SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM NAGAR, KATTANKULATHUR.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LAB MANUAL

(Regulation-2019)

BRANCH /SECTION : **EEE**

SEMESTER : **III**

SUBJECT CODE : **1905307**

SUBJECT : **Electrical Machines Laboratory -I**

ACADEMIC YEAR : **2022-2023 ODD**

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1905307 ELECTRICAL MACHINES LABORATORY – I **L T P C**
0 0 4 2

OBJECTIVES:

1. To expose the students to the operation of D.C. machines.
2. To expose the students to the operation of transformers.
3. To expose the students to the operation of generators.
4. To impart knowledge about open circuit and load characteristics.
5. To impart knowledge about performance characteristics.

LIST OF EXPERIMENTS:

1. Open circuit and load characteristics of DC shunt generator- critical resistance and critical speed.
2. Load characteristics of DC compound generator with differential and cumulative connections.
3. Load test on DC shunt motor.
4. Load test on DC compound motor.
5. Load test on DC series motor.
6. Swinburne's test and speed control of DC shunt motor.
7. Hopkinson's test on DC motor – generator set.
8. Load test on single-phase transformer and three phase transformers.
9. Open circuit and short circuit tests on single phase transformer.
10. Sumpner's test on single phase transformers.
11. Separation of no-load losses in single phase transformer.
12. Study of starters and 3-phase transformers connections.
13. Measurement of Magnetic Inrush current of Transformers (Single Phase).

COURSE OUTCOMES:

1. Ability to understand and analyze DC Generator.
2. Ability to understand and analyze DC Motor.
3. Ability to understand and analyze Transformers.
4. Ability to understand the performance characteristics.
5. Ability to understand the starters

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1905307– Electrical Machines Laboratory -I

III Semester - Electrical and Electronics Engineering

Duration: 2022-2023 (ODD SEMESTER)

INDEX

1. **Open circuit and load characteristics of DC shunt generator- critical resistance and critical speed.**
2. **Load characteristics of DC compound generator with differential and cumulative connections.**
3. **Load test on DC shunt motor.**
4. **Load test on DC compound motor.**
5. **Load test on DC series motor.**
6. **Swinburne's test and speed control of DC shunt motor.**
7. **Hopkinson's test on DC motor – generator set.**
8. **Load test on single-phase transformer and three phase transformers.**
9. **Open circuit and short circuit tests on single phase transformer.**
10. **Sumpner's test on single phase transformers.**
11. **Separation of no-load losses in single phase transformer.**
12. **Study of starters and 3-phase transformers connections.**
13. **Measurement of Magnetic Inrush current of Transformers (Single Phase).**

Additional Experiments

14. **Polarity test on single phase transformer.**
15. **Open circuit and load characteristics of separately excited d.c generator.**

CYCLE-I

EXP. NO.	DATE	EXPERIMENT NAME	PAGE NO	MARK	SIGNATURE

CYCLE-II

EXP. NO	DATE	EXPERIMENT NAME	PAGE NO	MARK	SIGNATURE

OPEN CIRCUIT AND LOAD CHARACTERISTICS OF SELF EXCITED D.C SHUNT GENERATOR

AIM:

To obtain the open circuit and load characteristics of a self-excited DC shunt generator and hence deduce the critical field resistance and critical speed.

APPARATUS REQUIRED:

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 - 2A)	MC	1
2.	Ammeter	(0 - 10A)	MC	1
3.	Voltmeter	(0 - 300V)	MC	1
4.	Rheostat	400 Ω/1.1 A, 1000 Ω/0.8 A	Wire wound	1 each

PRECAUTION

- **All the switches are kept open initially.**
- **The motor field rheostat is kept at minimum resistance position.**
- **The generator field rheostat is kept at maximum resistance *position***

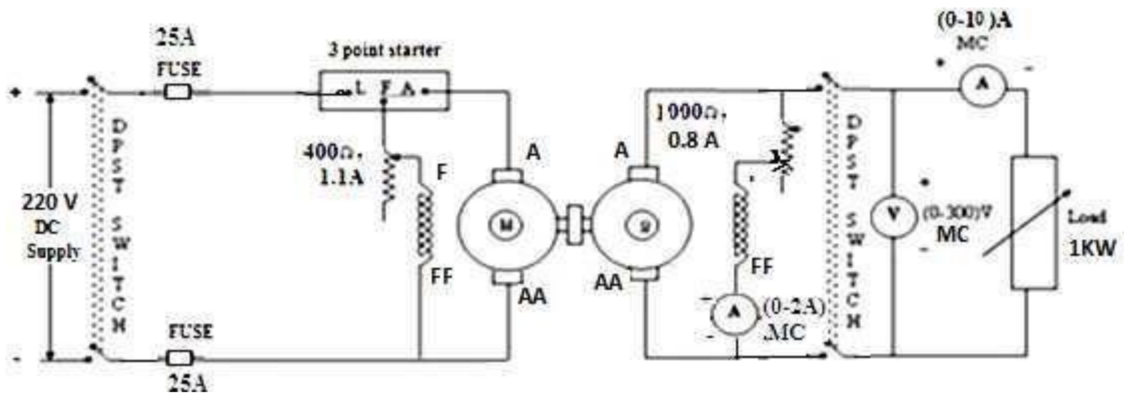
PROCEDURE

OPEN CIRCUIT CHARACTERISTICS:-

- **The connections are made as per the circuit diagram.**
- **After checking minimum position of motor field rheostat, maximum position of generator held rheostat, The DPST switch is closed and starting resistance is gradually removed.**
- **The motor is started using three point starter.**

- **By varying the field rheostat of the motor, the speed of the motor is adjusted to the rated speed of the generator.**
- **By varying the generator field rheostat, voltmeter and ammeter readings are taken in steps upto 120% of rated voltage.**
- **After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, the DPST switch is closed.**
- **Draw R_c line, such that it is tangent to the initial portion of O.C.C. at rated speed and passes through origin.**

CIRCUIT DIAGRAM



Name Plate Details

Motor

1. Supply Voltage : 220V
2. Current : 19A
3. Speed : 1500 rpm
4. Power : 5 HP

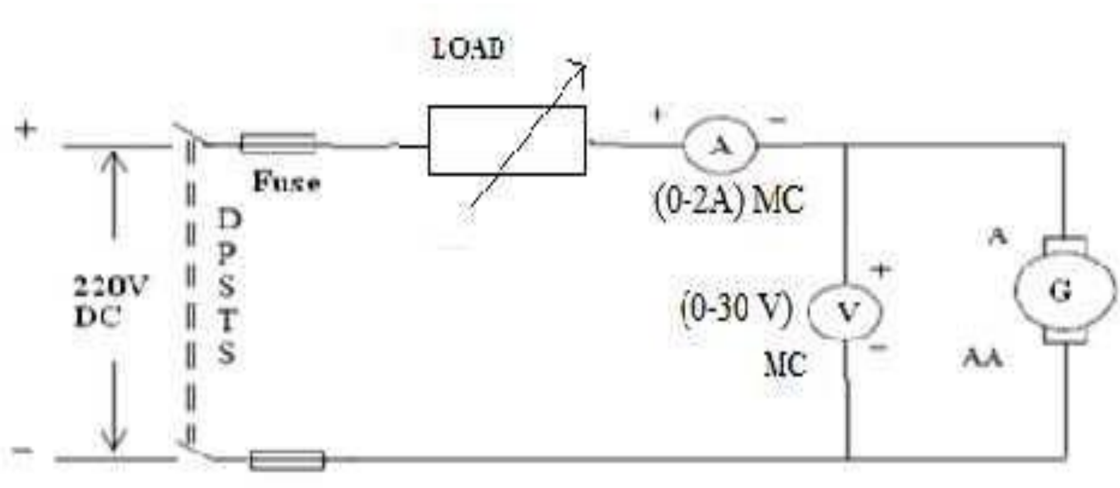
Generator

1. Supply Voltage : 220V
2. Current : 13.6A
3. Speed : 1500 rpm
4. Power : 3KW

TABULAR COLOUMN FOR OPEN CIRCUIT CHARACTERISTICS

Sl. No.	Field current, I_f Amperes	Generated EMF, E_g volts
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

MEASUREMENT OF RA FOR GENERATOR:

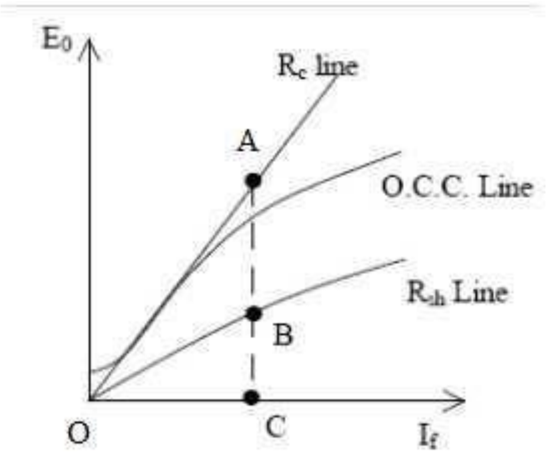


MEASUREMENT OF R_A:

S.No.	V (Volts)	I (Amps)	R_a (Ohms)
1 2 3 4 5			

Mean =

MODEL GRAPH:



LOAD TEST:

- **The connections are made as per the circuit diagram.**
- **The motor is started using three point starter.**
- **Run the MG set at rated speed**
- **Excite the Generator to its rated voltage after closing the SPSTS, and observe the readings on no load.**
- **Close the DPSTS on load side, vary the load for convenient steps of load current and**
  observe the meter readings.
- **Note that on each loading the speed should be rated speed.**
- **Load the Generator upto its rated capacity.**

TABULAR COLOUMN FOR LOAD CHARACTERISTICS

Speed =___________________rpm No Load Voltage =___________Volts

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

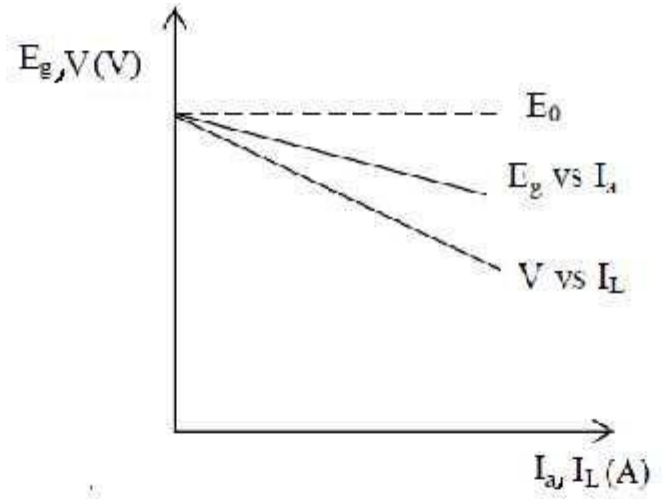
Formulas Required:

Load test:

For self excitation $I_a = I_L + I_f$

So, induced emf on load, $E_g = V + I_aR_a$

MODEL GRAPHS:



Inference :

RESULT:

Thus the open circuit and load characteristics of self excited D.C. Shunt Generator were drawn.

LOAD TEST ON D.C. COMPOUND GENERATOR WITH DIFEERENTIAL AND CUMULATIVE CONNECTION

AIM

To conduct the Load test on the given D. C. Compound Generator in the following modes.

1. **Cumulative Modes**
2. **Differential Modes**

APPARATUS REQUIRED:-

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0-2)A	MC	1
2.	Ammeter	(0-10)A	MC	1
3.	Voltmeter	(0-300)V	MC	1
4.	Rheostat	400 Ω/1.1A, 800 Ω/0.8A	Wire wound	1 each

PRECAUTION

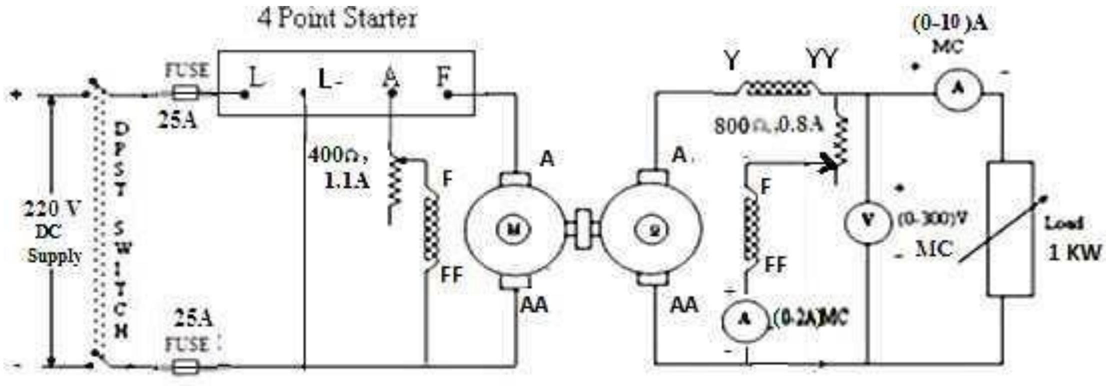
- **All the switches should be kept open.**
- **The field rheostat of the motor should be kept at minimum resistance position.**
- **The field rheostat of the generator should be kept at maximum resistance position.**

PROCEDURE

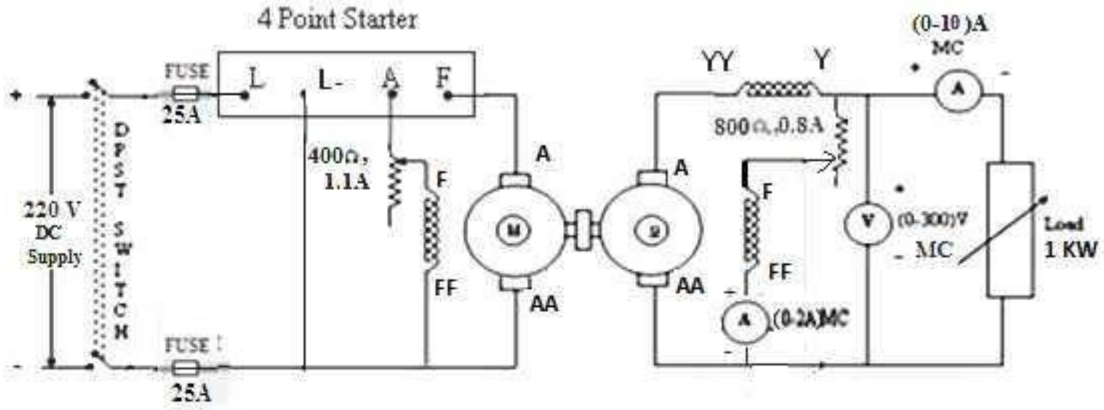
- **The connections are made as per the circuit diagram.**
- **The DPST switch is closed.**
- **The motor is started using four point starter.**
- **The field rheostat of the motor is adjusted to bring the motor speed to the rated speed of the generator.**
- **The generator field rheostat is adjusted till the voltmeter reads the rated voltage of the generator.**

