Important suggestions 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 principle components indicated in a 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

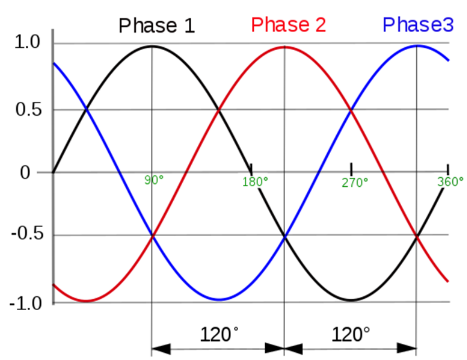
Q.1 A	**Attempt any TEN of the following : 20 Marks**
a)	**Define form factor and peak factor.**
Ans:	**1. Form factor :** **(Each Definition & Value: 1 Mark)** It is defined as the ratio of RMS value to the Average value of an alternating quantity **Value of Form factor: 1.11 (for a sinusoidal quantity)** **2. Peak (Crest) factorfor a sinusoidal quantity:** It is defined as the ratio of Maximum value/peak value to the RMS value. **Value of Crest (Peak) factor: 1.41 (for a sinusoidal quantity)**
b)	**Write any two difference points between a.c. and d.c. supply.**
Ans:	**Differentiate AC supply with DC supply:** **(Any Two Point Expected : 1 Mark each)**

S.No.	Points	AC Supply	DC Supply
1	Amount of energy that can be carried	Safe to transfer over longer city distances and can provide more power	Voltage of DC cannot travel very far until it begins to lose energy
2	Cause of the direction of flow of electrons	Rotating magnet along the wire	Steady magnetism along the wire
3	Frequency	The frequency of	The frequency of direct

		alternating current is 50Hz or 60Hz depending upon the country.	current is zero.
4	Direction	It reverses its direction while flowing in a circuit.	It flows in one direction in the circuit.
5	Current	It is the current of magnitude varying with time	It is the current of constant magnitude.
6	Flow of Electrons	Electrons keep switching directions - forward and backward.	Electrons move steadily in one direction or 'forward'.
7	Obtained from	A.C Generator and mains.	Cell or Battery.
8	Passive Parameters	Impedance.	Resistance only

c) Draw the voltage waveform of three phase a.c. supply for 0 to 2 ohm.

Ans: **Voltage waveform of a 3 phase supply with respect to time:** **(2 Mark)**



or equivalent figure

d) State the concept of phase sequence.

Ans: **Concept of Phase sequence:** **(2 Mark)**

The phase sequence is defined as the order in which all the phases attain there maximum positive values.

e) State the Faraday's law of electromagnetic induction.

Ans: **First Law: -** Whenever change in the magnetic flux linked with a coil or conductor, an EMF is induced in it. **OR** Whenever a conductor cuts magnetic flux, an EMF is induced in conductor. **(1 Mark)**

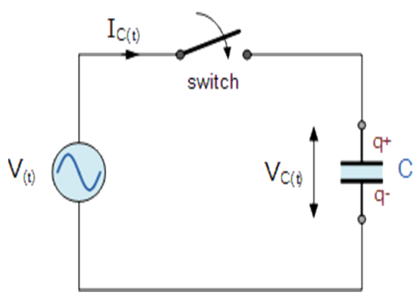
Second Law: - The Magnitude of induced EMF is directly proportional to (equal to) the rate of change of flux linkages. **(1 Mark)**

	$$e = \frac{-Ndt}{dt} d\phi$$
f)	**State Lenz's law.**
Ans:	**Statement Len's law:** **(2 Mark)** The direction of induced emf produced due to the process of electromagnetic induction is always such that, it will set up a current to oppose the basic cause responsible for inducing the emf.
g)	**Define transformation ratio and voltage ratio of transformer.**
Ans:	**i) Transformation Ratio (k):- ---(1 Marks)** It is the ratio of secondary number of turns to primary number of turns. OR It is the ratio of secondary voltage to primary voltage. **OR** It is the ratio of primary current to secondary current. **OR** $$Transformation\ \ ratio\ (k) = \frac{N_2}{N_1}\ or = \frac{E_2}{E_1}\ or = \frac{V_2}{V_1}\ or = \frac{I_1}{I_2}$$ **ii) Voltage Ratio:- ---(1 Marks)** It is the ratio of secondary voltage to primary voltage. $Voltage\ ratio = \frac{V_1}{V_2}$ **OR Student may write** $Voltage\ ratio = \frac{V_2}{V_1}$
h)	**What is the main purpose of using isolation transformer in electronic circuits ?**
Ans:	**Purpose of using isolation transformer in electronic circuits:** **(2 Marks)** An isolation transformer is a transformer used to transfer electrical power from a source of alternating current (AC) power to some equipment or device while isolating the powered device from the power source, usually for safety reasons.
i)	**Mention any two methods to control speed of 3-ph I.M.**
Ans:	**Following methods to control the speed of 3 phase induction motor:** **(2 Mark)** 1.By varying applied voltage (voltage control) 2. By Varying applied frequency (frequency control) 3. By varying number of poles of the stator winding (Pole changing control) 4. By rotor rheostatic control 5. By V/f method

j)	**Define synchronous speed and slip of 3-ph.M.**
Ans:	**i) Synchronous Speed:-** **(Each Definition : 1 Mark)** It is speed at which rotating magnetic field rotates in induction motor. **OR** $$N_S = \frac{120\ f}{P}$$ Where, $N_S = Syncronous\ \ speed \qquad f = Supply\ of\ \ frequency \quad and \quad P = Number\ of\ \ Pole$ **Synchronous Speed unit:** **Unit : RPM or RPS** **ii) Slip:-** It is the ratio the difference between the synchronous speed and actual speed of the rotor to synchronous speed. It is expression in percentage = $$\%\ \text{Slip} = \frac{N_S - N}{N_S}$$
k)	**Write down any two applications of servo motor.**
Ans:	**Applications of servo motor :** **(Any Two expected: 1 Mark each)** 1. Robotics 2. Conveyor Belts 3. Camera Auto Focus 4. Robotic Vehicle 5. Solar Tracking System 6. Metal Cutting & Metal Forming Machines 7. Antenna Positioning 8. Woodworking/CNC 9. Textiles 10. Printing Presses/Printers 11. Automatic Door Openers
l)	**State specialty of universal motor.**
Ans:	**Specialty of universal motor:** **(2 Mark)** Motors that can be used with a single phase AC source as well as a DC source of supply voltages
m)	**State the importance of ELCB in circuit.**
Ans:	**1. importance of ELCB in circuit:** **(2 Mark)** It protects person against shock due to leakage current also it protects circuit/ equipmentagainst overload and short circuit conditions.

