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Total No. of Questions : 09

B.Tech. (AI&ML/CE/CSE/CS&D/DS/EEE/EE/ECE/IT/ME/Robotics & AI/(Internet of Things and Cyber Security including Block Chain Technology) (Sem.–1)

BASIC ELECTRICAL ENGINEERING

Subject Code : BTEE101-18

M.Code : 93797

Date of Examination: 11-12-2023

Time : 3 Hrs. **Max. Marks : 60**

INSTRUCTIONS TO CANDIDATES :

1. **SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.**
2. **SECTION - B & C have FOUR questions each.**
3. **Attempt any FIVE questions from SECTION B & C carrying EIGHT marks each.**
4. **Select atleast TWO questions from SECTION - B & C.**

SECTION-A

1. Answer the following :

a) Classify various types of electric cables.

b) A series RL circuit draws a current of 1 A, when contacted across a 10 V, 50 Hz AC supply. Assuming the resistance 5 ohms, find the inductance of the circuit. What is its power factor.

c) What is phasor representation?

d) Based on power factor, categorize the different kinds of electrical loads.

e) What is the difference between wire & cable?

f) Give an explanation of the peak and from factors in terms of alternating current.

g) What are the classifications of magnetic materials based on their magnetic properties?

h) State and explain the Kirchhoffs Laws.

i) Identify and explain the different losses in a transformer,

j) State the purpose of earthing in electrical systems.

SECTION-B

2. For a balanced three-phase delta connection, determine the numerical relationship between the line and phase currents.

3. A series RLC circuit of R = 40 Ω, L = 50.07mH and a capacitor is connected across a 400V, 50Hz, A.C supply. This RLC combination draws a current of 10A.

   Calculate (i) Power factor of the circuit, (ii) Capacitor value.

4. Briefly introduce the single-phase induction motor. Discuss the methods used for starting induction motors.

5. State and explain Norton's theorem. Using Norton's theorem, determine the current flowing through the load resistance (R_L) in Figure 1.

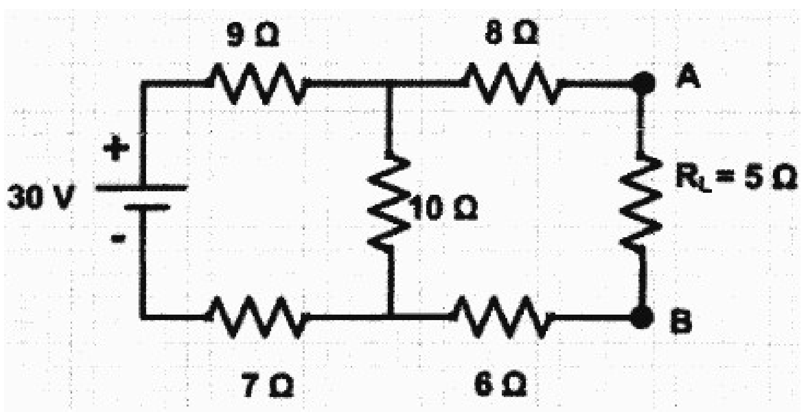


Fig.1

SECTION-C

6. Describe the BH curve and its significance in characterizing magnetic materials.

7. Compare Miniature Circuit Breaker (MCB) and Earth Leakage Circuit Breaker (ELCB).

8. Explain the principle of operation of a transformer. Derive an EMF equation for a single-phase transformer. Also, draw the phasor diagram of a single-phase transformer at leading power factor load.

9. What is the significance of a rotating magnetic field in motor operation? Describe the constructional features of a three-phase induction motor.

NOTE : Disclosure of Identity by writing Mobile No. or Making of passing request on any page of Answer Sheet will lead to UMC against the Student.

BASIC ELECTRICAL ENGINEERING

Subject Code :- BTEE-101-18

(Sem-1 Nov. 2023 Examination)

SECTION-A

Ques1. Answer the following :

(a) Classify various types of electric cables.

Answer: Cable : A solid conductor covered with insulation is known as a cable.

The cable may be single core or multiple core depending upon the number of conductors.

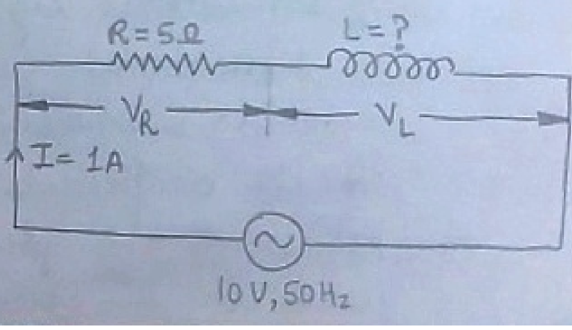
The cables may be classified as:

(1) V.I.R cables (Vulcanised Indian Rubber)
(2) P.V.C. Cables (Poly - Vinylchloride)
(3) T.R.S Cables (Tough Rubber sheathed)
or
C.T.S. Cables (Cab Tire Sheathed)
(4) Leather Sheathed Cables
(5) weather Proof cables.

(b) A series RL circuit draws a current of 1 A, when contacted across a 10 V, 50 Hz AC supply. Assuming the resistance 5 ohms, find the inductance of circuit. What is its power factor.

Answer: As given:

Current, $I = 1$ Ampere
Voltage, $V = 10$ Volts
Frequency, $f = 50$ Hz
Resistance, $R = 5\,\Omega$



To find

Inductance $L = ?$

Power factor $\cos\phi = ?$

We know,

Using ohm's law

$V = IR$

Here, in RL series circuit opposition is produced by the impedence Z of of the circuit.

$\therefore \quad V = IZ$

$Z = V/I = 10/1 = 10\ \Omega$

Also, $Z = \sqrt{R^2 + X_L^2} \Rightarrow Z^2 = R^2 + X_L^2$

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

$\therefore X_L = \sqrt{100 - 25}$

$\boxed{X_L = 8.66\ \Omega}$

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

$\therefore L = \frac{X_L}{2\pi f} = 0.0275\ H$

$\therefore \boxed{L = 27.5\ mH}$

Power factor $= \cos\phi = \frac{R}{Z} = \frac{5}{10} = \frac{1}{2}$

$\boxed{\cos\phi = 0.5}$

(c) What is phasor representation?

Answer: Phasor representation is a method used in electrical engineering to simplify the analysis of sinusoidal signals. It involves representing a sinusoidal waveform as a complex number, where the magnitude corresponds to the amplitude of the signal, and the angle represents the phase shift. This is particularly used in AC circuit analysis.

(d) Based on power factor, categorise the different kinds of electrical loads.

Answer: Electrical loads can be categorized based on power factor into three main types:-

(1) Leading Power Factor Load:

These loads have a power factor greater than 1 (cosine of the phase angle is positive).

Example: Capacitive loads.

(2) Unity Power Factor Load:

These loads have a power factor of 1 (cosine of the phase angle is 0.)

Example: Resistive Loads.

(3) Lagging Power Factor Load:

These loads have a power factor less than 1 (consine of the phase angle is negative).

Example: Inductive Loads.

(e) What is the difference between wire and cable?

	Wire	Cable
Definition	wire refers to a single conductor, usually made of metal such as copper or aluminium.	Cable consists of multiple wires bundled together and covered by insulation.
Function	It is used for the transmission of electrical signals over short distances.	It is designed to carry multiple signals over long distances.
Uses	Commonly used for basic electrical connections, like household wiring or small electronic devices.	Used in Ethernet cables for data transmission, power cables for appliances or structured cabling systems in buildings.

(f) Give an explanation of peak and form factors in terms of alternating current.

Answer: PEAK FACTOR: It is defined as the ratio of maximum value to the R.M.S. value of alternating current.

$$\text{Peak Factor} = \frac{I_{max}}{I_{rms}}$$

We know, $I_{rms} = \dfrac{I_{max}}{\sqrt{2}}$

$$\therefore \text{ Peak Factor} = \frac{I_{max}}{I_{max}/\sqrt{2}} = \sqrt{2}$$

Peak factor = 1.4142

FORM FACTOR: It is defined as the ratio of R.M.S value to the average value of alternating current

$$\text{Form Factor} = \frac{I_{rms}}{I_{avg.}}$$

We know

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$I_{avg} = \frac{2I_m}{\pi}$$

$$\therefore \text{ Form factor} = \frac{I_m/\sqrt{2}}{2I_m/\pi} = \frac{\pi}{2\sqrt{2}}$$

Form factor = 1.11

(g) What are the classifications of magnetic materials based on their magnetic properties?

