

# **ELECTRICAL AND ELECTRONICS LABORATORY MANUAL**

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS  
ENGINEERING****ELECTRICAL AND ELECTRONICS LABARATORY****LIST OF EXPERIMENTS**

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**VERIFICATION OF THEVENIN'S AND NORTON'S THEOREMS****AIM:**

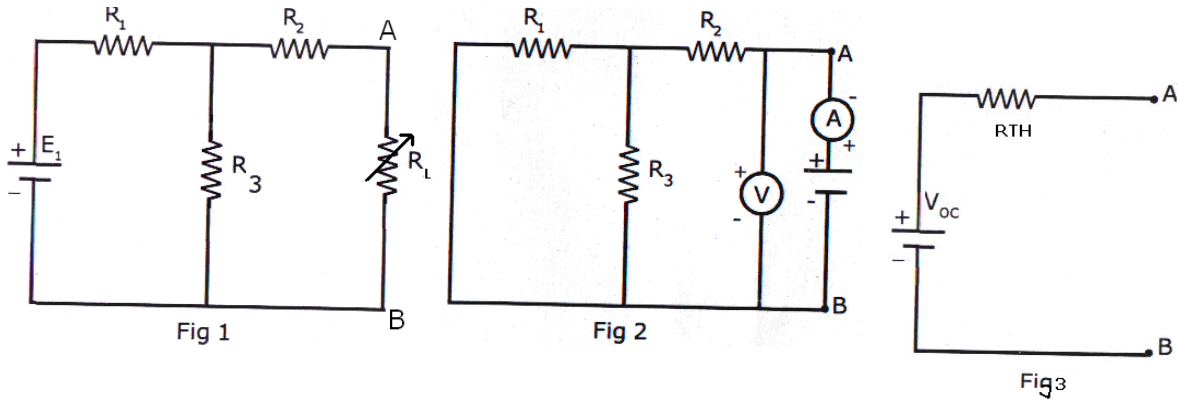
To Verify Thevenin's Norton's and Maximum power transfer theorems.

**APPARATUS:**

S.No	Equipment	Range	Type	Quantity
1.	Ammeter	0-200mA	MC	
2.	Voltmeter	0-20V	MC	
3.	Bread Board	-	-	1
4.	R.P.S	0-30V/0-1A	Dual channel	1
5.	Resistors			As required
6.	Connecting Wires			As required

**THEVENIN'S THEOREM.**

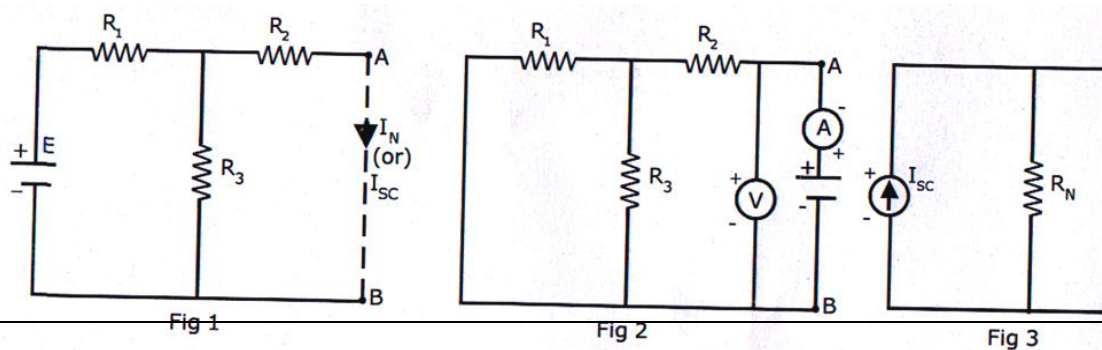
**STATEMENT:** - Any two terminal, linear, bilateral network having a number of voltage, current sources and resistances can be replaced by a simple equivalent circuit consisting of a single voltage source in series with a resistance, where the value of the voltage source is equal to the open circuit voltage across the two terminals of the network, and the resistance is the equivalent resistance measured between the terminals with all energy sources replaced by their internal resistances.

**CIRCUIT DIAGRAM:****PROCEDURE:**

1. Connect the circuit diagram as shown in fig1.
2. Measure  $V_{oc}$  between A and B terminals, by open circuiting AB terminals.
3. Connect the circuit as shown in fig2.
4. The resistance between A and B is obtained by using voltmeter, ammeter method, and the ratio of V & I gives  $R_{Th}$
5. Draw the Thevenin's equivalent circuit as shown in fig.3

**NORTON'S THEOREM**

**STATEMENT:** Any two terminal, linear, bilateral network with current sources, voltage sources and resistances can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance. The value of the current source is the short circuit current between the two terminals of the network and the resistance is the equivalent resistance measured between the terminals of the network with all the energy sources replaced by their internal resistances.

**Circuit Diagram:**

**PROCEDURE:**

1. Connect the circuit diagram as shown in fig1.
2. Measure the current  $I_{sc}$  (or)  $I_N$  through 'AB' by short-circuiting the resistance between A and B.
3. Connect the circuit diagram as shown in fig2.
4. The resistance between A and B is obtained by using. voltmeter, ammeter method and the ratio of V & I gives  $R_N$ .
5. Draw Norton's equivalent circuit by connecting  $I_N$  &  $R_N$  in parallel as shown in fig3.

**TABULAR COLUMN:**

Parameters	Theoretical Values	Practical Values
Voc		
Isc		
$R_{TH}$		

## SUPERPOSITION THEOREM AND RECIPROCITY THEOREM

### AIM:

To Verify Superposition Theorem and to find the RMS value of complex wave form

### APPARATUS:

S.No.	Equipment	Range	Type	Quantity
1.	Resistors	-	-	As required
2.	Multi-meter			1
3.	R.P.S	0-30V/0-1A	Dual channel	1
4.	Bread Board	-	-	1
5.	Connecting Wires			As required

### CIRCUIT DIAGRAM:

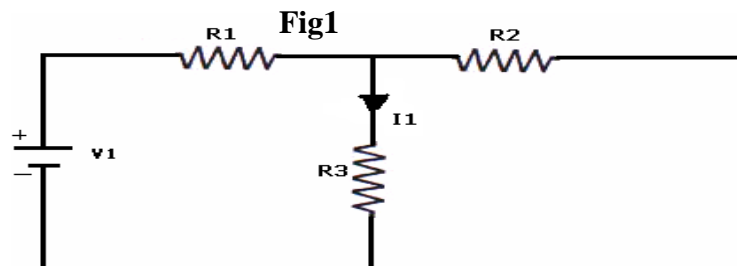
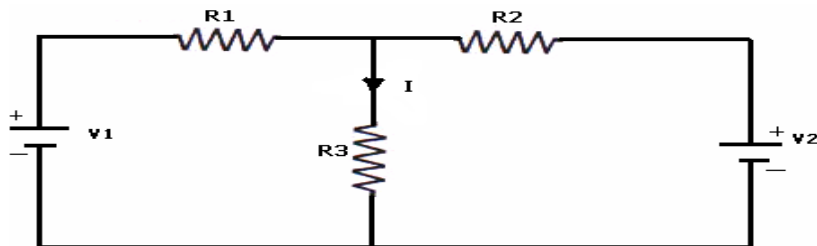


