AMIRAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

BASIC ELECTRICAL ENGINEERING

SUBJECT CODE: 3110005

ELECTRICAL ENGINEERING DEPARTMENT

B.E. 1ST/2ND SEMESTER

NAME:______________________________

ENROLLMENT NO: ______________________________

BATCH NO: ______________________________

YEAR: ______________________________

Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

CERTIFICATE

This is to certify that Mr. / Ms. ____ Of class___________________ Enrolment No __________________________has Satisfactorily completed the course in ___________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of ___________________ Engineering in the Academic year_______.

Date of Submission:-

Faculty Name and Signature
(Subject Teacher)

Head of Department
(Electrical)

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SUBJECT: BASIC ELECTRICAL ENGINEERING

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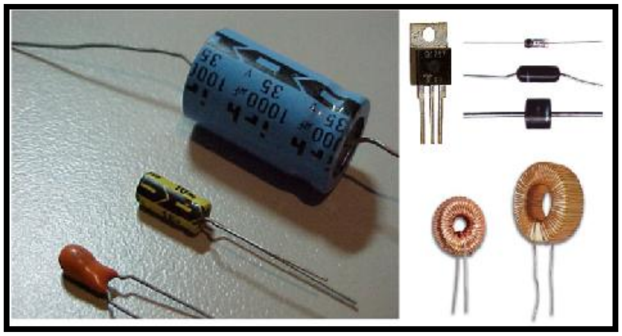
List of Experiments

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remarks
1	To Study the standard symbols used in Electrical Engineering.				
2	Introduction of tools, electrical materials.				
3	Verification of Kirchhoff`s laws.				
4	Measurement of Inductance and power factor in an R-L Series Circuit.				
5	Measurement of Capacitance and power factor in an R-C Series circuit.				
6	Measurement of Power factor in R-L- C series circuit by □ Analytically □ Graphically				
7	Measurement of the electrical power in a single phase AC circuit by using following method. □Voltmeter - Ammeter method □ Wattmeter method				
8	To study Cathode Ray Oscilloscope (CRO) and measure the electrical quantities.				
9	To study about DC & AC Machines.				
10	To do bill calculation of house				

EXPERIMENT: 01

Date:



Aim: To Study the standard symbols used in Electrical Engineering.

- Specific Objectives:

After studying the experiment one should be able to:

- Represent the electrical components, equipments & accessories in the circuit diagram.

Drawing is the language of engineer. For represent the various electrical connections, components equipment & accessories, the standard graphical symbols are used. These symbols should convey the same meaning to everyone. Following is the list of symbols generally used in basic Electrical Engineering.

Sr. No.	Particular	Symbol
1.	Positive	
2.	Negative	
3.	A.C. Supply	
4.	D.C. Supply	
5.	Single Phase	
6.	Three Phase	
7.	Phase Sequence	

8.	Crossed Wire	
9.	Connected Wire	
10.	Neutral	
11.	Earth	
12.	Fuse	
13.	Lamp	
14.	Lamps in series	
15.	Lamps in parallel	
16.	Resistance [Fixed] Resistance [Variable]	
17.	Tapped Resistance	
18.	Inductor [Fixed] Inductor [Variable]	
19.	Choke Coil	

20.	Capacitor [Fixed] Capacitor [Variable]	
21.	Electrolytic capacitor	
22.	Cell	
23.	Battery	
24.	<u>Ammeter</u> D.C. Ammeter A.C. Ammeter A.C./D.C. Ammeter	
25.	<u>Voltmeter</u> D.C. Voltmeter A.C. Voltmeter A.C./D.C. Voltmeter	
26.	Galvanometer	
27.	Watt meter	
28.	Single phase energy meter	
29.	Power factor meter	

30.	Frequency meter	
31.	Ohm meter	
32.	Synchroscope	
33.	Motor	
34.	Stepping Motor	
35.	Generator	
36.	Hand Generator	
37.	Transformer	
38.	Auto Transformer	
39.	Single phase variac	
40.	Delta connected load	

41.	Star connected load with or without neutral	
42.	Mechanical coupling	
43.	Single pole single throw switch [SPST Switch]	
44.	Single pole double throw switch [SPDT Switch]	
45.	Double pole double throw switch [DPDT switch]	
46.	Triple pole double throw switch [TPDT switch]	
47.	Two pole ON-OFF switch	
48.	Triple pole ON-OFF switch	
49.	Potential transformer	
50.	Current transformer	

51.	Two pin socket		
52.	Three pin socket		
53.	Diode		
54.	Zener diode		
55.	Tunnel diode		
56.	Varactor diode		
57.	Schottky diode		
58.	Light emitting diode		
59.	Photo diode		
60.	Transistor	PNP	
		NPN	
61.	Photo transistor		

62.	Motor generator set	
63.	Rotary converter	
64.	SCR	
65.	DIAC	
66.	TRIAC	
67.	UJT	
68.	n-Channel JFET	
69.	p-Channel JFET	
70.	MOSFET	

EXPERIMENT: 02

Date:

AIM: Introduction of tools, electrical materials.

Electric power is supplied for commercial and residential use in three phases with a neutral. Some of the low power consumption residential connections will have only a single phase with a neutral. The single-phase AC supply is 230V but a three-phase supply is 440V.

SAFETY MEASURES

1.Use approved tools, equipment's and protective devices.

2. Do not work under poor light or when you are tired.

3. Do not work in damp areas or in wet shoes or clothes.

4. Keep tools and equipment's clean and in good working condition.

5. Read all instructions carefully before using the appliances.

6. To prevent electrical hazards, DO NOT immerse appliances in water or Other liquids.

7. Always unplug an appliance before cleaning, or whenever it is not in use. Ensure that you pull by the plug and not the cord.

8. DO NOT operate any appliance with a damaged cord or plug.

9. Always use an appliance on a dry, level surface.

10. Keep appliances away from heated surfaces and open flames.

11. Check the electric power supply from the switch position.

TOOLS USED IN WIRING

PLIERS

Pliers are used to cut wire and also to hold it. Pliers have an insulated handle. Long nose pliers are used to hold wires in small space and also to tighten or loose small nuts.

SCREW DRIVERS

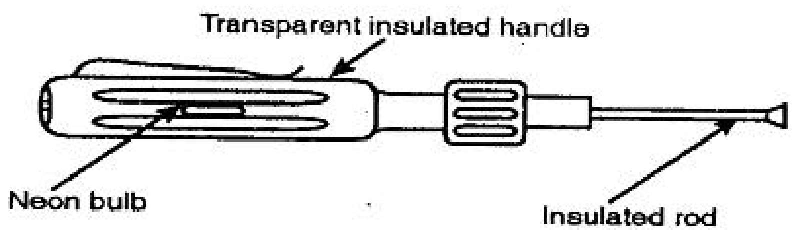
Screw Drivers Are Used To Tighten Screws In The Switches And Electrical Machines. Screw Drivers Of Various Sizes Are Used. Normally Screw Drivers Used In Electrical Work Are Insulated.