n)	**List any four tools used for safety in workshop.**
Ans:	**Following are the safety tools used in workshop:** **(Each point: 1/2 Mark)** 1. **Rubber Mats:** are placed in front of electrical panels and switch boards. 2. **Hand Gloves:** from protect shock in the working period. 3. **Tester:** To test the supply before working. 4. **Earthing:** Earth rod **OR** **(Any Four Tools Expected: 1 /2Mark each, Total 2 Marks)** 1. Rubber hand gloves of proper voltage rating. 2. Safety shoes 3. Safety Belt 4. Ladder 5. Earthing devices 6. Helmet 7. Line tester 8. Rope 9. Hand tools insulated 10. Dress code 100 % cotton etc.
Q.2	**Attempt any FOUR of the following : 16 Marks**
a)	**V = 200 sin (314 t$+\frac{\pi}{3}$) Determine :(i) Frequency (ii) V_{rms}(iii) V_{ave} (iv) Phaseangle**
Ans:	**Given data :** **v = 200 sin (314 t + $\frac{\pi}{3}$)** **Maximum ValueVm :** 200 V **i) Frequency** = $\frac{\omega}{2\pi}$ -- **(1/2 Mark)** $=\frac{314}{2\pi}$ $F = 49.97 \cong 50\ H_Z$ --- **(1/2 Mark)** **ii) RMS valueVrms =** 0.707 x Vm--- **(1/2 Mark)** = 0.707 x 200 = 141.4 Volt --- **(1/2 Mark)**

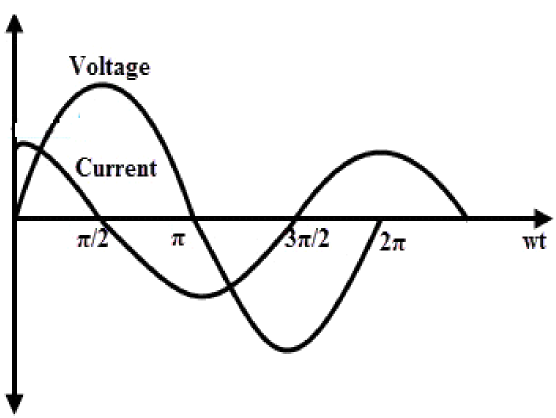
	iii) V_{avg} = 0.637 x Vm-- (1/2 Mark) = 0.637 x 200 = 127.4 Volt --- (1/2 Mark) iv) Phase angle ϕ = $\frac{\pi}{3} = 60^0$ -- (1/2 Mark) $\phi = 60^0$ --- (1/2 Mark)
b)	**Draw the waveform and phasor diagram for current and voltage when a.c. flows through a purely capacitive circuit. Also write equation for voltage and current.**
Ans:	**Schematic diagram of AC flowing through pure capacitive:** **(1 Mark)**



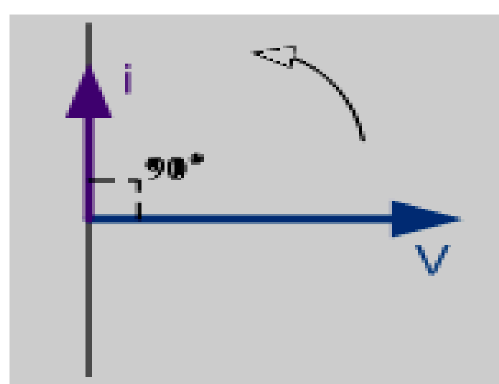
or equivalent Diagram

Pure capacitive circuit: **(Waveform & Phasor Diagram 1 Mark each)**

Waveform:

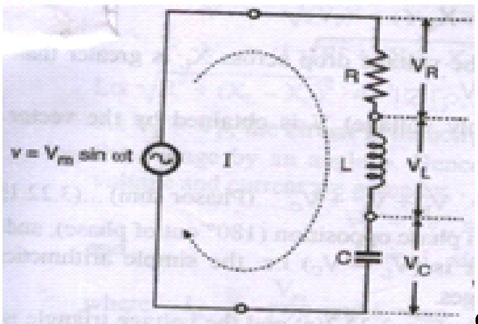


Phasor Diagram :



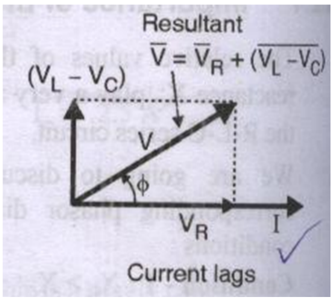
Expression for Voltage and Current: **(1 Mark)**

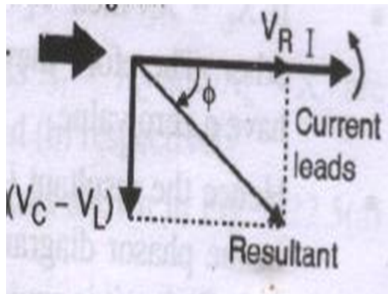
1. Equation for voltage $V = V_m \sin \omega t$
2. Equation for current $I = I_m \sin (\omega t + \frac{\pi}{2})$ or $I_m \sin (\omega t + 90^0)$

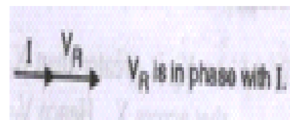
c)	**A coil of resistance 10 ohm and inductance 0.01 H are connected in series with 100 μF capacitor across 230 V, 50 Hz a.c. supply. Find :** **(i) X_L (ii) Xc (iii) Z (iv) I**
Ans:	**I= V/Z** **i) X_L =** $X_L = 2\pi f L$ -- **(1/2 Mark)** $= 2\pi \times 50 \times 0.01$ $X_L = 3.141\Omega$-- **(1/2 Mark)** **ii) X_L =** $X_C = \frac{1}{2\pi f C}$ -- **(1/2 Mark)** $= \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}$ $X_C = 31.8309\ ohm$ -- **(1/2 Mark)** **iii) Impedance Z =** $\text{Im}\,pedance\ Z = \sqrt{(R)^2 + (X_l - Xc)^2}$ ------------------------------------- **(1/2 Mark)** $\text{Im}\,pedance\ Z = \sqrt{(10)^2 + (3.1415 - 31.8309)^2}$ $\text{Im}\,pedance\ Z = 30.37\ ohm$ -- **(1/2 Mark)** **iv) To Find Current=** $I = \frac{V}{Z}, = \frac{230}{30.37}$ -- **(1/2 Mark)** $I = 7.573\ Amp$ -- **(1/2 Mark)**
d)	**Draw the phasor diagram of R-L-C series circuit when (i) $X_L > X_c$ (ii) $X_L = X_c$ (iii) $X_L < X_c$**
Ans:	**(R-L-C series circuit- 1 Marks, Phasor diagram-3 Mark)** **R-L-C Series circuit with phasor diagram :-**  **or Equivalent fig.**

