**Channabasaveshwara Institute of Technology**
(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)
**ISO 9001:2015 Certified Institution)**
NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka

Department of Electrical & Electronics Engineering

# ELECTRICAL MACHINES LABORATORY – 2

## 21EEL46

# Lab Manual

Version 7.0

MAY 2023

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Vinaya B K

**Reviewed by:**
Prof. V C Kumar

**Approved by:**
Prof. V C Kumar
Professor & Head
Dept. of EEE

| Electrical Machines Laboratory - 2 | | | |
|---|---|---|---|
| Course Code | 21EEL46 | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 0:0:2 | SEE Marks | 50 |
| Credits | 01 | Exam Hours | 03 |

**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.

| Sl. NO | Experiments |
|---|---|
| 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 | Swin burne'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. |
| 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 thee equivalent circuit of single phase induction motor and determine performance parameters. |
| 12 | Conduct an experiment to draw v and Inverted curves of synchronous motor at no load and load conditions. |

**Course outcomes (Course Skill Set):**

At the end of the course the student will be able to:
(1)Test DC machines to determine their characteristics and also to control the speed of DC motor.
(2)Pre-determine the performance characteristics of DC machines by conducting suitable tests.
(3)Perform load test on single phase and three phase induction motor to assess its performance.
(4)Conduct test on induction motor to pre-determine the performance characteristics.
(5)Conduct test on synchronous motor to draw the performance curves

**Assessment Details (both CIE and SEE)**

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 35% (18 Marks out of 50) in the semester-end examination(SEE).

**Continuous Internal Evaluation (CIE):**

CIE marks for the practical course is 50 Marks.

The split-up of CIE marks for record/ journal and test are in the ratio 60:40.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.

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## INSTITUTE VISION

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

## INSTITUTE 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 ofthe institute.

**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 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 various activities.
- To promote research and development in electrical technology and management for the benefit of the society.

**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

## PROGRAMME EDUCATIONAL OBJECTIVES

- To provide 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 various activities.
- To promote research and development in Electrical Engineering technology and management for the benefit of the society.

Program Specific Outcomes:

**PSO 1:** Able to apply the knowledge gained during the course of the program from Mathematics, Basic Computing, Basic Sciences and Social Sciences in general and all electrical courses in particular to identify, formulate and solve real life problems faced in Electrical Engineering domain and/or during Higher/Advanced Studies.

**PSO 2:** Able to provide socially acceptable technical solutions to complex electrical engineering problems with the application of modern and appropriate techniques for sustainable development.

**Program Outcomes (POs):**

**Engineering Graduates will be able to**

**PO 1. Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and engg. specialization to the solution of complex engineering problems.

**PO 2. Problem analysis**: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences

**PO 3. Design/development of solutions**: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations

**PO 4. Conduct investigations of complex problems**: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

**PO 5. Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

**PO 6. The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

**PO 7. Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

**PO 8. Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

**PO 9. Individual and team work**: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings

**PO 10. Communication**: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions

**PO 11. Project management and finance**: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments

**PO 12. Life-long learning Program**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

# ***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.

## 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:

CO1: Apply the knowledge on determining the characteristics of DC motors to find their efficiency.
CO2: Determine the suitable method of controlling the speed of DC motors.
CO3: Perform the load test on single phase and 3 phase Induction motors & DC series motors for finding the efficiency characteristics.
CO4: Analyse the performance characteristics by conducting pre-determination test for 3ϕ, 1 ϕ induction motors and DC shunt motor.
CO5:Acquire knowledge about the Performance testing of Induction generator.

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|
| **CO1:** | 3 | 3 | 3 | 1 | 2 | 2 | 2 |
| **CO2:** | 3 | 2 | 3 | | 1 | 2 | 2 |
| **CO3:** | 3 | 2 | 1 | 3 | 1 | 2 | 2 |
| **CO4:** | 2 | 3 | 3 | | 1 | 2 | 2 |
| **CO5:** | 3 | 3 | 1 | | 1 | 2 | 2 |

# INDEX PAGE

| Sl. No | Name of the Experiment | Date | | | Manual Marks (Max . 20) | Record Marks (Max. 10) | Signature (Student) | Signature (Faculty) |
|---|---|---|---|---|---|---|---|---|
| | | Conduction | Repetition | Submission of Record | | | | |
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**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGG.**

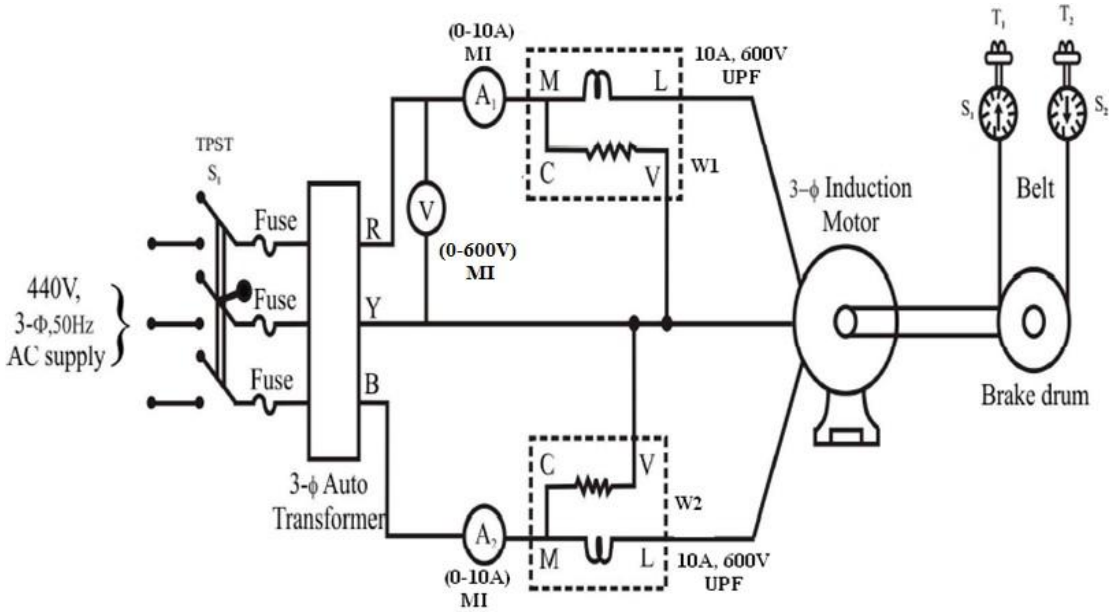
# CONTENTS

## First Cycle Experiments



## Second Cycle Experiments

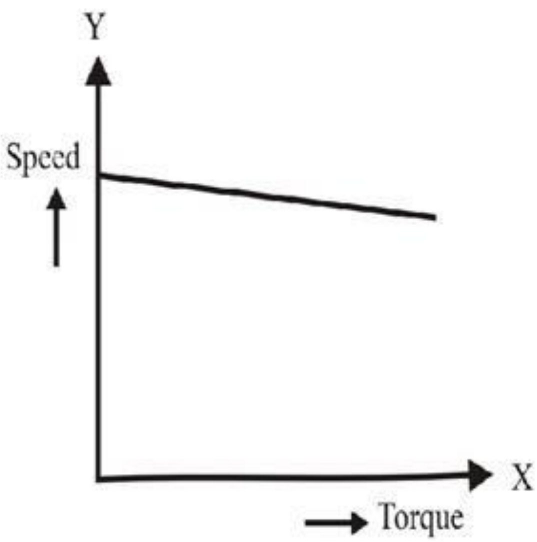
**CIRCUIT DIAGRAM:**

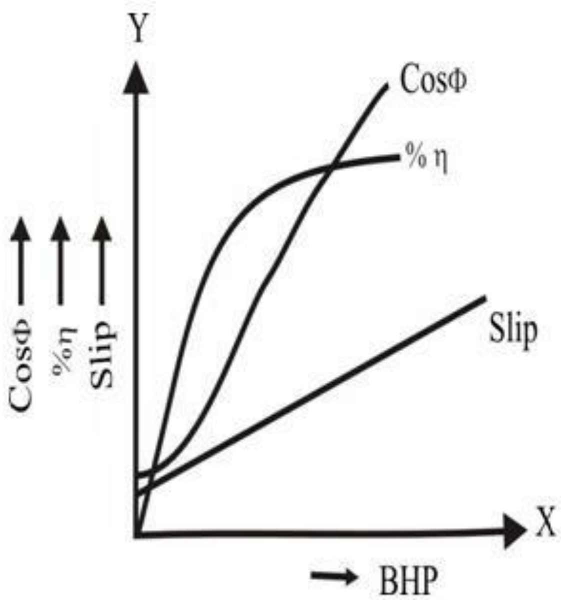



Circuit Diagram (1.a)
LOAD TEST ON 3-Φ INDUCTION MOTOR

| 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 pfiv) 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) = ($S_1 \sim S_2$) * 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 = $\frac{(N_S - N)}{N_S}$

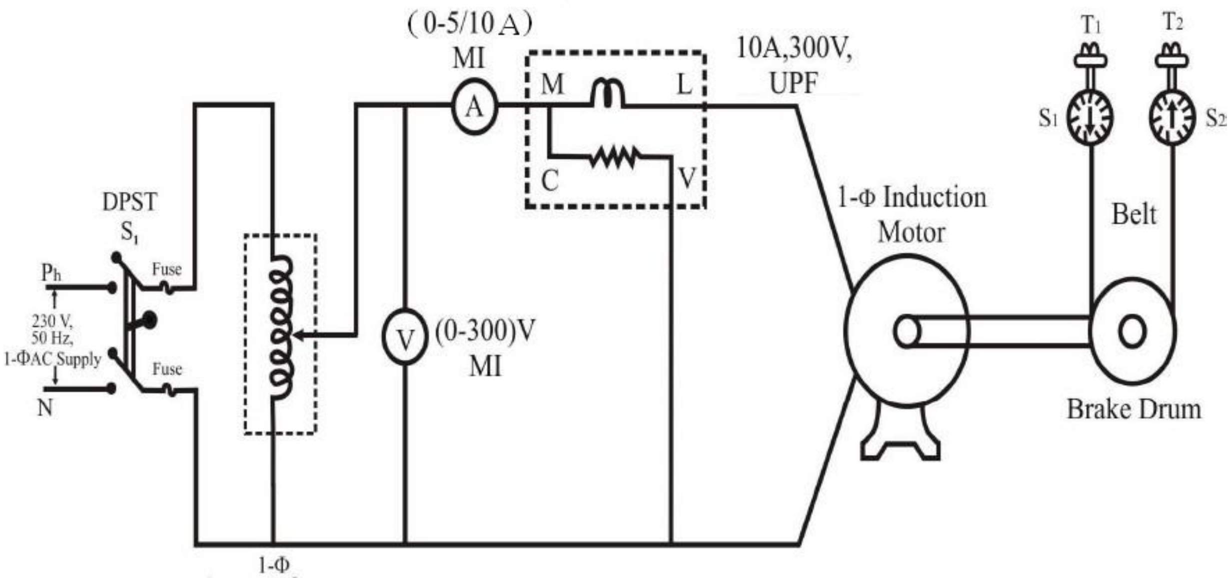
Ns = $\frac{120f}{P}$ Where P = No. of poles

