NED University of Engineering & Technology

Department of Electrical Engineering

LAB MANUAL

ELECTRICAL MACHINES II

(EE-347) For T.E.(EE)

Instructor name:_____

Student name:_____

Roll no: _____ **Batch:**_____

Semester: _____ **Year:**_____

LAB MANUAL

For the course

ELECTRICAL MACHINES II

(EE-347) For T.E.(EE)

Content Revision Team:

Dr. Abdul Ghani Abro, Ms. Najia Naveed

Last Revision Date: 28 Feb 2023

Approved By

The Board of Studies of Department of Electrical Engineering

Summary of Rubric Sheets for Data Entry in OBE MIS System [to be entered as they are on OBE portal with no scaling]

Lab #	Extent of achievement	Lab #	Extent of achievement	Lab #	Extent of achievement
	Total out of 32		Total out of 32		Total out of 32

Lab #	Extent of achievement	Lab #	Extent of achievement	Lab #	Extent of achievement
	Total out of 32		Total out of 32		Total out of 32

Add six total scores from above to get total Rubric score Out of 192	R=
Scaled to 25 marks (R/192)*25	S=
Lab Attendance percentage from portal:	A=
Attendance scaled to 5 marks: (A/100)*5	P=
For entry on NED exam portal Total lab sessionals out of 30: S + P	T=

PBL/OEL	Extent of achievement	Final	Extent of achievement
	Total out of 32		Total out of 32

Add two total scores from above to get total final Rubric Score Out of 64	Z=
For entry on NED exam portal Total Final Lab Marks scaled to 20 marks (Z/64)*20	F=

CONTENTS

Lab Session 01

OBJECTIVE

To learn identification of various electrical machines &their parts.

List of Machines Under Study

Transformers
Fan Motor (Ceiling & Exhaust)
Washing Machine Motor
Pump Motor
Juicer Motor
Toys Motor

THEORY

Introduction to Transformers

A transformer is a device that transfers electrical energy from one circuit to another by electromagnetic induction (transformer action). The electrical energy is always transferred without a change in frequency, but may involve changes in magnitudes of voltage and currents. The total VA at primary and secondary is always constant.

There are two types of transformers.
1. Core Type
2. Shell Type

Exercise:
Identify the following types of transformer & also label the parts.

Name Different Parts of Transformer:

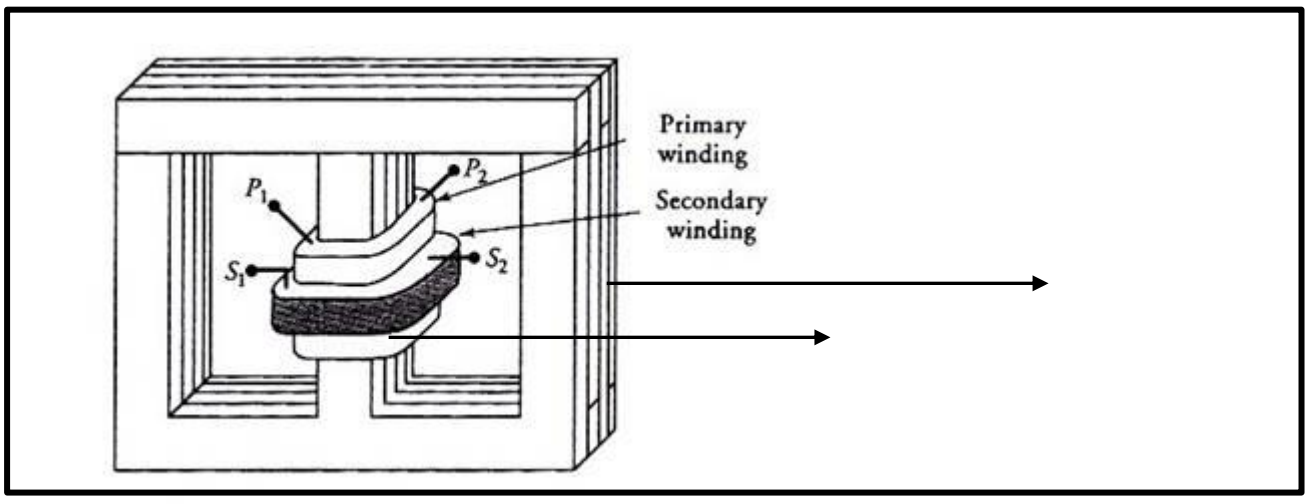


Figure :1.1Shell Type Transformer

Name different parts of transformer:

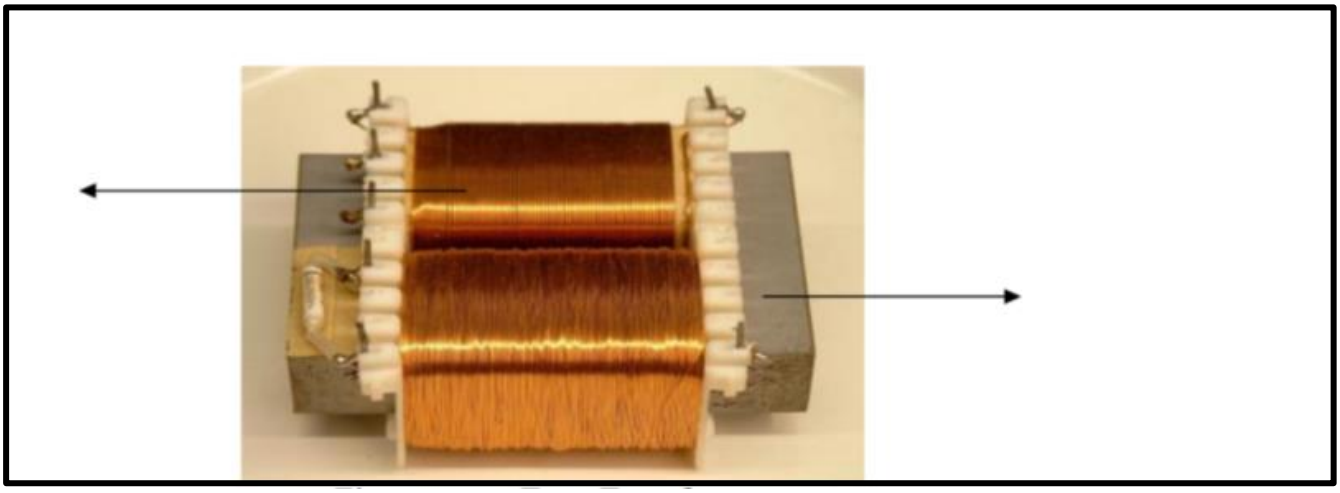


Figure: 1.2 Core Type Transformer

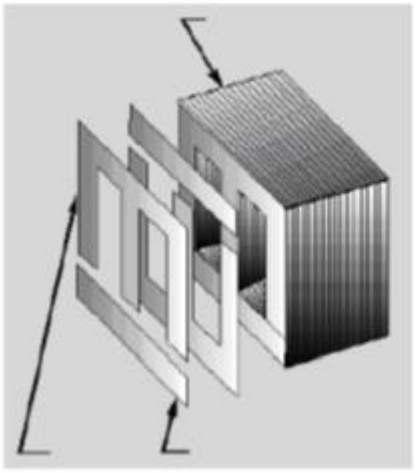


Figure: 1.3 E-I Type Core

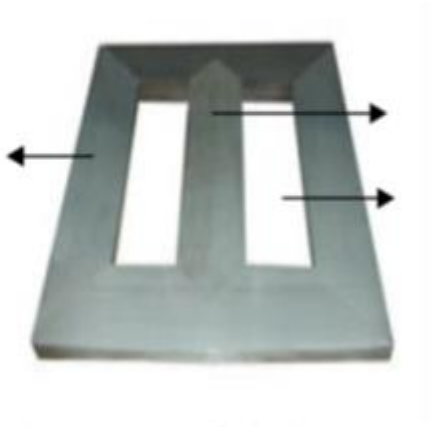


Figure:1.4Parts of Shell Type T/F Core

Universal Motor

The universal motor is a rotating electrical machine similar to DC series motor, designed tooperate either from AD or DC source. The stator & rotor windings of the motor are connected in series through the rotor commutator. The series motor is designed to move large loads with high torque in applications such as crane motor or lift hoist.