Answer: Based on their magnetic properties magnetic materials are mainly classified into three types:-

(1) Diamagnetic Materials:

The materials which are slightly repelled by a magnetic field and they do not retain th magnetic properties when the external field is removed. These materials have weak, negative susceptibility to magnetic fields.

(2) Paramagnetic Materials:

The materials which are slightly attracted b a magnetic field and they do not retain the magnetic properties when the external magnetic field is removed. These materials have small, positive susceptibility to magnetic fields.

(3) Ferromagnetic Materials:

The materials which exhibit a strong attraction of magnetic fields and are able to retain their magnetic properties after the external field has been removed. These materials have a large, positive susceptibility to an external magnetic field.

(h) State and explain the Kirchhoff's Law.

(1) Kirchhoff's First Law:

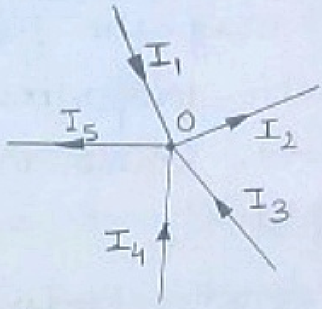
It relates to current flowing through the circuit. So, it is known as KCL "Kirchhoff's Current Law."

This law states that algebraic sum of current elements meeting at a point known as 'Junction' is Zero.

* All the incomming current is taken as positive and all the outgoing current is taken as negative.

Mathematically,

$$\sum I = 0$$



Eg: $I_1 - I_2 + I_3 + I_4 - I_5 = 0$

$I_1 + I_3 + I_4 = I_2 + I_5$

Sum of incoming current = Sum of outgoing current.

(2) Kirchhoff's Second Law:

It relates to the voltage in a closed circuit of an electric network. So, it is known as KVL "Kirchhoff's Voltage Law"

This law states that in a closed circuit algebraic sum of all the EMF and algebraic sum of all the voltage drop is zero.

Mathematically,

$$\sum EMF + \sum Voltage\ Drop = 0$$

i) Identify and explain the different losses in a transformer.

nswer: There are mainly two types of losses in a transformer:

(1) Variable Losses:

The current in primary and secondar

windings varies according to load and called Variable Losses.

Eg:- Copper Losses

The losses which occur in both primary and secondary windings due to their ohmic resistance

Copper losses = $I_1^2 R_1 + I_2^2 R_2$

(2) Fixed Losses:

When AC supply is given to 1° winding, flux is set-up in the core due to which these two types of losses occur:

(i) HYSTERISIS LOSSES

When AC supply is given to primary winding the flux genetated in the core is also alternating.. The core gets magnetized in the positive half cycle and demagnetized in negative half cycle. During demagnetization extra pressure is applied due to which core gets heat up and losses are generated in the form of heat called Hysterisis losses.

(ii) EDDY CURRENT LOSSES

The flux in the core is alterating. It links with magnetic material of core also. This induces an emf in the core and circulate Eddy Currents. Power is required to maintain these Eddy currents. This power is discipated in the form of heat. This is known as Eddy Current Losses.

(j) State the purpose of Earthing in electrical Systems.

Answer: Safety, Equipment protection and Interference Reduction are main purposes of Earthing in electrical systems.

(1) Safety: Earthing provideds a path for fault currents to safely dissipate into the ground, reducing the risk of electric shocks and fire hazards.

(2) Equipment Protection: It helps in stabilizing voltage levels and preventing damage to electrical appliances by providing a reference point for the system's voltage.

(3) Interference Reduction: Earthing minimizes electro-magnetic interference and creates a low-resistance path for unwanted curretnts to flow into the ground.

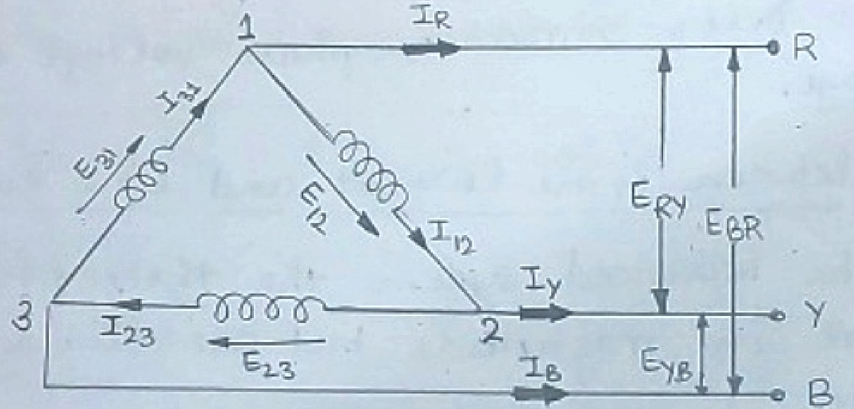
SECTION-B

Ques2: For a balanced three-phase delta connection, determine the numerical relationship between the line and phase currents.

Answer:

DELTA CONNECTION:

In delta connection, the finishing terminal of one winding is connected to starting terminal of other winding and so on. The three line conductors are run from the three junctions of the mesh called Line conductors.



The current flowing in each phase is called Phase Current (I_{PH}) and the current flowing through each line conductor is called Line Current (I_L).

The voltage across each phase is called Phase Voltage (V_{PH}) and the voltage across ~~each~~ two line conductors is called Line Voltage (V_L).

Relation between phase Voltage and Line Voltage

It is clear from the figure that the voltage across terminals 1 and 2 is the same as across the terminals R and Y. Therefore,

$V_{12} = V_{RY}$

Similarly

$V_{23} = V_{YB}$

and $V_{31} = V_{BR}$

where all the phase voltages are equal

$V_{12} = V_{23} = V_{31} = V_{PH}$

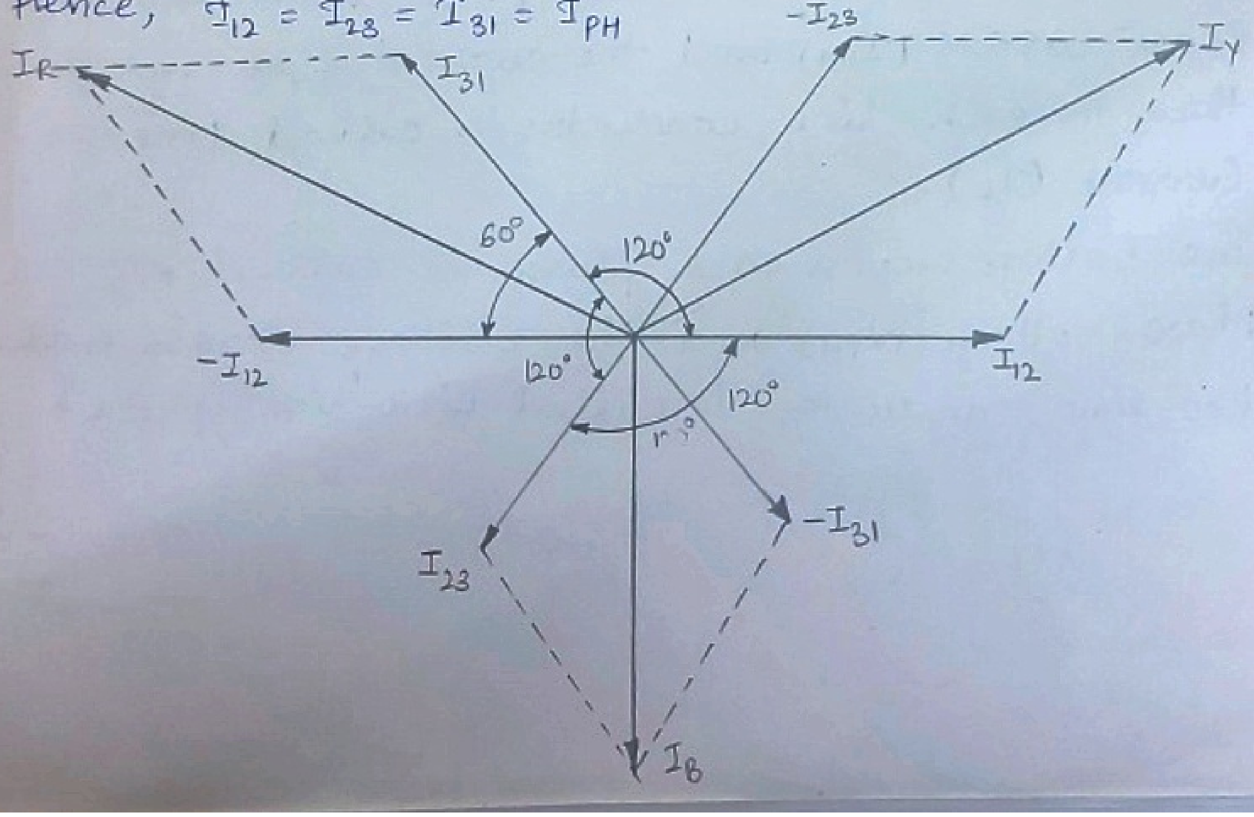
∴ Line Voltages ; $V_{RY} = V_{YB} = V_{BR} = V_L$