Phasor Diagram:

i) $X_L > X_C$ (lagging) **ii) $X_C > X_L$ (leading)** **iii) $X_L = X_C$ (UPF)**







e) **A series R-L circuit takes a current of 2 A when connected to 200 V, 50 Hz a.c. supply and consumes 300 watts. Calculate resistance, inductance, impedance and power factor.**

Ans:

Given Data:

I = 2 A, V = 200V, f = 50 Hz, and P = 300 watt

i) Impedance Z :

$$\therefore Z = \frac{V}{I} = \frac{200}{2}$$ --------------------------- **(1/2 Mark)**

$$\therefore Z = 100\ \Omega$$ --------------------------- **(1/2 Mark)**

ii) Resistance R :

$$\therefore Cos\varphi = \frac{R}{Z} \quad \therefore \quad R = Cos\varphi \times Z = 0.75 \times 100 -$$ ------------------------- **(1/2 Mark)**

$$\therefore \quad R = 75\,\Omega -$$ ----------------------- **(1/2 Mark)**

iii) Inductance L :

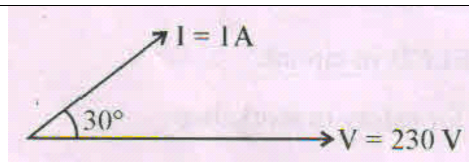
$$\therefore X_L{}^2 = Z^2 - R^2 -$$ -------------------------- **(1/2 Mark)**

$$\therefore X_L = \sqrt{Z^2 - R^2}$$

$$\therefore X_L = \sqrt{(100)^2 - (75)^2}$$

$$\therefore X_L = 66.14\ \Omega$$

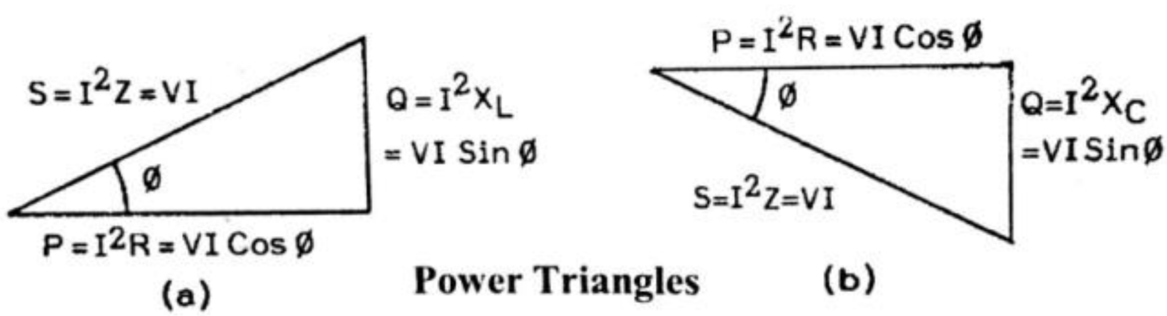
$$\therefore X_L = 2\,\pi\,F\,L \qquad \therefore\ L = \frac{X_L}{2\pi\,F}$$

	$\therefore\ L = \dfrac{66.14}{2\pi \times 50}$
	$\therefore\ L = 0.210\ H$ -------------------------- **(1/2 Mark)**
	iv) Power Factor :
	$\therefore P = V\ I\ Cos\ \phi$ - -------------------------- **(1/2 Mark)**
	$\therefore Cos\ \varphi = \dfrac{300}{200 \times 2}$
	$\therefore Cos\ \varphi = 0.75\ lag$ -------------------------- **(1/2 Mark)**
f)	**For below shown phasor diagram of R-L-C series circuit find (i) Impedance(ii) Power factor (iii) Power consumed (iv) Nature of circuit**
Ans:	
	i) Impedance Z :
	$\therefore Z = \dfrac{V}{I} = \dfrac{230}{1}$ -------------------------- **(1/2 Mark)**
	$\therefore Z = 230\ \Omega$ -------------------------- **(1/2 Mark)**
	ii) Power Factor :
	$\therefore Cos\varphi = Cos\,(30)$ ------------------------ **(1/2 Mark)**
	$\therefore Cos\ \varphi = 0.866\ leading$ ------------------------- **(1/2 Mark)**
	iii) Power Consumed P :
	$\therefore P = V\ I\ Cos\ \phi$ -------------------------- **(1/2 Mark)**
	$\therefore P = 230 \times 1 \times 0.866$
	$\therefore P = 199.18\,Watt$ -------------------------- **(1/2 Mark)**
	iv) Nature of Circuit : Capacitive -------------------------- **(1 Mark)**

Q.3 **Attempt any FOUR of the following : 16 Marks**

a) **Draw the power triangle and define active power. Reactive power and apparent power.**

Ans: **Power triangle:** **(1 Mark)**



Power Triangles

i) Active Power (P):- **(1 Mark)**

The active power is defined as the average power P_{avg} taken by or consumed by the given circuit.

$P = V.I.Cos\phi$ **Unit: -** Watt **OR** Kilowatt

ii) Reactive Power (Q):- **(1 Mark)**

The reactive power is defined as the product of V, I and sine of angle between V and I i.e. ϕ

Q= V.I. sin ϕ

Units: - VAR **OR**KVAR

iii) Apparent Power (S): **(1 Mark)**

This is simply the product of RMS voltage and RMS current.

