QMP 7.1 D/F

Channabasaveshwara Institute of Technology

(An ISO 9001:2008 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Electrical & Electronics Engineering

ELECTRICAL MACHINES LABORATORY – 2

Lab Manual

15EEL47

B.E - IV Semester

2016-17

Name: ____

USN: ____

Batch: ____________________Section: _________________

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Lab Manual

Version 1.0

Feb 2017

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SYLLABUS

ELECTRICAL MACHINES LABORATORY – 2

Sub Code: 15EEL47	**IA Marks: 20**
Hrs/week: 03	**Exam Hours: 03**
Total Hours: 42	**Exam Marks: 80**

1. Load test on dc shunt motor to draw speed – torque and horse power – efficiency characteristics.
2. Field Test on dc series machines.
3. Speed control of dc shunt motor by armature and field control.
4. Swinburne's Test on dc motor.
5. Retardation test on dc shunt motor.
6. Regenerative test on dc shunt machines.
7. Load test on three phase induction motor.
8. No load and Blocked rotor test on three phase induction motor to draw (i) equivalent circuit and (ii) circle diagram. Determination of performance parameters at different load conditions from (i) and (ii).
9. Load test on induction generator.
10. Load test on single phase induction motor to draw output versus torque, current, power and efficiency characteristics.
11. Conduct suitable tests to draw the equivalent circuit of single phase induction motor and determine performance parameters.
12. Conduct an experiment to draw V and Λ curves of synchronous motor at no load and load conditions.

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Sl. No	Name of the Experiment	Date			Manual Marks (Max . 20)	Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
Average								

Note:

- **If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the manual/observation and record will be evaluated for 50% of maximum marks.**

Course objectives & outcomes

Course objectives:

1. To perform tests on dc machines to determine their characteristics.
2. To control the speed of dc motor
3. To conduct test for pre-determination of the performance characteristics of dc machines
4. To conduct load test on single phase and three phase induction motor.
5. To conduct test on induction motor to determine the performance characteristics
6. To conduct test on synchronous motor to draw the performance curves.

Course outcomes:

At the end of the course the student will be able to:

1. Test dc machines to determine their characteristics.
2. Control the speed of dc motor
3. Pre-determine the performance characteristics of dc machines by conducting suitable tests.
4. Perform load test on single phase and three phase induction motor to assess its performance.
5. Conduct test on induction motor to pre-determine the performance characteristics
6. Conduct test on synchronous motor to draw the performance curves.

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OUR VISION

To create centers of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership.

OUR MISSION

- To provide high quality technical and professionally relevant education in a diverse learning environment.
- To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.
- To prepare the next generation of skilled professionals to successfully compete in the diverse global market.
- To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.
- To offer a wide variety of off-campus education and training programmes to individuals and groups.
- To stimulate collaborative efforts with industry, universities, government and professional societies.
- To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION:

To be a department of excellence in electrical and electronics Engineering education and Research, thereby to provide technically competent and ethical professionals to serve the society.

MISSION:

- To provide high quality technical and professionally relevant education in the field of electrical engineering.
- To prepare the next generation of electrically skilled professionals to successfully compete in the diverse global market.
- To nurture their creative ideas through research activities.
- To promote research and development in electrical technology and management for the benefit of the society.
- To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals in electrical sector.

Caution

1. *Do not play with electricity.*

2. *Carelessness not only destroys the valuable equipment in the lab but also costs your life.*

3. *Mere conductivity of the experiment without a clear knowledge of the theory is of no value.*

4. *Before you close a switch, think of the consequences.*

5. *Do not close the switch until the faculty in charge checks the circuit.*

‘General Instructions to Students’

1. Students should come with thorough preparation for the experiment to be conducted.

2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.

3. Name plate details including the serial number of the machine used for the experiment should be invariably recorded.

4. Experiment should be started only after the staff-in-charge has checked the circuit diagram.

5. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.

6. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.

7. Practical record should be neatly maintained.

8. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.

9. Theory regarding each experiment should be written in the practical record before procedure in your own words.

10. Come prepared to the lab with relevant theory about the Experiment you are conducting.

11. While using Electrolytic capacitors, connect them in the right polarity.

12. Before doing the circuit connection, check the active components, equipments etc, for their good working condition.

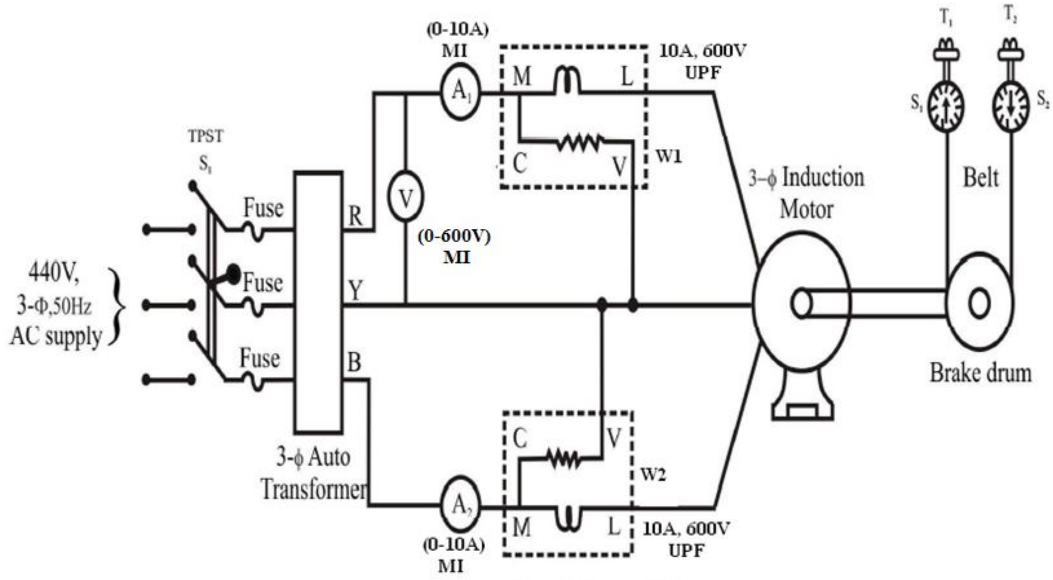
13. Do not use the multimeter, if the battery indication is low.

CONTENTS

First Cycle Experiments

Second Cycle Experiments

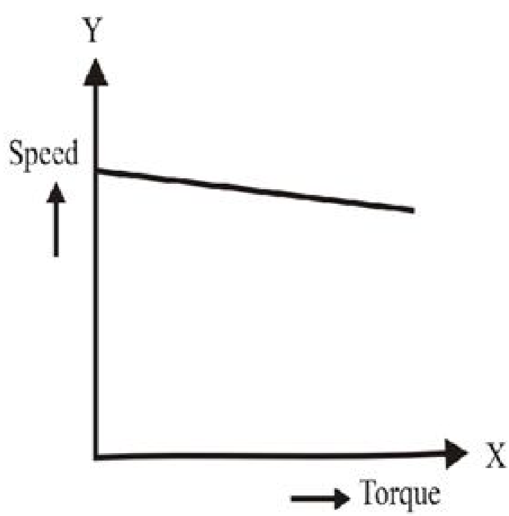
CIRCUIT DIAGRAM:

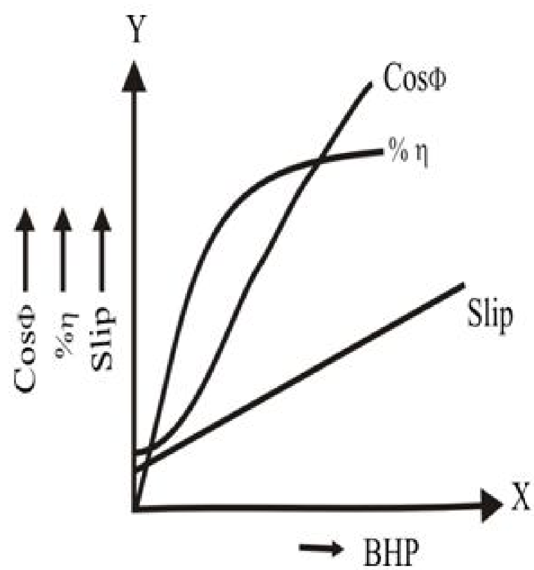


Circuit Diagram (1.a)
LOAD TEST ON 3-Φ INDUCTION MOTOR

Name Plate Details	
KW	
Volt	
Amp	
RPM	

MODEL GRAPH:





Experiment No. 1 Date: __/__/_____

LOAD TEST ON 3-Φ INDUCTION MOTOR

AIM: To conduct load test on three-phase induction motor and plot the following characteristics.
i) BHP V/S slip ii) BHP V/S η
iii) BHP V/S pf iv) Torque V/S speed.

APPARATUS REQUIRED:

Sl. No	Particulars	Range	Type	Quantity
01.	Voltmeter	0-600V	MI	01
02.	Ammeter	0-10A	MI	02
03.	Wattmeter	10A, 600V	UPF	02
04.	Tachometer	--	Contact Type	01

PROCEDURE:

1. Connections are made as shown in the circuit diagram (1.a)
2. Measure and notedown the circumference of brake drum by using cotton thread.
3. Spring balances S_1 and S_2 are kept in zero out-put position by operating the adjustment wheels T_1 and T_2.
4. By keeping the 3-Φ auto-transformer voltage in zero out-put position, the supply switch (S_1) is closed.
5. Vary the auto-transformer voltage gradually and apply the rated voltage of induction motor. [say 415V]
6. The no-load readings of all the meters and speed are noted down.
7. The Induction motor is loaded gradually by tightening the belt till the rated current. At each load all the meter readings and speed are noted down.
8. To stop the motor, the load is removed (belt is loosened), the 3-Φ auto-transformer voltage is reduced to its initial zero out-put position, the supply switch (S_1) is opened.

TABULAR COLUMN:

V_L = ________ Volts

Sl. No.	A_1 (Amps)	A_2 (Amps)	$I_L = \frac{A_1 + A_2}{2}$	W_1 (Watt)	W_2 (Watt)	Input (W_1+W_2) (Watt)	CosΦ	S_1 Kg	S_2 Kg	$S_1 \sim S_2$	N Speed (rpm)	T Torque (Kg-m)	BHP	Output (Watt)	Slip	η%

CALCULATION:

Circumference of the brake drum = _______ cm = ________m

Radius of the brake drum = r = $\frac{\text{Circumference of the brake drum}}{2\pi}$ = ________meters

Torque (T) = (S_1 ~ S_2) * r = ___________Kg-m

BHP = $\frac{2\pi NT}{4500}$ =

Output in Watts = BHP × 735.5

Input in Watts = (W_1 + W_2)

Therefore %Efficiency (ŋ) = $\frac{\text{OutPut}}{\text{Input}} \times 100$ **=**

Cos Φ = $\frac{W_1 + W_2}{\sqrt{3}.V_L.I_L}$

Slip = $\frac{(N_S - N)}{N_S}$

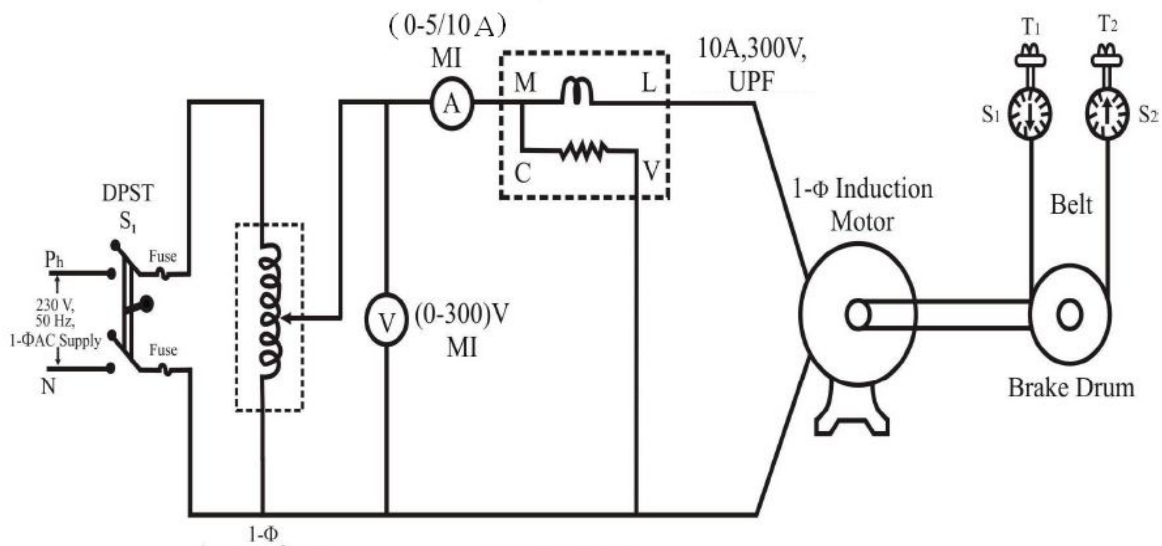
Ns = $\frac{120f}{P}$ Where P = No. of poles

NOTE: W_1 = (k_1 × Watt Meter Reading.) Where, $k_1 = \frac{(V_{sel} \times I_{sel} \times \text{Cos}\,\phi)}{\text{Full Scale Deflection}}$

W_2 = (k_2 × Watt Meter Reading.) Where, $k_2 = \frac{(V_{sel} \times I_{sel} \times \text{Cos}\,\phi)}{\text{Full Scale Deflection}}$

Signature of Staff-incharge

CIRCUIT DIAGRAM:



Circuit Diagram (2.a)
LOAD TEST ON 1-Φ INDUCTION MOTOR

Name Plate Details	
KW	
Volt	
Amp	
RPM	

TABULAR COLUMN:

Sl. No.	V (Volts)	A (Amps)	W (Watt)	S_1 Kg	S_2 Kg	$(S_1 \sim S_2)$ Kg	N Speed (rpm)	T Torque (Kg-m)	BHP	Output (Watt)	Slip	%η

NOTE: 1) W = (k × Watt Meter Reading.) Where, $k = \frac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

Experiment No. 2 **Date: __/__/_____**

LOAD TEST ON 1-Φ INDUCTION MOTOR

AIM:

To conduct load test on a given 1-Φ induction motor and plot the following characteristics. i) BHP V/S slip ii) BHP V/S η iii) BHP V/S pf iv) Torque V/S speed.

