

EE8311- ELECTRICAL MACHINES – I LABORATORY

SYLLABUS

COURSE OBJECTIVES

To validate the principles studied in theory by performing experiments in the laboratory

LIST OF EXPERIMENTS

1. Open circuit and load characteristics of DC shunt generator- critical resistance.
2. Load characteristics of DC compound generator with differential and cumulative connections.
3. Load test on DC shunt and compound motor.
4. Load test on 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 transformers.
8. Open circuit and short circuit tests on single phase transformer.
9. Polarity Test and Sumpner's test on single phase transformers.
10. Separation of no-load losses in single phase transformer.
11. Study of starters and 3-phase transformers connections.

COURSE OUTCOMES

1. Ability to perform the Open circuit and load characteristics of DC shunt generator- critical resistance.
2. Ability to understand the Load characteristics of DC compound generator with differential and cumulative connections.
3. Ability to perform the Load test on DC shunt control
4. Ability to perform the load test on compound motor.
5. To perform the Load test on DC series motor.
6. Ability to perform the Swinburne's test
7. Ability to perform the DC shunt motor.
8. Ability to perform the Hopkinson's test on DC motor – generator set.
9. Ability to perform the Load test on single-phase transformer.
10. Ability to perform the Load test on three-phase transformer.
11. Ability to perform the Open circuit and short circuit tests on single phase transformer.
12. Ability to perform the Polarity test on single phase transformers.
13. Ability to perform the Sumpner's test on single phase transformers.
14. Ability to perform the Separation of no-load losses in single phase transformer.
15. Ability to study the different types of starters and 3-phase transformers connections.

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Expt.No.1 OPEN CIRCUIT AND LOAD CHARACTERISTICS OF DC SHUNT GENERATOR

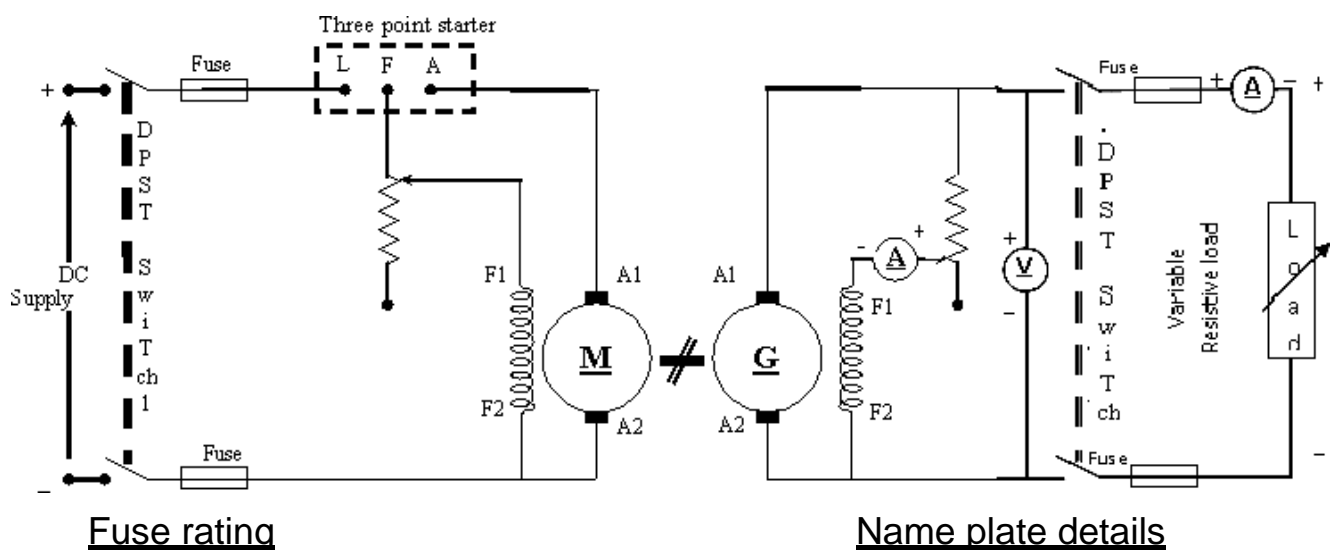
Aim:

To obtain open circuit characteristics and load characteristics of a DC shunt generator and find its critical resistance

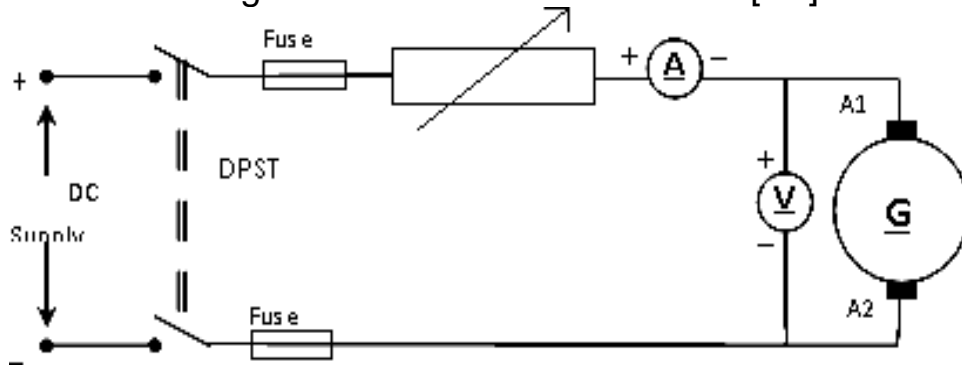
Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

Circuit Diagram:



Circuit diagram for find the generator armature resistance [R_a]



Precautions:

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

Procedure:

Open circuit test:

1. Make circuit as per the circuit diagram.
2. Close the DPST switch on motor side and motor start with the help of starter.
3. Adjust the motor field rheostat, till the runs at its generator rated speed.
4. Note down The voltage induced due to residual flux in the voltmeter connected across the armature circuit.
Close the SPST switch in field circuit of the generator.
5. The generator field rheostat in steps. At each step note down ammeter and voltmeter readings.
6. Repeat the above procedure till the voltmeter reads rated field current of the generator.
7. Reduce the terminal voltage of generator by varying generator field rheostat.
8. Reduce the speed of the motor by varying motor field rheostat.

Load test:

1. Adjust field rheostat of generator till armature induced emf reaches its rated voltage.
2. Close the DPST switch on generator load side.
3. Vary the load in steps, for each step of load note down the load current, field current, terminal voltage. Maintain the rated speed of the generation at each step of load.
4. Vary the load till ammeter reads the rated current of generator.

- Remove the load on generator in steps and open DPST switch on generator side.
- Vary Generator field rheostat to make generator and terminal voltage zero. Vary the motor field rheostat to reduce the motor speed.
- Open the DPST switch on supply side.

To find armature resistance R_a :

- Load on the loading arrangement should be zero.
- Close the DPST switch and vary the resistive load for various values and note down the corresponding values.
- Open the DPST switch after load brings to its initial condition.

Observation:

Open circuit test:

SL. No.	Field Current I_f (A)	Armature Voltage E_o (V)

Load test:

SL. No.	Field Current I_f (A)	Load Current I_L (A)	Terminal Voltage (V)	$I_a = I_L + I_f$ (A)	$E_g = V + I_a R_a$ (V)
1					

To find armature resistance R_a :

SL. No.	Armature voltage V_a in volts	Armature current (I_a) in amps	$R_a = V_a / I_a$ in ohms

Calculation:

$$E_g = V + I_a R_a \text{ (V)}$$

$$I_a = I_L + I_f \text{ (A) [for self Excited]}$$

Armature Resistance- R_a : _____ ohm

Where

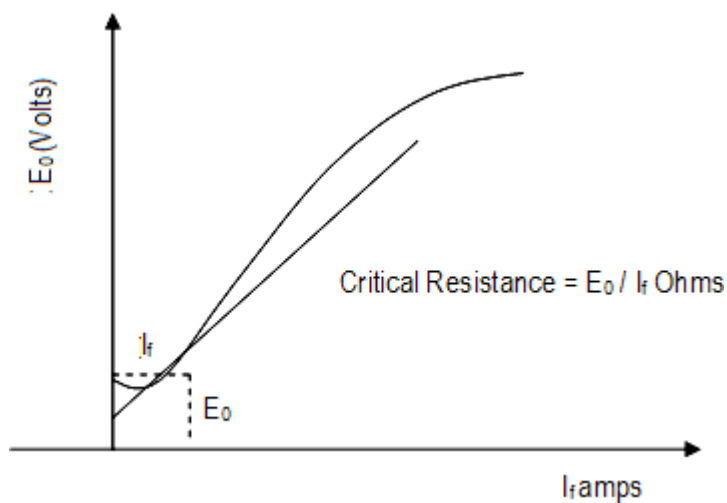
E_g : Generated EMF in V

V : Terminal Voltage in V

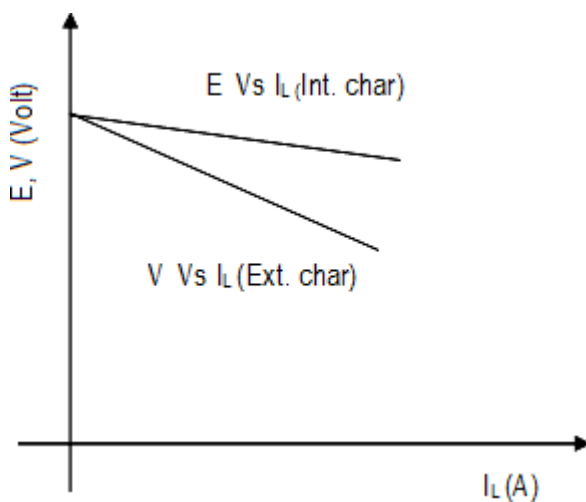
I_a : Armature Current in A

I_L	:	Line Current in A
I_f	:	Field Current in A
R_a	:	Armature Resistance in Ohm

Model graph:
Open Circuit test



load test



Result:

Thus the open circuit characteristics and load characteristics of a self-excited DC shunt generator were plotted and its critical resistance was obtained.

Outcome:

By conducting the open circuit test and load test the open circuit characteristics and load characteristics of a DC shunt generator with its critical resistance was understood.

Applications:

Shunt generators are used in supplying nearly constant loads. They are used for battery charging, for supplying the fields of synchronous machines and separately excited DC machines.

Viva – voce

1. How can you find the residual voltage of the generator?
2. State Faradays' law of electromagnetic induction and interaction.
3. What is the difference you can see experimentally between self excited and separately excited?
4. If any other prime mover can be used in this experiment?
5. What is a magnetization characteristic of DC generator?
6. What is meant by critical resistance of a generator?
7. What is meant by critical speed?
8. Why in a DC machine, the armature core should be laminated?
9. What are the applications of DC shunt generator?
10. What will be the no load emf, when the no load speed changes to 1000rpm?
11. What happen if the field current of the DC motor varies during load test?
12. What are the factors which represent the nature of external characteristics in DC shunt generator?
13. When load increases there is fall in generated voltage why?
14. What is the effect of armature reaction on external and internal characteristics of DC shunt generator?

Expt. No.2.LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR WITH DIFFERENTIAL AND CUMULATIVE CONNECTIONS

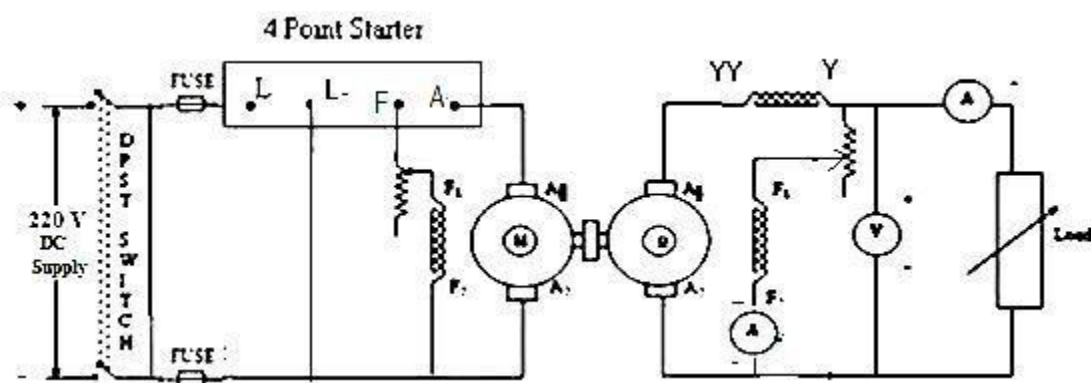
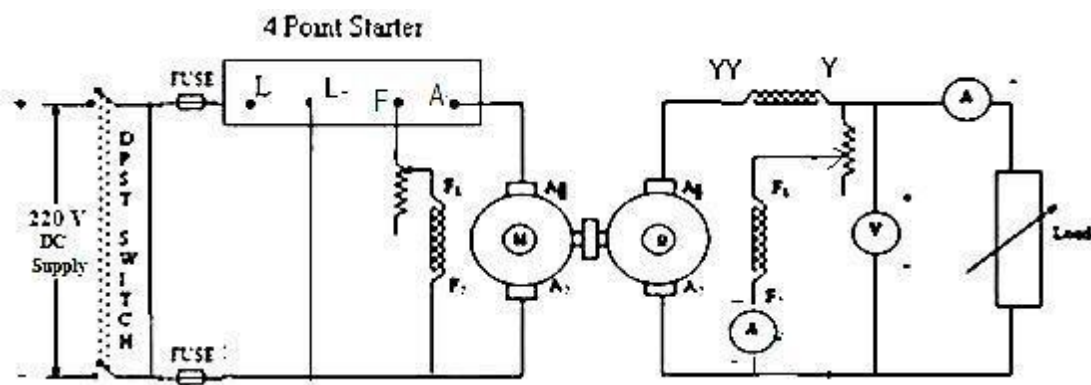
Aim:

To conduct the load test on the given DC compound generator with cumulative and differential connections.

Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

Circuit diagram:



Name Plate details

Precautions:

1. All the switches should be kept open at the time of starting.
2. The field rheostat of the motor should be kept at minimum resistance position.
3. The field rheostat of the generator should be kept at maximum resistance position.

Procedure:

1. Make the connections are made as per the circuit diagram.
2. Close the DPST switch on motor side.
3. Start the motor using four point starter.
4. Adjust the field rheostat of the motor to bring the motor speed to the rated speed of the generator.
5. Adjust the generator field rheostat till the voltmeter reads the rated voltage of the generator.
6. Close the DPST switch on generator.
7. Increase the load in steps.
8. At each step of loading, Note down the load current and load voltage.
9. The above procedure is repeated till the rated current.
10. Switch off the load gradually and make the motor and generator rheostat resistance position as instructed in the precaution.
11. Open the DPST switch on generator side and turn on motor
12. Interchange the terminal connection of the generator series field coil and repeat the procedure right from step.

Observation:

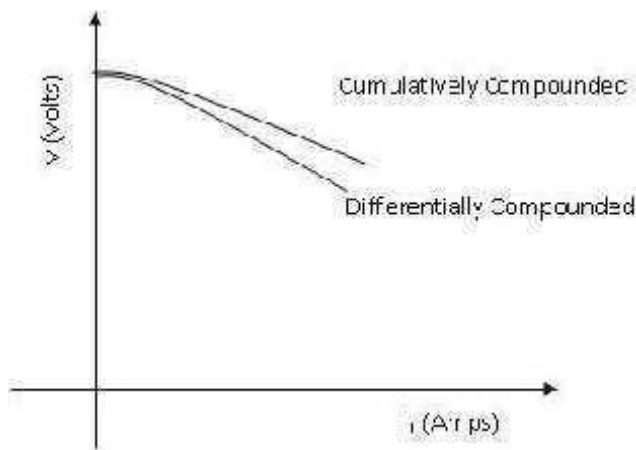
Cumulative Compound

SL. NO.	$I_L(A)$	$V_L(V)$

Differential Compound

SL. NO.	$I_L(A)$	$V_L(V)$

Model graph:



Result:

Thus the performance characteristics of the given DC compound generator were drawn for differential and cumulative connection.