Hence, in Delta connection phase voltage is equal to line voltage.

Relation Between Phase Current and Line current

As in the balanced system the three phase currents are equal in magnitude but are displaced from one another by 120° electrical apart.

Hence, $I_{12} = I_{23} = I_{31} = I_{PH}$



Applying Kirchhoff's Current Law at Node 1 we get

$$I_{31} = I_R + I_{12}$$

$$\therefore I_R = I_{31} - I_{12}$$

Similarly,

$$I_Y = I_{12} - I_{23}$$

and $I_B = I_{23} - I_{31}$

These relations are shown by the above phasor diagram.

Therefore, the resultant

$$I_R = \sqrt{I_{31}^2 + I_{12}^2 + 2 I_{31} I_{12} \cos 60^\circ}$$

$$I_L = \sqrt{I_{PH}^2 + I_{PH}^2 + 2 I_{PH} \cdot I_{PH} \cos 60^\circ}$$

$$I_L = \sqrt{3 I_{PH}^2}$$

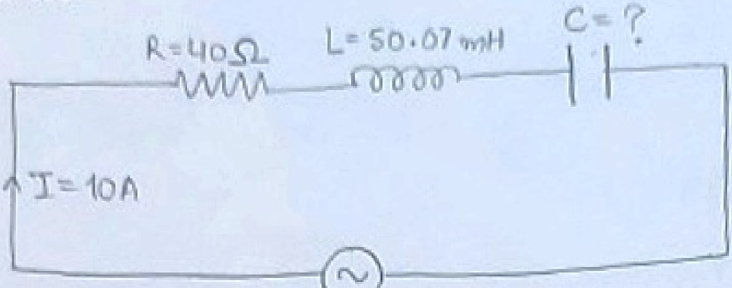
$$I_L = \sqrt{3}\, I_{PH}$$

Line Current = $\sqrt{3}$ (Phase Current)

Hence, in Delta connection line current is root three times of Phase current.

Ques 3. A series RLC circuit of $R = 40\,\Omega$, $L = 50.07\,mH$ and a capacitor is connected across a 400 V, 50 Hz AC supply. This RLC combination draws a current of 10 A.

Answer:



As given

Resistance, $R = 40\,\Omega$ ——— ①

Inductance, $L = 50.07\,mH = 50.07 \times 10^{-3}\,H$

Voltage, $V = 400$ Volts

Frequency, $f = 50$ Hz

Current, $I = 10$ A

To find:

Power factor of circuit $= \cos\phi = ?$

Capacitor Value, $C = ?$

We know,

$$V = IR \quad \text{(Ohm's law)}$$

Here, in RLC series circuit the opposition is offered by the impedance of the circuit

$$\therefore V = IZ$$

$$Z = \frac{V}{I} = \frac{400}{10} = 40\,\Omega$$

$$Z = 40\,\Omega \text{ ——— ②}$$

Now,

$$X_L = \omega L = 2\pi f L = 2 \times 3.14 \times 50 \times 50.07 \times 10^{-3}\,\Omega$$

$$X_L = 15.72\,\Omega$$

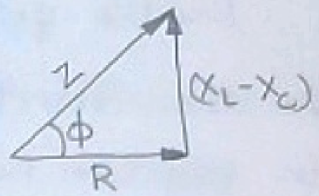
From equation (1) and (2) we find out that

$$Z = R$$

Therefore, the RLC series circuit has series rasonance

i.e. $X_L = X_C$

$\therefore X_C = 15.72\ \Omega$



(i) Power Factor, $\cos\phi = \frac{R}{Z}$

$$\cos\phi = \frac{40}{40} = 1 \quad , \quad \boxed{\cos\phi = 1}$$

As the power factor is unity, thus current and voltage are in same phase.

Now,

$$X_C = \frac{1}{\omega C}$$

$$\therefore C = \frac{1}{\omega X_C} = \frac{1}{2\pi f X_C} = \frac{1}{2 \times 3.14 \times 50 \times 15.72}$$

(ii) Capacitor value, $\boxed{C = 202.58\ \mu F}$

Ques:4 Briefly introduce the single-phase induction motor. Discuss the methods used for starting induction motors.

Answer: <u>Single-Phase Induction Motor.</u>

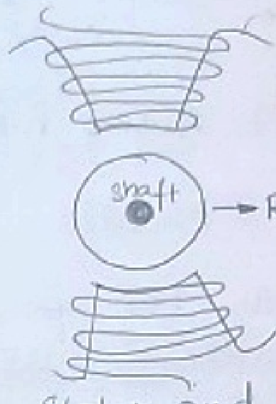
Single-phase induction motor is very simple and robust in construction. It operates on the principle of Electromagnetic Induction as that of Three-Phase Induction Motor.

The Stationary part is the Stator and the rotating part is the rotor. The Stator carries windings in the slots and the rotor is invariably of the squirrel cage type.

Double Field Revolving Theory :-

The magnetic field produced in a single phase induction motor can be explained through Double field revolving theory.

As the direction of voltage changes in negative half cycle, the direction of magnetic field produced in Stator also changes. The pole which is previously North pole becomes South pole and vice-versa.

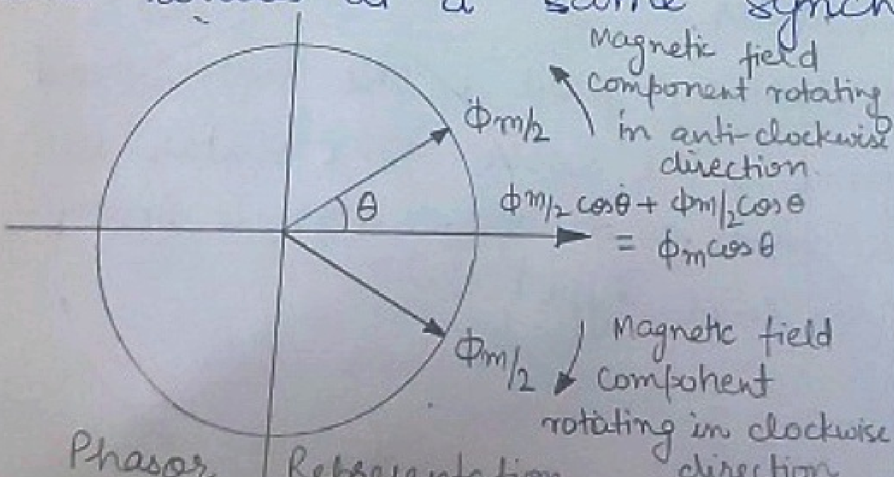


So we can say that a pulsating magnetic field is produced in stator.