HAMMERS

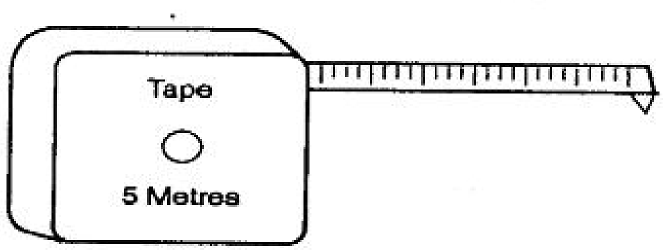
Ball Peen And Claw Hammers Are Commonly Used In Electrical Work Where Greater Power Is Required Striking.

Hacksaw

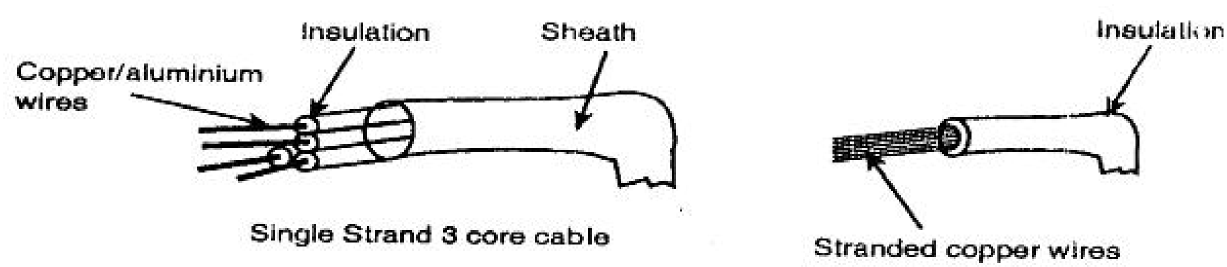
A Hacksaw Is Used To Cut Cable Armour, Conduit Pipes, Etc. It Has A Frame Where The Blade Is Tightened By Means Of A Wing Nut.



Line Tester



Measuring Tape



Cables/Wires

LINE TESTER

A Line Tester Is Used To Check The Electric Supply In The Line Or Phase Wire. It Has A Small Neon Bulb Which Indicates The Presence Of Power Supply. It Can Also Be Used As A Screw Driver To Tighten Small Screws In Switches.

MEASURING TAPE

A Measuring Tape Is Used To Measure The Length Of The Wire And Also To Mark The Positions Of The Switches And Other Electrical Fittings.

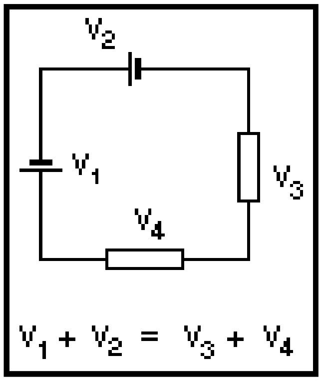
WIRES

An Electric Wire Is A Copper Or Aluminum Insulated Wire And Has One Or More Twisted Stands. Vulcanized Indian Rubber (Vir) Wire, Cotton Flexible Or Rubber Flexible Wire And Poly Vinyl Chloride (Pvc) Wires Are Commonly Used In House Wiring.

RESULT: We Have Studied All The Tools.

EXPERIMENT: 03

Date:



Aim: Verification of Kirchhoff ‘s laws.

- Specific Objectives:

After performing the experiment, one should be able to:
- Estimate the current in different branches of electric circuit.
- Determine the Kirchhoff’s Laws.

- Apparatus:

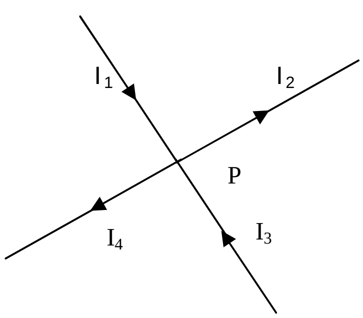
Rheostat	(300Ω, 1.7A)	Three
Ammeter	(0-10A) d.c.	One
Ammeter	(0-5A) d.c.	One
Ammeter	(0-2A) d.c.	Two
Voltmeter	(0-300V) d.c.	Four
D.C. Power Supply		

- Rationale:

Kirchhoff ‘s laws are used to find currents in different branches of electric circuits which may not be easily solved by Ohm’s law. These laws are applicable to both DC and AC circuits. There are two laws,
- Kirchhoff’s current law (KCL)
- Kirchhoff’s Voltage law (KVL)

First law: Kirchhoff ‘s current or point law.

Statement**:** The algebraic sum of all the currents meeting at a junction of a network is zero.



For the arrangement shown in fig. the arrows indicate the direction of flow of currents. The currents I_1, I_3 are coming towards the junction or point ’P’ and the currents I_2, I_4 are going away from the junction. Assume +ve sign for incoming currents and -ve sign for out going currents.

According to Kirchhoff ‘s currents law

$$\sum I = 0$$

i.e. $(+I_1) + (+I_3) + (-I_2) + (-I_4) = 0$

$$I_1 + I_3 = I_2 + I_4$$

Incoming currents = Out going currents

i.e. The sum of currents flowing inside the junction is equal to the sum of currents flowing outside the junction.

Second law: Kirchhoff's voltage or mesh law.

Statement**:** In any closed path (or mesh) of a network, the algebraic sum of products of currents and resistance of the conductor plus the algebraic sum of electromotive forces (e.m.f) in that path is zero.

$$\sum IR + \sum e.m.f = 0$$

The convention for a voltage rise may be given +ve sign and a voltage fall may be given -ve sign or vice Versa.

Determination of sign:

For e.m.f source: If we move from +ve terminal of e.m.f source to -ve terminal, there is fall in potential. Therefore e.m.f should be given -ve sign and if we move from -ve terminal to +ve terminal, there is a rise in potential therefore e.m.f should be given +ve sign.

For the product of current and resistance : If we travel through a resistance in the same direction as that of current flowing through it, there is fall in potential so product should be given -ve sign. On the other hand, if we travel through a resistance in the direction opposite to that of current flowing it, then there is a rise in potential so the product should be given +ve sign.

- Circuit Diagram:

- Observation:

For Kirchoff's Current Law

R_1 = __________ Ohm
R_2 = __________ Ohm
R_3 = __________ Ohm

Sr. No	Supply Voltage V (Volt)	Ammeter Reading (Amp)			Sum Of Current At Node (Amp)
		A_1	A_2	A_3	$A_1 = A_2 + A_3$
1					
2					
3					
4					
5					

For Kirchoff's Voltage Law

Sr. No	Voltage V (volt)	Current I (Amp)	Voltmeter Reading (Volt)			Sum Of Voltmeter (Volt)
			V_1	V_2	V_3	$V = V_1 + V_2 + V_3$
1						
2						
3						
4						
5						

- Procedure:

For Kirchoff's Current Law

- Connect the circuit as per shown in the diagram.
- Set the rheostats to their maximum position.
- Switch ON the supply & adjust the voltage.
- Note the reading of ammeter A_1, A_2, A_3 in the observation table.
- Decrease the resistance of rheostat in steps.
- Note the reading of ammeter A_1, A_2, A_3 in the observation table.