Fig2

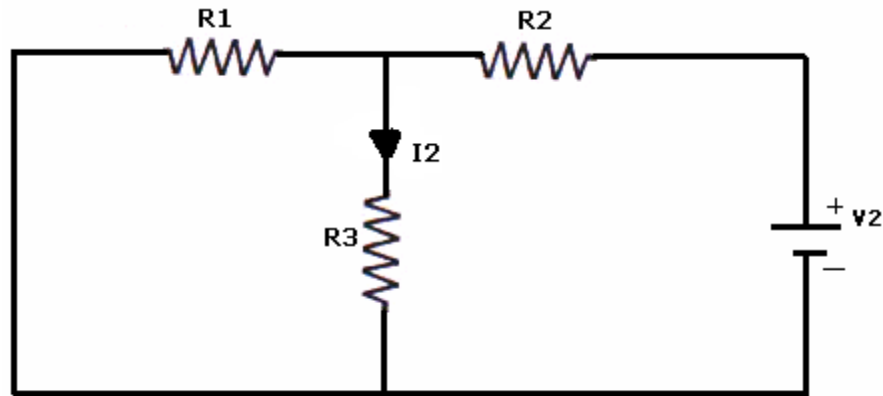


Fig3

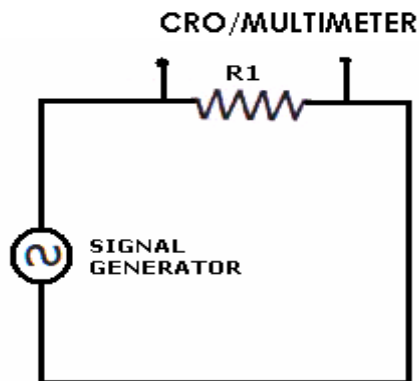


Fig 4

**PROCEDURE:**

1. Connect the circuit as shown in figure (1) and note down the current flowing through  $R_3$ . and let it be  $I$ .
2. Connect the circuit as shown in figure (2) and note down the ammeter Reading, and let it be  $I_1$ .
3. Connect the circuit as shown in figure (3) and note down the ammeter reading, and let it be  $I_2$ .
4. Verify for  $I = I_1 + I_2$ .
5. Compare the practical & theoretical currents.

**RESULT:**

## VERIFICATION OF RECIPROCITY THEOREM

### AIM:

To verify Reciprocity theorem both analytically and experimentally.

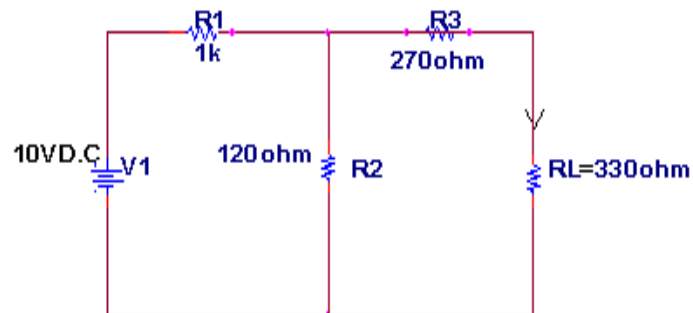
### APPARATUS REQUIRED:

S.No.	Equipment	Range	Type	Quantity
1.	Resistors	-	-	As required
2.	Multi-meter			1
3.	R.P.S	0-30V/0-1A	Dual channel	1
4.	Bread Board	-	-	1
5.	Ammeter	0-200mA	MC	1
6.	Connecting Wires			As required

### THEORY:

**STATEMENT:** “In a linear bi-lateral single source network ,the ratio of excitation to the response is constant when the position of excitation and response are interchanged”.

### CIRCUIT DIAGRAM:

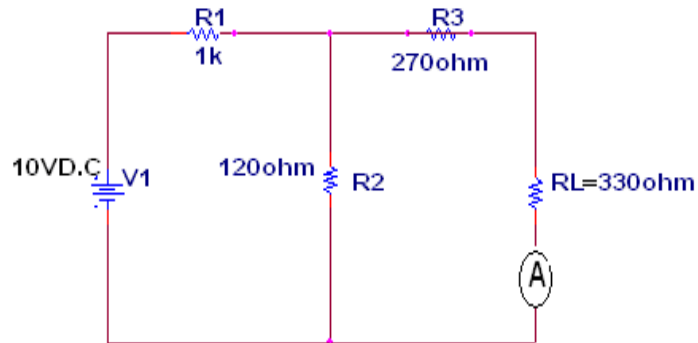




**CALCULATION:**

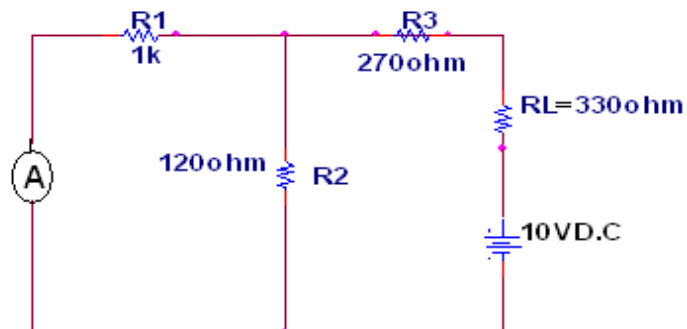
Step i) Calculation of  $I_L$  before interchanging the power supply,

$$I_L = I_2 = 1.5\text{mA}$$



Step ii) Calculation of  $I_L'$  after interchanging the power supply ,

$$I_L' = I_2' = 1.5\text{mA}$$

**PROCEDURE:**

1. For the given circuit diagram, theorem must be verified theoretically.
2. The ranges of the meters are selected according to the theoretical calculations.

3. Circuit connections are made as shown in figure.
4. Required supply is given to the circuit and the corresponding readings of ammeter and voltmeter are noted down.
5. Theoretical values are compared with practical values.