Exercise:
Identify the following types of motors & also label the parts.

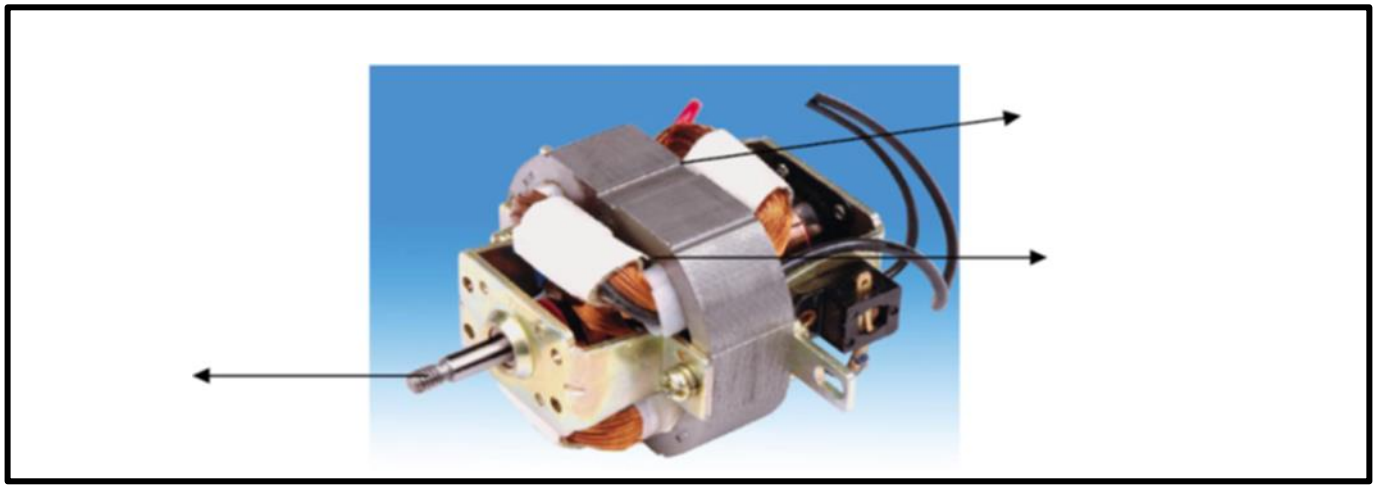


Figure: 1.6 Universal Motor

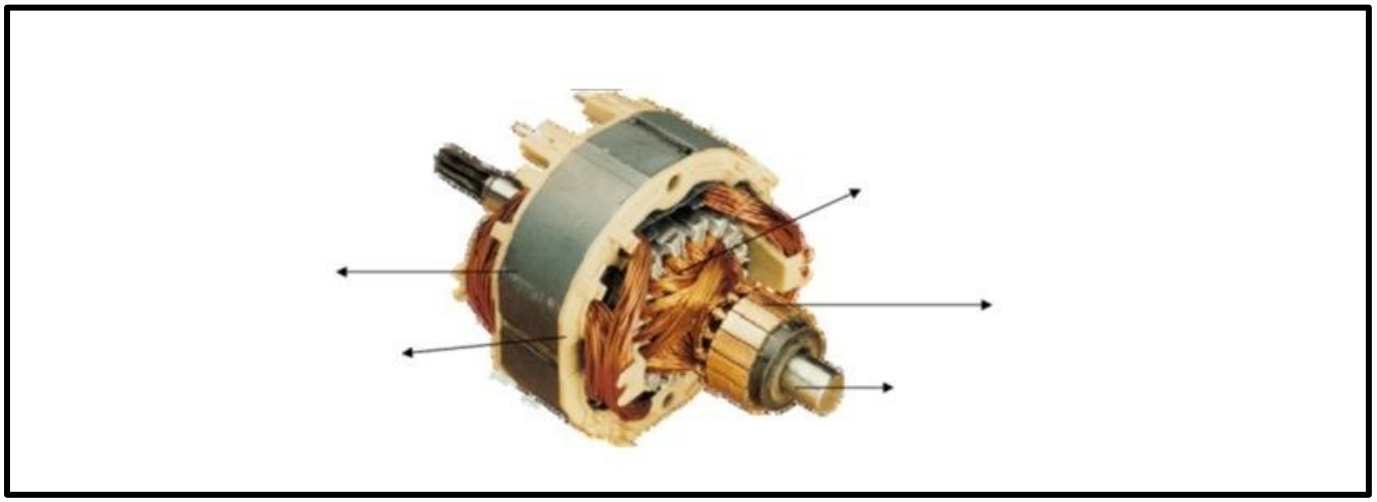


Figure: 1.7 Universal Motor

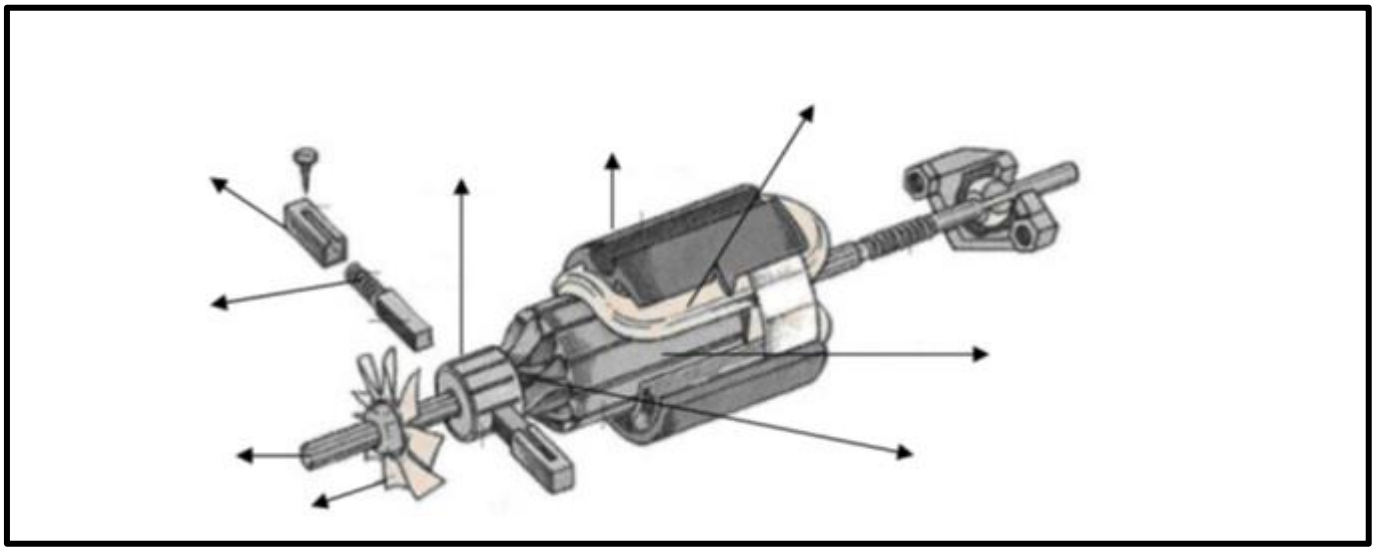


Figure:1.8Assembly of Universal Motor

Induction Motor

An Induction motor is a motor without rotor windings, the rotor receives electric power by induction rather than by conduction, exactly the same way the secondary of a 2 windings transformer receive its power from the primary.

The single-phase induction motor has no intrinsic starting torque. Starting torque can be achieved by either one of the method.

1. Split phase windings
