SUMMER– 2017 Examinations

Model Answer **Subject Code: 17318 (EEG)**

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.

SUMMER– 2017 Examinations
Model Answer **Subject Code: 17318 (EEG)**

1 Attempt any TEN of the following: 20

1 a) Define i) Form factor ii) Peak factor.

Ans:

i) Form Factor:

It is defined as the ratio of RMS value to average value of an alternating quantity. 1 mark

Form factor $= \frac{RMS\,Value}{Average\,Value}$

ii) Peak Factor:

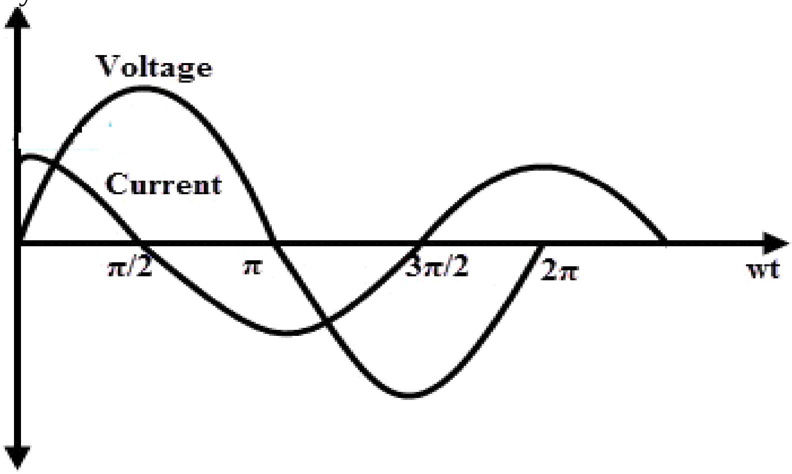
It is defined as the ratio of the peak or crest value to the RMS value of an alternating quantity. 1 mark

Crest factor $= \frac{Peak\,Value}{RMS\,Value}$

1 b) Draw the waveforms of voltage and current of pure capacitive circuit.

Ans:

In pure capacitive circuit, the voltage lags behind current by 90° or the current leads the voltage by 90°.



2 marks for labeled diagram

1 mark for unlabeled diagram

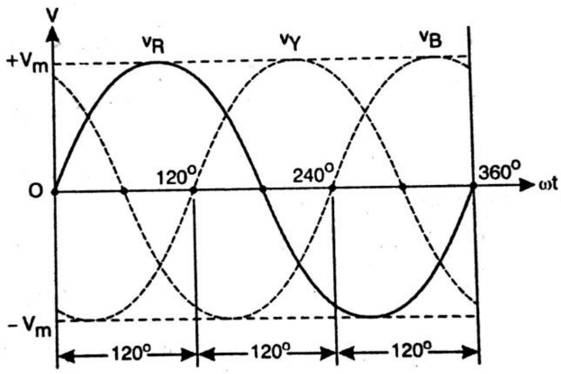
1 c) Define phase sequence in 3-phase ac supply.

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. 1 mark for definition

In the 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



1 mark for waveform

sequence is R-Y-B.

1 d) Define the bandwidth of a series resonant circuit and give expression of the same.

Ans:

Bandwidth of a series resonant circuit:

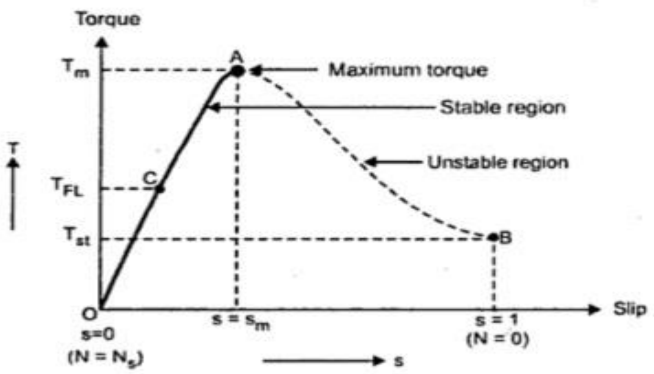
The bandwidth of the series resonant circuit is defined as the range of frequencies in which the rms magnitude of the current is equal to or greater than $\frac{1}{\sqrt{2}}$ times its maximum rms value at resonance. 1 mark

The bandwidth is given by, $B = \omega_2 - \omega_1 = \frac{R}{L}$ 1 mark

1 e) Draw Torque – Slip characteristics of induction motor.

Ans:

Torque – Slip characteristics of 3 phase induction motor:



2 marks for labeled diagram

1 mark for unlabeled diagram

1 f) State specification and two applications of Isolation transformer.

Ans:

Specifications of isolation transformer:-

- Power rating,
- Input voltage range,
- Load regulation,
- Frequency of input,
- Efficiency,
- Insulation resistance ,
- Ambient temperature ,
- Operating humidity,
- Audible noise

½ mark for each of any two = 1 mark

Applications of isolation transformer:-

1) Electronic testing
2) In pulse circuit
3) Analytical instruments
4) Power adapters for laptop computers
5) In UPS systems
6) Communication equipment

½ mark for each of any two = 1 mark

7) CNC machines
8) Medical instruments

1 g) State Fleming's Right hand rule.

Ans:

Fleming's Right Hand Rule:

Arrange the first three fingers of right hand such that they are mutually perpendicular to each other. If the first finger indicates the direction of flux, thumb indicates the direction of motion of the conductor with respect to magnetic field, then the middle finger points the direction of inducted emf / current. 2 marks for correct ans

1 h) State an electric motor for table fan.

