DMI COLLEGE OF ENGINEERING

DEPARTMENT OF EEE

LAB MANUAL

CLASS : **II YEAR EEE**

SEMESTER : **IV SEM**

SUBJECT CODE : **EE6411**

SUBJECT : **Electrical Machines - I Lab**

LIST OF EXPERIMENTS

EE6411 - ELECTRICAL MACHINES LABORATORY – I

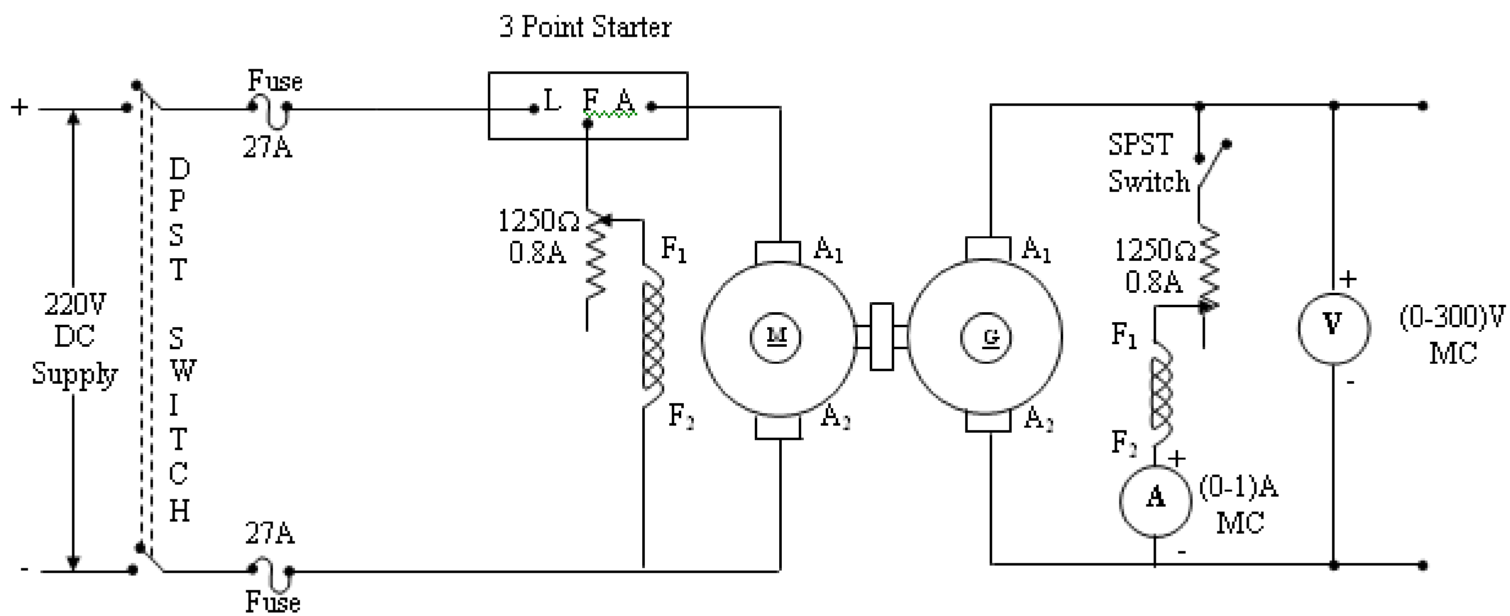
1. Open circuit and load characteristics of self excited DC shunt generators.
2. Load characteristics of DC compound generator with differential and cumulative connection.
3. Load characteristics of DC shunt and compound motor.
4. Load characteristics of DC series motor.
5. Swinburne's test and speed control of DC shunt motor.
6. Hopkinson's test on DC motor – generator set.
7. Load test on single-phase transformer and three phase transformer connections.
8. Open circuit and short circuit tests on single phase transformer.
9. Sumpner's test on transformers.
10. Separation of no-load losses in single phase transformer.
11. Study of Starters

INDEX

S.No	Date	Experiment Name	Marks	Sign
1A		Open circuit characteristics of Self excited DC shunt generators.		
1B		Load characteristics of Self excited DC shunt generators.		
2		Load characteristics of DC compound generator – Differential & Cumulative		
3A		Load characteristics of DC shunt motor		
3B		Load characteristics of DC compound motor		
4		Load characteristics of DC series motor		
5A		Swinburne's test		
5B		Speed control of DC shunt motor		
6		Hopkinson's test		
7		Load test on single-phase transformer		
8		Open circuit and short circuit tests on single phase transformer		
9		Sumpner's test on transformers		
10		Separation of no-load losses in single phase transformer		

LAB INCHARGE

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 RPM	1500 RPM

OPEN CIRCUIT CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

Ex.No:1A

Date:

AIM:

To obtain open circuit characteristics of self excited DC shunt generator and to find its 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 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.

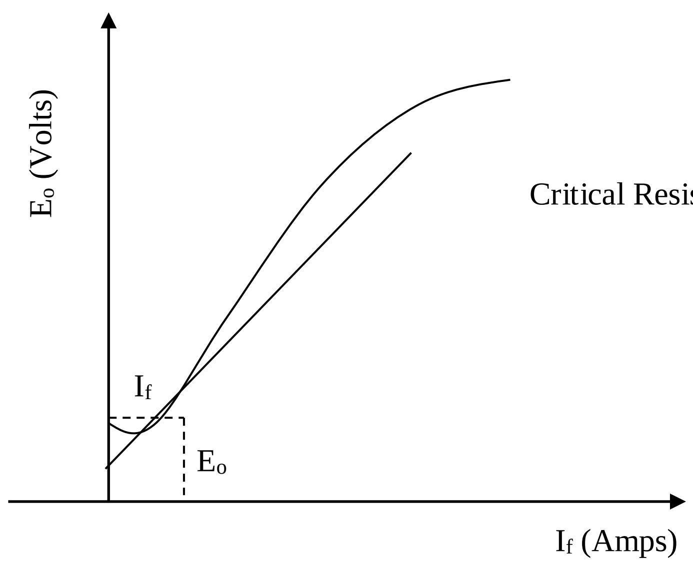
PROCEDURE:

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.

TABULAR COLOUMN:

S.No.	Field Current I_f (Amps)	Armature Voltage E_o (Volts)
1.		
2.		
3.		
4.		
5.		
6.		

MODEL GRAPH:



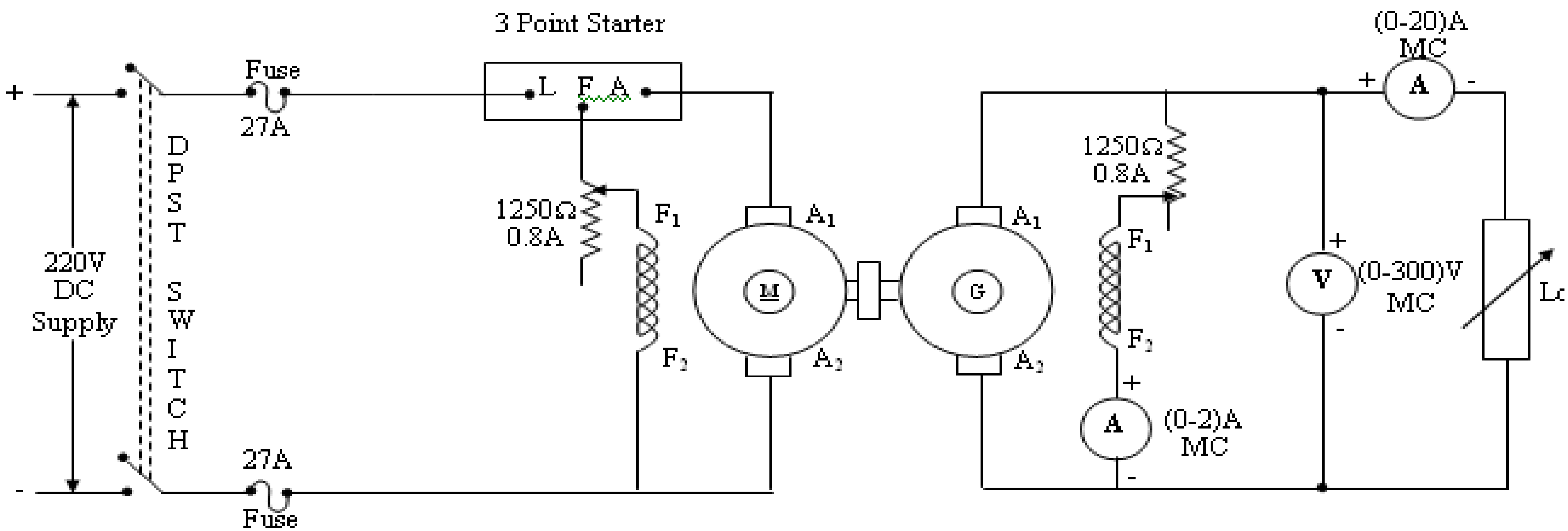
Critical Resistance = E_o / I_f Ohms

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.

RESULT:

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

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 RPM	1500 RPM

LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

Ex.No.1B

Date:

AIM:

To obtain 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

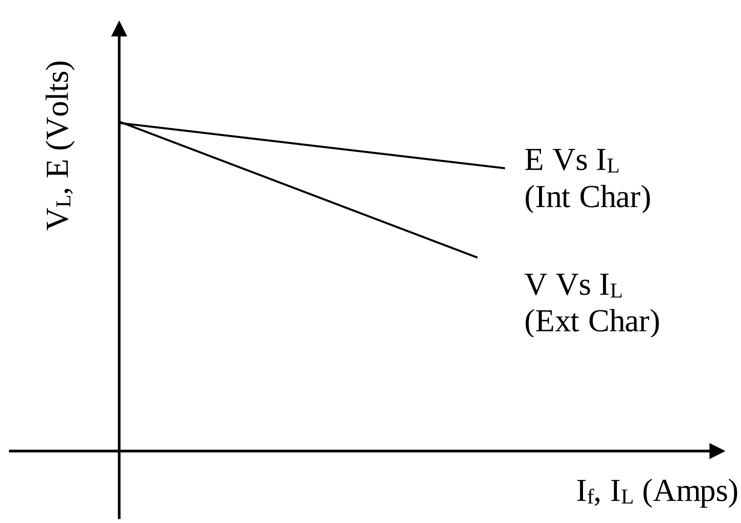
PRECAUTIONS:

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.