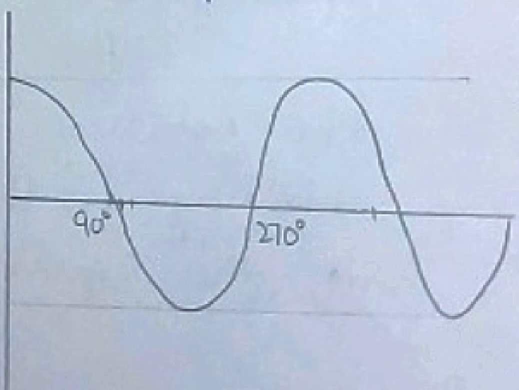
The magnetic field in stator is pulsating to-and-fro in clockwise and anti-clockwise direction.

The pulsating field produced in a single phase motor can be resolved into two components, one component rotating in clockwise direction and other component rotating in anti-clockwise direction.

Both the components have equal magnitude and rotates at a same synchronus speed.



Phasor Representation



Wave Diagram

Let ϕ_m be the pulsating field which has two Components each of magnitude $\phi_m/2$.

Both has some angular speed ω_s rad/sec but in opposite direction. The resultant of two fields is $\phi_m \cos\theta$. This shows that resultant field varies according to cosine of angle of θ.

Methods Used for Starting Induction Motors

(1) Direct-on-line (DOL) Starter

This method is used upto 5kW rating motors. In this method, Motor is switched ON direct to supply mains by switching conductors.
The starting current may be large as 10 times full load current.

To start the motor ON push button is pressed which energizes the no-volt coil by connecting it across two phases. The no-volt coil pull its pluger in such a way that all the normally open contacts are closed. Motor is connected across the supply through these contacts. The fourth contact serve as a hold on contact.

To off the motor, OFF push button is pressed which de-energizes the no-volt coil opening the main contacts.

) Star-Delta Starter

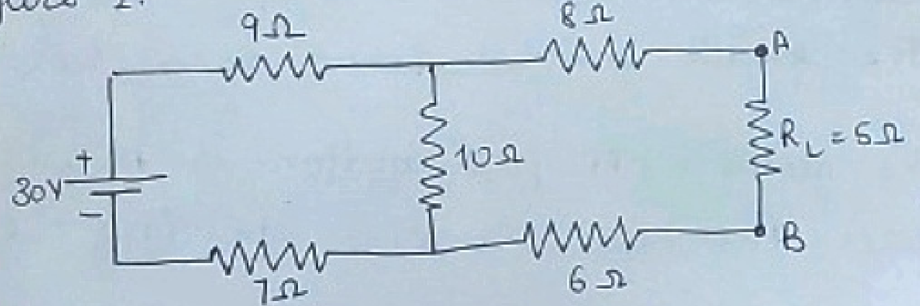
This method is based upon the principle that is star connection, voltage across each winding is phase voltage = $1/\sqrt{3}$ times line voltage whereas the same winding when connected in delta will have full line voltage across it.

So, at start, connections of the motors are made in star connection so that reduced voltage is applied across each winding. After the motor attains the speed core windings through the charge over switch are connected in delta across the same supply.

(B) Auto-Transformer Starter

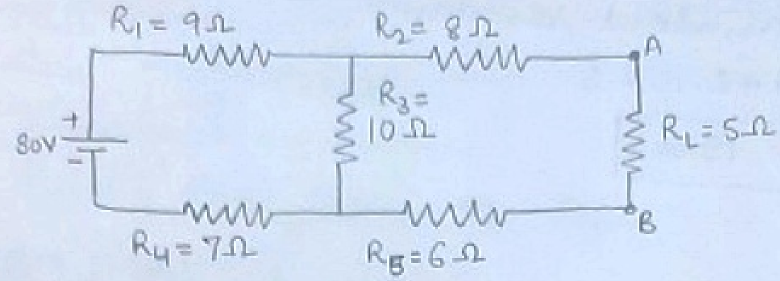
It is suitable for both star and delta connected motors. In this method, the starting current is limited by using a three-phase auto-transformer to reduce the initial stator applied voltage. It does not require difficult cabling. The main purpose of the autotransformer motor starter is to reduce the initial starting current of the electric motor to the voltage ratio of the transformer's square.

Ques 5: State and Explain Norton's Theorem. Using Norton's theorem determine the current flowing through the load resistance (R_L) in figure 1.

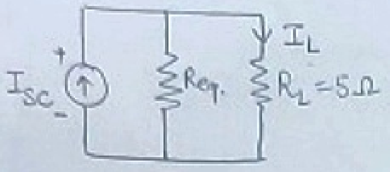


Answer: Norton's theorem states that Any two terminal bilateral linear DC circuit can be replaced by an equivalent circuit consisting of current source in parallel with resistor.

The given circuit is



The equivalent circuit according to Norton's theorem is:-

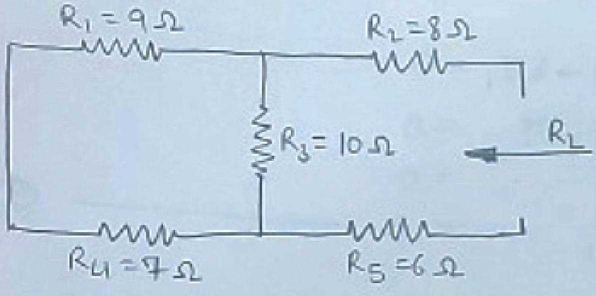


Here

$$I_L = I_{sc}\left(\frac{R_{eq}}{R_{eq}+R_L}\right)$$

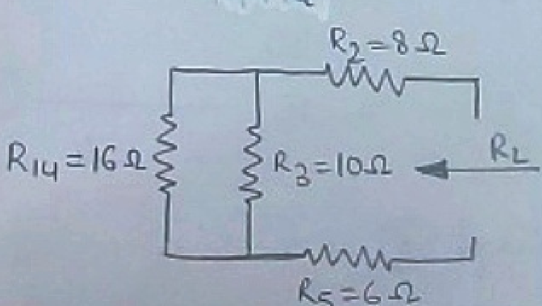
$$I_L = I_{sc}\left(\frac{R_{eq}}{R_{eq}+5}\right) \quad \text{— (1)}$$

Step - II : To find the equivalent resistance of circuit



Resistors R_1 and R_4 are in series;

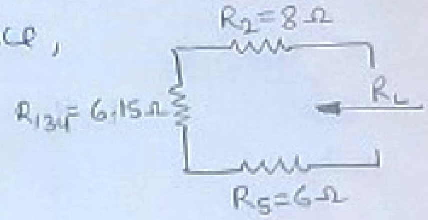
$$\therefore \; R_{14} = R_1 + R_4 = 9 + 7 = 16\,\Omega$$



Now, R_{14} and R_3 are in parallel;

$$\therefore \; R_{134} = \frac{R_{14} R_3}{R_{14} + R_3} = \frac{160}{26} = 6.15\,\Omega$$

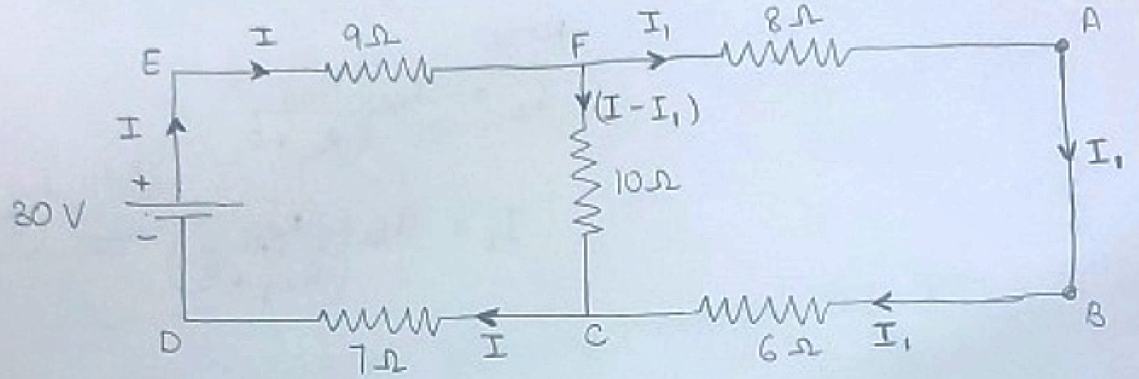
Now, all the three resistors are in series
Thus, the equivalent resistance,



$$R_{ep.} = 8 + 6.15 + 6$$

$$\boxed{R_{ep.} = 20.15\,\Omega}$$

Step-III To find the short circuit current of the circuit.



