SARDAR VALLABHBHAI PATEL INSTITUTE OF TECHNOLOGY
svit

Contents

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Subject	Basic Electrical Engg.	I.D. No.	19BEECG018	EC

EXPERIMENT: 1 **DATE:** 13/8/19

AIM: Study of Various Electrical Symbols and Electrical Instruments.

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STUDY OF VARIOUS ELECTICAL SYMBOLS

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THEORY:

Graphic symbols are used to denote electrical, electronic and mechanical components and devices. They are used to portray complex schematic and wiring circuit diagrams in a simple manner for conserving space. In order to make the diagrams easier to read, the graphic symbols, in many cases, resemble the actual component or its element. Thus, the graphic symbols serve as effective & precise means of communication, particularly in situations, which involve complex diagrams and devices.

We have selected a few commonly used symbols and have explained them first and the symbols are drawn in the latter part.

➢ FUSE:

Many circuits have a fuse in series as a protection against over load from a short circuit. Fuses are fabricated from low melting point alloys. Under normal load conditions, the current through the fuse will not produce excessive heat. If the circuit is overloaded or if a fault occurs, leading to a heavy rush of current, the fuse element melts due to high heat generated by this increased current. This blowing-up of the fuse thus opens the series circuit. The objective is to let the fuse blow before the components are damaged. A new fuse element can easily replace the blown fuse after the overload has been eliminated. Fuses are manufactured in a wide variety of shapes & current ratings. Fuse elements are made of tin-coated copper or nickel and aluminium. They are available in current ratings of 2 mA to hundreds of ampere.

➢ CELL & BATTERY:

A voltaic chemical cell is a combination of materials, which produce direct current (DC) from its internal chemical reactions. Each cell has two terminals +ve terminal & –ve terminal.

An electric battery consists of a number of electro-chemical cells, connected either in series or parallel. The voltage rating of battery depends upon voltage rating of group of cells (either connected in series or parallel). The voltage rating of cell is given by its open circuit voltage i.e. voltage it can produce when not connected to a load circuit. This voltage depends on the type of materials used and not the physical size of the cell.

➢ SWITCHES:

A switch is a device for opening and closing a circuit. They are manufactured in hundreds of sizes and types. Some of the more common ones are discussed below:

i. **Single pole Single – throw (SPST) Switch:**

Such switch has one lever or arm (i.e. Single pole). It can connect or disconnect one side of a line or a single wire circuit.

Example: Tumbler switch, piano switch using in house wiring, etc.

ii. **Single pole Double – throw (SPDT) Switch:**

Such switch has two ON positions. It is OFF when in the centre. As schematically shown in fig. it has one are (hence Single Pole) but can be moved into either one of the two positions. Obviously, it can close either one of the two circuits.

Example: blunder switch OFF & ON (Low speed, High Speed).

iii. **Double pole Single throw (DPST) Switch:**

Such a switch has only one position of closure but completes two contacts simultaneously. It fact it is similar to SPST switch except that it switches both sides of a wire line at once. It may also be used as two single pose switches acting together.

iv. **Double pole Double throw (DPDT) Switch:**

Such a switch has two poles and can be moved either to the right (Position A) or to the left (Position B).

v. **Rotary Switches:**

The best example of such a switch is the switch used in ceiling fan regulator. The symbol drawn is for a single pole rotary switch.

vi. **Push Button:**

Symbol is shown in fig. It is like a switch with a spring return system i.e. when button is pressed it makes contact or release contact as the case may be. When released it comes back to its normal position. [NC or NO]

> **RESISTOR:**

It is passive element. A resister is an electrical component with a known specified value of resistance. It is probably the most common component in all kinds of electronic equipment ranging from a small radio to a colour television receiver. As its name suggests, a resistor opposes the flow of current through it. Resistance is necessary for any circuit to do useful work. In fact without resistance, every circuit would be a short circuit.

Some of the common use of resistors are: -

(1) To establish proper value of circuit voltages due to IR drops.
(2) To limit current.
(3) To provide load.

Resistor can be connected in the circuit in either direction because they have no polarity. The types of resistor are:

i. **Fixed Resistor:**
It is such resistor, where we cannot change its resistance value.

ii. **Variable Resistor:**
It is such resistor, where we can change its resistance value.

iii. **Rheostat:**
One type of variable resistor which has two fixed terminal & one variable terminal or known as wire wound resistor they are constructed from a long fine wire i.e. high resistance wire (Nickel chromium wire) wound on a ceramic core. The advantage with a rheostate is that it can be used as a fixed resistor as well as a variable resistor

➢ **INDUCTORS:**

It is another passive element commonly used in electrical/electronic circuit It is nothing but coil wound on a core or former of some suitable material. It opposes any change in current. There are mainly two types of inductors on basis of their construction

i. **Air Core Inductor:**
It consists of number of turns of wire wound on a former made of ordinary cardboard. Since, there is nothing but air inside the coil it is termed as an air-cored inductor. It has the least inductance for a given number of turns & core length.

ii. **Iron-Core Inductor:**
It is that inductor in which a coil of wire is wound over a solid or laminated iron core. This construction leads to increase in its inductance as many times as the relative permeability (μr) of Iron.

➢ **CAPACITORS:**

A capacitor has two plates separated by dielectric medium. It is also passive element commonly used in electric circuit. It is a device which

- Has the ability to store charge which neither a resistor nor an inductor can do.
- Opposes any change of voltage in the circuit in which it is connected.
- Block the passage of direct current through it.

They are mainly of two types:

- Fixed Capacitor
- Variable Capacitor

➢ TRANSFORMER:

Basically transformer is power transformation device. It transfers power from one circuit to other either by increasing voltage level (decreasing current level) or by decreasing voltage level (increasing current level) i.e. It makes it possible to step up a relatively low generated voltage level to the possible most desirable high voltage (Step up transformer Np < Ns) or lower the voltage level for most convenient utilization level [esp. in home] (step down transformer Np > Ns). Its principle's based on mutual inductance principle. Normally transformer has two windings, which are electrically isolated & magnetically coupled.

➢ AUTO TRANSFORMER (VARIAC):

It is also one type of transformer but in this there is only one winding, which works as primary as well as secondary winding. It is also known, as variac.

➢ WATTMETER:

It measures electric power. They are of AC type & DC type

AC Power = VICosΦ Watt [Cos Φ – Power factor]

DC Power = VI Watt

It has two coils - one, which is known as current coil designated with M. & L. Second coil known as potential coil designated with C.V.

- Current coil always connected in series with circuit, as it measures current of Circuit.
- Voltage coil or potential coil is connected in paralleled to circuit as it measures Voltage of coil.

Combination measures power of circuit.

➢ CROSSOVER:

Symbol is as shown in fig. It means two wires are not meeting at a point

➢ JUNCTION:

Symbol is shown in fig. It means two wires are meeting at a point.

➢ DC GENERATOR:

Function of generator is to convert mechanical energy into electrical energy. DC generator is based on dynamically induced e.m.f. principle. In this generator output electrical energy is in term of DC so it is called DC generator.

➢ AC GENERATOR:

Converts mechanical energy into electrical energy. Electrical energy produced is an alternating quantity and hence called an AC generator. It operates on statically induced e.m.f. principle.

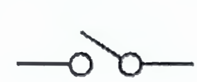
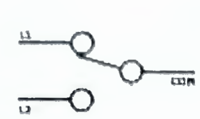
➢ DC MOTOR:

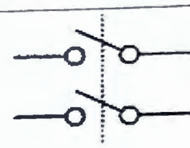
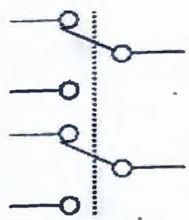
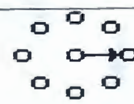
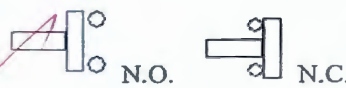
Function of motor is to convert electrical energy into mechanical energy. Its input electrical energy is in form of direct quantity so it is called DC Motor.

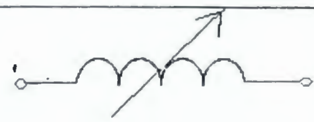
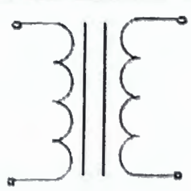
➢ AC MOTOR or INDUCTION MOTOR:

Converts AC electrical energy into mechanical energy.

SYMBOLS

DESCRIPTION	SYMBOLS
FUSE	
CELL/BATTERY	
SWITCHES	
i. Single pole single throw [SPST]	
ii. Single pole double throw switch [SPDT]	

iii. Double pole single throw switch [DPST]	
iv. Double pole double throw switch [DPDT]	
v. Rotary switch	
vi. Push button switch [NO & NC]	
RESISTORS	
i. Fixed resistors	
ii. Variable resistors	

iii. Rheostate	
INDUCTORS	
i. Fixed inductor or air core inductor	
ii. Variable inductor	
iii. Iron core inductor	
CAPACITORS	
i. Fixed capacitors	
ii. Variable capacitors	
TRANSFORMERS	
i. Iron core transformer	

METERS	
Ammeter	A
Voltmeter	V
Wattmeter	M PC C
NETWORK	
Resistor	

MOTOR / GENERATORS	
i. AC Motor	
ii. DC Motor	
iii. AC Generator [alternator]	
iv. DC Generator	

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STUDY OF VARIOUS ELECTICAL INSTRUMENTS

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THEORY:

There are various kinds of measuring instruments available in the market to measure different quantities such as Voltage, Current, Resistance, Speed etc. some of the common instruments used frequently are Multimeter, Tong Test (Clip-On Meter), Tachometer, Megger, Phase Sequence Meter etc. the functional behavior of all these meters is given below.

- **MULTIMETER:** A meter that can measure different quantities like voltage, current, resistance etc. and having multiple ranges of all such quantities is known as multimeter. They are basically of two types – Analog Fig. 1.1(a) and Digital Fig. 1.1(b). The operating procedure is similar in case of both analog as well as digital multimeter. To understand this let us see the procedure for measurement of voltage.
  - Voltage Measurement :
    - First check the type of voltage whether A.C. or D.C. and accordingly set the position of A.C. /D.C. selector switch.
    - Connect the black test probe to "Com" terminal & red test probe to "V" terminal.
    - Set the appropriate range of the voltage using range selector switch.

- Touch the measuring points in a circuit through the leads of the probe and read out the voltage from the screen if you are using a digital meter or from the scale if it is an analog meter.

In the similar way one can use the same meter for the measurement of current, resistance etc.

- **CLAMP ON METER:** It is also a kind of multimeter but with additional clips or clamps to measure A.C. current as shown in fig. 1.3. Normally whenever we want to measure current a meter is to be connected in series with the circuit. But it is not possible to break the circuit every time for the measurement of current. Hence a clip on meter has been designed to measure the A.C. current without breaking the circuit. The operation for measurement of current is explained below.

  - Current measurement :
    - Switch on the meter and set the selector switch on A.C.
    - Press the lever to open out the clamps and then insert the clamp such that the conductor or wire through which we want to measure the current comes exactly in the center of the clamps.
    - Note down the reading from the scale if it is an analog meter and from the screen if it is a digital meter.

Figure1. 1Analog Multimeter

Figure1. 2 digital multi meter

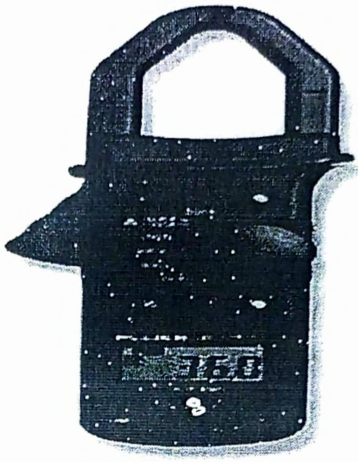

Figure1. 3 Clamp-on meter

In the measurement of any quantity if the magnitude of the quantity is higher than the range selected than in case of analog meter the pointer will move out of the scale and in digital meter, the meter will display a flashing "1" or "0L" which means the meter is overloaded and you will have to select higher range. To avoid above situation and hence the probable damage to the meter always start the measurement by keeping meter on highest range.