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)
1.					
2.					
3.					
4.					
5.					
6.					

MODEL GRAPH:



PROCEDURE:

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.

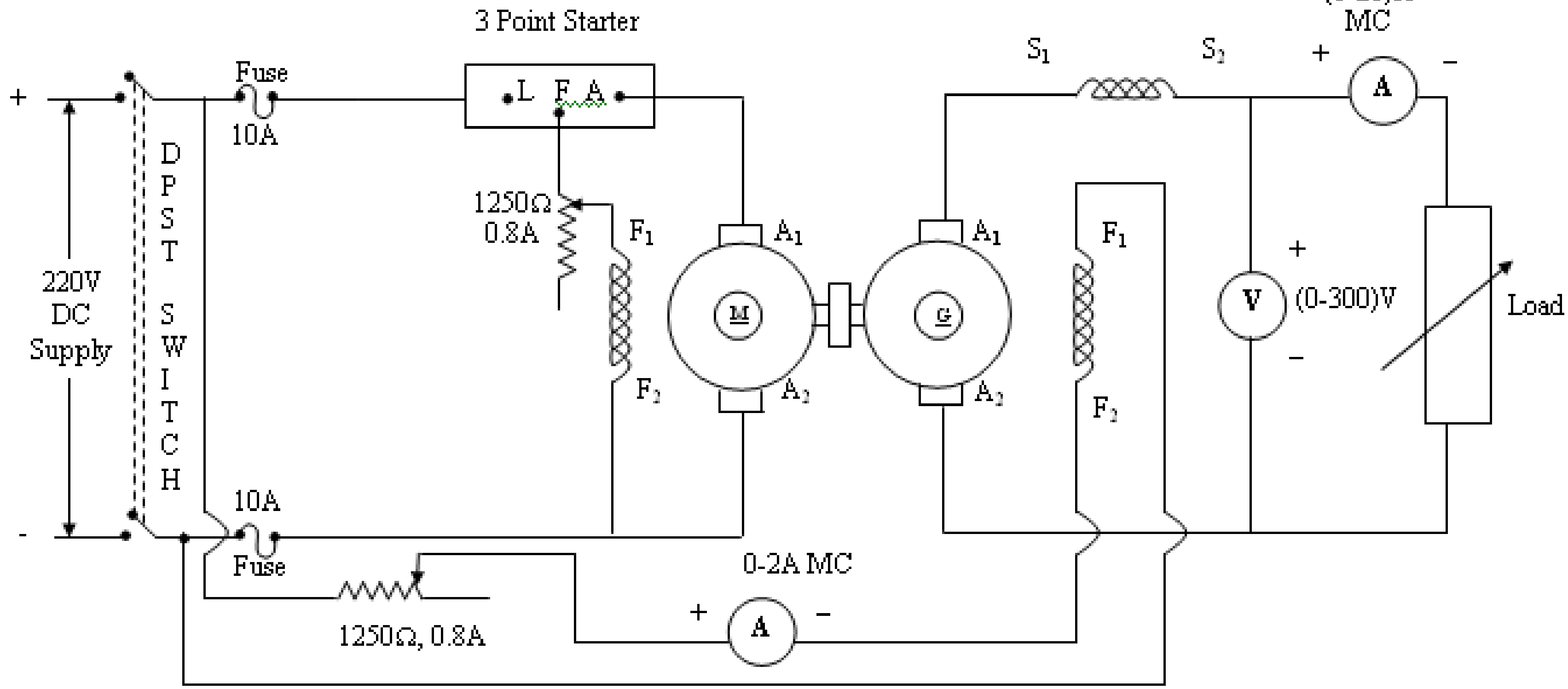
RESULT:

Thus the load characteristics of self excited DC shunt generator is obtained.

Viva Questions :

1. What is the principle of DC generator?
2. Mention the application of self excited DC generator.
3. Give the advantages and disadvantages of self excited DC generators.
4. What will be the value of current in open circuit condition?
5. What is the purpose of starter?
6. On what occasions DC generators may not have residual flux?
7. Define the term critical resistance referred to DC shunt generator.
8. Define the term critical speed in DC shunt generator.
9. The efficiency of generator rises to a maximum value and then decreases. Why?
10. What do you mean by residual magnetism in DC shunt generators?

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

	Motor	Generator
Rated Voltage :	220V	220V
Rated Current :	21A	21A
Rated Power :	3.5KW	7.5KW
Rated Speed :	1500 RPM	1500 RPM

LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR

Ex.No.2

Date:

AIM:

To obtain the load characteristics of DC Compound generator under cumulative and differential mode condition.

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

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.

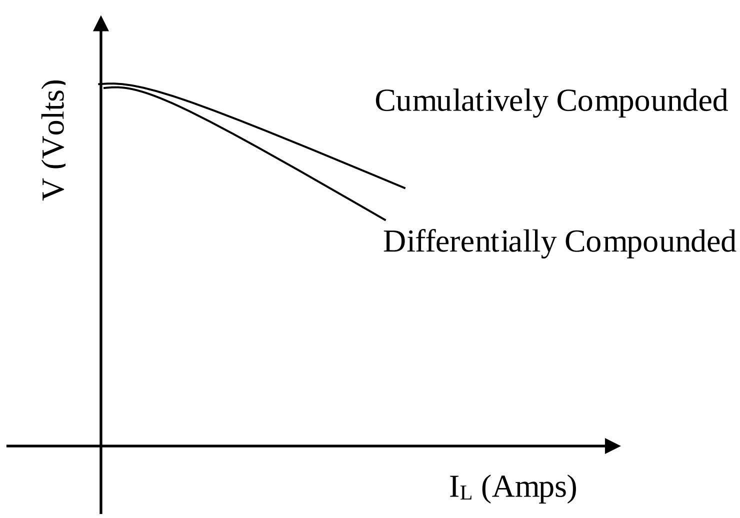
PROCEDURE:

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.

TABULAR COLUMN:

S.No.	Cumulatively Compounded		Differentially Compounded	
	V (Volts)	I_L (Amps)	V (Volts)	I_L (Amps)
1.				
2.				
3.				
4.				
5.				
6.				

MODEL GRAPH:



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.
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.

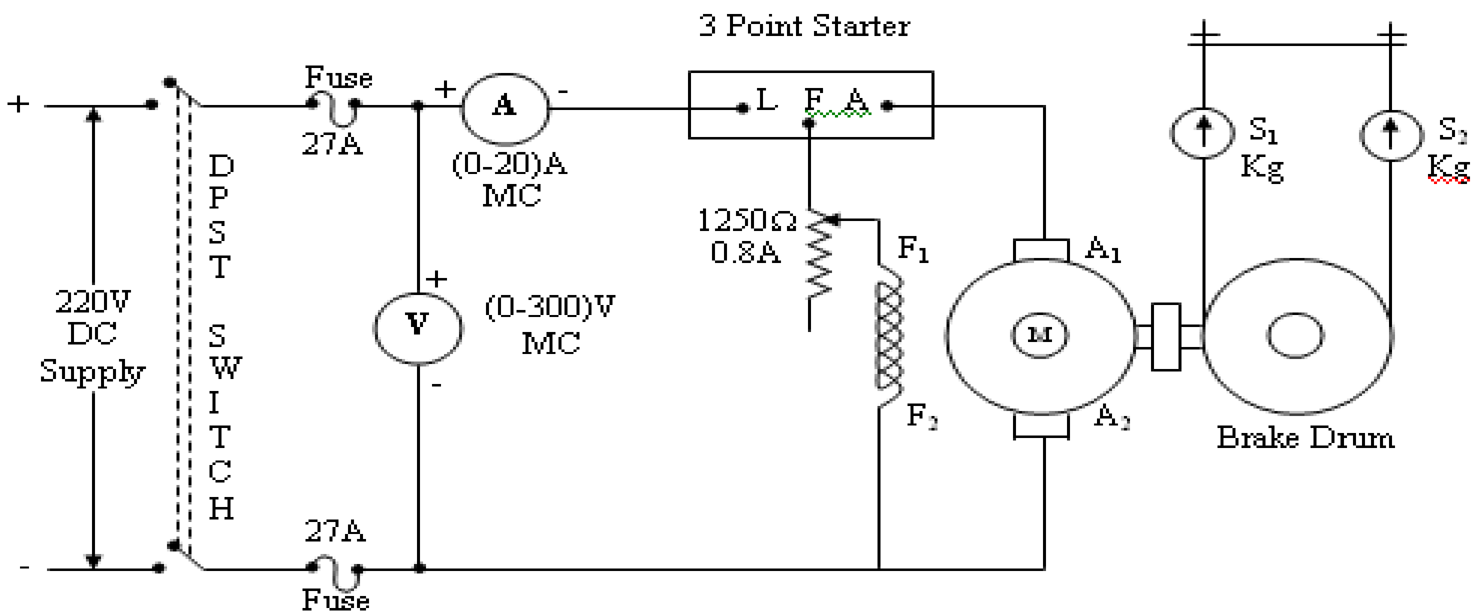
RESULT:

Thus load characteristics of DC compound generator under cumulative and differential mode condition are obtained

Viva Questions :

1. What is the standard direction of rotation of the DC generator and DC motor?
2. How should a generator be started?
3. What are the indications and causes of an overloaded generator?
4. Generator operates in the principle of Fleming's __________________.
5. Whether compound generators can be used as shunt and series generators? How?
6. An electrical machine can be loaded up to -------------------- % of rated current.
7. Why series generators are not used for power generation at the power house?
8. How do we conclude that connections between field coils and armature are correct?
9. How will you differentiate cumulative compound and differential compound generators?
10. Define commutation.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current : 21A
Rated Power : 3.5KW
Rated Speed : 1500 RPM

LOAD TEST ON DC SHUNT MOTOR

Ex.No.3A

Date:

AIM:

To conduct load test on DC shunt motor and to find 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	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