Applying KVL in loop ABCFA

$\Rightarrow \quad -6I_1 + 10(I - I_1) - 8I_1 = 0$

$\Rightarrow \quad -14I_1 - 10I_1 + 10I = 0$

$\Rightarrow \quad -24I_1 + 10I = 0$

$\Rightarrow \quad 5I - 12I_1 = 0 \quad \text{——— (2)}$

Applying KVL in loop EFCDE

$\Rightarrow \quad -9I - 10(I - I_1) - 7I + 30 = 0$

$\Rightarrow \quad -16I - 10I + 10I_1 + 30 = 0$

$\Rightarrow \quad -26I + 10I_1 = -30$

$\Rightarrow \quad 13I - 5I_1 = 15 \quad \text{——— (3)}$

Solving equantion (2) and (3)

$$65I - 156I_1 = 0$$
$$\underline{\overset{-}{}65I \;\overset{-}{+}\; 25I_1 = \overset{-}{}75}$$
$$-131I_1 = -75$$

$\therefore I_1 = 0.57\ A$

Thus, $I_{SC} = I_1$

$$I_{SC} = 0.57\ A$$

Putting the value of Rep. and I_{sc} in eq^n ①

we get

$$I_L = I_{sc}\left(\frac{Req}{Req+5}\right)$$

$$I_L = 0.57\left(\frac{20.15}{20.15+5}\right)$$

$$I_L = 0.46\ A$$

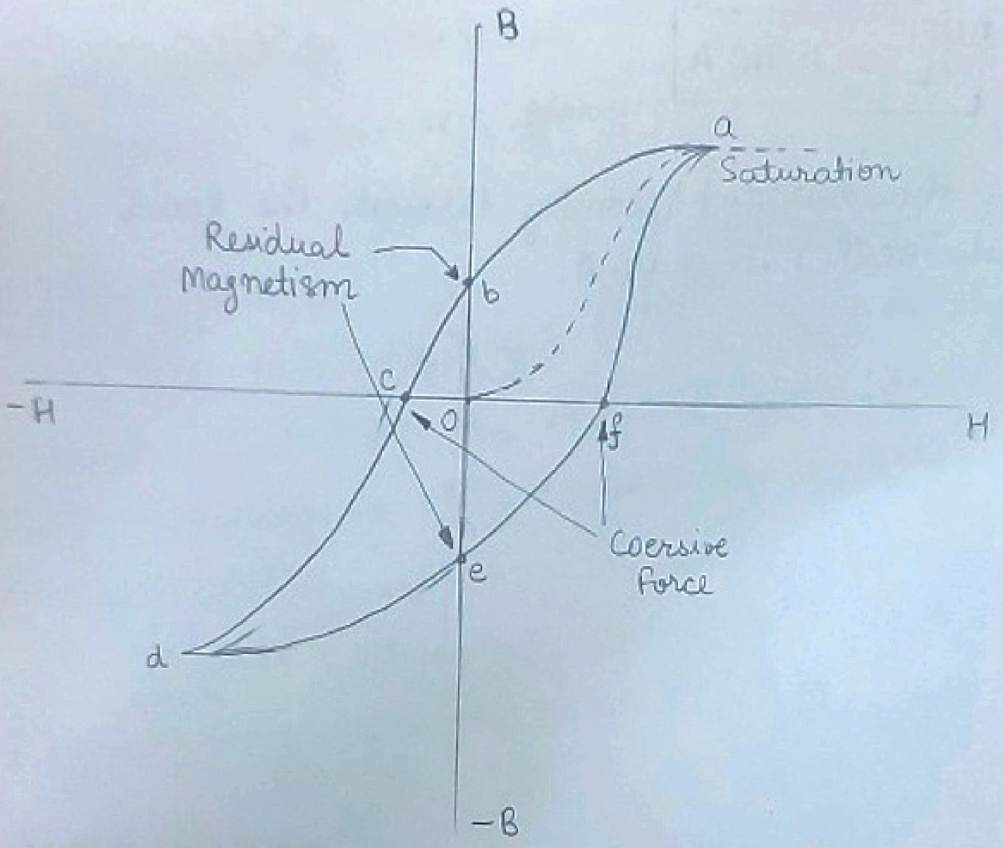
Thus, the current flowing through the load resistance (R_L) is 0.46 A.

SECTION-C

Ques 6: Describe the BH curve and its significance in characterizing magnetic materials.

Answer:

The BH curve, also known as the hysteresis loop is a graphical representation of the relationship between the magnetic flux density (B) and the magnetizing force (H) in a magnetic material. It plays a crucial role in characterizing magnetic materials and understanding their magnetic properties.



The magnetic hysterisis loop above, shows the behaviour of a ferromagnetic core graphically as the relationship between B and H is non-linear.

The B-H curve illustrates how a material responds to changing magnetic fields by plotting the magnetic flux density (B) against the magnetizing force (H)

The loop shape of the BH curve is due to hysteresis phenomenon, where the magnetic properties lag behind the changes in the magnetic field. It shows the material's ability to retain magnetisation even after the removal of the magnetic field.

SATURATION :

The curve initially rises steeply from 0 to a representing the rapid increase in magnetic flux density until saturation is reached (a onwards)

Saturation occurs when the material cannot further increases its magnetization under the applied magnetic field.

COERCIVITY :

The coercivity (H_c) is the magnetizing force required to reduce the magnetic flux density to zero, measuring the material's resistance to demagnetization.

Higher Coercivity implies better retention of magnetization. (Point 'c' and 'f').

RETENTIVITY :

The ability for a coil to retain some of its magnetism within the core after the magnetization process has stopped is called Retentivity, while the amount of flux ~~of~~ density still remaining in the core called "Residual Magnetism". (Point 'b' and 'e')

Different materials exhibit distinct BH curve shaphes based on their composition and magnetic characteristics. Soft magnetic materials have narrow loops, indicating low energy losses and quick response to magnetic fields, while hard magnetic materials have wider loops, indicating high coercivity and stability.

BH curves are crucial in designing magnetic components like transformers, inductors. and magnetic cores.

Ques.7 Compare Miniature Circuit Breaker (MCB) and Earth Leakage Circuit Breaker (ELCB).

1. Definition and function:

MCB: MCB is a device that ensures definite protection of wiring system and electrical equipments against over current and short circuit.

ELCB: It is a safety device used in electrical installations, it has high earth impedance to prevent shock. It detects small stray voltage on metal enclosure of electrical equipments and interrupts the circuit if a dangerous voltage is detected.

2. Construction:

MCB: MCB's construction can be explained by considering the following parts:

(i) Outer body made from special glass fibre
(ii) Contacts made of silver which provide long contact life, low contact resistance and low heat generation.
(iii) Operating Mechanism which is self-lubricating. Its components are made up of special plastic.
(iv) Arch extinguinshing contacts
(v) Fixing Arrangement : Chips are at the back of MCB to easily attach and remove it to or from the Din - Bar.
(vi) Interlocking of Multiple MCB's is done in order to trip off all the MCB's simultaneously

ELCB : ELCB consist of the following parts :
(i) Core Balance Current Transformer (CBCT)
(ii) A line wire to tranfer line current
(iii) Neutral wire
(iv) Residual Current source coil use to send signal when fault occur.
(v) Relay, a sensing devices which get signal from the residual coil and breaks the circuit.

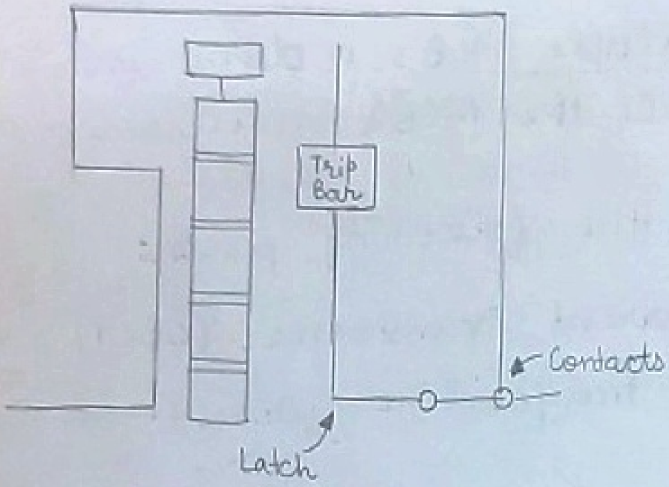
3. Tripping Mechanisms :

MCB : MCB operates on the magnetic and thermal effects of overcurrents.
Under the normal condition, it operates as Switch to make the circuit 'ON' or 'OFF'.

