NED University of Engineering & Technology
Department of Electrical Engineering

LAB MANUAL
For the course

ELECTRICAL MACHINES
(EE-246) For S.E.(EL)

Instructor name:___________________________________
Student name:______________________________________
Roll no:__________________ Batch:____________________
Semester:____________________ Year:__________________

LAB MANUAL
For the course

<u>ELECTRICAL MACHINES (EE-246) For S.E.(EL)</u>

Content Revision Team:
Dr. Abdul Ghani Abro, Muhammad Arshad, Ms. Najia Naveed

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:

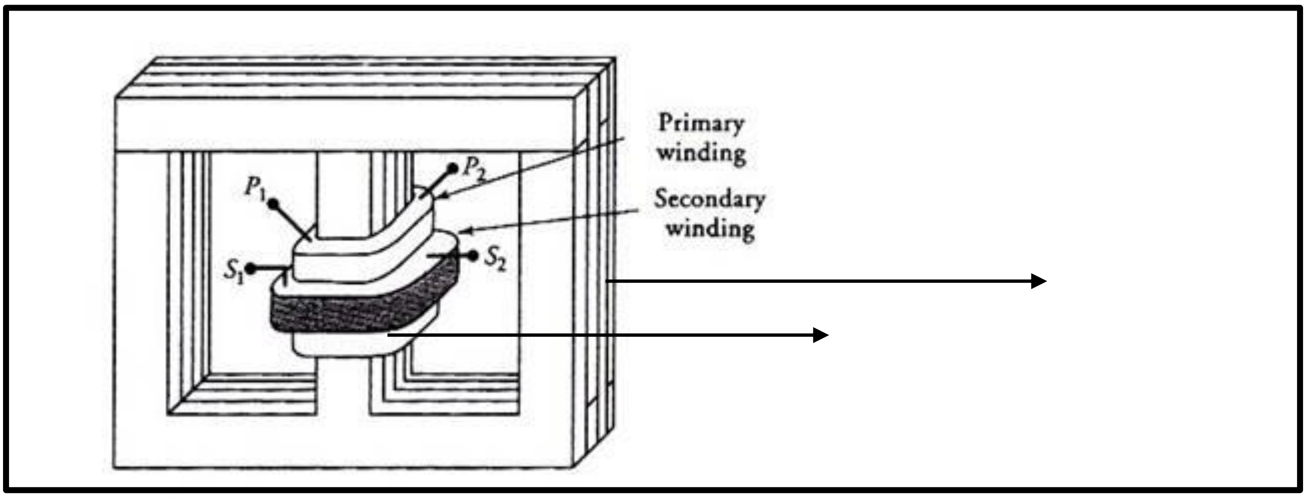


Figure :1.1Shell Type Transformer

Name different parts of transformer:

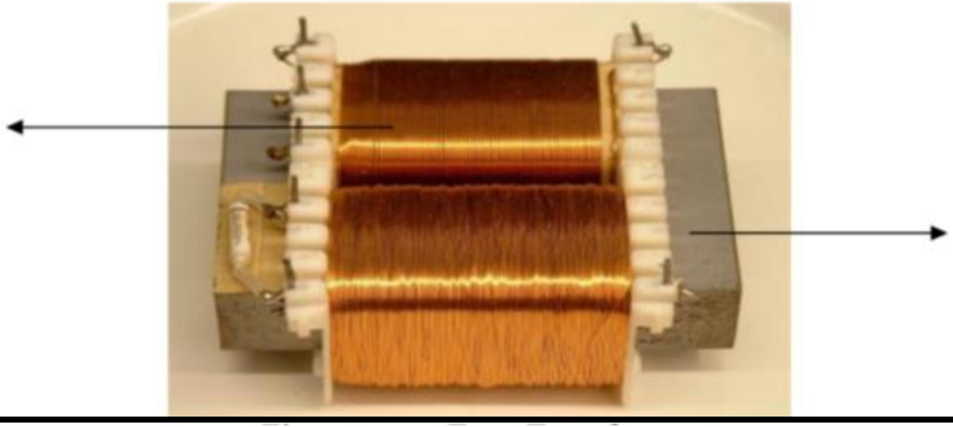
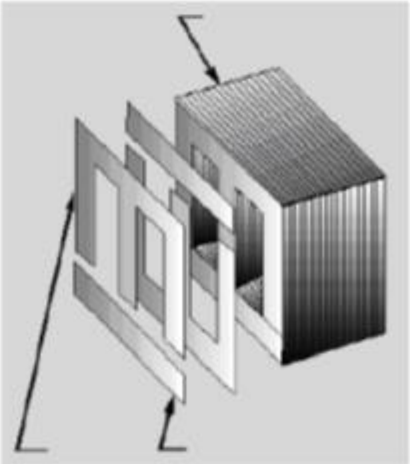


Figure: 1.2 Core Type Transformer



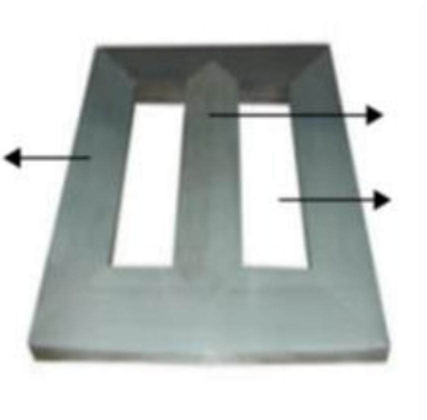


Figure: 1.3 E-I Type Core Figure:1.4Parts of Shell Type T/F Core

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.