Outcome:

The performance characteristics of the DC compound generator in cumulative and differential mode were verified.

Applications:

Cumulative Compound wound Generators are generally used Lighting, power supply purpose and for heavy power services because of their constant voltage property.

Viva – voce

1. Mention the basic requirements for the production of emf.
2. What causes sparking at the brushes?
3. Which rule gives the direction of induced emf?
4. Classify compound generator.
5. What is the relationship between flux and induced emf?
6. What is meant by armature reaction?
7. Differentiate over excitation and under excitation.
8. What are the applications of DC compound generator?
9. How can u compensate the fall in terminal voltage of a DC generator?
10. What will be the voltage across the shunt field winding of a level compound generator?
11. What will be the voltage across the shunt field winding in long shunt and short shunt connection?
12. Which type of compound generator will give drooping characteristics?
13. Can the series field and shunt field can be interchanged?

Expt. No.3 LOAD TEST ON DC SHUNT MOTOR

Aim:

To obtain the performance characteristics of the given D.C. shunt motor by conducting load test.

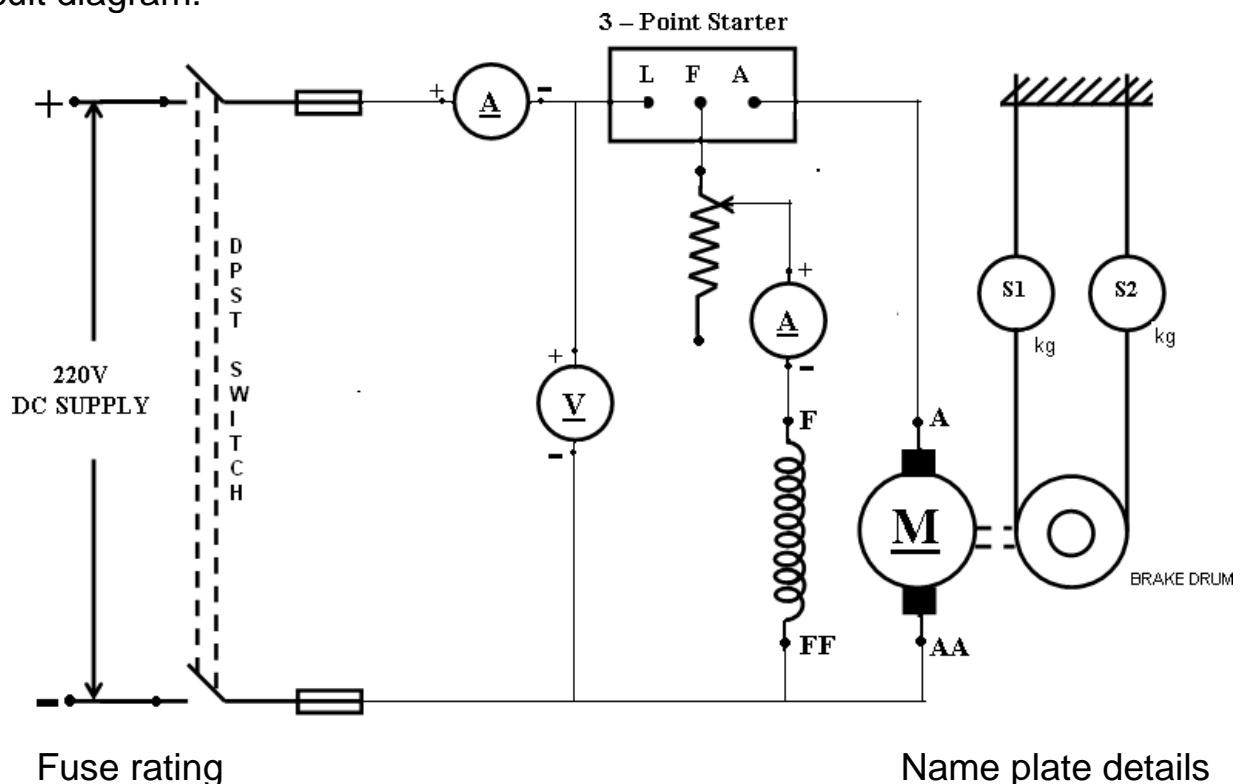
Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

Theory:

The performance of DC shunt motor such as torque, efficiency and speed with respect to output power can be determined by conducting an actual load test. This type of test is conducted on small capacity machines normally in the laboratories to study the behavior of the motor for different load conditions. The frictional load is introduced and the speed decreases and back emf reduces which will increase the current taken by the motor from the supply. Likewise for different frictional loads the motor parameters such as speed, torque and efficiency are studied.

Circuit diagram:



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. Make connections as per the circuit diagram.
2. Close the DPST switch and start motor using 3 point starter.
3. Adjust the field rheostat of the motor and run the motor at its rate speed.
4. Note down the Ammeter, Voltmeter readings, speed and spring balance readings under no load condition.
5. Increase the load on the motor in steps and at each step of load note down voltmeter, ammeter, spring balance readings and measure the speed of the motor.
6. Repeat the above procedure till ammeter reads 125% of the rated current.
7. Decrease the load on the motor & reduce the speed by adjusting motor field rheostat.
8. Open the DPST switch.

Observation:

Circumference of the Brake drum = _____ cm.

Sl.No	Voltage V_L (Volts)	Current I_L (Amps)	Spring Balance Reading		S= $S_1 \sim S_2$ (Kg)	Speed N (rpm)	Torque T (Nm)	Input Power P_i (Watts)	Output Power P_o (Watts)	Efficiency $\eta\%$
			S_1 (Kg)	S_2 (Kg)						

Calculation:

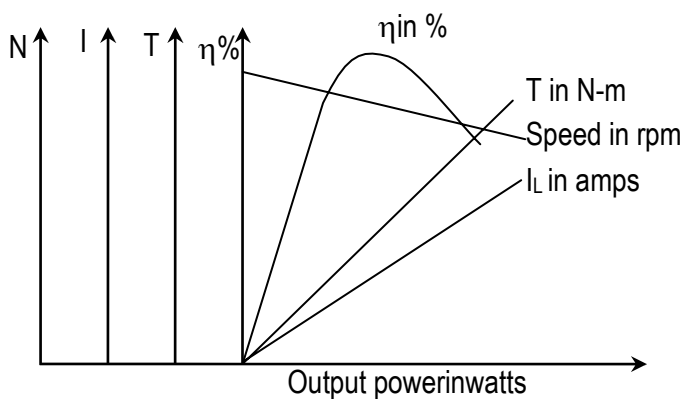
1. Circumference = $2 \pi r$
 Radius = $r = \text{Circumference} / (2 \pi)$
 = _____ meter
2. Torque (T) = $S * 9.81 * r$ Nm
3. Input Power (P_i) = $V_L * I_L$ watts
4. Output power (P_o) = $2\pi NT/60$ watts
5. Efficiency (η) = (Output power / Input power) X 100%

Where,

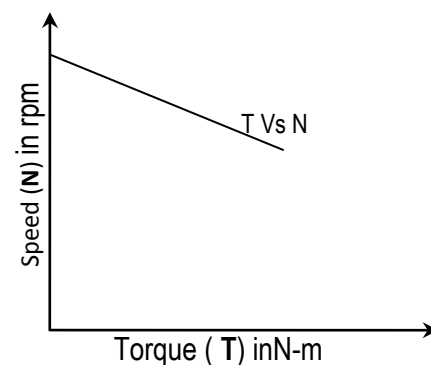
S	-	Load
r	-	Radius of brake
drum. V_L	-	Line Voltage
I_L	-	Line current
N	-	Speed in rpm
T	-	Torque in Nm

Model graph:

(a) Electrical characteristics



(b) Mechanical characteristics



Result:

Thus the load test on DC shunt motor was performed and its characteristics were drawn.

Outcome:

By conducting the load test on DC shunt motor the efficiency and the following performance characteristics: 1) Efficiency vs Output power (2) Torque vs Output power (3) Speed vs Output Power (4) Line current vs Output Power (5) Torque vs Speed were understood.

Applications:

The various applications of DC shunt motor are in Lathe Machines, Centrifugal Pumps, Fans, Blowers, Conveyors, Lifts, Weaving Machine, Spinning machines, etc

Viva – voce

1. What is the need for a starter?
2. Why a DC shunt motor is called a constant Speed motor?
3. State few applications of DC shunt motor.
4. How to reverse the direction of rotation of DC shunt motor?
5. Why the field rheostat of DC motor is kept at minimum resistance position while starting?
6. What are the mechanical and electrical characteristics of a DC shunt motor?
7. What is back emf in a dc motor?
8. How the input current increases as load increases?
9. What will be the effect of armature reaction in performance of dc shunt motor?

Expt. No.4 LOAD TEST ON DC COMPOUND MOTOR

Aim:

To draw the performance characteristics of the given DC compound motor by conducting load test.

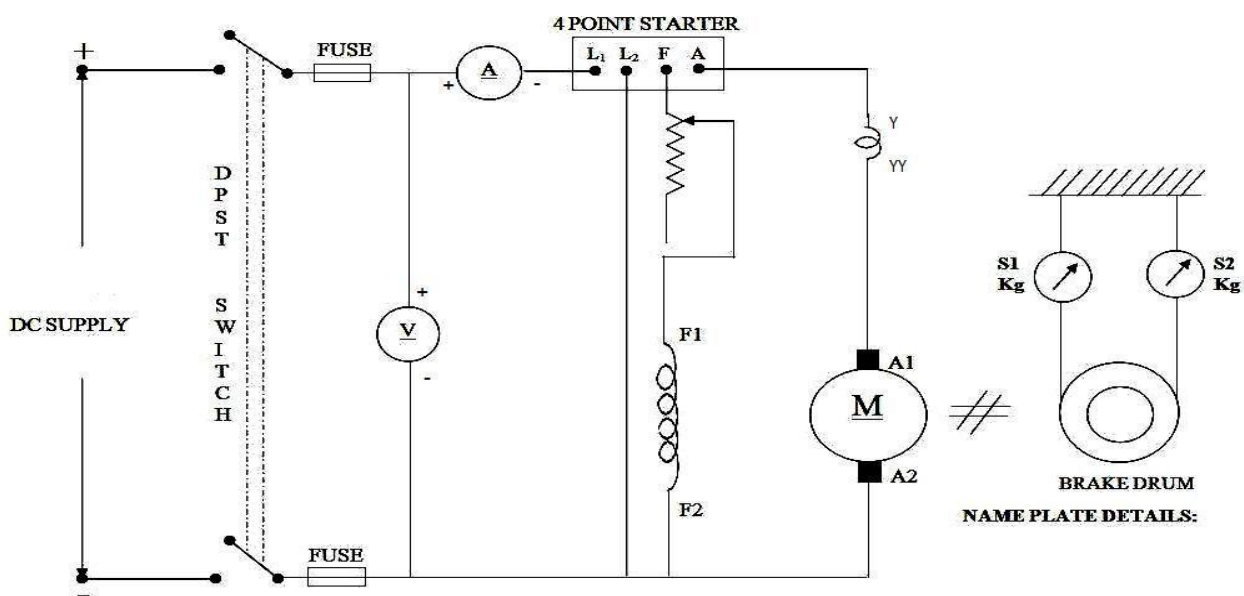
Apparatus Required:

SL. No.	Name of the equipment	Range & Type	Quantity

Differentially Compounded motor:

In this motor, the flux produced by both Field windings opposes each other. The graph between VL and IL is the External characteristic of the motor. The graph between E and Ia is the Internal characteristic of the motor.

Circuit diagram:



Fuse rating

Name plate details

Precautions:

1. The motor field rheostat should be kept at minimum resistance position at the time of starting.
2. The DPST switch and be kept in open position.

Procedure:

1. Circuit connections make the as per the circuit diagram.
2. Close the DPST switch.
3. State the motor using 4 point starter.
4. Adjust the motor field rheostat to get the rated speed.
5. Note down the ammeter, voltmeter spring balance reading at no loads and space.
6. The load in steps and note down voltmeter, ammeter, spring balance readings & speed are noted for various loads up to the rated current.

Observation:

Sl. No.	Voltage V_L (V)	Current I_L (A)	Spring Balance Reading		$S = S_1 - S_2$ (Kg)	Speed N (rpm)	Torque T (Nm)	Input Power P_i (W)	Output Power P_o (W)	Efficiency $\eta\%$
			S_1 (Kg)	S_2 (Kg)						
1										

Calculation:

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

Where,

S_1, S_2 are spring balance readings in kg.

R is Radius of brake drum in m.

Input power (P_i) = $V_L \times I_L$ watts

Where,

V_L is the line voltage in volts.

I_L is load current in A

$$\text{Output power (Po)} = (2\pi NT)/60$$

Where

N is Speed of motor in rpm.

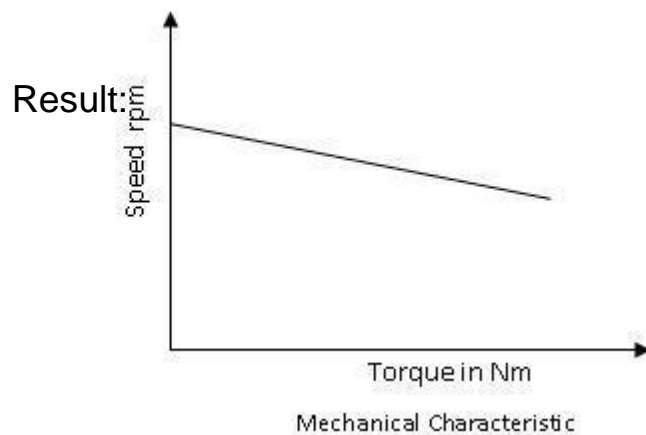
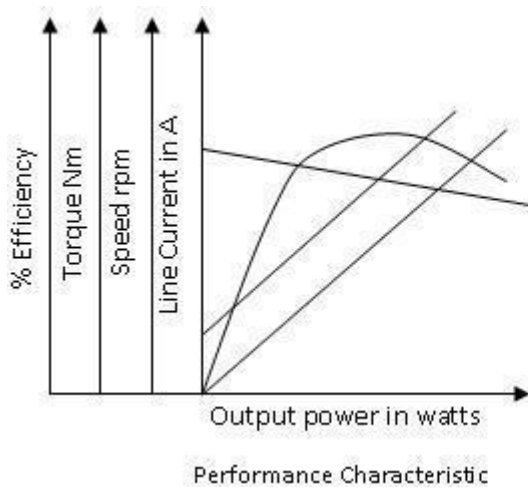
T is Torque in Nm.

$$\% \text{ Efficiency} = (P_o / P_i) \times 100$$

Circumference of brake drum $2\pi r =$ _____ m

Radius of brake drum = _____ m

Model Graph:



Result :

Thus the performance characteristics of the given DC compound motor were determined.

Outcome:

By conducting the load test on DC compound motor, the performance characteristic was understood.

Applications:

Compound motors are rarely used Presses Shears, Reciprocating machine because of its poor torque characteristics.

Viva – voce

1. What is the need for a starter?
2. State few applications of DC shunt motor.
3. What is the role of commutator in a DC motor?
4. State the principle operation of DC motor.
5. How may the direction of DC motor be able to be reversed?
6. Why the field rheostat of DC motor is kept at minimum position while starting?
7. What will happen if the field of the DC motor is opened while delivering load?
8. What will happen if both the field current and armature current are reversed?
9. Why should the field rheostat be kept in the position of minimum resistance?
10. What is the loading arrangement used in a DC motor?
11. What are the applications of a DC compound motor?
12. What is meant by torque?