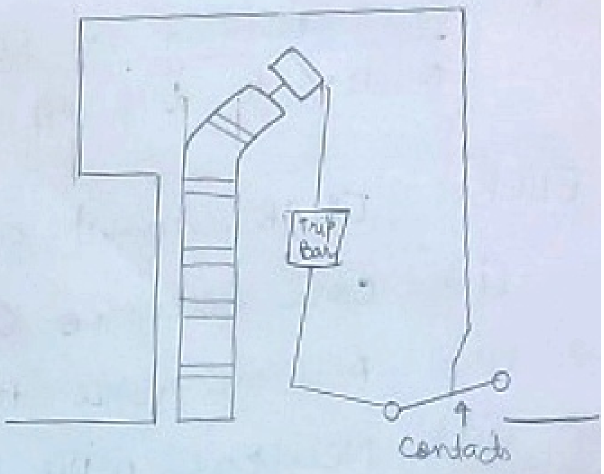
Under overload or shortcircuit condition, it automatically operates or trips so that current interruption takes place in a load circuit.
The automatic operation of MCB can be obtained in two ways :-

(a) Magnetic Tripping
(b) Thermal Tripping.

Thermal TRIPPING

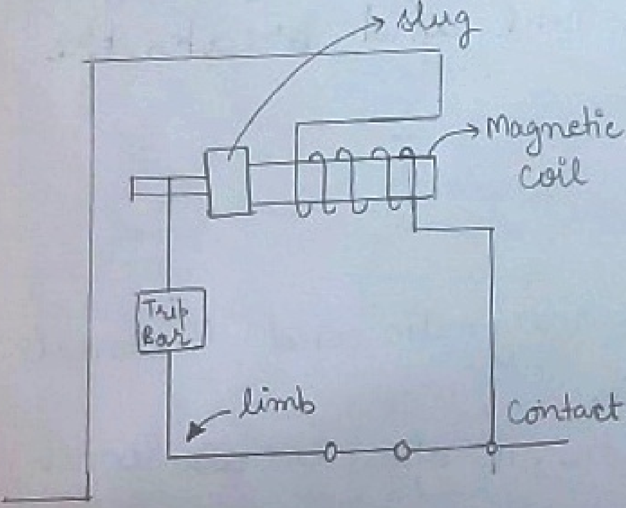


Normal Condition

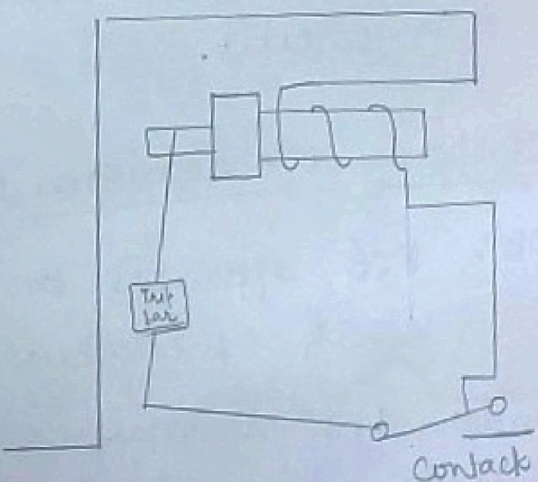


Overload condition

MAGNETIC TRIPPING



Normal Condition

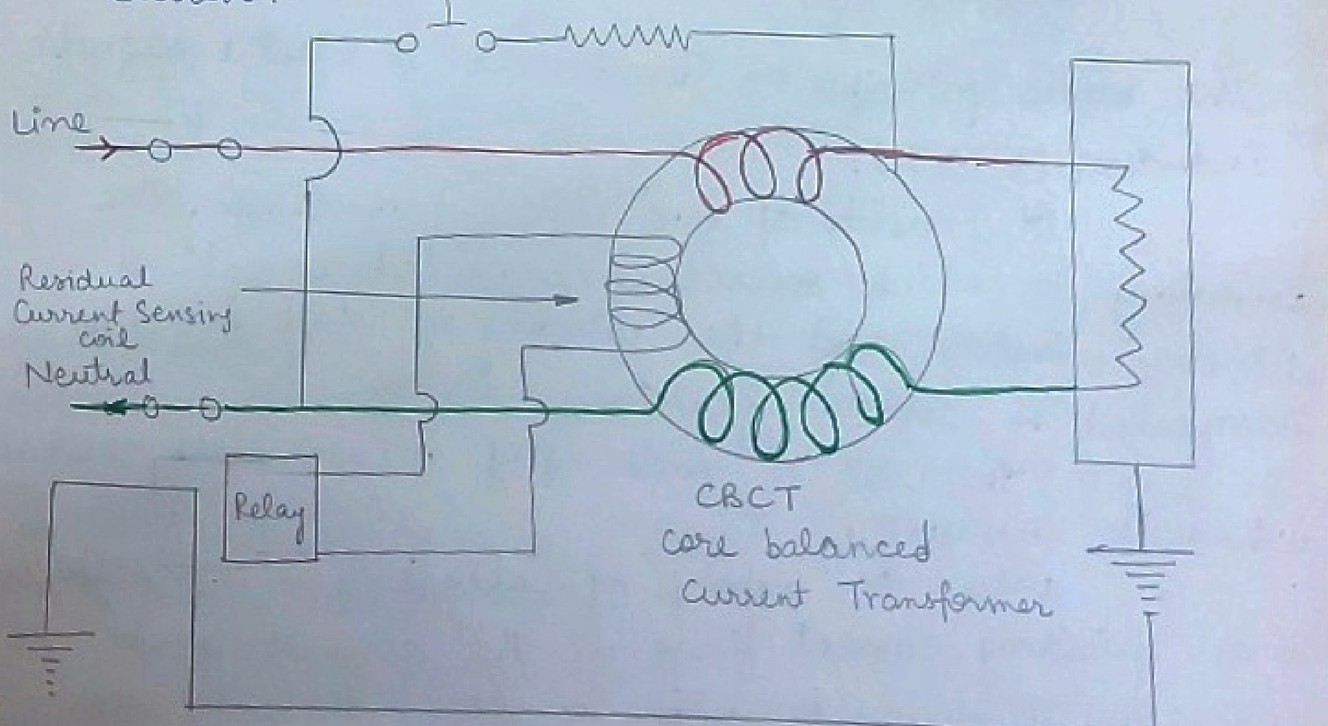


Overlad Condition

ELCB : ELCB operates by detecting the imbalance current between the live and neutral conductors, indicating a leakage to the ground.

Under normal condition, current entering the line conductor is equal to the current leaving the neutral conductor. Both the direction will be opposite, then according to flaming's law, emf will be induced but direction is opposite so that they will eliminate the effect of each other. Thus, no residual flux will be setup in the core.

Under a condition such that wire touches the equipment some of the current will be grounded which creates a difference between line conductor and neutral conductor. This difference will induce emf in the core. This flux will leak with residual current sensing coil. The current produced in that coil will work as signal for relay. The relay will send operating signal to circuit breaker. The circuit breaker will interupt the current.



