LORDS INSTITUTE OF ENGINEERING &TECHNOLOGY

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Department of Science and Humanities

Academic Year: 2022-23

Year: I Semester: I

QUESTION BANK

BASIC ELECTRICAL ENGINEERING

[U21EE101]

[Common to ECE, CSM, INF, AIML, & MECH]

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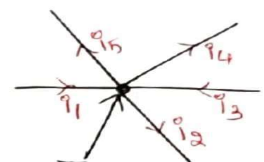
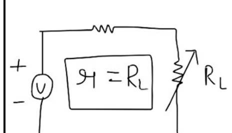
Note: A question bank is versatile and flexible FAQs that cover the entire syllabus of a subject. It is used by students and teachers for learning and assessment purposes only.

S.NO	Unit-1 (SAQ's)
1	State ohms law and write its limitations. Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance between them. The mathematical equation for Ohm's law is given as: V = IR where V is the voltage (in volts), I is the current (in amperes), and R is the resistance (in ohms). Limitations of Ohm's law: 1. It is applicable only for linear and homogeneous conductors, and not for non-linear conductors like diodes and transistors. 2. It does not take into account the effects of temperature, pressure, and other external factors that can affect the resistance of a conductor. 3. It is not applicable for conductors in which the resistance changes with the current, as in the case of thermistors and magnetic materials. 4. It is also not applicable to semiconductors, where the resistance changes with the applied voltage. Hence, Ohm's law should be used with caution and should be supplemented by other laws and principles to account for the limitations mentioned above.
2	State Kirchhoff's laws. i) Kirchoff's current law: consider a junction point in a complex network as shown in fig. Statement: The total current flowing towards a junction point is equal to the total currents flowing away from the junction point. From the above statement,  Junction point $\boxed{i_1 + i_3 = i_2 + i_4 + i_5}$ (or) The algebraic sum of all the currents meeting at a junction point is always zero. $\boxed{\Sigma I \text{ at junction point} = 0.}$ ii) Kirchoff's voltage law (KVL): The algebraic sum of all the branch voltages, around any closed path (or) closed loop is always zero. $\boxed{\text{Around a closed path } \Sigma V = 0.}$
3	State the Norton's theorem. A Linear network consisting of number voltage sources and resistances can be replaced by an equivalentnetwork having single current source (I_N) and a single resistance (R_N).
4	State the super position theorem. In a linear, Bilateral active network current through or voltage across any element is equal to algebraic sum ofthe currents or voltages produced by individual source

5	State the Thevenin’s theorem. A linear bilateral network consisting of number of voltage sources or resistances can be replaced by anequivalent network having a single voltage source Thevenin’s voltage V_{th} and a single resistance calledThevenin’ Resistance R_{th}
6	List the different types of voltage and current sources. The Voltage and Current sources are classified as Independent Sources 1. Independent Voltage Source 2. Independent Current Source Independent Sources 1. Voltage Dependent Voltage Source 2. Voltage Dependent Current Source 3. Current Dependent Voltage Source 4. Current Dependent Current Source
7	Define (i) Charge (ii) Electric Current (iii) Power (iv) Network (v) Circuit (i) Charge: Charge is a fundamental property of matter that describes the amount of electrical energy an object possesses. It is quantified in coulombs (C) and is either positive or negative, depending on whether the object has an excess or deficiency of electrons. (ii) Electric Current: Electric current is the flow of electric charge in a conductor. It is quantified in amperes (A) and is the rate at which electric charge flows through a conductor. Electric current is a measure of the flow of electrons through a conductor and is the result of a potential difference (voltage) applied across the conductor. (iii) Power: Power is a measure of the rate at which energy is converted from one form to another. In electrical systems, power is the rate at which electrical energy is converted into other forms of energy, such as light, heat, or motion. It is quantified in watts (W) and is equal to the product of voltage (V) and current (I). (iv) Network: A network is a set of interconnected components or elements that are connected together to perform a specific function. In electrical engineering, a network refers to an interconnection of electrical components, such as resistors, capacitors, inductors, and sources, that form a system with a specific behavior. (v) Circuit: A circuit is a closed path along which electrical current can flow. A circuit typically contains electrical components, such as resistors, capacitors, inductors, and sources, that are connected together to form a complete system that performs a specific function. The components in an electrical circuit are connected together in a way that allows the flow of electric current from one component to another.
8	State Maximum Power transfer theorem. Statement: - In an active resistive network, maximum power transfer to the load resistance takes place onlywhen the load resistance is equal to internal resistance of the applied voltage  V= DC Voltage Source

	r Internal resistance of DC Voltage source R= Variable Load Resistance
9	Define active and passive elements. Active Elements: - Active elements are the elements with supply power or energy to the network Eg: Voltage source, Current sources Passive Elements: - Passive elements are the elements which either store energy or dissipate energy in the form of heat. Eg: Inductor and capacitor can store energy resistor dissipates energy in the form of heat
10	Define unilateral and bilateral elements. Unilateral Element: A unilateral element (such as a diode or transistor) conducts current only in one direction. Bilateral Element: An element that conducts current in both directions and has the same magnitude is referred to as a bilateral element. Examples of such elements are resistance, inductance, and capacitance
11	Define linear network and non-linear network. **i) Linear Network :** A circuit or network whose parameters i.e. elements like resistances, inductances and capacitances are always constant irrespective of the change in time, voltage, temperature etc. is known as **linear network.** The Ohm's law can be applied to such network. The mathematical equations of such network can be obtained by using the law of superposition. The response of the various network elements is linear with respect to the excitation applied to them. **i) Linear Network :** A circuit or network whose parameters i.e. elements like resistances, inductances and capacitances are always constant irrespective of the change in time, voltage, temperature etc. is known as **linear network.** The Ohm's law can be applied to such network. The mathematical equations of such network can be obtained by using the law of superposition. The response of the various network elements is linear with respect to the excitation applied to them.
12	Illustrate resistors are in series. If ‘n’ number of resistors are connected. If ‘n’ number of resistors are connected in Series $R_{eq} = R_1 + R_2 + R_3 + \ldots\ldots\ldots R$
13	Illustrate inductors are in series. If ‘n’ number of inductors are connected. If ‘n’ number of inductors are connected in Series $L_{eq} = L_1 + L_2 + L_3 + \quad L_n$
14	Illustrate capacitors are in series. If ‘n’ number of capacitors are connected. If ‘n’ number of capacitors are connected $\frac{1}{Ceq} = \frac{1}{C1} + \frac{1}{C2} + \cdots \frac{1}{Cn} +$
15	Give the V-I Relationship for electrical circuits elements R, L & C. Here is the V-I relationship for the three basic electrical circuit elements: Resistor (R): In a resistor, the voltage (V) across the element is proportional to the current (I) flowing through it. The relationship is given by Ohm's law, which states that V = IR, where R is the resistance of the resistor. Inductor (L): In an inductor, the voltage across the element is proportional to the rate of change of the current flowing through it. The relationship is given by the equation $I = L\frac{dV}{dt}$ where L is the inductance of the inductor and di/dt is the rate of change of the current.

	Capacitor (C): In a capacitor, the voltage across the element is proportional to the charge stored on the plates. The relationship is given by the equation V = Q/C, where Q is the charge stored on the plates and C is the capacitance of the capacitor. The current flowing through a capacitor is proportional to the rate of change of the voltage across it and is given by the equation $$I = C\frac{dV}{dt}$$ Note that these relationships are valid only for ideal elements and assume that the elements are linear, meaning that their behavior can be described by a straight line. In reality, elements may exhibit non-linear behavior and the relationships may not hold.
S.NO	Unit-II (SAQ's)
16	Define Active power and Reactive power. **Active Power**: - Active power is defined as the product of $I_{r.m.s}$ & $V_{r.m.s}$ with cosine of phase angle "Ø" between them $$P = V_{rms} \times I_{rms} \times \cos\phi$$ $$P = VI\cos\phi \text{ Watt}$$ **Reactive Power**: - It is defined as the product of $I_{r.m.s}$ & $V_{r.m.s}$ with the sine of angle "Ø" between them. $$Q = V_{rms} \times I_{rms} \times \sin\phi$$ VAR (volt-ampes reactive)
17	Define time period and frequency. Time Period: - The time taken by alternating quantity to complete its one cycle is known as its time perioddenoted by "T" seconds. Frequency: - The number of cycles completed by an alternating quantity per second is known as frequency.It is denoted by 'f ' and it is measured in cycles / second which as Harts' Denoted as Hz
18	Define amplitude and peak to peak value. Amplitude: - The maximum value attained by alternating quantity during positive or negative half cycle iscalled its amplitude it is denoted by Vm & Im Vm = Peak value of Voltage Im = Peak value of Current
19	Define cycle, angular velocity. Cycle: - Each reputation of a set of positive and negative instantaneous values of the alternating quantity iscalled a cycle. Angular Frequency; - It is the frequency expressed in electrical radians per second. $\omega = 2\pi f$ radians/sec
20	Define effective value or R.M.S value.