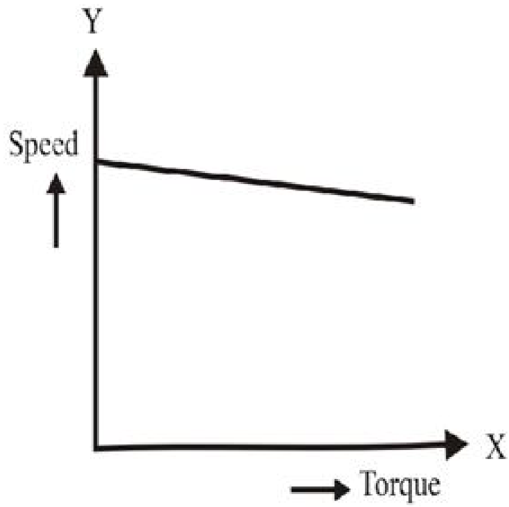
APPARATUS REQUIRED:

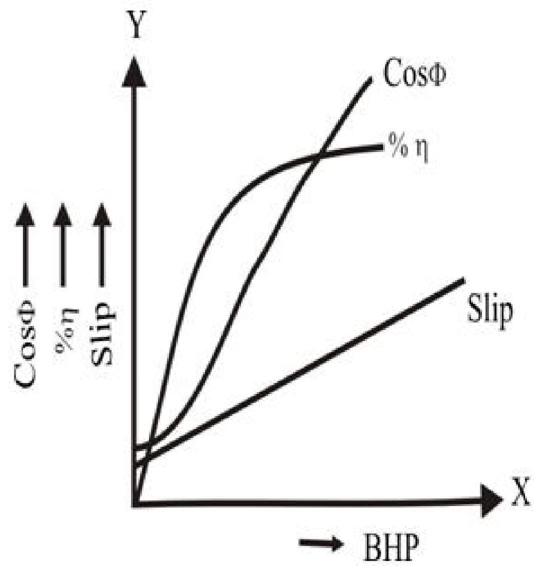
Sl. No	Particulars	Range	Type	Quantity
01.	Voltmeter	0-300V	MI	01
02.	Ammeter	0-5/10A	MI	01
03.	Wattmeter	10A, 300V	UPF	01
04.	Tachometer	--	Contact Type	01

PROCEDURE:

1. Connections are made as shown in the circuit diagram (2.a)
2. Measure and notedown the circumference of brake drum by using cotton thread.
3. Spring balances S_1 and S_2 are kept in zero out-put position by operating the adjustment wheels T_1 and T_2.
4. By keeping the auto-transformer voltage in zero out-put position, the supply switch (S_1) is closed.
5. Vary the auto-transformer voltage gradually and apply the rated voltage of induction motor. [say 230V]
6. The no-load readings of all the meters and speed are noted down.
7. The Induction motor is loaded gradually by tightening the belt till the rated current. At each load all the meters and speed readings are noted down.
8. To stop the motor, the load is removed (belt is loosened), the auto-transformer voltage is reduced to its initial zero out-put position, the supply switch (S_1) is opened.

MODEL GRAPH:





CALCULATION:

Circumference of the brake drum = _______ cm = ________m

Radius of the brake drum (r) = $\frac{\text{circumference of the break drum}}{2\pi}$ = __________meters

Torque (T) = $(S_1 \sim S_2) * r$ = -------------------------------- Kg-m

BHP = $\frac{2\pi NT}{4500}$ =

Input in Watts = W

Output in Watts = BHP × 735.6

$\text{Cos}\Phi = \frac{W}{V \times I}$

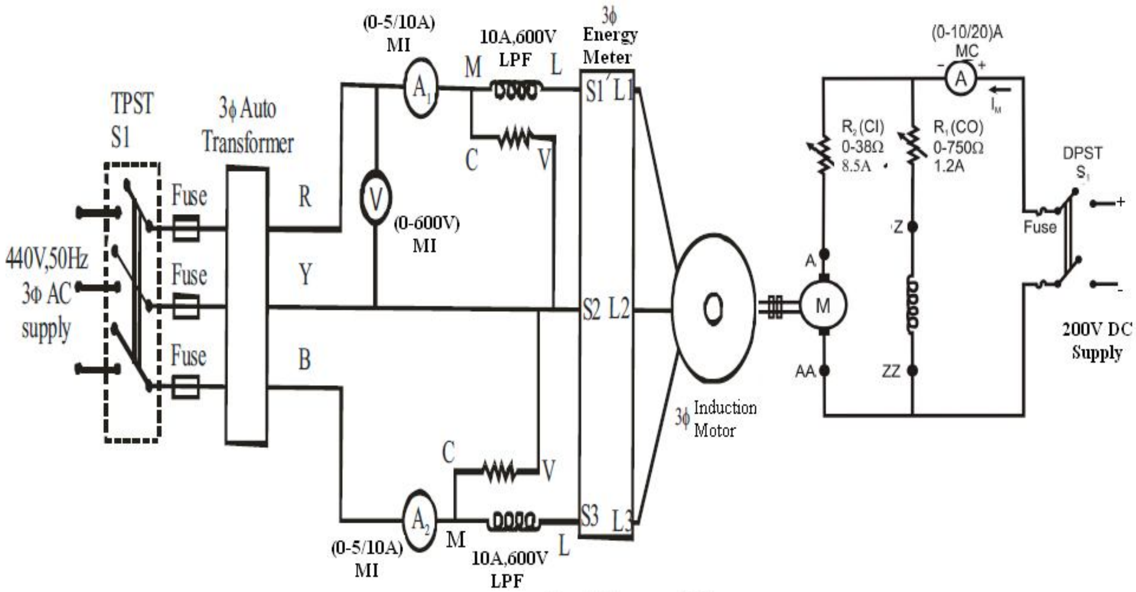
$\text{Slip} = \frac{(N_S - N)}{N_S}$

$N_s = \frac{120f}{P}$ Where P = No. of poles

Therefore; %Efficiency (ŋ) = $\frac{\text{OutPut}}{\text{Input}} \times 100$

Signature of Staff-incharge

CIRCUIT DIAGRAM:



Circuit Diagram (3.a)
LOAD TEST ON INDUCTION GENERATOR

Name Plate Details		
	MOTOR	GENERATOR
kW		
Volt		
Amp		
RPM		

TABULAR COLUMN:

Sl. No.	V_L (Volts)	I_L (Amps)	W_1 (Watt)	W_2 (Watt)	I_1 (Amps)	I_2 (Amps)	Output= W_1+W_2 (Watt)	Input= $V_L.I_L$ (Watt)	%η

Experiment No. 3 Date: __/__/_____

LOAD TEST ON INDUCTION GENERATOR

AIM:

To conduct load test on a given induction generator and to find its efficiency.

APPARATUS REQUIRED:

Sl. No	Particulars	Range	Type	Quantity
01.	Ammeter	(0-5)A	MC	01
02.	Ammeter	(0-5/10)A	MI	02
03.	Rheostat	0-750Ω,1.2A		01
04.	Wattmeter	10A, 600V	LPF	02
05.	Voltmeter	(0-600V)	MI	01
06.	Voltmeter	(0-250V)	MC	01

PROCEDURE:

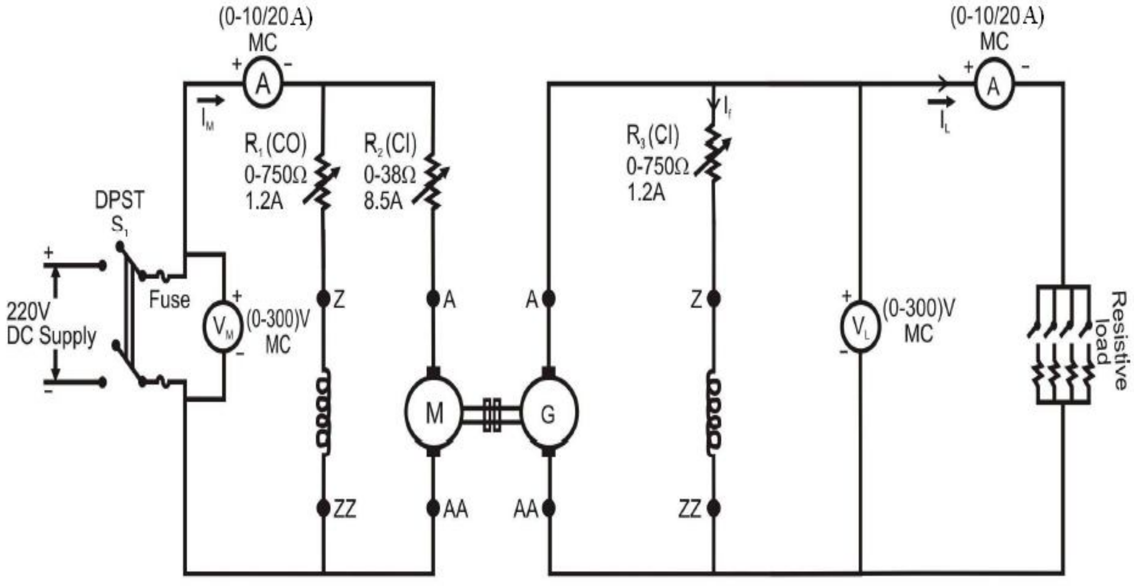
1. Connections are made as shown in the circuit diagram (3.a).
2. Close the 3-phase supply switch (S_1) and vary the 3-phase auto-transformer slowly by observing the rotation of induction motor up to 415V. if the rotation of induction motor is reverse i.e., opposite to the arrow mark as mentioned in induction motor, then bring the auto-transformer to zero position and change any two phase terminals.
3. Check the DC supply voltage and its polarity by using multimeter. Now slowly vary the Rheostat to cut-out position until the multimeter reads the D.C. supply voltage.
4. Now close the DC supply switch.
5. Vary the field excitation slowly by using the Rheostat (i.e., under excite) up to the stand-still rotation of energy meter. At this condition the Induction motor is floating on the bus bar.
6. Now slowly vary the rheostat (i.e., under excite) until the energy meter starts rotating in opposite direction. At this condition the Induction Motor is working as Induction Generator.
7. Note down all the meter readings by slowly varying the rheostat.
8. After taking the readings vary the rheostat until the rotation of energy meter comes to stand still position.
9. Now open the DC supply switch and bring back the rheostat to initial cut-in position and the 3-phase auto-transformer to zero position and then open the 3-phase supply switch (S_1).

NOTE: W = (k × Watt Meter Reading.) Where, k = $\frac{(V_{sel} \times I_{sel} \times \text{Cos}\,\phi)}{\text{Full Scale Deflection}}$

%Efficiency (ŋ) = $\frac{\text{OutPut}}{\text{Input}} \times 100$

Signature of Staff-incharge

CIRCUIT DIAGRAM:



Circuit Diagram (4.a)

LOAD TEST ON DC SHUNT MOTOR

Name Plate Details		
	MOTOR	GENERATOR
kW		
Volt		
Amp		
RPM		

Experiment No. 4 **Date: __/__/_____**

LOAD TEST ON A DC SHUNT MOTOR

AIM:

To conduct the load test on the given DC shunt motor and to plot the Following Characteristic curves - (1) Speed v/s BHP
(2) %η v/s BHP and
(3) Speed v/s Torque
(4) BHP v/s Torque

APPARATUS REQUIRED:

Sl. No	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V	MC	02
02	Ammeters	0-10/20 A	MC	02
03	Rheostats	0-750Ω, 1.2A 0-38 Ω,8.5A	- -	02 01
04	Tachometer	-	-	01

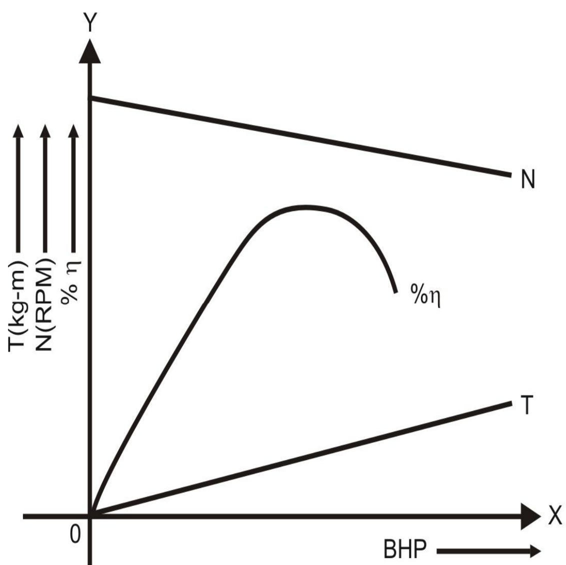
PROCEDURE:

1. Connections are made as shown in the circuit diagram (4.a).
2. Keeping the rheostat R_1 in the field circuit of motor in cut-out position, the rheostat R_2 in the armature circuit of the motor and the rheostat R_3 in the field circuit of the generator in cut-in positions and all load switches in off condition, the supply switch (S_1) is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. The generator voltage is built up to its rated value by gradually cutting out the rheostat R_3.
5. No load readings of all meters and speed are noted down.
6. The generator is loaded by gradually applying the loads. At each load, readings of all the meters and the speed are noted down.
7. The load on the generator is completely removed; all the rheostats are brought back to their respective initial positions and the supply switch (S_1) is opened.

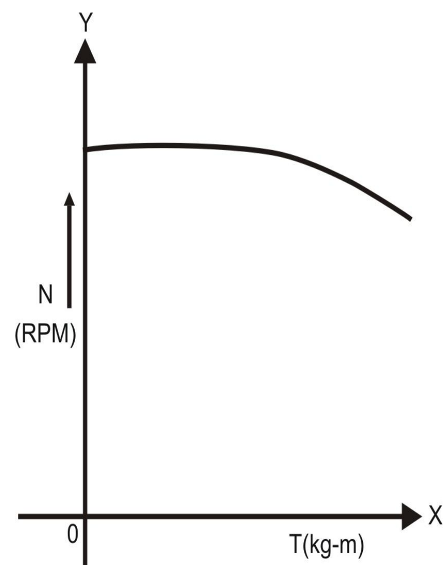
TABULAR COLUMN:

Sl. No	V_m (Volt)	I_m (Ampere)	V_L (Volt)	I_L (Ampere)	N (rpm)	Motor O/P (Watt)	BHP	%η	Torque (Kg-m)

MODEL GRAPHS



BHP v/s η,N,T



Torque v/s speed

CALCULATIONS:

Motor Input = $V_m \times I_m$ Watt

Motor Output = Generator Input Watt

Generator Output = $V_L \times I_L$ Watt

Assuming generator η as 0.85

Motor output = $(V_L \times I_L)/ 0.85$ Watt

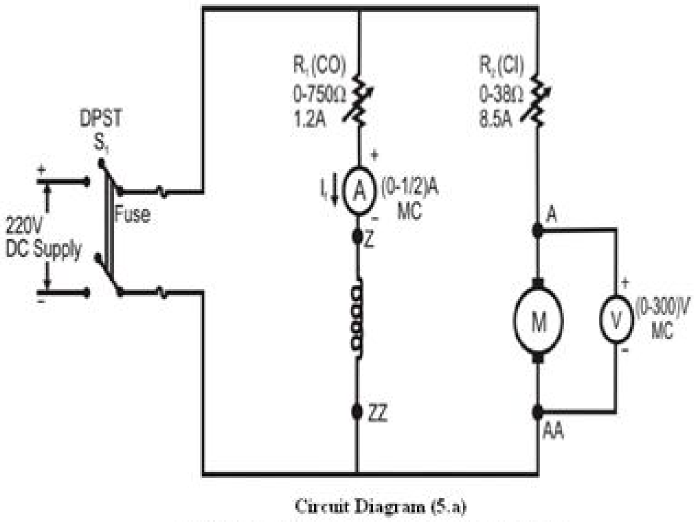
% η_{motor} = (Motor output in watt / motor input in watt) × 100

