

DHANALAKSHMI COLLEGE OF ENGINEERING

MANIMANGALAM, TAMBARAM, CHENNAI

B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING



IV SEMESTER

LAB MANUAL

EE6411 ELECTRICAL MACHINES LABORATORY - I

CIRCUIT DIAGRAM - LOAD TEST ON DC SHUNT MOTOR

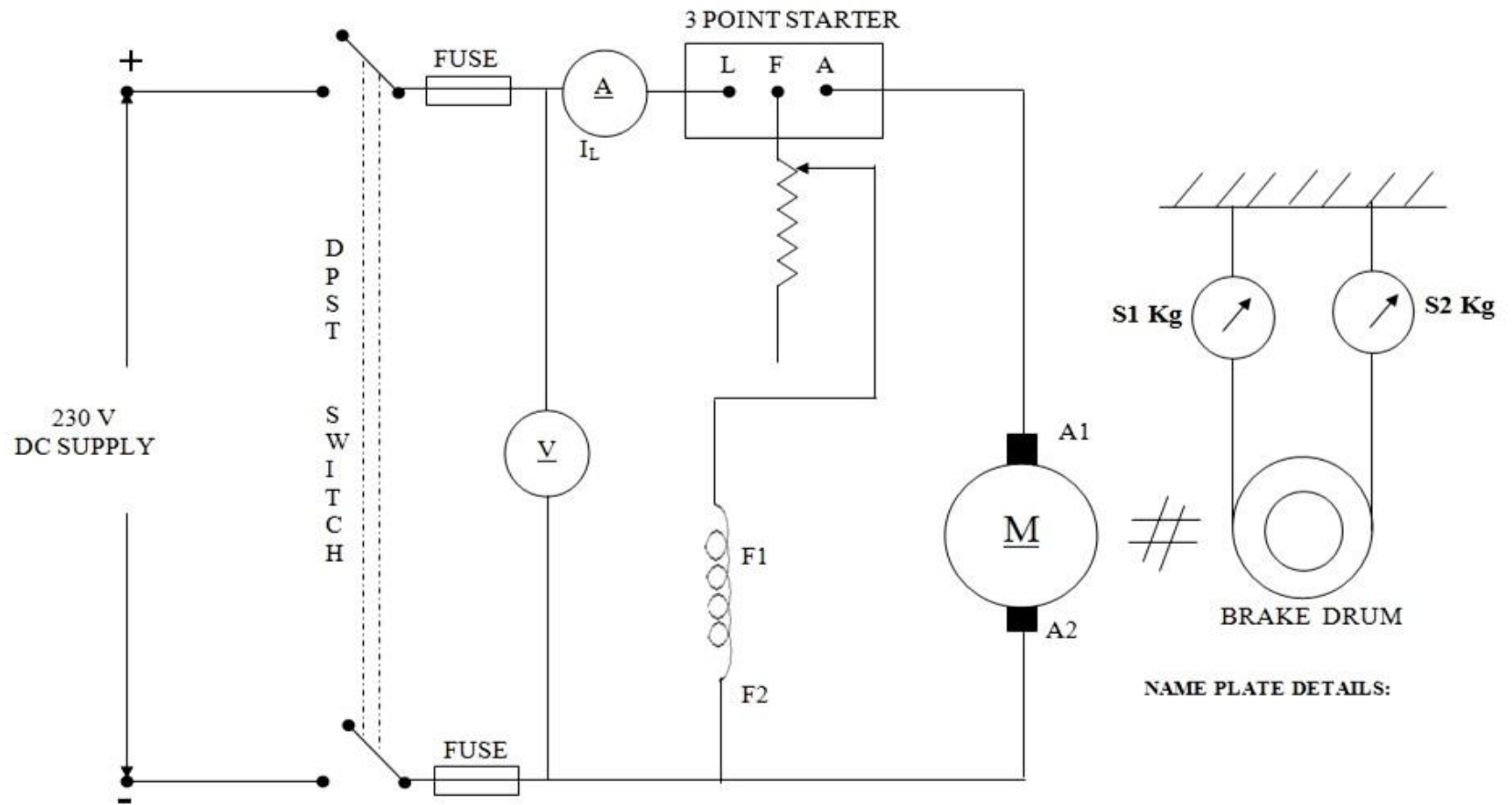


Figure 1.1 - Load Test on DC Shunt Motor

Ex. No:

LOAD TEST ON DC SHUNT MOTOR

Date :

AIM:

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

OBJECTIVES:

1. To determine the efficiency of the given DC shunt motor by conducting load test.
2. To find the various parameters such as torque, input power, output power etc.
3. To obtain the electrical and mechanical characteristics for the given DC shunt motor.

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
01.	Voltmeter			
02.	Ammeter			
03.	Rheostat			
04.	Tachometer			

FORMULA:

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

Where

S_1, S_2 – Spring balance readings in kg

R – Radius of brake drum in m

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

Where

V_L – line voltage in Volts

I_L – load current in A

3. Output power (P_o) = $\frac{2\pi N T}{60}$ watts

Where

N – Speed of motor in rpm

T – Torque in Nm

4. % Efficiency (η) = $\frac{P_o}{P_i} * 100$

Where

P_o - Output power in watts

P_i - Input power in watts

PRECAUTIONS:

1. The fuse is selected such that the current rating is 120% of rated current of the motor.
2. It is ensured that the starter handle is in OFF position.
3. The motor field rheostat should be kept at minimum resistance position at the time of starting.
4. Heat produced due to friction between belt and brake drum is reduced by pouring water inside the brake drum periodically.

PROCEDURE:

1. Circuit connections are made as per the circuit diagram shown in figure.
2. The supply is given by closing DPST switch.
3. The motor is started using 3 point starter.
4. The motor field rheostat is adjusted from its minimum resistance position to get the rated speed.
5. The no load readings of the voltmeter and spring balance are noted.
6. The load is increased and voltmeter, ammeter, spring balance readings & speed for various load currents up to the rated current are noted.
7. Performance characteristics are drawn from the tabulated readings & calculated values.

MODEL GRAPH:

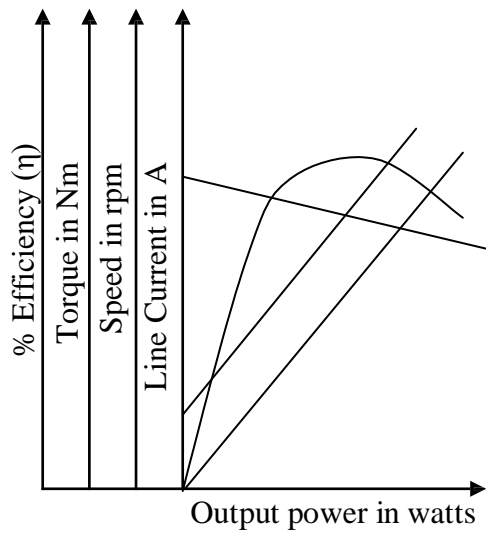


Figure 1.2 Performance Characteristic

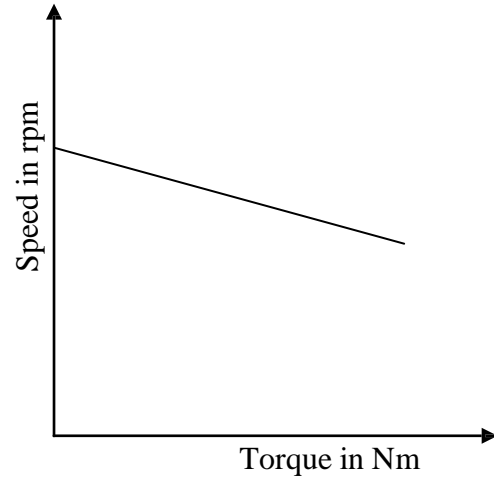


Figure 1.3 Mechanical Characteristic

MODEL CALCULATION:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM LOAD TEST ON DC SERIES MOTOR

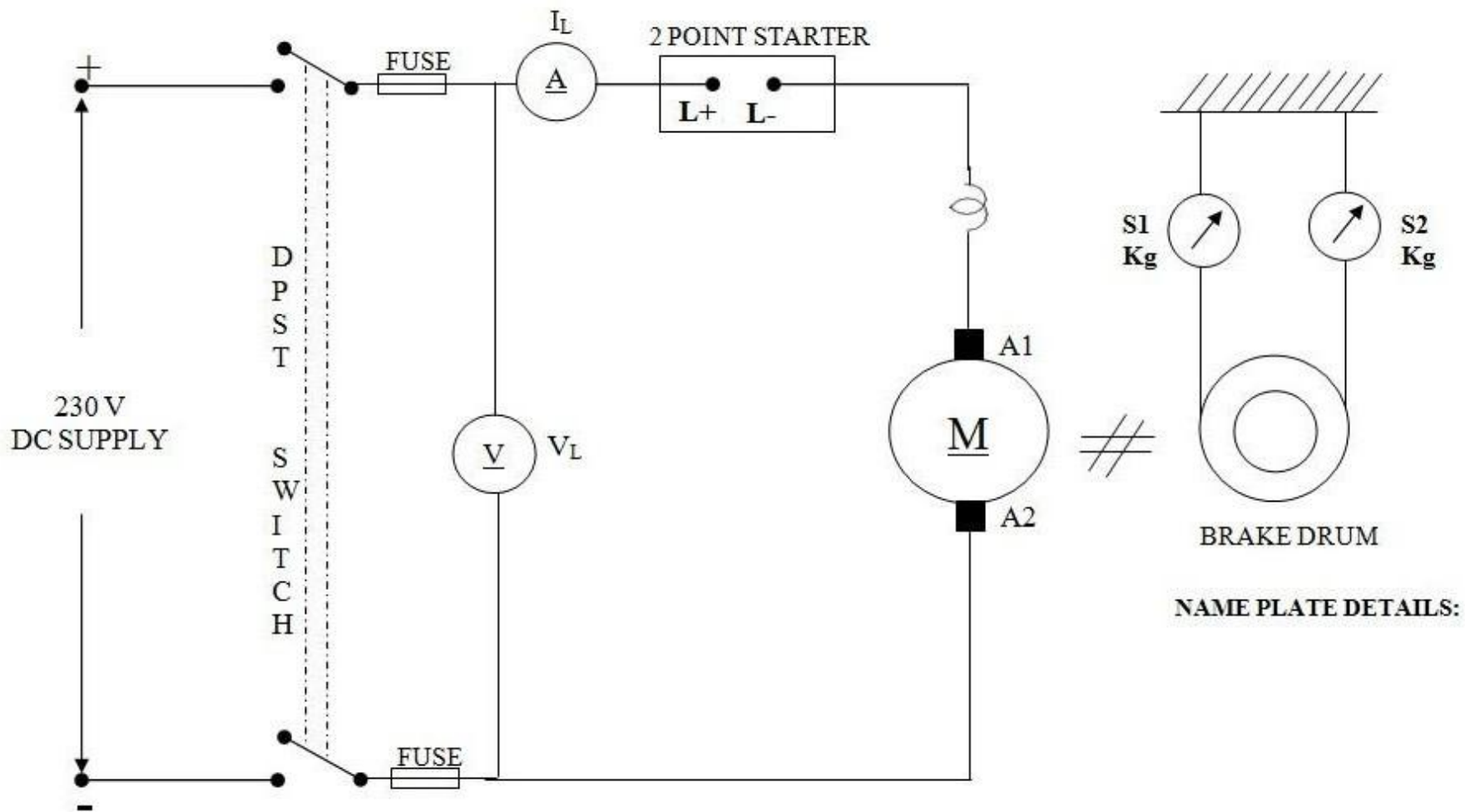


Figure 2.1 - Load Test on DC Series Motor

Ex. No:

LOAD TEST ON DC SERIES MOTOR

Date :

AIM:

To conduct the load test on DC series motor and also to draw the performance characteristics of the given motor.

OBJECTIVES:

1. To determine the efficiency of the given DC series motor by conducting load test.
2. To find the various parameters such as torque, input power, output power etc.
3. To obtain the electrical and mechanical characteristics for the given DC series motor.

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Ammeter			
2.	Voltmeter			
3.	Tachometer			

FORMULA:

1. Torque (T) = (S₁ ~ S₂) x 9.81 x R in Nm.

Where,

S₁, S₂ are spring balance readings in kg

R is the radius of brake drum in m

2. Power output (P_o) = $\frac{2\pi NT}{60}$ watts

Where,

N is the speed of the motor in rpm.

T is the torque in Nm.

3. Power input (P₁) = V_LI_L Watts.

Where,

V_L is the line voltage in volts.

I_L is load current in A.

4. Percentage efficiency (η) = $\frac{\text{Output power}}{\text{Input power}} \times 100$

Where,

P_0 – Output power in watts

P_i – Input power in watts

PRECAUTIONS:

1. Before the motor is started the brake drum is to be loaded to avoid high speed which will damage the winding?
2. The fuse is selected such that its rating is 120% of the rated current.
3. While making any change in the circuit the DPST switch must be kept open.
4. Heat produced due to friction between the belt and brake drum is related by adding water into the brake drum periodically.

PROCEDURE:

1. The circuit connections are made as per the circuit diagram shown in figure.
2. After some load is added to the brake drum, the DPST switch is closed.
3. The motor is started using two point starters.
4. The voltmeter, ammeter and spring balance readings and speed are noted down.
5. The same procedure is repeated for various loads upto the rated value of current.
6. The motor is switched off after reducing certain load on brake drum.
7. Performance characteristics are drawn using the tabulated readings & calculated quantities.

MODEL GRAPH:

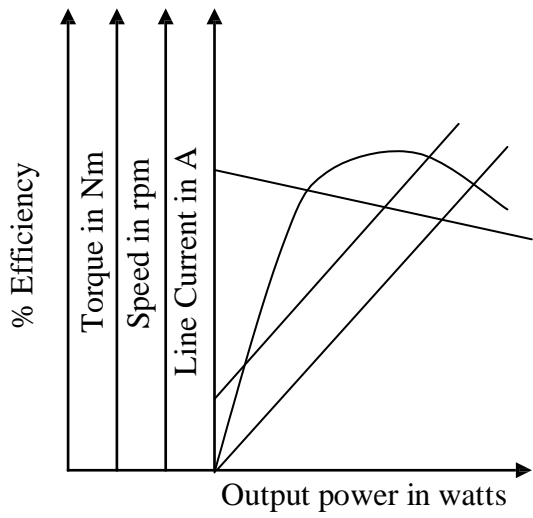


Figure 2.2 Performance Characteristics

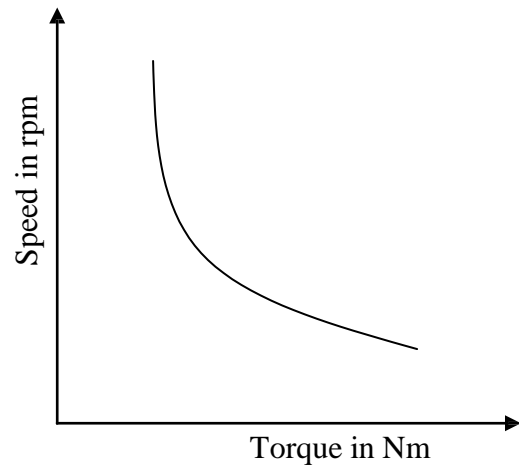


Figure 2.3 Mechanical Characteristics

MODEL CALCULATION:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM - LOAD TEST ON DC COMPOUND MOTOR

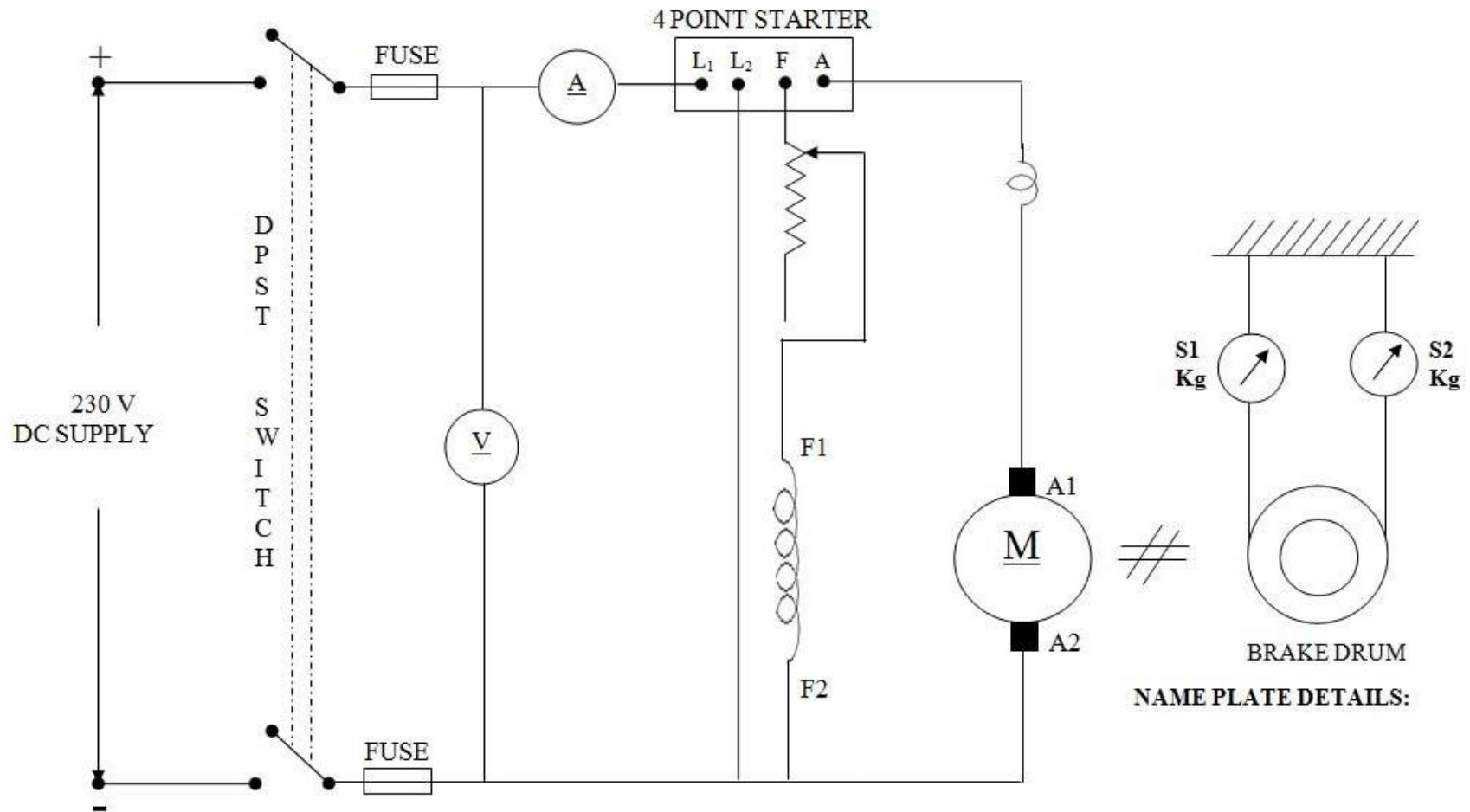


Figure 3.1 - Load Test on DC Compound Motor

Ex. No:	LOAD TEST ON DC COMPOUND MOTOR
Date :	

AIM:

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

OBJECTIVES:

1. To find the various performance parameters such as torque, input power, output power.
2. To determine the efficiency of the given DC compound motor by conducting load test.
3. To obtain the electrical and mechanical characteristics for given DC compound motor.