	$I_{rms} = \sqrt{\text{Mean or average of square of current}} = \sqrt{\frac{I_m^2}{2}} = \frac{I_m}{\sqrt{2}}$ $\boxed{I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m}$ The rms value of the sinusoidal alternating current is 0.707 times the maximum value or peak value or amplitude value of that alternating current. $\boxed{V_{r.m.s} = \frac{V_m}{\sqrt{2}} = 0.707 V_m}$
21	Write the relationship between line and phase voltages and currents for balanced delta and star connected system. Relationship between line and phase voltages is $\boxed{V_L = \sqrt{3} V_{ph}}$ Relationship between line and phase Currents is $\boxed{I_L = \sqrt{3} I_{ph}}$
22	Define average value or instantaneous value. The average value of an alternating quantity is defined as that value which is obtained by averaging all the instantaneous values over a period of half cycle. $\boxed{I_{av} = 0.637 I_m}$
23	Define form factor and peak factor. Form factor (k_f): - The form factor of an alternating quantity is defined as the ratio ofRMS value to Average Value Form factor(k_f) = $\frac{\text{r.m.s value}}{\text{Average value}}$ $\frac{0.707 I_m}{0.637 I_m}$ Peak factor (K_p) :- The Peak factor of an alternating quantity is defined as the ratio ofpeak value to r.m.s value. $K_p = \frac{\text{Peak value}}{\text{r.m.s value}} = \frac{\cancel{I_m}}{0.707 \cancel{I_m}} = 1.414$
24	Define apparent power and power factor. Apparent Power: - Active power is defined as the product of $I_{r.m.s}$ & $V_{r.m.s}$ It is known as apparent power its units are KV or KVA (Kilo-Volt-Ampere) Power factor is a measure of the efficiency of an alternating current (AC) electrical system. It is defined as the ratio of the active power (or real power) to the apparent power in an AC circuit. The

	active power is the actual power used to do work, while the apparent power is the product of the voltage and current in the circuit.
25	What is the difference between AC and DC?

(AC) Alternating Current	(DC) Direct Current
AC is easy to be transferred over longer distances – even betweentwo cities – without much energy loss	DC cannot be transferred over a very long distance. It loses electric power.
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is dependent upon the country. But generally, the frequency is 50 Hz	DC has no frequency or zero frequency.
In AC the flow of current changes its direction forward and backward periodically.	It flows in a single direction steadily.

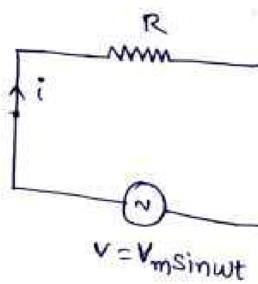
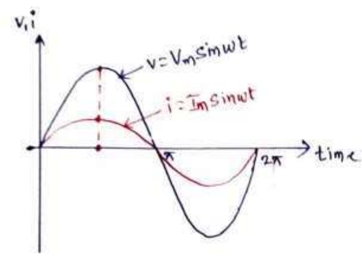
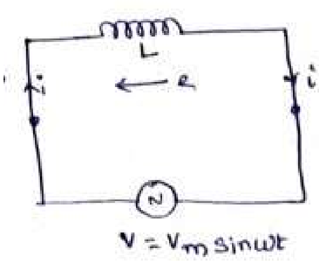
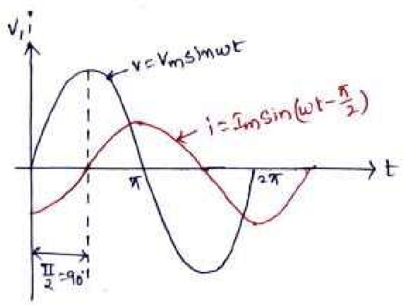
26 What are the advantages of 3 phase circuits over single phase Circuits?

There are several advantages of three-phase electrical systems over single-phase systems:

1. Increased Power Capacity
2. Higher Efficiency
3. Improved Voltage Stability
4. Reduced Maintenance Costs
5. Improved Power Quality
6. Reduced Wiring Costs

In summary, three-phase electrical systems offer several advantages over single-phase systems, including increased power capacity, higher efficiency, improved voltage stability, reduced maintenance costs, improved power quality, and reduced wiring costs.

27 An alternating circuit takes a power of 10 kW at a power factor of 0.8 lagging find i) Apparent power ii) Reactive power.

	Given data; power (P) = 10 KW Power factor ($\cos\phi$) = 0.8 lagging. Find Apparant power (S), Reactive power (Q) a) Apparant power(S) $S = VI$. $\cos\phi = \frac{P}{S}$ $\frac{0.8}{1} = \frac{10\times10^3}{S}$ $S = \frac{10\times10^3}{0.8}$ $S = 1.25\ KW$ $\boxed{S = 1.25\times10^3 W}$ b) Reactive power (Q) $Q = VI\sin\phi$ $\cos\phi = 0.8$. $\phi = \cos^{-1}(0.8) = 36.86$ $\sin\phi = 0.59$ $Q = VI\sin(36.86)$ $S = VI$. $Q = 1.25\times10^3 \sin(\ )$ $\boxed{Q = 735.7\ KVAR}$
28	Draw the pure resistive circuit with waveforms. Circuit Diagram  Wave Forms 
29	Draw the pure inductive circuit with waveforms Circuit Diagram  Wave Forms 
30	Draw the pure capacitive circuit with waveforms Circuit Diagram Wave Forms

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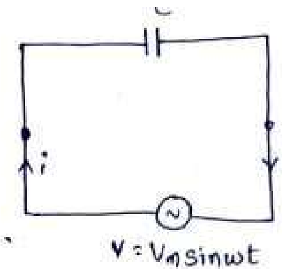
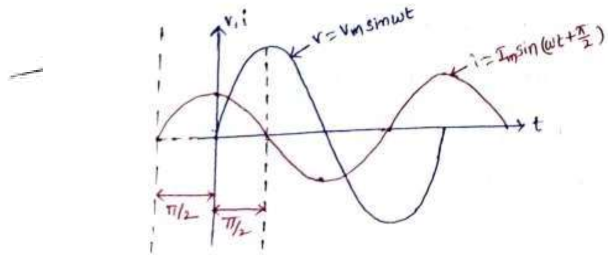
<tr><td></td><td>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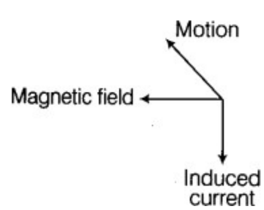
<tr><td>S.NO</td><td>Unit-III (SAQ's)</td></tr>
<tr><td>31</td><td>What is the basic principle of a DC generator?

The basic principle of a DC generator is Faraday's Law of Electromagnetic Induction. Faraday's Law states that when a magnetic field cuts across a conductor, it induces an electromotive force (EMF) in the conductor, which in turn generates a current.

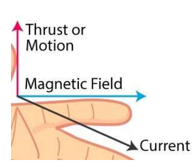
In a DC generator, this principle is applied by rotating a coil of wire within a magnetic field. As the coil rotates, the magnetic field cuts across the conductor, inducing an EMF and generating a current in the coil. This current is then sent through a commutator, which switches the direction of the current with each half-turn of the coil. The result is a continuous direct current (DC) output.</td></tr>
<tr><td>32</td><td>List the applications of D.C Motors.

DC motors have a wide range of applications, some of which are:

1. Industrial applications: DC motors are commonly used in heavy industries, such as steel mills, mines, and paper mills, for driving conveyors, pumps, fans, and cranes.
2. Transportation: Electric vehicles, such as electric cars, trains, and submarines, rely on DC motors for propulsion.
3. Automation: DC motors are used in automated systems, such as material handling equipment, assembly lines, and robotic systems</td></tr>
<tr><td>33</td><td>State Fleming’s Right- and left-hand rules.
Fleming’s Right Hand Rule

It states that if we stretch the thumb, forefinger and the middle finger of right hand at right anglesto one another in such a way that the forefinger points in the direction of magnetic field. Then, thumb gives the direction of motion of conductor (force), forefinger indicates direction of magnetic field and the middle finger points the direction of induced current.