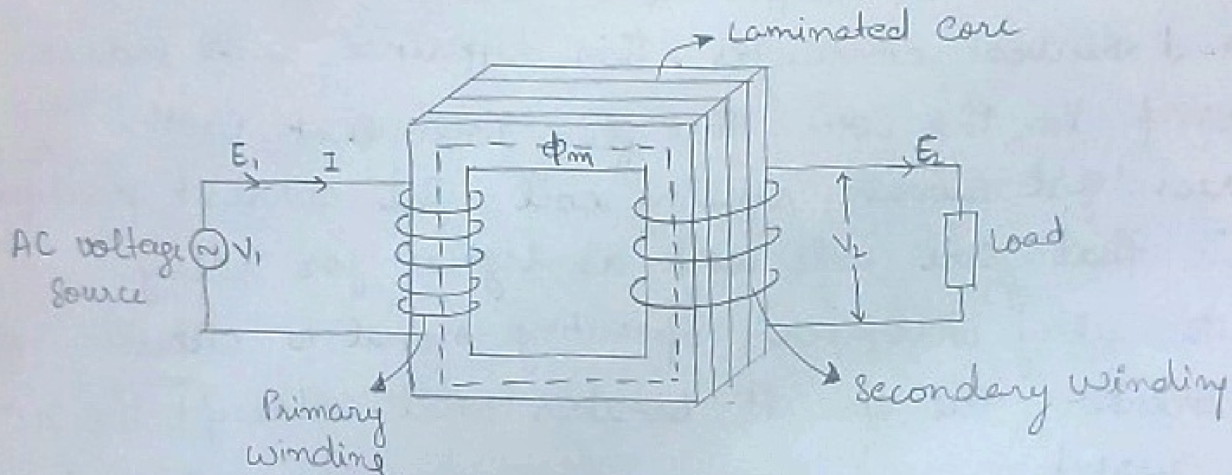
ELCB

Ques 8. Explain the principle of operation of a transformer. Derive an EMF equation for a single phase transformer. Also, draw the phasor diagram of a single phase transformer at leading power factor load.

Answer: Transformer

A transformer is a static device which transfer AC electric power from one circuit to another at a same frequency but voltage level may change.

Principle of Operation of a Transformer



The basic principle of Transformer is Electromagnetic Induction (E.M.I.).

It consists of two different windings. The winding to which source is connected is called Primary winding and the winding to which load is connected is called Secondary winding.

The core is made up of silicon steel material which is laminated.

When AC supply of voltage V_1 is connected to primary winding current flows in the circuit and alternating flux is set up in a core. It links with both primary and secondary winding. There is no electric connection between primary and secondary windings even then electric power is transferred from primary to secondary circuit through mutual flux.

According to Faraday's Law,

$$e = N \frac{d\phi}{dt}$$

$$\therefore e \propto N$$

$$E_1 \propto N_1$$

$$E_2 \propto N_2$$

∴ Transformer Ratio

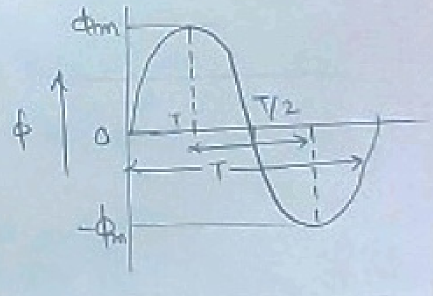
$$K = \frac{V_2}{V_1} = \frac{E_2}{E_1} = \frac{N_2}{N_1}$$

EMF equation for a single-phase transformer

We know,

$$\text{Average Rate of change of flux} = \frac{\phi_m - (-\phi_m)}{T/2}$$

$$= 2 \times \frac{2\phi_m}{T} = \frac{4\phi_m}{T}$$



Now, $\frac{1}{T} = f$

∴ Average rate of change of flux $= 4\phi_m f$ Wb/s

Also, we know

$$\text{Form Factor} = \frac{\text{RMS Value}}{\text{Average Value}}$$

$$1.11 = \frac{\text{RMS Value}}{\text{Avg. Value}}$$

$$\text{RMS Value} = 1.11 \times \text{Avg. Value}$$

∴ RMS Value of Rate of Change of flux = 1.11 × Avg. rate of change of flux

We get

RMS value of Rate of Change of flux $= 4.44\,\phi_m f$

we know

$$e = N\frac{d\phi}{dt}$$

$$\frac{d\phi}{dt} = \frac{e}{N}$$

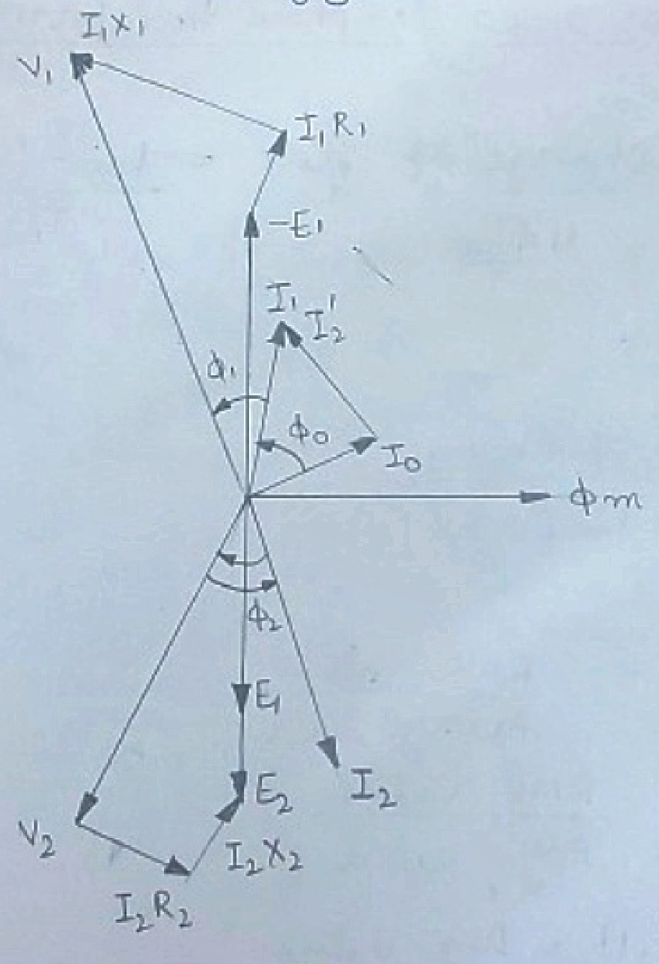
This is emf induced per turn

RMS value of emf per turn = RMS value of rate of change of flux = $4.44\,\phi_m f$

$\Rightarrow E_1 = 4.44\,\phi_m f N_1$ (RMS value of primary coil)

$\Rightarrow E_2 = 4.44\,\phi_m f N_2$ (RMS value of secondary coil)

⊛ Phasor Diagram representing the leading power factor load is as shown in figure



Ques9: What is the significance of rotating magnetic field in motor operation? Describe the constructional features of a three-phase induction motor.

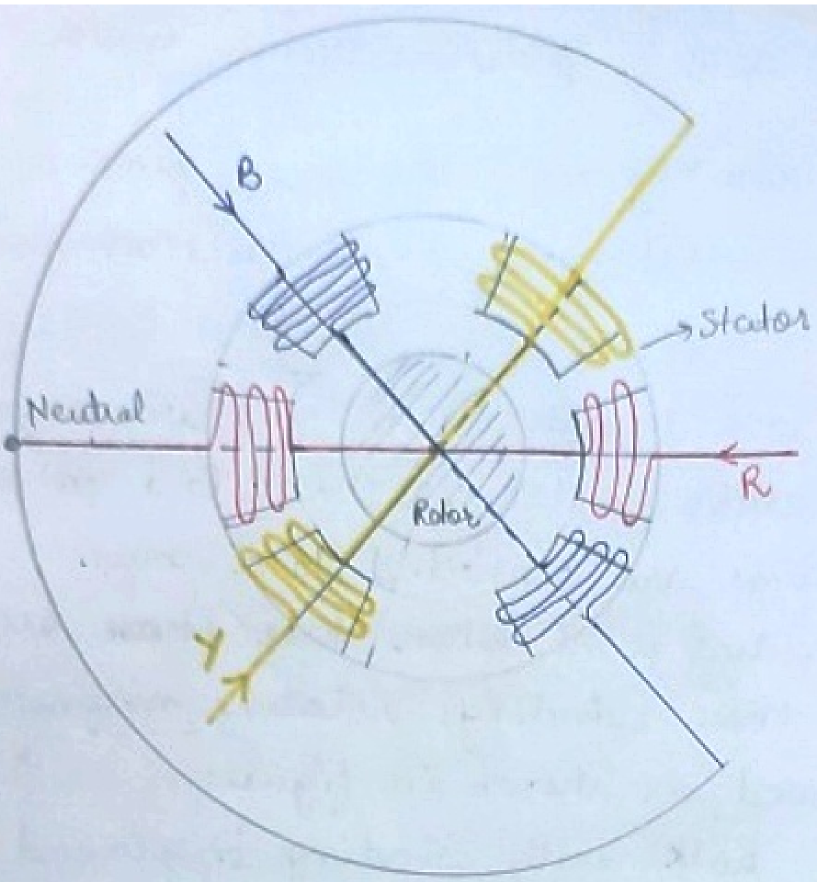
Answer: The rotating magnetic field play a significant role in the working of an induction motor. as follows:-