**TABULATION:**

Parameters	Analytically	Experimentally
$I_L$	<b>1.5mA</b>	
$I_L'$	<b>1.5mA</b>	
$V/I_L$	<b>6.66K<math>\Omega</math></b>	
$V/I_L'$	<b>6.66K<math>\Omega</math></b>	

**RESULT:**

## VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM

**AIM:** - To Verify Maximum power transfer theorem.

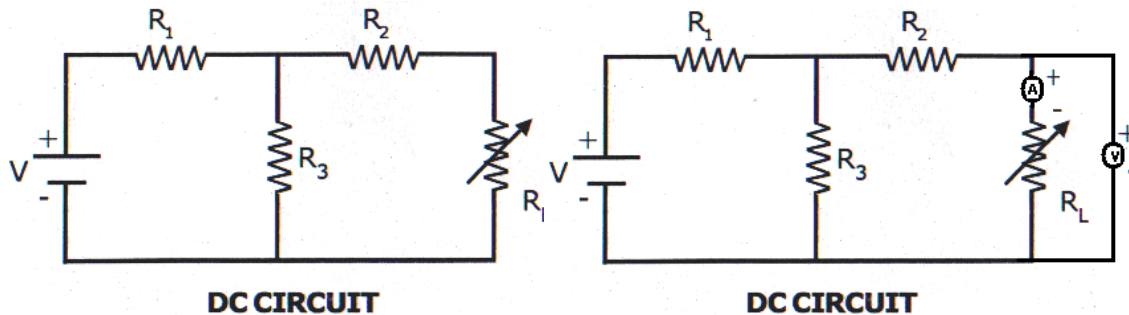
**APPARATUS:**

S.No.	Equipment	Range	Type	Quantity
1.	Resistors	-	-	As required
2.	Multi-meter			1
3.	R.P.S	0-30V/0-1A	Dual channel	1
4.	Bread Board	-	-	1
5.	Ammeter	0-200mA	MC	1
6.	Voltmeter	0-20V	MC	1
7.	Connecting Wires			As required

### STATEMENT:

The maximum power transfer theorem states that maximum power is delivered from a source resistance to a load resistance when the load resistance is equal to source resistance.  $R_s = R_L$  is the condition required for maximum power transfer.

### Circuit Diagram:

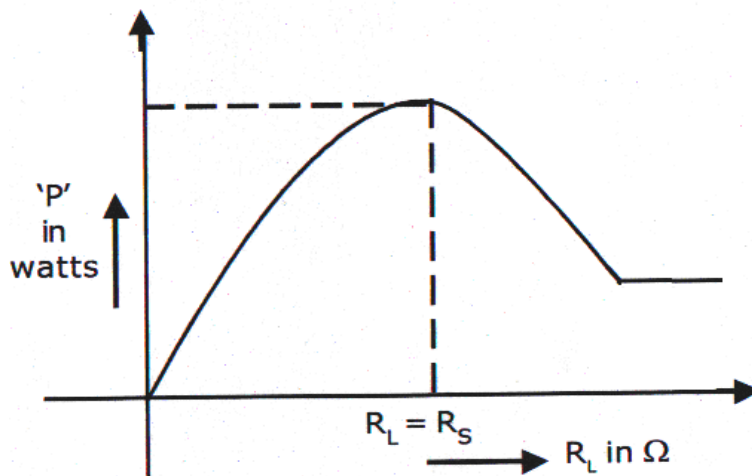


**PROCEDURE:**

1. Connect the circuit as shown in fig.
2. Vary the load resistance in steps and note down voltage across the load and current flowing through the circuit.
3. Calculate power delivered to the load by using formula  $P=V \cdot I$ .
4. Draw the graph between resistance and power (resistance on X- axis and power on Y- axis).
5. Verify the maximum power is delivered to the load when  $R_L = R_s$  for DC.

**TABULAR COLUMN:**

$R_L$	$V_L$	$I_L$	$P=VI$

**MODEL GRAPH:****RESULT:**

## MAGNETIZATION CHARACTERISTIC OF A D.C. SHUNT GENERATOR

### AIM:

To determine experimentally the magnetization or open circuit characteristic of a D.C Shunt generator and to determine the critical field resistance and critical speed.

### APPARATUS:

S.No.	Item	Type	Range	Quantity
1	Ammeter	M.C	0 – 2 A	1 No
2	Voltmeter	M.C	0 – 300 Volts	1 No
3	Rheostat	Wire wound	370 $\Omega$ / 1.7 A	2 No
4	Tachometer	Digital	0-3000 rpm	1 No

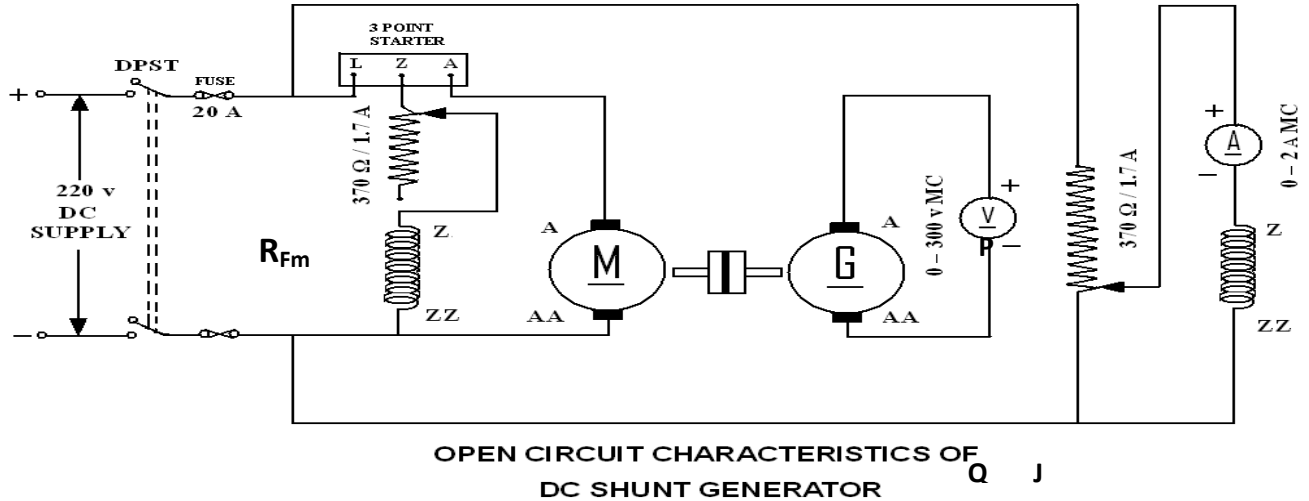
### NAME PLATE DETAILS:

#### MOTOR

<b>Voltage</b>	
<b>Field Current</b>	
<b>Armature Current</b>	
<b>Output</b>	
<b>Speed</b>	

#### GENERATOR

<b>Voltage</b>	
<b>Field Current</b>	
<b>Armature Current</b>	
<b>Output</b>	
<b>Speed</b>	

**CIRCUIT DIAGRAM:****PROCEDURE:**

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. **Keep the motor field rheostat ( $R_{fm}$ ) in the minimum position.** The jockey [J] of the potential divider should be at the minimum voltage position [P] and start the MG set.
3. Observe the speed of the generator using a tachometer and adjust to the rated value by varying the motor field rheostat. Keep the same speed through out the experiment.
4. Note down the terminal voltage of the generator. This is the e.m.f. due to residual magnetism.
5. Increase the generator field current  $I_f$  (ammeter) by gradually moving the jockey J in the direction P to Q. for every value of  $I_f$ , field resistance of the generator note down the corresponding voltmeter reading. Increase the field current till induced e.m.f is about 120% of rated value.
6. Repeat the same procedure for decreasing values of the same field currents ( $I_{fg}$ ) and finally note down the emf generated due to residual magnetism.