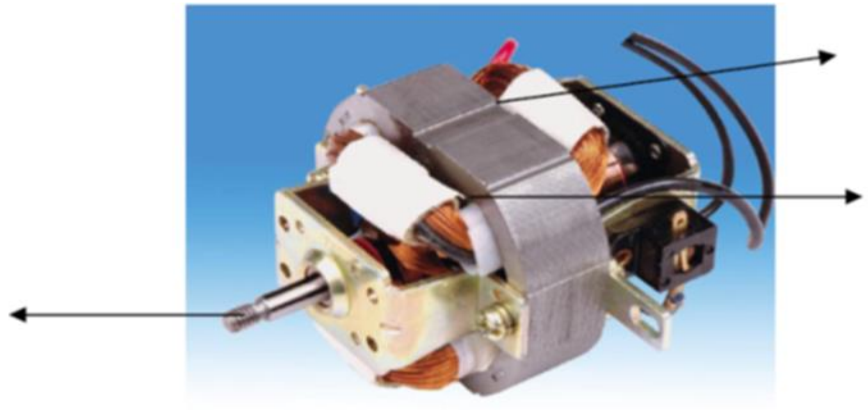


Figure: 1.6 Universal Motor

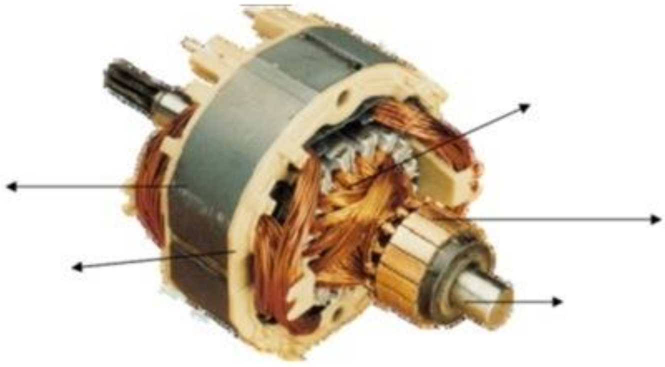


Figure: 1.7 Universal Motor

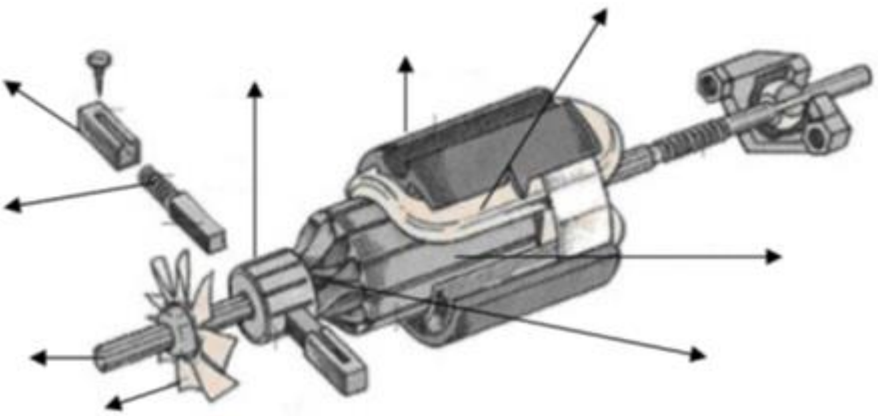


Figure:1.8Assembly of Universal Motor

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

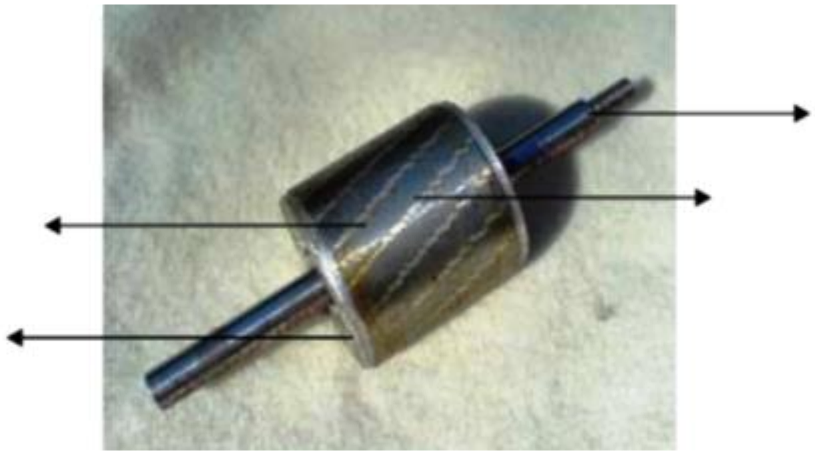


Figure 1.10 Squirrel cage rotor of induction motor

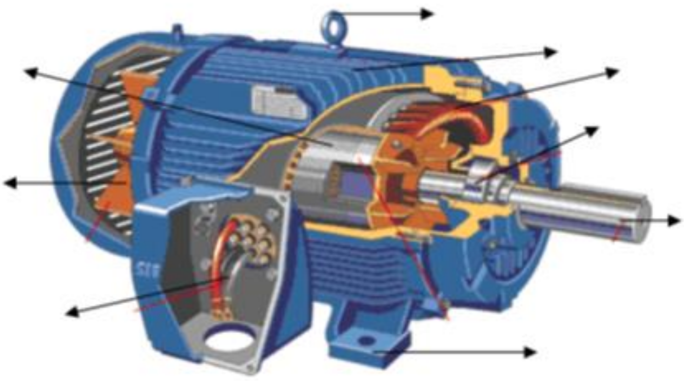


Figure: 1.11 Wound Rotor Induction Motor

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.

