

LABORATORY MANUAL
ELECTRICAL CIRCUITS AND MACHINES LAB (EE 219)
for
II/IV B.E. II-SEM MECH. AND PROD.



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DEPARTMENT OF ELECTRICAL ENGINEERING

ELECTRICAL CIRCUITS & MACHINES LAB

Instruction	3	Periods per week
Duration of University Examination	3	Hours
University Examination	50	Marks
Sessional	25	Marks

List of Experiments:

1. Verification of Thevenin's and Norton's Theorems
2. Measurement of Power by Two-Wattmeter Method
3. Study of Single-Phase R, L & C Series & Parallel Circuits
4. Study of Self and Mutual Inductance of Coils and their Interconnections
5. To Determine the Magnetization Curve of a Separately Excited DC Generator
6. To Determine the Load Characteristics of a Shunt Generator
7. To Determine the Performance Characteristics of a Shunt Motor
8. To Determine the Performance Characteristics of a Compound Motor
9. To Determine the Performance Characteristics of a Series Motor
10. Speed Control of DC Shunt Motor.
11. O.C. and S.C. Tests on Single-Phase Transformer.
12. Performance Characteristics of 3-Phase Induction Motor.
13. Speed Control Methods of Induction Motors.

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EXPT 1: BRAKE TEST ON D.C. COMPOUND MOTOR

AIM: To perform brake test on D. C. Compound motor and draw it's characteristics.

NAME PLATE DETAILS:

D.C. Compound Motor

Voltage----- Current -----

Power----- Speed-----

THEORY:

In a compound motor, we have both series winding and parallel winding. A winding is connected in series with the armature as in a Series DC motor. Another winding is connected in shunt with the armature as in a Shunt DC motor. This combination presents us the double advantage of having the torque characteristics of a series motor and the constant speed characteristic of a shunt motor in one compound wound motor. Depending on the relative polarity of the series and shunt windings, we have different types of compound motors. There are 3 major classifications of DC compound motors:

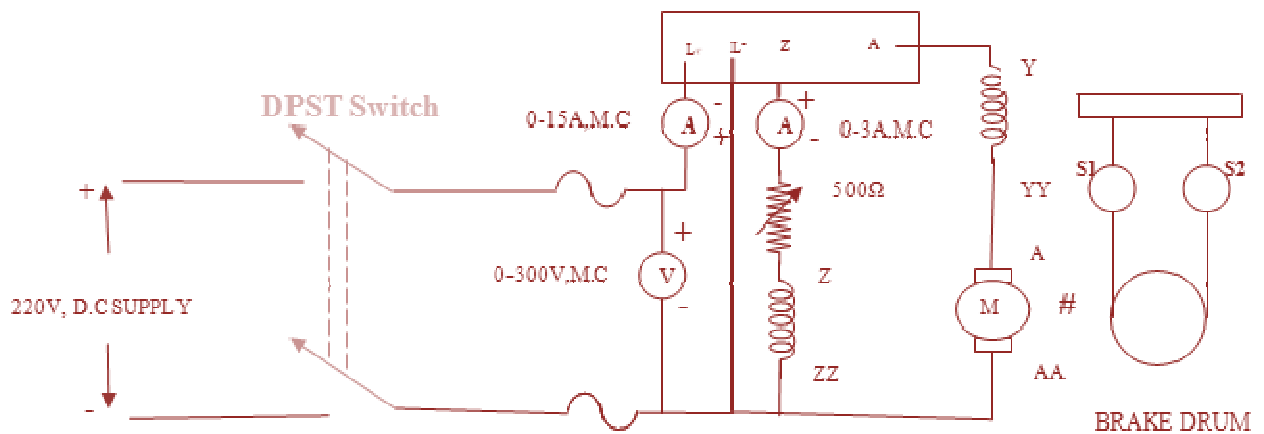
1. Cumulative compound motor
2. Differential compound motor

Cumulative wound motors give high starting torque like a series motor and reasonable good speed regulation at high speeds like a shunt dc motor. It can start with even huge loads and run smoothly (if the load varies only slightly) after that. As this type of motor offers the best of both series and shunt motor, it is practically suitable for most common applications, and so is widely used.

In differential compound motors, magnetic fields of the shunt winding oppose the armature magnetic fields and the series fields. This kind of differential winding provides different torque and speed characteristics. Here as the shunt field is producing an opposite effect, it is unlike a shunt motor. So when the load is reduced, differential compound motor behaves more like a series motor and tends to over speed. When the load is increased, its speed is reduced drastically.

EQUIPMENTS REQUIRED:

SL.NO	EQUIPMENTS	RANGE	QUANTITY
1	M.C. Voltmeter	0-300V	1
2	M.C. Ammeter	0-3A	1
3	M.C. Ammeter	0-15A	1
4	Field rheostat	500Ω	1
5	Tachometer		1

CIRCUIT DIAGRAM:**PROCEDURE:**

1. Connect the compound motor and the apparatus as per the circuit diagram.
2. Switch on the supply & start the motor with the help of starter on no load.
3. Adjust the speed up to the rated value note down the no-load readings of the meters.
4. Gradually increase the brake load and note down the readings and speed for different set of steps up to rated value.
5. Mean while pour water into the drum pulley for cooling.
6. After the observations of all readings reduce the load gradually and stop the motor on no-load.

OBSERVATIONS:

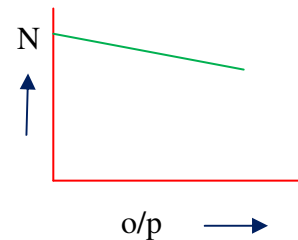
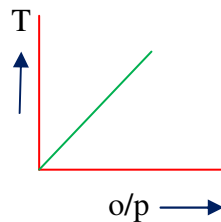
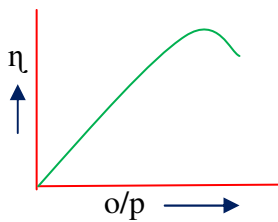
S. no	V (volts)	I _L (amp)	I _F (amp)	N (rpm)	Brake load		Torque (N-m)	Output	Input	Efficiency
					S ₁	S ₂				
1										
2										
3										
4										
5										

CALCULATIONS:

- Torque = (S₁-S₂)*R*g in N-m. Where R= Radius of brake drum.
- Output= (2πNT)/60 in watts.
- Efficiency(%)=(output/input)*100
- Input= V* I_L watts

EXPECTED GRAPHS:

- Output vs. efficiency.
- Torque vs. output.
- Speed vs. output



RESULT: Efficiency (%).....Torque (N-m) output

DISCUSSION OF RESULTS:

- Students will be able to discuss the performance of cumulative and differential compound motor according to their starting torque and speed regulation.

Viva questions

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

EXPT 2: MAGNETISATION CURVE OF A SEPARATELY EXCITED D.C GENERATOR

AIM: To obtain the magnetization characteristics (o. c. c) of a D .C. separately excited generator.

NAME PLATE DETAILS:

D.C. Compound Motor

Voltage-----

Current -----

Power-----

Speed-----

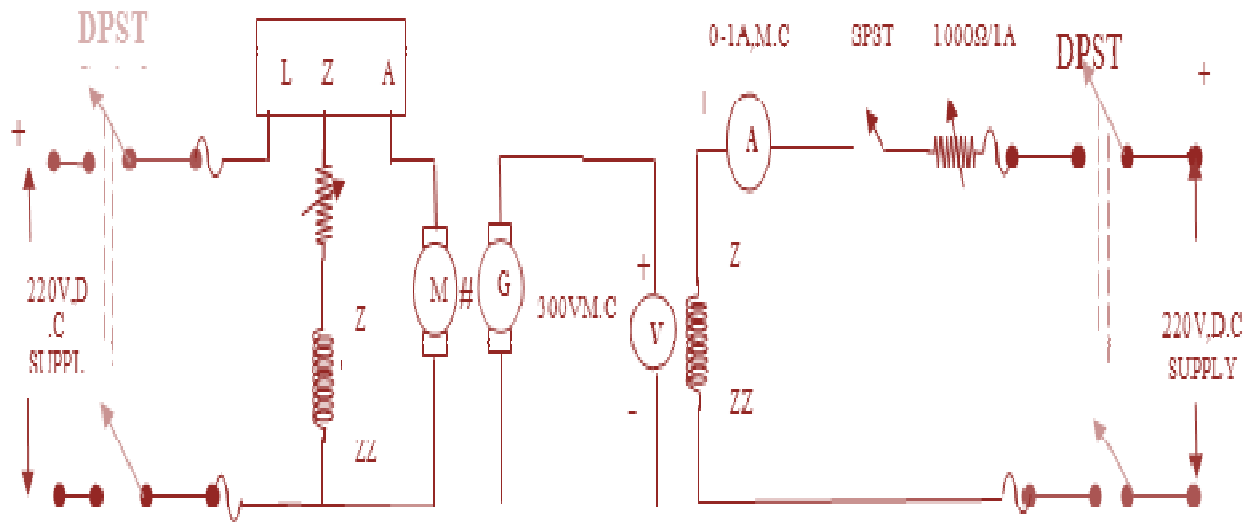
THEORY

An Electric generator consists of a rotor spinning in a magnetic field. The magnetic field may be produced by permanent magnets or by field coils. In the case of a machine with field coils, a current must flow in the coils to generate the field, otherwise no power is transferred to or from the rotor. The process of generating a magnetic field by means of an electric current is called *excitation*.