2. Capacitor type windings
3. Shaded pole stator

There are two types of rotor constructions.

1. Shaded cage rotor
2. Wound rotor

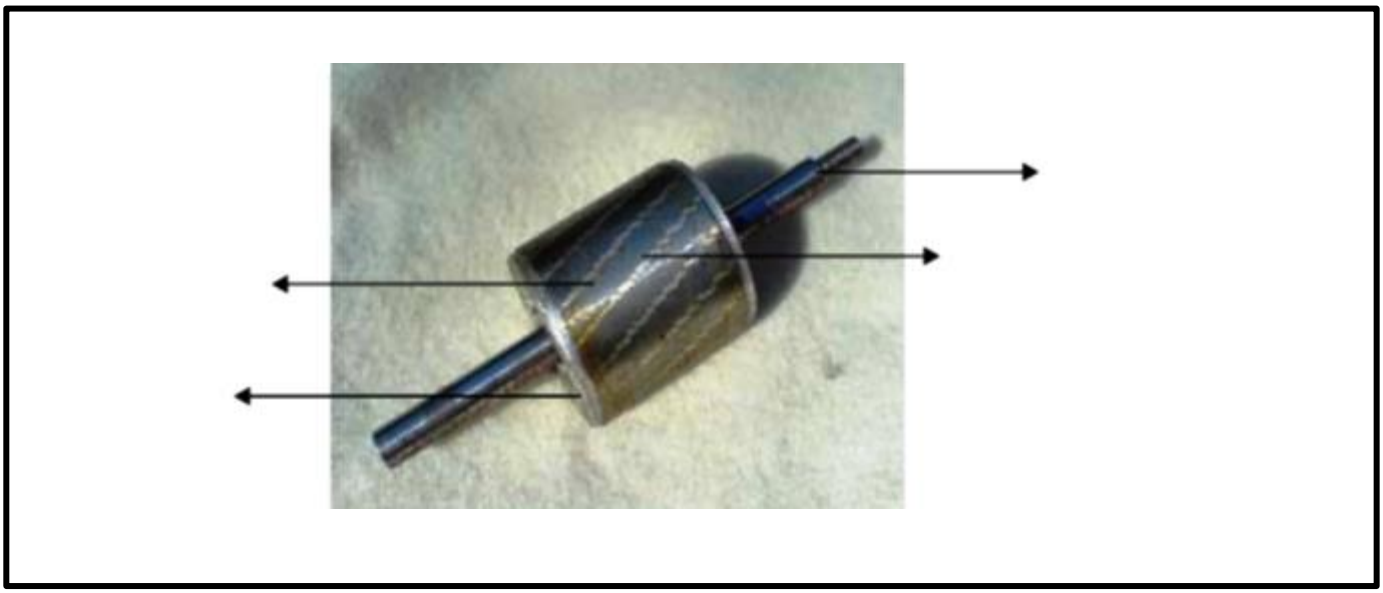


Figure 1.10 Squirrel cage rotor of induction motor

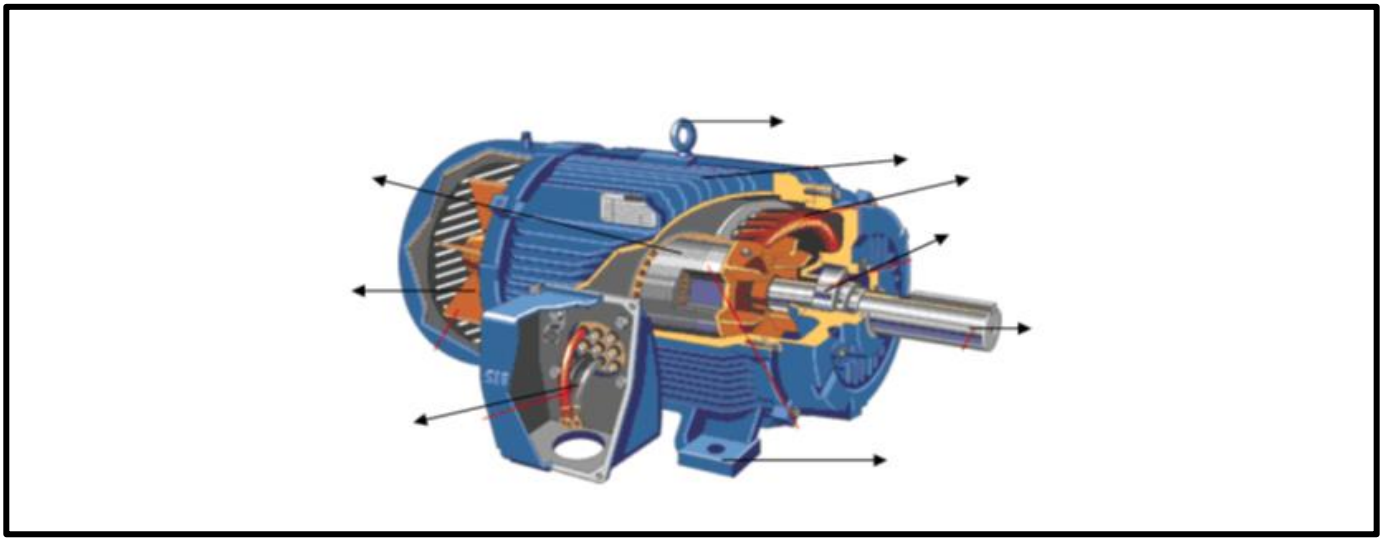


Figure: 1.11 Wound Rotor Induction Motor

PMDC motor

A permanent magnet DC motor is the simple motor that converts electrical energy into mechanical energy through the interactions of the two fields. One field is produced by a permanent magnet poles, the other field is produces by electrical current flowing in the armature windings. These two fields result in a torque which tends to rotate the rotor.