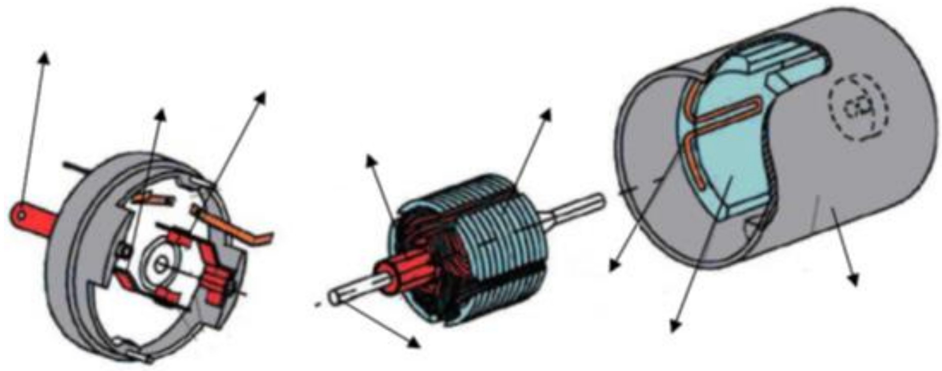


Figure:1.12 PMDC Motor's Assembly

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

Objective

Speed control of DC Motor by Armature and Flux control Method

APPARATUS

1. DC Motor on Bench 13-ES/EV or Bench 15-ES/EV
2. DC multi-range ammeter
3. DC multi range voltmeters
4. Digital tachometer

CIRCUIT DIAGRAM

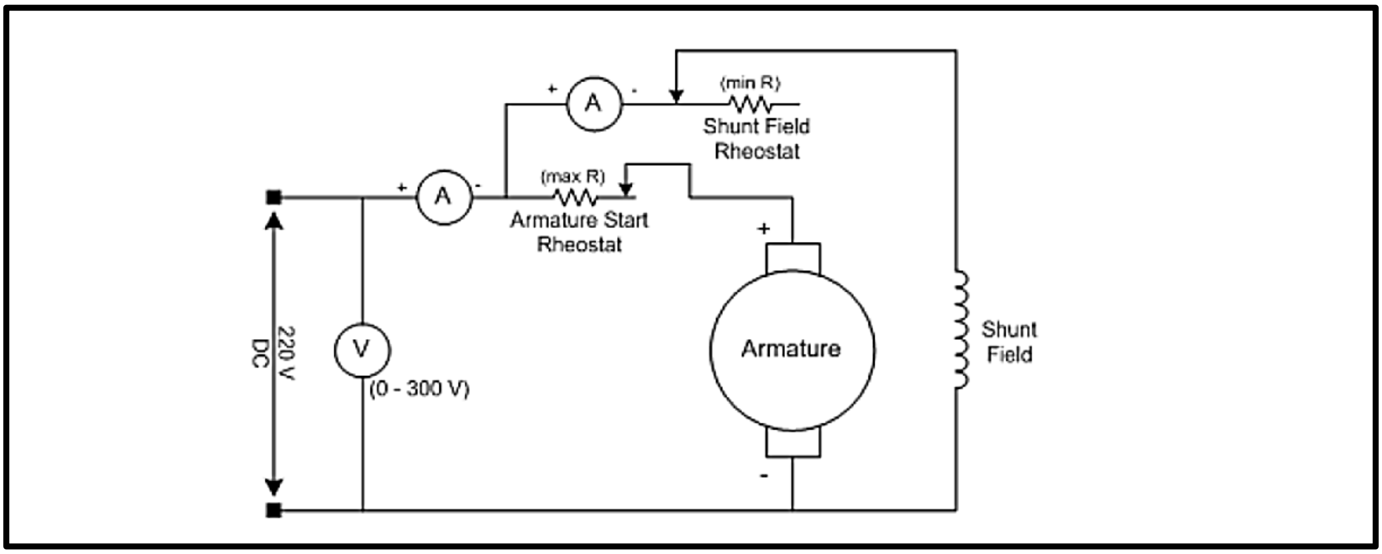


Fig 2.1 DC Shunt Motor

THEORY

This method is used to increase speed of DC motor above base speed.To understand what happens when the field resistance of dc motor is changed, assume that the field resistance is increased then the following sequence of cause and effect will take place

1. Increasing R_f causes I_f to decrease
2. Decreasing I_f Decreases
3. Decreasing lowers Ea
4. Decreasing Ea Increases Ia
5. Increasing Ia increases T_{ind}
6. Increasing T_{ind} makes $T_{ind} > T_{load}$, hence speed increases.
7. Increasing speed increases Ea
8. Increasing Ea decreases Ia
9. Decreasing Ia decrease T_{ind} until $T_{ind} = T_{load}$ at higher speed.

Naturally decreasing R_f would reverse the whole process and speed of motor will decrease.
It is important to bear in mind, changing field resistance does not affect torque induced ,at the end its magnitude remains same but at higher or lower speed depending upon change in resistance.

PROCEDURE

1. Make connections as shown in the circuit.
2. Keep the motor starting rheostat at its maximum position and field rheostat at its minimum position while starting motor.
3. Start the motor by pressing yellow switch, present on the panel, "ON" without load.
4. Adjust the motor start rheostat to its minimum value.
5. Decrease field current by the help of field rheostat step by step and take readings of field current and speed from digital tachometer at every step. Adjust the field rheostat to give maximum speed at which it is safe to operate the motor.