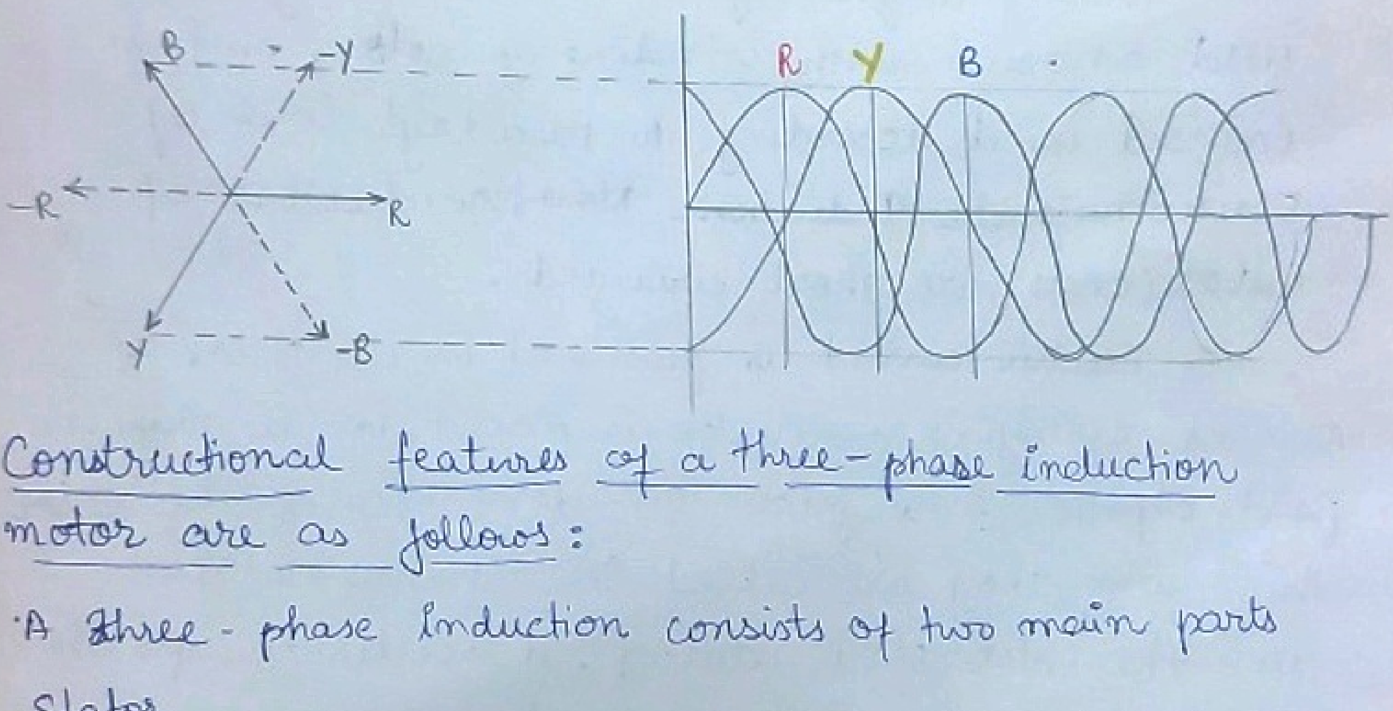
Firstly we wound stator with three windings having 120° phase difference between them. End points of these windings are connected to a common point called Neutral point. when three phase supply is given to these windings rotating magnetic field is produced as shown in figure.

Rotor with winding is placed inside the rotating magnetic field. Now rotating magnetic field associate with winding of rotor, emf is induced in it according to Faraday's law of Electromagnetic Induction. Now, conductors of rotor (ends) are short circuited.

∴ Electric current is produced in it. Now, a current carrying conductor is placed in a magnetic field experience a force. This force rotates the rotor that's why they are called Self-Starting Motors.

Now the rotor start rotating, it accelerate upto the speed of rotating magnetic field of stator i.e. Synchronous speed (N_s) when rotor attains synchronous speed their is no relative velocity between rotor and rotating magnetic field. No magnetic field is cut the rotor winding. There is no force acting on it at that instance. The speed of rotor slows down. This process continues and the motor starts working.





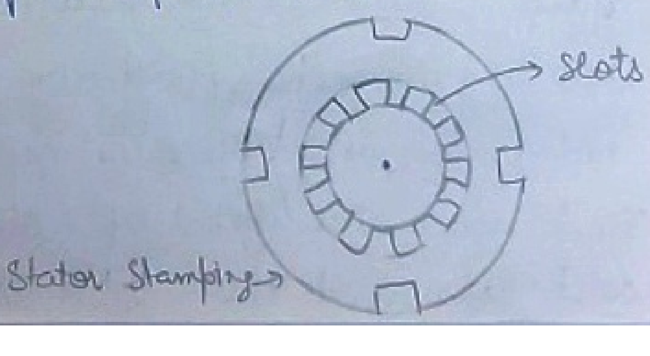
Constructional features of a three-phase induction motor are as follows:

A three-phase Induction consists of two main parts

- Stator
- Rotor

(1.) Stator : It is stationary part of the motor. It has three main parts :

(i) Outerframe
(ii) Stator core
(iii) Stator winding



(i) Outframe :- It is outer body of the motor. It's function is to support stator core and to protect the inner parts of the machine.

(ii) Stator Core :- The function of the stator core is to support the stator winding. It has to carry alternating magnetic field produced.

→ It is made of high grade silicon steel stampings to reduce hysteresis and eddy current losses.
→ The thickness of stamping varies from 0.3 mm to 0.5mm
→ The stampings are assembled under hydraulic pressure and are fixed to frame.
→ Slots are punched in the inner parts of the stampings to hold the stator windings.

(iii) Stator Windings: The stator core is wound with three phase windings which is supplied from 3-phase supply system.

→ The six terminals of windings are connected in the terminal box.

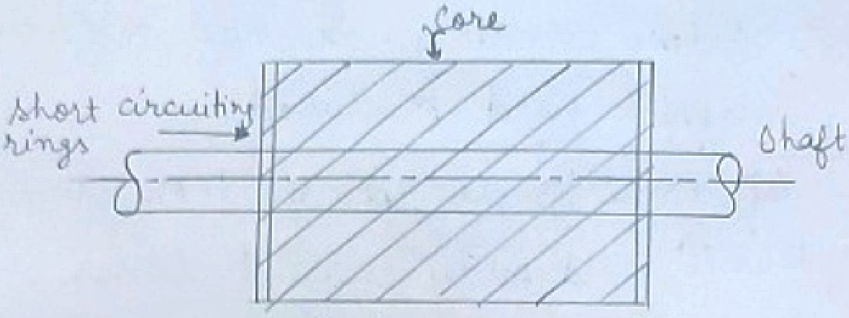
(2.) Rotor : Rotor is the rotating part of the motor.

There are two types of Rotors:

(i) Squirrel Cage Rotor: The motor employing this type of rotor are known as squirrel cage ~~ind~~ induction motors.

→ A squirrel cage rotor consist of a laminated cylindrical body having semi-closed circular slots and short-circuited at each ends by copper or aluminium rings.

The rotor winding is permanently short-circuited and it is not possible to add external resistance in the rotor circuit.



Squirrel Cage Rotor.

(ii) Phase-wound Rotor (Slip-ring Rotor)

- The motor employing this type of Rotor is called slip ring or phase wound induction motor.
- Slip ring rotor consist of laminated cylindrical core having semi-closed slots at the outer periphery and carries three-phase insulated windings.
- The rotor is wound with same number of poles as that of stator.