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Tachometer			

FORMULA:

1. Torque (T) = (S₁ ~ S₂) x R x 9.81 Nm.

Where,

S₁, S₂ are spring balance readings in kg.

R is Radius of brake drum in m.

2. Input power (P_i) = V_L x I_L watts

Where,

V_L is the line voltage in volts.

I_L is load current in A.

3. Output power (P_o) = $\frac{2\pi NT}{60}$ watts

Where,

N is Speed of motor in rpm.

T is Torque in Nm.

4. % Efficiency (η) = $\frac{P_o}{P_i} * 100$

Where,

P_o is Output power in watts.

P_i is input power in watts.

PRECAUTIONS:

1. The fuse is selected such that its rating is 120% of rated current of the motor.
2. It is ensured that the starter handle is in OFF position.
3. The motor field rheostat should be kept at minimum resistance position at the time of starting.
4. Heat produced due to friction between belt and brake drum is reduced by pouring water inside the brake drum periodically.

PROCEDURE:

1. Circuit connections are made as per the circuit diagram.
2. The supply is given by closing DPST switch.
3. The motor is started using 4 point starter.
4. The motor field rheostat is adjusted from its minimum resistance position to get the rated speed.
5. The ammeter, voltmeter and spring balance reading at no load are noted down.
6. The load is increased and voltmeter, ammeter, spring balance readings & speed are noted for various loads upto the rated current.
7. Performance characteristics are drawn using the tabulated readings & calculated quantities.

MODEL GRAPH:

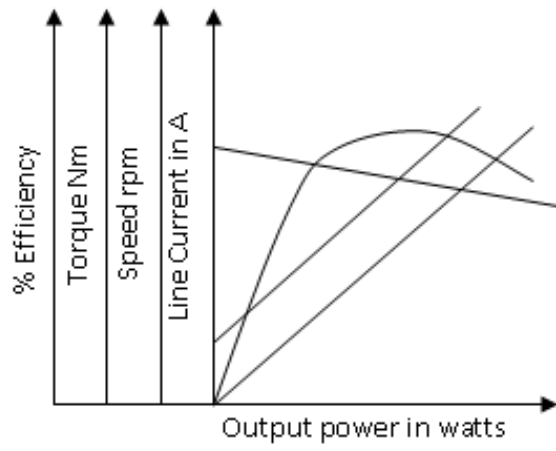


Fig 3.2 Performance Characteristic

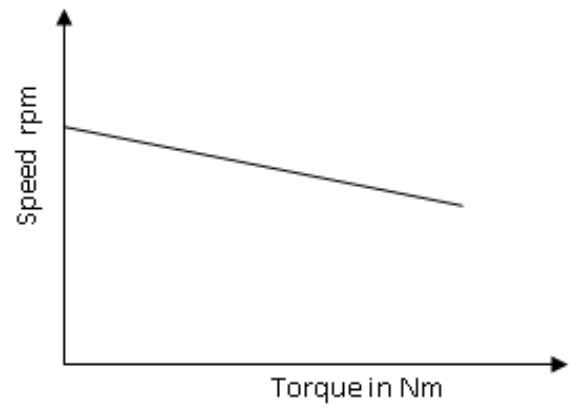


Fig 3.3 Mechanical Characteristic

MODEL CALCULATIONS:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: SPEED CONTROL OF DC SHUNT MOTOR

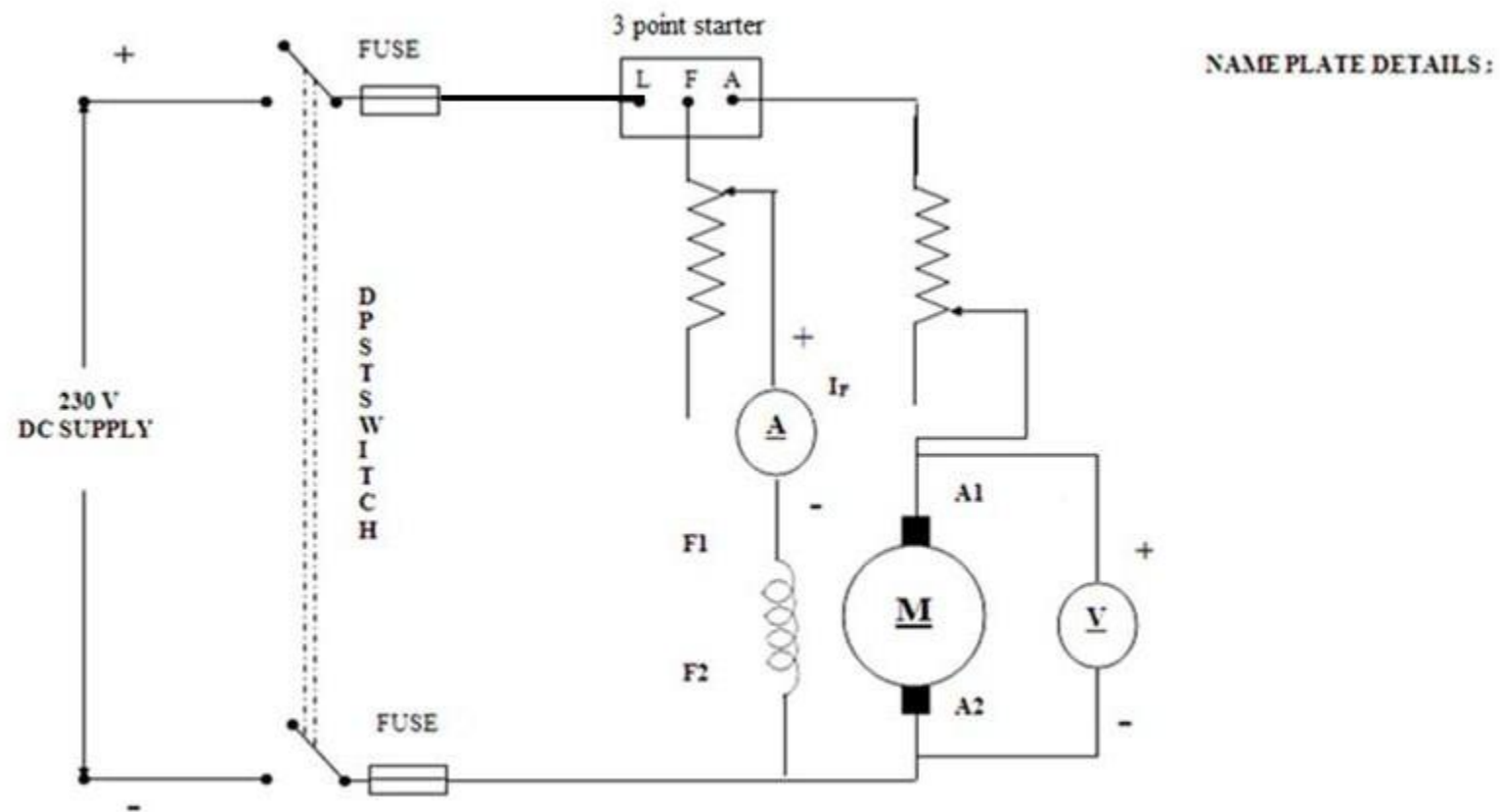


Figure 4.1 Speed control on DC Shunt Motor

Ex. No:	SPEED CONTROL OF DC SHUNT MOTOR
Date :	

AIM:

To study the speed control of the given dc shunt motor by field control method and armature control method.

OBJECTIVES:

1. To control the speed of DC shunt motor using armature control method.
2. To control the speed of DC shunt motor using field control method.
3. To find the armature resistance (R_a)
4. To obtain the characteristics of speed control by the above mentioned methods.

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Voltmeter			2
2.	Ammeter			1
				1
3.	Rheostat			1
				1
4.	Tachometer			1

FORMULA:

$$E_b = V_a - I_a R_a \quad (V)$$

Where

E_b – Back emf in volts.

V_a – Voltage across armature in volts.

I_a – Armature current in A.

R_a – Armature resistance in ohms = 1.5Ω (given).

Table 4.1 ARMATURE CONTROL METHOD

S.NO	$I_f =$	A	$I_f =$	A	$I_f =$	A
	V_a Volts	N rpm	V_a Volts	N rpm	V_a Volts	N rpm

Table 4.2 FIELD CONTROL METHOD

S.NO	$V_a =$	Volts	$V_a =$	Volts	$V_a =$	Volts
	I_f Amps	N rpm	I_f Amps	N rpm	I_f Amps	N rpm

PRECAUTION:

1. The fuse is selected in such way that its rating is 120% of the no load current.
2. The spring balance should be kept at zero position throughout the experiment.
3. Motor field rheostat should be kept at minimum position at the time of starting.

PROCEDURE:**FIELD CONTROL METHOD:**

1. Connections are made as per the circuit diagram.
2. DPST switch is closed & motor is started using three point starter.
3. The voltmeter connected parallel to armature should be kept at constant voltage (V_a) by not varying armature rheostat.
4. The field rheostat is varied and corresponding readings are noted down in tabular column. (I_f & N).
5. The same procedure is repeated for different armature voltages (V_a).
6. The required graph is plotted. (I_f & N).

ARMATURE CONTROL METHOD:

1. Connections are made as per the circuit diagram.
2. DPST switch is closed & motor is started using three point starters.
3. The ammeter is connected in series with the field rheostat. The field current (I_f) is maintained at constant value by adjusting the field rheostat.
4. The armature rheostat is varied and corresponding readings of E_b and N are noted down.
5. The same procedure is repeated for different field currents. (I_f).
6. The required graph is plotted (E_b Vs N).

MODEL GRAPH:

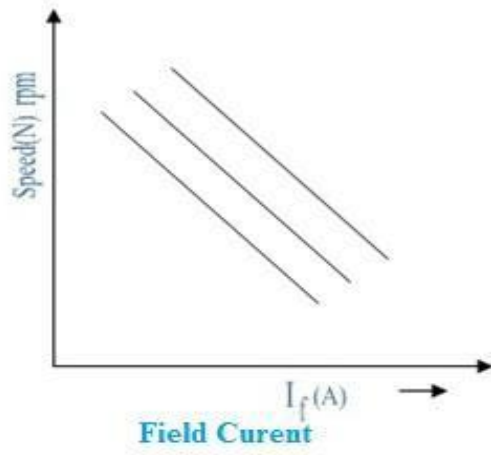


Figure 4.2 Field control method

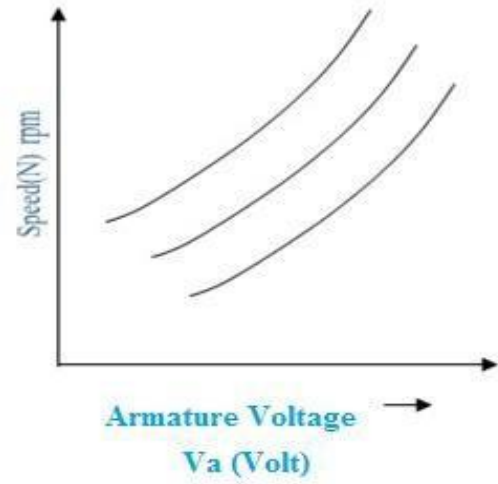


Figure 4.3 Armature control method

MODEL CALCULATION:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: OCC AND LOAD CHARACTERISTICS OF SEPERATELY EXCITED DC SHUNT GENERATOR

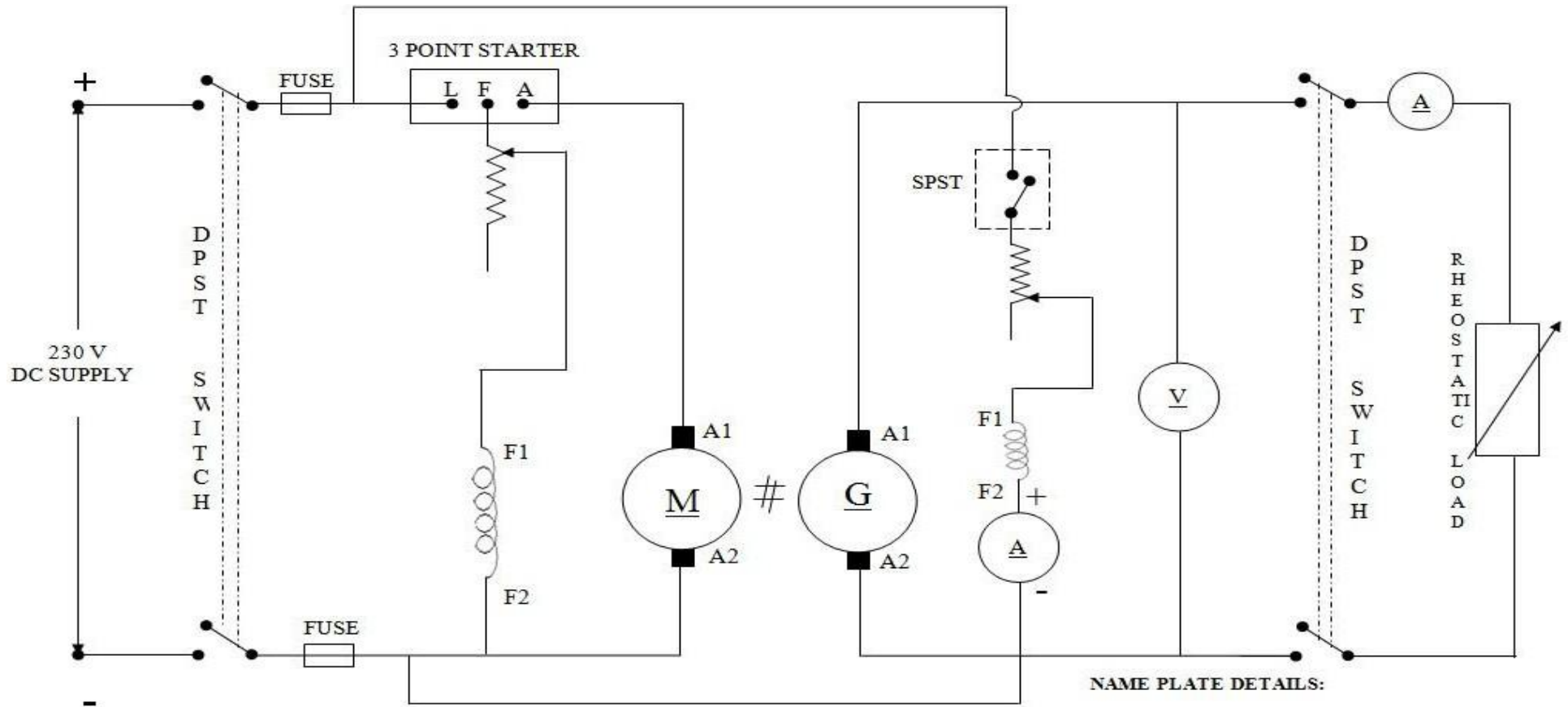


Figure 5.1 – OCC AND LOAD CHARACTERISTICS OF SEPERATELY EXCITED DC SHUNT GENERATOR

Ex. No:	OCC AND LOAD CHARACTERISTICS OF SEPERATELY EXCITED DC GENERATOR
Date :	

AIM:

To conduct a suitable experiment on the given dc generator and draw the OCC & load characteristics of the same when its field is separately excited.

OBJECTIVES:

1. To find the generated voltage (E_g) of a separately excited DC generator for different field currents (I_f) by open circuit test.
2. To find the armature resistance (R_a)
3. To determine Internal, External Characteristics of given DC generator by conducting load test.

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Ammeter			
2.	Voltmeter			
3.	Rheostat			
4.	Tachometer			
5.	DPST switch			
6.	SPST switch			
7.	Loading Rheostat			

FORMULA:

$$E_g = V_L + I_a R_a \quad \text{Volts}$$

Where E_g – Generated emf (V)

V_L – Load Voltage (V)

I_a – armature current (A)

R_a – Armature resistance in ohms = 1.5 (given).

Table 5.1 OPEN CIRCUIT CHARACTERISTICS TEST OF
DC SHUNT GENRATOR

S.NO	FIELD CURRENT I_f (A)	GENERATED VOLTAGE (E_g) (Volts)

Table 5.2 LOAD TEST ON DC SHUNT GENERATOR

Armature Resistance $R_a = 1.5$ ohm

S.NO	FIELD CURRENT I_f (A)	LOAD CURRENT I_L (A)	LOAD VOLTAGE V_L (Volts)	$I_a = I_L$ (A)	$E_g = V_L + I_a R_a$ (Volts)

PRECAUTION:

1. The motor field rheostat should be kept at minimum position at the time of starting.
2. The generator field rheostat should be kept at maximum position at the time of starting.
3. DPST switch 2 is kept open during OCC test.
4. SPST switch is opened at starting to note the residual voltage.

PROCEDURE:**OCC TEST:**

1. By closing DPST switch 1 & using 3 point starter the motor is started.
2. The motor field rheostat is adjusted and the rated speed is set.
3. The residual voltage is noted down from the voltmeter & SPST switch is closed.
4. The generator field rheostat is varied and the generated voltage (E_g) & corresponding field current (I_f) are noted.
5. The same procedure is repeated up to the rated voltage.