- **TACHOMETER:** It is used to measure the speed in rpm (revolution per minute) of any rotating machine. It has a pointed shaft, which is to be kept such that it touches the rotating shaft of the machine. The dial of meter gives the speed in rpm. The meter may be analog or digital.

- **MEGGER:** It is an instrument to measure the insulation resistance of the order of Mega ohm or more. The insulation resistance is the resistance of the insulating material and to measure it, a voltage, of the order of 500 to 5000 V is required. In Megger a dynamometer is used which generates the voltage of this order. Figure 1.5 shows analog and digital megger.

- **PHASE SEQUENCE METER:** This meter is used to check the phase sequence of a 3 - line. The phase sequence is nothing but the order of the phase in which the voltage of a phase attains maximum positive value one after another. E.g. if the phase sequence is R-Y-B than the voltage of R phase will attain maximum positive value first then the voltage of Y phase and then that of B phase. Figure 1.6 shows digital phase sequence indicator.

The phase sequence R-Y-B is said to be the correct phase sequence while R-B-Y is reverse phase sequence.

The phase sequence meter is a small 3 – induction motor having a pointer on the dial of the scale. The pointer of the meter will rotate in clockwise direction for correct phase sequence and in anticlockwise direction for reverse phase sequence.

Figure1. 4 Tachometer

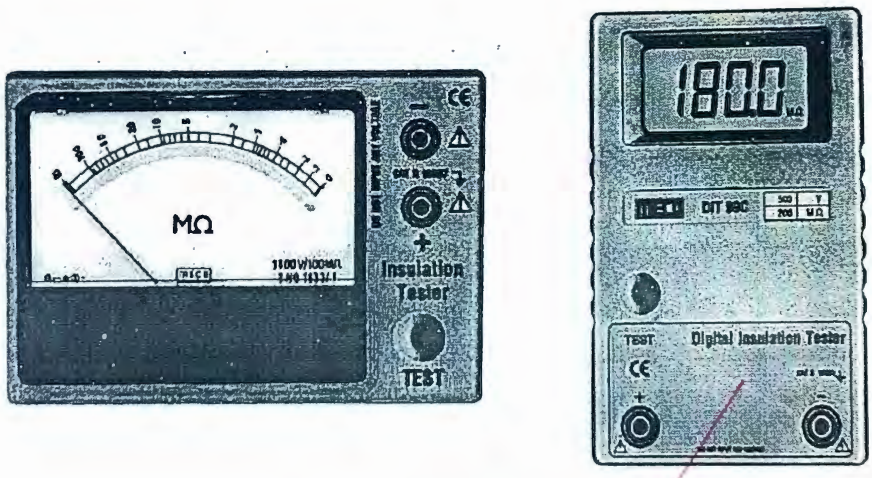

Figure1. 5 Analog and digital Megger

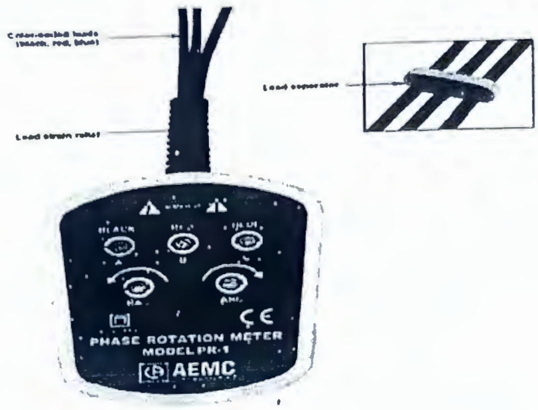

Figure1. 6 Phase sequence meter

CONCLUSION:

Studied about various electrical Symbols and Electrical instruments.

EXPERIMENT : 2 DATE: 18/19

TO STUDY EFFECT OF TEMPERATURE CO-EFFICIENT

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AIM: To study the effect of temperature on resistance of Tungsten and Carbon Material.

APPARATUS: 1 - ϕ Variance (0 – 270 Volts, 50 C/S, 5 A)

A.C. Voltmeter (0 – 250 V)

A.C. Ammeter (0 – 5 Amp)

Lamps (Tungsten & Carbon Filament), Rheostat, Connecting Wires

THEORY:

The effect of rise in temperature is different in different types of materials.

Metal: the resistance of pure metals (e.g. Copper, Aluminum etc) increases with rise in temperature. The increase in resistance is large and fairly regular for normal range of temperatures. For metals, temperature v/s resistance graph is a straight line. Hence they have positive temperature coefficient of resistance. The temperature – resistance graph for copper is shown if figure 2.1. If we extend this line backward, it cuts the temperature axis at -234.5°C. But actually the curve departs from the straight-line path at very low temperature.

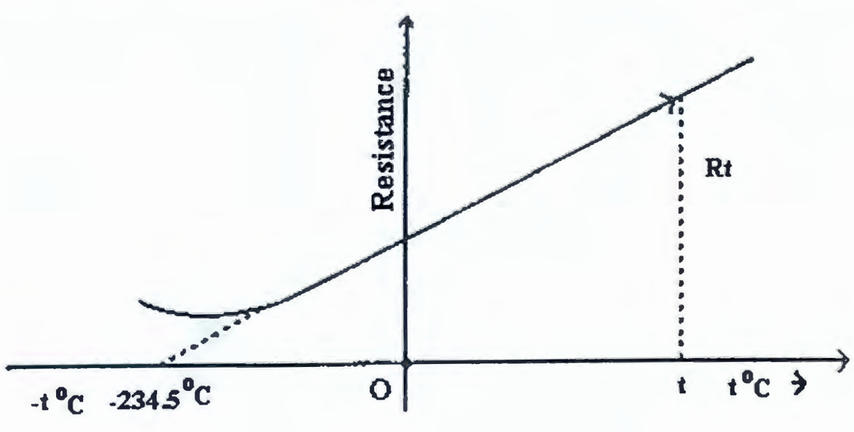
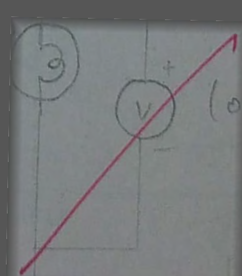


Figure 2.1

Effect of Temperature on Resistance

Substance	
1) Metals (Copper, Aluminum, Iron Etc.)	Resistance Increases [illegible]
2) Alloys (Eureka, Nichrome, Manganin Etc.)	Resistance Increases [illegible]
3) Insulation (Glass, Mica, Rubber), Semiconductor (Germanium, Silicon), Carbon Electrolytes,	Resistance Decreases [illegible]
4) Gases (Argon, Neon, Helium)	Resistance Decreases [illegible]

CIRCUIT DIAGRAM:



PROCEDURE:

- Connect the circuit as shown in figure 5.2 with the lamp of tungsten filament (material with positive temperature coefficient) and switch on 1- Φ A.C. supply. Set 230 V with the help of autotransformer in voltmeter V_1.
- Keep maximum resistance of the rheostat and note the reading of V_2 and I.
- Now change the resistance of the Rheostat and vary the current in the circuit.
- Note down such 4 to 5 readings, calculate value of R and corresponding value of temperature and plot the graph of R to t.

OBSERVATION: Room Temp. = 20°C R_{LAMP} at Room Temp. = 22 Ω

$\alpha_{Tungsten}$ at 20° C = 0.004403

OBSERVATION TABLE:

Lamp of Tungsten Filament (PTC Material)					Lamp of Tungsten Filament (PTC Material)				
Sr. No.	V_2 Volts	I Amp	R = V_2/ I Ω	Temp. °C	Sr. No.	V_2 Volts	I Amp	R = V_2/ I Ω	Temp. °C
1	50	0.44	113.64	966	5				
2	100	0.51	196.07	1963.43	6				
3	150	0.64	234.38	2212.46	7				
4	200	0.74	270.27	2583.02	8				

$$R_2 = R_1[1 + \alpha(t_2 - t_1)]$$

$$t_2 = \frac{\frac{R_2}{R_1} - 1}{\alpha} + t_1$$

CALCULATION:

1) $t_2 = \dfrac{\dfrac{113.64}{22} - 1}{0.00403} + 20$

$= 966\ °C$

2) $t_2 = \dfrac{\dfrac{196.07}{22} - 1}{0.00403} + 20$

$= 1963.43\ °C$

3) $t_2 = \dfrac{\dfrac{234.38}{22} - 1}{0.00403} + 20$

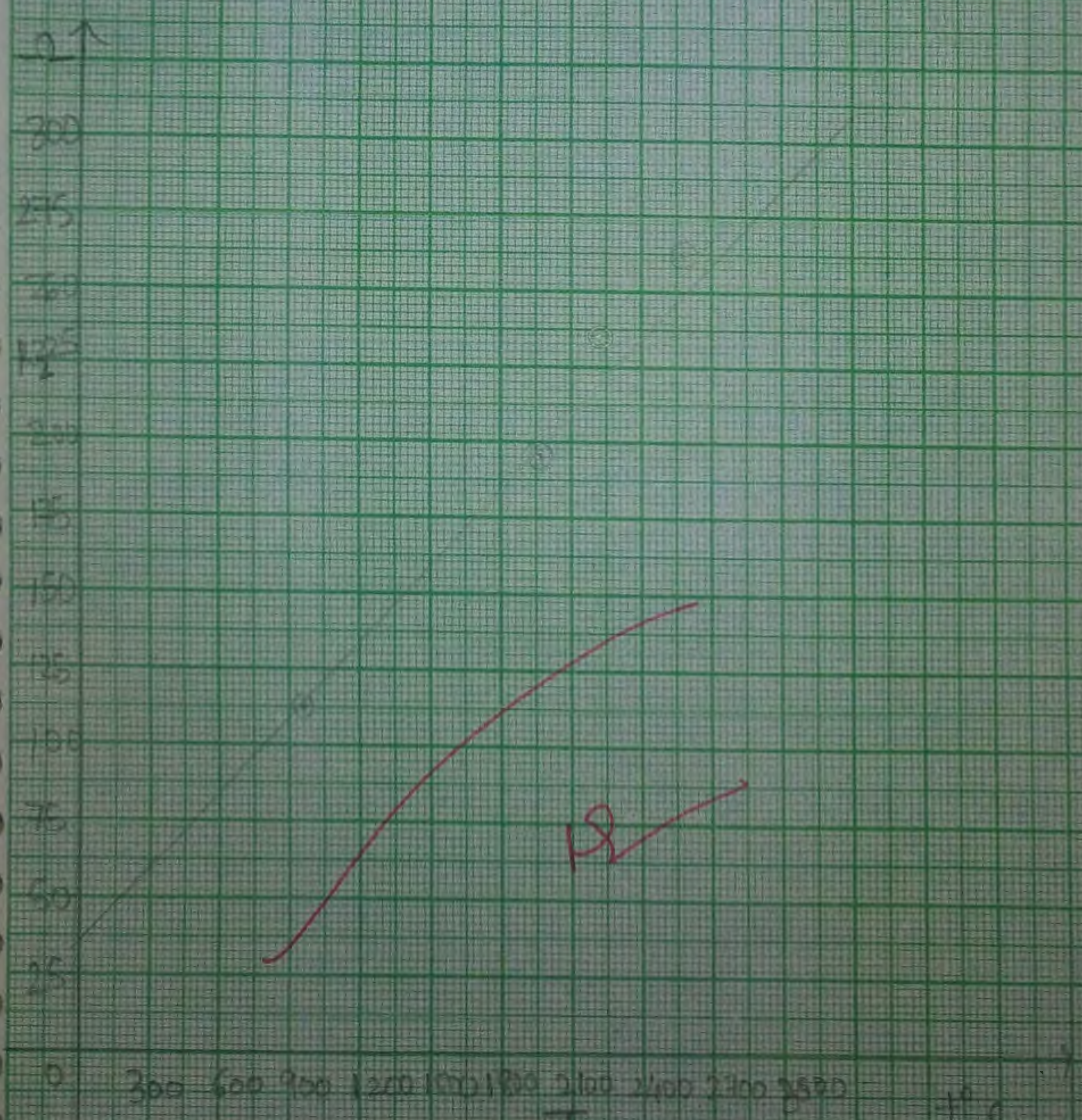
$= 2212.16\ °C$

4) $t_2 = \dfrac{\dfrac{270.27}{22} - 1}{0.00403} + 20$

$= 2583.02\ °C$

CONCLUSION:

Thus, we studied effect of temperature of tungsten & Carbon material.


