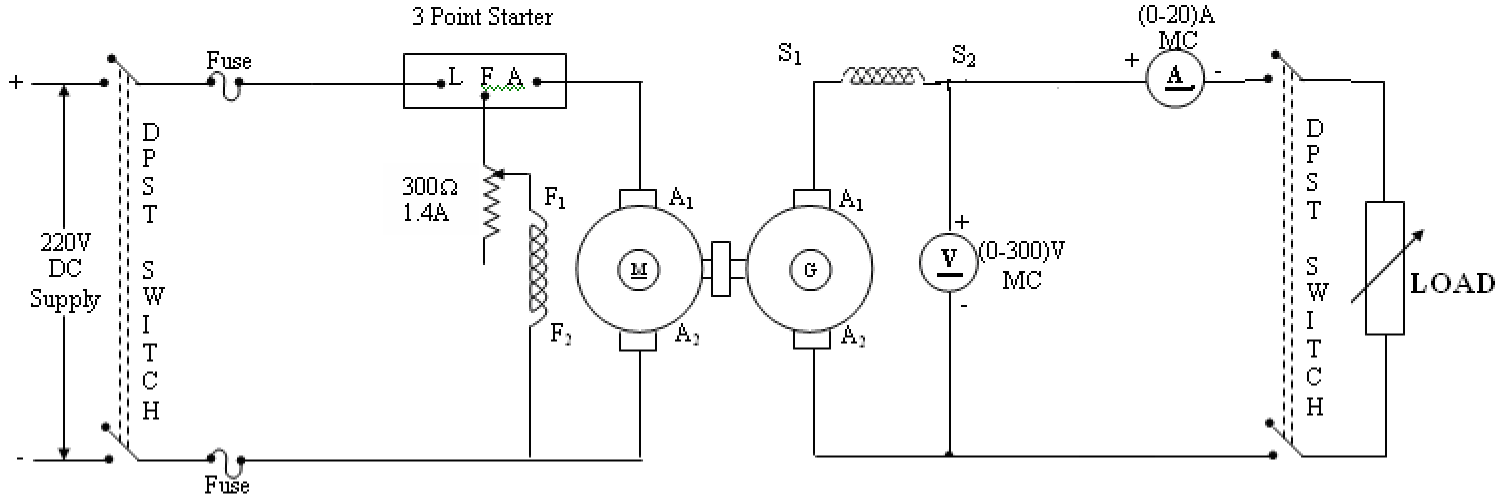


RESULT:

Thus load characteristics of DC shunt generator are obtained and its critical resistance is determined.

CIRCUITDIAGRAM

LOAD CHARACTERISTICS OF DC SERIES GENERATOR



FUSE RATING:

125% of rated current

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :		
Rated Current :		
Rated Power :		
Rated Speed :		

EXP.NO.4

LOAD CHARACTERISTICS OF D.C. SERIES GENERATOR

AIM:-

Obtain the load Characteristics of D.C. Series Generator.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	300Ω,1.4A	Wire Wound	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

Fuse Rating:

1. for Load Test 125% of rated current
2. for No load Test 10 % of rated Current

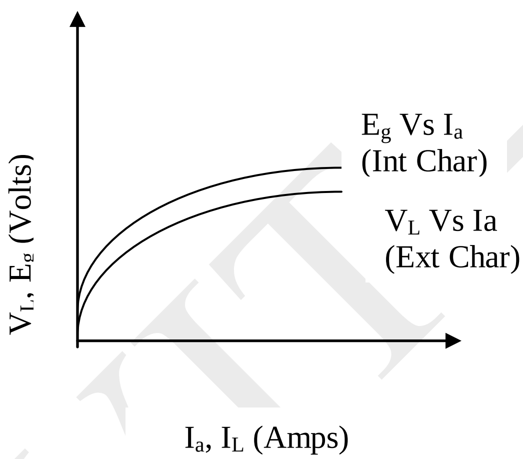
PRECAUTIONS:

1. The Starter handle should be kept in OFF position at the time of switching ON the supply to the DC motor.
2. The field rheostat of the DC shunt motor (prime mover) should be kept in the minimum resistance position.

TABULAR COLUMN:

S.NO	LOAD VOLTAGE (V_L)	ARMATURE CURRENT(I_a)	EMF GENERATED $E_g = V_L + I_a (R_a + R_s)$

MODEL GRAPH:



PROCEDURE:

1. Connections are given as shown in the circuit diagram.
2. The DC supply is switched ON and the DC shunt motor (prime mover) is started using the 3-point starter.
3. The motor is brought to its rated speed by adjusting its field rheostat and the same is checked with the help of a tachometer.
4. The load DPST is now closed and the loading rheostat is switched on in steps and at each step the motor speed is maintained constant by adjusting the motor field rheostat and then the terminal voltage (V_L) and the load current (I_L) are noted down.
5. The procedure is continued until the load current is equal to 120% of the rated current of the generator.
6. After the experiment is completed the load on the generator is gradually decreased to minimum and then the main supply is switched OFF.
7. The resistances of the armature and the series field winding of the generator are found by giving low voltage supply and connecting a voltmeter and ammeter.
8. The external and internal characteristics of the given DC series generator are plotted.

RESULT:

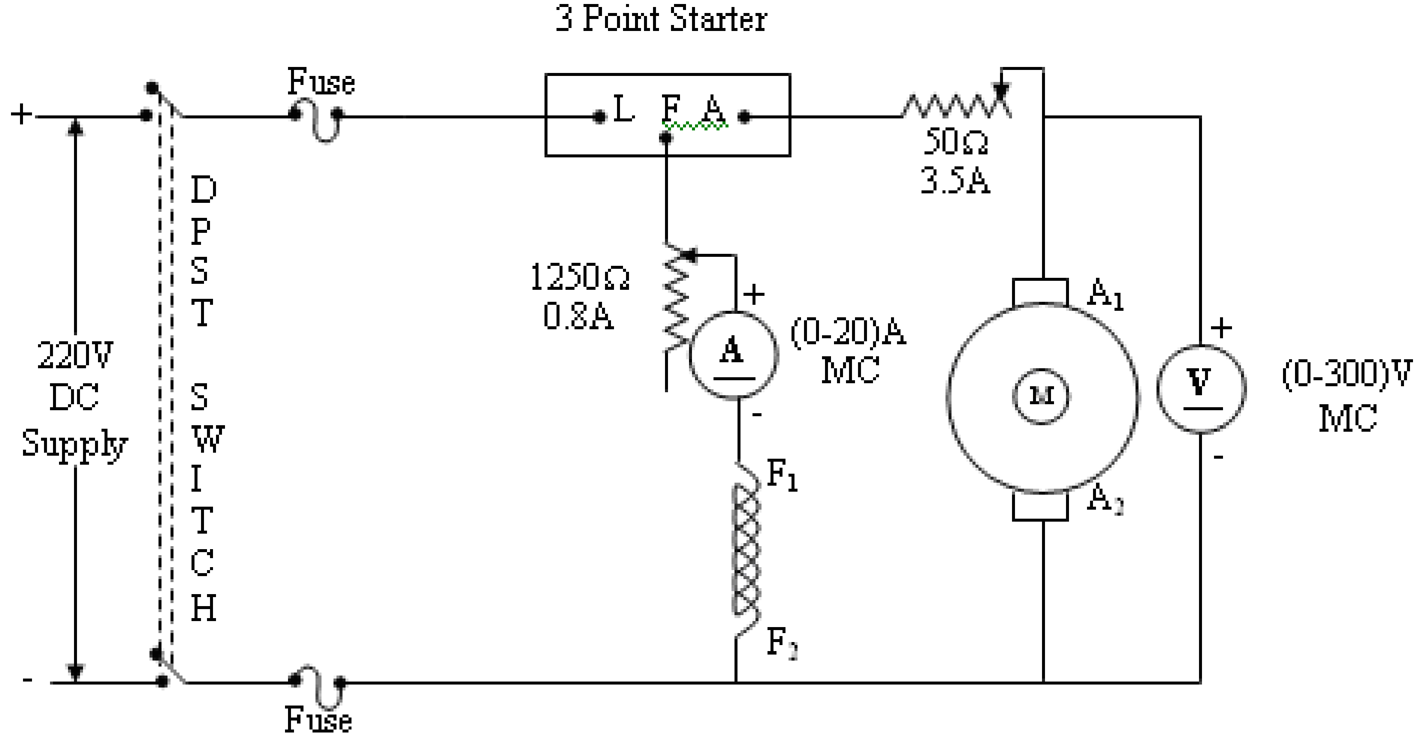
Thus we have been drawn the load characteristic curve of DC Series Generator.

VIVA QUESTIONS:

1. List the applications of DC Series generator.

CIRCUIT DIAGRAM:

SPEED CONTROL OF DC SHUNT MOTOR



FUSE RATING:

125% of rated current

NAME PLATE DETAILS:

Rated Voltage :

Rated Current :

Rated Power :

Rated Speed :

Ex.No. 5

SPEED CONTROL OF DC SHUNT MOTOR

AIM:

To obtain the characteristic curve and speed control of DC shunt motor by

a. Varying armature voltage with field current constant.
b. Varying field current with armature voltage constant

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20) A	MC	1
2	Voltmeter	(0-300) V	MC	1
3	Rheostats	1250Ω, 0.8A 50Ω, 3.5A	Wire Wound	Each 1
4	Tachometer	(0-3000) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

PRECAUTIONS:

1. Field Rheostat should be kept in the minimum resistance position at the time of starting and stopping the motor.
2. Armature Rheostat should be kept in the maximum resistance position at the time of starting and stopping the motor.

TABULAR COLUMN:

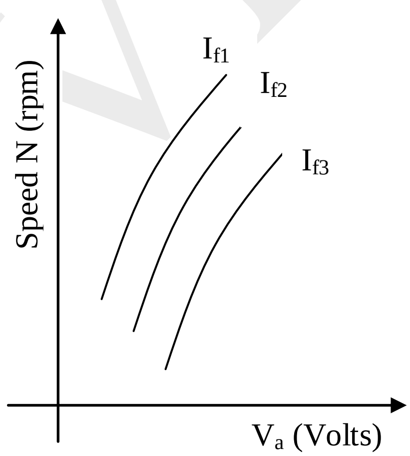
(i) Armature Voltage Control:

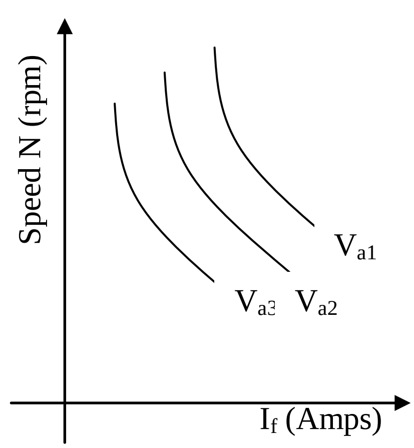
S.No.	I_{f1} =		I_{f2} =		I_{f3} =	
	Armature Voltage V_a (Volts)	Speed N (rpm)	Armature Voltage V_a (Volts)	Speed N (rpm)	Armature Voltage V_a (Volts)	Speed N (rpm)

(ii) Field Control:

S.No.	V_{a1} =		V_{a2} =		V_{a3} =	
	Field Current I_f (A)	Speed N (rpm)	Field Current I_f (A)	Speed N (rpm)	Field Current I_f (A)	Speed N (rpm)

MODEL GRAPHS:





PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the maximum position of armature rheostat and minimum position of field rheostat, DPST switch is closed

(i) Armature Control:

1. Field current is fixed to various values and for each fixed value, by varying the armature rheostat, speed is noted for various voltages across the armature.

(ii) Field Control:

1. Armature voltage is fixed to various values and for each fixed value, by adjusting the field rheostat, speed is noted for various field currents.
2. Bringing field rheostat to minimum position and armature rheostat to maximum position DPST switch is opened.