LOAD TEST:

1. The DPST switch 2 is closed when the rated voltage is reached.
2. Then the load is applied using loading rheostat and the load current (I_L), load voltage (V_L) & field current (I_f) are noted down for various load current.
3. The same procedure is repeated up to the rated current

MODEL GRAPH:

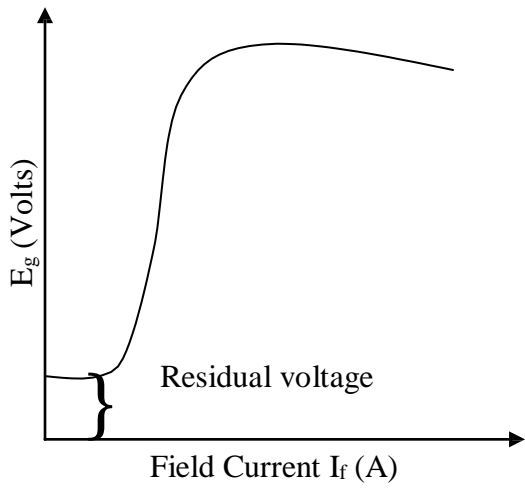


Figure 5.2 OCC Characteristics

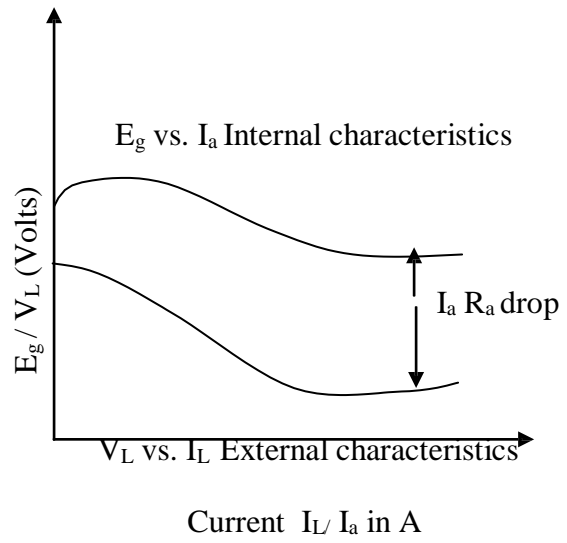


Figure 5.3 Load Characteristics

MODEL CALCULATION:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: OCC AND LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

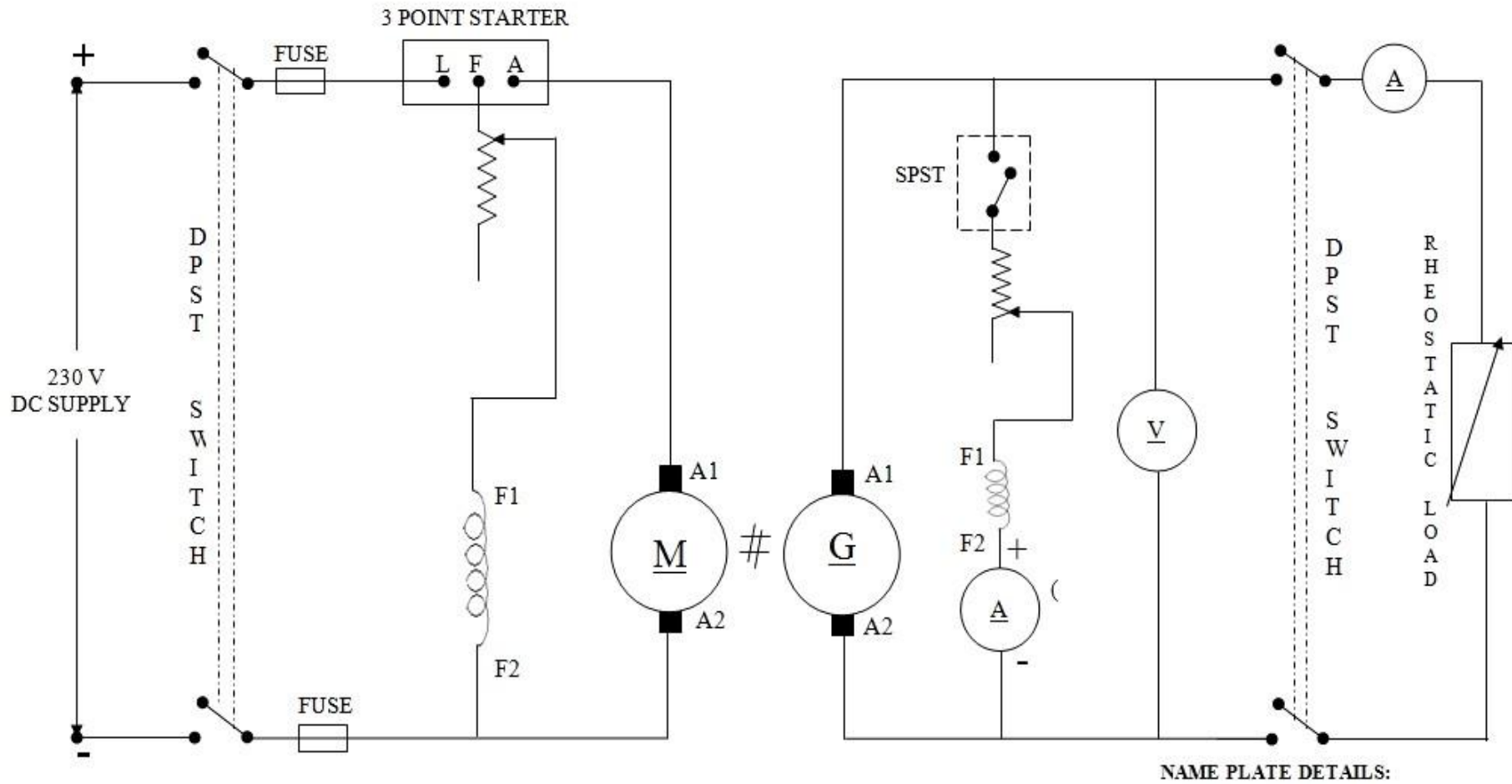


Figure 6.1 OCC AND LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

Ex. No:	OCC AND LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR
Date :	

AIM:

To conduct the suitable experiment on the given dc shunt generator and to draw the OCC & load characteristics of the same.

OBJECTIVES:

1. To find the generated voltage (E_g) of a separately excited DC generator for different field currents (I_f) by open circuit test.
2. To find the armature resistance (R_a)
3. To determine Internal, External Characteristics of given DC generator by conducting load test.

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Ammeter			
2.	Voltmeter			
3.	Rheostat			
4.	Tachometer			
5.	DPST switch			
6.	SPST switch			
7.	Loading Rheostat			

FORMULA:

$$E_g = V_L + I_a R_a \quad \text{Volts}$$

Where

E_g – generated emf (V)

V_L – Load Voltage (V)

I_a – armature current (A)

R_a – Armature resistance in ohms = 1.5 (given).

Table No 6.1 OPEN CIRCUIT CHARACTERISTICS TEST OF DC SHUNT GENRATOR

S.NO	FIELD CURRENT I_f (A)	GENERATED VOLTAGE E_g (Volts)

Table No 6.2 LOAD TEST OF DC SHUNT GENERATOR

Armature Resistance $R_a = 1.5$ ohm

S.NO	FIELD CURRENT I_f (A)	LOAD CURRENT I_L (A)	LOAD VOLTAGE V_L (Volts)	$I_a = I_L + I_f$ (A)	$E_g = V_L + I_a R_a$ (Volts)

PRECAUTION:

1. The motor field rheostat should be kept at minimum position at the time of starting.
2. The generator field rheostat should be kept at maximum position at the time of starting.
3. DPST switch 2 is opened during OCC test.
4. SPST switch is opened at starting to note the residual voltage.

PROCEDURE:**OCC TEST:**

1. By closing DPST switch 1 & using 3 point starter the motor is started.
2. The motor field rheostat is adjusted and the rated speed is set.
3. The residual voltage is noted down from the voltmeter & SPST switch is closed.
4. The generator field rheostat is varied and the generated voltage (E_g) & corresponding field current (I_f) are noted.
5. The same procedure is repeated up to the rated voltage.

LOAD TEST:

1. The DPST switch 2 is closed when the rated voltage is reached.
2. Then the load is applied using loading rheostat and the load current (I_L), load voltage (V_L) & field current (I_f) are noted down for various load current.
3. The same procedure is repeated up to the rated current

MODEL GRAPH:

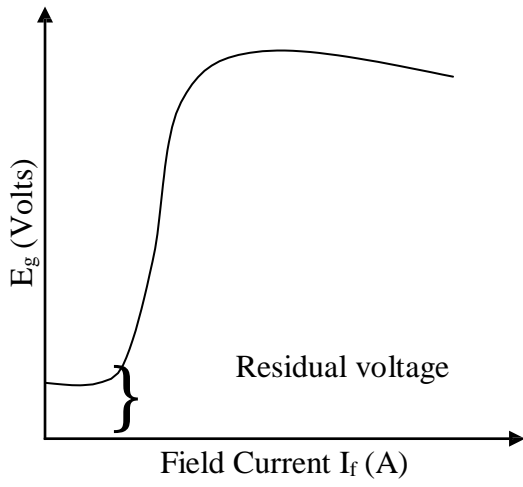


Figure 6.2 OCC Characteristics

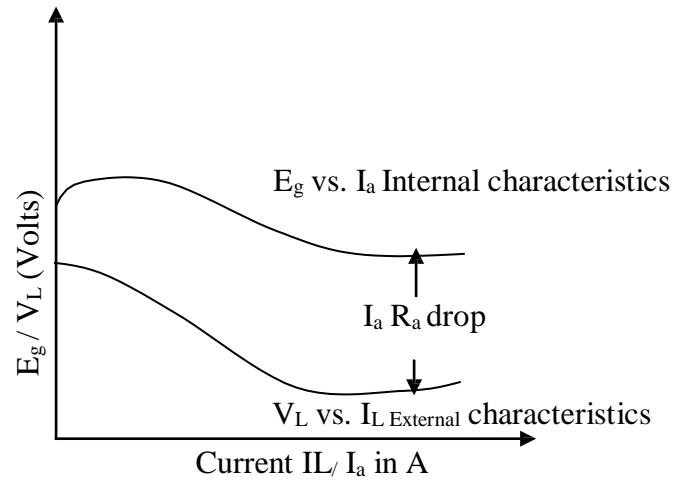


Figure 6.3 Load Characteristics

MODEL CALCULATION:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: LOAD TEST ON DC SERIES GENERATOR

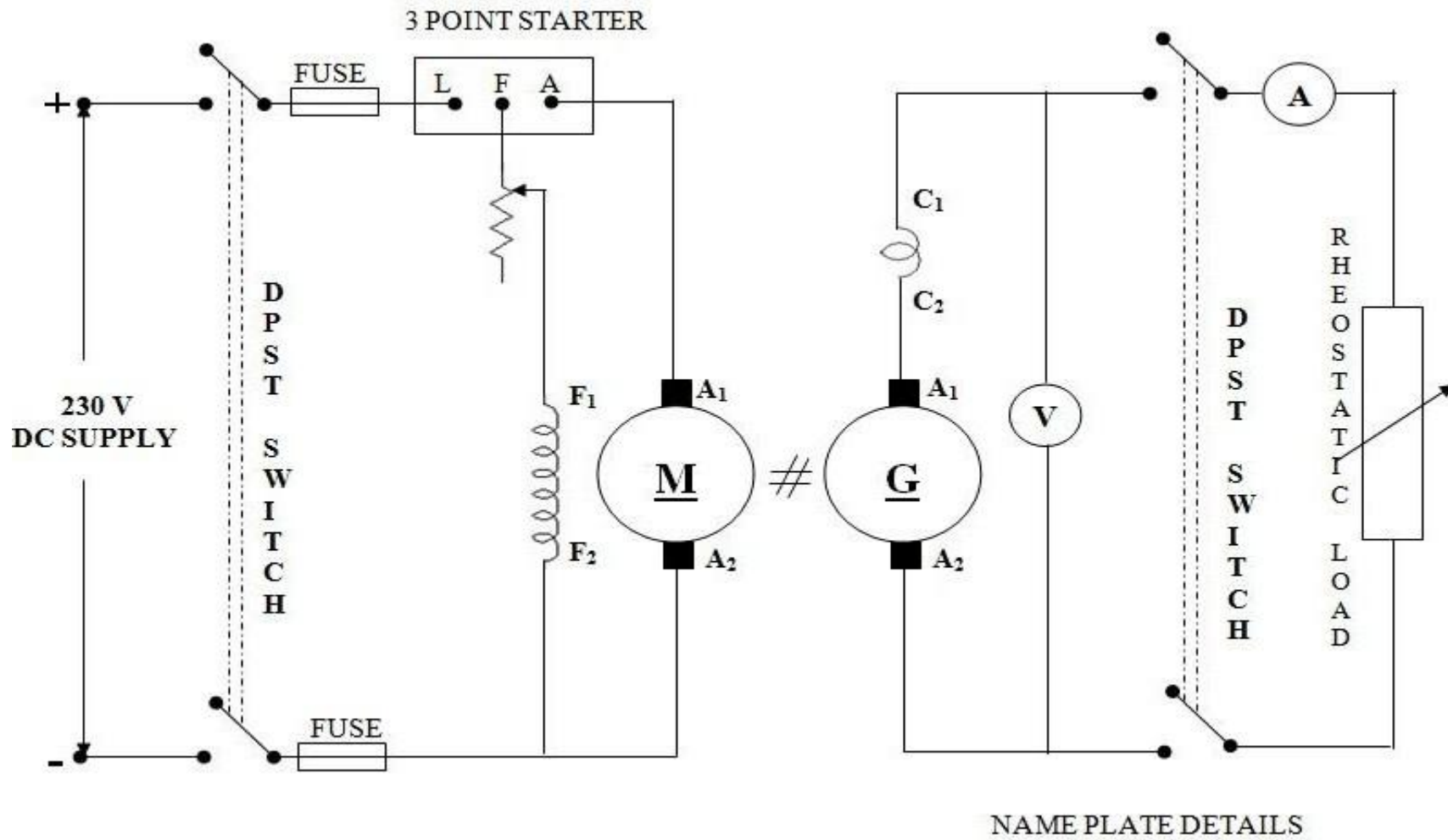


Figure 7.1 LOAD TEST ON DC SERIES GENERATOR

Ex. No:	LOAD CHARACTERISTICS OF DC SERIES GENERATOR
Date :	

AIM

To conduct the load test on DC series Generator and draw its load characteristics.

OBJECTIVES

1. To find the generated voltage (E_g) of a DC series generator for different field currents (I_f) by open circuit test.
2. To find the armature resistance (R_a)
3. To determine Internal, External Characteristics of given DC generator by conducting load test.

APPARATUS REQUIRED

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Tachometer			
5.	DPST switch			
6.	Loading rheostat			

PRECAUTION

1. Motor field rheostat should in minimum position at the time starting.

PROCEDURE

1. The circuit connections are made as per the circuit diagram.
2. DPST switch 1 is closed and the motor is started using three point starter.
3. Adjust the motor field rheostat and set the rated speed.
4. Close the DPST switch 2 and vary the loading rheostat.
5. Note down the voltmeter and ammeter reading in the tabular column.
6. Repeat the same procedure up to the rated current.
7. The required graph is plotted (I_L Vs V_L)

Table 7.1 LOAD CHARACTERISTICS OF DC SERIES GENRATOR

S.NO	LOAD CURRENT I_L (A)	LOAD VOLTAGE V_L (Volts)

MODEL GRAPH:

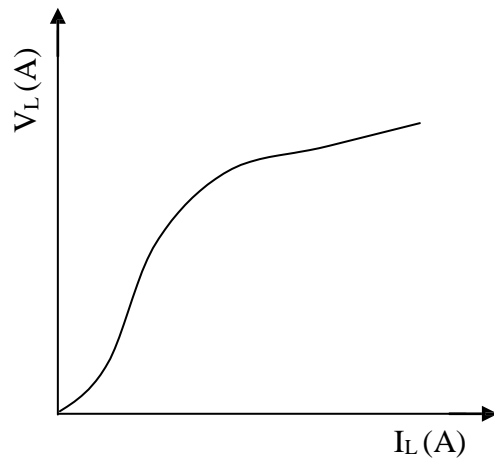


Figure 7.2 Load Characteristics

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: LOAD TEST ON DC COMPOUND GENERATOR

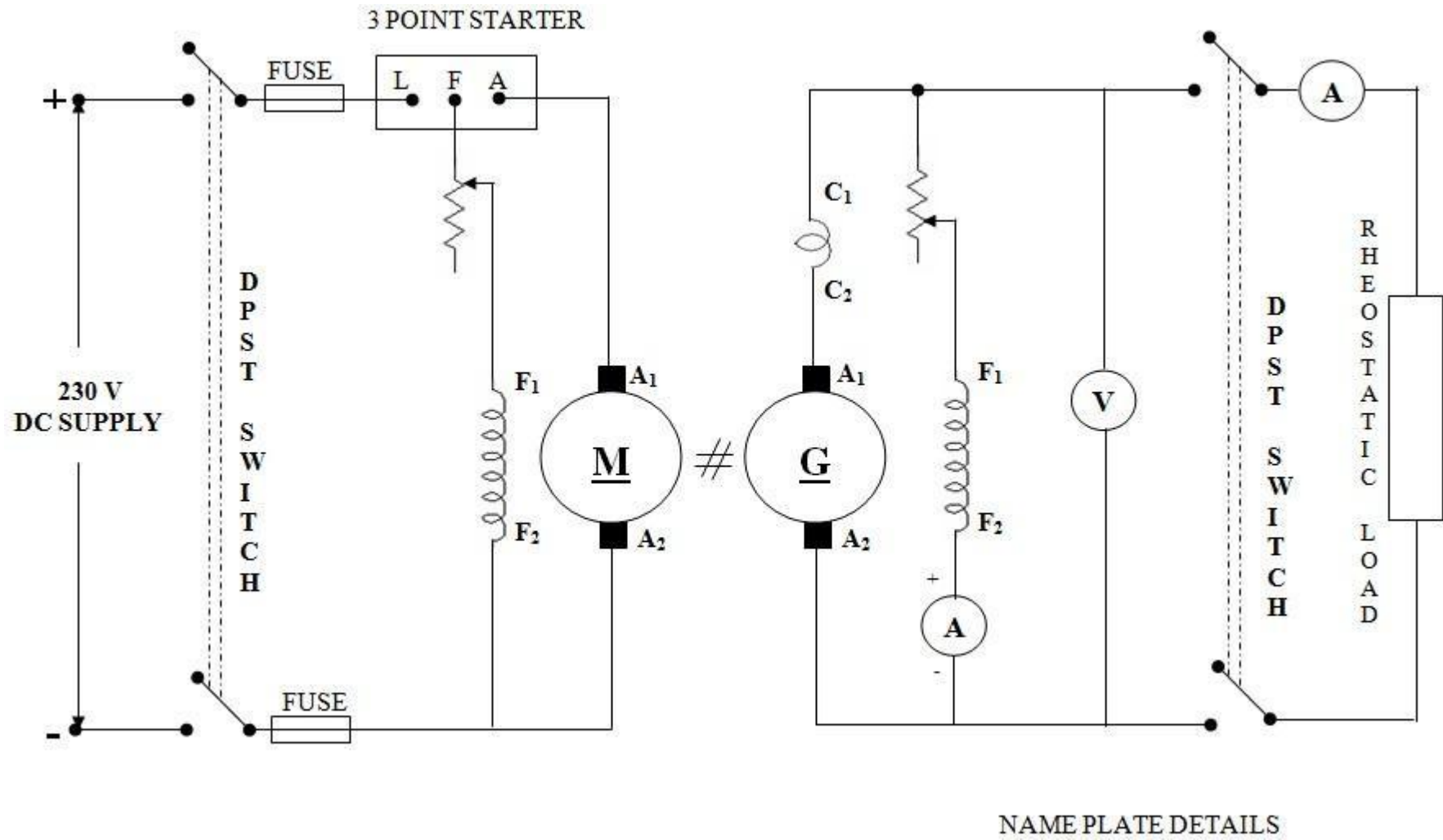


Figure 8.1 LOAD TEST ON DC COMPOUND GENERATOR

Ex. No:	LOAD CHARACTERISTICS OF DC COMPOUND GENERATOR
Date :	

AIM

To conduct the load test on DC compound generator and draw its load characteristics.