The **critical field resistance** is the maximum field circuit resistance for a given speed with which the shunt generator would excite. The shunt generator will build up voltage only if field circuit resistance is less than critical field resistance. It is a tangent to the open circuit characteristics of the generator at a given speed.

EQUIPMENTS REQUIRED:

SL.NO	NAME OF EQUIPMENT	TYPE	RANGE	QUANTITY
1	Ammeter	M.C	0-1A	1
2	Voltmeter	M.C	0-300V	1
3	Rheostat	Wire wound	1000Ω/1A	1

CIRCUIT DIAGRAM:**PROCEDURE:**

1. Make the connections as per the diagram, choosing the meters suitable to the ratings of the machines.
2. Keep the motor field rheostat in the minimum position that of the generator field rheostat in the maximum position and start the motor by means of a starter.
3. Run the set at rated speed.
4. Note down the terminal voltage of the M-G set with switch S.I. open. This e.m.f is due to the residual magnetism.
5. Close the switch S1, note down the field current of the generator and e. m. f induced by the generator.
6. Increase the field current of the generator in steps by cutting out the resistance of the field rheostat.
7. Note down the corresponding value of e.m.f induced by the generator.
8. The resistance should be changed in one direction.
9. The same procedure should be repeated with decreasing values of field current. Finally open S1 switch and note down the value of e.m.f generated by residual magnetism.

10. Draw the graph for the e.m.f generated Vs field current (both increasing and decreasing values)
11. Tangent to the mean of increasing and decreasing curve from the origin.
12. Find the critical resistance of the machines by taking the slope of the tangent.
13. Draw o.c.c at some other speed i.e. other than rated speed.
14. For critical speed measure the field resistance and draw field resistance line .along with o.c.c graph
15. Drop a perpendicular on o.c.c in such a way that it cuts R_c line at B and field resistance at C.
16. Thus $(N_c/N)=(AC/AB)$

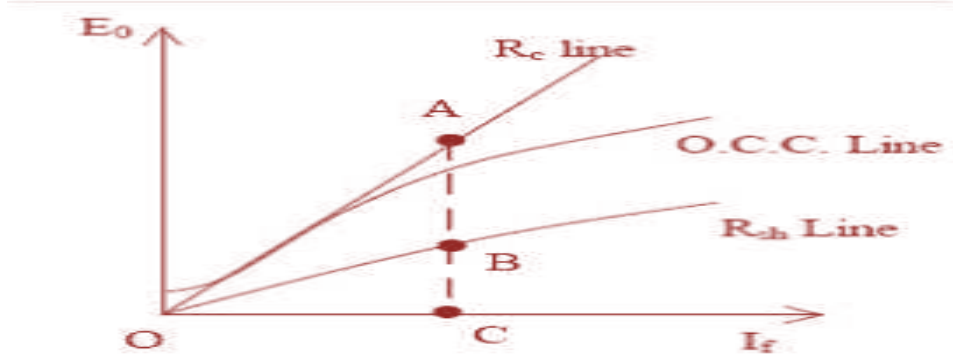
$$(N_c) = (AC/AB) * N$$

OBSERVATIONS:

S.NO	I_F	E_o (INCREASING)	E_o (DECREASING)

PRECAUTIONS:

1. All the connections should be clear and tight.
2. The voltmeter and ammeter should be carefully chosen so that their ranges are more than max. Values to be measured.
3. The field current should not be increased to cross rated value.

EXPECTED GRAPH:

RESULTS: Critical field resistance is-----

DISCUSSION OF RESULTS:

- Students will be able to change the field resistance to determine the critical field resistance as well as can discuss the importance of same.

Viva questions

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

EXPT 3: LOAD CHARACTERISTICS OF D.C. SHUNT GENERATOR

AIM: To conduct load test on a D.C. shunt generator and to draw its internal and external load characteristics.

NAME PLATE DETAILS:

D.C. Shunt Motor

Voltage-----

Current -----

Power-----

Speed-----

THEORY

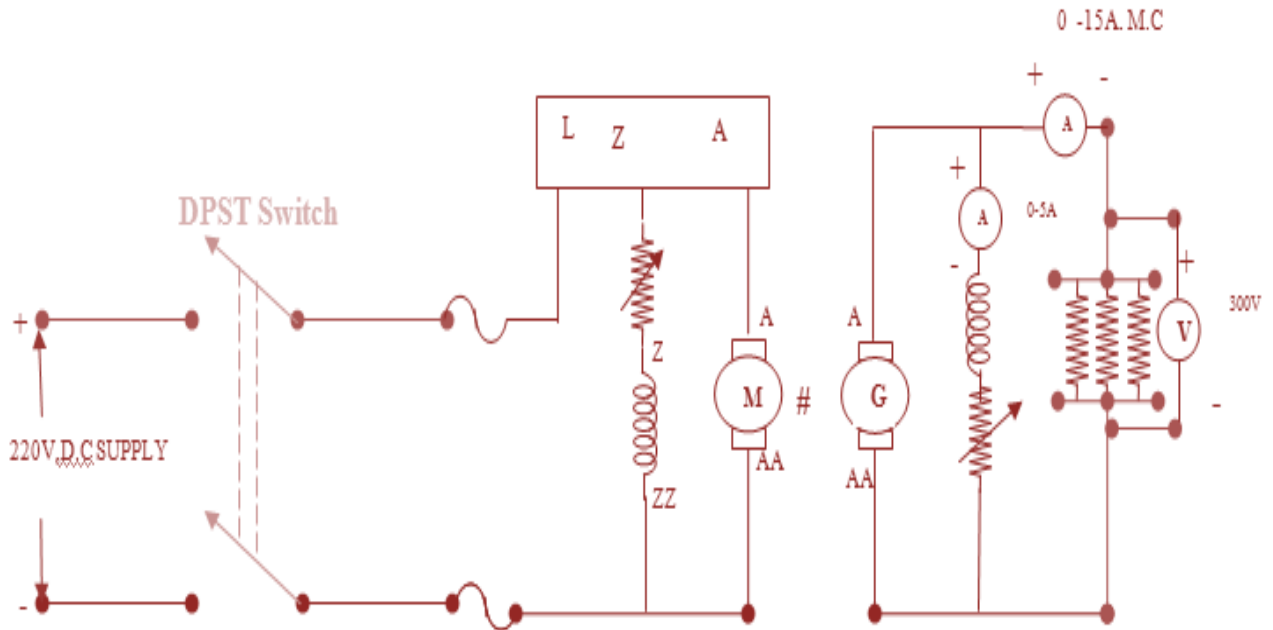
When the generator is loaded, flux per pole is reduced due to armature reaction. Therefore, E.m.f. E generated on load is less than the E.m.f. generated at no load. As a result, the internal characteristic (E/I_a) drops down slightly as shown in graph (curve 1). Curve 2 shows the external characteristic of a shunt generator. It gives the relation between terminal voltage V and load current I_L .

$$V = E - I_a R_a = E - (I_L + I_{sh}) R_a$$

Therefore, external characteristic curve will lie below the internal characteristic curve by an amount equal to drop in the armature circuit [i.e., $(I_L + I_{sh}) R_a$] as shown in Fig (ii). Note. It may be seen from the external characteristic that change in terminal voltage from no-load to full load is small. The terminal voltage can always be maintained constant by adjusting the field rheostat R automatically.

EQUIPMENTS REQUIRED:

SL.NO	NAME OF EQUIPMENT	TYPE	RANGE	QUANTITY
1	Voltmeter	M.C	0-300V	1
2	Ammeter	M.C	0-5A	1
3	Ammeter	M.C	0-20A	1

CIRCUIT DIAGRAM:**PROCEDURE:**

1. Make the connections as per the diagram, choosing the meters suitable to the ratings of the machines.
2. Keep the motor field rheostat in the minimum position, and that of generator field resistance maximum, the set is started and brought up to the rated speed and is maintained constant.
3. The terminal voltage of the generator is adjusted to the rated value with the help of the generator field rheostat and this position is maintained constant.
4. Put on the load and note the value of the load current I_L and the terminal voltage V and field current I_f for different values of load. Until load current exceeds the full load value by 20%
5. Assume armature Resistance (R_a) as 2 ohms.
6. The generator voltage E for each load current is calculated using

$$E_g = V + I_a \cdot R_a$$

Where $I_a = I_L + I_f$

7. Draw the external characteristics V vs. I_L
8. Internal characteristics E_g vs. I_a .

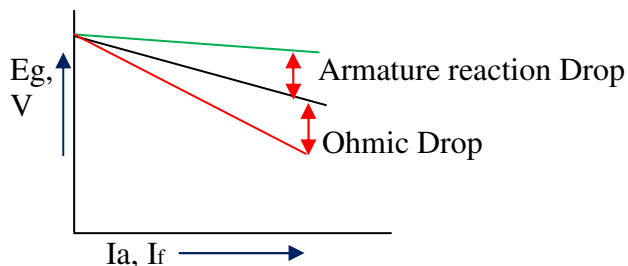
OBSERVATIONS:

S.NO	I_f	I_L	$I_a = I_L + I_f$	V	$E_g = V + I_a \cdot R_a$

PRECAUTIONS:

- All the connections should be clear and tight.
- The voltmeter and ammeter should be carefully chosen so that their ranges are more than max. Values to be measured.
- The field current should not be increased to cross rated value.
- During the experiment the speed of prime mover should remain constant.