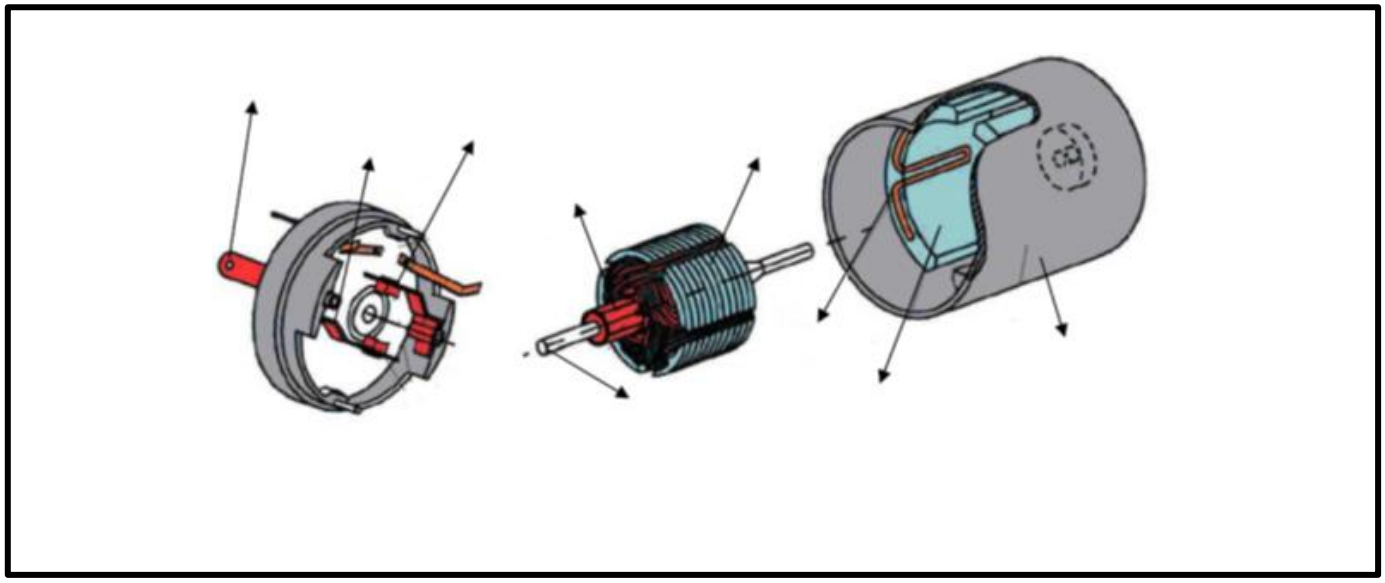


Figure:1.12 PMDC Motor's Assembly

PROCEDURE

In this lab, you are supposed to identify various machines presented to you during the laboratory session. Also get familiarize with their applications, components and basic working.

RESULT

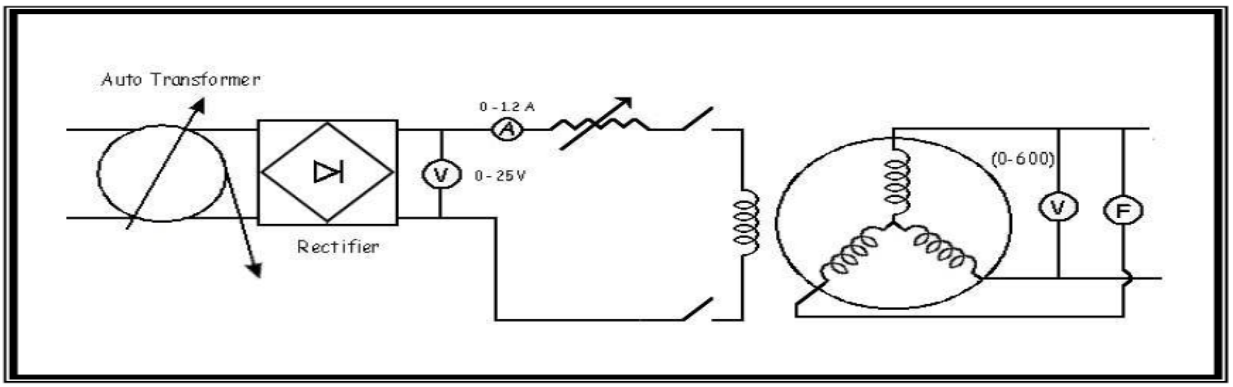
The basic parts of motors have visualized.

LAB SESSION 02

OBJECT:

To study the effect of field excitation on the generation of voltage by an alternator (Open circuit magnetization curve)

CIRCUIT DIAGRAM:



THEORY

A.C generator (alternator), consists of two parts, namely the field system and anarmature, but unlike a dc generator, alternator has rotating field system and an stationary armature, advantages of such system are given below. An excitation system is attached to give dc supply to the field. The advantages of rotating field and stationary armature are:

- Rotating field can run with high speed as output voltage is dependent on its rate.
- It is easy to insulate the stationary armature windings for high voltages.
- It is easy to collect the high voltage from a fixed terminal.
- Stator is outside of the rotor (fixed in yoke), so more space is available for 3-phase Winding

1. Make the connections as shown in figure
2. Excite the field with DC source
3. Adjust frequency of output to 50 Hz by adjusting speed of prime mover.
4. Nom increase the dc excitation current in steps.
5. Tabulate the readings after every step and draw the open circuit characteristics (O.C.C) or no load magnetization curve.

OBSERVATION:

S.No.	Rotor field excitation Current (I_f)	Terminal Voltage (V_T)

RESULTS Graphs between voltage and current

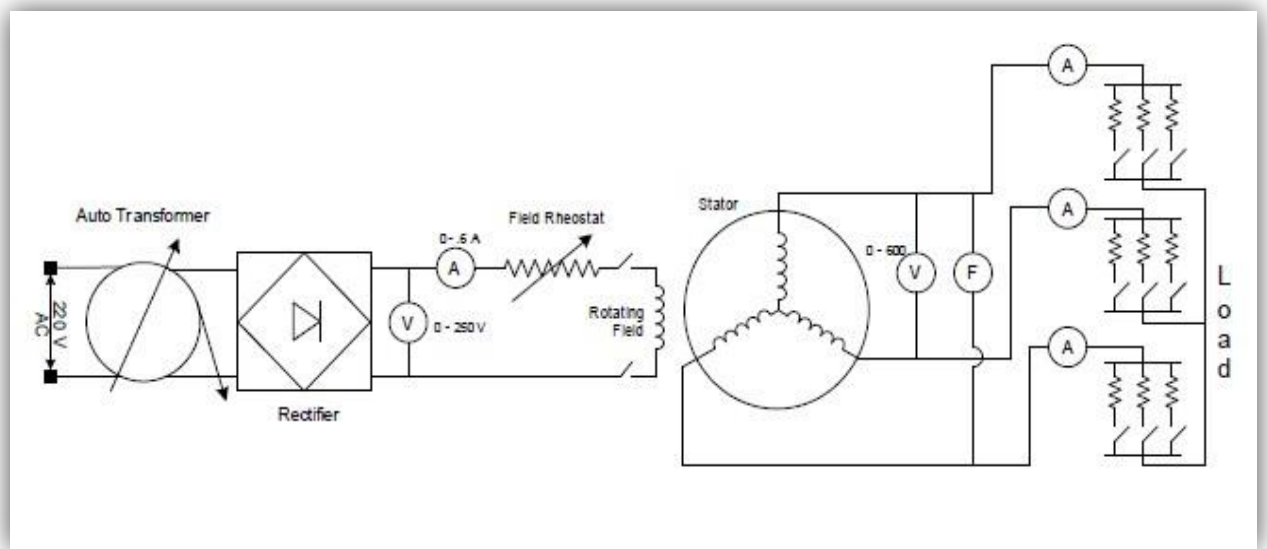
CONCLUSION:

LAB SESSION 03

OBJECT

To draw the load characteristic curves of alternator.