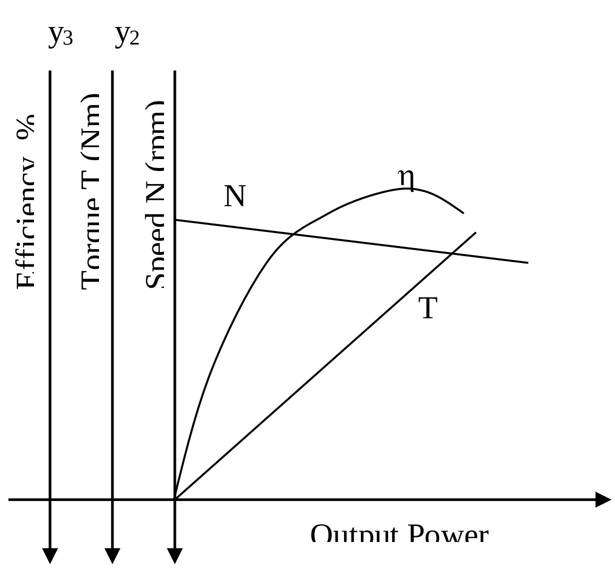
Output Power P_m = $\frac{2\pi NT}{60}$ Watts

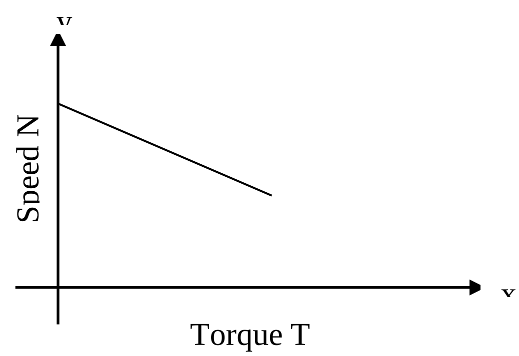
Efficiency η % = $\frac{\text{Output Power}}{\text{Input Power}} \times 100\%$

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)						
1.										
2.										
3.										
4.										
5.										
6.										

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.

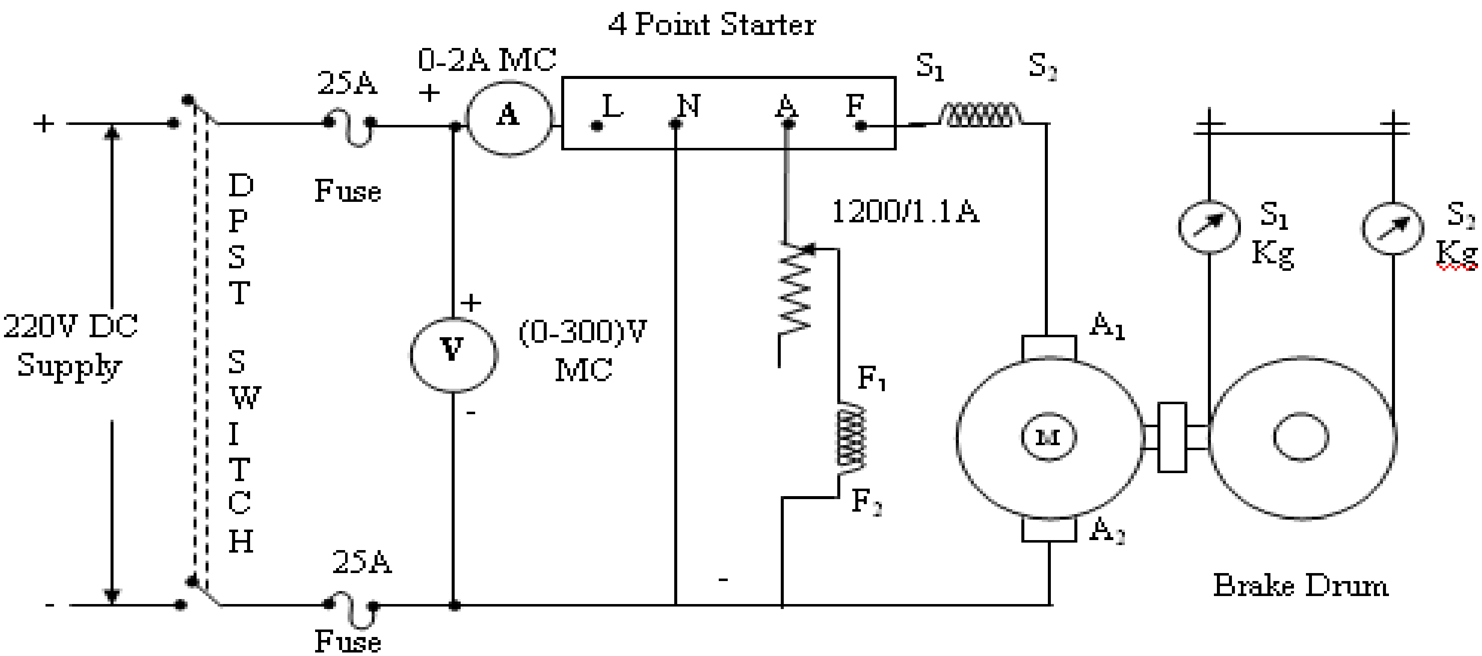
PROCEDURE:

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:

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

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 18.6}{100} = 23.25A$$

NAME PLATE DETAILS:

Rated Voltage :	220V
Rated Current :	18.6A
Rated Power :	3.5KW
Rated Speed :	1500 rpm.

LOAD TEST ON DC COMPOUND MOTOR

Ex.No.3B

Date:

AIM:

To conduct load test on DC compound motor and to find its 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	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

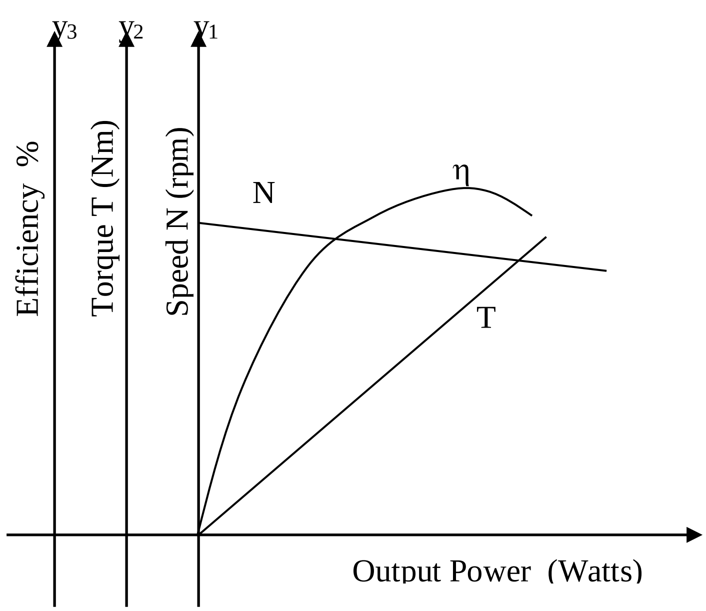
Output Power P_m = $\frac{2\pi NT}{60}$ Watts

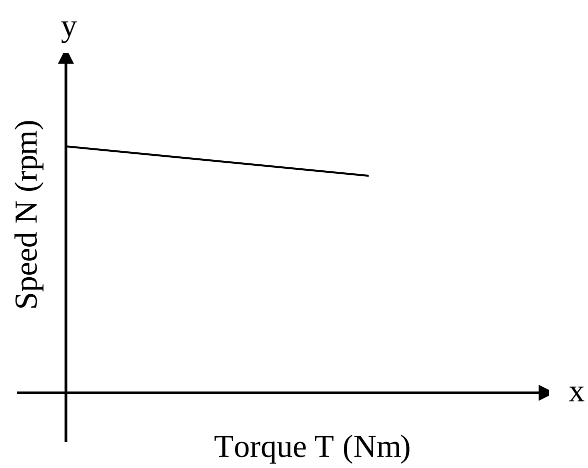
Efficiency η % = $\frac{\text{Output Power}}{\text{Input Power}} \times 100\%$

TABULAR COLOUMN:

S.No	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		(S_1~ 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)						
1.										
2.										
3.										
4.										
5.										
6.										

MODEL GRAPHS:





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.

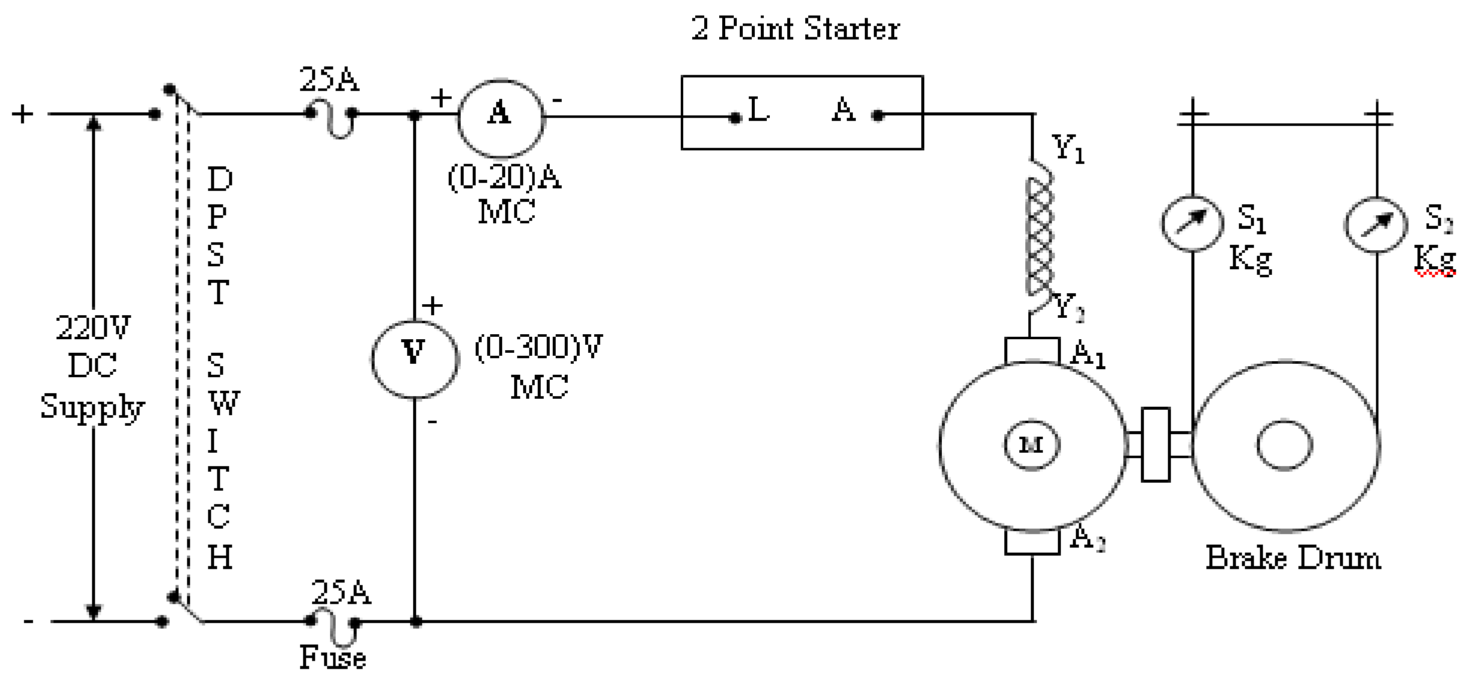
RESULT:

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

Viva Questions

1. State the principle of DC motor.
2. How may the direction of DC motor be able to be reversed?
3. Why the field rheostat of DC motor is kept at minimum position while starting?
4. What will happen if the field of the DC motor is opened?
5. What will happen if both the field current and armature current are reversed?
6. What will happen if the shunt motor is directly connected across the supply line?
7. Mention the applications of DC compound motor.
8. The differentially compounded motor has a tendency to start in the opposite direction, why?
9. What are the advantages of a compound motor?
10. Differentiate between cumulative compound and differential compound motors.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 20}{100} = 25A$$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current : 20A
Rated Power : 5KW
Rated Speed : 1500 RPM

LOAD TEST ON DC SERIES MOTOR

Ex.No.4

Date:

AIM:

To conduct load test on DC Series Motor and to find 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

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

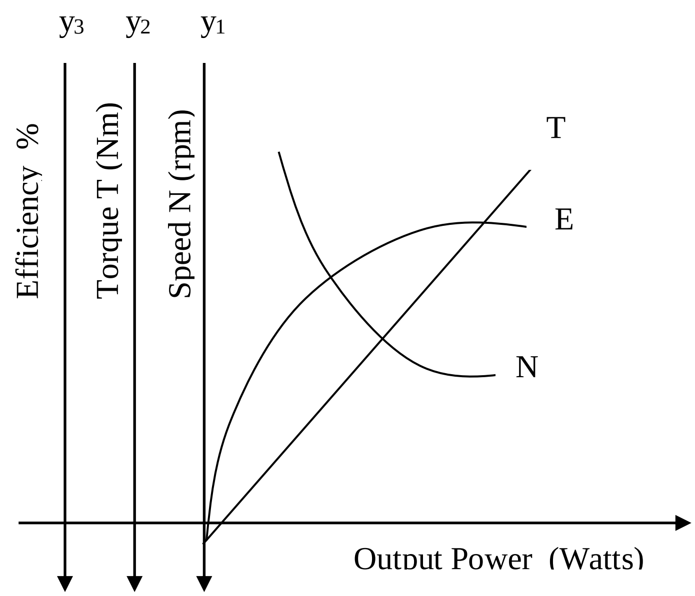
Output Power P_m = $\frac{2\pi NT}{60}$ Watts

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

TABULAR COLOUMN:

S.No	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		(S_1~ 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)						
1.										
2.										
3.										
4.										
5.										
6.										

MODEL GRAPH:



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.

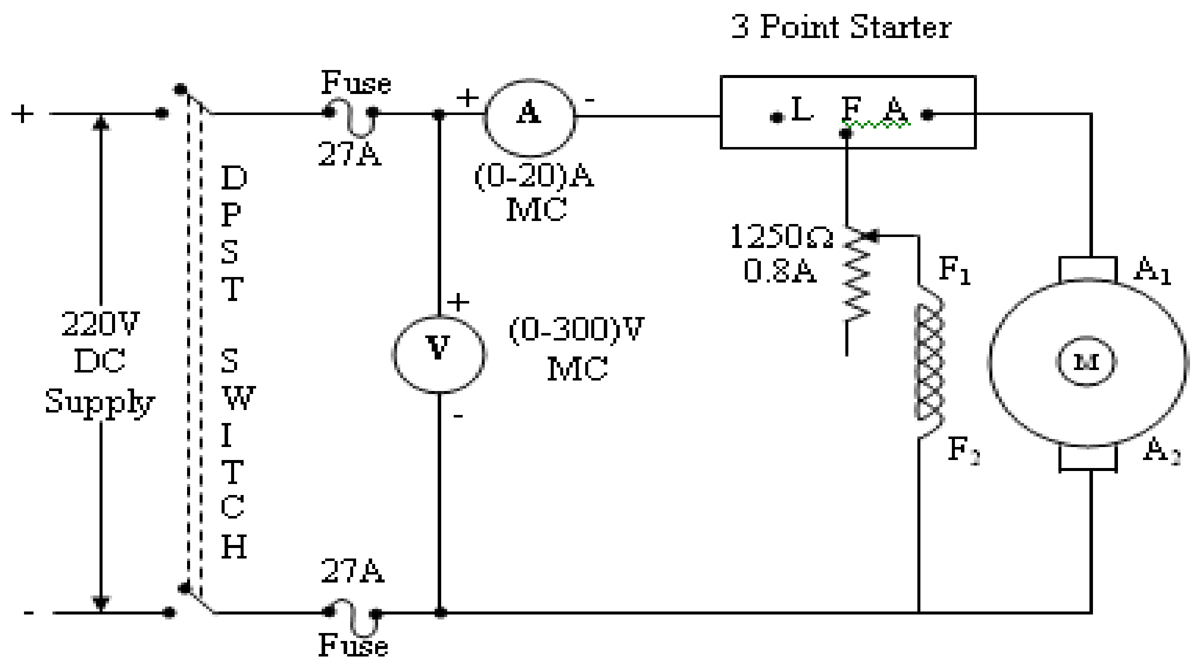
RESULT:

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

Viva Questions:

1. What are the applications of DC series motors?
2. What are the special features of a DC series motors?
3. Which type of starter is used for DC series motors?
4. How will you control the speed of DC series motor?
5. What will happen to the speed of series motor when the supply voltage is reduced?
6. What is the importance of no-load current of the motor?
7. Why we use starters to start DC motors?
8. DC series motors should never be started on no-load. Why?
9. Why the DC series motors have high starting torque?
10. What is meant by speed losses in DC machines?

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

Rated Voltage	:	220V
Rated Current	:	21A
Rated Power	:	3.5KW
Rated Speed	:	1500 RPM

SWINBURNE'S TEST

Ex. No. 5A

Date:

AIM:

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

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	Wire Wound	1
4	Tachometer	(0-3000) rpm	Digital	1
5	Resistive Load	5KW,230V	-	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

FORMULAE:

Hot Resistance R_a = 1.2 X R Ω

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

Where I_{ao} = $(I_o – I_f)$ Amps

AS MOTOR:

Load Current I_L = _____ Amps

Armature current Ia = $I_L – I_f$ Amps

Copper loss = $I_a^2 R_a$ watts

Total losses = Copper loss + Constant losses

Input Power = VI_L watts

TABULAR COLOUMN:

AS MOTOR: I_f = ______________A

S. No.	V (Volts)	I_L (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%
1.								
2.								
3.								
4.								
5.								
6.								

AS GENERATOR:

I_f = ______________A

S. No.	V (Volts)	I_1 (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%
1.								
2.								
3.								
4.								
5.								
6.								

Output Power = Input Power – Total losses

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

AS GENERATOR:

Load Current I_L = _____ Amps

Armature current Ia = $I_L + I_f$ Amps

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

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

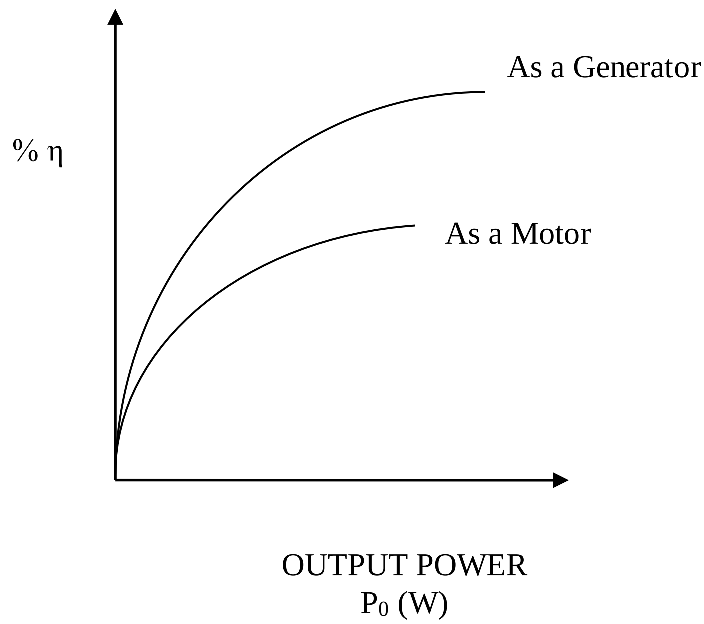
PRECAUTIONS:

The field rheostat should be in the minimum position at the time of starting and stopping the motor

PROCEDURE:

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.