EXPECTED GRAPHS:



Plot the following graphs 1. V vs. I_L (external characteristics).

2. E_g vs. I_a (internal characteristics).

RESULTS: Fig. show internal as well as external characteristics of D.C. shunt generator.

DISCUSSION OF RESULTS:

- Students will be able to discuss the effect of armature reaction on D.C. shunt generator as well as voltage drop due to ohmic loss.

VIVA:

1. What are the various factors on which the shape of external characteristics depends?
2. Establish the relation between terminal voltage and load current for a d.c shunt generator.
3. How can you obtain internal characteristics from external characteristics of a D.C. shunt generator?
4. Is the terminal voltage of a D.C. shunt generator on load same as its induced voltage. Why?
5. Give applications of shunt generator.

EXPT 4: SPEED CONTROL OF A DC SHUNT MOTOR

AIM: To vary the speed of a DC Shunt motor by (1) Field control method and
(2) Armature control method.

NAME PLATE DETAILS:

D.C. Shunt Motor

Volage-----

Current -----

Power-----

Speed-----

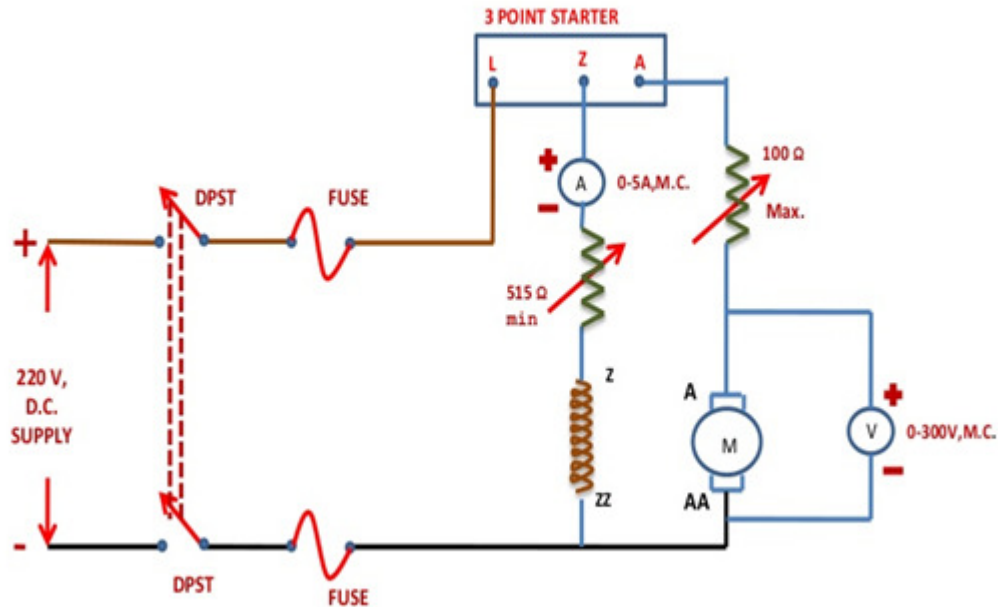
THEORY

Variation of Flux or Flux Control Method: By decreasing the flux, the speed can be increased and vice versa. The flux of a dc motor can be changed by changing I_{sh} with help of a shunt field rheostat. Since I_{sh} is relatively small, shunt field rheostat has to carry only a small current, which means $I_{sh}^2 * R$ loss is small, so that rheostat is small in size.

Armature or Rheostatic Control Method: This method is used when speeds below the no-load speed are required. As the supply voltage is normally constant, the voltage across the armature is varied by inserting a variable rheostat in series with the armature circuit. As controller resistance is increased, voltage across the armature is decreased, thereby decreasing the armature speed. For a load constant torque, speed is approximately proportional to the voltage across the armature. From the 65 speed/armature current characteristic, it is seen that greater the resistance in the armature circuit, greater is the fall in the speed

EQUIPMENTS REQUIRED:

SL.NO	NAME OF EQUIPMENT	TYPE	RANGE	QUANTITY
1	Voltmeter	M.C	0-300V	1
2	Ammeter	M.C	0-5A	1
3	Tachometer	-	-	1
4	Rheostats	-	515Ω,100Ω	2

CIRCUIT DIAGRAM:**PROCEDURE:**

1. Make the connections as per the diagram, choosing the meters suitable to the ratings of the machines.
2. Keep the motor field rheostat in the minimum position, and that of armature circuit maximum (these must be the positions of the two Rheostats every time the motor is started)
3. Give the supply and start the motor. Adjust the resistance in series with armature in order to get a voltage of (say 120V) across the armature.

1. FIELD CONTROL

1. Keeping the voltage across armature constant, increase the resistance in series with the field winding to vary field current.
2. Note down the speed of the motor at different values of field current. Tabulate the readings till the field rheostat reaches its max value.

OBSERVATIONS:

<u>S.NO</u>	<u>Field current(I_f)</u> <u>Amps</u>	<u>Speed (N)</u> <u>r.p.m</u>

2. ARMATURE CONTROL:

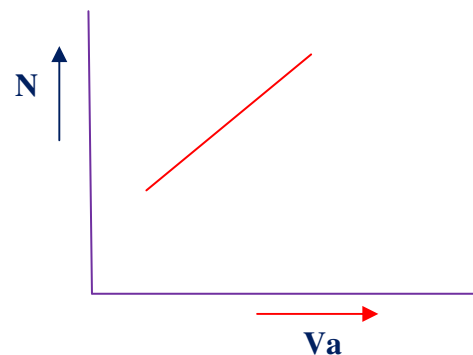
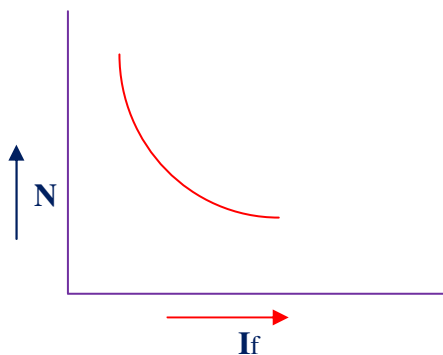
1. Keeping the field current constant at a particular value, and vary the voltage across the armature by varying the resistance in series with armature.
2. Note down the speed at different values of voltage across the armature and tabulate the readings till the armature rheostat reaches its minimum position.

OBSERVATIONS:

<u>S.No.</u>	<u>V_a (Volts)</u>	<u>Speed (N)</u> <u>r.p.m</u>

EXPECTED GRAPHS:

- Plot the following graphs
 - Field current vs. speed.
 - Armature voltage vs. speed.



DISCUSSION OF RESULTS:

- Students will be able to discuss the effect of armature voltage field resistance on D.C. shunt motor to control the speed.

PRECAUTIONS:

- All the connections should be clear and tight.
- The voltmeter and ammeter should be carefully chosen so that their ranges are more than max. Values to be measured.
- The field current should not be increased to cross rated value.

Viva Questions

1. Why Series motors cannot be started without load?
2. Advantages of DC motors over AC motors
3. What are the applications of DC series motors?
4. What is back emf and its significance in DC motor?
5. How speed is controlled in DC shunt motor?
6. Why starter is required in DC motor for starting?
7. What is critical resistance in DC motor?
8. What are the different losses in DC motor?
9. What is Armature Reaction in DC motor and its impact?
10. What is Commutation failure?
11. Advantages of Dummy windings in DC motors?
12. On what principle does DC motor operates?
13. What are the applications of DC Shunt motors?

EXPT 5: MEASUREMENT OF POWER BY TWO WATTMETER METHOD

AIM: To Measure the power consumed by a 3-phase load using 2-wattmeter method.