For Kirchoff's Voltage Law

- Connect the circuit as per shown in the diagram.
- Set the rheostats to their maximum position.
- Switch ON the D.C. power supply & adjust the voltage.
- Note the reading of voltmeter V_1, V_2, V_3 in the observation table.
- Decrease the resistance of rheostat in steps.
- Note the reading of voltmeter V_1, V_2, V_3 in the observation table.

- **Calculation:**

Apply the Kirchhoff's Laws to the given circuit & calculate currents & voltage in different branches.

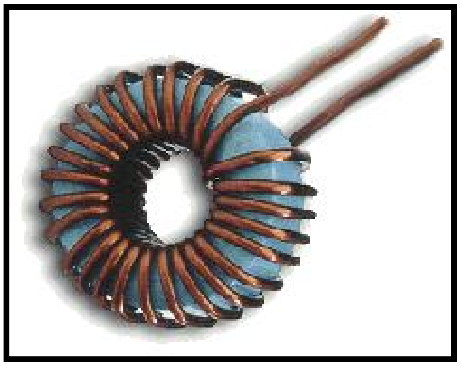
- **Conclusion:**

- Multiple choice Questions:

1. According to KCL the
   (a) Sum of currents in a series circuit is zero.
   (b) Sum of currents entering a junction is equal to the sum of current leaving that junction
   (c) Sum of currents in a parallel circuit is zero.
   (d) Both sum of current entering a junction as well as sum of currents leaving a junction is zero each.
2. Kirchhoff's current law is applicable only to:
   (a) Electric circuit (c) Closed loops in a network
   (b) Electronic circuit (d) Junctions in a network
3. Polarity of voltage drop across a resistor is determined by the
   (a) Value of resistor
   (b) Value of current through resistor
   (c) Direction of current through the resistor
   (d) Polarity of voltage source.
4. A resistance of 10Ω is connected across a supply of 200 V. If a resistor R is now connected in parallel with the above 10Ω resistance, the current drawn from the supply gets doubled. The value of the unknown resistance R is
   (a) 5Ω (c) 15Ω
   (b) 10Ω (d) 20Ω
5. Kirchhoff's voltage law is concerned with
   (a) IR drops (c) Junction voltage
   (b) Battery emfs (d) Both (a) & (b)

EXPERIMENT: 04

Date:



Aim: Measurement of Inductance and power factor in an R-L Series Circuit.

- Specific Objective:

After performing this experiment one should be able to:

  - Define power factor & inductance
  - Measure the power factor of R-L series circuit.

- Apparatus:

▪ Voltmeter	(0-300 V)	Three
▪ Ammeter	(0-5 A)	One
▪ Lamp bank	(Resistance)	One
▪ Choke coil	(Inductance)	One
▪ Single phase variac	(250V, 5A)	One

- Rationale:

The figure shows the Resistance (Lamp bank) and Inductance (Choke coil) connected in series across an AC supply voltage of 230 V. Because of the inductance, the current in this circuit will be lagging behind the voltage by 90° in an ideal case. But the choke coil has its own inherent resistance. The current will not be lagging by exact 90° but somewhat less. The Inductance and the powerfactor of the circuit can be found out graphically as explained below.

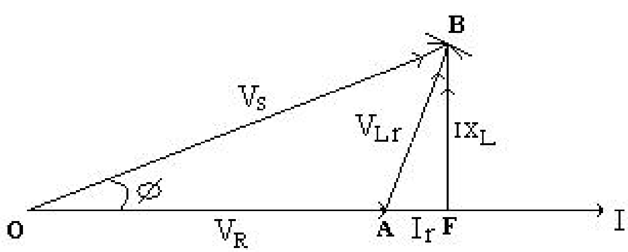
Let, I = Current in the circuit

V_s = Supply Voltage

V_R = Voltage drop across the resistance (Lampbank)

V_{Lr} = Voltage drop across the inductance (chock coil)

The vector diagram can be constructed as follows:



RL SERIES

- From the vector diagram, it is found that the perpendicular BF represents pure inductive drop across the choke coil and is equal to IX_L, while segment AF represents the pure resistive drop due to the inherent resistance 'r' of the choke coil.

- Dividing IX_L by the circuit current (or load current) I, we get the value of the inductive reactance X_L.

- From the equation $X_L = 2\pi fL$, the inductance value can be found considering the frequency to be 50 hertz.

- Angle BOA represents the powerfactor angle Ø. Cosine of this angle gives the power factor of the circuit.

- Procedure:

  - As shown in the circuit diagram, connect different equipments and meters.

  - Then, keeping all the lamps OFF, give the supply to the circuit. You will notice that the ammeter does not show any reading meaning that the circuit is open because of the OFF position of lamps.

  - Now, connect the Resistance of the circuit by switching ON any one switch of the lamp bank. You will notice that the current is flowing through this circuit. Note down different meter readings into the observation table.

  - Again, switch ON one more switch of the Lampbank. You will observe that the current has increased. Note down this second set Of readings. Repeat this process for five times & note down five different sets of observations.

  - Switch OFF supply after completion of the experiment.

- Circuit Diagram:

- Observation:

Sr. No.	Circuit Current **I** **Amp**	Supply Voltage **V_s** **Volts**	Voltage Across Lamp bank **V_R** **Volts**	Voltage Across Choke coil **V_{Lr}** **Volts**	Phase Angle = = **¤ deg.**	Power factor **Cos ¤**	Drop Due to coil Reactance IX_L **Volts**	Coil Inductance **L = $\frac{X_L}{2®\text{-}f}$** **Henry**
1								
2								
3								
4								
5								

- Calculation:

Draw the vector diagram for each reading & Calculate the value of Inductance & Power factor of circuit.

