



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC-27001-2013 Certified)

Summer– 2018 Examinations
Model Answer

Subject Code: 22215 (EEC)

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 should assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given 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 should give credit for any equivalent figure/figures drawn.
- 5) Credits to 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 (as long as the assumptions are not incorrect).
- 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



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1 Attempt any **FIVE** of the following: 10

1 a) Define Faraday's first law of electromagnetic induction.

Ans:

Faraday's First Law:

Whenever a changing magnetic flux links with a conductor, an emf is induced in that conductor.

2 Marks

OR

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

1 b) Define :

(i) Form factor

(ii) Peak factor

Ans:

(i) Form factor:

The form factor of an alternating quantity is defined as the ratio of the RMS value to the average value.

$$\text{Form factor} = I_{\text{rms}}/I_{\text{av}} = 0.707 I_m / 0.637 I_m = 1.11 \text{ (For sinusoidal quantity)}$$

OR

$$\text{Form factor} = V_{\text{rms}}/V_{\text{av}} = 0.707 V_m / 0.637 V_m = 1.11 \text{ (For sinusoidal quantity)}$$

1 Mark for
each
Definition

(ii) Peak factor:

The peak factor of an alternating quantity is defined as the ratio of its maximum value to the rms value.

$$\text{Peak factor} = V_m/V_{\text{rms}} = 1.414 \text{ (For sinusoidal quantity)}$$

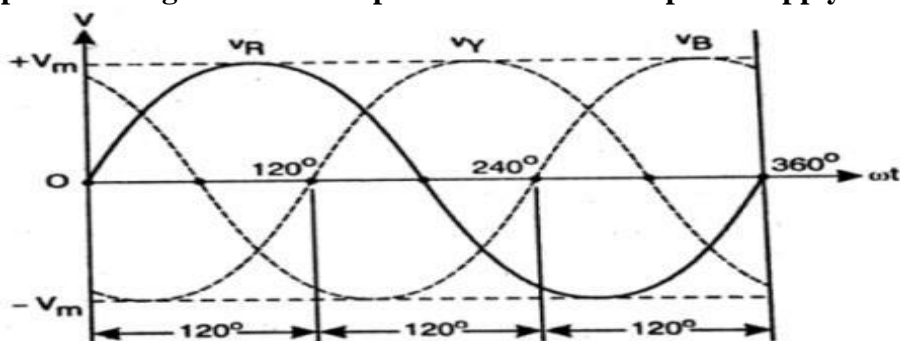
OR

$$\text{Peak factor} = I_m/I_{\text{rms}} = 1.414 \text{ (For sinusoidal quantity)}$$

1 c) Draw 3- phase voltage waveform of a.c. supply with respect to time.

Ans:

Three-phase Voltage waveform representation of three phase supply:



2 Marks for
labeled
waveform

1 Mark for
unlabeled
waveform



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1 d) State working principle of transformer.

Ans:

Working principle of transformer :

Transformer works on the principle of mutual electromagnetic induction. When AC voltage is applied to the primary winding it causes ac current to flow through primary winding which produces alternating flux in the core. This changing flux links with the secondary winding and according to Faraday's law of electromagnetic induction, an emf is induced in the secondary winding. The current flows in the secondary circuit if load is connected.

2 Marks

1 e) Write two applications of D.C. series motor.

Ans:

The applications of D.C. series motor:

1. Cranes
2. Hoists
3. Trolley and cars
4. Conveyors
5. For traction work i.e. electric locomotives
6. Elevator
7. Air compressor

1 Mark for
each of any 2
applications
= 2 Marks

1 f) List different types of stepper motor. State one application of stepper motor.

Ans:

Types of stepper motor :

- (i) Variable – reluctance motor
- (ii) Permanent- magnet motors
- (iii) Hybrid motors.

Any two
Types

1 Mark

+

Any one
Application

1 Mark

=

2 Marks

Applications of stepper motor :

In robotics,
In CNC machines,
In computers, printers, tape readers,
In Watches,
In biomedical applications such as X-ray machines, CT scan,
In Process control systems.

1 g) State function of ELCB.

Ans:

Functions of ELCB:

1. Provides protection to apparatus by detecting the unsafe magnitudes of leakage currents diverting to earth.
2. Disconnect the supply to the circuit if line to ground fault occurs.
3. Provides protection to users by detecting the unsafe magnitudes of leakage currents diverting to earth.

