**Winter – 2016 Examinations**

**Model Answer** **Subject Code: 17331 (ETG)**

Important Instructions to examiners:

1. The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2. The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3. The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
4. While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5. Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6. In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7. For programming language papers, credit may be given to any other program based on equivalent concept.

**Winter – 2016 Examinations**
**Model Answer** **Subject Code: 17331 (ETG)**

**1 (A) Attempt any SIX of the following:** **12**

1 A) a) State Ohm's law with equation

**Ans:**

**Ohm's law:** Ohm's law 1 Mark

As long as physical conditions (such as dimensions, pressure and temperature) are constant, the potential difference or voltage applied across the conductor is directly proportional to current flowing through it.

i.e $V \alpha I$ or $V = R I$ Equation 1 Mark

where R = constant of proportionality, called as the resistance of the conductor

1 A) b) State Kirchhoff's current law with an example.

**Ans:**

**Kirchhoff's laws:**

**Kirchhoff's Current Law (KCL):** Statement of KCL 1 Mark

It states that in any electrical network, the algebraic sum of the currents meeting at a node (point or junction) is zero.

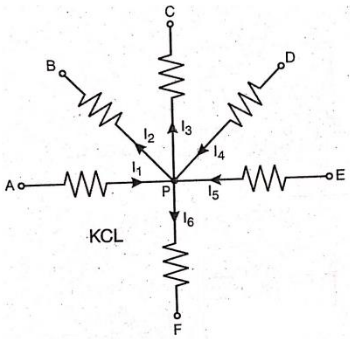
i.e $\Sigma I=0$

At junction point P, $I_1-I_2-I_3+I_4+I_5-I_6 = 0$ Example/ Diagram 1 Mark

**Sign convention**:

Incoming current at the node is considered to be positive and outgoing current to be negative.

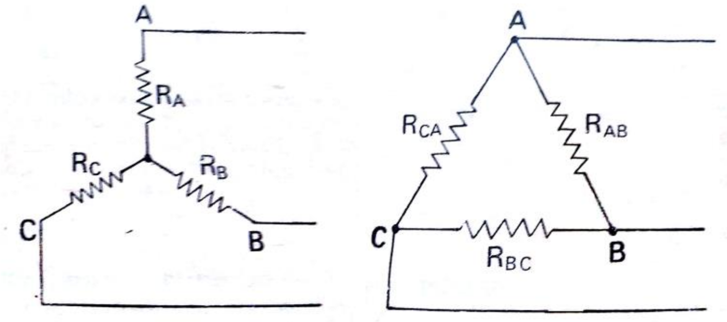
**OR Equivalent Example**.




1 A) c) Write formula for conversion of star to delta conversion.

**Ans:**

**Formula for conversion of star to delta conversion:**




2 Marks.

$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A}$$

$$R_{CA} = R_A + R_C + \frac{R_A R_C}{R_B}$$

**OR Equivalent formula**

1 A) d) State Faraday's law of electromagnetic induction.

**Ans:**
**Faraday's Laws of Electromagnetic Induction:**
**First Law:**
Whenever a changing magnetic flux links with a conductor, an emf is induced in that conductor.

OR

When a conductor cuts across magnetic field, an emf is induced in that conductor. 1 Mark

**Second Law:**
The magnitude of induced emf is directly proportional to the rate of change of flux linking with the conductor or the rate of flux cut by the conductor. 1 Mark

1 A) e) Compare between statically & dynamically induced emf. (any two points).
**Ans:**
**Comparison between statically & dynamically induced emf:**

| **Statically induced emf** | **Dynamically induced emf** |
|---|---|
| Emf is induced without any relative motion between conductor and magnetic field. | Emf is induced due to relative motion between conductor and magnetic field. |
| Emf is induced when changing magnetic field links with a conductor. | Emf is induced when conductor cuts the magnetic field due to relative motion between them. |
| Direction of statically induced emf is given by Lenz's law. | Direction of dynamically induced emf is given by Fleming's Right hand rule. |
| Two types: Self-induced emf<br>Mutually induced emf | No such further classification |
| e.g. emf induced in transformer windings | e.g emf induced in Generator, Alternator armature windings |

Any 2 points 1 Mark each

1 A) f) Write the relation between
i) Phase and line current
ii) Phase and line voltage , for star and delta connection.
**Ans:**

For star connection, Line current = Phase current

i.e $I_L = I_{ph}$

Line voltage $= \sqrt{3}$ (Phase Voltage) 1 Mark

i.e $V_L = \sqrt{3}V_{ph}$

For delta connection, Line current $= \sqrt{3}$ Phase current

i.e $I_L = \sqrt{3}\, I_{ph}$ 1 Mark

Line voltage = Phase Voltage

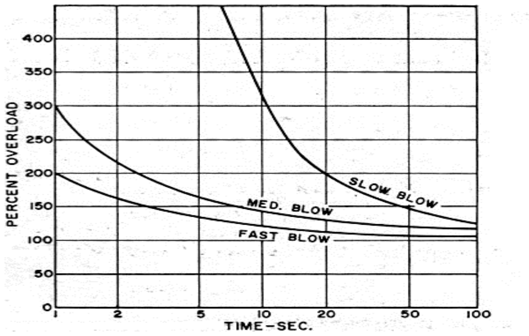
i.e $V_L = V_{ph}$

1A g) Classify fuses and also draw the characteristics of fuse.

**A:**

**Classification of fuses**:

i. Semi enclosed or rewireable type
ii. Totally enclosed or cartridge type
iii. Drop out fuse — Any 2 types 1 Mark
iv. Expulsion fuse
v. H.R.C fuse
vi. Striker fuse
vii. Switch fuse
viii. Metal clad fuse




1 Mark

Characteristics of Fuse

1A h) Explain need of earthing.

**Ans:**

**Need of earthing:**

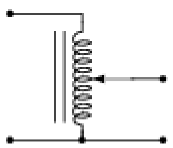
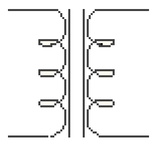
i) Earthing is needed for safety of working personnel, safety of equipment. — Any 2 points 1 Mark each
ii) For protection, as under such circumstances, the low resistance path results in heavy current drawn from supply which is sensed to trip the circuit or blow fuses.
iii) Earthing is also needed in electrical installations of substations to hold the neutral voltage to very low values so that fault on one phase does not affect the other (neutral earthing).
iv) Earthing is required for balancing system voltages.

**1 B) Attempt any <u>TWO</u> from the following: 8**

1 B) a) Compare auto transformer with two winding transformer.

**Ans:**

**Comparison of auto transformer with two winding transformer:**

| | Autotransformer | Two winding Transformer |
|---|---|---|
| 1 | Only one winding, part of the winding is common for primary and secondary. | There are two separate windings for primary and secondary. |
| 2 | Movable contact exist | No movable contact between primary and secondary |
| 3 | Electrical connection between primary and secondary. | Electrical isolation between primary and secondary windings. |
| 4 | Comparatively lower losses. | Comparatively more losses |
| 5 | Efficiency is more as compared to two winding transformer. | Efficiency is less as compared to autotransformer. |
| 6 | Copper required is less, thus copper is saved. | Copper required is more. |
| 7 | Spiral core construction | Core type or shell type core construction |
| 8 | Special applications where variable voltage is required. | Most of the general purpose transformers where fixed voltage is required. |
| 9 | Cost is less | Cost is more |
| 10 | Better voltage regulation | Poor voltage regulation |
| 11 |  Symbol of Autotransformer |  Symbol of Two winding transformer |

Any 4 points
1 Mark each

1 B) b) Explain principle of working of induction motor (single phase) with its operation.

**Ans:**

**Principle of working and operation of single phase induction motor:**

The stator of single phase Induction motor is provided with an auxiliary or starting winding in addition to main or running winding. The starting winding is located $90^0$ electrical from main winding & operates only during the brief period when the motor starts up. The starting winding has high resistance & relatively low reactance. While the main winding has low resistance & large reactance.