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, $k = \dfrac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

**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 pfiv) Torque V/S speed.

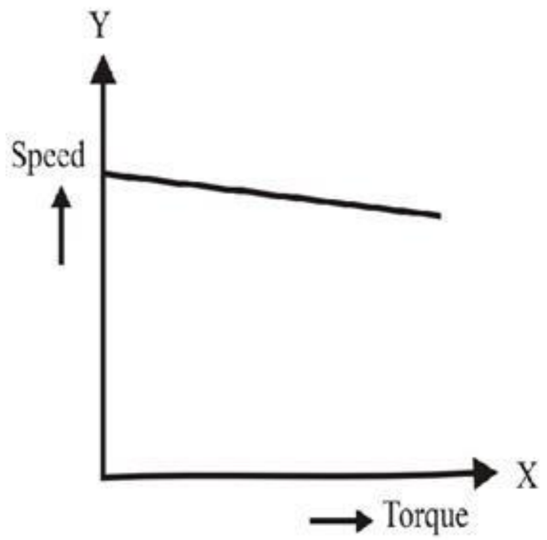
**APPARATUS REQUIRED:**

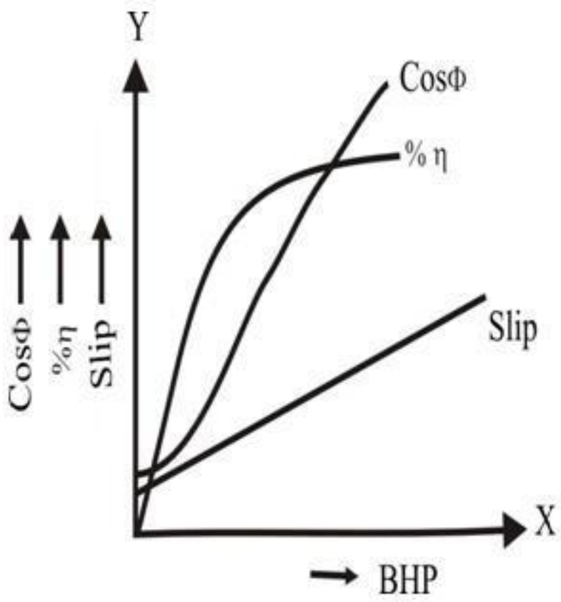
| Sl. No | Particulars | Range | Type | Quantity |
|---|---|---|---|---|
| 01. | Voltmeter | 0-300V | MI | 01 |
| 02. | Ammeter | 0-5/10A | MI | 01 |
| 03. | Wattmeter | 10A, 300V | UPF | 01 |
| 04. | Tachometer | -- | Contact Type | 01 |

**PROCEDURE:**

1. Connections are made as shown in the circuit diagram (2.a)
2. Measure and noted own 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

CosΦ = $\frac{W}{V \times I}$

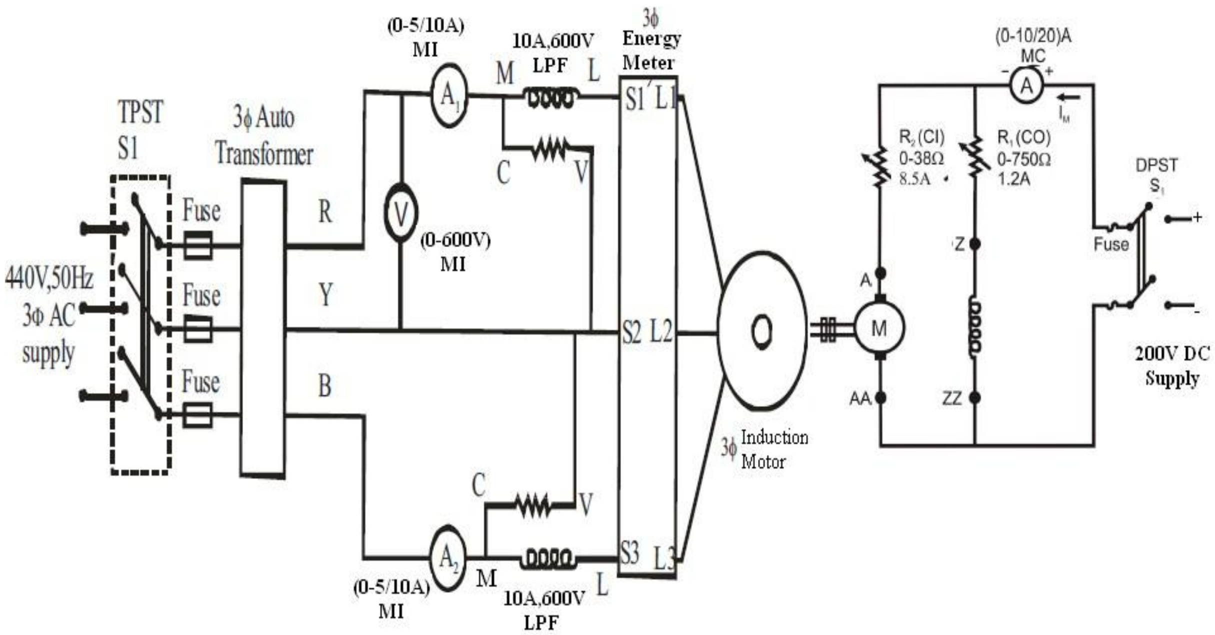
Slip = $\frac{(N_S - N)}{N_S}$

Ns = $\frac{120f}{P}$ 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 | 0-750Ώ,1.2A | | 01 |
| 04. | Wattmeter | 10A, 600V | LPF | 02 |
| 05. | Voltmeter | (0-600V) | MI | 01 |
| 06. | Voltmeter | (0-250V) | MC | 01 |

**PROCEDURE:**

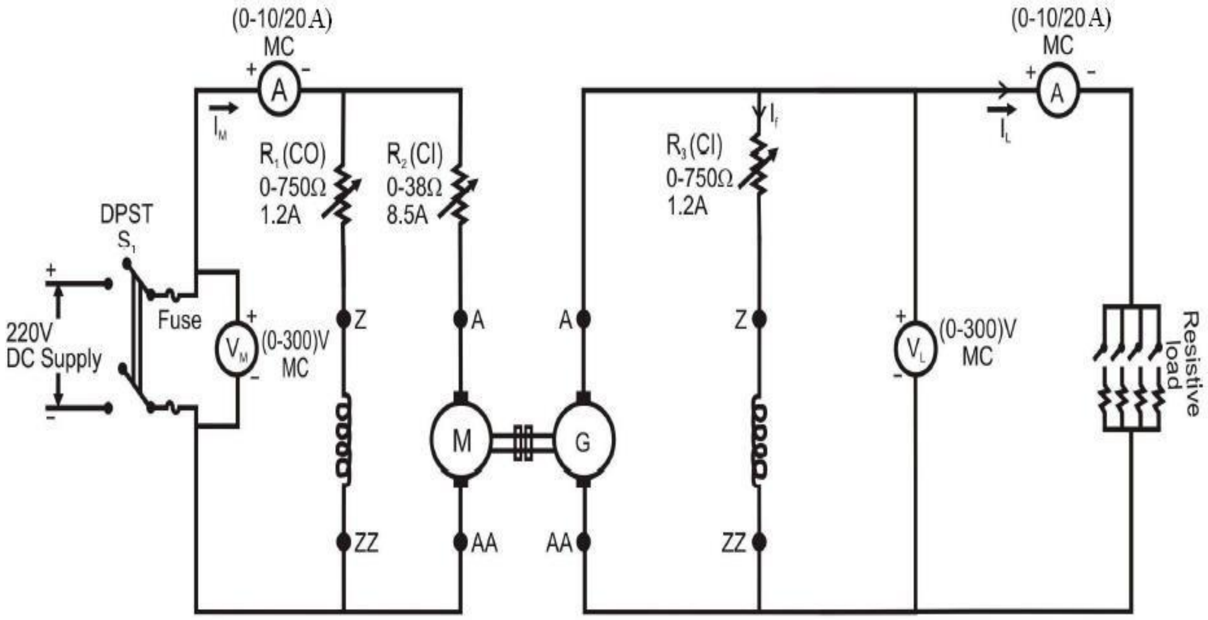
1. Connections are made as shown in the circuit diagram (3.a).
2. Close the 3-phase supply switch ($S_1$) and vary the 3-phase auto-transformer slowly by observing the rotation of induction motor up to 415V. if the rotation of induction motor is reverse i.e., opposite to the arrow mark as mentioned in 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, $k = \frac{(V_{sel} \times I_{sel} \times \cos\phi)}{\text{Full Scale Deflection}}$

%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<br>0-38 Ω,8.5A | -<br>- | 02<br>01 |
| 04 | Tachometer | - | - | 01 |

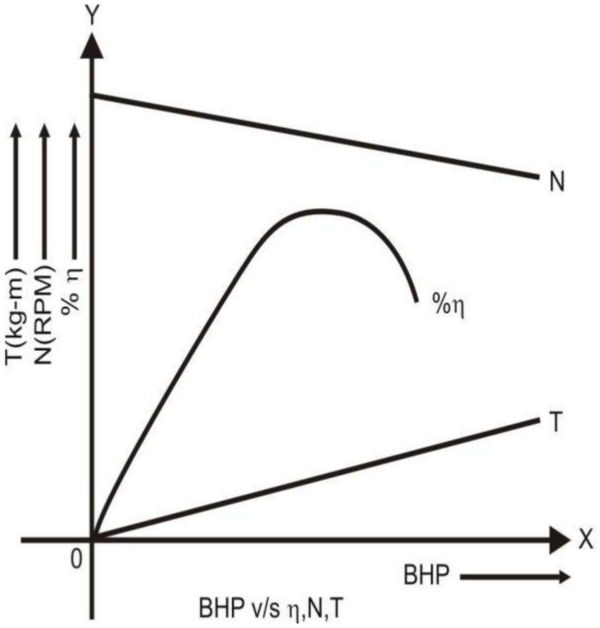
**PROCEDURE:**

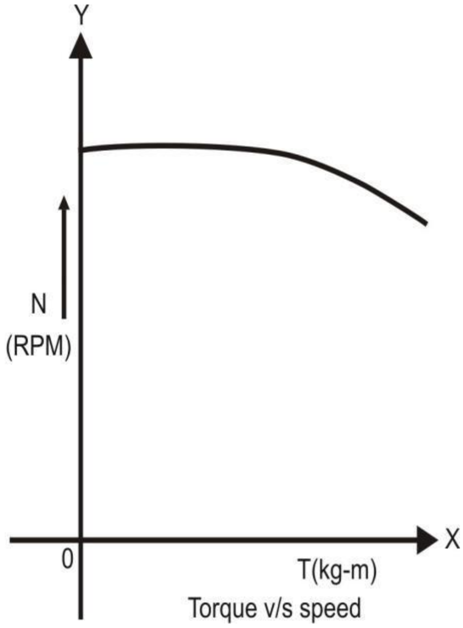
1. Connections are made as shown in the circuit diagram (4.a).
2. Keeping the rheostat $R_1$ in the field circuit of motor in cut-out position, the rheostat $R_2$in the armature circuit of the motor and the rheostat $R_3$ in the field circuit of the generator in cut-in positions and all load switches 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**