Ans:

1. Split Phase induction Motor
2. Capacitor Start Induction Motor
3. Capacitor Start capacitor run induction Motor
4. Permanent Split Capacitor (PSC) Motor
5. Universal motor
6. Shaded pole type induction motor

2 marks for any one

Any of the above motors can be used for table fan.

1 i) Give classification of types of wires used in electrical installation.

Ans:

Types of wires used in electrical installation:

1) CTS (Cab Tyre Sheathed) or TRS (Tough Rubber Sheathed) wire
2) VIR (Vulcanized India Rubber) wire
3) PVC (Polyvinyl chloride) wire
4) Flexible wire

1 mark for each of any two types

1 j) Give any two differences between A. C. and D. C. Quantity.

Ans:

Sr. No.	Ac quantity	Dc quantity
1	It reverses its direction or polarity.	Its direction or polarity does not change or reversed.
2	The magnitude continuously varies with respect to time	The magnitude of the quantity is constant. .
3	The frequency of alternating quantity is non-zero, e.g 50 Hz.	The frequency of D. C. quantity is zero.

1 mark for each of any two differences = 2 marks

1 k) List the factors considered for selection of intermediate frequency transformer.

Ans:

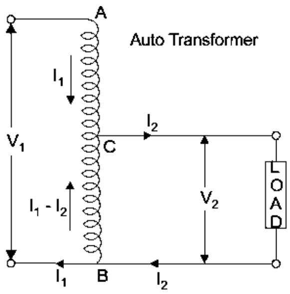
Factors to be considered for selection of intermediate frequency transformer:

1) Output frequency or range of frequency
2) Input impedance

3) Output impedance 4) Voltage gain 5) Power gain 6) Frequency ratio 7) Selectivity	½ mark for each of any four factors = 2 marks

1 l) Draw neat constructional sketch of auto transformer.

Ans:



OR

Any other equivalent diagram

2 marks for labeled diagram

1 mark for unlabeled diagram

1 m) List the speed control methods of 3 phase induction motors.

Ans:

Speed control methods of 3 phase induction motor:

1) By Varying applied frequency (Frequency control) 2) By varying applied voltage (Stator voltage control) 3) Rotor resistance control. 4) By varying number of poles of the stator winding (Pole Changing) 5) By Voltage/ frequency control (V/f) method	½ mark for each of any four = 2 marks

1 n) Alternating current is given by i = 28.28 sin (2π 50×t). Find R.M.S value of current.

Ans:

R.M.S Value of current = $I_{max} \times 0.707$ — 1 mark

= $28.28 \times 0.707 = 19.99$ amp — 1 mark

2 Attempt any FOUR of the following: 16

2 a) Equations for voltage and current in a circuit are given by:

$v = V_m \sin(\omega t)$

$i = I_m \sin(\omega t + 90°)$

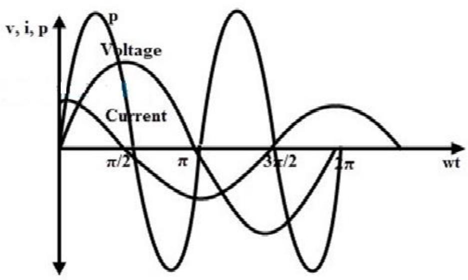
State what type of circuit is it? Draw waveform of voltage, current and power for the circuit.

Ans:

Type of circuit:

Purely <u>Capacitive</u> circuit, as current is leading voltage by 90°. — 1 mark for type

Waveforms for Voltage, Current and Power:



1 mark for each of three waveforms = 3 marks

2 b) Explain why 1- ϕ I. M. (induction motors) do not have starting torque.

Ans:

When single phase AC supply is given to main winding, it produces alternating flux. According to double field revolving theory, alternating flux can be represented by two opposite rotating fluxes of half magnitude. These oppositely rotating fluxes induce current in rotor & there interaction produces two opposite torques, hence the net torque is Zero and the rotor remains standstill. Hence Single-phase induction motor does not have starting torque. — 4 marks for correct reason

OR

Single phase induction motor has distributed stator winding and a squirrel-cage Rotor. When fed from a single-phase supply, its stator winding produces a flux (or field) which is only alternating i.e. one which alternates along one space axis only. It is not a synchronously revolving (or rotating) flux as in the case of a two or a three phase stator winding fed from a 2 or 3-phase supply. Now, alternating or pulsating flux acting on a stationary squirrel-cage rotor cannot produce rotation (only a revolving flux can produce rotation). That is why a single phase motor does not have starting torque.

2 c) Explain the necessity of earthing.

Ans:

Necessity of earthing:

Earthing of metallic cover provides a low resistive path for the leakage currents, which are due to accidental unwanted connection of electrically live conductor to metallic cover. Due to earthing, the metallic cover is maintained to ground/earth potential, thereby it protects human from shocks, as leakage current flows through earthing wire and not through the body of person touching the metallic cover. Earthing ensures safety and Protection of electrical equipment and Human by discharging the electrical leakage current to the earth. Therefore earthing is necessary. — 4 marks for correct answer

2 d) Define and explain the meaning of Q-factor and give expression for Q-factor in RLC series circuit.

Ans:

Quality Factor (Q-factor):

The quality factor basically represents a figure of merit of a component (practical inductor or capacitor) or a complete circuit. — 1 mark for explanation

It is a dimensionless number and expressed as: $Q = 2\pi\left[\frac{Maximum\ energy\ stored}{Energy\ dissipated\ per\ cycle}\right]$ — 1 mark for equation

OR

In series circuit it is defined as voltage magnification in the circuit at resonance

OR

It is also defined as the ratio of the reactive power of either the inductor or the capacitor to the average power of the resistor. 1 mark for definition

Expression of Q Factor:

$$Q\ factor = voltage\ magnification = \frac{1}{R}\sqrt{\frac{L}{C}}$$ 1 mark for expression

2 e) A delta connected balanced load has impedance of (3 + j4) Ω connected to a 230V, 3 ϕ, 50 Hz AC supply. Calculate value of line and phase currents, line and phase voltages, power consumed by each impedance and total power consumed.