CONNECTION DIAGRAM



THEORY

The purpose of the experiment is to study the relationship of armature current drawn and frequency of alternator against increase in load. As we know, increase in load will increase current drawn and thus causes increase in load dependent losses. Hence on increasing load, voltage will drop from rated to lower value depending upon load magnitude and its power factor of alternator. Whereas frequency is dependent on magnitude of net torque, as counter torque increase with increase in load because of its dependence on load current. Increase in counter torque decrease the net torque and net result is decrease frequency of generator. For maintaining voltage level we have to increase DC excitation and for frequency maintenance speed of prime mover is increased.

PROCEDURE

1. Make connections according to the given circuit.
2. Switch on prime mover, adjust output voltage of alternator by adjusting DC excitation and for frequency, control speed of prime mover.
3. Note down reading of different instruments connected.
4. Start increasing load in steps and after every step note down readings of instruments.
5. Plot graph between output voltage and load current.
6. Plot graph between frequency and load current.
7. Read the meters and note down the readings carefully

OBSERVATION TABLE

S.No	I_1(A)	I_2(A)	I_3(A)	V(Volts)	I_f(A)	$I_L=I_1+I_2+I_3$ (A)
1						
2						
3						

RESULT: Graph between Vt and Il

CONCLUSION

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Course Code and Title: _____

Laboratory Session: No._____ Date: _____

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to identify equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to describe the use of the equipment for the lab work.	Never describes the use of equipment.	Rarely able to describe the use of equipment.	Occasionally describe the use of equipment.	Often able to describe the use of equipment.	Frequently able to describe the use of equipment.
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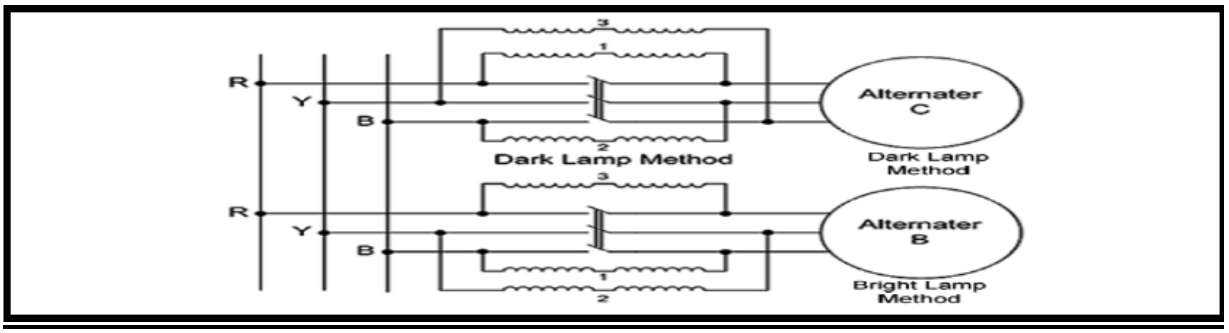
Group Work Contributes in a group-based lab work.	Never participates.	Rarely participates.	Occasionally participates and contributes.	Often participates and contributes.	Frequently participates and contributes.

LAB SESSION 04

OBJECTIVE:

To study parallel operation of 3-phase synchronous generator using lamp method.

CIRCUIT DIAGRAM:



THEORY

The operation of connecting an alternator in parallel with another alternator or with common bus bar is known as synchronization of alternators. Nowadays common trend is to run different generating station in parallel due many advantages we are getting like increased reliability, increased cost effectiveness and etc. For synchronization we have to consider matching of different parameters of generator because without matching these parameters one cannot synchronize generators. It is never advisable to connect a stationary alternator to a line bus bar because stator induced emf being zero, a short circuit will result. For the purpose of synchronization of alternator, the following conditions are satisfied.

1. The terminal voltage of the oncoming alternator must be the same as that of the bus bar.
2. The speed of the incoming alternator must be such that its frequency should be slightly greater than bus bar frequency.
3. The phase sequence and phase angle of the alternator must be same as that of another generator or bus bar.

Voltages of generator and bus bar are matched with the help of voltmeters, frequency with frequency meters. In addition to this, for the purpose of phase sequence and phase angle matching usually the bulb method is used, either dark method or light method known as Bright Lamp method and Dark Lamp method. Another popular approach is to use synchronous scope.

PROCEDURE

1. Make connections according to the given circuit.
2. Start one of synchronous generators and fix its output parameters as rated one.
3. Start another synchronous generator and fix its output parameters equal to first one.
4. Before synchronizing both generators match their output parameters as discussed above.
5. Read the meters and note down the readings carefully

OBSERVATION:

Conditions of parallel operation verified or not

RESULT:

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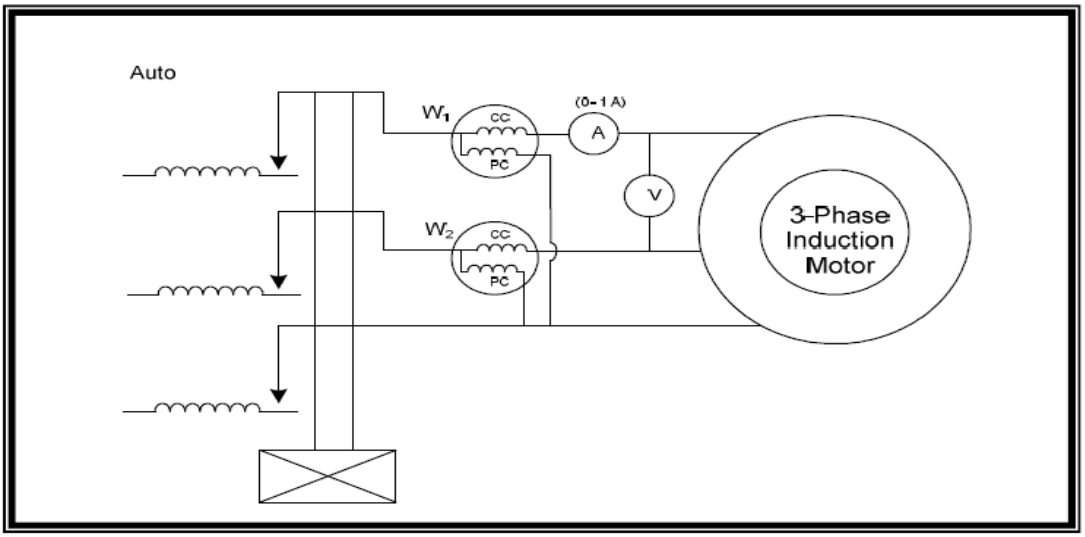
LAB SESSION 05