Q
300
275
250
225
200
175
150
125
100
75
50
25
0
300 600 900 1200 1500 1800 2100 2400 2700
T2
t°C

EXPERIMENT :3 DATE: 26/08/19

TO STUDY KIRCHOFF'S LAWS

****

AIM: To verify Kirchhoff's Laws (KCL & KVL).

APPARATUS: Kit (with D.C. source), digital multi meter, connecting wires

THEORY:

Kirchhoff's current law:-

Kirchhoff's first law is known as Kirchhoff's current law and is based on the principle of ***conservation of charge.*** It states, **"The algebraic sum of all the currents meeting at a junction or node in any electrical circuit is zero".**

A node is a point where two or more than two branches are meeting. A junction is a point where three or more than three branches are meeting.

Consider the case of few conductors meeting at a point as shown in figure 3.1

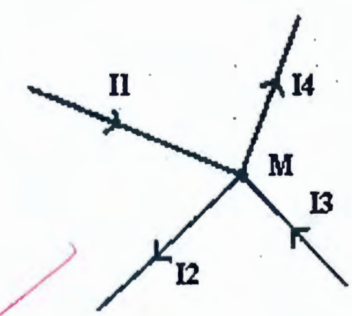


Figure 3.1

The arrows indicate the direction of current flow. Accordingly, the current I_1 and I_3 are coming towards the junction M and the current I_2 and I_4 are going away from the junction. Assume positive sign for incoming currents and negative sign for outgoing currents.

According to Kirchhoff's current law

$\Sigma I = 0$

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

$I_1 + I_3 = I_2 + I_4$

I.e. current entering the junction = current leaving the junction bove law (

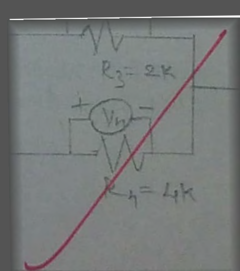
Sign for Emf Sources

"-Ve sign"

"+Ve sign"

Figure 3.2

... in figure 3.2 if we go from positive terminal of emf source to the negative ... assigned –Ve (negative) sign.



- Measure current in the circuit and voltage across each resistance connected in the circuit.
- Verify KCL and KVL.
- For different values of current note down such 2 to 3 readings.

OBSERVATION TABLE:

Sr. No.	V Volts	I mA	I_1 mA	I_2 mA	V_1 Volts	V_2 Volts	V_3 Volts	V_4 Volts
1	5	1.3	1.1	0.2	2.4	2.5	2.5	2.4
2	10	2.8	2.1	0.7	4.9	5.0	5.0	4.9
3	15	4.4	3.1	1.4	7.4	7.5	7.5	7.4

CALCULATION:

Verification of KCL:

Verify KCL for node 'A' and 'B'

$I = I_1 + I_2 =$ 1.1 + 0.2 = 1.3 mA

(1) $I = I_1 + I_2 = 1.1 + 0.2 = 1.3\text{ mA}$

(2) $I = I_1 + I_2 = 2.1 + 0.7 = 2.8\text{ mA}$

(3) $I = I_1 + I_2 = 3.1 + 1.4 = 4.4\text{ mA}$

Verification of KVL:
Verify KVL for Loop1 and Loop2.

$$V = I_1R_1 + I_1R_3 = V_1 + V_3$$

Or, $$V = I_2R_2 + I_2R_4 = V_2 + V_4$$

(1) $\cancel{V} = \cancel{I_1}\ \cancel{(1.1)2k} + \cancel{(1.1)}\ 2k$ $\qquad V = V_1 + V_3$

$= \cancel{2.2k + 2.2k}$ $\qquad = 2.4 + 2.5$

$= \cancel{4.4k}$ $\qquad = 4.4\ V$

(2) $V = V_2 + V_3 = 4.9 + 5.0 = 9.9 \simeq 10V$

(3) $V = V_1 + V_3 = 7.4 + 7.5 = 14.9 \simeq 15V$.

CONCLUSION:

We studied & Verified Kirchoff's Laws (KCL & KVL)

RIMENT:4

16/09/19

Figure 4.1

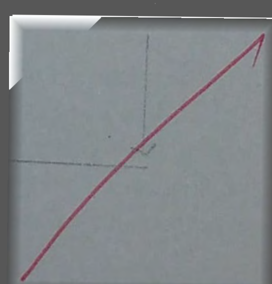
...'S THEOREM THEORY:

...n"s Theorem states that, Any two-terminal network containing a ...
...placed by an equivalent series circuit having a voltage source V_{th} ...
V_{th}= open circuited voltage between the two terminals.
R_{th}= the resistance between two terminals of the circuit obtained by ...
and voltage sources replaced by their internal resistances, if any.

SARDA

- Connect R_L back acr

(to calculate R_{th}):



OBSERVATION TABLE E = 10 V

	Theoretical	Practical
V_{TH}	9.565	9.55
R_{TH}	195.65	200
V_L	9.183	9.0
I_L	1.983	2.0

NORTON'S THEOREM THEORY:

Norton"s Theorem states that, Any network having two terminals A and B can be replsced by a current source of output I_N in parallel with a resistance R_N,

I. The output I_N of the current source is equal to the current that would flow through AB when A and B are short-circuited.

II. The resistance R_N is the resistance of the network measured between terminals A and B with load (R_L) removed and sources of energy replaced by their internal resistances, if any.

PROCEDURE:

Connect the circuit as shown in the main figure.

- First remove R_L from the network and assign the terminal A and B from where R_L is removed, apply a short circuit at the terminal A and B.
- Determine current through short circuit applied across terminal A and B. This current is known as Norton"s equivalent current source $I_{SC} = I_N$.
- Remove the source of energy and replace it by its internal resistance and determine equivalent resistance between terminal A and B.
- Draw Norton"s equivalent network. In this network connect R_L back to Norton"s equivalent network.
- Calculate the current through R_L using current divider rule.

$(I_1 - I_2)$

$= 0$

$200 I_2$

0.048

195

189

Observation Table: E = 10 V

	Theoretical	Practical
I_{SC}	48	44.4 mA
R_N	195.6 Ω	200.2 Ω
V_L	9.01V	9.2 V
I_L	1.9mA	1.7mA

CONCLUSION:

Thus we verified Thevenin's and Norton's Theorem by finding the values Theoretically and practically.

EXPERIMENT: 5 **DATE:** 23/9/19

TO STUDY R-L SERIES CIRCUIT

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AIM: To measure resistance and capacitance of an AC R-L series circuit.

APPARATUS:

Single phase 50Hz ac supply(230 V,5 amp)

single phase auto transformer(0-270V, 5 amp)

Single phase capacitor bank

Rheostat (100 Ω, 5 amp)

02 nos. AC voltmeter(0-300 V);

Flexible wire

THEORY:

Consider a circuit in which a pure resistance of R ohm and a pure inductive coil of inductance of L Henry are connected in series as shown in Figure 5.1 (a).

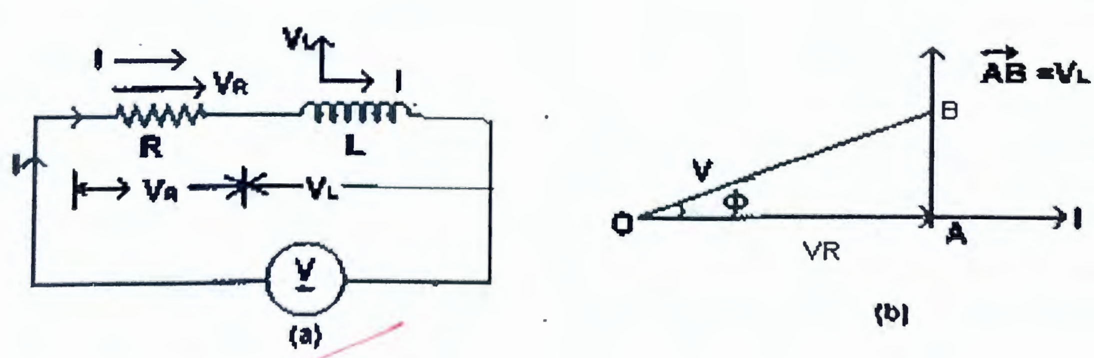


Figure: 5.1

Let, V = rmsvalueoftheappliedvoltage

I = rmsvalueoftheresultantcurrent

VR=IR=PotentialdifferenceacrossR

VL=IXL= PotentialdifferenceacrossL

f = frequencyoftheappliedvoltage

As the two elements are connected in the series, the same current will flow through both of them. So it is convenient to draw Phasor diagram by taking as areference Phasor.

Potential differenceacross R is inphase with the current I, where as potential difference (VL) across Inductor leads the current I by 90. This is shown in the Phasor diagram of above figure-5.1 (b). From which the magnitude of the applied voltage and power factor

angle ϕ of the circuit are given by,

$$V = \sqrt{(v_R{}^2 + v_L{}^2}$$

$$V = \sqrt{I^2R^2 + I^2RX^2}$$

$$= I\sqrt{R^2 + X_L^2}$$

$$V/I = \sqrt{R^2 + X_L^2}$$

=Z ImpedanceofR-Lseriescircuit

$\tan\phi = V_L / V_R = IX_L / IR = X_L/Rs$

$\phi = \tan^{-1} (X_L / R)$

Figure 5.2

... above figure 5.2,

- Keepautotransformeratzeroposi...
- Setsuitablesupplyvoltageandfo...
  correspondingvaluesofcurrenta...