Expt. No. 5 LOAD TEST ON DC SERIES MOTOR

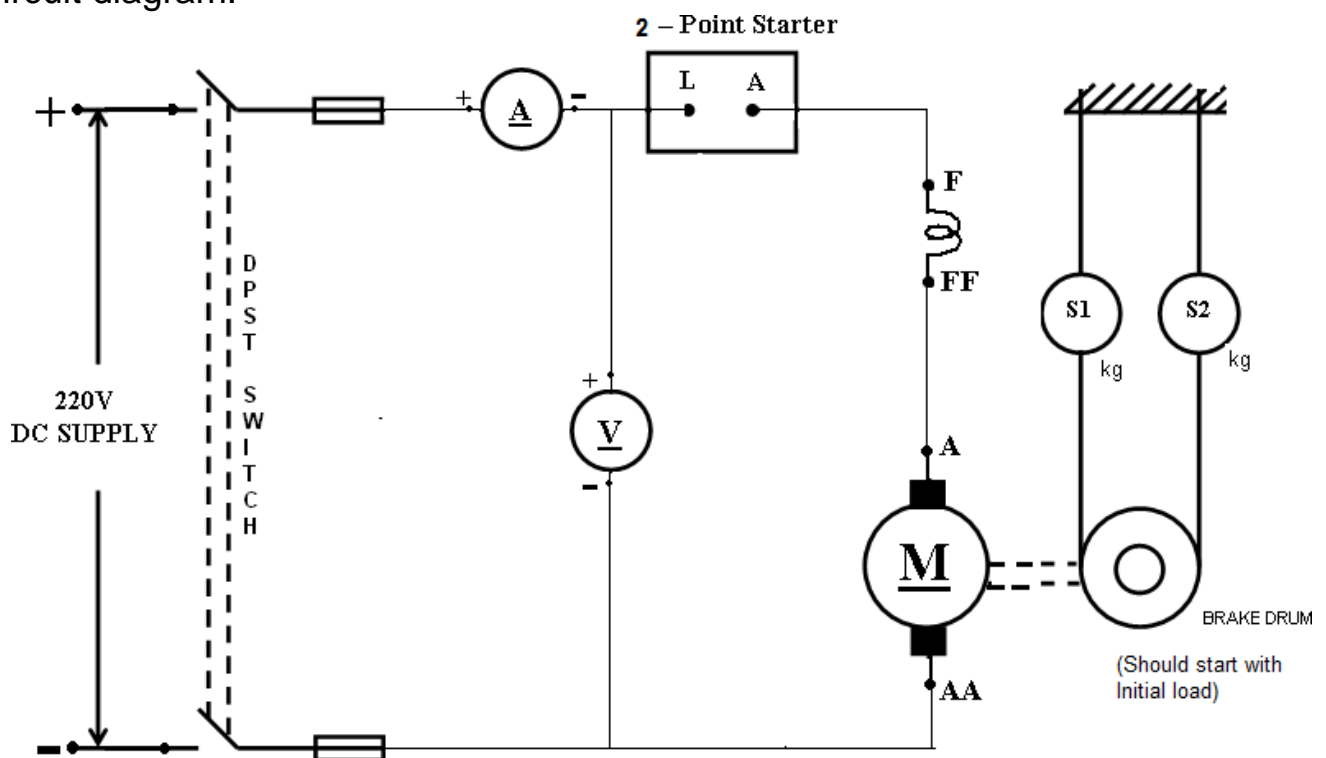
Aim:

To obtain the performance characteristics of a DC series motor by conducting load test.

Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

Circuit diagram:



Fuse rating

Name plate details

Precautions:

1. DC series motor should be started and stopped with initial load.
2. Brake drum should be cooled with water when it is under load.

Procedure:

1. Make circuit as per the circuit diagram.
2. Close the DPST switch and start the motor using 2-point starter.
3. Note down the readings of ammeter, voltmeter, speed and spring balance readings on initial condition.
4. Increase the load on in steps the motor and at each step of load, note down voltmeter, ammeter, spring balance readings and speed of the motor.
5. Repeat the above procedure till the ammeter read the rated current of the motor.
6. Reduce the load on the motor to the initial load condition.
7. Open the DPST switch.

Observation:

Circumference of the Brake drum=_____cm.

Sl.No.	Voltage V_L (Volts)	Current I_L (Amps)	Spring Balance Reading		$S=S_1 \sim S_2$ (Kg)	Speed N (rpm)	Torque T (Nm)	Input Power P_i (Watts)	Output Power P_o (Watts)	Efficiency $\eta\%$
			S_1 (Kg)	S_2 (Kg)						

Calculation:

1. Radius of Brake Drum

$$\text{Circumference} = 2 \pi r =$$

$$\text{Radius} = r = \text{Circumference} / (2 \pi)$$
$$= \underline{\hspace{2cm}} \text{ meter}$$

2. Torque (T) = $S \times 9.81 \times r$ Nm
3. Input Power (Pi) = $V_L \times I_L$ watts
4. Output power (Po) = $2\pi NT/60$ watts
5. Efficiency (η) = Output power / Input power X 100 %

Where,

S	-	Load
r	-	Radius of brake drum.
V_L	-	Line Voltage
I_L	-	Line current
N	-	Speed in rpm
T	-	Torque in Nm

Result:

Thus the load test on DC series motor was performed and its characteristics were drawn.

Outcome:

By conducting the load test on DC series motor the efficiency and the following performance characteristics:

1) Efficiency vs Output power (2) Torque vs Output power (3) Speed vs Output Power (4) Line current vs Output Power (5) Torque vs Speed were understood.

Applications:

DC series motors are basically used where the requirement is high starting torque. In earlier days, it was used in cranes, lift, etc.. But in low power applications, series dc motors which can also be used as universal motors (motors which work both on ac and dc) are used like mixer, grinder, etc.

Viva – voce

1. Why a DC series motor should not be started without load?
2. Why a DC series motor has a high starting torque?
3. Compare the resistances of the field windings of DC shunt and series motor?
4. What are the applications of DC series motor?
5. Comment on the Speed – Torque characteristics of a DC series motor.
6. What is the precaution to be taken when working with a D.C series motor?
7. What is the need for starter with a D.C motor?
8. How does a 2-point starter function?
9. Explain the shape of the electrical and mechanical characteristics.
10. What is the condition for maximum efficiency in a D.C motor?
11. What are the different losses occurring in a D.C machine?
12. How are the meter ratings selected for this experiment?
13. Give some applications of D.C series motor

Expt. No.6 SWINBURNE'S TEST OF A DC SHUNT MOTOR

Aim:

To predetermine the efficiency of the given DC shunt machine while running as a motor and as a generator by conducting Swinburne's test

Apparatus required:

Sl.No.	Apparatus Name	Range	Type	Quantity

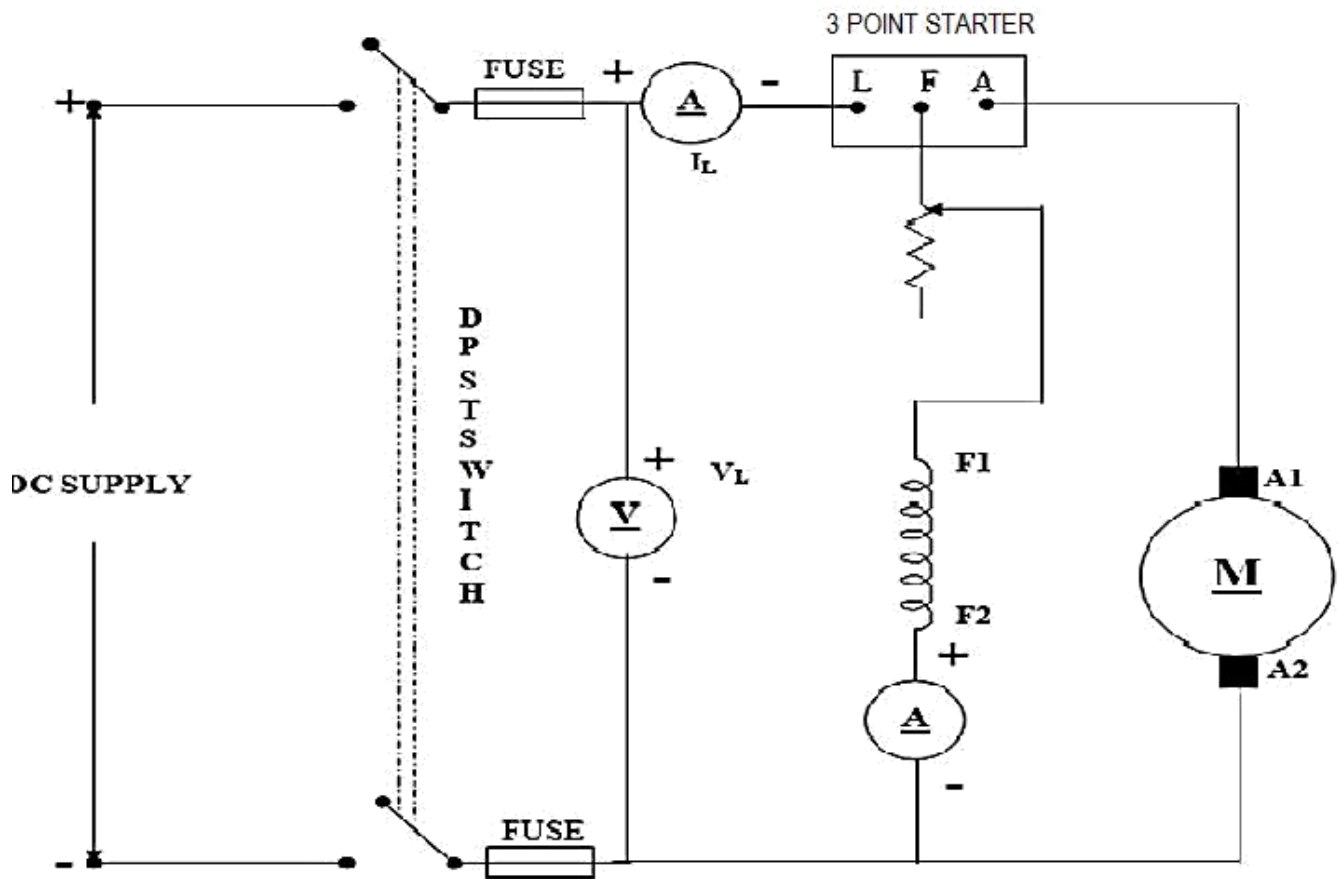
Precautions:

1. The field rheostat should be kept at minimum resistance position.
2. There should be no load on the brake down at the time of starting the experiment.

Procedure:

1. Make the connections as per the circuit diagram.
2. Close the DPST switch and start the motor using three point starter.
3. Adjust the motor field rheostat is adjusted to run the motor at rated speed.
4. At rated speed, note down the values of line voltage, no load current.
5. Calculate and tabulate the efficiency of the machine as a motor and as a generator for each assumed load current up to rated current.
6. Drawn the characteristic curve between the output power and efficiency for both the cases

Circuit Diagram:



Fuse Rating

Name Plate Details

Observation:

Sl. No.	Line voltage V_L (Volts)	Line current I_L (A)	Field current I_f (A)

Performance of DC Machine as a Motor

Armature Resistance=

Line Voltage=

Constant Loss=

I_f =

Sl. No.	Load current I_L (A)	Armature current $I_a = I_L - I_f$ (A)	Armature Copper loss $I_a^2 r$ (W)	Total loss $W_c + W_{cu}$ (W)	Input power $V_L I_L$ (W)	Output power (W)	Efficiency %

Performance of DC Machine as a Generator

Armature Resistance=

Line Voltage=

Constant Loss=

Sl. No.	Load current I_L (A)	Armature current $I_a = I_L + I_f$ (A)	Armature Copper loss $I_a^2 r$ (watts)	Total loss $W_c + W_{cu}$ (watts)	Output power $V_L I_L$ (watts)	Input power (watts)	Efficiency %

Calculation:

Input Power = output power + total losses (W) at no load output power = 0

Input power = total losses (W)

Total losses = copper loss+ constant loss (Wc)

Constant loss=total loss-copper loss

Wc=input power at no load - copper loss

For Motor

$I_a = I_L - I_f$

Constant loss $W_c = V_L I_L$ (at no load)- $I_a^2 R_a$ Watts

Copper loss= $I_a^2 R_a$ Watts

Total loss = copper loss+ constant loss watts

Input power $P_i = V_L I_L$ Watts

Output power $P_o =$ input power- total losses Watts

For Generator

$I_a = I_L + I_f$

Constant loss $W_c = V_L I_L$ (at no load) - $I_a^2 R_a$ Watts

Copper loss= $I_a^2 R_a$ Watts

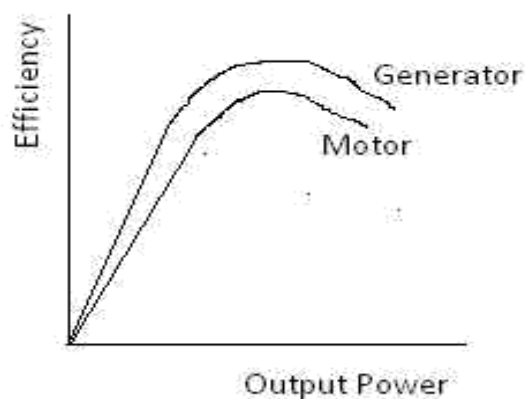
Total loss = copper loss+ constant loss watts

Output Power $P_o = V_L I_L$ Watts

Input power $P_i =$ Output power + total losses Watts

Percentage of efficiency, % $\eta =$ Output power / Input power

Model Graph:



Result:

Thus the efficiency of the DC machine has been predetermined and characteristics were drawn.

Outcome:

By conducting the efficiency of the DC machine has been predetermined and characteristics were understood.

Applications:

Swinburne test is usually conducted in no load condition. The parameters obtained in no load conditions are used to predict the efficiency of machine at any desired load condition without loading the machine manually, but by calculation.

Viva – voce

1. What is meant by losses in DC motor?
2. Classify various types of losses occur in DC motor.
3. What is meant by no load losses?
4. What is copper loss and where does it occur in the DC motor?
5. What is iron loss and where does it occur in a motor?
6. Mention the basic requirements for the production of emf.
7. What is the role of magnetic field in electromechanical energy conversions?
8. Which type of winding is selected for low voltage, high current DC machines?
9. State the condition for maximum efficiency of a DC motor.
10. What are the advantages of Swinburne's test?
11. Why generator efficiency is higher than motor efficiency. Explain it?
12. What are the disadvantages of Swinburne's test?