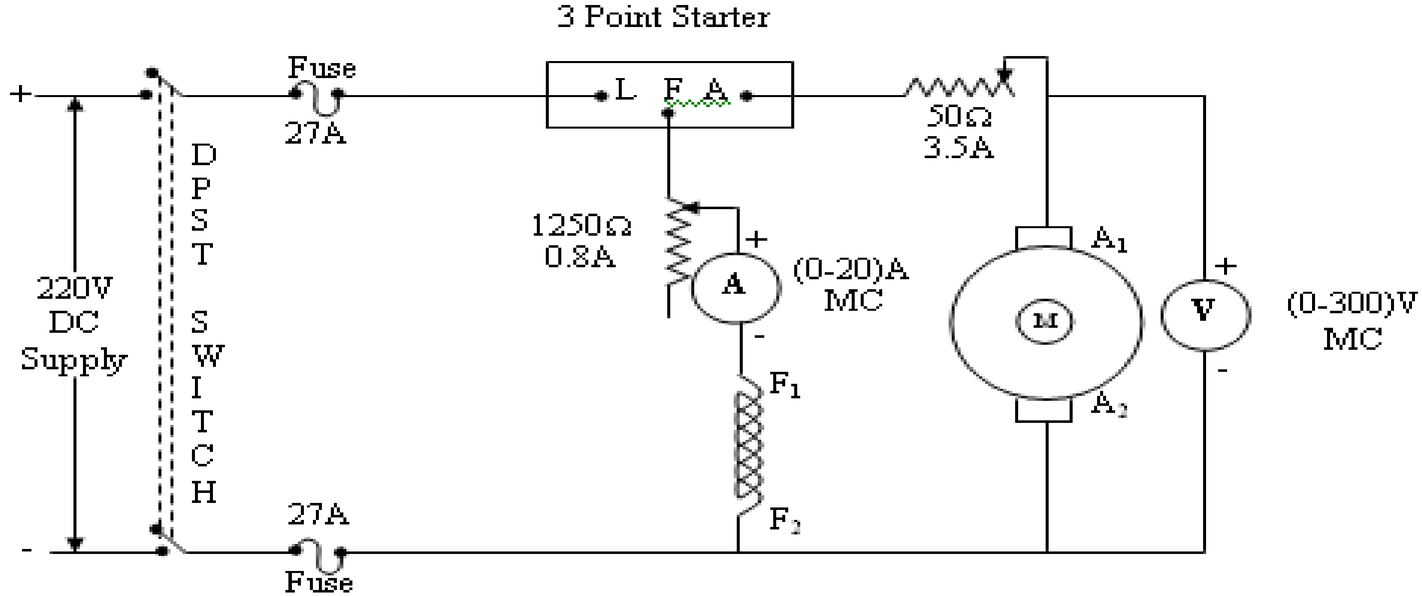
MODEL GRAPH:



RESULT:

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

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 21}{100} = 26.25A$$

NAME PLATE DETAILS:

Rated Voltage	:	220V
Rated Current	:	21A
Rated Power	:	3.5KW
Rated Speed	:	1500 RPM

SPEED CONTROL OF DC SHUNT MOTOR

Ex.No. 5B

Date:

AIM:

To obtain 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
2. Armature Rheostat should be kept in the maximum resistance position

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.

TABULAR COLUMN:

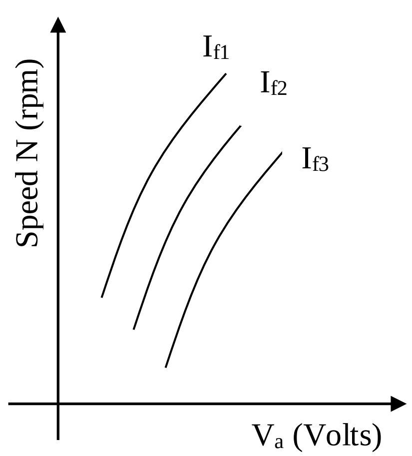
(i) Armature Voltage Control:

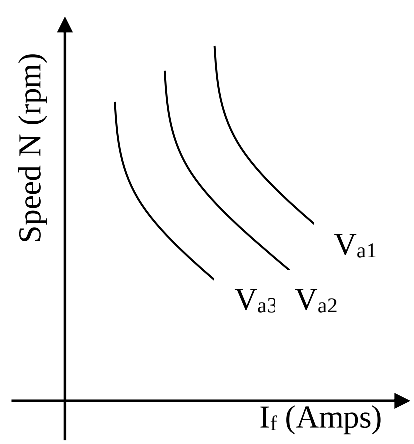
S.No.	I_{f1} =		I_{f2} =		I_{f3} =	
	Armature Voltage V_a (Volts)	Speed N (rpm)	Armature Voltage V_a (Volts)	Speed N (rpm)	Armature Voltage V_a (Volts)	Speed N (rpm)

(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:





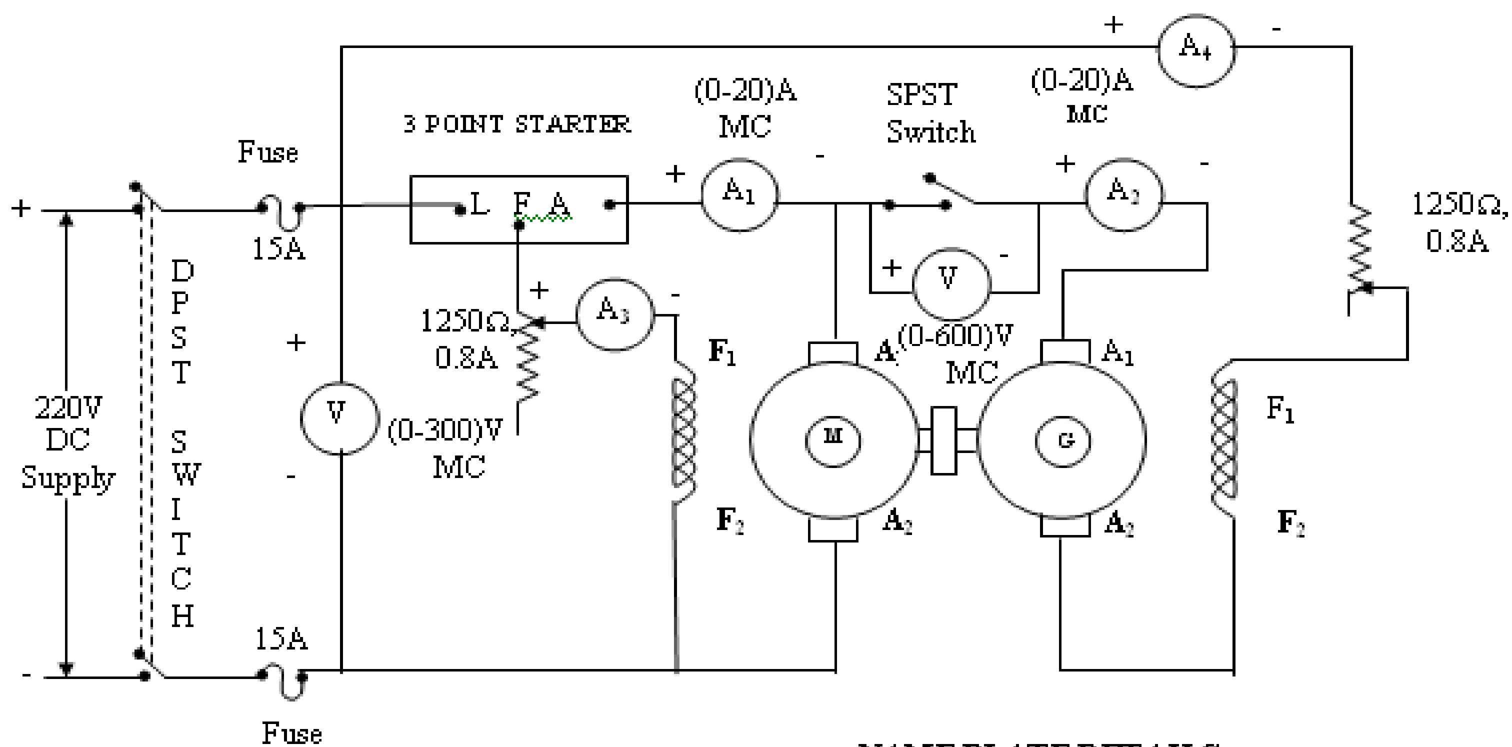
RESULT:

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

Viva Questions:

1. State the advantage of Swinburne’s test.
2. Is it possible to conduct Swinburne’s test on DC series motor? Justify.
3. State the Torque equation of DC motor.
4. Which one of the speed will be higher either no-load speed or full load speed?
5. What will be the efficiency of the motor at no-load?
6. What will be the approximate value of armature and field resistance of DC motors?
7. Why the armature control method is employed only below the rated speed in DC shunt motors?
8. Why the field control method is employed only above the rated speed in DC shunt motors?
9. Where we use shunt motor?
10. Why is field control method superior to armature control method for DC shunt motors?

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.

HOPKINSON'S TEST

Ex.No. 6

Date:

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	(0-1)A (0-20) A	MC MC	1 2
2	Voltmeter	(0-300) V (0-600)V	MC MC	1 1
3	Rheostats	1250Ω, 0.8A	Wire Wound	2
4	Tachometer	(0-3000) rpm	Digital	1
5	Resistive Load	5KW,230V	-	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

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 = $V I_1 - \left[(I_1+I_2)^2 Ra + I_2^2 Ra\right]$ watts.

Stray loss per machine = W/2 watts.

TABULAR COLUMN:

S. No	Supply Voltage V (Volts)	I_1 (Amp)	I_2 (Amp)	I_3 (Amp)	I_4 (Amp)	$I_1 + I_2$ (Amp)	Motor Arma ture Cu Loss W (watts)	Generat or Arma ture Cu Loss W (watt)	Total Stray losses W (watt)	Stray Loss Per M/c w/2 (watt)

AS MOTOR:

S.No	V (Volt)	I_1 (Amp)	I_2 (Amp)	I_3 (Amp)	Motor Armatu re Cu Loss W (Watts)	Field Loss (Watt)	stray losses /2 (Watt)	Total Losses W (Watt)	O/P Powe r (Watt)	I/P Powe r (Watt)	Effi cien cy η%

AS GENERATOR:

S.No.	V (Volt)	I_1 (Amp)	I_2 (Amp)	Motor Armatu re Cu Loss W (Watts)	Field Loss (Watts)	Stray losses /2 (Watt)	Total Losses W (Watt)	Output Power (Watts)	Input Power (Watt)	Efficiency η%

AS MOTOR:

Input Power = Armature input + Shunt field input

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

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

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

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

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

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

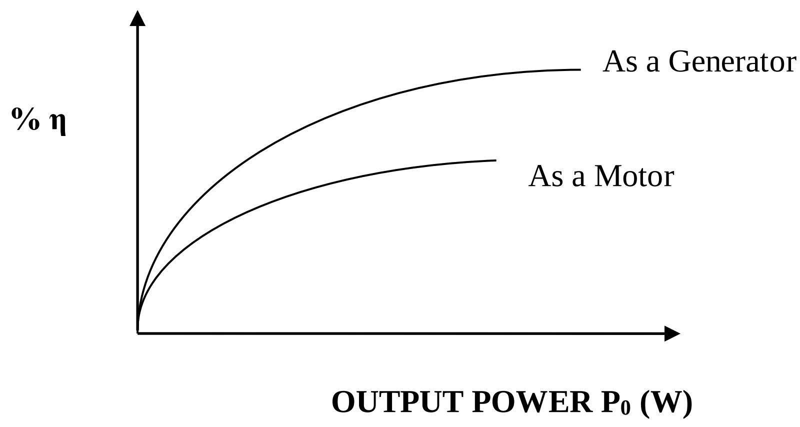
PRECATUIONS:

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:

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 V_1 is made to read zero by adjusting field rheostat of generator and SPST switch is closed.