Ans:

Z = 3+j4 ohm, R/ph = 3 ohm, X_L/ph = 4 ohm, Z = 5 ohm

cosϕ = R/Z = 3/5 = 0.6 — 1 mark for V_L and V_{ph}

In delta connection, Line voltage = Phase voltage

$\therefore V_L = V_{ph}$

Therefore, **Line voltage = Phase voltage = 230 volt**

Phase current $I_{ph} = V_{ph}/Z = 230/5 =$ **46 amp** — 1 mark for I_{ph} and I_L

In delta connection, Line current = √3 x Phase current = √3 x 46 = **79.67 amp**

Power in each phase $P_{ph} = V_{ph}\ I_{ph} \cos\phi = 230 \times 46 \times 0.6 =$ **6348 watt** — 1 mark

Total Power consumed $P_T = \sqrt{3}\ V_L\ I_L \cos\phi = \sqrt{3} \times 230 \times 79.67 \times 0.6$

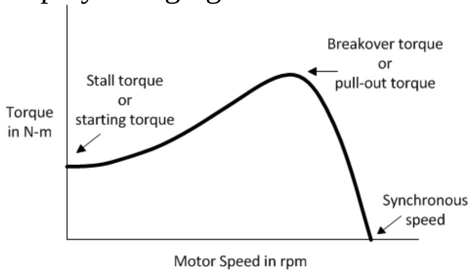
= **19042.96 watt** — 1 mark

2 f) Draw Torque- Speed characteristics of 3ϕ induction motor and explain.

Ans:

Torque- Speed characteristics of 3ph induction motor:

When slip (s) ≈ 0, the rotor speed is equal to synchronous speed (i.e N ≈ Ns), torque is almost zero at synchronous speed. As load on motor increases, speed decreases, slip increases and the torques increases. For lower values of load, torque is proportional to slip, and characteristic is having linear nature. At a particular value of slip, maximum torque is obtained at condition $R_2 = sX_2$. For higher values of load i.e. for higher values of slip, torque becomes inversely proportional to slip and characteristic becomes hyperbolic in nature. The maximum torque condition can be obtained at any required slip by changing rotor resistance. 2 marks for explanation



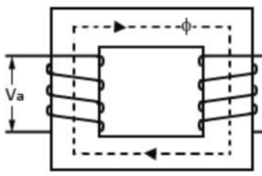
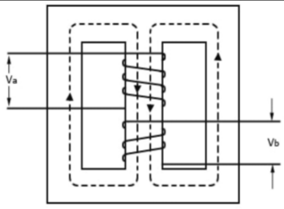
Speed-Torque Curve for a Three-Phase Induction Motor

2 marks for characteristic curve

3 Attempt any FOUR of the following: 16

3 a) Differentiate between core type and shell type transformer.

Ans:

Sr. No.	Core Type Transformer	Shell Type Transformer
1		
2	The Winding surrounds the core	The core surrounds the windings
3	Magnetic Flux has only one continuous path	Magnetic Flux is distributed into two paths
4	Suitable for high voltage & less output	Suitable for less voltage & high output
5	Easy for repairs	Difficult for repairs
6	Less in Weight	More in Weight
7	It has one window opening	It has two windows opening
8	Mechanical protection for core is less	Mechanical protection for core is More
9	Cooling is more	Cooling is not effective
10	Cylindrical winding is used	Sandwich type winding

1 mark for each of any four differences = 4 marks

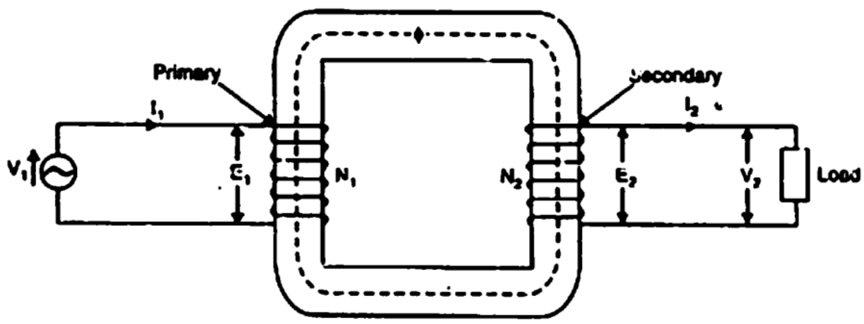
3 b) Explain the working principle of a single phase transformer.

Ans:

Working principle of a single phase transformer:

A transformer essentially consists of two windings, the primary and secondary, wound on a common laminated magnetic core as shown in Fig. The winding connected to the a.c. source is called primary winding (or primary) and the one connected to load is called secondary winding (or secondary). The alternating voltage V_1 whose magnitude is to be changed is applied to the primary. Depending upon the number of turns of the primary (N_1) and secondary (N_2), an alternating e.m.f. E_2 is induced in the secondary. This induced e.m.f. E_2 in the secondary causes a secondary current I_2. Consequently, terminal voltage V_2 will appear across the load.

2 marks for schematic diagram



2 marks for explanation of working principle

Working

When an alternating voltage V_1 is applied to the primary, an alternating flux ϕ is set up in the core. This alternating flux links with both the windings and induce e.m.f.s

E_1 and E_2 in them according to Faraday's laws of electromagnetic induction. The e.m.f. E_1 is termed as primary e.m.f. and e.m.f. E_2 is termed as secondary e.m.f. If the secondary or load circuit is closed, then the secondary emf E_2 delivers current I_2 through load

3 c) State the necessity of starter in case of three phase induction motor.