Any one
function
= 2 Marks

2 Attempt any **THREE** of the following:

12

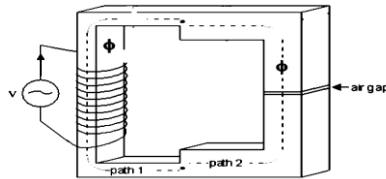


- 2 a) Explain with neat diagram series and parallel magnetic circuits.

Ans:

Series magnetic circuit: When different magnetic materials having different lengths, cross sectional areas and permeability are connected one after another, in which same flux is established in different sections, then it is called series magnetic circuit.

1 Mark
Explanation



Valid Figure
1 Mark

Fig. Series magnetic circuit

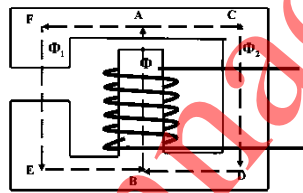
Parallel magnetic circuit: Magnetic circuit which has more than one path for magnetic flux, is called as parallel magnetic circuit. Reluctances are in parallel.

Total flux, $\Phi = \Phi_1 + \Phi_2$

Path 1: BAFE

Path 2: BACD

1 Mark
Explanation



Valid Figure
1 Mark

Fig. Parallel magnetic circuit.

= 4 Marks

- 2 b) Explain the concept of lagging and leading phase angle by waveform.

Ans:

i) Leading phase angle :

When two ac quantities of same frequency do not attain their respective zero or peak values simultaneously, then the quantities are said to be out-of-phase quantities. The quantity which attains the respective zero or peak value first, is called 'Leading Quantity'.

2 Marks for
Explanation

In the following first diagram, the voltage attains its zero or positive peak first and after an angle of ϕ , the current attains its respective zero or positive peak value, hence voltage is said to be leading the current by an angle of ϕ . Similarly, in the second diagram, the current is said to be leading the voltage by ϕ .

ii) Lagging phase angle:

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

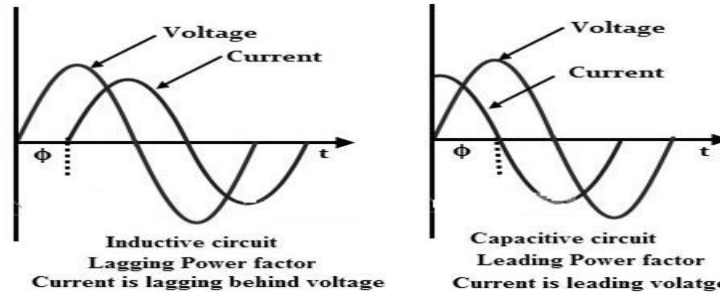
In the following first diagram, the current attains its zero or positive peak later than the voltage after an angle of ϕ , hence current is said to be lagging the voltage by an angle of ϕ . Similarly, in the second diagram, the voltage is said to be lagging the current by ϕ .



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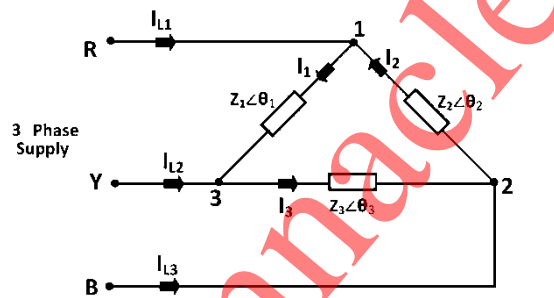
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2 Marks for any one neat labeled diagram

- 2 c) Draw delta connected load. State relation between:
i) Line voltage and phase voltage.
ii) Line current and phase current.

Ans:



2 Marks for neat labeled diagram and

- i) **Relation between Line voltage and phase voltage in delta connection:**

Line voltage = Phase voltage

$$V_L = V_{ph}$$

- ii) **Relation between Line current and phase current in delta connection:**

Line current = $\sqrt{3}$ phase current

$$I_L = \sqrt{3} I_{ph}$$

2 Marks for relations (1 mark each) = 4 Marks

- 2 d) List the main parts of D.C. motor. Give the function of any two parts.

Ans:

Main parts of D.C. motor and their functions:

Part	Functions
Yoke	i) Provides mechanical support for poles. ii) Acts as protecting cover for machine. iii) Carries magnetic flux.
Pole Core & Pole Shoes	i) Provides support for the field winding, which is placed around it. ii) Allows the field winding to produce magnetic flux in it. iii) Pole shoes spread out the magnetic flux over the armature periphery more uniformly.