**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

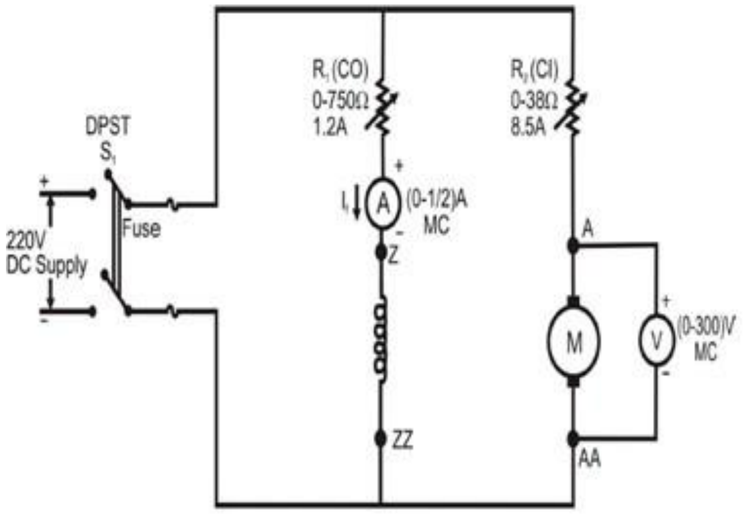
% $\eta_{motor}$ = (Motor output in watt/ motor input in watt) × 100

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)

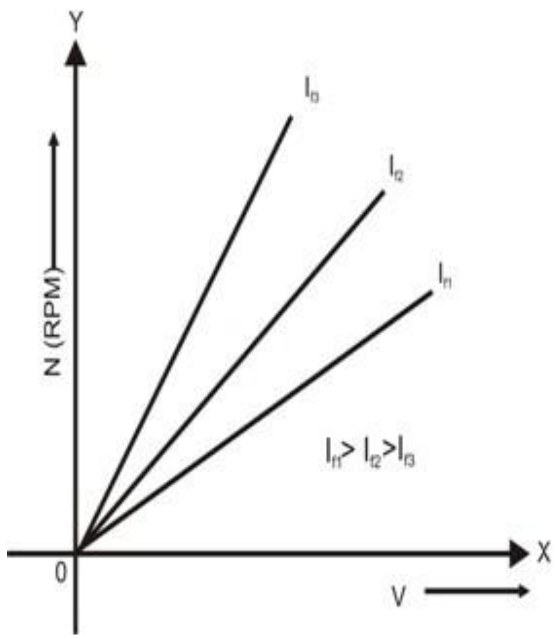
**SPEED CONTROL OF DC SHUNT MOTOR**

Name Plate Details

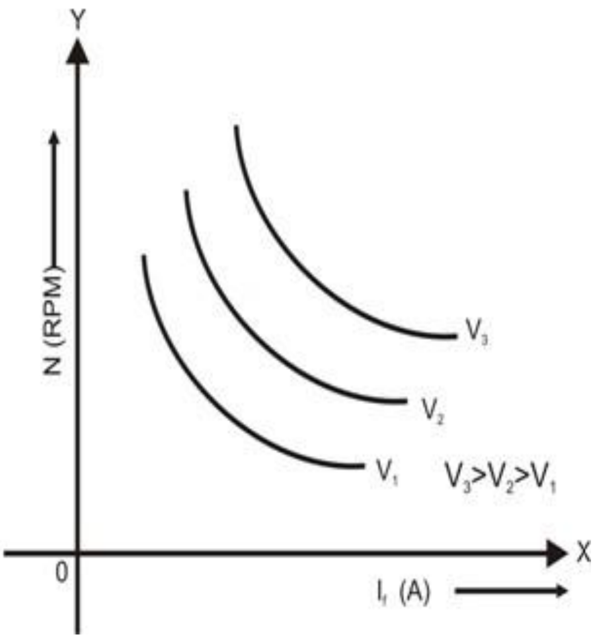
| | Motor |
|---|---|
| Kw | |
| Volt | |
| Amp | |
| rpm | |

**MODEL GRAPHS**

1. Armature Control Method




2. Flux Control Method



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

# SPEED CONTROL OF DC 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<br>0-750Ω,1.2A | - | 01<br>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 themotor 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)

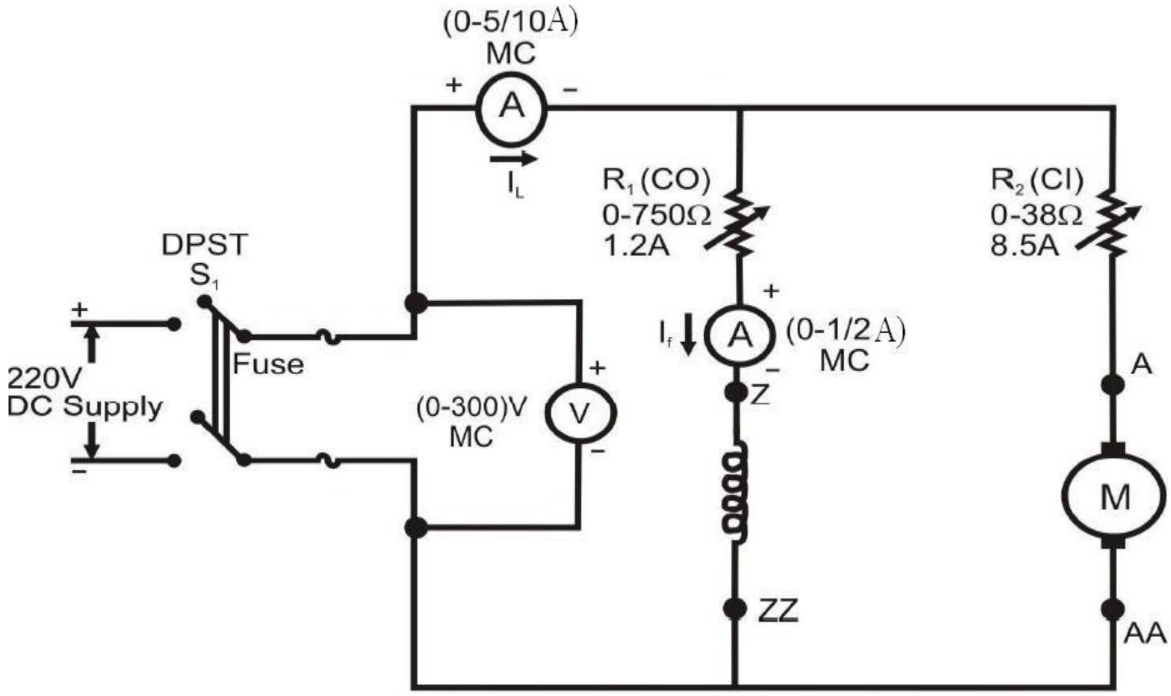
| Sl. No | $I_f$ Ampere | Speed rpm |
|---|---|---|
| | | |

Armature Voltage =____Volt (Constant)

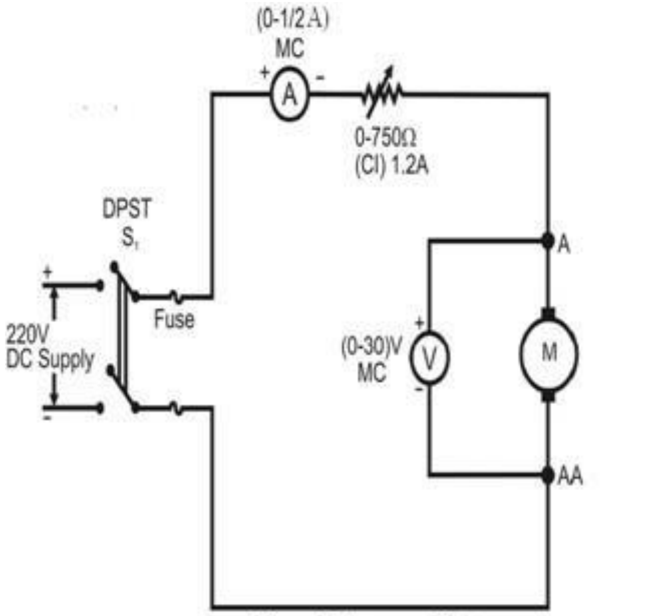
| Sl. No | $I_f$ Ampere | Speed rpm |
|---|---|---|
| | | |

**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<br>0-30V | MC<br>MC | 01<br>01 |
| 02 | Ammeters | 0-5A<br>0-1/2A | MC<br>MC | 01<br>01 |
| 03 | Rheostats | 0-750Ω,1.2A<br>0-38Ω,8.5A | - | 01<br>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 themotor 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:Tabulation of Results:**

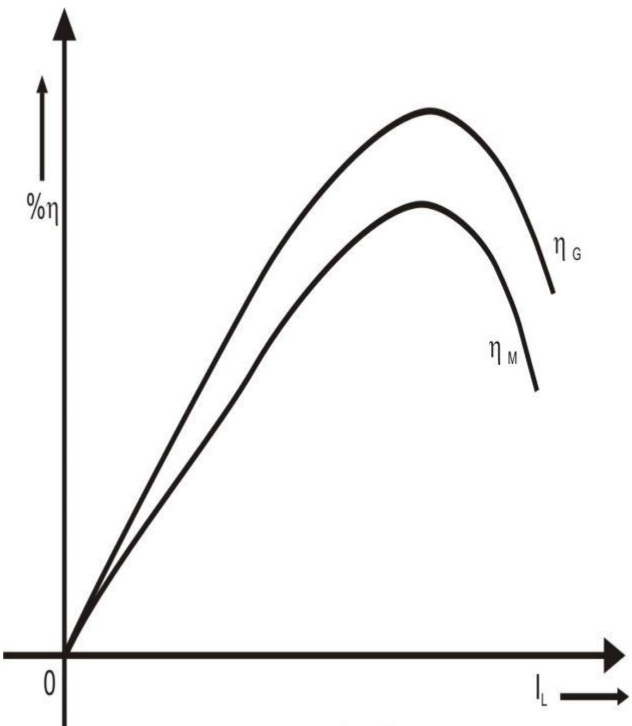
| Sl. No | $V_L$ Volt | $I_L$ Amp | $I_f$ Amp |
|---|---|---|---|
| | | | |