B.H.P = Motor output in watt / 735.5

Torque = (B.H.P × 4500) / 2 π N Kg-m

Signature of Staff-incharge

CIRCUIT DIAGRAM:



Circuit Diagram (5.a)

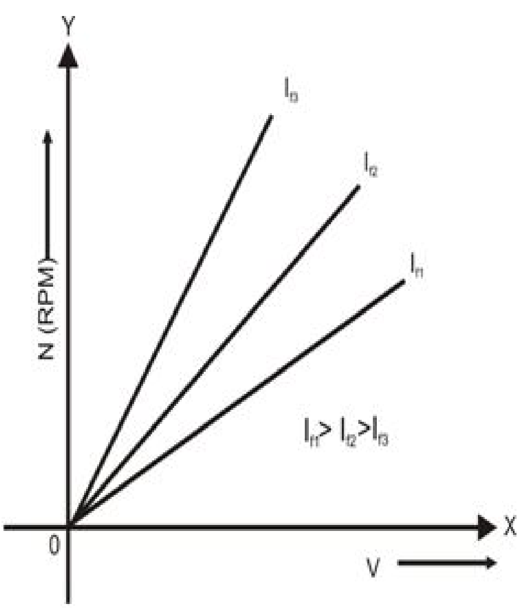
SPEED CONTROL OF DC SHUNT MOTOR

Name Plate Details

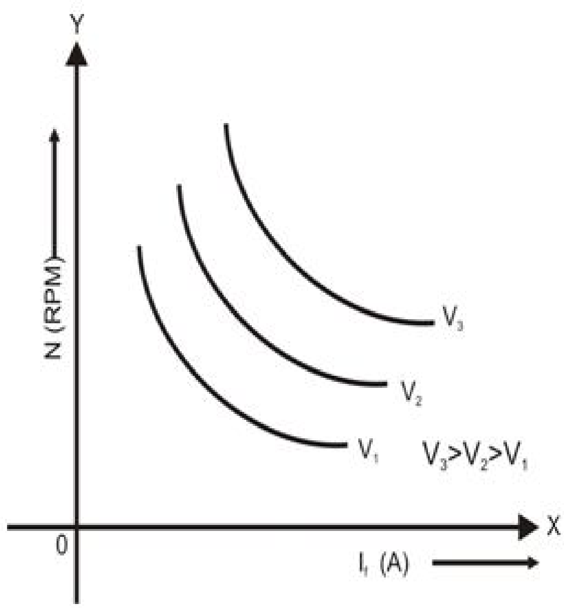
	Motor
Kw	
Volt	
Amp	
rpm	

MODEL GRAPHS

1. Armature Control Method



2. Flux Control Method



Experiment No. 5 **Date: __/__/_____**

SPEED CONTROL OF D.C SHUNT MOTOR

AIM:

To control the speed of D.C. Shunt motor by- (1) Armature control method
(2) Field Flux control method

APPARATUS REQUIRED:

Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeter	0-300V	MC	01
02	Ammeter	0-1/2A	MC	01
03	Rheostats	0-38 Ω,8.5A 0-750Ω,1.2A	-	01 01
04	Tachometer	-	-	01

PROCEDURE:

I. Armature Control Method

1. Connections are made as shown in the circuit diagram (5.a)
2. Keeping the rheostat R_1 in the field circuit of motor in cut-out position, the rheostat R_2 in the armature circuit of the motor in cut-in positions the supply switch (S_1) is closed.
3. Field current (I_f) is adjusted to a constant value by adjusting the rheostat R_1 and the rheostat R_2 is gradually cut-out in steps and at each step the readings of voltmeter and the speed are noted down.
4. The above procedure is repeated for another value of field currents.
5. All rheostats are brought back to their respective initial Positions and the supply switch (S_1) is opened

II. Field Flux Control Method

1. Keeping the rheostat R_1 in the field circuit of the motor in cut-out position, the rheostat R_2 in the armature circuit of the motor in cut-in position, the supply switch (S_1) is closed.
2. The rheostat R_2 is adjusted to get the required voltage across the armature
3. The rheostat R_1 is gradually brought to cut-in in steps and at each step the readings of ammeter and speed are noted down.
   [Note: The rheostat $R_1$is cut-in till the speed is little above the rated speed of Motor]
4. The experiment is repeated for another value of armature voltage.
5. All rheostats are brought back to their respective initial Positions and the supply switch (S_1) is opened.
6. The graphs are plotted as shown in model graphs (1 and 2).

TABULAR COLUMN:

1. Armature Control Method

I_f = ______Ampere (Constant)

Sl. No	Va Volts	Speed rpm

I_f= _______Ampere (Constant)

Sl. No	Va Volts	Speed rpm

2. Field Flux Control Method

Armature Voltage = ____Volt (Constant)

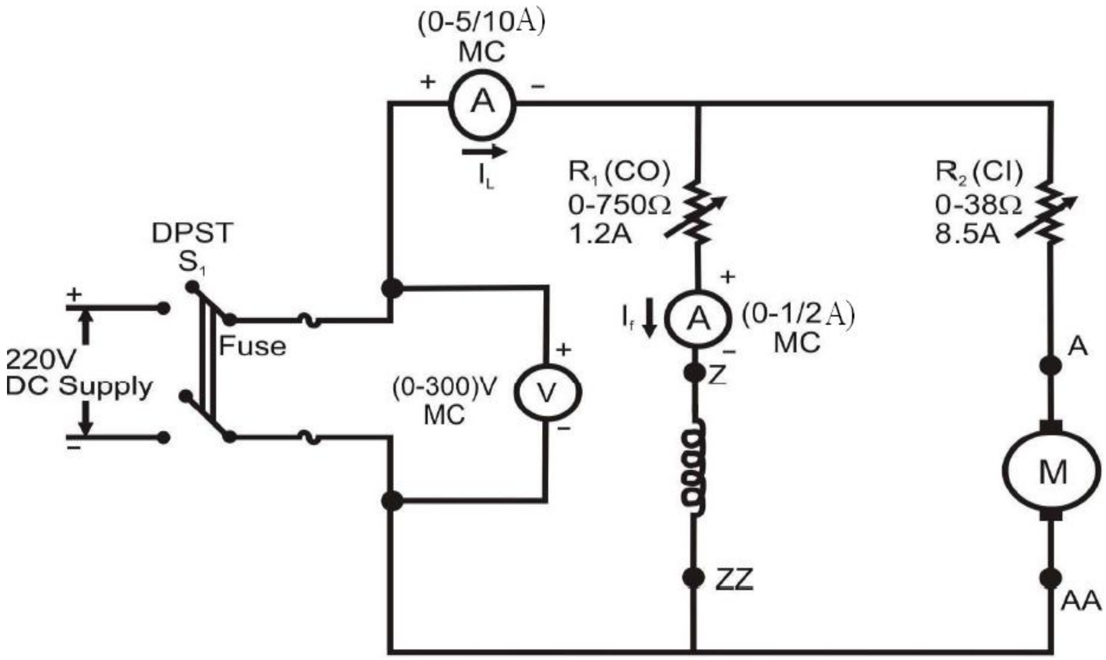
Sl. No	I_f Ampere	Speed rpm

Armature Voltage =____Volt (Constant)

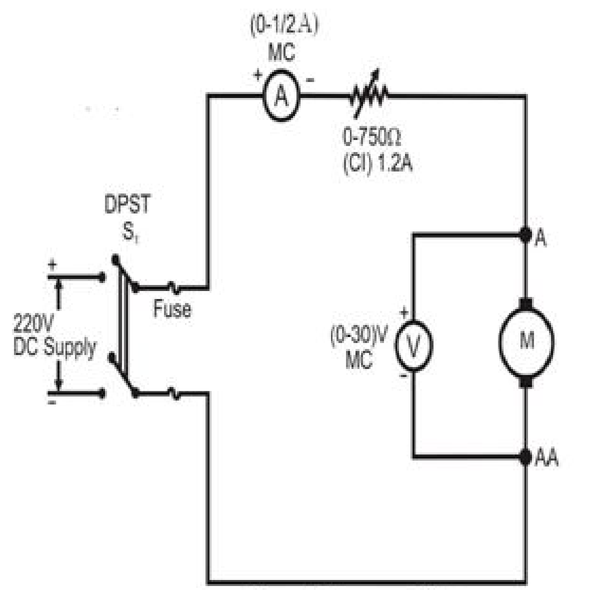
Sl. No	I_f Ampere	Speed rpm

Signature of Staff-incharge

CIRCUIT DIAGRAM:



CIRCUIT DIAGRAM (6.a)
SWINBURNE'S TEST



Circuit Diagram (6.b)
DETERMINATION OF ARMATURE RESISTANCE (Ra)

Name Plate Details

	Motor
Kw	
Volt	
Amp	
rpm	

Experiment No. 6 **Date: __/__/_____**

SWINBURNE'S TEST

AIM:

To determine the constant losses and hence to find the efficiency of a given DC Machine at any desired load.

APPARATUS REQUIRED:

Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V 0-30V	MC MC	01 01
02	Ammeters	0-5A 0-1/2A	MC MC	01 01
03	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	01 01
04	Tachometer	-	-	01

PROCEDURE:

1. Connections are made as shown in the circuit diagram (6.a).
2. Keeping the rheostat R_1 in the field circuit of motor in cut-out position, the rheostat R_2 in the armature circuit of the motor in cut-in positions the supply switch(S_1) is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and cutting in the rheostat R_1 if necessary.
4. Readings of all the meters and speed are noted down.
5. All the rheostats are brought back to their respective initial positions and the supply switch (S_1) is opened.
6. The graph of Efficiency v/s Load current is plotted as shown in Model Graph.

Determination of Armature Resistance (R_a) by V-I method:

a. Connections are made as shown in the circuit diagram(6.b)
b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
c. The supply switch (S_1) is opened.

TABULAR COLUMN:

Sl. No	V_L Volt	I_L Amp	I_f Amp

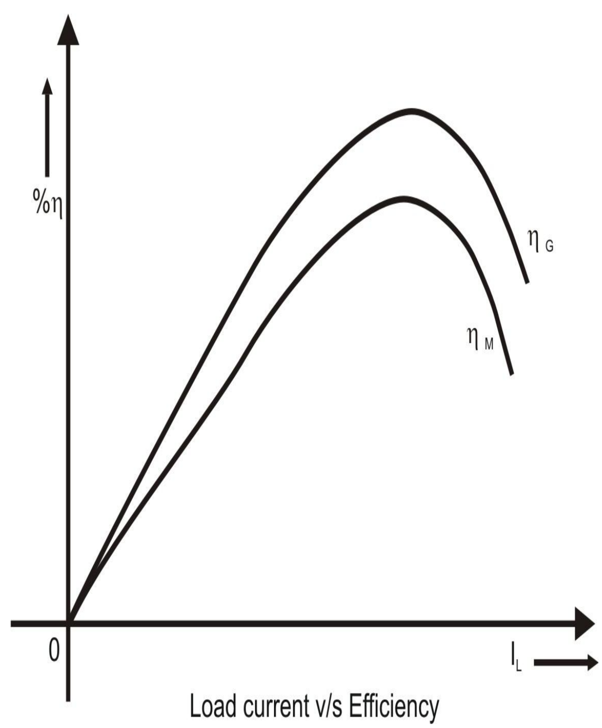
Determination of Armature Resistance (R_a):

Sl. No.	V (Volts)	I (Ampere)	Resistance Ra = V/I Ω

Tabulation of Results:

Sl. No.	Load (X)	% η_m	% η_g
1.	Full Load		
2.	¾ of F.L		
3.	½ of F.L		
4.	¼ of F.L		

MODEL GRAPH:



CALCULATION:

I_L = No-load motor current, Ampere

I_f = Field current, Ampere

V_L= No-load motor terminal voltage, Volt

i. No-load input power = $V_L \times I_L$ Watts
ii. Armature copper loss = $(I_L - I_f)^2 \times Ra$ Watts
iii. Constant losses, Wc = No load input power – armature Cu loss

I. Efficiency when working as a motor

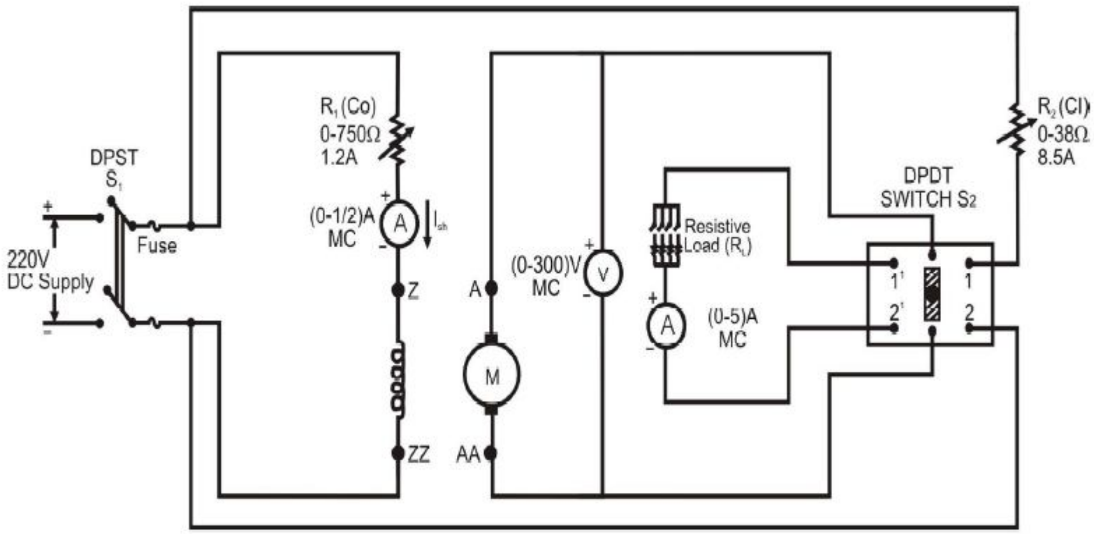
a. $I_a = (x.I_{FL} - I_f)$ Ampere
   Where x= (1, ¾, ½, ¼)
b. Armature copper loss = $(I_a)^2 \times R_a$ Watts = $(x.I_{FL} - I_f)^2 \times Ra$ Watts
c. Total losses = (Wc + armature copper loss) Watts
d. Input to the motor = $V_1 (x.I_{FL})$ Watts
   (V_1 is the rated voltage of the Motor)
e. Output of the motor = (Input - Total losses) Watts
f. $\%\eta$ = (Output / Input) × 100

II. Efficiency when working as a generator

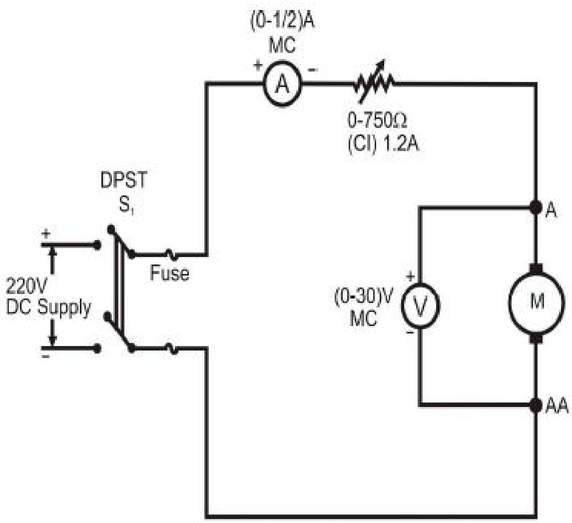
a. $I_{ag} = (xI_{FL} + I_f)$ Ampere
   Where x= (1, ¾, ½, ¼)
b. Armature copper loss = $(I_{ag})^2 \times R_a$ Watt = $(x.I_{FL} + I_f)^2 \times Ra$ Watts
c. Total losses = (Wc + armature copper loss) Watts
d. Output of generator = $V_1(x.I_{FL})$ Watts
   (V_1 is the rated voltage of the Generator)
e. Input to the generator = (Output + Total losses) Watts
f. $\%\eta_g$ = (Output / Input) × 100

Signature of Staff-incharge

CIRCUIT DIAGRAM:



Circuit Diagram (7.a)
RETARDATION TEST



Circuit Diagram (7.b)
Determination of Armature Resistance

Name Plate Details

	Motor
Kw	
Volt	
Amp	
rpm	

Determination of Armature Resistance (R_a):

Sl. No.	V (Volts)	I (Ampere)	Resistance Ra = V/I Ω

Experiment No. 7 **Date: __ / __ / _____**

RETARDATION TEST

AIM:

To determine the stray loss and hence to find the efficiency of the given D.C. shunt motor and Shunt generator.