Expt. No.7 SPEED CONTROL OF A DC SHUNT MOTOR

Aim:

To obtain speed control characteristics of the given D.C. shunt motor by armature and field control methods

Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

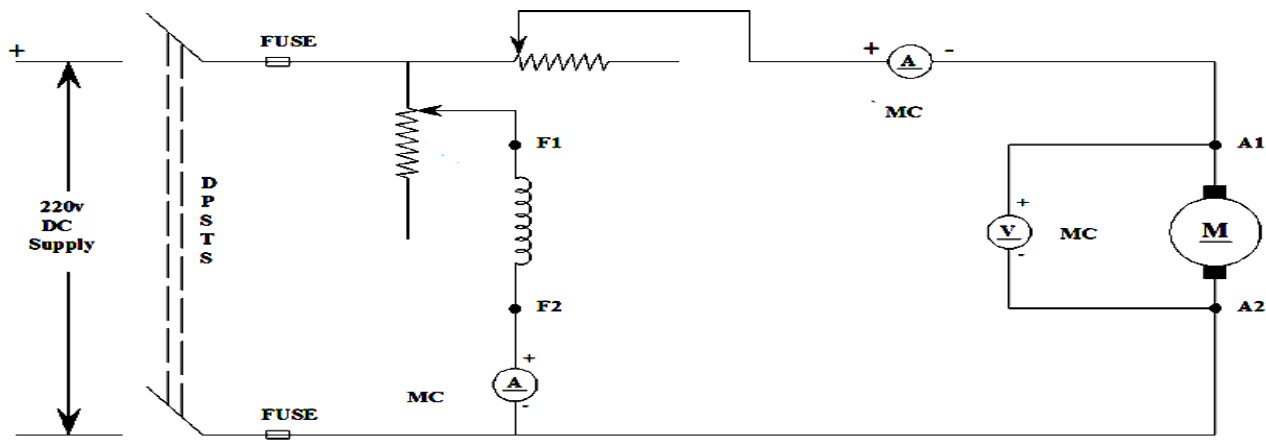
Precautions:

1. The rheostat connected in series with armature should be kept in maximum resistance position
2. The rheostat connected in series with field should be kept in minimum resistance position

Procedure:

1. Connect circuit as per the circuit diagram.
2. Close the DPST switch and adjust the armature rheostat till the rated voltage of the motor is obtained
3. Adjust the field rheostat to make the motor to run at the rated speed.
4. In armature control, Keep the field current constant and vary the armature voltage by varying the armature rheostat. Note down for various voltages, the speed of the motor..
5. Repeat the above step for different value of field current and note down the corresponding voltage and speed.
6. Keeping armature voltage at its rated value, vary the field current for various field current and note down the speed of motor and field current.
7. Repeat the above step for different value of armature voltage and note down the corresponding field current and speed.
8. After the above steps keep the armature rheostat in maximum resistance position and field rheostat in minimum resistance position, open DPST switch.

Circuit diagram:



Fuse Rating

Name Plate Details

Observation:
Field Control Method

Armature Control Method

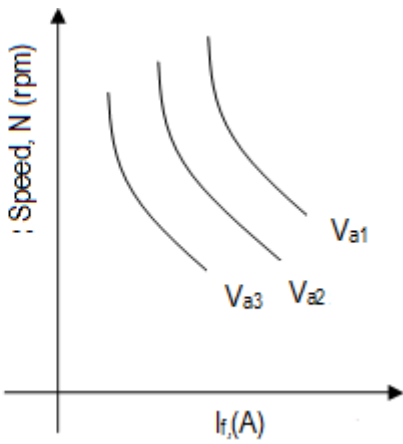
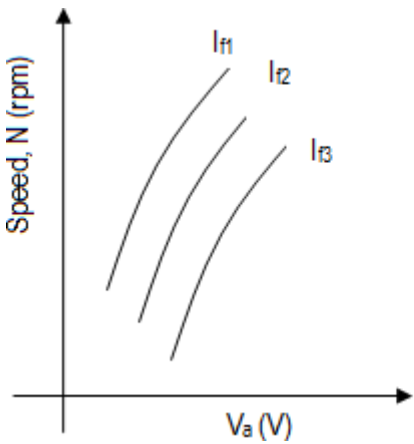
Armature voltage= v

Field Current= A

Sl.No.	I_f (A)	N (rpm)

Sl.No.	V_a (V)	N (rpm)

Model graph:



Result:

Thus the Armature and field speed control characteristics were drawn for various various field current and armature voltage.

Outcome:

By conducting this experiment, the D.C shunt motor characteristics are studied by Armature – controlled and Field control methods.

Applications:

The Speed control method is used where very sensitive speed control of the motor is required (e.g electric excavators, elevators, etc.)

Viva – voce

1. The test conducted for speed control in laboratory for what load and why?
2. In armature control the variation of speed below the rated speed explain
3. Why speed is increasing in field control method?
4. What will be type of characteristics possible using armature control when the motor is loaded
5. What will be type of characteristics possible using field control when the motor is loaded

Expt. No.8 LOAD TEST ON DC SERIES GENERATOR

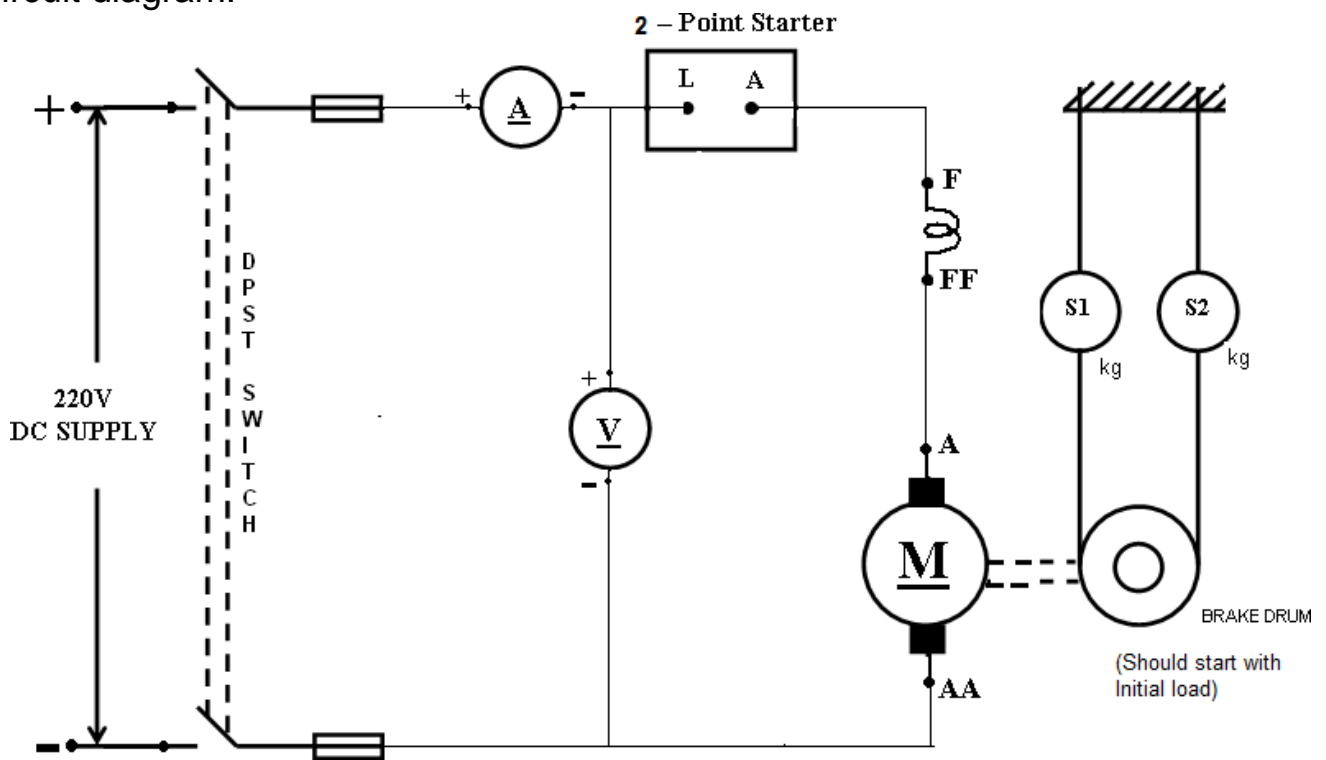
Aim:

To obtain the performance characteristics of a DC series motor by conducting load test.

Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

Circuit diagram:



Fuse rating

Name plate details

Precautions:

1. DC series motor should be started and stopped with initial load.
2. Brake drum should be cooled with water when it is under load.

Procedure:

1. Make circuit as per the circuit diagram.
2. Close the DPST switch and start the motor using 2-point starter.
3. Note down the readings of ammeter, voltmeter, speed and spring balance readings on initial condition.
4. Increase the load on in steps the motor and at each step of load, note down voltmeter, ammeter, spring balance readings and speed of the motor.
5. Repeat the above procedure till the ammeter read the rated current of the motor.
6. Reduce the load on the motor to the initial load condition.
7. Open the DPST switch.

Observation:

Circumference of the Brake drum= _____ cm.

Sl.No	Voltage V_L (Volts)	Current I_L (Amps)	Spring Balance Reading		$S=S_1 \sim S_2$ (Kg)	Speed N (rpm)	Torque T (Nm)	Input Power P_i (Watts)	Output Power P_o (Watts)	Efficiency $\eta\%$
			S_1 (Kg)	S_2 (Kg)						

Calculation:

6. Radius of Brake Drum

$$\text{Circumference} = 2 \pi r =$$

$$\text{Radius} = r \quad R = \text{Circumference} / (2 \pi) = \text{_____meter}$$

7. Torque (T) = $S \times 9.81 \times r$ Nm
8. Input Power (Pi) = $V_L \times I_L$ watts
9. Output power (Po) = $2\pi NT/60$ watts
10. Efficiency (η) = Output power / Input power X 100 %

Where,

S	-	Load
r	-	Radius of brake drum.
V_L	-	Line Voltage
I_L	-	Line current
N	-	Speed in rpm
T	-	Torque in Nm.

Result:

Thus the load test on DC series motor was performed and its characteristics were drawn.

Outcome:

By conducting the load test on DC series motor the efficiency and the following performance characteristics:

1) Efficiency vs Output power (2) Torque vs Output power (3) Speed vs Output Power (4) Line current vs Output Power (5) Torque vs Speed were understood.

Applications:

They are used for supplying field excitation current in DC locomotives for regenerative braking. These types of generators are used as boosters to compensate the voltage drop in the feeder in various types of distribution systems such as railway service.

Viva – voce

14. Why a DC series motor should not be started without load?
15. Why a DC series motor has a high starting torque?
16. Compare the resistances of the field windings of DC shunt and series motor?
17. What are the applications of DC series motor?
18. Comment on the Speed – Torque characteristics of a DC series motor.
19. What is the precaution to be taken when working with a D.C series motor?
20. What is the need for starter with a D.C motor?
21. How does a 2-point starter function?
22. Explain the shape of the electrical and mechanical characteristics.
23. What is the condition for maximum efficiency in a D.C motor?
24. What are the different losses occurring in a D.C machine?
25. How are the meter ratings selected for this experiment?
26. Give some applications of D.C series motor

Expt. No.9 HOPKINSON'S TEST ON DC MOTOR – GENERATOR SET

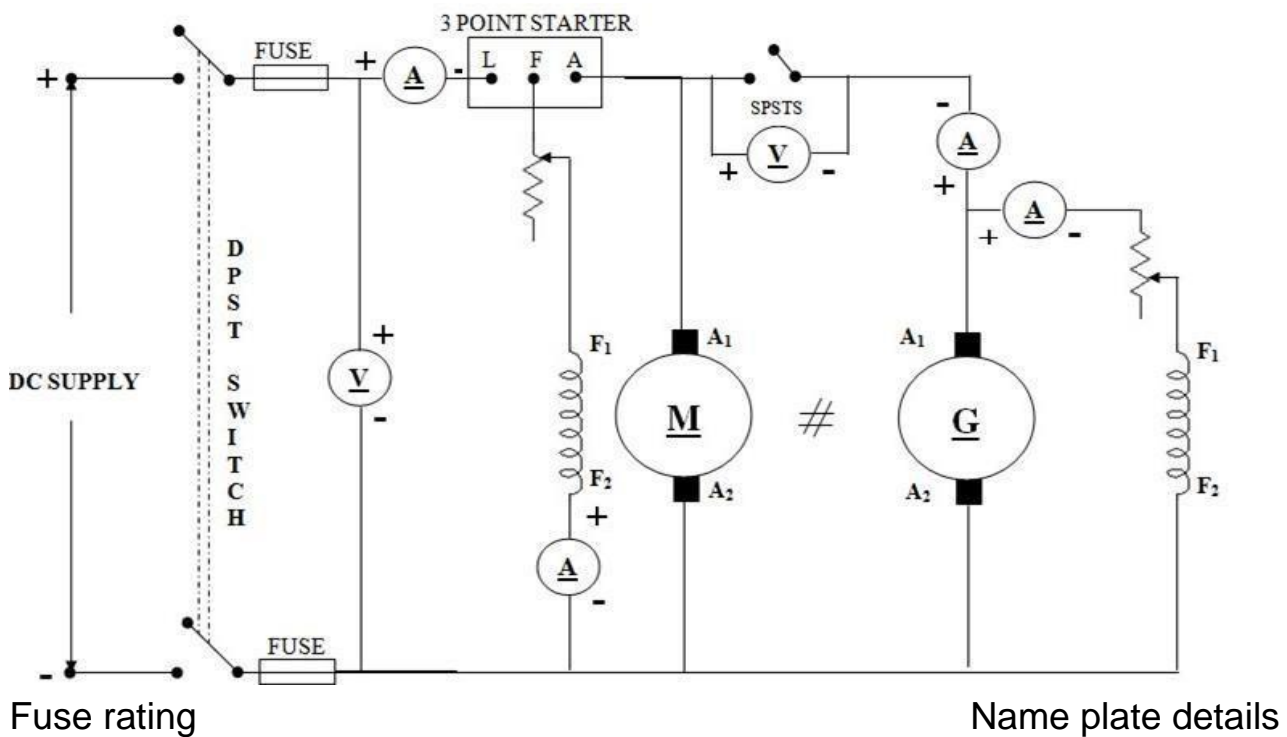
Aim:

To conduct full load test on two Identical DC shunt machines and draw the performance characteristics of the same machine.

Apparatus required:

Sl.No.	Apparatus Name	Range	Type	Quantity

Circuit diagram:



Precautions:

1. The field rheostat of the machine marked M should be kept at minimum position at the time of starting.
2. The field rheostat of the machine marked G should be kept at maximum position at the time of starting.
3. SPST switch should be open at the time of starting.

Procedure:

1. Make the Connections as per the circuit diagram.
2. Close the DPST switch and start the motor using three point starters.
3. Adjust the field rheostat of the motor to the rated speed.
4. Adjust the field rheostat of generator until voltmeter V_1 reads zero.
5. Close the SPST switch.
6. Adjust the field rheostat, for different load on to the machines.
7. For each step, note down all the meter readings in the tabulation.

Observation

Sl. No.	Supply Voltage (V)	Generator Current (A)	Motor Current (A)	Motor Field Current (A)	Efficiency of DC Generator					
					Input Power (W)	Armature Copper Loss (W)	Shunt Copper Loss (W)	Total Loss (W)	Output Power (W)	Efficiency%

Sl. No.	Supply Voltage (V)	Generator Current (A)	Motor Current (A)	Motor Field Current (A)	Efficiency of DC Generator					
					Input Power (W)	Armature Copper Loss (W)	Shunt Copper Loss (W)	Total Loss (W)	Output Power (W)	Efficiency%

Calculations:

$$\text{Motor input} = V (I_1 + I_2)$$

Where,

V = supply voltage to motor

I_1 = current delivered by the generator (generator current)

I_2 = current taken from the supply (motor current)

$$\text{Generator output} = V I_1 \text{ Watts}$$

Let

R_a = armature resistance of each machine = 1.5 ohm (given)

I_3 = Exciting current of the generator

I_4 = Exciting current of the motor

$$\text{Armature cu loss in generator} = (I_1 + I_3)^2 R_a \text{ watts} \quad (1)$$

$$\text{Armature cu loss in motor} = (I_1 + I_2 - I_4)^2 R_a \text{ watts} \quad (2)$$

$$\text{Shunt cu loss in generator} = V I_3 \text{ watts} \quad (3)$$

$$\text{Shunt cu loss in motor} = V I_4 \text{ watts} \quad (4)$$

$$\text{Stray losses of both machine} = w \text{ (say)} \quad (5)$$

$$\text{Power drawn from the supply} = V I_2 \text{ watt} \quad (6)$$

$$(1) + (2) + (3) + (4) + (5) = (6)$$

$$\text{Total stray loss for the set} = w$$

$$w = V I_2 - [(I_1 + I_3)^2 R_a + (I_1 + I_2 - I_4)^2 R_a + V I_3 + V I_4]$$

$$I_4 \text{ Stray loss per machine} = w/2$$

Efficiency for generator:

$$\text{Generator output} = V I_1 \text{ watt}$$

$$\text{Total losses} = (I_1 + I_3)^2 R_a + V I_3 + w/2 = W_g \text{ watt}$$

$$\text{Generator input} = V I_1 + W_g \text{ watt}$$

$$\text{Efficiency of the generator} = V I_1 / (V I_1 + W_g)$$

Efficiency for Motor:

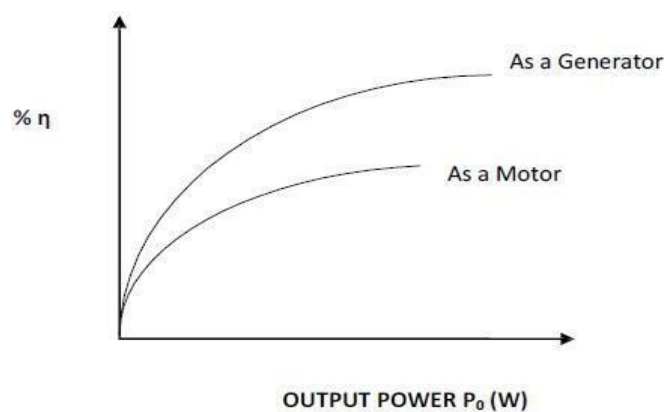
Motor input = $V(I_1 + I_2)$ watt

Total losses = $(I_1 + I_2 - I_A)^2 R_A + VI_A + W/2 = W_m$ watt

Generator input = $V(I_1 + I_2) - W_m$ watt

Efficiency of the generator = $V(I_1 + I_2) - W_m / V(I_1 + I_2)$

Model graph:



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.