OBJECTIVES

1. To find the generated voltage (E_g) of a DC compound generator for different field currents (I_f) by open circuit test.
2. To find the armature resistance (R_a)
3. To determine Internal, External Characteristics of given DC generator by conducting load test.

APPARATUS REQUIRED

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Tachometer			
5.	DPST switch			
6.	Loading Rheostat			

THEORY

$$E_g = V_L + I_a (R_a + R_{se}) \text{ volts}$$

Where,

E_g = generated voltage in volts

V_L = load Voltage in volts

I_a = armature current (A)

R_a = Armature resistance in ohms = 2.3 Ω (given).

R_{se} = Resistance of the series field winding

Table 8.1 LOAD TEST OF DC COMPOUND GENERATOR

Armature resistance $R_a = 2.3 \Omega$ (given)

S.NO	FIELD CURRENT I_f (A)	LOAD VOLTAGE V_L (V)	LOAD CURRENT I_L (A)	$I_a = I_L + I_f$ (A)	$E_g = V_L + I_a(R_a + R_{se})$ (V)

$$I_a = I_L + I_f$$

Where,

I_L = load current in A

I_f = field current in A

PRECAUTION

1. The fuse is selected such that it has 120% of the rated current of DC shunt motor.
2. The field rheostat of the motor should be kept at maximum resistance position at starting.
3. The field rheostat of the generator should keep at minimum resistance position at starting.
4. DPST switch 2 should be kept open during built up of voltage across the generator armature.

PROCEDURE

1. The Connections are made as per the circuit diagram.
2. DPST switch 1 is closed and the motor is started using three point starter.
3. The field rheostat of the motor is adjusted to get the rated speed of the motor.
4. The field rheostat of the generator is adjusted to get rated voltage in the voltmeter that is connected across the generator armatures.
5. The DPST switch 2 is closed.
6. Then the rheostatic load is applied.
7. The same procedure is repeated up to the rated current is obtained.
8. The Readings are tabulated in the tabular column.

Table 8.2 LOAD TEST OF DC COMPOUND GENERATOR

Armature resistance $R_a = 2.3 \Omega$ (given)

S.NO	FIELD CURRENT I_f (A)	LOAD VOLTAGE V_L (V)	LOAD CURRENT I_L (A)	$I_a = I_L + I_f$ (A)	$E_g = V_L + I_a(R_a + R_{se})$ (Volts)

MODEL GRAPH

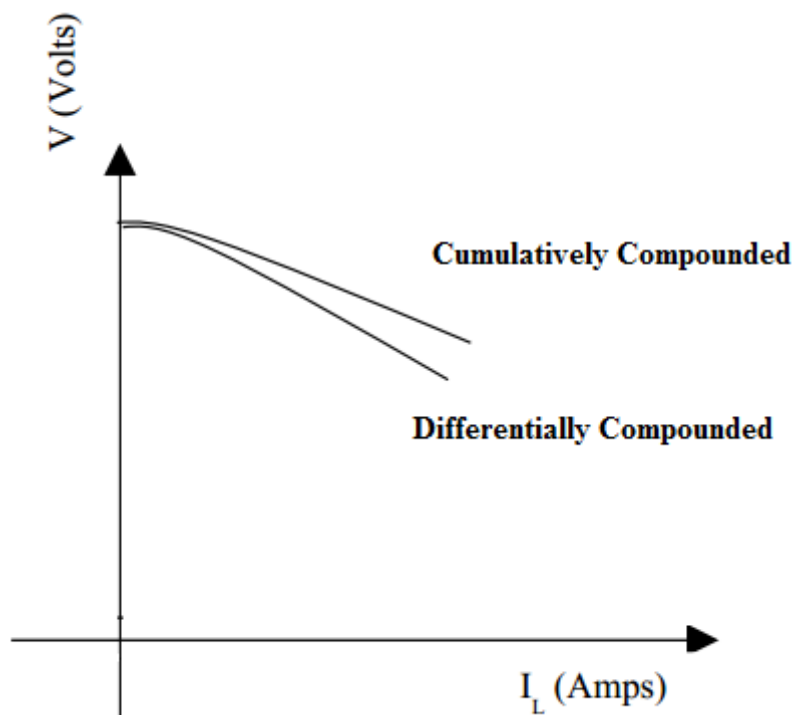


Figure 8.2 Load Characteristics

MODEL CALCULATION



PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: SWINBURNES TEST ON DC MACHINE

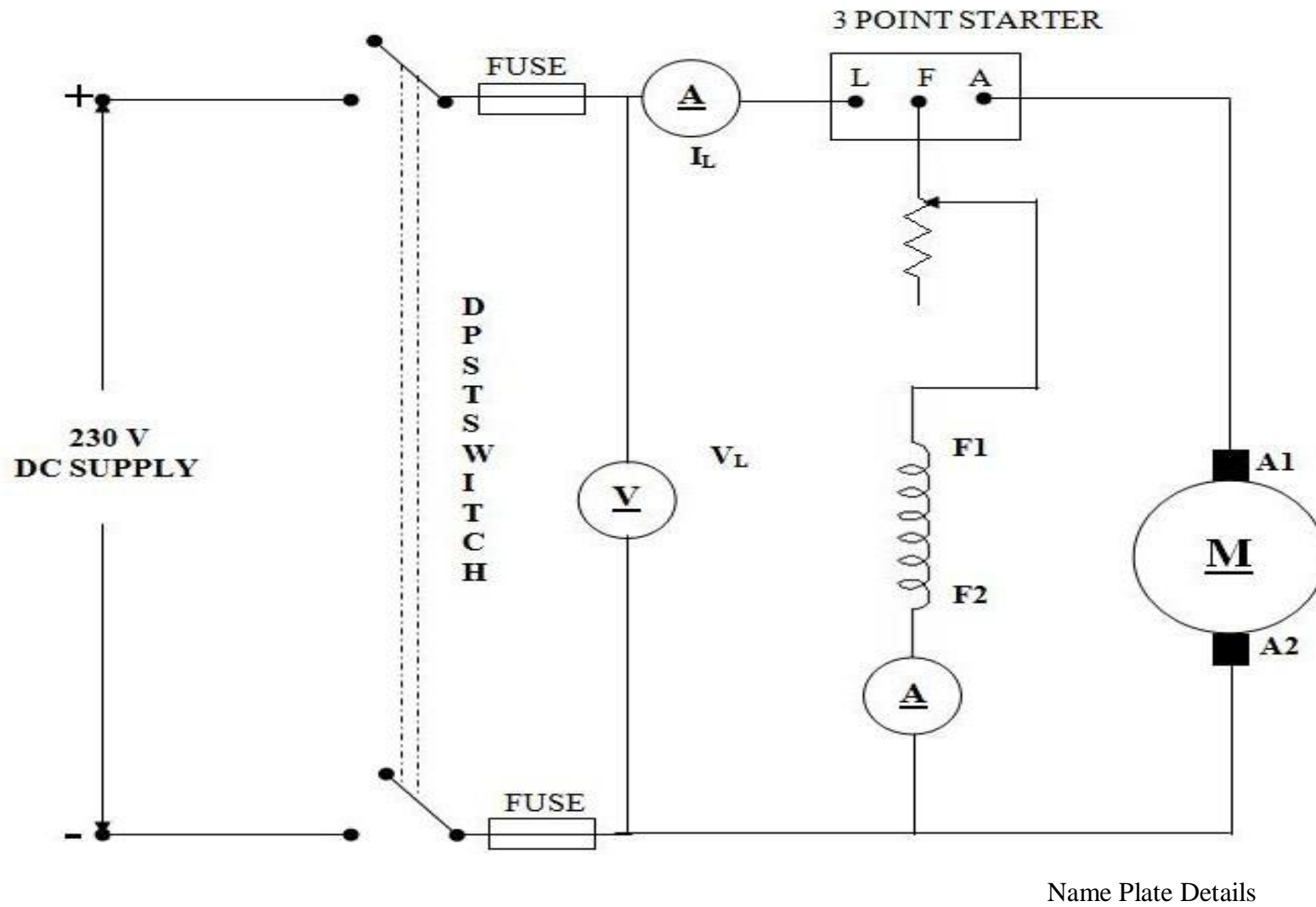


Figure 9.1 SWINBURNES TEST ON DC MACHINE

Ex. No:	SWINBURNE'S TEST ON DC MACHINE
Date :	

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.

OBJECTIVE

To determine the efficiency at various load current while operating as a motor and generator and plot a graph output Vs $\eta\%$

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Tachometer			

FORMULA USED

Input Power = output power + total losses (watts)

At no load output power = 0

Input power = total losses (watts)

Total losses = copper loss+ constant loss (W_c) (watts)

Constant loss=total loss-copper loss

W_c =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

Table 9.1 SWINBURNE'S TEST

$$\text{Percentage of efficiency} = \frac{P_o}{P_i} * 100$$

FOR GENERATOR

$$I_a = I_L + I_F$$

$$\text{Constant loss } W_c = V_L I_L \text{ (at no load)} - I_a^2 R_a \quad \text{Watts}$$

$$\text{Copper loss} = I_a^2 R_a \quad \text{Watts}$$

$$\text{Total loss} = \text{copper loss} + \text{constant loss watts}$$

$$\text{Output Power } P_o = V_L I_L \quad \text{Watts}$$

$$\text{Input power } P_i = \text{Output power} + \text{total losses Watts}$$

$$\text{Percentage of efficiency} = \frac{P_o}{P_i} * 100$$

PRECAUTIONS

1. Fuse should be selected such that its current rating is 120% of no load current of the motor.
2. Motor field rheostat should be kept at minimum resistance position at starting.

PROCEDURE

1. Connections are made as per the circuit diagram shown in the figure.
2. The DPST switch is closed and motor is started using three point starter.
3. The motor field rheostat is adjusted to run the motor at rated speed.
4. At rated speed, the values of line voltage, no load current and field current are noted down in the tabular column.
5. The efficiency of the machine as a motor and as a generator for each assumed load current up to rated current are calculated and tabulated in the respective tabular column.
6. The characteristic curve between the output power and efficiency are drawn for both the cases.

Table 9.3 PERFORMANCE OF DC MACHINE AS A GENERATOR

Armature Resistance= 1.5 Ohms (GIVEN)

Line Voltage =

Constant Loss =

S.no	Load current I_l (A)	Armature current $I_a = i_l + i_f$ (A)	Armature Copper loss $I_a^2 r_a$ (watts)	Total loss $W_c + W_{cu}$ (watts)	Output power V_{il} (watts)	Input power (watts)	Efficiency %

MODEL GRAPH

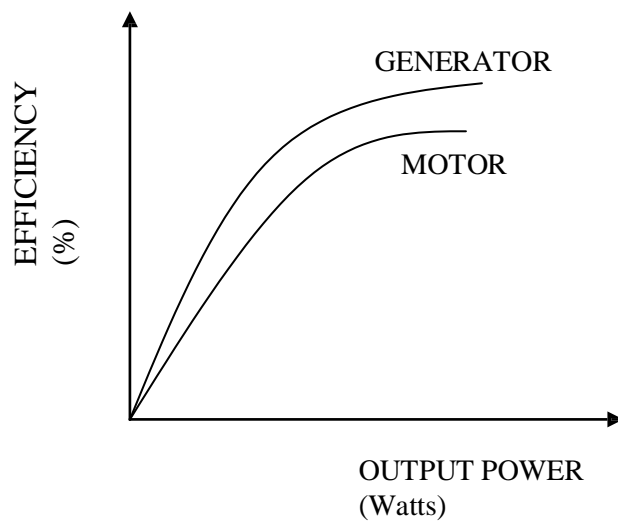


Figure 9.2 Performance Characteristics

MODEL CALCULATION

DC MACHINE AS A MOTOR

DC MACHINE AS A GENERATOR

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

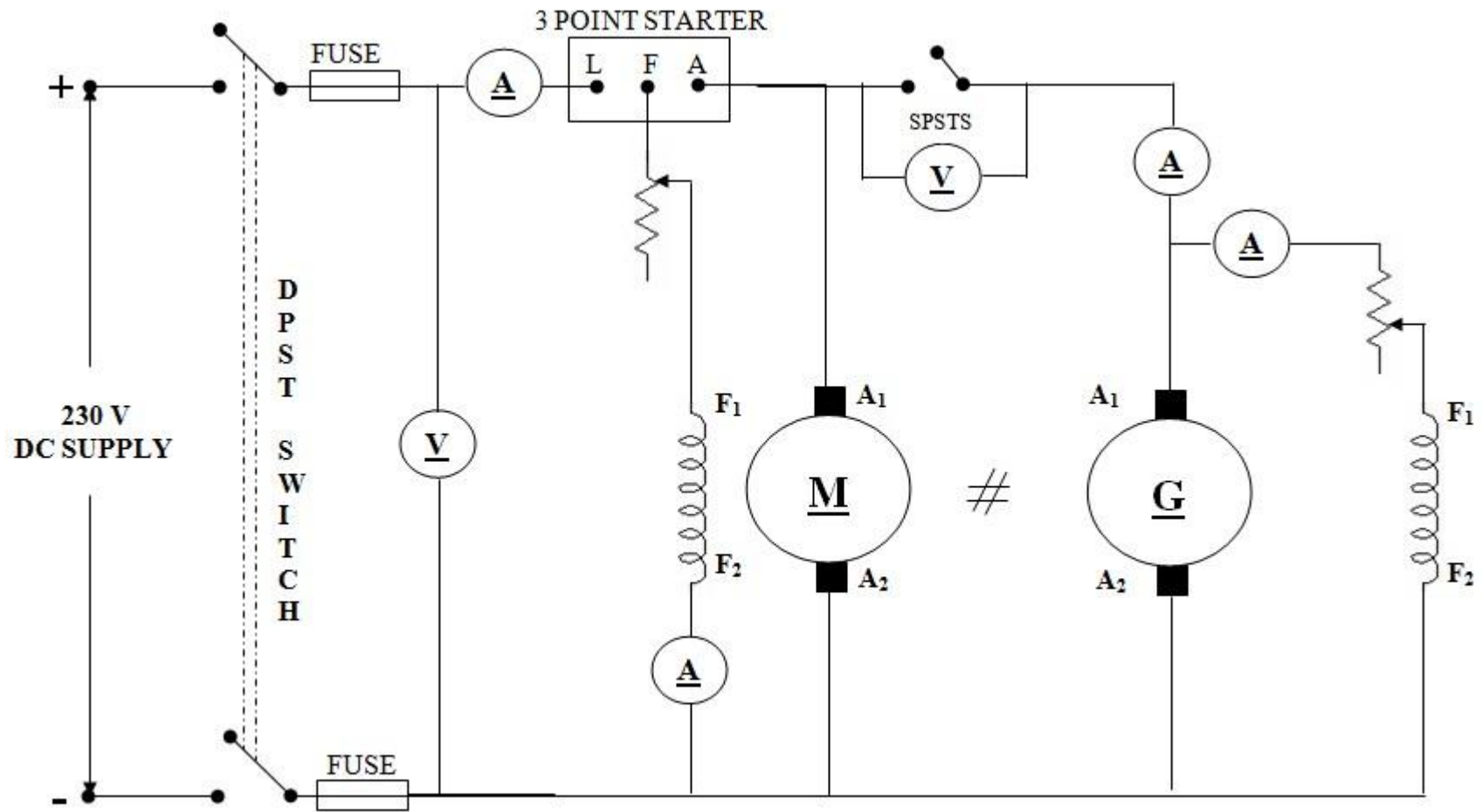
RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: HOPKINSONS TEST ON DC MOTOR- GENERATOR SET



NAME PLATE DETAILS:

Figure 10.1 HOPKINSONS TEST ON DC MOTOR- GENERATOR SET

Ex. No:	HOPKINSON'S TEST ON DC MACHINES
Date :	

AIM

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

OBJECTIVE

1. To determine the stray losses of the machines.
2. To obtain efficiency curves for the motor and generator and draw the curves.

APPARATUS REQUIRED

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Tachometer			
5.	SPST			

FORMULA USED

1. 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)

2. Generator output = $V I_1$ Watts

3. 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

Armature cu loss in generator = $(I_1 + I_3)^2 R_a$ watts (1)

Armature cu loss in motor = $(I_1 + I_2 - I_4)^2 R_a$ watts(2)

Shunt cu loss in generator = $V I_3$ watts.. (3)

Shunt cu loss in motor = $V I_4$ watts(4)

Stray losses of both machine = w (say)(5)

Power drawn from the supply = V I₂ watts(6)

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

Total stray loss for the set = w

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

Stray loss per machine = $\frac{w}{2}$

4. Efficiency for generator:

Generator output = V I₁ watts

Total losses = (I₁ + I₃)²R_a + V I₃ + w/2 = W_g watts

Generator input = V I₁ + W_g watts

Efficiency of the generator = V I₁ / (V I₁ + W_g)

5. Efficiency for Motor:

Motor input = V (I₁ + I₂) watts

Total losses = (I₁ + I₂ - I₄)²R_a + V I₄ + w/2 = W_m watts

Generator input = V (I₁ + I₂) - W_m watts

Efficiency of the generator = V (I₁ + I₂) - W_m / V (I₁ + I₂)

PRECAUTION

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. The circuit Connections is made as per the circuit diagram shown in the figure.
2. DPST switch is closed and machine M is started using three point starter.
3. SPST switch between two machines is still opened.
4. The machine M field rheostat is adjusted and the rated speed is set.
5. Machine M drives machine G as a generator and its voltage is read on voltmeter V₁.
6. The field rheostat of the machine is adjusted until voltmeter V₁ reads zero. It means that its voltage is the same as that of the main supply.
7. Now SPST is closed.
8. By adjusting the respective field rheostat, any load can be applied on to the machine.