APPARATUS REQUIRED:

Sl. No.	Particulars	Range	Type	Quantity
01.	Voltmeters	0-30V 0-300V	MC MC	01 01
02.	Ammeters	0-5A 0-1/2A	MC MC	01 01
03.	Rheostats	0-750Ω,1.2A 0-38Ω,8.5A	-	01 01
04.	Tachometer	-	-	01
05.	Stopwatch	-	-	01

PROCEDURE:

1. Connections are made as shown in the circuit diagram (7.a)
2. Keeping the rheostat R_1 in the field circuit of motor in cut-out position, the rheostat R_2 in the armature circuit of the motor in cut-in position, the load rheostat R_L in the armature circuit of motor in fixed position and the DPDT switch (S_2) in1-2 position, the supply switch (S_1) is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. Readings of Voltmeter (V_1) and Ammeter A_1 (I_{sh}) are noted down.
5. DPDT switch (S_2) is opened, time taken by the motor to reach zero speed is noted down (t_1 second) and the corresponding reading of voltmeter is (V_2).
6. Again the motor is brought to the rated speed as explained in step no.2 and 3.
7. DPDT switch (S_2) is opened and immediately thrown on to the position 1'-2' and at this instant; the reading of ammeter A (I_{L1}) is noted down.
8. Time taken by the motor to reach zero speed is noted down (t_2 second) and the corresponding reading of Ammeter is (I_{L2}).
9. All other rheostats are brought back to their respective initial positions, the DPDT switch (S_2) and supply switch (S_1) are opened.

Determination of Armature Resistance (R_a) by V-I Method:

a. Connections are made as shown in the circuit diagram (7.b)
b. Keeping the rheostat in cut-in position, the supply switch is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
c. The supply switch (S_1) is opened.

TABULAR COLUMN:

Sl. No.	V (Volts)	I (Ampere)	Resistance $R_a = V/I$ Ω

Sl. No	I_{sh} Amps	V_1 Volts	V_2 Volts	$V=(V_1+V_2)/2$ Volts	I_{L1} Amps	I_{L2} Amps	$I_L=(I_1+I_2)/2$ Amps	t_1 Sec	t_2 Sec

Calculation:

V_1 = Rated Voltage, Volt.

V_2 = Voltage after opening the DPDT switch and at the instant, of 5% reduction in speed, Volt.

Average Voltage across the load = $V = (V_1 + V_2) / 2$ Volt

I_{L1} = Load current at the instant when DPDT switch is along 1'-2', Ampere

I_{L2} = Load current at the instant of 5% reduction in speed, Ampere

$I_L = (I_1 + I_2) / 2$ Ampere

Total Input = $V_r I_r$ Watt

Power absorbed by the load resistance = $W_1 = VI_L$ Watt

Stray loss = $W_S = W_1 * [t_2 / (t_1 - t_2)]$ Watt

- Efficiency When Working as a Motor:

Aramature current $I_a = I_r - I_{sh}$ --------------------------------------(1)

Armature copper loss = $I_a^2 R_a$ Watt --------------------------------------(2)

Shunt field Copper loss = V I_{sh} Watt ---(3)

Total Losses = (1) + (2) + (3) Watt

Motor Output =Motor Input - Total Losses Watt

Motor efficiency = η_m = Motor Output / Motor Input *100

- Efficiency When Working as a Generator:

Generator Output = V_r I_r Watt --------------------------------------(4)

Armature copper loss = $I_a^2R_a$ Watt --------------------------------------(5)

Shunt field Copper loss = V I_{sh} Watt ---(6)

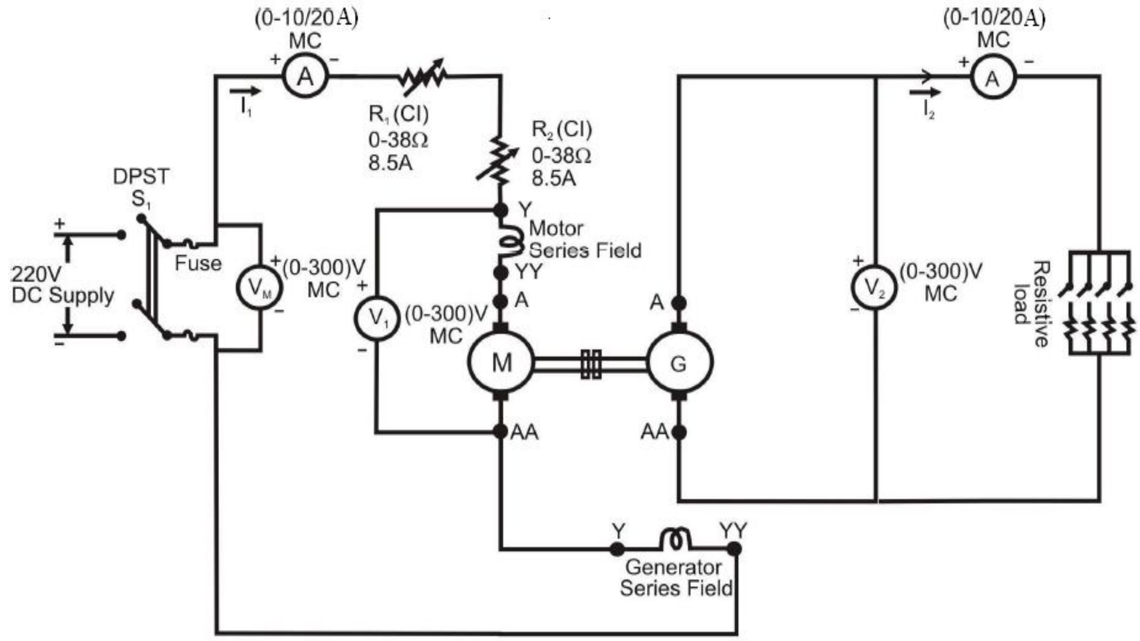
Total Losses = (4) + (5) + (6) Watt

Generator Input = Generator Output-+Total Losses Watt

Generator efficiency = η_m = Generator Output / Generator Input *100

Signature of Staff-incharge

CIRCUIT DIAGRAM:



CIRCUIT DIAGRAM (8.a)
FIELD TEST ON DC SERIES MOTOR

Name Plate Details

	Motor	Generator
Kw		
Volt		
Amp		
rpm		

Experiment No. 8 Date: __/__/_____

FIELD TEST ON DC SERIES MOTOR

AIM

To determine the stray loss and hence to find the efficiency of the given two identical DC series machines.

APPARATUS REQUIRED:

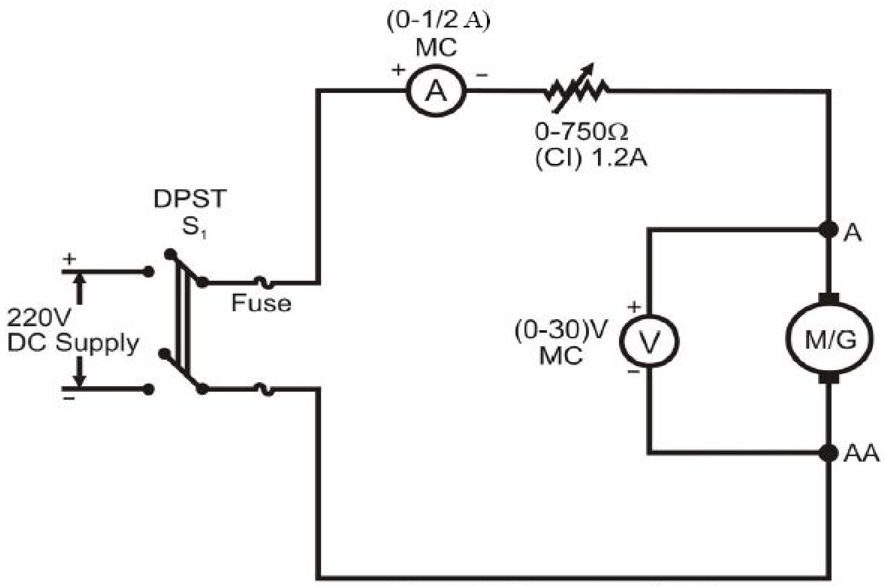
Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-300V 0-30V	MC MC	02 01
02	Ammeters	0-10/20 A 0-1/2 A	MC MC	02 02
03	Rheostats	0-38Ω,8.5A	-	02
04	Tachometer	-	-	01
05	Multi meter	-	-	01

PROCEDURE:

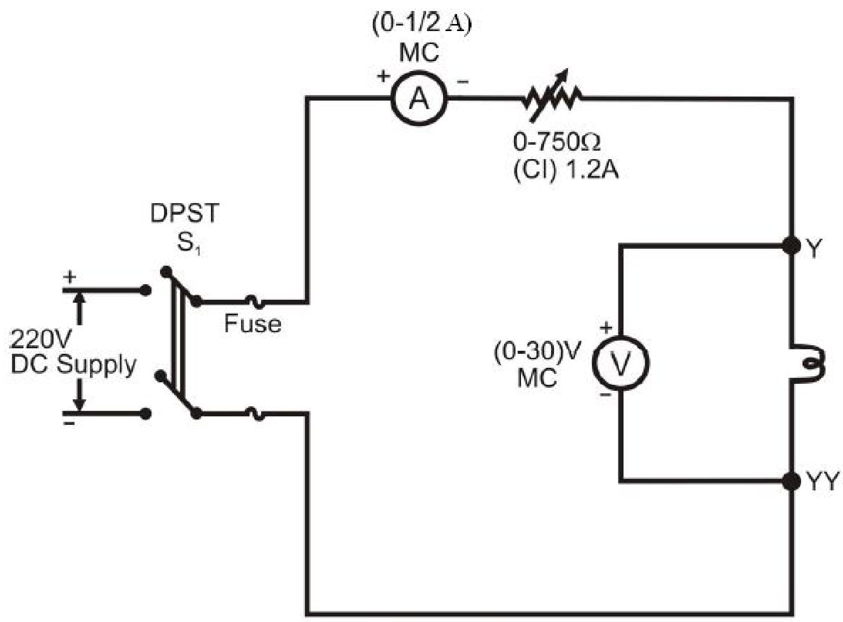
1. Connections are made as shown in the circuit diagram (8.a)
2. Keeping all the load switches in ON condition and the rheostat R_1 and R_2 are in cut-in position, the supply switch (S_1) is closed.
3. The rheostat R_1& R_2 are completely cut-out by simultaneously decreasing the load, till the machine acquires the rated current.
4. Measure the Voltage across Generator and Motor series field windings using Multi meter
5. The rheostat R_1& R_2 are brought back to their cut-in positions by simultaneously increasing the load if necessary and Switch (S_1) is opened

Determination of Armature Resistance (R_a) and Series Field Resistance (R_{se}) of Both Motor and Generator by V-I method.

a. Connections are made as shown in the circuit diagram (8.b)and (8.c)
b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
c. The supply switch (S_1) is opened



Circuit Diagram (8.b)
DETERMINATION OF ARMATURE RESISTANCE(Ra)



Circuit Diagram (8.c)
DETERMINATION OF SERIES FIELD RESISTANCE(R_{se})

TABULAR COLUMN

Sl.No.	V_M (Volts)	V_1 (Volts)	V_2 (Volts)	I_1 (Amps)	I_2 (Amps)

Determination of Armature Resistance (R_a)

Remarks	V (Volts)	I (Amps)	Ra =V/I Ω
Genetator			
Motor			

Determination of Series Field Resistance (R_{se})

Remarks	V (Volts)	I (Amps)	Rse =V/I Ω
Genetator			
Motor			

Tabulation of Results

Motor				Generator			
I/P (Watt)	Total Loss (Watt)	O/P (Watt)	%η	I/P (Watt)	Total Loss (Watt)	O/P (Watt)	%η

CALCULATION:

1. To find the stray loss

   Input to the whole set = $V_M I_1$ Watt

   Output of the Generator = $V_2 I_2$ Watt

   Total Losses of the set; P_T = Input – Output

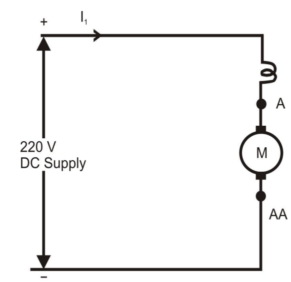
   Series field and Armature Copper losses of Motor = $I_1^2 (R_a + R_{se})$ Watt -----(1)

   Series field and Armature Copper losses of Generator = $I_1^2 R_{se} + I_2^2 R_a$ ...... (2)

   Total Copper Losses of the Set; P_c = (1) + (2) Watt

   Stray Loss of the Set; $W_s = P_T - P_C$ Watt

   Stray Loss of each Machine = $W_s / 2$ Watt



2. Determination of Motor efficiency

   Motor Input = $(x.V_1 I_1)$ Watt → I_1= rated current

   Where x= (1, ¾ , ½, ¼)

   Motor Losses = $(x.I_1^2 (R_a + R_{se}) + W_s / 2)$Watt

   Motor Output = $(x.V_1 I_1 - (x.I_1^2 (R_a + R_{se})) - W_s / 2)$ Watt

   $\%\eta_m$ = O/P / I/P ×100.

.