1 Mark for each of any four parts = 4 Marks



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Field Winding	Produces mmf and consequently magnetic flux when carries current.
Armature	i) It houses the armature conductors. ii) It provides rotation of armature conductors in the magnetic field.
Armature Winding	Provides conductors to - induce emf in it (in generator) - produce force on it (in motor)
Commutator	i) Works as media to collect from or to send current to the armature winding. ii) Helps to maintain unidirectional current in armature winding.
Brush	i) To inject or collect current from rotating armature winding. ii) To facilitate electrical connection of rotating armature winding to external stationary circuit.
Bearings	i) To support the rotor and reduce friction for smooth rotation of rotor. ii) Maintains rotor in a fixed physical position relative to the stator.
Shaft	Used to transfer mechanical power

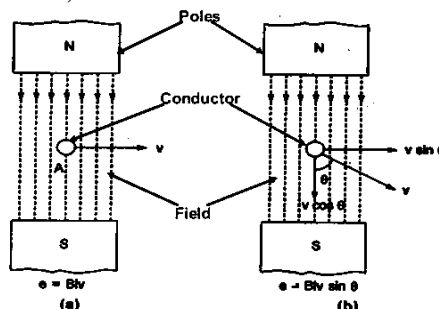
3 Attempt any **THREE** of the following: 12

3 a) Explain dynamic and static induced emf with neat diagram.

Ans:

Dynamically Induced EMF:-

- In this case, either coil moves or magnet moves, so that there is relative motion between coil & magnetic field. Thus magnetic field is cut by coil & emf is induced in it. The emf induced due to relative motion is called dynamically induced emf. 1 Mark
- The expression for induced EMF is $e = B.l.v.\sin\phi$
- Dynamically induced EMF is observed in DC generator, Induction Motors, Back EMF in D.C. Motor, Alternators.



1 Mark for diagram

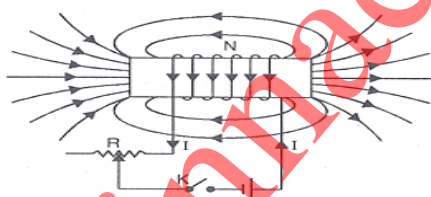


Statically Induced EMF:-

- In this case, neither coil moves nor magnet moves. The changing magnetic field links with stationary coil and emf is induced. The emf induced without any motion is called statically induced emf.
- Statically induced EMF is having two main types:
 - Self-induced EMF: The changing magnetic flux produced by coil when links with the coil itself, the emf induced in it is called self-induced emf.
 - Mutually induced EMF : The changing magnetic flux produced by one coil when links with the second coil, the emf is induced in second coil. This emf is called mutually-induced emf.
- The expression for induced EMF is $e = -L(di/dt)$ or $= -N(d\phi/dt)$.

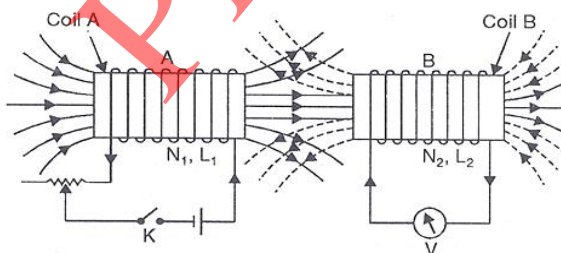
1 Mark

Self-induced EMF:



1 Mark for any one diagram

Mutually induced EMF :



3 b) Compare auto transformer with two winding transformer. (Any four Points)

Ans:

Comparison of Autotransformer with Two winding transformer:

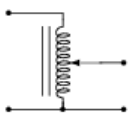
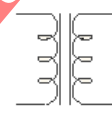
Sr. No.	Autotransformer	Two winding Transformer
1	Only one winding, part of the winding is common for primary and secondary.	There are two separate windings for primary and secondary.
2	Movable contact exist	No movable contact between primary and secondary



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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

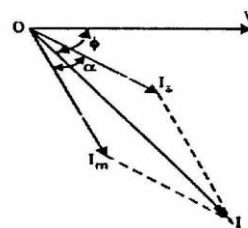
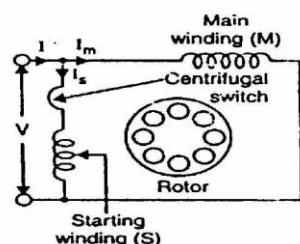
1 Mark for each of any valid four points = 4 Marks

3 c) Draw and explain split phase induction motor.