When these two stator windings which are connected in parallel are energized from single phase supply, they draw the currents. The current drawn by main winding & starting winding have reasonable phase angle between them. Consequently, revolving field approximating to that of two phase machine is produced which starts the motor.

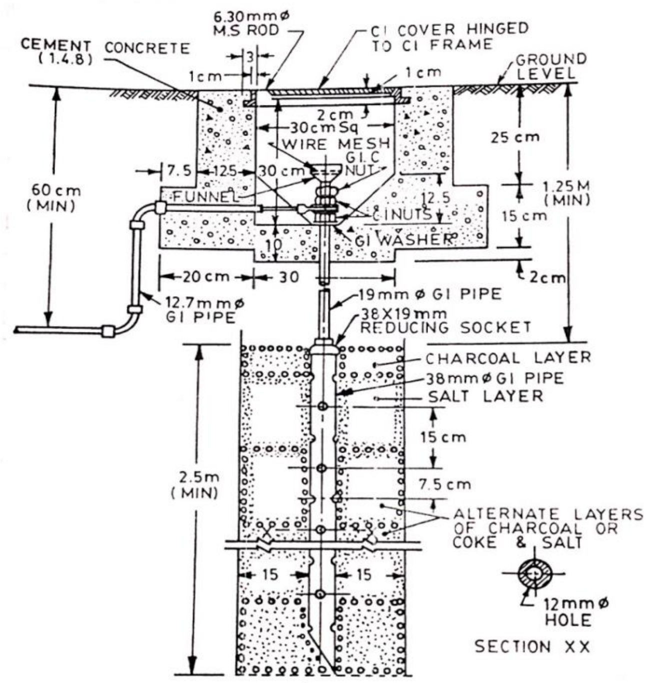
When motor reaches about 75% of synchronous speed, the centrifugal switch opens the staring winding & motor runs with main winding.

Working and operation 4 Marks

1 B) c) Explain pipe earthing with neat diagram.

**Ans:**

**Pipe Earthing:**



A typical illustration of pipe earthing.

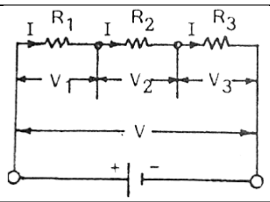
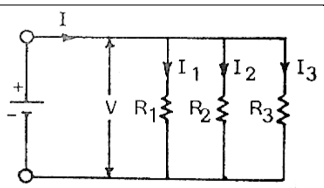
Diagram 2 Marks

**Explanation:**
Here GI pipe of 38mm diameter & 2.5m length is embedded vertically in the ground as shown in figure. The earth wires are fastened to the top section of the pipe with nut bolts. The length of pipe depends upon condition of soil & moisture. The pit area around GI pipe is filled with alternate layer of charcoal & salt for improving earthing system.
Water pouring arrangement from top section is provided as shown in figure.
The earthing resistance has to be checked time to time accordingly.

Explanation 2 Marks

**2 Attempt any FOUR from the following: 16**

2 a) Compare series and parallel circuit with four points.
**Ans:**
**Comparison between series and parallel circuit:**

| Sr. No. | Series Circuit | Parallel Circuit |
|---|---|---|
| 1 |   |   |
| 2 | A series circuit is that circuit in which the current flowing through each circuit element is same. | A parallel circuit is that circuit in which the voltage across each circuit element is same. |
| 3 | The sum of the voltage drops in series resistances is equal to the | The sum of the currents in parallel resistances is equal to the total |

| | | | |
|---|---|---|---|
| | applied voltage V. $\therefore$ V = $V_1$+$V_2$+$V_3$ | circuit current I. $\therefore$ I = $I_1$+$I_2$+$I_3$ | Any 4 points 1 Mark each |
| 4 | The effective resistance R of the series circuit is the sum of the resistances connected in series. $R = R_1 + R_2 + R_3 + \cdots$ | The reciprocal of effective resistance R of the parallel circuit is the sum of the reciprocals of the resistances connected in parallel. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$ | |
| 5 | Resultant resistance $R = R_1 + R_2 + R_3 + \cdots$ | Resultant conductance $G = G_1 + G_2 + G_3 + \cdots$ | |
| 6 | Different resistors have their individual voltage drops. | Different resistors have their individual currents. | |
| 7 | Example: Fuse connection | Example: Connection of various lamps & appliances | |

2 b) Find current through 2Ω resistor using mesh loop. (fig.1)

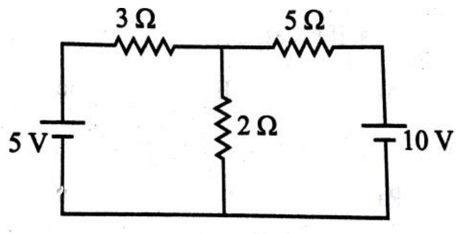
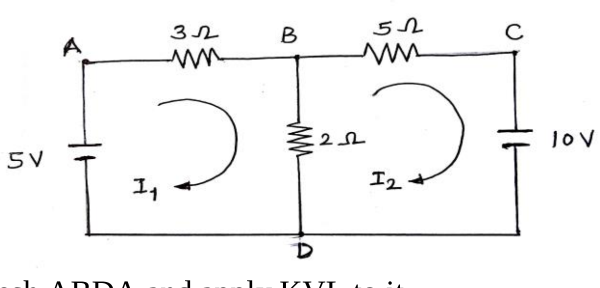



Figure-1

**Ans:**

**Current through 2Ω resistor using mesh loop:**

Assign mesh currents $I_1$ and $I_2$ to meshes ABDA and BCDB as shown in following fig**.**




Consider Loop/ Mesh ABDA and apply KVL to it

$-3I_1 - 2(I_1 - I_2) + 5 = 0$ OR

$-3I_1 - 2I_1 + 2I_2 = -5$ OR

$-5I_1 + 2I_2 = -5$ OR

$5I_1 - 2I_2 = 5$ ------------------- (1) 1 Mark

Consider Loop/ Mesh BCDB and apply KVL to it

$-5I_2 - 10 - 2(I_2 - I_1) = 0$ OR

$-5I_2 - 10 - 2I_2 + 2I_1 = 0$ OR

$-7I_2 - 10 + 2I_1 = 0$ OR

$2I_1 - 7I_2 = 10$ ------------------- (2) 1 Mark

Multiply eq (1) by 2 and eq (2) by 5, We get

$10I_1 - 4I_2 = 10$ -------------------------(3)

$10I_1 - 35I_2 = 50$ ------------------------(4)

Subtracting eq (3) from eq (4), We get

$-31 I_2 = 40 \therefore I_2 = \frac{40}{-31} = -1.290$ A 1 Mark

Putting this value of $I_2$ in eq. (1 or 2), we get

$I_1 = 0.484$ A

Hence current through 2Ω resistance is, 1 Mark

$I_1 - I_2 = 0.484 - (-1.290) =$ **1.774A (from B to D)**

2 c) Simplify given circuit using star-delta conversion and find resistance across AB (fig.2)

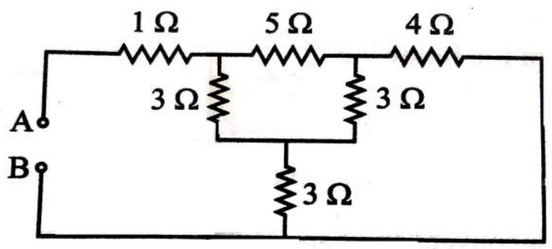



**Figure-2**

**Ans:**

**Resistance across AB:**

Converting three 3Ω resistances in star into equivalent delta as shown in fig 2C-1