OBSERVATION TABLE :

Sr. No.	V_S Volt	V_R Volt	V_L Volt	I Amp.
1	200	137	130	2.5
2	150	95.5	116	1.5
3	150	95	105	2.05
4	150	108	95	1.6
5	150	105	97	1.8

CALCULATION:

- $V_R = I*R$

  $R = V_R/I$

- $V_L = I*X_L$

  $X_L = V_L/I$

  $X_L = \omega*L = 2*\pi*f*L$

  $L = X_L/2*\pi*f$

- $\Phi = \tan^{-1}(X_L/R)$

(1) $R = \frac{137}{2.5} = 54.8$ (2) $R = \frac{95.5}{1.5} = 63.66$ (3) $R = \frac{95}{2.05} = 46.34$ (4) $R = \frac{108}{1.6} = 67.5$ (5) $R = \frac{105}{1.8} = 58.33$

(1) $X_L = \frac{130}{2.5} = 52$ (2) $X_L = \frac{116}{1.5} = 77.33$ (3) $X_L = \frac{105}{2.05} = 51.21$ (4) $X_L = \frac{95}{1.6} = 59.38$ (5) $X_L = \frac{97}{1.8} = 53.89$

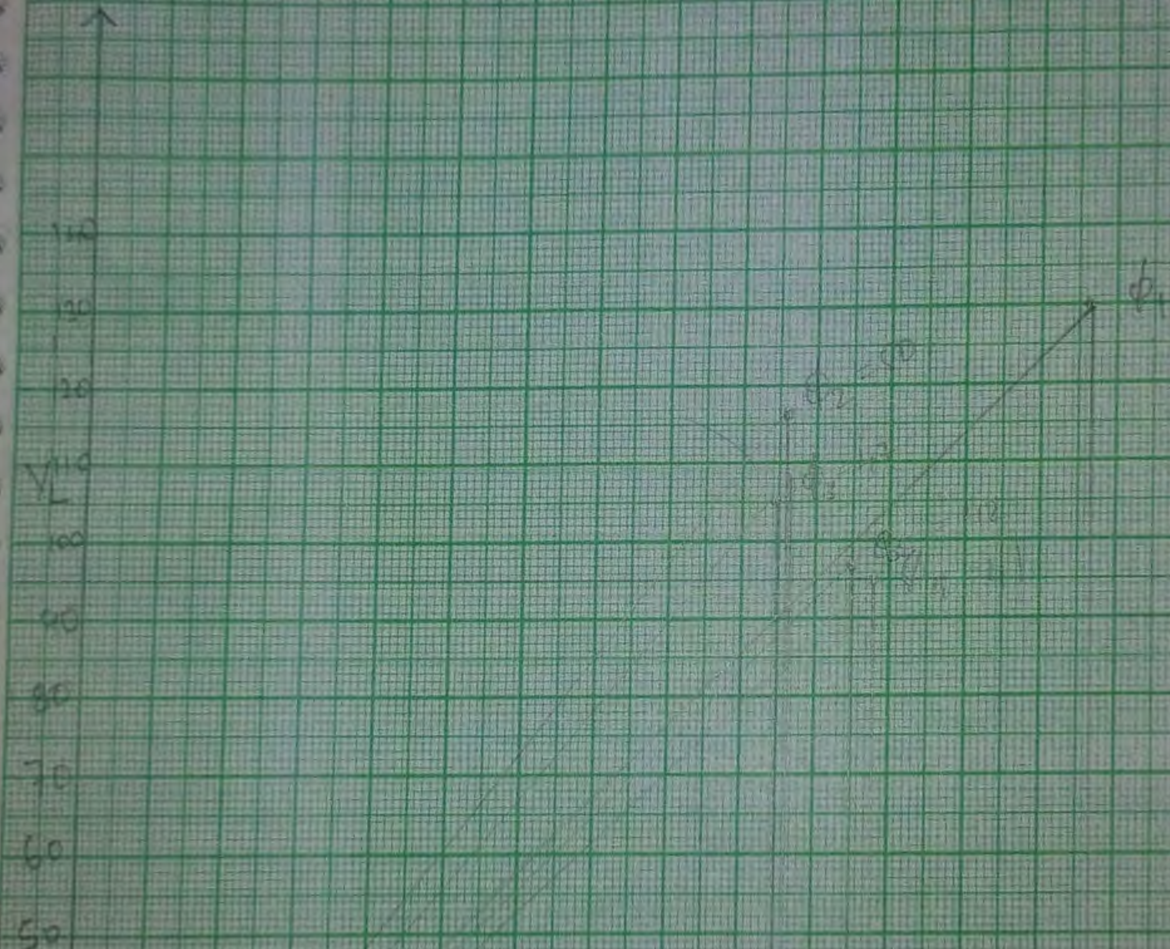
(1) $L = \frac{52}{2\times\pi\times 50} = 0.165$ (2) $L = \frac{77.33}{2\times\pi\times 50} = 0.25$ (3) $L = \frac{51.21}{2\pi 50} = 0.163$ (4) $X_L = \frac{59.38}{2\times\pi\times 50} = 0.189$ (5) $L = \frac{53.89}{2\times\pi\times 50} = 0.172$

(1) $\phi = \tan^{-1}\left(\frac{52}{54.8}\right) = 43.49$ (2) $\phi = \tan^{-1}\left(\frac{77.33}{63.66}\right) = 50.54$ (3) $\phi = \tan^{-1}\left(\frac{51.21}{46.34}\right) = 47.85$ (4) $\phi = \tan^{-1}\left(\frac{59.38}{67.5}\right) = 41.34$ (5) $\phi = \tan^{-1}\left(\frac{53.89}{58.33}\right) = 42.73$

Scale

x-axis 1 cm = 10 (V)

y-axis 1 cm = 10 (V)



RESULT TABLE:

Sr. No.	$R = V_R/I$ Ω	$X_L = V_L/I$ Ω	$L = X_L/2\pi.f$ Henry	$\Phi = \tan^{-1}(X_L/R)$ Degree	p.f. = cos Φ
1	54.8	52	0.165	43.49	0.881
2	63.66	77.33	0.25	50.54	0.963
3	46.34	51.21	0.163	47.85	- 0.748
4	67.5	59.38	0.189	41.34	- 0.878
5	58.33	53.89	0.172	42.73	0.313

CONCLUSION:

Thus, we had measured ~~resistance~~ resistance & capacitance of an AC R-L circuit.

Experiment No.: 06 **Date:** 30/9/19

TO STUDY R-C SERIESCIRCUIT

****

AIM: To measure resistance and capacitance of an AC R-C series circuit.

APPARATUS:

Single phase, 50 Hz Power Supply(230 volt, 5 Amp.) Single phase

Auto Transformer (0-270 Volt, 5 Amp.) Single phase Capacitor

bank

Rheostat (100Ω 5amp.)

02 nos. A.C. Voltmeter (0-300V);

A.C. Ammeter (0-5 amp.)

Flexible wire.

THEORY:

Consider a circuit in which resistance of R ohm and a pure capacitor having capacitance C farad are connected in series as shown in figure 6.1.

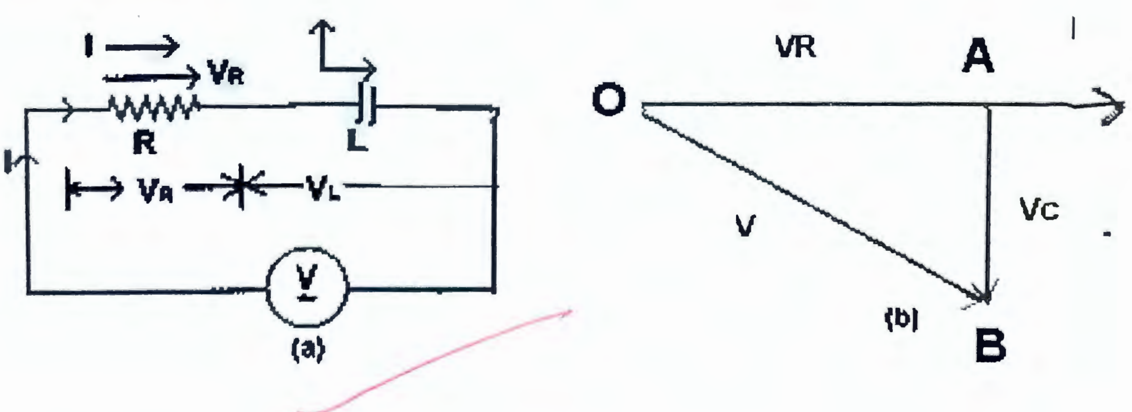


Figure 6.1

Let,

V = r.m.s. value of applied voltage

I = r.m.s. value of resultant or total current V_R = I.R. =

potentialdifferenceacrossR

V_C = I.X_C = potential difference across C f =

frequencyoftheappliedvoltage

As the two elements areconnected inseries, the totalcurrent will flow throughboth of them. So it is convenient to draw Phasordiagrambytaking thecurrent as areference Phasor.

Potential difference V_R across resistance is in phase with the current. Whereas potential difference V_C across the capacitor lags the current by 90^0.

This is shown in the Phasor diagram of above figure from which the magnitude of the applied voltage and power factor of the circuit are given by,

$$V = \sqrt{(v_R^2 + v_C^2}$$

$$V = \sqrt{I^2R^2 + I^2X^2_c}$$

$$= I$$

$$\sqrt{R^2 + X_c^2} \quad V/I =$$

= Z Impedance of R-L series circuit tan ϕ =

V_L/V_R = IX_C/ I.R = X_C/ R

$\phi = \tan^{-1} (X_C / R)$

DIAGRAM:

Figure 6.2

PROCEDURE:

- Connect the circuit as shown in figure 6.2.
- Keep autotransformer at zero position and switch ON single phase [illegible]
- Set suitable supply voltage and for a particular position of the [illegible] corresponding values of current and voltages i.e. V_S, V_R, V_L and I
- Take five readings for different positions of [illegible]
- Calculate the values of Resistance, Inductance and po[illegible]

OBSERVATION TABLE:

Sr. No.	V_S Volt	V_R Volt	V_C Volt	I Amp.
1	200	185	102	1
2	250	220	116	1.1
3	200	192	63	1.05
4.	250	243	70	1.2
5	200	186	167	3.1

CALCULATION:

❖ $V_R = I.R$

$R = V_R / I$

(1) $R = \frac{185}{1} = 185\,\Omega$ (2) $R = \frac{220}{1.1} = 200\,\Omega$ (3) $R = \frac{192}{1.05} = 182.86\,\Omega$ (4) $R = \frac{243}{1.2} = 202.5\,\Omega$ (5) $R = \frac{186}{3.1} = 60\,\Omega$

❖ $V_C = I.X_C$

$X_C = V_C / I$

(1) $X_C = \frac{102}{1} = 102$ $X_C = \frac{116}{1.1} = 105.45$ $X_C = \frac{63}{1.05} = 60$ $X_C = \frac{70}{1.2} = 58.33$ $X_C = \frac{167}{3.1} = 53.87$