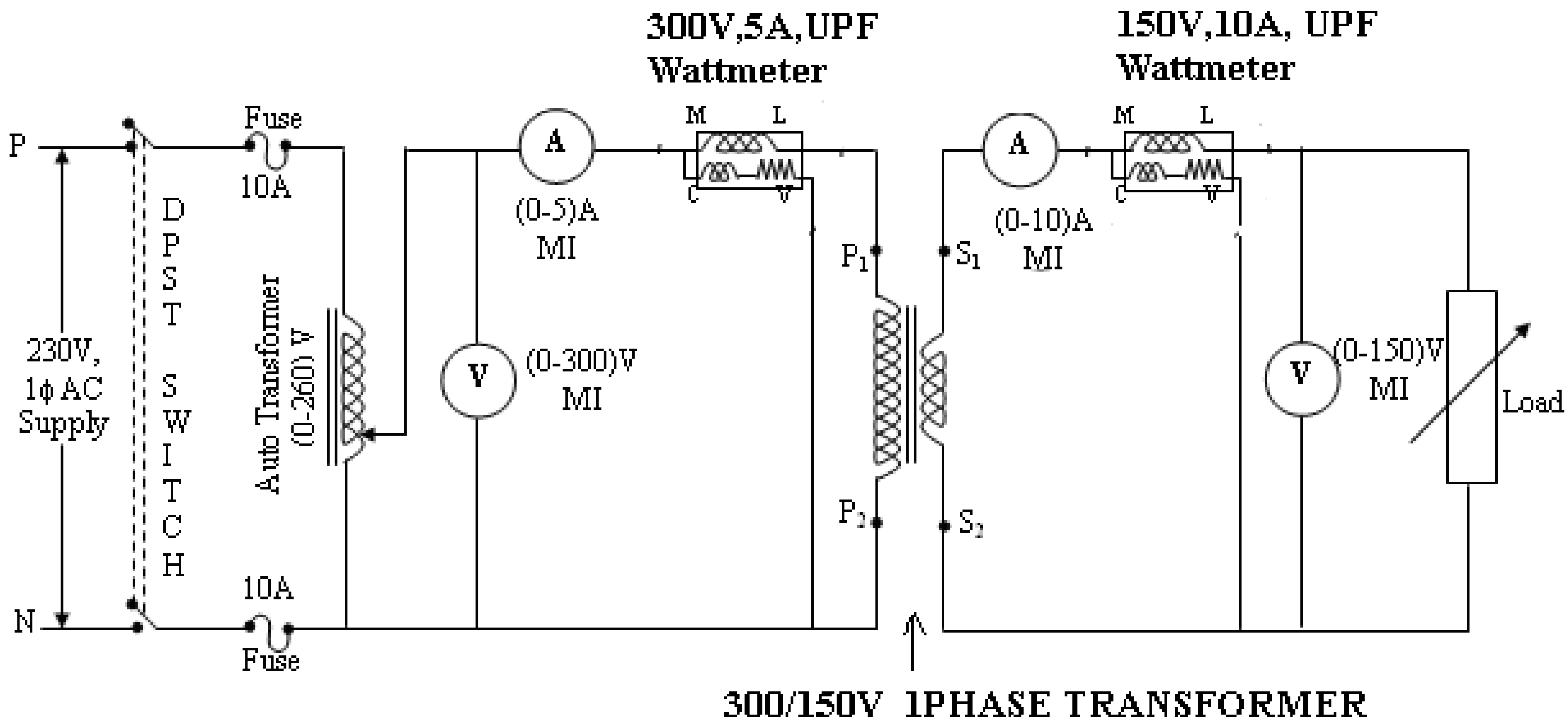
RESULT:

Thus we have been obtained the speed control characteristic curve of DC Shunt motor.

VIVA QUESTIONS

1. Give the relation of speed with respect to emf and flux.
2. List the disadvantages of these methods.

CIRCUIT DIAGRAM: **LOAD TEST ON 1PH TRANSFORMER**



FUSE RATING:

125% of rated current

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :		
Rated Current :		
Rated Power :		

Ex.No. 6

LOAD TEST ON A SINGLE PHASE TRANSFORMER

AIM:

To find the efficiency and regulation of single phase transformer by using load test.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	UPF UPF	1 1
4	Auto Transformer	1ϕ, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

FORMULAE:

Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

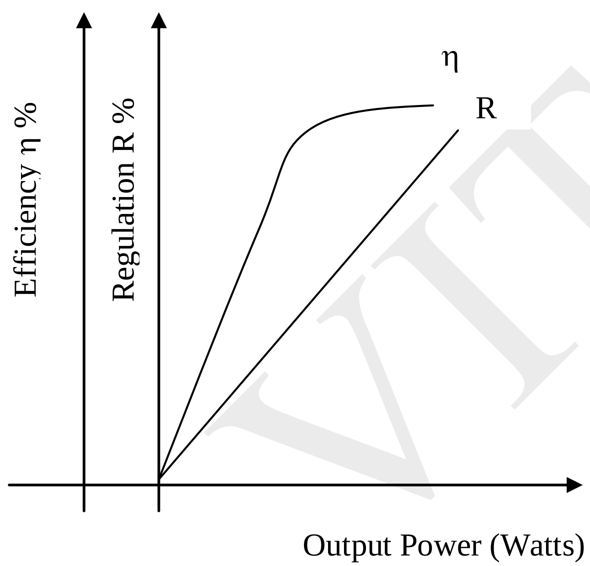
$$\text{Efficiency } \eta \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

$$\text{Regulation R } \% = \frac{V_{NL} - V_{FL}\text{ (Secondary)}}{V_{NL}} \times 100\%$$

TABULAR COLUMN:

S.No.	Load	Primary			Secondary			Input Power W_1 x MF	Output Power W_2 x MF	Efficiency η %	% Regulation
		V_1 (Volts)	I_1 (Amps)	W_1 (Watts)	V_2 (Volts)	I_2 (Amps)	W_2 (Watts)				

MODEL GRAPHS:



PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.

RESULT:

Thus we have been obtained the characteristic curve of 1φ transformer.

VIVA QUESTIONS:

1. List the application of Transformer and types.
2. What is the function of Buchol's Relay in transformer?
3. What do you understand by regulation of a transformer?
4. What are the other methods of testing transformers?
5. What is the disadvantage of testing a transformer using load test?
6. Is a high or low value of regulation preferred for a transformer? Give reasons.
7. What are the reasons for the drop in terminal voltage as the secondary current is increased?

Ex.No. 7

OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

AIM:

Predetermine the efficiency and regulation of a single phase transformer and draw equivalent circuit.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V	MI	2
3	Wattmeter	(150V, 5A) (150V, 5A)	LPF UPF	1 1
4	Connecting Wires	2.5sq.mm	Copper	Few

FORMULAE:

Core loss: $W_o = V_o I_o \cos \phi_o$

$\cos \phi_o = \dfrac{W_o}{V_o I_o}$ $\qquad \phi_o = \cos^{-1} \dfrac{W_o}{V_o I_o}$

$I_\omega = I_o \cos \phi_o$ (Amps) $\qquad I_\mu = I_o \sin \phi_o$ (Amps)

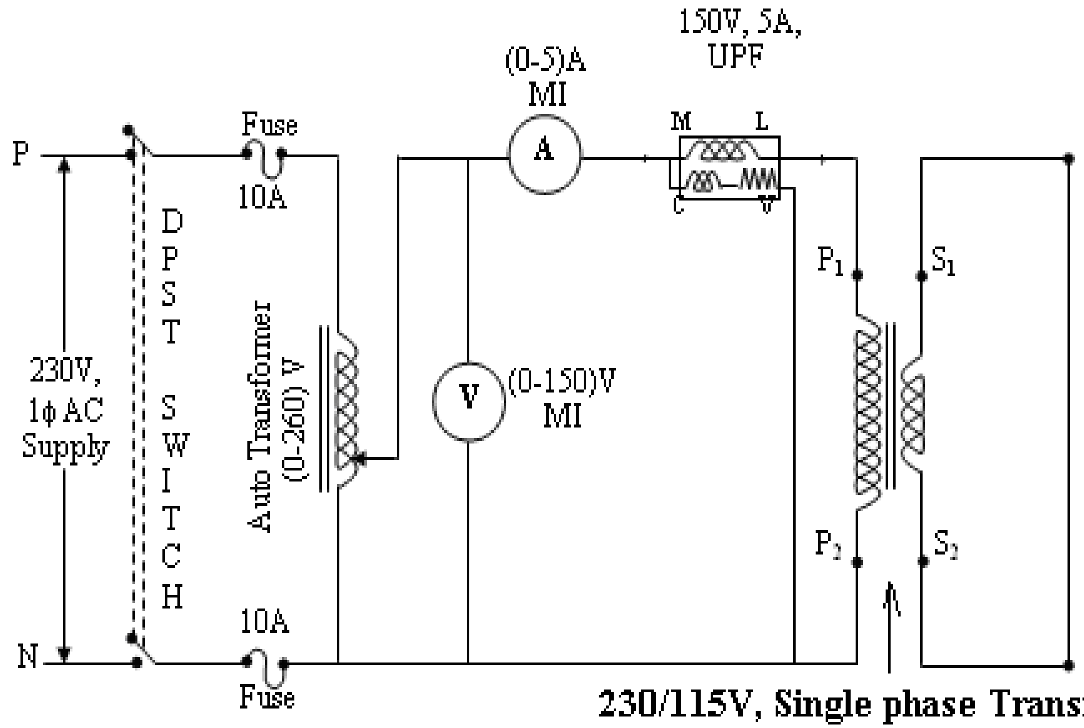
$R_o = \dfrac{V_0}{I_\omega}\ \Omega$ $\qquad X_o = \dfrac{V_0}{I_\mu}\ \Omega$ $\qquad R_{o2} = \dfrac{W_{sc}}{I_{sc}^2}\ \Omega$

$Z_{o2} = \dfrac{V_{sc}}{I_{sc}}\ \Omega$ $\qquad X_{o2} = (Z_o^2 - R_{o2}^2)^{1/2}$

$R_{o1} = \dfrac{R_{02}}{K^2}\ \Omega$ $\qquad X_{o1} = \dfrac{X_{02}}{K^2}\ \Omega$ $\qquad K = \dfrac{V_2}{V_1} = 2$

the power factor is, upf, o.8 p.f lag and 0.8 p.f lead

SHORT CIRCUIT TEST:



230/115V, Single phase Transformer

FUSE RATING:

125% of rated current

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :		
Rated Current :		
Rated Power :		

Percentage Efficiency: **for all loads and p.f.**

$$\text{Efficiency } \eta\% = \frac{\text{Output Power}}{\text{Input Power}} = \frac{(X) \times \text{KVA rating} \times 1000 \times \cos\phi}{\text{Output power} + \text{losses}}$$

$$= \frac{(X) \times \text{KVA rating} \times 1000 \times \cos\phi}{(X) \times \text{KVA rating} \times 1000 \times \cos\phi + W_o + X^2 W_{sc}}$$

Percentage Regulation:

$$R\% = \frac{(X) \times I_{sc} (R_{o2} \cos\phi \pm X_{o2} \sin\phi)}{V_2} \times 100$$

+ = lagging
- = leading

Where X is the load and it is 1 for full load, ½ for half load, ¾ load, ¼ load etc.. and the power factor is, upf, o.8 p.f lag and 0.8 p.f lead

PRECAUTIONS:

1. Auto Transformer should be in minimum voltage position at the time of closing & opening DPST Switch.

TABULAR COLUMN:

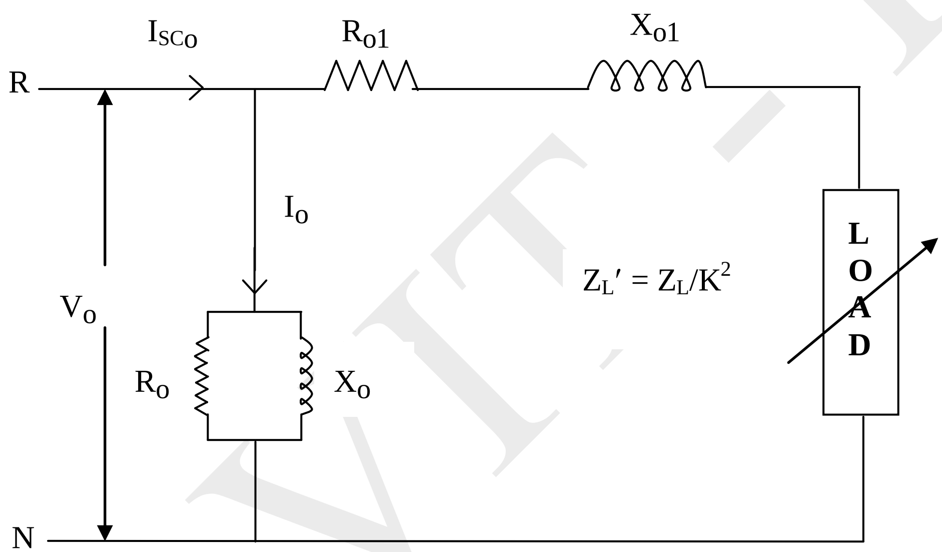
OPEN CIRCUIT TEST:

V_{sc} (Volts)	I_{sc} (Amps)	W_{sc} (Watts)

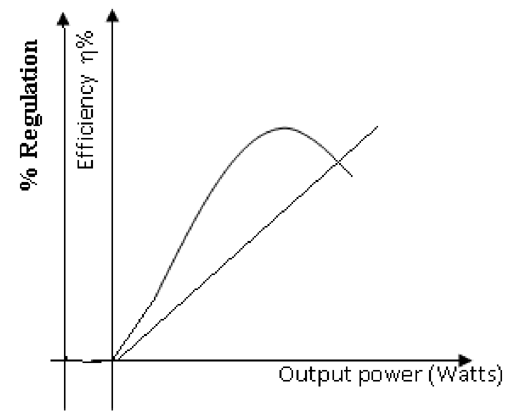
SHORT CIRCUIT TEST:

V_o (Volts)	I_o (Amps)	W_o (Watts)

EQUIVALENT CIRCUIT:



MODEL GRAPHS:



PROCEDURE:

OPEN CIRCUIT TEST:

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer (variac) is adjusted get the rated primary voltage.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

SHORT CIRCUIT TEST:

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer (variac) is adjusted get the rated primary current.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

RESULT:

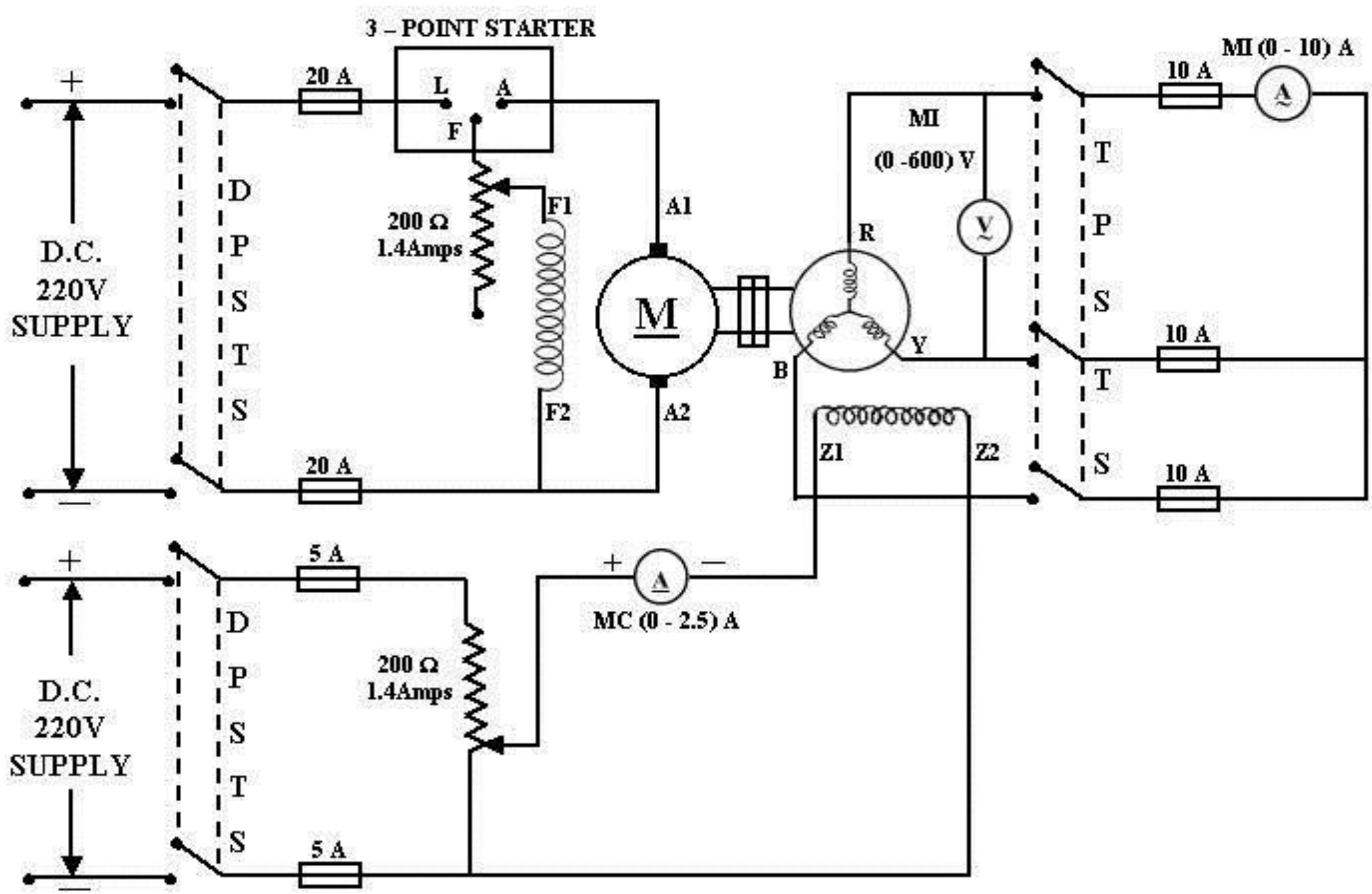
The O.C and S.C tests are conducted on the single phase transformer and the efficiency and regulation graphs and also the equivalent circuit as referred to H.V side are drawn.

VIVA QUESTIONS

1. How are the meter ratings selected for O.C and S.C tests?
2. Why is the O.C test conducted on the l.v side of the transformer and S.C test on h.v side?
3. What are the losses measured in an O.C test?
4. What are the losses measured in an S.C test?
5. What is the condition for maximum efficiency in a transformer?
6. What is meant by ‘regulation’ of a transformer?
7. Is a high or low value of regulation preferred? Why?
8. How can the parameters on one side of the transformer be transferred to the other side?

REGULATION OF ALTERNATOR BY EMF AND MMF METHODS

CIRCUIT DIAGRAM



EXP.NO. 8

REGULATION OF 3–PHASE ALTERNATOR BY EMF AND MMF METHODS

AIM:

To predetermine the regulation of 3-phase alternator by EMF and MMF methods and also draw the vector diagrams.

APPARATUS REQUIRED:

SL.NO	Name of the Apparatus	Type	Range	Quantity
1	Ammeter	MC	0 – 1/2 A	1
2	Ammeter	MI	0 – 5/10 A	1
3	Voltmeter	MC	0 – 10 V	1
4	Voltmeter	MI	0 – 600 V	1
5	Rheostat	Wire wound	250 Ω, 1.5 A	1
6	Rheostat	Wire wound	1200Ω, 0.8 A	1
7	Tachometer	Digital	---	1
8	TPST knife switch	--	--	1

NAME PLATE DETAILS:

DC Motor

Rated Voltage :
Rated Current :
Rated Speed :
Rated Power :
Excitation Voltage :
Excitation Current :
Excitation Voltage :
Excitation Current :

3Φ Alternator

Rated Voltage :
Rated Current :
Rated Speed :
Rated Power :
Rated Frequency :
Excitation Voltage :
Excitation Current :

THEORY:

The regulation of a 3-phase alternator may be predetermined by conducting the Open Circuit (OC) and the Sort Circuit (SC) tests. The methods employed for determination of regulation are EMF or synchronous impedance method, MMF or Ampere Turns method and the ZPF or Potier triangle method. In this experiment, the EMF and MMF methods are used. The OC and SC graphs are plotted from the two tests. The synchronous impedance is found from the OC test. The regulation is then determined at different power factors by calculations using vector diagrams. The EMF method is also called pessimistic method as the value of regulation obtained is much more than the actual value. The MMF method is also called optimistic method as the value of regulation obtained is much less than the actual value. In the MMF method the armature leakage reactance is treated as an additional armature reaction. In both methods the OC and SC test data are utilized.

PRECAUTIONS:

(i) The motor field rheostat should be kept in the minimum resistance position.

(ii) The alternator field potential divider should be kept in the minimum voltage position.

(iii) Initially all switches are in open position.

PROCEDURE: (FOR BOTH EMF AND MMF METHODS)

1. Note down the name plate details of the motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch ON the supply by closing the DPST switch.
4. Using the Three point starter, start the motor to run at the synchronous speed by adjusting the motor field rheostat.
5. Conduct Open Circuit test by varying the potential divider for various values of field current and tabulate the corresponding Open Circuit Voltage readings.
6. Conduct Short Circuit test by closing the TPST switch and adjust the potential divider to set the rated armature current and tabulate the corresponding field current.
7. The Stator resistance per phase is determined by connecting any one phase stator winding of the alternator as per the circuit diagram using MC voltmeter and ammeter of suitable ranges.

PROCEDURE TO DRAW GRAPH FOR EMF METHOD:

1. Draw the Open Circuit Characteristic curve (Generated Voltage per phase VS Field current).
2. Draw the Short Circuit Characteristics curve (Short circuit current VS Field current)
3. From the graph find the open circuit voltage per phase (E_1 (ph) for the rated short circuit current (Isc).
4. By using respective formulae find the Zs, Xs, Eo and percentage regulation.

PROCEDURE TO DRAW GRAPH FOR MMF METHOD:

1. Draw the Open Circuit Characteristic curve (Generated Voltage per phase VS Field current).
2. Draw the Short Circuit Characteristics curve (Short circuit current VS Field current)
3. Draw the line **OL** to represent

FORMULAE:

1. Armature Resistance Ra = Ω
2. Synchronous Impedance $Zs = \frac{\text{O.C. voltage}}{\text{S.C. current}}$
3. Synchronous Reactance $Xs = \sqrt{Zs^2 - Ra^2}$
4. Open circuit voltage for lagging p.f = $\sqrt{(V\cos\Phi + IaRa)^2 + (V\sin\Phi + IaXs)^2}$
5. Open circuit voltage for leading p.f. = $\sqrt{(V\cos\Phi + IaRa)^2 + (V\sin\Phi - IaXs)^2}$
6. Open circuit voltage for unity p.f = $\sqrt{(V + IaRa)^2 + (IaXs)^2}$
7. Percentage regulation = $\frac{Eo - V}{V} \times 100$

TABULAR COLUMNS

REGULATION OF 3-PHASE ALTERNATOR BY EMF AND MMF METHODS

OPEN CIRCUIT TEST:

S.No.	Field Current (If)	Open Circuit Line Voltage (Vo_L)	Open circuit Phase Voltage (Voph)
	Amps	Volts	Volts

SHORT CIRCUIT TEST:

S.No.	Field Current (If)	Short Circuit Current (120% to 150% of rated current) (I_{SC})
	Amps	Amps

REGULATION OF 3-PHASE ALTERNATOR BY EMF AND MMF METHODS

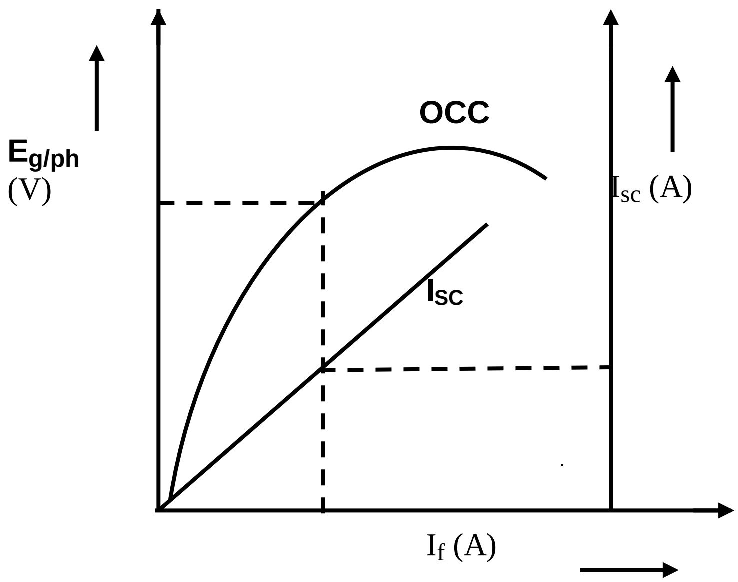
EMF METHOD:

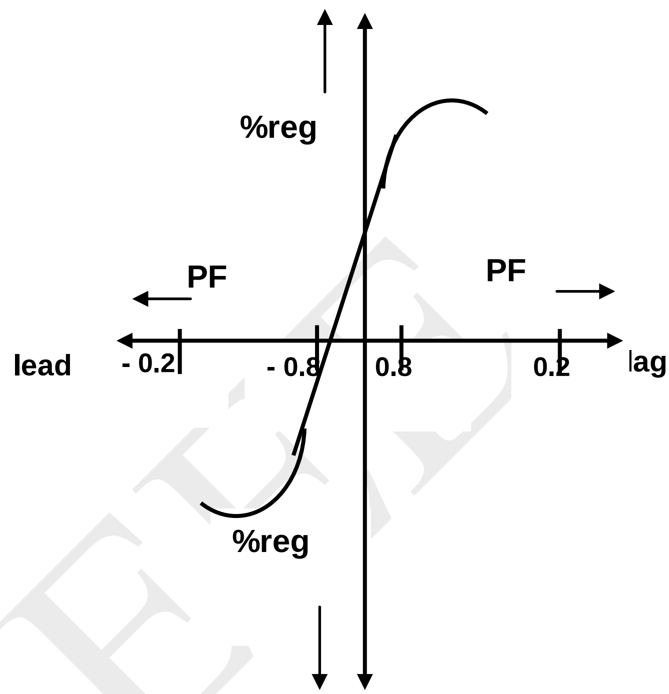
SL.NO.	Power factor	Eph (V)		% Regulation	
		Lag	Lead	Lag	Lead

MMF METHOD:

SL.NO.	P.F	V_{ph} (V)	I_{f1} (A)	I_{f2} (A)	I_{fr} (A)		Eph (V)		% Regulation	
					Lag	Lead	Lag	Lead	Lag	Lead

MODEL GRAPH:





RESULT:

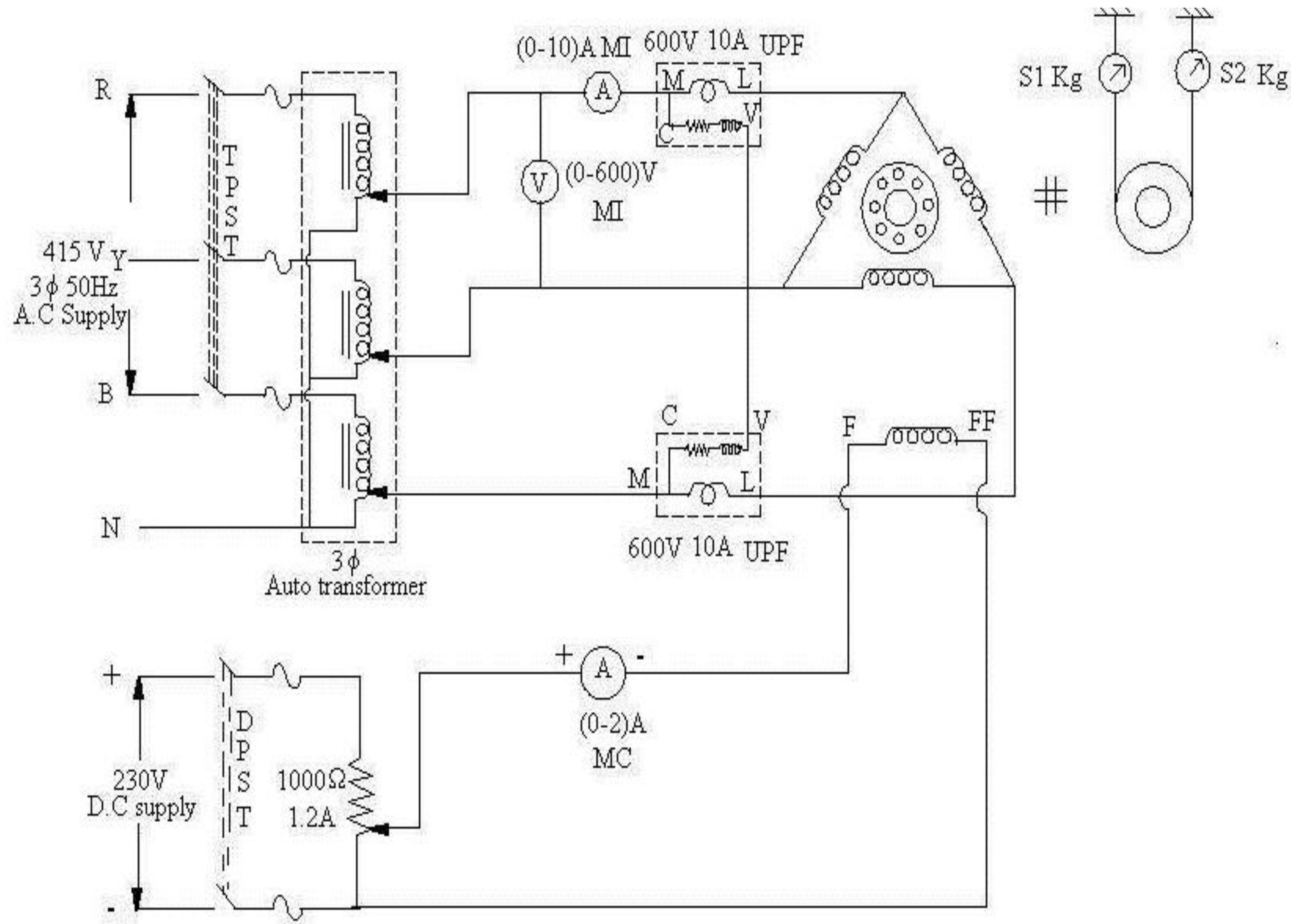
Thus, the open and short circuit tests were conducted on the given 3- phase alternator and the regulation of the alternator was predetermined by EMF and MMF method.

VIVA QUESTIONS:

1. What is meant by voltage regulation?
2. What is meant by Synchronous Impedance?
3. What is OC test ?
4. What is SC test?
5. What is meant by mmf or field ampere turns?

V AND INVERTED V CURVE OF THREE PHASE SYNCHRONOUS MOTOR

CIRCUIT DIAGRAM



Ex:NO-9

V AND INVERTED V CURVE OF THREE PHASE SYNCHRONOUS MOTOR

AIM

To obtain V and inverted V curves of a 3 phase Synchronous Motor.

APPARATUS REQUIRED:

S.No	Name of the apparatus	Type	range	Quantity
1	Ammeter	MI	(0-5)A	2
2.	Voltmeter	MI	(0-600)V	2
3.	Ammeter	MC	(0-2)A	1
4.	Rheostat		1000Ω,1.2A	1
5.	Wattmeter	UPF	600V,5A	2

FUSE RATING:

125% of rated current (full load current)

FORMULA USED:

$$\text{Tan}\ \phi = \sqrt{3}\ (W_1 - W_2)/\ (W_1 + W_2)$$

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

$$\text{Power factor} = \cos\phi$$

TABULAR COLUMN:

S.No	I_f(Amps)	I_a(Amps)	W_1(watts)		W_2(watts)		P.F Cos ϕ
			Obs	Act	Obs	Act	

PRECAUTION:

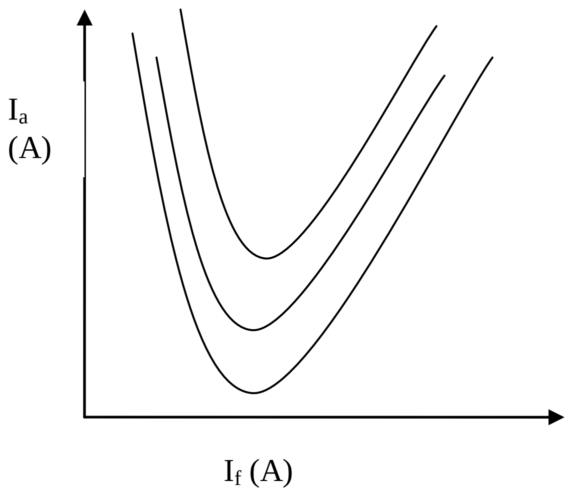
1. The auto transformer is kept in the minimum position.
2. The potential divider is kept in a position such that the voltage is minimum.
3. TPST switch should be kept open.

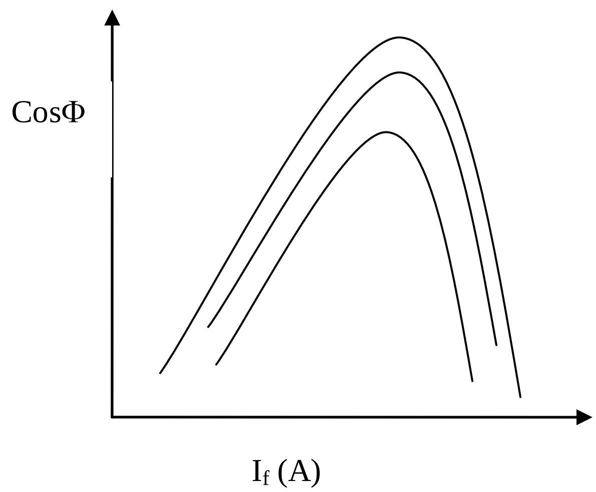
PROCEDURE:

1. Connections are given as per the circuit diagram.
2. After observing the precautions the AC supply is switched ON and the TPST is closed.
3. Now close the DPST switch and increases the field current.
4. Increasing the field current decrease the armature at a particular point. The further increase in field current will increase armature current. Note down the reading and bring back the potential divider to its minimum position.
5. Follow the steps at no load.
6. Now apply some load and repeat then procedure and tabulate the readings.
7. V curves are plotted between armature current and field current.
8. Inverted V curve plotted between power factor and field current.

MODEL GRAPH:

(1) Armature current Vs Excitation current. (2) Power factor Vs Excitation current.





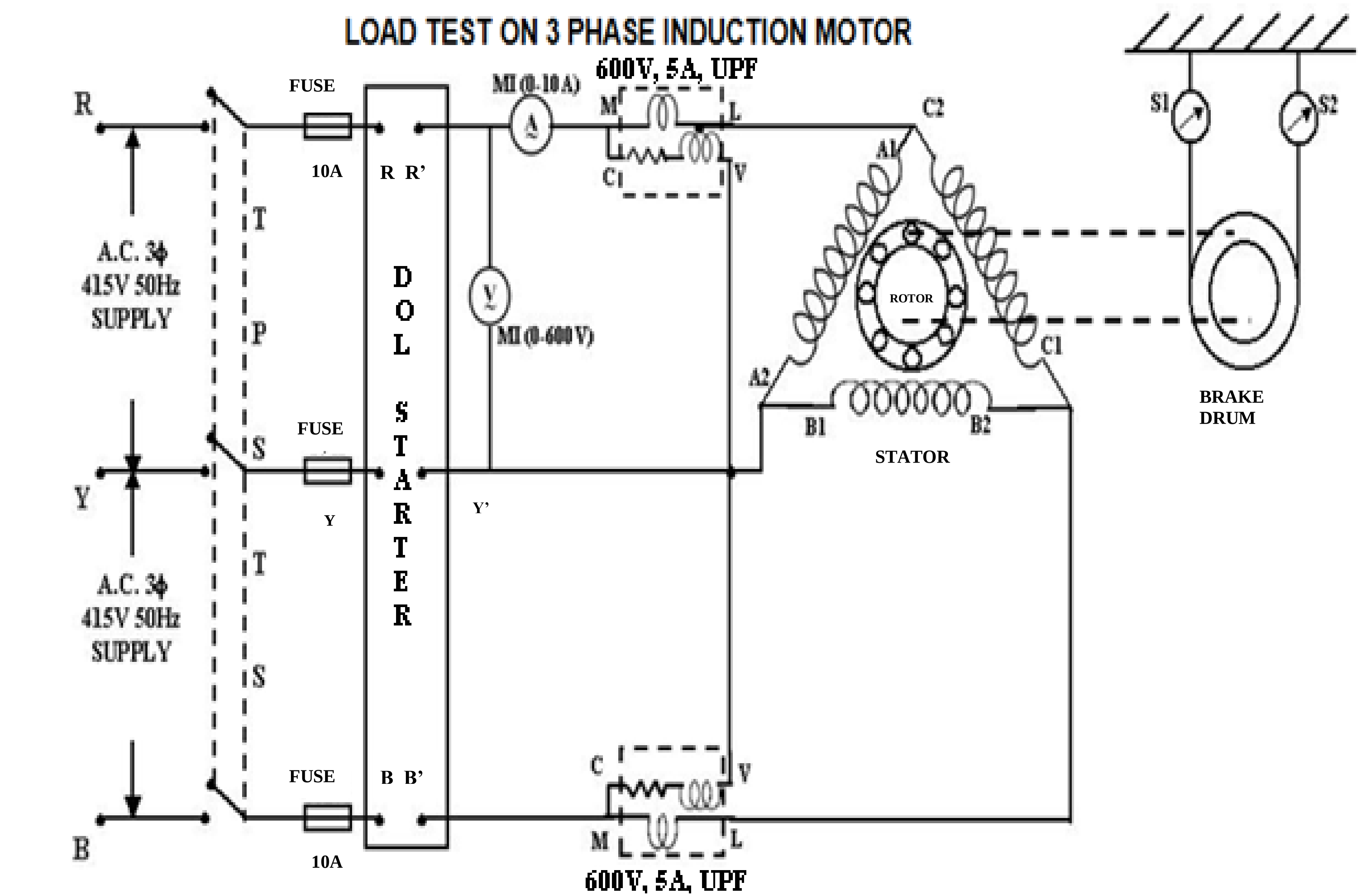
RESULT:

Thus the V and inverted V curves of the three phase synchronous motor were drawn.