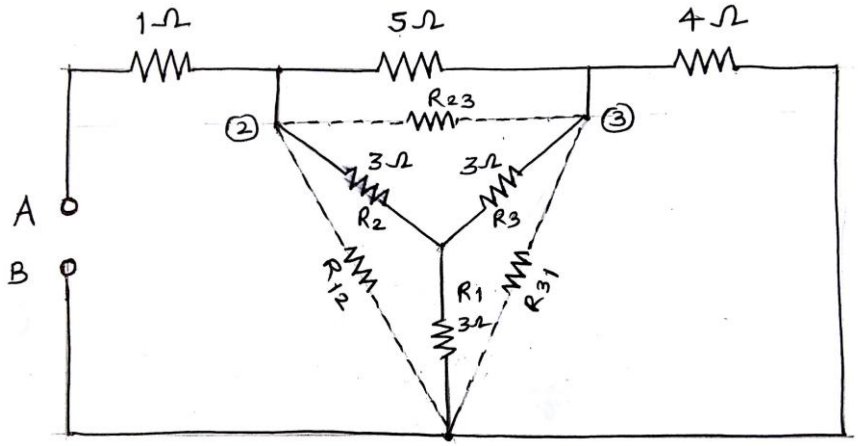



Fig. 2 C- 1

$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3} = 3 + 3 + \frac{3 \times 3}{3} = 9\Omega$

$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1} = 3 + 3 + \frac{3 \times 3}{3} = 9\Omega$

$R_{31} = R_3 + R_1 + \frac{R_3 R_1}{R_2} = 3 + 3 + \frac{3 \times 3}{3} = 9\Omega$

The circuit becomes as below; 1 Mark

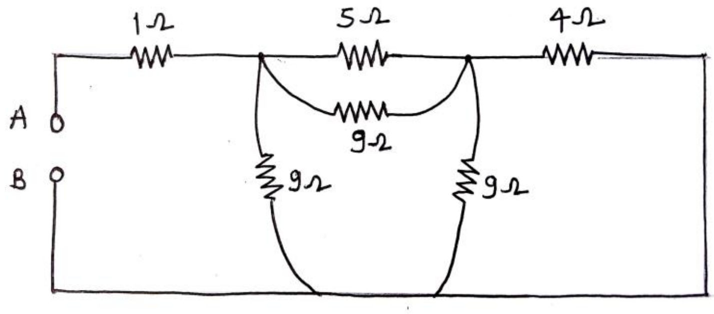



Fig. 2 C- 2

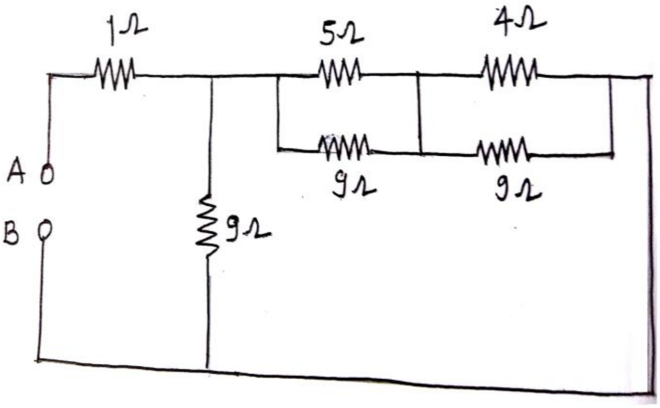



Fig. 2 C- 3

In Fig. 2 C- 3 , 5 Ω resistance is parallel with 9 Ω and also 4 Ω with 9 Ω

$\therefore 5||9 = \frac{5 \times 9}{5+9} = 3.214\ \Omega$ and $4||9 = \frac{9 \times 4}{9+4} = 2.769\ \Omega$

Now circuit becomes as shown in fig. 2 C- 4 wherein 3.214 Ω is in series with 2.769 Ω — 1 Mark

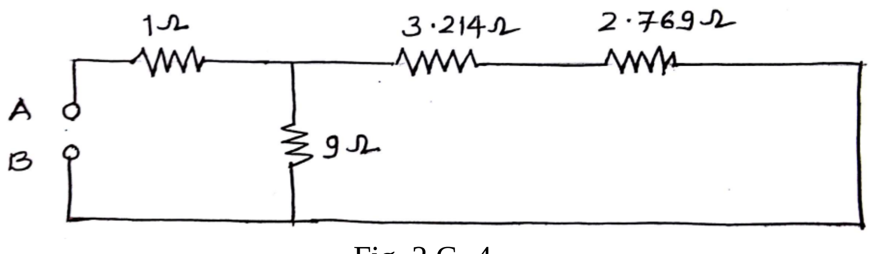



Fig. 2 C- 4

$\therefore$ 3.214 + 2.769 = 5.983 Ω which is in parallel with 9 Ω

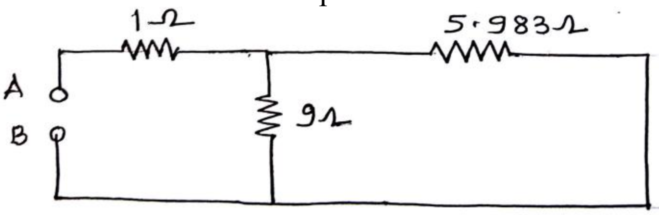
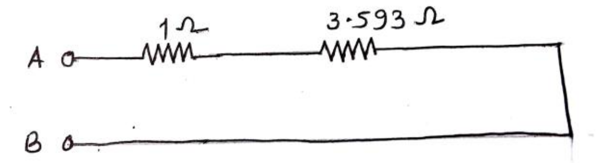



Fig. 2 C- 5

$\therefore 9||5.983 = \frac{9 \times 5.983}{9+5.983} = \frac{53.8515}{14.9832} = 3.594\ \Omega$ — 1 Mark

The circuit becomes as below;




1 Mark

Fig. 2 C- 6

Ultimately,

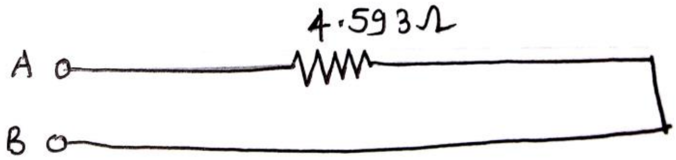



Fig. 2 C- 7

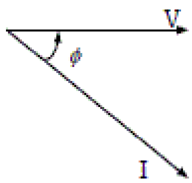
$\therefore$ $R_{AB} = 1 + 3.593 = 4.593\ \Omega$

2 d) Draw phasor representation for
  i) In phase current
  ii) Lagging current
  iii) Leading current with respect to sinusoidal voltage. Define phase difference.

**Ans**:
**Phasor representation for applied voltage (V) and resultant current (I):**
  i) In phase current:

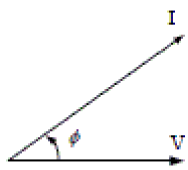
1 Mark


  ii) Lagging current:




1 Mark

  iii) Leading current:

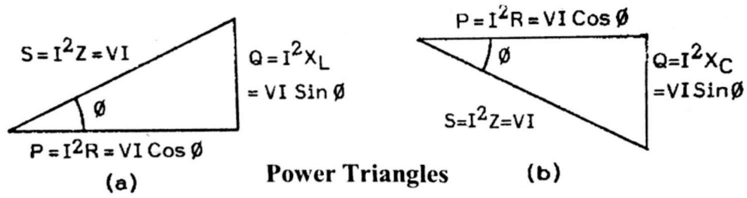



1 Mark

**Phase Difference:**
When two alternating quantities of same frequency attain their respective zero values at different instants of time, then they are said to have phase difference & the angular distance between their corresponding zero values is the angle of phase difference. 1 Mark

2 e) Define power triangle with active, reactive and apparent power formulas.
**Ans:**

**Power Triangle:**
The power triangles for inductive circuit and capacitive circuit are shown in the fig. (a) and (b) respectively.
Three sides of power triangle are Active power (P), Reactive power (Q) and Apparent power (S). Any one power triangle



Power Triangles

1 Mark

Hence

$S^2 = P^2 + Q^2$ OR
$S = \sqrt{(P^2 + Q^2)}$ OR
$S = P \pm j\,Q$

1 Mark

Apparent power (S) is given by simply the product of voltage & current.

$$S = VI = I^2Z \text{ volt-amp}$$

Active power (P) is given by the product of voltage, current and the cosine of the phase angle between voltage and current. 1 Mark

$$P = VI\cos\emptyset = I^2R \text{ watt}$$

Reactive power (Q) is given by the product of voltage, current and the sine of the phase angle between voltage and current. 1 Mark

$$P = VI\sin\emptyset = I^2X \text{ volt-amp-reactive}$$

2 f) Explain measurement of single phase power measurement using dynamometer type wattmeter.