$X_C = 1/ \acute{\omega}.C = 1/ 2\pi.f.C$

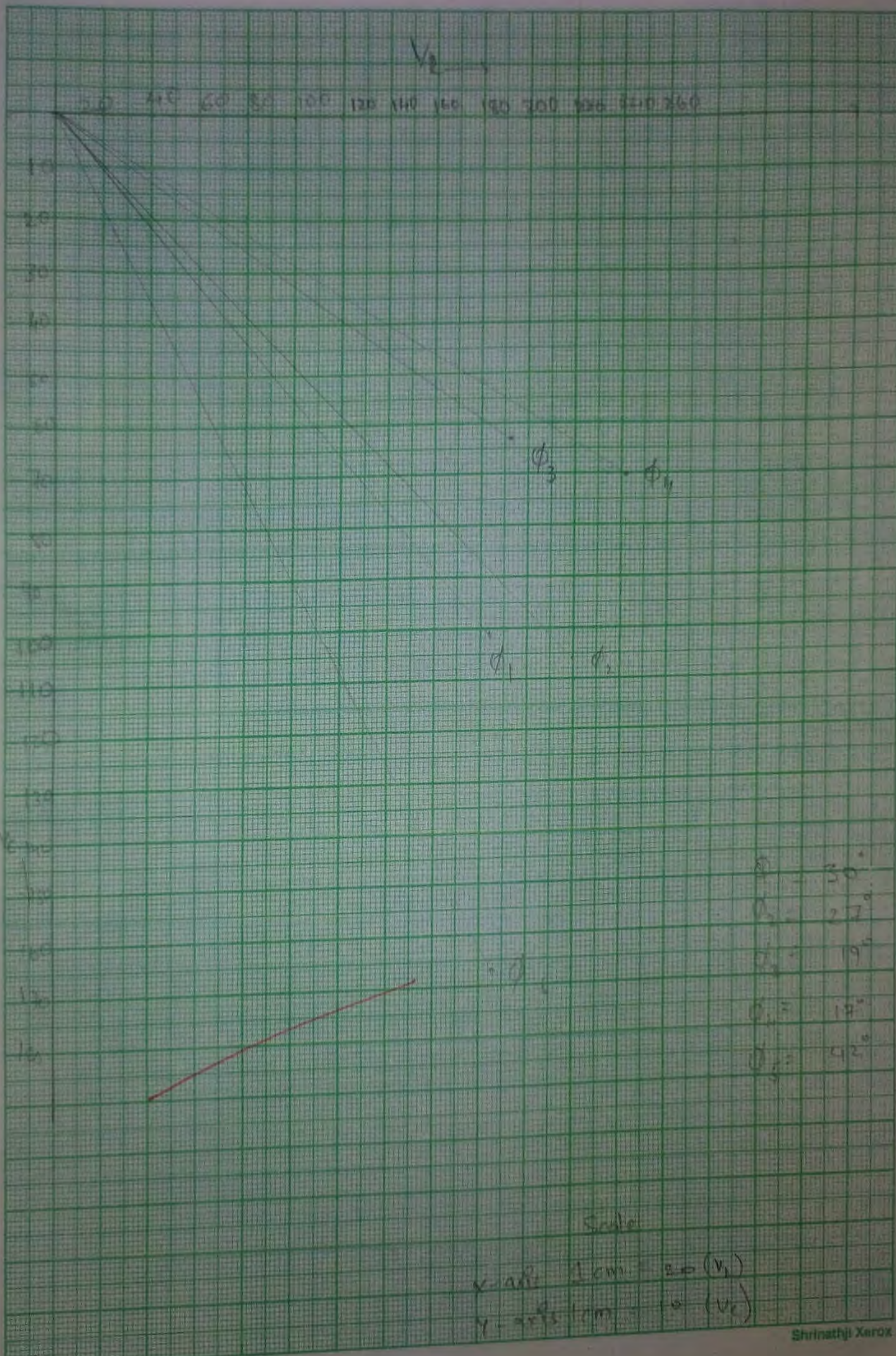
$C = 1/ 2\pi.f. X_C = 1/ 2\pi.50. X_C$

(1) $C = \frac{1}{100\pi(102)} = 3.12 \times 10^{-5}$ (2) $C = \frac{1}{100\pi(105.45)} = 3.01 \times 10^{-5}$ (3) $C = \frac{1}{100\pi(60)} = 5.30 \times 10^{-5}$ (4) $C = \frac{1}{100\pi(58.33)} = 5.4 \times 10^{-5}$

❖ $\Phi = \tan^{-1}(X_C/R)$

(1) $\phi = \tan^{-1}(102/185) = 0.50$ (2) $\phi = \tan^{-1}(105.45/200) = 0.48$ (3) $\phi = \tan^{-1}\left(\frac{60}{182.86}\right) = 0.32$ (4) $\phi = \tan^{-1}\left(\frac{58.33}{202.5}\right) = 0.28$

(5) $\phi = \tan^{-1}(53.87/60) = 0.73$


V_2
20 40 60 80 100 120 140 160 180 200 220 240 260
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
V_c
ϕ_3
ϕ_4
ϕ_1
ϕ_2
ϕ_5
$\phi_1 = 30°$
$\phi_2 = 27°$
$\phi_3 = 19°$
$\phi_4 = 17°$
$\phi_5 = 42°$
Scale
X-axis 1 cm = 20 (V_1)
Y-axis 1 cm = 10 (V_c)

RESULT TABLE:

Sr. No.	$R = V_R/I$ Ω	$X_C = V_C/I$ Ω	$C = 1/2\pi.f.X_C$ Henry	$\Phi = \tan^{-1}(X_C/R)$ Degree	p.f. = cos Φ
1	185	102	3.12×10^{-5}	0.50	0.878
2	200	105.45	3.01×10^{-5}	0.48	0.887
3	182.86	60	5.30×10^{-5}	0.32	0.95
4	208.5	58.33	5.4×10^{-5}	0.28	0.961
5	60	53.87	5.90×10^{-5}	0.73	0.75

CONCLUSION:

We know the relationship & measure resistance & Capacitance of an AC R-C Series circuit.

EXPERIMENT: 7 **DATE:** 21/10/19

TO STUDY R-L-C SERIES CIRCUIT

****

AIM: To perform resonance in AC series circuit.

APPARATUS: -Ø, 50 c/s power supply (230V, 5 Amp) 1-Ø Auto Transformer (0 – 270 V, 5 Amp)

Iron core Inductor / 1-Ø variac	Rheostat (100 ohm, 5 Amp)
5-nos. of Voltmeter (0-300V)	Ammeter (0-5 Amp)
1 – Ø Wattmeter (230 V, 5A)	flexible wires.

THEORY:

In series R-L-C circuit , a resonance condition occurs when voltage across inductor and voltage across capacitor becomes equal OR inductive reactance is equal to capacitive reactance (X_L=X_C). The frequency in resonance condition is called resonant frequency (f_r). In resonance condition, power factor becomes unity.

Consider three elements R, L and C connected n series across AC supply is as shown in the figure 6.1(a).

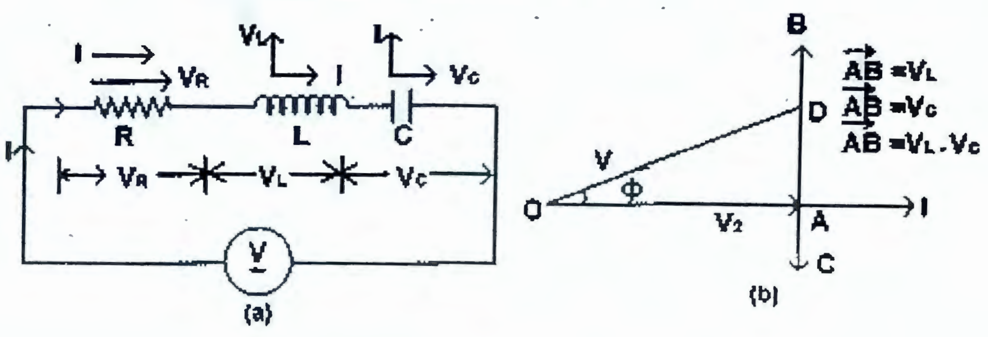


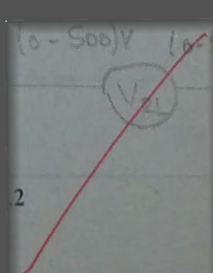
Figure 7.1

Let,

V	= rms value of the applied voltage	
I	= rms value of the resultant total current	
V_R	= I R	= potential difference across Resistance

SvSARDA

$V_L = I X$



.2

- Switch on the a. c. supply and apply suitable voltage to the circuit so that the readings in all the meters are just readable. Note down readings of current (I), voltages (Vs, V_R, V_L, Vc and V_{RL}) and power P.
- Change the value of R, L and C take another set of readings.
- Take one reading for series resonance condition.

OBSERVATION TABLE(R-L-C Series Circuit):

Sr. No.	Vs Volts	V_R Volt	V_L Volt	Vc Volt	V_{RL} Volt	V_{LC} Volt	I Amp	P Watt
1	80V	73	57	48	80	9	0.86	80
2	120V	111	72	60	140	12	1.1	120
3	160V	150	85 ~~154~~	72	180	13	1.25	190
4	200V	188	96	80	220	16	1.5	180
5	122V	112	119	119	170	0	1.06	130
6	122	112	100	120	158	20	1.06	130

CALCULATION:

⇒ V_R = I R

⇒ R = V_R/I 85.88, 100.90, 120, 125.33

⇒ V_L = I X_L

⇒ X_L = V_L/I 67.05, 65.45, 68, 64

⇒ X_L = ωL

⇒ L = X_L/2πf 0.21, 0.20, 0.21, 0.20

⇒ Vc = I Xc

⇒ Xc = Vc / I 56.47, 54.54, 57.6, 53.34

⇒ Xc = 1 / ωc

⇒ C = 1 / 2πf Xc 56.4 μF, 58.3 μF, 55.3 μF, 59.7 μF

CALCULATION TABLE:

Sr. No.	R= V_R/I Ω	X_L= V_L/I Ω	Xc=Vc/I Ω	Z=Vs/I Ω	L = X_L/ 2πf Henry	C= 1 / 2πf Xc Farad	Ø= $\cos^{-1}$ (R/Z) Degree
1	85.88	67.05	56.47	94.11	2.1×10^{-1}	2.8×10^{-3}	4.21×10^{-1}
2	100.9	65.45	54.54	109.09	2.08×10^{-1}	2.9×10^{-3}	3.89×10^{-1}
3	120	68	57.6	128	2.16×10^{-1}	2.76×10^{-3}	3.55×10^{-1}
4	125.3	64	53.33	133.3	2.03×10^{-1}	2.98×10^{-3}	3.48×10^{-1}

PHASOR DIAGRAM OF R-L-C SERIES CIRCUIT:

STEPS for Plotting phasor diagram: -

(1) Take current as reference phasor.

(2) From 0.draw vector V_R over current phasor with suitable scale. Suppose V_R = 100V, then take scale 1 cm = 10V, so V_R = 10 cm. The tip of vector Vr gives point C.

(3) Draw an arc equal in length to V_L from point C.

(4) Draw an arc equal to V_{RL} from point O, which will intersect the arc of V_L at point A.

(5) From point A, draw a perpendicular line on I, this is equal to AD = V_{XL} = voltage drop due to nductive reactance.(V_{XL} =AD x voltage scale)

(6) The horizontal line which is equal to CD = V_{rL} = voltage drop due to resistance of inductive coil.(V_{rL} = CD x voltage scale)

(7) From point A, draw an arc equal to Vc in downward direction.

(8) From point O, draw an arc equal to Vs (=supply voltage), which will intersect the arc of Vc at point B.

(9) From point B, draw horizontal line.

(10) From point A, draw perpendicular line in downward direction so as to cut the horizontal line drawn from point B at point M.

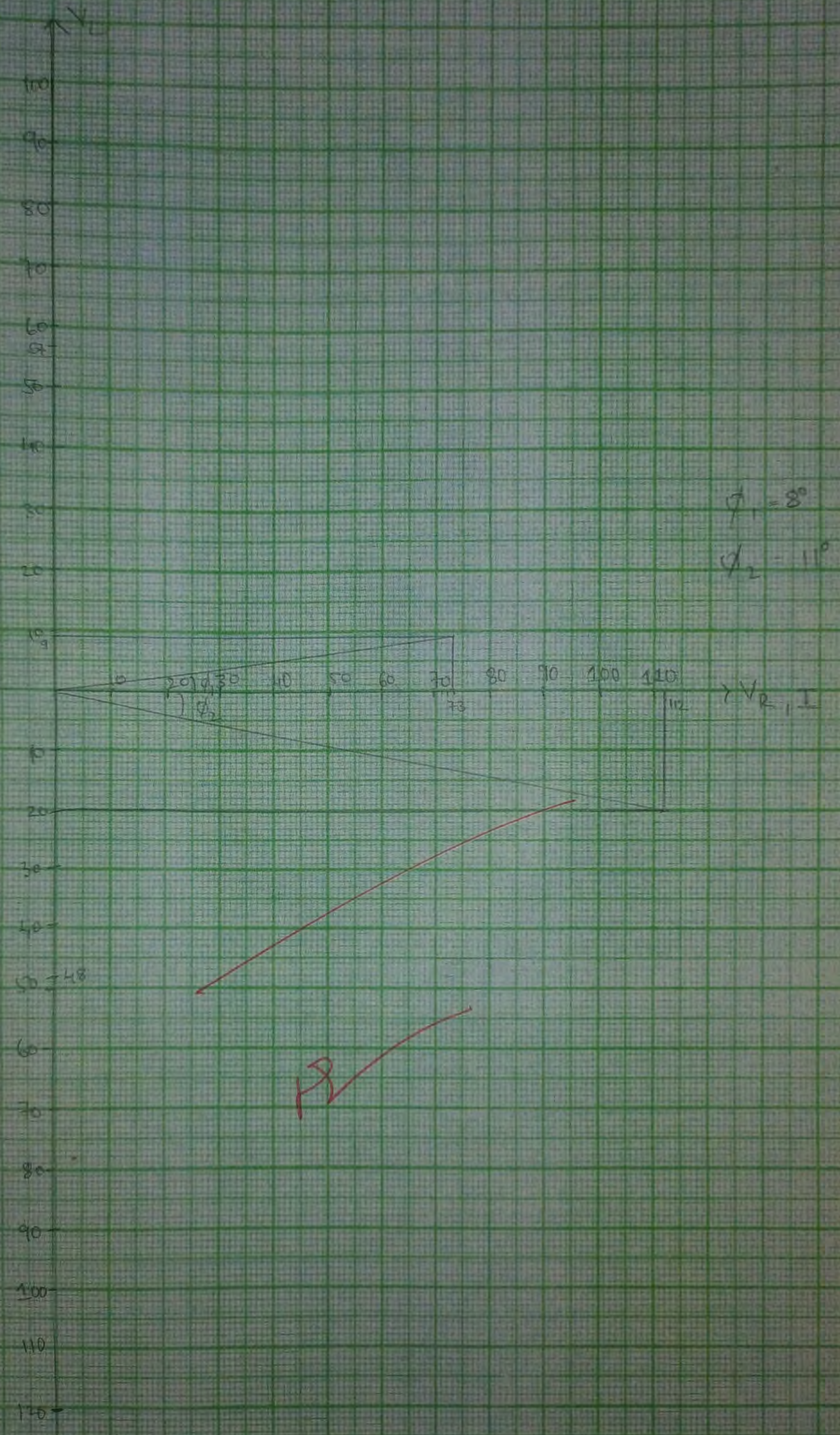
(11)AM = Vxc = voltage drop due to capacitive reactance.(Vxc = AM x voltage scale)

(12)BM = Vrc = voltage drop due to resistance of capacitor.(Vrc =BM x voltage scale)

(13)Measure angle Ø – phase angle between Vs and I.