============¤===Z==||||||||||=

Cos ¤==Z===||||||||||

IX_L = _________

X_L = _________

$$L = \frac{X_L}{2 \text{®} f}$$

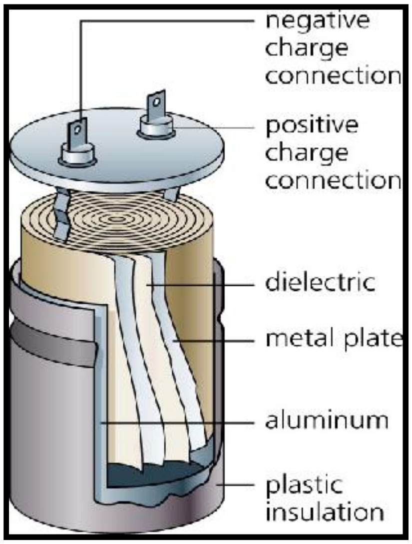
- Conclusion :

- Multiple choice Questions:

1. When two sinusoidal waves are 90^O out of phase, then
   (a) Both have their peak values at the same instant
   (b) Both have their minimum values at the same instant
   (c) One has its peak value, while the other has zero value
   (d) None of the three.
2. The direction of current in an AC circuit is
   (a) Always in one direction (c) Varying from time to time
   (b) Unpredicted (d) None of the above
3. When a pure inductance is connected to an A.C. source, the voltage_________ the current through it by ________
   (a) Lags, 90^O (c) Lags, 45^O
   (b) Leads, 90^O (d) Leads, 45^O
4. In a series R-L circuit, the phase difference between the A.C. source and current increases when
   (a) R is increased (c) X_L is decreased
   (b) X_L is increased (d) Supply frequency is decreased

EXPERIMENT: 05

Date:



Aim: Measurement of Capacitance and power factor in an R-C Series Circuit.

- Specific Objective:

After performing this experiment one should be able to:

  - Define power factor & Capacitance.
  - Measure the power factor of R-C series circuit.

- Apparatus:

▪ Voltmeter	(0-300 V)	Three
▪ Ammeter	(0-5 A)	One
▪ lamp bank	(Resistance)	One
▪ Static Capacitor	(Capacitance)	One
▪ Single phase variac	(250V, 5A)	One

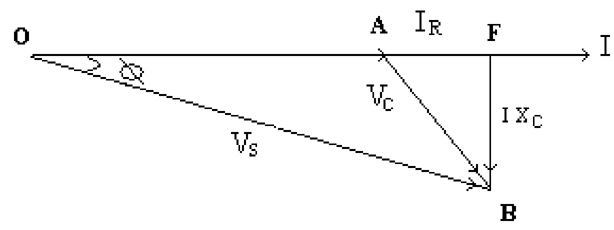
- Rationale:

The figure shows the Resistance (Lamp bank) and Capacitor (Capacitance) connected in series across an AC supply voltage of 230 V. Because of the Capacitance, the current in this circuit will be leading ahead the voltage by 90° in an ideal case. But the capacitor has its own inherent resistance; the current will not be leading by exact 90° but somewhat less. The Capacitance and power factor of the circuit can be found out graphically as explained below.

Let,

I = Current in the circuit
V_s = Supply Voltage
V_R = Voltage drop across the resistance (lamp bank)
V_{cr} = Voltage drop across the Capacitor

The vector diagram can be constructed as follows:



- From the above vector diagram, it is found that the perpendicular BF represents pure capacitive drop across the capacitor and is equal to IX_C, while segment AF represents the pure resistive drop due to the inherent resistance 'r' of the capacitor
- Dividing IX_C by the circuit current (or load current) I, we get the value of the capacitive reactance X_C.
- From the equation $X_C = 1 / (2\pi fC)$, the capacitance value can be found by considering the frequency to be 50 hertz.
- Angle BOA represents the power factor angle ø. Cosine of the angle gives the power factor of the circuit.

- **Procedure:**
    - As shown in the circuit diagram, connect different equipments and meters.
    - Then, keeping all the lamps OFF, give the supply to the circuit. You will notice that the ammeter does not show any reading meaning that the circuit is open because of the OFF position of lamps.
    - Now, connect the Resistance of the circuit by switching ON any one switch of the lamp bank. You will notice that the current is flowing through this circuit. Note down different meter readings into the observation table.
    - Again, switch ON one more switch of the Lampbank. You will observe that the current has increased. Note down this second set of readings. Repeat this process for five times & note down five different sets of observations.
    - Switch OFF supply after the completion of the experiment.

- Circuit Diagram:

- Observation:

Sr. No.	Circuit Current **I AMP**	Supply Voltage **V_S Volts**	Voltage Across Lamp bank **V_R Volts**	Voltage Across Capacitor **V_{CR} Volts**	Phase Angle : : : **¤:deg.**	Power factor **Cos ¤**	Drop Due To Capacitive Reactance IX_c **Volts**	Capacitance **C= 1 / 2®:f X_c** Farad
1								
2								
3								
4								
5								

- **Calculation:**

Draw the vector diagram for each reading & calculate the value of capacitance & power factor of circuit.

===========¤===Z===|||||||=

Cos ¤==Z==||||||||||

IX_C = ______

X_C = ______

$$C = \frac{1}{2\pi f X_c} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{ F}$$

- **Conclusion :**

- **Multiple choice Questions:**

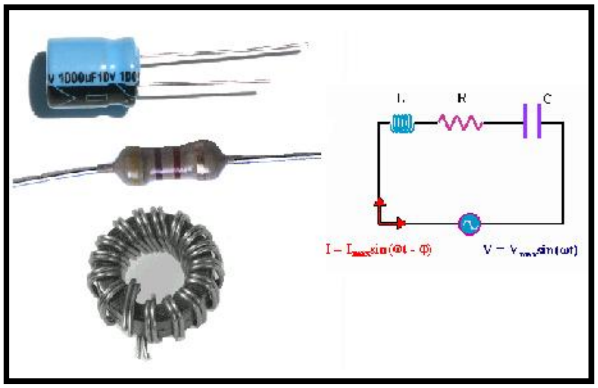
1. In a R-C series circuit, X_C = R, then the phase angle between the applied voltage and circuit current is
   (a) 30^O (c) 60^O
   (b) 45^O (d) 90^O

2. For a frequency of 50 H_Z, the reactance offered by a capacitor is 10Ω, if the frequency is increased to 100 H_Z, the resistance becomes:
   (a) 40Ω (c) 5Ω
   (b) 20Ω (d) 2.5Ω

3. If e_1 = 100 sin 2∏f & e_2 = 100 sin (2∏f - Ø), then
   (a) e_1 lags e_2 by Ø (c) e_2 lags e_1 by Ø
   (b) e_1 is in phase with e_2 (d) None of above

EXPERIMENT: 06

Date:



Aim: Measurement of Power factor in R-L- C series circuit by

- Analytically
- Graphically

- Specific Objective:
  After performing this experiment one should be able to:
  - Define the power factor.
  - Draw the vector diagram of R-L-C series circuit & find the power factor.

- Apparatus:

▪	Ammeter	(0-5 A)	One
▪	Voltmeter	(0-300 V)	Four
▪	Wattmeter	(0-750 W)	One
▪	Lamp bank		One
▪	Capacitor		One
▪	Choke coil		One
▪	Single phase variac	(250V, 5A)	One

- Rationale:

The figure shows the Resistance (Lampbank), Capacitance (capacitor) and Inductance (Choke coil) connected in series across a 230V A.C. supply the power factor of this circuit can be found out by two methods.