7. Draw the characteristics of generated emf ( $E_{fg}$ ) versus field current for both increasing and decreasing values of field current. Draw the average O.C.C
8. Draw a tangent to the initial portion of average O.C.C from the origin. The slope of this straight line gives the critical field resistance.

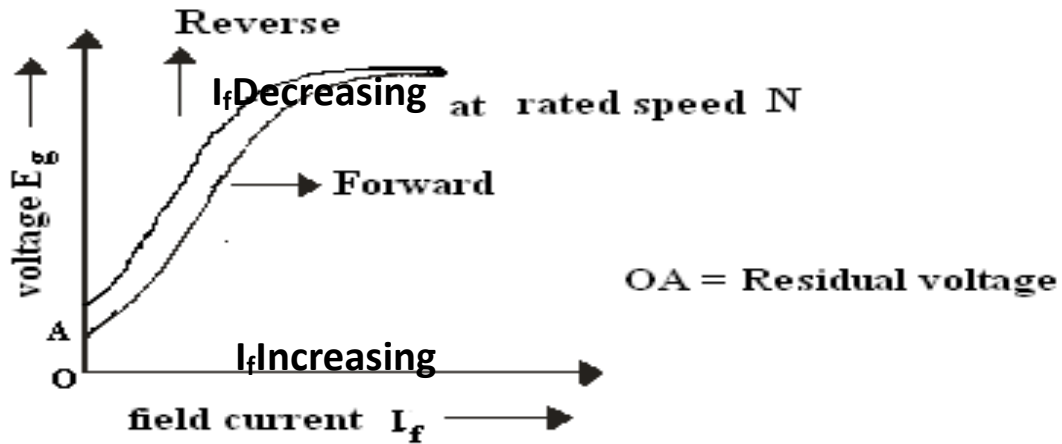
**TABULAR COLUMN:**

S.No.	ASCENDING		DESCENDING	
	Field current( $I_f$ ) (amp)	Generated voltage ( $E_g$ )(volts)	Field current( $I_f$ ) (amp)	Generated voltage ( $E_g$ )( volts)

**PRECAUTIONS:-**

1. The experiment should be done at constant speed.
2. The jockey should be moved only in one direction (i.e., from P to Q or Q to P). It should not be moved back and forth for obtaining a particular field current.
3. At zero field there would be some emf due to residual magnetism
4. Avoid parallax errors and loose connections

**MODEL GRAGH:**



### VIVA Questions:

1. Under what conditions does the DC shunt generator fail to self-excite?
2. Define critical field resistance?
3. OCC is also known as magnetization characteristic, why?
4. How do you get the maximum voltage to which the generator builds up from OCC?
5. What does the flat portion of OCC indicate?
6. Why OCC does not start from origin?
7. Does the OCC change with speed?

### RESULT:



## SWINBURNE'S TEST ON A D.C. SHUNT MACHINE

### AIM:

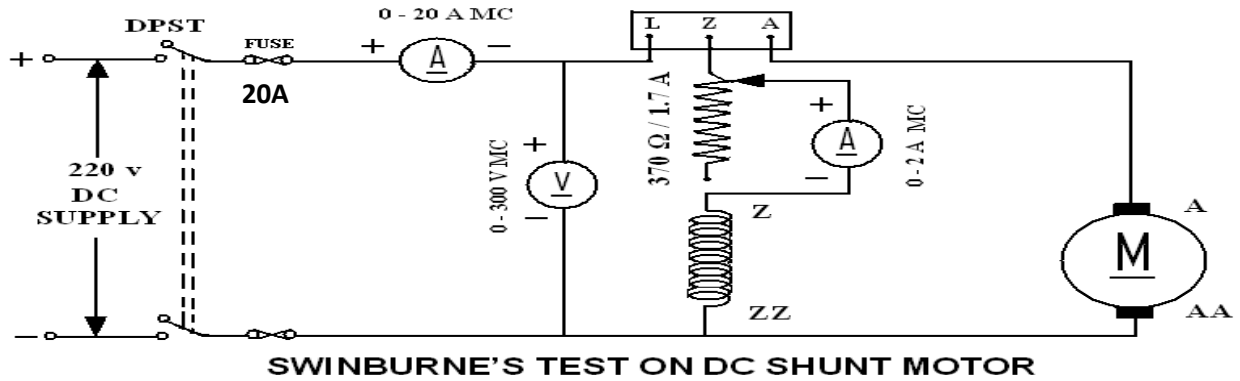
To pre-determine the efficiency of a DC shunt machine when run both as generator and motor.

### APPARATUS REQUIRED:

S. No.	Name of the Equipment	Range	Type	Quantity
1.	Voltmeter	0-300V	M.C	01
2.	Ammeter	0-2A	M.C	01
		0-2A	MC	01
3.	Rheostat	370 $\Omega$ / 1.7 A	-	01
4.	Tachometer	0-9999 RPM	DIGITAL	01

### Motor

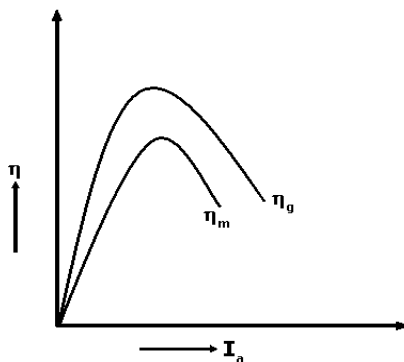
<b>Voltage</b>	
<b>Field Current</b>	
<b>Armature Current</b>	
<b>Output</b>	
<b>Speed</b>	

**CIRCUIT DIAGRAM:****PROCEDURE:**

1. Choose the proper ranges of meters after noting the name plate details of the given machine and make the connections as per the circuit diagram.
2. Keep the motor field rheostat ( $R_{fm}$ ) in the minimum position, Start the motor by closing the switch and operating the starter slowly.
3. Run the motor at rated speed by adjusting the motor field rheostat.
4. Note down the voltage, no load current and field current.

**TABULAR COLUMN:**

S. No.	V	$I_{Lo}$	$I_f$

**Model Graph:**

**CALCULATIONS FOR SWINBURNE'S TEST**

From the no load test results,

Supply voltage =  $V_L$  Volts.

No load line current =  $I_{Lo}$  Amperes.

Field current =  $I_f$  Amperes.

Therefore No load Armature Current =  $I_{ao} = I_L - I_f$  Amperes.

Resistance cold =  $R_m$

Effective resistance  $R_e = 1.25 \times R_m$  ohms.