3. Determination of Generator efficiency

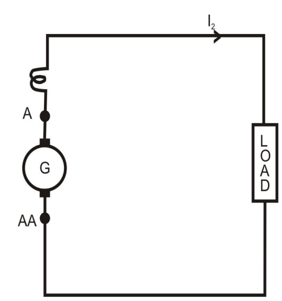
   Generator Output = $xV_r I_r$ Watt → I_r= rated current

   Where x= (1, ¾ , ½, ¼)

   Generator Losses = $x.I_2^2 R_a + I_1^2 R_{se} + (W_s / 2)$ Watt

   Generator Input = $(xV_2 I_2 + (x.I_1^2 R_{se}) + I_2^2 R_a + W_s / 2)$ Watt

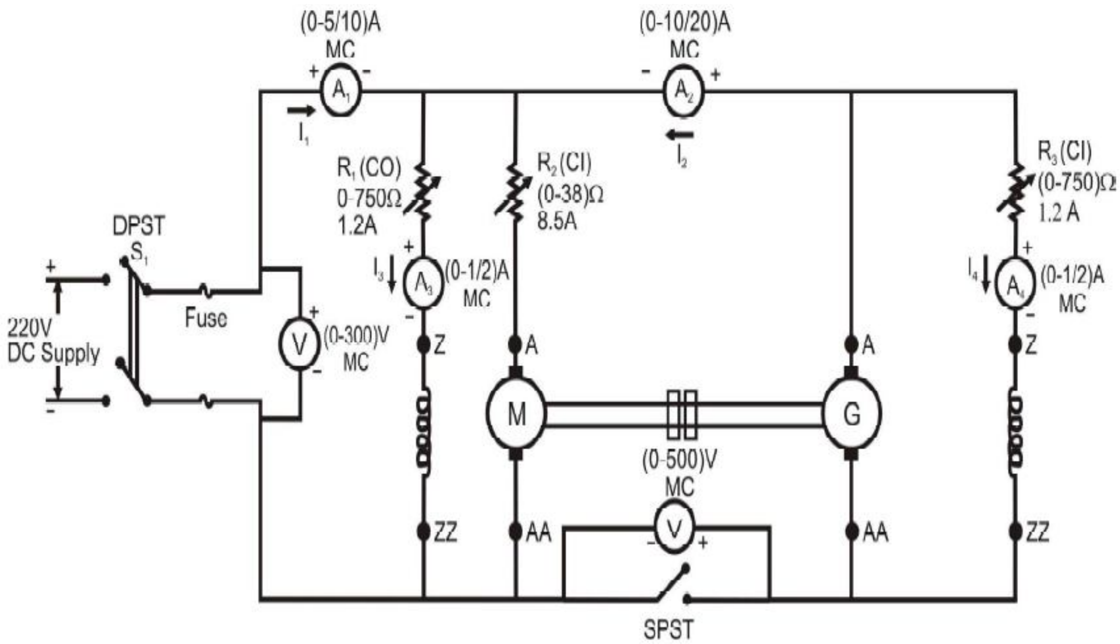
   $\%\eta_g = \frac{\text{output}}{\text{Input}} \times 100$



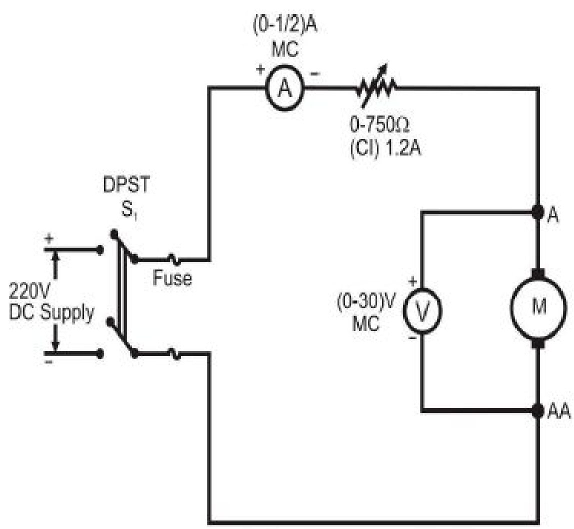
Calculation........

Signature of Staff-incharge

CIRCUIT DIAGRAM



Circuit Diagram (9.a)
REGERATIVE TEST



Circuit Diagram (9.b)
Determination of Armature Resistance

Name Plate Details

	Motor
Kw	
Volt	
Amp	
rpm	

Determination of Armature Resistance (R_a):

Sl.No	V (Volts)	I (Ampere)	Resistance Ra = V/I Ω

Experiment No. 9 **Date: __/__/_____**

REGENERATIVE TEST

AIM:

To determine the stray loss and hence to find the efficiency of the given two Identical DC Machines.

APPARATUS REQUIRED:

Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeters	0-500V 0-300V	MC MC	01 01
02	Ammeters	0-10/20A 0-1/2A 0-5/10 A	MC MC MC	01 02 01
03	Rheostats	0-750Ω,1.2A 0-38,8.5A	- -	02 01
04	Tachometer	-	-	01

PROCEDURE:

1. Connections are made as shown in the circuit diagram (9.a)
2. Keeping the rheostat R_1 in the field circuit of motor in cut-out position, the rheostat R_2 in the armature circuit of the motor and the rheostat R_3 in the field circuit of the generator in cut-in positions and the SPST switch in open position, the supply switch (S_1) is closed.
3. The motor is brought to its rated speed by cutting out the rheostat R_2 and then by cutting in the rheostat R_1, if necessary.
4. The excitation of the generator is increased gradually by cutting out the rheostat R_3, until the voltmeter connected across the SPST switch reads zero.
5. The SPST switch is closed. Now the generator is connected in parallel with the motor.
6. The generator is overexcited or the motor is under excited by varying their field rheostats. At I_2=rated current, the readings of all the meters are noted down.
7. The rheostat R_3 (if the motor is under excited vary the rheostat R_1) is brought to its initial position, then the SPST switch is opened, all other rheostats are brought back to their respective initial positions, and supply switch (S_1) is opened.

Determination of Armature Resistance (R_a) by V-I Method

a. Connections are made as shown in the circuit diagram (9.b)

b. Keeping the rheostat in cut-in position, the supply switch (S_1) is closed, Rheostat

is adjusted to any value of current (say 1A) and the readings of ammeter and Voltmeters are noted down.

c. The supply switch (S_1) is opened.

Tabular column					Stray Loss of Each M/C	MOTOR				GENERATOR			
V Volt	I_1 amp	I_2 Amp	I_3 Amp	I_4 Amp		I/P Watt	Total Loss Watt	O/P Watt	% Efficiency	I/P Watt	Total Loss Watt	O/P Watt	% efficiency

CALCULATIONS

I. To find stray losses of each machine

Armature copper loss of motor $= (I_1 + I_2 - I_3)^2 \times R_{am}$ Watt -----------------(1)

Field copper loss of motor $= V \times I_3$ Watt -----------------------------(2)

Armature copper loss of generator $= (I_2 + I_4)^2 \times R_{ag}$ Watt ----------------------(3)

Field copper loss of generator $= V \times I_4$ Watt -----------------------------(4)

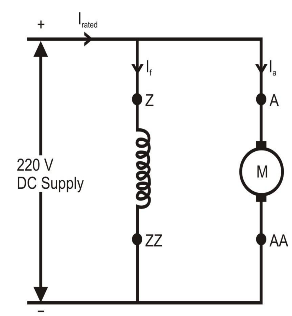
Total copper losses = (1) + (2) + (3) + (4)

Total I/P to the M-G set $= V \times I_1$ Watts

Stray losses for both machines $= W_s = [(V \times I_1)$ - Total copper losses] Watt

Therefore Stray loss for each M/C $= W_s / 2$ Watt

II. Efficiency when working as a motor



I/P to the motor $= V\,(x.\,I_{rated})$ Watt

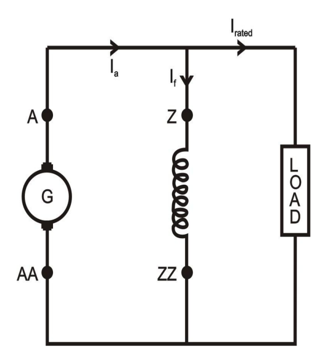
Where x = (1, 3/4, 1/2, 1/4)

Total losses $= (x.I_{rated} - I_3)^2 \times R_{am} + (V \times I_3) + (W_s / 2)$ Watt

O/P of motor = (I/P of motor – Total loss) Watt

$\%\eta_m$ = (output/ input) ×100

III. Efficiency when working as a generator



O/P of the generator $= V\,(x.\,I_{rated})$ Watt

Where x = (1, 3/4, 1/2, 1/4)

Total losses $= (x.\,I_{rated} + I_4)^2 \times R_{ag} + (V \times I_4) + (W_s / 2)$ Watt

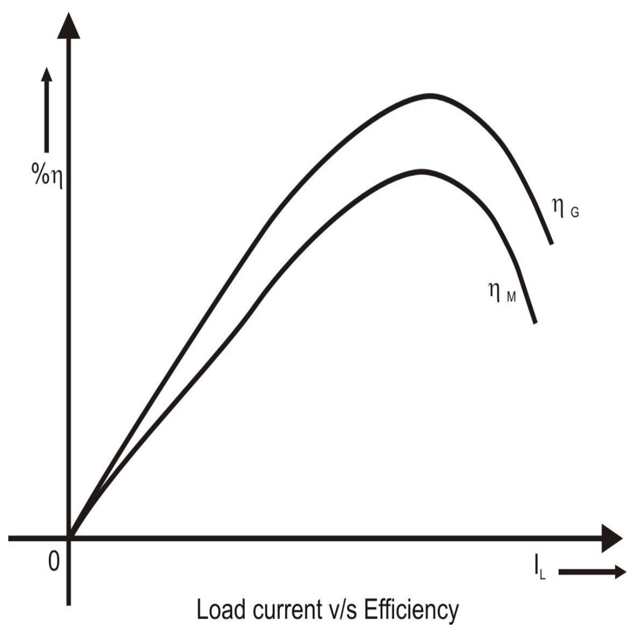
I/P to the generator = (O/P of the generator + Total losses) Watt

$\%\ \eta_g$ = (output / input) ×100

TABULAR COLUMN

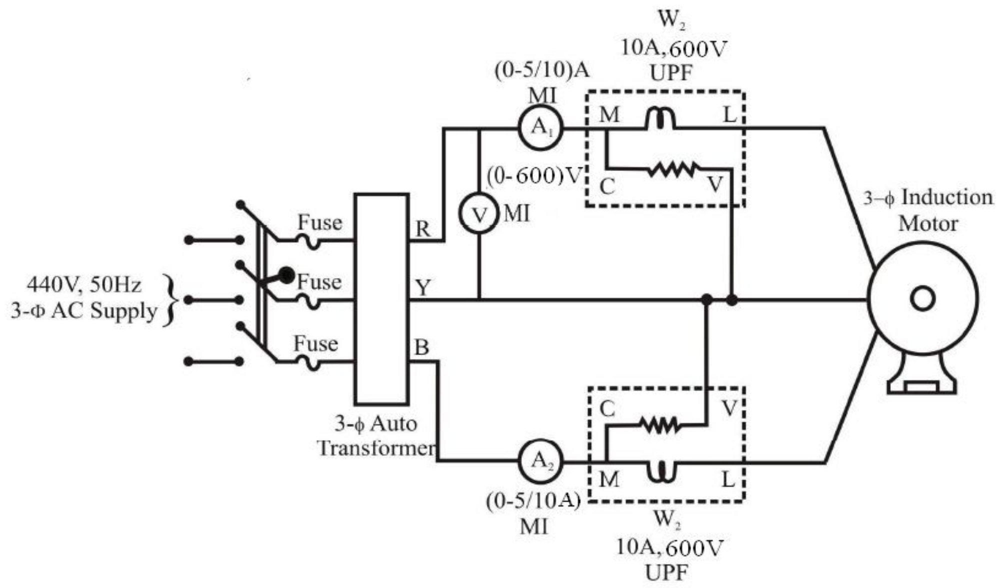
Sl. No	% η_g	% η_m

MODEL GRAPH



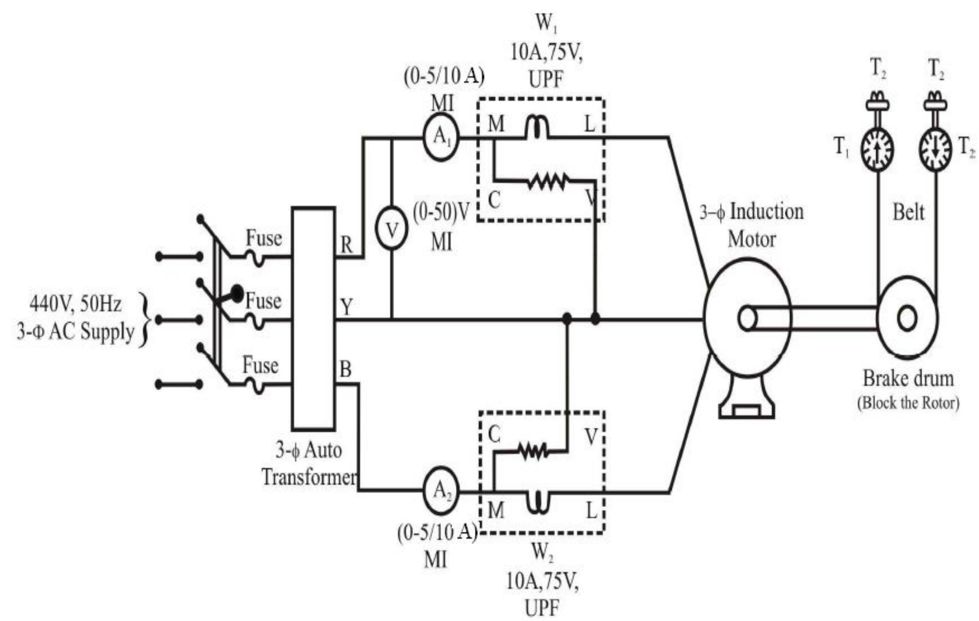
Signature of Staff-incharge

CIRCUIT DIAGRAM:



Circuit Diagram (10.a)

OPEN CIRCUIT TEST.



Circuit Diagram (10.b)

BLOCKED CIRCUIT TEST

Name Plate Details	
KW	
Volt	
Amp	
RPM	

Experiment No. 10 Date: __/__/_____

NO LOAD & BLOCKED ROTOR TEST ON 3-Φ INDUCTION MOTOR

AIM:

To conduct no-load and blocked rotor tests on a given 3-Φ induction motor to draw the circle diagram and equivalent circuit

APPARATUS REQUIRED:

Sl. No	Particulars.	Range	Type	Quantity
01.	Voltmeter	0-500V 0-50V	MI MI	01 01
02.	Ammeter	0-5/10A	MI	02
03	Wattmeter	10A,500V	UPF	02
		10A,75V	UPF	02

PROCEDURE:

1) OPEN CIRCUIT TEST.

1. Connections are made as shown in the circuit diagram (10.a).
2. Keeping the 3-Φ auto-transformer voltage in zero out-put position, the supply switch (S_1) is closed.
3. By varying the 3-Φ auto-transformer, the rated voltage of 3-Φ induction motor is applied. All the meter readings are noted down.
4. To stop the motor, the 3-Φ auto-transformer is brought back to its initial zero out-put position, the supply switch (S_1) is opened.