Unit: volt-ampere (VA) or kilo-volt-ampere (kVA)

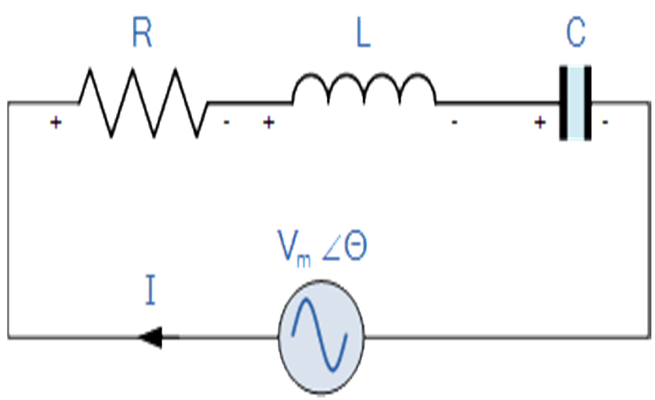
or Mega-vol-ampere (MVA)

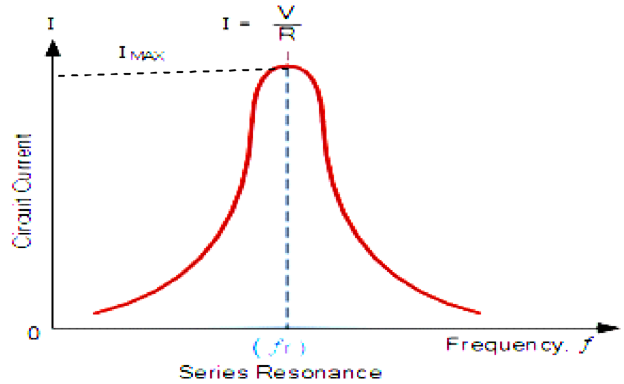
$S = VI = I^2Z$ volt-amp

b) **Give the significance of power factor. Write down the power factor for purely inductive, capacitive and resistive circuit.**

Ans: **Significance of Power factor: (Any two point expected)** **(2 Mark)**

1. P.F. increases current reduce so; cross section of conductor decreases hence its cost is educes.
2. P.F. increases current reduce so, cross section of conductor decreases hence weight

	decreases. So design of supporting structure becomes lighter. 3. Copper losses Decreases, Hence transmission efficiency increases. 4. Voltage drop reduces, hence voltage regulation becomes better 5. Handling capacity (KW) of each equipment increases as p.f. increases. 6. Less capacity (KVA) rating of equipments arerequired so capital cost decreases. 7. Cost per unit (KWH) decreases. **Write down the power factor for purely inductive, capacitive and resistive circuit.** (2 Mark) i) Purely inductive: Zero (lag) ii) Purely Capacitive: Zero (lead) iii) Purely Resistive: 1
c)	**State the condition for resonance. Write about the value of current during series resonance. Show the graphical representation of current in series resonance circuit.**
Ans:	1. **Condition for resonance:** (2 Mark)  In a series RLC circuit theSeries Resonance occurs at point were the inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor. In other words**, XL = XC.** 2. **Value of current during series resonance.** (1 Mark) **Current** during series resonance is **maximum** as value of impedance is equal to resistance in the circuit.

	3. Graphical representation of current: **(1 Mark)**  or equivalent circuit
d)	**Define resonant frequency and Q-factor. Give relation of each.**
Ans:	**i) Resonant frequency:** **(2 Marks)** In a series RLC circuit there becomes a frequency point were the inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor. In other words, XL = XC. The point at which this occurs is called the **Resonant Frequency.** $$f = \frac{1}{2\pi\sqrt{LC}}$$ Where f = Resonant Frequency. L = Inductance in Henery. C = Capacitance in farads. **ii) Q-factor:** **(2 Marks)** In series circuit it is defined as voltage magnification in the circuit at resonance. **OR** In parallel circuit it is defined as equal to the current magnification in the circuit at resonance **Expression of Q Factor**: $Q\ factor = \frac{1}{R} \times \sqrt{\frac{L}{C}}$
e)	**List the advantages of 3-ph supply over single phase (any four).**
Ans:	**Advantages of 3-phase supply over 1-phase supply:** **(Any Four points each point 1 Mark)** 1. **More output:-** for the same size output of poly-phase machines is always higher than single phase machines. 2. **Smaller size:-**for producing same output the size of three phase machines is always smaller than that of single phase machines.

	3. **More power is transmitted-** it is possible to transmit more power using a three phase system than single system. 4. **Smaller cross-sectional area of conductors-** if the same amount of power is transmitted then the cross-sectional area of the conductors used for three phase system is small as compared to that of single phase system. 5. Better power factor-power factor of three phase machines is better than that of single phase machines. 6. Three phase motors are self starting-three phase ac supply is capable of producing a rotating magnetic field when applied to stationary windings, the three phase ac motors are self starting. While single phase induction motor needs to use additional starter windings 7. Horse power rating of three phase motors is greater than that of single phase motor. 8. Power delivered by asingle phase system fluctuates whereas for three phase system power delivered to the load is the same at any instant.
f)	**Give relation between line and phase current, line and phase voltage for 3-ph balanced (i) Star connected and (ii) Delta connected load.**
Ans:	**(i) Star connected:** **(2 Mark)** **a)** The relation between line current and phase current in star connected load. $I_L = I_{ph}$ **b)**The relation between line voltage and phase voltage in star connected Load $V_L = \sqrt{3}\, V_{Ph}$ **(ii) Delta connected load:** **(2 Mark)** **a)** The relation between line current and phase current in delta connected circuit. $I_L = \sqrt{3}\ \ I_{ph}\ \ OR\ \ I_{ph} = I_L / \sqrt{3}\quad where\ I_L\ is\ line\ Current\ and\ I_{ph}\ is\ phase\ Currnts$ **b)** The relation between line voltage and phase voltage in delta connected circuit $V_{ph} = V_L\quad where\ V_L = line\ voltage\ \&\ Vph = Phase\ volatge$

Q.4	**Attempt any FOUR of the following : 16 Marks**	
a)	**Three impedances of (4 + 3j) ohms each are connected in star to a 3-ph, 440 V, 50 Hz balance a.c. supply. Calculate line voltage, phase voltages, line current phase current, power factor and power.**	

Ans: **Solution:-**

i) line voltage V_L = 440 Volt -------------------------------- **(1/2 Mark)**

In Star connection $V_{Ph} = \frac{V_L}{\sqrt{3}}$

ii) Phase voltage V_{ph} = 440 Volt

$V_{Ph} = \frac{440}{\sqrt{3}} = 254.034 \ \ volt$ -- **(1/2 Mark)**

iii) Phase current (I_{ph}) ;

$Phase\ current\ \ (I_{Ph}) = \frac{V_{Ph}}{Z_{Ph}}$ ------------------------------------ **(1/2 Mark)**

$Phase\ current\ \ (I_{Ph}) = \frac{254.034}{(4+3j)} = \frac{254.034}{5\angle 36.86}$

$Phase\ current\ \ (I_{Ph}) = 50.80\angle -36.86$ -------------------------- **(1/2 Mark)**

iv) Line current (I_{line}) ;

Phase current is equal to line current :-

$\therefore Line\ \ current\ \ (I_L) = 50.80\angle -36.86$ ---------------------------- **(1/2 Mark)**

v) Power factor.