- **DPST switch on the generator side is closed.**
- **The load is increased in steps.**
- **At each step of loading all the meter readings are noted.**
- **The above procedure is repeated till the ammeter reads the rated current.**
- **Switch off the load gradually and make the motor and generator rheostat resistance position as instructed in the precaution.**
- **Turn off the supply**
- **Interchange the terminal connection of the generator series field coil and repeat the procedure right from the first step.**

DIFFERENTIAL SHUNT



CUMULATIVE SHUNT



Name Plate Details

Motor	**Generator**
1. Supply Voltage: 220V	1. Supply Voltage:220V
2. Current:19A	2. Current:13.6A
3. Speed :1500 rpm	3. Speed:1500 rpm
4. Power: 5 HP	4. Power: 3KW

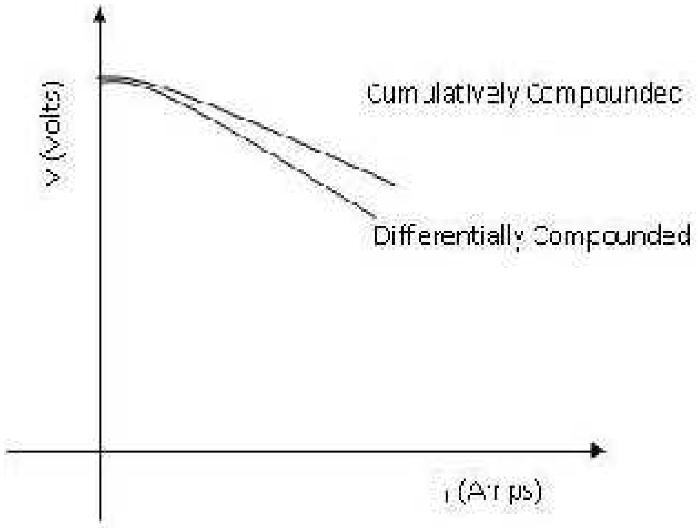
CUMULATIVE COMPOUND MOTOR

Sl. No.	I_L (A)	V_L (V)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

DIFFERENTIAL COMPOUND MOTOR

Sl. No.	I_L (A)	V_L (V)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

MODEL GRAPHS:



Inference :

RESULT

Thus the performance characteristics of the DC Compound Generator were drawn.

LOAD CHARACTERISTICS OF D.C SHUNT MOTOR

AIM:

1. **To determine the efficiency of DC Shunt Motor.**
2. **To obtain the performance characteristics of Shunt Motor.**

APPARATUS REQUIRED

Sl. No.	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0 - 2A)	MC	1
2.	Ammeter	(0 - 10A)	MC	1
3.	Voltmeter	(0 - 300V)	MC	1
4.	Rheostat	400 Ω/1.1A	Wire wound	1 each

PRECAUTIONS:

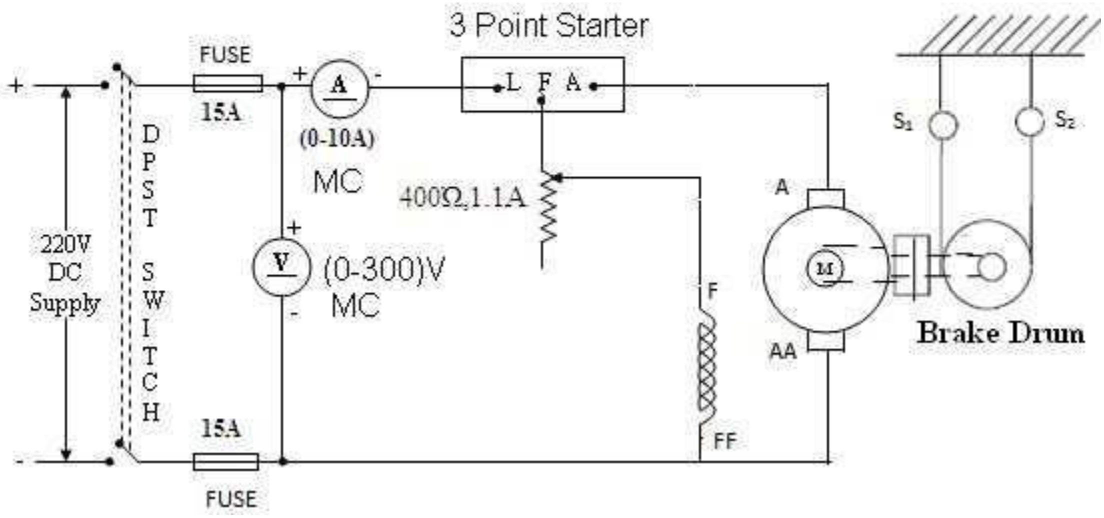
At the time of switching on and switching off the supply,

- **The field rheostat should be at the minimum resistance position.**
- **There should not be any load on the motor.**

PROCEDURE

- **The connections are given as per the circuit diagram.**
- **The DPST switch is closed.**
- **The motor is started using the starter.**
- **The speed of the motor is adjusted to the rated value by varying the field rheostat.**
- **The no load readings are noted.**
- **The load on the brake drum increased in steps.**
- **At each step of loading the meter readings are noted.**
- **The procedure is repeated till the ammeter reads the rated current.**

CIRCUIT DIAGRAM FOR BRAKE TEST ON D.C. SHUNT MOTOR



Name Plate Details

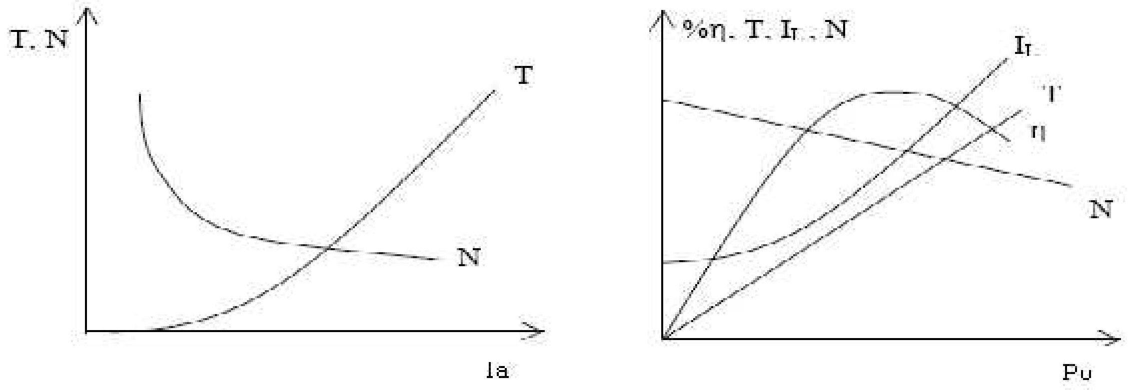
Motor

1. Supply Voltage: 220V
2. Current:12A
3. Speed :1500 rpm
4. Power: 3 Hp

TABULAR COLUMN

Sl. No.	Voltage, V_L (V)	Current I_L (A)	Spring balance			Speed Rpm	Torq-ue N-m	Input P_i watts	Output P_m watts	Efficiency In %
			S_1 Kg	S_2 Kg	$S1 \sim S2$ kg					
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										

MODEL GRAPHS:



FORMULA USED:-

Circumference of brake drum = 2 x π x R in meter

R – Radius of the brake drum

Torque, T =(S1-S2)x9.81xR Nm

Input power, $P_i = V_L \times I_L$ in Watts

Output power, $P_0 = (2 \times \pi \times N \times T) / 60$ in Watts

% Efficiency, $\eta = (P_0 / P_i) \times 100$

Inference:

RESULT:

Thus the performance characteristics of the DC Shunt Motor were drawn.

LOAD TEST ON D.C. COMPOUND MOTOR

AIM

To perform the load test on the given DC Compound M otor and draw the performance characteristics.

APPARATUS REQUIRED:-

Sl. No.	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0 - 15) A	MC	1
2.	Ammeter	(0 - 2) A	MC	1
3.	Voltmeter	(0 - 300) V	MC	1
4.	Rheostat	400Ω, 1.1 A	-	1

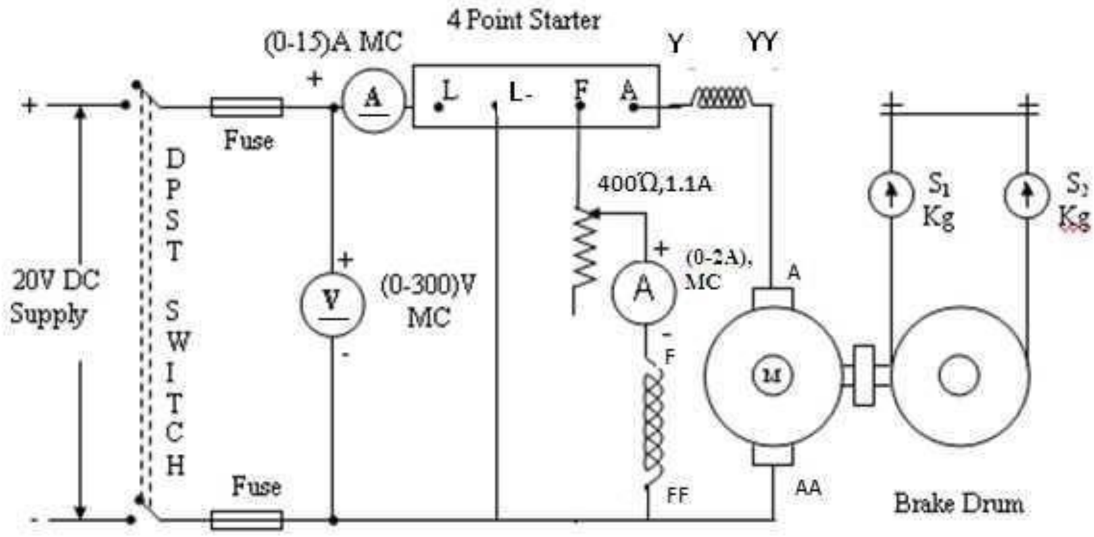
PROCEDURE

- **The connections are given as per the circuit diagram.**
- **The DPST switch is closed.**
- **The motor is started using the four point starter.**
- **The speed of the motor is adjusted to the rated value by varying the field rheostat.**
- **The no load readings are noted.**
- **The load on the brake drum increased in steps.**
- **At each step of loading the meter readings are noted.**
- **The procedure is repeated till the ammeter reads the rated current.**

PRECUATION

- **All the switches are kept open initially.**
- **The field rheostat should be kept at minimum resistance position.**
- **There should not be any load when start and stop the motor.**
- **While starting the motor, the starter handle is moved slowly from OFF to ON position.**
- **While running on load, the brake drum should be cooled by pouring water inside the brake drum.**

CIRCUIT DIAGRAM LOAD TEST ON DC COMPOUND MOTOR:



Name Plate Details

Motor

1. Supply Voltage: 220V
2. Current:19Amps
3. Speed :1500 rpm
4. Power: 5 HP

FORMULA USED:-

Circumference of brake drum = 2 x π x R in metre

R = Radius of the brake drum

Torque, T = (S1~S2) x9.81xR in Nm

Input power, $P_i = V_L \times I_L$ in Watts

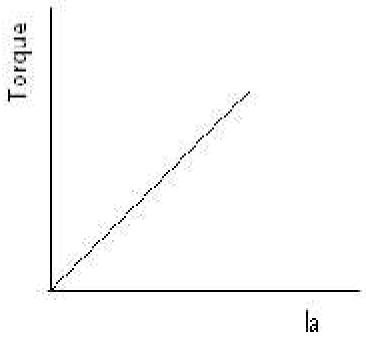
Output power, $P_0 = (2 \times \pi \times N \times T) / 60$ in Watts

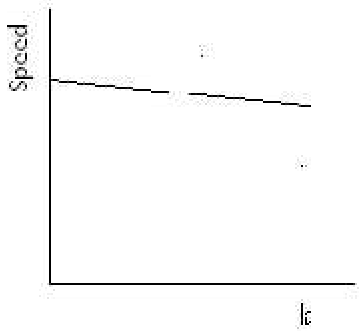
% Efficiency, $\eta = (P_0 / P_i) \times 100$

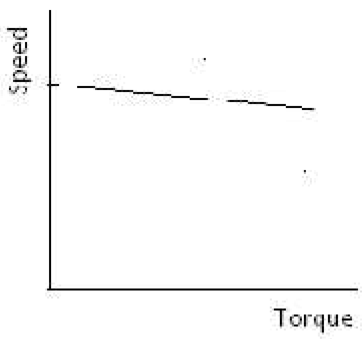
TABULAR COLOUMN

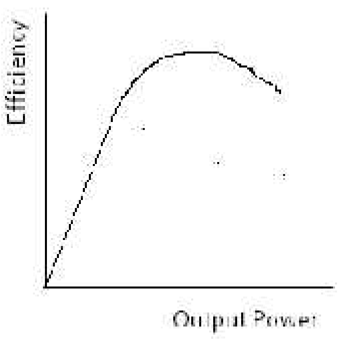
Sl. No.	**Voltage, V_L (V)**	**Current I_L (A)**	**Spring balance**			**Speed Rpm**	**Torq -ue N-m**	**Input P_i watts**	**Output P_m watts**	**Efficiency In %**
			S_1 Kg	**S_2 Kg**	**$S1 \sim S2$ kg**					
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										

MODEL GRAPHS:









Inference:

RESULT:

Thus the performance characteristics of the DC Compound Motor were drawn.