No load copper losses are  $= I_{ao}^2 R_e$

No load power input =  $V_L I_L$

Constant losses = (No load power input - No load copper losses). ----- (1)

**Efficiency as motor:**

Efficiency = output/input = (input – total losses)/ input.

Where total losses = constant losses + variable losses.

Constant losses are known value from the equation (1)

Variable loss =  $I_a^2 R_e$  , where  $I_a = I_L - I_f$

Input =  $V_L I_L$ .  $V_L$  is rated voltage of the machine

Assume line currents ( $I_L$ ) as 2, 4, 6, ---- 20A and find corresponding efficiency

**Efficiency as generator:**

Efficiency = output/input = output / (output + total losses).

Where losses = constant losses + variable losses

Constant losses are same for both motor and Generator

Armature Current =  $I_a = I_L + I_F$

Variable loss =  $I_a^2 R_e$

Output power =  $V_L I_L$ .  $V_L$  is rated voltage of the machine

Assume load currents ( $I_L$ ) as 2, 4, 6, ---- 20A and find corresponding efficiencies

### TABULAR COLUMN:

**As a Motor:**      **Rated voltage  $V_L =$**       **Rated speed  $N =$**

S. No.	$I_L$	$V_L I_L$ INPUT Power	Constant losses $W_{const.}$	Copper losses $W_{cu} = I_a^2 R_e$	Total losses = ( $W_{cons.} +$ $W_{cu}$ )	Output power = (input power – losses)	$\eta$

**As a Generator:**      **Rated voltage  $V_L =$**       **Rated speed  $N =$**

S. No.	$I_L$	$V_L I_L$ Out power	Constant losses $W_{const.}$	Copper losses $W_{cu} = I_a^2 R_e$	Total loss = ( $W_{cons.} +$ $W_{cu}$ )	Input power = (output power + losses)	$\eta$

**PRECAUTIONS:**

- Run the motor at rated speed and rated voltage
- Avoid loose connections and parallax errors

**RESULTS:**

**VIVA Questions:**

1. Will the values deduced from the Swinburne's method exactly coincide with the value realized by direct loading on the machine? Why?
2. Why are the constant losses calculated by this method less than the actual losses?
3. Can we conduct Swinburne's test on dc series motor?
4. What are the drawbacks of Swinburne's test?

## BRAKE TEST ON DC SHUNT MOTOR

### AIM:

To obtain the performance characteristics of DC shunt motor by direct loading.

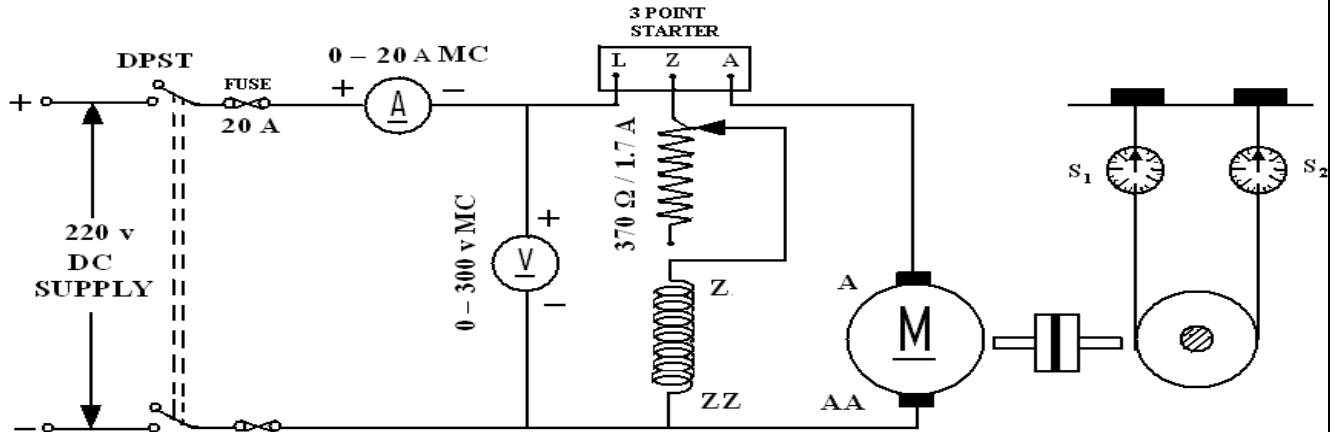
### APPARATUS REQUIRED:

S. No.	Name of the Equipment	Range	Type	Quantity
1.	Voltmeter	0-300V	M.C	01
2.	Ammeter	0-2A	M.C	01
3.	Ammeter	0-15A	M.C	01
3.	Rheostat	0-370 $\Omega$ /1.7A	-	01
4.	Tachometer	-	Digital	01
5.	Connecting wires	-	-	As per required

### NAME PLATE DETAILS:

#### Motor

<b>Voltage</b>	
<b>Field Current</b>	
<b>Armature Current</b>	
<b>Output</b>	
<b>Speed</b>	

**CIRCUIT DIAGRAM:****BRAKE TEST ON DC SHUNT MOTOR****PROCEDURE:**

1. Make the connections as shown in the circuit diagram.
2. Keeping the field rheostat ( $R_f$ ) at the minimum position, switch on the supply and start the motor.
3. Adjust the speed of the motor on no load to its rated value by means of the field rheostat. DO NOT DISTURB THE POSITION OF THE RHEOSTAT THROUGH OUT THE TEST.
4. Put on the load by tightening the screws of the spring balances. Note down the spring tensions, the speed, the voltage and the currents at different loads until full load current obtained.

**CALCULATIONS:**

1. Measure the circumference of the brake drum and calculate its radius ( $r$ ), in meters.
2. Calculate the torque,  $T = Wrg$  (N.m). Where  $W = W_1 - W_2$  = spring balance reading (the difference between the spring tensions) and 'g' is acceleration due to gravity i.e. 9.81. Calculate the power output of the motor given by  $P_0 = 2\pi nT/60$
3. Calculate the input power,  $P_1 = VI_L$  ( $I_L$  is the line current =  $I_a + I_f$ ).

