ST.ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

ANGUCHETTYPALAYAM, PANRUTI-607 110.

EE8311 ELECTRICAL MACHINES I LABORATORY MANUAL

II YEAR / IV SEMESTER
B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

DOs and DON'T DOs in Laboratory

1. Understand the equipment to be tested and apparatus to be used.
2. Do not touch the live terminals.
3. Select proper type (AC or DC) and range of meters, Use suitable wires (type and size).
4. All the connection should be tight. Do not leave loose wires (i.e. wires not connected).
5. Get the connection checked before switching 'ON' the supply.
6. Never exceed the permissible values of current, voltage, and / or speed of any machine.
7. Switch ON or OFF the load gradually and not suddenly.
8. Strictly observe the instructions given by the Staff / Lab Instructor

LIST OF EXPERIMENTS

1. Load test on DC shunt motor.
2. Load test on DC series motor.
3. Load test on DC compound motor.
4. Speed control of DC shunt motor (Armature, Field control).
5. Open circuit and load characteristics of self-excited DC shunt generator.
6. Open circuit and load characteristics of separately-excited DC shunt generator.
7. Load characteristics of DC compound generator (differential and cumulative connections).
8. Swinburne's test on DC shunt motor.
9. Hopkinson's test on DC motor-generator set.
10. Load test on single-phase transformer.

11. Load test on Three-phase transformer
12. Open circuit and short circuit tests on single phase transformer.
13. Separation of no-load losses in single phase transformer.
14. Polarity Test on single phase transformers.
15. Sumpner's test on single phase transformers.
16. Study of starters and 3-phase transformers connections

Ex.No.1

LOAD TEST ON DC SHUNT MOTOR

AIM:

To conduct the load test on DC shunt motor, to find its characteristics and efficiency.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	750Ω, 2A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

PRECAUTIONS:

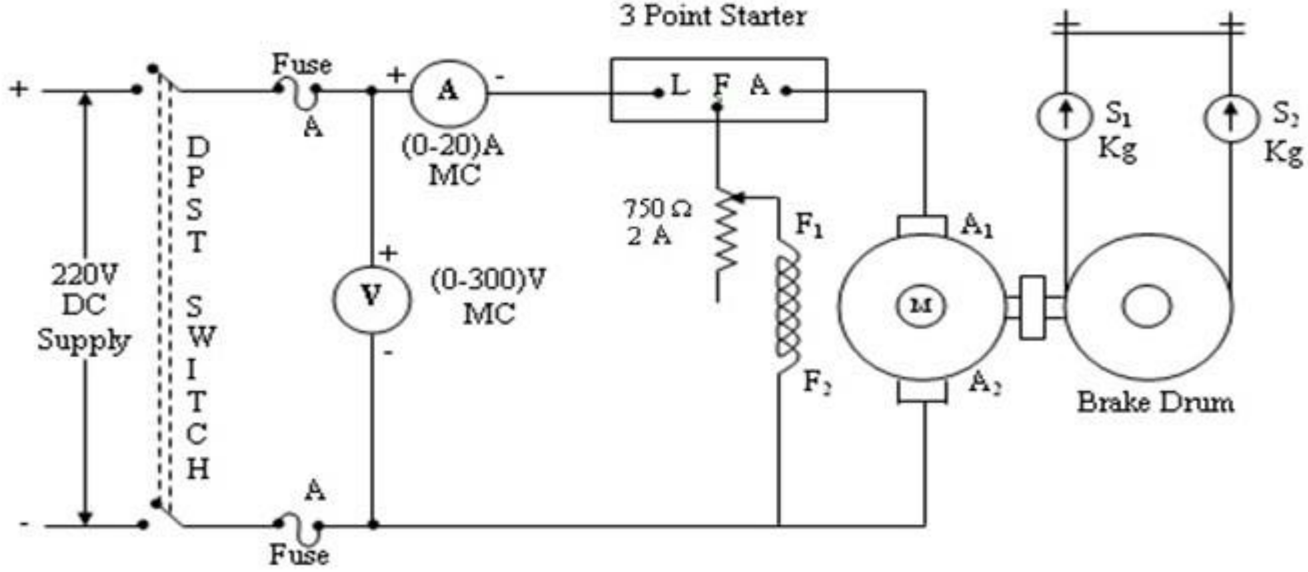
1. DC shunt motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

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.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

Rated Voltage	:	V
Rated Current	:	A
Rated Power	:	KW
Rated Speed	:	RPM

TABULAR COLUMN:

S.No	Voltage V (V)	Current I (A)	Spring Balance Reading		$(S_1 \sim S_2)$ Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watt)	Input Power P_i (Watt)	Efficiency η%
			S_1(Kg)	S_2(Kg)						
1.										
2.										
3.										
4.										
5.										

Radius of the Brake drum R = cm

Thickness of the Brake drum Belt t = cm

FORMULAE:

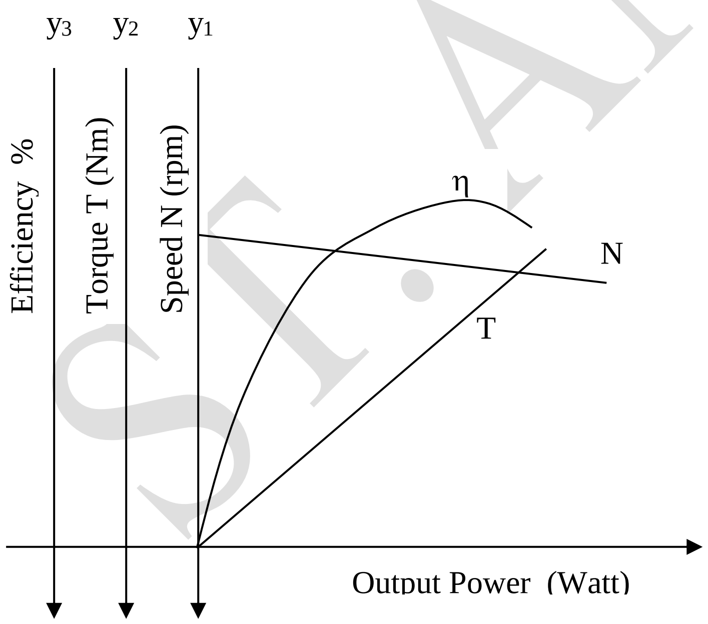
Torque $T = (S_1 \sim S_2) \times (R+t/2) \times 9.81$ Nm

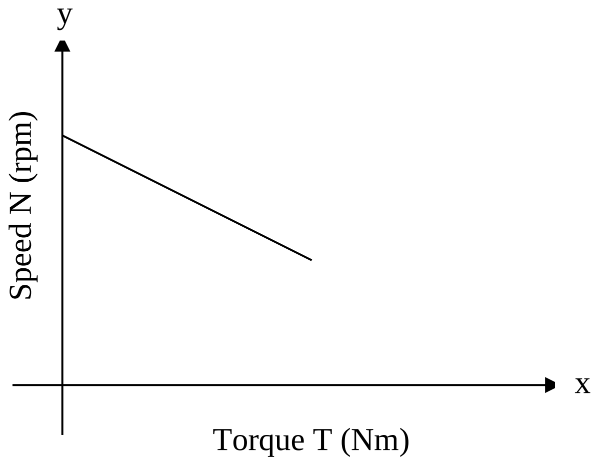
Input Power $P_i = VI$ Watt

Output Power $Pm = \frac{2\pi NT}{60}\ Watt$

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

MODEL GRAPHS:





RESULT:

Thus load test on DC shunt motor is conducted and its characteristics and efficiency is determined and plotted.

Ex.No.2

LOAD TEST ON DC SERIES MOTOR

AIM:

To conduct load test on DC Series Motor, to find its characteristics and efficiency.

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

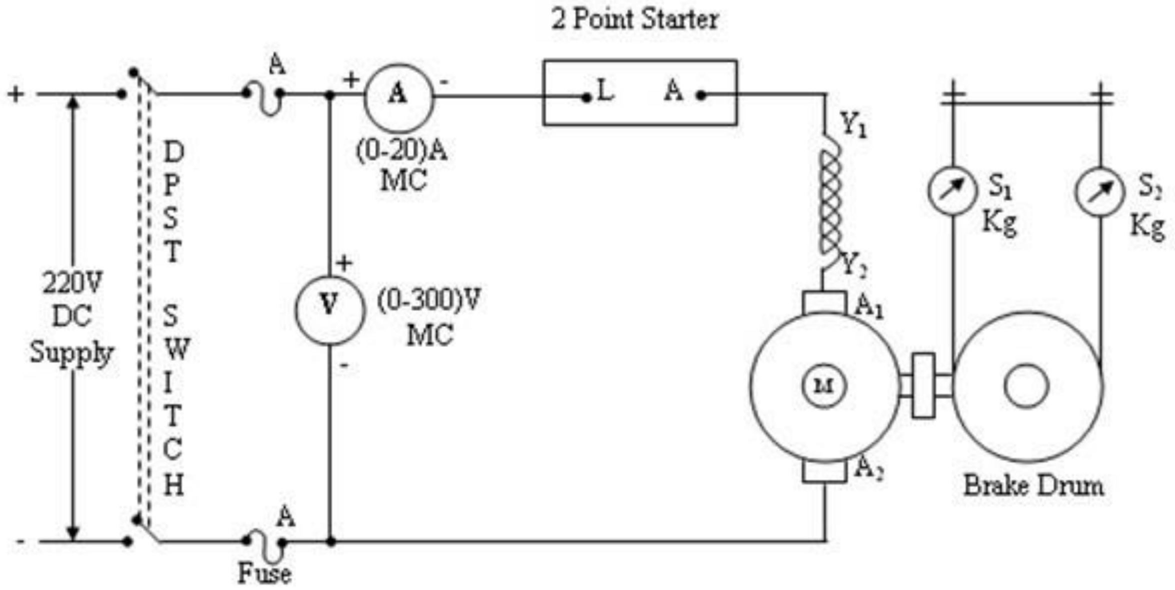
PRECAUTIONS:

1. The motor should be started and stopped with load
2. 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 load condition, DPST switch is closed and starter resistance is gradually removed.
3. For various loads, Voltmeter, Ammeter readings, speed and spring balance readings are noted.
4. After bringing the load to initial position, DPST switch is opened.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \text{A}$$

NAME PLATE DETAILS:

Rated Voltage	:	V
Rated Current	:	A
Rated Power	:	KW
Rated Speed	:	RPM

TABULAR COLUMN:

S.No	Voltage V (V)	Current I (A)	Spring Balance Reading		(S_1~S_2) Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watt)	Input Power P_i (Watt)	Efficiency η%
			S_1(Kg)	S_2(Kg)						
1. 2. 3. 4. 5.										

Radius of the Brake drum R = cm

Thickness of the Brake drum Belt t = cm

FORMULAE:

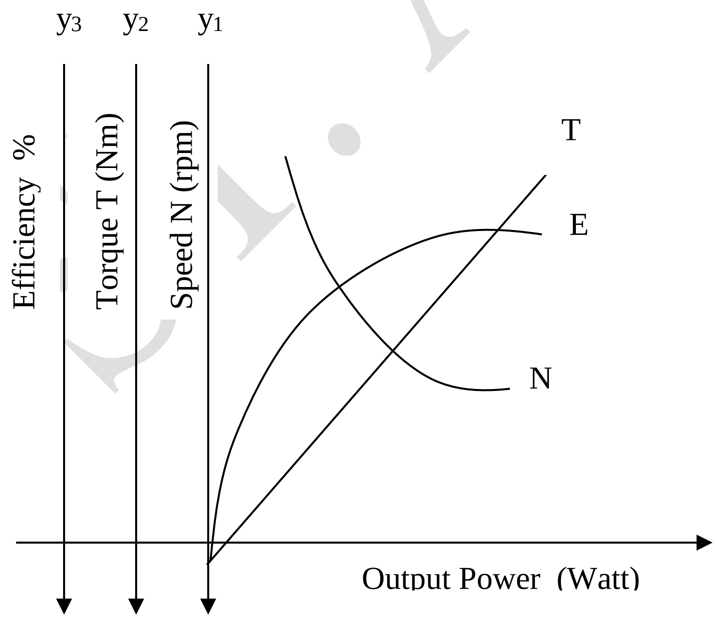
Torque T = (S_1 ~ S_2) x (R+t/2) x 9.81 Nm

Input Power P_i = VI Watt

Output Power $Pm = \frac{2\pi NT}{60}\ \ Watt$

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

MODEL GRAPH:



RESULT:

Thus load test on DC series motor is conducted and its characteristics and efficiency is determined and plotted.

Ex. No. 3

LOAD TEST ON DC COMPOUND MOTOR

AIM:

To conduct the load test on DC compound motor, to find its characteristics and efficiency.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	750Ω, 2A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few

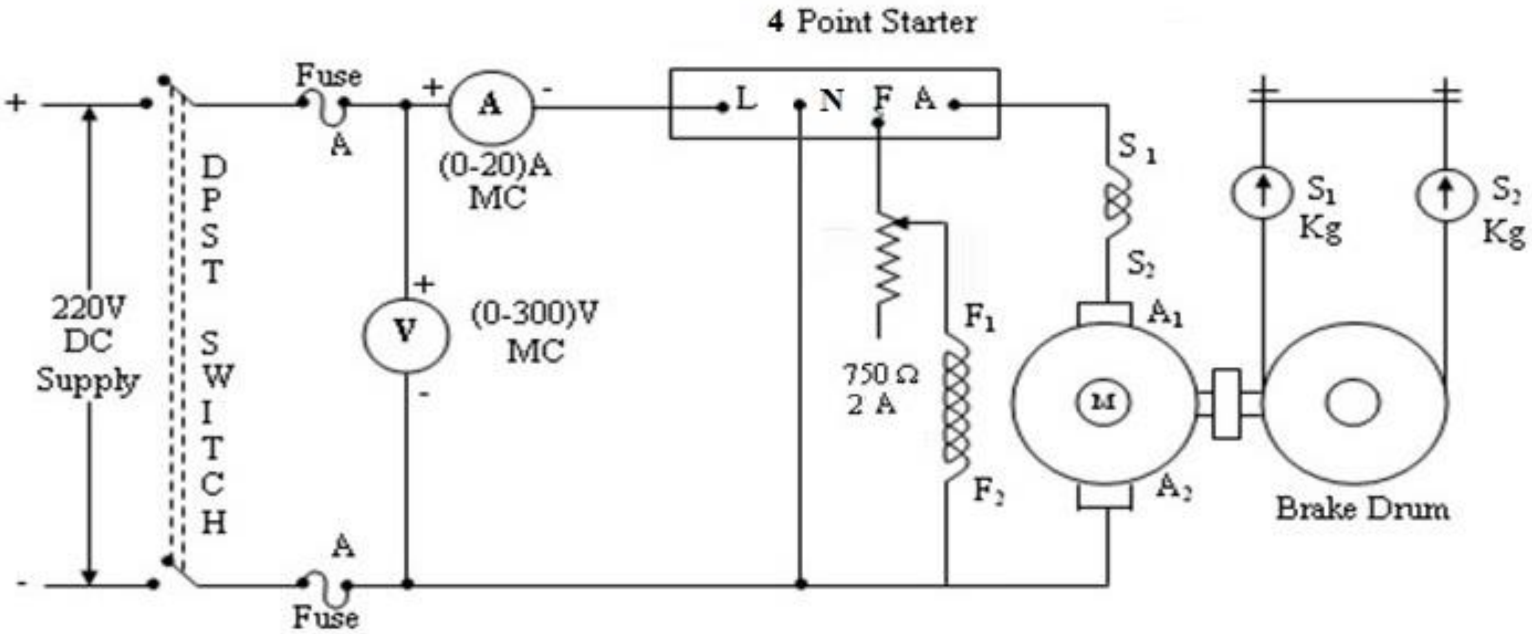
PRECAUTIONS:

1. DC compound 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.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

Rated Voltage	:	V
Rated Current	:	A
Rated Power	:	KW
Rated Speed	:	RPM

TABULAR COLUMN:

S.No	Voltage V (V)	Current I (A)	Spring Balance Reading		$(S_1 \sim S_2)$ Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watt)	Input Power P_i (Watt)	Efficiency η%
			S_1(Kg)	S_2(Kg)						
1.										
2.										
3.										
4.										
5.										

Radius of the Brake drum R = cm

Thickness of the Brake drum Belt t = cm

FORMULAE:

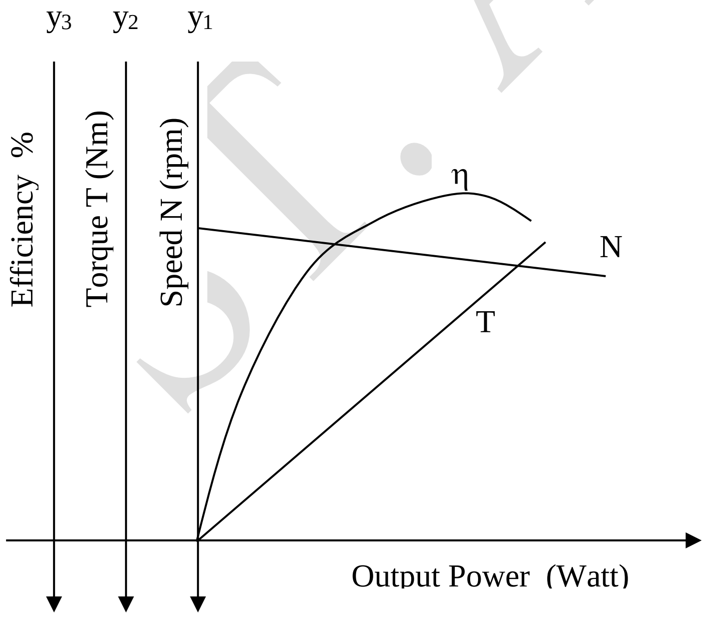
Torque T = $(S_1 \sim S_2)$ x (R+t/2) x 9.81 Nm

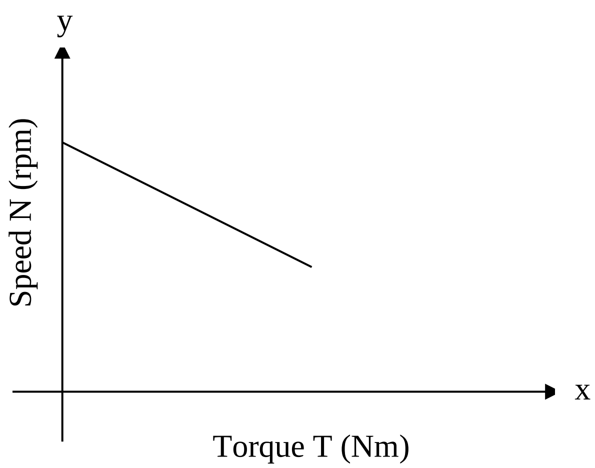
Input Power P_i = VI Watt

Output Power $Pm = \frac{2\pi NT}{60}\ \ Watt$

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

MODEL GRAPHS:





RESULT:

Thus load test on DC compound motor is conducted and its characteristics and efficiency is determined and plotted.

Ex. No. 4

SPEED CONTROL OF DC SHUNT MOTOR

AIM:

To control the speed of DC shunt motor by

a. Varying armature voltage with field current constant. (Armature control)
b. Varying field current with armature voltage constant. (Field control)

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20) A	MC	1
2	Voltmeter	(0-300) V	MC	1
3	Rheostats	750Ω, 2A 50Ω, 2A	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.