Outcome:

By conducting the Hopkinson's test on a pair of identical DC machines the efficiency of the machine as generator and as motor are pre-determined was studied.

Applications:

Hopkinson's Test is also known as Regenerative Test, Back to Back test and Heat Run Test. Large machines can be tested at rated load without consuming much power from the supply.

Viva – voce

1. Explain Regenerative Test?
2. What is a stray loss?
3. What are the conditions to be satisfied before connecting two DC generators in parallel?
4. What are the advantages of Hopkinson's test?
5. What are the causes are responsible for over-heating of commutator in a DC Machine?
6. What will happen to the speed of a DC motor when its flux approaches zero?
7. When the total losses are increased by 5% what will be the performance of the machine as a motor and as a generator?
8. Is it possible to get same efficiency for motor and generator? How?
9. Why the generator alone can't feed the motor power requirement?
10. What happens if accidentally motor and generator are interchanged in the connection?

Expt. No.10 LOAD TEST ON A SINGLE PHASE TRANSFORMER

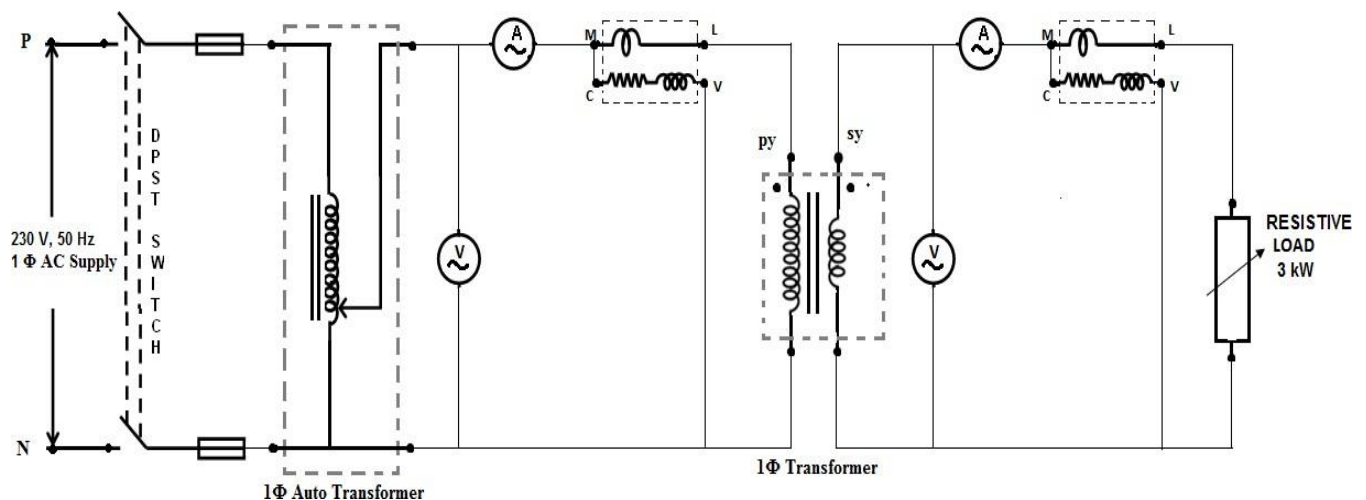
Aim:

To determine efficiency and regulation characteristics of a single phase transformer by conducting load test

Apparatus required:

SL. No.	Name of the equipment	Range & Type	Quantity

Circuit diagram:



Theory:

Transformer is a two winding static device which is electrically apart and magnetically linked. One winding namely primary is connected to source which in turn draws a current produces magnetic flux linking with second winding called secondary winding.

The voltage induced in both winding having same frequency, the magnetic of voltage induced depends upon number of turn in respective coils. When the secondary is connected to electrical load a current is circulated in secondary coil which in turn alters the flux in iron core. Due to this additional current is taken from by primary from source, which is equal to load connected on secondary side likewise various loads on secondary , primary inputs are measured and its performance can be determined.

Precautions:

1. DPST switch on secondary side of transformer is kept open during starting.

Procedure:

1. Connect circuit as per the circuit diagram.
2. Close DPST switch on primary side(LV)
3. Note down ammeter, voltmeter and wattmeter readings on LV and HV side of transformer.
4. Close the DPST switch on the load side and increase the load in steps, note down all meter readings at each step.
5. Repeat the above procedure till the current on the H.V side is equal to its rated value.
6. Decrease the load to its minimum, adjust the auto transformer to the minimum potential position and switch off supply.

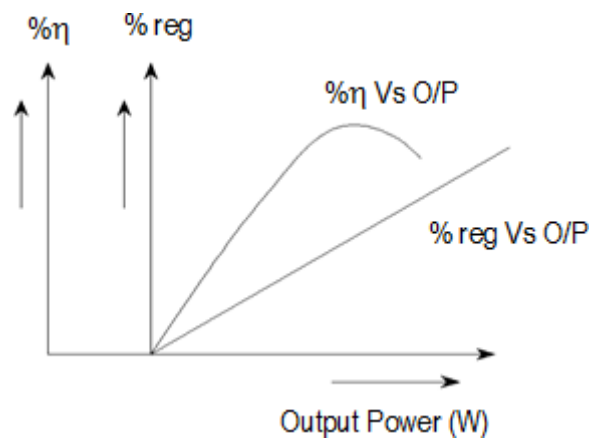
Observation:

S. No.	INPUT			OUTPUT			$\eta(\%)$	%Regulation
	V_{LV} (V)	I_{LV} (A)	W_{LV} (W)	V_{HV} (V)	I_{HV} (A)	W_{HV} (W)		

Calculations:

1. The Output Power of the transformer = $W_{H.V}$ Wattmeter reading on the H.V side
2. The Input Power of the transformer = $W_{L.V}$ = Wattmeter reading on the L.V side
3. % Efficiency (η) = (Output Power / Input Power) * 100
4. % Regulation = $((V_{H.V. (no load)} - V_{H.V. (load)}) / V_{H.V. (no load)}) * 100$

Model graph:



Result:

Thus the efficiency and regulation of a transformer is obtained by load test.

Outcome:

By conducting this experiment the efficiency and regulation of the single phase transformer at different load conditions was studied.

Applications:

They operate as step down voltage transformer and decrease the home voltage value to the value suitable for electronics supplying. On the secondary side rectifier is usually connected to convert AC voltage to the DC voltage which is used in electronics application.

Viva – voce

1. What is mean by voltage regulation?
2. Why efficiency of transformer is high at all loads comparing with any ac /dc motor?
3. Why iron loss is constant at all loads?
4. How current taken from supply by the primary, when secondary side is loaded

Expt. No. 11 LOAD TEST ON THREE PHASE TRANSFORMER

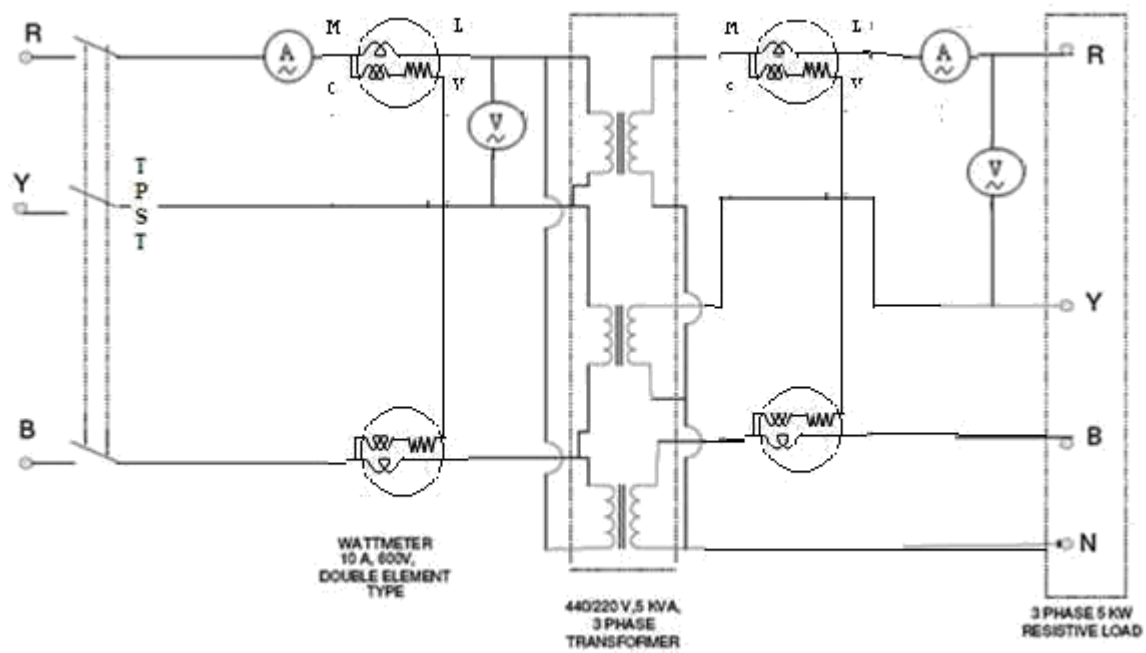
Aim:

To determine the regulation and efficiency of three-phase transformer by direct loading.

Apparatus required:

SL. No.	Apparatus	Range & Type	Quantity

Circuit diagram



Fuse Rating

Name Plate Details

Precautions:

1. All the switches should be kept open.
2. The auto transformer should be kept at minimum potential position.

Procedure:

1. Connect the circuit as shown in figure.
2. Keep load on transformer at off position.
3. Keeping auto transformer at zero position, switch on 3-Phase supply.
4. Now increase dimmer stat voltage for 440V.
5. Note down the no-load readings.
6. Then increase the load in steps till rated current of the transformer & note down corresponding readings.
7. Calculate efficiency & regulation for each reading.

Observation

Sl. No.	V ₁ Volt	I ₁ Ampere	W ₁ Watt	V ₂ Volt	I ₂ Ampere	W ₂ Watt	Efficiency	Regulation

Calculations:

Input power = $W_1 + W_2$ Watts

Output power = $\sqrt{3} V_2 I_2$ Watts

%Efficiency = $(\text{output} / \text{Input}) \times 100$

%Regulation = $(V_{NL} - V_L) / V_L$

Result:

Thus the efficiency and regulation of a three phase transformer were calculated by conducting load test.

Outcome:

Efficiency and regulation of a three phase transformer was verified.

Applications:

3 phase Transformers are used to increase or decrease the alternating voltages in electric power applications.

Expt. No. 12 OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON A SINGLE PHASE TRANSFORMER

Aim:

To determine equivalent circuit parameters of a single phase transformer by conducting open circuit test and short circuit test also predetermine the efficiency and regulation characteristics..

Apparatus required:

Sl. No.	Name of the equipment	Range & Type	Quantity

Theory:

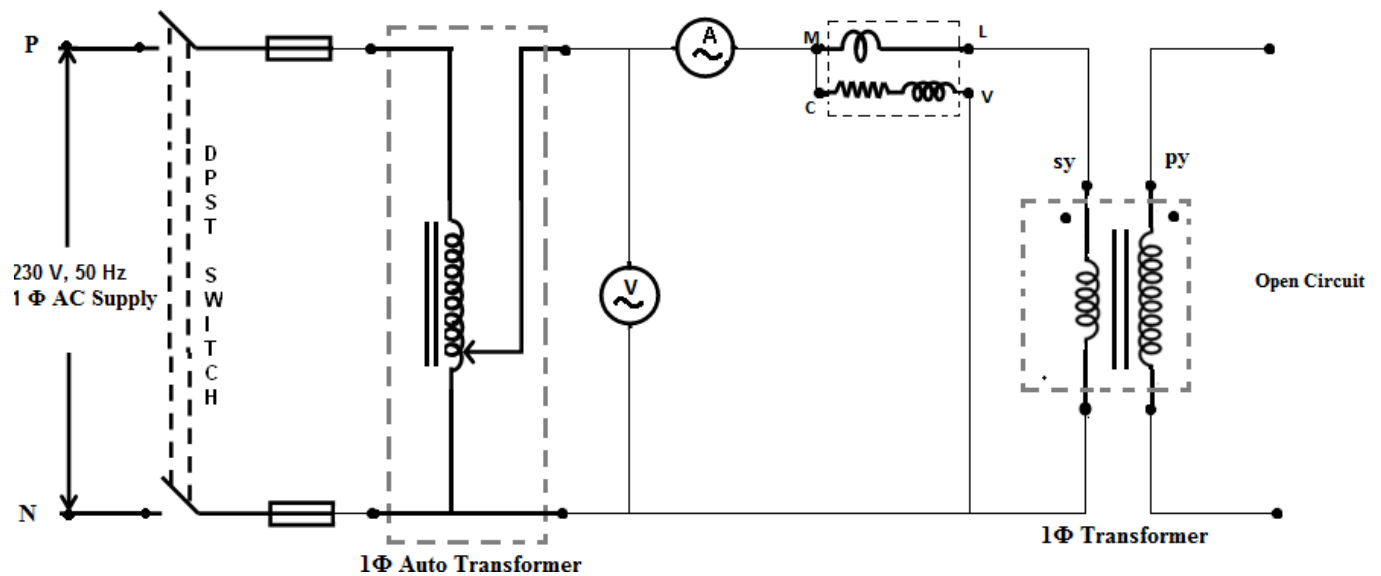
The transformer parameters such as resistance and leakage reactance of the primary and secondary coils can be determined experimentally. By knowing these parameters the performance of transformer namely efficiency at different loads and voltage regulation at different power factors at different load can be obtained. Since primary and secondary coils are mutually couple above parameters can be referred to either side called as equivalent parameters referred to respective sides. In order to determine these parameters open circuit and short circuit can be performed in transformer.

In the open circuit test normally the high voltage side is open circuited because at high voltage source may not available at the testing place. The rated voltage of the LV winding is applied and corresponding no load current and no load power is noted. The power input to the transformer on open circuit represents the power required to overcome the losses such as iron and copper loss. The flux in the transformer confined to the iron core which will require lesser MMF to link with the HV coil. The iron core will offer minimum reluctance and hence MMF which will take lesser current from source. The copper loss due to this current is very small when compared to iron loss. The power input to the transformer on no load represents iron loss.