Ans:

Necessity of starter for three phase induction motor:

The three-phase induction motor has three-phase stator winding and short circuited rotor winding. The motor can be treated as rotating transformer with short circuited secondary as the power is transferred from stator (Primary) to rotor (short-circuited secondary) by electro-magnetic induction, just similar to transformer. 4 marks for correct answer

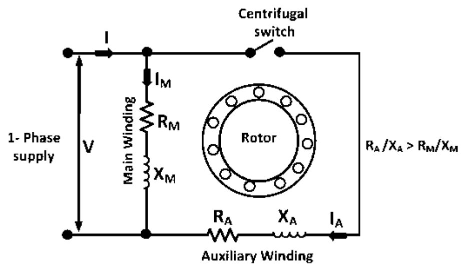
When the rotor is stationary and supply is given to three-phase stator winding, the three-phase currents in stator winding produce rotating magnetic field in the air-gap between stator and rotor. The rotating magnetic field rotates at synchronous speed with respect to stationary rotor. Therefore the relative motion between rotating magnetic field and stationary rotor winding is comparatively larger that that under running condition. The emf induced in the rotor winding is higher and circulates large currents in rotor winding as it is short-circuited. Due to transformer action, the larger current in rotor (secondary) is reflected on the stator (primary) side and it draws high current from the source. If this current persists for longer time, the stator winding may get damaged due to large i^2R loss and subsequent heating in stator winding. To limit this high starting current the starter is necessary for three-phase induction motor.

However, once motor starts running, the rotor rotates in the same direction as that of rotating magnetic field, resulting less relative motion between magnetic field and rotor. This ultimately reduces the emf induced in rotor and subsequently the rotor currents. The reflected rotor current on stator side also get reduced during running condition. Thus starter is needed only at the time of starting and not under running condition, hence termed as 'starter'.

3 d) Draw the schematic representation of split phase induction motor. State its applications.

Ans:

Schematic representation of split phase induction motor:



2 marks for diagram

Applications:

1. Centrifugal pumps
2. Blowers
3. Washing machine

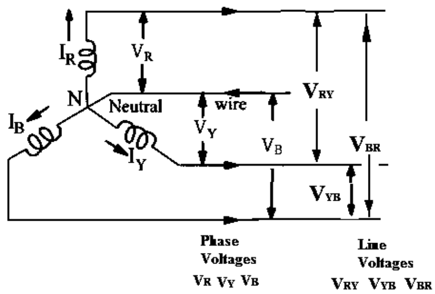
1 mark for

4. Air conditioning fans
5. Mixer grinder
6. Floor polishers
7. Drilling machine
8. Lathe machine

each of any two applications = 2 marks

3 e) Draw a 3 phase star connected supply system and state the relation between V_{ph} and V_L, I_{ph} and I_L. State an expression to determine power in the circuit.

Ans:



2 marks for diagram

Relation between line values and phase values for Star connection

Line voltage = √3 Phase voltage

$V_L = \sqrt{3} V_{ph}$ 1 mark

Line current = Phase current

$I_L = I_{ph}$

Expression for Power

Total 3-phase power,

$P = \sqrt{3}\ V_L\ I_L \cos\phi$ OR $P = 3\ V_{ph}\ I_{ph} \cos\phi$ 1 mark

3 f) Explain the phenomenon of resonance in R-L-C series circuit.

Ans:

Resonance in R-L-C series circuit:

The resonance of a series RLC circuit occurs when the inductive and capacitive reactances become equal in magnitude. As the frequency is increased from zero towards higher values, at a certain frequency f_r, $X_L = X_C$ and the net reactance of the circuit becomes zero. This is resonance condition. At resonance, the voltages across the inductive reactance and capacitive reactance (X_L and X_C) are equal but opposite. Resonance is the phenomenon in AC circuit in which circuit exhibits unity power factor or applied voltage and resulting current are in phase with each other. Under series resonance condition: $X_L=X_C$, 2 marks

Power factor is unity or 1 i.e. $\cos\phi = 1$ 2 marks

Impedance (Z) = Resistance (R)

Current is maximum

4 Attempt any FOUR of the following: 16

4 a) State four advantages of polyphase circuits over single phase circuits.

Ans:

Advantages of poly-phase (3-phase) circuits over Single-phase circuits:

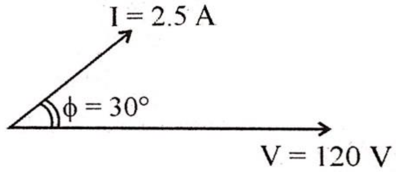
1. **More output:-** For the same size, output of poly-phase machines is always higher

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 transmission:-** 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. **Poly-phase motors are self-starting:-** Three-phase ac supply is capable of producing a rotating magnetic field when applied to stationary three-phase windings, thus three phase ac motors are self-starting. However, single phase induction motor needs to use additional starter winding.
7. **Smooth Operation, Less vibrations:-** Torque produced in three-phase machines is constant at particular operating conditions, hence machines run smoothly. However, the torque produced in single-phase machines is fluctuating, so motor causes large vibrations.
8. **Smooth Power delivery:-** The power is delivered to load smoothly by a three-phase machines whereas, single phase motors deliver fluctuating power to the load.

1 mark for each of any four advantages = 4 marks

4 b) For a phasor diagram shown in Fig., find (i) Impedance (ii) Power factor (iii) Total power (iv) Values of components connected in series. Assume f =50 Hz.



4 bits 1 mark each = 4 marks

Ans:

Current is leading hence it is RC series circuit.