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

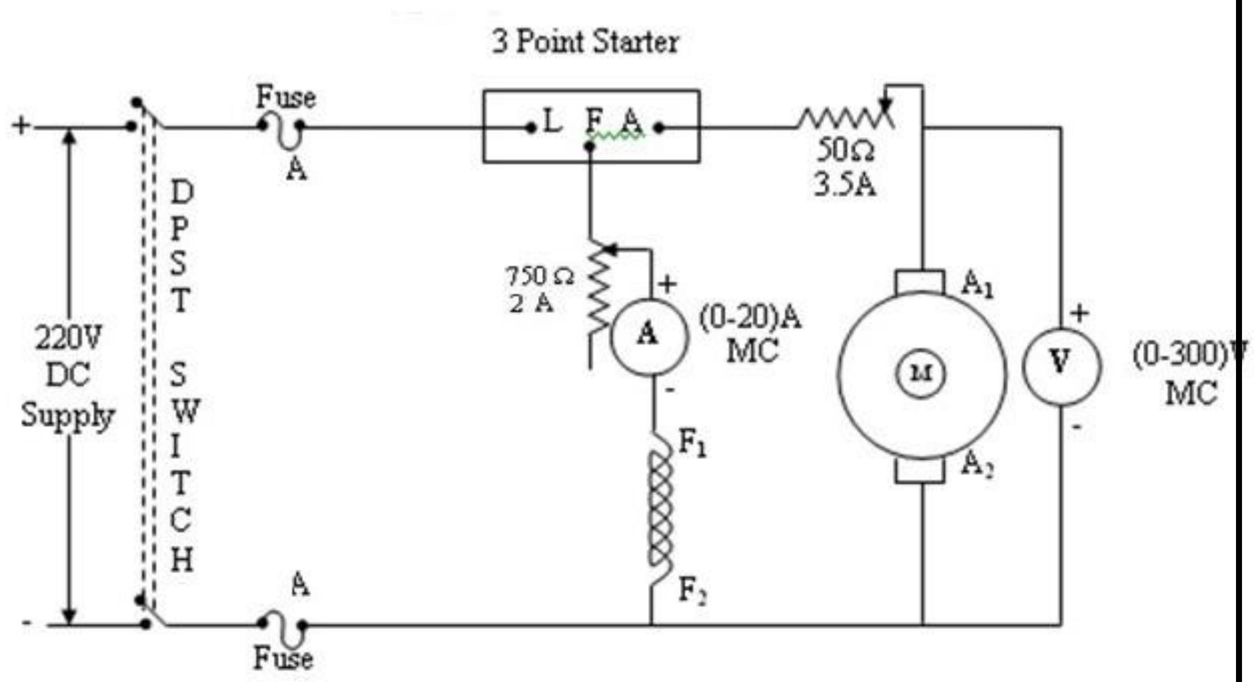
(i) Armature Control:

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.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \quad A$$

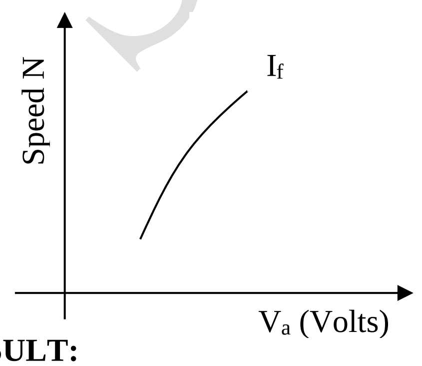
NAME PLATE DETAILS:

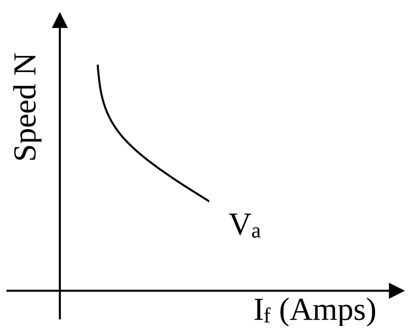
Rated Voltage : V
Rated Current : A
Rated Power : KW
Rated Speed : RPM

TABULAR COLUMN:

S.No.	ARMATURE CONTROL		FIELD CONTROL	
	I_f = (A)		V_a = (V)	
	Armature Voltage V_a (V)	Speed N (rpm)	Field Current I_f (A)	Speed N (rpm)

MODEL GRAPHS:





RESULT:

Thus the speed of DC Shunt Motor is controlled by using Armature control and Field control methods.

Ex.No.5

OPEN CIRCUIT AND LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

AIM:

To conduct open circuit test and load test on self-excited DC shunt generator, to obtain its open circuit characteristics and load characteristics of the machine

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-5)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	750Ω, 2A	Wire Wound	2
4	SPST Switch	-	-	1
5	Tachometer	(0-1500)rpm	Digital	1
6	Connecting Wires	2.5sq.mm.	Copper	Few
7	Loading Rheostat	5KW, 230V	-	1

PRECAUTIONS:

1. The field rheostat of motor should be in minimum resistance position at the time of starting and stopping the machine.
2. The field rheostat of generator should be in maximum resistance position at the time of starting and stopping the machine.
3. SPST switch is kept open during starting and stopping.
4. No load should be connected to generator at the time of starting and stopping.

PROCEDURE: (OPEN CIRCUIT TEST)

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 rated speed.
4. Voltmeter and ammeter readings are taken when the SPST switch is kept open.

5. After closing the SPST 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, SPST switch is opened and DPST switch is opened.

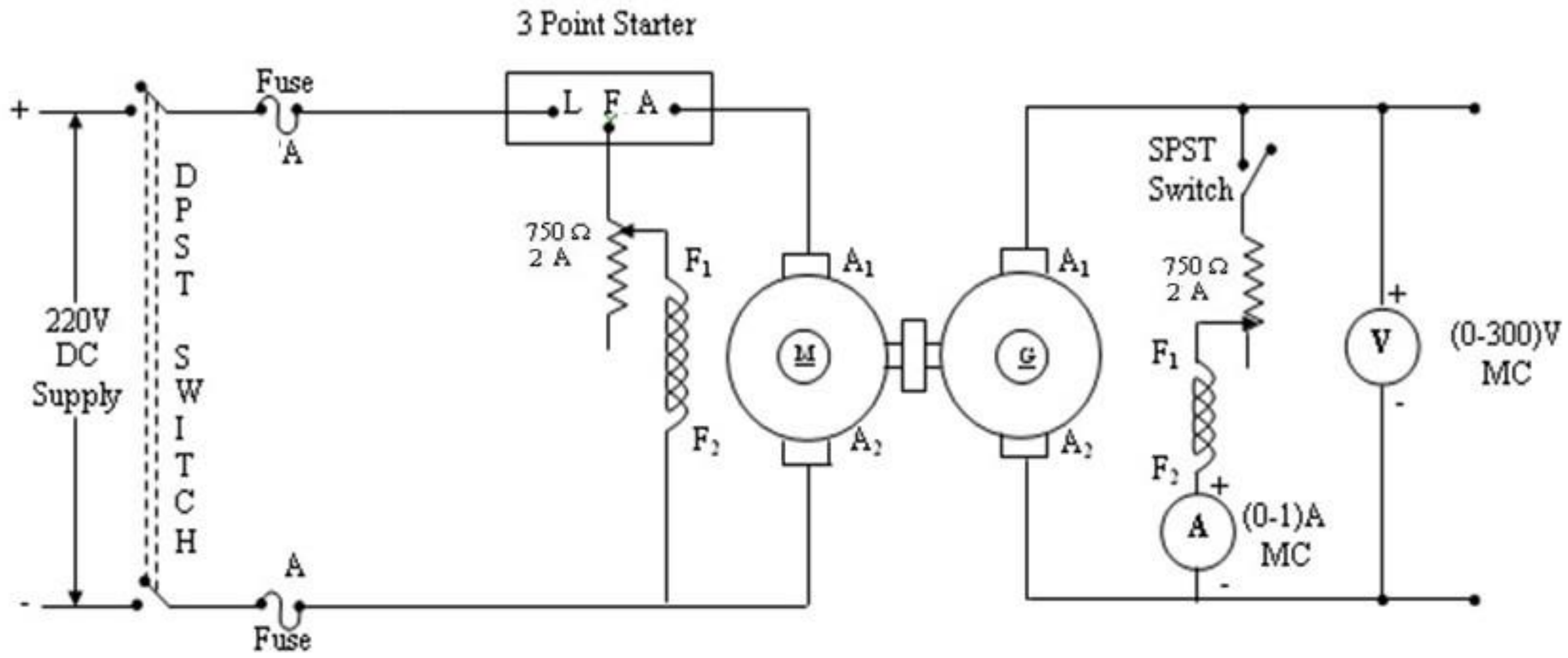
PROCEDURE: (LOAD TEST)

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.

PROCEDURE: (R_a TEST)

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 by varying the load in steps.
4. Armature resistance in Ohms is calculated as $R_a = (Vx1.5) / I$

CIRCUIT DIAGRAM:



FUSE RATING:

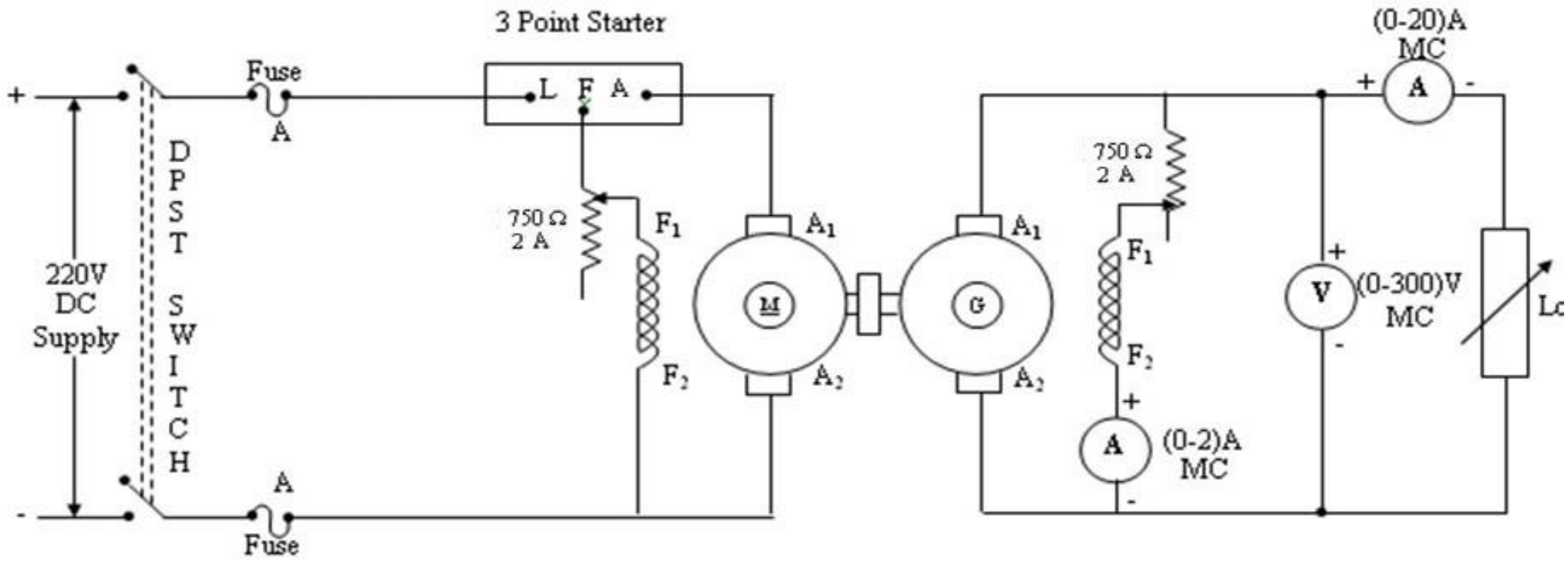
125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KW	KW
Rated Speed :	RPM	RPM

CIRCUIT DIAGRAM:



FUSE RATING:

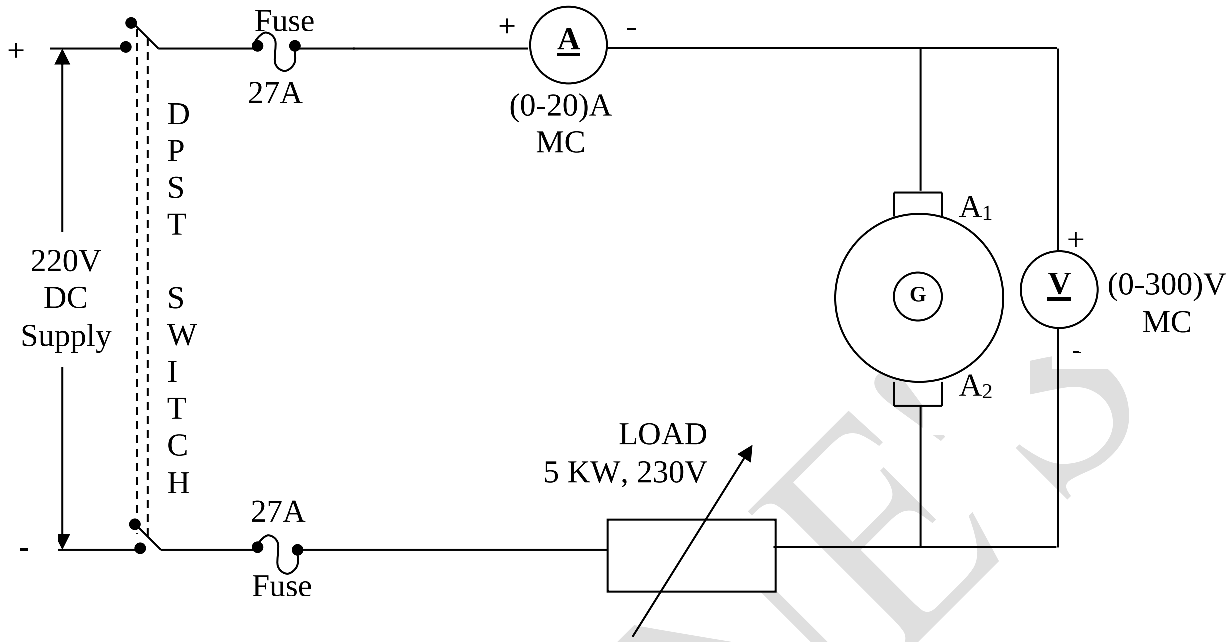
125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KW	KW
Rated Speed :	RPM	RPM

DETERMINATION OF ARMATURE RESISTANCE:



TABULAR COLUMN: (OCC TEST)

S.No.	Field Current I_f (A)	Armature Voltage E_o (V)
1.		
2.		
3.		
4.		
5.		

TABULAR COLUMN: (LOAD TEST)

S.No.	Field Current I_f (A)	Load Current I_L (A)	Terminal Voltage V (V)	Armature Current $I_a = I_L + I_f$ (A)	Generated emf $E_g = V + I_a R_a$ (V)
1.					
2.					
3.					
4.					
5.					

TABULAR COLUMN: (R_a TEST)

S.No.	Voltage V (V)	Current I (A)	Armature Resistance R_a (Ohm)
1.			
2.			
3.			
4.			
5.			

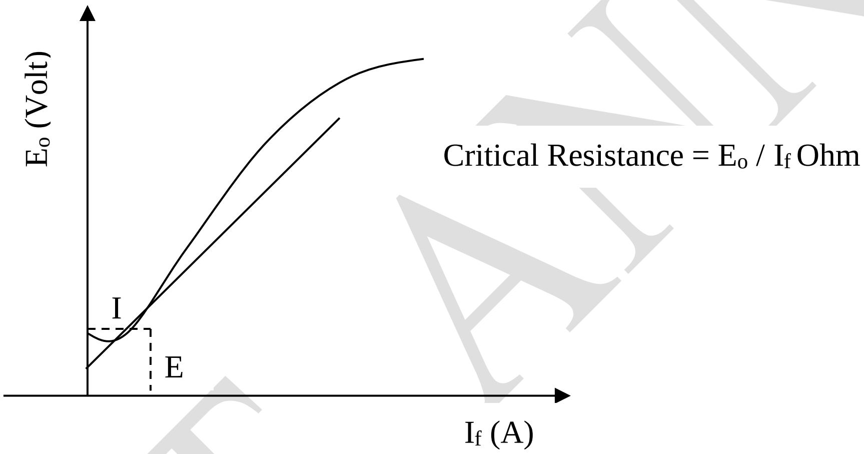
FORMULAE:

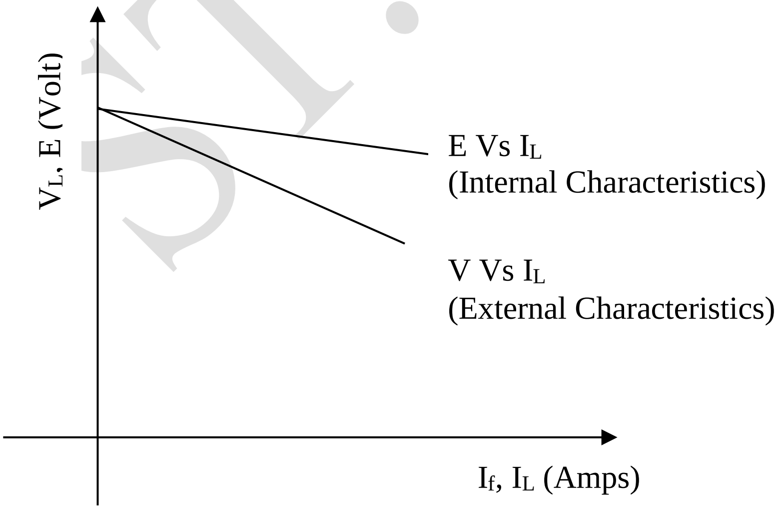
$E_g = V + I_a R_a$ (V)

$I_a = I_L + I_f$ (A)

Critical Resistance $R_c = E_o / I_f$ (Ohm)

MODEL GRAPH:





RESULT:

Thus the open circuit test and load test on self-excited DC shunt generator are conducted and its open circuit characteristics and the load characteristics are obtained and its critical resistance is determined.

Ex.No.6

OPEN CIRCUIT CHARACTERISTICS AND LOAD CHARACTERISTICS OF SEPARATELY EXCITED DC SHUNT GENERATOR

AIM:

To conduct open circuit test and load test on separately excited DC shunt generator, to obtain its open circuit characteristics and load characteristics of the machine

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	750Ω, 2A	Wire Wound	2
4	Tachometer	(0-1500)rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few
4	Loading Rheostat	5KW, 230V	-	1

PRECAUTIONS:

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

PROCEDURE: (OPEN CIRCUIT TEST)

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 rated speed.
4. By varying the generator field rheostat, voltmeter and ammeter readings are taken.
5. After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, DPST switch is opened.