9. Generator current I_1 is adjusted step by step by increasing the excitation of machine G or by reducing the excitation of machine M.
10. From the tabulated readings, efficiency of the motor (machine M) and efficiency of the generator (machine G) for different I_1 up to rated current can be calculated.
11. Performance characteristics can be drawn for both the machines
(Output power Vs % efficiency)

MODEL CALCULATION FOR DC MOTOR

MODEL GRAPH

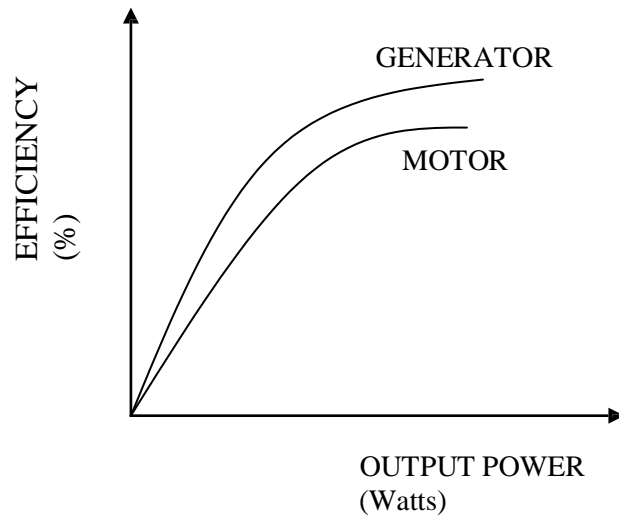
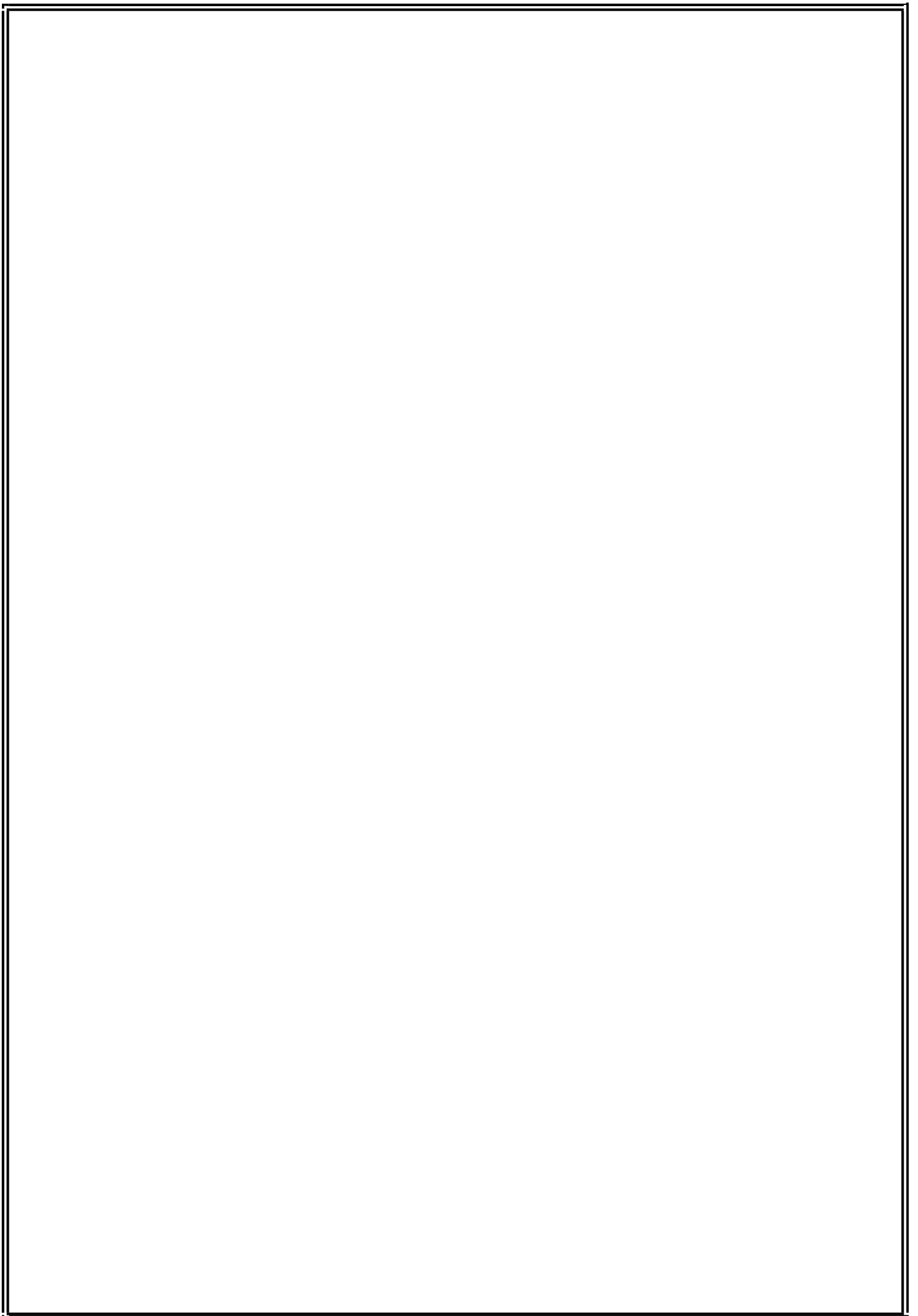


Fig 10.2 Performance Characteristics

MODEL CALCULATION FOR DC GENERATOR



PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM FOR LOAD TEST ON SINGLE PHASE TRANSFORMER:

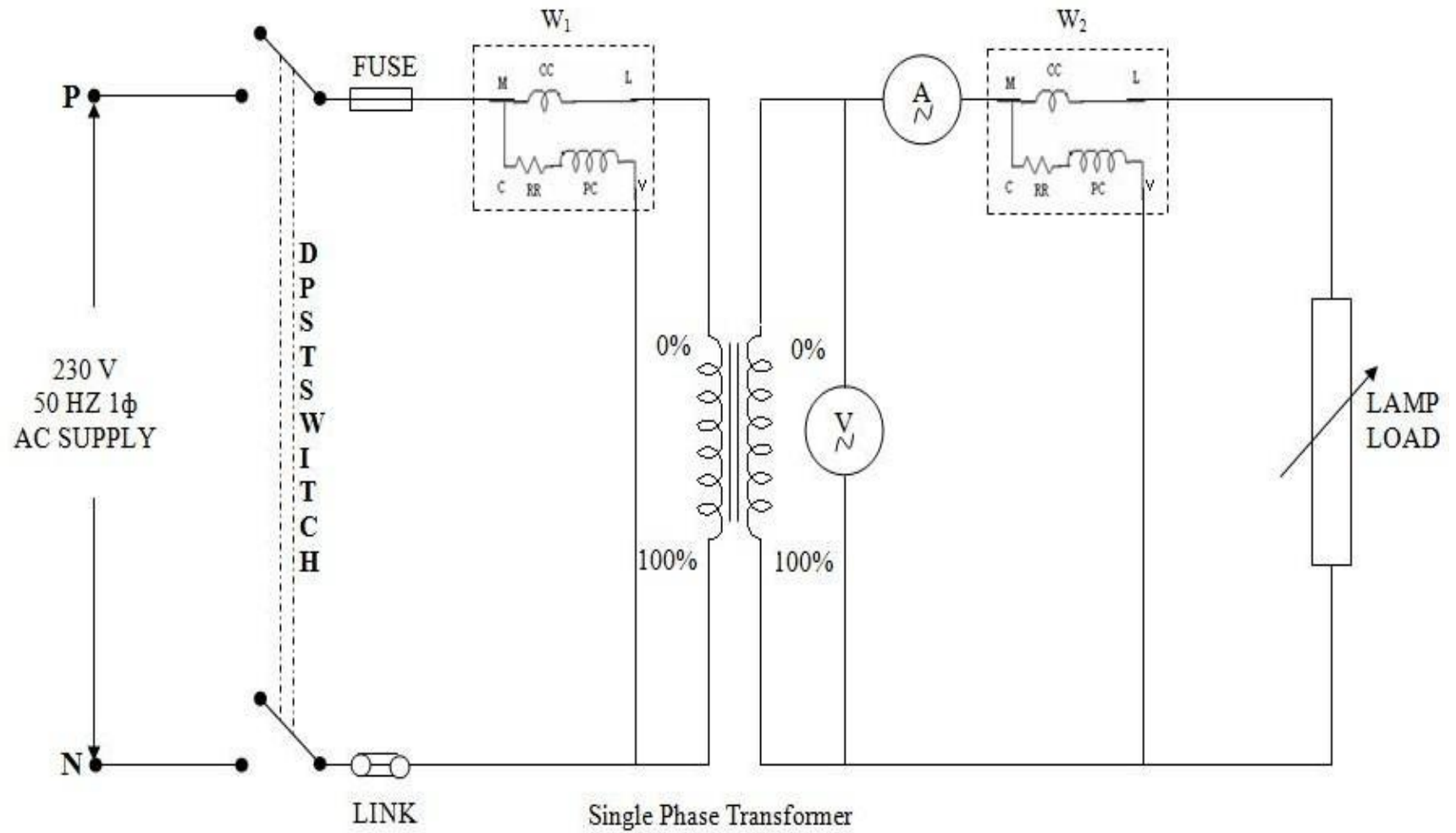


Figure 11.1 LOAD TEST SINGLE PHASE TRANSFORMER

Ex. No:

LOAD TEST ON SINGLE PHASE TRANSFORMER

Date :

AIM

To draw the load characteristics of a given single phase transformer by conducting load test.

OBJECTIVE

To plot the following graphs

1. Load current Vs efficiency
2. Load current Vs % regulation

APPARATUS REQUIRED

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Transformer			
2.	Ammeter			
3.	Voltmeter			
4.	Wattmeter			
5.	Lamp Load			

FORMULA USED

1. Percentage of efficiency = $\frac{W_2}{W_1} \times 100$

2. Percentage of up regulation = $\frac{V_{nl} - V_{fl}}{V_{fl}} \times 100$

3. Percentage of down regulation = $\frac{V_{nl} - V_{fl}}{V_{nl}} \times 100$

Where W_1 = is the input power in watts

W_2 = is the output power in watts

V_{fl} = is the full load voltage in volts

V_{nl} = is the no load voltage in volts.

PRECAUTIONS

1. Fuse should be selected such that its current rating is 120% of no load current of the transformer.
2. The DPST switch is kept opened at the time of starting the experiment while giving connections.
3. The load should be in the off position while at the start of the experiment.

PROCEDURE

1. The connections are made as per the circuit diagram shown in the diagram.
2. The DPST switch is closed and the supply is given to the circuit
3. The no load readings are noted.
4. By varying the lamp load in steps, corresponding ammeter, voltmeter and wattmeter readings are noted down.
5. The same procedure is repeated up to the rated current.
6. All the readings are tabulated in tabular column and required quantities are calculated to draw characteristics curves.

MODEL CALCULATION

MODEL GRAPH:

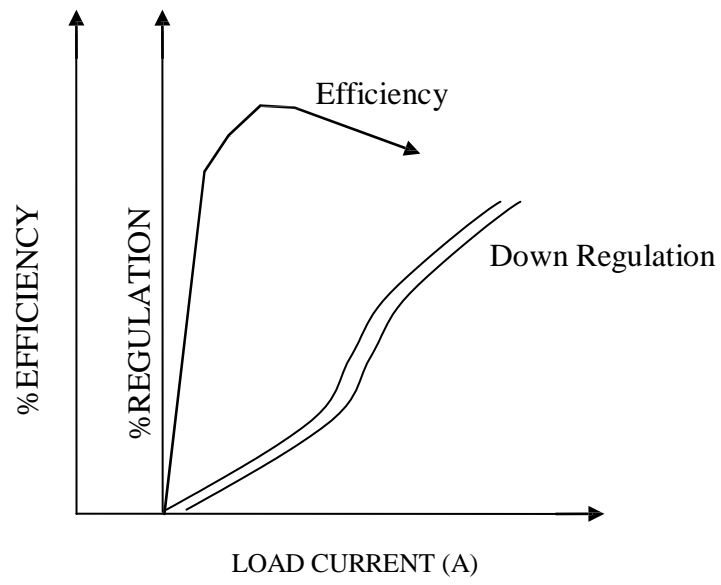


Figure 11.2 Performance Curve

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: OPEN CIRCUIT TEST ON SINGLE PHASE TRANSFORMER

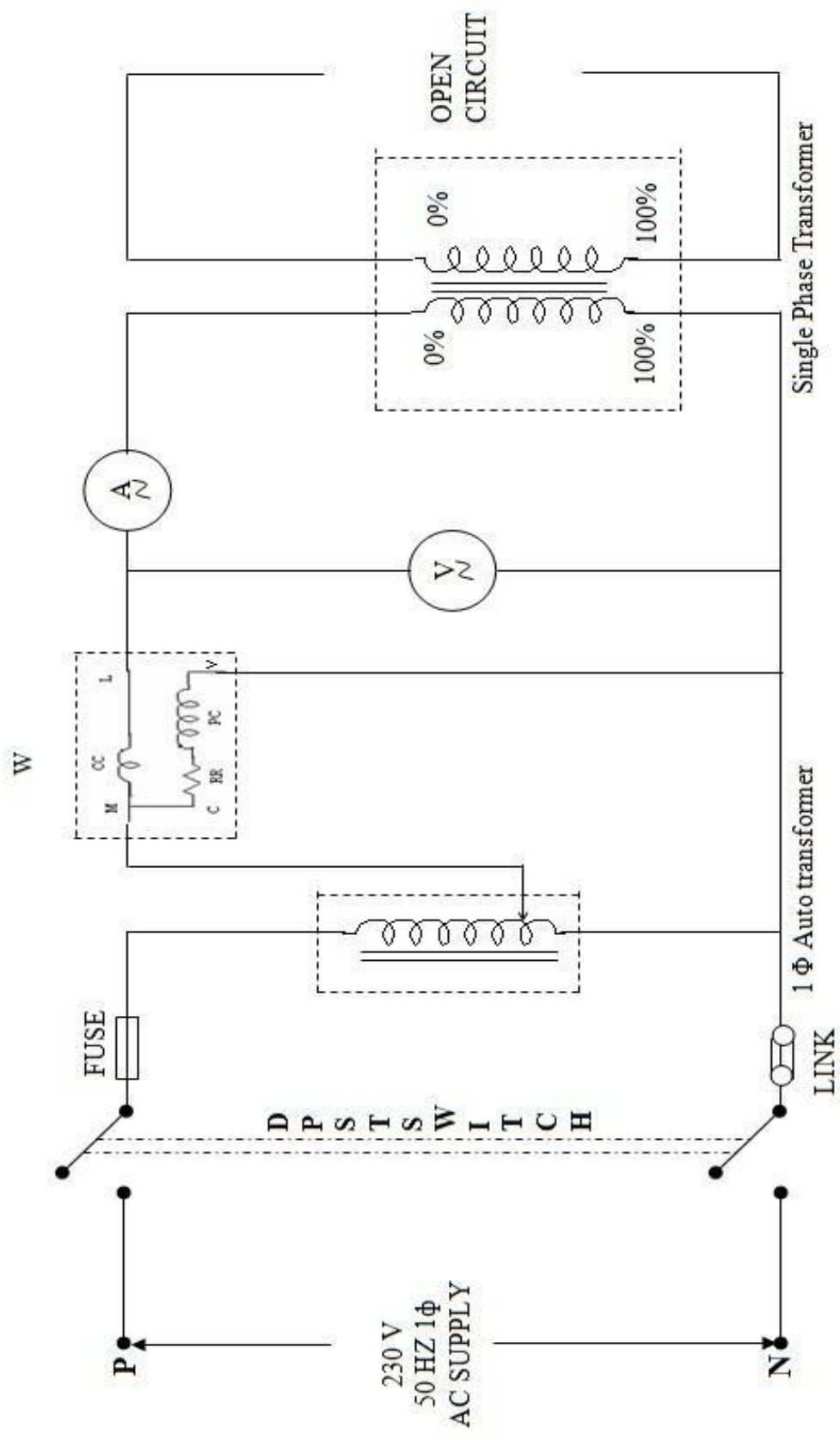


Figure 12.1 OPEN CIRCUIT TEST ON SINGLE PHASE TRANSFORMER

Ex. No:	OPEN CIRCUIT AND SHORT CIRCUIT TEST ON SINGLE PHASE TRANSFORMER
Date :	

AIM

To conduct the open circuit and short circuit test on given single phase transformer and predetermine its efficiency and regulation of the same machine.