NAME PLATE DETAILS:

Voltage----- Current -----
Power----- Speed-----

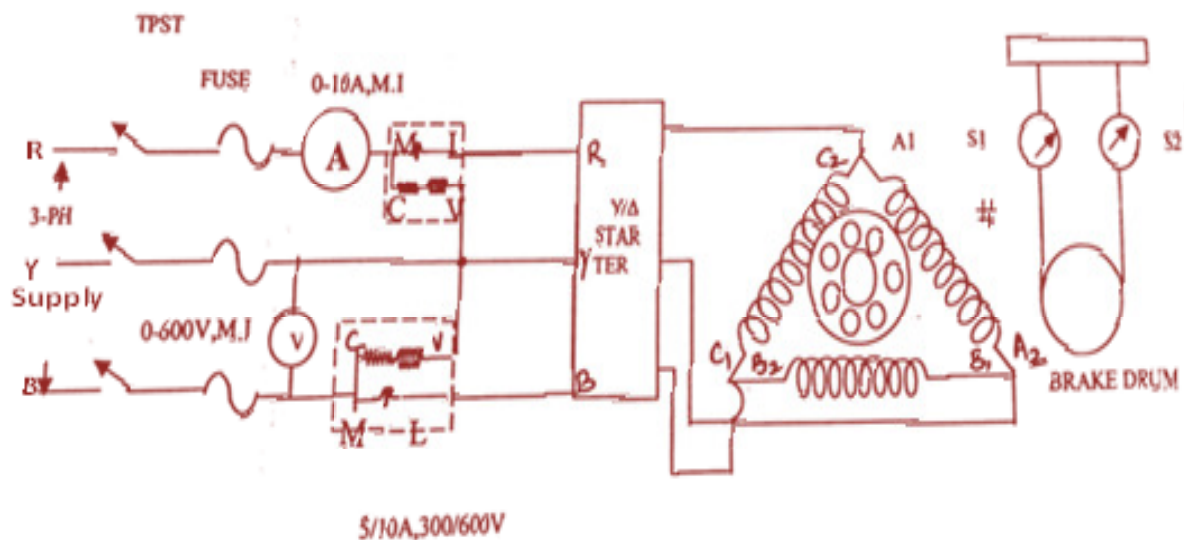
THEORY:-

Surprisingly, only two single phase watt meters are sufficient to measure the total power consumed by a three phase balanced circuit. The two watt meters are connected as shown in figure. The current coils are connected in series with two of the lines .The pressure (or voltage) coils of the two watt meters are connected between that line and reference.

APPARATUS:

S.No	Apparatus	Range	Type	Quantity
1	Voltmeter	0-600V	M.I	1
2	Ammeter	0-10A	M.I	1
3	Wattmeter	5/10A,300/600V	U.P.F	2

Circuit Diagram:



PROCEDURE:

1. Make the connections as per the circuit the diagram. Avoid the loose connections.
2. Switch on TPST Switch; gradually increase the 3-phase variac voltage to the rated voltage of the motor and observe the readings of speed, voltage, current and power.
3. Gradually apply the load on motor using brake apply.
4. Pour enough water in to the brake.
5. Note down the spring balance readings, the speed, the voltage and the currents at different loads until a line current of 90 percent of full load current is reached.
6. Gradually decrease 3-phase variac voltage to zero and open TPST Switch.

OBSERVATIONS:

Voltage	Current	w ₁	w ₂	w ₁ +w ₂	w ₁ -w ₂	Cosφ

Calculations:

Input Power= (w₁+w₂)

Power factor = Cos [tan⁻¹ √(3 (w₁-w₂)/ (w₁+w₂))]

DISCUSSION OF RESULT:

- Students will be able to discuss how the Power and power factor can be measure with two watt meter method efficiently.

VIVA QUESTIONS AND ANSWERS

Q.1. How many coils are there in a single in a single phase wattmeter?

A. In general there are two coils in the wattmeter. One coil is known as current coil and other coil is known as pressure coil or voltage coil.

Q.2. What do you understand by phase sequence in reference to 3-phase circuits?

A. Phase sequence in three phase circuits means the order in which the phase voltages attain their respective maximum positive voltages.

Q.3 What is the phase sequence of a 3-phase system in general?

A. The phase sequence of a three phase system is R, Y, B.

Q.4 How the phase sequence of a three phase system can be changed?

A. If the connections of any two phases are interchanged, the phase sequence can be changed.

Q.5 Is the method used in this experiment applicable to unbalanced loads?

A. Yes, we can use this method for unbalanced loads.

Q.6 Can you measure reactive power in a three phase circuit using this method?

A. Yes the reactive power is given by the relation. $Q = \sqrt{3} (W_1 - W_2)$

Q.7 Which type of wattmeter is generally used for measuring power in a.c. circuits?

A. Dynamometer type of instruments are generally used for measurement of power.

Q.8 How a wattmeter is connected in an a.c. circuit?

A. There are four terminals in wattmeter. There are two coils in wattmeter one is current coil (low resistance) in wattmeter and other is pressure coil (higher resistance). The current coil is always connected in series and pressure coil is connected in parallel.

EXPT 6: LOAD TEST ON 3- PHASE INDUCTION MOTOR

AIM: To study the performance of induction machine as a motor.

NAME PLATE DETAILS:

Voltage----- Current -----
Power----- Speed-----

THEORY:

The load test on 3-phase induction motor is performed to obtain its various characteristics including efficiency. A belt and brake drum arrangement as shown in the circuit diagram can load the motor. If S_1 and S_2 are the tensions provided at the two sides of the belt, then the load torque is given by

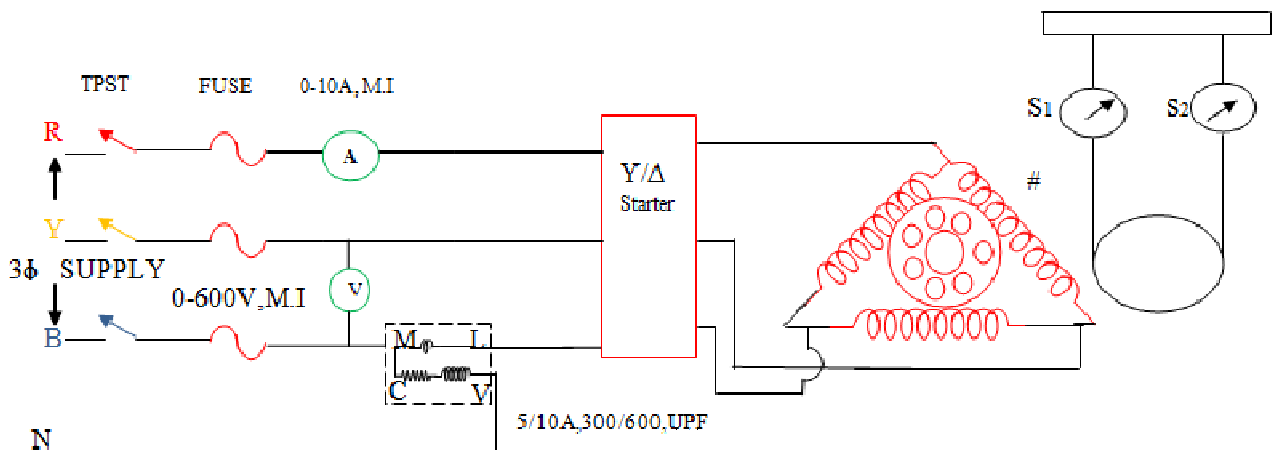
$$T = (S_1 - S_2) * 9.81 * R \quad \text{N-m.}$$

Where R is the radius of the brake drum in meter.

APPARATUS REQUIRED:

S.No	Apparatus	Range	Type	Quantity
1	Voltmeter	0-600V	M.I	1
2	Ammeter	0-10A	M.I	1
3	Wattmeter	5/10A,300/600V	U.P.F	1

CIRCUIT DIAGRAM:



PROCEDURE:

1. Make the connections as shown.
2. Select suitable ranges of meters. Start the motor with the help of starter & observe the readings of speed, voltage, current & power.
3. Using the brake apply load in steps on the induction motor at each step & take the readings of two spring balances & various instruments.
4. Apply load upto the rated value of current.
6. Gradually remove the load from the motor.
5. Gradually decrease 3-phase variac voltage to zero and open TPST Switch.

TABULAR COLUMN:

S. no	V (volts)	I _L (amp)	N (rpm)	Watt meter	Brake load		Torque (N-m)	Output	Input	Efficiency
					S ₁	S ₂				
1										
2										
3										
4										

CALCULATIONS:

Input power = $3 \cdot W \cdot \text{multiplication factor}$ (Watts)

Torque (T) = $(S_1 - S_2) \cdot R \cdot g$ (N-M)

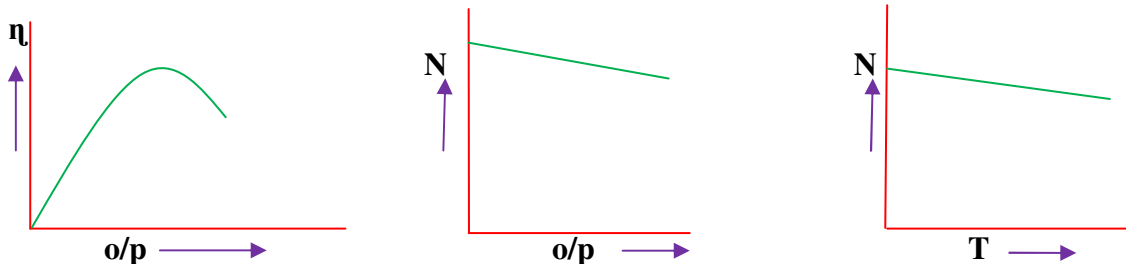
Output power = $(2 \cdot \pi \cdot N \cdot T) / 60$ (Watts)

Power factor = $(\text{Input power}) / (\sqrt{3} \cdot V_1 \cdot I_1)$

Efficiency = Output / Input

GRAPHS:

1. Output Vs Torque
2. Output Vs Speed
3. Output Vs efficiency



DISCUSSION OF RESULT:

- Students will be able to discuss the efficiency of motor with respect to output as well as torque with respect to speed of motor.