PROCEDURE: (LOAD TEST)

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. 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

PROCEDURE: (R_a TEST)

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 $R_a = (Vx1.5) / I$

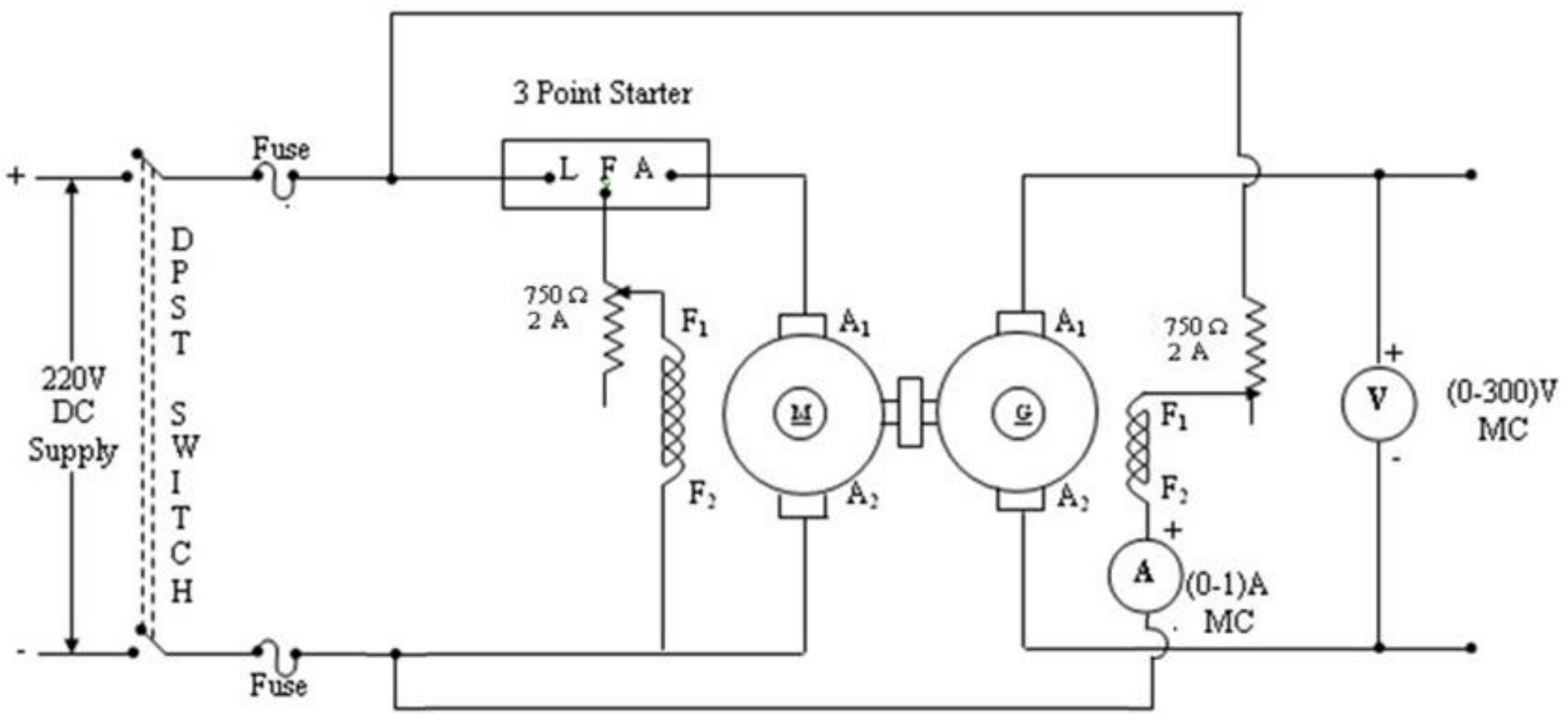
FORMULAE:

$E_g = V + I_a R_a$ (V)

$I_a = I_L + I_f$ (A)

Critical Resistance $R_c = E_o / I_f$ (Ohm)

CIRCUIT DIAGRAM:



FUSE RATING:

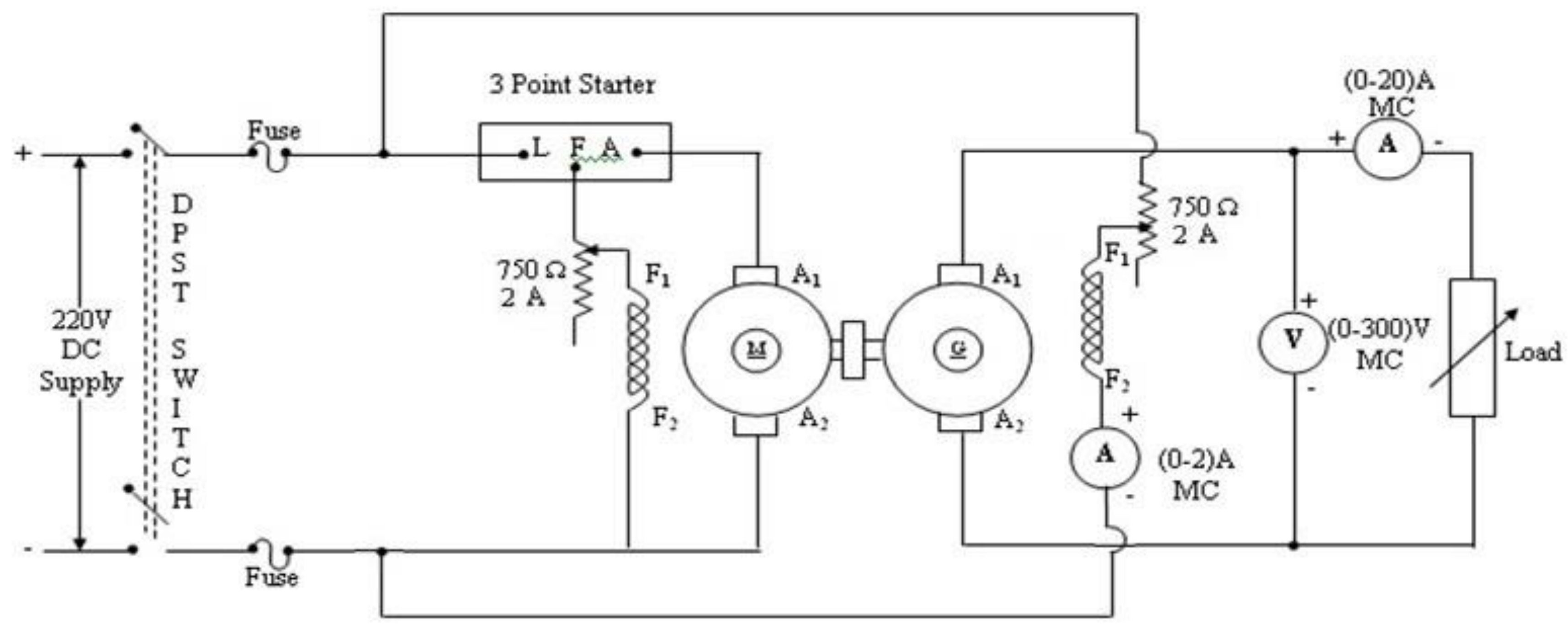
125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KW	KW
Rated Speed :	RPM	RPM

CIRCUIT DIAGRAM:



FUSE RATING:

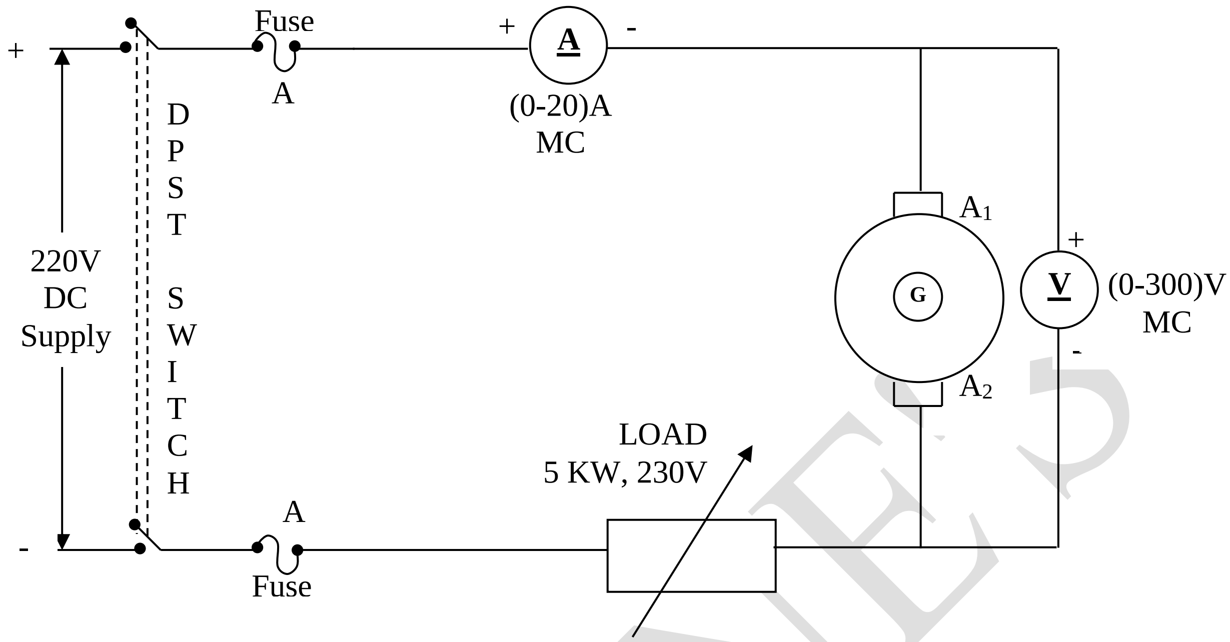
125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KW	KW
Rated Speed :	RPM	RPM

DETERMINATION OF ARMATURE RESISTANCE:



TABULAR COLUMN: (OCC TEST)

S.No.	Field Current I_f (A)	Armature Voltage E_o (V)
1.		
2.		
3.		
4.		
5.		

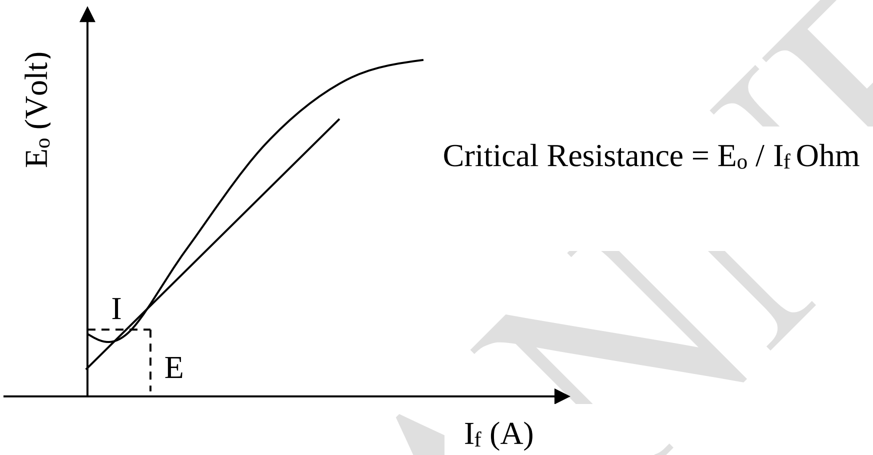
TABULAR COLUMN: (LOAD TEST)

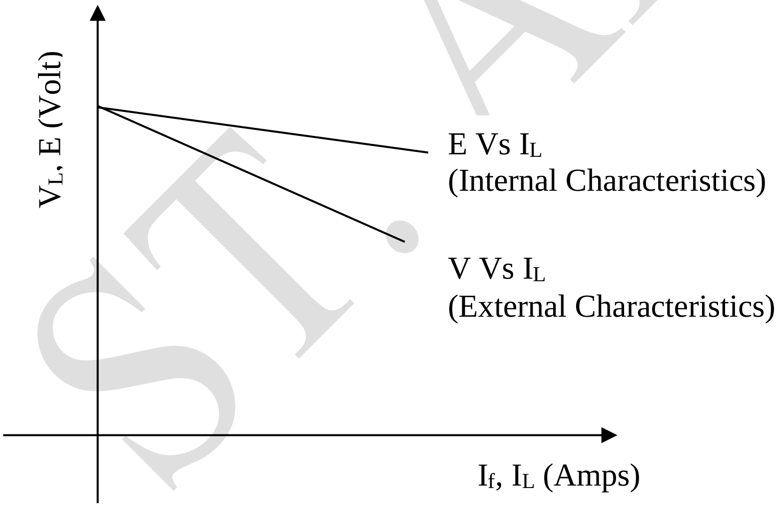
S.No.	Field Current I_f (A)	Load Current I_L (A)	Terminal Voltage V (V)	Armature Current $I_a = I_L + I_f$ (A)	Generated emf $E_g = V + I_a R_a$ (V)
1.					
2.					
3.					
4.					
5.					

TABULAR COLUMN: (R_a TEST)

S.No.	Voltage V (V)	Current I (A)	Armature Resistance R_a (Ohm)
1.			
2.			
3.			
4.			
5.			

MODEL GRAPH:





RESULT:

Thus the open circuit test and load test on separately-excited DC shunt generator are conducted and its open circuit characteristics and the load characteristics are obtained and its critical resistance is determined

Ex.No.7

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR

AIM:

To conduct load test on DC compound generator, to obtain its load characteristics under cumulative and differential mode connection of the machine

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	750Ω, 2A	Wire Wound	2
4	Tachometer	(0-1500)rpm	Digital	1
5	Connecting Wires	2.5sq.mm.	Copper	Few
4	Loading Rheostat	5KW, 230V	-	1

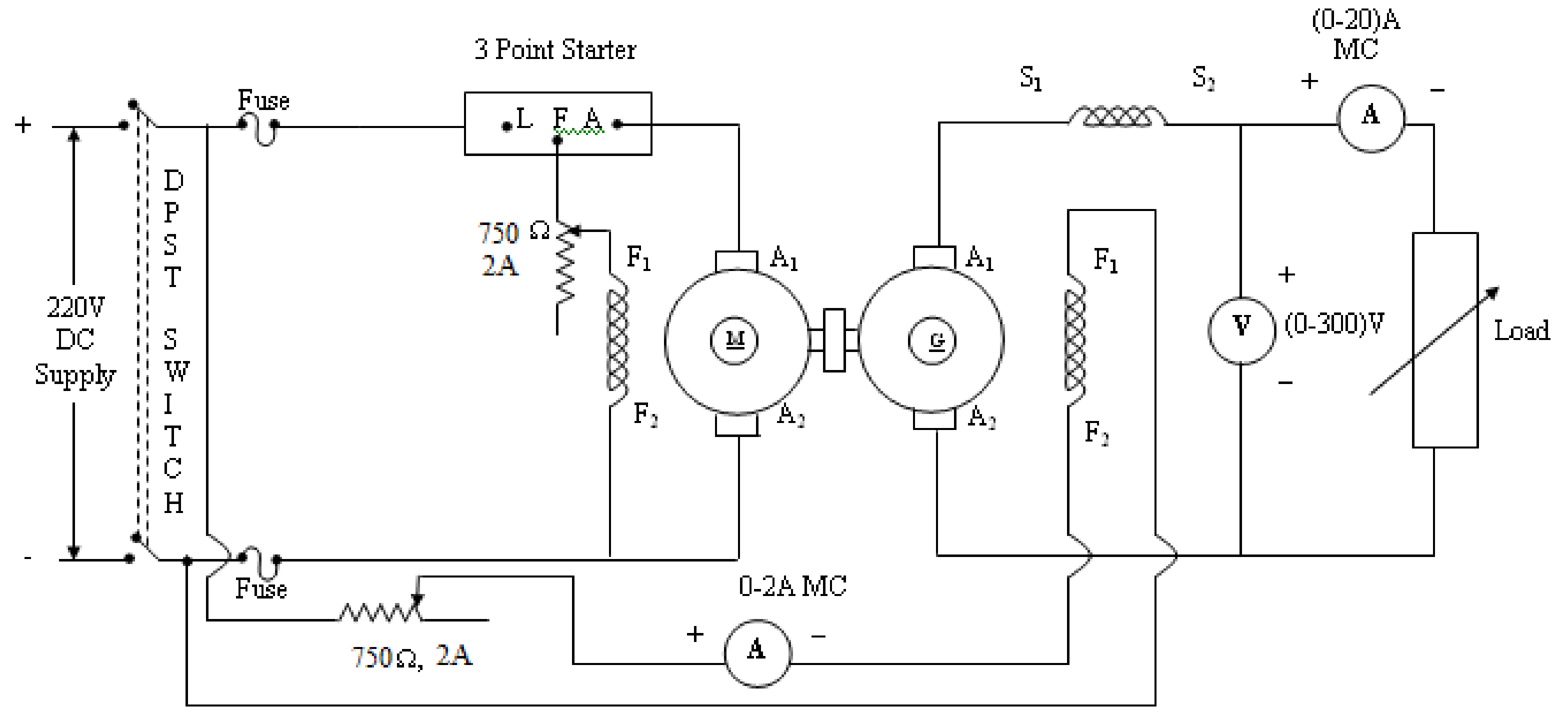
PRECAUTIONS:

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

PROCEDURE: (LOAD TEST)

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.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times \quad}{100} = \quad A$$

NAME PLATE DETAILS:

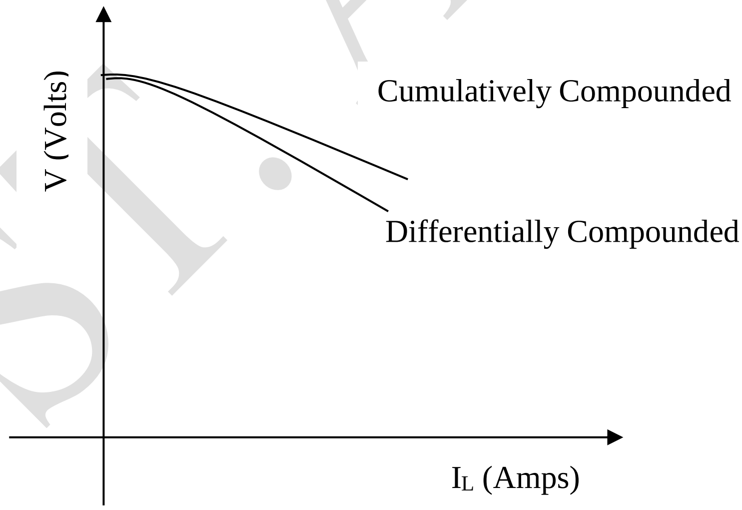
	Motor	**Generator**
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KW	KW
Rated Speed :	RPM	RPM

5. 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
6. The connections of series field windings are reversed the above steps are repeated.
7. The values of voltage for the particular currents are compared and then the differential and cumulative compounded DC generator is concluded accordingly

TABULAR COLUMN:

S.No.	Cumulatively Compounded		Differentially Compounded	
	V (Volts)	**I_L (Amps)**	**V (Volts)**	**I_L (Amps)**

MODEL GRAPH:



RESULT:

Thus the load test on DC compound generator is conducted and its load characteristics under cumulative and differential mode connection are obtained.

Ex.No.8

SWINBURNE'S TEST

AIM:

To conduct Swinburne's test on DC shunt motor to Pre-determine efficiency when it works as generator and motor without actually loading the machine

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A	MC	1
2	Ammeter	(0-20)A	MC	1
3	Voltmeter	(0-300)V	MC	1
4	Rheostats	750Ω, 2A	Wire Wound	1
5	Tachometer	(0-1500)rpm	Digital	1
4	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 the machine.