In short circuit test normally low voltage side is short circuited because for a given rating the LV side will have a larger current. A variable voltage is applied on the HV side which in turn circulates a large current in the HV side because the LV side is short circuited. This is because a voltage is induced in the LV side which will circulate current, this will make the HV coil to take high current hence a low voltage is sufficient to circulate rated current on the HV side. For this voltage flux passing through the iron core is less and magnetic circuit is unsaturated. The power input under this condition corresponds to the copper loss of the transformer and iron loss is less when compared to copper loss and it is neglected. From the above, the power input on short circuit corresponds to copper loss which is used to determine the equivalent resistance referred to the LV side. It is not mandatory to circulate rated current on short circuit, since the resistance is constant for a given transformer.

Circuit diagram:

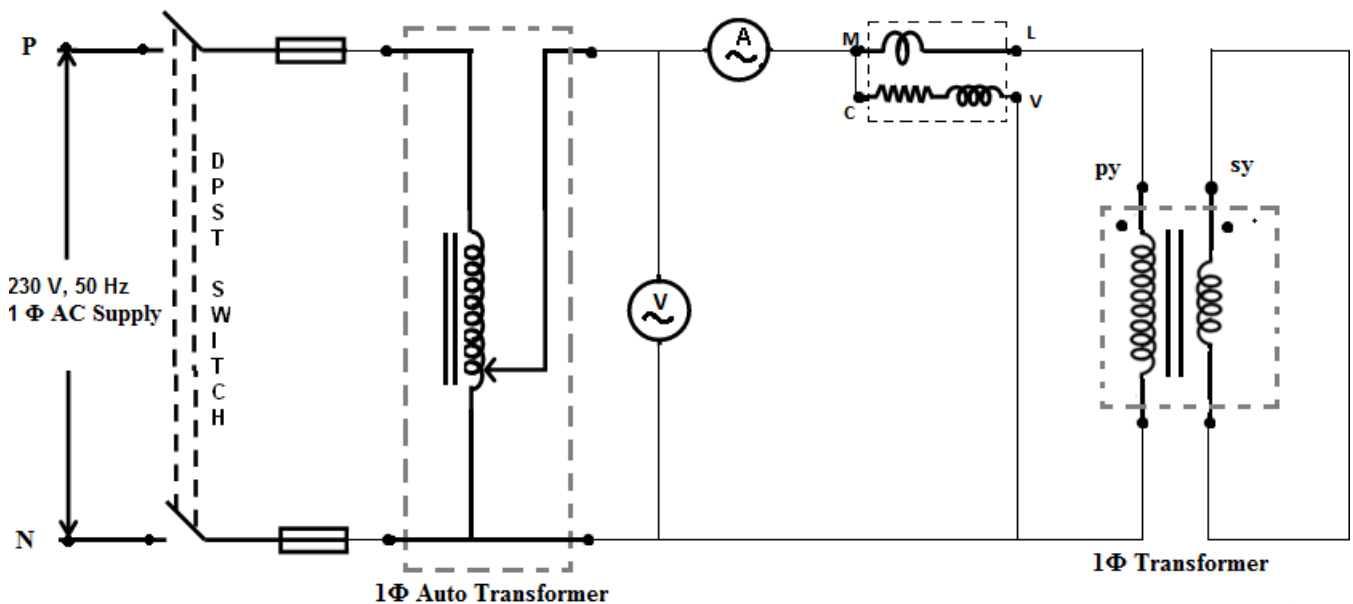
Open circuit test:



Fuse rating

Name plate details

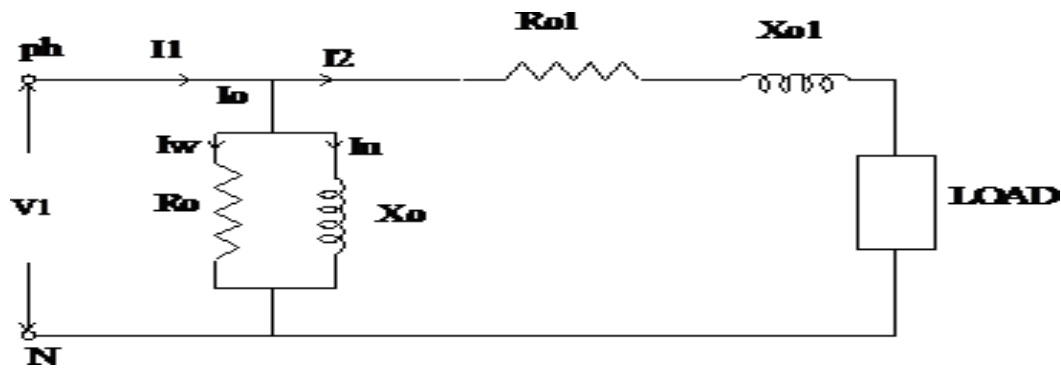
Short circuit test:



Fuse rating

Name plate details

Equivalent circuit referred to HV side:



Precaution:

1. Keep the autotransformer in its minimum potential position at the time of starting and stopping the experiment.

Procedure:

Open circuit test:

1. Connect the circuit as per the circuit diagram.
2. Close the DPST switch.
3. Adjust the autotransformer till the rated voltage of the L.V. winding of the transformer.
4. Note down the ammeter (I_0), and Wattmeter (W_0) readings.
5. Reduce the voltage to minimum value and open DPST switch.

Short circuit test:

1. The circuit connections as per the circuit diagram.
2. Short circuit the L.V winding and keeping the autotransformer in its minimum position, the DPST switch is closed.
3. Adjust the auto transformer, the rated current I_{HV} is circulated through the H.V winding, (Note:

$$I_{H.V} = \frac{\text{KVA rating} \times 1000}{V_{H.V}}$$

4. Note down the voltmeter (V_{sc}) and the Wattmeter (W_{sc}) readings..
5. Reduce the voltage to minimum value and open DPST switch.

Observation:

Test	Voltage (V)	Current (A)	Power (W)
O.C. TEST (On L.V side)	$V_o =$	$I_o =$	$W_o =$
S.C. TEST (On H.V side)	$V_{sc} =$	$I_{sc} =$	$W_{sc} =$

To predetermine the efficiency:

% Of Load X	Output Power (W)	Copper Loss (W)	Total Loss (W)	Input Power (W)	Efficiency (%)

To predetermine the % regulation:

Power Factor	% Reg. For Lagging P.F	% Reg. For Leading P.F

Calculation:

I. To obtain the equivalent circuit parameters referred to H.V side:

- From the O.C test the constant loss (Iron loss) is noted $W_c = W_o =$ _____ Watt.
- From the S.C test the full load copper loss is noted $W_{F.L} = W_{sc} =$ _____ watt.

For a transformer, the equivalent circuit parameters can be determined either with respect to H.V side or with respect to L.V side. If the parameters are estimated on the H.V side the resulting equivalent circuit is called H.V side

equivalent circuit of the transformer. From the O.C test R_o and X_o are calculated using the following expressions,

$$R_{0(L.V)} = \frac{V_0}{I_w} \Omega \quad X_{0(L.V)} = \frac{V_0}{I_m} \Omega \quad \text{Where } I_w = I_0 \cos \phi_0, I_m = I_0 \sin \phi_0$$

$$\phi_0 = \cos^{-1} \left[\frac{W_0}{VI} \right]$$

Since these values are calculated with respect to L.V side (because O.C test is conducted on the L.V side), the equivalent values of ' R_o ' and ' X_o ' as referred to H.V side are determined as

$$R_{0(H.V)} = \frac{R_{0(L.V)}}{K^2} \Omega \quad X_{0(H.V)} = \frac{X_{0(L.V)}}{K^2} \Omega$$

Where $K = (\text{secondary voltage}) / (\text{primary voltage})$

$K = 115/230$ for a step down operation; $K = 230/115$ for a step up operation.

Since we are assuming a step down operation $K = 115/230 = 0.5$.

$$R_{T(H.V)} = \frac{W_{sc}}{I_{sc}^2} \Omega, Z_{T(H.V)} = \frac{V_{sc}}{I_{sc}} \Omega \quad X_{T(H.V)} = \sqrt{Z_{T(H.V)}^2 - R_{T(H.V)}^2} \Omega$$

$R_{T(H.V)}$ and $X_{T(H.V)}$ are the total equivalent resistance and reactance of the transformer as referred to the H.V side whose values are calculated from the S.C test.

Now the H.V side equivalent circuit is drawn and the parameters values are mentioned in the circuit.

II. To predetermine the efficiency:

The percentage efficiency is then predetermined for different load conditions for a specified load power factor using the expression,

$$\text{Output power} = x \cdot \text{KVA} \cdot \cos \phi \cdot 1000 \text{ Watt}$$

$$\text{Copper loss} = x^2 \cdot W_{sc} \text{ Watt}$$

$$\text{Total loss} = \text{Core loss } (W_o) + \text{Copper loss watt}$$

$$\text{Input power} = \text{Output Power} + \text{Total loss Watt}$$

$$\% \text{Efficiency} = (\text{Output Power} / \text{Input Power}) \times 100\%$$

Where ' x ' is the fraction of the full load which is 0.25 for 25% load, 0.5 for 50% load, 0.75 for 75% load, 1.0 for full load and 1.25 for 125% load and $\cos \phi$ is the load p.f (assumed as 0.8 lag).

The efficiency values so calculated are entered in the tabular column as shown below.

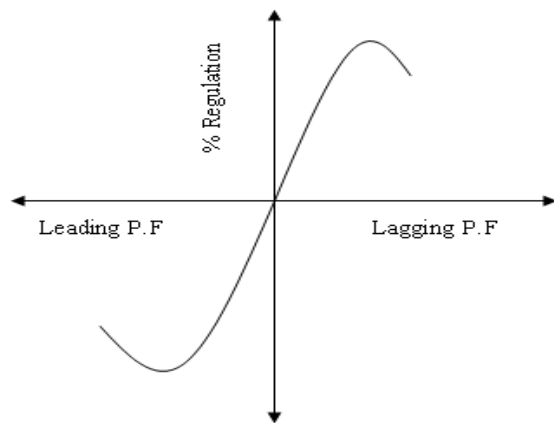
III. To predetermine the percentage regulation:

$$\% \text{ Regulation} = \frac{I_{H.V} (R_{T(H.V)} \cos \phi \pm X_{T(H.V)} \sin \phi)}{V_{HV}} \times 100, \text{ Where '+' for lagging power factor, '-' for leading Power}$$

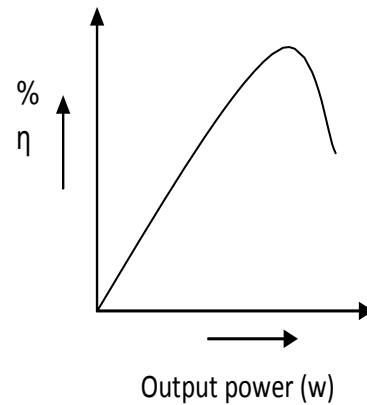
factor, $I_{H.V}$ = Rated current on H.V side, $V_{H.V}$ = Rated voltage on H.V side

Model graph:

Regulation curve:



Efficiency curve:



Result:

By conducting open circuit test and short circuit test the efficiency and regulation characteristics are predetermined.

Outcome:

By conducting the open circuit test and short circuit test on a single-phase transformer and the efficiency and regulation was predetermined. The equivalent circuit referred to H.V side and performance characteristics: (i) % η vs Output Power (ii) % Regulation vs Power factor was understood.

Applications:

By using open circuit test can measure the loss of no-load losses means that iron losses. • By using short circuit test can measure the loss of full-load losses means that Cu-losses. • It can find the efficiency by using of iron losses and cu-losses.

Viva – voce

1. Explain why the efficiency of transformer is very high compared to other machines.
2. State the conditions under which OC test is conducted on a transformer in terms hv/lv windings and justify.
3. What is mean by watt less component and watt full component?
4. State the conditions under which SC test is conducted on a transformer in terms HV/LV windings and justify.
5. State why the open circuit tests on a transformer is conducted at rated voltage?
6. Why HV winding is normally opened in open circuit test?
7. Why LV winding is normally shorted in Short circuit test?

Expt. No.10 (a) Polarity Test on single phase transformers.

Aim

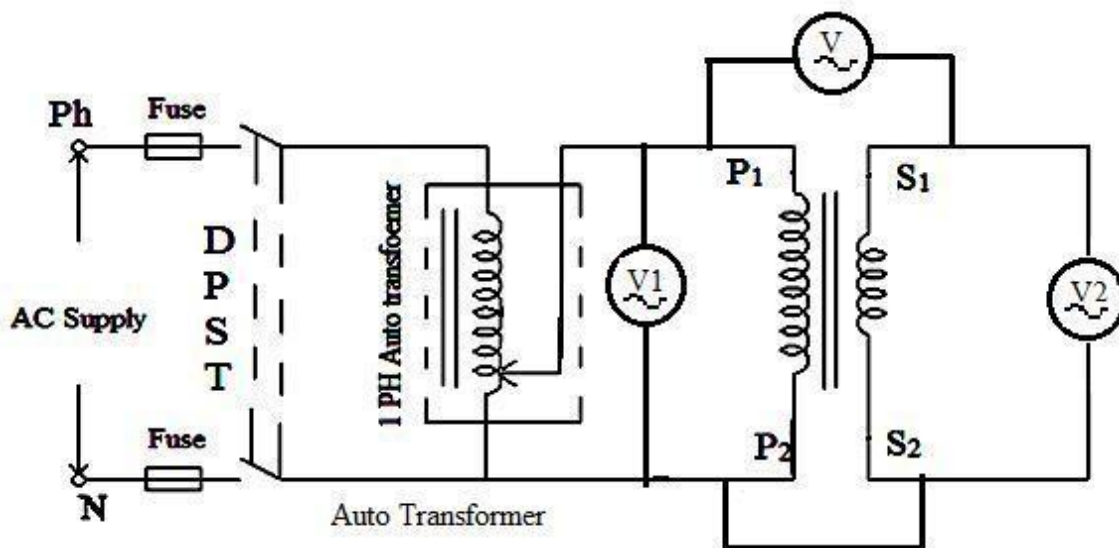
To determine the polarity of the given single phase transformer.

Apparatus Required:

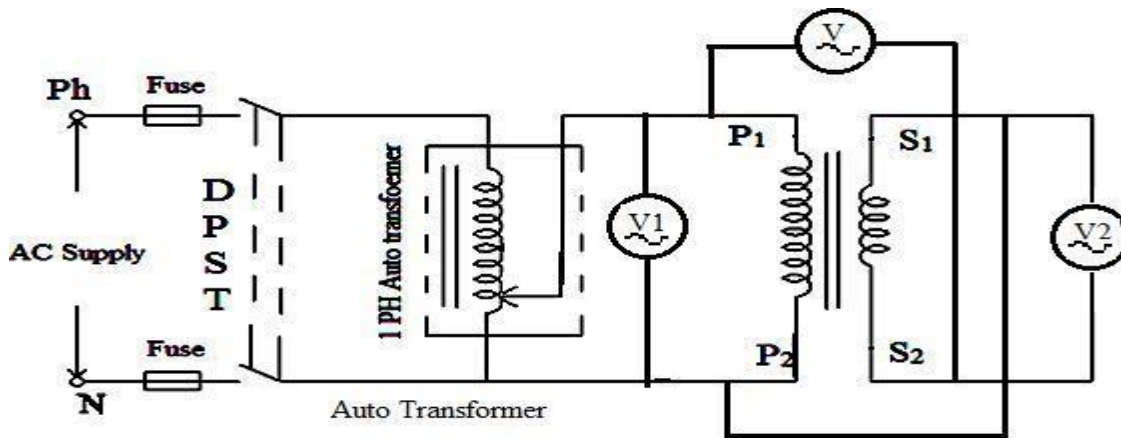
SL. No.	Name of the equipment	Range & type	Quantity

Circuit Diagram:

Subtractive polarity



Additive polarity



Fuse Rating

Name Plate Details

Precautions:

1. Auto transformer must be kept in minimum position while switching on and switching off the supply.
2. Transformer should be operated under rated values.