VIVA QUESTIONS:

1. Explain what is meant by a 3-phase induction motor?
2. Write the classification of 3-phase induction motor?
3. State the steps to draw the equivalent circuit of 3-phase induction motor?
4. State the condition for maximum torque of 3-phase induction motor?
5. Give the different methods of speed control of I.M.
6. How do you calculate slip speed?
7. State the condition when induction motor acts as induction generator?
8. Give the other name for induction generator

EXPT 7: THEVENIN'S THEOREM AND NORTON'S THEOREMS

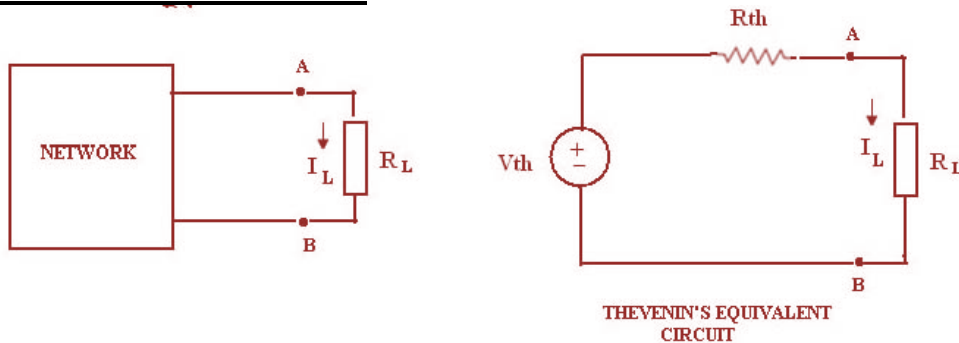
AIM: To verify Thevenin's Theorem and Norton's Theorem.

APPARATUS:

1. Regulated power supply.
2. Digital multimeter.
3. Decade resistance box.
4. Resistance network.

THEORY:

THEVENIN'S THEOREM:



Any linear bilateral network with respect to two terminals (A and B) can be replaced by a single voltage source V_{th} in series with a single resistance R_{th} . Where, V_{th} is the open circuit voltage across the load terminals and R_{th} is the internal resistance of the network as viewed back into the open circuited network from the terminals A and B with voltage sources and current sources replaced by their internal resistances. Then the current in the load resistance is given by,

$$I_L = V_{th} / (R_{th} + R_L)$$

NORTON'S THEOREM:

Any linear bilateral network with respect to a pair of terminals (A and B) can be replaced by a single current source I_N in parallel with a single resistance R_N . Where, I_N is the short circuit current in between the load terminals and $R_N (= R_{th})$ is the internal resistance of the

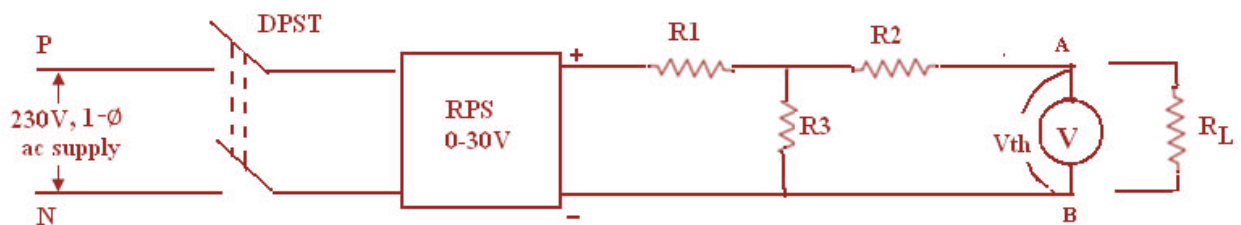
network as viewed back into the open circuited network from the terminals A and B with voltage sources and current sources replaced by their internal resistances. Then the current in the load resistance is given by

$$I_L = I_N \left\{ \frac{R_N}{R_N + R_L} \right\}$$

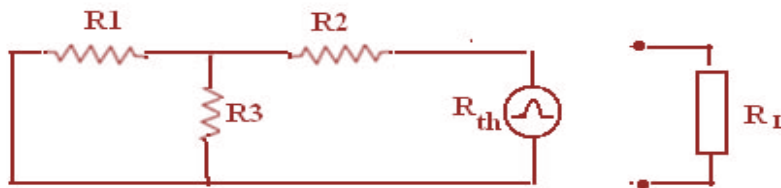
THEVENIN'S THEOREM:

CIRCUIT DIAGRAMS:

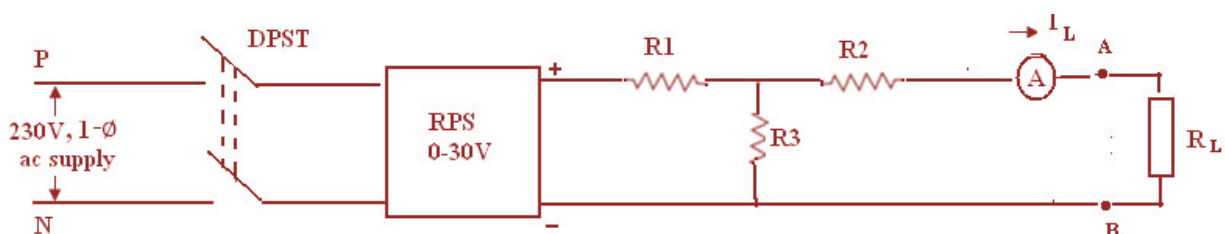
To find Thevenin's Voltage:



To find Thevenin's resistance:



To find load current:



PROCEDURE:

1. Connect the circuit as shown in fig.3 and apply suitable voltage. Note down the open circuit voltage (V_{th}).

2. Connect the circuit as shown in fig.4 and note the Thevenin's resistance R_{th} by means of a multimeter.
3. Connect the circuit as shown in fig.5. For a particular value of load resistance R_L , keeping the voltage of RPS at the same value as in step 1, note the value of the current. Verify the current value obtained by applying the Thevenin's theorem i.e. I_L should be equal to $V_{th}/(R_{th}+R_L)$.
4. Repeat step 3 for various values of load resistances and compare with the calculated values, as obtained by applying Thevenin's theorem.
5. Vary the input voltage and take three sets of readings (step 2 need not be repeated as long as the network is not changed).

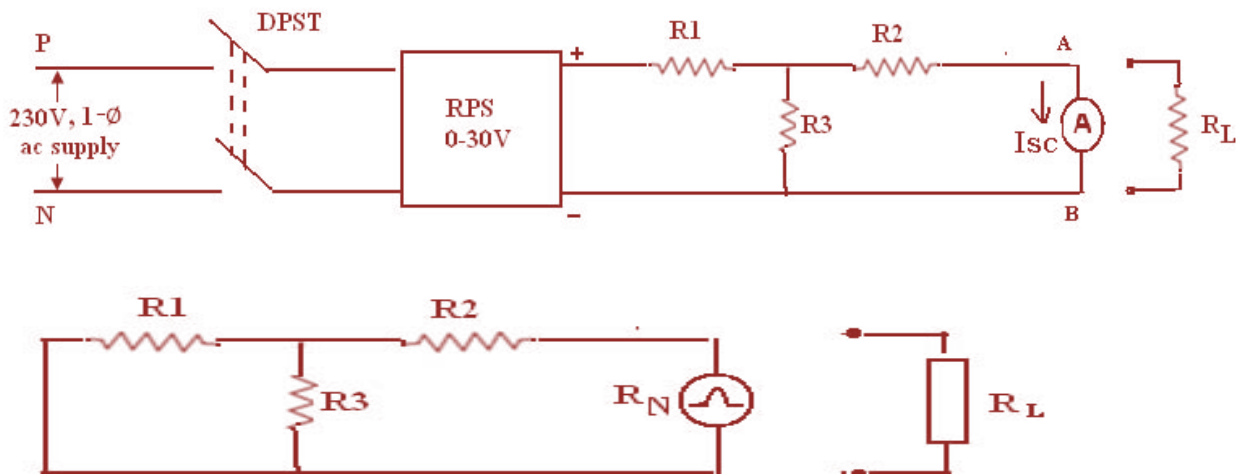
OBSERVATIONS:

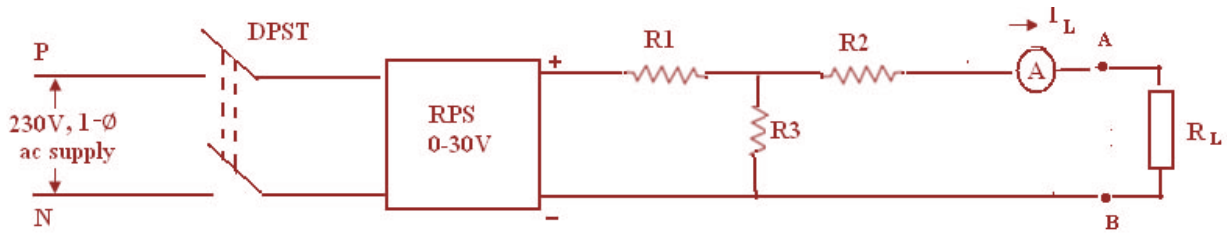
$R_{th} = \dots\dots\dots$ ohms.