$\therefore\ \ Power\ \ \ factor = Cos\phi = Cos\ (-36.86)$

$\therefore\ \ Power\ \ \ factor = Cos\phi = 0.80\ \ lagging$ ---------------------------- **(1/2 Mark)**

vi) Power:

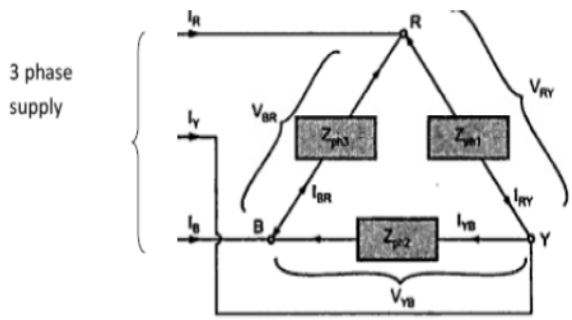
$P\ \ = 3 * V_{ph} * I_{ph} * \cos\theta$ ------------------------------------ **(1/2 Mark)**

$P\ \ = 3 * 254.034 * \ 50.80 * 0.8$

$P\ \ = 30971.82\ watt$---- -------------------------------- **(1/2 Mark)**

b) **Draw delta connected 3-ph load and show line and phase voltages and current on it.**

Ans: **Draw the connection diagram:-** (Diagram : 2 Marks)

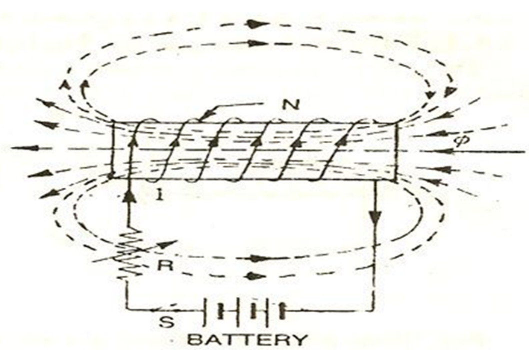


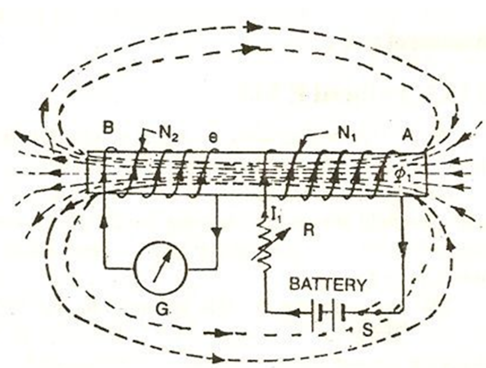
OR **equivalent diagram**

1. Line voltages = Phase voltages (1 Mark)
2. Line currents = I_R, I_Y, and I_B. (1/2 mark)
3. Phase currents = I_{RY}, I_{YB}, and I_{BR}. (1/2 mark)

c) **Explain self induced emf, mutually induced emf and dynamically induced emf.**

Ans: **Figure:-** (1 Mark)





OR

i) Self inducedemf : (1 Mark)

Self-induced emf is the e.m.f induced in the coil due to the change of flux produced by linking it with its own turns. This phenomenon of self-induced emf

$$e \,\alpha\, \frac{dI}{dt} \;or\; e = L\,\frac{dI}{dt}$$ **OR**

In the Statically induced emf flux linked with coil or winding changes (dΦ/dt) and coil or winding is stationary such induced emf is called Statically induced emf

$$E = -\,N\,(d\Phi/dt)$$

	ii) mutually induced emf : **(1 Mark)** The emf induced in a coil due to the change of flux produced by another neighbouring coil linking to it, is called **Mutually Induced emf.** $e_m \; \alpha \; \frac{dI_1}{dt} or \;\; e = M \; \frac{dI_1}{dt}$ **iii) Dynamically induced emf:** **(1 Mark)** If flux linking with a particular conductor is brought about by moving the coil in stationary field or by moving the magnetic field w.r.t. to stationary conductor. Then the e.m.f. induced in coil or conductor is known as "Dynamically induced e.m.f. E = B l. v. sinθ volts
d)	**State Fleming's right hand rule and write down formula for energy stored in magnetic field.**
Ans:	**1. Fleming's Right Hand Rule:** **(2 Mark)** Arrange three fingers of right hand mutually perpendicular to each other, if the first figure indicates the direction of flux, thumb indicates the direction of motion of the conductor, then the middle finger will point out the direction of inducted current. **2. Formula for energy stored:** **(2 Mark)** The formula for the energy stored in a magnetic field is $\boldsymbol{E = \frac{1}{2} LI^2}$ **Joules**
e)	**Define regulation and efficiency of transformer. Which transformer will he said to be a quality transformer one with regulation 2% or the other with regulation 4% ?**
Ans:	**i) Efficiency:-**It is the ratio of output power to the input power of the transformer. **(1 Mark)** **OR** $Transmission \;\; Efficency \; = \frac{Output \; power \;\; at \; receiving \;\; end}{Input \; power \;\; at \; sending \;\; end} \times 100$ - $\eta_T \% = \frac{Output \; (P_R) \; (Load(power) \; at \; reciving \; end)}{Output \; (P_R) + Total \; losses} \times 100$ **Where, P_R is o/p power at receiving end** **OR**

% Efficiency = $\frac{P_R}{P_R + I^2 R_T} \times 100$ ------ $for - 1 - Phase$ $Where,\ R_T\ is\ total\ resistance$

OR

% Efficiency =

$\frac{P_R}{P_R + 3 I^2 R_{ph}} \times 100$ ------ $for - 3 - Phase$ $Where,\ R\ is\ resistance\ of\ per\ phase$ **OR**

% Efficiency = $\frac{output\ power}{output\ power + total\ copper\ losses} \times 100$ **(1 Mark)**

----

ii) Voltage Regulation: **(1 Mark)**

Voltage regulation is nothing but voltage drop in transmission line expressed in % of receiving end voltage

OR

It is the change in terminal voltage from No Load to Full Load expressed in % of No Load voltage.