4. Calculate the percentage efficiency,  $\eta = P_0/P_1 \times 100$

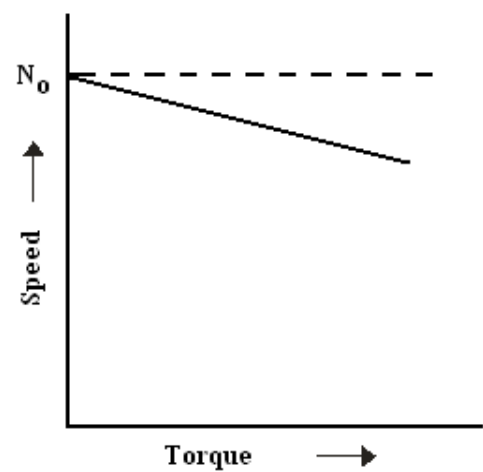
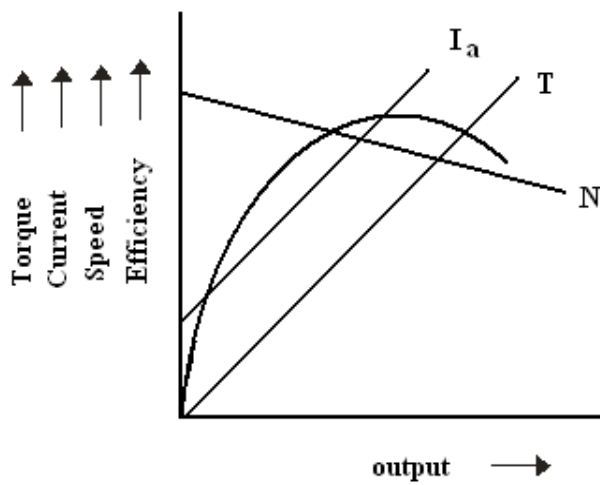
### TABULAR COLUMN

#### For Load Test:

Radius of Brake Drum:

S.No.	V <sub>L</sub> (V)	I <sub>L</sub> (A)	Speed (r.p.m.)	Spring Balance readings (Kgs)			Torque (N-m)	I.P (KW)	O.P (KW)	$\eta$ O.P / I.P (%)
				S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub> ~S <sub>2</sub>				

#### Model graphs:





**RESULT:**

**VIVA Questions:**

1. Why did you use a 3-point starter for starting a D.C shunt motor?
2. If starter is not available, how can you start a D.C motor?
3. What is the efficiency range of a D.C motor?
4. Where can you use the D.C shunt motor?
5. Why is it considered as a constant speed motor?

## OPEN CIRCUIT & SHORT CIRCUIT TEST ON A SINGLE PHASE TRANSFORMER

**AIM:**

To perform open circuit and short circuit test on a single phase transformer and to pre-determine the efficiency, regulation and equivalent circuit of the transformer.

**APPARATUS REQUIRED:**

Sl. No.	equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
			(0-150)V	1 no
2	Ammeter	MI	(0-2)A	1 no
			(0-20)A	1 no
3	Wattmeter	Dynamo type	(0-150)V LPF	1 no
			(0-2.5)A	
4	Wattmeter	Dynamo type	(0-150)V UPF	1 no
			(0-10)A	
5	Connecting Wires	*****	*****	Required

**Transformer Specifications:**

Transformer Rating :( in KVA) \_\_\_\_\_

Winding Details:

LV (in Volts): \_\_\_\_\_

LV side current: \_\_\_\_\_

HV (in Volts): \_\_\_\_\_

HV side Current: \_\_\_\_\_

Type (Shell/Core): \_\_\_\_\_

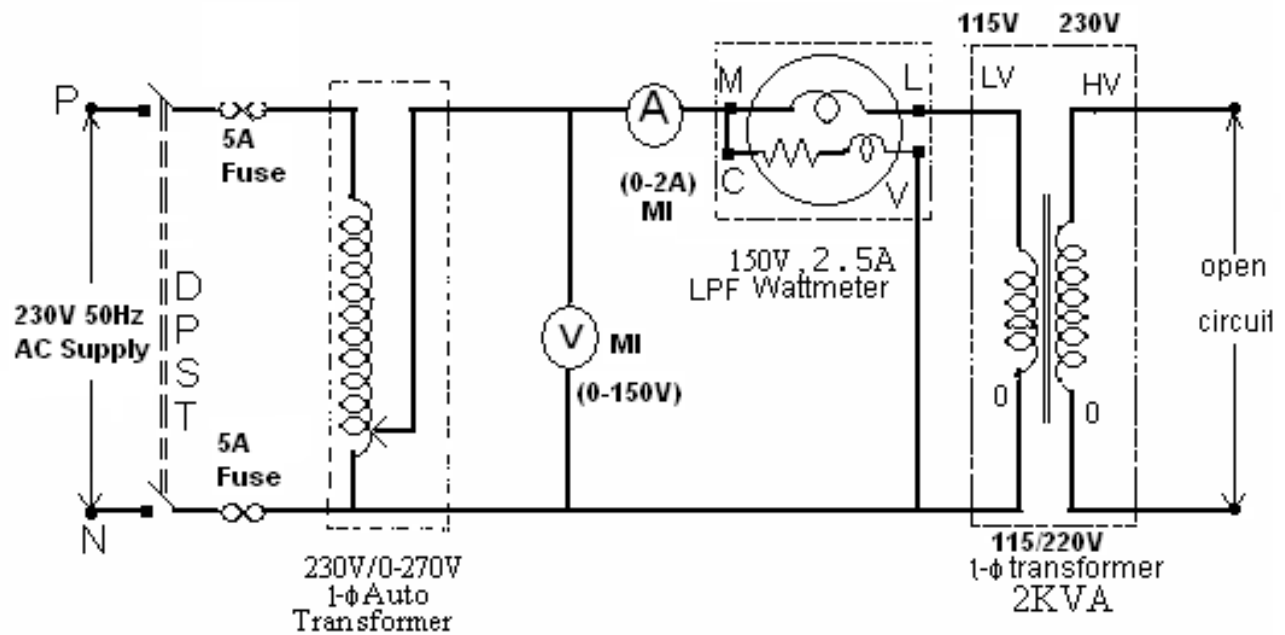
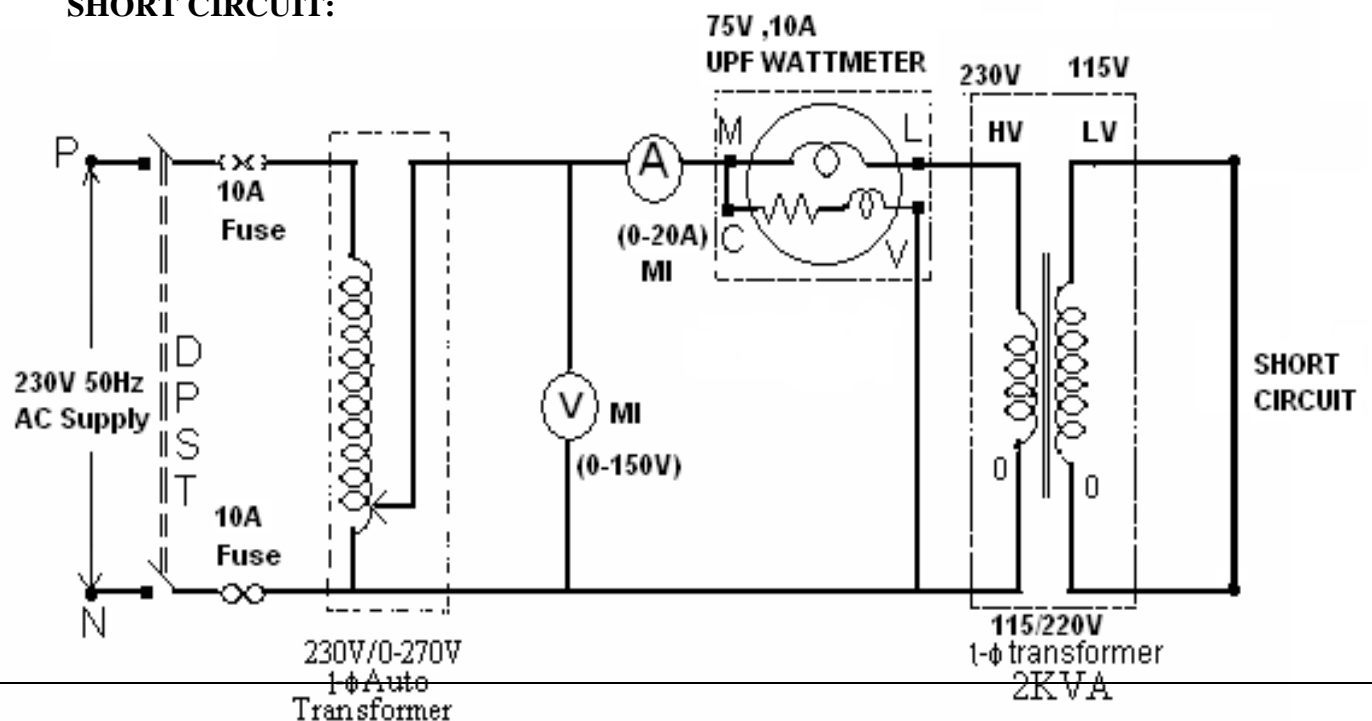
**Auto transformer Specifications:**