**Ans:**

**Measurement of single phase power using dynamometer type wattmeter:**

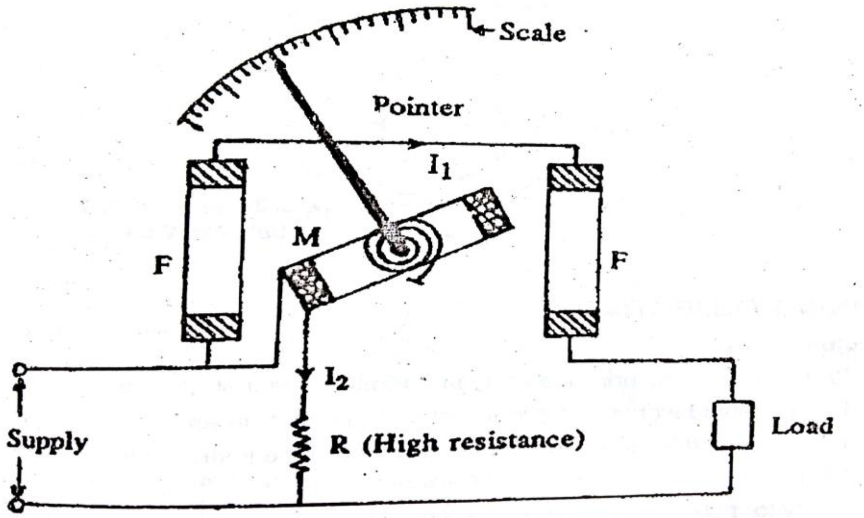



Diagram 1 Mark

In a dynamometer type wattmeter a fixed coil (current coil) is connected in series with the load. This coil is divided in two parts (essentially two coils), each having thick cross section with less number of turns. They are connected in series or parallel depending upon the current range. The moving coil (pressure coil) is connected across load. It is thin in cross section and has more number of turns. It is mounted in between fixed coils, also a non-inductive high resistance is connected in series with it. When wattmeter is connected for measurement of power consumed by single phase load, The reading of wattmeter is given by multiplication of voltage across pressure coil (V), Current through current coil (I) and cosine of angle between V & I. Explanation 3 Marks

Hence,

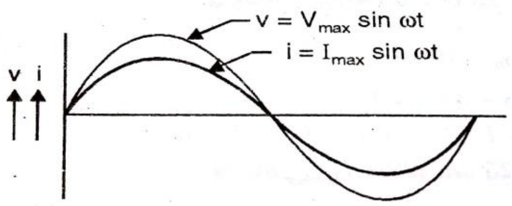
$P = V\,I \cos \Phi$ watts

**3 Attempt any FOUR from the following: 16**

3 a) Draw waveform of voltage and current for ac circuits containing
 i) Resistance only
 ii) Capacitance only
 iii) Inductance only
 iv) Capacitance and resistance

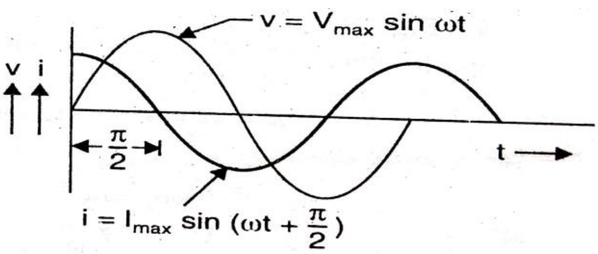
**Ans:**

**i) Waveform of voltage and current for ac circuits containing Resistance only**



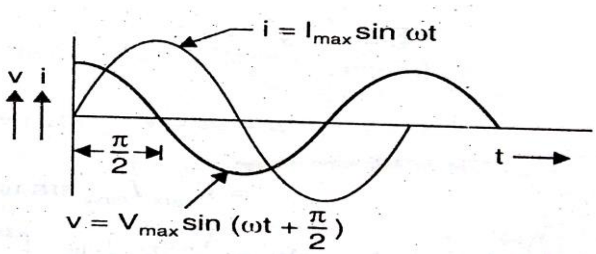

1 Mark

**ii) Waveform of voltage and current for ac circuits containing Capacitance only**



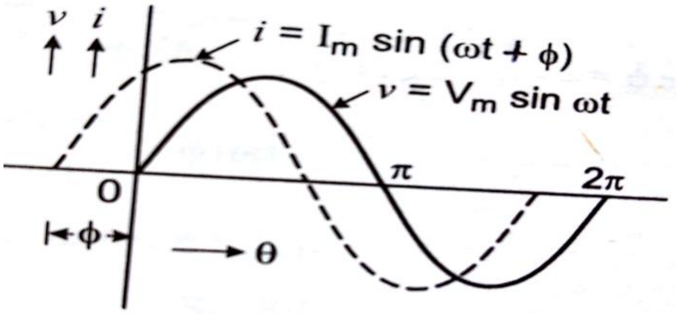

1 Mark

**iii) Waveform of voltage and current for ac circuits containing Inductance only**




1 Mark

**iv) Waveform of voltage and current for ac circuits containing Capacitance and resistance:**




1 Mark

3 b) Sinusoidal waveform completes a cycle within 0.02 sec time period. Find cycles completed in 1minute and frequency of AC supply.

**Ans:**

**Given:**

Time period, T = 0.02sec**,**

Time period ,T = 0.02sec = time taken to complete one cycle

Cycles completed in one minute i.e. 60sec are

$= \frac{60}{0.02}$= **3000 cycles**. 2 Marks

Frequency ,f = $\frac{1}{T}$ = $\frac{1}{0.02}$ = **50 Hz or 50 cycles/sec** 2 Marks

3 c) Define RMS value and Average value.

**Ans:**

**RMS Value of Sinusoidal AC Waveform:**

The RMS value is the Root Mean Square value. It is defined as the square root of the mean value of the squares of the alternating quantity over one cycle. 2 Marks

**And/OR**

For an alternating current, the RMS value is defined as that value of steady current (DC) which produces the same heat or power as is produced by the alternating current during the same time under the same conditions.

**Average Value of Sinusoidal AC Waveform:**

The average value is defined as the arithmetical average or mean value of all the values of an alternating quantity over one cycle. 2 Marks

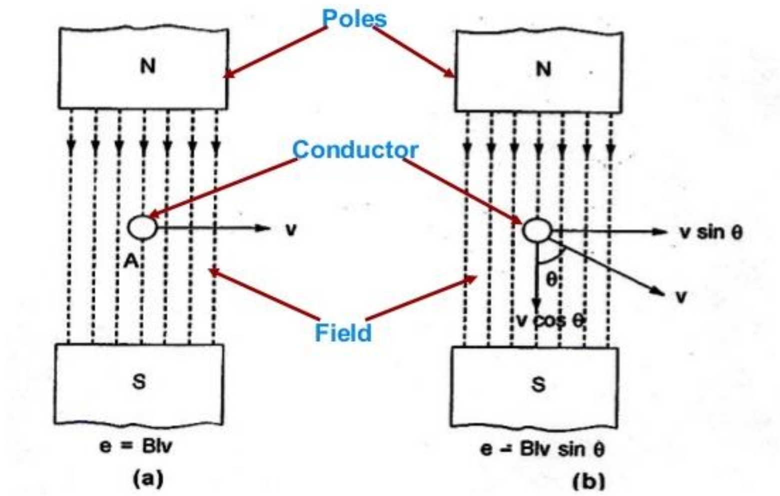
**And/OR**

For an alternating current , the average value is defined as that value of steady current (DC) which transfers the same charge as is transferred by the alternating current during the same time under the same conditions.