S.No.	V_s	V_{th}	R_L	I_L (Measured Value)	I_L (By applying theorem) $I_L = V_{th}/(R_{th}+R_L)$

NORTON'S THEOREM:

CIRCUIT DIAGRAMS:





PROCEDURE:

1. Connect the circuit as shown in fig.6 and by applying suitable voltage through RPS, determine the short circuit current (I_{sc}).
2. Note down the load currents for various values of load resistance (R_L) and compare with the theoretical values obtained using Norton's equivalent circuit.(fig.5).
3. Repeat steps 1 & 2 for various values of source voltages.
(Note R_N is same as R_{th} obtained in Thevenin's equivalent circuit).

OBSERVATIONS:

$R_N = \dots\dots\dots$ ohms.

<u>S.No.</u>	V_s	I_{sc}	R_L	I_L (Measured Value)	I_L (by applying theorem) $I_L = I_N R_N / (R_N + R_L)$

DISCUSSION OF RESULTS:

- Students will be able to discuss how complicated circuit Voltage and Current can be determined by using Thevenin's and Norton's theorem.

Viva questions/answers

1. To what type of circuit Thevenin's theorem is applicable

Ans. Linear and bilateral

2. What is the use of Thevenin's theorem?

Ans. To convert the complex ckt into a voltage source and a series resistance

3 How RTH is connected with the ckt?

Ans. In series

4. How is RTH connected with the load resistance?

Ans. In series

5. What modification is done in galvanometer to convert it into a ammeter?

Ans. A large resistance in parallel

6. What modification is done in the galvanometer to convert it into a voltmeter?

Ans. A series resistance

7. Resistance is a n active element or the passive?

Ans. Passive

8. To what type of network Norton's theorem applicable?

Ans. Two terminal linear network containing independent voltage and current sources.

9. How is RN connected to IN?

Ans. In the parallel

10. What is placed in place of voltage sources while calculating the RN?

Ans. Their internal resistance replaces these.

11. Give an example of unilateral ckt?

Ans. Diode rectifier

12. What is unilateral ckt?

Ans. Whose characteristics changes with the change in direction of operation

13. Give one example of the bilateral n/w?

Ans. Transmission lines

EXPT 8: PERFORMANCE CHARACTERISTICS OF A SHUNT MOTOR

AIM: To perform brake test on D. C. Shunt motor and draw the characteristics.

NAME PLATE DETAILS:

D.C. Shunt Motor

Voltage-----

Current -----

Power-----

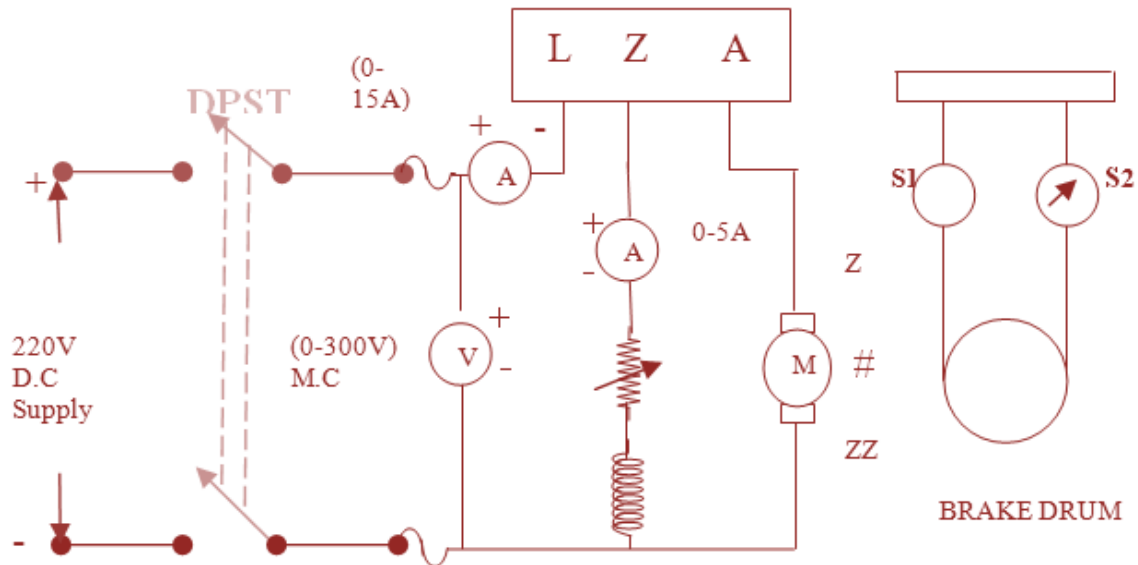
Speed-----

THEORY:

The field coil and the armature windings are connected in shunt or parallel across the power source. The armature winding consists of relatively few turns of heavy gauge wire. The voltage across two windings is the same but the armature draws considerably more current than the field coil. Torque is caused by the interaction of the current carrying armature winding with the magnetic field produced by the field coil. If the DC line voltage is constant, the armature voltage and the field strength will be constant. The speed regulation is quite good; the speed is a function of armature current and is not precisely constant. As the armature rotates within the magnetic field, an EMF is induced in its winding. This EMF is in the direction opposite to the source EMF and is called the counter EMF (CEMF), which varies with rotational speed. Finally, the current flow through the armature winding is a result of the difference between source EMF and CEMF. When the load increases, the motor tends to slow down and less CEMF is induced, which in turn increases the armature current providing more torque for the increased load

EQUIPMENTS REQUIRED:

Sl.No	Equipments	Range	Type	Quantity
1	Voltmeter	0-300V	M.C	1
2	Ammeter	0-5A	M.C	1
3	Ammeter	0-15A	M.C	1
4	Field rheostat	500Ω		1
6	Tachometer	--	--	1

CIRCUIT DIAGRAM:**PROCEDURE:**

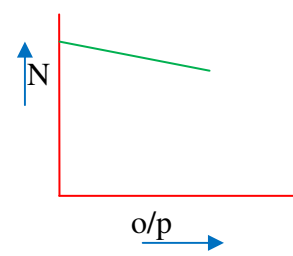
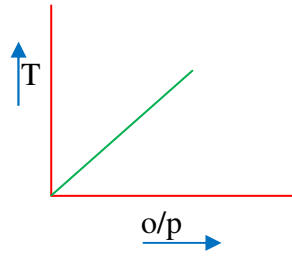
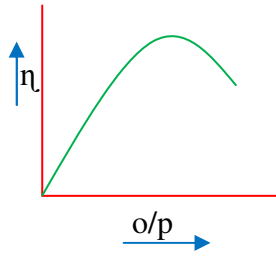
1. Connect the shunt motor and the apparatus as per the circuit diagram.
2. Switch on the supply & start the motor with the help of starter on no load.
3. Adjust the speed up to rated value note down the no-load readings of the meters.
4. Gradually increase the brake load and note down the readings and speed for different set of steps up to rated value.
5. Mean while pour water into the drum pulley for cooling.
6. After the observations of all readings reduce the load gradually and stop the motor on no-load.

TABULAR COLUMN:

S. no	V (volts)	I_L (amp)	I_F (amp)	N (rpm)	Brake load		Torque (N-m)	Output	Input	Efficiency
					S ₁	S ₂				
1										
2										
3										
4										
5										

EXPECTED GRAPHS:

1. Output vs. efficiency.
2. Torque vs. output.
3. Speed vs. output.

**CALCULATIONS:**

- Torque = $(S_1 - S_2) \cdot R \cdot g$ in N-m. Where R= Radius of brake drum.
- Output = $(2 \pi N T) / 60$ in Watts.
- Efficiency (%) = $(\text{output} / \text{input}) \times 100$
- Input = $V \times I_L$ Watts

RESULT: Torque Output Efficiency.....

DISCUSSION OF RESULT:

- Students will be able to discuss, if the D.C. line voltage is constant, the armature voltage will be constant and thus the magnetic field strength will be constant. This consistency leads to a reasonably constant speed of operation.

Viva Questions:

- 1) What is speed regulation?
- 2) What are the different types of motor?
- 3) What are the characteristics of D.C shunt motor?
- 4) What is the condition for maximum efficiency?
- 5) What are the different methods to reduce the iron losses?
- 6) What are the applications of D.C Shunt Motor?

EXPT 9: PERFORMANCE CHARACTERISTICS OF A SERIES MOTOR

AIM: To perform brake test on D. C. Series motor and draw the characteristics.