Procedure:

1. Connect the circuit as shown in circuit diagram.
2. Switch on the single phase AC supply.
3. Record the voltages V_1 , V_2 and V_3 .
4. Repeat the step 3 after connecting terminals S_1 and S_2 .

Note: If $V_3 < V_1$ – Subtractive Polarity

$V_3 > V_1$ – Additive Polarity

Observation:

Subtractive polarity

Sl. No.	V ₁	V ₂	V = V ₂ - V ₁

Additive polarity

Sl. No.	V ₁	V ₂	V = V ₂ + V ₁

Result:

Thus the Polarity of the given single phase Transformer is determined by conducting a polarity test.

Outcome:

By conducting the Polarity test on the given single phase Transformer, the concept of polarity was understood.

Applications:

Polarity testing of transformers is vital before connecting them in parallel. Otherwise, with incorrect polarity, it is not possible to connect them in parallel.

Viva – voce

1. What is a transformer?
2. What do you mean by turns ratio of a transformer?
3. What is transformation ratio of a transformer?
4. What are the different polarities of a transformer?
5. What is the condition of additive polarity?

Expt. No.14 Sumpner's test on single phase transformers.

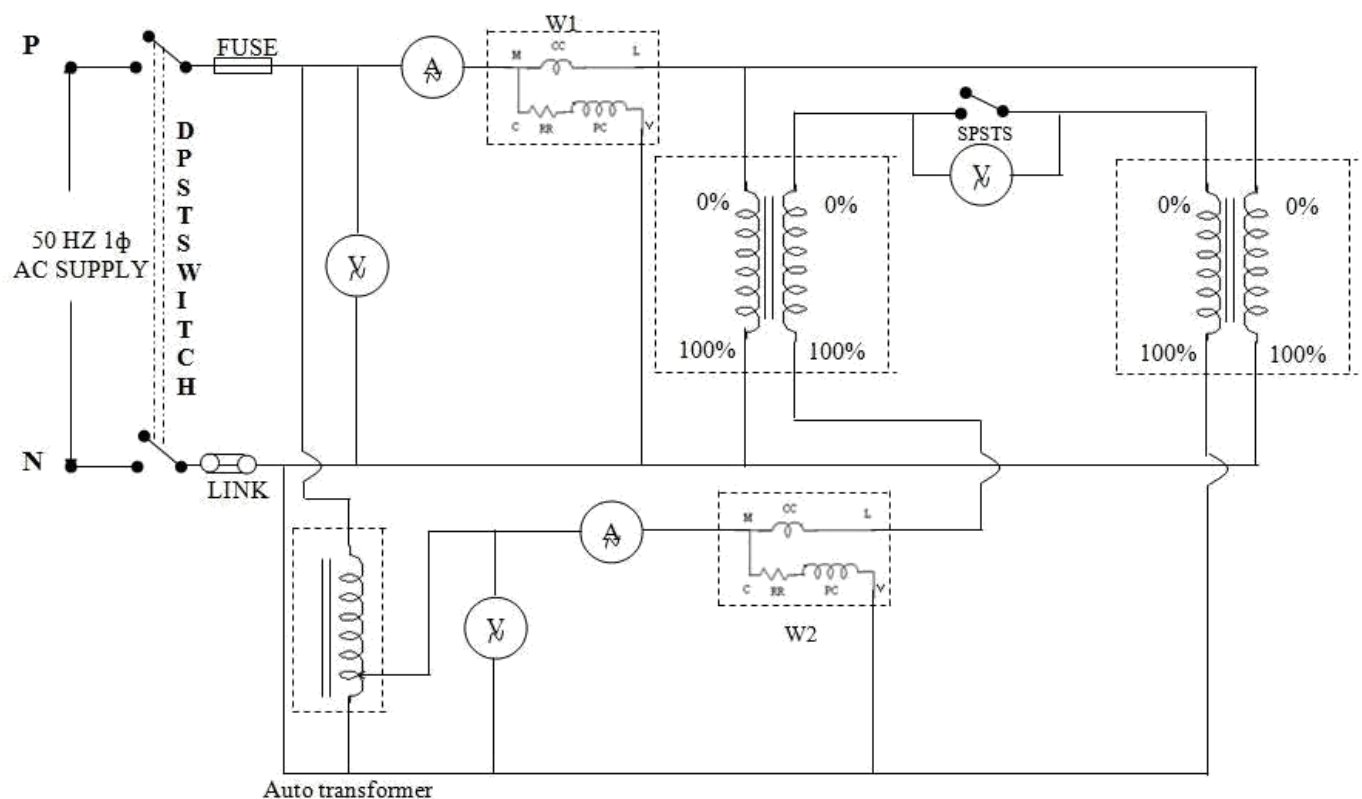
Aim

To predetermine the efficiency and regulation of the given single phase Transformers by conducting back-to-back test.

Apparatus Required:

Sl.No.	Apparatus Name	Range & Type	Range Type	Quantity

Circuit Diagram:



Fuse Rating

Name Plate Details

Precautions:

1. Auto Transformer should be kept in zero position, before switching on the AC supply.

Procedure:

1. Make the connections as shown in the circuit diagram.
2. Rated voltage of 110V is adjusted to get in voltmeter by adjusting the variac of the Autotransformer 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 inter changed 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.

Observation:

Sumpner's Test on Single Phase Transformer

Sl.No.	Primary Voltage (Volts)	Primary Current (A)	W ₀ (watts)		Secondary Voltage (Volts)	Secondary Current (A)	Secondary Power (Watts)	W ₀ (watts)	
			Observed	Actual				Observed	Actual

Predetermination of % Efficiency of Single Phase Transformer

Sl.No.	Power Factor Cos Φ	Load Ratio (X)	Output Power (Watts)	Input Power (Watts)	% Efficiency
		0			
		0.25			
		0.50			
		0.75			
		1			

Predetermination of % Regulation of Single Phase Transformer

Sl.No.	Load Ratio (X)	Power Factor Cos Φ	Regulation In %	
			For Leading Power Factor	For Lagging Power Factor
		0		
		0.25		
		0.50		
		0.75		
		1		

Calculations:

Core loss = W_o

Copper Loss = full load cu loss $\times (1/x)^2$

Total loss = Core loss + Copper loss

Output = $V_2 I_2 \cos\phi$

Input = output + total loss

% Efficiency = $\text{output}/\text{input} \times 100$

Power Factor on No Load:

$\cos\Phi = (W_o / V_o I_o)$

Working component $I_w = I_o \cos\Phi$

Magnetizing component $I_\mu = I_o \sin\Phi$

Resistance $R_o = V_o / I_w$ in Ω

For Short Circuit Test:

Equivalent resistance $R_{01} = W_{sc} / I_{sc}$ in Ω

Equivalent impedance $Z_{01} = V_{sc} / I_{sc}$ in Ω

Equivalent leakage reactance $X_2 = \sqrt{(Z_{01} - R_{01})}$ in Ω

Voltage ratio = V_2/V_1

$R_{02} = K^2 R_{01}$

$X_{02} = K^2 X_{01}$

Percentage Of Regulation

Lagging PF = $(I^2 R_{02} \cos \phi + I^2 X_{02} \sin \phi) / V_2$

Leading PF = $(I^2 R_{02} \cos \phi - I^2 X_{02} \sin \phi) / V_2$

Result:

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

Outcome:

By conducting the efficiency and regulation of a given single phase Transformer is carried out by conducting back-to-back test was understood.

Applications:

Sumpner's test is used to put large transformer on full load.

Viva – voce

1. How can you determine the efficiency of transformer?
2. What are the differences in Sumpner's test and open circuit and short circuit test?
3. Which windings are connected in parallel in this test?
4. How much voltage is applied on primary side while conducting the Sumpner's test?
5. How much voltage is applied on secondary side while performing the experiment?
6. How the secondary windings of transformers are connected for conducting the Sumpner's test?
7. How much current flows on primary side and secondary side of transformer while performing the experiment?
8. What do you mean by phase opposition in reference to Sumpner's test on transformer?
9. What is the condition to be satisfied by the two transformers to be tested through Sumpner's test?
10. What does the reading of wattmeter on primary side indicate?

Expt. No.11 Separation of no-load losses in single phase transformer.

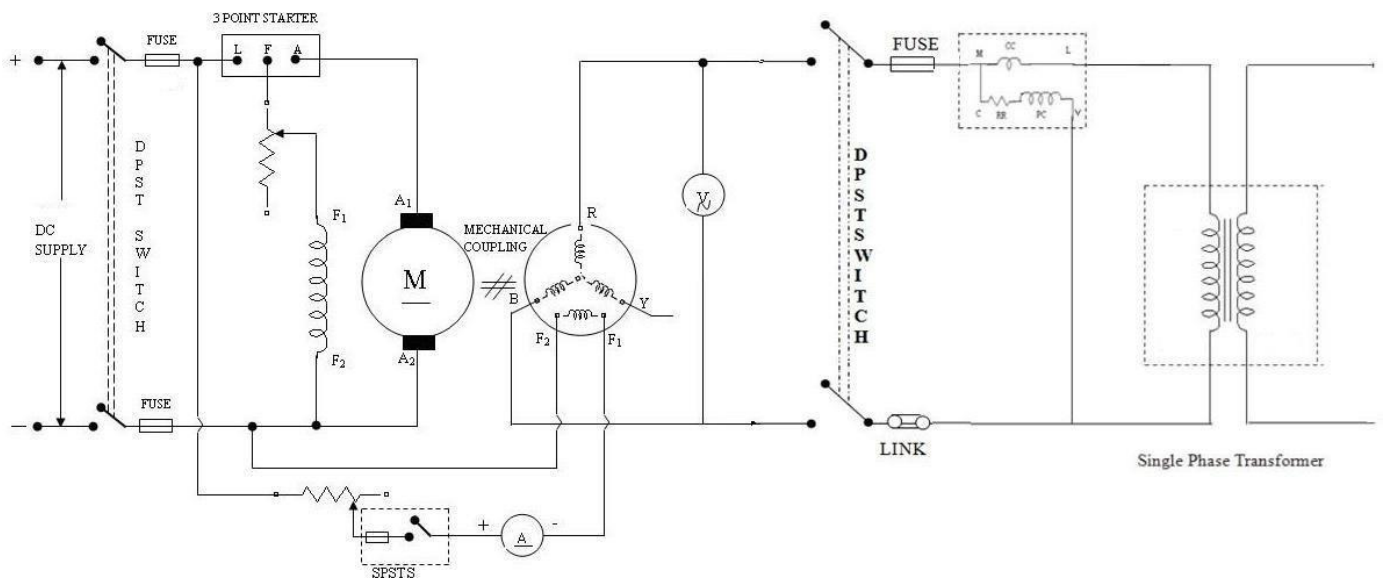
Aim

To separate the no load losses of a transformer in to eddy current loss and hysteresis loss.

Apparatus Required:

Sl. No.	Apparatus Name	Range & Type	Quantity

Circuit Diagram:



Fuse Rating

Name Plate Details

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. Make the connections as per the circuit diagram.
2. Close the DPST switch.
3. Start the DC motor is started by using the 3 point starter and brought to rated speed by adjusting its field rheostat.
4. Vary the alternator field rheostat gradually the rated primary voltage is applied to the transformer.
5. Vary the frequency the motor field rheostat and the readings of frequency are noted and the speed is also measured by using the tachometer.
6. Repeat the above procedure for different frequencies and the tabulate readings..
7. The motor is switched off by opening the DPST switch after bringing all the rheostats to the initial position.

Observation:

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

Calculations:

Frequency, $f = (P \times N_s) / 120$ in Hz P = No. of Poles & N_s = Synchronous speed in rpm.

Hysteresis Loss $W_h = A \times f$ in Watts A = Constant (obtained from graph)

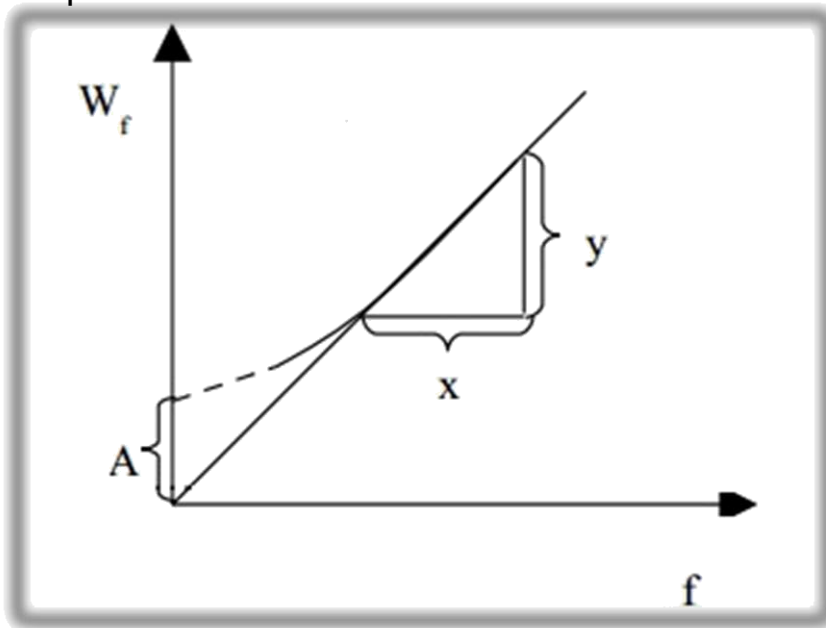
Eddy Current Loss $W_e = B \times f^2$ in Watts B = Constant (slope of the tangent drawn to the curve)

Iron Loss $W_i = W_h + W_e$ in Watts

$W_i / f = A + (B \times f)$

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 $(W_i / f) / \Delta f$

Model Graph:



Result:

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

Outcome:

By conducting separation of eddy current and hysteresis loss from the iron loss on a single-phase transformer was understood.

Viva – voce

1. What is mean by iron loss? Why it occurs in transformer?
2. What are the no-load losses in transformer?
3. What is the relation between different no-load losses and frequency?
4. Why we need to maintain v/f ratio as constant while doing this experiment?
5. What depicts the area of hysteresis loop?
6. How can we vary the input voltage/frequency of transformer? Suggest a suitable method

Expt. No. 12 STUDY OF DC AND INDUCTION MOTOR STARTERS

Aim:

To study the different kinds of DC and induction motor starters

Theory:

The value of the armature current in a DC shunt motor is given

$$I_a = (V - E_b) / R_a$$

Where V = applied voltage.

R_a = armature resistance.

E_b = Back emf.

In practice the value of the armature resistance is of the order of one ohm and at the instant of starting the value of the back emf is zero volts. Therefore under starting conditions the value of the armature current is very high. This high inrush current at the time of starting may damage the motor. To protect the motor from such dangerous current the DC Motors are always started using starters.

The types of DC motor starters are

i) Two point starters ii) Three point starters iii) Four point starters.

The functions of the starters are i) It protects from dangerous high speed. ii) It protects the motor from overloads.

i) Two point starters:

It is used for starting DC series motors which has the problem of over speeding due to the loss of load from its shaft. Here for starting the motor the control arm is moved in clock-wise direction from its OFF position to the ON position against the spring tension. The control arm is held in the ON position by the electromagnet E. The exciting coil of the hold-on electromagnet E is connected in series with the armature circuit. If the motor loses its load, current decreases and hence the strength of the electromagnet also decreases. The control arm returns to the OFF position due to the spring tension, thus preventing the motor from over speeding. The starter also returns to the OFF position when the supply voltage decreases appreciably. L and F are the two points of the starter which are connected with the motor terminals.

ii) Three point starter:

It is used for starting the shunt or compound motor. The coil of the hold on electromagnet E is connected in series with the shunt field coil. In the case of disconnection in the field circuit the control arm will return to its OFF position due to spring tension. This is necessary because the shunt motor will over speed if it loses excitation. The starter also returns to the OFF position in case of low voltage supply or complete failure of the supply. This protection is therefore called No Volt Release (NVR).