OBJECT

To study the effect of applied voltage on power factor & current drawn by 3-Φinduction motor

CONNECTION DIAGRAM



THEORY

The induction motor consists of a stator and rotor. The stator is connected to the three phase supply & produce rotating magnetic field. So an induction motor is like a transformer with stator forming primary and rotor forming the secondary winding with the small air gap in the magnetic circuit. Upon increasing voltage at no load, reactive current drawn by induction motor will increase, therefore power factor of induction motor decreases but total current drawn will increase upon increase voltage at no load. Here power is measured by two wattmeter method. The advantage of using two wattmeter method is, we can also measure power factor along with power consumed. When power factor is equal to 0.5 one wattmeter will show 00 Watt but second will give some reading. When power factor is less than 0.5 one will measure the negative power because phase angle between current & voltage is more than 90 and other in positive direction. When power factor is more than 0.5 both will deflect in positive direction. As induction motor draw 5 to 7 times the rated current at start so it is necessary to start it with reduced voltage by the help of an auto transformer. **P.f = W1+W2 / (3)½ VI**

PROCEDURE

1. Make connections according to the given circuit.
2. By increasing voltage gradually from zero to some value, start induction motor, once it gets its steady state position stop increasing voltage
3. Note down the readings of different instruments connected.
4. Now increase the voltage in steps and after every step note down the reading.
5. Read the meters and note down the readings carefully

OBSERVATION

S.No	V (Volts)	I (Amp)	W1 (Watts)	W1 (Watts)	W=W1 + W2	pf
1						
2						
3						
4						
5						

CALCULATIONS

Show the calculations of power factor at each voltage.

RESULT

Discuss the result of practical.

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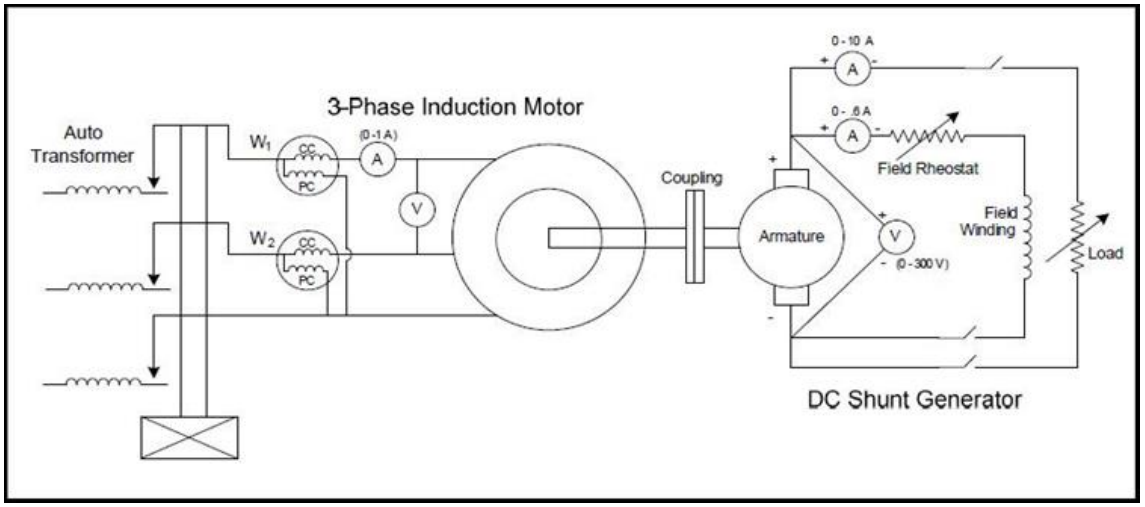
LAB SESSION
06

OBJECT

To draw the load characteristic curves of three-phase Induction Motor.

CONNECTION DIAGRAM



THEORY

Induction motor is asynchronous and variable speed motor. As we know power factor of induction motor is around 0.2 (very poor) at no load, because no use full work is done except meeting negligible mechanical losses. As we go on increasing shaft load motor will draw more active current component for it has to produce use full work. Hence as we increase load on induction motor, current drawn will increase along with increase in power factor, which usually at full load is around 0.85. Here load is DC self-excited shunt generator On increasing shaft load, net torque acting on shaft of induction motor decreases causing decrease in speed of induction motor for developing more electromagnetic torque. Here power is measured by two wattmeter method. The advantage of using two wattmeter method is, we can also measure power factor along with power consumed. When power factor is equal to 0.5 one wattmeter will show 00 Watt but second will give some reading. When power factor is less than 0.5 one will deflect in negative direction because phase angle between current & voltage is more than 90 where as other in positive direction. When power factor is more than 0.5 both will deflect in positive direction. **P.f = W1+W2 / (3)1/2 * VI**

PROCEDURE

1. Make connections according to the given circuit.
2. By increasing voltage gradually from zero to rated value, start induction motor.

3. Energize field of shunt dc generator and build rated voltage across terminals of DC shunt generator and note down required parameters of induction motor with help of connected instruments.

4. Connect load across terminals of generator and start increasing load in small increments.
5. After every increment, note down readings of connected instruments.

6. Plot the graph between speed and load current and between power factor of induction motor and load current.

7. Read the meters and note down the readings carefully.

OBSERVATION

Idc= _____ A

S.No.	V(volts)	I_{ac}(amps)	W1(watts)	W2(watts)	W=W1+W2	N(rpm)

RESULT:

Power factor of induction motor at full load is_____ and speed at full load is_____.

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LAB SESSION 07

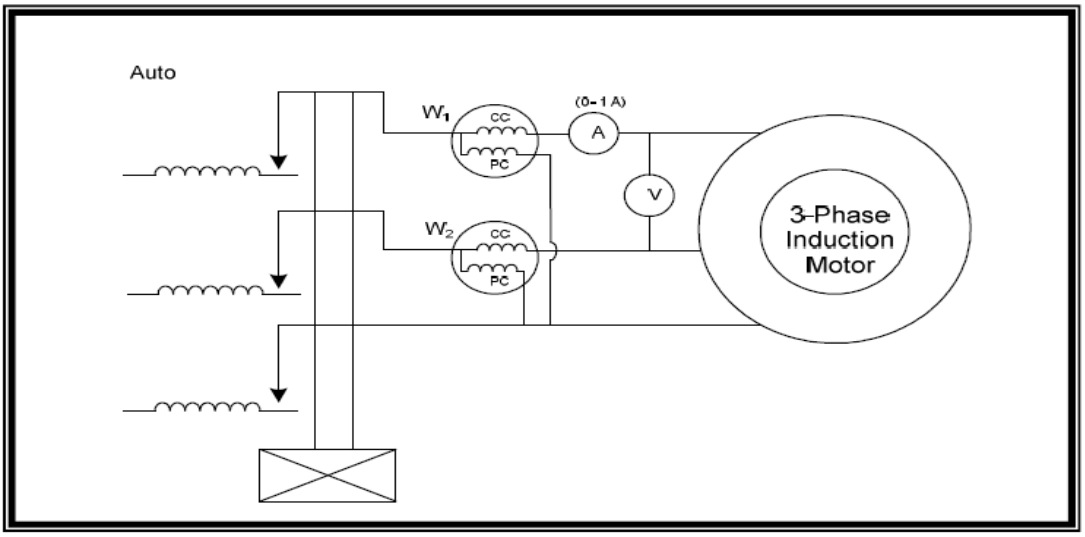
OBJECT

To perform blocked rotor test of 3-phase induction motor.