OBJECTIVE

1. Predetermine the efficiency at different load at UPF and 0.8 Power factor lagging.
2. Predetermine the full load regulation at different power factor.
3. Draw the following curves
 - a. Output Vs $\eta\%$
 - b. Power factor Vs %Regulation

APPARATUS REQUIRED:

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	single phase Transformer			
1.	Ammeter			
2.	Voltmeter			
3.	Wattmeter			
4.	Autotransformer			

FORMULA USED

$$1. R_0 = \frac{V_o}{I_o \cos\phi_o} \text{ Ohms}$$

$$2. \cos\phi_0 = \frac{W_o}{V_o I_o}$$

Where W_0 = open circuit wattmeter reading in watts

V_0 = open circuit voltage in volts

CIRCUIT DIAGRAM: SHORT CIRCUIT TEST ON SINGLE PHASE TRANSFORMER

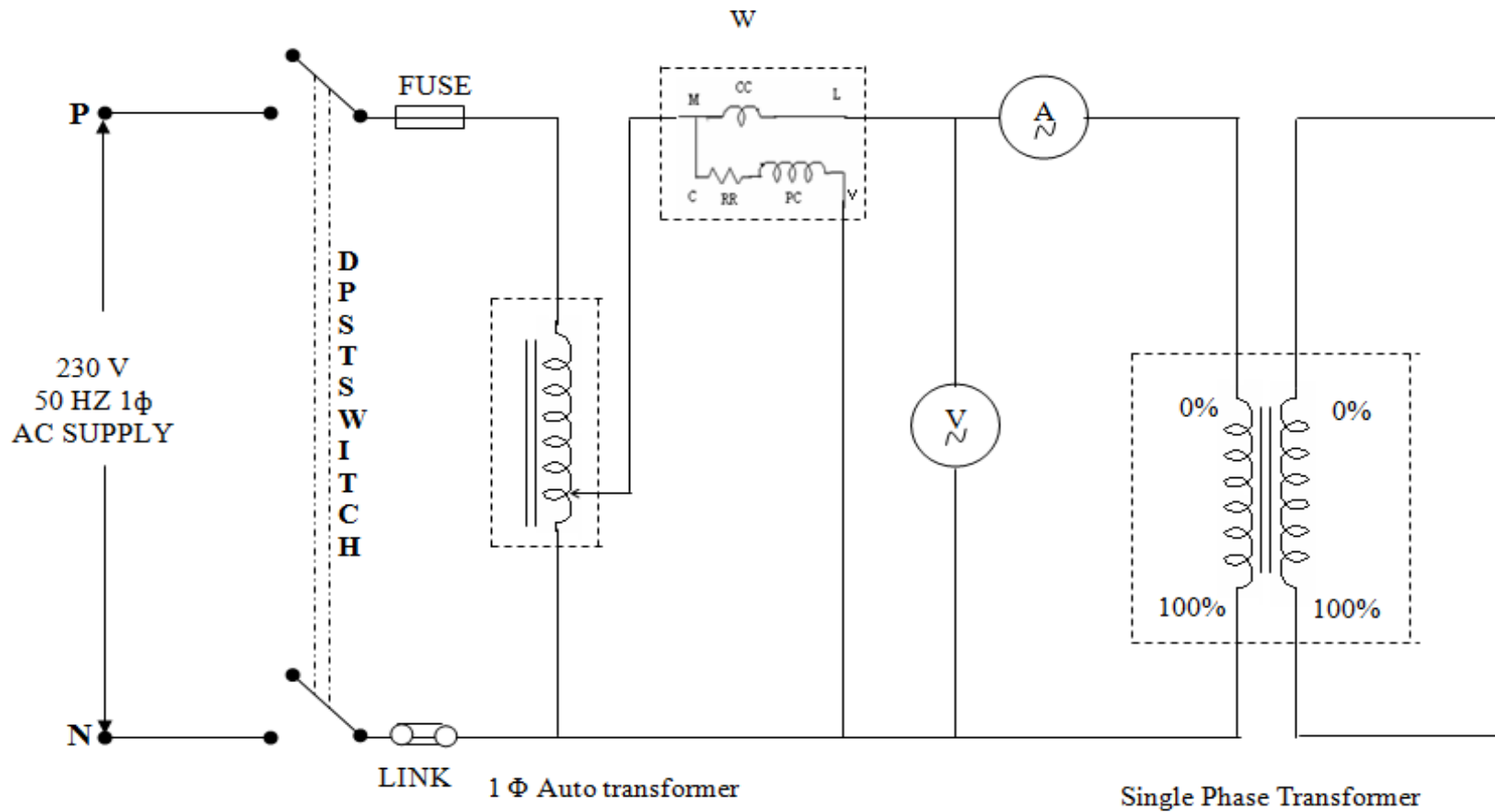


Figure 12.2 SHORT CIRCUIT TEST ON SINGLE PHASE TRANSFORMER

I_0 = open circuit current in A

$$3. X_0 = \frac{V_o}{I_o \sin \phi_o} \text{ Ohms}$$

$$4. R_{01} = \frac{W_{sc}}{I_{sc}^2} \text{ Ohms}$$

$$5. Z_{01} = \frac{V_{sc}}{I_{sc}} \text{ Ohms}$$

$$6. X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} \text{ Ohms}$$

Where,

$\cos \phi$ = power factor

W_o = open circuit wattmeter reading or core loss in watts.

I_o = open circuit ammeter reading in amps.

V_o = open circuit voltmeter reading in volts.

R_0 = primary no load resistance in ohms.

X_0 = primary no load reactance in ohms.

W_{sc} = short circuit wattmeter reading in watts.

I_{sc} = short circuit ammeter reading in amps.

V_{sc} = short circuit voltmeter reading in watts

X = load ratio.

R_{01} = Equivalent Resistance of the transformer as referred to primary in ohms

X_{01} = Equivalent Reactance of the transformer as referred to primary in ohms

Z_{01} = Equivalent impedance of the transformer as referred to primary in ohms

$$7. \text{Percentage Efficiency} = \left[\frac{(X * \text{VA rated} * \text{pf})}{(X * \text{VA rated} * \text{pf}) + X^2(\text{total loss})} \right] * 100$$

MODEL GRAPH

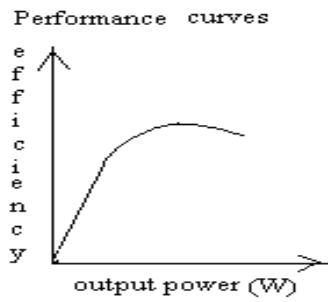


Figure 12.3 Performance curve

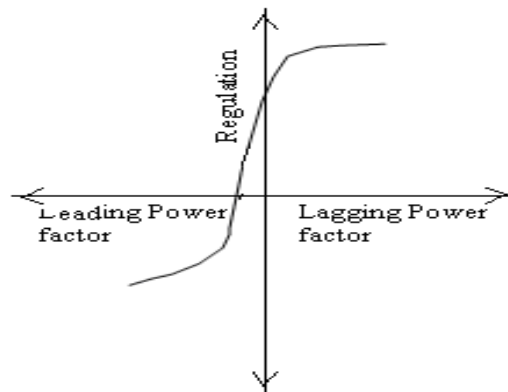


Figure 12.4 Regulation curve

Table 12.1 OPEN CIRCUIT TEST

MULTIPLYING FACTOR=

S.NO	VOLTMETER READING (Volts)	AMMETER READING (A)	WATTMETER READING (Watts)

CORE LOSS -----

Table 12.2 SHORT CIRCUIT TEST

MULTIPLYING FACTOR=

S.NO	VOLTMETER READING (Volts)	AMMETER READING (A)	WATTMETER READING (Watts)

FULL LOAD COPPER LOSS -----

$$8. \% \text{ Regulation} = \left(\frac{X * I_{sc}(R_{01} \cos \phi \pm X_{01} \sin \phi)}{V_{sc}} \right) \times 100$$

Leading pf:

$$\% \text{ Regulation} = \left(\frac{X * I_{sc}(R_{01} \cos \phi - X_{01} \sin \phi)}{V_{sc}} \right) \times 100$$

Lagging pf:

$$\% \text{ Regulation} = \left(\frac{X * I_{sc}(R_{01} \cos \phi + X_{01} \sin \phi)}{V_{sc}} \right) \times 100$$

9. Output power = X * VA rated x power factor watts

10. Input power = (X * VA rated x power factor) + $W_o + X^2 W_{sc}$ watts

PRECAUTIONS

1. The fuse selected such that 120% of its rated current.
2. The DPST switch is kept open while making circuit connections.
3. At the time of starting and at the end of the experiment the autotransformer is kept at minimum position.

PROCEDURE

OPEN CIRCUIT TEST

1. Connections are made as per the circuit diagram shown in the figure.
2. The DPST switch is closed and the autotransformer is adjusted to get rated voltage.
3. The open circuit readings are taken and tabulated in tabular column.

SHORT CIRCUIT TEST

1. Connections are made as per the circuit diagram shown in the figure.
2. The DPST switch is closed and the auto transformer is adjusted to get the rated current.

Table 12.3 PREDETERMINATION OF % REGULATION OF SINGLE PHASE TRANSFORMER

S.NO	LOAD RATIO X	POWER FACTOR COS Φ	PERCENTAGE REGULATION	
			LEADING POWER FACTOR	LAGGING POWER FACTOR

Table 12.4 PREDETERMINATION OF % EFFICIENCY OF SINGLE PHASE TRANSFORMER

S.NO	POWER FACTOR	LOAD RATIO X	OUTPUT POWER (Watts)	INPUT POWER (Watts)	% EFFICIENCY
		0			
		0.25			
		0.5			
		0.75			
		1			

MODEL CALCULATION

% REGULATION OF SINGLE PHASE TRANSFORMER

% EFFICIENCY OF SINGLE PHASE TRANSFORMER

EQUIVALENT CIRCUIT DIAGRAM FOR TRANSFORMER:

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: SUMPNER'S TEST ON SINGLE PHASE TRANSFORMER

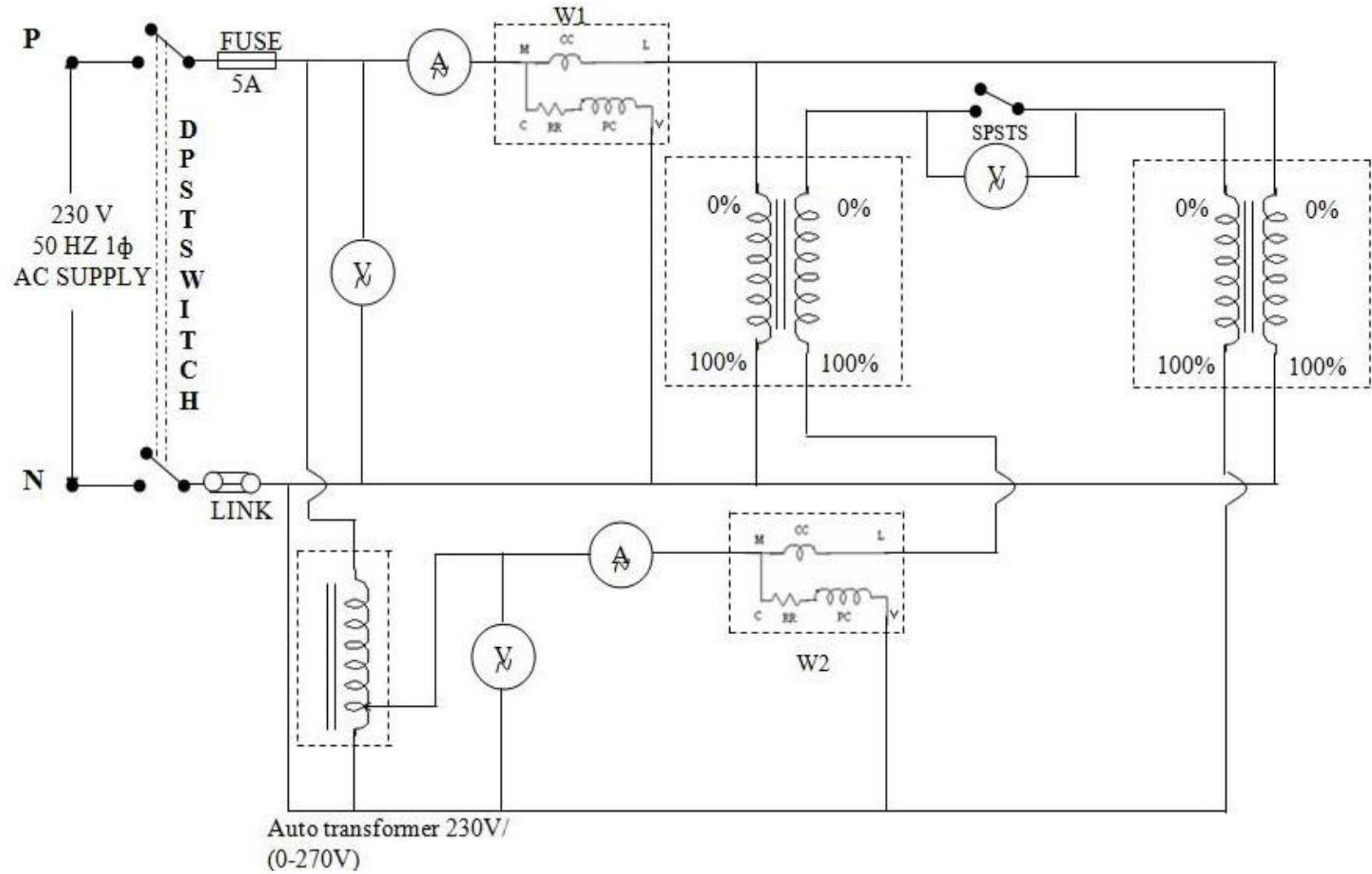


Figure 13.1 SUMPNER'S TEST ON SINGLE PHASE TRANSFORMER

Ex. No:	SUMPNER'S TEST ON SINGLE PHASE TRANSFORMERS
Date :	

AIM

To conduct sumpner's test on given two identical single phase transformers and to predetermine the regulation and efficiency of the transformer.

OBJECTIVE

1. To study the paralleling process for two identical transformers.
2. To determine the equivalent circuit parameters of each transformer.
3. To predetermine the efficiency at different loads at 0.8 and 1.0 power factors.
4. To predetermine the full load regulation for different power factors.
5. To draw the following graph
 - a. Output Vs % η
 - b. Power factor Vs %Regulation

APPARATUS REQUIRED

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Single phase Transformer			
2.	Ammeter			
3.	Voltmeter			
4.	Wattmeter			
5.	Auto transformer			

FORMULA USED

$$1. \cos\phi_0 = \left(\frac{W_0}{V_0 I_0} \right)$$

Where W_0 = open circuit wattmeter reading in watts

V_0 = open circuit voltage in volts

Table 13.1 SUMPNER'S TEST ON SINGLE PHASE TRANSFORMER

S.NO	PRIMARY VOLTAGE (Volts)	PRIMARY CURRENT (A)	SECONDARY VOLTAGE (Volts)	SECONDARY CURRENT (A)	SECONDARY POWER (watts)

I_0 = open circuit current in A

$$2. R_0 = \left(\frac{V_0}{I_0 \cos \phi_o} \right) \text{ ohms}$$

$$3. X_0 = \left(\frac{V_0}{I_0 \sin \phi_o} \right) \text{ ohms}$$

$$4. R_{01} = \left(\frac{W_{sc}}{I_{sc}^2} \right) \text{ ohms}$$

$$5. Z_{01} = \left(\frac{V_{sc}}{I_{sc}} \right) \text{ ohms}$$

$$6. X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} \text{ Ohms}$$

$$7. \text{Total loss} = W_o + X^2 W_{sc} \text{ watts}$$

$$8. \text{Output power} = X * \text{VA rated} * \cos \Phi \text{ watts}$$

$$9. \text{Input power} = (X * \text{VA rated} * \cos \Phi) + W_o + X^2 W_{sc} \text{ watts}$$

$$10. \% \text{ Efficiency} = (\text{output power} / \text{input power}) * 100 \text{ watts}$$

$$11. \% \text{ Regulation} = (X * I_{sc} (R_{01} \cos \phi + X_{01} \sin \phi) / V_{sc}) * 100 \text{ for lagging pf}$$

$$12. \% \text{ Regulation} = (X * I_{sc} (R_{01} \cos \phi - X_{01} \sin \phi) / V_{sc}) * 100 \text{ for leading pf}$$

Where,

$\cos \phi$ = power factor

W_o = open circuit wattmeter reading or core loss in watts.

I_o = open circuit ammeter reading in A.

V_o = open circuit voltmeter reading in volts.

R_0 = primary no load resistance in ohms.

X_0 = primary no load reactance in ohms.

W_{sc} = short circuit wattmeter reading in watts.

I_{sc} = short circuit ammeter reading in A.

Table 13.2 PREDETERMINATION OF % EFFICIENCY OF SINGLE PHASE
TRANSFORMER

S.NO	POWER FACTOR COS ϕ	LOAD RATIO (X)	OUTPUT POWER (watts)	INPUT POWER (watts)	% EFFICIENCY
		0			
		0.25			
		0.5			
		0.75			
		1			

V_{sc} = short circuit voltmeter reading in watts

X = load ratio.

R_{01} = Equivalent Resistance of the transformer as referred to primary in ohms

X_{01} = Equivalent Reactance of the transformer as referred to primary in ohms

Z_{01} = Equivalent impedance of the transformer as referred to primary in ohms

PRECAUTIONS

1. The fuse selected such that 120% of its rated current.
2. The DPST switch is kept open at the initial condition.
3. The Auto transformer is kept at minimum position at the starting and at the end.

PROCEDURE

1. Connections are made as per the circuit diagram shown in the figure.
2. DPST switch is closed and SPST switch is kept open.
3. If the voltmeter across the SPST switch reads zero, SPST is closed. Otherwise, the polarity of any of the transformer secondary is changed and then SPST is closed.
4. All meter readings on the primary side are noted down and tabulated.
5. The auto transformer is adjusted to get rated current in the secondary of ammeter.
6. All meter readings on the secondary side are noted down and tabulated.
7. From the primary meter readings (OC readings) and the secondary meter readings (SC readings) % efficiency and % regulation of given two identical single phase transformer are predetermined and they are tabulated.