Ans:

- The stator of a split-phase induction motor is provided with an auxiliary or starting winding S in addition to the main or running winding M.
- The starting winding is located 90° electrical from the main winding and operates only during the brief period when the motor starts up. The two windings are so designed that the starting winding S has a high resistance and relatively small reactance while the main winding M has relatively low resistance and large reactance as shown in the schematic connections. Consequently, the currents flowing in the two windings have reasonable phase difference ($\alpha = 25^\circ$ to 30°) as shown in the phasor diagram.
- When the two stator windings are energized from a single-phase supply, the main winding carries current I_m while the starting winding carries current I_s .

2 Marks for diagram and 2 Marks for explanation = 4 Marks





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- Since main winding is highly inductive while the starting winding is highly resistive, the currents I_m and I_s have a reasonable phase angle ($\alpha = 25^\circ$ to 30°) between them.
- Consequently, a revolving field approximating to that of a 2-phase machine is produced which starts the motor.
- When the motor reaches about 75% of synchronous speed, the centrifugal switch opens the circuit of the starting winding. The motor then operates as a single-phase induction motor and continues to accelerate till it reaches the normal speed. The normal speed of the motor is below the synchronous speed and depends upon the load on the motor.

3 d) Give the working of MCCB.

Ans:

Working of MCCB: (Molded Case Circuit Breaker)

- The operating mechanism consisting of lever, spring, contacts etc. is used to open or close the MCCB electrically.
- The arc extinguisher facilitates for the quenching of arc by lengthening it which is produced when MCCB gets opened and current is interrupted.
- The trip unit is the brain of the circuit breaker. It senses the overload or short-circuit condition and trip mechanism is operated to trip the MCCB.
- When overload occurs, the thermal relay mechanism permits overload for short duration, then bimetal strip actuates the tripping mechanism to open the MCCB contacts.
- When short-circuit occurs, large magnetic force produced by short-circuit current operates the lever to trip the MCCB immediately and open the contacts.

4 Marks for
explanation

4 **Attempt any THREE of the following:**

12

4 a) Find ~~reluctance~~ reluctance, flux, mmf required and exciting current for an iron ring with 200 turns having diameter of 15cm and 10cm^2 cross sectional area if flux density 1Wb/m^2 and permeability of 500.

Ans:

Given: 1) $d = 15\text{ cm} = 15 \times 10^{-2}\text{ m} = 0.15$ 2) $a = 10\text{ cm}^2 = 10 \times 10^{-4}\text{ m}^2$
3) $N = 200$ 4) $B = 1\text{ Wb/m}^2$ 5) $\mu_r = 500$ 6) $\mu_0 = 4\pi \times 10^{-7}$

To find: 1) $S = ?$ 2) $\phi = ?$ 3) $\text{mmf} = ?$ 4) $I = ?$

1. Reluctance:

$$S = \frac{l}{\mu_0 \mu_r a}$$

$$\text{But } l = \pi d = \pi \times 15 \times 10^{-2} = \pi \times 0.15 = 0.4712\text{ m}$$

$$S = \frac{0.4712}{4\pi \times 10^{-7} \times 500 \times 10 \times 10^{-4}} = 7.5 \times 10^5\text{ AT/Wb}$$



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2. Flux:

$$\text{Flux density } B = \frac{\text{Flux}}{\text{Area}} = \frac{\phi}{a}$$

$$\Phi = B \times a = 1 \times 10 \times 10^{-4} = 1 \text{ mWb}$$

1 Mark for
each correct
answer
= 4 Marks

3. MMF:

$$\text{MMF} = \phi \times S = 1 \times 10^{-3} \times 7.5 \times 10^5 = 750 \text{ AT}$$

4. Current:

$$\text{MMF} = N \times I$$

$$750 = 200 \times I$$

$$I = 3.75 \text{ A}$$

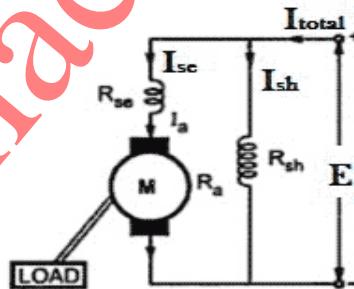
- 4 b) Draw a schematic diagram of long shunt D.C. compound motor. Give one application.