APPARATUS

1. Induction Motor on Bench 10-ES/EV or Bench 14-ES/EV
2. Voltmeter (0-600V)
3. Ammeter (0-6A)
4. Two watt meters (0-120W)
5. Auto transformer

CONNECTION DIAGRAM



THEORY

For the performance analysis of induction motor, we need to have motor parameters. In those cases where motor parameters are not readily available from the manufacture, they can be approximated from different tests. One of them is blocked rotor test. This test is similar to short-circuit test of transformer. Purpose of this test is to determine load dependent losses and stator & rotor reactance &rotor resistance. The rotor is blocked to prevent rotation and balanced voltages are applied to the stator terminals at rated frequency. Applied voltage is gradually increased till rated current is achieved. Current, voltage and power are measured at the motor input and from this data motor parameters are calculated.

PROCEDURE

1. Make the circuit as shown in figure.
2. Disconnect the load connected, if any.
3. Keep rotor of induction motor pressed, so that it cannot rotate even upon energization.
4. Keep yellow switch "ON" and start increasing voltage slowly till rated current is achieved.

5. Note down the readings of all instruments connected

OBSERVATION

S. No	Voltage	Current	Power

CALCULATIONS

Show the calculations of load losses , stator and rotor reactance and stator and rotor resistance.

RESULT

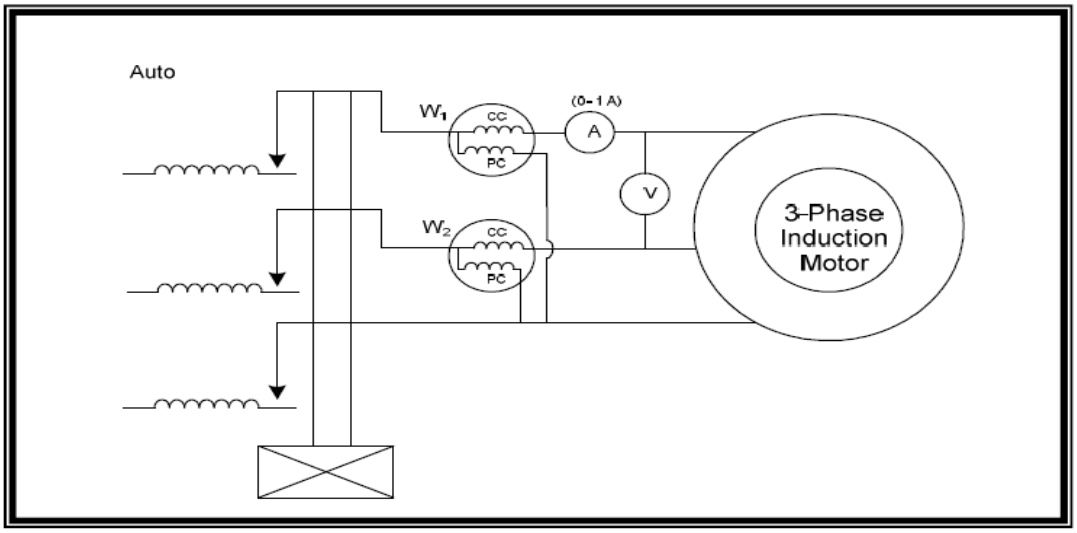
Magnitude of load losses= watts
Magnitude of stator and rotor reactance= Ω
Magnitude of stator and rotor resistance= Ω

LAB SESSION 08

OBJECT

To carry out no load test of 3-phase induction motor

CONNECTION DIAGRAM



THEORY

For the performance analysis of induction motor, we need to have motor parameters. In those cases where motor parameters are not readily available from the manufacture, they can be approximated from different tests. One of them is no load test. Purpose of this test is to find out no load losses i.e core (magnetizing reactance) and mechanical losses for at this condition power consumed is basically because of these losses. Balanced three phase voltages are applied to the stator terminals at the rated frequency with the rotor uncoupled from any mechanical load. Current, voltage and power are measured at the motor input.

PROCEDURE

1. Make the circuit as shown in figure.
2. Disconnect the load connected, if any.
3. Start the motor by pressing yellow switch "ON" without load.
4. Note down the readings of all instruments connected.

OBSERVATION

S. No	Voltage	Current	Power

CALCULATIONS

Show the calculations of no-load losses and magnetization reactance.

RESULT

Magnitude of no-load losses = watts

Magnitude of magnetization reactance = Ω

LAB SESSION 09

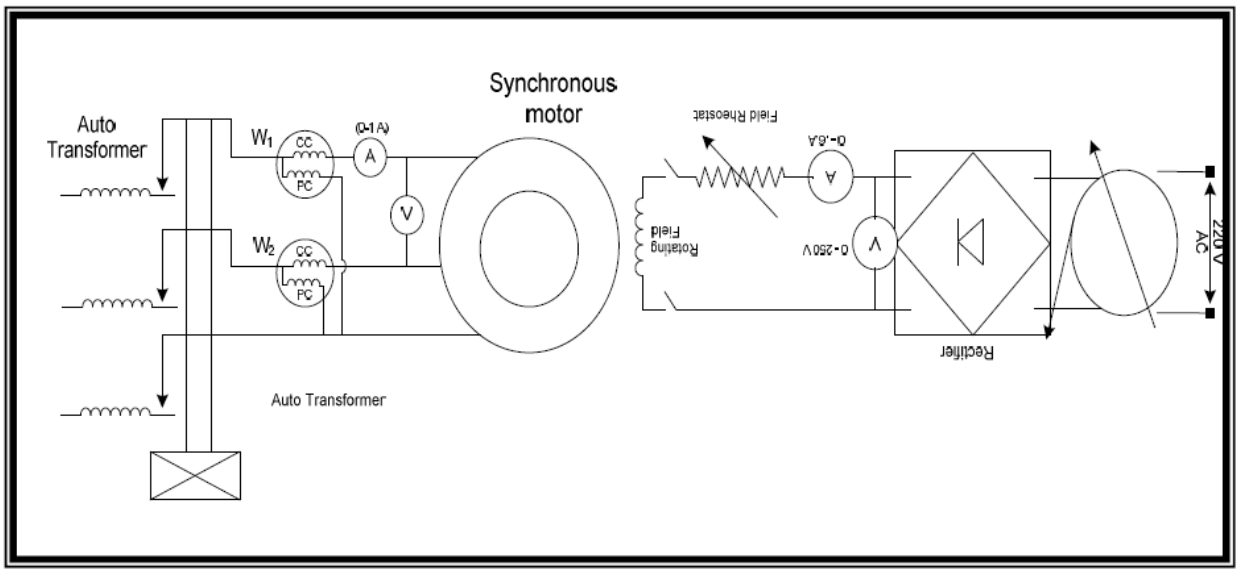
OBJECT:

To observe the effect of excitation voltage on power factor and armature current of Synchronous motor.