Fleming’s Left Hand Rule

Fleming’s Left-Hand Rule states that if we arrange our thumb, forefinger and middle finger of the left-hand perpendicular to each other, then the thumb points towards the direction of the force experienced by the conductor, the forefinger points towards the direction of the magnetic field andthe middle finger points towards the direction of the electric current.

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34	State the Faraday's Law of electromagnetic induction. Faraday's Law of Electromagnetic Induction states that the electromotive force (EMF) induced in a conductor is directly proportional to the rate of change of the magnetic flux linked with the conductor. Mathematically, it can be expressed as: EMF = $-d\Phi/dt$ Where, EMF = Electromotive force (V) $d\Phi/dt$ = rate of change of magnetic flux (Weber/second) Faraday's Law is one of the fundamental principles of electrical engineering and forms the basis for the operation of many electrical devices, including generators, transformers, and motors. It explains how a changing magnetic field can induce an electrical current in a conductor and is a key component of the theory of electromagnetic induction.
35	A single-phase transformer has 50 primary and 1000 secondary turns. Net cross-sectional area of the core is 400 cm2. If the primary winding is connected to 50 Hz supply at 400 V, Calculate the value of Maximum flux density on core and the emf induced in the secondary. Given, Number of primary turns = 50 Number of secondary turns = 1000 Net cross-sectional area of core = 400 cm^2 Supply frequency = 50 Hz Supply voltage = 400 V The maximum flux density, B can be calculated using the equation: $$B = \frac{(V * f)}{(4.44 * N * A)}$$ where, V = Supply voltage f = Supply frequency N = Number of turns in the winding A = Net cross-sectional area of the core Substituting the given values, $$B = \frac{(400 * 50)}{(4.44 * 50 * 400 * 10^{\wedge} - 4))}$$ B = 2.82 Tesla The emf induced in the secondary, E_2can be calculated using the equation: E_2= 4.44 * f * B * Secondary Substituting the given values, E_2 = 4.44 * 50 * 2.82 * 1000 E_2= 142000 V Hence, the maximum flux density on the core is 2.82 Tesla and the emf induced in the secondary is 142000 V.
36	List the different types of dc generators.

	1. Self-excited Generators 2. Series Generators 3. Shunt Generators 4. Compound Generators 5. Permanent Magnet Generators 6. Brushless Generators 7. Separately Excited Generators
37	Write the EMF equation of transformer. The EMF equation of a transformer can be expressed as follows: EMF = 4.44 * f * N * ΔΦ Where: • EMF is the electromotive force induced in the secondary winding in volts • f is the frequency of the alternating current in Hertz • N is the number of turns in the winding • ΔΦ is the change in magnetic flux in Weber, which occurs during one cycle of the alternating current.
38	List the different types of transformers. There are several types of transformers based on different factors, including their construction, use, and application. Some of the common types of transformers are: 1. Step-up transformer 2. Step-down transformer 3. Isolation transformer 4. Auto transformer 5. Oil-immersed transformer
39	Define efficiency and losses in transformer. Efficiency of a transformer is defined as the ratio of the output power to the input power, and it is expressed as a percentage. The efficiency of a transformer depends on the various losses that occur within the transformer. Losses in transformer are the energy losses that occur within the transformer and reduce the efficiency of the transformer. The major losses in a transformer are: 1. Copper Loss: Copper loss is the energy lost due to the resistance of the windings. It occurs as a result of the current flowing through the windings. 2. Core Loss: Core loss is the energy lost in the magnetic core of the transformer due to the hysteresis and eddy current losses in the core material. 3. Stray Loss: Stray loss is the energy lost due to the leakage of magnetic flux from the core to the surroundings. By reducing these losses, the efficiency of the transformer can be improved.
40	Mention the various application of 1-Φ transformers. The various applications of single-phase transformers are: 1. Domestic appliances: Single-phase transformers are widely used in household appliances such as refrigerators, air-conditioners, and washing machines to step down the voltage to a level that is safe for use in homes. 2. Power Supply: Single-phase transformers are also used in power supplies for electronic devices such as computers, televisions, and cell phones. 3. Lighting: Single-phase transformers are used in lighting systems, particularly for low voltage applications. 4. Industrial Applications: Single-phase transformers are used in small industrial applications such as machine tools, air compressors, and material handling equipment. 5. Distribution Transformer: Single-phase transformers are also used in electrical power distribution systems to step down the voltage from the high-voltage transmission lines to a level that is suitable for residential and commercial use.
41	What is the function of commutator in dc machine. The function of a commutator in a DC machine (such as a DC motor or a DC generator) is to ensure that the current flows in the correct direction in the armature winding.

	The armature winding of a DC machine consists of multiple coils of wire that are connected to the commutator segments. When the armature rotates, the magnetic field generated by the current flowing through the coils also rotates. The commutator ensures that the current direction in each coil is reversed as it moves from one commutator segment to the next, so that the magnetic field remains stationary in the machine. This is essential for the proper operation of a DC machine, as it allows for the transfer of energy between the electrical and mechanical systems.
42	List out the essential parts of dc machine. The essential parts of a DC machine are: 1. Armature: It is the rotating part of the machine where the electromotive force (EMF) is induced. 2. Field Poles: They are the stationary part of the machine that carries the magnetic field. 3. Commutator: It is a cylindrical component that collects the current from the armature winding and delivers it to the external circuit. 4. Brush Assembly: It is a mechanical component that makes electrical contact with the commutator. 5. Shaft: It is the rotating part that carries the armature and the commutator. 6. Frame: It is the stationary part that supports the other components of the machine. 7. Stator: It is the stationary part that carries the field winding. 8. Field Winding: It is the winding that generates the magnetic field in the DC machine. 9. Bearings: They support the shaft and allow it to rotate smoothly. 10. Terminal Block: It provides electrical connection between the external circuit and the DC machine.
43	What is the function of armature coil. The function of the armature coil in a DC machine (DC generator or DC motor) is to carry the current that induces the electromotive force (EMF) or the current that drives the motor. The armature coil is wound around the core of the machine and rotates within the magnetic field provided by the field winding or permanent magnets. In a DC generator, the armature coil rotates in the magnetic field, cutting the magnetic lines of force and inducing an EMF in the coil. This induced EMF is proportional to the rate of change of magnetic flux, which is in turn proportional to the speed of rotation. The induced EMF is collected by the commutator and the brushes and is supplied to the load.
44	Classify the dc generators based on their field excitation. DC generators can be classified into two types based on their field excitation: 1. Separately Excited DC Generators: In this type of generator, the field windings are supplied by an external source of DC voltage. This separate DC source is used to magnetize the field poles and produce the magnetic field. 2. Self-Excited DC Generators: In this type of generator, the field windings are part of the armature circuit and are supplied with DC voltage by the generator itself. The armature winding induces an emf in the field winding, which then produces a magnetic field. The classification of DC generators based on field excitation is an important aspect in the design and selection of a DC generator for specific applications.
45	A 6pole lap wound armature has 1200 conductors and flux per pole of 0. 02wb.determine the generated emf when running at 600 rpm. To determine the generated emf in a 6-pole lap wound armature running at 600 RPM, the following formula can be used: $$\mathrm{EMF} = \frac{(2 * \pi * N * f * p * \Phi)}{60}$$ where: N = speed of rotation in RPM f = number of conductors per pole

	p = number of poles Φ = flux per pole in weber Given: N = 600 RPM f = 1200 conductors p = 6 poles Φ = 0.02 Wb So, $$\mathrm{EMF} = \frac{(2 * \pi * 600 * 1200 * 6 * 0.02)}{60}$$ EMF = 6.28 * 720 * 0.12 EMF = 5616 V Hence, the generated emf in the armature when running at 600 RPM is 5616 V.
S.NO	Unit-IV (SAQ's)
46	Why induction motors called asynchronous motors? Induction motors are called asynchronous motors because they don't run at the same speed as the power supply frequency. Instead, the speed of the induction motor is determined by the difference between the supply frequency and the speed at which the magnetic field rotates inside the motor. This difference in speed creates a slip, which is a measure of how far the motor's speed lags behind the supply frequency. As a result, the speed of the induction motor is asynchronous or out-of-step with the supply frequency, hence the name "asynchronous motor."
47	List the applications of D.C Motor List out the disadvantages of a 1-Φ induction motor over 3-Φ induction motor. Applications of DC Motors: 1. Electric vehicles 2. Robotics 3. Machine tools 4. Conveyors and hoists 5. Cranes and hoists 6. Electric pumps 7. Compressors 8. Blowers and fans 9. Household appliances 10. Medical equipment Disadvantages of a 1-Φ Induction Motor compared to a 3-Φ Induction Motor: 1. Lower efficiency: 1-Φ induction motors are less efficient than 3-Φ motors due to their single-phase power supply. 2. Larger size: 1-Φ induction motors are typically larger in size compared to 3-Φ motors of the same power rating. 3. Higher cost: 1-Φ induction motors are generally more expensive compared to 3-Φ motors due to their complex design and larger size.
48	A 3-Φ ,50Hz induction motor has 4poles.if the slip is 3% at a certain load. Determine the speed of the rotor and frequency of the induced EMF in the rotor. The speed of the induction motor is given by: Speed (N) = (120 * f) / P Where f is the supply frequency (50 Hz), and P is the number of poles (4).