3 d) Explain dynamically induced emf with its diagram. Write applications of dynamically induced emf.

**Ans:**

**Dynamically induced emf:**




1 Mark

Explanation 2 Marks

The emf induced in coil or conductor when field/ flux is of constant magnitude and conductor cuts the flux when there is relative motion between conductor & flux, is called as dynamically induced emf.

Consider the figure, here the conductor having effective length l meters moving at right angle to unifrom magnetic field of flux density B wb/m$^2$ with a velocity of v m/s. Hence emf induced in the conductor is

e =Blv volts

and if the conductor moves with an angle Ө then emf induced in the conductor is e =Blvsin Ө volts.

One application 1Mark

**Apllications of dynamically induced emf:**

i) DC Generator
ii) Alternator

3 e) A capacitor of 100µF is connected across a 200V, 50Hz single phase supply. Calculate:

i) The reactance of the capacitor.
ii) Rms value of current and
iii) The maximum value of current.

**Ans:**

**Given:** C= 100 µF= 100× 10$^{-6}$F, V= 200V, F= 50Hz

i) The reactance of the capacitor

$$Xc = \frac{1}{2\pi f C} = \frac{1}{2\pi\times 50\times 100\times 10^{-6}} = 31.8309\ \Omega$$

2 Marks

ii) Rms value of current

$$Irms = \frac{V}{X_c} = \frac{200}{31.8309} = 6.2832\ A$$

1 Mark

iii) The maximum value of current.

$I_{max} = \sqrt{2} \times I_{rms} = \sqrt{2} \times 6.2832 = 8.8857$ A

1 Mark

3 f) Explain power factor with its significance.

**Ans:**

**Power Factor & its significance:**

**Power Factor:** It is the cosine of the angle between the applied voltage and the resulting current.

Power factor = cosϕ

where, ϕ is the phase angle between applied voltage and current.

OR

It is the ratio of True or effective or real power to the apparent power. 1 Mark

$$\text{Power factor} = \frac{\text{True Or Effective Or Real Power}}{\text{Apparent Power}} = \frac{\text{VIcos}\emptyset}{\text{VI}} = \cos\emptyset$$

OR

It is the ratio of circuit resistance to the circuit impedance.

$$\text{Power factor} = \frac{\text{Circuit Resistance}}{\text{Circuit Impedance}} = \frac{\text{R}}{\text{Z}} = \cos\emptyset$$

**Significance of Power Factor:**

The apparent power drawn by a circuit has two components:

i) Active power & ii) Reactive power

Active power should be as large as possible because it is the component which does useful work in the circuit and is possible if reactive power component is small and power factor is approaching to unity. Significance 3 Marks

Thus power factor of a circuit is a measure of its effectiveness in utilizing the apparent power drawn by it. Higher the power factor, higher is the utilization of apparent power.

**4 Attempt any FOUR of the following: 16**

4 a) Simplify following circuit using node voltage method and find out voltage across 5Ω resistor. (fig 3).

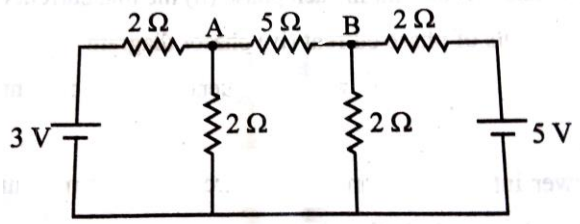
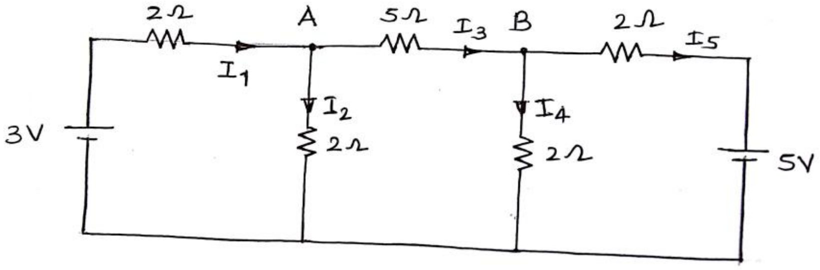



**Figure-3**

**Ans:**




At node A $I_2 + I_3 = I_1$

$$\frac{V_A}{2} + \frac{V_A - V_B}{5} = \frac{3 - V_A}{2}$$

Multiplying by 10 to both sides

$$\left(\frac{V_A}{2} \times 10\right) + \left(\frac{V_A - V_B}{5}\right) \times 10 = \left(\frac{3 - V_A}{2}\right) \times 10$$

$5V_A + 2V_A - 2V_B = 15 - 5\ V_A$
$5V_A + 5V_A + 2V_A - 2V_B = 15$
$12\ V_A - 2\ V_B = 15$ --------------------(1)

1 Mark

At node B $I_4 + I_5 = I_3$

$$\frac{V_B}{2} + \frac{V_B - 5}{2} = \frac{V_A - V_B}{5}$$

Multiplying by 10 to both sides

$$\left(\frac{V_B}{2} \times 10\right) + \left(\frac{V_B - 5}{2}\right) \times 10 = \left(\frac{V_A - V_B}{5}\right) \times 10$$

$5V_B + 5V_B - 25 = 2\ V_A - 2\ V_B$
$5V_B + 5V_B + 2V_B - 2V_A = 25$
$12\ V_B - 2\ V_A = 25$ OR $-2\ V_A + 12\ V_B = 25$ --------------------(2)
Multiplying eq. (1) by 2 and eq. (2) by 12 1 Mark
Adding both we get,

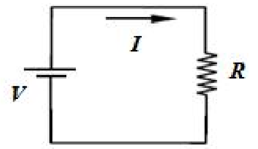
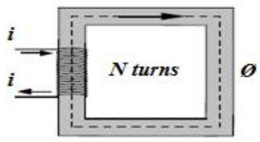
$$\begin{aligned} & 24V_A - 4V_B = 30 \\ + \ & -24V_A + 144V_B = 300 \\ & 140V_B = 330 \end{aligned}$$

$\therefore\ V_B = 2.357$ volts
Putting this in eq(1), we get ½ Mark
$12V_A - 2 \times 2.357 = 15$ ½ Mark
$\therefore\ V_A = 1.642$ volts
**Voltage across 5Ω resistance = $V_B - V_A$ = 0.715volts. (with B positive w. r. t. A)** 1 Mark

4 b) Compare electric circuit and magnetic circuit.
**Ans:**
**Comparison between electric and magnetic circuit:**
**A)Similarities:**

| Sr. No. | Electric circuit | Magnetic circuit |
|---|---|---|
| 1 | Current: flow of electrons through conductor is current, it is measured in amp. | Flux: lines of magnetic force through medium from N pole to S pole form flux. It is measured in weber. |
| 2 | EMF: It is driving force for current, measured in volts. | MMF: It is driving force for flux, measured in amp-turn. |
| 3 | Resistance: It is opposition of conductor to current, measured in ohms | Reluctance: It is opposition offered by magnetic path to flux, measured in AT/wb. |
| 4 | Resistance is directly proportional to length of conductor. | Reluctance is directly proportional to length of magnetic path. |
| 5 | For electric circuit, we define the conductivity. | For magnetic circuit, we define permeability. |
| 6 | Electric circuit is closed path for current. | Magnetic circuit is closed path for magnetic flux. |

Any 4 points 1 Mark each

| | | |
|---|---|---|
| 7 | For electric circuit<br>I = EMF/resistance | For magnetic circuit<br>Φ= MMF/reluctance |
| 8 | Voltage = IR | M M F = Φ S |
| 9 | Resistivity | Reluctivity |
| 10 |  |  |

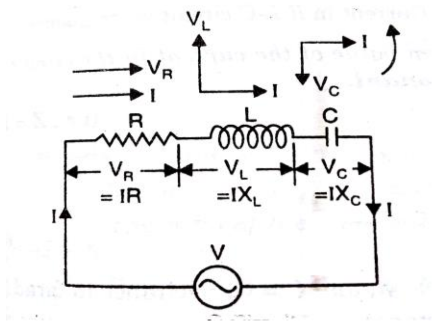
**b)Dissimilarities:**

| Sr. No. | Electric circuit | Magnetic circuit |
|---|---|---|
| 1 | Electric current flows. | Flux does not actually flow. |
| 2 | Energy is needed continuously for the flow of current | Energy is only needed for establishment of field(flux) |
| 3 | Current cannot pass through the insulator | Flux can pass through almost all materials including air |
| 4 | Electrical insulator is available | Magnetic insulator does not exits |

4 c) Explain RLC series circuit and series resonance with phasor diagram.