APPARATUS:

1. Bench 14-ES/EV
2. DC multi-range ammeter
3. DC multi-range ammeter
4. Voltmeters
5. Multi range watt meters

CONNECTION DIAGRAM:



THEORY

The synchronous motor is a doubly excited motor, the stator is connected to the three phase supply & produce rotating magnetic field whereas rotor is given across DC excitation. Upon increasing 3-ϕ ac voltage to stator at no load keeping dc excitation constant, reactive current drawn by synchronous motor will increase as no use full work is produced at no load condition except meeting the mechanical losses. Therefore power factor of synchronous motor decreases but total current drawn will increase upon increase voltage at no load. Here power is measured by two wattmeter method. The advantage of using two wattmeter method is, we can also measure power factor along with power consumed. When power factor is equal to 0.5 one watt-meter will show 00 power but second will give reading. When power factor is less than 0.5 one will measure the negative power because phase angle between current & voltage is more than 90 and other in positive direction. When power factor is more than 0.5 both will measure positive power. As synchronous motor draw 5 to 7 times the rated current at start so it is necessary to start it with reduced voltage by the help of an auto transformer. **P.f = W1+W2 / (3)½ VI**

Procedure:

1. Make connections according to the given circuit.
2. Switch on supply of synchronous motor by pressing yellow switch.
3. Once motor starts running on synchronous speed, start increasing DC excitation in steps.
4. After every step note down reading of instruments connected.

OBSERVATION

S. No	V_{AC}	I_{AC}	W_1	W_2	V_{DC}	I_{DC}	P.F

RESULT:

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Department of Electrical Engineering

Course Code and Title: _____

Laboratory Session: No._____ Date: _____

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to identify equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to describe the use of the equipment for the lab work.	Never describes the use of equipment.	Rarely able to describe the use of equipment.	Occasionally describe the use of equipment.	Often able to describe the use of equipment.	Frequently able to describe the use of equipment.
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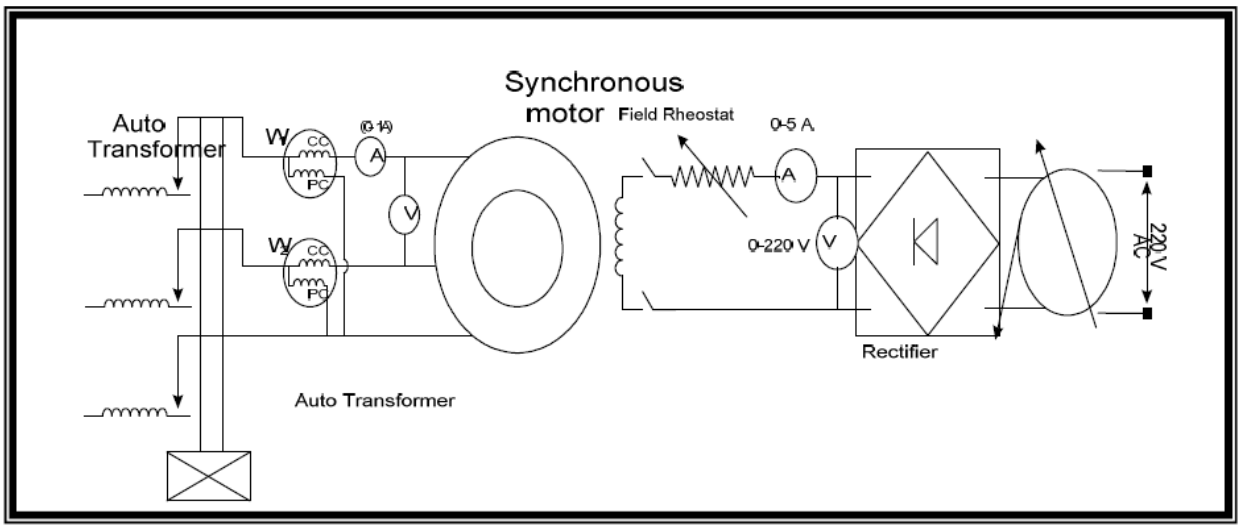
Group Work Contributes in a group-based lab work.	Never participates.	Rarely participates.	Occasionally participates and contributes.	Often participates and contributes.	Frequently participates and contributes.

LAB SESSION
10

OBJECT:
To study the effect of applied voltage on power factor & current drawn by 3-Φ Synchronous Motor

APPARATUS:
1. Bench 11-ES/EV
2. Voltmeter
3. Ammeter
4. Two wattmeters
5. Auto transformer

CONNECTION DIAGRAM:



THEORY
Synchronous motor is doubly excited and constant speed motor. As we know power factor of synchronous motor is very poor at no load and at under excitation state, because no use full work is done except meeting negligible mechanical losses. As we go on increasing shaft load on synchronous motor, motor will draw more active current component for it has to produce use full work. Hence as we increase load on synchronous motor, current drawn will increase along with increase in power factor, keeping excitation voltage constant. Here load is DC self-excited shunt generator. As we know generator has counter torque which opposes input mechanical power given by synchronous motor and counter torque is dependent load current. As generator deliver more current on increasing load, hence will develop more counter torque, thus more load will be reflected on synchronous motor. On increasing load, net torque acting on shaft of synchronous motor decrease causing momentary decrease in speed of synchronous motor for increasing load angle. As load angle increases, synchronous motor will regain its synchronous speed. Therefore speed of synchronous motor will remain same at all load conditions. Here power is measured by two wattmeter method. The advantage of using two watt-meter method

is, we can also measure power factor along with power consumed. When power factor is equal to 0.5 one wattmeter will show 00 power but second will give reading. When power factor is less than 0.5 one will measured the negative power because phase angle between current &voltage is more than 90 and other in positive direction. When power factor is more than 0.5 both will measure positive power.

P.f = W1+W2 / (3)1/2 * VI

PROCEDURE:

1. Make connections according to the given circuit.
2. By increasing voltage gradually from zero to some value, start synchronous motor, once it gets its steady state position stop increasing voltage
3. Give dc excitation as soon as motor reaches near to synchronous speed.
4. Note down the readings of different instruments connected.
5. Now increase the voltage in steps and after every step note down the reading.
6. Read the meters and note down the readings carefully

OBSERVATION

S. No	$V(Volts)_{AC}$	$I\ (Amp)_{AC}$	$W_1(Watts)$	$W_2(Watts)$	W1+W2	P. f

RESULT

Power factor of motor at no load and at full voltage is_____

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Laboratory Session: No._____ Date: _____

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Cover Page for Each PBL/OEL

Course Code:	EE-347
Course Name:	Electrical Machines II
Semester:	
Year:	
Section:	
Batch:	
Lab Instructor name:	
Submission deadline:	

PBL or OEL Statement:

To operate single phase transformers in parallel

Deliverables:

A well written and well formatted report which includes

1. Advantages of transformer parallel operation.

2. Necessary conditions for putting transformers in parallel.

3. Procedure to put transformers in parallel.

4. Readings and graphs (wherever applicable) taken which transformers operating in parallel.

5. Conclusion of the experiment

5. Electrical circuit of transformer operating in parallel.

Methodology:

Students are suggested to arrange two or more single phase transformers and study the parallel operation literature. Formulate circuit diagram and operate the transformers in parallel.

Guidelines:

Make a group of two students. Perform the tasks as suggested in deliverable and methodology

Rubrics:

Standard rubrics are attached with the subject manual.

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