MODEL GRAPH:



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**.**

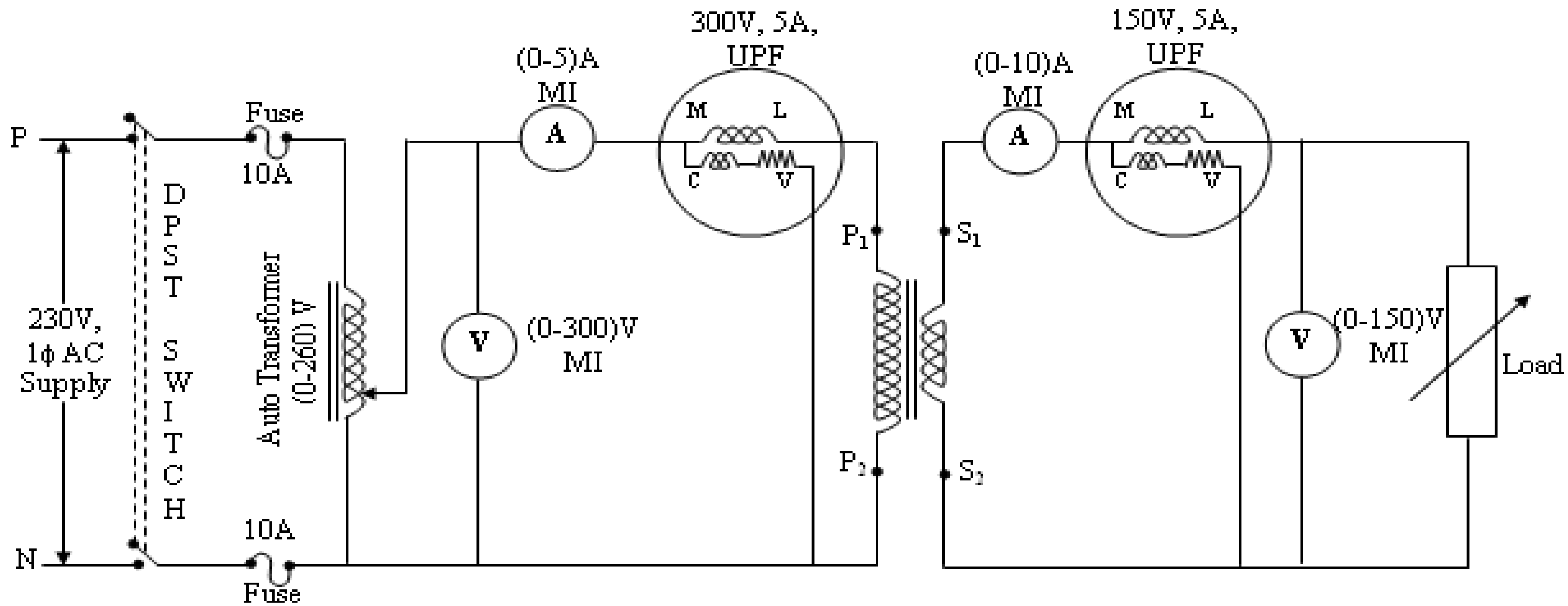
RESULT:

Thus Hopkinson's test is conducted on a pair of identical DC machines the efficiency of the machine as generator and as motor are pre-determined.

Viva Questions:

1. What are the advantages of Hopkinson's test over Swinburne's test and what are its limitations?
2. What is the function of no-voltage release (NVR) coil provided in a DC motor starter?
3. How does a 4-point starter differ from 3-point starter?
4. What are the other names of Hopkinson's test?
5. What are the advantages of Hopkinson's test?
6. A DC motor fails to start when switched on. What could be the reasons and remedies?
7. When does the armature of dc motor likely to get over-heated?
8. What is the function of interpoles?
9. How the interpoles are connected?
10. Name different methods of electrical braking of DC motors.

CIRCUIT DIAGRAM:



FUSE RATING:

125% of rated current

$$\frac{125 \times 5}{100} = 6.25A$$

NAME PLATE DETAILS:

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

LOAD TEST ON A SINGLE PHASE TRANSFORMER

Ex.No. 7

Date:

AIM:

To conduct load test on single phase transformer and to find 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

FORMULAE:

Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

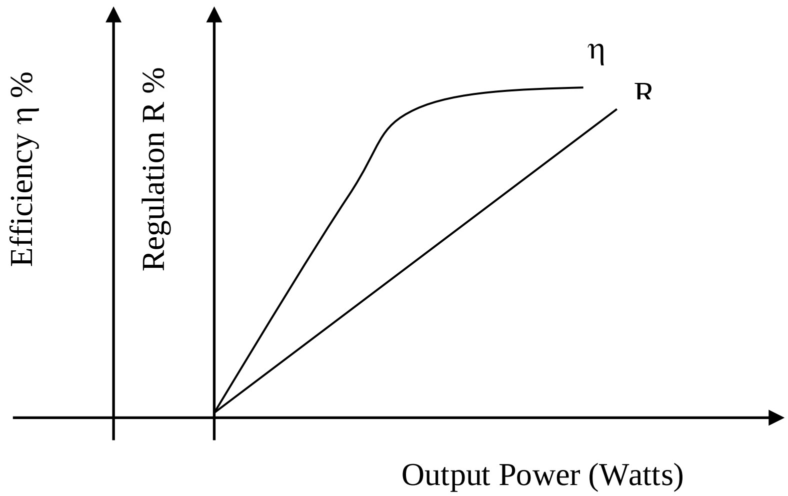
$$\text{Efficiency } \eta \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

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

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 (Amp)	W_1 (Watt)	V_2 (Volt)	I_2 (Amp)	W_2 (Watt)				
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											

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:

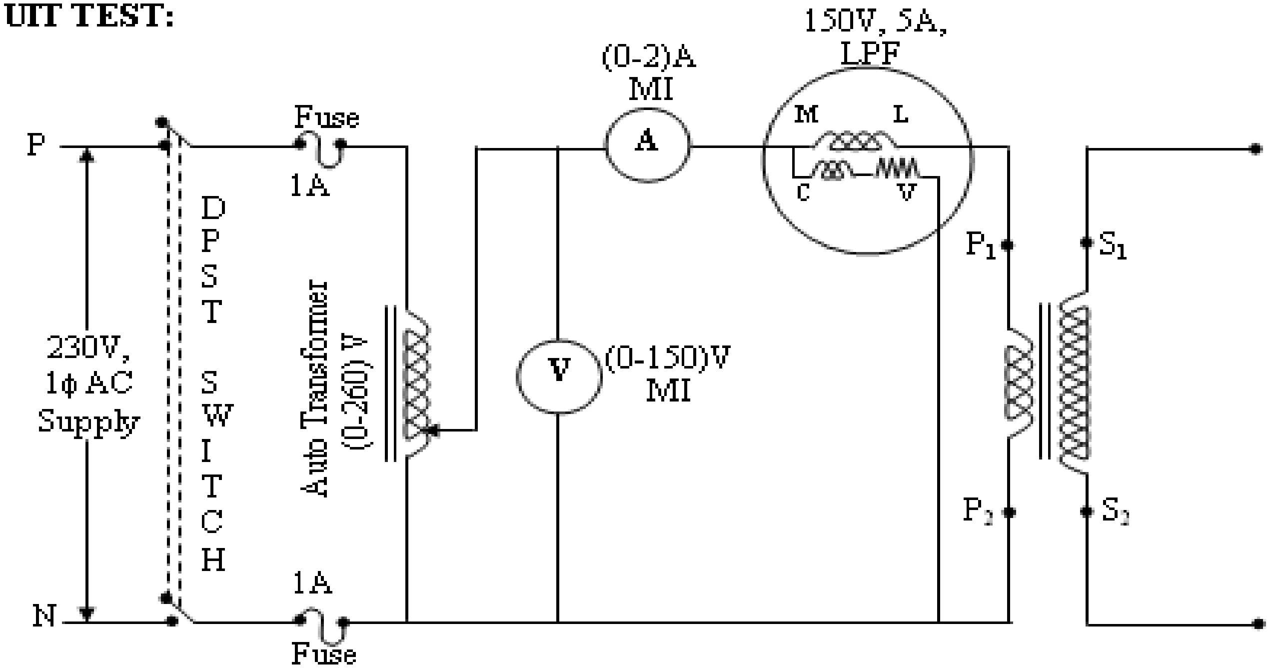
Thus the load test on single phase transformer is conducted.

Viva Questions:

1. What is the function of a transformer?
2. What is a load?
3. Why do we perform load test when the efficiency can be determined by O.C. and S.C. tests?
4. Mention the types of transformer.
5. Explain the operating principle of a transformer.
6. List out general applications of transformer.
7. What are core type transformers?
8. What are shell type transformers?
9. Distinguish between power and distribution transformer.
10. Define voltage regulation of a transformer.