Input Voltage (in Volts): \_\_\_\_\_

Output Voltage (in Volts): \_\_\_\_\_

frequency (in Hz): \_\_\_\_\_

Current rating (in Amp): \_\_\_\_\_

**CIRCUIT DIAGRAM:****OPEN CIRCUIT:****SHORT CIRCUIT:**

**PROCEDURE:****Open circuit test:**

1. Connections are made as per the circuit diagram.
2. Ensure that variac is set to zero output voltage position before starting the experiment.
3. Switch ON the supply. Now apply the rated voltage to the Primary winding by using Variac.
4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.
5. Then Variac is set to zero output position and switch OFF the supply.
6. Calculate  $R_o$  and  $X_o$  from the readings.

**Short Circuit Test:**

1. Connections are made as per the circuit diagram.
2. Ensure that variac is set to zero output voltage position before starting the experiment.
3. Switch ON the supply. Now apply the rated Current to the Primary winding by using Variac.
4. The readings of the Voltmeter, ammeter and wattmeter are noted down in Tabular form.
5. Then Variac is set to zero output position and switch OFF the supply.
6. Calculate  $R_{o1}$  and  $X_{o1}$  from the readings.

**OBSERVATIONS:****1) For OC test**

Sl no.	Voltmeter reading ( $V_o$ )	Ammeter reading ( $I_o$ )	Wattmeter reading $W_o$	$R_o$	$X_o$	$\cos \phi_o$

**II) For SC test**

Sl no.	Voltmeter reading ( $V_{SC}$ )	Ammeter reading ( $I_{SC}$ )	Wattmeter reading $W_{SC}$	$R_{01}$	$Z_{01}$	$X_{01}$

**MODEL CALCULATIONS:**

Find the equivalent circuit parameters  $R_0$ ,  $X_0$ ,  $R_{01}$ ,  $R_{02}$ ,  $X_{01}$  and  $X_{02}$  from the O. C. and S. C. test results and draw the equivalent circuit referred to L. V. side as well as H. V. side.

Let the transformer be the step-down transformer

Primary is H. V. side.

Secondary is L. V. side

$$R_0 = \frac{V_1}{I_w} \quad \text{where } I_w = I_0 \cos \phi_0$$

$$X_0 = \frac{V_1}{I_m} \quad \text{Where } I_m = I_0 \sin \phi_0$$

$$R_{01} = \frac{W_{SC}}{I_{SC}^2}, \quad Z_{01} = \frac{V_{SC}}{I_{SC}}$$

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} : X_{02} = K^2 X_{01} \quad \text{Where } K = \frac{V_2}{V_1} = \text{Transformation ratio.}$$

Calculations to find efficiency and regulation

For example at  $\frac{1}{2}$  full load

Copper losses =  $W_{SC} \times (1/2)^2$  watts, where  $W_{SC}$  = full – load copper losses

Constant losses =  $W_0$  watts

Output =  $\frac{1}{2}$  KVA  $\times \cos \phi$  [ $\cos \phi$  may be assumed]

Input = output + Cu. Loss + constant loss

$$\% \text{ efficiency} = \frac{\text{Output}}{\text{Input}} \times 100$$

Efficiency at different loads and P.f's

$$\cos \phi = \underline{\hspace{2cm}}$$

Regulation: From open circuit and Short circuit test

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

‘+’ for lagging power factors

‘-’ for leading power factor

S.No	p.f.	% reg	
		Lag	Lead

**Cos $\phi$  = 1.0**

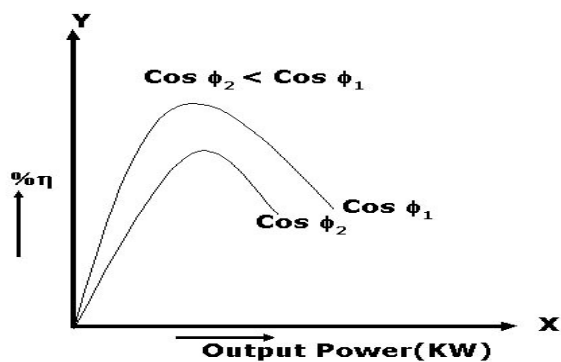
S.No	Load	Wcu (W)	O/P (W)	I/P (W)	$\eta$ (%)

**Cos $\phi$  = 0.8**

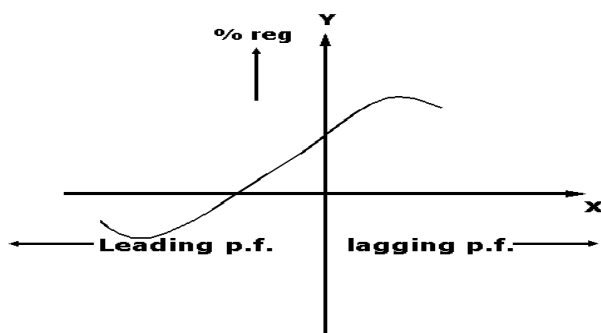
S.No	Load	Wcu (W)	O/P (W)	I/P (W)	$\eta$ (%)

**GRAPHS:** Plots drawn between

- (i) % efficiency Vs output



- (ii) % Regulation Vs Power factor



**PRECAUTIONS:**

- (i) Connections must be made tight
- (ii) Before making or breaking the circuit, supply must be switched off

**RESULT:**

## BRAKE TEST ON 3- $\phi$ SQUIRREL CAGE INDUCTION MOTOR

### AIM:

To determine the efficiency of 3-  $\phi$  induction motor by performing load test. To obtain the performance curves for the same.

### APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	0-9999 RPM	1 no
5	Connecting Wires	*****	*****	Required

### NAME PLATE DETAILS:

<b>Power rating</b>	
<b>Voltage</b>	
<b>Current</b>	



Speed(RPM)	
Frequency	
PF	

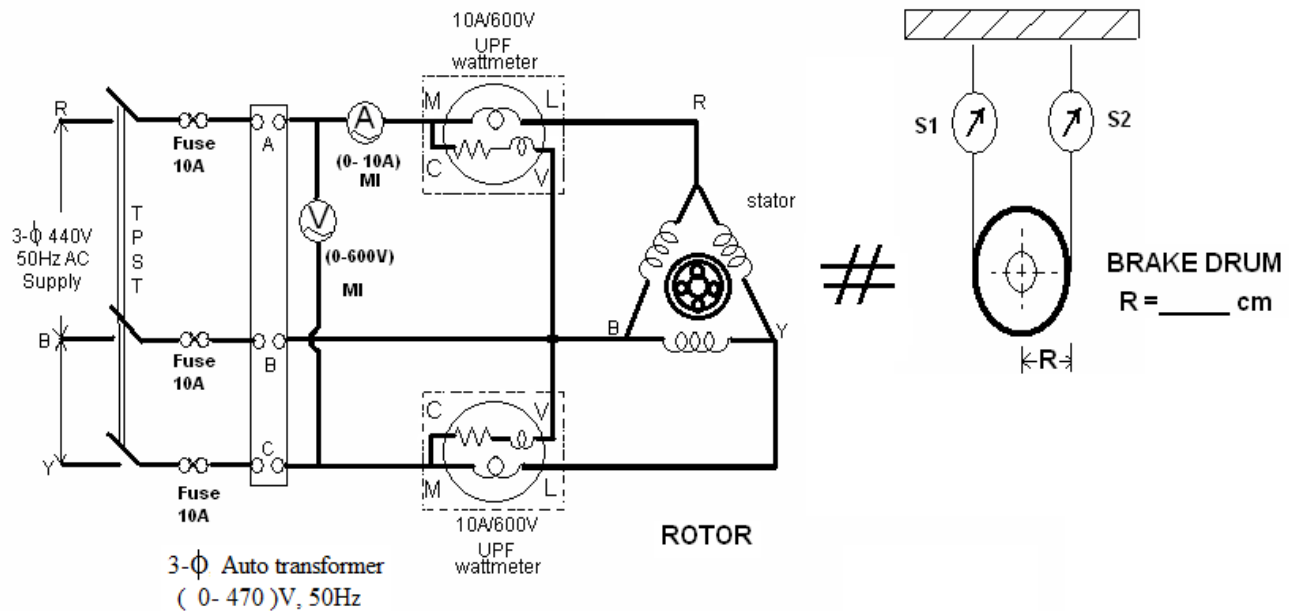
**3-  $\phi$  Auto transformer Details:**

Input Voltage: \_\_\_\_\_ (Volt)

Output Voltage: \_\_\_\_\_ (Volt)

Current: \_\_\_\_\_ (Amp.)

Freq.: \_\_\_\_\_ (Hz)

**CIRCUIT DIAGRAM:****PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. Ensure that the 3-  $\phi$  variac is kept at minimum output voltage position and belt is freely suspended.

3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter at no-load.
5. Now increase the mechanical load by tightening the belt around the brake drum gradually in steps.
6. Note down the various meters readings at different values of load till the ammeter shows the rated current.
7. Reduce the load on the motor finally, and switch OFF the supply.

#### MODEL CALCULATIONS:

Input power drawn by the motor  $W = (W_1 \pm W_2)$  watts

Shaft Torque,  $T_{sh} = 9.81 (S_1 \sim S_2) R$  N-m       $R \rightarrow$  Radius of drum in mts.

Output power in watts =  $\frac{2\pi N T_{sh}}{60}$  watts

% efficiency =  $\frac{\text{output power in watts}}{\text{Input power in watts}} \times 100$

% slip =  $\frac{N_s - N}{N_s} \times 100$        $\left[ \text{where } N_s = \frac{120 \times f}{p} \right]$

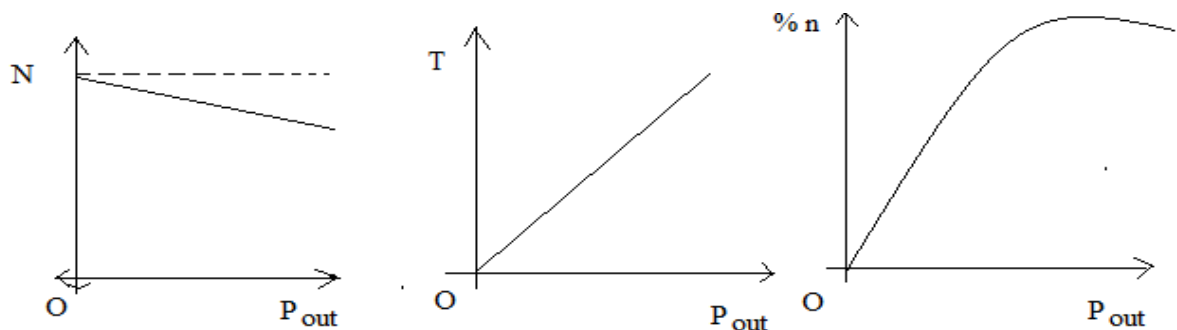
power factor of the induction motor  $\cos \phi = \frac{W}{\sqrt{3} V_L I_L}$

**OBSERVATIONS:**

S. No.	V (Volts)	I (Amps)	Power, W (Watts)		Speed (RPM)	Torque (N-m)	Spring balance (Kg)		% Slip	Cos Ø	Output Power (W)	%η	
			W <sub>1</sub>	W <sub>2</sub>			S <sub>1</sub>	S <sub>2</sub>					

**MODEL GRAPHS:**

1. Speed or slip Vs output power
2. Torque Vs output power
3. % efficiency Vs output power



**PRECAUTIONS:**

1. Connections must be made tight
2. Before making or breaking the circuit, supply must be switched off

**RESULT:**

**VIVA Questions:**

1. Why starter is used? What are different types of starters?
2. Compare a slip ring induction motor with cage induction motor?
3. Why the starting torque is zero for a Single Phase induction motor and non-zero of 3phase induction motor?
4. What are the disadvantages of this method?
5. Can we use rotor resistance method for starting?