So, N = (120 * 50) / 4 = 1500 rpm

The speed of the rotor relative to the rotating magnetic field in the stator is given by the slip, which is defined as the difference between the synchronous speed and the actual rotor speed. The synchronous speed is given by:

Synchronous speed (Ns) = (120 * f) / P

So, Ns = (120 * 50) / 4 = 1500 rpm

The actual rotor speed (Nr) is given by:

Nr = Ns * (1 - slip)

Where slip is expressed as a fraction (0 < slip < 1). In this case, the slip is 3%, which is 0.03.

So, Nr = 1500 * (1 - 0.03) = 1470 rpm

The frequency of the induced EMF in the rotor is given by:

f_induced = (slip * f)

So, f_induced = (0.03 * 50) = 1.5 Hz

Therefore, the speed of the rotor is 1470 rpm and the frequency of the induced EMF in the rotor is 1.5 Hz.

49 Compare 3 phase squirrel cage and slip ring induction motor.

Squirrel Cage Induction Motors	Slip Ring Induction Motors
1. Simple and rugged construction: Squirrel cage induction motors have a simple and rugged construction, with a laminated iron rotor and a cage-like aluminum or copper conductor. 2. Low cost: Squirrel cage motors are less expensive compared to slip ring motors due to their simple construction and lower maintenance requirements. 3. Easy maintenance: Squirrel cage induction motors have no commutator or brushes, making them easy to maintain.	1. High starting torque: Slip ring induction motors have a high starting torque, making them suitable for high-torque applications. 2. Good speed control: Slip ring motors can be controlled by varying the resistance in the rotor circuit, providing good speed control. 3. High power range: Slip ring motors are available in a wide range of power ratings, making them suitable for large-scale industrial applications.

50 How are 3-Φ induction motors are self-starting

3-phase induction motors are self-starting because of the rotating magnetic field that is created by the interaction between the stator windings and the rotor. The stator windings, which are fed with a 3-phase AC power supply, generate a rotating magnetic field that cuts across the rotor conductors, inducing a current in the rotor. This current, in turn, creates its own magnetic field that interacts with the stator field, causing the rotor to rotate.

	The interaction between the stator and rotor fields creates a torque on the rotor that drives it in the direction of the rotating stator field. This process is self-starting because the interaction between the two magnetic fields is self-sustaining once it has been initiated.
51	Mention the various application of 3-Φ induction motor. Three-phase induction motors are widely used in a variety of industrial, commercial, and residential applications due to their reliability, efficiency, and versatility. Some of the common applications of three-phase induction motors are: 1. Industrial Applications 2. HVAC Systems 3. Agricultural Applications 4. Material Handling 5. Power Generation 6. Residential Applications
52	Classify the different types of 1-Φ induction motor. Single-phase induction motors are classified into several types based on their design, construction, and method of starting. The most common types of single-phase induction motors are: 1. Split-Phase Induction Motors 2. Capacitor-Start Induction Motors 3. Permanent Split Capacitor (PSC) Motors 4. Shaded Pole Motors 5. Repulsion Start Induction Run Motors
53	Classify the different types of 3-Φ induction motor Three-phase induction motors are classified into several types based on their design, construction, and method of starting. The most common types of three-phase induction motors are: 1. Squirrel Cage Induction Motors 2. Slip Ring Induction Motors 3. Wound Rotor Induction Motors 4. Synchronous Motors
54	Mention the various application of 1-Φ induction motor. Single-phase induction motors are widely used in a variety of domestic, commercial, and industrial applications due to their simple design, reliability, and low cost. Some of the most common applications of single-phase induction motors include: 1. Household appliances: Single-phase induction motors are commonly used in small household appliances such as fans, blowers, refrigerators, washing machines, and air conditioning units. 2. Industrial machinery: They are used in a wide range of industrial machinery, including conveyors, pumps, compressors, and machine tools. 3. Agricultural equipment: Single-phase induction motors are used in agricultural equipment such as irrigation pumps, grain threshers, and feed mixers. 4. Office equipment: They are used in office equipment such as photocopiers, printers, and paper shredders.
55	List the advantages and disadvantages of slip ring induction motor. Advantages of Slip Ring Induction Motors: 1. High starting torque: Slip ring induction motors have a high starting torque, which makes them ideal for applications that require high starting power, such as cranes and hoists. 2. Adjustable speed control: The slip rings on the rotor of the motor allow for adjustable speed control, making them ideal for applications where variable speed is required. 3. Reversibility: The slip ring induction motor can be easily reversed, making it suitable for applications where direction of rotation needs to be changed. Disadvantages of Slip Ring Induction Motors: Complex construction: The construction of slip ring induction motors is more complex compared to squirrel cage induction motors, which can make them more expensive and difficult to maintain.

	Maintenance: The slip rings and brushes on the rotor of the motor can wear out over time, requiring regular maintenance and replacement. High losses: The losses in slip ring induction motors are higher compared to squirrel cage induction motors, due to the increased resistance of the slip rings and brushes.
56	Write the advantages and disadvantages of capacitor run motor. Advantages of Capacitor-Run Motors: 1. Improved power factor: Capacitor-run motors have a higher power factor compared to other types of single-phase induction motors, which can lead to lower energy costs and improved power quality for the user. 2. Increased starting torque: The addition of a capacitor to the motor circuit can increase the starting torque, making capacitor-run motors ideal for applications that require high starting power. 3. Improved reliability: The simple design of capacitor-run motors can lead to improved reliability and a longer lifespan compared to other types of single-phase induction motors. Disadvantages of Capacitor-Run Motors: 1. Complex starting circuit: The starting circuit for a capacitor-run motor can be more complex compared to other types of single-phase induction motors, which can make it more difficult to install and maintain. 2. Maintenance: The capacitor used in the motor circuit can fail over time, requiring replacement and maintenance to keep the motor running. 3. Reduced efficiency: The efficiency of capacitor-run motors can be lower compared to other types of single-phase induction motors, due to the power losses in the starting circuit.
57	Why the induction motor called rotating transformer? Justify. A 6-pole, 3-phase Induction motor connected to 50Hzsupply.Ifitisrunning at 970rpm, find the slip. In the case of an induction motor, the stator winding is the primary winding, and the rotor winding is the secondary winding. The stator creates a magnetic field that induces an electromotive force (EMF) in the rotor, causing the rotor to rotate and generate its own magnetic field. This interaction between the magnetic fields of the stator and rotor is what causes the rotor to rotate, just as in a transformer, the magnetic fields of the primary and secondary windings interact to transfer energy from one coil to the other. Problem Solution The slip is defined as the difference between the synchronous speed and the actual speed of the rotor in an induction motor. The synchronous speed of a 3-phase, 6-pole induction motor connected to a 50Hz supply is given by the formula: $N_s = 120f / p$ $N_s = 120 * 50 / 6 = 1000$ RPM So, the slip is given by: $S = (N_s - N) / N_s$ $S = (1000 - 970) / 1000 = 0.03$

	This means that the rotor is rotating 3% slower than the synchronous speed, and this value of the slip represents the efficiency of the induction motor. The higher the slip, the lower the efficiency of the motor.
58	List the different applications of resistor start motor. 3-phase induction motors are widely used in a variety of industrial and commercial applications due to their robustness, efficiency, and reliability. Some of the common applications of 3-phase induction motors are: 1. Pumping and water treatment 2. Conveyor systems 3. Compressors 4. Blowers and fans 5. Machine tools 6. Material handling 7. Agricultural equipment 8. Food and Beverage Industry
59	Define the synchronous generator. A synchronous generator, also known as an alternator, is a device that converts mechanical energy into electrical energy. It works by rotating a magnetic field within a stationary set of coils, which induces a voltage in the coils and generates an alternating current (AC) output. The rotating magnetic field is typically created by a prime mover, such as a steam turbine or a gasoline engine, which drives a rotor that is wound with coils of wire. The main advantage of a synchronous generator is that it can produce a highly stable and consistent AC voltage output Synchronous generators are commonly used in power generation systems, such as hydroelectric and thermal power plants, where they provide the bulk of the electrical power supply. They are also used in industrial applications
60	Mention the various applications of alternator. Synchronous generators, also known as alternators, have a wide range of applications due to their ability to generate a highly stable and consistent AC voltage output. Some of the common applications of alternators are: 1. Power Generation: Alternators are widely used in power generation systems, such as hydroelectric, thermal, and wind power plants, to generate the bulk of the electrical power supply. 2. Backup Power: Alternators are used in backup power systems, such as diesel-powered generator sets, to provide emergency power in case of a power outage. 3. Marine Applications: Alternators are used in marine applications, such as ships and offshore platforms, to provide electrical power for the onboard systems and equipment. 4. Industrial Applications: Alternators are used in industrial applications, such as process control and manufacturing environments, where a stable power source is required. 5. Transportation: Alternators are used in transportation applications, such as trains and vehicles, to provide electrical power for the onboard systems and equipment. 6. Renewable Energy: Alternators are used in renewable energy systems, such as wind turbines and micro-hydro systems, to generate electrical power from renewable sources.