LOAD TEST ON D.C. SERIES MOTOR

AIM:

- **To determine the efficiency of D.C Series Motor.**
- **To obtain the performance characteristics of DC Series Motor.**

APPARATUS REQUIRED:

Sl. No.	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0-20)A	MC	1
2.	Voltmeter	(0-300)V	MC	1

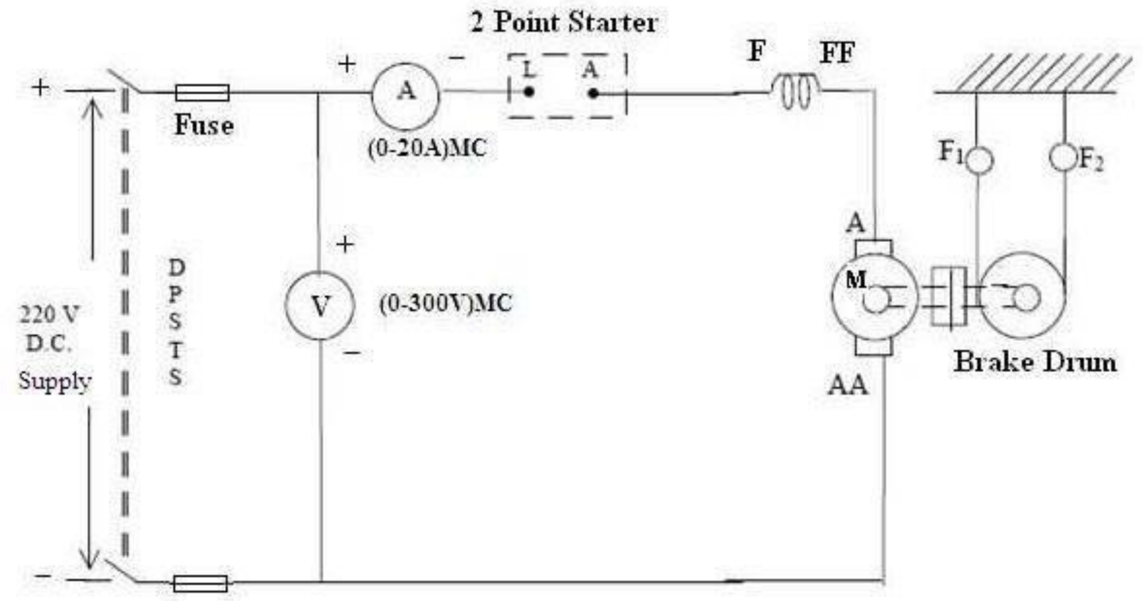
PRECAUTION:

The motor should be started with some initial load.

PROCEDURE:

1. **Connections are given as per circuit diagram.**
2. **Before starting the motor some initial load is applied to the motor by using the brake drum with spring balance.**
3. **Using two-point starter the motor is started to run.**
4. **The meter readings are started at its initial condition.**
5. **Gradually load the machine up to rated current and corresponding meter readings were noted.**
6. **After the observation of all the readings the load is released gradually up to the initial load condition.**

CIRCUIT DIAGRAM FOR BRAKE TEST ON D.C. SERIES MOTOR:



Name Plate Details **Fuse Rating**

Motor

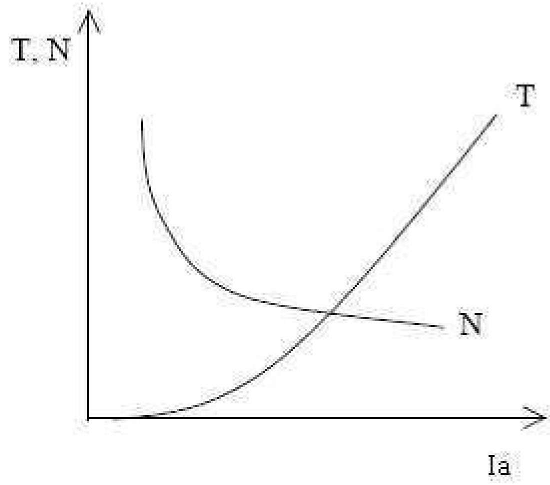
1. Supply Voltage: 220V
2. Current:12 Amps
3. Speed : 1500 rpm
4. Power: 3 HP

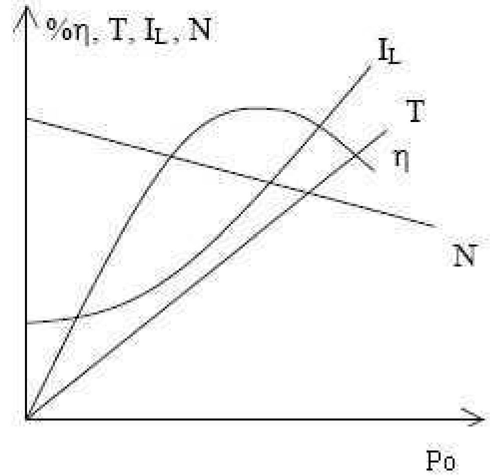
TABULAR COLOUMN

Radius of brake drum, r =___________mts.

S.No.	Voltage V_L (Volts)	Current I_L (Amps)	Spring Balance (Kg)			Speed N (rpm)	Torque T (Nm)	Output Power P_o (Watts)	Input Power P_i (Watts)	Efficiency η %
			F_1	F_2	$F_1 \sim F_2$					
1.										
2.										
3.										
4.										

MODEL GRAPHS:





FORMULAE USED:

Circumference of the brake drum =______metre

Radius of the brake drum, r =______metre

Torque applied on the shaft of the rotor, T = (F1 ~ F2)* r × 9.81 Nm

Output power, Po = (2πNT)/60 Watts

Input power Pi = V × I_L Watts Efficiency = (P_o / P_i)

Inference:

RESULT:

Thus the performance characteristics of the DC Series Motor were drawn.

SWINBURNE'S TEST

AIM

To predetermine the efficiency o the DC Machine when it act as

(i) Motor

(ii) Generator

APPARATUS REQUIRED:-

Sl.No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 -5) A	MC	1
2.	Ammeter	(0 - 2) A	MC	1
3.	Voltmeter	(0 - 300)V	MC	1
4.	Rheostat	400, 1.1 A	Wire wound	1
5.	Tachometer		Digital	1

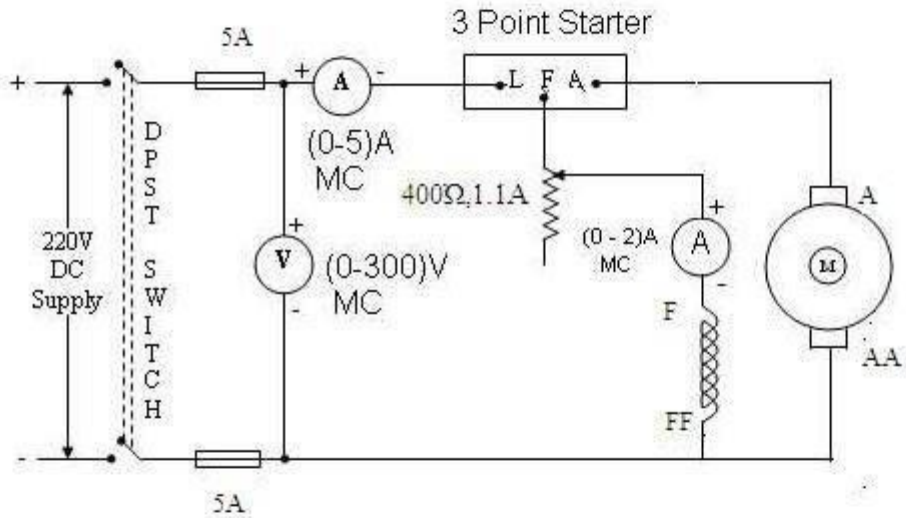
PRECAUTION:

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

PROCEDURE:

1. **The connections are made as per the circuit diagram.**
2. **The DPST switch is closed.**
3. **The motor is started with the help of three point starter.**
4. **The field rheostat of the motor is adjusted to bring the motor speed to the rated value.**
5. **The no load current, voltage and shunt field current are noted.**

CIRCUIT DIAGRAM SWINBURNE'STEST :



Name Plate Details **Fuse Rating**

1. Supply Voltage : 220V
2. Current :12 Amps
3. Speed : 1500 rpm
4. Power: 3 HP

TABULAR COLOUMN

Voltage, V (volts)	Field current, I_f (A)	No load current, I_0 (A)

For Motor

S.No	Line Current I_L(A)	Field Current I_f (A)	$I_a = I_L - I_f$ (A)	$W_{Cu} = I^2_a R$	Constant Loss (watts)	Total Loss (watts)	Input Power (watts)	Output Power (watts)	Efficiency %η

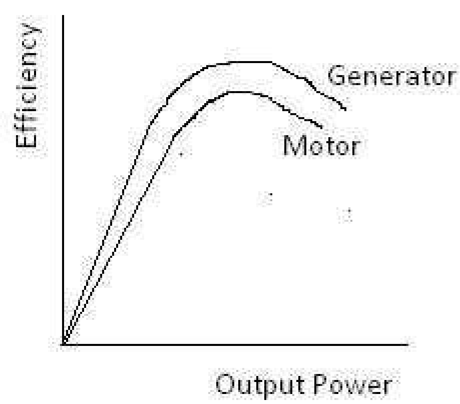
For Generator

S.No.	Line Current, I_L (A)	Field current I_f (A)	$I_a = I_L + I_f$ (A)	$W_{Cu} = I_a^2 R_a$	Constant Loss (watts)	Total Loss (watts)	Input Power (watts)	Output Power (watts)	Efficiency %η

Measurement of

Voltage (v)	Current(A)	Armature resistance R_a(ohms)
1.		
2.		
3.		
4.		
5.		
		Mean ==

<u>Model Graph</u>



<u>FORMULA USED:</u>

Constant loss $W_c = V\,I_o - (I_a - I_f)^2 R_a$

R_a = Resistance of armature

For Motor

1. Armature Current $I_a = I_L - I_f$
2. Armature Copper Loss $W_{cu} = I_a^2 R_a$
3. Total loss $W_t = W_c + W_{cu}$
4. Input power $P_i = VI_L$
5. Output Power $P_o = P_i - W_t$
6. Efficiency = (Output Power / Input Power)

For Generator

1. Armature Current $I_a = I_L + I_f$
2. Armature Copper Loss $W_{cu} = I_a^2 R_a$
3. Total loss $W_t = W_c + W_{cu}$
4. Output power $P_o = VI_L$
5. Input Power $P_i = P_o + W_t$
6. Efficiency == (Output Power / Input Power)

Inference:

RESULT:

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

SPEED CONTROL OF D.C. SHUNT MOTOR

AIM

To draw the speed characteristics of DC Shunt Motor by

(1) Armature control method

(2) Field control method

APPARATUS REQUIRED:-

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 -5) A	MC	1
2.	Ammeter	(0 - 2) A	MC	1
3.	Voltmeter	(0 - 300)V	MC	1
4.	Rheostat	400, 1.1 A; 50, 15A	Wire wound	1
5.	Tachometer		Digital	1

PRECAUTION:

1. All the switches are kept open initially.
2. The field rheostat should be kept at minimum resistance position.
3. The armature rheostat should be kept at maximum resistance position.

PROCEDURE:

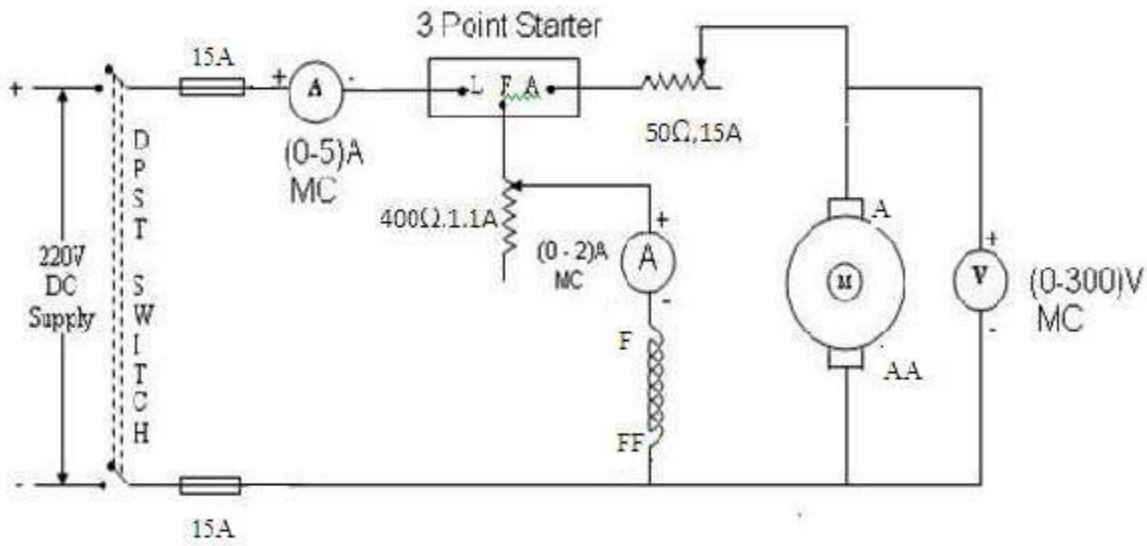
ARMATURE CONTROL METHOD:-

1. The connections are given as per the circuit diagram.
2. The DPST switch is closed.
3. The field current is varied in steps by varying the field rheostat.
4. In each step of field current the armature voltage is varied in steps by varying the armature rheostat.
5. In each step of armature rheostat variation the meter readings (Voltmeter & Tachometer) are noted.

FIELD CONTROL METHOD:-

1. **The connections are given as per the circuit diagram.**
2. **The DPST switch is closed.**
3. **The armature voltage is varied in steps by varying the armature rheostat.**
4. **In each step of armature voltage the field current in steps by varying the field rheostat.**
5. **In each step of field rheostat the meter readings (Ammeter & tachometer) are noted.**

CIRCUIT DIAGRAM:



Name Plate Details

Fuse Rating

Supply Voltage : 220V

Current :12 Amps

Speed : 1500 rpm

Power: 3 HP

TABULAR COLOUMN:

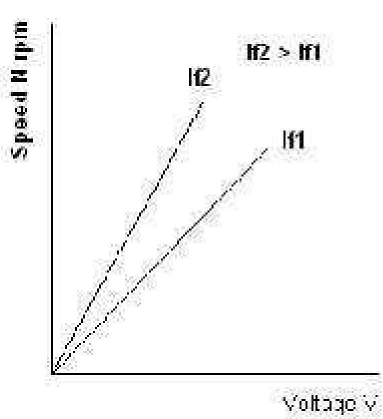
ARMATURE VOLTAGECONTROL:

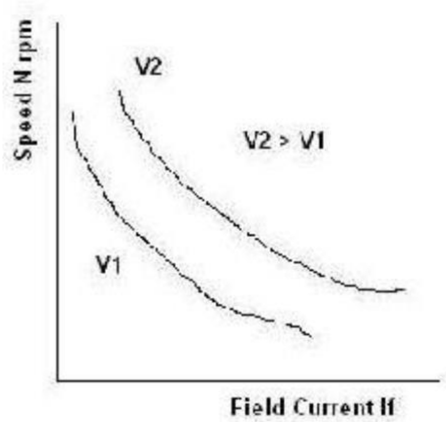
S.No	I_{F1} = A		I_{F2} = A	
	Voltage V	Speed N rpm	Voltage V	Speed N rpm

FIELD CONTROL:

S.No	Voltage V_1 = V		Voltage V_2 = V	
	Field current I_F A	Speed N rpm	Field current I_F A	Speed N rpm
1.				
2.				
3.				
4.				