- Analytical method
- Graphical method

Analytical Method:

Here, we can calculate power factor directly by dividing the Power Watts of the circuit by the Volt-ampere (VA) of the circuit. Power of the circuit are measured from the Wattmeter connected in the circuit, while volt-ampere (VA) of the circuit are calculated by multiplying the supply voltage Vs and the current I.

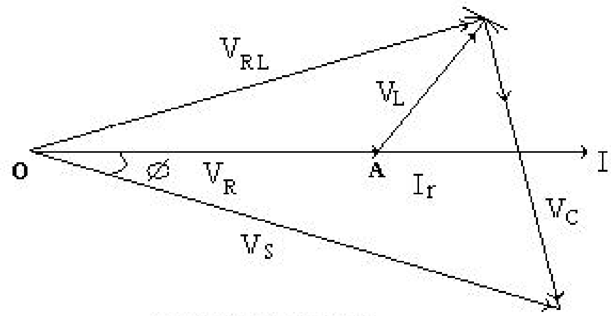
Graphical Method:

Power factor can be obtained from the voltage vector diagram of the circuit as follow:

Let, I =Current in the circuit.

V_s =Supply Voltage.
V_R =Voltage drop across Resistance in Phase with current I.
V_L =Voltage drop across Inductance leading current I by 90° (approx).
V_c =Voltage drop across Capacitance lagging current I by90° (approx).
V_{RL} =Voltage drop across Resistance & Inductance.

Now, a voltage triangle can be constructed by considering the above voltage as follow:



POWER IN RLC

From the above vector diagram, one can easily measure the power factor angle ø of the circuit. And then the power factor is calculated by taking cosine of that angle i.e. cosø.

- Procedure:

  - As shown in the circuit diagram, connect different equipments and meters.
  - Then, keeping all the lamps OFF, give the supply to the circuit. You will notice that the ammeter does not show any reading meaning that the circuit is open because of the OFF position of lamps.
  - Now, connect the Resistance of the circuit by switching ON any one switch of the lamp bank. You will notice that the current is flowing through this circuit. Note down different meter readings into the observation table.
  - Again, switch ON one more switch of the Lampbank. You will observe that the current has increased. Note down this second set of readings. Repeat this process for five times and note down five different sets of observations.
  - Switch OFF supply after completion of the experiment.

- Circuit Diagram:

- Observation:

Sr No	Supply Voltage V_s Volts	Voltage across Lampbank V_R Volts	Voltage Across Choke Coil V_L Volts	Voltage Across Lampbank & Choke Coil V_{RL} Volts	Voltage Across Capacitor V_C Volts	Circuit Current I Amp	Power From Wattmeter P Watts
1							
2							
3							
4							
5							

- **Result:**

Sr. No.	Volt-ampere V_s I (VA)	Power factor Graphically Cosø	Power factor Analytically Cosø
1			
2			
3			
4			
5			

- **Calculation:**

Draw the vector diagram for each reading & calculate the power factor graphically & analytically.

- Conclusion:

- Multiple choice Questions:

1. In RLC circuit, supplied from an ac source, the reactive power is proportional to the
   (a) Average energy stored in the electric field.
   (b) Average energy stored in the magnetic circuit.
   (c) Sum of the average energy stored in the electric field and that stored in the magnetic field.
   (d) Difference between the average energy stored in the electric field and that stored in the magnetic field.

2. In an R-L-C series circuit, the power factor of the circuit will be equal to __________ when $X_L = X_C$.
   (a) 0 (c) 0.5
   (b) Unity (d) 0.8

3. In an ac circuit, low reactive power in comparison to true power indicates
   (a) Low power factor (c) low efficiency
   (b) High power factor (d) High efficiency

4. Power loss in an electrical circuit can take place in
   (a) Inductance only (c) Capacitance only
   (b) Inductance and resistance (d) Resistance only

5. The product of apparent power and Sin of the phase angle between circuit voltage and current is called the _______________ power.
   (a) True (c) Reactive
   (b) Wattless (d) Any of (b) and (c).

EXPERIMENT: 07

Date:

Aim: Measurement of the electrical power in a single phase AC circuit by using following method.

- Voltmeter - Ammeter method
- Wattmeter method

- **Specific Objective:**

  After performing the experiment, one should be able to:
  - Measure the power by wattmeter
  - Know the importance of multiplying factor in wattmeter.

- **Apparatus:**

▪	Lamp bank		One
▪	Ammeter	(0-10A)	One
▪	Voltmeter	(0-300V)	One
▪	Wattmeter	(0-750W)	One
▪	Single phase variac	(230V, 15A)	One

- **Rationale:**

Power is defined as the rate of change of energy. Electric power in a single phase AC system is given by the equation

$$P = VICos\Phi \text{ Watts}$$

Where, V is the voltage applied across the load
I is the current in the circuit
CosΦ is the power factor of the given load

For resistive load, the power factor is unity. Therefore the equation for power becomes P = VI Watts. This power can be measured by two different methods:

Voltmeter - Ammeter method:

In this method, we use a voltmeter and ammeter for measurement of the voltage and the current flowing in the circuit. The multiplication of voltage & current gives us the power at which the energy is consumed by the resistance.

Wattmeter method:

Here, we use a single phase wattmeter to measure the power directly. Generally this method is used for measurement of power in 1-Φ ac circuit. In this case we required multiplying factor for the wattmeter, which is given by the following formula.

$$\text{Multiplying factor} = \frac{(\text{Voltage coil range})\ (\text{Current coil range})}{(\text{Full scale deflection of wattmeter})}$$

The wattmeter has four terminals:

M = Main terminal connected to the main supply
L = Load terminal connected to the load of the circuit
C = Common terminal shorted with the terminal M
V = Voltage terminal connected across the load

The reading obtained by voltmeter - ammeter method (FIRST) can be compared with reading of wattmeter method (SECOND) and the percentage error can be found out as below.

$$\%\ \text{Error} = 100\text{x}\ \frac{(\text{Power by second method}) - (\text{Power by first method})}{(\text{Power by second method})}$$

- **Procedure:**
  - Connect the circuit as shown in the circuit diagram. Ensure that the variac is on zero position. Note that we are using both the Methods of power measurement simultaneously.
  - Switch ON the supply by keeping the lamp board is on OFF position. You will note that the current does not flow through the circuit.
  - Increase the voltage with the help of variac until voltmeter shows 220 Volts. Note that still the current is not flowing, because the lamps are on OFF position.
  - Now switch ON any one switch of the lamp board. You will find the current has started to flow. Note down the reading of Voltmeter, ammeter and wattmeter.
  - Switch ON second switch of the lamp board and note down the readings. You will find that the current has increased meaning that the resistance has decreased. This means that the lamps are connected in parallel.
  - Repeat the process for three more times until you have a set of five observations.
  - Calculate the percentage error.