	7. Data Centers: Alternators are used in data centers to provide backup power for the servers and other critical equipment in case of a power outage. These are just a few of the many applications of alternators. They are a versatile and reliable choice for a wide range of applications, due to their ability to generate a highly stable and consistent AC voltage output, even under varying loads and conditions.
S.NO	Unit-V (SAQ's)
61	Write the essential components of battery backup. A battery backup system, also known as an uninterruptible power supply (UPS), is a system that provides a reliable source of power in case of an electrical power outage. The essential components of a battery backup system are: 1. Batteries: The batteries store electrical energy and provide power to the load during a power outage. Lead-acid batteries are commonly used in battery backup systems, but other types of batteries, such as lithium-ion, can also be used. 2. Charger: The charger is responsible for charging the batteries and maintaining their charge level. It ensures that the batteries are fully charged and ready to provide power when needed. 3. Inverter: The inverter is responsible for converting the DC power stored in the batteries into AC power. It provides a clean and stable AC voltage output to the load. 4. Transfer Switch: The transfer switch is responsible for transferring the load from the main power source to the battery backup system during a power outage. It ensures a seamless transition from main power to battery power and vice versa. 5. Control Circuit: The control circuit is responsible for monitoring the main power source and controlling the operation of the other components in the system. It provides protection and fault-detection capabilities and alerts the user in case of a problem. 6. Display Panel: The display panel provides information about the status of the battery backup system, including the battery charge level, system status, and error messages. These are the essential components of a battery backup system. The design and configuration of a battery backup system can vary depending on the specific requirements and application, but these components form the foundation of a reliable and effective battery backup solution.
62	Differentiate fuse and circuit breaker.

FUSES	CIRCUIT BREAKERS
1. A fuse operates by melting a metal element when the current exceeds a certain level. This opens the circuit and prevents further current flow, protecting the electrical equipment from damage 2. Fuses respond quickly to an overcurrent condition 3. Fuses are typically less expensive than circuit breakers 4. Fuses come in a variety of shapes, sizes, and ratings	1. A circuit breaker, on the other hand, operates by tripping a switch mechanism when the current exceeds a certain level. This opens the circuit and prevents further current flow, protecting the electrical equipment from damage. 2. Circuit breakers are slower to respond than fuses, but they provide a more reliable and consistent level of protection 3. whereas circuit breakers can be reset and used many times over their lifetime.

		4. circuit breakers can be differentiated based on their construction, trip characteristics, and thermal-magnetic rating.

63	In a house there are 10 lamps 25 watt used 4 hours per day a 300watts refrigerator used 24 hours per day and 150-watt water pump used 10 hours. How much electrical energy used for a month The total electrical energy used for the house for a month can be calculated as follows: Solution: - For the lamps: Each lamp uses 25 watts per hour, and there are 10 lamps, so the total power used by the lamps is 25W * 10 = 250W. The lamps are used for 4 hours per day, so the total energy used by the lamps per day is 250W * 4 hours = 1000 watt-hours (Wh). For a month, the total energy used by the lamps is 1000Wh * 30 days = 30000Wh. For the refrigerator: The refrigerator uses 300 watts per hour, and it is used 24 hours a day, so the total energy used by the refrigerator per day is 300W * 24 hours = 7200Wh. For a month, the total energy used by the refrigerator is 7200Wh * 30 days = 216000Wh. For the water pump: The water pump uses 150 watts per hour, and it is used for 10 hours a day, so the total energy used by the water pump per day is 150W * 10 hours = 1500Wh. For a month, the total energy used by the water pump is 1500Wh * 30 days = 45000Wh. The total electrical energy used for the house for a month is the sum of the energy used by the lamps, refrigerator, and water pump: 30000Wh + 216000Wh + 45000Wh = 300000Wh. Therefore, the total electrical energy used for the house for a month is 300000Wh or 300kWh.
64	Illustrate the types of cables. 1. Power cables 2. Control cables 3. Data cables 4. Fiber optic cables 5. Audio/Video cables 6. Instrumentation cables 7. Welding cables
65	What is the importance of power factor? Power factor is a measure of the efficiency of an electrical system, and it is an important factor to consider in the design and operation of electrical power systems. The power factor is defined as the ratio of real power (measured in watts) to apparent power (measured in volt-amperes) in an electrical system.

	1. Energy Efficiency 2. Electrical System Capacity 3. Power Losses 4. Voltage Stability 5. Utility Company Penalties
66	List out the different characteristics of batteries. Batteries are an important source of electrical energy and are widely used in various applications. The different characteristics of batteries include: 1. Voltage 2. Capacity 3. Discharge rate 4. Self-discharge rate 5. Cycle life 6. Operating temperature 7. Cost 8. Environmental impact In conclusion, the different characteristics of batteries are important to consider in determining the best battery for a particular application. The voltage, capacity, discharge rate, self-discharge rate, cycle life, operating temperature, cost, and environmental impact are all important factors to consider when selecting a battery.
67	Write the specifications for wires used for domestic wiring. The specifications for wires used for domestic wiring vary depending on the country and its electrical codes and regulations. In general, the following specifications should be considered when selecting wires for domestic wiring: 1. Conductors Material 2. Size 3. Voltage Rating 4. Insulation 5. Temperatures 6. Flexibility 7. Colour Code 8. Fire Resistance
68	What are the disadvantages if low power factor. There are several disadvantages of having a low power factor in a power system: 1. Increased Energy Losses 2. Increased Utility Costs 3. Overloading of Equipment 4. Reduced Power Transmission Capacity 5. Harmonic Distortion
69	What is fuse? A fuse is a safety device used in electrical systems to protect against overloading and short-circuits. It is a type of electrical protection that interrupts the flow of electric current in the event of a fault or excessive current.

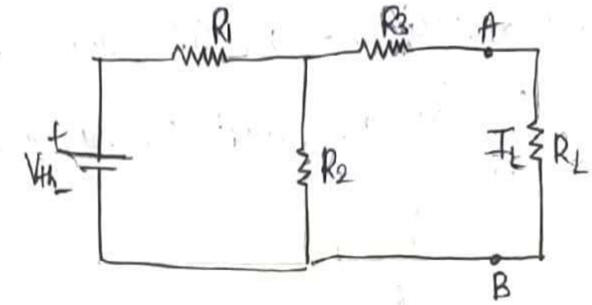
	A fuse typically consists of a metal wire or filament that melts when the current exceeds a specified value, known as the fuse rating. The melted wire acts as an open circuit, breaking the flow of current and protecting the electrical equipment connected to the circuit.
70	What is meant by earthing? Earthing, also known as grounding, refers to the process of establishing a direct electrical connection between a conductive object and the earth. The primary purpose of earthing is to provide a safe and reliable path for electrical current to flow in the event of a fault, such as a short-circuit. In electrical systems, earthing is achieved by connecting a conductor, known as an earth conductor, to an electrode that is buried in the ground. The earth conductor is connected to the electrical equipment, creating a low-impedance path to the earth. This allows any stray current that may flow in the event of a fault to be safely redirected to the earth, protecting people and equipment from electrical shock or damage.
71	Differentiate between primary and secondary cells. Primary cells and secondary cells are two types of batteries that differ in their construction and the way they produce electrical energy. Primary cells are batteries that are designed to be used once and then disposed of. They are non-rechargeable and produce electrical energy through a chemical reaction that cannot be reversed. Primary cells are commonly used in applications where a small, portable source of power is required, such as flashlights, remote controls, and smoke detectors. Secondary cells, on the other hand, are rechargeable batteries that can be used multiple times. They produce electrical energy through a reversible chemical reaction, allowing them to be recharged and used again. Secondary cells are commonly used in applications where a more convenient, cost-effective, and environmentally friendly source of power is required, such as smartphones, laptops, and electric vehicles.
72	Classify the cables according to the voltage grading. 1. Low Voltage (LV) Cables: These cables are designed for use in systems with voltages up to 1000V AC. They are commonly used for lighting and power distribution in residential and commercial buildings. 2. Medium Voltage (MV) Cables: These cables are designed for use in systems with voltages between 1kV and 33kV. They are commonly used for power distribution in industrial and commercial applications. 3. High Voltage (HV) Cables: These cables are designed for use in systems with voltages greater than 33kV. They are commonly used for transmitting electrical energy over long distances, such as between power plants and substations.
73	State the factors on which the choice of wiring system depends. The choice of a wiring system depends on several factors, including: 1. Voltage level 2. Current capacity 3. Environmental conditions 4. Physical space constraints 5. Cost 6. Fire safety and codes 7. Future expansion
74	Write the benefits of power factor improvement. There are several benefits to improving the power factor of an electrical system, including: 1. Increased energy efficiency 2. Reduced energy costs 3. Improved power quality