% Regulation = $\frac{V2\ No\ Load - V2\ Full\ Load}{V2\ No\ Load}$x100

OR

% Regulation = $\frac{Sending\ End\ Voltage - Receiving\ End\ Voltage}{Receiving\ End\ Voltage} \times 100$

% Voltage Regulation = $\frac{V_S - V_R}{V_R} \times 100$ ------------------- **for 1-phase**

Where, V_R = receiving end voltage V_S = Sending end voltage

$\%\ Regulation = \frac{I_R(R_T\ Cos\phi_R \pm X_T\ Sin\phi_R)}{V_R} \times 100$ ------------ **For 1-phase**

Where, R_T = Total resistance & X_T = Total reactance

Where,"+ ve" sign is used when Power factor is lagging.

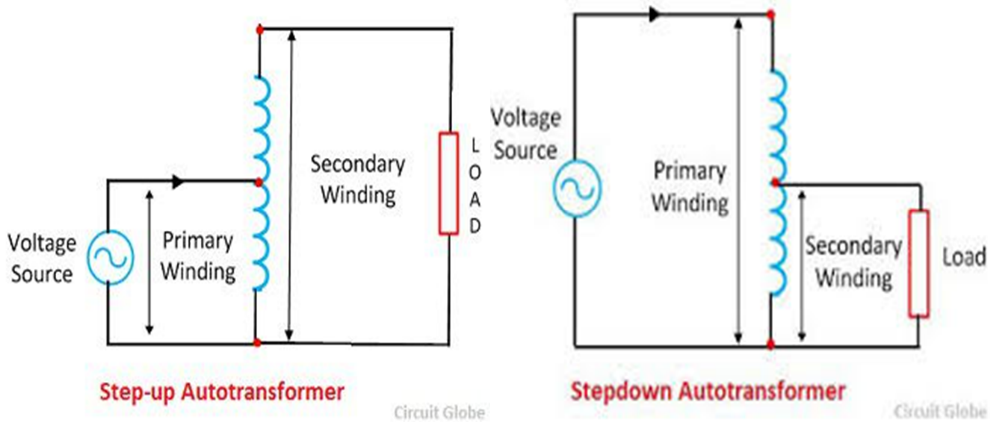
"- ve" sign is used when Power factor is Leading.

Which transformer will he said to be a quality transformer one with regulation 2% or the other with regulation 4%: **(1 Mark)**

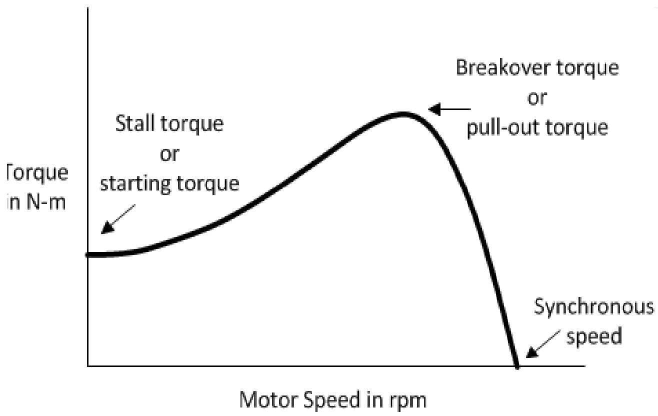
- 2% regulation is said to be better for a quality transformer.

f)	**Write down one application of each transformer:(i) Audio freq. (iii) Intermediate freq. (ii) Radio freq. (iv) Pulse transformer**	
Ans:	**i) Application Audio frequency Transformer:** **(Any One expected 1 Mark)** 1) Speakers 2) Tannoy's or other such sound actuators **ii) Application Radio frequency Transformer:** **(Any One expected 1 Mark)** 1. Radio Frequency transformers carry radio frequency (RF) signals ranging from about 3 kHz to 300 GHz. 2. RF transformers are typically low-power devices used for impedance matching. **iii) Application Intermediate frequency Transformer:** **(Any One expected 1 Mark)** 1. Long wave broadcast receivers 2. Analogue television receivers using system 3. FM radio receivers 4. AM radio receivers 5. Satellite uplink-downlink equipment 6. Terrestrial microwave equipment 7. Radar 8. RF Test Equipment **iv) Application Pulse Transformer:** **(Any One expected 1 Mark)** 1. For changing the amplitude of voltage pulse 2. For inverting the polarity of the pulse 3. For coupling different stages of pulse amplifier 4. As an Isolation Transformer 5. Digital circuits, Telecommunication	
Q.5	**Attempt any FOUR of the following :16 Marks**	
a)	**A 1.5 kVA, 230/110 V, 50 Hz single phase transformer has 80 turns on secondary winding. Calculate number of primary turns full load primary and secondary currents.**	
Ans:	$V_I = 230\,V \quad V_2 = 110\,V \quad N_I = ? \quad N_2 = 80 \quad I_1 = ? \quad I_2 = ?$ **i) To Find full load Primary current I_1:-** $I_1 = \frac{KVA \times 10^3}{V_1 \; volt}$ -- **(1/2 Mark)**	

	$$I_1 = \frac{1.5\times10^3}{230}$$ $$I_1 = 6.52\ Amp$$ -- **(1/2 Mark)** **ii) To Find full load Secondary I_2:** $$I_2 = \frac{KVA\times10^3}{V_2\ volt}$$ …………………….……………. **(1/2Mark)** $$I_2 = \frac{1.5\times10^3}{110}$$ $$I_2 = 13.63 Amp$$ -- **(1 Mark)** **iii) Number of primary winding turns N_1:** $$\frac{V_2}{V_1} = \frac{N_2}{N_1} \text{ OR } \frac{V_1}{V_2} = \frac{N_1}{N_2},$$ $$N_1 = \frac{V_1}{V_2}\times N_2$$ --- **(1/2 Mark)** $$N_1 = \frac{230}{110}\times 80$$ $$N_1 = 167.27\ turns$$ ---**(1 Mark)**
b)	**State the emf equation of a single phase transformer. Write meaning of each term.**
Ans:	➢ **EMF equation of Transformer:-** **(4 Marks)** **Let, N_1=** Number of turns in the primary **N_2=** Number of turns in the Secondary **Øm=** Maximum flux in core (wb)= BmxA **F =** Frequency E_1 = 4.44 f $\phi m N_1$ **E_1 = 4.44 f BmAN$_1$** Secondary winding: E_2 = 4.44 f $\phi m N_2$ **E_2 = 4.44 f Bm A N$_2$**

c)	**Can auto transformer be used as step up and step down transformer? If yes, show the circuits.**
Ans:	Yes, auto transformer can be used as a step up and step down transformer.----------- **(1 Mark)** **Circuits Diagram:** **(3 Marks)** 
d)	**Explain the working principle of 3-ph I.M.**
Ans:	**Working principle of 3-phase induction motor:** **(Working principle:4 Mark)** ➢ When 3-phase stator winding is energized from a 3-phase supply, a rotating magnetic field is set up in air gap which rotates round the stator at synchronous speed Ns (= 120 f/P). ➢ The rotating field passes through the air gap and cuts the rotor conductors, which as yet, are stationary. ➢ Due to the relative speed between the rotating flux and the stationary rotor, e.m.f.sare induced in the rotor conductors. ➢ Since the rotor circuit is short-circuited, currents start flowing in the rotor conductors. ➢ The current-carrying rotor conductors are placed in the magnetic field produced by the stator. ➢ Consequently, mechanical force acts on the rotor conductors. ➢ The sum of the mechanical forces on all the rotor conductors produces a torque which tends to move the rotor. ➢ In the same direction as the rotating field according to Lenz's law.