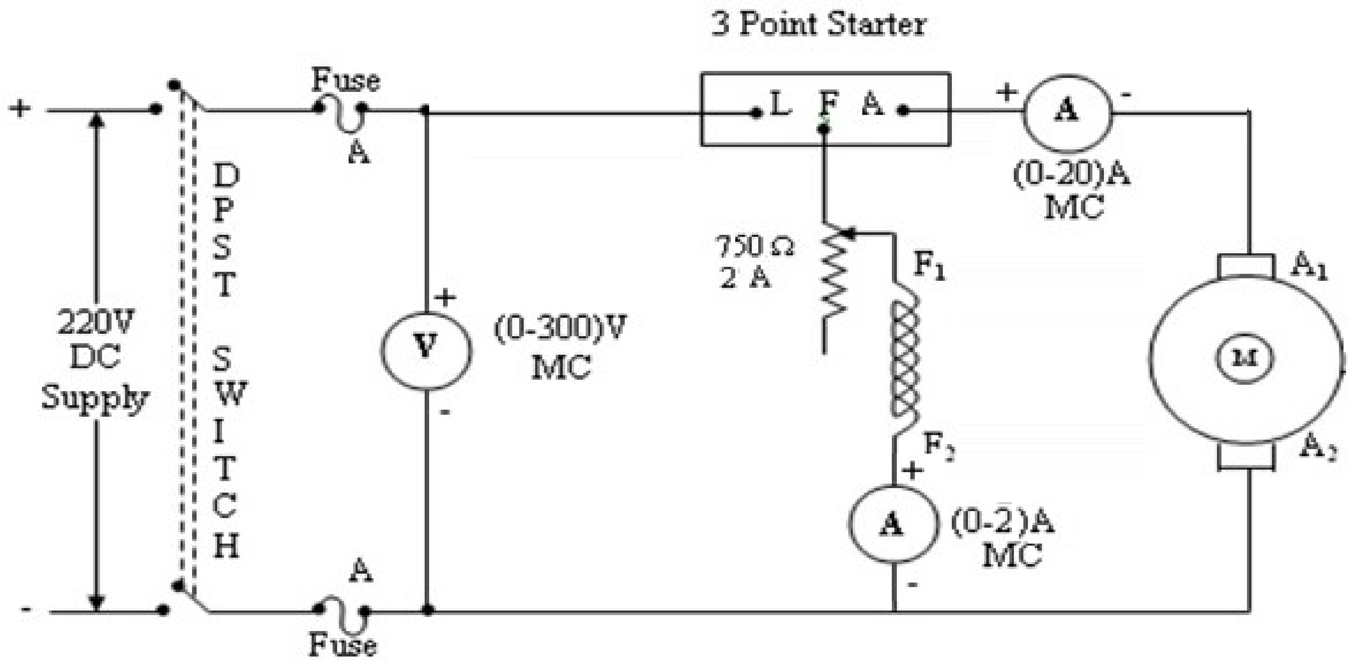
PROCEDURE: (NO LOAD TEST)

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. By adjusting the field rheostat, the machine is brought to its rated speed.
4. The armature current, field current and voltage readings are noted.
5. The field rheostat is then brought to minimum position DPST switch is opened.

PROCEDURE: (R_a TEST)

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

CIRCUIT DIAGRAM:



FUSE RATING:

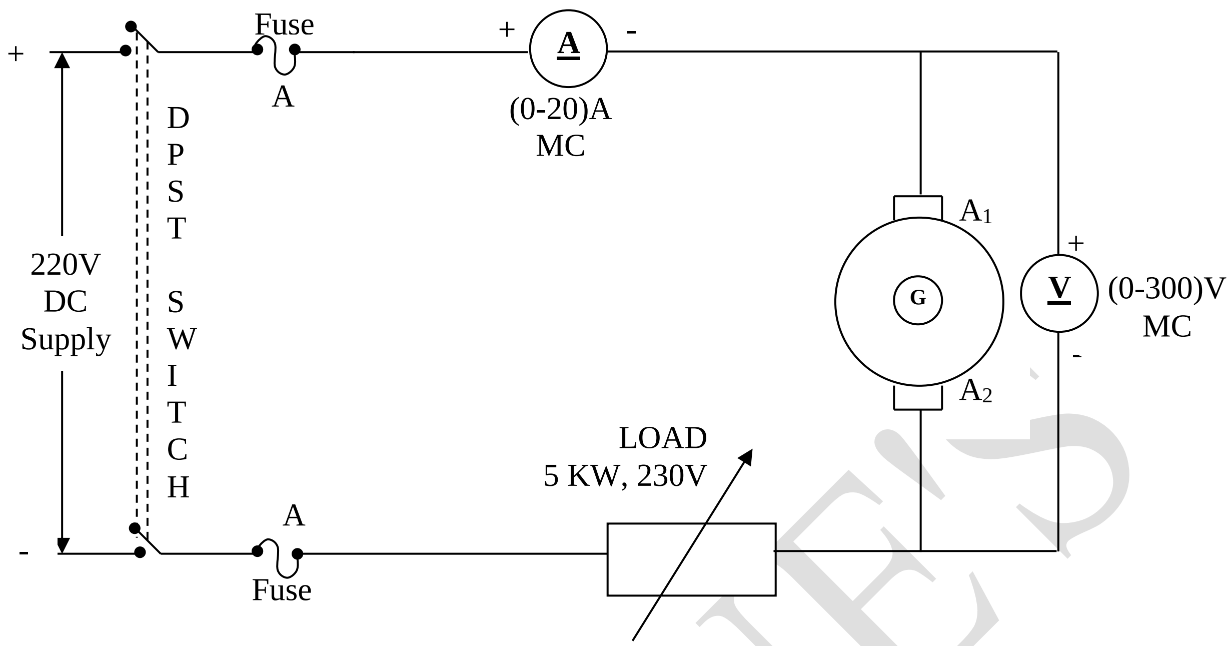
125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

Rated Voltage	:	V
Rated Current	:	A
Rated Power	:	KW
Rated Speed	:	RPM

DETERMINATION OF ARMATURE RESISTANCE:



TABULAR COLUMN: (NO LOAD TEST)

S.No.	Field Current I_f (A)	Armature Current I_0 (A)	Armature Voltage V (V)
1.			

TABULAR COLUMN: (R_a TEST)

S.No.	Voltage V (V)	Current I (A)	Armature Resistance R_a (Ohm)
1.			
2.			
3.			
4.			
5.			

TABULAR COLUMN: (AS MOTOR)

S. No.	Voltage V (V)	Load Current I_L (A)	Field Current I_f (A)	Armature Current I_a (A)	Copper loss Ia^2Ra (W)	Total Losses (Watts)	Input Power (Watts)	Output Power (Watts)	Efficiency η%
1.									
2.									
3.									
4.									
5.									

TABULAR COLUMN: (AS GENERATOR)

S. No.	Voltage V (V)	Load Current I_L (A)	Field Current I_f (A)	Armature Current I_a (A)	Copper loss Ia^2Ra (W)	Total Losses (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%
1.									
2.									
3.									
4.									
5.									

FORMULAE:

Resistance R_a = 1.2 X R Ω

Constant losses = $VI_o - I_{ao}^2 R_a$ watts

Where I_{ao} = $(I_o - I_f)$ A

AS MOTOR:

Load Current I_L = _____ A (Assume 15%, 25%, 50%, 75% of rated current)

Armature current Ia = $I_L - I_f$ A

Copper loss = $I_a^2 R_a$ watts

Total losses = Copper loss + Constant losses

Input Power = VI_L watts

Output Power = Input Power – Total losses

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

AS GENERATOR:

Load Current I_L = _____ A (Assume 15%, 25%, 50%, 75% of rated current)

Armature current Ia = $I_L + I_f$ A

Copper loss = $I_a^2 R_a$ watts

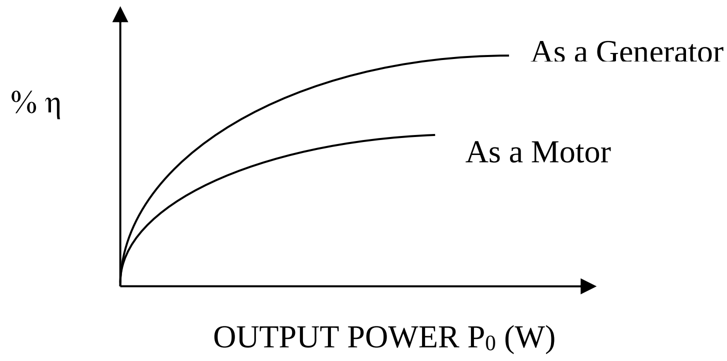
Total losses = Copper loss + Constant losses

Output Power = VI_L watts

Input Power = Output Power +Total losses

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

MODEL GRAPH:



RESULT:

Thus the efficiency of the D.C machine is predetermined by Swinburne's test.

Ex.No.9

HOPKINSON'S TEST

AIM:

To conduct Hopkinson's test on a pair of identical DC machines to pre-determine the efficiency of the machine as generator and as motor.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A	MC	1
2	Ammeter	(0-20)A	MC	1
3	Voltmeter	(0-300)V	MC	1
4	Voltmeter	(0-600)V	MC	1
5	Rheostats	750Ω, 2A	Wire Wound	2
6	Tachometer	(0-1500)rpm	Digital	1
7	Connecting Wires	2.5sq.mm.	Copper	Few

PRECAUTIONS:

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

PROCEDURE: (HOPKINSON'S TEST)

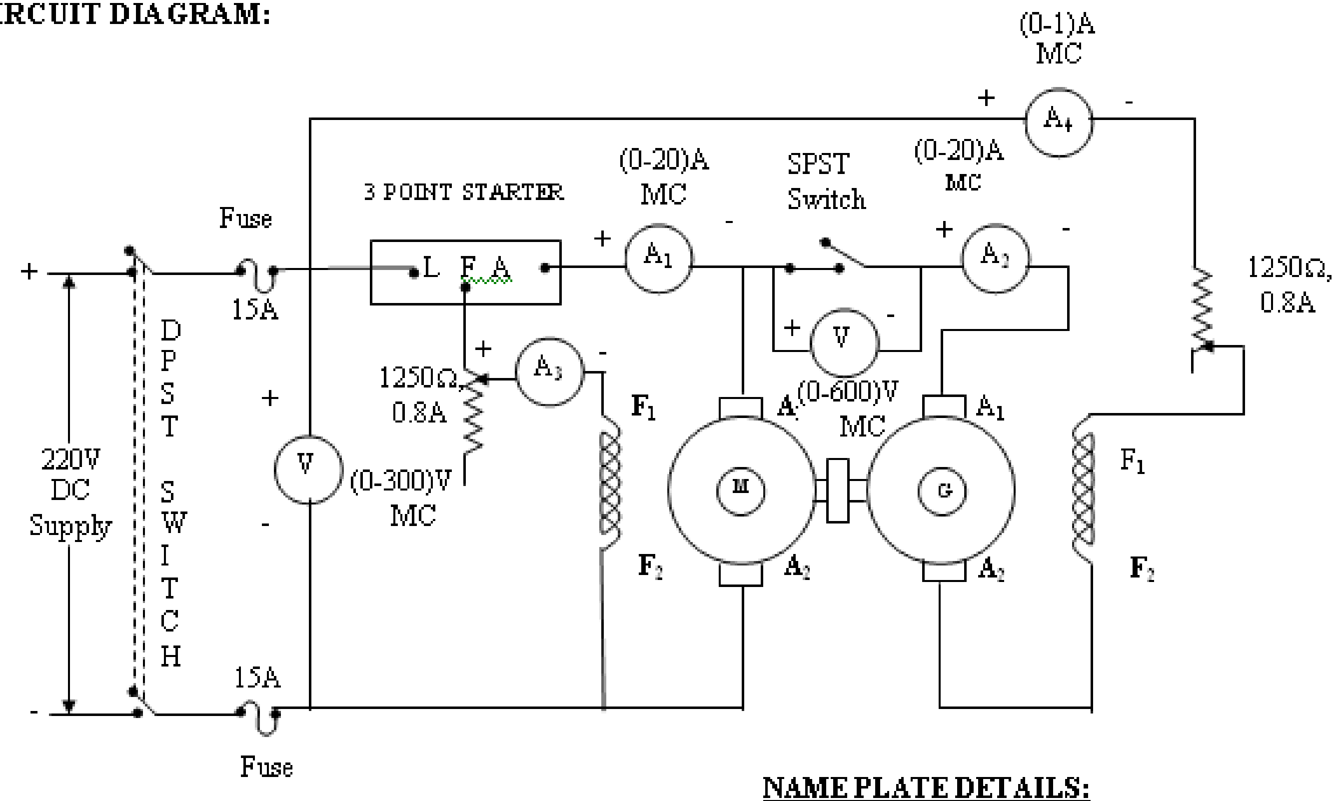
1. Connections are made as per the circuit diagram.
2. After checking the minimum position of field rheostat of motor, maximum position of field rheostat of generator, opening of SPST switch, DPST switch is closed and starting resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat of the motor.
4. The voltmeter V1 is made to read zero by adjusting field rheostat of generator and SPST switch is closed.

5. By adjusting field rheostats of motor and generator, various Ammeter readings, voltmeter readings are noted.
6. The rheostats and SPST switch are brought to their original positions and DPST switch is opened.

PROCEDURE: (R_a TEST)

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

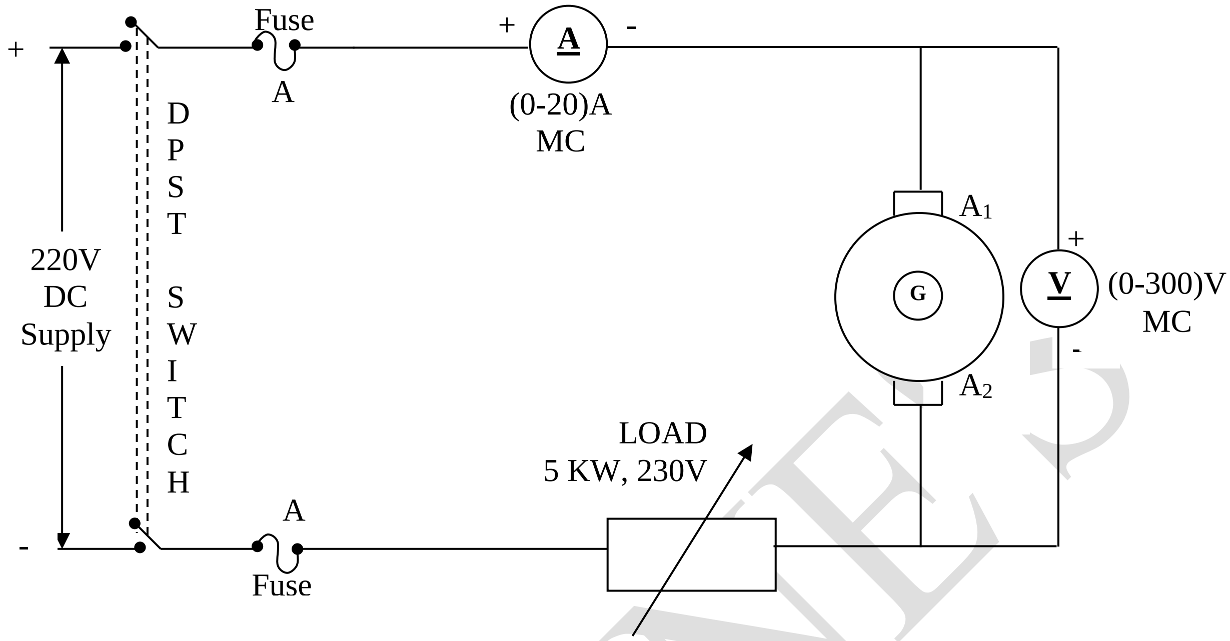
CIRCUIT DIAGRAM:



NAME PLATE DETAILS:

	SHUNT MOTOR	SHUNT GENERATOR
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 rpm.	1500rpm.

DETERMINATION OF ARMATURE RESISTANCE:



TABULAR COLUMN: (HOPKINSON'S TEST)

S.No.	Supply Voltage (V)	I_1 (Amps)	I_2 (Amps)	I_3 (Amps)	I_4 (Amps)	$I_1 + I_2$ (Amps)	Motor Armature Cu Loss (W)	Generator Armature Cu Loss (W)	Total Stray losses (W)	Stray Loss Per M/c w/2 (W)

TABULAR COLUMN: (R_a TEST)

S.No.	Voltage V (V)	Current I (A)	Armature Resistance R_a (Ohm)
1.			
2.			
3.			
4.			
5.			

TABULAR COLUMN: (AS MOTOR)

S.No.	V (V)	I_1 (A)	I_2 (A)	I_3 (A)	Motor Armature Cu Loss (W)	Field Loss (W)	stray losses/2 (W)	Total Losses W (W)	O/P Power (W)	I/P Power (W)	η%

TABULAR COLUMN: (AS GENERATOR)

S.No.	V (Volts)	I_1 (Amps)	I_2 (Amps)	Motor Armature Cu Loss W (Watts)	Field Loss (Watts)	Stray losses /2(Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

FORMULAE:

Input Power = VI_1 watts

Motor armature cu loss = $(I_1+ I_2)^2$ Ra watts

Generator armature cu loss = I_2^2 Ra watts

Total Stray losses W = $V I_1 - (I_1+I_2)^2 Ra + I_2^2 Ra$ watts.

Stray loss per machine = W/2 watts.

AS MOTOR:

Input Power = Armature input + Shunt field input

= $(I_1+ I_2) V + I_3V = (I_1+I_2+I_3) V$

Total Losses = Armature Cu loss + Field loss + stray loss

= $(I_1 + I_2)^2 Ra + VI_3 + W/2$ watts

$$\text{Efficiency } \% = \frac{\text{Input power} - \text{Total Losses}}{\text{Input Power}} \times 100\%$$

AS GENERATOR:

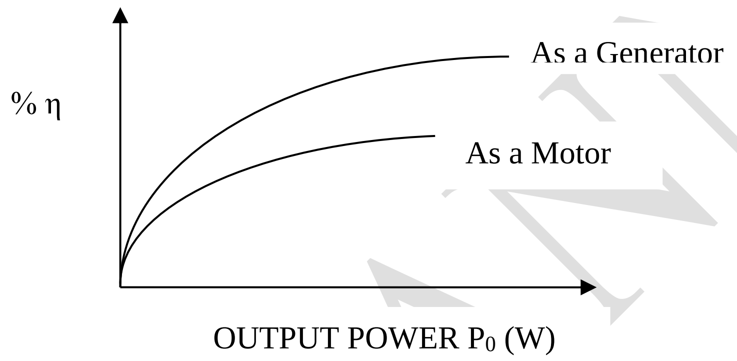
Output Power = VI_2 watts

Total Losses = Armature Cu loss+ Field Loss + Stray loss

= I_2^2 Ra + VI_4 + W/2 watts

$$\text{Efficiency } \% = \frac{\text{Output power}}{\text{Output Power+ Total Losses}} \times 100\%$$

MODEL GRAPH:



RESULT:

Thus the efficiency of the D.C machine is predetermined by Hopkinson's test.

Ex. No. 10

LOAD TEST ON A SINGLE PHASE TRANSFORMER

AIM:

To conduct load test on single phase transformer to find its efficiency and percentage regulation.