CIRCUIT DIAGRAM:

OPEN CIRCUIT TEST:



FUSE RATING:

10% of rated current

$$\frac{10 \times 5}{100} = 0.5A$$

NAME PLATE DETAILS:

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

OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

Ex.No. 8

Date:

AIM:

To predetermine the efficiency and regulation of a transformer by conducting open circuit test and short circuit test and to 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: $W_o = V_o I_o \cos \phi_o$

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

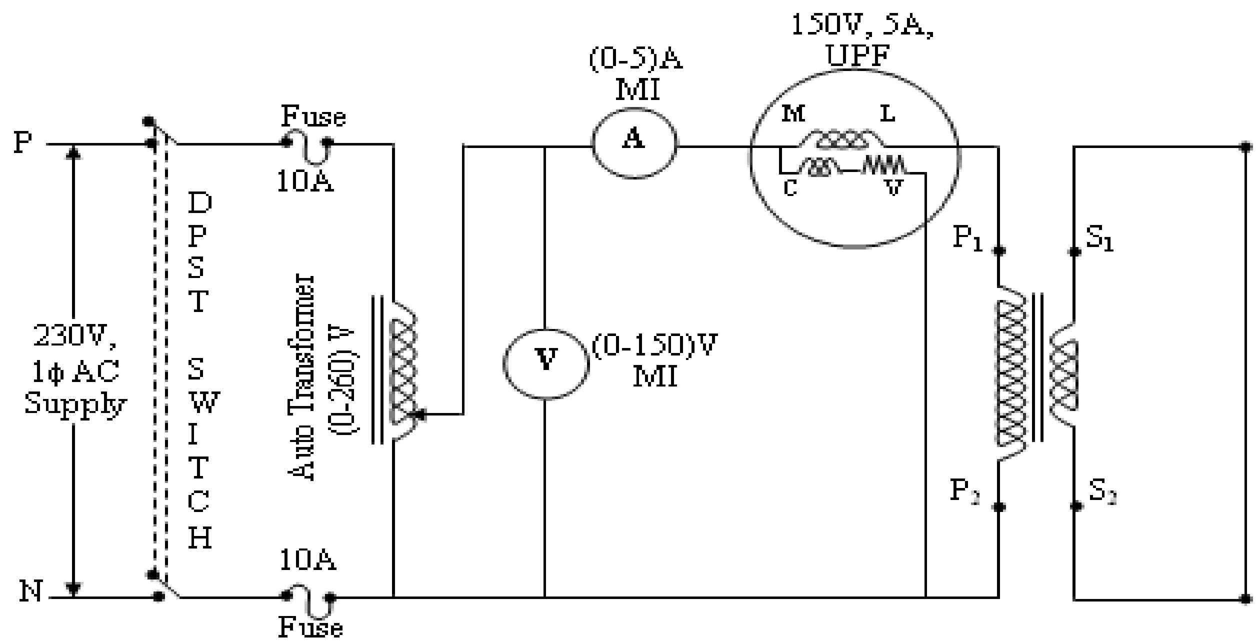
$I_\omega = I_o \cos \phi_o$ (Amps) $\qquad I_\mu = I_o \sin \phi_o$ (Amps)

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

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

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

SHORT CIRCUIT TEST:



FUSE RATING:

125% of rated current

$$\frac{125 \times 5}{100} = 6.25A$$

NAME PLATE DETAILS:

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

Percentage Efficiency: for all loads and p.f.

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

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

Percentage Regulation:

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

+ - 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

TABULAR COLUMN:

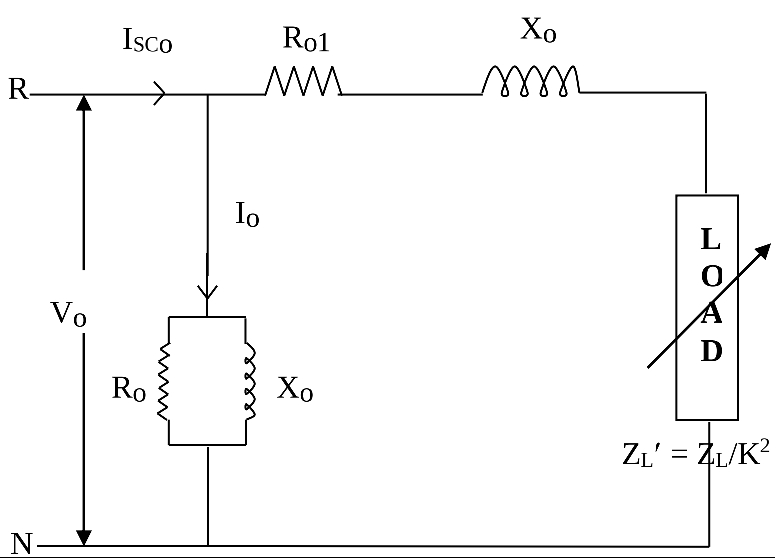
OPEN CIRCUIT TEST:

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

SHORT CIRCUIT TEST:

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

EQUIVALENT CIRCUIT:



PRECAUTIONS:

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

PROCEDURE:

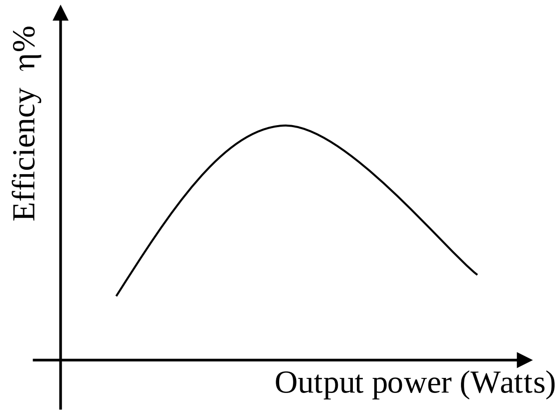
OPEN CIRCUIT TEST:

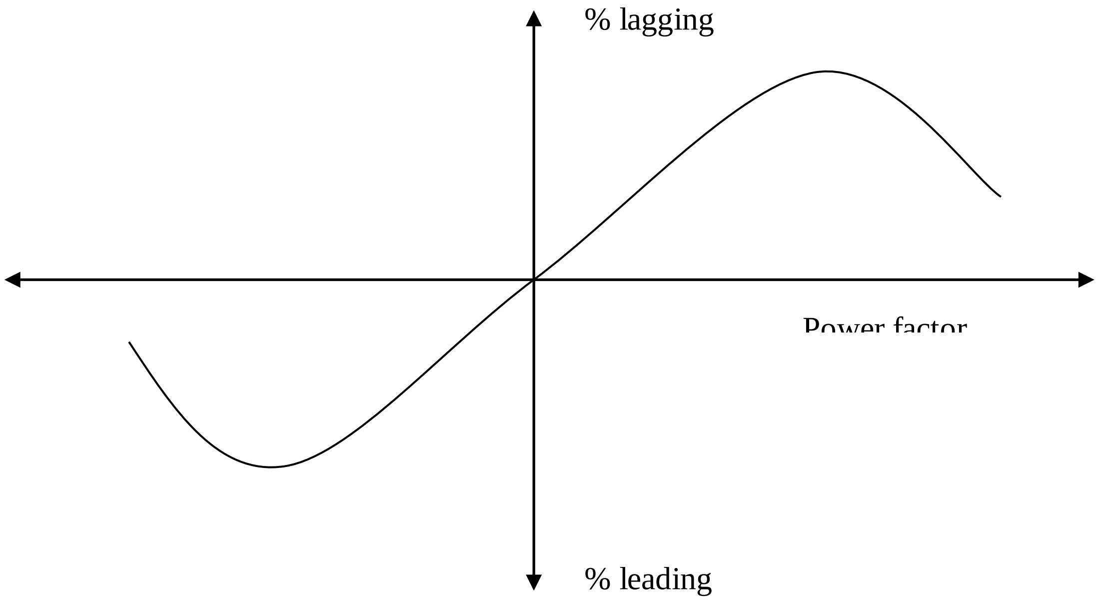
1. Connections are made as per the circuit diagram.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer variac is adjusted get the rated primary voltage.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again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

MODEL GRAPHS:

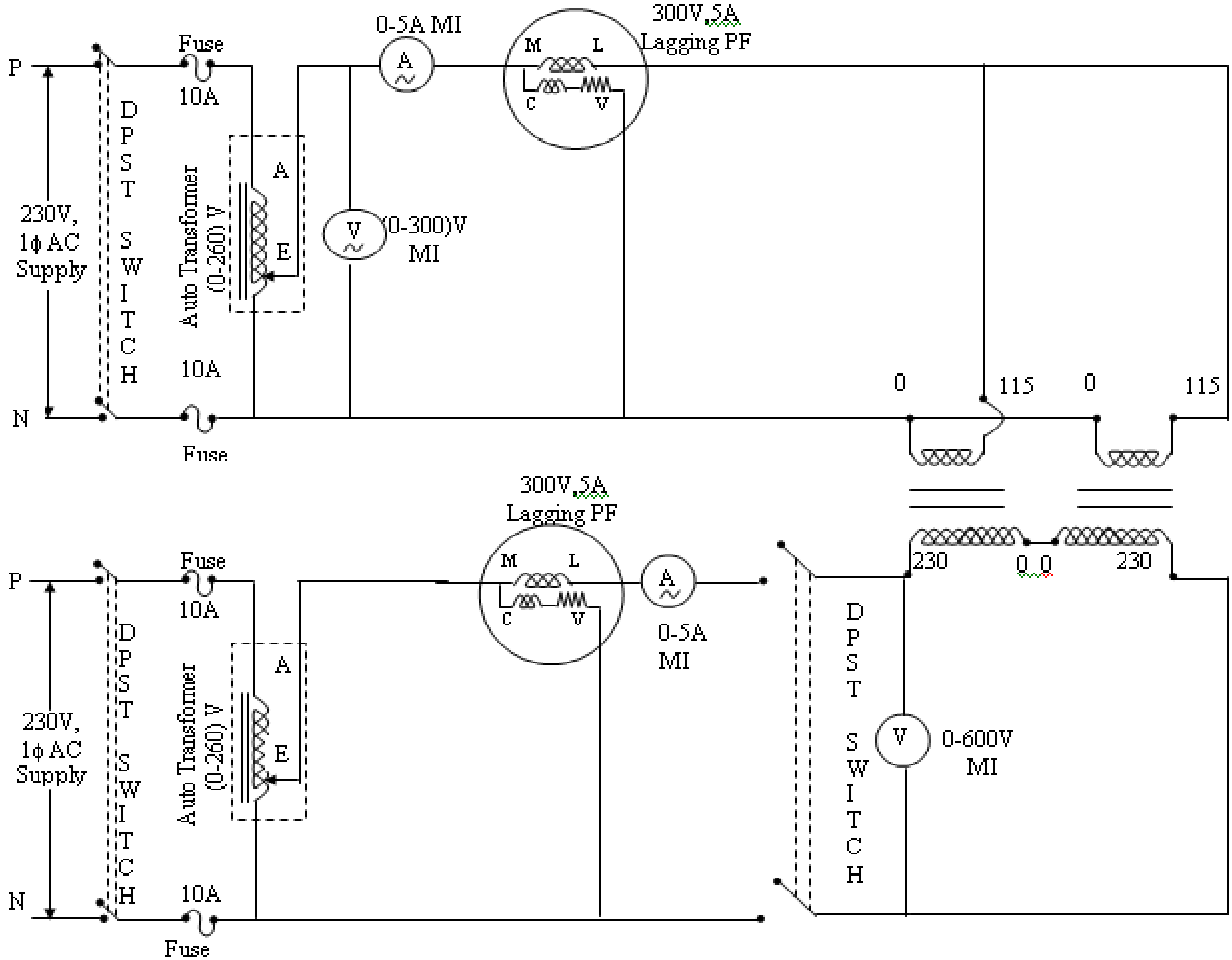




RESULT:

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.