OBSERVATIONS

Table 2.1 Relation of Field Current & Speed

S.No.	Field Current	Speed
	I_f (A)	N(RPM)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Speed control of a D.C. Shunt Motor by armature rheostat control method

THEORY

This method is used to decrease speed of DC motor below base speed. To understand what happens when the armature resistance of DC motor is changed, assume that the armature resistance is increased then the following sequence of cause and effect will take place

1. Increasing $R_a$causesIa to decrease
2. Decreasing Ia decreases T_{ind}
3. Decreasing T_{ind}makes$T_{ind}<T_{load}$, hence speed decreases.
4. Decreasing speed decreases Ea
5. Decreasing Ea increases Ia again.
6. Increasing Ia increases T_{ind}until$T_{ind}= T_{load}$at lower speed.

Naturally decreasing Ra would reverse the whole process and speed of motor will increase. It is important to bear in mind, changing armature resistance does not effect torque induced ,at the end its magnitude remains same but at higher or lower speed depending upon change in resistance.

PROCEDURE

1. Make connections as shown in the circuit.
2. Keep the motor starting rheostat at its maximum position and field rheostat at its minimum position while starting motor.
3. Start the motor by pressing yellow switch "ON" without load.
4. Adjust the motor start rheostat to its minimum value.
5. Increase the value of starting resistance by the help of motor start rheostat step by step and take readings of voltage across armature and speed from digital tachometer at every step.

OBSERVATIONS

Table 2.2 Relation of Armature Voltage & Speed

S. No	Armature Voltage	Speed
1	**Va(V)**	**N (RPM)**
2		
3		
4		
5		
6		
7		
8		

RESULT

Speed increases as the field excitation decreases.
Speed is very nearly proportional to the applied voltage in the case of armature control method.

EXERCISE:

Answer the following questions:

Why do we set the armature rheostat at maximum and field rheostat at minimum?

____
____
____
____

After starting motor, why do we set the Ra to its minimum?

____
____
____
____

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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 03

OBJECT
Modeling of Single Phase Transformer (Short Circuit & Open circuit Test).

Short Circuit Test

APPARATUS
1. Voltmeter (0-15V)
2. Wattmeter (0-750)
3. Ammeter (0-15A)

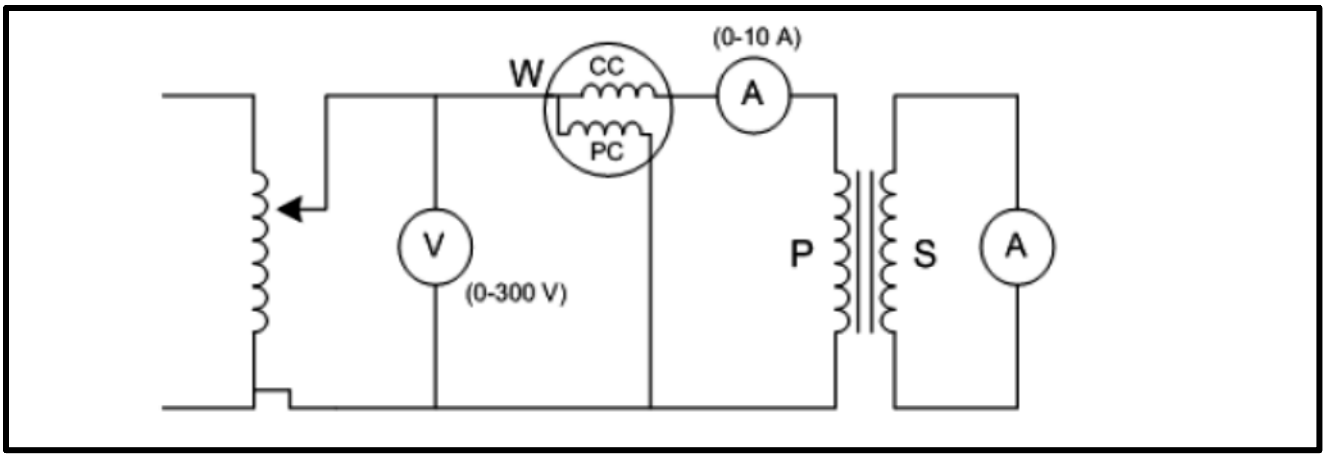


Fig 3.1 Transformer Short Circuit Test

THEORY
In this test one winding (usually low voltage winding) is short circuited by a thick conductor or by means of ammeter (Which may serve an additional purpose of indicating rated load). A low voltage (5-10% of the normal voltage) at normal frequency is applied to the primary and gradually increased, till full load current is flowing in both primary and secondary. Since in this test the applied voltage is a small percentage of the normal voltage the mutual flux produced is also a small percentage of its normal value. Hence core losses are very small with the result that the wattmeter reading represents the full load copper loss.

PROCEDURE
1. Make connections according to the given circuit.
2. Connect primary of transformer with variable ac voltage supply.
3. Note down transformer rated current from name plate data and keep on increasing voltage until you get rated current read by Ammeter connected.
4. Once you get rated current at any specific voltage level, note down reading of instruments
5. Connected and calculate different parameters.

OBSERVATION
Table 3.1 Observation

S.No	W_{sc}(watt)	V_{sc} (Volts)	I_{sc} (Ampere)	I_{sec} (Ampere)