- Circuit Diagram:

- Observation:

Sr. No.	Supply Voltage V (Volts)	Circuit Current I (Amp)	Calculated Power $P_1 = VI$ (Watts)	Measured Power P_2 (Watts)	% error $\frac{P_2 - P_1}{P_2} \times 100$
1					
2					
3					
4					
5					

- Calculation:

(Calculate the power and percentage errors for each reading)

- Conclusion:

- Multiple choice questions:

1. Wattmeter is an instrument which measures
   (a) Instantaneous power (c) Average real power
   (b) Apparent power (d) Reactive power
2. In AC circuit I SinØ is called the _________component
   (a) Wattles (b) Reactive
   (c) Quadrature (d) Any of these
3. The power in the single phase circuit is given by
   (a) VI (b) VI CosØ
   (c) VI SinØ (d) None of above
4. The dynamometer wattmeter can be used to measure
   (a) D.C. power only (c) A.C. power only
   (c) A.C. & D.C. power (d) A.C. power of 1- Ø circuit
5. During the measurement of power in a 3- Ø circuit, the readings of the wattmeters are W_1=500W, W_2=200W. The reading of W_2 has been taken after reversing its pressure coil connections. The total power is
   (a) 300W (c) 500W
   (b) 700W (d) 200W

EXPERIMENT: 8

Date:

Aim: To study Cathode Ray Oscilloscope (CRO) and measure the electrical quantities.

- Specific Objective:

  After performing the experiment, one should be able to:
  - Analyze the current and voltage waveform.
  - Measure AC and DC voltage, current, frequency, resistance, phase difference.

- Rationale:

A CRO is basically a very fast X – Y plotter. It displays an input signals verses another signal or verses time. The heart of CRO is the Cathode Ray Tube (CRT). The rest of the instrument consists of circuitry necessary to operate the CRT.

Cathode Ray Tube:

The schematic diagram of a CRT along with its control circuit as shown in figure -1. It consists of three basic components.

- The Electron Gun: It produces a sharply focused beam of electrons accelerated to a very high velocity.
- The Deflection system: It deflects the electrons both in the horizontal and vertical planes, electro statically in accordance with the waveform to be displayed.
- The Fluorescent screen: It is the screen upon which the beam of electrons impinges to produce the spot of visible light.

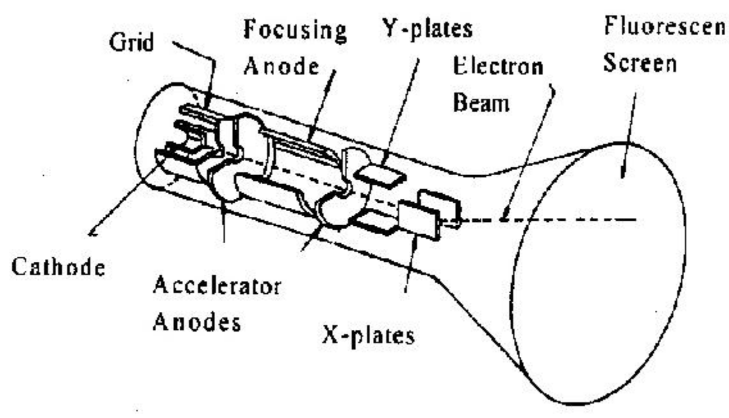


Fig. 1 Cathode Ray Tube

These three components of CRT are put inside a highly evaluated funnel shape glass envelope. The large end of this tube is coated on the inside with a phosphor material which fluoresces when high velocity electron strike it. When the electron strike it. When the electron beam strikes the screen besides giving out visible light. Secondary emission electrons are also released. These electrons are collected by the conducive coating deposited on the inside surface of the glass bulb. The coating is an aqueous solution of graphite known as aquadag, which is electrically connected to the final anode as shown in figure 1.

The electron gun fires electrons at a very high speed. These electrons are emitted from the hearted cathode. The electron grid is a nickel cylinder surrounding the cathode. It has a small hall in the far end through which the emitted electrons can get pass the grid. The control grid controls the number of electrons passing through it. Since the brightness of the spot on the face of the screen depends upon the beam intensity. It can be control by changing the negative bias on the control grid. The electrons coming out of the control grid are accelerated by the high potential applied to the accelerating anode. The electron gun emits a very narrow accelerated beam. This beam passes through the deflection system consisting of two pairs of parallel plates. As shown in figure -2 the Y deflection plates are placed horizontally in the tube.

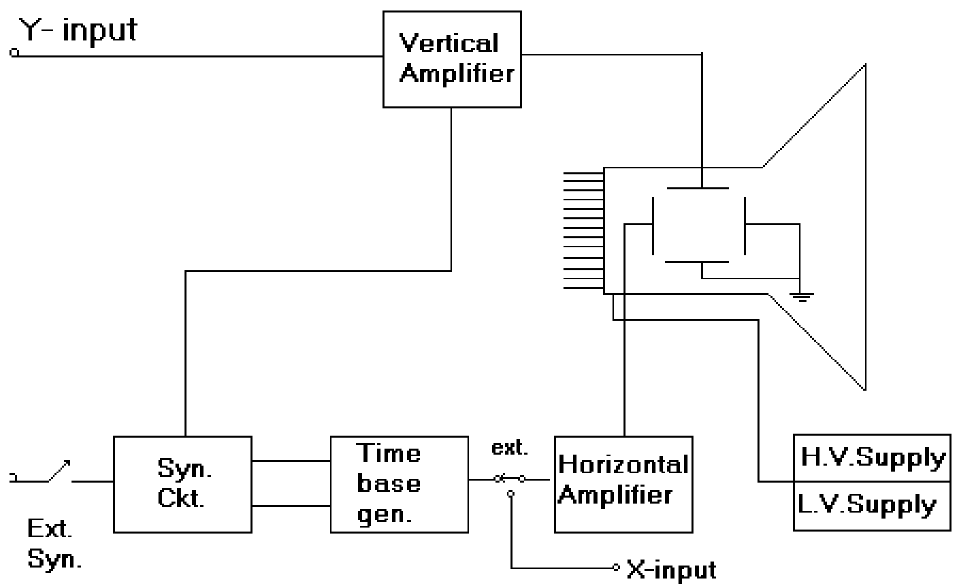


Fig. 2 Block Diagram of CRO

Any voltage applied to this set of plates moves the electron beam up and down. The X deflection plates are kept vertically. Any voltage applied to this set of plates moves the spot on the screen to the left or to the right. If no voltage is applied to either set of plates, the spot should locate at center of the screen. The initial centering of the spot can be done by using the X shift and Y shift controls.

The block diagram of CRO shows the various subsystems as follows:

- The vertical deflection system.
- The horizontal deflection system including the time – base generator and synchronization circuitry.
- The Cathode Ray Tube (CRT).
- The high voltage and low voltage power supply.