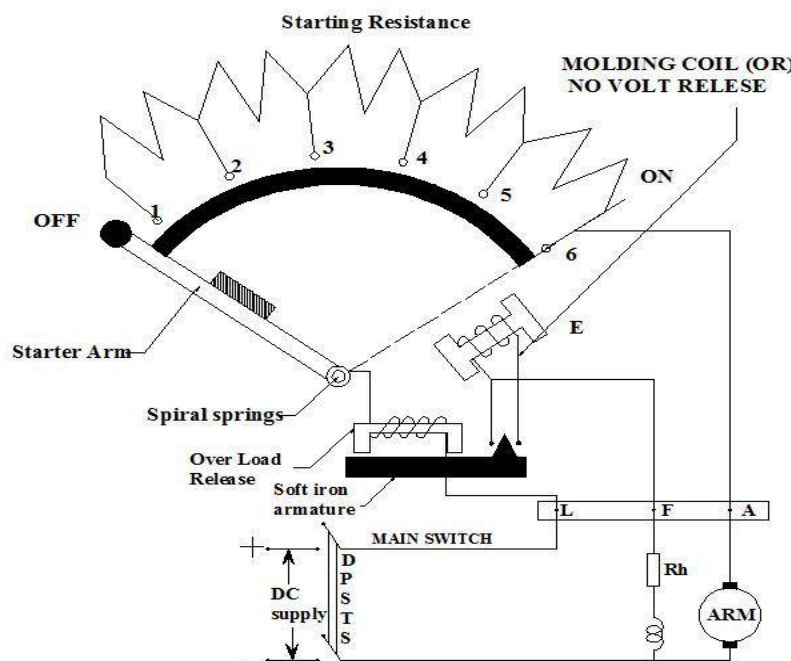
Over load protection:

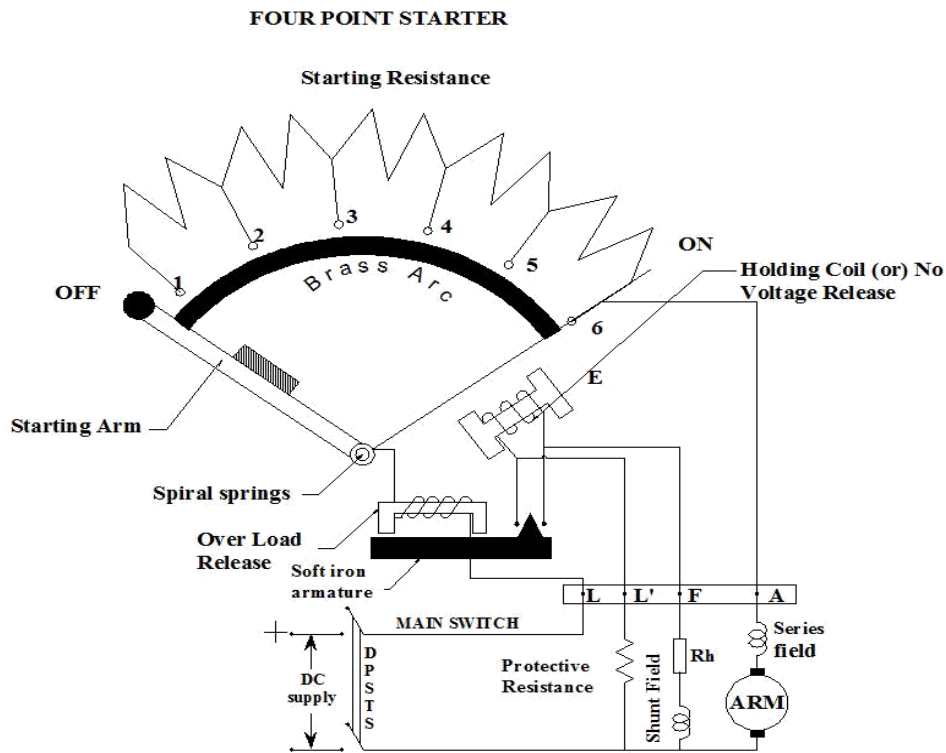
When the motor is over loaded it draws a heavy current. This heavy current also flows through the exciting coil of the over load electromagnet (OLR). The electromagnet then pulls an iron piece upwards which short circuits the coils of the NVR coil. The hold on magnet gets de-energized and therefore the starter arm returns to the OFF position, thus protecting the motor against overload. L, A and F are the three terminals of the three point starter.

iii) Four point starter:

In a four point starter arm touches the starting resistance, the current from the supply is divided into three paths. One through the starting resistance and the armature, one through the field circuit, and one through the NVR coil. A protective resistance is connected in series with the NVR coil. Since in a four point starter the NVR coil is independent of the field circuit connection, the DC motor may over speed if there is a break in the field circuit. A DC motor can be stopped by opening the main switch. The steps of the starting resistance are so designed that the armature current will remain within the certain limits and will not change the torque developed by the motor to a great extent.

THREE POINT STARTER





Auto – transformer starting:

An auto transformer starter consists of an auto transformer and a switch as shown in the figure. When the switch S is put on START position, a reduced voltage is applied across the motor terminals. When the motor picks up speed, say to 80 per cent of its normal speed, the switch is put to RUN position. Then the auto-transformer is cut out of the circuit and full rated voltage gets applied across the motor terminals.

The circuit diagram in the figure is for a manual auto-transformer starter. This can be made push button operated automatic controlled starter so that the contacts switch over from start to run position as the motor speed picks up to 80% of its speed. Over-load protection relay has not been shown in the figure. The switch S is air-break type for small motors and oil break type for large motors. Auto transformer may have more than one tapping to enable the user select any suitable starting voltage depending upon the conditions.

Series resistors or reactors can be used to cause voltage drop in them and thereby allow low voltage to be applied across the motor terminals at starting. These are cut out of the circuit as the motor picks up speed.

Star- delta method of starting:

The starter phase windings are first connected in star and full voltage is connected across its free terminals. As the motor picks up speed, the windings are disconnected through a switch and they are reconnected in delta across the supply terminals. The current drawn by the motor from the lines is reduced to as compared to the current it would have drawn if connected in delta. The motor windings, first in star and then in delta the line current drawn by the motor at starting is reduced to one third as compared to starting current with the windings delta-connected.

In making connections for star-delta starting, care should be taken such that sequence of supply connections to the winding terminals does not change while changing from star connection to delta connection. Otherwise the motor will start rotating in the opposite direction, when connections are changed from star to delta. Star-delta starters are available for manual operation using push button control. An automatic star – delta starter used time delay relays (T.D.R) through which star to delta connections take place automatically with some pre-fixed time delay. The delay time of the T.D.R is fixed keeping in view the starting time of the motor.

Full voltage or direct –on-line starting:

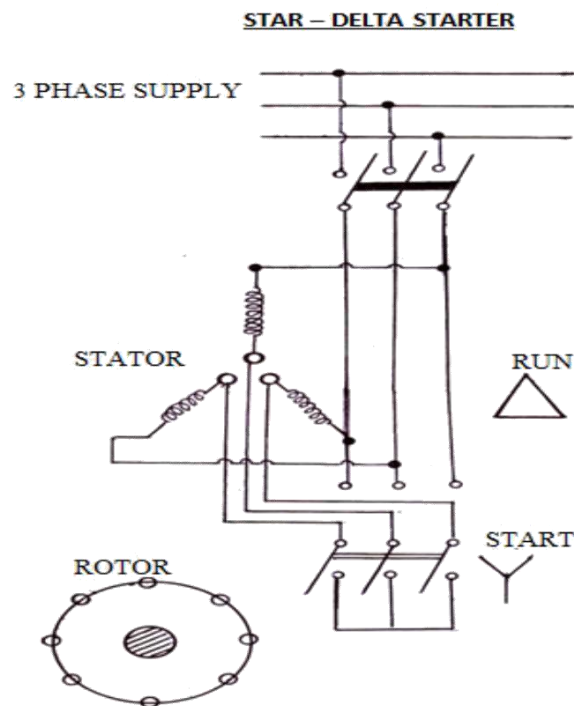
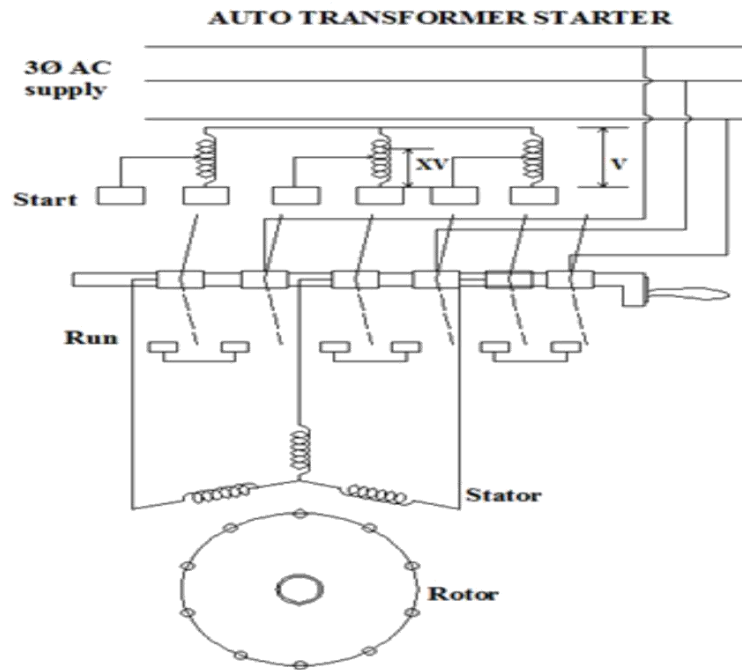
When full voltage is connected across the stator terminals of an induction motor, large current is drawn by the windings. This is because, at starting the induction motor behaves as a short circuited transformer with its secondary, i.e. the rotor separated from the primary, i.e. the stator by a small air-gap.

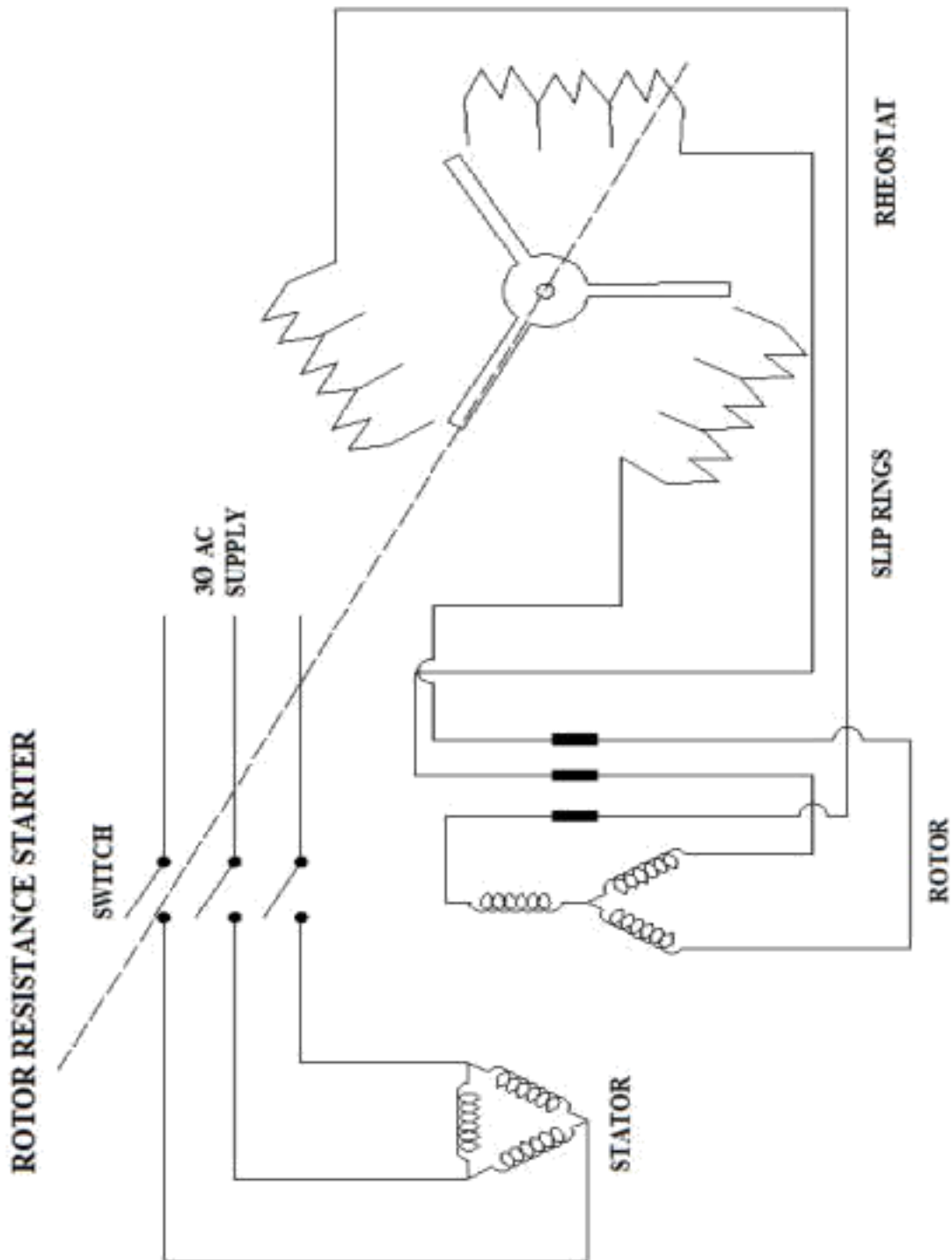
At starting when the rotor is at standstill, emf is induced in the rotor circuit exactly similar to the emf induced in the secondary winding of a transformer. This induced emf of the rotor will circulate a very large current through its windings. The primary will draw very large current from the supply mains to balance the rotor ampere-turns. To limit the stator and rotor currents at starting to a safe value, it may be necessary to reduce the stator supply voltage to a low value. If induction motors are started direct-on-line such a heavy starting current of short duration may not cause harm to the motor since the construction of induction motors are rugged. Other motors and equipment connected to the supply lines will receive reduced voltage. In industrial installations, however, if a number of large motors are started by this method, the voltage drop will be very high and may be really objectionable for the other types of loads connected to the system. The amount of voltage drop will not only be dependent on the size of the motor but also on factors like the capacity of the power supply system, the size and length of the line leading to the motors etc. Indian Electricity Rule restricts direct on line starting of 3 phase induction motors above 5 Hp. Rotor resistance starter:

In a slip-ring (wound rotor) induction motor, resistance can be inserted in the rotor circuit via slip rings, so as to increase the starting torque. The starting current in the rotor winding is

$$(I_2)_{st} = \frac{E_r}{\sqrt{(r_2 + R_{ext})^2 + (x_2)^2}}$$

Where R_{ext} = Additional resistance per phase in the rotor circuit.





Result:

Thus the starters used of dc and induction motor were studied.

Outcome:

The different type of dc and induction motor starters was understood.

Viva – voce

1. Why the starter is necessary for a DC motor?
2. What are the advantages of auto transformer starter?
3. Name the various types of starters commonly used for starting on induction motor.
4. What is the function of a starter in DC motor?
5. State the advantages and disadvantages of DOL starter.
6. What are the different types of protection provided in starter used for a three phase induction motor?
7. Name the different types of starters used in DC motor.
8. Name the different types of starters used in AC motor.
9. What are the methods of starting in three phase squirrel cage IM?
10. What are the objectives of rotor resistance starter?
11. What are the disadvantages of auto transformer starter?
12. What type of starter is used for slip ring IM?
13. What is the advantage of four point starter over a three point starter used for DC motors?
14. What are the effects of increasing rotor resistance on starting current and starting torque?
15. Name the type of induction motor which produces high starting torque.