e)	**Draw the torque-speed characteristics of 3-ph I.M. Explain about the nature.**
Ans:	**Torque-Speed characteristics :** **(Characteristics -2 Marks & Explanation:- 2 Mark)**



Speed-Torque Curve for a Three-Phase Induction Motor

or Equivalent fig

Explanation: From the above characteristics:-

- When Slip (S) $\cong 0$ (i.e $N \cong Ns$) torque is almost zero at no load, hence characteristics start from origin
- As load on motor increases Slip increases and therefore torques increases.
- For lower values of load, torque proportional to slip, and characteristics will having linear nature.
- At a particular value of Slip, maximum torque conditions will be obtained which is $R_2 = SX_2$
- For higher values of load i.e. for higher values of slip, torque inversely proportional to slip and characteristics will having hyperbolic nature. In short breakdown occurs due to over load.
- The maximum torque condition can be obtained at any required slip by changing rotor resistance.

f)	**Define synchronous speed. Write down the formulas for slip, slip speed, rotor frequency.**
Ans:	**Synchronous Speed:-** **(Definition: 1 Mark)**

It is speed at which rotating magnetic field rotates in induction motor. **OR**

$$N_S = \frac{120\ f}{P}$$

Where,

$N_S = Syncronous\ \ speed \qquad f = Supply\ of\ \ frequency \quad and \quad P = Number\ of\ \ Pole$

Synchronous Speed unit:

Unit : RPM or RPS

i) Slip:- **(1 Mark)**

It is the ratio the difference between the synchronous speed and actual speed of the rotor to synchronous speed.

It is expression in percentage =

$$\text{Slip} = \frac{N_S - N}{N_S}$$

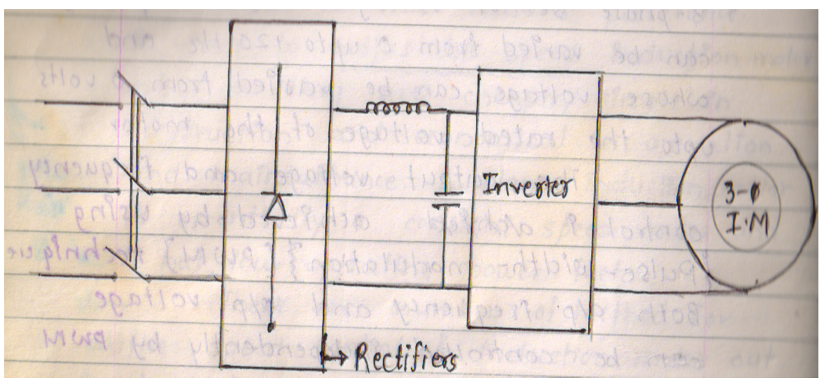
ii) Slip Speed:- $Ns - N$ **Unit : RPM or RPS** **(1 Mark)**

iii) Rotor Frequency:- $S.f$ **Unit : Hertz** **(1 Mark)**

Q.6 Attempt any FOUR of the following : 16 Marks

a) Explain the speed control method of 3-Ph I.M. using variable frequency drive using thyristor.

Ans: **By Voltage/ frequency control (V/f) method:** **(Figure : 2 Mark & Explanation: 2 Mark)**



- If the ratio of voltage to frequency is kept constant, the flux remains constant.
- The maximum torque which is independent of frequency can be maintained approximately constant.
- However at a low frequency, the air gap flux is reduced due to drop in the stator impedance and the voltage has to be increased to maintain the torque level.
- This type of control is usually known as Volts/ Hertz or V/f control.
- A simple circuit arrangement for obtaining variable voltage and frequency is as shown in the above figure.

b) **Write down the constructional difference between squirrel cage and slip ring 3-ph I.M.**

Ans: **(Any four point expected: 1 Mark each)**

S.No	3-phase squirrel cage I.M	Slip ring 3-Ph I.M
1	Rotor is in the form of bars	Rotor is in the form of 3-ph winding
2	No slip-ring and brushes	Slip-ring and brushes are present
3	External resistance cannot be connected in the rotor circuit	External resistance can be connected in the rotor circuit
4	Small or moderate starting torque	High Starting torque
5	Starting torque is of fixed	Starting torque can be adjust
6	Simple construction	Completed construction
7	High efficiency	Low efficiency
8	Less cost	More cost
9	Less maintenance	Frequent maintenance due to slip-ring and brushes.
10	Starting power factor is poor	Starting power factor is adjustable & large
11	Size is compact for same HP	Relatively size is larger
12	Speed control by stator control method only	Speed can be control by stator & rotor control method

c) **Explain the working principle of stepper motor. Mention its types. Write any two applications.**

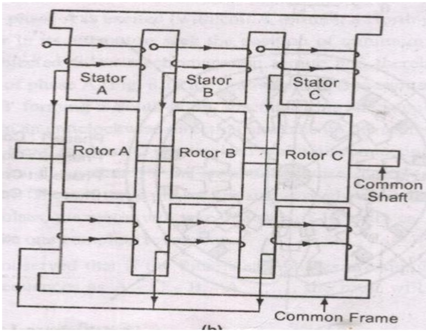
Ans: **Working Principle of stepper Motor-** **(1 Mark)**

A stepper motor rotates through a fixed angular step in response to each input current pulse received by its controller**.**

Types of Stepper Motor :- **(2 Mark)**

1) Variable Reluctance Motor
2) Permanent Magnet Motor

1) Variable Reluctance Motors:- **(Explanation not compulsory)**



or equivalent dia.