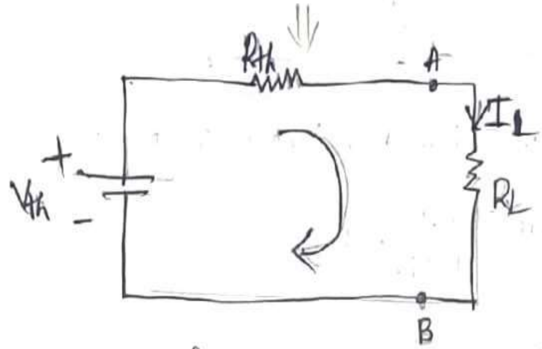
	4. Enhanced equipment reliability 5. Increased capacity of electrical distribution systems 6. Improved system safety 7. Enhanced system performance 8. Better compliance with regulations Overall, power factor improvement provides significant benefits in terms of energy efficiency, cost savings, reliability, and safety, making it an important consideration for any electrical system.
75	What are the applications of batteries. Batteries have a wide range of applications in various fields, including: 1. Portable electronics: Batteries are commonly used to power portable devices such as smartphones, laptops, and tablets. 2. Renewable energy systems: Batteries are used in renewable energy systems, such as solar and wind systems, to store excess energy for use when it is needed. 3. Backup power: Batteries are commonly used to provide backup power in case of a power outage, ensuring that critical systems, such as data centers and medical equipment, continue to operate. 4. Electric vehicles: Batteries are a key component in electric vehicles, providing the energy needed to power the vehicle's electric motor. 5. Toys and consumer products: Batteries are used in a wide range of consumer products, such as toys, remote controls, and flashlights. Overall, batteries play a crucial role in enabling the use of portable and mobile electronics, and in providing backup power for critical systems. They are also an essential component in the growth of renewable energy and electric vehicle technologies.
S.NO	Unit-I (LAQ's)
76	State & Explain Thevenin’s theorem.

Roll No.

THEVENIN'S THEOREM

Statement:- A linear bilateral network consisting of a no. of voltage sources (or) resistences can be replaced by an Equivalent network having a single voltage source Thevenin's voltage (V_{th}) & a single resistence called Thevinin's Resistance (R_{th}).

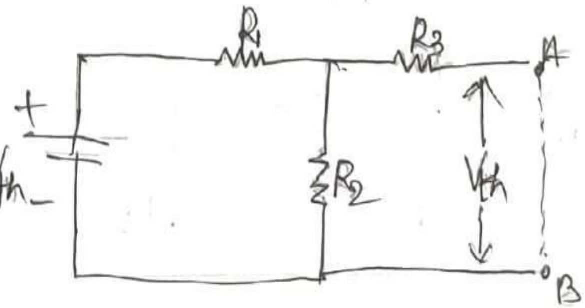




$$I_L = \frac{V_{th}}{R_{th} + R_L} \quad \text{—} \ (1)$$

To find V_{th} :-

The load resistance R_L is removed.



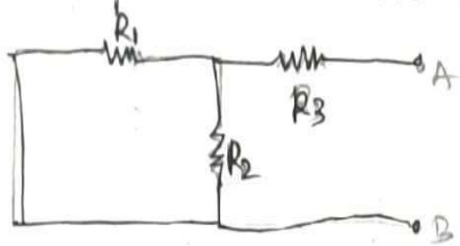
The current I in the circuit is given by

$$I = \frac{V}{R_1 + R_2}$$

$$V_{th} = IR_2 \Rightarrow \frac{V}{R_1+R_2} R_2 = V_{th} \quad \text{—— (2)}$$

To find R_{th} :-

The load resistance R_L is removed, the cell is disconnected & wires are short as shown in fig

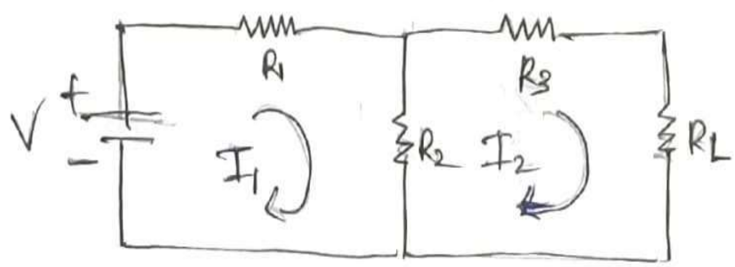


R_{th} = R_1 parallel with R_2 & series with R_3

$$R_{th} = \frac{R_1R_2}{R_1+R_2} + R_3 \quad \text{—— (3)}$$

substitute (2) & (3) in I_L i.e., (1)

$$I_L = \frac{\dfrac{VR_2}{R_1+R_2}}{\left(\left(\dfrac{R_1R_2}{R_1+R_2}\right) + R_3\right) + R_L}$$



Apply KVL

$$V - IR_1 - R_2(I_1 - I_2)$$

$$I_1 R_1 - I_1 R_2 + R_2 I_2 = V$$

$$V = (R_1 + R_2) I_1 - I_1 R_2 \quad \text{—— (5)}$$

Apply KVL in mesh (II) or loop :-

$$I_2 (R_2 + R_3 + R_L) - I_1 (R_2) = 0$$

$$I_1 = \frac{I_2 (R_2 + R_3 + R_L)}{R_2} \quad \text{—— (6)}$$

by using (6) in (5) we get

$$(R_1 + R_2)\left[\frac{I_2 (R_1 + R_3 + R_L)}{R_L}\right] - I_2 R_2 = V$$

$$\left[(R_1 + R_2)\frac{(R_2 + R_3 + R_L)}{R_L} - R_2\right] I_2 = V$$

$$\left[\frac{(R_1 R_2 + R_1 R_3 + R_1 R_2 + R_2^2 + R_2 R_3 + R_2 R_L)}{R_2} - R_2\right] I_2 = V$$

$$\left[\frac{R_1 R_2 + R_3(R_1 + R_2) + R_L(R_1 + R_2) + R_2^2 - R_2^2}{R_2}\right] I_2 = V$$

$$\left[\frac{R_1 R_2 + R_3(R_1 + R_2) + R_L(R_1 + R_2)}{R_2}\right] I_2 = V$$

$$I_2 = \frac{VR_2}{R_1R_2 + R_3(R_1+R_2) + R_L(R_1+R_2)}$$

Dividing numerator ~~by~~ & denominator by (R_1+R_2) we get

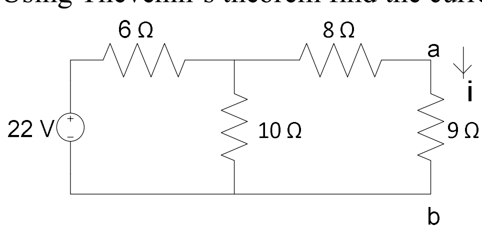
$$I_2 = \frac{\dfrac{VR_2}{R_1+R_2}}{\dfrac{R_1R_2}{R_1+R_2} + R_3 + R_L}$$

$$I_2 = I_L$$

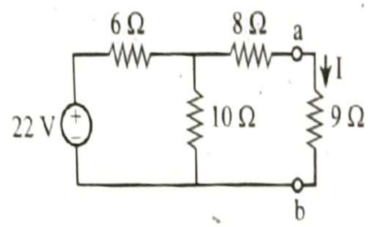
Which is same as Equation (4)

Hence proved.

77 Using Thevenin's theorem find the current 'I' in 9Ω resistor.



(b) Using Thevenin's theorem, find the current 'I' in 9 Ω resistor.



Figure

Answer :

The given circuit is shown in figure (1).