NAME PLATE DETAILS:

D.C. Series Motor

Voltage-----

Current -----

Power-----

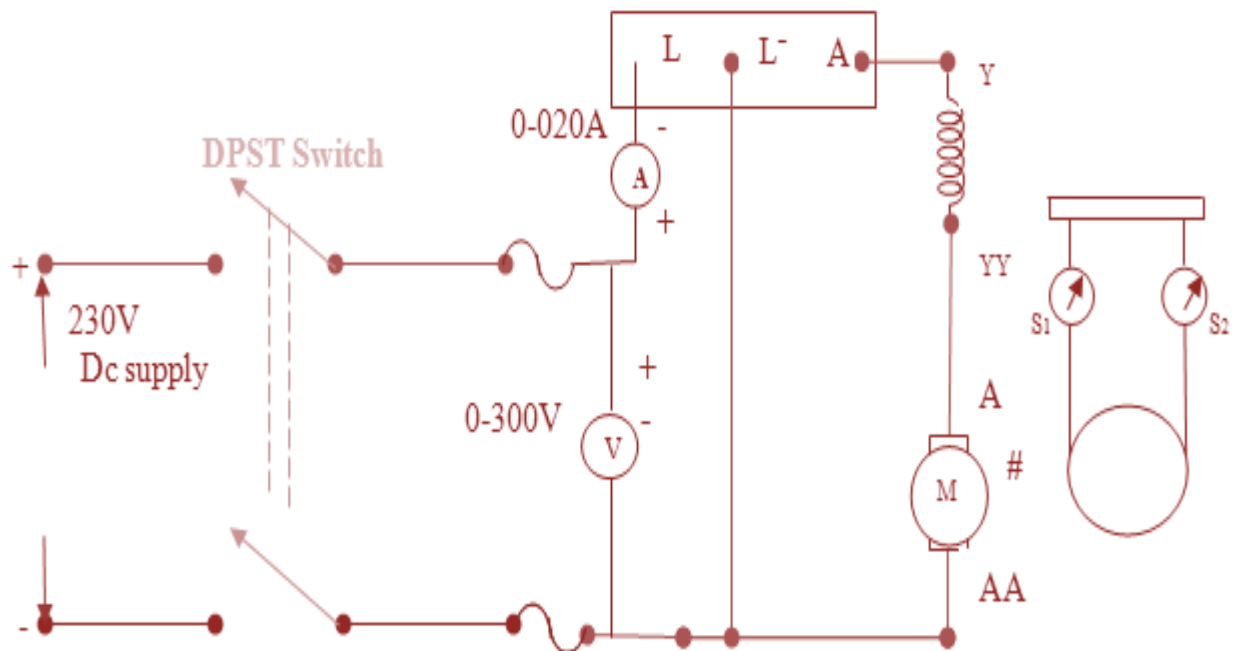
Speed-----

THEORY:

The field coil and armature windings are connected in series to the power source. The field coil is wound with a few turns of heavy gauge wire. In this motor, the magnetic field is produced by the current flowing through the armature winding; with the result that the magnetic field is weak when the motor load is light (the armature winding draws a minimum current). The magnetic field is strong when the load is heavy (the armature winding draws a maximum current). The armature voltage is nearly equal to the PS line voltage (just as in the shunt wound motor if we neglect the small drop in the series field). Consequently, the speed of the series wound motor is entirely determined by the load current. The speed is low at heavy loads, and very high at no load. In fact, many series motors will, if operated at no load, run so fast that they destroy themselves. The high forces, associated with high speeds, cause the rotor to fly apart, often with disastrous results to people and property nearby. The torque of any DC motor depends upon the product of the armature current and the magnetic field. For the series wound motor this relationship implies that the torque will be very large for high armature currents, such as occur during start-up. The series wound motor is, therefore, well adapted to start large heavy-inertia loads, and is particularly useful as a drive motor in electric buses, trains and heavy duty traction applications.

EQUIPMENTS REQUIRED:

Sl.No	Equipments	Range	Type	Quantity
1	Voltmeter	0-300V	M.C	1
2	Ammeter	0-20A	M.C	1
3	Tachometer	--	--	1

CIRCUIT DIAGRAM:**PROCEDURE:**

1. Connect the Series motor and the apparatus as per the circuit diagram.
2. Before start the motor some initial load must be put on the motor by using brake drum with spring balance arrangement.
4. Start the motor with the help of two point starter.
5. Gradually increase the brake load and note down the readings and speed for different set of steps up to rated value.

5. Mean while pour water into the drum pulley for cooling.
6. After the observations of all readings reduce the load gradually and stop the motor on initial load.

TABULAR COLUMN:

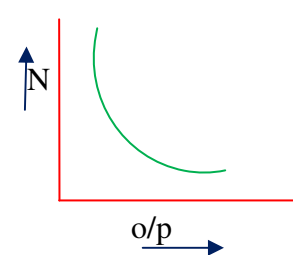
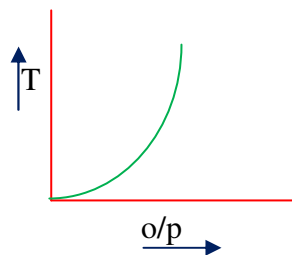
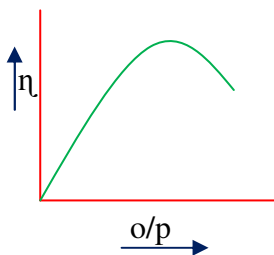
S. no	V (volts)	I _L (amp)	N (rpm)	Brake load		Torque (N-m)	Output	Input	Efficiency
				S ₁	S ₂				
1									
2									
3									
4									
5									

CALCULATIONS:

- Torque = (S₁-S₂)*R*g in N-m. Where R= Radius of brake drum.
- Output= (2πNT)/60 in Watts.
- Efficiency(%)=(output/input) *100
- Input= V × I_L Watts

EXPECTED GRAPHS:

1. Output vs. efficiency.
2. Torque vs. output.
3. Speed vs. output.



RESULT: Torque Output Efficiency.....

DISCUSSION OF RESULT:

- Students will be able to discuss the series winding produces a machine with very high speed regulation.
- The operating speed of the series motor is a function of its load current.
- Starting torque of the motor.

Viva questions:

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

EXPT 10: O.C. AND S.C. TESTS ON SINGLE-PHASE TRANSFORMER

AIM: To perform open and short circuit test on a single phase transformer and determine efficiency and parameters of the equivalent circuit.

NAME PLATE DETAILS:

Voltage-----

Current -----

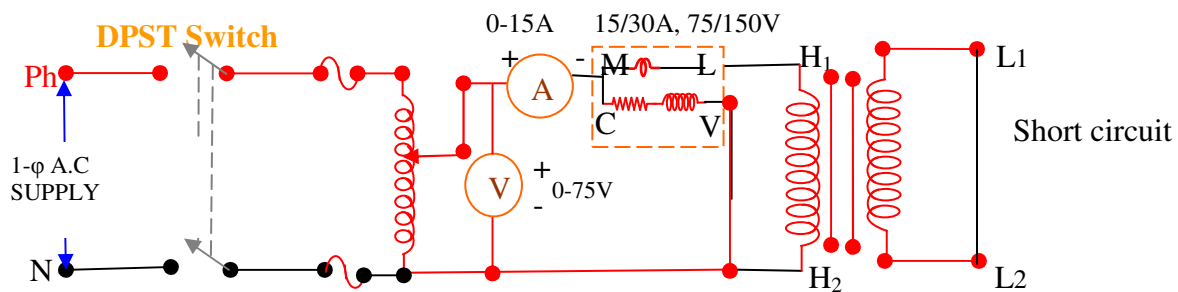
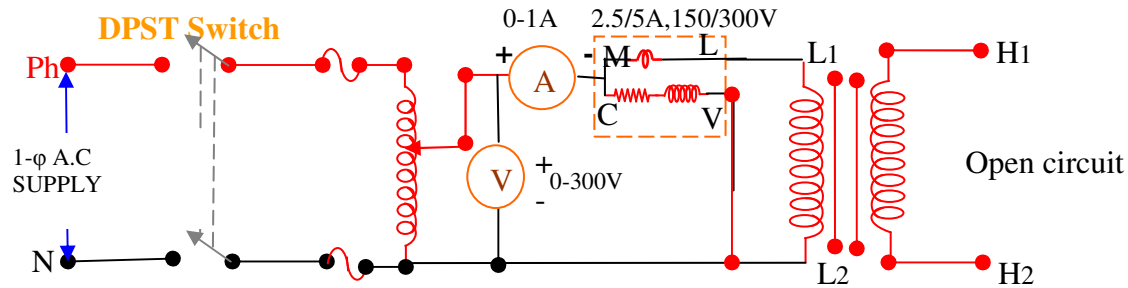
KVA.....

THEORY:

Transformers are capable of either increasing or decreasing the voltage and current levels of their supply, without modifying its frequency, or the amount of Electrical Power being transferred from one winding to another via the magnetic circuit. A single phase voltage transformer basically consists of two electrical coils of wire, one called the “Primary Winding” and another called the “Secondary Winding”. A transformer does not require any moving parts to transfer energy. This means that there are no friction or windage losses associated with other electrical machines. However, transformers do suffer from other types of losses called “copper losses” and “iron losses” but generally these are quite small. Copper losses, also known as I^2R loss are the electrical power which is lost in heat as a result of circulating the currents around the transformers copper windings, hence the name. Copper losses represent the greatest loss in the operation of a transformer. The actual watts of power lost can be determined (in each winding) by squaring the amperes and multiplying by the resistance in ohms of the winding (I^2R).