Working:-

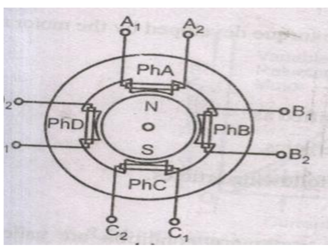
When phase A is excited rotor attempts minimum reluctance between stator and rotor and is subjected to an electromagnetic torque and there by rotor rotates until its axis coincides with the axis of phase A.

Then phase 'B' is excited disconnecting supply of phase 'A' then rotor will move 30 anticlockwise directions. The Same process is repeated for phase 'C'

In this way chain of signals can be passed to get one revolution and direction can be also changed.

OR

2) Permanent Magnet Motor:-



or equivalent dia.

Working :-

If the phase is excited in ABCD, due to electromagnetic torque is developed by interaction between the magnetic field set up by exciting winding and permanent magnet.

Rotor will be driven in clockwise direction.

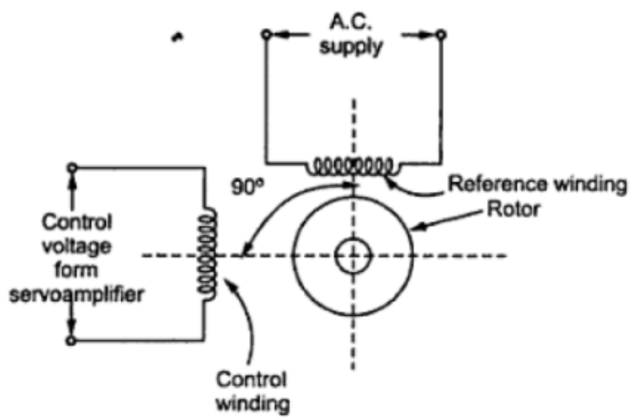
Applications of stepper motor- **(Two application expected-1 Mark)**

1.Suitable for use with computer controlled system
2. Widely used in numerical control of machine tools.
3. Tape drives
4. Floppy disc drives
5. Computer printers

6. X-Y plotters
7. Robotics
8. Textile industries
9. Integrated circuit fabrication
10. Electric watches
11. In space craft's launched for scientific explorations of planets.
12. In the production of science friction movies
13 Automotive
14. Food processing
15. Packaging

d) State the working principle of a.c. servo motor and draw its torque speed characteristics.

Ans: **Figure :** **(Figure : 1 Mark & Principle : 2 Mark)**



or equivalent figure

Principle of working of servo motor:

There are some special types of application of electrical motor where rotation of the motor is required for just a certain angle not continuously for long period of time. For these applications some special types of motor are required with some special arrangement which makes the motor to rotate a certain angle for a given electrical input (signal). Such motors can be ac or dc motors. When controlled by servo mechanisms are termed as servomotors.

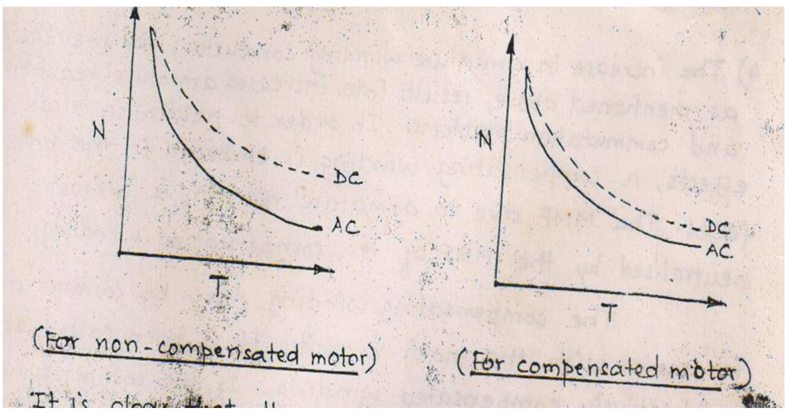
These consist of main and control winding and squirrel cage / drag cup type rotors. Vr is the voltage applied to the main or reference winding while Vc is that applied to control winding which controls the torque- speed characteristics. The 90^0 space displacement of the two coils/windings and the 90^0 phase difference between the voltages applied to them result in production of rotating magnetic field in the air gap due to which the rotor is set in motion. The power signals can be fed from servo amplifiers either to the field or armature depending upon the required characteristics.

OR

Working of AC Servomotor:

- The control Phase is usually supplied from a servo amplifier.
- The speed and torque of the rotor are controlled by the phase difference between the control voltage and the reference phase voltage.
- The direction of rotation of the rotor can be reversed by reversing the phase difference, from leading to lagging (or vice versa) between the control phase voltage and the reference phase voltage.

Torque -speed characteristics of A.C. Servo Motor: **(1 Mark)**



e) **Give the necessity of earthing. State the range of voltage between earth and neutral of healthy wiring.**

Ans: **Necessity of Earthing: (Any Two point are expected)** **(2 Mark)**

1. To provide an alternative path for the leakage current to flow towards earth.
2. To save human life from danger of electrical shock due to leakage current.
3. To protect high rise buildings structure against lightening stroke.
4. To provide safe path to dissipate lightning and short circuit currents.
5. To provide stable platform for operation of sensitive electronic equipments.

The range of voltage between earth and neutral of healthy wiring: **(2 Mark)**

For a healthy wiring the voltage between earth and neutral is considered to be zero volts.

f) **Write advantages of MCCB over fuse (any four).**

Ans: **(Any Four points expected: 1 Mark each point, Total: 4 Marks)**

S. No.	Particulars	MCCB	Fuse
1	Function	Circuit breakers perform switching operations (make and break operations) alone. Fault detection is made by protective relays	Fuse is used for the detection of fault as well as the interruption of circuit.
2	Principle of operation	Overload by bimetallic strip. SC by Solenoid using electromagnetic attraction force	The operation of electric fuses is based on the heating property of electric current.
3	Mode of operation	Manual operation. To make circuit breakers automatic, additional relay arrangements should be made.	Completely automatic
4	Additional equipments required	For automated operations additional relay arrangements should be needed.	No additional equipments are needed.
5	Operating time	Operating time of circuit breakers are more than that of the fuses. (0.02 -0.05 seconds)	Operating time of fuses is very small, close to 0.002 seconds.
6	Breaking capacity	Breaking capacity of circuit breaker is large.	Breaking capacity of fuses is small.
7	Operating current	0.5A to 63A	Few mA to A Small to medium
8	Size	Medium	Smallest
9	Running cost	Nil	Highest
10	type of connection	Only in phase	Only in phase

---END---