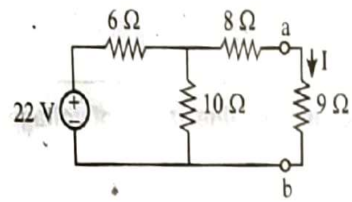


Figure (1)

To determine,

The current in 9 Ω resistor i.e., across terminals '*a-b*' using Thevenin's theorem.

In order to determine, current through 9 Ω resistor using Thevenin's theorem first we need to obtain Thevenin's voltage V_{th} and Thevenin's resistance across load terminals *a* - *b*.

To obtain Thevenins voltage open circuiting load terminal as shown in figure (2).

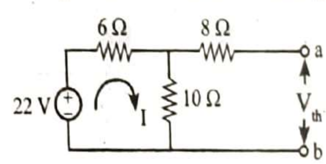


Figure (2)

Here, the current in 8 Ω resistor is zero due to open circuiting of terminals 'a' and 'b'.

From figure (2), the current I is given by,

$$I = \frac{V}{R} = \frac{22}{6+10} = \frac{22}{16}$$

$$\therefore \quad I = 1.375 \text{ A}$$

The Thevenin's voltage V_{th} across terminals a and b is similar to the voltage across 10 Ω resistor.

$$\therefore \quad V_{th} = V_{10\,\Omega} = IR_{10\,\Omega}$$

$$= 1.375 \times 10$$

$$\therefore \quad V_{th} = V_{ab} = 13.75 \text{ V}$$

Now,

The Thevenin's resistance R_{th} is calculated by short circuiting the voltage source in circuit of figure (2). The modified circuit is shown in figure (3) as,

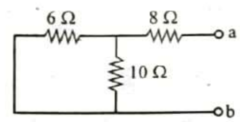


Figure (3)

From figure (3), it is clear that the resistance 6 Ω and 10 Ω are in parallel and their equivalent is in series with 8 Ω resistor. Thus, the Thevenin's resistance is given by,

$$R_{th} = (6 \| 10) + 8$$

$$= \left(\frac{6 \times 10}{6+10}\right) + 8$$

$$= 3.75 + 8$$

$$\therefore \quad R_{th} = 11.75\ \Omega$$

Therefore, the required Thevenin's equivalent circuit with load at terminals a-b is given by,

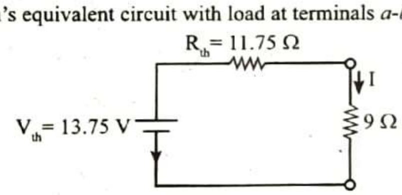


Figure (4)

Now, the current in 9 Ω resistor is given as,

$$I = \frac{V_{th}}{R_{th} + R_L}$$

$$= \frac{13.75}{11.75 + 9}$$

$$= \frac{13.75}{20.75}$$

$$\therefore \quad I = 0.662 \text{ Amps}$$

78	State and prove Norton's theorem.

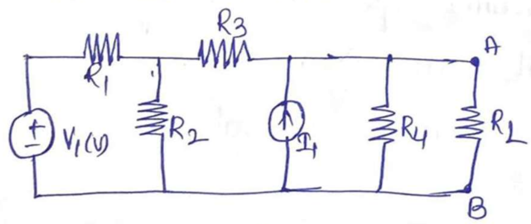
Norton's theorem:

Statement: Any combination of linear bilateral circuit elements and active sources, regardless of the connection (or) complexity connected to a given load R_L, can be replaced by a simple two terminal network, consisting of a single current source of I_N amperes and a single impedance of 'R_{eq}' in parallel with it, across the two terminals of the load R_L.

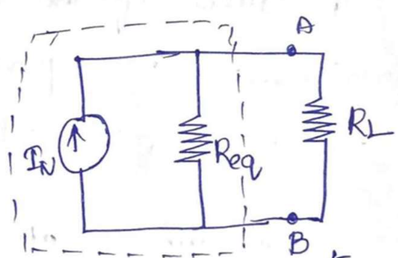
The I_N is the short circuit current flowing through the short circuited path, replaced instead of R_L. It is also called norton's current (I_N).

Explanation of Norton's theorem:-

consider the network shown in below. The terminals A-B are in the load terminals where R_L is connected.



a)



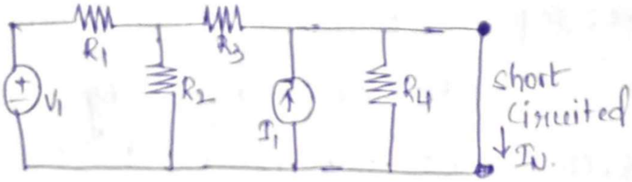
Norton's equivalents

(b)

According to the norton's theorem, the network can be replaced by a current source I_N and equivalent resistance R_{eq} parallel with it, across the load terminals, as shown in figure (b).

For obtaining the current I_N, short the load terminals AB as shown below.

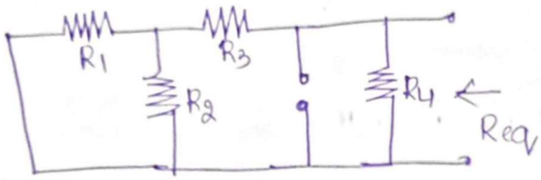
To calculate I_N



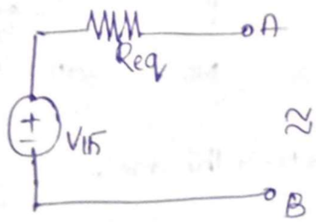
Then find the current using simplification network techniques.

While to calculate R_{eq} use the same procedure as discussed.

To calculate R_{eq}:-



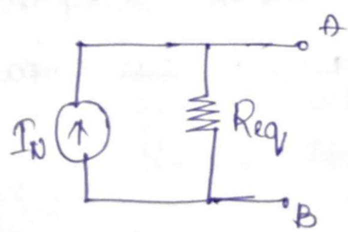
This theorem is called dual of the thevenin's theorem. because, if the thevenin's equivalent voltage source is converted to equivalent current source using source transformation, we get the norton's equivalent.



$$I_N = \frac{V_{Th}}{R_{eq}}.$$

$\approx$

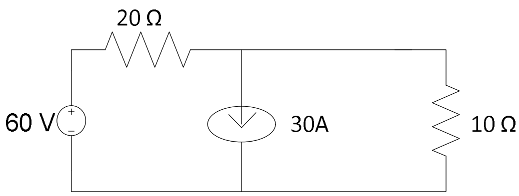
(or) $V_{Th} = I_N \times R_{eq}$



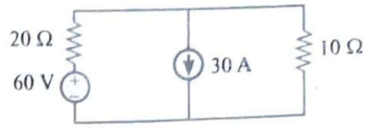
$$\boxed{I_L = I_N \times \frac{R_{eq}}{R_{eq}+R_L}}$$

$$\boxed{R_{eq} = \frac{V_{oc}}{I_{sc}}}$$

79 Find the current through 10 Ω Resistance in the following circuit using Norton's theorem.



Q11. (a) Find the current flowing through 10 Ω resistance in the following circuit using Norton's theorem.



Figure

Answer :

Given circuit is shown in figure (1).

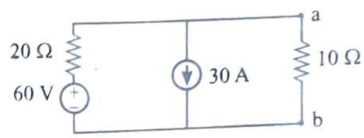


Figure (1)

Short circuting the terminal $a-b$. This results in a circuit diagram as shown in figure (2).

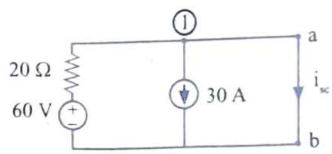


Figure (2)

Applying KCL at node (1), we get,

$$\frac{0-60}{20}+i_{sc}=30$$

$$-3+i_{sc}=-30$$

$$i_{sc}=-27\text{ A}$$

$$\therefore \quad i_{sc}=i_N=-27\text{ A}$$

Now, in order to calculate R_N, all independent sources must be deactivated resulting in circuit diagram as shown in figure (3).

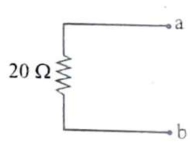


Figure (3)

Here, $R_N = 20\ \Omega$,

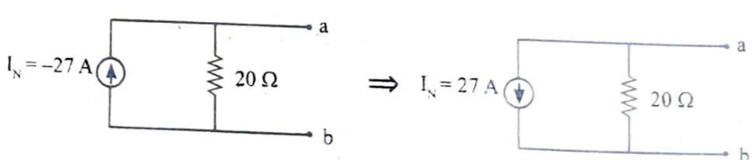


Figure (4)

	Current through 10 Ω is given by $$I_{10\,\Omega} = I_N \times \frac{R_N}{R_N + R_L} = 27 \times \frac{20}{20+10} = 18\text{ A}$$
80	State and explain Super Position Theorem

Super position theorem:-

This theorem is applicable for linear and bilateral networks.