CONCLUSION:

Learned to perform Resonance in AC Circuit & phasor diagram of it.



V_L
V_R, I
ϕ_1
ϕ_2
73
112
48
$\phi_1 = 8^\circ$
$\phi_2 = 11^\circ$
18

EXPERIMENT:8 DATE: 18/11/19

STAR- DELTA RELATIONSHIP

****

AIM: To find out relationship between current and voltage in 3-phase star and delta connected loads.

STAR CONNECTION:

APPARATUS: 3-Ø, 50 c/s, 440 V A. C. Supply

3-Ø Auto Transformer (0 – 440 V, 15 A)

Ammeter (0-5 Amp)

3-nos. of Lamp Load (230 V, 2 KV A)

Voltmeter (0-500V)

Voltmeter (0-300V)

THEORY:

STAR CONNECTION:

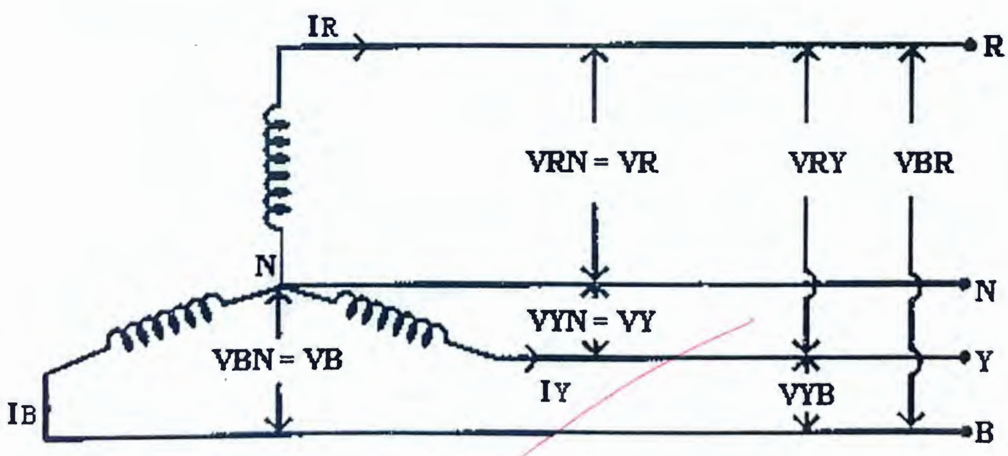


Figure 8.1

Figure 7.1 shows 3 – Ø, 4 wires (star connected) balance system. The emf across each winding is called phase voltage, they are denoted by V_{RN}, V_{YN} and V_{BN} and voltage between any two lines (winding) is called line voltage and are represented by V_{RY}, V_{YB} and V_{BR} respectively. Current flowing in each winding is known as the phase current and current flowing in each line is called line current. Since the system is balance,

$I_R = I_Y = I_B = Iph$

$I_{L1} = I_{L2} = I_{L3} = I_L$

$V_{RN} = V_{YN} = V_{BN} = Vph$

$V_{RY} = V_{YB} = V_{BR} = V_l$

Relation between Line Current and Phase Current:

$I_R = I_{L1} = Iph = I_L$

$I_Y = I_{L2} = Iph = I_L$

$I_B = I_{L3} = Iph = I_L$

Thus in star connection, Line current, Il = Phase current, Iph

Relation between Line Voltage and Phase Voltage:

The relationship between line voltage and phase voltage can be found using phasor diagram as shown in figure 7.2 below.

E.g. Line voltage between terminals R and Y can be given as,

$\mathbf{V_{RY} = V_{RN} + V_{YN}}$ **(Bold letters are used to represent vectors)**

$\mathbf{= V_{RN} + (-V_{YN}) = V_{RN} - V_{YN}}$ **= Phasor difference**

Similarly,

$\mathbf{V_{YB} = V_{YN} - V_{BN}}$

$\mathbf{V_{BR} = V_{BN} - V_{RN}}$

Hence it is clear that in star connected system; line voltage is obtained as the vector difference of two corresponding phase voltages. For example, V_{RY} is found by vector addition of $\mathbf{V_{RN}}$ and reserved $\mathbf{V_{YN}}$ and the diagonal of parallelogram gives its magnitude. Since sides of the parallelogram are equal in length, the angle between two-phase voltages is 60°.

The resultant or line voltage is given by,

$V_{RY} = V_{RN} - V_{YN} = 2V_{ph} \cos 30° = 2v_{ph} \sqrt{3}/2$

$V_{RY} = \sqrt{3}\ V_{ph}$

Line voltage = √3 Phase Voltage

PHASOR DIAGRAM:

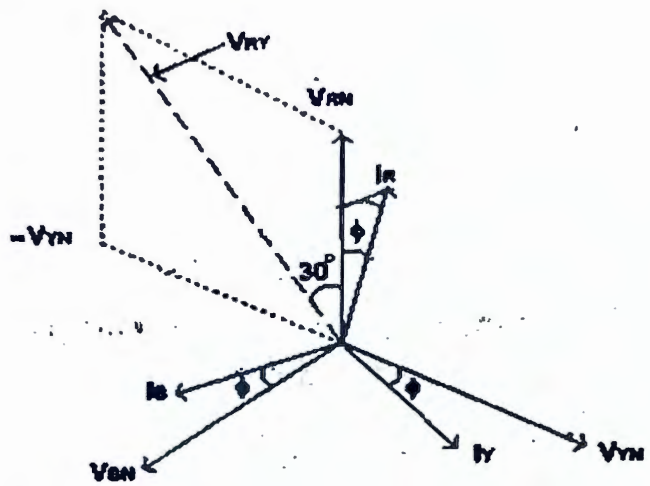


Figure 8.2

CIRCUIT DIAGRAM:

Figure 8.3

PROCEDURE:

- Connect the circuit as shown in figure 8.3.
- First set auto transformer at zero position and switch on 3 – Ø 440V, 50 c/s supply.
- With the help of Auto transformer set the line voltage to 230 V and set balance load in the lamp load.
- Note down corresponding readings of Vph, I_L and Iph.
- Adjust another value of balance load and note down same readings.
- Take such four to five readings.

OBSERVATION TABLE: (Star Connection)

Sr. No.	V_L Volt	Vph Volt	I_L = Iph Amp	V_L/Vph	I_L/Iph	Rph=Vph/Iph Ω
1	50	29	0.5	0.72	1	58
2	75	43	0.7	1.74	1	61.42
3	100	57	0.9	0.75	1	63.33
4	125	79	1	1.76	1	71
5	150	85	1.15	1.74	1	73.91

DELTA CONNECTION:

APPARATUS: 3-Ø, 50 c/s, 440 V A. C. Supply

3-Ø Auto Transformer (0 – 440 V, 15 A)

Ammeter (0-5 Amp)

3-nos. of Lamp Load (230 V, 2 KV A)

Voltmeter (0-500V)

Voltmeter (0-300V)

THEORY:

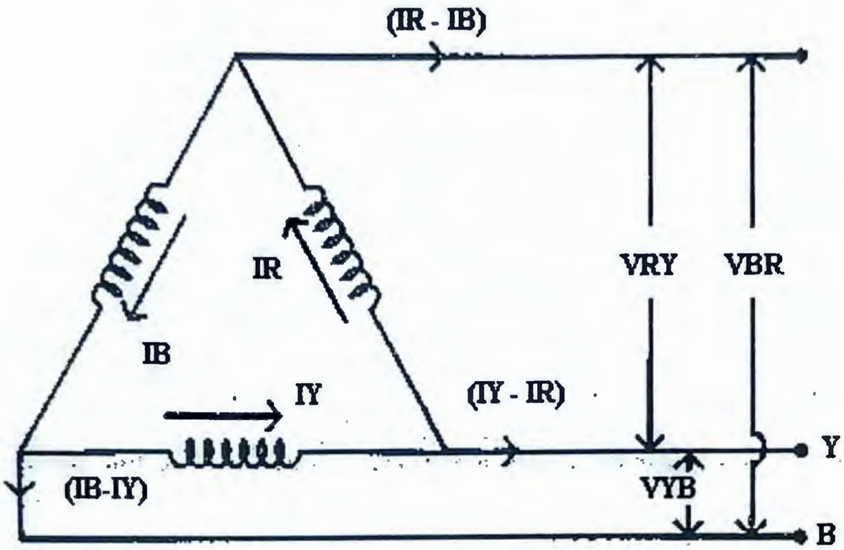


Figure 8.4

Figure 8.4 shows 3 – Ø, 3 wires (delta connected) balance system. The emf across each winding is called phase voltage. They are denoted by V_R, V_Y and V_B and voltage between any two lines (winding) is called line voltage. They are represented by V_{RY}, V_{YB} and V_{BR} respectively. Current flowing in each winding is known as the phase current and current flowing in each line is called line current. Since the system is balance,

$I_R = I_Y = I_B = Iph$

$I_{L1} = I_{L2} = I_{L3} = I_L$

$V_R = V_Y = V_B = Vph$

$V_{RY} = V_{YB} = V_{BR} = V_L$

Relation between Line Voltage and Phase Voltage:

$V_R = V_{RY} = Vph = V_L$

$V_Y = V_{YB} = Vph = V_L$

$V_B = V_{BR} = Vph = V_L$

Thus in delta connection, Line voltage is equal to phase voltage.

Relation between Line Current and Phase Current:

The relationship between line current and phase current can be found using phasor diagram as shown in figure 7.5 below.

Here, $I_R = I_Y = I_B = Iph$

$I_{L1} = I_{L2} = I_{L3} = I_L$

From the phasor diagram, the current flowing in each line is the vector difference of two phase currents.