EQUIPMENTS REQUIRED:

Sl.No	Equipments	Range	Type	Quantity
1	Voltmeter	0-300V	M.I.	1
2	Voltmeter	0-300V	M.I.	1
3	Ammeter	0-2A	M.I	1
4	Ammeter	0-15A	M.C	1
5	Wattmeter	2.5/5A,150/300V	L.P.F	1
6	Wattmeter	15/30A,75/150V	U.P.F	1

CIRCUIT DIAGRAMS:**PROCEDURE:****Open circuit test:**

1. Make the connection as per the circuit diagram.
2. Increase the voltage by means of variac until rated current is reached.
3. Note the values of no load current (I_o), voltage (V_o) and Wattmeter reading (P_o).
4. Make sure that variac should be initial position before switching off supply.

OBSERVATION: $V_o =$ $I_o =$ $P_o =$ **Short circuit test:**

1. Make the connection as per the circuit diagram.
2. Increase the voltage by means of variac until rated current is reached.
3. Note the values of no load current (I_{sc}), voltage (V_{sc}) and Wattmeter reading (P_{sc}).
4. Make sure that variac should be initial position before switching off supply.

OBSERVATION:**V_{sc} =****I_{sc} =****P_{sc} =****CALCULATIONS:**

From O.C. test:

$$P_o = V_o \times I_o \times \cos\phi_o$$

$$\cos\phi_o = P_o / (V_o \times I_o)$$

$$\text{Equivalent resistance} = V_o / I_o \times \cos\phi_o$$

$$\text{Magnetizing reactance } X_o = V_o / I_o \times \sin\phi_o$$

From S. C. test:

$$R_{o1} = P_{sc} / I_{sc}^2$$

$$Z_{o1} = V_{sc} / I_{sc}$$

$$X_{o1} = \sqrt{(Z_{o1}^2 - R_{o1}^2)}$$

Assume load $X = 1/4, 3/4, 1/2, 1$

$$\text{Iron Loss} = P_i$$

$$\text{Copper Loss at 'X' times full load} = X^2 \times P_{sc}$$

$$\text{Total losses} = P_i + X^2 \times P_{sc}$$

$$\text{Output} = X \times S \times \cos\phi$$

Where S is capacity of transformer in VA

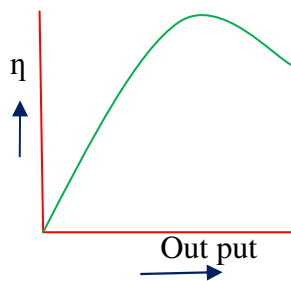
$$\text{Assume } \cos\phi = 0.8$$

$$\text{Input} = \text{Output} + \text{total losses}$$

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

S.No	X	Iron loss P_i	Copper loss $X^2 \times P_{sc}$	Total losses $P_i + (X^2 \times P_{sc})$	Out pout $X \times S \times \cos\phi$	Input+Total losses	%Efficiency

EXPECTED GRAPH



PRECAUTIONS:

1. All the connections should be tight and clean
2. Special care should be taken while selecting the range of Meters for S.C. and O.C. test
3. While conducting S.C.test, the voltage applied should be initially set at zero and then increased slowly. If a little higher voltage than required voltage is applied then there is danger of transformer being damaged.

DISCUSSION OF RESULT:

- Students will be able to determine the core and copper loss as well as efficiency of transformer by conducting O.C. and S.C tests.

Viva questions

1. When a transformer is energized what types of losses occur in the magnetic frame of the transformer?
2. What information can be obtained from open circuit test of a transformer?
3. Why in open circuit test HV side is always kept open?
4. What is the power factor of a transformer under no load test situation?
5. What is the magnitude of no load current as compared to full load current?

EXPT: LOAD TEST ON SINGLE PHASE TRANSFORMER

AIM: To determine the efficiency.

To find the variation of secondary terminal voltage with respect to the load current.

NAME PLATE DETAILS:

Primary Voltage-----

Primary Current -----

Secondary Voltage-----

Secondary Current -----

KVA Rating.....

APPARATUS REQUIRED:

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

PRECAUTION:

1. The Variac should be kept in minimum position while switching on and switching off the supply side DPST'S.
2. At the time of switching on the supply there should not be any load connected.

RANGE FIXING:

Rated primary current, $I_1 = \text{Rated capacity in VA}$

Primary voltage, V_1

Rated secondary current, $I = \text{Rated capacity in VA}$

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

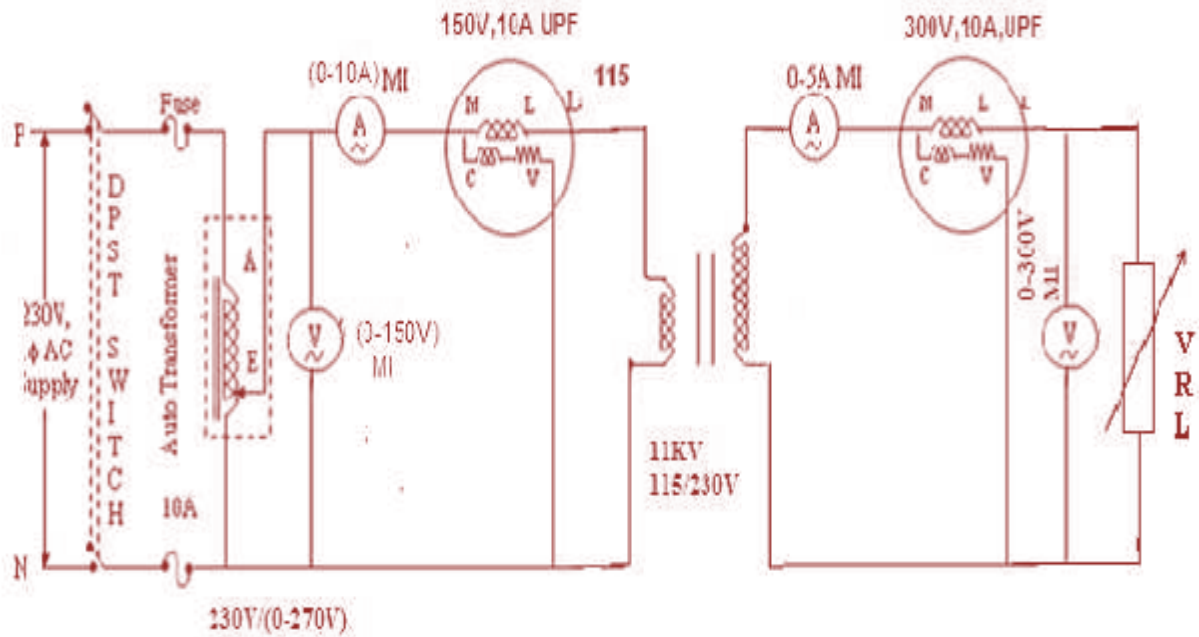
Input Power = W_P

$$\% \eta = (W_s / W_P) \times 100$$

$$\% \text{ Regulation} = ((V_{S0} - V_S) / V_{S0}) \times 100$$

(Where V_{S0} – no load secondary rated terminal voltage)

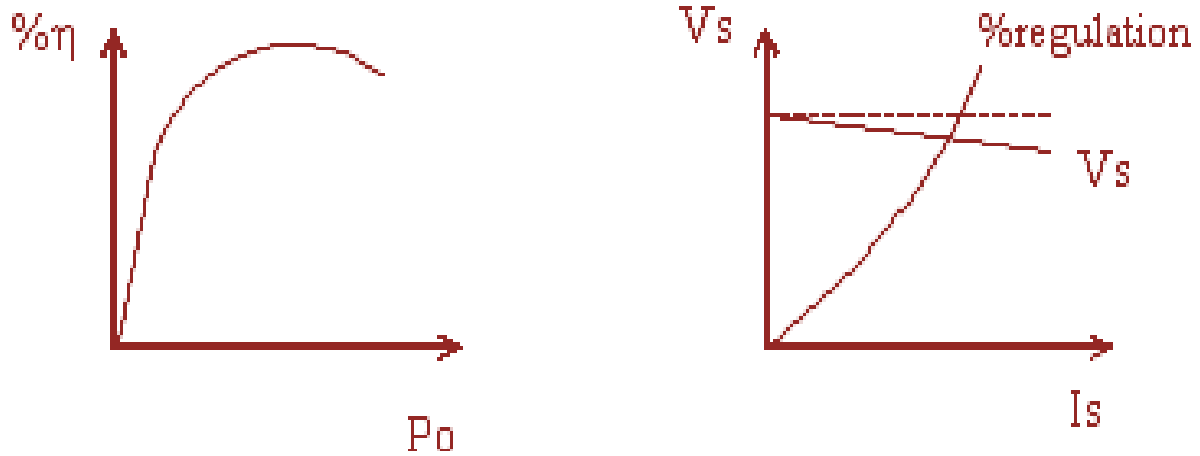
CIRCUIT DIAGRAM:



Note: - Where V R L is Variable resistive load.

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:**RESULT:**

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

Discussion of Results:

- Students will be able to discuss the effect of load on a single phase transformer's efficiency as well as regulation.