Ans:

Long shunt D.C. compound motor :

Applications:

1. Rolling mills
2. Cutting and shearing tools.
3. Presses
4. Punches
5. Conveyors
6. Elevators.

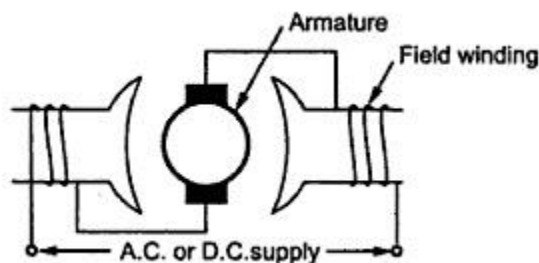


Labeled
diagram 3
Marks and 1
Mark for any
one
application=
4 Marks

- 4 c) Explain in brief the working of universal motor.

Ans:

Working of universal motor:



i) Working of universal motor with DC supply:

- When the universal motor is fed with a DC supply, then current flows in the field winding, it produces an electromagnetic field. The same current also flows through the armature conductors.
- According to basic motor principle, when a current carrying conductor is placed in the magnetic field, it experiences a mechanical force and torque exerted on

2 Marks



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the current carrying armature conductors, therefore the rotor starts to rotate.

ii) Working of universal motor with AC supply:

- When fed with AC supply, current flows through armature and field winding. So current carrying armature conductors are in magnetic field experiences mechanical force and ultimately produces unidirectional torque, because armature winding and field winding are connected in series, they carry same current.
- Hence, as polarity of AC voltage changes and current reverses its direction, the direction of current in armature conductors and magnetic field in the air-gap reverses at the same time.
- The direction of magnetic field and the direction of armature current reverses in such a way that the direction of force experienced by armature conductors remains same.

2 Marks

4 d) With a neat sketch give the working of shaded pole induction motor.

Ans:

Working of Shaded Pole 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 produces the magnetic flux in the shaded part of pole 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 on the flux wave to examine the effect of shading band as shown in the figure.

At instant t_1 : The flux is positive and rising, hence the shading band current produces its own flux to oppose the rising main flux. Due to this opposition, the net flux in shaded portion of pole is lesser than that in unshaded portion. Thus the magnetic axis lies in the unshaded portion and away from shaded portion.

At instant t_2 : The flux is maximum, the rate of change of flux is zero. So the shading band emf and current are zero. Thus the flux distribution among shaded and unshaded portion is equal. The magnetic axis lies in the centre of the pole.

At instant t_3 : The flux is positive but decreasing, hence according to Lenz's rule, the shading band emf and current try to oppose the fall in the main flux. So the shading band current produces its own flux which aids the main flux. Since shading band produces aiding flux in shaded portion, the strength of flux in shaded portion increases and the magnetic axis lies in the shaded portion. Thus it is seen that as time passes, the magnetic 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 is sufficient to provide starting torque to squirrel cage rotor and rotor rotates.

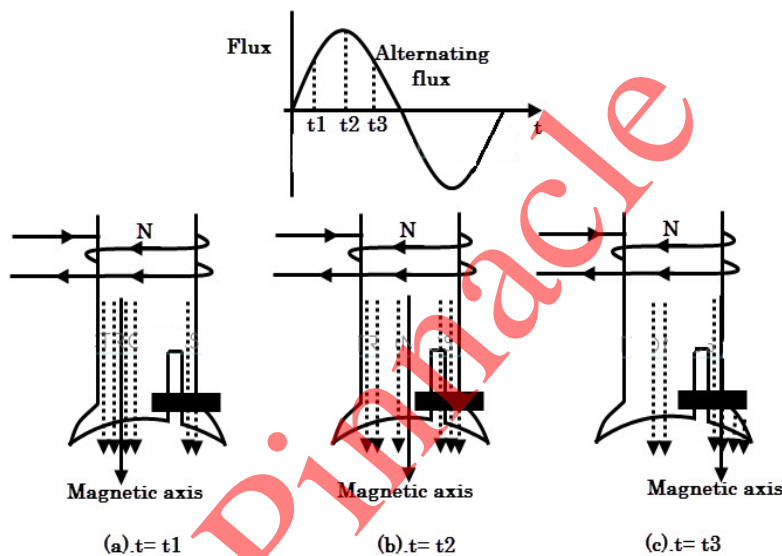
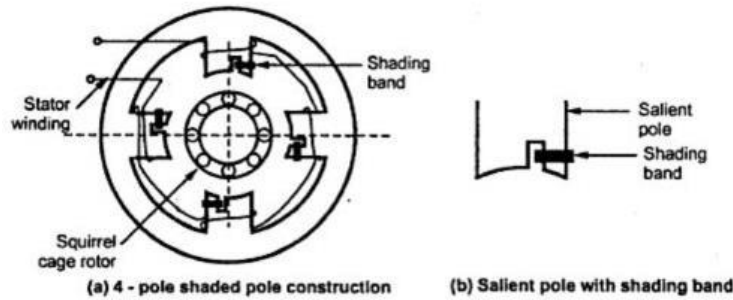
2 Marks for
Diagram
+
2 Marks for
Explanation
=
4 Marks