ARMATURE VOLTAGE CONTROL **FIELD CONTROL**





Inference:

RESULT:

Thus the speed characteristics of the DC Shunt Motor were drawn.

HOPKINSON'STEST

AIM:

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

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A (0-20) A	MC MC	2 2
2	Voltmeter	(0-300) V (0-600)V	MC MC	2 1
3	Rheostats	400Ω, 1.1 A 800Ω, 0.8 A	Wire wound	1 1

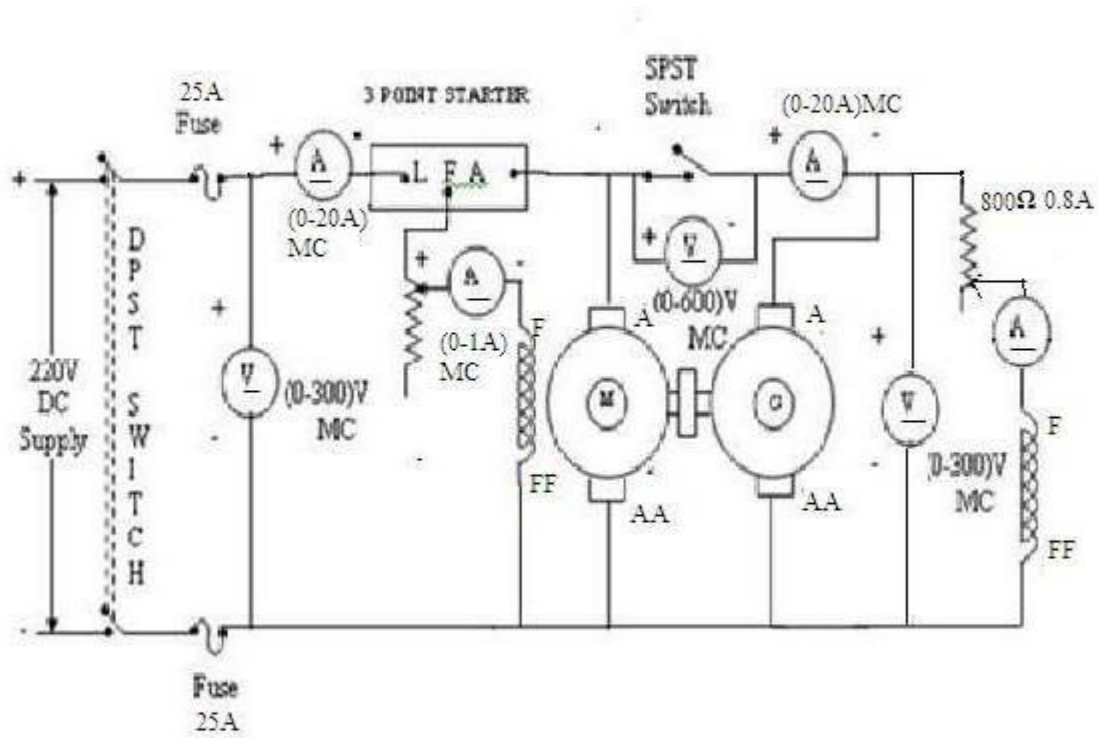
PRECATUIONS:

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

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of field rheostat of motor, maximum position of field rheostat of generator, opening of SPST switch, DPST switch is closed and starting resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat of the motor.
4. The voltmeter V_1 is made to read zero by adjusting field rheostat of generator and SPST switch is closed.
5. By adjusting field rheostats of motor and generator, various Ammeter readings, voltmeter readings are noted.
6. The rheostats and SPST switch are brought to their original positions and DPST switch is opened.

CIRCUIT DIAGRAM FOR HOPKIN'S TEST

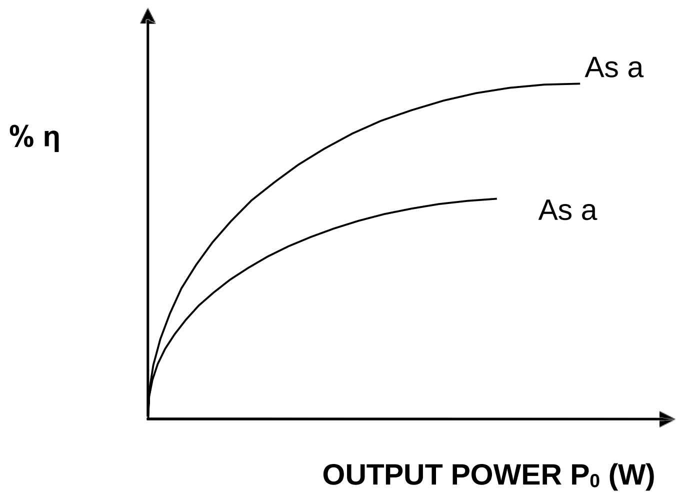


Name Plate Details

Motor	**Generator**
Supply Voltage : 220V	Supply Voltage : 220V
Current : 19Amps	Current : 13.6Amps
Speed : 1500 rpm	Speed : 1500
Power : 5 HP	Power : 3KW

Fuse Rating

MODEL GRAPH:



TABULAR COLUMN:

S.No.	Supply Voltage V_S (V)	I_S (A)	I_{FM} (A)	V_A (A)	I_{FG} (A)	I_{LG} (A)

AS MOTOR:

S.No.	I_{LG} (A)	Armature Cu Loss W (Watts)	Field Loss (Watts)	Stray loss (Watts)	Total Losses W_t (Watts)	O/P Power (W)	I/p Power (W)	% η
1.								
2.								
3.								
4.								
5.								
6.								

AS GENERATOR:

S.No.	I_{LG} (A)	Armature Cu Loss W (Watts)	Field Loss (Watts)	Stray loss (Watts)	Total Losses W_t (Watts)	O/P Power (W)	I/p Power (W)	% η
1.								
2.								
3.								
4.								
5.								
6.								

FORMULAE USED:

Input Power	**= VI_1 watts**
Motor armature cu loss	**= $(I_1 + I_2)^2$ Ra watts**
Generator armature cu loss	**= I_2^2 Ra watts**
Total Stray losses W	**= $V I_1 - (I_1+I_2)^2 Ra + I_2^2 Ra$ watts.**
Stray loss per machine	**= W/2 watts.**

AS MOTOR:

Input Power $= \text{Armature input} + \text{Shunt field input}$

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

Total Losses $= \text{Armature Cu loss} + \text{Field loss} + \text{stray loss}$

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

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

AS GENERATOR:

Output Power $= VI_2$ watts

Total Losses $= \text{Armature Cu loss} + \text{Field Loss} + \text{Stray loss}$

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

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

Inference:

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.

LOAD TEST ON SINGLE PHASE TRANSFORMER

AIM:

To determine the efficiency and also to find the variation of secondary terminal voltage with respect to the load current.

APPARATUS REQUIRED:

S.No.	Item	Type	Range	Quantity
1	Auto Transformer	230/(0-270) V, 1φ	-	1
2	Wattmeter	300 V, 10A 150 V, 10 A	UPF UPF	1 1
3	Ammeter	(0-10) A (0-5) A	MI MI	1 1
4	Voltmeter	(0-300) V (0-150) V	MI MI	1 1
5	Connecting Wires	2.5sq.mm	Copper	Few
6	Load	(5 KW,230V)	-	1

PRECAUTION:

1. The Variac should be kept in minimumposition while switching on and switching off the supply side DPSTS.

2. At the time of switching on the supply there should not be any load connected.

RANGE FIXING:

Rated primary current, $I_1 = \dfrac{Rated\ capacity\ in\ VA}{Primary\ voltage,\ V_1}$

Rated secondary current, $I_2 = \dfrac{Rated\ capacity\ in\ VA}{Secondary\ voltage,\ V_2}$

The load used is resistive in nature.

$\therefore$ **The range of A_P, V_P, W_P are …………A, ……………V,................. W respectively.**

The range of A_s, V_s, W_s are ……………A, …………….V,....................W respectively.

PROCEDURE:

1. **Excite the transformer to its rated voltage on no load.**
2. **Observe the meter readings at no load.**
3. **Gradually load the transformer and note the meter readings for each loading.**
4. **Load the transformer to its rated capacity i.e. till it draws rated current from the supply.**

Note that applied voltage to the primary side should be kept at its rated voltage on loading.

FORMULA USED:

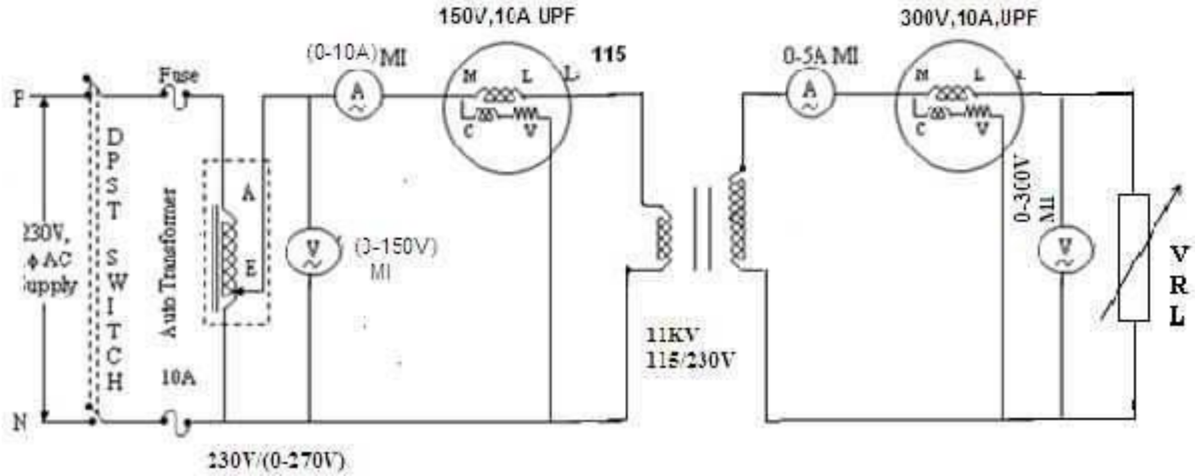
Output power = W_S

Input Power = W_P

% $\eta = \dfrac{W_S}{W_P} \times 100$

% Regulation = $\dfrac{V_{S0} - V_S}{V_{S0}} \times 100$ **(where V_{S0} – no load secondary rated terminal voltage)**

CIRCUIT DIAGRAM:



VRL-Variable Resistive Load

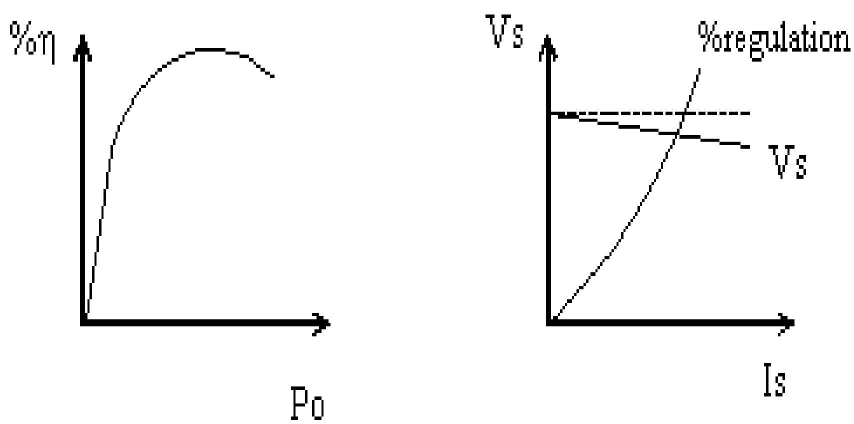
Name Plate Details

1. Single phase transformer
2. Primary voltage: 230V
3. Secondary voltage:115V
4. Power capacity:1KVA

TABULAR COLUMN:

Sl. No.	V_P Volts	I_P Amps	W_P (Watts)		V_S Volts	I_S Amps	W_S (Watts)		% Efficiency	% Regulation
			Observed	Actual			Observed	Actual		

MODEL GRAPHS:



Inference:

RESULT:

Thus the efficiency and regulation of a Three phase Transformer were calculated.

LOAD TEST ON A THREE PHASE TRANSFORMER

AIM:

Determination of Regulation & Efficiency of three-phase transformer by direct loading.

APPARATUS REQUIRED:-

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Voltmeter	0-600 V	MI	1
2.	Voltmeter	0-300V	MI	1
3.	Ammeter	0-10A	MI	1
4.	Ammeter	0-20A	MI	1
5.	Wattmeter	600V,5/10A,UPF		4
6.	Resistive load	3ph 415V,5kw		1

PRECAUTIONS:

All the switches should be kept open.

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 dimmer stat at zero position, switch on 3-Phase supply.

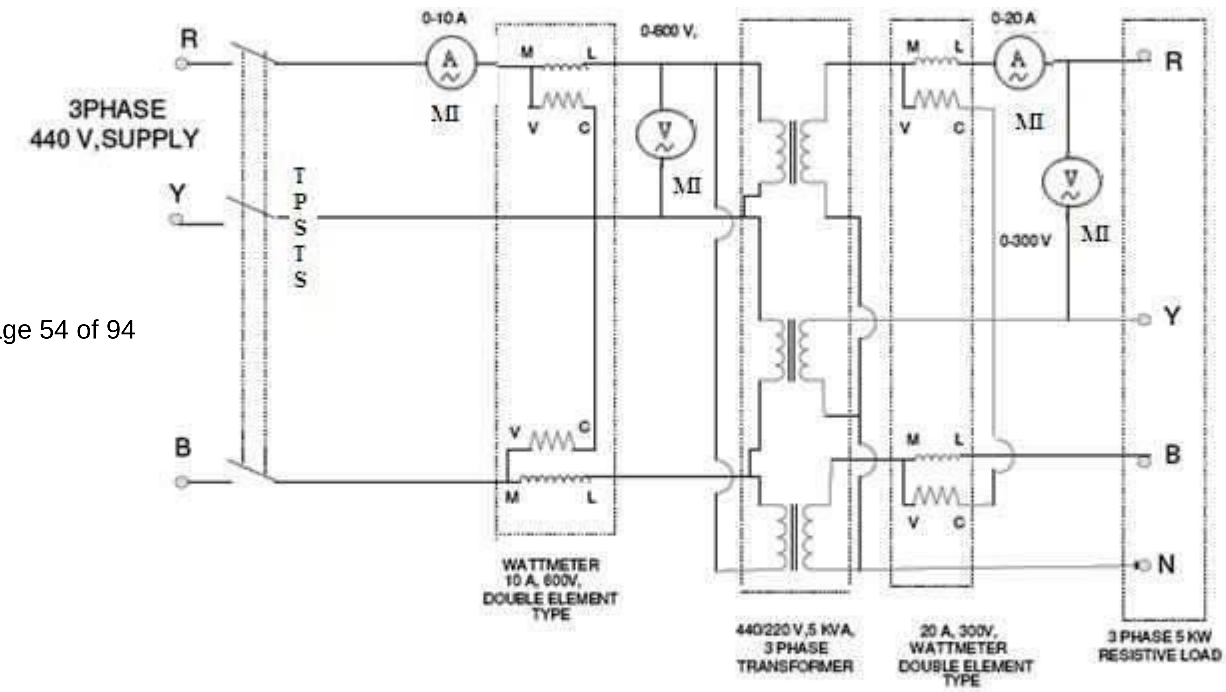
4) Now increase dimmer stat voltage for 440 V.