Determination of Armature Resistance ($R_a$):

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

| Sl. No. | Load (X) | % $\eta_m$ | % $\eta_g$ |
|---|---|---|---|
| 1. | Full Load | | |
| 2. | ¾ of F.L | | |
| 3. | ½ of F.L | | |
| 4. | ¼ of F.L | | |

**MODEL GRAPH:**




Load current v/s Efficiency

**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

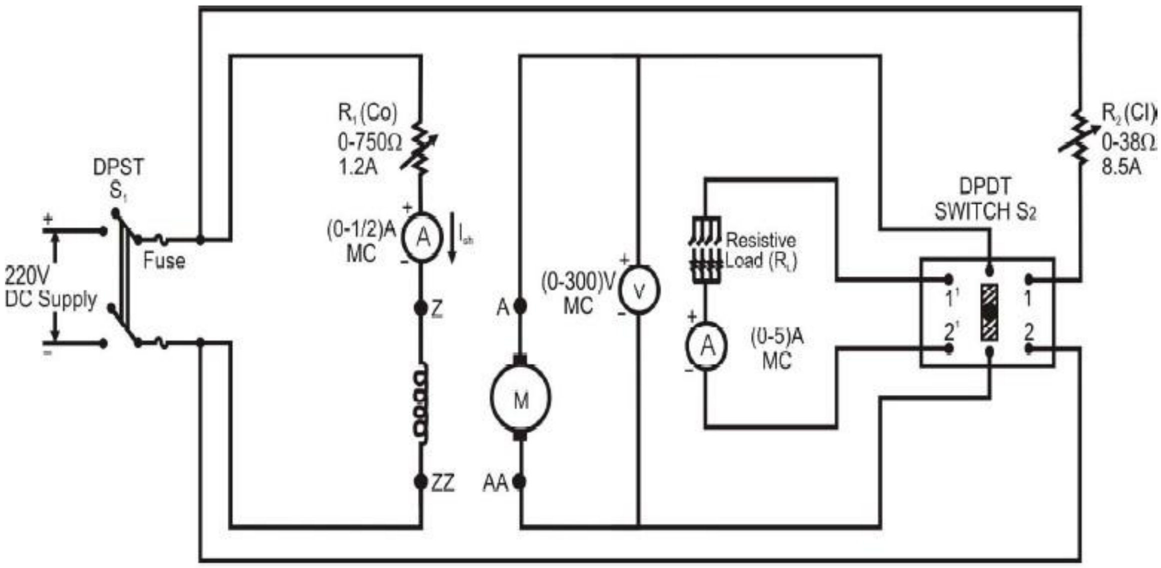
a. $I_a = (x.I_{FL} - I_f)$Ampere
   Where x= (1, ¾, ½, ¼)
b. Armature copper loss = $(I_a)^2 \times R_a$ Watts = $(x.I_{FL} - I_f)^2 \times Ra$ Watts
c. Total losses = (Wc + armature copper loss) Watts
d. Input to the motor = $V_1 (x.I_{FL})$ Watts
   ($V_1$ is the rated voltage of the Motor)
e. Output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

II. Efficiency when working as a generator

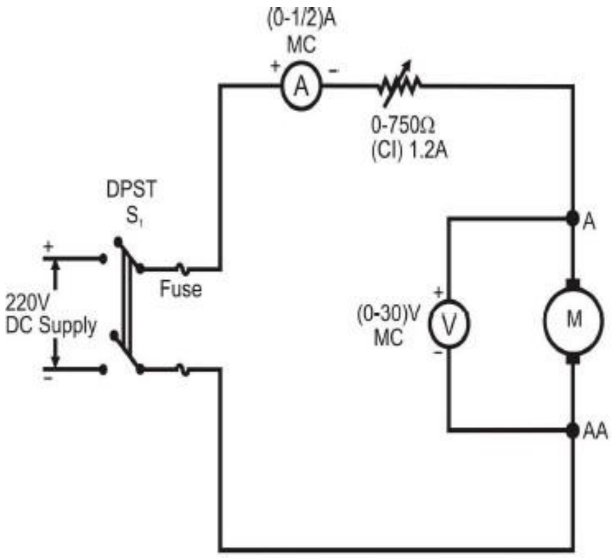
a. $I_{ag} = (xI_{FL} + I_f)$Ampere
   Where $x$= (1, ¾, ½, ¼)
b. Armature copper loss = $(I_{ag})^2 \times R_a$ Watt = $(x.I_{FL} + I_f)^2 \times Ra$ Watts
c. Total losses = (Wc + armature copper loss) Watts
d. Output of generator = $V_1(x.I_{FL})$ Watts
   ($V_1$ is the rated voltage of the Generator)
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<br>0-300V | MC<br>MC | 01<br>01 |
| 02. | Ammeters | 0-5A<br>0-1/2A | MC<br>MC | 01<br>01 |
| 03. | Rheostats | 0-750Ω,1.2A<br>0-38Ω,8.5A | - | 01<br>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 themotor in cut-in position, the load rheostat $R_L$in thearmature circuitof 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 Ra = 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 $I_a = I_r - I_{sh}$

Armature copper loss = $I_a^2 R_a$ Watt -------------------------------------(1)

Shunt field Copper loss = $V I_{sh}$ Watt------------------------------------------ (2)

Total Losses = (1) + (2) Watt

Motor Output =Motor Input - Total Losses Watt

Motor efficiency = $\eta_m$ = Motor Output / Motor Input *100

- Efficiency When Working as a Generator:

Generator Output = $V_r I_r$ Watt

Armature copper loss = $I_a^2 R_a$ Watt -------------------------------------- (3)

Shunt field Copper loss = V $I_{sh}$ Watt------------------------------------------- (4)

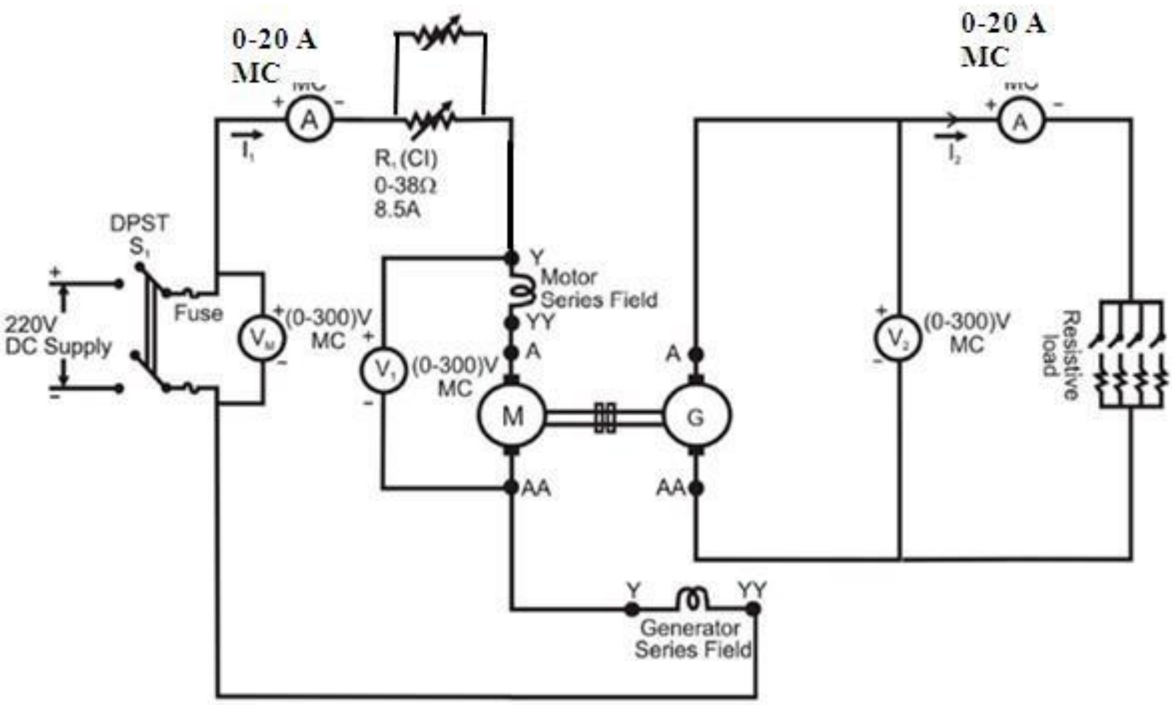
Total Losses = (3) + (4) Watt

Generator Input = Generator Output-+Total Losses Watt

Generator efficiency = $\eta_m$ = Generator Output / Generator Input *100

**Signature of Staff-incharge**

**CIRCUIT DIAGRAM:**




**CIRCUIT DIAGRAM (8.a)**

Name Plate Details

| | Motor | Generator |
|---|---|---|
| Kw | | |
| Volt | | |
| Amp | | |
| rpm | | |

**TABULAR COLUMN**

| Sl.No. | $V_M$ (Volts) | $V_1$ (Volts) | $V_2$ (Volts) | $I_1$ (Amps) | $I_2$ (Amps) | N (rpm) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Experiment No. 8** Date:___/___/______

# LOAD CHARACTERISTICS OF DC SERIES MOTOR

**AIM**

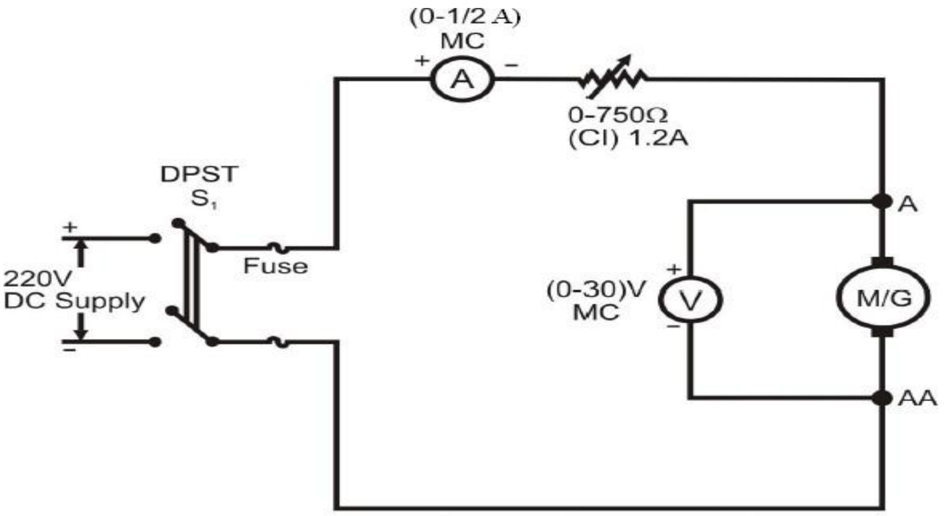
To determine the stray loss and hence to find the efficiency of the given two identical DC series machines.