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4 e) Give the function of fuse and switch.

Ans:

Functions of fuse:

- To break the circuit under fault condition.
- To provide overcurrent protection to the circuit.
- To provide short circuit protection to the circuit.
- To provide safety to the users.

2 Marks
for two
functions

Functions of Switch:

- To make the electric circuit manually.
- To break the electric circuit manually.

2 Marks

5 Attempt any **TWO** of the following:

12

5 a) An alternating voltage is represented by $v = 50.5 \sin (314t + 90^\circ)$. Calculate frequency, amplitude, RMS value and phase difference.

Ans:



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Given Data:

$$v = 50.5 \sin(314t + 90^\circ)$$

On comparing with the standard form $v = V_m \sin(\omega t + \phi)$

Maximum voltage = $V_m = 50.5$ volt

Angular frequency = Angular Velocity = $\omega = 314$ rad/sec

Phase angle = $\phi = 90^\circ$

1) Frequency (f):

$$\text{Angular frequency } \omega = 2\pi f$$

$$314 = 2 \times 3.14 \times f$$

$$f = 50 \text{ Hz}$$

2 Marks

2) Amplitude:

$$\text{Amplitude} = \text{Peak or Maximum value} = V_m = 50.5 \text{ volt}$$

1 Mark

3) RMS Value:

$$V_{rms} = 0.707 \times V_m$$

$$V_{rms} = 0.707 \times 50.5 = 35.70 \text{ volt}$$

2 Marks

4) Phase difference:

$$\phi = 90^\circ \text{ (leading)}$$

1 Mark

- 5 b) A balanced 3- ϕ star connected load consist of three resistances each of four ohms connected to 400V, 3 phase 50 Hz supply, find (i) Phase voltage (ii) Phase current (iii) Line current (iv) Power consumed.

Ans:

Given Data:

Load is star connected.

Line voltage = $V_L = 400$ Volt

$$\text{Frequency} = f = 50 \text{ Hz}$$

$$\text{Resistance per phase} = R_{ph} = 4 \Omega$$

1) Phase voltage: $V_{ph} = \frac{V_L}{\sqrt{3}} = 400/\sqrt{3} = 230.94 \text{ Volt}$

1 Mark

2) Phase current: $I_{ph} = \frac{V_{ph}}{R_{ph}} = \frac{230.94}{4} = 57.73 \text{ ampere.}$

2 Marks

3) Line Current: $I_L = I_{ph} = 57.73 \text{ ampere}$

1 Mark

4) Power consumed: $P = \sqrt{3} \times V_L \times I_L \times \cos\phi$
 $= \sqrt{3} \times 400 \times 57.73 \times 1$
 $= 39996.51 \text{ watt or } 39.99 \text{ KW}$

2 Marks

OR

$$\text{Power consumed} = P = 3 \times V_{ph} \times I_{ph} \times \cos\phi.$$

$$= 3 \times 230.94 \times 57.73 \times 1$$

$$= 39996.49 \text{ watt or } 39.99 \text{ KW}$$



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- 5 c) 20kVA, 3300/ 240 V, 50 Hz single phase transformer has 80 turns on secondary winding. Calculate no of primary winding turns, full load primary and secondary currents and maximum value of flux in the core.