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

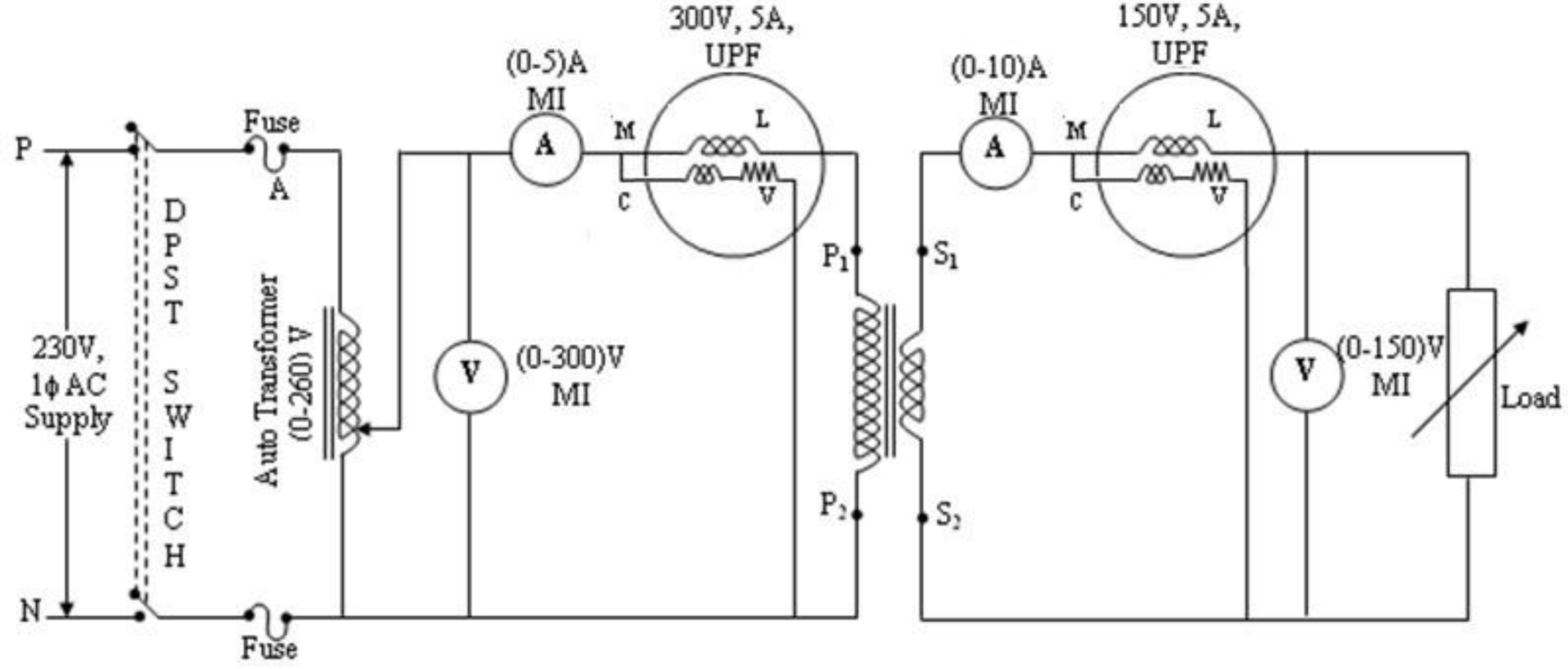
PRECAUTIONS:

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.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KVA	KVA

TABULAR COLUMN:

S. No.	Primary			Secondary			Input Power P_i (W)	Output Power P_o (W)	Efficiency η%	% Regulation
	V_1 (V)	I_1 (A)	W_1 (W)	V_2 (V)	I_2 (A)	W_2 (W)				
1.										
2.										
3.										
4.										
5.										

FORMULAE:

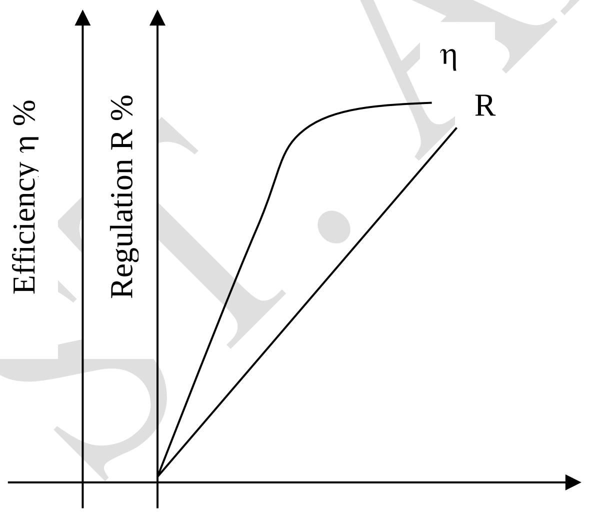
Input Power $P_i = W_1$ x Multiplication factor

Output Power $P_o = W_2$ x Multiplication factor

Efficiency $\eta\ \% = \frac{Output\ power\ (Secondary)}{Input\ power\ (Primary)}\ X\ 100\ \%$

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

MODEL GRAPHS:



RESULT:

Thus the load test on single phase transformer is conducted and the machine's efficiency and % regulation are calculated and plotted.

Ex. No. 11

LOAD TEST ON A THREE PHASE TRANSFORMER

AIM:

To conduct load test on Three phase transformer to find its efficiency and percentage regulation.

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 (0-600) 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

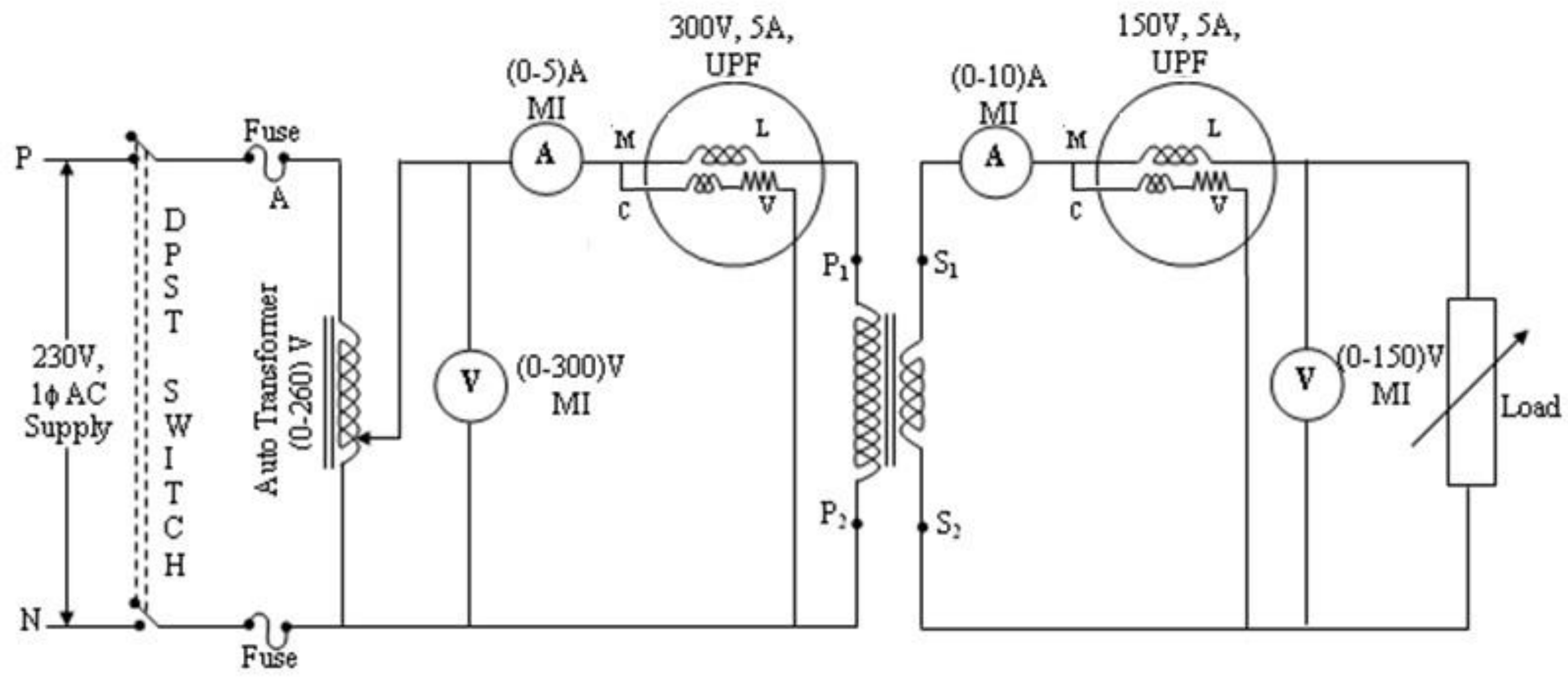
PRECAUTIONS:

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 TPST 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 TPST switch is opened.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KVA	KVA

TABULAR COLUMN:

S. No.	Primary			Secondary			Input Power P_i (W)	Output Power P_o (W)	Efficiency η%	% Regulation
	V_1 (V)	I_1 (A)	W_1 (W)	V_2 (V)	I_2 (A)	W_2 (W)				
1.										
2.										
3.										
4.										
5.										

FORMULAE:

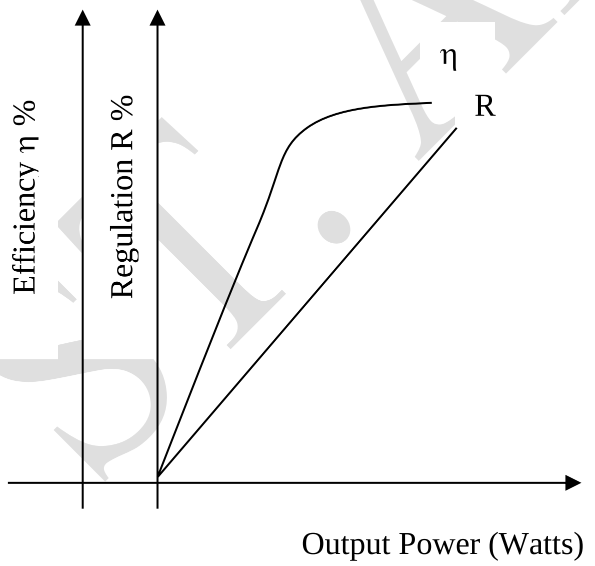
Input Power $P_i = W_1$ x Multiplication factor

Output Power $P_o = W_2$ x Multiplication factor

Efficiency $\eta\ \% = \frac{Output\ power\ (Secondary)}{Input\ power\ (Primary)}\ X\ 100\ \%$

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

MODEL GRAPHS:



RESULT:

Thus the load test on Three phase transformer is conducted and the machine's efficiency and % regulation are calculated and plotted.

Ex. No. 12

OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

AIM:

To conduct open circuit test and short circuit test on a single phase transformer, to predetermine its efficiency and regulation and to draw its equivalent circuit.

APPARATUS REQUIRED:

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

PRECAUTIONS:

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

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.

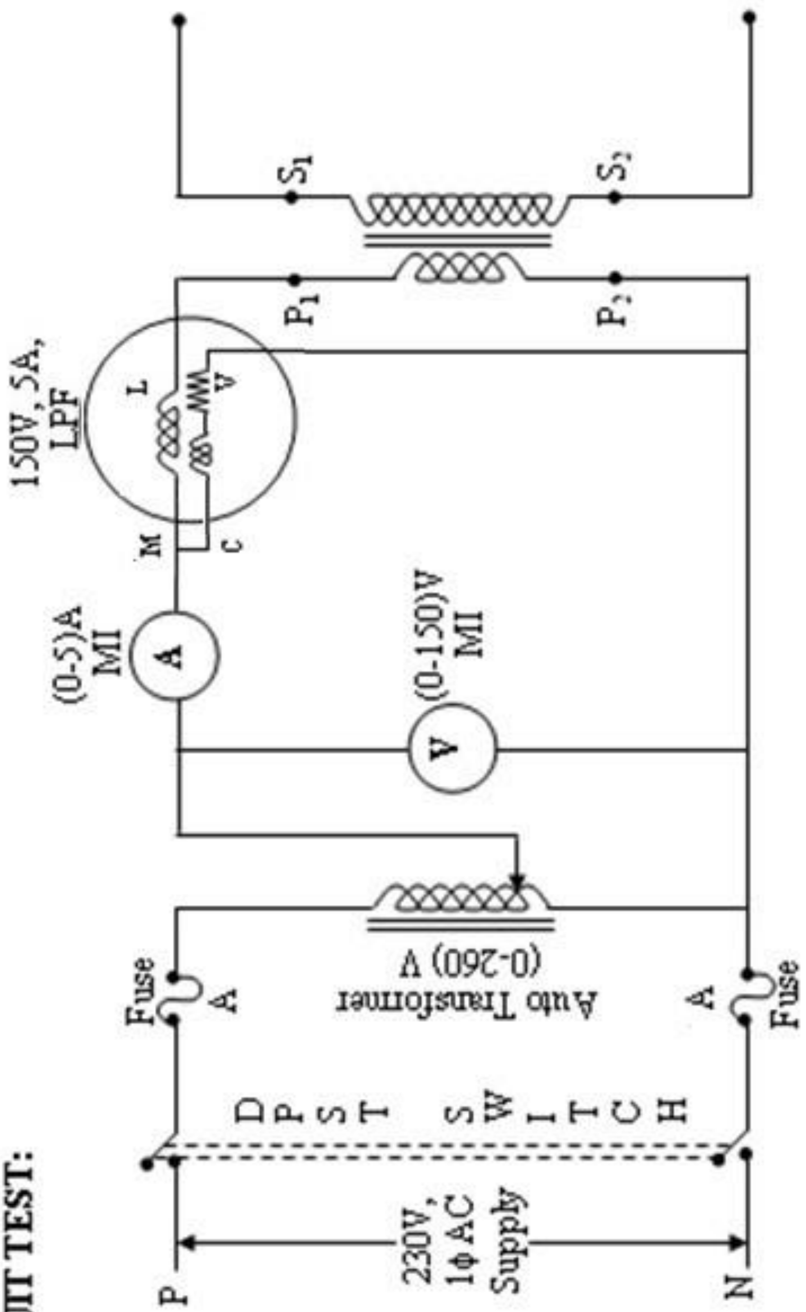
SHORT CIRCUIT TEST:

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.

CIRCUIT DIAGRAM:

OPEN CIRCUIT TEST:



NAME PLATE DETAILS:

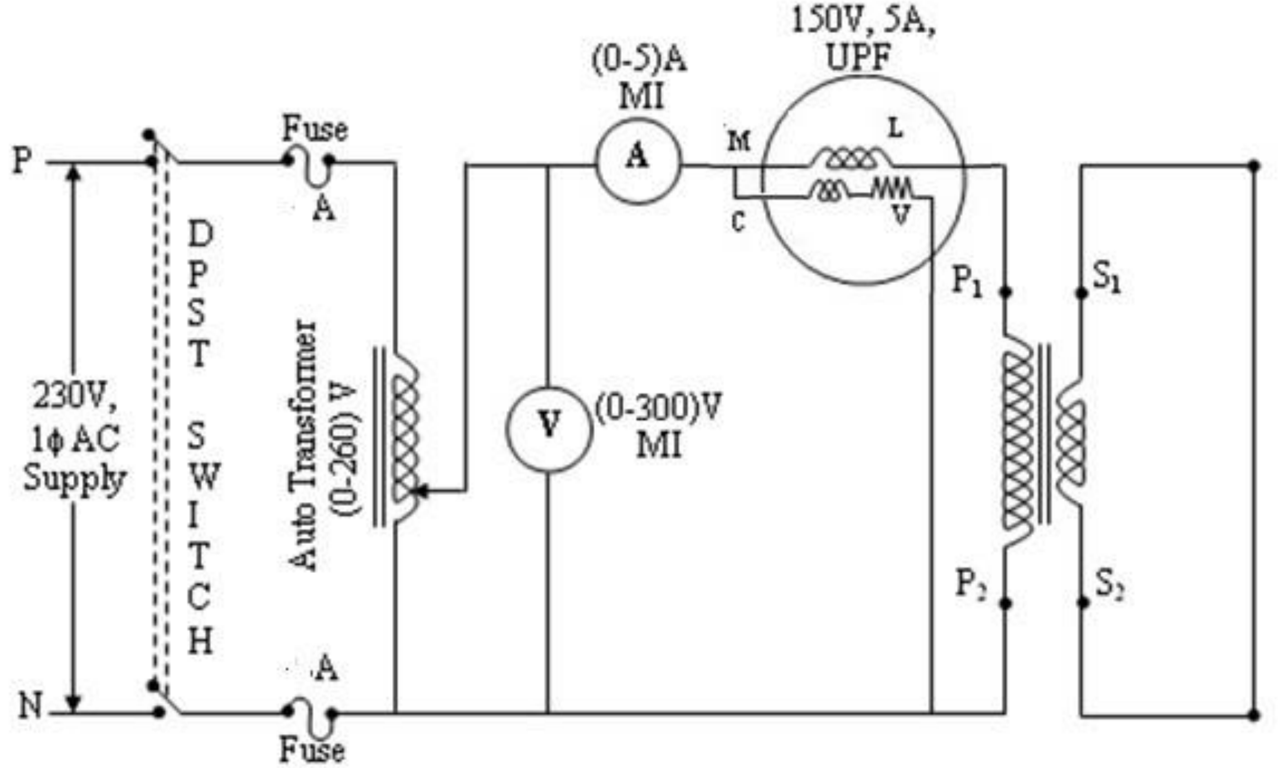
	Primary	Secondary
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KVA	KVA

FUSE RATING:

125% of rated current

125 x ---------- = A
100

SHORT CIRCUIT TEST:



FUSE RATING:

125% of rated current

$$\frac{125 \times}{100} = \quad A$$

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :	V	V
Rated Current :	A	A
Rated Power :	KVA	KVA

TABULAR COLUMN:

OPEN CIRCUIT TEST:

Vo (V)	Io (A)	Wo (W)

SHORT CIRCUIT TEST:

V_{sc} (V)	I_{sc} (A)	W_{sc} (W)

Sl. No.	Load Fraction X	Core loss W_O (W)	Copper loss W_C (W)	Total loss W_T (W)	Output Power (W)	Input Power (W)	Efficiency %	% Regulation	
								Lagging	Leading
1.	0.25								
2.	0.50								
3.	0.75								
4.	1.00								
5.	1.25								

FORMULAE:

For Efficiency and Regulation:

Percentage Efficiency: **pf = 0.8**

Core Loss W_O = (W)

Copper loss $W_C = X^2 W_{sc}$ (W)

Total losses = Core Loss W_O + Copper loss W_C

Output Power = (X) x KVA rating x 1000 x cos ϕ (W)

Input Power = Output power + Total losses

Efficiency $\eta\ \% = \frac{Output\ power\ (Secondary)}{Input\ power\ (Primary)}\ X\ 100\ \%$

Percentage Regulation: **pf = 0.8**

Regulation $R\ \% = \frac{(X)\ I_{SC}\ (R_{02}\cos\phi \pm X_{02}\sin\phi)}{V_2}\ X\ 100\ \%$

(+ for lagging; – for leading)

For equivalent circuit:

Core loss: $W_o = V_o I_o \cos \phi_o$ (W)

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

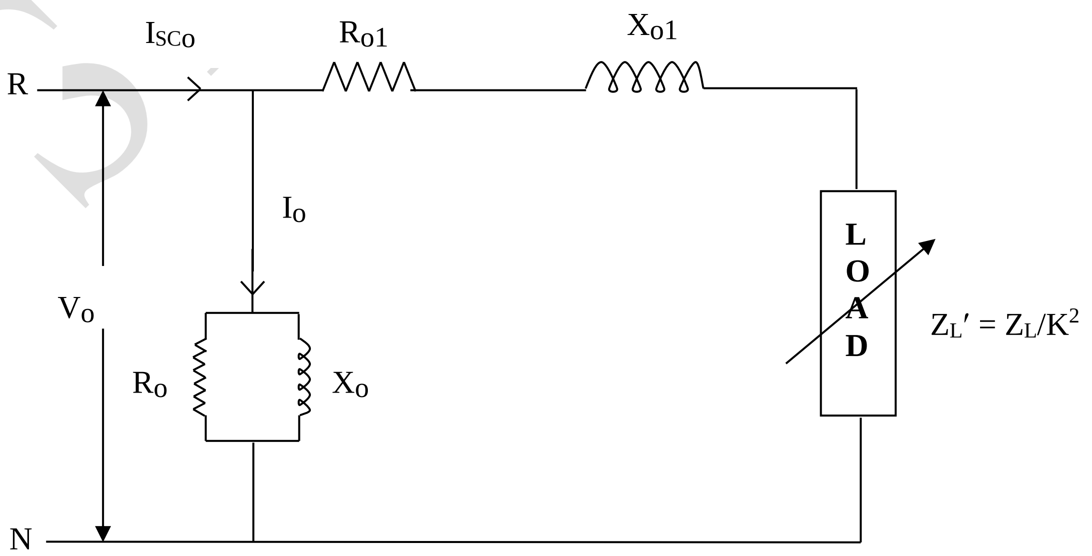
$I_\omega = I_o \cos \phi_o$ (A) $\qquad I_\mu = I_o \sin \phi_o$ (A)