(a) Power factor = cosine of angle between voltage and current

$= \cos\phi = \cos(30°) =$ **0.866 leading**

(b) Total Power $P = VI\cos\phi = 120 \times 2.5 \times 0.866 =$ **259.8 watts**

(c) Power $P = I^2R$ Therefore $R = P/I^2 = 41.568\ \Omega$

$\therefore$ **Resistance=41.568 Ω**

(d) Power factor $\cos\varphi = R/Z$ therefore $Z = R/\cos\phi = 41.568/0.866$

$\therefore$ **Impedance Z = 48 Ω**

(e) $X_C = \sqrt{(Z^2 - R^2)} = \sqrt{(48^2 - 41.568^2)} = 24.00\ \Omega$

$X_C = 1/(2\pi fC)$ Therefore $C = 1/(2\pi f X_C) = 1/(2\ \pi \times 50 \times 24.00)$

$\therefore$ **Capacitance C =1.32 F**

4 c) Compare statically induced emf to dynamically induced emf.

Ans:

Sr. No.	**Statically Induced emf**	**Dynamically induced emf**
1	The conductor is stationary and	When the emf is induced because

	magnetic field is changing, then the emf induced is called statically induced emf. This emf is induced without any relative motion between conductor and magnetic field.	of relative motion between conductor and magnetic field, then such emf is called dynamically induced emf. In this case the conductor cuts the magnetic field due to relative motion between them.	1 mark for each point = 4 marks
2	Direction of statically induced emf is given by Lenz's Rule.	Direction of dynamically induced emf is given by Fleming's Right Hand Rule	
3	Power transformation is highly efficient.	Power transformation is comparatively less efficient.	
4	Example: Transformer	Example: Generator, Alternator	

4 d) State different types of powers in Electrical Circuit. Draw power triangle and write units for each power.

Ans:

Powers in Electrical Circuits:

(i) Apparent Power (S):

This is simply the product of RMS voltage and RMS current. 1 mark

Unit: volt-ampere (VA) or kilo-volt-ampere (kVA)
or Mega-vol-ampere (MVA)

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

(ii) Active Power or Real Power or True Power (P):

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

Unit: watt (W) or kilo-watt (kW) or Mega-watt (MW)

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

(iii) Reactive Power or Imaginary Power (Q):

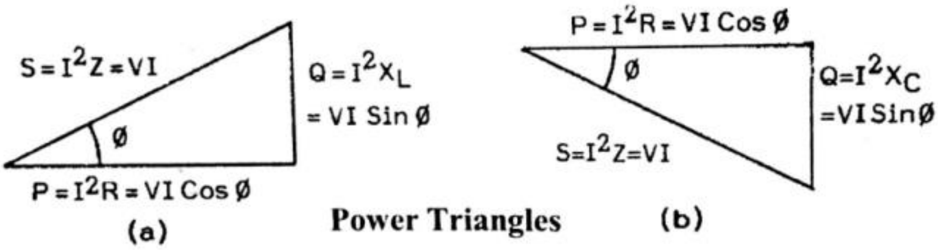
Reactive power (Q) is given by the product of voltage, current and the sine of the phase angle between voltage and current.

Unit: volt-ampere-reactive (VAr), or kilo-volt-ampere-reactive (kVAr) or Mega-volt-ampere-reactive (MVAr) 1 mark

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

Power Triangle:

The power triangles for inductive circuit and capacitive circuit are shown in the fig. (a) and (b) respectively.

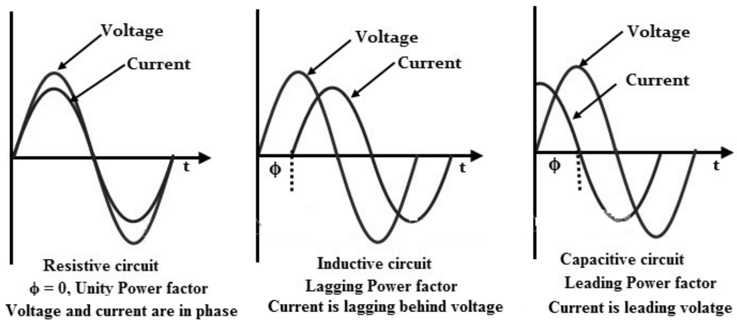


Power Triangles

1 mark (any one)

4 e) Explain the concept of lagging and leading of I or V by waveform and mathematical equation in AC circuit.

Ans:



1 mark for inductive circuit waveform

1 mark for capacitive circuit waveform

When two alternating quantities attain their respective zero or peak values simultaneously, the quantities are said to be in-phase quantities. Mathematically, the in-phase quantities are expressed as,

$$v = V_m \sin(\omega t) \text{ volt}$$
$$i = I_m \sin(\omega t) \text{ amp}$$

1 mark for concept of lagging

When the quantities do not attain their respective zero or peak values simultaneously, then the quantities are said to be out-of-phase quantities.

1 mark for concept of leading

The quantity which attains the respective zero or peak value first, is called 'Leading Quantity'.

The quantity which attains the respective zero or peak value later, is called 'Lagging Quantity'.

In above diagram, it is seen that for inductive circuit, the current is lagging behind the voltage or the voltage is said to be leading the current. Mathematically, the voltage and current can be expressed as,

$$v = V_m \sin(\omega t) \text{ volt} \qquad \text{(Leading quantity)}$$
$$i = I_m \sin(\omega t - \phi) \text{ amp} \qquad \text{(Lagging quantity)}$$

Similarly, for capacitive circuit, the current is leading the voltage or the voltage is said to be lagging behind the current. Mathematically, the voltage and current can be expressed as,

$$v = V_m \sin(\omega t) \text{ volt} \qquad \text{(Lagging quantity)}$$
$$i = I_m \sin(\omega t + \phi) \text{ amp} \qquad \text{(Leading quantity)}$$

4 f) Compare universal motor with servomotor on the basis of (1) Construction (2) Size (3) Cost (4) Torque developed (5) Application.