Front Panel Control of A General Purpose CRO:

- Power ON: Puts the instrument to main supply with LED indication.
- Focus: This is adjusted with the conjunction with the intensity and astigmatism controls for obtaining sharpest trace on the screen.
- Intensity: This is the brightness control which is adjusted for the desired brightness level of trace.
- Horizontal And Vertical Shift: Horizontal and vertical position controls apply bias voltages to the horizontal and vertical deflection plates respectively and thereby bring the trace to the desired position on the screen.
- Vertical Gain: This is a potentiometer which continuously variable over each range of the vertical attenuator.
- Horizontal Gain: This is a potentiometer which provides continuous control of the amplitude of the signal coupled to the horizontal amplifier. In normal use the horizontal trace on a CRT is adjusted to four fifth of the CRT diameter.
- Vertical Range or Multiplier or Selector: This is calibrated step attenuator which selects the multiplier of a voltage divider in the vertical input circuit. In controls the extent of vertical deflection of the beam.
- Level: Variable control, selects the trigger point on the displayed waveform.
- Auto/Norm: In Auto mode trace is displayed in absence of any input signal. The display is then automatically triggered for signals above 30 Hz depending upon correct setting of Trigger LEVEL control.
- Int/ Ext:
  - Int: Display triggers from signals derived from CH1, CH2 or line.
  - Ext: Triggering from any other external source fed through EXT TRIG BNC socket.
- Line: Triggers from power line frequency.
- Horizontal Range or Multiplier or Selector: This is calibrated step attenuator which selects the multiplier of a time divider in the horizontal input circuit.
- Synchronous Selector: This is a rotary switch selects either internal, external or line synchronization.

Application of CRO:

- Study of voltage and current waveform.
- Measurement of AC and DC voltage.
- Measurement of currents.
- Measurement of frequency.
- Examination of heartbeats.

- **Observation:**

  - Measurement of Frequency

$\frac{\text{Time}}{\text{Division}}$	No. of Division	Time= $\frac{\text{Time}}{\text{Division}}$ X Div. (sec)	Frequency f = 1/Time (Hz)

  - Measurement of Voltage

$\frac{\text{Volt}}{\text{Division}}$	No. of Division	$V_m = \frac{\text{Volt}}{\text{Division}}$ X Div. (sec)	$V_{rms} = V_m / \sqrt{2}$ (volts)

- Conclusion:

- Multiple choice questions:

1. A CRO has an electron gun having
   (a) Indirectly heated cathode and control grid.
   (b) Horizontal and vertical deflection plates
   (c) Phosphorescent screen.
   (d) All of the above
2. The signal to be observed on the screen of a CRO is applied across
   (a) X – plates (c) Accelerating anodes
   (b) Y – plates (d) Focusing anodes
3. CRO can not measure directly (without external aid)
   (a) Voltage (c) Current
   (b) Frequency (d) Phase angle between two voltages.
4. Maximum operating frequency of CRO is mainly governed by
   (a) Vertical amplifier (c) Cathode ray tube
   (b) Horizontal amplifier (d) Time-base circuit
5. While measuring frequency using CRO, two complete waves occupy 8cm on X axis. The time base was set to 5µs/cm. The frequency of the signal is
   (a) $25MH_Z$ (c) $50MH_Z$
   (b) $25KH_Z$ (d) $50KH_Z$

EXPERIMENT: 9

Date:

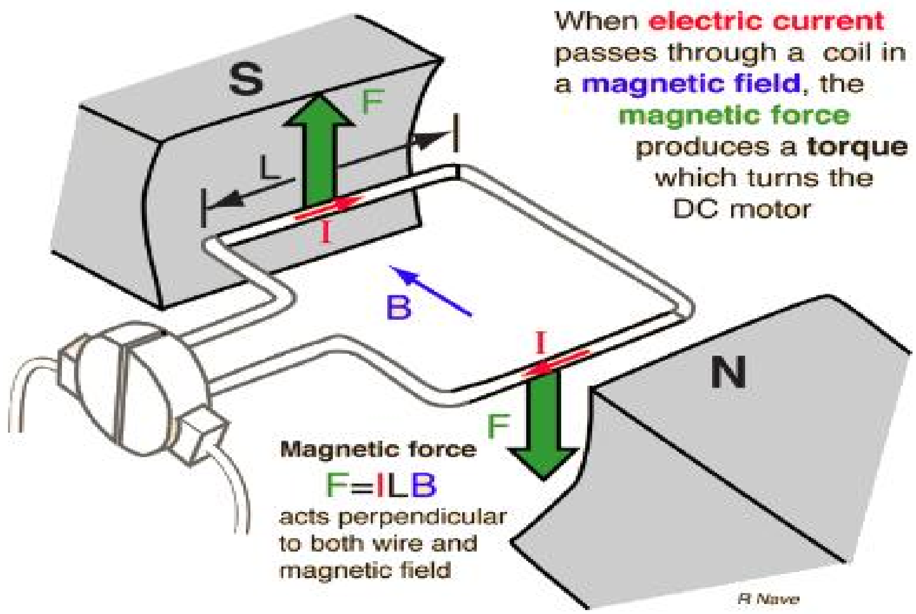
Aim: To study DC & Ac Machines.

Introduction:

A machine that converts DC power into mechanical power is known as a DC motor.

Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force.

The direction of this force is given by Fleming's left hand rule and magnitude is given by;



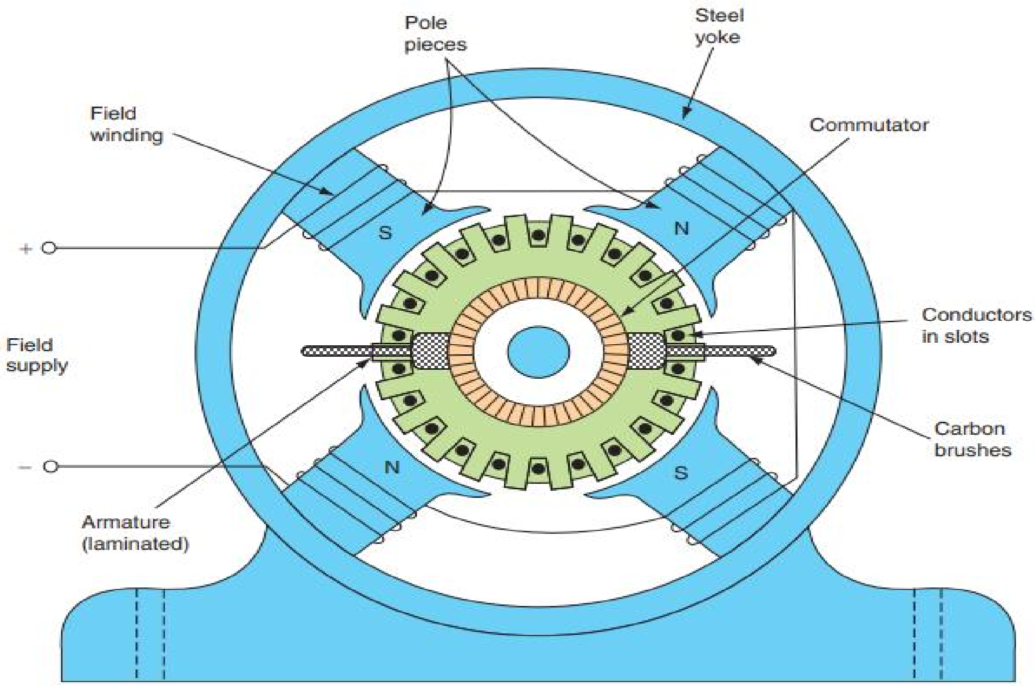
Basically, there is no constructional difference between a DC motor and a DC generator. The same DC machine can be run as a generator or motor.