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

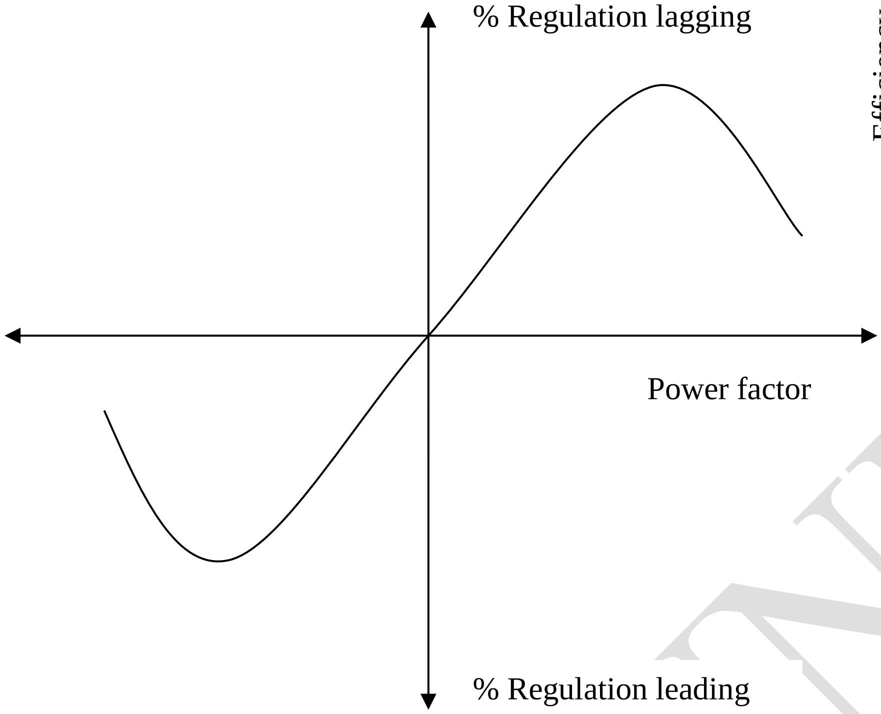
$$Z_{o2} = \frac{V_{sc}}{I_{sc}}\ \Omega \qquad X_{o2} = (Z_o^2 - R_{o2}^2)^{1/2}\ \Omega$$

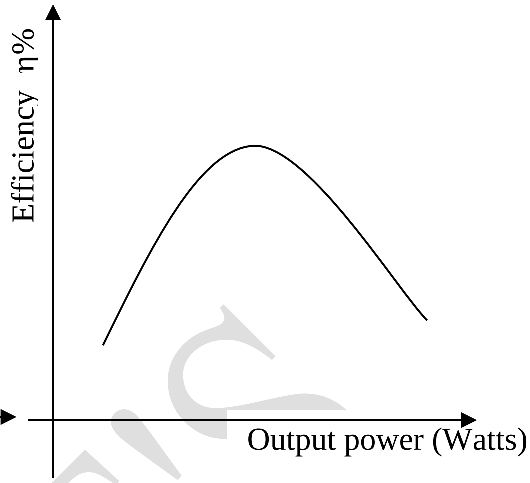
$$R_{o1} = \frac{R_{02}}{K^2}\ \Omega \qquad X_{o1} = \frac{X_{02}}{K^2}\ \Omega \qquad K = \frac{V_2}{V_1} = 2$$

EQUIVALENT CIRCUIT:



MODEL GRAPHS:





RESULT:

Thus the efficiency and regulation of a transformer is predetermined by conducting open circuit test and short circuit test and the equivalent circuit is drawn.

Ex. No. 13

SEPARATION OF NO LOAD LOSSES IN A SINGLE PHASE TRANSFORMER

AIM:

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

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Rheostat	1250Ω , 0.8A	Wire Wound	2
2	Wattmeter	300 V, 5A	LPF	1
3	Ammeter	(0-2) A	MC	1
4	Voltmeter	(0-300) V	MI	1
5	Connecting Wires	2.5sq.mm	Copper	Few

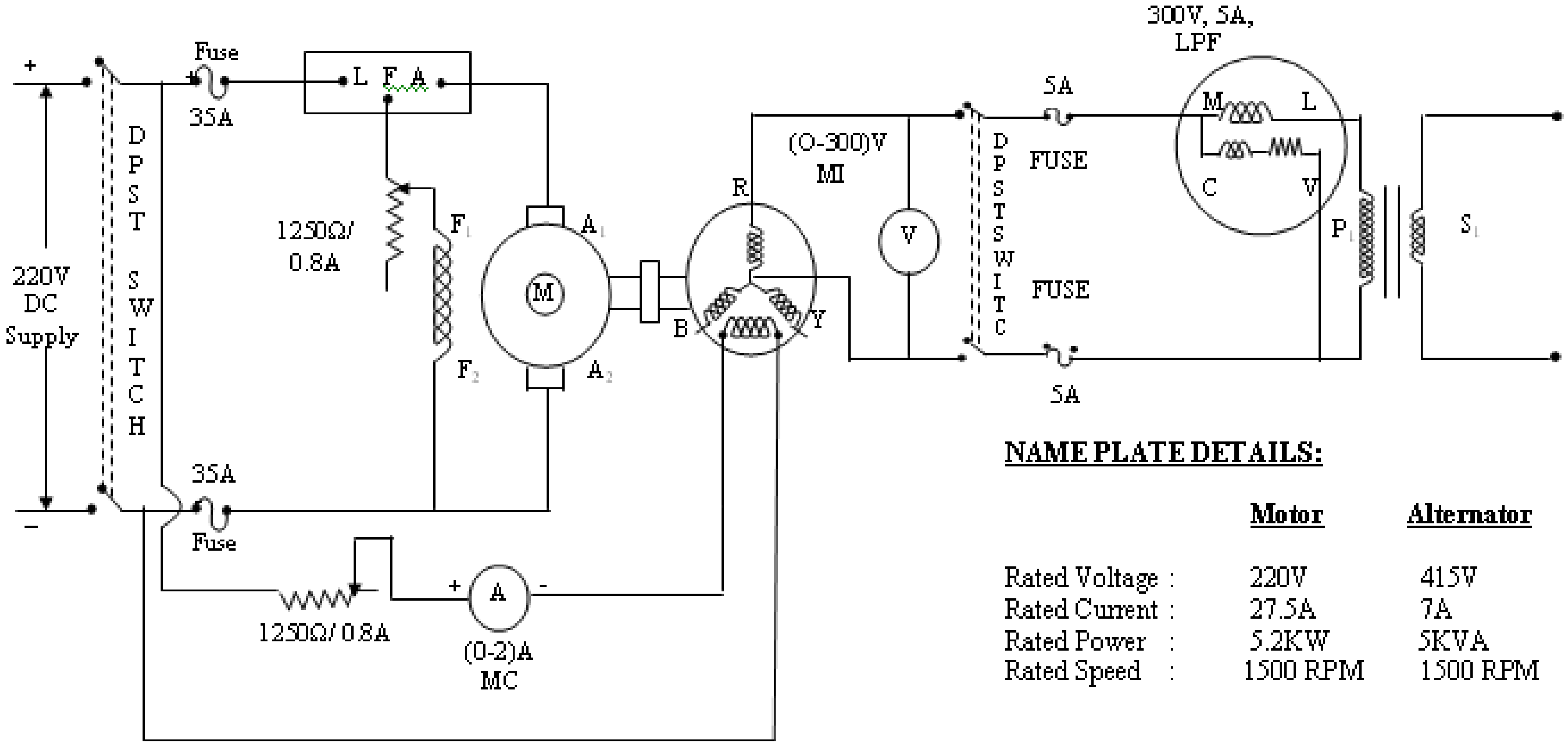
PRECAUTIONS:

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

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.

CIRCUIT DIAGRAM:



NAME PLATE DETAILS:

	Motor	Alternator
Rated Voltage :	220V	415V
Rated Current :	27.5A	7A
Rated Power :	5.2KW	5KVA
Rated Speed :	1500 RPM	1500 RPM

FUSE RATING:

125% of rated current

$$\frac{125 \times 27.5}{100} = 34.37\ A$$

NAME PLATE DETAILS:

	Primary	Secondary
Rated Voltage :	230V	115V
Rated Current :	5A	10A
Rated Power :	1KVA	1KVA

TABULAR COLUMN:

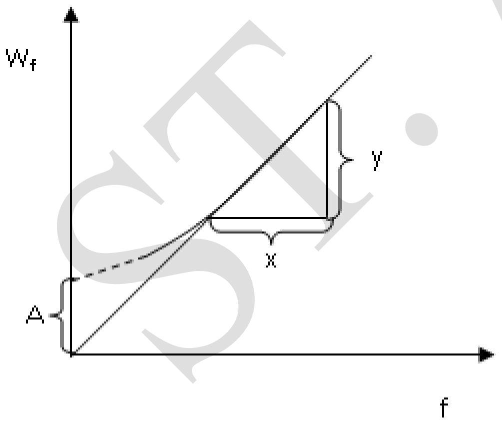
S.No.	Speed N (rpm)	Frequency f (Hz)	Voltage V (Volts)	Wattmeter reading Watts	Iron loss Wi (Watts)	W_i / f Joules

FORMULAE:

1. Frequency, f =(P*N_S) / 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 W_e = B * f^2 in Watts B = Constant (slope of the tangent drawn to the curve)
4. Iron Loss W_i = W_h + W_e in Watts W_i / 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 W_i / f and frequency f. The Constant B is $\Delta(W_i / f) / \Delta f$

MODEL GRAPHS:



RESULT:

Thus separation of eddy current and hysteresis loss from the iron loss on a single-phase transformer is conducted.

Ex. No. 14

SUMPNER'S TEST

AIM:

To predetermine the efficiency and regulation of a given single phase Transformer by conducting back-to-back test and also to find the parameters of the equivalent circuit.

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Auto Transformer	(0-270) V	-	2
2	Wattmeter	300 V, 10A 75 V, 5 A	LPF UPF	1 1
3	Ammeter	(0-2) A (0-20) A	MI MI	1 1
4	Voltmeter	(0-75) V (0-150) V	MI MI	1 1
5	Connecting Wires	2.5sq.mm	Copper	Few

PRECAUTIONS:

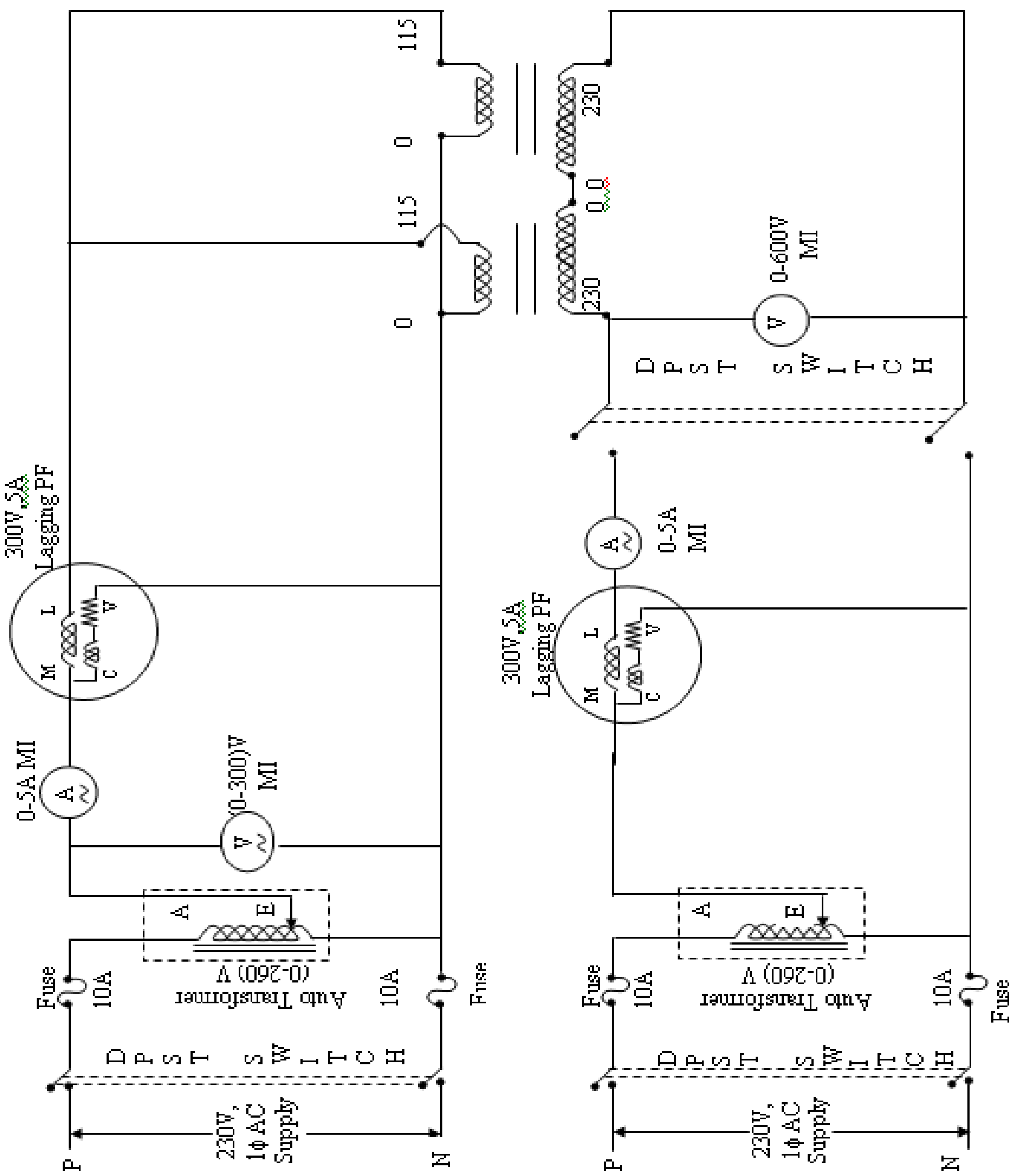
1. Auto Transformer whose variac should be in zero position, before switching on the ac supply.
2. Transformer should be operated under rated values.

PROCEDURE:

1. Connections are made as shown in the circuit diagram.
2. Rated voltage of 110V is adjusted to get in voltmeter by adjusting the variac of the Auto Transformer which would be in zero before switching on the supply at the primary side.
3. The readings of voltmeter, ammeter and wattmeter are noted on the primary side.
4. A voltmeter is connected across the secondary and with the secondary supply off i.e switch S is kept open. The voltmeter reading is noted.
5. If the reading of voltmeter reads higher voltage, the terminals of any one of secondary coil is interchanged in order that voltmeter reads zero.

6. The secondary is now switched on and SPST switch is closed with variac of auto transformer is zero.
7. After switching on the secondary the variac of transformer (Auto) is adjusted so that full load rated secondary current flows.
8. Then the readings of wattmeter, Ammeter and voltmeter are noted.
9. The Percentage Efficiency and percentage regulation are calculated and equivalent circuit is drawn.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

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

FORMULAE:

Core loss of each transformer $W_o = \dfrac{W_1}{2}$ Watts

Full load copper loss of each transformer $W_c = \dfrac{W_2}{2}$ Watts.

$W_o = V_1 I_1 \cos \varphi_o$ $\quad \varphi_o = \cos^{-1} \dfrac{W_o}{V_1 I_1}$ $\quad I_1 = \dfrac{I_o}{2}$ A

$I_w = I_1 \cos\Phi o$ $\quad I_\mu = I_1 \cos\Phi$ $\quad V2 = V_s/2 \times A$

$Ro = V_1 / I_w$ $\quad Xo = V_1 / I_\mu$ $\quad R_{o2} = W_c / I_2^2$ $\quad Z_{o2} = V_2 / I_2$

$Xo_2 = \sqrt{Zo_2^2 - Ro_2^2}$

Copper loss at various loads = $I_2^2 Ro_2$

PERCENTAGE REGULATION:

1. Upf : $I_2 / V (Ro_2 \cos\Phi o) \times 100$
2. Lagging pf : $I_2 / V (Ro_2 \cos\Phi o + Xo_2 \sin\Phi o) \times 100$
3. Leading pf : $I_2 / V (Ro_2 \cos\Phi o - Xo_2 \sin\Phi o) \times 100$

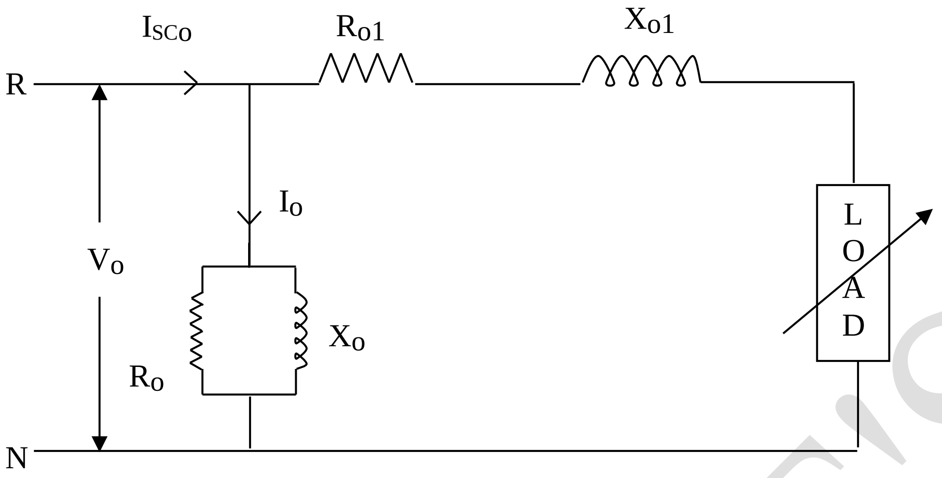
Output Power (1) Upf : 3Kw

(2) Pf : 3Kw $\cos\Phi o$

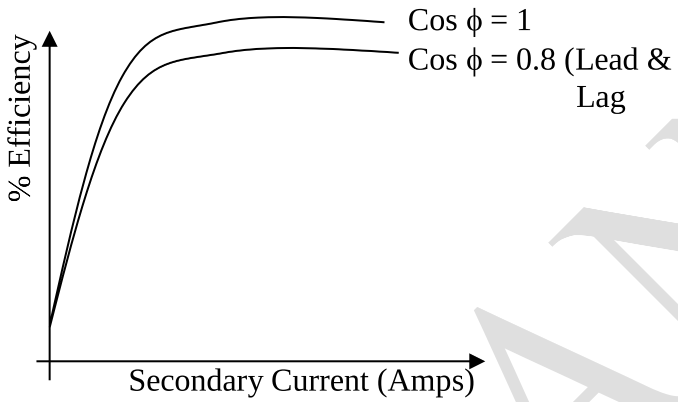
Input Power = Output Power + Core loss + Cu loss

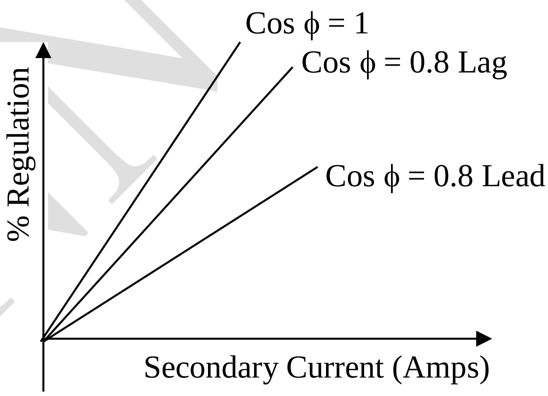
$$\text{Efficiency } \eta\% = \frac{\text{Output power}}{\text{Input Power}} \times 100\%$$

EQUIVALENT CIRCUIT:



MODEL GRAPHS:





RESULT:

Thus the efficiency and regulation of a given single phase Transformer is carried out by conducting back-to-back test and the equivalent circuit parameters are found out.