**Ans:**

**RLC series resonance circuit:**

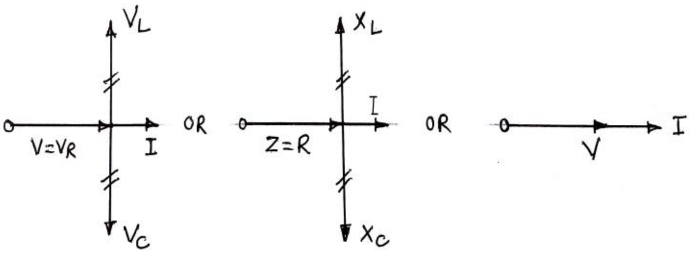



1 Mark

A series circuit containing resistance, inductance and capacitance, is resonant when the circuit power factor is unity,($X_L = X_C$) i.e. applied voltage and current are in phase. 1 Mark

This condition is termed as series resonance.

**Phasor diagram of RLC series resonance circuit:**




1 Mark

Consider phasor diagram, here in resonance condition voltage across inductance ($V_L$) is equals to voltage across capacitance ($V_C$) and cancells each other being $180^0$ out of phase, applied voltage V ( or $V_R$ ) is in phase with resultant current I. Similarly, inductive reactance and capacitive reactance are equal and out of phase hence cancells out and circuit impedance Z becomes equal to circuit resistance R. — 1 Mark

4 d) How reactive power can be minimized in inductive circuit to make unity power factor?

**Ans:**

**Methods of reactive power minimization in inductive circuit to make unity power factor:**

In inductive circuit, the ohmic value of inductive reactance is $X_L$ , and it is equal to $2\pi f L$ ohms.

i) When we connect a capacitor in series with inductor in such a way that $X_C$ (= $\frac{1}{2\pi f C}$ ) becomes equals to $X_{L.}$ Then $X_C$ & $X_L$ being equal get cancelled with each other. Then circuit becomes series resonant circuit and circuit impedance becomes equal to circuit resistance, circuit power factor becomes unity.

ii) When we connect a capacitor in parallel with inductive branch, then the value of capacitor is so chosen that the capacitor branch current $I_C$ equals to $I_L \sin \Phi_L$ ( where $\Phi_L$ is angle between applied voltage and inductor branch current ) then circuit becomes parallel resonant circuit and circuit power factor becomes unity.

iii) For making unity power factor for inductive circuit, connect capacitor in series (or parallel) and make it series (or parallel) resonant circuit by adjusting the input frequecy as resonant frequency.

OR any equivalent method may be considered.

Any one method with explanation 4 Marks

4 e) Explain working principle of shaded pole motor.

**Ans:**

**Shaded pole single-phase induction motor:**

When single phase supply is applied across the stator winding, an alternating field is created. The flux distribution is non uniform due to shading bands on the poles. The shading band acts as a single turn coil and when links with alternating flux, emf is induced in it. The emf circulates current as it is simply a short circuit. The current produce the magnetic flux in the shaded part of core to oppose the cause of its production which is the change in the alternating flux produced by the winding of motor. Now consider three different instants of time $t_1$, $t_2$, $t_3$ of the flux wave to examine the effect of shading band as shown in the fig below. The magnetic neutral axis shifts from left to right in every half cycle, from non-shaded area of pole to the shaded area of the pole. This gives to some extent a rotating field effect which may be sufficient to provide starting torque to squirrel cage rotor and rotor rotates.

Explanation 3Marks

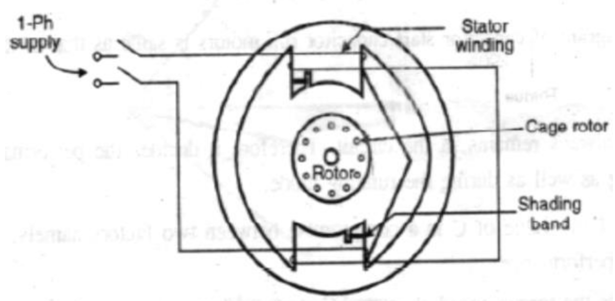
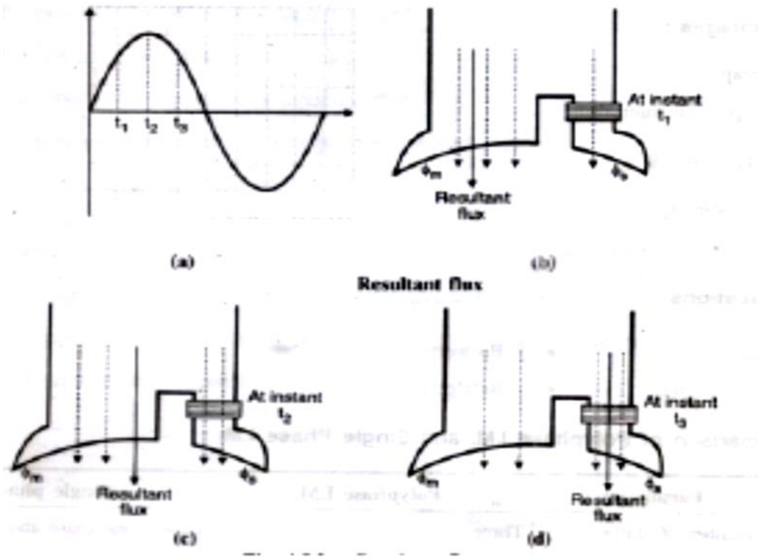


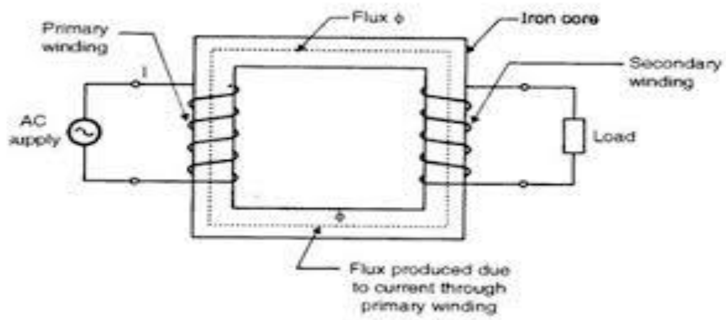

Diagram 1Mark

**OR**




4 f) Explain construction and working principle of transformer.

**Ans:**




Construction 2 Marks

**Construction of single phase transformer:**

Single-phase transformer essentially consists of following components:

i) Windings: Two windings generally of copper are placed round the core and are insulated from each other and also from the core.

ii) Core: Magnetic core is made up of thin silicon steel laminations which act as a magnetic circuit.

For big size transformers, tank is used to accommodate the core-winding assembly.

In fact, the core-winding assembly is kept immersed in oil in the tank. The oil acts as a cooling medium and also the insulating medium. The terminals are taken out of the tank using bushings. The supply is connected to primary winding and load is connected to secondary winding.