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.

CIRCUIT DIAGRAM FOR LOAD TEST ON THREE PHASE TRANSFORMER



MODEL CALCULATION:-

Input power = $W_1 + W_2$ Watts

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

% Efficiency = (output / Input) x 100

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

TABULAR COLOUMN

Sl. No.	V1 Volts	I1 Amperes	W1 Watts	V2 Volts	I2 Amperes	W2 Watts	Efficiency	Regulation

Inference:

RESULT:

Thus the efficiency and regulation of a three phase transformer were calculated.

OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON SINGLE- PHASE TRANSFORMER

AIM:

1. **To obtain the equivalent circuit of transformer.**
2. **To predetermine the efficiency and regulation of transformer.**
3. **To predetermine the maximum efficiency of transformer**

APPARATUS REQUIRED:

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

PRECAUTION:

1. **Variac must be kept in minimum position while switching on and switching off the supply.**
2. **LPF wattmeter for O.C. test and UPF wattmeter for S.C. circuit test should be used.**

RANGE FIXING:

O.C. Test:

Full load primary current $I_1 = \dfrac{Full\ load\ capacity\ in\ VA}{Primary\ voltage\ V_1}$

Full load secondary current I_2 $= Full\ \ load\ Capacity/Secondary\ voltage V_2$

Let both O.C. and S.C. test be conducted on primary side.

On O.C. test the current drawn by the transformer is about 5 – 10% of Full load Primary current. ∴ Ammeter range is (0 -)A

The rated primary voltage will be applied. ∴ Voltmeter range (0 -

)V Observation:

O.C. Test:

M.F. =

V_0 (Volts)	I_0 (Amps)	W_0 (Watts)	
		Observed	Actual

S.C. Test:

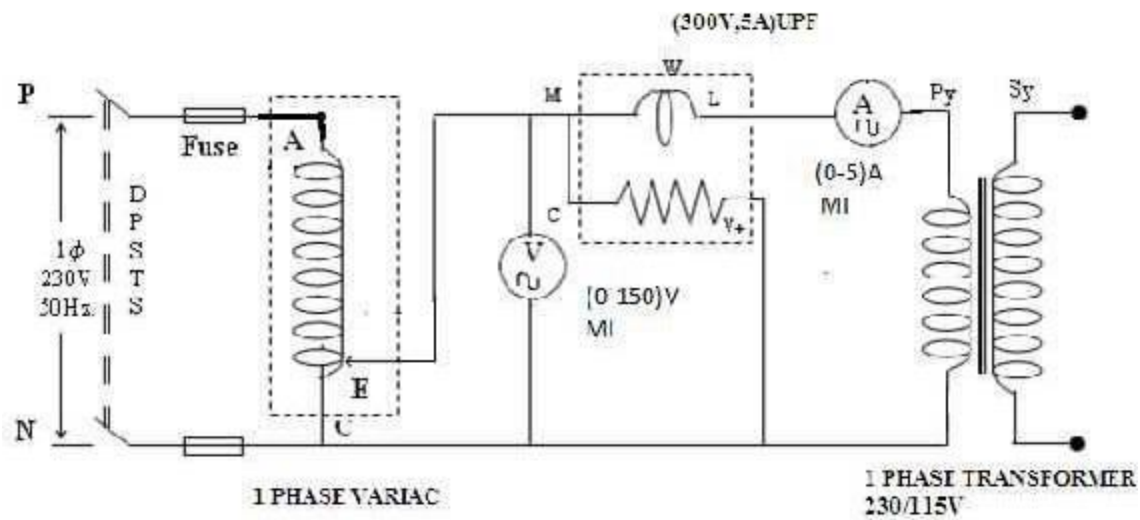
M.F. =

V_{sh} (Volts)	I_{sh} (Amps)	W_{sh} (Watts)	
		Observed	Actual

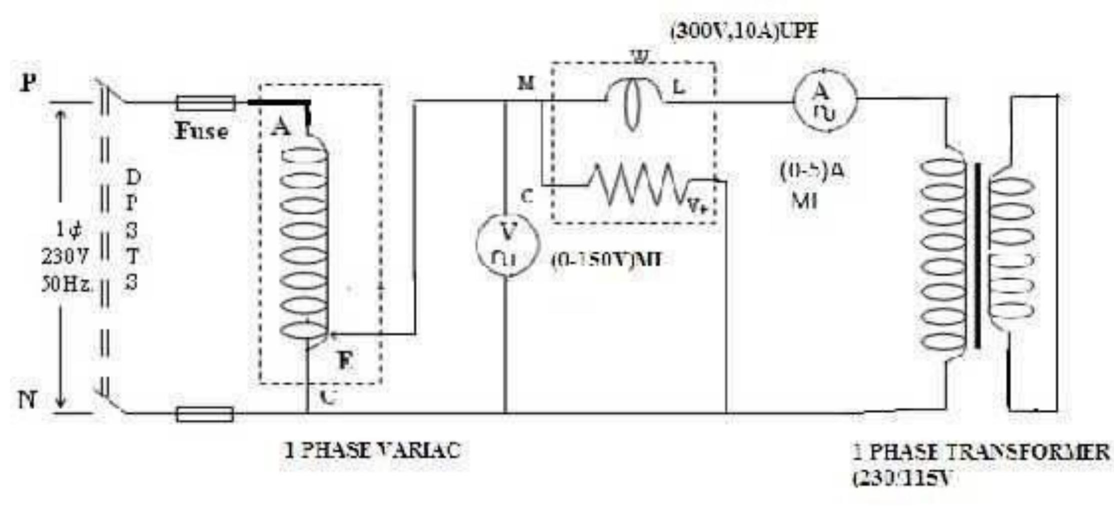
EQUIVALENT CIRCUIT OF THE TRANSFORMER REFERRED TO PRIMARY SIDE:

CIRCUIT DIAGRAM FOR O.C. & S.C. TESTS ON SINGLE PHASE TRANSFORMER:

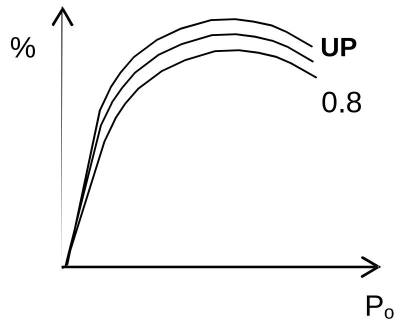
O.C. TEST:

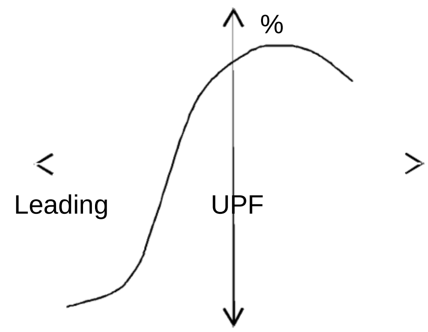


S.C. TEST:



MODEL GRAPHS:





WATTMETER:

The current rating and voltage rating of Wattmeter are to be nearer to the value calculated above.

On O.C. condition the reactive power drawn is more and the active power drawn is less.

So power factor on no-load will be very low.

∴ LPF wattmeter can be used.

The range of wattmeter is V, A, LPF.

S.C. TEST:

The voltage applied to the transformer primary to circulate rated full load current is about 5 to 10% of rated primary voltage.

∴ The voltmeter range is (0 -)V

Ammeter range is (0 -)A

The active power drawn by the transformer on S.C. condition is more and reactive power drawn is less. ∴ UPF wattmeter can be used.

Range of wattmeter is ………V,............. A, UPF.

PROCEDURE:

1. **With the help of Variac, apply rated voltage to the transformer in O.C. test and circulate rated current in S.C. test. Note down the corresponding meter readings.**

MODEL CALCULATION:

1) EQUIVALENT CIRCUIT:

Power factor on no load $Cos\phi_0 = \frac{W_0}{V_0 I_0}$

Working component of no load current, $I_w = I_0 Cos\phi_0$

Magnetising component of no load current, $I_\mu = I_0 Sin\phi_0$

Resistance to account iron losses, $R_0 = \frac{V_0}{I_w}$

Reactance to account magnetization of the core, $X_0 = \frac{V_0}{I_\mu}$

Equivalent resistance of the transformer referred to primary, $R_{01} = \frac{W_{sc}}{I_{sc}^2}$

(assuming S.C. test is conducted on primary side)

PREDETERMINATION OF EFFICIENCY:

S. No.	% of load x	Copper loss $W_c = X^2 W_{sc}$ (Watts)	T.L. = $W_i + W_c$ (Watts)	Cosϕ = 1			Cosϕ = 0.8			Cosϕ = 0.6		
				P_o (Watts)	P_i (Watts)	η	P_o (Watts)	P_i (Watts)	η	P_o (Watts)	P_i (Watts)	η
1	0											
2	20											
3	40											
4	60											
5	80											
6	100											
7	120											

PREDETERMINATION OF FULL LOAD REGULATION:

S.No.	CosΦ	SinΦ	% Regulation	
			Lagging p.f.	Leading p.f.
1	0			
2	0.2			
3	0.4			
4	0.6			
5	0.8			
6	1.0			

Equivalent impedance of the transformer referred to primary, $Z_{01} = \frac{V_{sc}}{I_{sc}}$

Equivalent leakage reactance of the transformer referred to primary, $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

Voltage transformation ratio, $K = \frac{V_2}{V_1}$

Equivalent resistance of the transformer referred to secondary, $R_{02} = K^2 R_{01}$

Equivalent leakage reactance of the transformer referred to secondary, $X_{02} = K^2 X_{01}$**.**

I_2' **- Secondary rated current referred to Primary side**

V_2' **– Secondary rated voltage referred to Primary side**

II) PREDETERMINATION OF EFFICIENCY:

Let the load be x% of FL kVA and cosϕ - load power factor

Power output, P_0 = x (FL kVA) cosϕ× 1000

Copper Losses, $W_c = x^2 W_{sc}$

Total Losses, $W = W_i + W_c$ (where W_i is approx. equal to W_0)

Power input $P_i = P_0 + W$

Efficiency, $\eta = \frac{P_0}{P_i}$

III) PREDETERMINATION OF FULL LOAD REGULATION:

% Regulation = $\frac{(I_2 R_{02} \cos\phi \pm I_2 X_{02} \sin\phi)}{V_2} \times 100$

Where I_2- Full load secondary current.

V_2- rated secondary voltage

Cosϕ - Load power factor

+ve sign for lagging power factor load

-ve sign for leading power factor load

IV) MAXIMUM EFFICIENCY–PREDETERMINATION:

For maximum η, copper loss = Iron loss

i.e. $I_2^2 R_{02} = W_i$

Load current corresponding to maximum efficiency $I_2 = \sqrt{\frac{W_i}{R_{02}}}$

Then, maximum η can be determined for any load power factor as below.

Cos ϕ-- load power factor (assume)

Power output, $P_o = V_2 I_2 \cos\phi$

Total losses, $W = 2 W_i$

Power output, $P_o = P_i + W$

Maximum efficiency $\eta_{max} = \frac{P_o}{P_i} \times 100$

RESULT:

Thus the efficiency and regulation of the Single phase Transformer was predetermined and Equivalent circuit was drawn.

SUMPNER'S TEST ON TRANSFORMERS

AIM :

To predetermine the Efficiency and Regulation of a given Single phase Transformer by conducting back-to-back test.