**APPARATUS REQUIRED:**

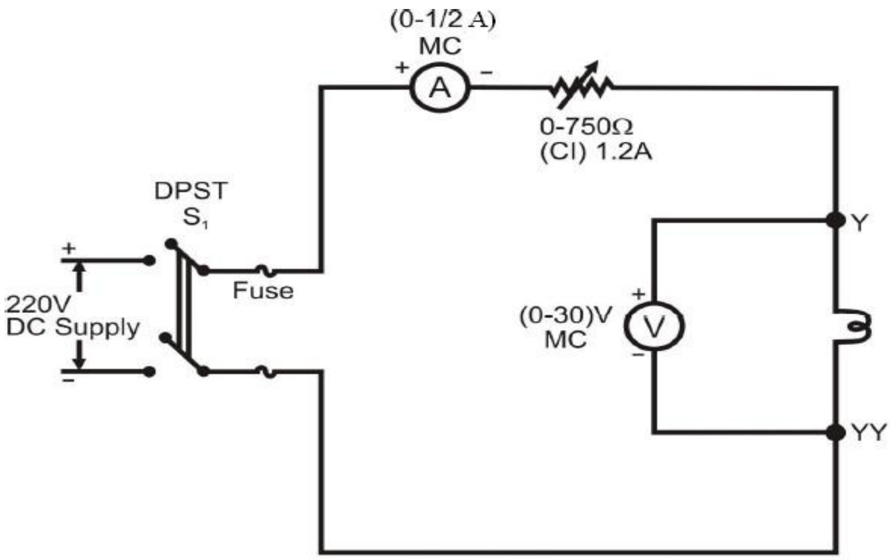
| Sl. No. | Particulars | Range | Type | Quantity |
|---|---|---|---|---|
| 01 | Voltmeters | 0-300V<br>0-30V | MC<br>MC | 02<br>01 |
| 02 | Ammeters | 0-10/20 A<br>0-1/2 A | MC<br>MC | 02<br>02 |
| 03 | Rheostats | 0-38Ω,8.5A | - | 02 |
| 04 | Tachometer | - | - | 01 |
| 05 | Multi meter | - | - | 01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

**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. So that motor acquires the less than rated current.
4. Apply the load on the generator step by step till it reaches the rated current of motor and note down the all meter readings in each step.
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.




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




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

Determination of Armature and Field Resistance:

| Remarks | V (Volts) | I (Amps) | Ra =V/I Ω |
|---|---|---|---|
| Armature | | | |
| Field | | | |

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

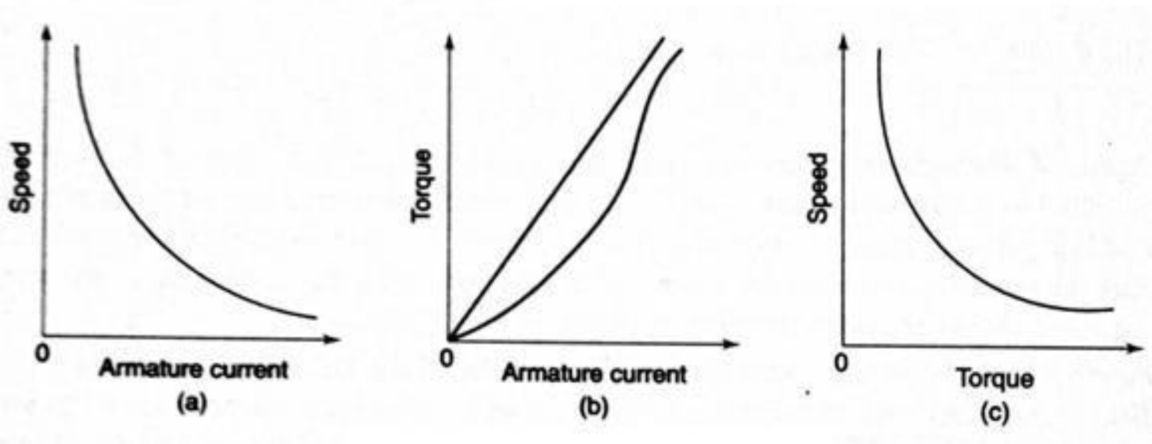
- **a.** Connections are made as shown in the circuit diagram (8.b)and (8.c)
- **b.** Keeping the rheostat in cut-in position, the supply switch ($S_1$) is closed, Rheostat is adjusted to any value of current (say 1A) and the readings of ammeter and voltmeter are noted down.
- **c.** The supply switch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

**CALCULATION**

$E_b = V_1 - I_1 (R_a + R_{se})$ Volt

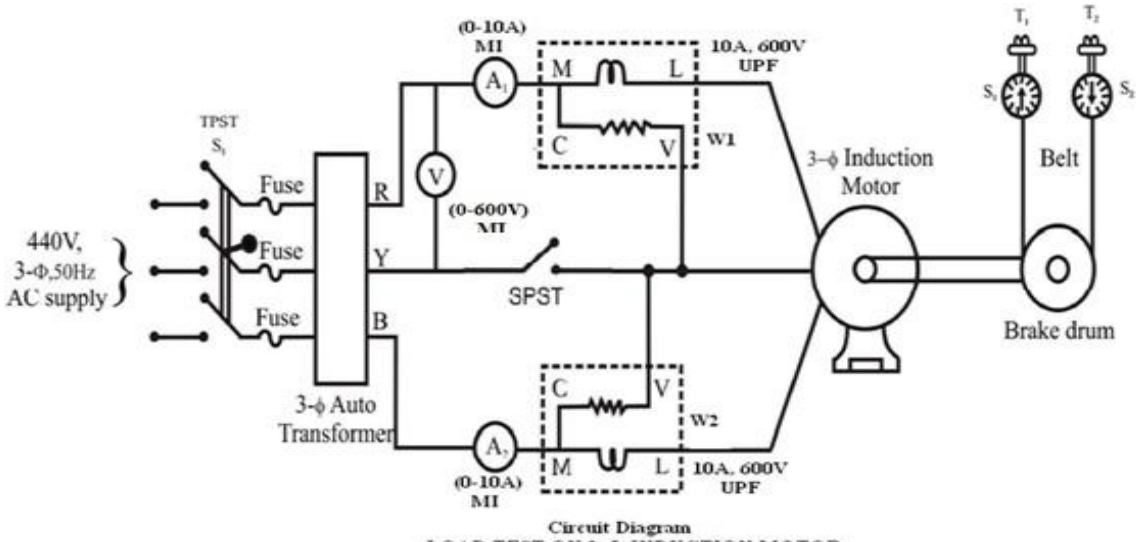
$$T = 9.55 \; \frac{E_b I_1}{N} \quad \text{N-m}$$

Various characteristics of DC series motor



**Signature of Staff-incharge**

**CIRCUIT DIAGRAM**




Circuit Diagram
LOAD TEST ON 3-Φ INDUCTION MOTOR

**TABULAR COLUMN:**

1. When run on 3ph Supply

| 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) | $P_{3ph}=(W_1+W_2)$ (Watt) | N (rpm) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

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

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

2. When one of 3ph line open

| 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) | $P_{sph}=(W_1+W_2)$ (Watt) | N (rpm) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

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

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

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

**Regenerative TEST**

**AIM:**

Performance of a three phase induction motor when run on three phase supply and when one of the three lines is open.

**APPARATUS REQUIRED:**

| Sl. No | Particulars. | Range | Type | Quantity |
|---|---|---|---|---|
| 01. | Voltmeter | 0-600V<br>0-300V | MC<br>MC | 01<br>01 |
| 02. | Ammeter | 0-10/20<br>0-5/10A<br>0-1/2 | MC<br>MC<br>MC | 01<br>01<br>02 |
| 03. | Rheostats | 0-750Ω,1.2A<br>0-38,8.5A | - | 01 |
| 04. | Tachometer | - | - | 01 |

**PROCEDURE:**

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

2. Keeping the rheostat R1 in the field circuit of motor in cut-out position, the rheostat R2 in the armature circuit of the motor and the rheostat R3 in the field circuit of the generator in cut-in positions and the SPST switch in open position, the supply switch (S1) is closed.

3. The motor is brought to its rated speed by cutting out the rheostat R2 and then by cutting in the rheostat R1, if necessary.

4. The excitation of the generator is increased gradually by cutting out the rheostat R3, 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 I2=rated current, the readings of all the meters are noted down.

7. The rheostat R3 (if the motor is under excited vary the rheostat R1) 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 (S1) is opened.

**Determination of Armature Resistance (Ra) 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 (S1) 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 (S1) 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)

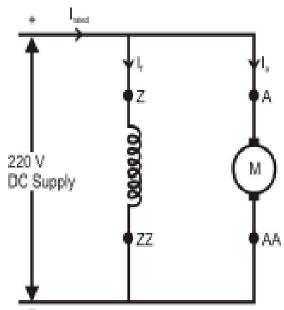
Total copper losses = (1) + (2) + (3) + (4)

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

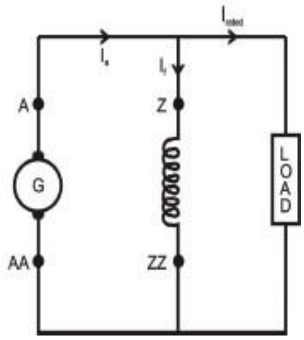
O/P of the generator = V (x. $I_{rated}$ )Watt