RESULT
The copper losses of single phase transformer are__________ Watts

Open Circuit Test

APPRATUS

1. Voltmeter (0-300V)
2. Ammeter (0-2A)
3. Wattmeter (0-120W)

CIRCUIT DIAGRAM

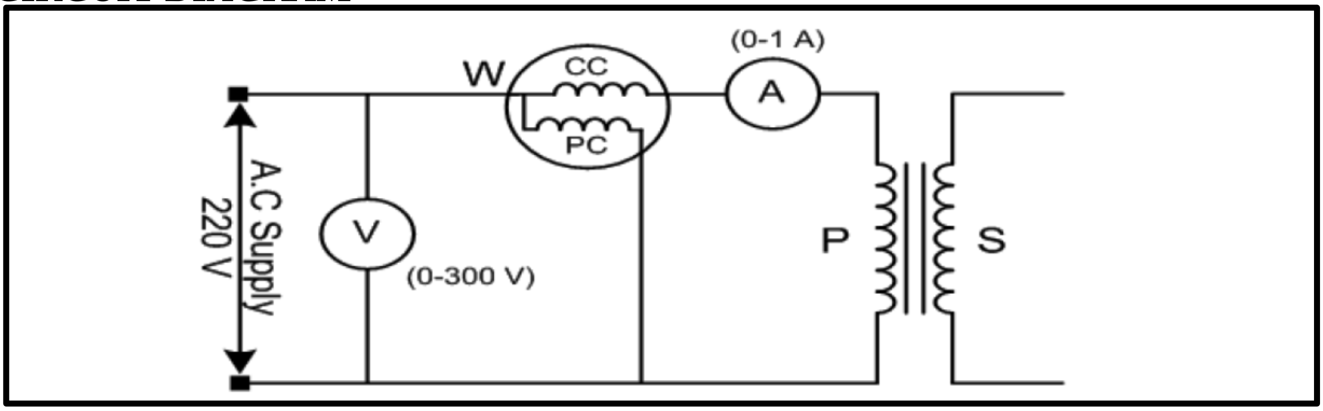


Fig 3.2 Transformer Open Circuit Test

THEORY

The purpose of this test is to determine no load loss or core loss and no load current Io which is helpful in finding Xo and Ro. One winding of the transformer which-ever is convenient but usually high voltage winding is left open and the other is connected to its supply of normal volt and frequency. A wattmeter, voltmeter and ammeter are connected in low voltage winding i.e. Primary winding in the present case. Normal voltage is applied to primary normal flux will be set up in the core hence normal iron loss will occur which are recorded by the wattmeter. As the primary no load I_o is small usually 2-10% of rated load current Cu losses is negligible small in primary I will in secondary b/c it is open. Therefore the wattmeter reading will show practically the core loss under no load condition.

OBSERVATIONS

Table 3.2 Observation

S.No	W_0(watt)	V_0 (Volts)	I_o (Ampere)

RESULT: The iron losses of single phase transformer are ___________ watt.

EXERCISE: Answer the following questions:

Why do we perform short circuit & open circuit test on a transformer? What information we get?

____

____

____

____

Why do we apply rated voltage in open circuit test and below rated voltage in short circuit test?

____

____

____

____

____

CALCULATIONS:

Calculate the value of Xm, Rc, Req,p&Xeq,p from the observations table.

Lab Session 04

Objective:

To find out the efficiency and voltage regulation of a single -phase step down transformer.

APPARATUS

1. Two Voltmeters (0 300V), (0 150V)
2. Two Ammeters (0 1A)
3. Step- down transformer
4. Variable load

Connection Diagram:

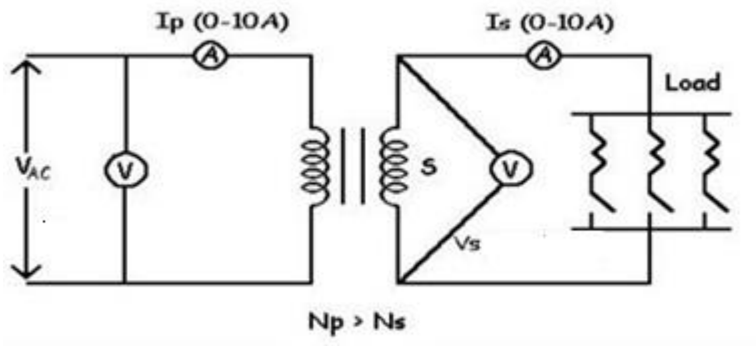


Fig 4.1 Single Phase Step-down Transformer

Theory:

A step-down transformer transforms the high voltage at primary side to a lower voltage at the secondary side. It works on the principle of mutual induction i.e. the transformer secondary winding has an induced EMF due to the change in voltage across the primary winding. The transformer used in this practical is a step-down transformer. The applied voltage is 220V and secondary voltage is 150V. The efficiency of a transformer at a particular load is defined as the ratio between output power and input power.

$$\eta = \frac{Vs\ Is\ \text{Cos}\,\Theta}{Pcu + Pcore + Vs\ Is\ \text{Cos}\,\Theta} X100$$

When we increase load at the secondary terminals of a transformer, current drawn by transformer will increase. This increase in current will cause will increase in load dependent losses, Cu loss and leakage magnetic loss, hence causes decrease in output voltage. The change in secondary voltage from no load to full load with respect to no load voltage or with respect to full
load voltage is called voltage regulation.

$$\mathbf{V_R = [(V_{SNL} - V_{SFL}) / V_{SFL}] \times 100\%.} \qquad 220V$$

Table: 4.1 Open & Short Circuit test Results.

Open Circuit Test	Short Circuit Test
$V_{oc= 220V}$	$V_{sc= 8.5V}$
$I_{oc= 0.7A}$	$I_{sc= 9.0A}$
$W_{oc= 22W}$	$W_{sc= 55W}$

Procedure:

1. Make the connections as shown in figure.
2. Switch on primary supply and read the no load secondary voltage.
3. Increase the load on the secondary side insteps
4. Following every step take reading.