Ex. No.15

STUDY OF AC & DC STARTERS

AIM:

To study the theory and working of different types of AC & DC starters.

D. C. MOTOR STARTER:

At starting, Eb =0 because speed of motor is zero. Armature current of motor is equal to,

$$Ia = V- Eb / Ra ;$$

$$\text{so } Ia = V/ Ra \ (Eb = 0)$$

Since Ra is very small so motor will draw large armature current. To limit the armature current in safe value we add some external resistance in armature circuit. A mechanism which adds resistance during starting only is known as starter.

There are two types of starters which are commonly used for DC. motor

i. 3 - point starter

ii. 4 - point starter

3- POINT STARTER:

When motor is started, starting arm is moved slowly towards the ON position; As soon as arm touches the stud no. 1 full starting resistance gets connected in the armature circuit. Field current receives supply directly the starting armature current is equal to, Ia = V / (Ra + Rst). The arm is moved against the spring force towards the ON position. When the arm travels towards ON position, the starting resistance is gradually removed from armature circuit. Since motor takes full speed, motor develops full back E.M.F. the starting arm carries a soft iron piece which is held by attraction of the hold on coil. Starter remains in ON position because the electromagnetism formed by NO VOLT COIL

FUNCTION OF HOLD ON (NO VOLT COIL)

1) In case of supply failure NO VOLT COIL gets de-energized and the starting arm will be released to OFF position. This is automatically done by spring action.

2) It holds the plunger in ON position

3) It gives the protection against field failure

OVERLOAD COIL

Overload coil is a electromagnet connected in series with armature. When current exceeds beyond certain predetermined value the electromagnet will become strong and it attracts plunger. Due to this voltage across NO VOLT COIL becomes zero. This will make hold on coil de – energized due to which arm gets to OFF position and motor gets disconnected from supply.

LIMITATIONS OF THREE POINT STARTER

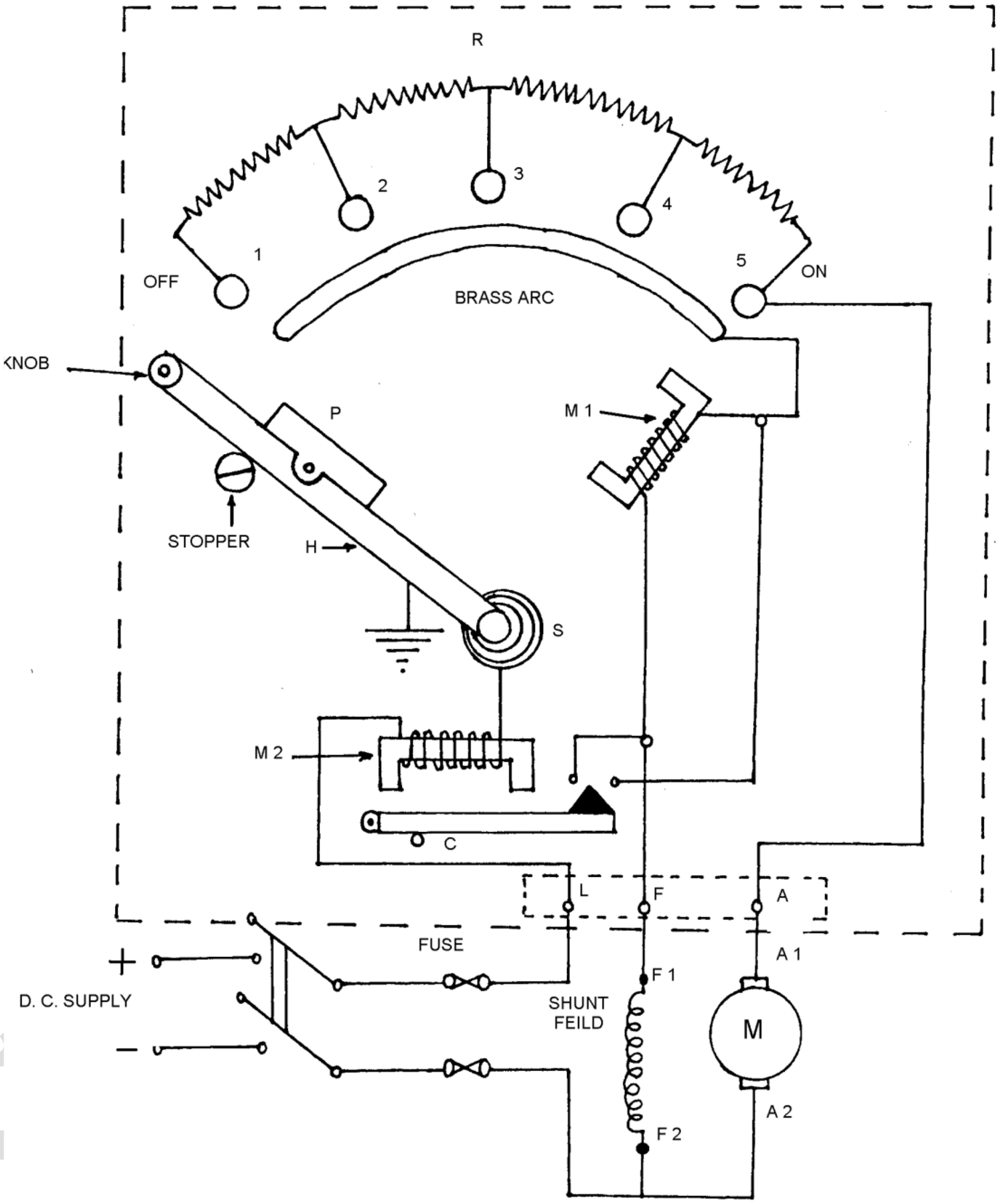
1) When motor is in ON position the starting resistance gets remove form armature circuit at the same time it gets attached to field circuit, which is dangerous to the motor.

2)When we control speed of motor by field control method, resistance in field circuit reduces field current which increases the speed of motor at the same time there is chance under ON condition motor could disconnect from supply due to de energisation of HOLD ON COIL, due to less field current.

4 - POINT STARTER

4 - Point starter with brass arc overcomes limitations of 3- point starter; Using brass arc covers first limitation. Making field circuit path independent of hold coil circuit by making forth point in addition with 3-point circuit covers second limitation. When field current is reduced while controlling speed of motor will not effect on magnetic field of hold on coil because circuit of hold coil is separate than field coil circuit.

3- POINT STARTER



P - SOFT IRON PIECE

H - HANDEL

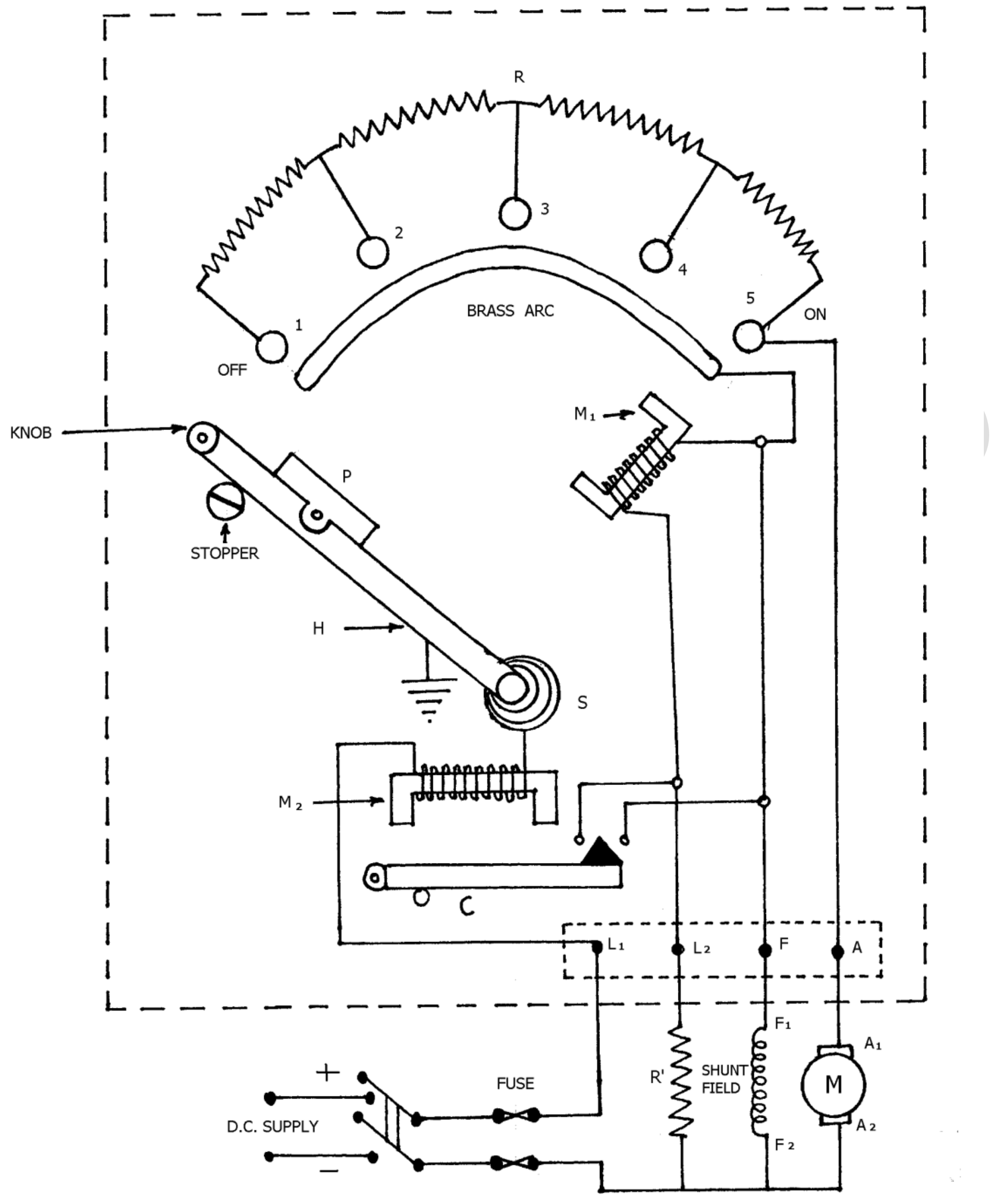
S - SPIRAL SPRING

M 1 - HOLD ON COIL

M 2 - OVER LOAD COIL

C - CUREENT CONTROL RELAY

4- POINT STARTER



- C - CURRENT CONTROL RELAY
- M_2 - OVER LOAD COIL
- P - SOFT IRON PIECE
- H - HANDLE
- S - SPIRAL SPRING
- M_1 - HOLD ON COIL

A. C. MOTOR STARTER:

If normal supply voltage is applied to stationary motor then the motor takes very large initial current. Induction Motor when direct switched takes 5 to 7 times their full load current & develops only 1.5 to 2.5 times their full load torque. This will produce large line drop affect the operation of other electrical equipment connected in same circuit. Starters should be used for the motors of rating above 25 KW to 40KW.

Types of starters generally used are as follows:

For Squirrel-cage Motors:

a. Direct on line starter.

b. Primary Resister/Reactor Starter.

c. Auto -transformer Starter.

d. Star-Delta Starter.

For Slip Ring Induction Motor

a. Rotor Rheostat Starter.

1. DIRECT ON LINE STARTER:

In this type of starter the triple pole single throw switch is used. By using that switch we can directly connect motor to full supply voltage. Hence it is known as Direct on line starter. This starter is used for the motors of the rating below 25 KW to 40 KW. Because the starting current drawn by the motor does not affect so much to the equipment's which are connected to same line.

2. PRIMARY RESISTER/REACTOR STARTER:

In this type of starter supply is given to stator through Resistor or reactor therefore it is called as primary resistor starter. Their purpose is to drop some voltage applied across the motor terminal, thus the initial current drawn by the motor is reduced. When motor attends 80% of the speed total resistance is cut out from circuit.

3. AUTO TRANSFORMER STARTER:

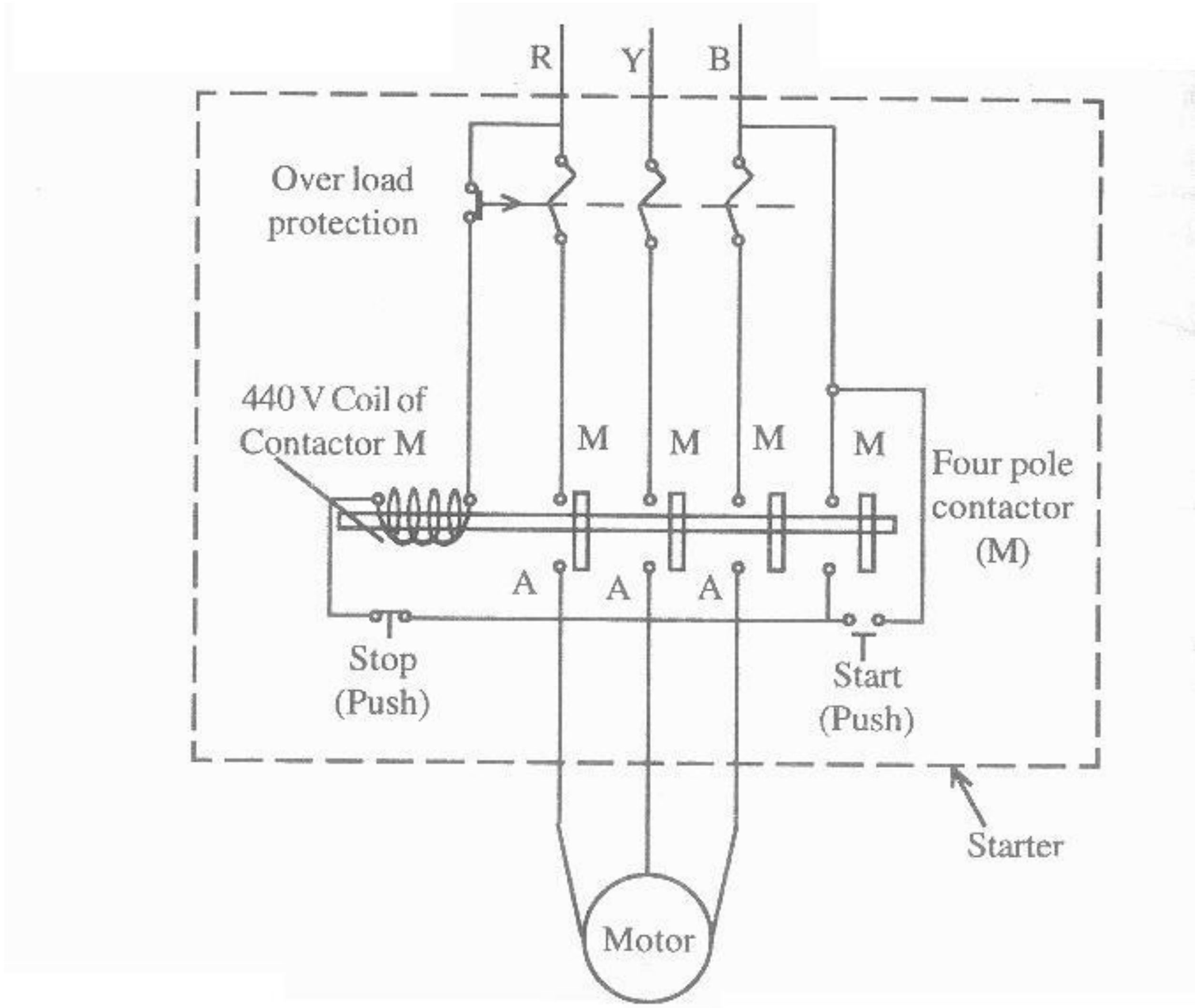
In this starter the supply is given to stator through an Auto Transformer. This method is used for both star & delta connected motors. When the motor has run up to 80% of the full load speed, connections are so changed that autotransformers are cut out from the supply. The switching is done with air break or oil immersed switch.

4. STAR-DELTA STARTER:

This starter is used for those motors, which are built to run normally with a delta connected stator winding. This starter uses the triple pole double throw switch which connects the stator winding of motor in star when it is in position one, and it connects the stator winding of motor in delta when it is in position Two. In the starting period the switch is kept in position one, so that the stator winding will be star connected & it has reduced voltage applied across it to limit the starting current. When motor attends 50% to 60% position of switch is changed to two i.e. stator winding of motor is connected in delta so that full supply voltage is applied across winding & motor will run as normal Induction Motor.

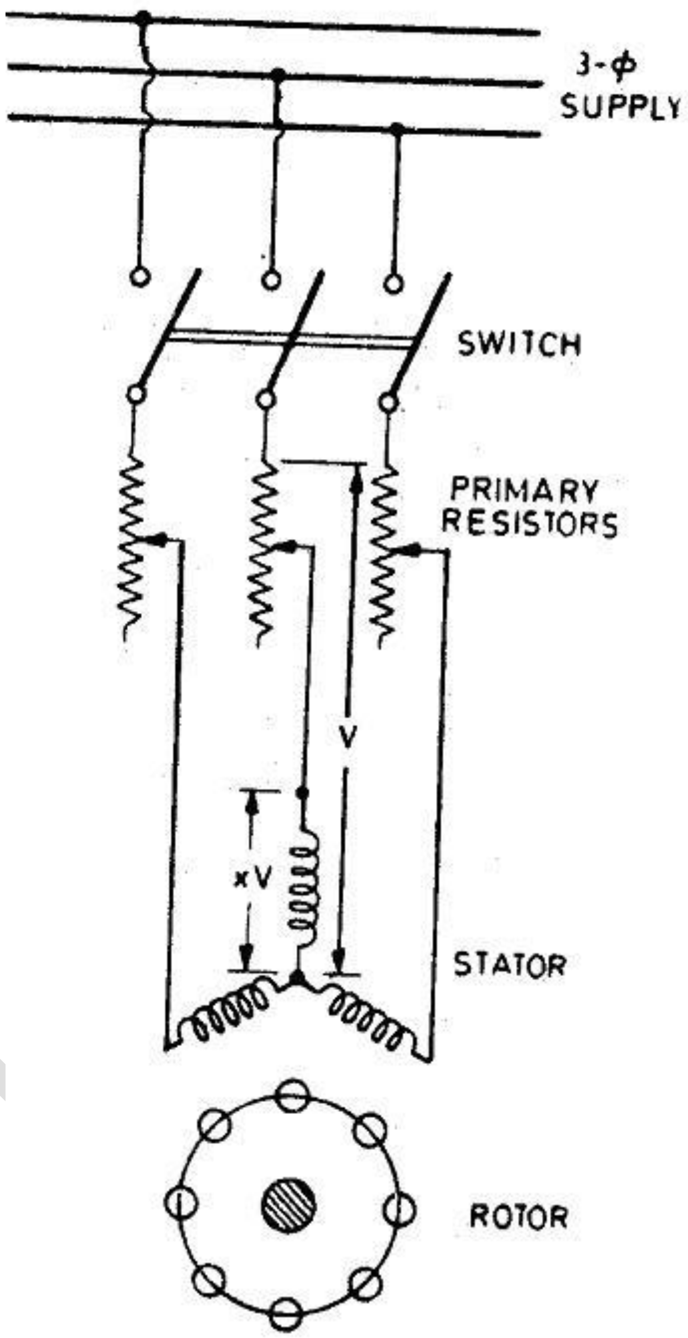
5. ROTOR RHEOSTAT STARTER:

This starter is used for slip-ring Induction motor. In this motors full supply voltage is applied across stator & starting current is controlled by inserting star connected rheostat in rotor circuit. As Induction motor is same as transformer if we control rotor current automatically stator current get controlled. The star connected resistance being gradually cut out of the rotor circuit as motor gathers speed. Because of this rotor resistance during starting period power factor of motor is also improved as well as starting torque improved.