VIVA QUESTIONS:

1. In which motor we perform this experiment?
2. What is the speed nature of 3-phase synchronous motor?
3. What is the purpose of this experiment?
4. What is the characteristic of v curve?
5. What is the characteristic of Λ curve?
6. What are the different range of loads used in this experiment?
7. How will you apply load in this experiment?
8. Application of synchronous motor?
9. What is the armature current nature when load is applied in V curve?
10. What is the field current nature when load is applied in Λ curve?

CIRCUIT DIAGRAM



EX NO-10

LOAD TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR

AIM:

To conduct the direct load test on the given three phase induction motor and to determine and plot its performance characteristics.

APPARATUS REQUIRED:

S.No.	Name of Apparatus	Range	Type	Quantity
1.	Voltmeter	(0-600)V	MI	1
2.	Wattmeter	600 V,5A	UPF	2
3.	Ammeter	(0-10)A	MI	1
4.	Tachometer	-	Digital	1
5.	TPST Switch	-	-	1
6.	Three phase Variac	-	-	1
7.	Connecting Wires	-	-	As Needed

NAME PLATE DETAILS:

3Φ Induction motor

Rated Voltage :
Rated Current :
Rated Speed :
Rated Power :
Rated Frequency :

FUSE RATING;

125% of rated current

FORMULA:

Input power = W1 x MF1+ W2 x MF2 (watts)

Torque (T)= (S1 ~ S2) x 9.81 x r (N-m)

Output power = 2ΠNT / 60 watts

Efficiency = output power / input power x 100%

$$Slip = \frac{N_s - N}{N_s} X100$$

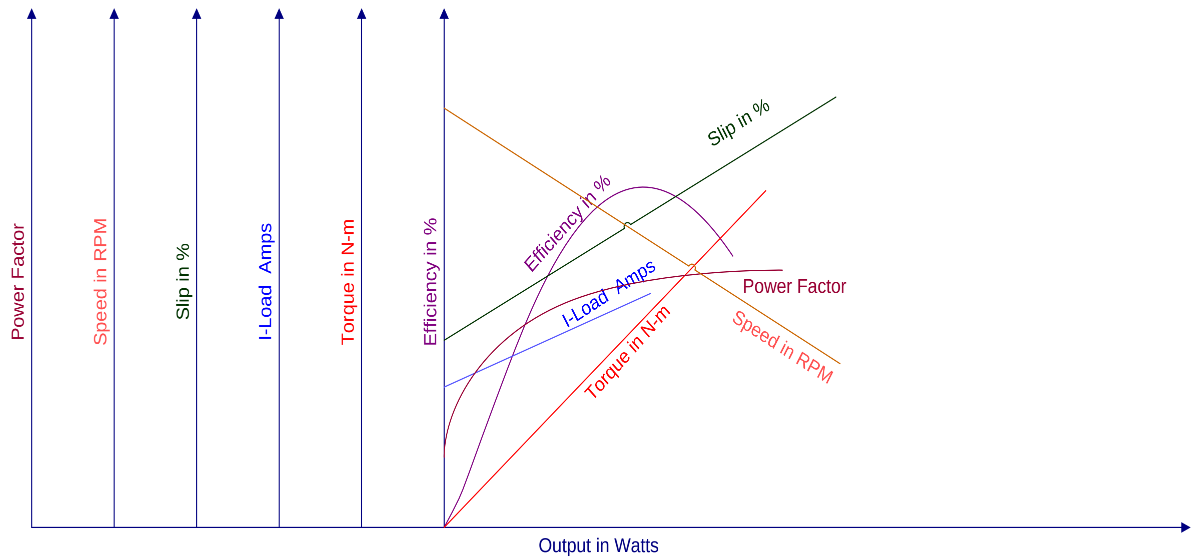
S1, S2= spring balance readings in Kg.
r = radius of the brake drum in m (circumference / 2Π)
N = Actual speed of the rotor in rpm
T = Torque
[Ns-synchronous speed=120*f/P [RPM] [N-speed of the motor]
P- No of poles ,f- Frequency of the supply]
Cosφ= (W1+W2)/ (√3VI)
[Cosφ-power factor, V-voltmeter reading, A-ammeter reading]

TABULATIONS:

Multiplication Factor of the watt meters=

S.No	V	I	Input Power				W1+W2	Speed	Spring Balance			Torque $(S1 \sim S2) X 9.81 X r$	Output Power $\frac{2\pi NT}{60}$	Slip $\frac{N_s - N}{N_s} x100$	Efficy	Power Factor $Cos\phi = \frac{i/p}{3V_{ph}I_{ph}}$
			W1		W2											
			O	A	O	A			S1	S2	S1~S2					
	Volts	Amps	Watts					RPM	Kg	Kg	Kg	NM	Watts	%	%	

MODEL GRAPH:



PRECAUTIONS:

1. There should be no load at the time of starting.
2. Auto transformer must be kept at minimum voltage position

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. Observing the precautions the TPST switch is closed.
3. Adjust the auto transformer to get the rated voltage.
4. A set of no load readings are noted down.
5. Apply the load gradually and note down ammeter, voltmeter and wattmeter readings simultaneously, care should be taken that load current should not exceed the rated current.

Disconnect the load and bring the autotransformer to minimum position and open the TPST switch.

RESULT:

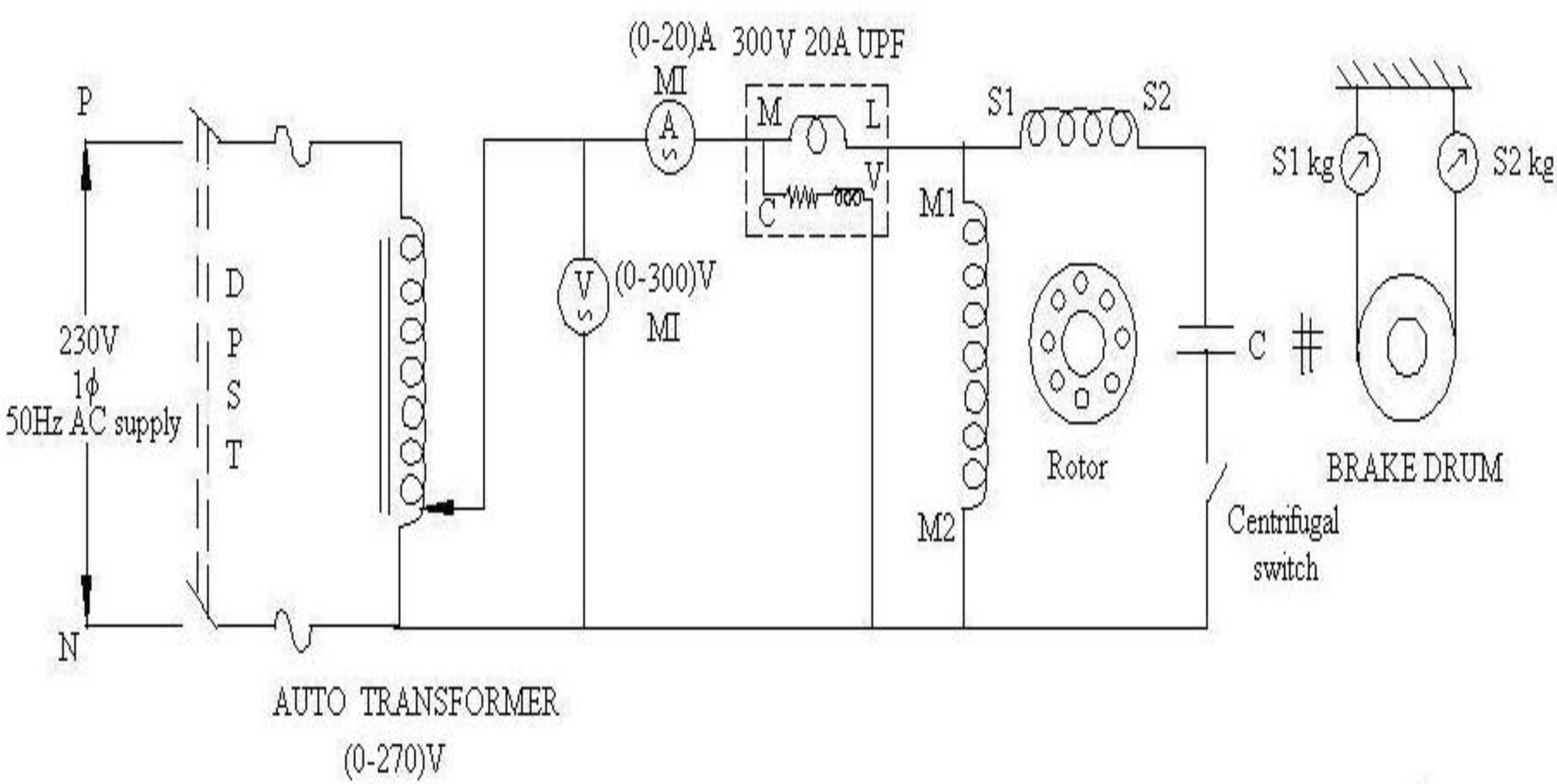
Thus the load test on three phase squirrel cage induction motor was conducted and the performance characteristic curves were drawn.

VIVAQUESTIONS

1. How are the meter ratings selected for this experiment?
2. Why does one of the wattmeters read -ve at starting?
3. What is ‘slip’ in an induction motor?
4. What are the two types of 3-φ induction motors and what is the difference between the two?
5. What is the value of slip at starting?
6. What are the advantages and disadvantages of squirrel cage induction motor?
7. What is the condition for maximum torque in an induction motor?
8. What are the different losses in an induction motor?
9. Gives one applications of 3-φ squirrel cage induction motor?
10. Explain a typical Torque-slip characteristic.
11. What is the effect of increased rotor resistance on the performance of an induction machine?

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

CIRCUIT DIAGRAM:



EX.NO. 11

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

To conduct the direct load test on the given single phase induction motor and to determine and plot its performance characteristics.

APPARATUS REQUIRED:

S.No.	Name of Apparatus	Range	Type	Quantity
1.	Voltmeter	(0-300)V	MI	1
2.	Wattmeter	300V,10A	UPF	1
3.	Ammeter	(0-10)A	MI	1
4.	Tachometer	-	Digital	1
5.	TPST Switch	-	-	1
6.	Single phase Variac	-	-	1
7.	Connecting Wires	-	-	As Needed

NAME PLATE DETAILS:

1Φ Induction motor

Rated Voltage :

Rated Current :

Rated Speed :

Rated Power :

Rated Frequency :

FUSE RATING :

Fuse rating = 125% of rated current

FORMULA USED:

Torque = $9.81 \times (S_1-S_2) \times R$ Nm, where R is the radius of the brake drum in meter.