2. BLOCKED ROTOR TEST.

1. Connections are made as shown in the circuit diagram (10.b).
2. The brake-drum of the induction motor is blocked from rotation by tightening the belt.
3. By keeping the 3-Φ auto-transformer voltage in zero out-put position, the supply switch (S_1) is closed.
4. By operating the 3-Φ auto-transformer very slowly, a low voltage is applied, such that the rated current of the induction motor flows in the stator winding. All the meter readings are noted down.
5. To stop the motor, the 3-Φ auto-transformer is brought back to its initial zero out-put position, loosened the belts of brake drum, then open the supply switch (S_1).

TABULAR COLUMN:

1. OPEN-CIRCUIT TEST.

Sl. No.	V_0 (Volts)	A_1 (Amps)	A_2 (Amps)	$I_0=(A_1+A_2)/2$ (Amps)	W_1 (Watt)	W_2 (Watt)	$W_0=(W_1+W_2)$ (Watt)

NOTE: 1 W_1 = (k_1 × Watt Meter Reading.) Where, $k_1 = \frac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

W_2 = (k_1 × Watt Meter Reading.) Where, $k_2 = \frac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

2. SHORT-CIRCUIT TEST.

Sl. No.	V_{SC} (Volts)	A_1 (Amps)	A_2 (Amps)	$I_{SC}=(A_1+A_2)/2$ (Amps)	W_1 (Watt)	W_2 (Watt)	$W_{SC}=(W_1+W_2)$ (Watt)

NOTE: W_1 = (k_1 × Watt Meter Reading.) Where, $k_1 = \frac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

W_2 = (k_2 × Watt Meter Reading.) Where, $k_2 = \frac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

CONSTRUCTION OF CIRCLE DIAGRAM:

1. Proper scale (I e 1 cm = _________ Amps) is selected.
2. Vector OO' Representing the no-load current I_0 is drawn at an angle Φ_0 with respect to Y-axis.
3. At point O', a line O'X' is drawn parallel to X- axis.
4. Vector OA representing I_{SN} is drawn at an angle Φ_{SC} with respect to Y-axis.
5. Vector O'A is joined, which represents the out-put line.
6. The out-put line O'A is bisected as follows;
   a) With O' as center, radius more than half of O'A, draw an arc on either side of O'A.
   b) Similarly with A as center and same radius an arc is drawn on either side of O'A.
   c) The intersections of the arcs on either side of O’A are joined. This line gives the perpendicular bisector.
7. Let the perpendicular bisector cuts the horizontal through O'X’ at point C.
8. With C as center O'C as radius, a semi circle is drawn, which passes through point A.
9. From point A, a perpendicular line AB is drawn to X-axis, thus the vertical line AB represents power I/P at short circuit ie W_{SN}.
10. Power scale = $\dfrac{W_{SN}}{\text{AB in Cm}}$ Watt/cm.
11. Now point D is located on AB, such that (To draw torque line)

$$\frac{\text{Rotor Copper Loss}}{\text{Stator Copper Loss}} = 1$$

12. OD is joined which represents torque line.

    Now, AD = Rotor copper loss, Watt

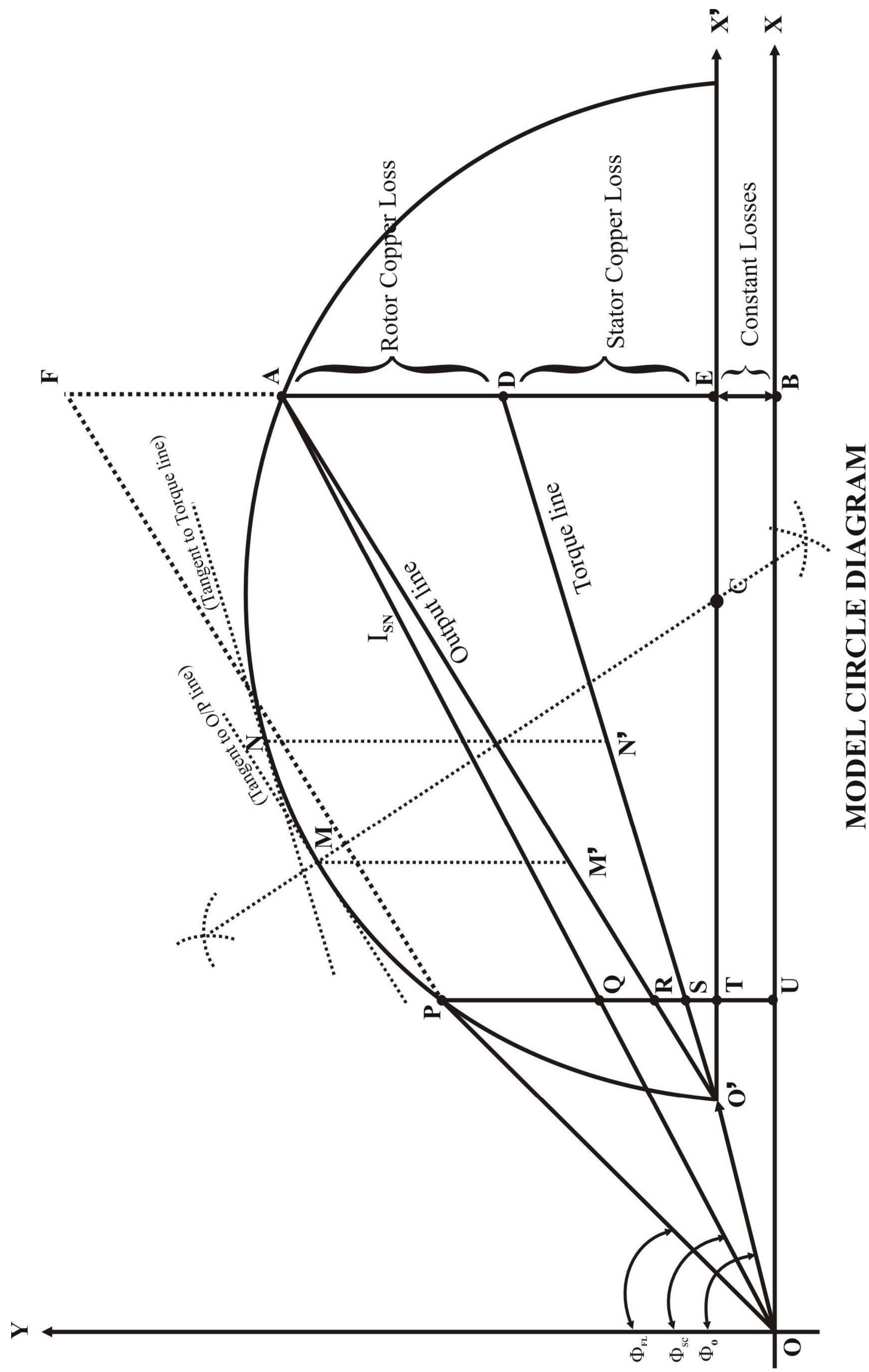
    DE = Stator copper loss, Watt

    EB = Constant loss, Watt
13. Determination of operating point at rated HP:
14. Out-put of motor = HP$\times$735.5 Watt.
15. Point F is located on AB extended such that

    AF = $\dfrac{\text{HP}\times 735.5}{\text{Power Scale}}$

16. At point F a parallel line is drawn to the out-put line, which meets the semi-circle at point P.
17. At point P a perpendicular line to X-axis is drawn cutting the out-put and torque lines at R and S.

18. OP represents the full load current.



CALCULATION:

a) No-Load power factor:

$$\text{Cos}\,\Phi_0 = \frac{(W_0)}{\sqrt{3}\times V_0 \times I_0} = \_\_\_\_\_\_\_\_\_\_$$

$$\text{Therefore}\quad \Phi_0 = \text{Cos}^{!}\left(\frac{(W_0)}{\sqrt{3}\times V_0 \times I_0}\right) = \_\_\_\_\_\_\_\_\_\_\_\_$$

b) Power factor at short-circuit condition:

$$\text{Cos}\,\Phi_{SC} = \frac{(W_{SC})}{\sqrt{3}.V_{SC}.I_{SC}} = \_\_\_\_\_\_\_\_\_\_\_\_$$

$$\text{Therefore}\quad \Phi_{SC} = \text{Cos}^{!}\left(\frac{(W_{SC})}{\sqrt{3}.V_{SC}.I_{SC}}\right) = \_\_\_\_\_\_\_\_\_\_\_\_$$

c) Short-Circuit current corresponding to normal voltage:

$$I_{SN} = \frac{V_{[Rated]}}{V_{SC}}\times I_{SC} = \_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ Amps.}$$

d) Short-circuit input power corresponding to normal voltage:

$$W_{SN} = \left(\frac{V_{Rated}}{V_{SC}}\right)^2 \times W_{SC} = \_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ Watt.}$$

e) Power scale = $\frac{W_{SN}}{\text{AB in Cm}}$ = _____________ Watt/Cm.

Therefore; 1 Cm = _____________ Watt.

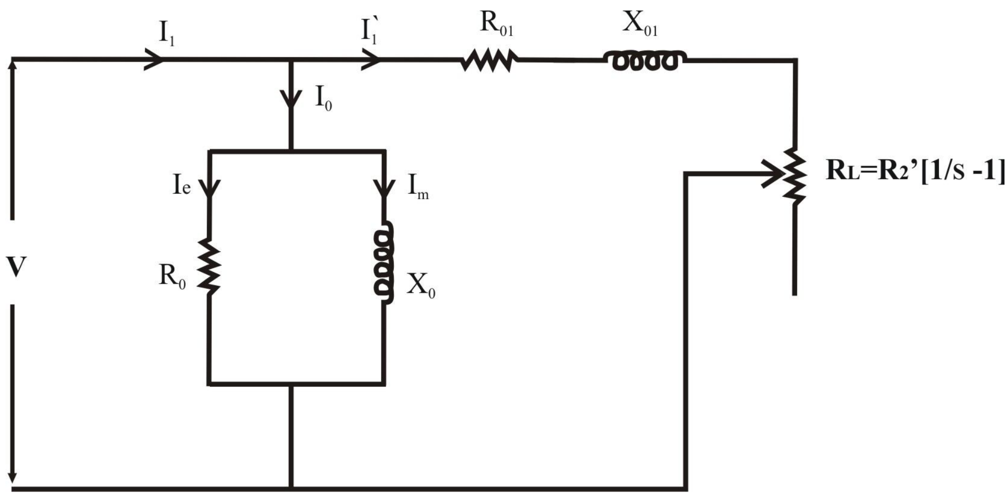
Calculation Using Circle Diagram:

1. Power factor at full load = Cos Φ_{FL}
2. Efficiency at full load = $\frac{PR}{PU}\times 100$
3. Slip at full load = $\frac{\text{Rotor Copper Loss}}{\text{Rotor Input}} = \frac{SR}{SP}$
4. Torque at full load = PS×Power Scale, Synchronous-Watt
5. Line Current = OP× Current Scale, Amps
6. Determination of maximum quantities;

   a. Maximum out-put:
   - Draw a tangent to the semi-circle parallel to the out-put line. This tangent touches the semi-circle at point M.
   - From point M, draw a vertical line cutting the out-put line at point M$^{!}$; MM$^{!}$ Represents the maximum out-put.
     Maximum out-put in Watt = M M$^{!}$ in cm × Power Scale.

   b) Maximum torque (rotor input):
   - Draw a tangent to the semi-circle parallel to the torque line. This tangent touches the semi-circle at point N.
   - From point N, draw a vertical line cutting the torque line at point N$^{!}$; NN$^{!}$ Represents the maximum torque.
     Maximum torque in Synchronous Watt = NN$^{!}$ In cm × Power Scale.

EQUIVALENT CIRCUIT:



CALCULATIONS:

$W_o = \sqrt{3}\, V_o I_o \cos \Phi_o$

$$\cos \Phi_o = \frac{(Wo)}{\sqrt{3} \times Vo \times Io} = \_\_\_\_\_\_\_\_\_\_$$

$Z_0 = V_o/\sqrt{3}I_o$

$R_0 = V_o/\sqrt{3}I_e$
$I_e = I_o \cos \Phi_o$
$I_m = I_o \sin \Phi_o$

$$X_0 = \frac{V}{\sqrt{3} \times I_m}\ \Omega$$

Calculations for blocked rotor test:

Short circuit power factor $\cos \Phi_{sc} = \dfrac{Wsc}{\sqrt{3} \times Vsc \times Isc}$

Input power on short circuit $P_s = 3\ I^2 R_{01}$ (I= Phase current)

Resistance per phase as referred to stator $R_{01} = \dfrac{Wsc}{3 \times I^2 sc}$

Motor equivalent impedance per phase as referred to stator

$Z_{01} = V_{sc}/\sqrt{3}I_{sc}$

Reactance per phase

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}\ \Omega$$

$R_2^1 = R_{01}$ (Assuming)

We consider $X_1 = X^i_2$ hence $X_1 = X^i_2 = X_{01}/2$

The efficiency of the induction motor can be calculated as
Power input = out put + losses
Losses = $W_o + 3\ I^2\ R_{o1}$
Power output = $3I^2.R_L$
I = Load current.

R_L = variable load resistance

$$\text{Efficiency} = \frac{\text{power output}}{\text{power input}} \times 100$$

$$= \frac{I_{sc}.R_L}{W_i} \times 100$$

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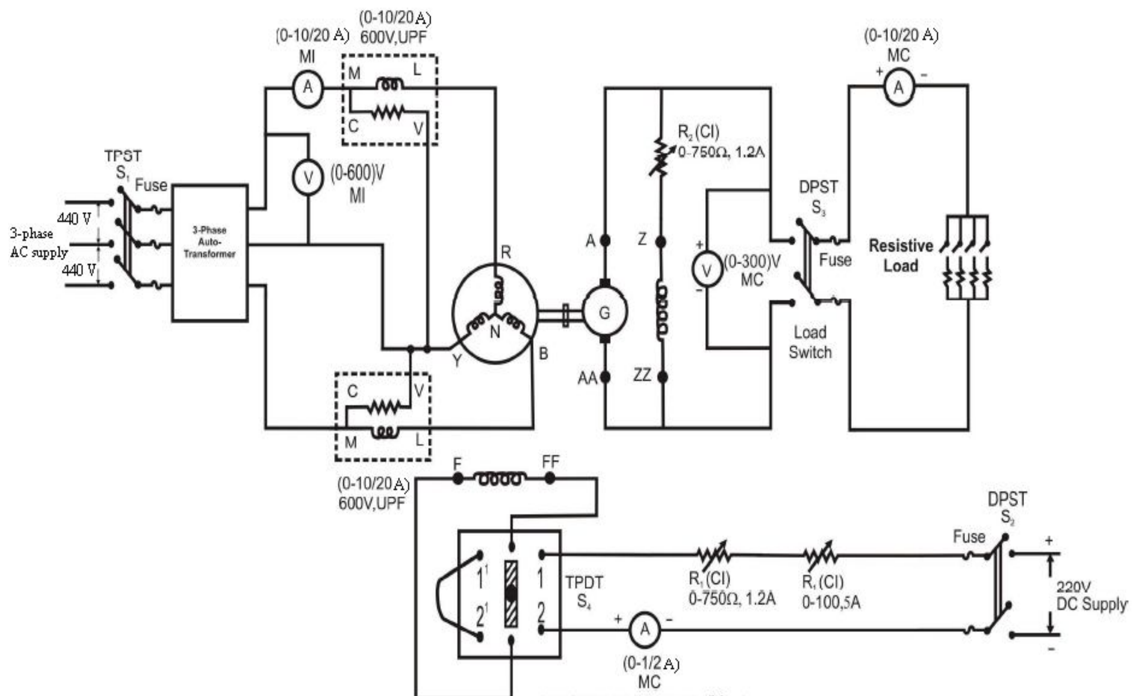
CIRCUIT DIAGRAM:



CIRCUIT DIAGRAM (12.a)
V AND INVERTED V CURVES

Name Plate Details

D.C. Shunt Generator	Synchronous Motor
Kw	HP
Volt	Phase
Amp	Hz
rpm	Volt
	amp

Experiment No. 11 **Date: __/__/_____**

V AND Λ CURVES OF SYNCHRONOUS MOTOR

AIM

To obtain V and Λ curves of synchronous motor.