Working of DC Motor

Consider a part of a multipolar d.c. motor as shown in Figure below. When the terminals of the motor are connected to an external source of d.c. supply:

1. the field magnets are excited developing alternate N and S poles
2. the armature conductors carry currents.

All conductors under N-pole carry currents in one direction while all the conductors under S-pole carry currents in the opposite direction.
Suppose the conductors under N-pole carry currents into the plane of the paper and those under S-pole carry currents out of the plane of the paper as shown in Figure.



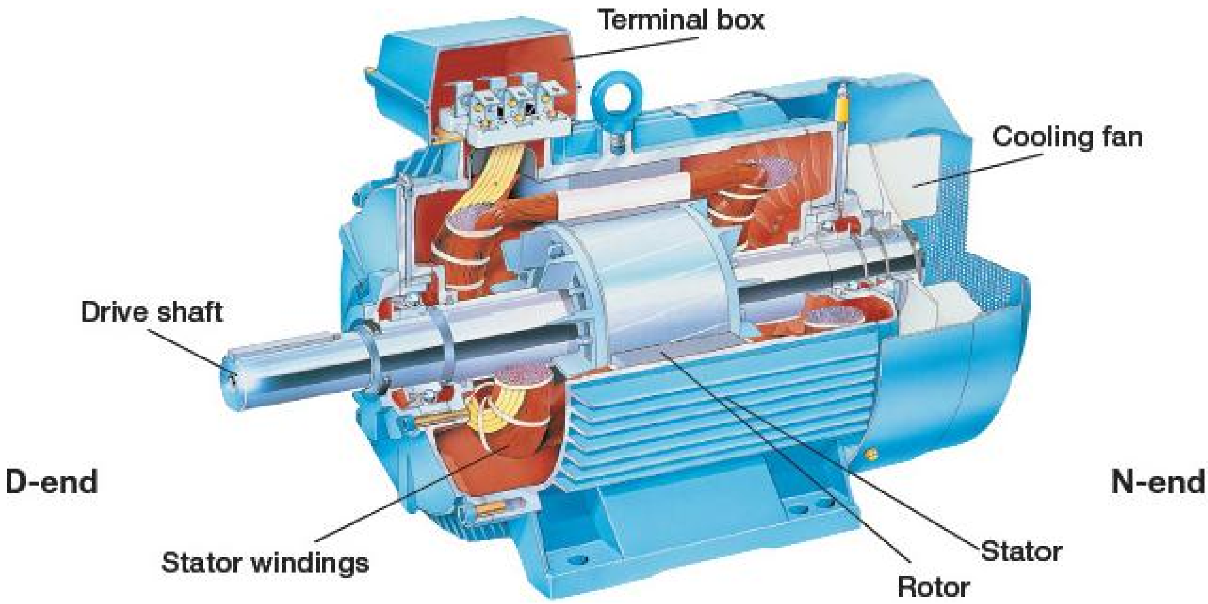
Since each armature conductor is carrying current and is placed in the magnetic field, mechanical force on it.

On applying Fleming's left hand rule, it is clear that force on each conductor is tending to rotate the armature in anticlockwise direction. All these forces add together to produce a driving torque which set the armature rotating

When the conductor moves from one side of a brush to the other, the current in that conductor is reversed and at the same time it comes under the influence of next pole which is of opposite polarity. Consequently, the direction of force on the conductor remain the same.

It should be noted that the function of a commutator in the motor is the same as in a generator. By reversing current in each conductor as it passes from one pole to another, it helps to develop a continuous and unidirectional torque.

INDUCTION MOTORS



Introduction :

- When the three windings in the stator of an induction motor are connected to a three-phase voltage source, currents flow in the windings and a rotating magnetic field is established in the stator. If there is no load connected to the motor shaft, the three-phase current drawn by the stator windings is called the exciting current. This current, at line voltage, provides the reactive power necessary to establish the rotating magnetic field in the stator and the real power dissipated in the copper windings and core.

- The speed of the rotating stator field is determined by the frequency of the three-phase waveforms supplied by the source, 60 Hz in North America, and by the number of magnetic poles with which the stator is built. This speed is known as the synchronous speed and is measured in revolutions per minute, RPM. Poles always come in pairs (a north pole and a south pole) and for a two-pole motor, the field will complete 60 revolutions every second and thus synchronous speed is 3600 RPM. This is as fast as any induction motor can ever turn when excited by 60 cycle waveforms. Electric utilities maintain system frequency with great precision (in order to make electric clocks run accurately, among other things). Therefore, synchronous speed may be considered a constant value for a given motor.

- The rotor of an induction motor consists of a laminated steel core with slots and some type of winding. The two most common types of winding are the squirrel cage rotor and the wound rotor (using copper windings). The squirrel cage rotor will be discussed in a later section of the experiment. In the wound rotor, three sets of windings are set in the slots of the core material. Each winding is brought out to a slip ring on the shaft of the rotor. Terminating the windings on slip rings allows flexibility in the manner in which the windings are configured by allowing resistors to be placed in WYE or DELTA across them. The resistors are sized to accurately control the magnitude of currents in the rotor windings.

- The rotating three-phase magnetic field produced by the stator induces an alternating voltage on each of the rotor windings. If the rotor is not turning, the rate at which each rotor winding cuts the lines of flux produced by the magnetic field will be equal to the synchronous speed and the induced voltages in the rotor will be at the same frequency as the source voltage. This condition is called 100% slip. As the rotor is turned in the same direction as the rotating magnetic stator field, the rate at which the rotor windings cut lines of flux will decrease and the induced voltages in the rotor windings will decrease in frequency and magnitude. If the rotor is turned at a rate equal to the synchronous speed, its windings will not cut any lines of flux and the induced voltages will be zero in magnitude and frequency. This condition is called 0% slip. The torque produced by the motor drops to zero at 0% slip and thus, for all practical purposes, an induction motor cannot actually achieve synchronous speed. Conversely, if the rotor is turned in the opposite direction with respect to the stator field, but at synchronous frequency, the induced voltages will have twice the magnitude and frequency as compared to the 100% slip condition.

RESULT: We Have Studied Dc and Ac machines.

EXPERIMENT: 10

AIM : To do Bill Calculation of House