Ans:

Comparison between Universal motor and Servo motor:

Particulars	Universal Motor	Servo Motor	
Construction	It is basically series motor (armature winding and field winding in series) which can work on AC as well as DC supply	It has an assembly of four things DC motor, gearing set, control circuit and a position sensor.	1 mark
Size	Comparatively bigger in size	Comparatively smaller in size	1 mark
Cost	Cheaper	Comparatively costly	1 mark for cost and torque
Torque developed	Large	Moderate	
Applications	Household applications: Drill machines Grinder Washing machine Sewing machine Fans Small water pumps	Position control systems: robotic arms, legs or rudder control system and toy cars	1 mark

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

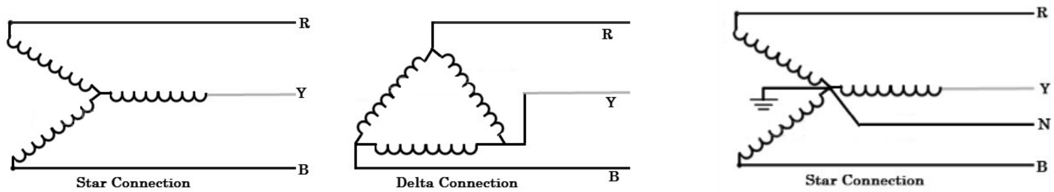
5 a) What are the different ways of interconnection of phases in a 3-phase system? Why is it required?

Ans:

Different ways of interconnections in 3-phase system are

(i) Three phase, three wire star connected system. 1 mark for each of three types = 3 marks

(ii) Three phase, three wire delta connected system.



Three Phase Three Wire Systems   Three Phase Four Wire Systems

(iii) Three phase, four wire star connected system.

When single-phase loads are to be supplied from three-phase supply system, three-phase, four-wire star connected system is used in distribution system. However, if each phase of 3-phase system is used separately with separate neutral, more conductors will be required for transmission of power, and also this will make the system complicated and expensive. Due to this reason, the three-phase, three-wire star or delta connections are used in transmission. 1 mark

5 b) Define efficiency and % voltage regulation of a transformer.

Ans:

Efficiency:

It is defined as the ratio of output power to the input power of the transformer. 1 mark

Efficiency $= \frac{Output\ Power}{Input\ Power}$ 1 mark

% Voltage Regulation:

It is the change in secondary terminal voltage of transformer when the load is changed from no-load to full load, expressed as fraction or percentage of no-load secondary voltage. 1 mark

% voltage regulation = $[(V_0 - V_{FL})/ V_0] \times 100$ 1 mark

where, V_0 is the no-load secondary voltage

V_{FL} is the full-load secondary voltage

5 c) State and explain Faradays laws of electromagnetic induction and its two applications in electrical engineering.

Ans:

Faraday's first law of electromagnetic induction: 1 mark

When a conductor cuts or is cut by the magnetic flux, an EMF is induced in the conductor.

OR

Whenever a changing magnetic field links with a conductor, an emf is induced in the conductor.

Faraday's second law of electromagnetic induction:

The magnitude of EMF induced in the conductor or coil is proportional to rate of flux cut by the conductor or coil. 1 mark

OR

The magnitude of EMF induced in the conductor or coil is proportional to rate of change of flux linking with the conductor or coil.

Two applications in electrical engineering:

1) **DC Generator:** In DC generator, there is a winding rotated in the gap between the two stationary poles. The winding acts like a conductor and during its rotation in the gap between two poles, it cuts the magnetic field between the poles. According to Faraday's law of electromagnetic induction, emf is induced in the armature winding. If the load is connected across this winding, the emf circulates the current and we get electrical energy out of the armature winding. 1 mark
2) **Transformer:** Transformer is a static device consisting of two windings placed on common magnetic core. When one winding is connected to AC source, it carries alternating current and alternating magnetic field is produced in the core. This alternating or changing magnetic field links with the second winding. According to Faraday's law of electromagnetic induction, an emf is induced in the second winding. If the load is connected to second winding, the emf circulates the current and we get power out of second winding. Thus power is transferred from first winding to second winding through electromagnetic induction. 1 mark

5 d) Why transformer rating is given in terms of kVA and not in KW?

Ans:

Load power factor is not fixed quantity as secondary load may vary. Hence rating cannot be given in kW but it has to be in VA or kVA which will give the correct capacity. An important factor in the design and operation of electrical machines is the relation between the life of the insulation and operating temperature of the machine. Therefore, temperature rise resulting from the losses is a determining factor in the rating of a machine. We know that copper loss in a transformer depends on current and iron loss depends on voltage Therefore, the total loss in a transformer depends on the volt-ampere product only and not on the phase angle between voltage and current i.e., it is independent of load power factor. For this reason, the rating of a transformer is in kVA and not kW.