APPARATUS REQUIRED:

Sl. No.	Particulars	Range	Type	Quantity
01	Voltmeter	0 –300 V	MC	01
02	Ammeters	0-10/20A 0-10/20A 0- 1/2 A	MC MI MC	01 02 01
03	Rheostats	0-750Ω,1.2A	-	02
04	Watt meters	0-600V, 10/20A	UPF	02

PROCEDURE:

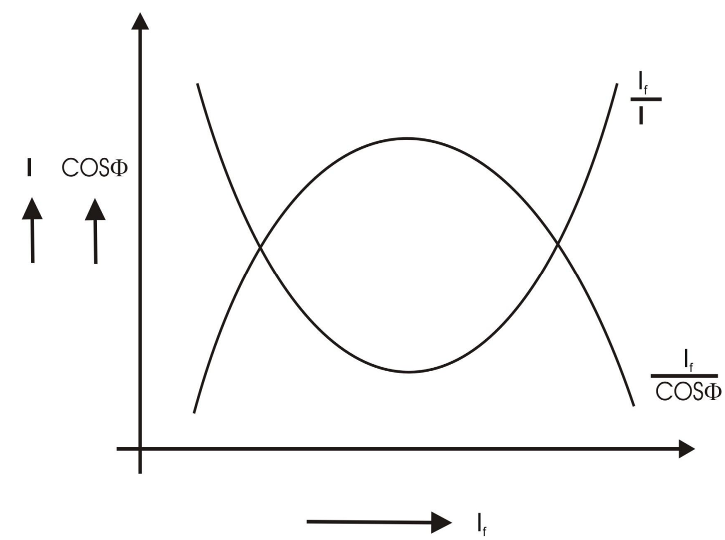
1. Connections are made as shown in the circuit diagram (11.a)
2. The TPDT switch (S4) in 1' & 2' position. (The field of the synchronous motor (F and FF) is temporarily shorted).
3. Keeping load switch (S_3) open, the both rheostats R_1 in the field circuit of synchronous motor in cut-in position and rheostat R_2 in the field circuit of generator in cut-in positions, the exciter switch DPST (S_2) and supply switch TPST (S_1) are closed.
4. The output of the three phase Auto transformer is increased slightly, and the direction of rotation of the motor is observed. If the motor runs in opposite direction of the marked position then bring back the Auto Transformer to Zero position and change any two phases of the supply Terminals.
5. The out-put of the three phase auto-transformer is again increased till the synchronous motor attains 50% of its rated speed, immediately the TPDT (S_4) is switch over to 1 & 2 position. And then increase to rated voltage.
6. The excitation of synchronous motor is varied in steps by cutting-out the rheostats R_1, at no-load, the readings of all the meters are noted down.
7. The rheostat R_1 is brought back to cut-in position and generator voltage is built up to its rated value by gradually cutting out the rheostat R_2.
8. The load switch (S_3) is closed and the load on the generator is adjusted to any convenient value (Say ¼, ½ or ¾ of the rated load current) and the excitation of synchronous motor is varied in steps by cutting-out the rheostat R_1. At each step readings of all the meters are noted down.

   (NOTE: The selected load current is kept constant throughout the experiment)
9. The load on generator is gradually removed, the load switch (S_3) is opened, all the rheostats are brought back to their respective initial positions, and the TPDT (S_4) is opened.

TABULAR COLUMN:

Sl. No	I Amps	I_f Amps	I_L Amps	W_1 Watt	W_2 Watt	CosΦ	Remarks
							No Load Condition
							Loaded Condition

MODEL GRAPH:



Graph No (1)

CALCULATION:

Power factor is given by

CosΦ = $\text{Cos}[\tan^{-1}\sqrt{3}\{(W1-W2)/(W1+W2)\}]$

10. The out-put of the 3-phase auto-transformer is brought zero out-put position, then the supply switch (S_1) and the exciter switch (S_2) is opened.
11. Following graphs are plotted as shown in model graph no (1)
    i. Supply current v/s Field current → V curve and
    ii. Power factor v/s Field current. → Λ curve.

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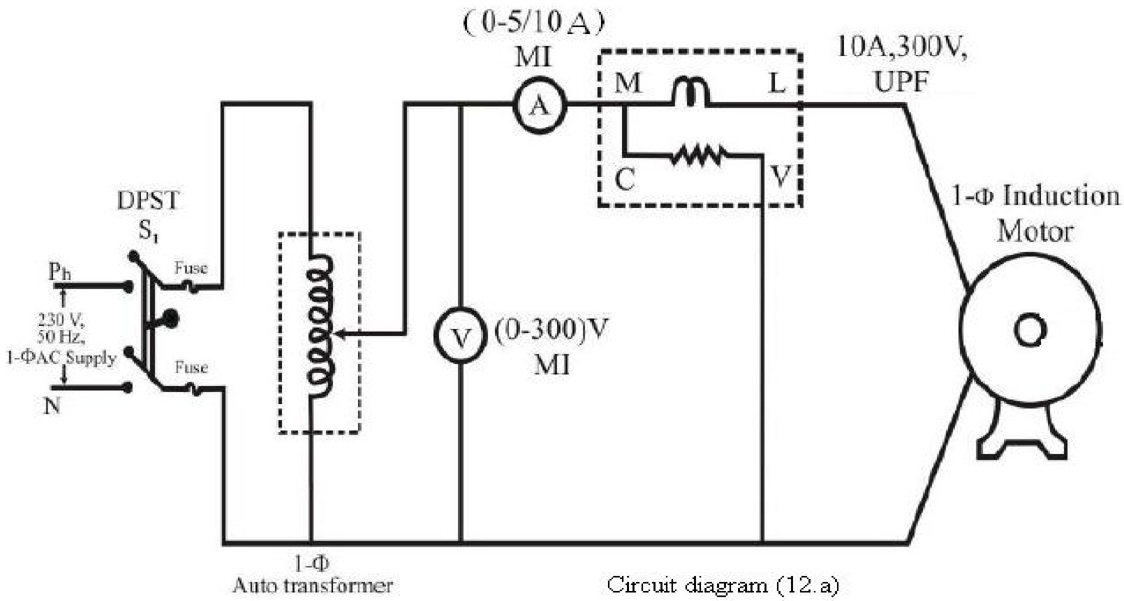
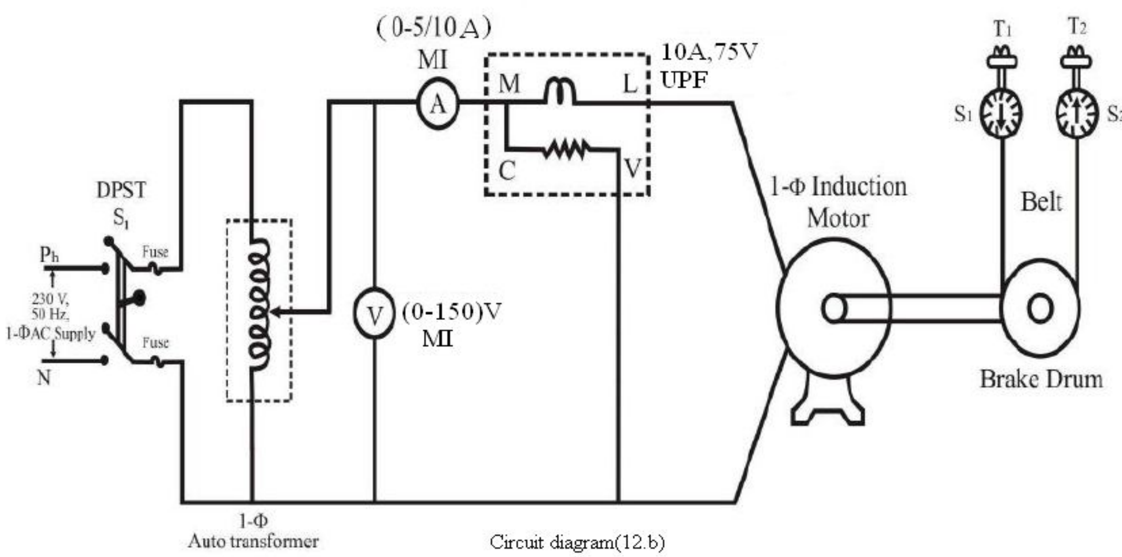
CIRCUIT DIAGRAM:



Circuit diagram (12.a)

OPEN CIRCUIT TEST



Circuit diagram(12.b)

BLOCKED ROTOR TEST

Name Plate Details	
KW	
Volt	
Amp	
RPM	

Experiment No. 12 Date: __/__/_____

Equivalent circuit of a 1-phase Induction Motor

AIM:

Draw the equivalent circuit of the single phase Induction motor by conducting (a) No-load test (b) Blocked rotor test.

APPARATUS REQUIRED:

Sl. No	Particulars	Range	Type	Quantity
01.	Voltmeter	0-300V 0-150V	MI	01
02.	Ammeter	0-5/10A	MI	01
03.	Wattmeter	10A, 300V 10A,150V	UPF	01
04.	Tachometer	--	Contact Type	01

PROCEDURE:

1) OPEN CIRCUIT TEST.

5. Connections are made as shown in the circuit diagram (12.a).
6. Keeping the 1-Φ auto-transformer voltage in zero out-put position, the supply switch (S_1) is closed.
7. By varying the 1-Φ auto-transformer, the rated voltage of 1-Φ induction motor is applied. All the meter readings are noted down.
8. To stop the motor, the 1-Φ auto-transformer is brought back to its initial zero out-put position, the supply switch (S_1) is opened.

2. BLOCKED ROTOR TEST.

6. Connections are made as shown in the circuit diagram (12.b).
7. The brake-drum of the induction motor is blocked from rotation by tightening the belt.
8. By keeping the 1-Φ auto-transformer voltage in zero out-put position, the supply switch (S_1) is closed.
9. By operating the 1-Φ auto-transformer very slowly, a low voltage is applied, such that the rated current of the induction motor flows in the stator winding. All the meter readings are noted down.
10. To stop the motor, the 1-Φ auto-transformer is brought back to its initial zero out-put position, loosened the belts of brake drum, then open the supply switch (S_1).

TABULAR COLUMN:

3. OPEN-CIRCUIT TEST.

Sl. No.	V_0 (Volts)	A (Amps)	W_0 (Watt)

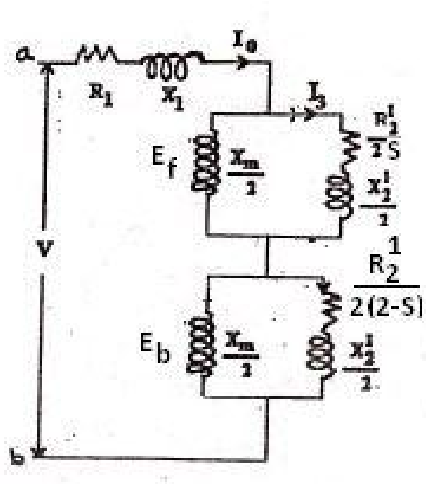
NOTE: 1) W = (k × Watt Meter Reading.) Where, k = $\frac{(V_{sel} \times I_{sel} \times \text{Cos}\,\phi)}{\text{Full Scale Deflection}}$

4. SHORT-CIRCUIT TEST.

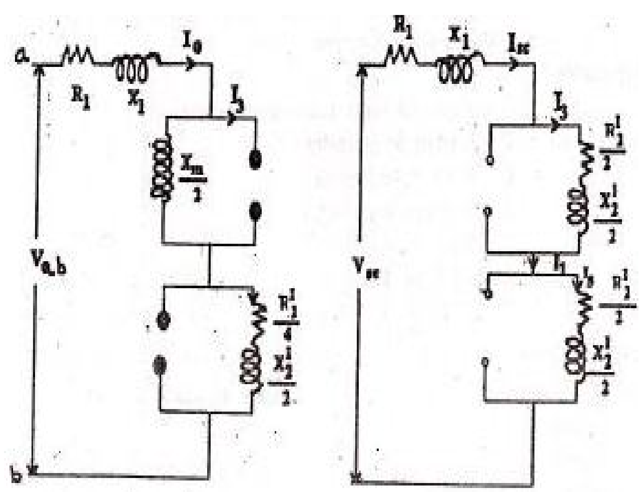
Sl. No.	V_{sc} (Volts)	A (Amps)	W_{sc} (Watt)

NOTE: 1) W = (k × Watt Meter Reading.) Where, k = $\frac{(V_{sel} \times I_{sel} \times \text{Cos}\,\phi)}{\text{Full Scale Deflection}}$

EQUIVALENT CIRCUIT:



Equivalent circuit of
1-ϕ induction motor



Equivalent circuits for
no-load and blocked rotor

CALCULATION:

The DC resistance of main winding of stator i.e, R_{dc} is measured by multimeter. The effective value of resistance is taken 1.3 times R_{dc} i.e R_1.

BLOCKED ROTOR TEST

Assuming

NO –LOAD TEST

Calculation for efficiency:

$$(i)\ Z_f = R_f + JX_f = \frac{J.\frac{X_m}{2}\left[\frac{R_2^1}{2S} + J\frac{X_2^1}{2}\right]}{\frac{R_2^1}{2S} + \left[\frac{X_2^1}{2} + \frac{X_m}{2}\right]} = ...ohms$$

$where Z_f$ = Forward Impedance

$$(ii)\ Z_b = R_b + JX_b = \frac{J.\frac{X_m}{2}\left[\frac{R_2^1}{2(2-S)} + J\frac{X_2^1}{2}\right]}{\frac{R_2^1}{2(2-S)} + \left[J\frac{X_2^1}{2} + \frac{X_m}{2}\right]} = ...ohms$$

$where Z_b$ – *backward* Im *pedance*

(iii) $Z_T = Z_f + Z_b + Z_1$ [where $Z_1 = R_1 + JX_1$] = ...ohms

(vi) Current drawn by the motor at above slip

I_1=V/Zt=............Amps

(v) $\cos P = \frac{R_1}{Z_1}$.