$\mathbf{I_{L1} = I_R - I_B}$ **(Bold letters are used to represent vectors)**

$\mathbf{I_{L2} = I_Y - I_R}$

$\mathbf{I_{L3} = I_B - I_Y}$

Current inline 1 can be found as the vector difference of the two corresponding phase current. For example, I_{L1} can be obtained by adding I_R and reserved I_B and the diagonal of the parallelogram as shown in phasor diagram gives its value. Since the sides of the parallelogram are equal in magnitude and angle between two-phase voltage is 60°,the resultant current or the line current is given as,

$\mathbf{I_{L1} = I_R - I_B}$

$= 2\ Iph \cos 30° = 2\ Iph\sqrt{3}/2$

$I_L = \sqrt{3}\ Iph$

Line current = √3 Phase current

PHASOR DIAGRAM:

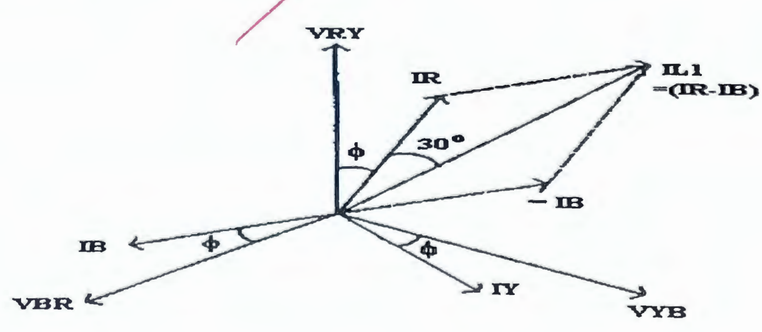


Figure 8.5

IT DIAGRAM:

R R

Figure 8.6

- Connect the circuit as shown in figure 8.6.
- First set auto transformer at zero position an
- With the help of Auto transformer set the li
lamp load.
- Note down corresponding readings of V_L, I_L
- Adjust another value of balance load and no
- Take such four to five readings.

OBSERVATION TABLE: (Delta Connection)

Sr. No.	V_L=Vph Volt	I_L Amp	Iph Amp	V_L/Vph	I_L/Iph	Rph=Vph/Iph Ω
1	50	1.5	0.9	1	1.66	55.55
2	75	2.0	1.2	1	1.68	62.5
3	100	2.3.	1.4	1	1.64	71.42
4	125	2.6	1.58	1	1.64	79.11
5	150	2.9	1.70	1	1.70	88.2

CONCLUSION:

Learn the relationship between current & Voltage in 3 phase Star & delta Connected loads.

EXPERIMENT:9 **DATE:** 2/12/19

AIM: To measure 3 – Ø power in A.C. circuit using two-watt meters.

APPARATUS: 3-Ø, 50 c/s, 440 V A.C. Supply

3-Ø Auto Transformer (0 – 440 V, 15 A)

Ammeter (0-5 Amp)

Voltmeter (0-500V), Voltmeter (0-300V)

2 Nos of Watt meter (250 V, 10 A)

3 Nos of lamp Load (230 V, 2 KVA)

THEORY:

Power in a 3-Ø system with balanced or unbalanced load can be measured by two- wattmeter method. The load may be star or delta connected. For any kind of load whether balanced or unbalanced it can be proved that the total power absorbed by the load is the algebraic sum of the power measured by two watt meters. For example, consider a star connected load as shown in figure 8.1.

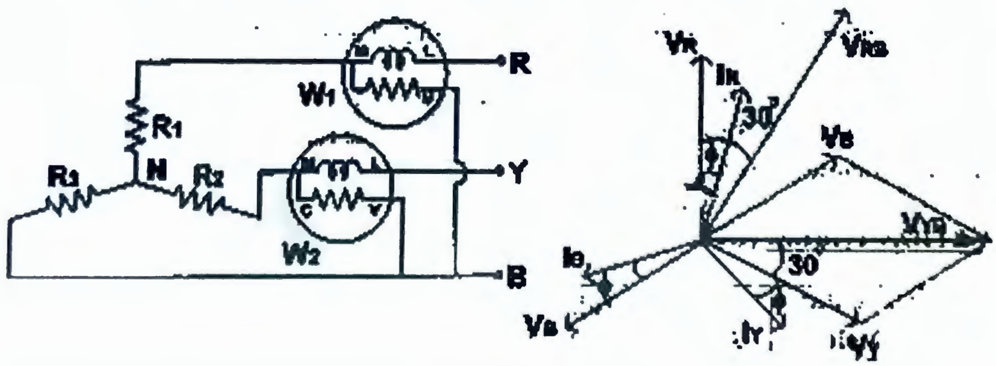


Figure 9.1

Let V_R, V_Y, V_B be the rms values of phase voltages and I_R, I_Y and I_B be the rms value of the currents. Let the currents lag behind their respective phase voltages by angle Ø.

Current through the current coil of wattmeter W1 = I_R

Potential difference across pressure coil of wattmeter W1 = $V_{RB} = V_{RN} - V_{BN} = V_R - V_B$

From the vector diagram of figure 13.1(b), the phase difference between V_{RB} and I_R is (30°- Ø).

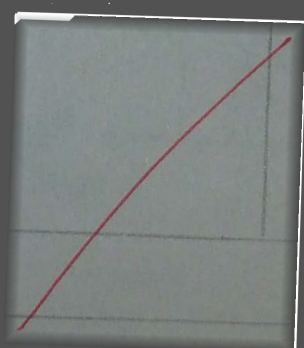
Power m

Similarly

$(30° + φ)$

… $W = W_1 + W_2$

… $\cos(30° - φ) + V_L I_L \cos(30° + φ) = \sqrt{3}\, V_L I_L \cos φ$



PROCEDURE:

- Connect the circuit as shown in the figure 9.2.
- Keeping autotransformer on zero position, switch on 3 – Ø, 440 V supply.
- Adjust line-to-line voltage to 230 V & switch on equal no. of lamps in each phase.
- Note down various readings i.e. V_L, Vph, I_L, Iph, W1 and W2.
- Now, again switch on one or two lamps in each phase and take the same readings.
- Similarly, take four to five sets of readings.
- Calculate the total power consumed and power factor of the load.
- Observe W1 = W2 or not.

OBSERVATION TABLE:

Sr. No.	V_L Volts	Vph Volts	I_L Amp	Iph Amp	W1 Watt	W2 Watt	P=W1+W2 Watt	Cos Ø = p/√3 V_L I_L
1	100	58	1.4	1.4 ~~120~~	120	120	240	$\frac{240}{242.48}$ = 0.9896
2	150	8.5	1.65	1.65	200	210	410	0.9575
3	200	115	1.9	1.9	340	370	690	0.92
4	250	144	2.3	2.3	420	470	890	1.00
5	300	171	2.2	2.2	550	620	1170	1.02

CONCLUSION:

Thus, we measured 3 ø power in A.C circuit using two-watt metters.

EXPERIMENT:10

DATE: 9/12/19

ELCTRICAL MACHINES

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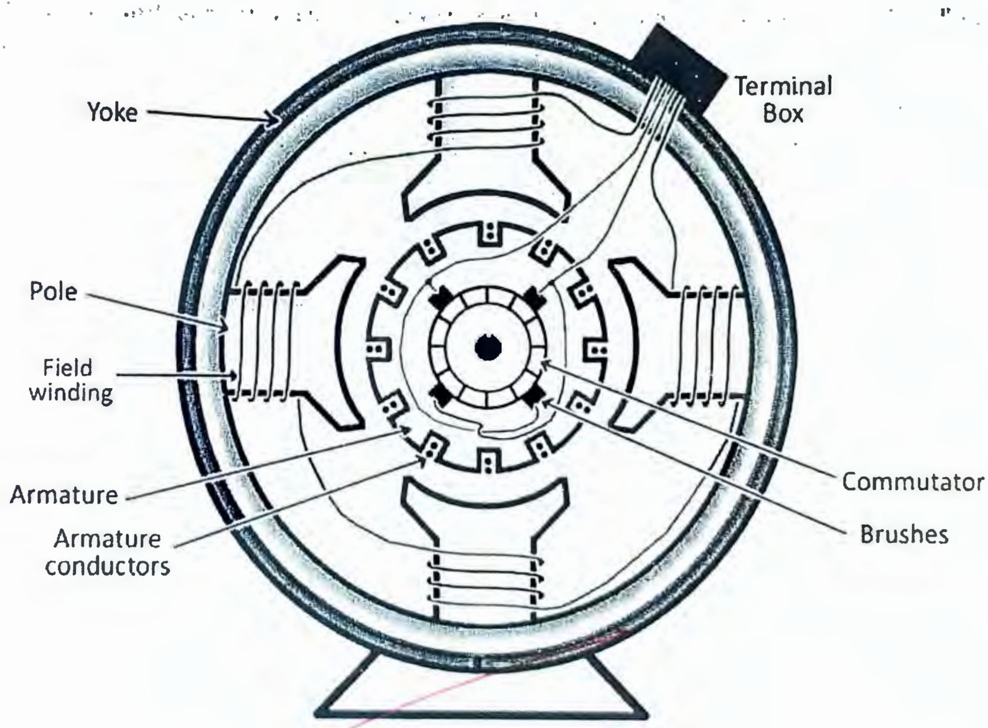
AIM:To study about construction of electrical machines

DC GENERATOR

A dc generator is an electrical machine which converts mechanical energy into **direct current electricity**. This energy conversion is based on the principle of production of dynamically induced emf.

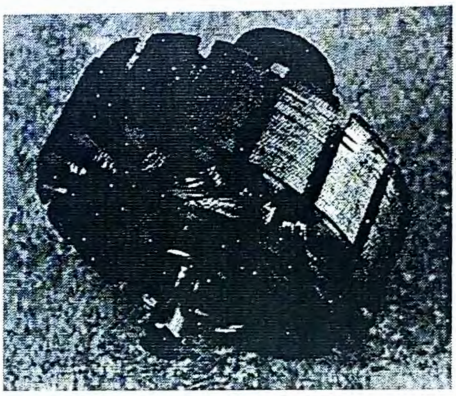
CONSTRUCTION OF A DC MACHINE:

A DC generator can be used as a DC motor without any constructional changes and vice versa is also possible. Thus, a DC generator or a DC motor can be broadly termed as a **DC machine**. These basic constructional details are also valid for the **construction of a DC motor**. Hence, let's call this point as **construction of a DC machine.**



The above figure shows constructional details of a simple **4-pole DC machine**. A DC machine consists of two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

1. **Yoke:** The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding.
2. **Poles and pole shoes:** Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes; (i) they support field coils and (ii) spread out the flux in air gap uniformly.
3. **Field winding:** They are usually made of copper. Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.



1. **Armature core:** Armature core is the rotor of a dc machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.
2. **Armature winding:** It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.
3. **Commutator and brushes:** Physical connection to the armature winding is made through a commutator-brush arrangement. The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils. Each segment is connected to an armature coil and the commutator is keyed to the shaft. Brushes are usually made from carbon or graphite.

They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

THREE PHASE INDUCTION MOTOR

A three phase induction motor runs on a three phase AC supply. 3 phase induction motors are extensively used for various industrial applications because of their following advantages -

- They have very simple and rugged (almost unbreakable) construction
- they are very reliable and having low cost
- they have high efficiency and good power factor
- minimum maintenance required
- 3 phase induction motor is self starting hence extra starting motor or any special starting arrangement is not required

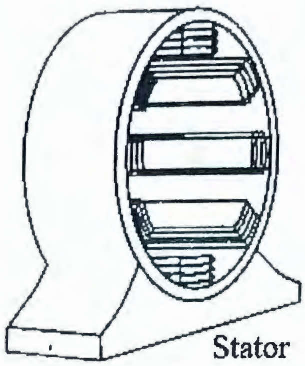
They also have some disadvantages

- speed decreases with increase in load, just like a DC shunt motor
- if speed is to be varied, we have sacrifice some of its efficiency

CONSTRUCTION OF A 3 PHASE INDUCTION MOTOR

Just like any other motor, a 3 phase induction motor also consists of a stator and a rotor. Basically there are two types of 3 phase IM - 1. Squirrel cage induction motor and 2. Phase Wound induction motor (slip-ring induction motor). Both types have similar constructed rotor, but they differ in construction of rotor. This is explained further

STATOR



The stator of a 3 phase IM (Induction Motor) is made up with number of stampings, and these stampings are slotted to receive the stator winding. The stator is wound with a 3 phase winding which is fed from a 3 phase supply. It is wound for a defined number of poles, and the number of poles is determined from the required speed. For greater speed, lesser number of poles is used and vice versa. When stator windings are supplied with 3 phase ac supply, they produce alternating flux which revolves with synchronous speed. The synchronous speed is inversely proportional to number of poles ($N_s = 120f / P$). This revolving or rotating magnetic flux induces current in rotor windings according to Faraday's law of mutual induction.