Table 13.3 PREDETERMINATION OF % REGULATION OF SINGLE PHASE
TRANSFORMER

S.NO	LOAD RATIO (X)	POWER FACTOR COS ϕ	REGULATION IN %	
			FOR LEADING POWER FACTOR	FOR LAGGING POWER FACTOR
	0			
	0.25			
	0.5			
	0.75			
	1			

MODEL CALCULATION

% EFFICIENCY OF SINGLE PHASE TRANSFORMER

% REGULATION OF SINGLE PHASE TRANSFORMER

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

CIRCUIT DIAGRAM: SEPERATION OF NOLOAD LOSSES ON SINGLE PHASE TRANSFORMER

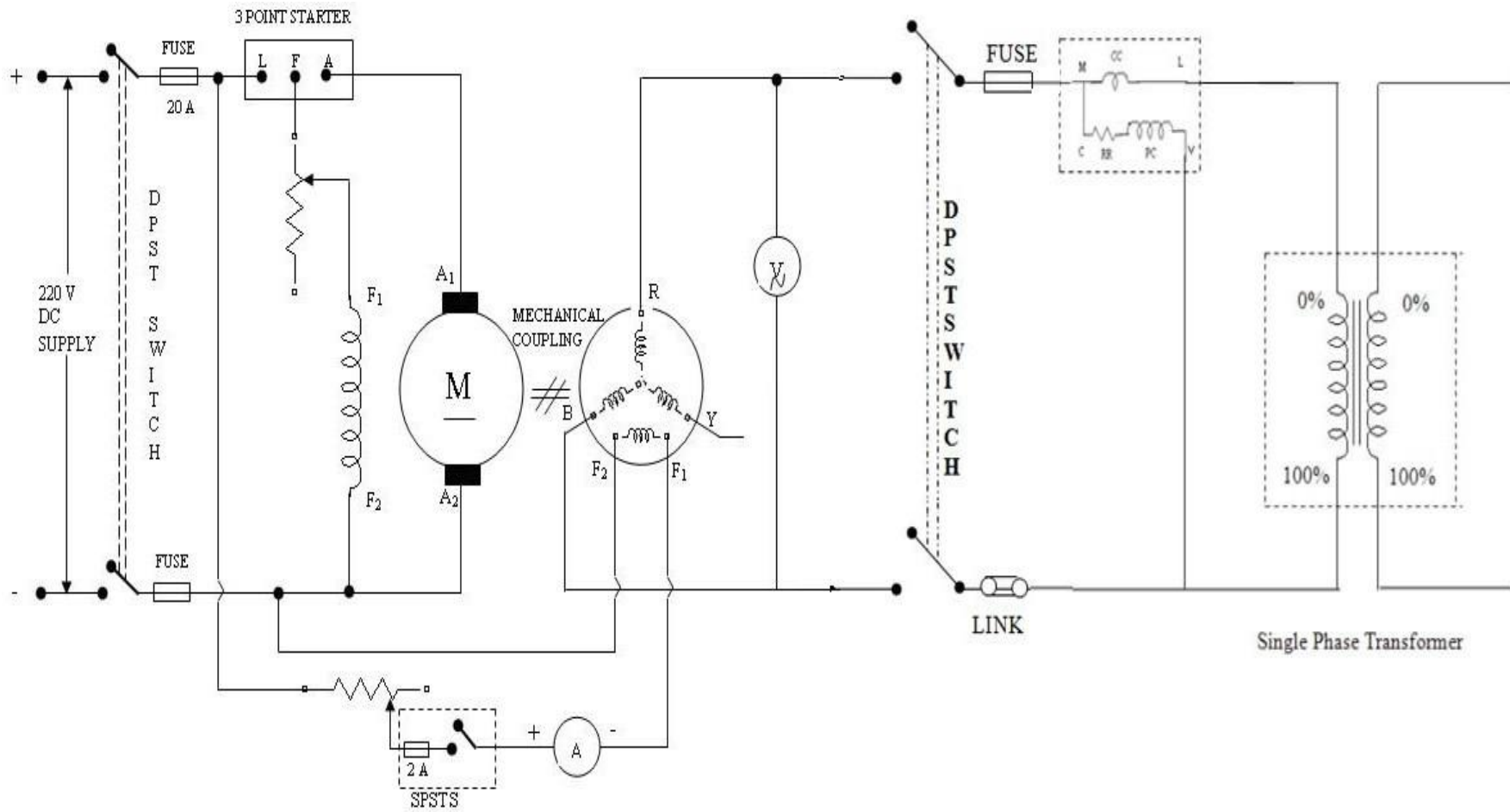


Figure 14.1 SEPERATION OF NO LOAD LOSSES ON SINGLE PHASE TRANSFORMER

Ex. No:	SEPERATION OF NO LOAD LOSSES ON SINGLE PHASE TRANSFORMERS
Date :	

AIM

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

OBJECTIVE

1. To study about the core losses of a single phase transformer.
2. To Separate the no load losses of a single phase transformer.
3. .To draw the following graph
 - a. Frequency Vs power

APPARATUS REQUIRED

S.NO	APPARATUS NAME	RANGE	TYPE	QUANTITY
1.	Single phase Transformer			
2.	Ammeter			
3.	Rheostat			
4.	Wattmeter			
5.	Voltmeter			
6.	Connecting Wires			

FORMULAE USED

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

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

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

TABLE 14.1: SEPERATION OF NO LOAD LOSSES ON SINGLE PHASE TRANSFROMER

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

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 field 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.

MODEL GRAPH

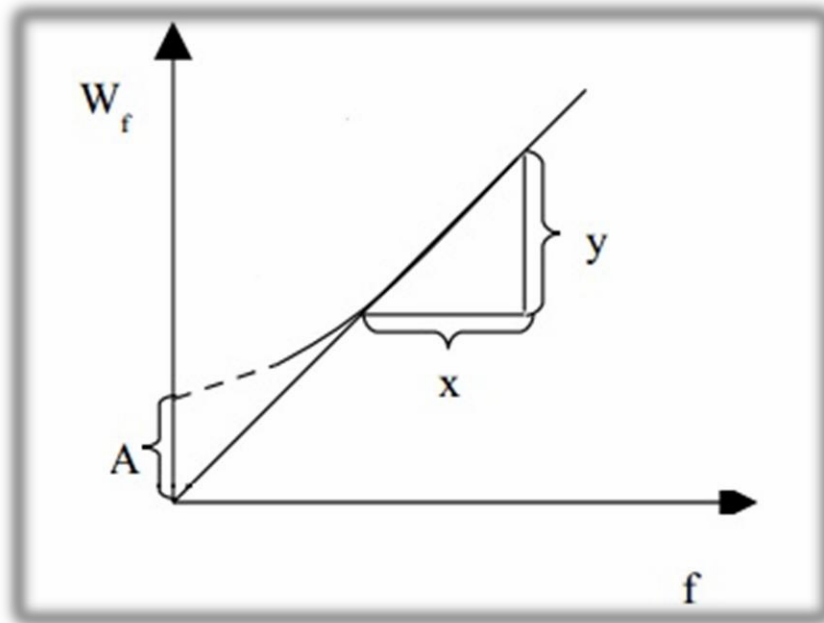


Figure 14.2 Power Vs frequency graph

MODEL CALCULATION

PRELAB QUESTION AND ANSWERS

POSTLAB QUESTION AND ANSWERS

RESULT:

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of faculty

TWO POINT STARTER

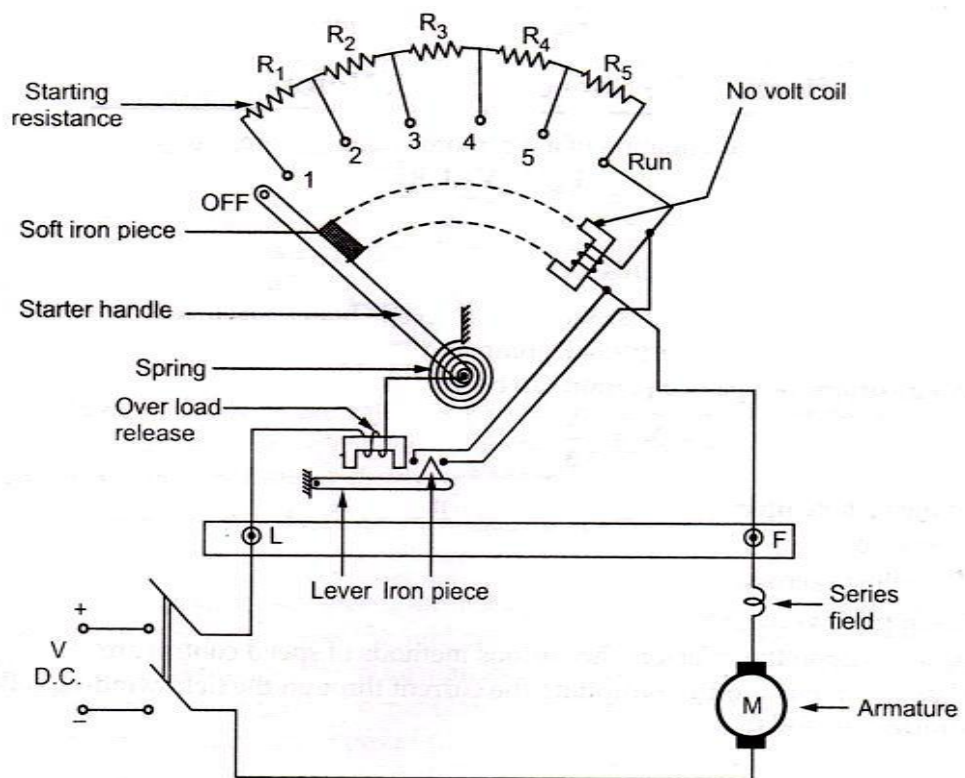


Figure 15.1 Two point starter

Ex. No:	STUDY OF D.C MOTOR AND INDUCTION MOTOR STARTERS.
Date :	

AIM:

To study the necessity of starters for DC motors and Induction motors

OBJECTIVES:

1. To study the need for limiting the high starting current.
2. To study the starting of various DC motors and Induction motors by using starters.

THEORY:

TWO POINT STARTER:

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

The action of the starter is similar to that of three point starter. The handle of the starter is in OFF position. When it is moved to ON, motor gets the supply and the entire starting resistance is in series with the armature and field. It limits the starting current. The current through no volt coil energizes it and when handle reaches to RUN position, the no volt coil holds the handle by attracting the soft iron piece on the handle. Hence the no volt coil is also called hold on coil. The main problem in case of d.c. series motor is its overspeeding action when the load is less. This can be prevented using two point starters. The no volt coil is designed in such a way that it hold the handle in RUN position only when it carries sufficient current, for which motor can run safely. If there is loss of load then current drawn by the motor decreases, due to which no volt coil loses its required magnetism and releases the handle. Under spring force, handle comes back to OFF position, protecting the motor from overspeeding. Similarly if there is any supply problem such that voltage decreases suddenly then also no volt coil releases the handle and protects the motor from adverse supply conditions.

THREE POINT STARTER

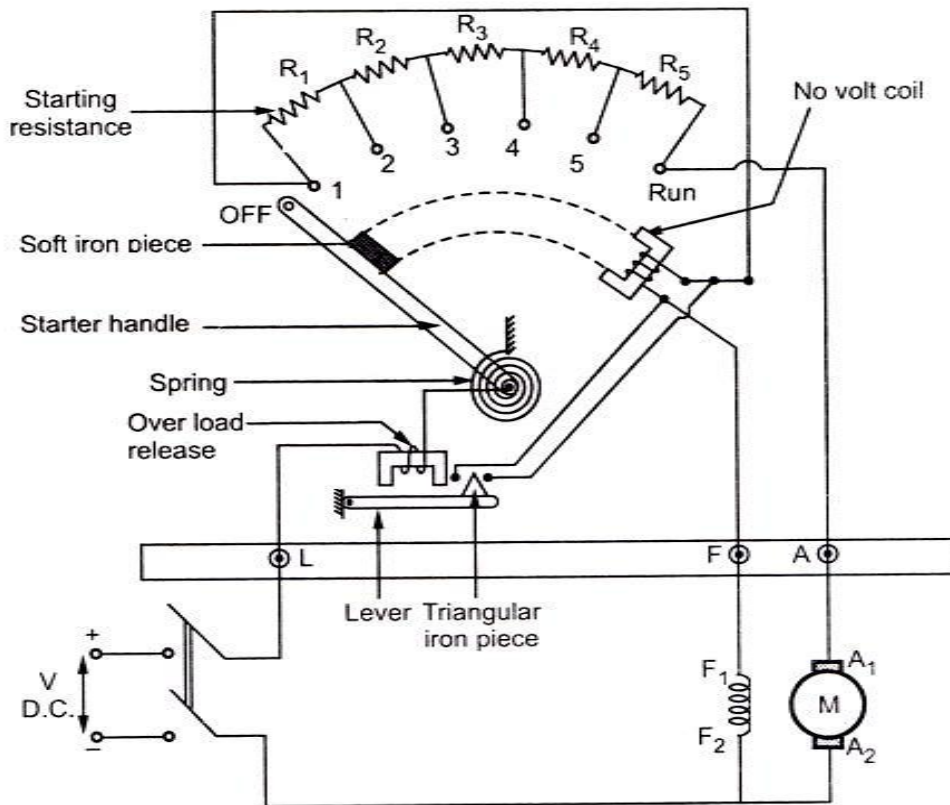


Figure 15.2 Three point starter

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

THREE POINT STARTER:

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

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

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

OPERATION:

Initially the handle is in the OFF position. The d.c. supply to the motor is switched on. Then handle is slowly moved against the spring force to make a contact with stud No. 1. At this point, field winding gets supply through the parallel path provided to starting resistance, through NVC. While entire starting resistance comes in series with the armature and armature current which is high at start, gets limited. As the handle is moved further, it goes on making contact with studs 2, 3, 4 etc . , cutting out the starting resistance gradually from the armature circuit. Finally when the starter handle is in 'RUN' position, the entire starting resistance gets removed from the armature circuit and motor starts operating with normal speed. The handle is moved manually, and the obvious question is how handle will remain in the 'RUN' position, as long as motor is running. Let us see the action of NVC which will give the answer to this question along with some other functions of NVC.

STAR-DELTA STARTER

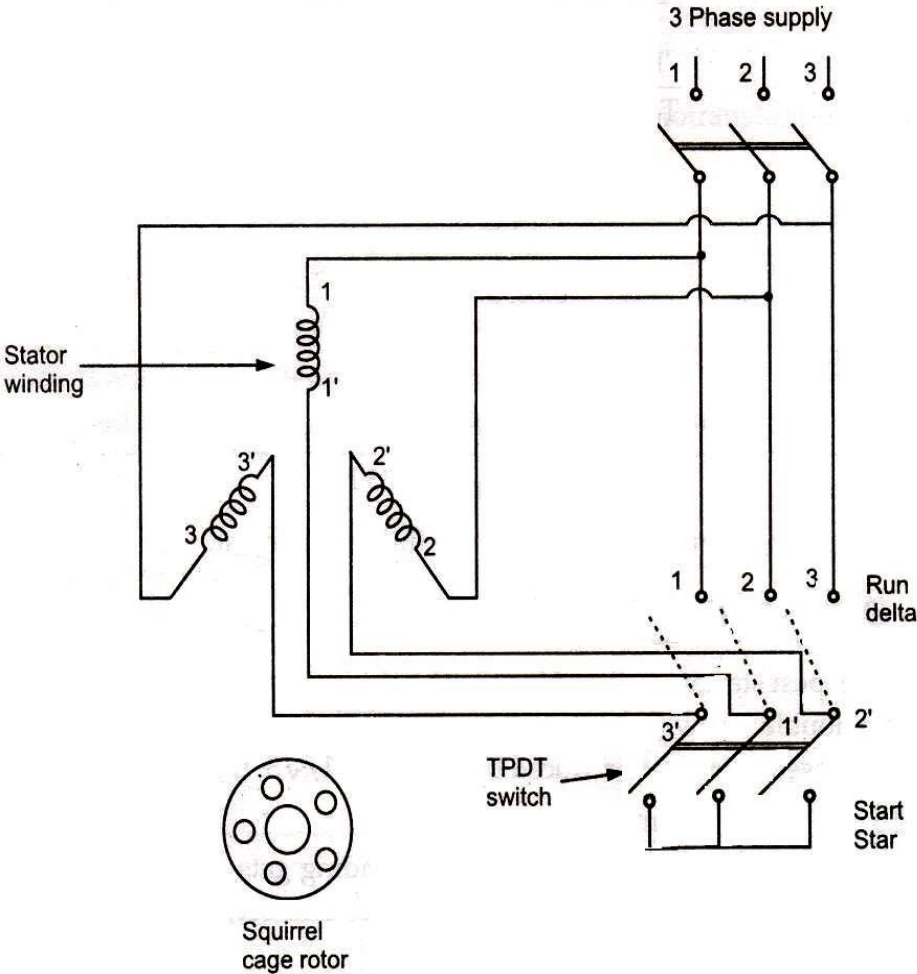


Figure 15.3 Star delta Starter

FUNCTIONS OF NO VOLT COIL:

1. The supply to the field winding is derived through NVC. So when field current flows, it magnetizes the NVC. When the handle is in the 'RUN' position, soft iron piece connected to the handle gets attracted by the magnetic force produced by NVC. Design of NVC is such that it holds the handle in 'RUN' position against the force of the spring as long as supply to the motor is proper. Thus NVC holds the handle in the 'RUN' position and hence also called hold on coil.
2. Whenever there is supply failure or if field circuit is broken, the current through NVC gets affected. It loses its magnetism and hence not in a position to keep the soft iron piece on the handle, attracted. Under the spring force, handle comes back to OFF position, switching off the motor. So due to the combination of NVC and the spring, the starter handle always comes back to OFF position whenever there is any supply problem. The entire starting resistance comes back in series with the armature when attempt is made to start the motor everytime. This prevents the damage of the motor caused due to accidental starting.
3. NVC performs the similar action under low voltage conditions and protects the motor from such dangerous supply conditions as well.

ACTION OF OVERLOAD RELEASE:

The current through the motor is taken through the OLR, an electromagnet. Under overload condition, high current is drawn by the motor from the supply which passes through OLR. Below this magnet, there is an arm which is fixed at its fulcrum and normally resting in horizontal position. Under overloading, high current through OLR produces enough force of attraction to attract the arm upwards. Normally magnet is so designed that up to a full load value of current, the force of attraction produced is just enough to balance the gravitational force of the arm and hence not lifting it up. At the end of this arm, there is a triangular iron piece fitted. When the arm is pulled upwards the triangular piece touches to the two points which are connected to the two ends of NVC. This shorts the NVC and voltage across NVC becomes zero due to which NVC loses its magnetism. So under the spring force, handle comes back to the OFF position, disconnecting the motor from the supply. Thus motor gets saved from the overload conditions

DIRECT ONLINE STARTER

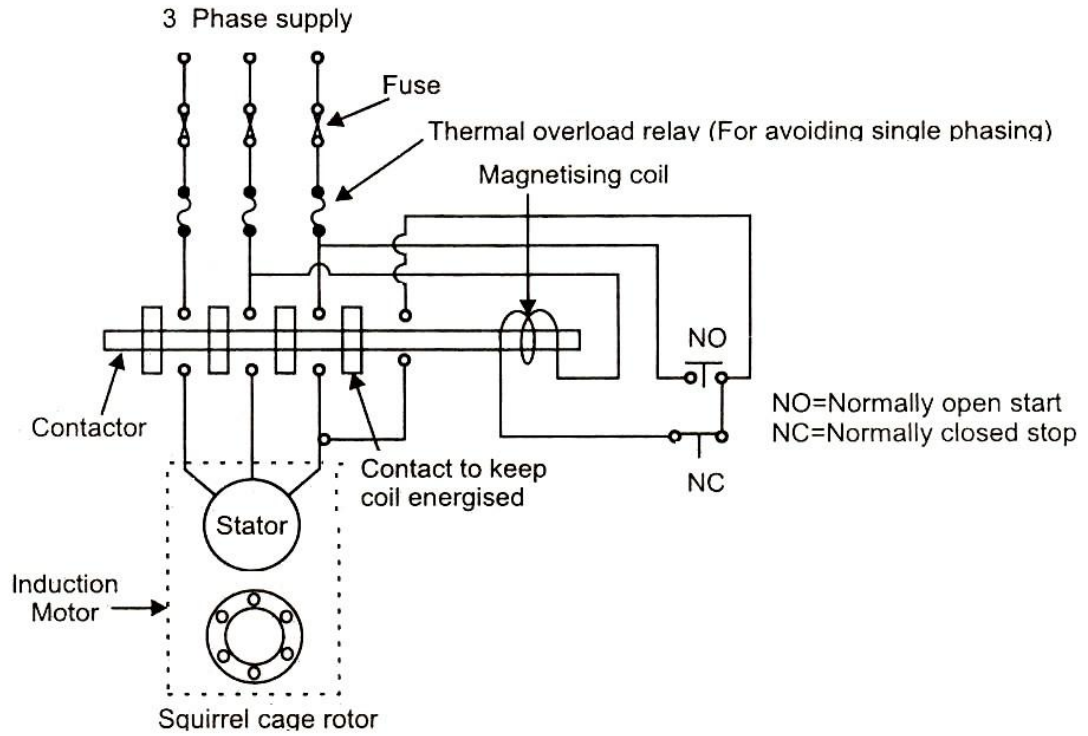


Figure No 15.4 Direct online Starter

DISADVANTAGES:

In this starter, the NVC and the field winding are in series. So while controlling the speed of the motor above rated, field current is reduced by adding an extra resistance in series with the field winding. Due to this, the current through NVC also reduces. Due to this, magnetism produced by NVC also reduces. This may release the handle from its RUN position switching off the motor. To avoid the dependency of NVC and the field winding four point starters is used, in which NVC and the field winding are connected in parallel.