Observation

No load secondary voltage V_{SNL}=_________Volts

Table 4.2 Observation

S.No.	Amount of Load	V_p(Volts)	Ip (A)	V_s(Volts)	I_s (A)
1	No Load				
2	Half Load				
3	Full Load				

Calculation:

For Half Load:

$$1. \eta = \frac{Vs\ Is\ \operatorname{Cos}\Theta}{Pcu + Pcore + Vs\ Is\ \operatorname{Cos}\Theta} X100$$

$Pcore = (\frac{Vp}{K})2 / Rc$: $P_{copper} = I^2_{sc} \times R_{eq}$

2. $V_R = [(V_{SNL} – V_{SHL}) / V_{SHL}] \times 100\%$.

For Full Load:

$$1. \eta = \frac{Vs\ Is\ \operatorname{Cos}\Theta}{Pcu + Pcore + Vs\ Is\ \operatorname{Cos}\Theta} X100$$

2. $V_R = [(V_{SNL} – V_{SFL}) / V_{SFL}] \times 100\%$.

Result:

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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 05

OBJECTIVE

To perform blocked rotor and no-load test of 3-phase induction motor. (Modeling of 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

CONNECTIONDIAGRAM

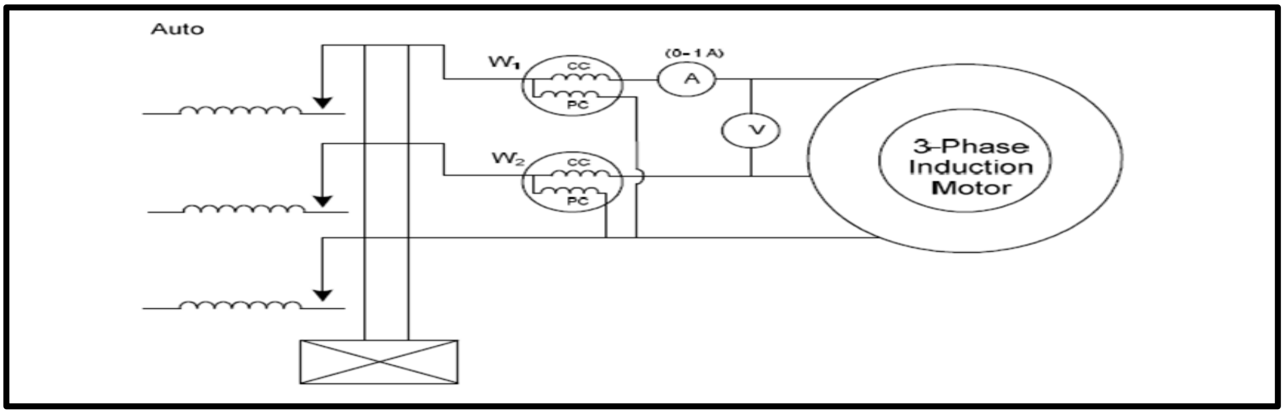


Fig 5.1 Three Phase Induction Motor for block rotor test

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 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 5.1.
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

Table 5.1 Observation

S. No	Voltage	Current	W_1	W_2	W_T

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

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

CONNECTIONDIAGRAM

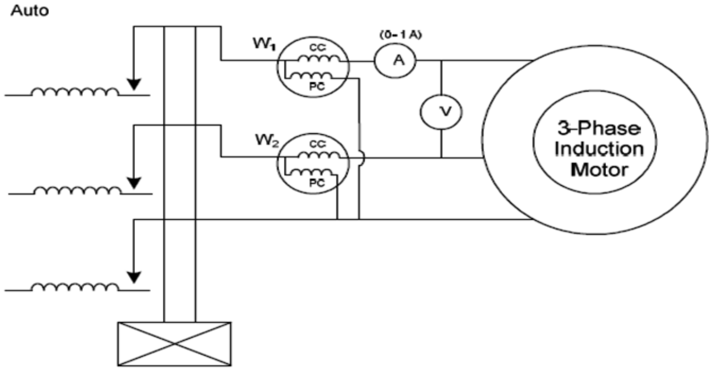


Fig 5 .2 Three Phase Induction Motor for **NO LOAD TEST**

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 5.2
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

Table 6.1 Observation

S. No	Voltage	Current	W_1	W_2	W_T

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 06

OBJECT

To study the effect of applied voltage on power factor & current drawn by 3-Φinduction motor at no Load.

CONNECTIONDIAGRAM

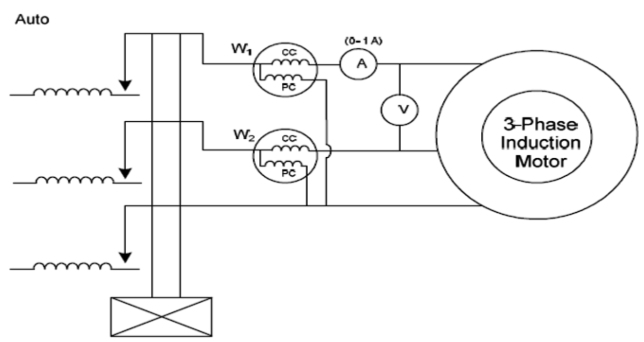


Fig 6.1 Three Phase Induction Motor

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 = W_1+W_2 / $(3)^{½}$ 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

Table 6.1 Observation

S.No	V(Volts)	I(Amp)	W_1 (Watts)	W_2 (Watts)	$W=W_1 + W_2$	P.F
1						
2						
3						
4						
5						

CALCULATIONS

Show the calculations of power factor at each voltage.

RESULT

Discuss the result of practical.