ROTOR

As described earlier, rotor of a 3 phase induction motor can be of either two types, squirrel cage rotor and phase wound rotor (or simply - wound rotor)

Squirrel Cage Rotor:

Squirrel Cage Rotor

Most of the induction motors (upto 90%) are of squirrel cage type. Squirrel cage type rotor has very simple and almost indestructible construction. This type of rotor consist of a cylindrical laminated core, having parallel slots on it. These parallel slots carry rotor conductors. In this type of rotor, heavy bars of copper, aluminum or alloys are used as rotor conductors instead of wires. Rotor slots are slightly skewed to achieve following advantages -

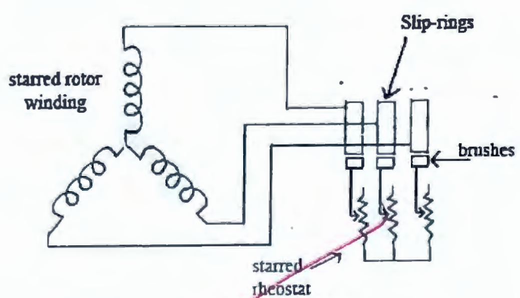
1. it reduces locking tendency of the rotor, i.e. the tendency of rotor teeth to remain under stator teeth due to magnetic attraction.

2. increases the effective transformation ratio between stator and rotor

3. increases rotor resistance due to increased length of the rotor conductor

The rotor bars are brazed or electrically welded to short circuiting end rings at both ends. Thus this rotor construction looks like a squirrel cage and hence we call it. The rotor bars are permanently short circuited, hence it is not possible to add any external resistance to armature circuit.

Phase Wound Rotor:



Phase wound rotor connections

Phase wound rotor is wound with 3 phase, double layer, distributed winding. The number of poles of rotor are kept same to the number of poles of the stator. The rotor is always wound 3 phase even if the stator is wound two phase.

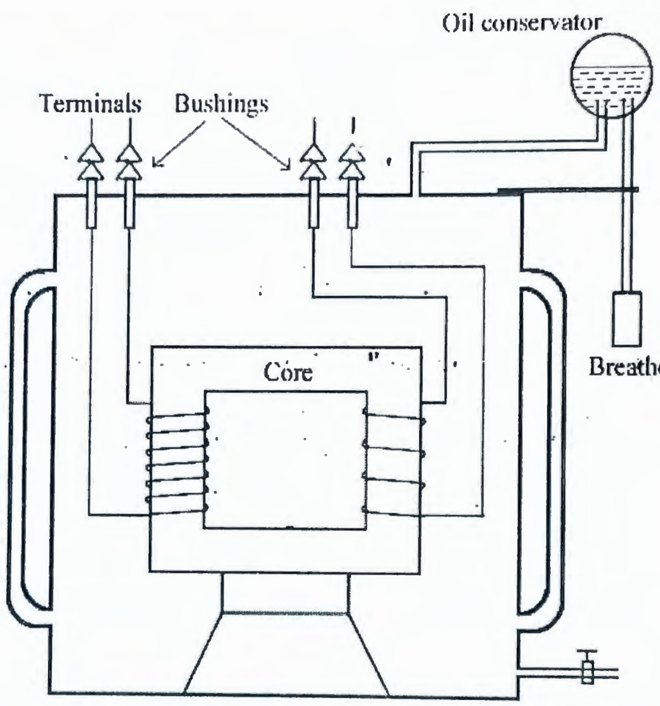
The three phase rotor winding is internally star connected. The other three terminals of the winding are taken out via three insulated sleep rings mounted on the shaft and the brushes resting on them. These three brushes are connected to an external star connected rheostat. This arrangement is done to introduce an external resistance in rotor circuit for starting purposes and for changing the speed / torque characteristics.

When motor is running at its rated speed, slip rings are automatically short circuited by means of a metal collar and brushes are lifted above the slip rings to minimize the frictional losses.

ELECTRICAL TRANSFORMER

Electrical transformer is a static electrical machine which transforms electrical power from one circuit to another circuit, without changing the frequency. Transformer can increase or decrease the voltage with corresponding decrease or increase in current.

BASIC CONSTRUCTION OF TRANSFORMER



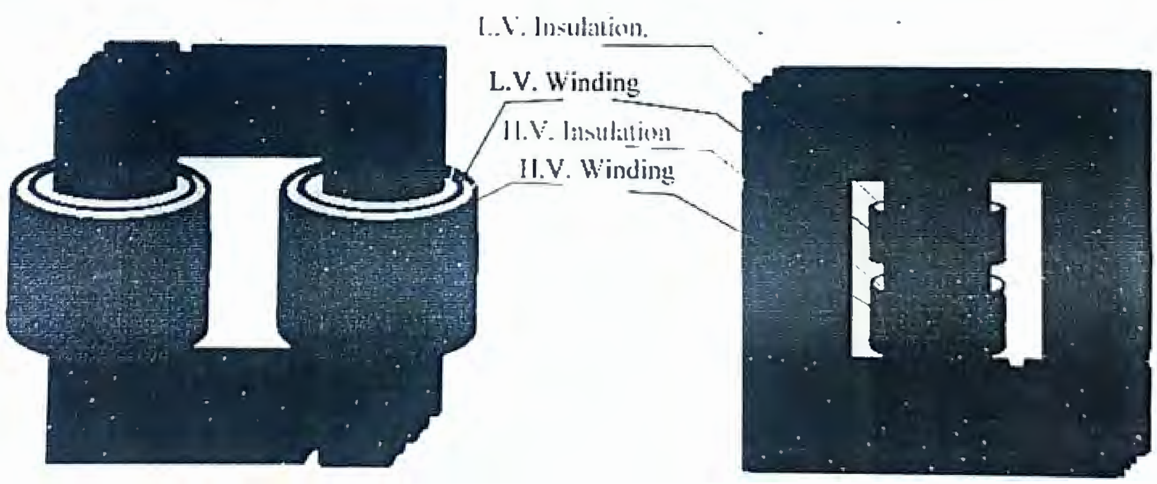
Basically a transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core. A transformer may also consist of a container for winding and core assembly (called as tank), suitable bushings to take our the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. The figure at left illustrates the basic construction of a transformer.

In all types of transformers, core is constructed by assembling (stacking) laminated sheets of steel, with minimum air-gap between them (to achieve continuous magnetic path). The steel used is having high silicon content and sometimes heat treated, to provide high permeability and low hysteresis loss. Laminated sheets of steel are used to reduce eddy current loss. The sheets are cut in the shape as E,I and L. To avoid high reluctance at joints, laminations are stacked by alternating the sides of joint. That is, if joints of first sheet assembly are at front face, the joints of following assemble are kept at back face.

TYPES OF TRANSFORMERS

Transformers can be classified on different basis, like types of construction, types of cooling etc.

(A) On the basis of construction, transformers can be classified into two types as; (i) Core type transformer and (ii) Shell type transformer, which are described below.



Core type | Shell type

(I) Core Type Transformer

In core type transformer, windings are cylindrical former wound, mounted on the core limbs as shown in the figure above. The cylindrical coils have different layers and each layer is insulated from each other.

Materials like paper, cloth or mica can be used for insulation. Low voltage windings are placed nearer to the core, as they are easier to insulate.

(Ii) Shell Type Transformer

The coils are former wound and mounted in layers stacked with insulation between them. A shell type transformer may have simple rectangular form (as shown in above fig), or it may have a distributed form.

(B) On the basis of their purpose

1. Step up transformer: Voltage increases (with subsequent decrease in current) at secondary.
2. Step down transformer: Voltage decreases (with subsequent increase in current) at secondary.

(C) On the basis of type of supply

1. Single phase transformer
2. Three phase transformer

(D) On the basis of their use

1. Power transformer: Used in transmission network, high rating
2. Distribution transformer: Used in distribution network, comparatively lower rating than that of power transformers.
3. Instrument transformer: Used in relay and protection purpose in different instruments in industries
   - Current transformer (CT)
   - Potential transformer (PT)

(E) On the basis of cooling employed

1. Oil-filled self cooled type
2. Oil-filled water cooled type
3. Air blast type (air cooled)

AC Generator (Alternator)

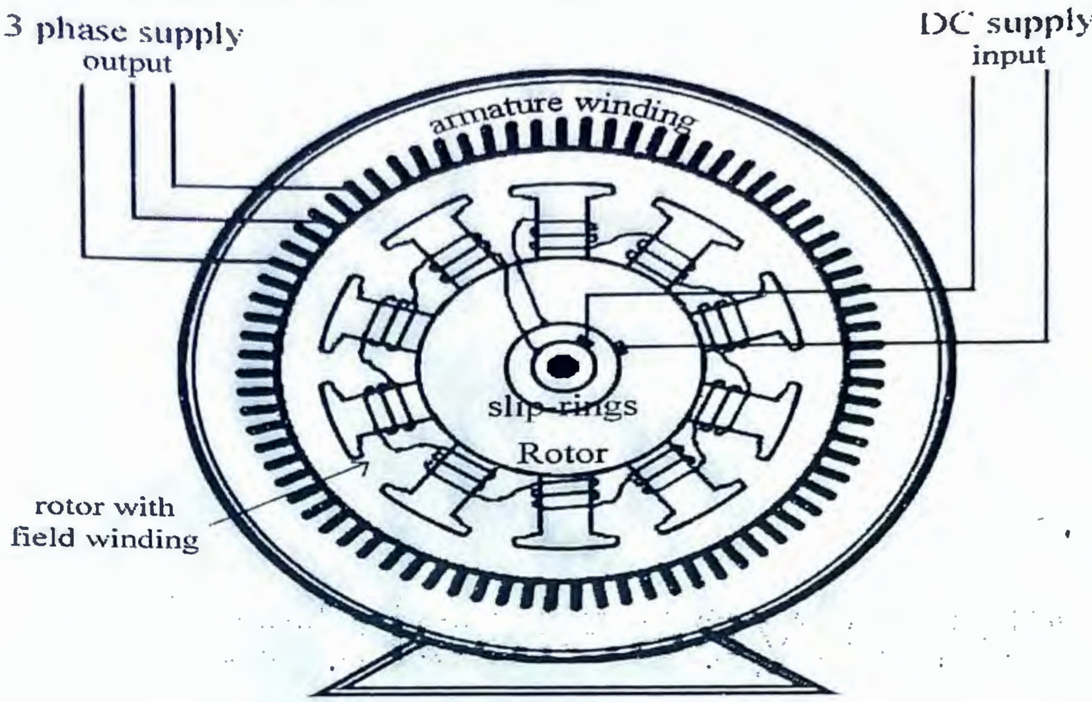
An **alternator** is an electrical machine which converts mechanical energy into alternating electric energy. They are also known as **synchronous generators**.

CONSTRUCTION OF AC GENERATOR (ALTERNATOR)

Main parts of the alternator, obviously, consists of stator and rotor. But, the unlike other machines, in most of the alternators, field exciters are rotating and the armature coil is stationary.

STATOR:

Unlike in DC machine stator of an alternator is not meant to serve path for magnetic flux. Instead, *the stator is used for holding armature winding*. The stator core is made up of lamination of steel alloys or magnetic iron, to minimize the eddy current losses.



CONCLUSION:

Thus, we studied about construction of electrical machines.