1 mark for Cu loss α I

1 mark for Iron loss α V

2 marks for temp α VI

OR

1) The output of transformer is limited by heating and by the losses.
   Two types of losses in the transformer: (1) Iron loss, (2) Copper loss
2) Iron loss depends on the transformer voltage (v)
   Copper loss is depends on transformer current (I)
3) As the losses depends on voltage (V) and Current (I) and almost unaffected by load power factor

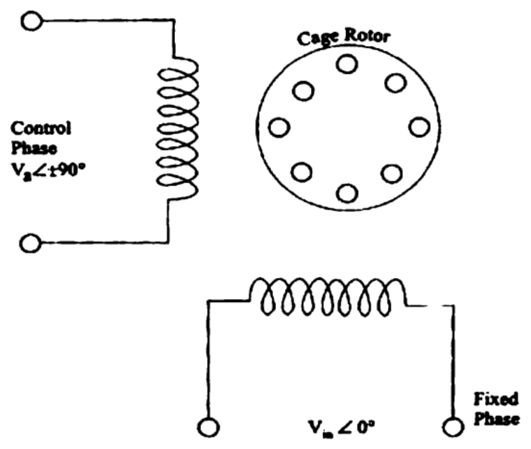
   Hence transformer output is expressed in VA or KVA not in KW.

5 e) Explain the working of AC servo motor with a neat diagram.

Ans:

Principle of working of servo motor:

There are some special applications 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. These motors are used for position control or in servo mechanisms, hence are termed as servomotors. The AC servomotor consists of main and control winding and squirrel cage / drag cup type rotors. V_r is the voltage applied to the main or reference winding while V_c 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 force or torque is exerted on rotor and is set in motion.



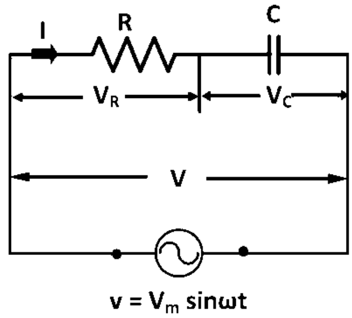
2 Marks for working

2 marks for diagram

5 f) For R-C circuit (i) Draw circuit diagram (ii) Write voltage and current equations (iii) Draw vector diagram (iv) Draw impedance triangle.

Ans:

(i) Circuit diagram



1 mark

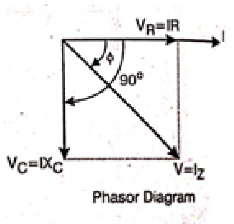
(ii) Equations

$v = V_m \sin(\omega t)$ volt

$i = I_m \sin(\omega t + \phi)$ amp

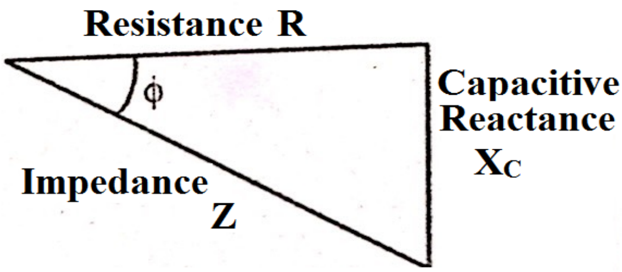
1 mark

(iii) Vector diagram



1 mark

(iv) Impedance Tringle



Impedance triangle for R-C series circuit

1 mark

6 Attempt any FOUR of the following: 16

6 a) Compare squirrel cage induction motor and slip ring induction motor.

Ans:

Squirrel cage I. M.	Slip ring I. M.
1) Rotor is of Squirrel cage type	Rotor is of phase wound type
2) It has no slip rings on shaft	It has three slip rings on shaft
3) It is economical	It is comparatively expensive
4) It requires very little maintenance.	It requires maintenance more than Squirrel cage I. M.

1 mark for each of any four points

5) It has small or moderate starting torque.	It has high starting torque.
6) External resistances cannot be inserted in rotor circuit.	External resistances can be inserted in the rotor circuit
7) Simple and robust construction.	Complicated and bulky construction.
8) Rotor is permanently short circuited.	One end of rotor is connected to slip rings
9) Starting torque cannot be adjusted.	Starting torque can be adjusted by varying the external resistance.
10) Speed cannot be controlled from rotor	Speed can be controlled from rotor side
11) Better efficiency	Low efficiency.
12) Power factor is better at running conditions.	Power factor is better at starting conditions.
13) Less rotor 'Cu' losses.	More rotor 'Cu' losses
14) High starting current (5 to 6 times full load)	Starting current is about twice the full load current.
15) Used in workshop for lathe machines, drill machines, grinding machines, blowers, water pumps, printing machines, fans, etc. where constant speed with medium starting torque is required.	Used in cranes, lifts, elevators, compressors, locomotives etc. where high starting torque is required.

6 b) State and explain Fleming's Right hand rule.

Ans:

Fleming's Right hand rule:

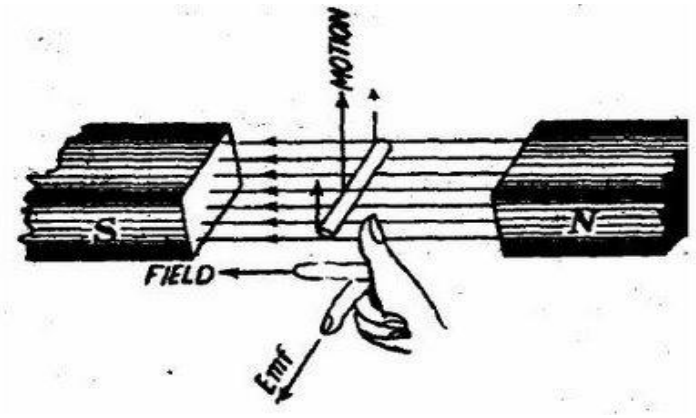
Arrange three fingers of right hand mutually perpendicular to each other, if the first fingure indicates the direction of flux, thumb indicates the direction of motion of the conductor, then the middle finger will point out the direction of inducted current. 2 marks for statement

OR

Fleming's right hand rule state that, outstretch the first three fingers of right hand perpendicular to each other such that first finger pointing the direction of magnetic field, thumb directing the motion of the conductor with respect to magnetic field, then second finger will indicate the direction of induced e. m. f.(or current).