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1.	Auto Transformer	230/(0-270) V	-	2
2.	Wattmeter	150 V, 2A 150 V, 5 A	LPF UPF	1 1
3.	Ammeter	(0-5) A	MI	2
4.	Voltmeter	(0-75) V (0-150) V (0 -600) V	MI MI MI	1 1 1
5.	Connecting Wires	2.5sq.mm	Copper	Few

PRECAUTIONS:

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

FORMULA USED:

Core loss =W_o

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

Total loss =Core loss +Cu loss

Output = $V_2 I_2 \cos\varphi$

Input= output + total loss

% Efficiency = output/input *100

POWER FACTOR ON NO LOAD:

$\cos\Phi=(W_o/V_oI_o)$

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 $R_{01} = W_{scc}/ I_s{}^2$

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

Equivalent leakage reactance $X_{01} = \sqrt{(Z_{01}^2 - R_{01}^2)}$ in Ω

Voltage ratio= V_2/V_1

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

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

PERCENTAGE OF REGULATION

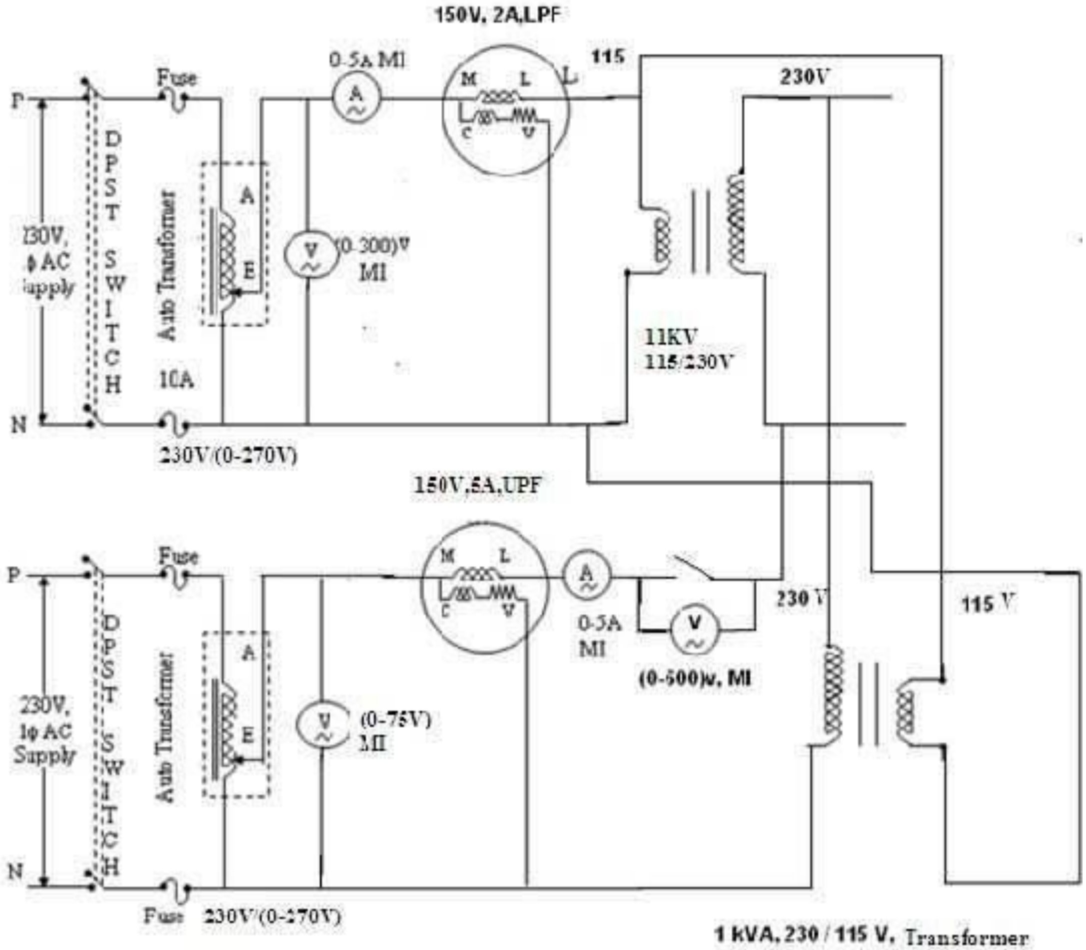
Lagging PF = $(I_2R_{02} Cos\Phi + I_2X_{02} Sin\Phi)/ V_2$

Leading PF = $(I_2R_{02} Cos\Phi - I_2X_{02} Sin\Phi)/ V_2$

PROCEDURE:

1. **Connections are made as shown in the circuit diagram.**
2. **Rated voltage of 110V is adjusted to get in voltmeter by adjusting the variac of the Auto Transformer which would be in zero before switching on the supply at the primary side.**
3. **The readings of voltmeter, ammeter and wattmeter are noted on the primary side.**
4. **A voltmeter is connected across the secondary and with the secondary supply off i.e switch S is kept open. The voltmeter reading is noted.**
5. **If the reading of voltmeter reads higher voltage, the terminals of any one of secondary coil is interchanged in order that voltmeter reads zero.**
6. **The secondary is now switched on and SPST switch is closed with variac of auto transformer is zero.**
7. **After switching on the secondary the variac of transformer (Auto) is adjusted so that full load rated secondary current flows.**
8. **Then the readings of wattmeter, Ammeter and voltmeter are noted.**
9. **The Percentage Efficiency and percentage regulation are calculated and equivalent circuit is drawn.**

CIRCUIT DIAGRAM:



TABULAR COLUMN:

V_O	I_O	W_O (watts)		V_{Sc}	I_{Sc}	W_{Sc} (watts)	
(V)	(A)	OBSERVED	ACTUAL	(V)	(A)	OBSERVED	ACTUAL

To find Efficiency

Load	Core loss W_o (Watts)	Cu loss W_c(Watts)	Total loss W_T(watts)	Output power W_o(watts)		Input power W_i(watts)		% η	
				UPF	0.8	UPF	0.8	UPF	0.8

To find Regulation

Load	Cosφ	Sinφ	I_2Re_2 Cosφ	I_2 Xe_2 Sinφ	%Regulation	
					LAG	LEAD

Inference:

RESULT:

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

SEPARATION OF NO LOAD LOSSES IN A SINGLE PHASE TRANSFORMER

AIM:

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

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Rheostat	400Ω,1.1A	Wire Wound	1
2	Wattmeter	300 V, 5A	LPF	1
3	Ammeter	(0-2) A	MC	1
4	Voltmeter	(0-300) V	MI	1
5	Connecting Wires	2.5sq.mm	Copper	Few

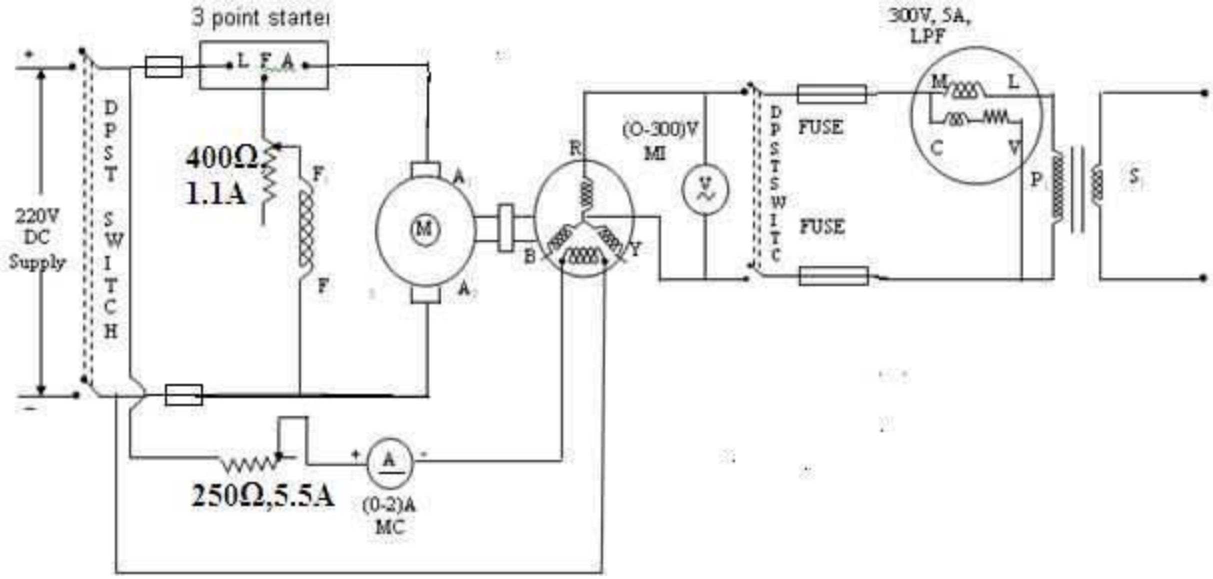
PRECAUTIONS:

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

PROCEDURE:

1. **Connections are given as per the circuit diagram.**
2. **Supply is given by closing the DPST switch.**
3. **The DC motor is started by using the 3 point starter and brought to rated speed by adjusting its field rheostat.**
4. **By varying the alternator filed rheostat gradually the rated primary voltage is applied to the transformer.**
5. **The frequency is varied by varying the motor field rheostat and the readings of frequency are noted and the speed is also measured by using the tachometer.**
6. **The above procedure is repeated for different frequencies and the readings are tabulated.**
7. **The motor is switched off by opening the DPST switch after bringing all the rheostats to the initial position.**

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S.No.	Speed N (rpm)	Frequency f (Hz)	Voltage V (Volts)	Wattmeter reading Watts	Iron loss Wi (Watts)	W_i / f Joules
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

FORMULAE USED:

1. **Frequency, $f = (P*N_S) / 120$ in Hz**

   P = No.of Poles & Ns = Synchronous speed in rpm.

2. **Hysteresis Loss $W_h = A * f$ in Watts A = Constant (obtained from graph)**

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

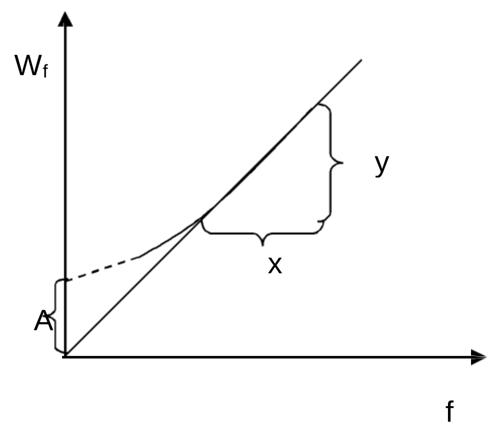
4. **Iron Loss $W_i = W_h + W_e$ in Watts**

   $W_i / f = A + (B * f)$

Here the Constant A is distance from the origin to the point where the line cuts the Y- axis in the graph between W_i / f and frequency f.

The Constant B is $\Delta(W_i / f) / \Delta f$

MODEL GRAPH:



Inference:

RESULT:

Thus separation of Eddy current and Hysteresis loss from the iron loss on a Single-phase Transformer is conducted.

STUDY OF STARTERS AND THREE PHASE CONNECTIONS OF A TRANSFORMER

AIM:

To Study about the starters and Three phase connection of a Transformer.

EQUIPMENT REQUIRED:

Sl No.	Name of the Apparatus	Quantity
1	Two Point starter	1
2	Three Point starter	1
3	Four Point starter	1
4	DOL Starter	1
5	Auto transformer Starter	1
6	Star-Delta Starter	1
7	Rotor Resistance Starter	1

THEORY :

The value of the armature current in a D.C Shunt Motor is given by

$$I_a = (V – E_b)/ R_a$$

Where

V = applied voltage.

R_a = armature resistance.

E_b = Back .e.m.f .

In practice the value of the armature resistance is of the order of 1 ohms and at the instant of starting the value of the back e.m.f 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 D.C motors are always started using starters.

The types of D.C motor starters are

i) Two point starters

ii) Three point starters

iii) Four point starters.

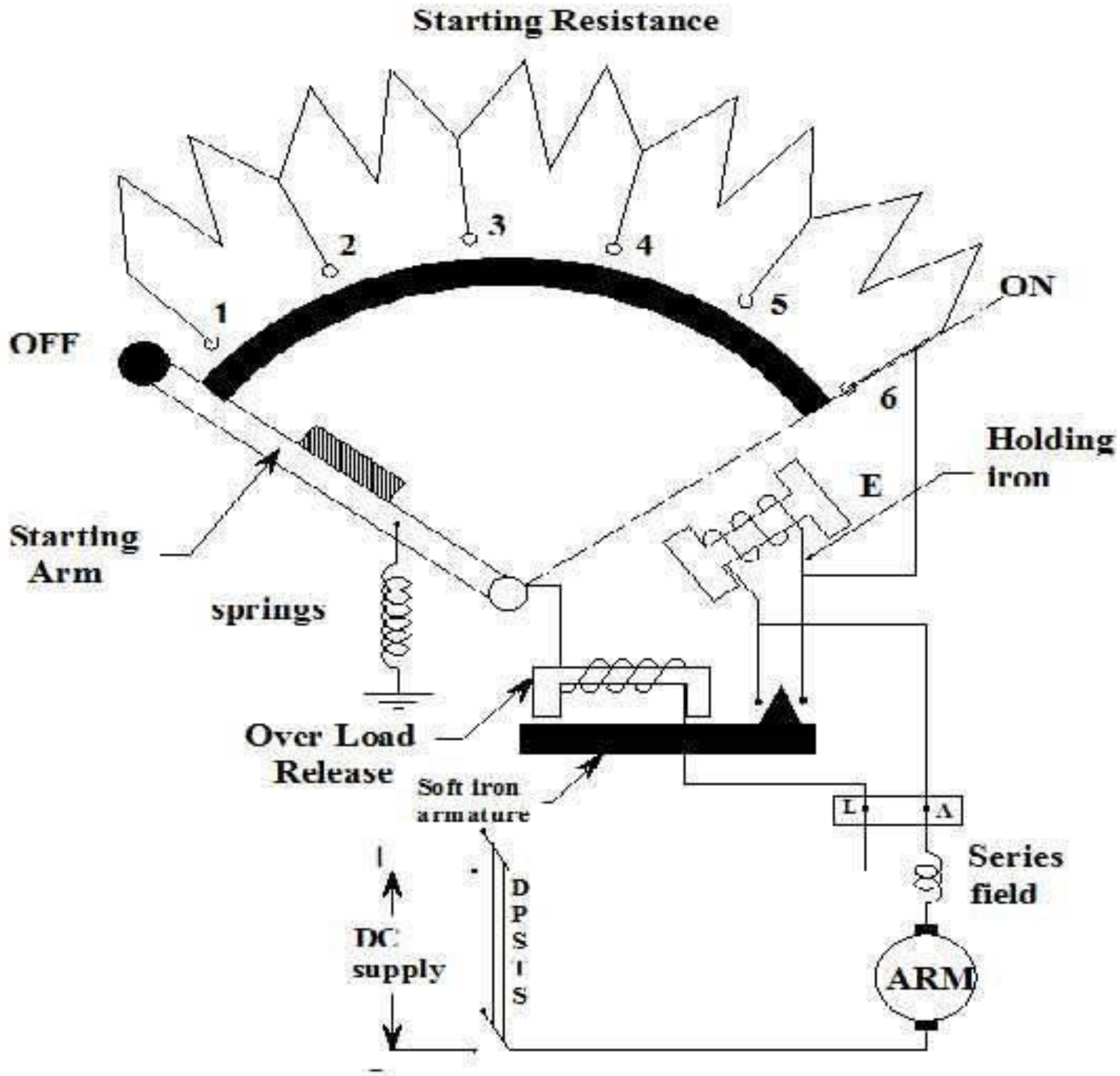
The functions of the starters are

i) It protects the from dangerous high speed. ii) It protects the motor from overloads.

i) TWO POINT STARTERS

It is used for starting D.C. 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

TWO POINT STARTER



ii) THREE POINT STARTER: (Refer fig 2)

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 is called No Volt Release (NVR).