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) $\times$100




**TABULAR COLUMN**

| Sl. No | % $\eta_g$ | % $\eta_m$ |
|---|---|---|
| | | |

**PERFORMANCE COMPARISION:**

| WHEN RUN ON 3PH SUPPLY | | | | | | |
|---|---|---|---|---|---|---|
| Sl. No. | Torque | BHP | Output | Input | Efficiency | Cos Φ |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| WHEN ONE OF 3PH LINE OPEN | | | | | | |
| Sl. No. | Torque | BHP | Output | Input | Efficiency | Cos Φ |
| | | | | | | |
| | | | | | | |
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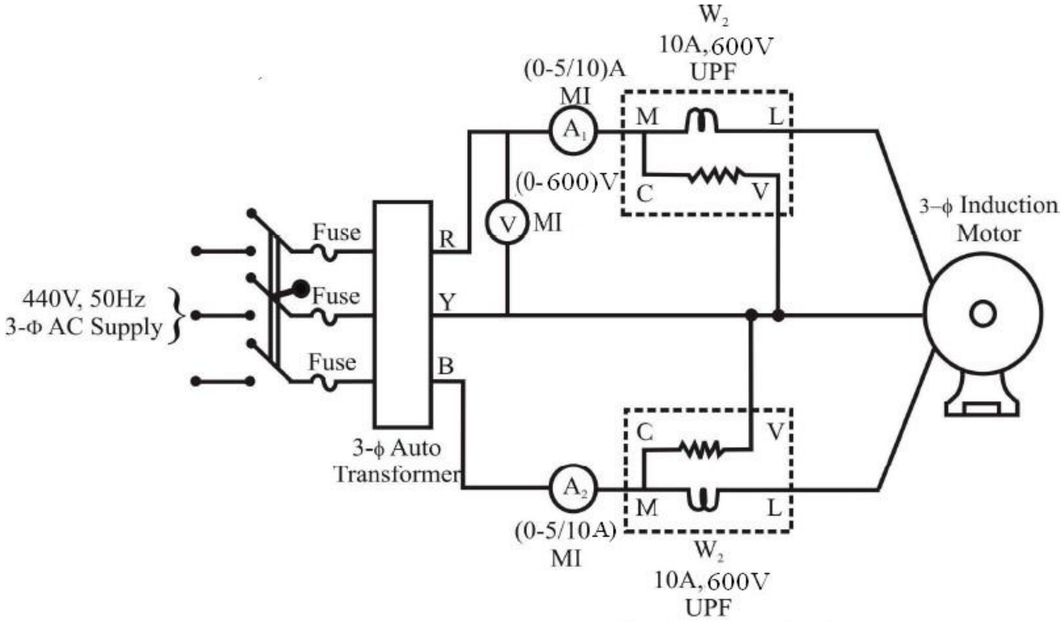
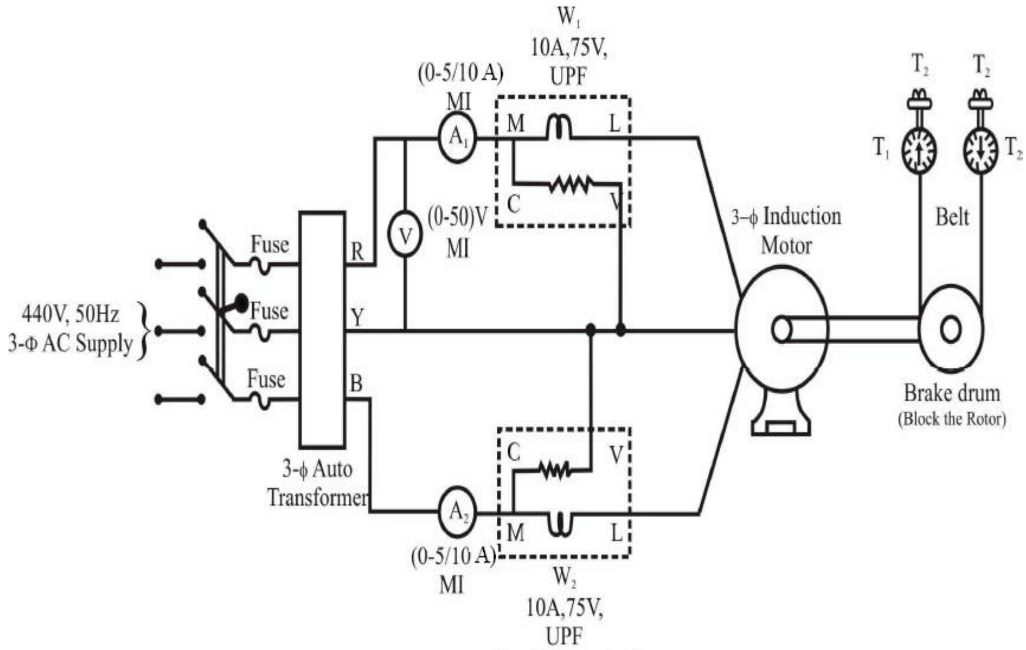
**Signature of Staff-incharge**

**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<br>0-50V | MI<br>MI | 01<br>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.

5. Connections are made as shown in the circuit diagram (10.b).
6. The brake-drum of the induction motor is blocked from rotation by tightening the belt.
7. By keeping the 3-Φ auto-transformer voltage in zero out-put position, the supply switch ($S_1$) is closed.
8. 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.
9. 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: $1W_1$ = ($k_1$ × 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 $\Phi_0$ 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 $\Phi_{SC}$ 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 = $\frac{W_{SN}}{\text{AB in Cm}}$ 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.

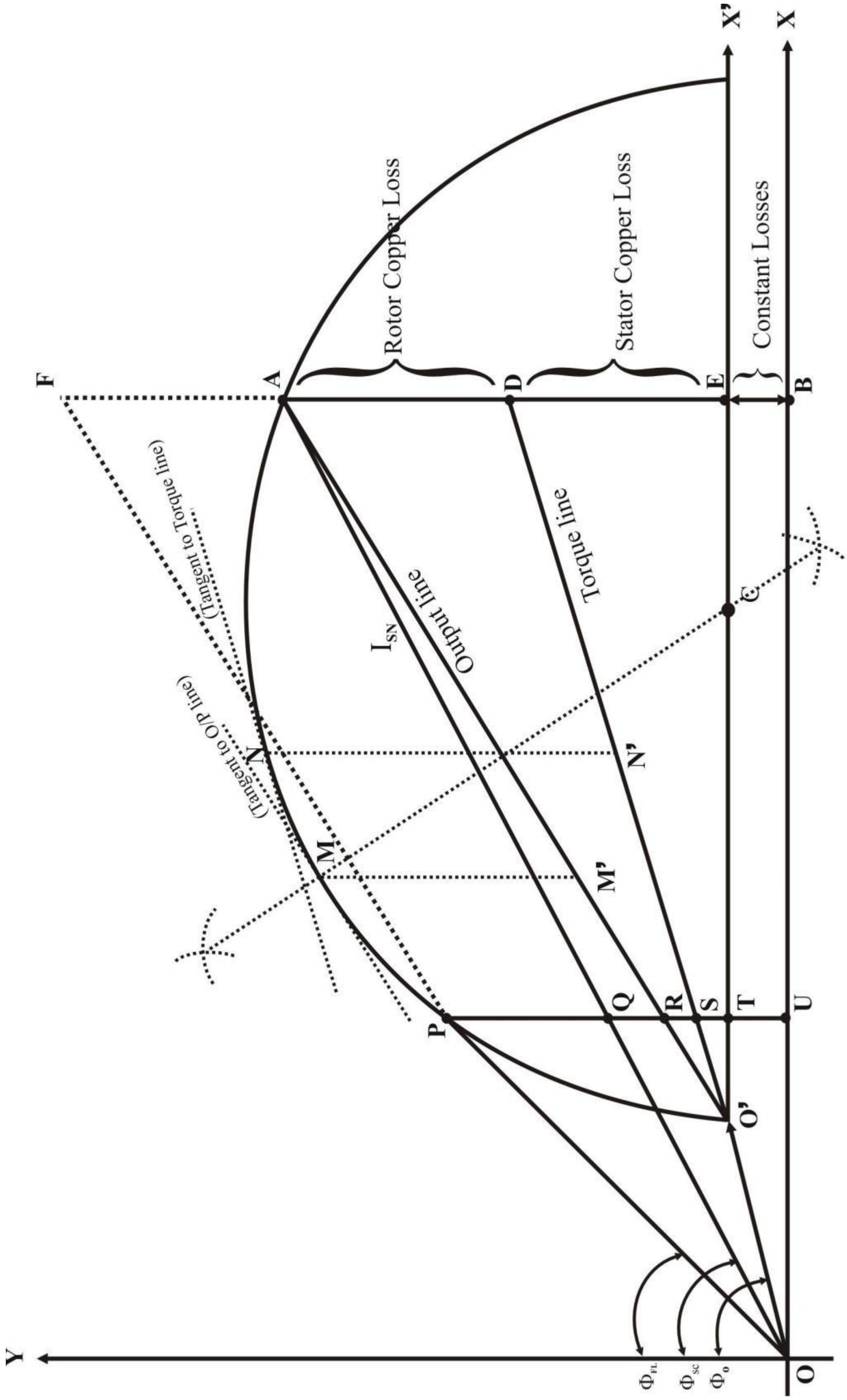
    Now, AD = Rotor copper loss, Watt

    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

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

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.




**MODEL CIRCLE DIAGRAM**

**CALCULATION:**

a) No-Load power factor:

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

$$\text{Therefore} \quad \Phi_0 = \text{Cos}^{-1}\left(\frac{(W_0)}{\sqrt{3} \times V_0 \times I_0}\right) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

b) Power factor at short-circuit condition:

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

$$\text{Therefore} \quad \Phi_{SC} = \text{Cos}^{-1}\left(\frac{(W_{SC})}{\sqrt{3}.V_{SC}.I_{SC}}\right) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

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 = $\frac{W_{SN}}{AB \text{ in Cm}}$ =________________ Watt/Cm.

Therefore; 1 Cm = ________________Watt.

Calculation Using Circle Diagram:

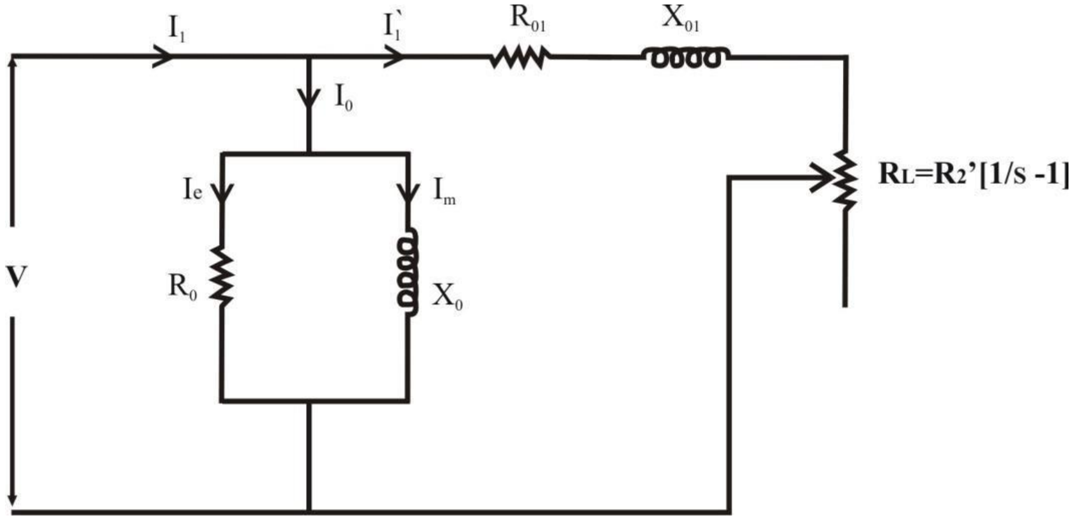
1. Power factor at full load = Cos $\Phi_{FL}$
2. Efficiency at full load = $\frac{PR}{PU} \times 100$
3. Slip at full load = $\frac{\text{Rotor Copper Loss}}{\text{Rotor Input}} = \frac{SR}{SP}$
4. Torque at full load = PS $\times$ Power Scale, Synchronous-Watt
5. Line Current = OP $\times$ Current 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$^{1}$; MM$^{1}$ Represents the maximum out-put.
     Maximum out-put in Watt = M M$^{1}$ in cm $\times$ 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$^{1}$; NN$^{1}$ Represents the maximum torque.
     Maximum torque in Synchronous Watt = NN$^{1}$ In cm $\times$ 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 $Cos\ \Phi_{sc} = \frac{Wsc}{\sqrt{3}\times Vsc \times Isc}$

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

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

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.