Output power, $P_o = 2\pi NT/60$ Watts

Input power, $P_i = W_1+W_2$ Watts

%Efficiency, $\%\eta$ = (output power/input power) ×100

% Slip = (Ns-N)/N ×100

Power factor = $\cos\varphi = W/VI$

THEORY:

1phase Induction motor are not self-starting IM. One method of making them of self-starting is by providing auxiliary winding on the stator. The rotor has a proper 3-phase winding with three leads brought out through slips rings and brushes. These leads are normally short circuited when the motor is running. Resistances are introduced in the rotor circuit via the slip rings at the time of starting to improve the starting torque.

The rotating field created by the stator winding moves past the shorted rotor conductors inducing currents in the latter. These induced currents produce their own field which rotates at the same speed (synchronous) with respect to the stator as the stator – produced field. Torque is developed by the interaction of these two relatively stationary fields. The rotor runs at a speed close to synchronous but always slightly lower than it. At the synchronous speed no torque can be developed as zero relative speed between the stator field and the rotor implies no induced rotor currents and therefore no torque.

PRECAUTION*:*

1) Before switching on the supply the variac is kept in minimum position.
2) Initially these should be on no load while starting the motor

PROCEDURE:

Connections are given as per the circuit diagram.

1) Switch on the supply at no load condition.
2) Apply the rotor voltage to the motor using the variac and note down the readings at ammeter And wattmeter.
3) Vary the load in suitable steps and note down all the meter readings till fill load condition.

VIVAQUESTIONS

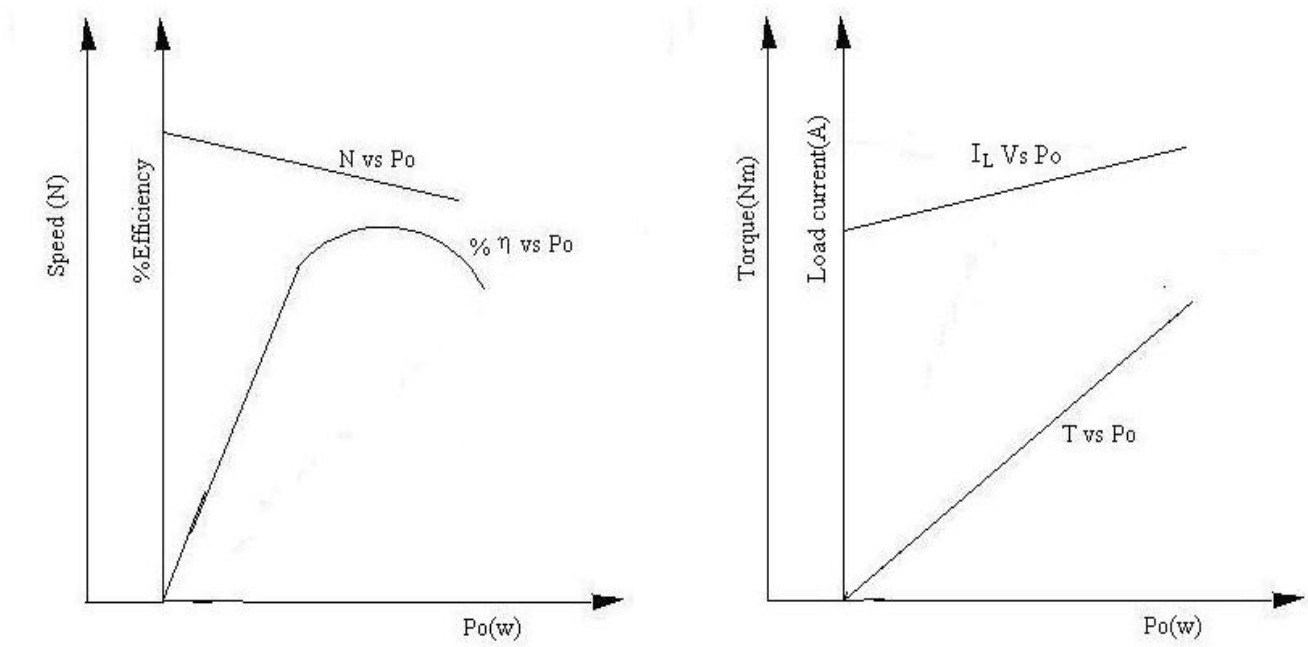
1. What is the purpose of this experiment?
2. Whether single phase induction motor self starting motor?
3. What are the starting methods of single phase induction motor?

TABULAR COLUMN:

R=…………..m

S.no	V_L volts	I_L Amps	S1 kg	S2 kg	S kg	W1 watts	W2 watts	Speed rpm	Torque Nm	P_o watts	P_i watts	Slip %	%η

MODEL GRAPH:



RESULT:

Thus load test on the single phase induction motor has been conducted and its performance characteristics determined.

EX.NO. 12

SPEED CONTROL OF THREE PHASE SLIP RING INDUCTION MOTOR

AIM:

To Control the speed control of 3 phase slip ring induction motor by rotor resistance control.

APPARATUS REQUIRED

S.NO	NAME OF THE APPARATUS	TYPE	RANGE	QUANTITY
1	Ammeter	MI	(0-10A)	1
2	Voltmeter	MI	(0-600V)	1
3	Rotor Resistance Starter	-	-	1
4	Auto transformer	3 Phase	415/(0-470)V	1
5	Tachometer	Digital	-	1
6	Wattmeter	LPF	600V,10A	2
7	Connecting Leads	-	-	Required

THEORY:

Rotor Rheostat Control:

In this method, which is applicable to slip ring induction motors alone, the motor speed is reduced by introducing an external resistance in the rotor circuit. For this purpose, the rotor starter may be used provided it is continuously rated. This method is in fact similar to the armature rheostat control method of d.c shunt motors.

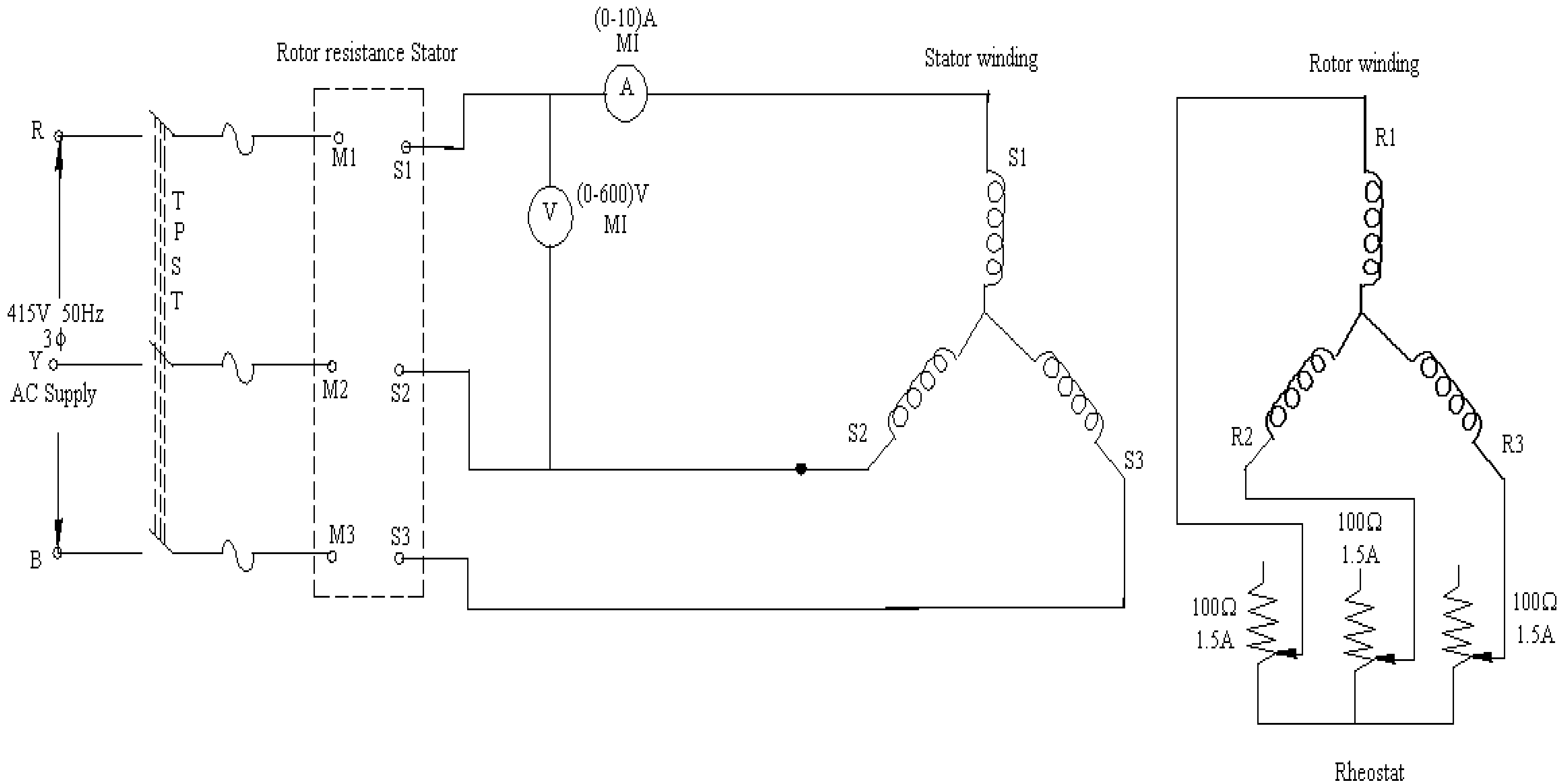
NAME PLATE DETAILS:

3Φ Induction motor

Rated Voltage :
Rated Current :
Rated Speed :
Rated Power :
Rated Frequency :

SPEED CONTROL OF THREE PHASE SLIP RING INDUCTION MOTOR

CIRCUIT DIAGRAM



PRECAUTION:

The motor input current should not exceed its rated value.

PROCEDURE:

1) Connections are given as per the circuit diagram.
2) Keep the rotor resistance stator output as zero voltage & the external rotor resistance at minimum resistance position.
3) Switch ON the supply & increase the input voltage to stator winding upto its rated value.
4) Measure the speed.
5) Now increase the rotor resistance in steps & note the corresponding values of speed.
6) Draw a graph of rotor resistance versus speed.

TABULAR COLUMN:

S.NO.	EXTERNAL ROTOR RESISTANCE IN OHMS	SPEED (RPM)

GRAPH:

- Draw a graph of rotor external resistance versus speed.

RESULT:

Thus the speed of 3 phase slip ring induction motor was controlled by rotor resistance control method.

VIVAQUESTIONS

1) What will happen if the rotor circuit of a slip ring I.M. is kept open & electric supply is given to its stator winding.
2) What is the constructional difference between a slip-ring & a squirrel cage I.M.
3) Draw & explain the Torque-speed characteristic of a slip ring I.M. for different values of rotor resistance.
4) What is the effect of changing the rotor resistance on the slip at max torque SMT.
5) Can a I.M. rotate at synchronous speed? Justify your answer.

EX.NO. 13a STUDY OF DC STARTERS

AIM:

To study about the various types of starters.

NECESSITY OF STARTERS:

The current drawn by the armature is given by the relation

$$I=(V-E)/R$$

Where V is the supply voltage, E is the back EMF and R is the armature resistance.