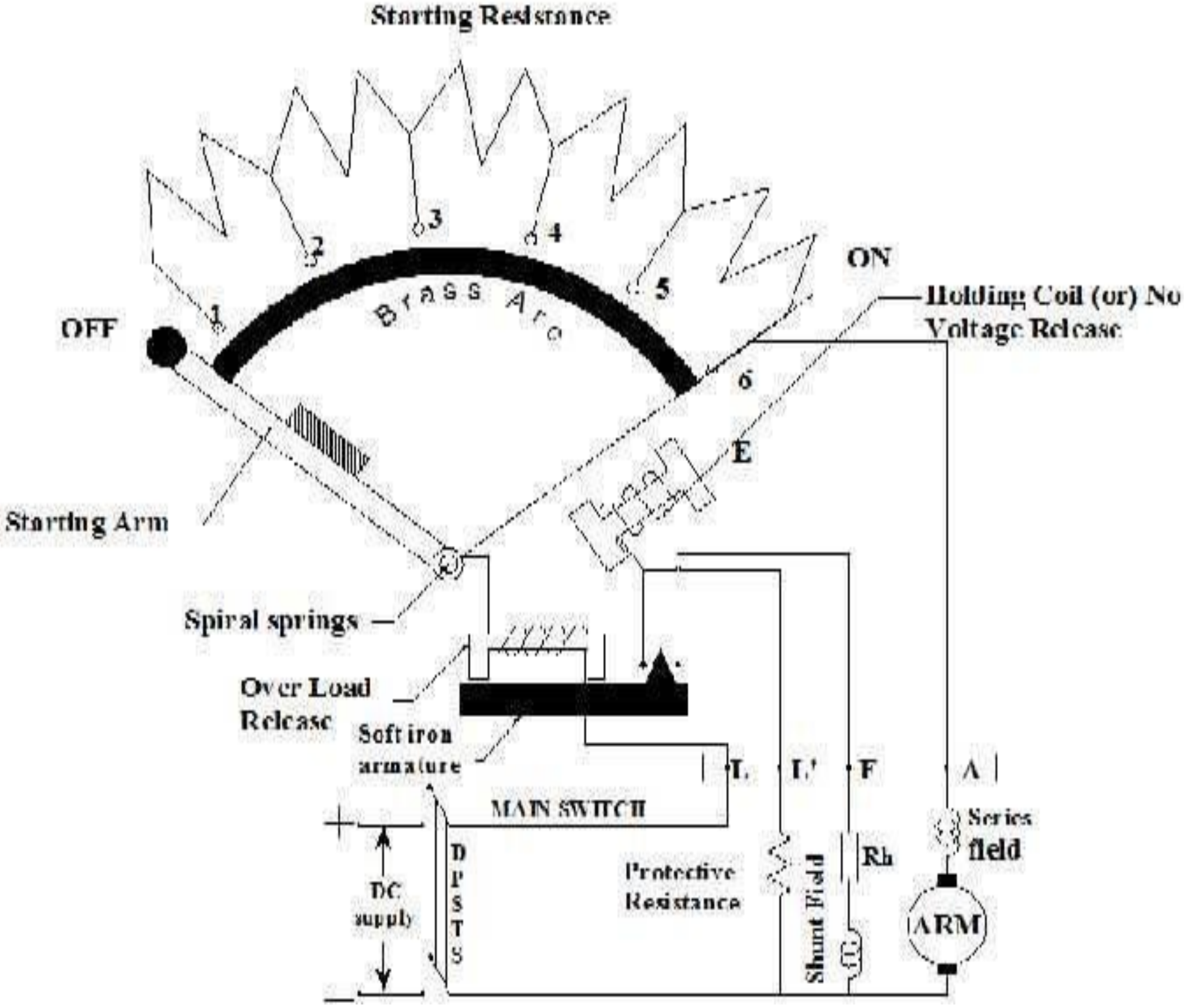
Over load protection:

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 upwar6.ds 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.

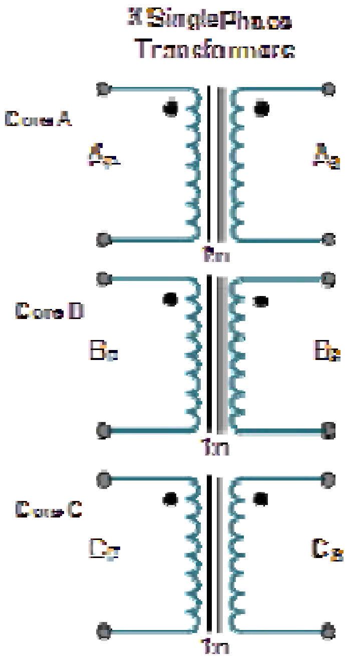
iii) FOUR POINT STARTER:

The connection diagram of the four point starter is shown in Fig 3. 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 of the field ckt connection , the d.c motor may over speed if there is a break in the field circuit. A D.C 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.

FOUR POINT STARTER



Three Phase Transformer Connections



Primary Configuration		Secondary Configuration	
Delta (Mesh)	△	Delta (Mesh)	△
Delta (Mesh)	△	Star (Wye)	Y
Star (Wye)	Y	Delta (Mesh)	△
Star (Wye)	Y	Star (Wye)	Y
Interconnected Star		Delta (Mesh)	△
Interconnected Star		Star (Wye)	Y

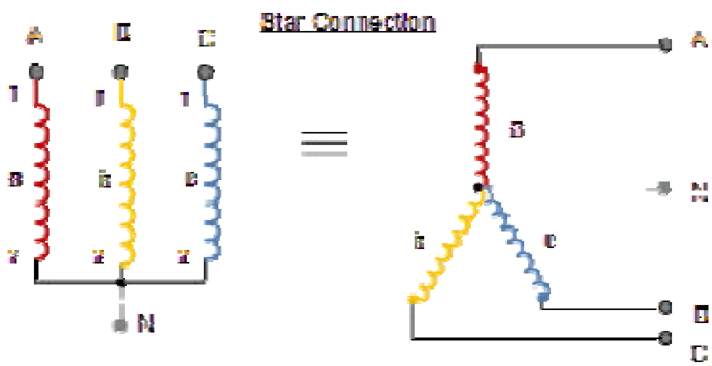
The primary and secondary windings of a transformer can be connected in different configuration as shown to meet practically any requirement. In the case of *three phase transformer* windings, three forms of connection are possible: "star" (wye), "delta" (mesh) and "interconnected-star" (zig-zag). The combinations of the three windings may be with the primary delta-connected and the secondary star- connected, or star-delta, star-star or delta-delta, depending on the transformers use. When transformers are used to provide three or more phases they are generally referred to as a **Polyphase Transformer**.

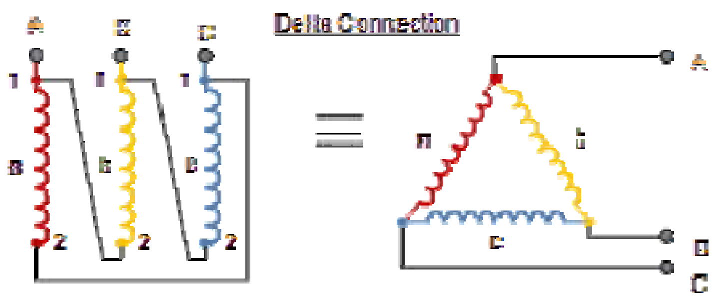
Three Phase Transformer Star and Delta Configurations

But what do we mean by "star" and "delta" three-phase transformer connection. A three phase transformer has three sets of primary and secondary windings. Depending upon how these sets of windings are interconnected, determines whether the connection is a star or delta configuration. The available voltage which are each displaced from the other by 120 electrical degrees and flow of the transformers currents are also decided by the type of the electrical connection used on both the primary and secondary sides. With three single- phase transformers connected together, the magnetic flux's in the three transformers differ in phase by 120 time-degrees. With a single the three-phase transformer there are three magnetic flux's in the core differing in time-phase by 120 degrees.

The standard method for marking three phase transformer windings is to label the three primary windings with capital (upper case) letters A, B and C, used to represent the three-phases of RED, YELLOW and BLUE. The secondary windings are labelled with small (lower case) letters a, b and c. Each winding has two ends normally labelled 1 and 2 so that, for example, the second winding of the primary has ends which will be labelled B1 and B2, while the third winding of the secondary will be labelled c1 and c2 as shown.

Transformer Star and Delta Configurations





Symbols are generally used on a three phase transformer to indicate the type or types of connections used with upper case Y for star connected, D for delta connected and Z for interconnected star primary windings, with lower case y, d and z for their respective secondaries. Then, Star-Star would be labelled Yy, Delta-Delta would be labelled Dd and interconnected star to interconnected star would be Zz for the same types of connected transformers.

Transformer Winding Identification

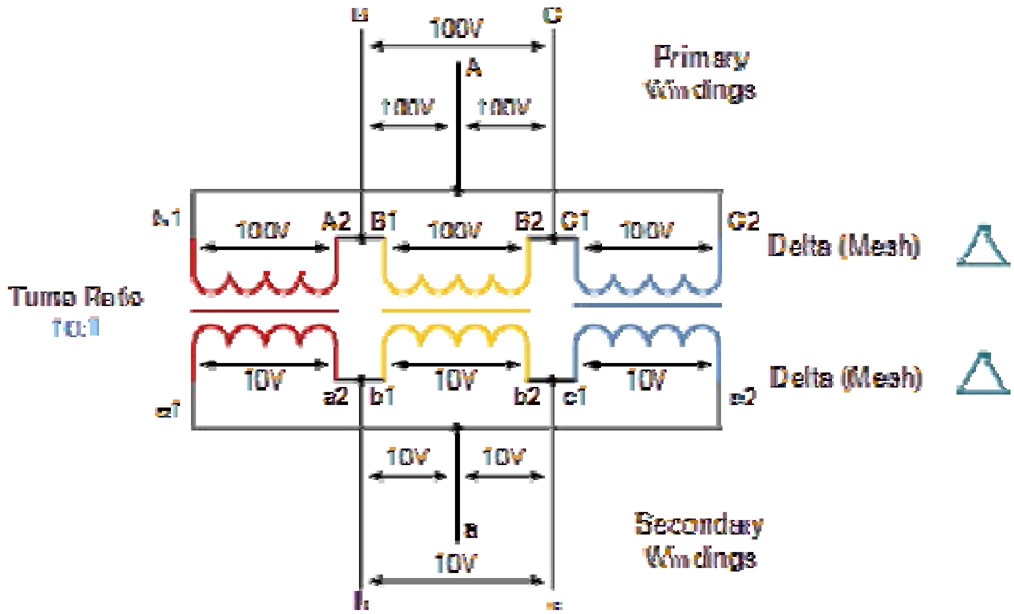
Connection	Primary Winding	Secondary Winding
Delta	D	d
Star	Y	y
Interconnected	Z	z

We now know that there are four ways in which three single-phase transformers may be connected together between primary and secondary three-phase circuits. The configurations are delta-delta, star-star, star-delta,

and delta-star. Transformers for high voltage operation with the star connections has the advantage of reducing the voltage on an individual transformer, reducing the number of turns required and an increase in the size of the conductors, making the coil windings easier and cheaper to insulate than delta transformers.

The delta-delta connection nevertheless has one big advantage over the star-delta configuration, in that if one transformer of a group of three should become faulty or disabled, the two remaining ones will continue to deliver three-phase power with a capacity equal to approximately two thirds of the original output from the transformer unit.

Transformer Delta and Delta Connections



In a **delta connected (Dd) group** of transformers, the line voltage, V_L is equal to the supply voltage, $V_L = V_S$. But the current in each phase winding is given as: $1/\sqrt{3} \times I_L$ of the line current, where I_L is the line current. One disadvantage of delta connected three phase transformers is that each transformer must be wound for the full-line voltage, (in our example above 100V) and for 57.7 per cent, line current. The greater number of turns in the winding, together with the insulation between turns, necessitate a larger and more expensive coil than the star connection. Another disadvantage with delta connected three phase transformers is that there is no "neutral" or common connection.

In the **star-star arrangement** (Yy), (wye-wye), each transformer has one terminal connected to a common junction, or neutral point with the three remaining ends of the primary windings connected to the three-phase mains supply. The number of turns in a transformer winding for star connection is 57.7 per cent, of that required for delta connection.

The **star connection** requires the use of three transformers, and if any one transformer becomes fault or disabled, the whole group might become disabled. Nevertheless, the star connected three phase transformer is especially convenient and economical in electrical power distributing systems, in that a fourth wire may be connected as a neutral point, (n) of the three star connected secondaries as shown.

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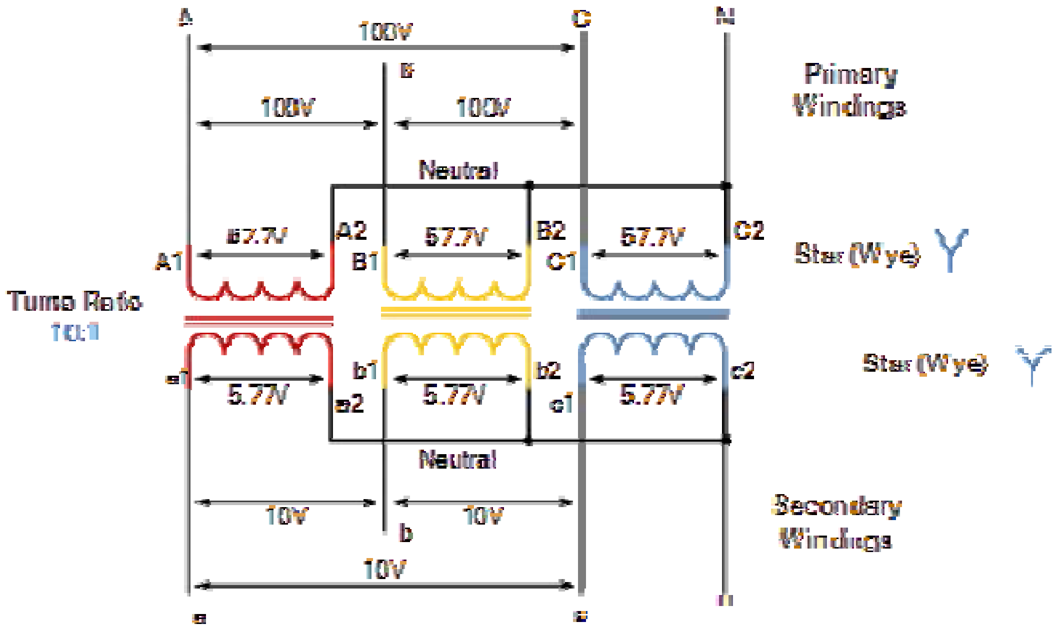


The voltage between any line of the three-phase transformer is called the "line voltage", V_L, while the voltage between any line and the neutral point of a star connected transformer is called the "phase voltage", V_P. This phase voltage between the neutral point and any one of the line connections is $1/\sqrt{3} \times V_L$ of the line voltage. Then above, the primary side phase voltage, V_P is given as.

$$V_P = \frac{1}{\sqrt{3}} \times V_L = \frac{1}{\sqrt{3}} \times 100 = 57.7 \text{ Volts}$$

Result:

Measurement of Magnetic Inrush current of Transformers (Single Phase).