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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 07

OBJECT

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

CONNECTION DIAGRAM

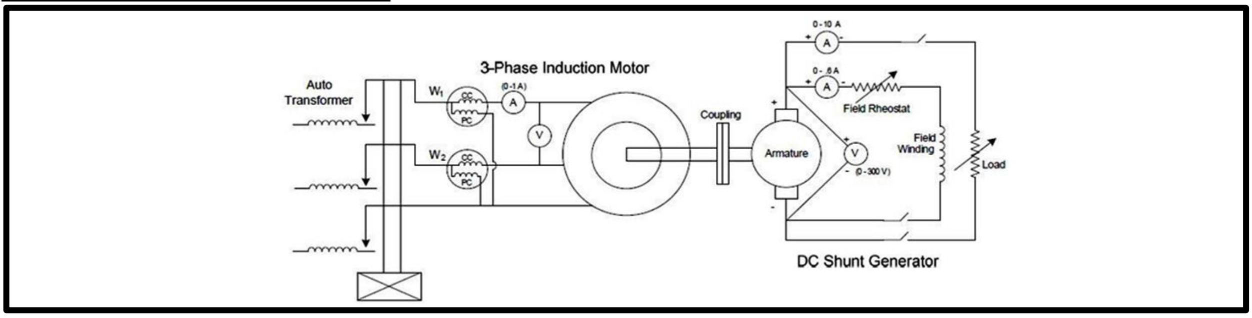


Fig 7.1 Three Phase Induction Motor

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

Table 7.1 Observation

S.No	V (Volts)	I_{ac} (Amp)	W_1 (Watts)	W_2 (Watts)	$W=W_1 + W_2$	I_L	P.F
1							
2							
3							
4							
5							

RESULT

Power factor of induction motor at full load is__________

Lab session 08

OBJECTIVE:

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

CIRCUIT DIAGRAM:

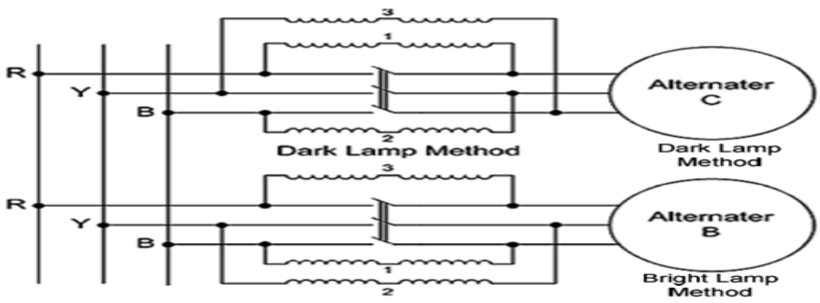


Fig 8.1 Two Alternator Connected In Parallel

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:

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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 09

OBJECTIVE:

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

CIRCUIT DIAGRAM:

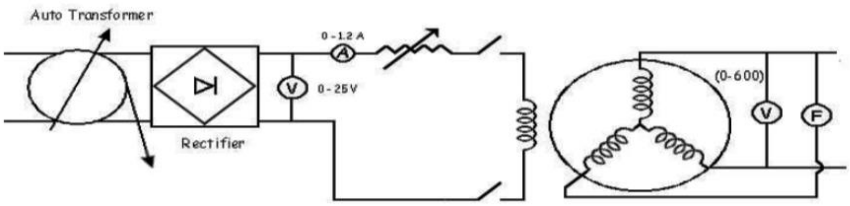


Fig 9.1 Alternator connection for open circuit characteristics

THEORY

A.C generator (alternator), consists of two parts, namely the field winding and an armature winding but unlike a dc generator, alternator has rotating field system and an stationary armature, advantages of such system are given below. In this practical open circuit characteristics of three phase alternator is analyzed by increasing field current. When we increase filed current flux will increase and due to increase in flux terminal voltage of alternator will increase. 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:

Table 9.1 Observation

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

RESULTS

Draw Graph between voltage & current

CONCLUSION:

Lab session 10

OBJECT

To draw the load characteristic curves of alternator.

CONNECTION DIAGRAM

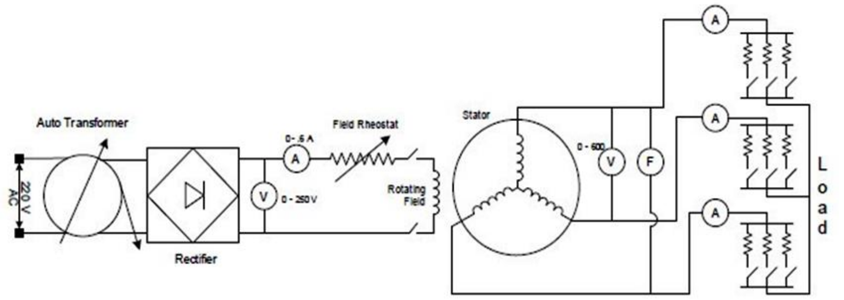


Fig 10.1 Alternator

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

Resistive Circuit

Table 10.1 Observation when resistive circuit

S.#	Load	I_1(A)	I_2(A)	I_3(A)	V(Volts)	I_f(A)	I_T	Power (KW)	P.F
1	No Load								
2	Balance Load								
3	Un-balance Load								

Resistive & Inductive Circuit

Table 10.2 Observation when resistive and inductive circuit

S.#	I_1(A)	I_2(A)	I_3(A)	V(Volts)	I_f(A)	$I_L=I_1+I_2+I_3$ (A)	Power (KW)	Power Factor
1								

Resistive & Capacitive Circuit

Table 10.3 Observation when resistive and capacitive circuit

S.#	I_1(A)	I_2(A)	I_3(A)	V(Volts)	I_f(A)	$I_L=I_1+I_2+I_3$ (A)	Power (KW)	Power Factor
1								

Voltage Regulation for Resistive Circuit

$VR = [(V_{nl} - V_{fl}) / V_{fl}] \times 100\%$.