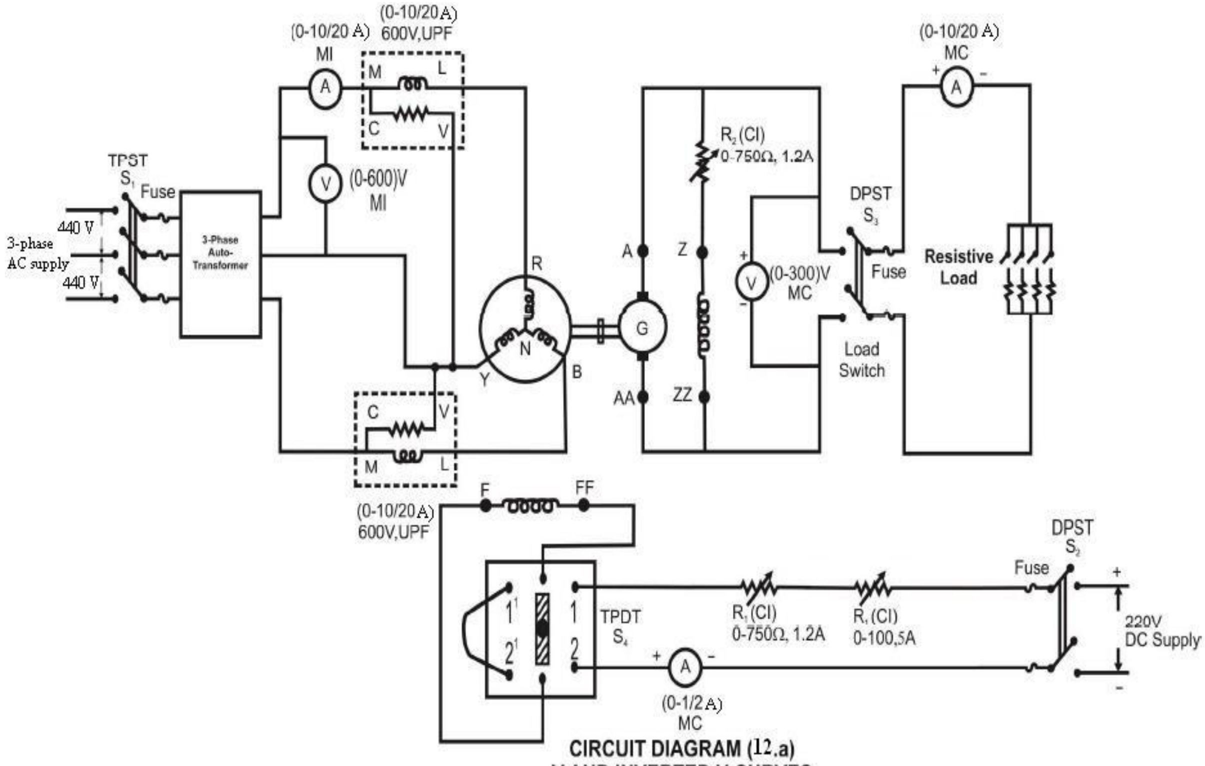
$R_L$ = variable load resistance

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

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

**Signature of Staff-incharge**

**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<br>0-10/20A<br>0- 1/2 A | MC<br>MI<br>MC | 01<br>02<br>01 |
| 03 | Rheostats | 0-750Ω,1.2A | - | 02 |
| 04 | Watt meters | 0-600V, 10/20A | UPF | 02 |

**PROCEDURE:**

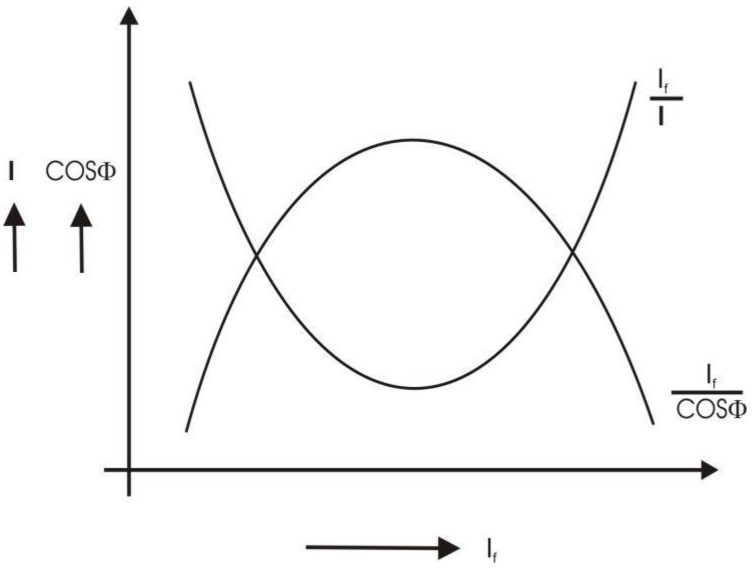
1. Connections are made as shown in the circuit diagram (11.a)
2. The TPDT switch (S4) in 1′ & 2′ position. (The field of the synchronous motor (F and FF) is temporarily shorted).
3. Keeping load switch ($S_3$) open, the both rheostats $R_1$ in the field circuit of synchronous motor in cut-in position 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:**

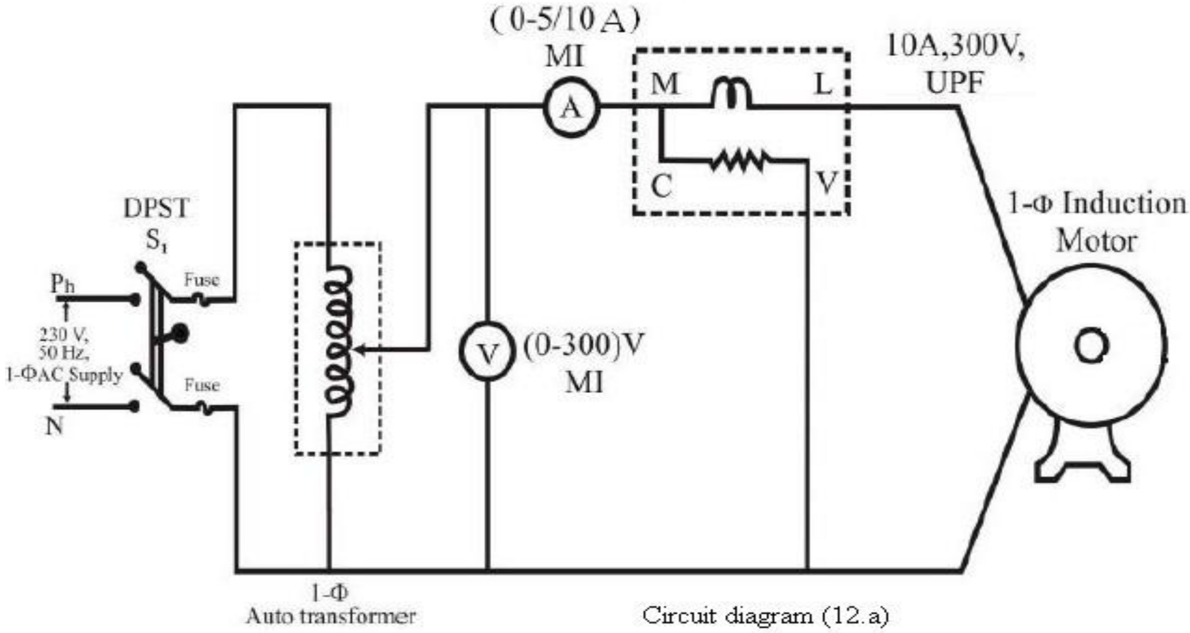
Power factor is given by

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

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.

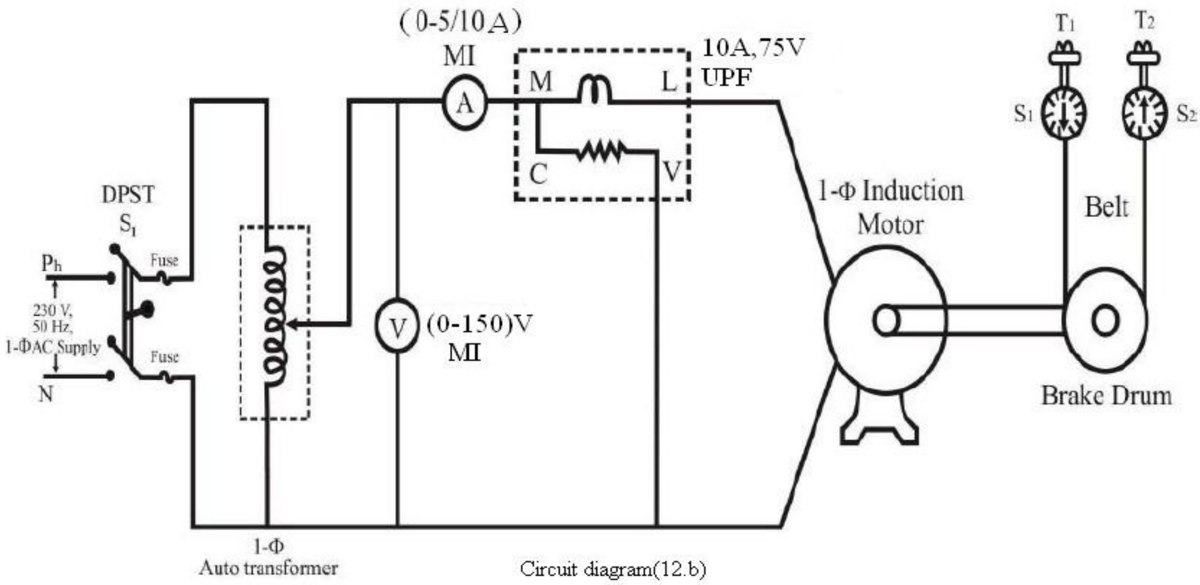
**Signature of Staff-incharge**

**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<br>0-150V | MI | 01 |
| 02. | Ammeter | 0-5/10A | MI | 01 |
| 03. | Wattmeter | 10A, 300V<br>10A,150V | UPF | 01 |
| 04. | Tachometer | -- | Contact Type | 01 |

**PROCEDURE:**

1) OPEN CIRCUIT TEST.