AIM:

To measure of Magnetic Inrush Current of a Single phase Transformer

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1.	**Auto Transformer**	**230/(0-270) V**	**-**	2
2.	**Single phase transformer**	**5KVA,115/230V**	**-**	1
3.	**Voltmeter**	**(0 -300)V**	**MI**	1
4.	**Voltmeter**	**(0 -150)V**	**MI**	1
5.	**Ammeter**		**MI**	1
6.	**Ammeter**		**MI**	1
7.	**Digital Storage Oscilloscope**			1
8.	**Multimeter**			
9.	**Connecting Wires**	**2.5sq.mm**	**Copper**	Few

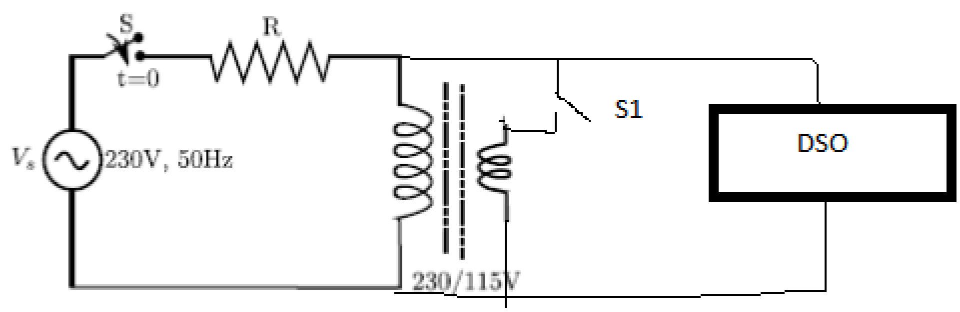
PRECAUTION:

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 circuit diagram.
2. Switch on the single phase AC supply.
3. Record the voltages V1 and V2.
4. Close the switch S at time, t=0
5. Capture the current magnitude versus time using a storage oscilloscope.
6. Measure and analyze current transient differ for different instants of switching.
7. Switch off the supply.

EQUIVALENT CIRCUIT OF PROPOSED TRANSFORMER FOR INRUSH CURRENT:



INTRODUCTION:

INRUSH current is the transient response to the switching of a sinusoidal voltage supply upon the transformer, arising from a temporary saturation of the core.

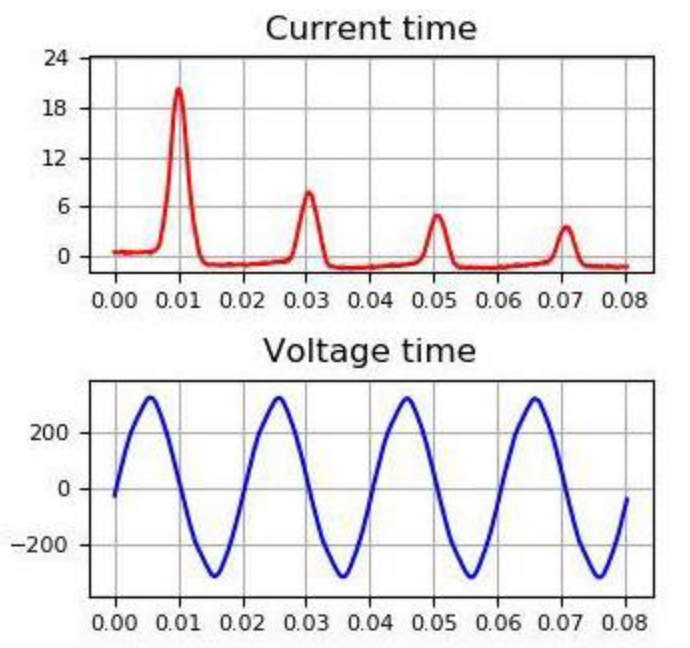
Electrical transformers are essential parts of power supply networks and it is important that their life-time to be preserved. The inrush current of this devices could determine malfunctioning of the transformers or even others component of the network. For this reason, determining the inrush current for single-phase transformers is an important issue in power quality analysis of electrical grids.

Any iron-core transformer absorbs an inrush current when they are instant connected to the power supply grid. This current has a typical waveform characterized by a high amplitude (even 20 time higher than the rated current of the device) and has a single polarity for a few periods until it reaches its state value. These inrush currents determine numerous unfavourable effects on the devices and on the power supply network. The inrush current is directly influenced by the B-H allure of the magnetic core and especially by the remanence of the magnetic flux density. The measure of the inrush current peak value and duration) becomes very significant in conserving

the life-time of a transformer. The high value of the inrush current may cause electro dynamical and thermal stresses which may determine damaging or malfunctioning of equipment components.

TABULAR COLOUMN:

Time	Frequency	Current	Voltage



RESULT:

Thus the magnetic current of single phase transformer is measured and analyzed for current transient differ for different instants of switching.

POLARITY TEST ON SINGLE PHASE TRANSFORMER

AIM:

To determine the polarity of a Single phase Transformer

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1.	**Auto Transformer**	**230/(0-270) V**	**-**	**2**
2.	**Voltmeter**	**(0 -600)V**	**MI**	3
3.	**Connecting Wires**	**2.5sq.mm**	**Copper**	**Few**

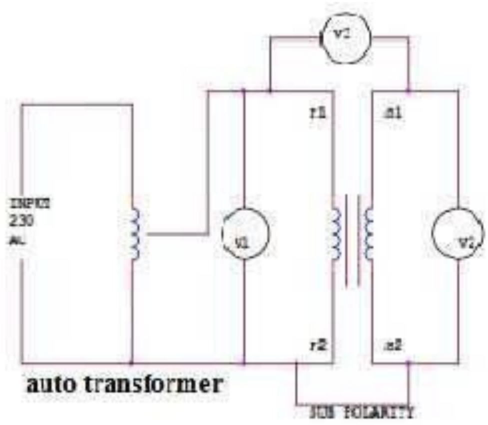
PRECAUTION:

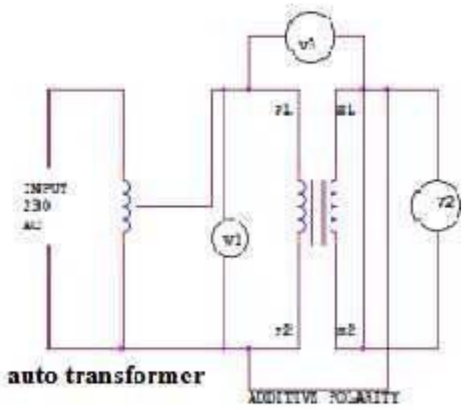
3. **Auto transformer must be kept in minimum position while switching on and switching off the supply.**
4. **Transformer should be operated under rated values.**

PROCEDURE:

8. **Connect the circuit as shown circuit diagram.**
9. **Switch on the single phase AC supply.**
10. **Record the voltages V_1 V2 and V_3. In Case $V_3 < V_1$ polarity is subtractive.**
11. **Repeat the step 3 after connecting terminals A1 and a2. In case $V_3 > V_1$ polarity is additive.**
12. **Switch of the supply.**

CIRCUIT DIAGRAM FOR POLARITY TEST ON SINGLE PHASE TRANSFORMER:





TABULAR COLOUMN:

Subtractive polarity:

S.No	V_1	V_2	$V_3 = V_2 - V_1$

Additive polarity:

S.No	V_1	V_2	$V_3 = V_2 + V_1$

Inference:

RESULT:

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

OPEN CIRCUIT AND LOAD CHARACTERISTICS OF SEPERATELY EXCITED D.C GENERATOR

AIM:

To obtain open circuit and load characteristics of separately excited d.c shunt generator.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	400Ω , 0.8A	Wire	2

PRECAUTION

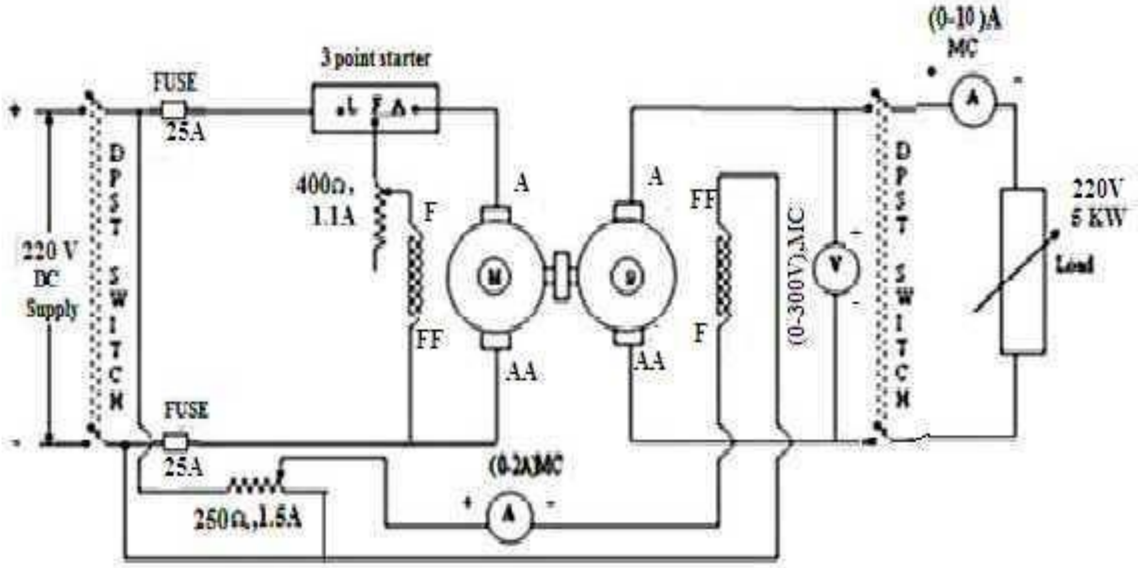
- **All the switches are kept open initially.**
- **The motor field rheostat is kept at minimum resistance position.**
- **The generator field rheostat is kept at maximum resistance position.**

PROCEDURE

OPEN CIRCUIT CHARACTERISTICS:-

- **The connections are made as per the circuit diagram.**
- **After checking minimum position of motor field rheostat, maximum position of generator field rheostat, the supply side DPST switch is closed and starting resistance is gradually removed.**
- **The motor is started using three point starter.**
- **By varying the field rheostat of the motor, the speed of the motor is adjusted to the rated speed of the generator.**
- **By varying the generator field rheostat, voltmeter and ammeter readings are taken.**
- **After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, the DPST switch is closed.**

CIRCUIT DIAGRAM

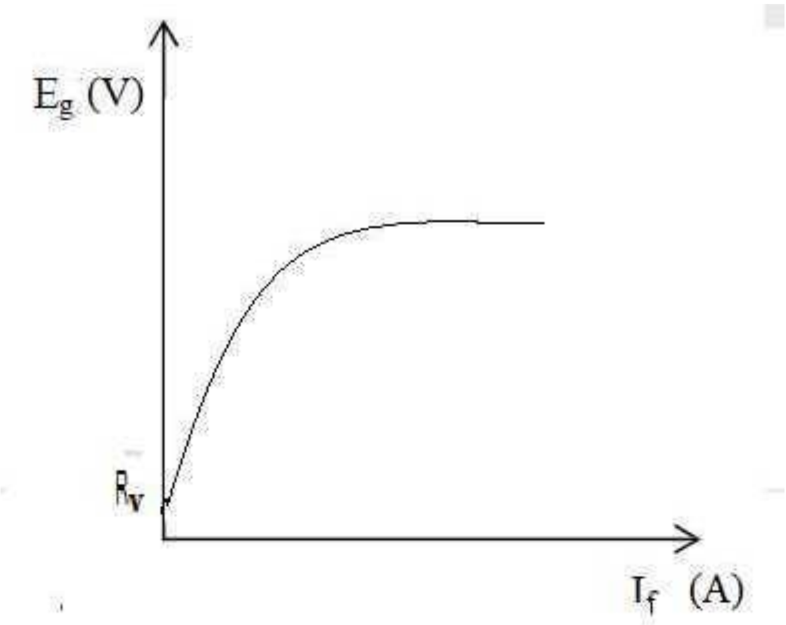


TABULAR COLOUMN:

Sl. No.	Field current, I_f Amperes	Generated EMF, E_g volts
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

MODEL GRAPH:-

OPEN CIRCUIT CHARACTERISTICS:-



MODEL CALCULATION:-

Armature current, $I_a = I_L = I_f$

Generated EMF, $E_g = (V + I_a R_a)$

LOAD TEST:

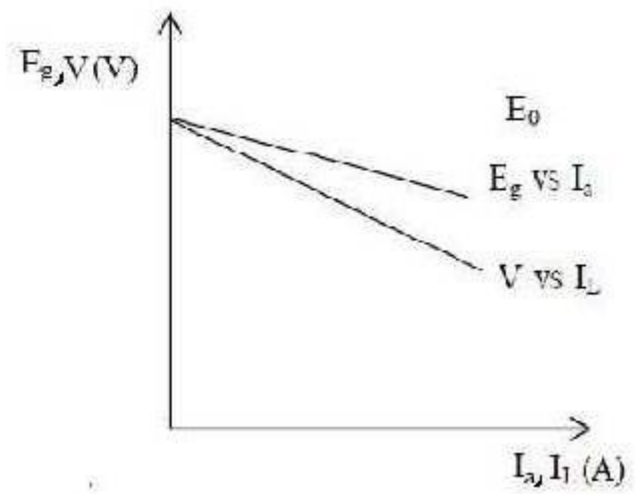
- **Keeping the generator side DPST open, the field rheostat in the generator side is adjusted for the rated voltage of the generator which is seen in the voltmeter.**
- **Now the DPST switch is closed and the resistive load is put up on the generator step by step. The terminal voltage, armature and load current values are noted down for each step from the respective meters.**
- **Note that while taking each set of readings, the field current is maintained constant as that for rated voltage [because due to heating, shunt field resistance is increased.**

TABULAR COLOUMN:

Sl. No.	Voltage, V_L (Volts)	Current, I_L (Amperes)	Armature Current, I_a (Amperes)	Generated EMF, E_g (Volts)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

MODEL GRAPH:-

LOAD TEST:



MODEL CALCULATION:-

Armature current, $I_a = I_L = I_f$

Generated EMF, $E_g = (V + I_a R_a)$

RESULT:

Thus the open circuit and load characteristics of Separately excited D.C. Shunt Generator were drawn.