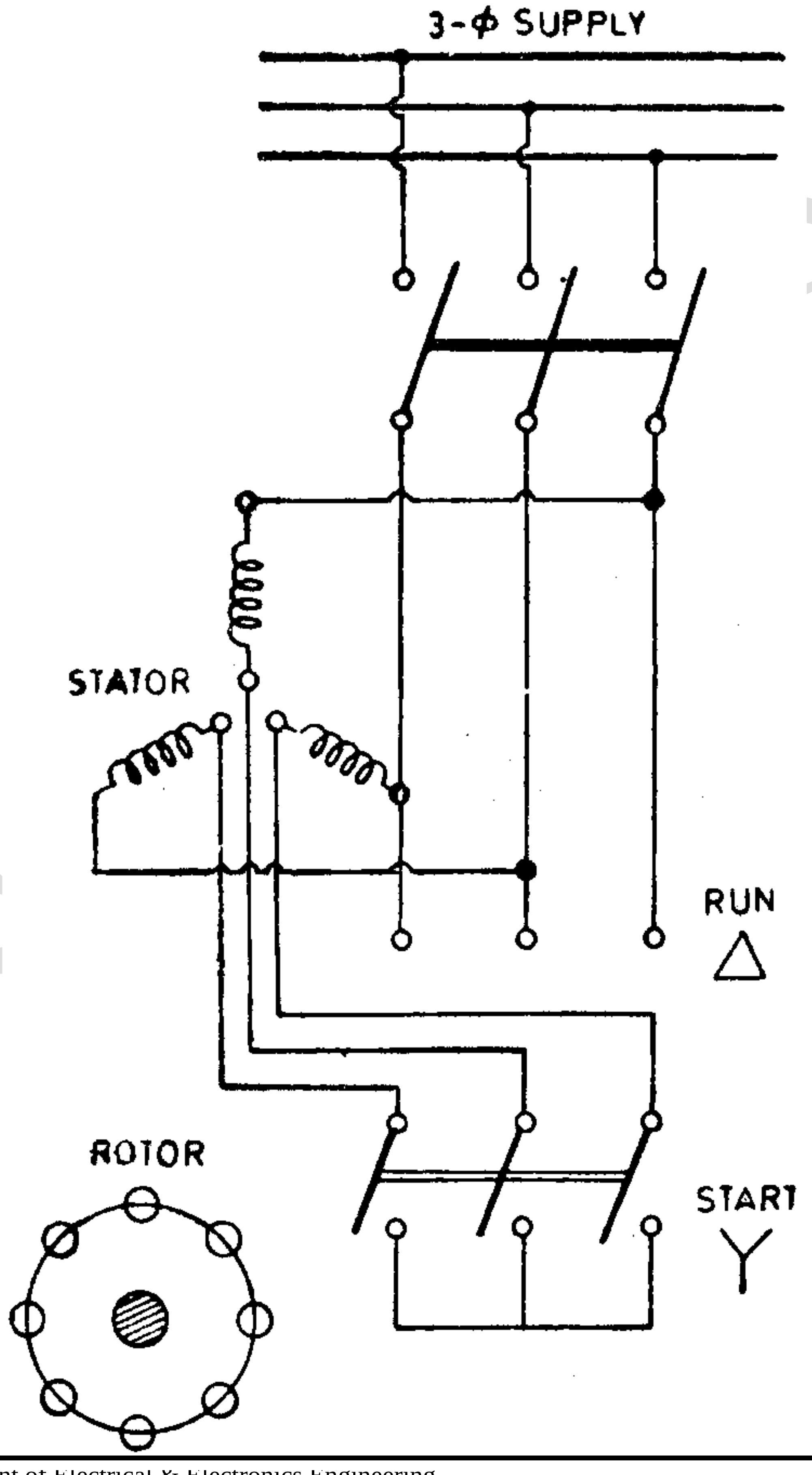

R
Y
B
Over load
protection
440 V Coil of
Contactor M
M
M
M
M
Four pole
contactor
(M)
A
A
A
Stop
(Push)
Start
(Push)
Starter
Motor

D. O. L. STARTER

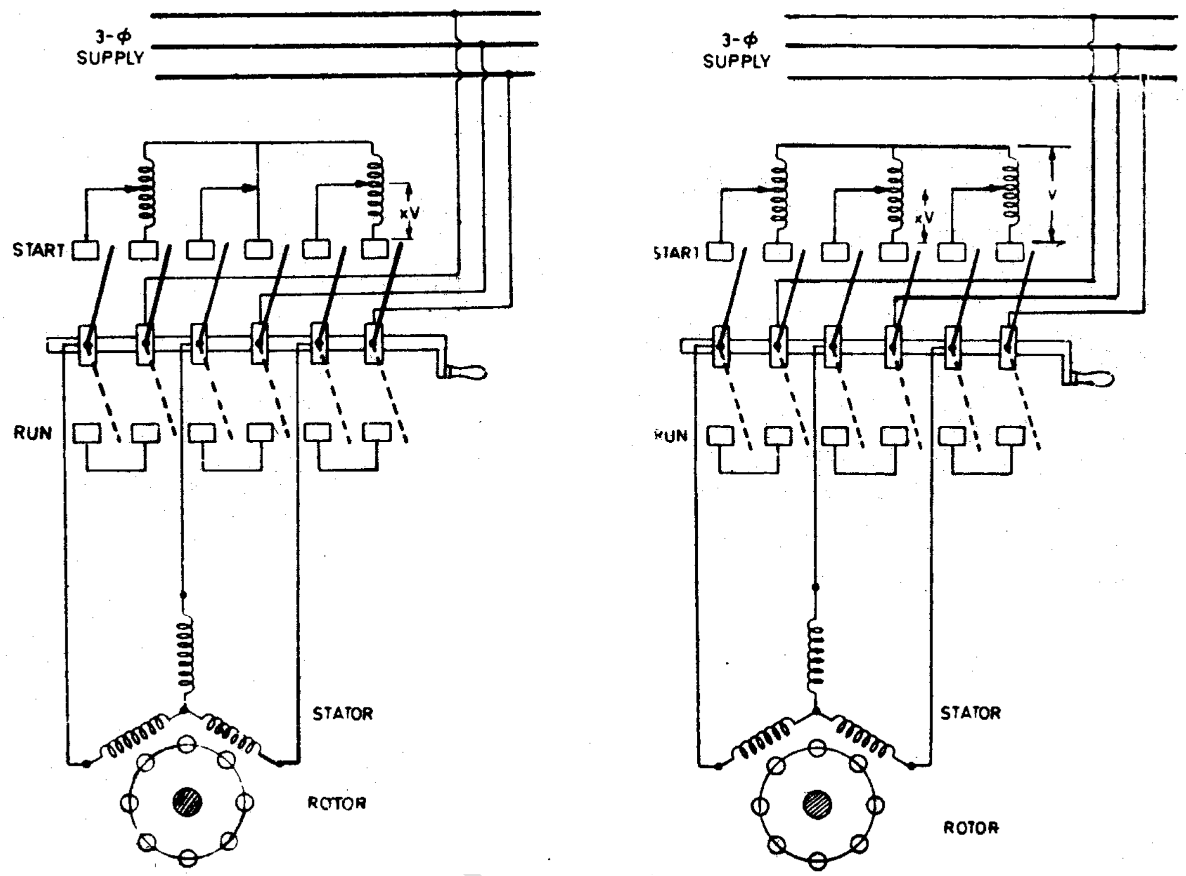
PRIMARY RESISTANCE STARTER



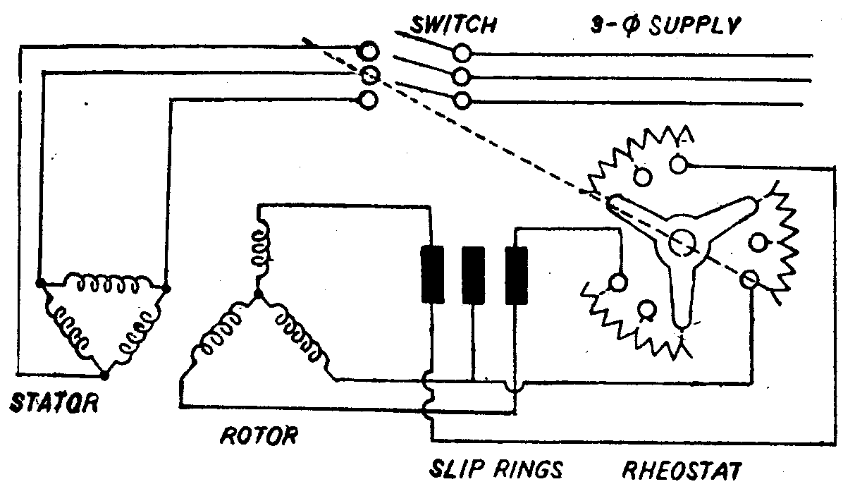
STAR - DELTA STARTER



AUTO - TRANSFORMER STARTER



ROTOR RESISTANCE STARTER



RESULT:

Thus the DC & AC starters are classified and studied.

ELECTRICAL MACHINES- I VIVA QUESTIONS WITH ANSWERS

1. **Which material is used for the core of a transformer and why?**
   Laminations of specially alloyed silicon steel (silicon content 4–5 per cent) are used due to its high electrical resistance, high permeability, non-ageing characteristics and minimum iron loss.
2. **What is stacking factor? What is its approximate value?**
   Stacking factor is the ratio of iron content in the laminated varnished core by volume. Its value is about 90 per cent, that is, 10 per cent volume is occupied by varnish and air.
3. **What is the emf equation of a transformer?**
   E_{rms} = 4.44 Fm fN V
   Where,
   F_m = maximum value of the flux linkage with both the windings,
   f = frequency of the supply,
   N = number of turns.
4. **Why are LT windings placed near the core?**
   LT windings are placed near the core to reduce the total dielectric strength of the insulating materials provided on the winding.
5. **What do you mean by power transformer?**
   Transformers that are used on transmission lines for the transmission and distribution of relatively large quantities of energy are called power transformers.
6. **The windings of a transformer are divided into several coils because?**
   It is difficult to wind as one coil
7. **What will happen if the d.c. machine is operated below rated speed?**
   This will result in overheating due to two reasons; First, more field current has to be maintained in order to produce the rated voltage. Second, decrease in fanning action due to decrease in speed.
8. **What will happen if the d.c. shunt motor opened accidentally running on no-load has its shunt field winding?**
   The field will be reduced to only to the value of residual flux.
   The speed will be very high.
   The parts of motor may even fly apart.
9. **A d.c. shunt motor is found suitable to drive fans because they require?**
   Small torque at start up and large torque at high speeds
10. **What is the power factor of a transformer at no load?**
    At no load, the power factor of a transformer is very low and lagging, whereas the power factor on load is nearly equal to the power factor of the load, which it is carrying.
11. **What are the essential parts of a transformer?**
    The essential parts of a transformer are as follows:
    Magnetic circuit consisting of laminated iron core and clamping structure
    Primary winding
    Tank filled with insulating oil
    HT terminals with bushings
    LT terminals with bushings
    Conservator tank
    Breather
    Vent pipe
    Thermometer
12. **How is magnetic leakage reduced?**
    Magnetic leakage is reduced to a minimum by sectionalizing and interleaving the primary and secondary windings.
13. **What is the permissible maximum flux density in transformer core?**
    1.6–1.8 Wb/m^2
14. **What are the two basic types of transformers?**
    The two basic types of transformers are:

The isolation type in which the two windings are physically isolated and electrically insulated from each other.
The auto transformer type in which one coil is used for both the windings.

15. **What are the types of windings according to the construction?**
According to the construction, the types of windings are:
Sandwich type and
Cylindrical type
16. **What is an ideal transformer?**
A transformer having an overall efficiency of 100 per cent is called an ideal transformer.
17. **Oil in transformers is used to?**
To cool the windings
18. **What do you understand by external characteristics of a d.c. generator?**
The graph between the terminal voltage and load current is known as external characteristics of a d.c. generator, provided speed and field current remain constant.
19. **If the rated speed of a d.c. shunt motor is 1440 r.p.m, which method of speed control would you suggested to obtain a speed of 1500 r.p.m?**
Field control method of speed control is suggested.
20. **What is the normal phase difference between the voltage and the no-load current in a transformer?**
The no-load current in a transformer normally lags behind the voltage by about 80°– 85°.
21. **What is the use of iron core in a transformer?**
The iron core is used in a transformer to provide continuous easy magnetic path of low reluctance.
22. **What is called grain-oriented laminations?**
Grain-oriented laminations are cold rolled laminations specially annealed to orient the iron crystals, that is, the grains in a uniform way in the direction of rolling to get very high permeability and low hysteresis loss.
23. **Why is the frequency not changed during transformation of electrical energy in a transformer?**
As the same flux having a definite frequency is responsible for the production of emf on both the primary and secondary windings, there is no question of change in the frequency.
24. **What are the types of transformers?**
Types of transformers are:
Step up transformer
Step-down transformer.
25. **How does a transformer contribute towards the widespread popularity of AC system over DC?**
High voltage of AC system can be obtained using a transformer for transmission of electrical power. Using a transformer, AC voltage can be increased or decreased without any power loss.
26. **What is the most important precaution in any experiment with d.c. shunt motor?**
Before switching on d.c. supply, a sufficient resistance should be put in series with the armature of the d.c. shunt motor.
27. **Does the direction of rotation of d.c. shunt motor would get reversed if the armature current and field current both are reversed?**
No.
28. **What is the difference between cylindrical-type and sandwich-type winding?**
In cylindrical-type winding, the length of the coils is equal to the length of the core limb. The primary and secondary windings are placed one over the other, placing low-voltage winding nearer the core, whereas in sandwich-type winding HT and LT windings are placed lengthwise one above and other like a sandwich.
29. **What is the name of the winding to which supply is given?**
The name of the winding is Primary winding.

30. **What is the name of the winding from which the supply is taken for load connections?**
Secondary winding.
31. **Why are iron cores in transformers made laminated?**
Iron cores are made laminated to reduce eddy current loss.
32. **What determines the thickness of the lamination or stamping?**
Frequency determines the thickness of the lamination or stamping.
33. **Why are the laminations insulated from each other?**
The laminations are insulated from each other by insulating varnish or thin paper to break the path of eddy currents and thus reduce eddy current loss.
34. **What is the phase relationship between the primary and secondary voltages of a transformer?**
The primary and secondary voltages of a transformer are 180° out of phase.
35. **What is turn ratio of a transformer?**
The ratio of the number of turns in the primary to the number of turns in the secondary-windings is called the turn ratio or the ratio of transformation of the transformer, which is indicated by a constant.
36. **What is voltage ratio of a transformer?**
Voltage ratio is the ratio of the voltage between the line terminals of one winding to that between the line terminals of another winding at no load.
37. **What are the types of transformers according to the arrangement of iron cores?**
There are three types:
Core type,
Shell type and
Distributed core or Berry type.
38. **What magnetic circuit is formed in Berry-type constructions and why?**
Distributed magnetic circuits are formed in Berry-type construction because of its distributed cores.
39. **What is called limb of a transformer?**
The vertical portion of the iron core where the windings are placed is called limb of a transformer.
40. **What do you mean by step-up and step-down transformers?**
When a transformer converts low voltage to high voltage, it is called a step-up transformer and when the transformer converts high voltage to low voltage it is called a step-down transformer.
41. **What do you mean by distribution transformers?**
When transformers are used for distributing the energy from transmission lines as well as networks for local consumption and the secondaries are directly connected to the consumer's load, they are called distribution transformers.
42. **What do you mean by lighting transformer?**
A transformer used to supply a distribution circuit having no motors connected to it is called lighting transformer.
43. **When the required thickness of lamination in a transformer decreases?**
When the applied voltage increases
44. **The size and construction of bushings in a transformer depend upon the?**
Size of tank and voltage supplied.
45. **What is the resistance of the field winding of a D.C. shunt generator kept low?**
If the field resistance of a D.C. generator is more than particular value (critical resistance), the generator will fail to build up the voltage. For this reason, the field resistance of a D.C. shunt generator is kept low.
46. **What range of speed can you get with the field control method of speed control of d.c. shunt motor?**
Speed higher than rated speed can be obtained by using this method.

47. **What range of speed can you get with the armature control method of speed control of d.c. shunt motor?**
Speed lower than the rated speed can be obtained by the armature control method.
48. **What is the most essential condition for the voltage build up for a d.c. shunt generator?**
There should be a residual magnetism in the poles of the DC shunt generator.
49. **What happens if DC supply is applied to the transformer?**
If DC supply is given to the transformer, the current will not change due to constant supply.
So the mutual induction is not possible and thus the transformer will not work.
The primary winding resistance is very small.
For DC supply, the primary winding inductive reactance is zero.
So the primary will draw very high current for dc supply, consequently extra heat generated and thus the transformer get damaged.
Hence the DC supply should not be applied to the transformer.
50. **What is the application of equivalent circuit of a single phase transformer? [Anna Univ. Dec-2005]**
The equivalent circuit is the electrical model of the transformer. Once the equivalent circuit parameters are obtained, then the regulation & efficiency of the transformer at any power factor and load conditions can be obtained without actually loading the transformer.
51. **What is synchronous speed?**
For synchronous machines there exists a fixed relationship between number of poles P, frequency f and the speed of the machine. The speed of the synchronous machine for the given number of poles and the rated frequency is called the synchronous speed (Ns)
The expression for synchronous speed is
Ns = 120f/P
f = frequency
P = No of poles of the machine
52. **What is meant by torque? or Define torque?**
A turning or twisting force about an axis is defined as torque.
53. **How can we reduce the eddy current loss in the electrical machine?**
By using laminated core construction, the eddy current loss can be reduced.
The laminated core divides the solid iron core into thin laminations.
The path of eddy currents is broken due to the insulating material sheets between the laminations.
Thus the eddy currents and losses generated by them can be minimized.
54. **In DC generators, the series field winding has low resistance while the shunt field winding has high resistance. Why?**
Always the series field winding is connected in series with armature.
Hence it has to carry the armature current which directly gets decided by the load.
So the current passing though series field winding is of high level.
The voltage drop across series field winding gets added to the voltage drop across armature winding while deciding the back emf. This voltage drop must be very small.
Hence as the current through series field winding is high, in order to keep voltage drop across it to a small value, its resistance is very low.
The shunt field winding is directly connected across the rated supply voltage hence to limit current through it, resistance is very high.
55. **Explain the principle of the transformer? [Anna Univ. May-2010]**
The transformer works in the principle of mutual induction.
Mutual Induction:
When two coils are inductively coupled and if current in one coil is changed uniformly then an emf gets induced in the other coil.When the path is closed on the second coil, the induced emf can drive a current on it.