**Working of single phase transformer:**

Transformer works on the principle of Mutual electromagnetic induction. When AC voltage is applied to the primary winding, it produces alternating flux in the core. This flux links with the secondary winding and according to Faraday's law of electromagnetic induction, an emf is induced in the secondary winding and the current flows in the secondary circuit if load is connected. Working 2 Marks

**5 Attempt any FOUR from the following: 16**

5 a) A capacitor of 10 µF is connected across a 200V, 50Hz single phase supply. Calculate:

i) The reactance of the capacitor.
ii) rms value of current
iii) The maximum current.
iv) Maximum power for one complete cycle

**Ans:**

**Given:**

C= 100 µF= 100× $10^{-6}$ F, V= 200V, f = 25Hz

i) The reactance of the capacitor.

$Xc = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 25 \times 100 \times 10^{-6}}$ = 636.6197 Ω 1 Mark

ii) Rms value of current 1 Mark

$Irms = \frac{V}{X_c} = \frac{200}{636.6197}$ = 0.31415 A

iii) The maximum current. 1 Mark

$I_{max} = \sqrt{2} \times I_{rms} = \sqrt{2} \times 0.31415 = 0.44428$ A

iv) Maximum power for one complete cycle:

Instantaneous power is given by $p = v.i = V_m \sin(\omega t) . I_m \sin(\omega t + 90°)$

$\therefore p = V_m I_m \frac{1}{2}\{\cos(-90°) - \cos(2\omega t + 90°)\} = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}\{-\cos(2\omega t + 90°)\}$ 1 Mark

$\therefore p = P_{max}\{-\cos(2\omega t + 90°)\}$

$\therefore Maximum\ Power\ P_{max} = \frac{V_m \times I_m}{2} = V_{rms} I_{rms}$

$\therefore Maximum\ Power\ P_{max} = 200 \times 0.31415 = 62.83\ watt$

$But\ average\ power\ over\ one\ cycle\ in\ pure\ capacitive\ circuit\ is\ Zero$

5 b) State advantages of three phase circuits over single phase circuits.

**Ans:**

**Advantages of three phase circuits over single phase circuits:**

i. Three phase transmission line requires less conductor material for same power transfer at same voltage.
ii. For same frame size, three phase machine gives more output.
iii. For same rating, three phase machines have small size.
iv. Three phase motors produce uniform torque.

1 Mark for each of any four

v. Three phase induction motors are self-starting.
vi. For same rating, three phase motors have better power factor.
vii. Three phase transformers are more economical. Power capacity to weight ratio is more.
viii. Three phase machines have higher efficiencies.
ix. Three phase system is more economical with regards to generation, transmission and distribution of power.
x. Three phase system requires less maintenance and it increases the life of the system.
xi. In three phase system rotating magnetic field is produced rather than the pulsating field produced by single phase system.

5 c) Define phase sequence in 3 ϕ supply with waveform. What is correct phase sequence?

**Ans:**

**Phase Sequence:**

Phase sequence is defined as the order in which the voltages (or any other alternating quantity) of the three phases attain their positive maximum values. — Definition 2 Marks

In the shown waveforms, it is seen that the R-phase voltage attains the positive maximum value first, and after angular distance of 120°, Y-phase voltage attains its positive maximum and further after 120°, B-phase voltage attains its positive maximum value. So the phase sequence is R-Y-B.

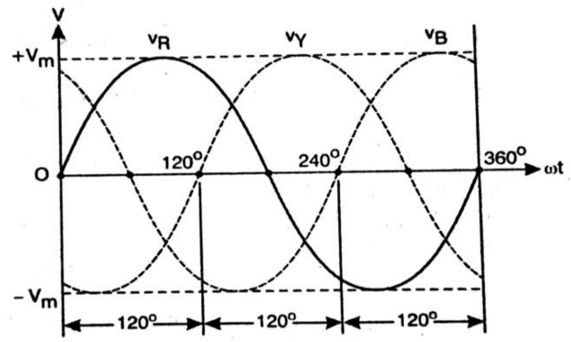



Diagram 1 Mark

**Correct phase sequence is R-Y-B**.

Correct phase sequence 1 Mark

5 d) Define
i) Balanced load
ii) Balanced supply
iii) Unbalanced load
iv) Unbalanced supply

**Ans:**

**i) Balanced Load:**

Balanced three phase load is defined as star or delta connection of three equal impedances having equal real parts and equal imaginary parts.

e.g Three impedances each having resistance of 5Ω and inductive reactance of 15Ω connected in star or delta

1 Mark for each definition

**ii) Balanced Supply:**

Balanced supply is defined as three phase supply voltages having equal magnitude but displaced from each other by an angle of 120° in time phase.

e.g $V_a = 230\angle 0°$ volt, $V_b = 230\angle -120°$ volt, $V_c = 230\angle 120°$ volt represents balanced supply.

**iii) Unbalanced Load:**

If a load not satisfies the condition of balance it is called as unbalanced load. OR
When the magnitudes and phase angles of three impedances are differ from each other, then it is called as unbalanced load.

**iv) Unbalanced supply:**

If a supply does not satisfy the condition of balance it is called as unbalanced supply. OR
Unbalanced supply is defined as three phase supply voltages having unequal magnitude and/or unequal displacement from each other.

5 e) Explain: "How current in 3 $\phi$ load can be limit using different connections".

**Ans:**

**Method of limiting current in 3 $\phi$ load:**

i) By converting delta connected load into star connection, the load current can be reduced or limited to $\frac{1}{\sqrt{3}}$ times.
ii) By connecting resistors in series with each phase of load, the load current can be reduced or limited as per the value of resistances.
iii) By connecting appropriate rated fuses in series with each phase of load, the load current is not permitted to rise above certain value and thus limited.
iv) By using 3 $\phi$auto- transformers or by applying reduced voltage technique, the load current can be reduced or limited.

Any two methods 2 mark each= 4 Marks

OR equivalent method may be considered.

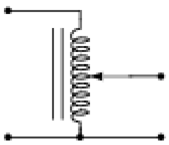
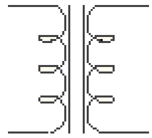
5 f) Compare autotransformer with two winding transformer.

**Ans:**

**Comparison of auto transformer with two winding transformer:**

| | Autotransformer | Two winding Transformer |
|---|---|---|
| 1 | Only one winding, part of the winding is common for primary and secondary. | There are two separate windings for primary and secondary. |
| 2 | Movable contact exist | No movable contact between primary and secondary |
| 3 | Electrical connection between primary and secondary. | Electrical isolation between primary and secondary windings. |
| 4 | Comparatively lower losses. | Comparatively more losses |
| 5 | Efficiency is more as compared to two winding transformer. | Efficiency is less as compared to autotransformer. |
| 6 | Copper required is less, thus copper is saved. | Copper required is more. |
| 7 | Spiral core construction | Core type or shell type core construction |
| 8 | Special applications where variable voltage is required. | Most of the general purpose transformers where fixed voltage is required. |
| 9 | Cost is less | Cost is more |
| 10 | Better voltage regulation | Poor voltage regulation |

Any four points 1 Mark each

| | | |
|---|---|---|
| 11 |  Symbol of Autotransformer |  Symbol of Two winding transformer |

**6 Attempt any FOUR of the following: 16**

6 a) A 3ϕ, 200kW, 50Hz, delta connected induction motor is supplied from 3 ϕ 440V, 50Hz ac supply. The efficiency and p.f. is 91% & 0.86 respectively. Calculate i) current in each phase ii) the line current iii) active & reactive components of phase current iv) phasor diagram.