10. Connections are made as shown in the circuit diagram (12.a).
11. Keeping the 1-Φ auto-transformer voltage in zero out-put position, the supply switch ($S_1$) is closed.
12. By varying the 1-Φ auto-transformer, the rated voltage of 1-Φ induction motor is applied. All the meter readings are noted down.
13. 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.

14. Connections are made as shown in the circuit diagram (12.b).
15. The brake-drum of the induction motor is blocked from rotation by tightening the belt.
16. By keeping the 1-Φ auto-transformer voltage in zero out-put position, the supply switch ($S_1$) is closed.
17. 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.
18. 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) |
|---|---|---|---|
| | | | |

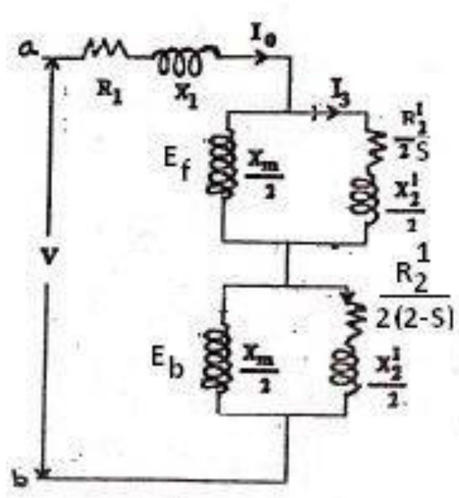
NOTE: 1) W = (k × Watt Meter Reading.) Where, k = $\dfrac{(V_{sel} \times I_{sel} \times \text{Cos}\,\phi)}{\text{Full Scale Deflection}}$

4. SHORT-CIRCUIT TEST.

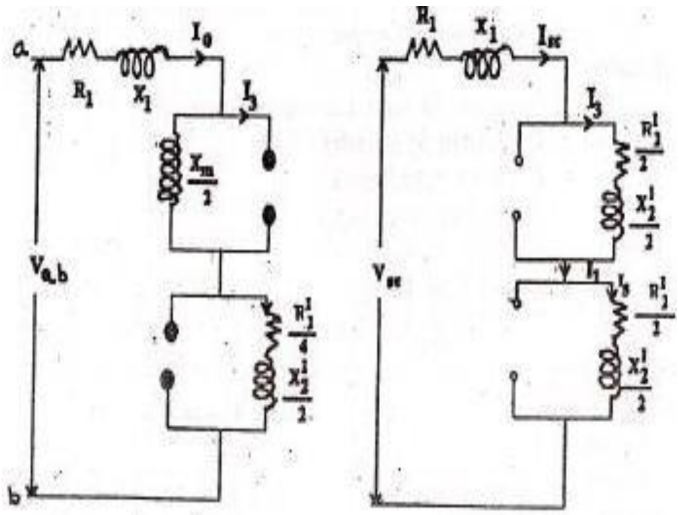
| Sl. No. | $V_{sc}$ (Volts) | A (Amps) | $W_{sc}$ (Watt) |
|---|---|---|---|
| | | | |

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

**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

$$\mathbf{Z_S} = \frac{\mathbf{V_S}}{\mathbf{I_S}}$$

$$\mathbf{R_S} = \mathbf{R_1} + \mathbf{R'_2} = \frac{\mathbf{W_S}}{\mathbf{I^2_S}}$$

$$X_S = \sqrt{Z_S{}^2 - X_S{}^2}$$

Assuming $R_1 = R_2{}' = \frac{R_S}{2}$ and $X_1 = X_2{}' = \frac{X_S}{2}$

$$\mathbf{R_1} = \mathbf{R_2}'$$

$$\mathbf{X_1} = \mathbf{X_2}'$$

NO –LOAD TEST

$$Z_0 = \frac{V_0}{I_0}$$

$$X_0 = \sqrt{Z_0{}^2 + [R_1 + \frac{R'_2}{4}]^2}$$

$$\frac{X_M}{2} = [X_0 - X_1 - (\frac{X'_2}{2})]$$

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) $\text{Cos P} = \frac{R_t}{Z_t}$.

(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

$I_3 = \frac{E_f}{Z_3} =$……………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

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

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

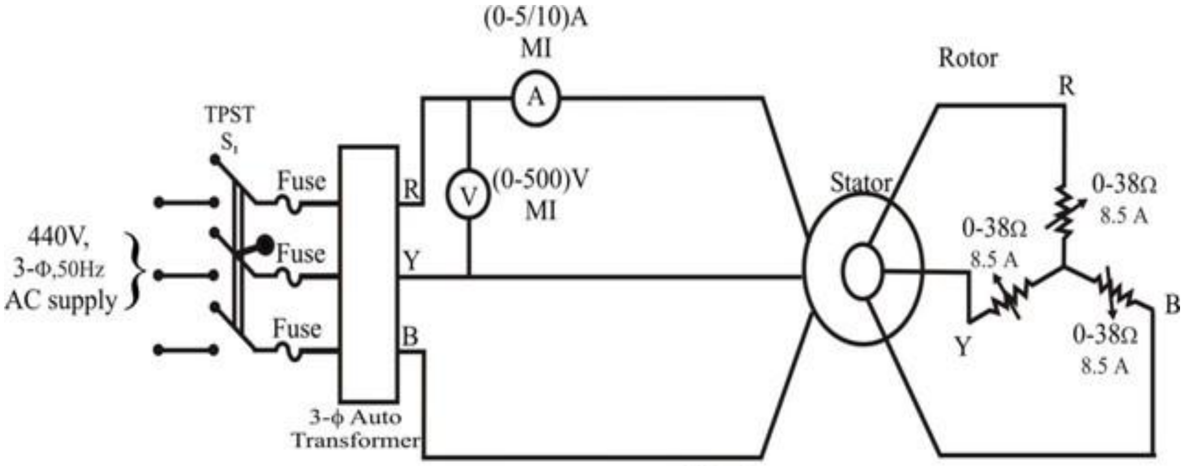
(ix) Net Torque $(\tau = \tau_f - \tau_b$ Syn - watts.

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

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

**Signature of Staff-incharge**

CIRCUIT DIAGRAM:




Circuit Diagram (13.a)

**SPEED CONTROL OF 3-Φ INDUCTION MOTOR**

TABULAR COLUMN:

| Sl.No | I (Amps) | V (Volts) | N Speed (rpm) |
|---|---|---|---|
| | | | |

**"ADDITIONAL EXPERIMENT"**

**Experiment No. 13** Date:___/__/______

**SPEED CONTROL OF 3-Φ INDUCTION MOTOR**

AIM:

To control the speed of a given 3-Φ slip-ring induction motor by using rotor resistance.

APPARATUS REQUIRED:

| Sl. No | Particulars. | Range | Type | Quantity |
|---|---|---|---|---|
| 01. | Voltmeter | 0-500V | MI | 01 |
| 02. | Ammeter | 0-5/10A | MI | 01 |
| 03. | Tachometer | -- | Contact Type. | 01 |
| 04 | Rheostats | 0-38Ω,8.5A | -- | 03 |

PROCEDURE:

1. Connections are made as shown in the circuit diagram (13.a).
2. By keeping the 3-Φ auto transformer voltage in zero out-put position, the 3-Φ rotor resistance in maximum resistance (Rheostats in cut-in position) position, the supply switch ($S_1$) is closed.
3. By varying the 3-Φ auto transformer the rated voltage of the induction motor is applied. [Say 415V]. All the meter readings and motor speed are noted down.
4. All the 3 rheostats are gradually decrease in steps. At each step the readings of all the meters and speed are noted down.
5. To stop the machine, the 3-Φ rotor resistance is brought back to their initial position and 3-Φ auto transformer to its initial zero out-put position, the supply switch ($S_1$) is opened.

**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 v/s Speed characteristics of a given DC shunt motor by conducting 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 DC 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 DCmotor 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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2. Electric Machinery and Transformers (The Oxford Series in Electrical and Computer Engineering) by Bhag S. Guru and Hüseyin R. Hiziroglu (Jul 20, 2000)

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6. Theory of Alternating Current Machinery, Alexander S. Langsdorf TATA MCGRAW HILL.

7. Electrical Technology Volume – II, by B.L.THERAJA, S Chand Publication.
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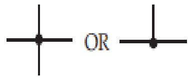
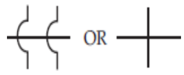
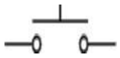
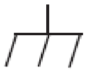
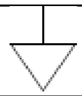
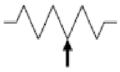
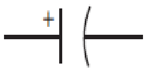
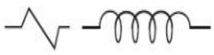
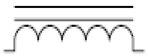
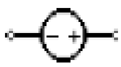
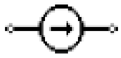
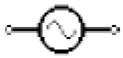
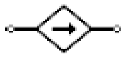
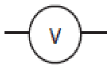
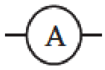
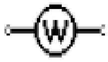
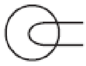
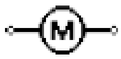
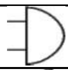
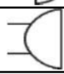
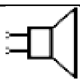
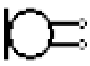
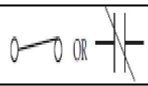
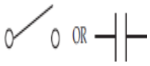
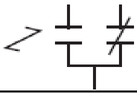
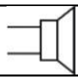
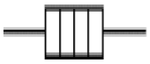
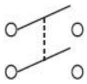
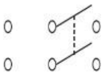
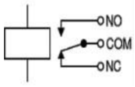
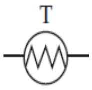
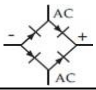
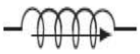
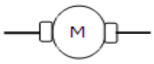
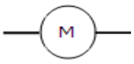
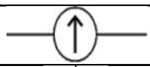
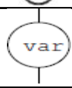
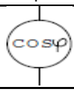
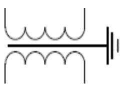
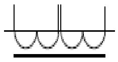
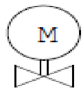
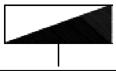
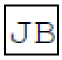
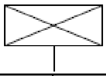
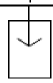
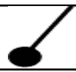
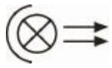
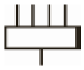
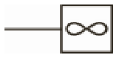
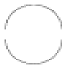
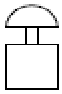
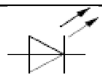
**Appendix**

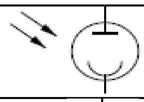
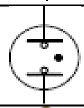
**STUDY OF ELECTRICAL SYMBOLS**

| 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** |  |