Voltage Regulation for Resistive &Inductive Circuit

$VR = [(V_{nl} - V_{fl}) / V_{fl}] \times 100\%$.

Voltage Regulation for Resistive &Capacitive Circuit

$VR = [(V_{nl} - V_{fl}) / V_{fl}] \times 100\%$.

RESULT:

Draw a Graph between V_t and I_l

CONCLUSION:

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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 11

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:

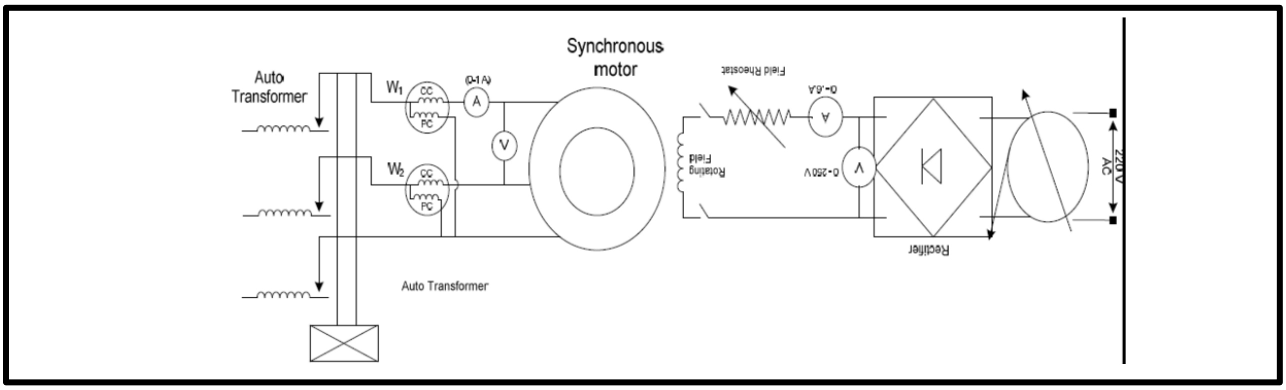


Fig 11.1 Three Phase Synchronous Motor

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-ɸ 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 onewatt-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. **$P.f = W_1+W_2 / (3)^{1/2} VI$**

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 connect

OBSERVATION

Table 11.1 Observation

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

RESULT

Lab session 12

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 watt-meters
5. Auto transformer

CONNECTION DIAGRAM:

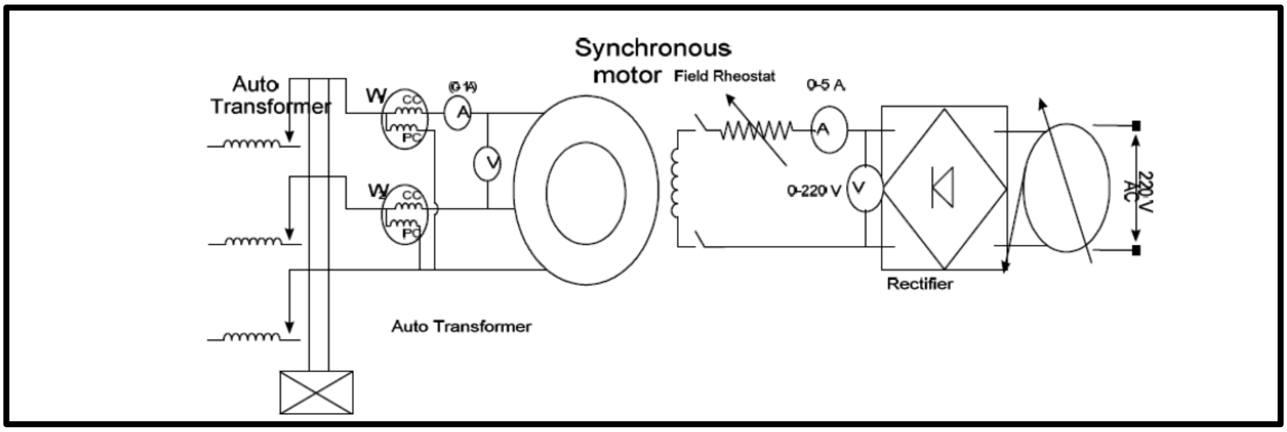


Table 12.1 Three Phase Synchronous Motor

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 useful 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 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.

P.f = $W_1+W_2 / (3)_{1/2}$ * 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

Table 12.1 Observation

S.No	$V(Volts)_{AC}$	$I(Amp)_{AC}$	W_1(Watts)	W_2(Watts)	W1+W2	P.F	I_{DC}	V_{DC}

RESULT

Power factor of induction motor at no load and at full voltage is_______

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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.

OPEN ENDED LAB-1

Objective:

To perform the parallel operation of two single-phase transformers.

a. First perform open circuit and short circuit test of both transformers. Also find out the efficiency and voltage regulation.
b. Do polarity Test on each transformer and connect them with regard to their polarities.
c. Connect load on parallel connection of transformer and prove the equal load sharing according to the KVA rating of each transformer

Cover Page for Each PBL/OEL

Course Code:	EE-246
Course Name:	Electrical Machines for SE EL
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.

NED University of Engineering & Technology
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.
Procedural Skills Displays skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to imitate the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use Displays skills to perform related mathematical calculations using the observations from lab work.	Not able to use lab work observations into mathematical calculations.	Able to slightly use lab work observations into mathematical calculations.	Able to somewhat use lab work observations into mathematical calculations.	Able to moderately use lab work observations into mathematical calculations.	Able to fully use lab work observations into mathematical calculations.
Safety Adherence Adherence to safety procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling Equipment care during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care	Often handles equipment with required care.	Handles equipment with required care.
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.