**Ans:**

**Given:**

$P_{out}$= 200kW= 200× $10^3$ W, $V_L$= 440V, f = 50Hz, η= 0.91%, p.f.= cosϕ = 0.86

O/P power of motor = 200× $10^3$ W

I/P power of motor = $\frac{200\times 10^3}{0.91}$ = 219780.2198 watts

P = $\sqrt{3}\, V_L I_L \cos\phi$

∴ Line current $I_L$= $\frac{P}{\sqrt{3}\times V_L \cos\phi}$ = $\frac{219780.2198}{\sqrt{3}\times 440\times 0.86}$ =335.333A 1 Mark

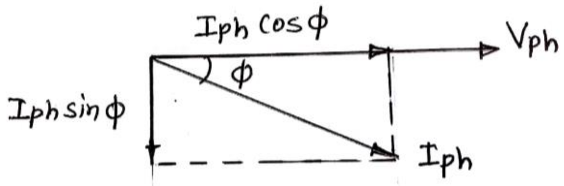
As motor is delta-connected, 1 Mark

Phase current = $\frac{I_L}{\sqrt{3}}$ = $\frac{335.333}{\sqrt{3}}$ = 193.6048 A

Active componenet of Phase current = $I_{ph}\cos\phi$ = 193.6048 × 0.86
= 166.500A ½ Mark

as cosϕ = 0.86 ϕ= 30.68 ∴ sinϕ = 0.5102

Reactive componenet of Phase current = $I_{ph}\sin\phi$
= 193.6048 × 0.5102
= 98.785A ½ Mark




1 Mark

6 b) Explain RLC series resonance with frequency and current, voltage characteristics.

**Ans:**

The curve between circuit current and the frequency of the applied voltage is shown in figure. It shows the resonance curve of a typical R-L-C series circuit. Here current reaches its maximum value at the resonant frequency ($f_r$), falling off on either side of that point. It is because if the frequency is below $f_r$ , $X_C > X_L$ and the net reactance is no longer zero. If the frequency is above fr, then $X_L > X_C$ and the net reactance is again not zero. In both cases the circuit impedance will be more than the impedance $Z_r$ (= R) at resonance. The result is that the magnitude of circuit current decreases rapidly as the frequency changes from resonant frequency. Explanation 3 Marks

Also the smaller is the resistance; the greater is the current at resonance and sharper the curve.

In series resonance voltage across inductance and voltage across capacitance are equal in magnitude and $180^0$ out of phase hence cancels each other and applied voltage appears across circuit resistance.

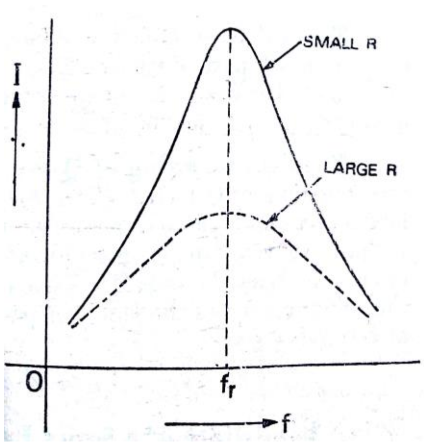
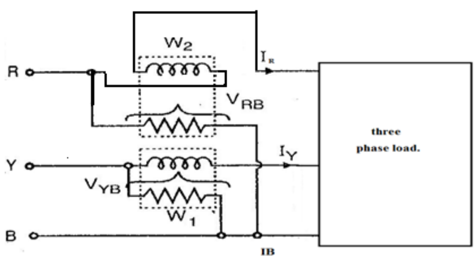


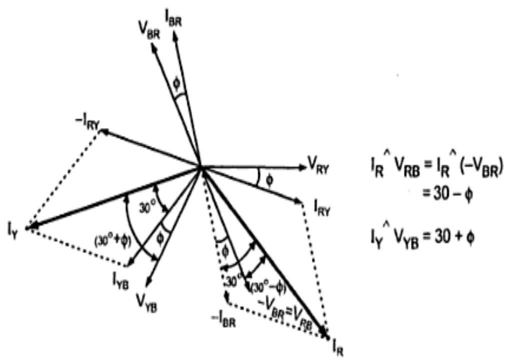

Diagram 1 Mark

6 c) Show that the power intake by a three phase circuit can be measured by two wattmeters connected properly in the circuit.

**Ans:**

**Measurement of power by Two wattmeter method:**




1 Mark each for Circuit Diagram & Phasor diagram = 2 Marks

Consider the connections of two wattmeter method for three phase balance load as shown in circuit diagram and its Phasor diagram.

Referring these two diagrams,

$V_L = V_{RB} = V_{YB}$, $I_L = I_R = I_Y$

Ø = phase angle between voltage and current of the phases.

Derivation 2 Marks

Reading $W_1 = V_{RB}\ I_R\ \cos(30 - Ø)$

$= V_L\ I_L \cos(30 - Ø)$

& $W_2 = V_{YB}\ I_Y\ \cos(30 + Ø)$

$= V_L\ I_L \cos(30 + Ø)$

$\therefore W_1 + W_2 = V_L\ I_L\ \{ \cos(30 - Ø) + \cos(30 + Ø)\}$

$= V_L\ I_L\ \{(\cos30\cos Ø + \sin30\sin Ø) + ( \cos30\cos Ø - \sin30\sin Ø)\}$

$= V_L\ I_L\ \{\cos 30 \cos Ø + \sin 30 \sin Ø + \cos 30 \cos Ø - \sin 30 \sin Ø\}$
$= V_L\ I_L\ \{2 \cos 30 \cos Ø\}$
$= V_L\ I_L\ \{2 (\sqrt{3}/2) \cos Ø\}$
$\therefore W_1 + W_2 = \sqrt{3}\ V_L\ I_L \cos Ø$

**$\therefore$ Total active power P = $(W_1 + W_2) = \sqrt{3}\ V_L\ I_L \cos Ø$**

In this way the two wattmeters read the power intake by a three phase circuit.

6 d) Explain working of universal motor. State its applications.

**Ans:**

**Working of universal motor:**

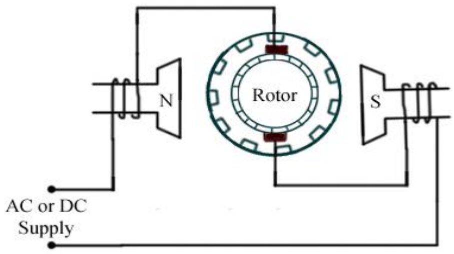



Diagram 1 Mark

- It is modified DC series motor which can work on AC as well as DC supply.
- When motor is connected to supply current flows through field winding and armature winding, field winding produces flux and armature winding carries current.
- When current carrying conductor placed in magnetic field it experiences a mechanical force and motor starts running.
- The force is directly proportional to the product of main flux and armature Current. F (or torque) $\alpha$ (flux)(Armature current)

Working 2 Marks

**Applications of universal motor:**

1) Vacuum cleaners
2) Mixers
3) Dryers
4) Sewing machines
5)Electric shavers

Any two applications 1 Mark

6 e) Classify transformer w.r.t. i) voltage level ii) construction iii) supply used iv) application.

**Ans:**

**Classification of Transformer:**

i) Voltage level:- Step-up and Step Down
ii) Construction:- Core type, Shell type , Berry type and amorphous core type
iii) Supply used:- Single phase and Three phase
iv) Application:- Power transformer, Distribution transformer, Isolation Transformer, Testing Transformer, Auto-transformer

Any two types in each classification ½ Mark each = 4 Marks

6 f) i) Classify fuses.
ii) Compare fuse and MCB

**Ans:**

**i) Classification of fuses**:

1. Semi enclosed or rewireable type
2. Totally enclosed or cartridge type
3. Drop out fuse
4. Expulsion fuse
5. H.R.C fuse
6. Striker fuse
7. Switch fuse
8. Metal clad fuse

Any four types 2 Marks

**ii) Comparison of Fuse and MCB:**

| Sr. No. | Fuse | MCB |
|---|---|---|
| 1 | Needs replacement after every operation. | Can be reused after successful operation. |
| 2 | Fuse melts/fuses in case of excessive load (due to increase in temperature). | MCB trips off in case of excessive load (works on bimetal expansion or induced magnetism). |
| 3 | Less safe as compared to MCB. | More safe than fuse. |
| 4 | Relatively economical than MCB. | Relatively costlier than fuse. |
| 5 | Cannot take complete care of single phasing | Can take care of single phasing. |

Any two points 2 Marks