Explanation:

In the arrangement shown in the figure, a conductor is moved up in the gap between two poles such that it cuts the magnetic lines of force (flux). According to Faraday's law of electromagnetic induction, an emf is induced in the conductor. The direction of this dynamically induced emf is given by Fleming's Right Hand rule. The first three fingers of right hand are stretched out such that they are perpendicular to each other. If the first finger points the direction of magnetic field from north pole to south pole, the thumb points the upward direction of motion of the conductor with respect to stationary magnetic field, then the middle (second) finger points the 1 mark for explanation direction of emf induced in the conductor.



1 mark for any equivalent diagram

6 c) Define synchronous speed, slip and rotor frequency.

Ans:

Synchronous speed:

It is the constant speed of the rotating magnetic field produced in the air gap by three-phase currents flowing through the three-phase stator winding. — 1 Mark for definition

It is given by,

$$N_S = 120\ f/P$$

where N_S be the synchronous speed in rpm, — 1 mark for equation of N_S

f be the frequency of stator currents in Hz

P be the no. of poles for which three-phase winding is wound.

Slip:

The ratio of the difference between synchronous speed (Ns) and actual speed (N) of the rotor to the synchronous speed (Ns) is known as slip (s). — 1 Mark for slip

i.e. slip, $s = (N_S - N)/ Ns$

OR

The difference between synchronous speed and actual speed of the rotor expressed as fraction or percentage of synchronous speed, is called slip.

$$\%s = \{(Ns - N)/Ns\}\times 100$$

Rotor frequency :

The frequency of rotor emf is proportional to relative speed (N_S – N) of rotating stator field with respect to the rotor. — 1 Mark for rotor frequency

It is given by

f_r = slip x supply frequency = s.f

6 d) Explain working of 3 phase induction motor.

Ans:

Working principle of 3-phase induction motor:

- 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 are stationary initially.
- Due to the relative speed between the rotating flux and the stationary rotor, e.m.f.s are 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.

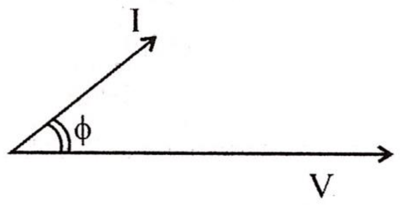
4 marks for stepwise working

6 e) What is power factor? State its significance.

Ans:

Power factor :

It is the cosine of angle between voltage and current, i.e. cosϕ



2 marks for definition of pf

OR

The power factor can be defined as the ratio of true power to the apparent power.

cosϕ ={True or Real Power / Apparent Power }= {kW/kVA}

The power factor can be defined as the ratio of resistance to the impedance.

cosϕ = {R/Z}

Significance of power factor:

In AC circuits, when applied voltage V produces current I in the circuit, the ture power supplied to circuit is not only VI, but it is VIcosϕ. Thus for computing real or true power, the product VI need to be multiplied by a factor cosϕ, hence it is called the power factor. Being cosine of angle, its maximum value is 1.

2 Marks for significance

Usually supply voltage is maintained constant. So if pf cosϕ is having lower value, for same true power, the required current becomes large. The current causes i^2R losses in the system and reduces the efficiency. Therefore, power factor cosϕ is important and it decides the performance of the system. It significantly affects the performance of the system operation.

6 f) Explain the necessity of earthing and state any four safety precautions while working with electrical systems.

Ans:

Necessity of Earthing:

Earthing of metallic cover provides a low resistive path for the leakage currents, which are due to accidental unwanted connection of electrically live conductor to metallic cover. Due to earthing, the metallic cover is maintained to ground/earth potential, thereby it protects human from shocks, as leakage current flows through earthing wire and not through the body of person touching the metallic cover. Earthing ensures safety and protection of electrical equipment and Human by discharging the electrical leakage current to the earth. Therefore earthing is necessary. 2 marks

Safety precautions to be taken while working with Electrical systems :

1. Avoid working on live parts.
2. Switch off the supply before starting the work.
3. Never touch a wire till you are sure that no currents are flowing.
4. Do not guess, whether electric current is flowing through a circuit by touching.
5. Insulate yourself on the insulating material like wood, plastic etc. before starting the work on live main.
6. Your hand & feet must be dry (not wet) while working on live main.
7. Rubber mats must be placed in front of electrical switch board/ panel.
8. Use hand gloves, Safety devices & proper insulated tools.
9. Ground all machine tools, body, and structure of equipment.
10. Earthing should be checked frequently.
11. Do not use aluminum ladders but use wooden ladders.
12. Use proper insulated tools & safety devices.
13. When working on live equipment obey proper instruction.
14. Do not work on defective equipment.
15. Use safe clothing.
16. Use shoes with rubber soles to avoid shock.
17. Do not wear suspected Necklace, arm bands, finger ring, key chain, and watch with metal parts while working.
18. Do not use defective material. Do not work if there is improper illumination such as in sufficient light or unsuitable location producing glare or shadows.
19. Do not work if there is an unfavorable condition such as rain fall, fog or high wind.
20. Do not sacrifice safety rules for speed.
21. Do not allotted work to untrained person (worker) to handle electrical equipment.
22. Make habit to look out for danger notice, caution board, flags, and tags.
23. Inspect all electrical equipment & devices to ensure there is no damage or exposed wires that may causes a fire or shock.
24. Avoid using electrical equipment near wet, damp areas.
25. Use approved discharge earth rod for before working.
26. Never speak to any person working upon live mains.
27. Do not Do the work if you are not sure or knowledge of the condition of equipment/ machine.

½ mark for each of any four = 2 marks