(vi) Voltage across forward rotor = $E_f = I_1 \times Z_f$ = ...Volts

(vii) Impedance of the rotor = $Z_3 = \left[\left(\frac{R_2^1}{2s}\right)^2 + \left(\frac{X_2^1}{2}\right)^2\right]^{1/2}$ = ohms

$I_3 = \frac{E_f}{Z_r}$ = ...Amps

$\tau = I_3^2\left[\frac{R_2^1}{2s}\right]$ in syn - watts

(viii) Voltage across the backward rotor = $E_b = I_1 \times Z_b$ = ...V

$$Z_5 = \left[\left(\frac{R_2^1}{2(2-s)}\right)^2 + \left(\frac{X_2^1}{2}\right)^2\right]^{1/2} = \text{.........volts}$$

$$I_5 = \frac{E_b}{2s}; \tau_b = I_2^2\left[\frac{R_2^1}{2(2-s)}\right] = \text{Syn - watts}$$

(ix) Net Torque ($\tau = \tau_f - \tau_b$ Syn - watts.

$$\text{Mechanical output} = P_m = \frac{2 \pi N \tau}{60}$$

$$\text{percent } \eta = \left(\frac{P_m}{VI\cos\phi}\right) X100.$$

Signature of Staff-incharge

QUESTION BANK

1. By conducting suitable experiment, Pre determine the efficiency of the given DC machine when running as motor for a Load of _____________% by conducting suitable experiment
2. By conducting suitable experiment, Pre determine the efficiency of the given DC machine when running as Generator for a load of __________ % by conducting suitable experiment
3. Draw the Armature Voltage v/s Speed and Field current vs Speed characteristics of a given DC shunt motor by conducting a necessary Tests.
4. By conducting suitable experiment demonstrate that Speed can be controlled in both forward and reverse directions for a DC shunt motor.
5. Draw the following Curves for a given DC shunt motor by conducting load test.

   (a) % Efficiency Vs BHP (c) T Vs BHP

   (b) N Vs T (d) N Vs BHP

6. Conduct a suitable test on a given DC shunt motor and obtain the following parameters at __________ % load.

   (a) % efficiency (d) N

   (b) BHP (e) Motor power input

   (c) T Vs BHP

7. Conduct the regenerative test on two similar DC machines and pre-determine efficiency of a motor at ___________ % load.
8. Conduct the regenerative test on two similar DC machines and pre-determine efficiency of a generator at __________ % load.
9. Conduct the Back to Back test to pre-determine the efficiency of a motor at _______ load and efficiency of a generator at _______load.
10. Conduct Retardation Test and predetermine the efficiency as a generator at _________ Load.
11. Conduct Retardation Test and predetermine the efficiency as a Motor at _________ Load.

12. Conduct Retardation Test and predetermine the efficiency as a generator and as a Motor at _________ Load.
13. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' curve at no Load.
14. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' curve at 3A Load.
15. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'Λ' curve at no Load.
16. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'Λ' curve at 2A Load.
17. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' and 'Λ' curve at No Load.
18. Conduct suitable experiment on a 3-phase Synchronous motor to draw 'V' and 'Λ' curve at 4A Load.
19. Conduct Field test on a D.C Series Machines and calculate Its Efficiency as a Motor at __________Load.
20. Conduct Field test on a D.C. Series Machines and calculate Its efficiency, as a Generator at __________ load.
21. Conduct Field test on a D.C. Series Machines and calculate Its efficiency, as a Generator and as a Motor at __________ load.
22. Conduct Field test on a D.C. Series Machines, to draw the % efficiency vs Load curve.
23. Draw the torque V_S speed characteristic of a 3 – Phase induction motor by conducting necessary test on it.
24. Conduct load test on a 3 – Phase induction motor and draw BHP V_S η, BHP V_S P.f and BHP V_S slip characteristics.
25. Conduct load test on a 3 – Phase induction motor and determine at ¾ full load slip, η, Torque and output.
26. Conduct necessary tests on a 3 – Phase induction motor and draw its equivalent circuit.
27. Draw the torque V_S speed characteristic of a Single – Phase induction motor by conducting necessary test on it.

28. Conduct load test on a Single – Phase induction motor and draw BHP V_S η, BHP V_S P.f and BHP V_S slip characteristics.

29. Conduct load test on a Single – Phase induction motor and determine at ¾ full load slip, η, Torque and output.

30. Conduct necessary tests on a 3 – Phase induction motor to draw its circle diagram. Assume stator copper loss is equal to Rotor copper loss.

31. Conduct necessary tests on a 3 – Phase induction motor to draw its circle diagram and from it determine the following at maximum torque output, η, slip and power factor.

32. Draw the circle diagram of a 3 – Phase induction motor by conducting necessary tests and calculate at maximum output, η, slip, power factor and input current.

33. Draw the circle diagram of a 3 – Phase induction motor and calculate at full load η, output, slip, torque & P.f.

34. Draw the circle diagram of a 3 – Phase induction motor and calculate at 10 Amps the output, η, slip, torque & Power factor.

35. Conduct necessary test on a given 3 – Phase induction motor and draw voltage V_S speed characteristic.

36. Conduct load test on a given induction generator and find its efficiency at ¾ full load.

37. Conduct load test on a given induction generator and find its efficiency at 5A load.

38. Determine the efficiency and regulation for three single phase transformers connected in y-Δ at full load..

VIVA – VOCE QUESTIONS

1. Load test on Single Phase Induction Motor

1. What are the different types of single phase induction motor?
2. Why a single phase induction motor is not self starting?
3. How do you make a single phase induction motor self starting?
4. Explain briefly the working of split phase induction motor.
5. What are the applications of split phase induction motor?
6. What is the function of capacitor in capacitor start and induction run motor?
7. What are the advantages of capacitor start and capacitor run induction motor?
8. Draw the approximate equivalent circuit for single phase induction motor.

2. Load test on 3- Phase Induction motor

1. What is the basic principle of operation of a 3- phase induction motor?
2. What is the function of Stator?
3. What do you mean by the term Synchronous speed?
4. What is 'slip' in Induction motor? Why the slip is never zero in an Induction motor?
5. What is the frequency of induced current in the rotor of an induction motor at stand still and while it is running?
6. Mention the different types of Rotors?
7. What are the differences in construction between Squirrel- cage and Phase wound- rotor of an Induced Motor? What are their applications?
8. Why the rotor bars of a squirrel cage rotor are skewed?
9. What is the advantage of phase wound rotor?
10. How torque is produced in an induction motor?
11. How the starting torque of phase wound rotor does is improved?
12. What is the condition for maximum starting torque? and maximum torque under running condition?
13. Draw the torque slip characteristics and explain.
14. What do you mean by Pullout or Break down torque?

5. Circle Diagram of 3- phase Induction motor

1. What are the losses taking place in 3- phase induction motor?
2. How much operating characteristics of a three phase Induction motor can be computed by use of circle diagram?

3. What are the losses taking place in a three phase induction motor?
4. How do you determine the friction and windage loss from no-load test?
5. How do you determine the maximum output and minimum torque from circle diagram?
6. What is the expression for rotor copper loss?
7. What do you mean by Synchronous Watt?
8. Draw an approximate equivalent circuit for 3- phase induction motor. Draw the vector diagram.
9. What are the similarities between a transformer and a 3- phase induction motor?
10. What do you mean by “Crawling and Cogging”?

5. Induction Generator

1. What do you understand the floating conditions.
2. What is the use of three phase Energy meter?
3. Explain the meaning of excitation.

6. DC Machines

1. Why should the field rheostat be kept in the position of minimum resistance?
2. What is the loading arrangement used in a DC motor?
3. How can the direction of rotation of a DC shunt motor be reversed?
4. What are the mechanical and electrical characteristics of a DC shunt motor?
5. What are the applications of a DC shunt motor?
6. What is meant by armature reaction?
7. How should a generator be started?
8. How should a Shunt or compound generator be started?
9. When a generator loses its residual flux due to short circuit, how can it be made to build up?
10. What causes heating of armature?
11. What will happen if both the currents are reversed?
12. What will happen if the field of a DC shunt motor is opened?
13. What happens if the direction of current at the terminals of series motor is reversed?

14. Explain what happens when a DC motor is connected across an AC supply?
15. Why does a DC motor sometimes spark on light load?
16. A DC motor fails to start when switched on. What could be the possible reasons and remedies?
17. What is meant by back?
18. Discuss different methods of speed control of a DC motor.
19. Why a DC series motor should not be started at No load?
20. What are the losses that occur in DC machines?
21. State some present day uses of DC machines.
22. Why a DC series motor should never be stared without load?
23. Why a DC series motor has a high starting torque?
24. Compare the resistances of the field windings of DC shunt and series motor?
25. What are the applications of DC series motor?
26. Comment on the Speed – Torque characteristics of a DC series motor.
27. How does the torque vary with the armature current in a DC series motor?
28. How does the speed of a DC shunt motor vary with armature voltage and field current?
29. Compare the resistance of the armature and field winding.
30. What is the importance of speed control of DC motor in industrial applications?
31. Which is of the two methods of speed control is better and why?
32. Why is the speed of DC shunt motor practically constant under normal load condition?
33. What are the factors affecting the speed of a DC shunt motor?
34. What is meant by residual magnetism?
35. What is critical field resistance?
36. What is meant by saturation?
37. What is the difference between external and internal characteristics?
38. What is the purpose of Swinburne's test?

39. What are the constant losses in a DC machine?
40. What are the assumptions made in Swinburne's test?
41. Why is the indirect method preferred to the direct loading test?
42. The efficiency of DC machine is generally higher when it works as a generator than motor. Is this statement true or false? Justify your answer with proper reasons
43. What is the purpose of Hopkinson's test?
44. What are the precautions to be observed in this test?
45. What are the advantages of Hopkinson's test?
46. What are the conditions for conducting the test?
47. Why the adjustments are done in the field rheostat of generator and motor?
48. If the voltmeter across the SPST switch reads zero what does it indicate? If it does not read zero value what does it indicate?
49. What are the other names for Hopkinson's test?
50. Why is armature resistance less than field resistance of dc shunt machine?
51. Why is armature resistance more than field resistance of dc series machine?
52. Write the EMF equation of DC and AC machine.
53. Write the torque equation of DC motor.

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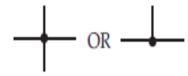
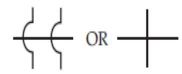
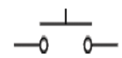
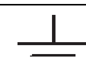
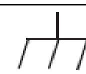
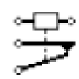
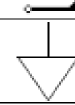
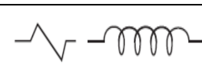
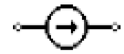
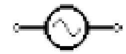
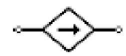
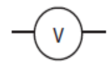
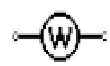
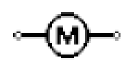
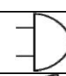
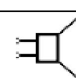
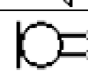
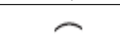
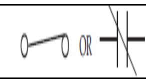
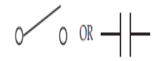
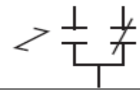
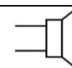
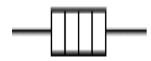
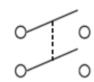
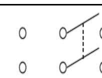
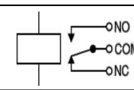
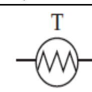
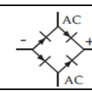
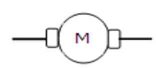
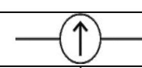
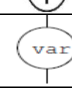
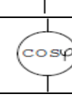
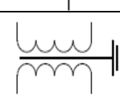
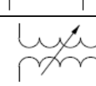
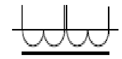
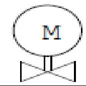
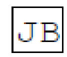
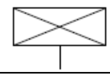
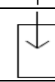
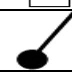
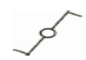
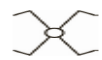
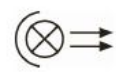
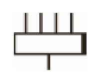
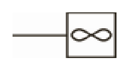
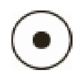
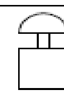
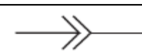
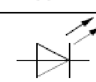
Appendix

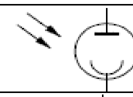
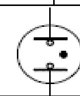
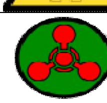
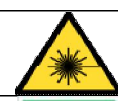
STUDY OF ELECTRICAL SYMBOLS

Sl. No.	Particulars	Symbol
1	**Electrical wire**	———————
2	**Connected wires**	
3	**Not connected wires**	
4	**SPST Toggle switch**	
5	**SPDT Toggle switch**	
6	**Pushbutton Switch (N.O)**	
7	**Pushbutton Switch (N.C)**	
8	**Earth Ground**	
9	**Chassis ground**	
10	**SPST Relay**	
11	**SPDT Relay**	
12	**Digital Grounding**	
13	**Resistor**	
14	**Potentiometer**	
15	**Variable Resistor**	
16	**Polarized Capacitor**	
17	**Inductor**	
18	**Iron-core Inductor**	
19	**Variable Inductor**	

20	DC Voltage Source	
21	Current Source	
22	AC Current Source	
23	Generator	
24	Battery Cell	
25	Battery	
26	Controlled Voltage Source- DC	
27	Controlled Current source	
28	Voltmeter	
29	Ammeter	
30	Ohm meter	
31	Wattmeter	
32	Lamp/Light/Bulb	
33	Motor	
34	Transformer	
35	Fuse	
36	Electrical Bell	
37	Buzzer	
38	Bus	
39	Loudspeaker	
40	Microphone	
41	Arial Antenna	
42	Circuit Breaker	

43	Contacts Closed – NC	
44	Contacts Open - NO	
45	AC Generator	
46	DC Generator	
47	Relay with Transfer Contacts	
48	Current Transformer	
49	Loud Speaker	
50	Heater	
51	DPST	
52	DPDT	
53	Relay with Contacts	
54	Thermistor	
55	Full wave, Bridge Type Rectifier	
56	Inductor Solenoid / Coil	
57	DC Motor	
58	AC Motor	
59	Galvanometer	
60	VAR Meter	
61	Power-Factor Meter	
62	Isolation Transformer	
63	Variable Voltage Transformer	

64	Auto Transformer	
65	Current Transformer with Two Secondary Windings On One Core	
66	Motor Operated Valve	
67	Electrical Distribution Panel	
68	Junction Box	
69	Instrument Panel or Box	
70	Lightning Arrestor	
71	Lighting Rod	
72	Choke	
73	One-way switch	
74	Two-way switch	
75	Intermediate switch	
76	Spot light	
77	Distribution Board	
78	Fan	
79	Joint Box	
80	Short circuit device	
81	Emergency push button	
82	Lighting outlet position	
83	Lighting outlet on wall	
84	Connector	
85	Light Emitting Diode	

86	**Photo Cell**	
87	**Voltage Indicator capacitive**	
88	**General caution**	
89	**Poisonous sign**	
90	**Radio Activity sign**	
91	**Ionizing radiation sign**	
92	**Non-ionizing radiation sign**	
93	**Biohazard sign**	
94	**Warning sign**	
95	**High voltage sign**	
96	**Magnetic field symbol**	
97	**Chemical weapon symbol**	
98	**Laser hazard sign**	
99	**First Aid**	
100	**Fire Extinguisher**