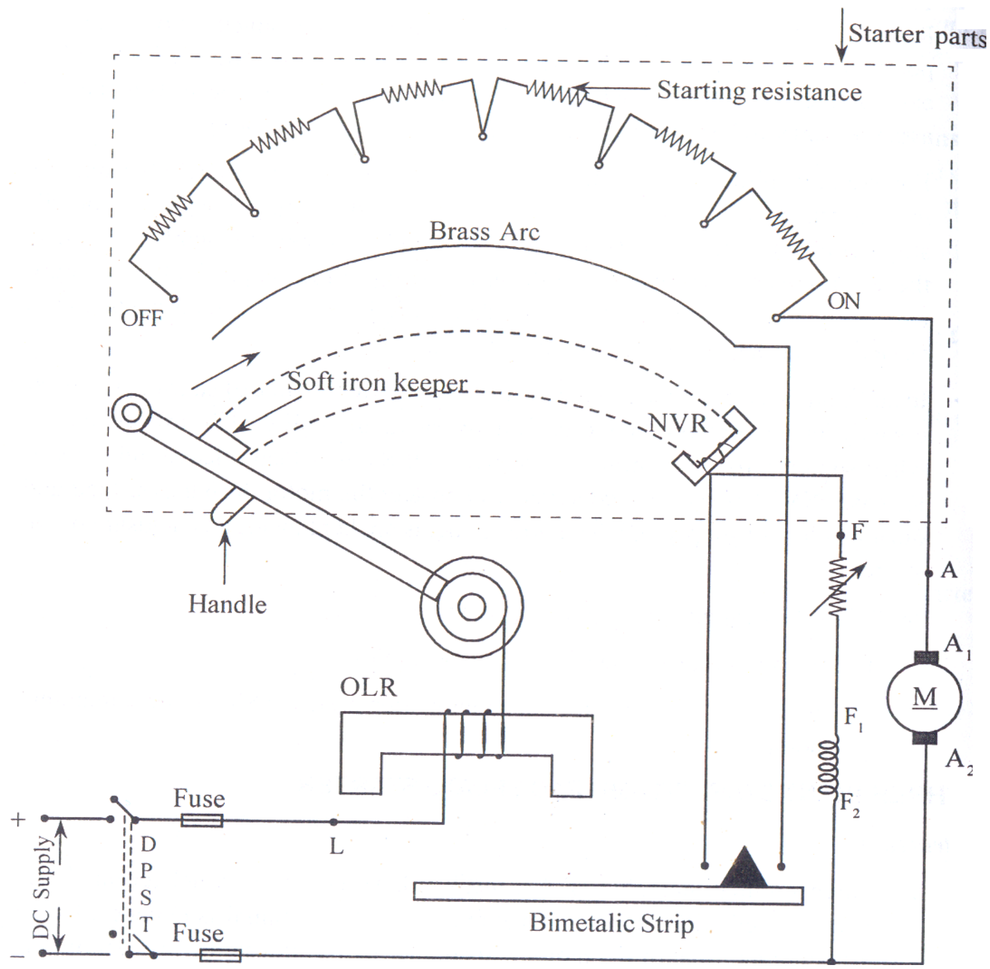
When the motor is at rest, there is ,as yet, obviously to back the EMF developed in the armature. if, now full supply voltage is developed across the stationary armature, it will draw a very large amount of current since the armature resistance is relatively small. consider the case of a 44v,5HP(373 Kw) motor having a cold armature resistance of 0.25Ω and a full load current of 50A. if this motor is started from the line directly, it will draw a starting current of 400/0..25=1760A which is 1760/50=35.2 times its full load current. this excessive current will blow out the fuses and prior to that ,it will damage the commutator and brushes. To avid this happening a resistance is introduced in series with the armature(for the duration of starting period only, say 5 to 10 seconds)which limits the starting current to a safe value. The starting resistance is gradually cut out as the motor gains speed and develops the back emf which then regulates the speed.

Very small motor may, however be started from rest by connecting them directly to the supply lines. It does not result in any harm to the motor for the following reasons:

1. Such motors have a relatively high armature resistance than large motors, hence their starting is not so high.
2. Being small, they have low moment of inertia, hence they speed up quickly
3. The momentary large starting current taken by them is not sufficient to produce a large disturbance in the voltage regulation of the supply lines.

   In fig.1 is shown the resistance R used for starting a shunt motor. It will be seen that the starting resistance R is in series with the armature and does not with the motor as a whole.

The field winding is connected directly across the lines. Hence shunt field current is independent of the resistance R. If R were introduced in the motor circuit, then I_{sh} will be small at the start hence starting torque T_{st} would be small ($\because T_a \alpha \phi\ I_a$) and there would be some difficulty in starting a motor.



THREE- POINT STARTER

The internal wiring for such a starter is shown if the fig2 and it is seen that basically the connections are the same as in the fig1 except for the additional protective devices used here. The three terminals of the starting box are marked as A, B, C. One line is directly connected to one armature terminal and one field terminal which are tied together. The other line is connected to point A which is further connected to the starting arm L, through the over –current(or over load) release M.

To start the motor ,the main switch is first closed and then the starting arm is slowly move to the right. As soon as the arm makes contact with stud no.1, the field circuit is directly connected across the line and at the same time full starting resistance R_S is placed in series with the armature. The starting current drawn by the armature=$V/(R_A+R_S)$ where R_S is the starting resistance. as the arm is further moved, the starting resistance is gradually cut out till, when the arm reaches the running position, the resistance is all cut out. The arm moved over the various studs against a strong spring which tends to restore it to OFF position. There is a soft iron piece S attached and held by an electromagnet E energized by the shunt current. It is variously known as “HOLD-ON” coil, LOW-VOLTAGE(or NO-VOLTAGE) realize.

It will be seen that as the arm is moved from stud 1 to the last stud, the field current has to travel back through that portion of the starting resistance that has been cut out of the armature circuit. This results in slight decrease of shunt current. But as the value of starting resistance is very small as compared to shunt field resistance, this slight decrease in I is negligible. This defect can, however, be remedied by using a brass are which is connected to stud no.1 fig3.

The normal function of HOLD-ON coil is to hold the arm in the full running position when the motor is in running position. But, in case of failure or disconnecting of the supply or break in the field circuit, it is de-energized thereby releasing the arm which is pulled back by the spring to the OFF position. This prevents the stationary armature from being put across the lines again when the supply when the supply is restored after temporary shut down. This would have happened if the arm were left in the full null position. One great advantage of connecting the HOLD-ON coil in series with the shunt field is that, should the field circuit become open, the starting arm immediately springs back to the OFF position thereby preventing the motor from running away.

The over-current release consists of electromagnet connected in the supply line. If the motor becomes over-loaded beyond a certain predetermined value, then D is lifted and short-circuits the electromagnet. Hence, the arm is released and returns to OFF position.

The form of over-load protection described above is becoming obsolete, because it cannot be made either as accurate or as reliable as a separate well-designed circuit breaker with a suitable time element attachment. Many a times a separate magnetic contractor with an overload relay is also used.

Often the motors are protected by thermal overload relays in which a bimetallic strip is heated by the motor is itself heating up. Above a certain temperature, this relay trips and opens the line contractor thereby isolating the motor from the supply.It is desired to control the speed the motor in addition ,then a field rheostat is connected in the field circuit as shown in the fig2.the motor speed can be increased by weakening the flux($N \propto 1/\phi$)Obviously ,there is a limit to the speed increase obtained in this way, although speed ranges of three or four are

possible. If too much resistance is ‘cut-in’ by the field rheostat, then field current is reduced very much so that it is unable to create enough electromagnetic pull to overcome the spring tension. Hence, the arm is pulled back to OFF position. It is this undesirable feature of a three-point starter which it makes it unsuitable for use with variable speed motors. This has resulted in wide range application of four point starters.

FOUR POINT STARTER

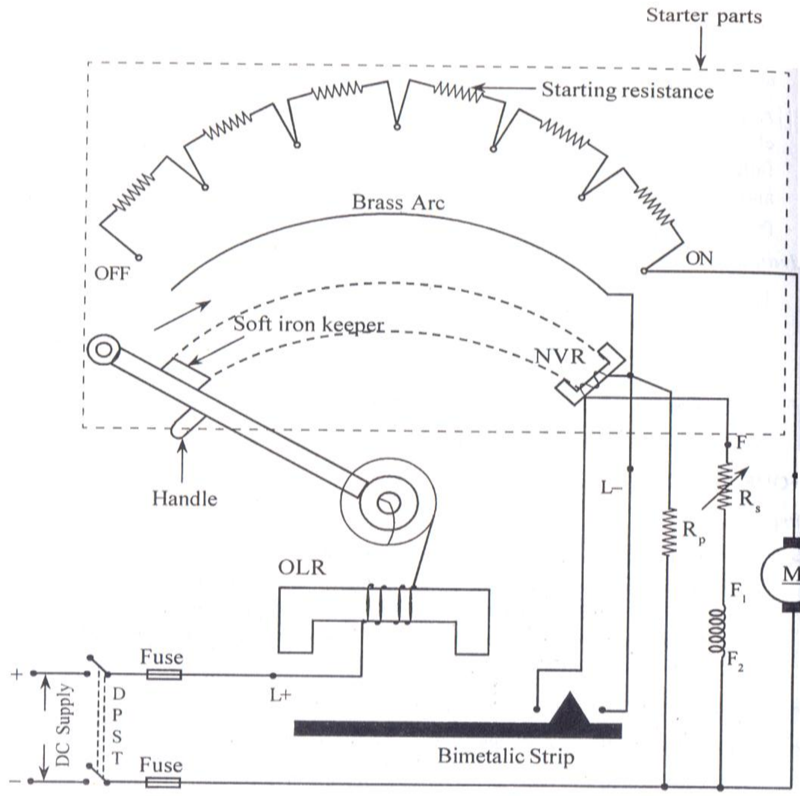
Such a starter with its internal winding is shown connected to a long –shunt compound motor in fig4.when compared to the three-point starter, it will be noticed that one important change has been made i.e., the HOLD-ON coil has been taken out of the shunt field and has been connected directly across the line through a protecting resistance as shown. When the arm touches stud no.1, then the line current divides into three parts

(i)One part passes through starting resistance R_s, series field and motor armature.

(ii)The second part passes through the shunt field and its field rheostat R_h

(iii)The third part passed through the HOLD-ON coil and current protecting resistance R.

It should be particularly noted that with this arrangement any change of current in the shunt field circuit does not at all affect the current passing through the HOLD-ON coil because the two circuits are independent of each other. It means that the electromagnetic pull exerted by the HOLD-ON coil will always be sufficient and will prevent the spring from restoring the starting arm to OFF position no matter how the field rheostat or regulator is adjusted.



RESULT:

Thus the performance characteristics and operation of DC starters are studied.

EXPT : 13b **STUDY OF AC STARTERS**

AIM:

To Study the AC motor starters.

NECESSITY OF STARTER:

In a three phase induction motor, the magnitude of an induced e.m.f. in the rotor circuit depends on the slip of the induction motor. This induced e.m.f. effectively decides the magnitude of the rotor current. The rotor current in the running condition is given by,

$$I_{2r} = \frac{sE_2}{\sqrt{R^2_2 + (s\,\chi_2)^2}}$$

But at start, the speed of the motor is zero and slip is at its maximum i.e. unity. So magnitude of rotor induced e.m.f. is very large at start. As rotor conductors are short circuited, the large induced e.m.f. circulates very high current through rotor at start.

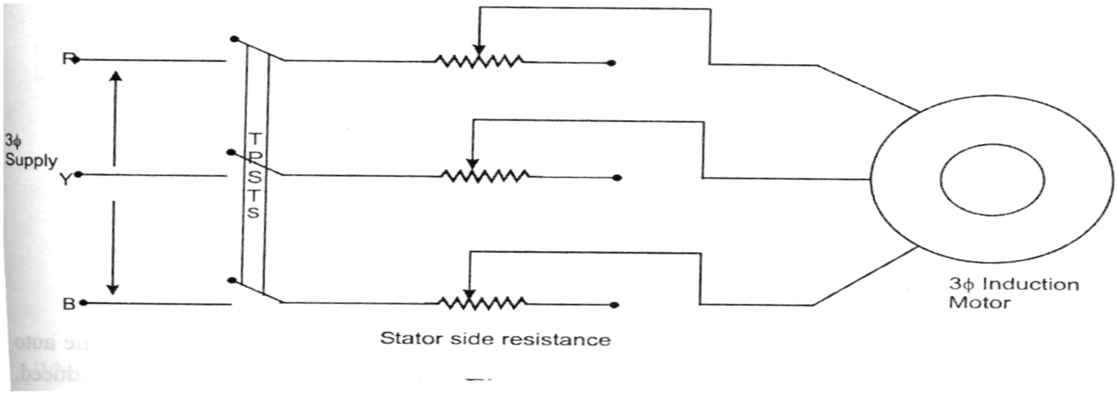
The condition is exactly similar to a transformer with short circuited secondary. Such a transformer when excited by a rated voltage, circulates very high current through short circuited secondary. As secondary current is large, the primary also draws very high current from the supply.

Similarly in a three phase induction motor, when rotor current is high, consequently the stator draws a very high current from the supply. This current can be of the order of 5 to 8 times the full load current, at start.