STAR-DELTA STARTERS:

This is the cheapest starter of all and hence used in very commonly for induction motors. It uses triple pole double throw (TPDT) switch. The switch connects the stator winding in star at start. Hence per phase voltage gets reduced by the factor $1/\sqrt{3}$. due to this reduced voltage, the starting current is limited.

When the switch is thrown on the other side, the windings gets connected in delta, across the supply. So it gets normal rated voltage. The windings are connected in delta when the motor gathers sufficient speed.

The operation of the switch can be automatic by using relays which ensures that motor will not start with the switch in run position. The cheapest of all and maintenance free operation are the two important advantages of this starter. While its limitations are, it is suitable for normal delta connected motors and the factor by which voltage changes is $1/\sqrt{3}$ which can not be changed.

DIRECT ONLINE STARTER:

In case of small capacity motors having rating less than 5 h.p., the starting current is not very high and such motors can withstand such starting current without any starter. Thus there is no need to reduce the applied voltage, to control the starting current. Such motors use a type of starter which is used to connect stator directly to the supply lines without any reduction in voltage. Hence the starter is known as Direct On Line starter.

AUTO TRANSFORMER STARTER

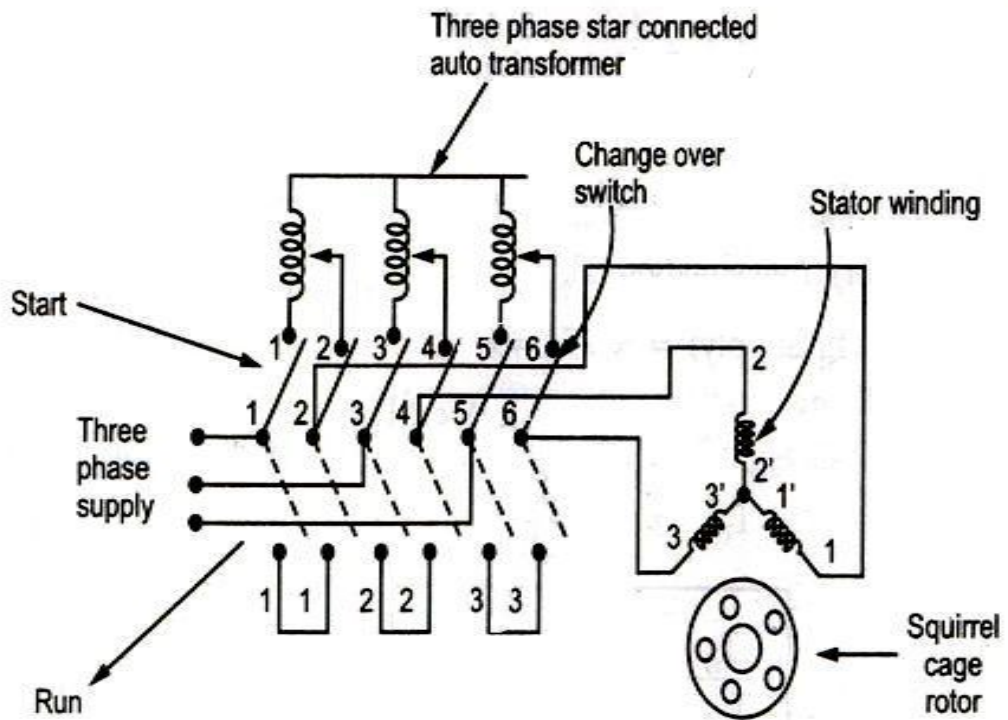


Figure 15.5 Auto Transformer Starter

Though this starter does not reduce the applied voltage, it is used because it protects the motor from various severe abnormal conditions like overloading, low voltage, single phasing etc.

The NO contact is normally open and NC is normally closed. At start, NO is pushed for fraction of second due to which coil gets energized and attracts the contactor. So stator directly gets supply. The additional contact provided, ensures that as long as supply is ON, the coil gets supply and keeps contactor in ON position. When NC is pressed, the coil circuit gets opened due to which coil gets de – energized and motor gets switched OFF from the supply.

Under overload condition, current drawn by the motor increases due to which there is an excessive heat produced, which increases the temperature beyond the limit. Thermal relays get opened due to high temperature, protecting the motor from overload conditions.

AUTO TRANSFORMER STARTER:

A Three phase star connected auto transformer can be used to reduce the voltage applied to the stator. Such starter is called autotransformer starter. It consists of a suitable change over switch. When the switch is in the start position, the stator winding is supplied with reduced voltage. This can be controlled by tapings provided with auto transformer. When motor gathers 80% of the normal speed, the change over switch is thrown in to run position.

Due to this rated voltage gets applied to stator winding. The motor starts rotating with normal speed. Changing of switch is done automatically by using relays. The power loss is much less in this type of starting. It can be used for both star and delta connected motors.



RESULT

MARKS ALLOCATION

Details	Marks Allotted	Status	Marks Awarded
Pre Lab Questions	10		
Observation	20		
Lab Conduction	30		
Calculation & Graphs	20		
Result	10		
Post Lab Questions	10		
Total	100		

Signature of Faculty

I. LOAD TEST ON DC SHUNT MOTOR

Pre-lab

1. What is the type of energy conversion taking place in an electrical motor?
2. What is the purpose for load test on shunt motor?
3. Which parameter limits the amount of load to be added to the motor?
4. What are the meters used in this experiment? Mention their type and use?
5. What are the precautions to be ensured before switching the motor?
6. What is back emf?
7. What is the purpose of starter in the experiment?
8. By using multimeter how can you identify a DC shunt motor?
9. What is the amount of load to be applied to dc shunt motor at the time of starting?
why that much of load to be added at the start ? What happens if not?
10. What are the types of starters to be used for shunt, series & compound motor?

Post-lab

1. Suggest a suitable place for applying shunt motor based upon the inference of this experiment?
2. Why shunt motor is called as low starting torque motor?
3. What happen if field supply is removed when a motor is running at rated condition?
4. What is the function of overload release coil?
5. Explain how the direction of rotation of a DC shunt motor can be reversed.
6. What happens when (i) direction of field current is reversed (ii) direction of armature current is reversed (iii) direction of both currents are reversed
7. A shunt motor consumes a field current of 0.75A at 75% of full load if suddenly load on the motor is increased to 95% what happens to field current?
8. What happens when an A.C supply is given to a dc motor?
9. If the direction of rotation of motor is reversed what are the changes that can be seen in the plots of load test

II. LOAD TEST ON DC SERIES MOTOR

Pre-Lab

1. What is the difference between series and shunt motor?
2. What is the basic principle of DC motor
3. What is the function of commutator in DC motor?
4. What is the purpose of brake drum in the experiment?
5. State the precautions to be observed in starting a DC series motor.
6. What is the relation between torque and armature current in series motor (both condition)?
7. Suggest a suitable place for applying the series motor based upon the inference of this experiment?
8. What should be the value resistance of series field winding (high/low)? Why?

Post Lab

1. What is the electrical equivalent of mechanical power developed in motor?
2. What is the maximum value of efficiency? Explain why it can't be greater than that value?
3. Why water has to be poured in break drum?
4. What happens to the following parameters while increasing the load (i) speed (ii) load current (iii) Torque
5. Draw the efficiency curve of motor and explain why its shape is so?
6. What is the frequency of A.C and D.C supply used in the experiment (India)?
7. Which supply is relatively more dangerous A.C (or) D.C?
8. Specify a rule to calibrate the meter ratings, fuse rating and rheostat rating for the experiment.
9. If the direction of rotation of motor is reversed what are the changes that can be seen in the plots of load test

III. LOAD TEST ON DC COMPOUND MOTOR

Pre Lab

1. What are the two types of compound motor?
2. What is the advantage of compound motor over shunt/series motor?
3. What will be the effect on dc compound motor if its series winding is reversed?
4. What is the application of dc compound motor?
5. Explain the energy conversion equation of motor?
6. Why two winding are used in dc compound motor?
7. What will happen to the motor if the coil current direction is reversed (i)series field (ii)shunt field(iii)both.
8. How the direction of rotation of dc compound motor can be reversed?

Post Lab

1. What is the relation between field current, armature current, total current?
2. What happen if field supply is removed when a motor is running at rated condition?
3. What happens to dc compound motor when its series field winding is burnt in(i)long shunt (ii)short shunt motor?
4. How will you find the compound motor with help of multimeter?
5. What is the resistance of shunt field and series field? What is your inference from the value of resistance?
6. A shunt motor which is connected to a fan. Accidentally the one of the field winding is not connected and the motor is power on. What happens if the left out field is (i) shunt field (ii) series field?

IV. SPEED CONTROL OF DC SHUNT MOTOR

Pre Lab

1. If the direction of rotation of motor is reversed what are the changes that can be seen in the plots of speed control test.
2. What are the methods in which speed can be controlled in dc shunt motor
3. Mention the method of speed control to be used to control the speed above and below rated speed?
4. How to calculate the fuse rating of D.C machine?
5. What is the difference between DC toy motor and the DC motor in the lab?

Post Lab

1. Why load current drawn in the speed control test is small? If speed control is possible with high load current?
2. What will happen to the speed of a DC motor when its flux approaches zero?
3. Define speed regulation? Should it be high or low for a good D.C shunt motor?
4. What do you mean by saturation of magnetic field? Will this affect the performance of the motor? How?
5. Where do you find carbon brush in the motor? What is the purpose of it?

V. D.C SEPARATELY EXCITED SHUNT GENERATOR

Pre lab

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?

Post lab

1. What will be the no load emf, when the no load speed changes to 1000 rpm?
2. What happen if the field current of the dc motor varies during load test?
3. What are the factors which represent the nature of external characteristics in dc shunt generator?
4. When load increases there is fall in generated voltage why?
5. What is the effect of armature reaction on external and internal characteristics of dc shunt generator?

VI. DC SELF EXCITED SHUNT GENERATOR

Pre lab

1. What is the purpose of electric motor in load test of electric generator?
2. Explain the types of DC generators
3. What is the nature of current (A.C/D.C) produced in armature of D.C generator?
4. State the function of a commutator in a DC generator
5. What are the possible losses in electrical generator
6. What is the principle of electrical motor and electrical generator (Flemings rule)?
7. What is the purpose of brush in dc generator?

Post lab

1. If the field direction is reversed in self excited generator and operated what happens?
2. What is armature reaction?
3. What are the effects of armature reaction
4. How can an A.C supply be obtained from a D.C generator?
5. How can you increase the generated voltage in a constant speed prime mover system?

VII. DC SERIES GENERATOR

Pre Lab

1. What is the difference in load test of series generator?
2. What do you know about series field winding?
3. What is commutator?
4. Mention various types of load used for loading purpose.
5. Difference between DC series motor and series generator.
6. What are the applications of dc series generator?

Post Lab

1. Why we are always going for resistive load rather than inductive or capacitive load?
2. Why the no of turns in series motor is less?
3. Why dc generator is said to have raising characteristic?
4. What happens if we vary the speed of the prime mover? Compare the characteristics at two different speeds?
5. What is the prime mover used in this experiment? What is the purpose of prime mover ?

VIII. LOAD TEST ON DC COMPOUND GENERATOR

Pre lab:

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 mean by armature reaction?
7. Difference of lower excitation and under excitation.
8. What are the applications of dc compound generator?

Post Lab:

1. How can u compensate the fall in terminal voltage of a dc generator?
2. What will be the voltage across the shunt field winding during level compound generator?
3. What will be the voltage across the shunt field winding during long shunt and short shunt connection?
4. Which type of compound generator will give drooping characteristics?
5. Can series field and shunt field can be interchanged?

IX. SWIN BURN TEST

Pre Lab

1. What is mean by losses in dc motor?
2. Classify various types of losses occur in dc motor.
3. What is mean 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 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 in a DC motor.
10. Why the output power is zero at no load condition?

Post Lab

1. What are the advantages of Swinburne's test?
2. Why generator efficiency is higher than motor efficiency. Explain it?
3. What happen, if the armature copper loss is very low compared to constant losses in a dc machine?
4. What are the disadvantages of Swinburne's test?
5. What happen if variable losses become zero?

X. HOPKINSON'S TEST

Pre Lab:

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 factors determine the load distribution amongst a number of DC shunt generators in parallel?
5. What are the advantages of hopkinson's test
6. What causes are responsible for over-heating of commutator in a D.C. Machine?

Post Lab:

1. What will happen to the speed of a DC motor when its flux approaches zero?
2. When the total losses are increased by 5% then what will be the performance of the machine as a motor and as a generator?
3. If it possible to get same efficiency for motor and generator. How?
4. Why the generator alone can't feed the motor power requirement?
5. What happens if accidentally motor and generator are interchanged in the connection?

XI. LOAD TEST ON SINGLE PHASE TRANSFORMER

Pre Lab

1. What is the role of iron core in a transformer?
2. What is the energy balance equation?
3. How much phase shift offered by a transformer?
4. Whether transformer is an energy conversion device?
5. How can we compare transformer with control system?
6. What is mean by voltage regulation?
7. Name the 2 main performance indices of a transformer?
8. What is transformation ratio?

Post Lab

1. What is the need for conducting load test?
2. What is the amount of maximum load that can be applied to the transformer?
3. Why current drawn from the supply increases when load is increased?
4. If ammeter connected in parallel unfortunately what will happen?
5. If voltmeter connected in series unfortunately what will happen?
6. What is the drawback in direct loading method? How it can be minimized?
7. What is the nature of output voltage/current waveform in transformer when its excited with square wave voltage?
8. What is the nature of output voltage/current waveform in transformer when its excited with square wave current?
9. Why V/F ratio maintained as a constant in transformer?
10. Name the material used to manufacture transformer core?
11. What will happen if dc supply is connected at the input of transformer?

XII. OC / SC TEST ON SINGLE PHASE TRANSFORMER

Pre-Lab

1. The nature of induced emf in transformer in terms in space/time variation is?
2. Explain why the efficiency of transformer is very high compared to other machines.
3. State the conditions under which OC test is conducted on a transformer in terms hv/lv windings and justify.
4. What are the equivalent circuit parameters?
5. What is mean by wattless component and wattfull component?
6. State the conditions under which SC test is conducted on a transformer in terms hv/lv windings and justify.
7. Specify the ammeter range which is connected in the hv winding when test performed for 100% winding and 50% winding
8. State why the open circuit test on a transformer is conducted at rated voltage?
9. Why we need to conduct OC/SC test on transformer?

Post-Lab

1. Why OC/SC test is more suitable than direct loading of transformer?
2. Which losses are found by using OC test?
3. Which losses are found by using SC test?
4. If OC test performed for rated voltage and less than rated frequency what is the effect in a transformer?
5. If SC test performed for rated voltage and less than rated frequency what is the effect in a transformer?
6. What is mean by steady state current?
7. State the conditions under which the transformer voltage regulation is zero.
8. State the conditions under which the transformer voltage regulation is maximum.
9. During short circuit about 6 p.u voltage is required to produce half the rated current, then % voltage regulation of transformer is?
10. Explain why only a low voltage is applied to the transformer during SC test.
11. What is the maximum voltage regulation of transformer in terms of p. u quantities?

XIII. SUMPNER'S TEST

Pre-lab

1. Define all day efficiency of a transformer.
2. What are the two methods used to predetermine the efficiency and voltage regulation? list out the major difference between them and suggest the suitable test.
3. What is mean by specific weight of transformer?
4. The efficiency of two identical transformers under load conditions can be determined by which test?
5. Why transformers are rated in KVA?
6. What is Auto-transformer?
7. What is Ideal transformer?
8. What is magnetostiction?
9. What is the difference between isolation transformer and ideal transformer?
10. How is magnetic leakage reduced to a minimum in commercial transformers?
11. Mention the factors on which hysteresis loss depends?
12. Post-lab
13. What is the condition for maximum Efficiency in transformer?

Post Lab

1. How does change in supply frequency affect the operation of a given transformer with constant supply voltage?
2. What is the relation between laminations of the core and supply frequency
3. What is the difference between stacking factor and utilization factor?
4. How can you identify the polarity of the lv/hv windings?
5. State the conditions under which the transformer efficiency is maximum in terms of load power factor
6. How can eddy current loss be minimized?

XIV. SEPERATION OF NO LOAD LOSSES ON SINGLE PHASE TRANSFORMERS

Pre-Lab

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?

Post Lab

1. How to obtain the two different losses after completion of this experiment?
2. What is the drawback if v/f ratio not maintained as constant while doing this experiment?
3. What are two ways to minimize the eddy current loss?
4. What will happen to the no load losses if transformer is loaded?
5. After completion of this experiment how to extract the different no load losses of the transformer?
6. Whether transformer can be connected in parallel? If yes then why?
7. Why the field of alternator separately connected to supply?