CIRCUIT DIAGRAM:



SUMPNER'S TEST

Ex.No. 9

Date:

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

FORMULAE:

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

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

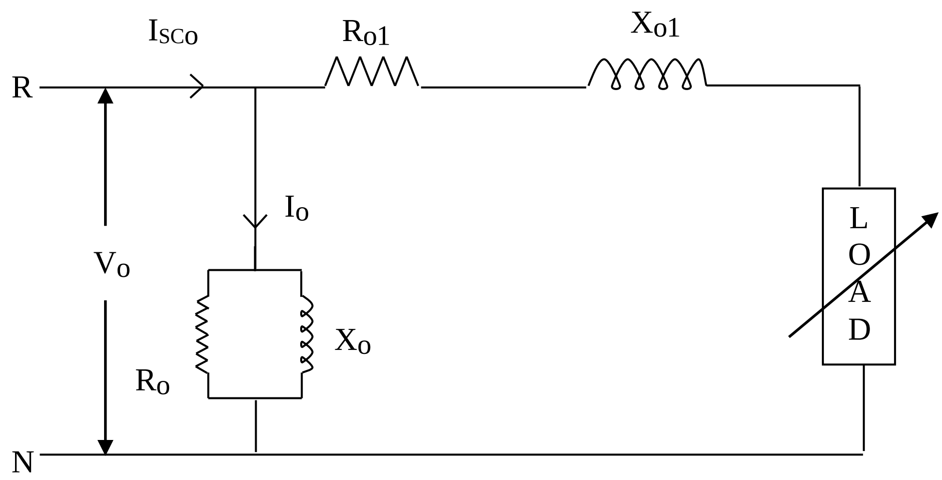
$W_o = V_1 I_1 \cos \varphi_o$ $\qquad \varphi_o = \cos^{-1} \frac{W_o}{V_1 I_1}$ $\qquad I_1 = \frac{I_o}{2}$ A

$Iw = I_1 \cos\Phi o$ $\qquad I\mu = I_1 \cos\Phi$ $\qquad V2 = Vs/2 \times A$

$Ro = V_1 / Iw$ $\qquad Xo = V_1 / I\mu$ $\qquad R_{o2} = Wc / I2^2$ $\qquad Z_{o2} = V_2 / I_2$

$Xo_2 = \sqrt{Zo_2^2 - Ro_2^2}$ $\qquad$ Copper loss at various loads $= I_2^2 Ro_2$

EQUIVALENT CIRCUIT:



PERCENTAGE REGULATION:

1. Upf : I_2 / V (Ro_2 CosΦo) X 100

2. Lagging pf : I_2 / V (Ro_2 CosΦo + Xo_2SinΦo) X 100

3. Leading pf : I_2 / V (Ro_2 CosΦo - Xo_2SinΦo) X 100

Output Power (1) Upf : 3Kw
(2) Pf : 3Kw CosΦo

Input Power = Output Power + Core loss + Cu loss

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

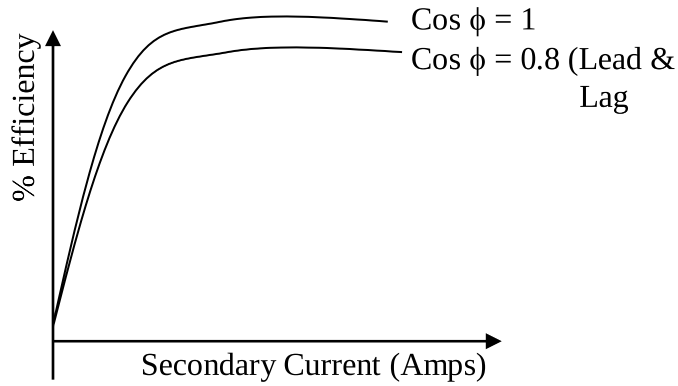
PRECAUTIONS:

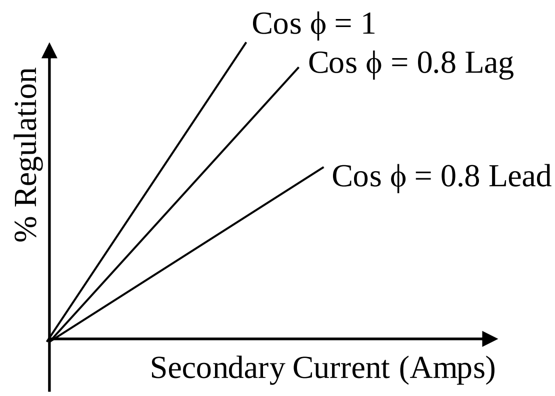
1. Auto Transformer whose variac should be in zero position, before switching on the ac supply.
2. Transformer should be operated under rated values.

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.

MODEL GRAPHS:



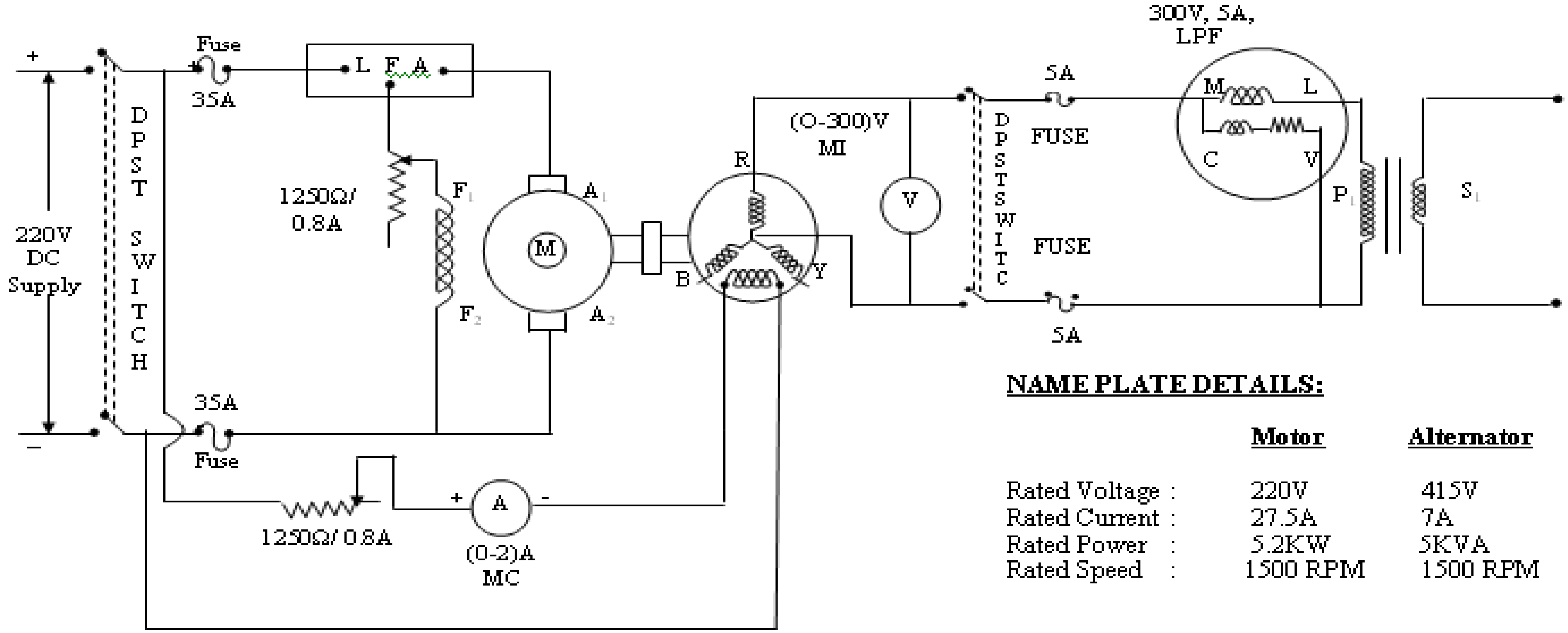


6. The secondary is now switched on and SPST switch is closed with variac of auto transformer is zero.
7. After switching on the secondary the variac of transformer (Auto) is adjusted so that full load rated secondary current flows.
8. Then the readings of wattmeter, Ammeter and voltmeter are noted.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

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.

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

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

NAME PLATE DETAILS:

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

SEPARATION OF NO LOAD LOSSES IN A SINGLE PHASE TRANSFORMER

Ex.No. 10

Date:

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

FORMULAE:

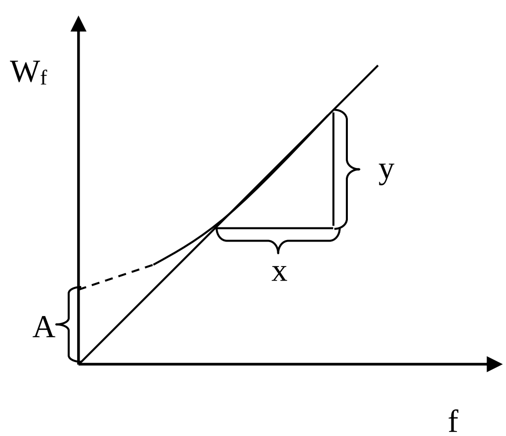
1. Frequency, $f = (P*N_S) / 120$ in Hz
   P = No.of Poles   Ns = Synchronous speed in rpm.
2. Hysteresis Loss $W_h = A * f$ in Watts
   A = Constant (obtained from graph)
3. Eddy Current Loss $W_e = B * f^2$ in Watts
   B = Constant (slope of the tangent drawn to the curve)
4. Iron Loss $W_i = W_h +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

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 $\Delta(W_i / f) / \Delta f$

TABULAR COLUMN:

S.No	Speed N (rpm)	Frequency f (Hz)	Voltage V (Volts)	Wattmeter reading Watts	Iron loss Wi (Watts)	W_i / f Joules
1.						
2.						
3.						
4.						
5.						

MODEL GRAPH:



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.

RESULT:

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