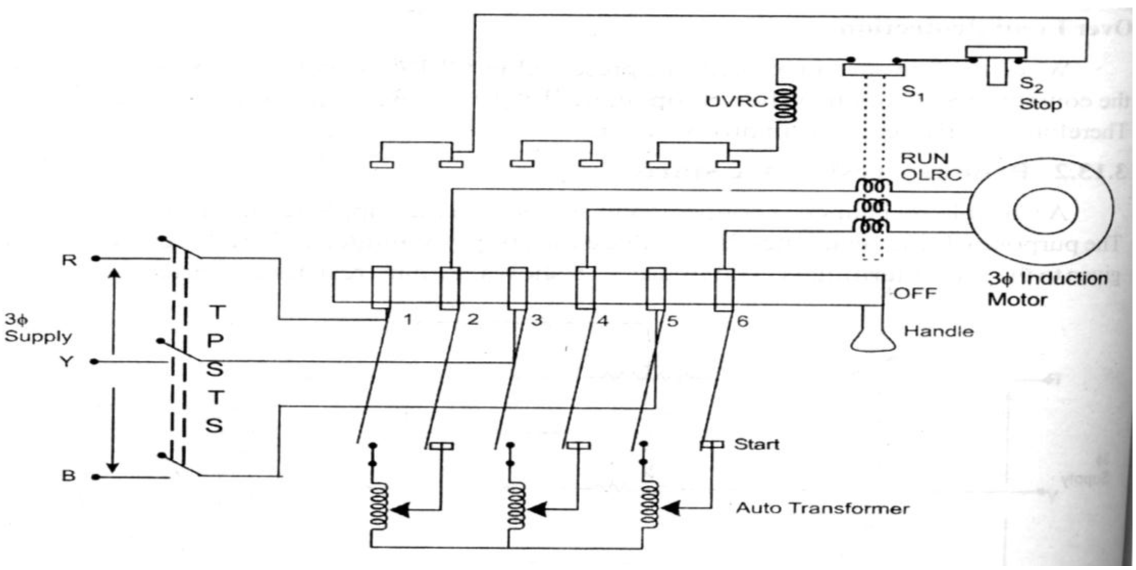
Due to such heavy inrush of current at start there is possibility if damage of the motor winding. Similarly such sudden inrush of current causes large line voltage drop. Thus other appliances connected to the same line may be subjected to voltage spikes which may affect their working. To avoid such effects, it is necessary to limit the current drawn by the motor at start. The starter is a device which is basically used to limit high starting current by supplying reduced voltage to the motor at the time of starting. Such a reduced voltage is applied only for short period and once rotor gets accelerated, full normal rated voltage is applied.

Not only the starter limits the starting current but also provides the protection to the induction motor against overt loading and low voltage situations. The protection against single phasing is also provided by the starter. The induction motors having rating below 5 h.p. can withstand starting currents hence such motors can be started directly on line. But such motors also need overload, single phasing and low voltage protection which is provided by a starter.

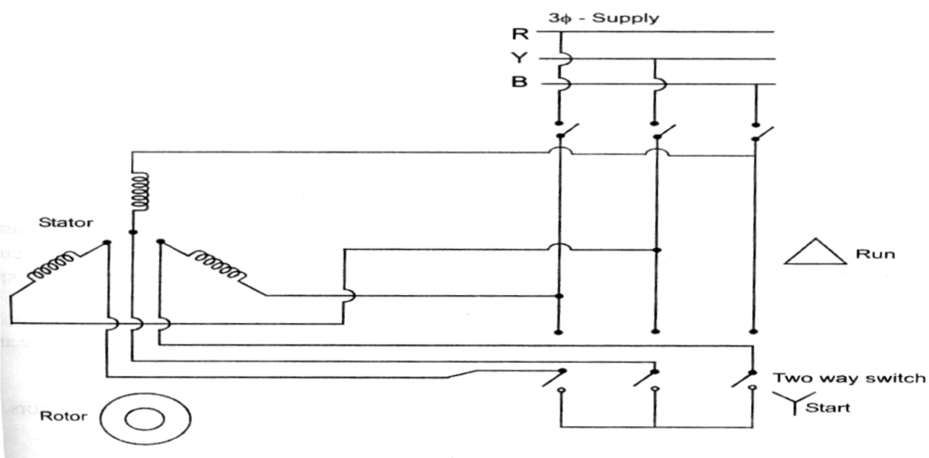
CIRCUIT DIAGRAM:
Stator Resistance Starter



Autotransformer Starter



Star-Delta Starter



STATOR RESISTANCE STARTER:

In order to apply the reduced voltage to the stator of the induction motor, three resistances are added in series with each phase of the stator winding. Initially the resistances are kept maximum in the circuit. Due to this large voltage gets dropped across the resistances. Hence a reduced voltage gets applied to the stator, which reduces the high starting current. The schematic diagram showing stator resistances is shown in the Fig.3.1. When the motor starts running, the resistances are gradually cut off from the stator circuit. When the resistances are entirely removed from the stator circuit i.e. rheostats in RUN position then rated voltage gets applied to the stator. Motor runs with normal speed. The starter is simple in construction and cheap. It can be used for both star and delta connected stator. But there are large power losses due to resistances. Also the starting torque of the motor reduces due to reduced voltage applied to the stator.

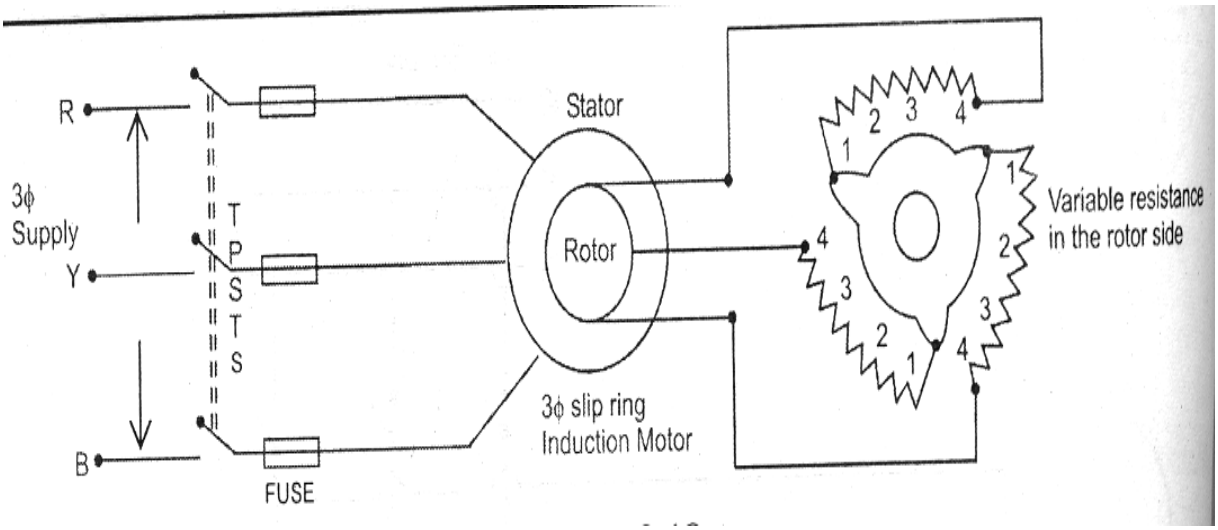
AUTOTRANSFORMER STARTER:

A three phase star connected autotransformer can be used to reduce the voltage applied to the stator. Such a starter is called an autotransformer starter. The schematic diagram of autotransformer starter is shown in the Fig. It consists of a suitable change over switch. When the switch is in the start position, the stator winding is supplied with reduced voltage. This can be controlled by tapping provide with autotransformer. When motor gathers 80% of the normal speed, the change over switch is thrown into run position. Due to this, rated voltage gets applied to stator winding. The motor starts rotating with normal speed. Changing of switch is done automatically by using relays. The power loss is much less in this type of starting. It can be used for both star and delta connected motors. But it is expensive than stator resistance starter.

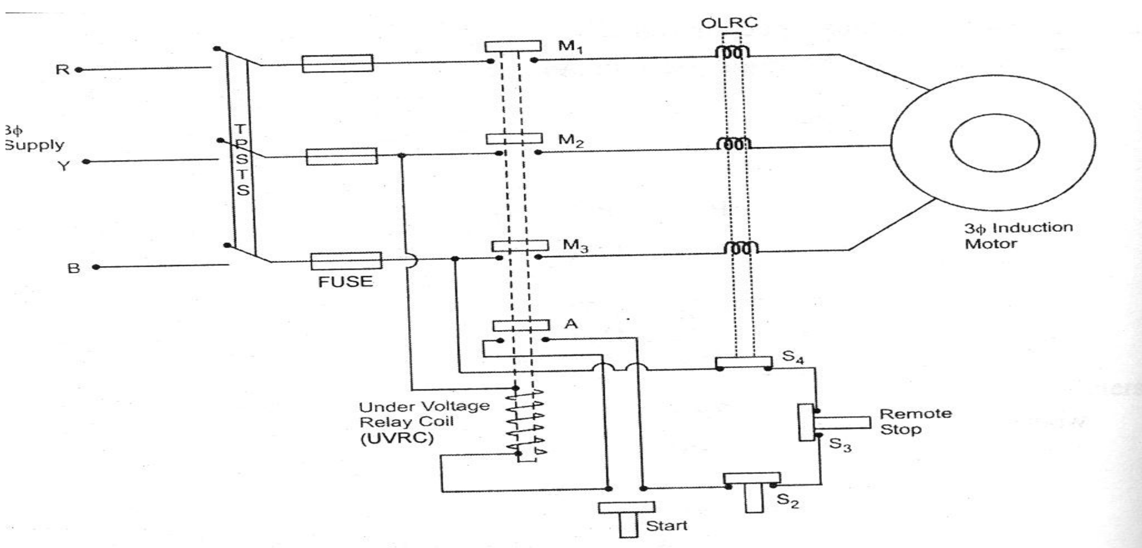
STAR – DALTA STARTER:

This is the cheapest starter of all and hence used very commonly for the induction motors. It uses triple pole double throw (TPDT) switch. The switch connects the stator winding in star at start. Hence per phase voltage gets reduced by the factor $1 / \sqrt{3}$. Due to this reduced voltage, the starting current is limited. When the switch is thrown on other side, the winding gets connected in delta, across the supply. So it gets normal rated voltage. The windings are connected in delta when motor gathers sufficient speed. The agreement of star – delta starter is shown in the Fig.. The operation of the switch can be automatic by using relays which ensures that motor will not start with the switch in Run position. The cheapest of all and maintenance free operation are the two important advantages of this starter. While is limitations are, it is suitable for normal delta connected motors and the factor by while voltage change is $1 \sqrt{3}$ which cannot be changed.

Rotor Resistance Starter



Direct On Line Starter



ROTOR RESISTANCE STARTER:

To limit the rotor current which consequently reduces the current drawn by the motor from the supply, the resistance can be inserted in the rotor circuit at start. This addition of the resistance in rotor is in the form of 3 phase star connected rheostat. The arrangement is shown in the Fig.3.4. The external resistance is inserted in each phase of the rotor winding through slip ring and brush assembly. Initially maximum resistance is in the circuit. As motor gathers speed, the resistance is gradually cutoff. The operation may be manual or automatic. We have seen that the starting torque is proportional to the rotor resistance. Hence important advantage of this method is not only the starting current is limited but starting torque of the motor also gets improved. The only limitation of the starter is that it can be used only for slip ring induction motors as in squirrel cage motors, the rotor is permanently short circuited.

DIRECT ON LINE STARTER (D.O.L):

In case of small capacity motors having rating less than 5 h.p., the starting current is not very high and such motors can withstand such starting current without any starter. Thus there is no need to reduce applied voltage, to control the starting current. Such motors use a type of starter which is used to connect stator directly to the supply lines without any reduction in voltage. Hence the starter is known as direct on line starter. Though this starter does not reduce the applied voltage, it is used because it protects the motor from various severe abnormal condition like over voltage, single phasing etc. The Fig.3.5 shows the arrangement of various components in direct on line starter. The NO contact is normally open and NC is normally closed. At start, NO is pushed for fraction of second due to which coil gets energized and attracts the contactor. So stator directly gets supply. The additional contact provided, ensures that as long as supply in ON, the coil gets supply and keeps contactor in ON position. When NC is pressed, the coil circuit gets opened due to which coil gets de-energized and motor gets switched OFF from the supply. Under over load condition, current drawn by the motor increase due to which there is an excessive heat produced, which increase temperature beyond limit. Thermal relays get opened due to high temperature, protecting the motor from overload conditions.

RESULT:

Thus the AC motor starters were studied.