Ans:

Given Data:

kVA = 20 kVA

Primary voltage = $V_1 = 3300$ Volt

Secondary voltage = $V_2 = 240$ Volt

Frequency = 50Hz

No. of turns on secondary = $N_2=80$

- 1) **Primary winding turns (N_1):**

$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

$$N_1 = \frac{3300}{240} \times 80 = \mathbf{1100 \text{ turns}}$$

1 Mark

- 2) **Full load primary current (I_1):**

$$\text{KVA} = \frac{V_1 I_1}{1000}$$

$$I_1 = \frac{20 \times 1000}{3300}$$

$$I_1 = \mathbf{6.06 \text{ ampere}}$$

1.5 Marks

- 3) **Full load secondary current (I_2):**

$$\text{KVA} = \frac{V_2 I_2}{1000}$$

$$I_2 = \frac{20 \times 1000}{240}$$

$$I_2 = \mathbf{83.33 \text{ ampere}}$$

1.5 Marks

- 4) **Maximum value of flux in core (ϕ_m)**

$$E_1 = 4.44 \times f \times \phi_m \times N_1$$

$$3300 = 4.44 \times 50 \times \phi_m \times 1100$$

$$\phi_m = \mathbf{0.0135 \text{ wb or } 13.5 \text{ mwb}}$$

2 Marks

OR

$$E_2 = 4.44 \times f \times \phi_m \times N_2$$

$$240 = 4.44 \times 50 \times \phi_m \times 80$$

$$\phi_m = \mathbf{0.0135 \text{ wb or } 13.5 \text{ mwb}}$$

- 6 **Attempt any TWO of the following:**

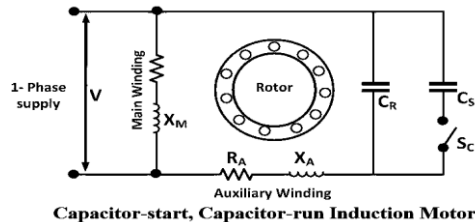
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- 6 a) Draw schematic diagram of capacitor start capacitor run induction motor. Give any two applications of the same.

Ans:

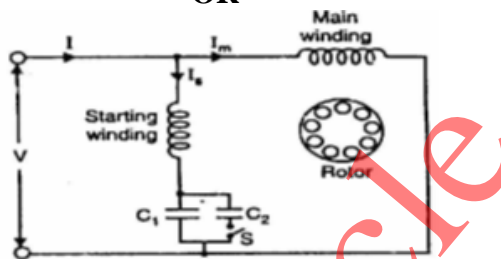


Capacitor-start, Capacitor-run Induction Motor:



Capacitor-start, Capacitor-run Induction Motor

OR



4 Marks for labeled diagram
3Marks for partially labeled diagram
2 Marks for un-labeled diagram

Applications of Capacitor-start, Capacitor- run Induction Motor:

Fans, Blowers, Grinder, Drilling Machine, Washing Machine, Refrigerator, Air conditioner, Domestic Water Pumps, Compressor.

2 Marks for each of any 2 applications

6 b) What is earthing? Give the importance of earthing.

Ans:

Earthing:

Earthing means connecting metallic body of the electrical equipment to earth to avoid the hazards due to leakage current. If the leakage current keeps circulating in the body of the equipment, it might result in electrical shock to person who touches the metallic body.

Definition of earthing
= 2 Marks

Importance of Earthing:

- To provide protection and safety to the operator.
- To provide protection and safety to the equipment.
- To facilitate the balanced supply conditions.
- To provide safe path to discharge lightning and short circuit currents.
- To isolate the faulty section.
- To protect installation from sudden high voltages, switching surges with lightning arrestor and surge suppressor.

Any four importances
= 4 Marks

6 c) Write two applications of each of the following:(i) Fuse (ii) MCB (iii) MCCB.

Ans:

i) Applications of fuse:

- Used in domestic installations to provide short circuit protection.
- Used in commercial / Industrial installations to provide overload and short



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circuit protection.

- Used in educational institutes for practical.
- Used for protection of various appliances.
- Used for protection of various electronic circuits.

2 Marks

ii) Applications of MCB:

- Used in lightning circuits.
- Used in distribution feeders.
- Used in switching motors.
- Used in capacitors.
- Used in power circuits.
- Used in control transformers.

2 Marks

iii) Applications of MCCB:

Used in

- Distribution feeders,
- Distribution transformers,
- Diesel generating sets
- L.T capacitors
- Rectifiers panels,
- U.P.S, Electronic equipment,
- Motors,
- Furnaces

2 Marks