Statement:- In any multisource complex network consisting of linear bilateral elements, the voltage across (or) current through any given element of the network is equal to the algebraic sum of the individual voltages and currents, produced independently across (or) in that element by each source acting independently when all the remaining sources are replaced by their respective internal resistance.

Explanation of super position theorem:-

consider a network, shown in below figure having two voltages V_1 and V_2.

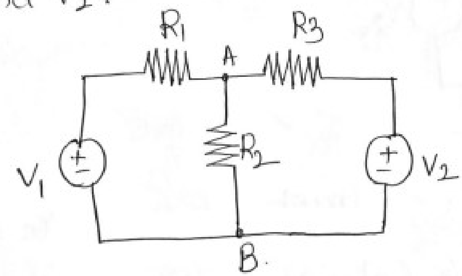
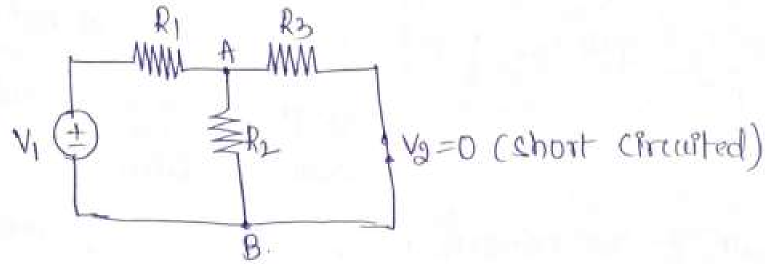
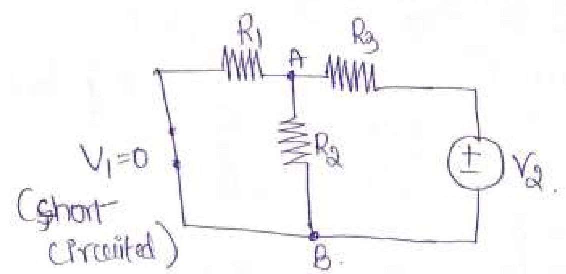
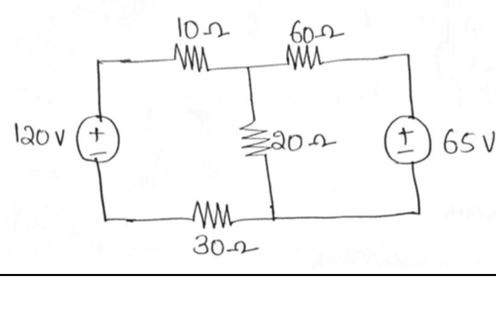


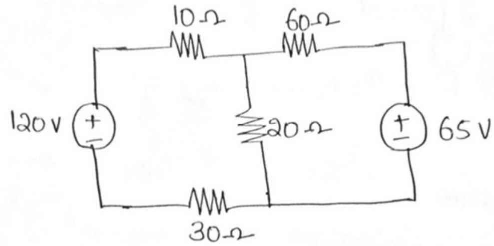
Figure (1)

Let us calculate, the current in branch A-B of the given network using super position theorem.

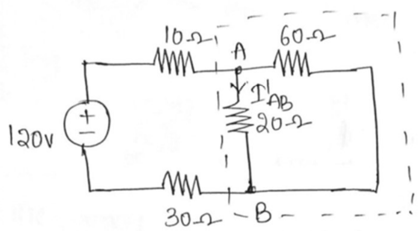
Step1:- According to super position theorem consider each source independently, Let source V_1 is alone acting V_2 is short circuited.

	Hence the circuit becomes as shown in below.  Using the other network reduction techniques, obtain the current through branch A-B. i,e: I_{AB} due to V_1 (alone). Step2:- Now consider source V_2 is alone, with V_1 replaced by short circuited.  The current obtain by the above circuit due to V_2 is acting. i,e: I_{AB} due to V_2 (alone) Step3:- According to superposition theorem, the total current through branch A-B is the sum of the current through branch A-B produced by each source acting independently. $\boxed{\text{Total } I_{AB} = I_{AB} \text{ due to } V_1 + I_{AB} \text{ due to } V_2}$
81	Use super position theorem find the current through 20 Ω resistor shown in below figure. 

(1) Use Superposition theorem to find the current through 20 ohms resistor shown in below figure.



Sol: Step1:- consider 120V alone, shorting 65V.

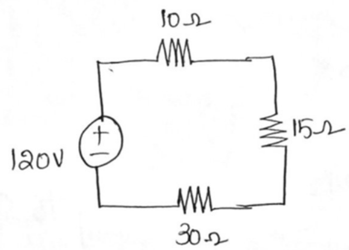


20Ω and 60Ω are in parallel.

20Ω and 60Ω are in parallel.

$$20\Omega \| 60\Omega$$

$$= \frac{20 \times 60}{20+60} = 15\Omega.$$



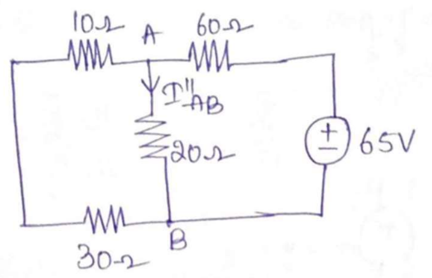
The current flowing through the branch A-B due to 120V is given by

$$I_T = \frac{120}{10+15+30} = 2.1818A.$$

$$I'_{AB} = I_T \times \frac{60}{20+60}$$

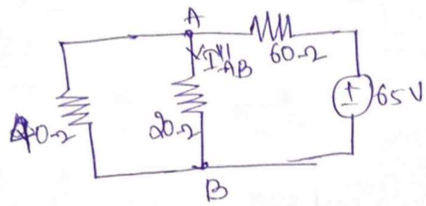
$$\boxed{I'_{AB} = 1.6363A}$$

Consider 65V alone, Shorting 120V.



30Ω and 10Ω are in series.

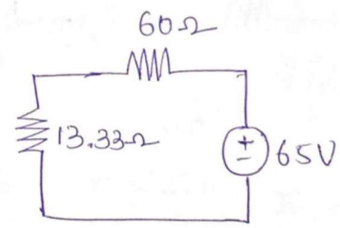
$$10\Omega + 30\Omega = 40\Omega.$$



40Ω and 20Ω are in parallel.

$$40\Omega \parallel 20\Omega$$

$$\frac{40 \times 20}{40+20} = 13.33\Omega$$



Total current $I_T = \dfrac{65}{60+13.33} = 0.8863A$

$$I''_{AB} = I_T \times \frac{40}{40+20} = 0.8863 \times \frac{40}{40+20} = 0.5909$$

The total current through 20Ω resistance, according to Super Position theorem.

$$I_{20\Omega} = I'_{AB} + I''_{AB}$$

$$= 1.6363 + 0.5909$$

$$\boxed{I_{20\Omega} = 2.2272A}$$

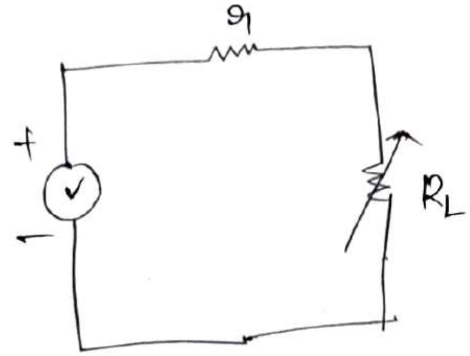
82	State and explain the maximum power transfer theorem.

①

Maximum Power Transfer Theorem

Statement: It states that the DC voltage source will deliver maximum power to the variable load resistance only when the load resistance is equal to the source resistance.

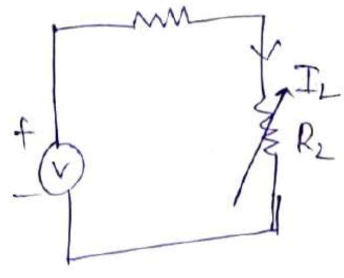
Proof:



Consider a circuit shown in fig where.
V = DC voltage source.
r = Internal resistance of DC voltage
R_L = Variable load resistance

(V) ~~DC voltage → maxi-~~ $\boxed{r = R_L}$

Let I_L be the current flowing through load resistance R_L



$$I_L = \frac{V}{r + R_L} \text{ (ohm's law)} \quad -① $$

Power transferred ~~to~~ to the load resistance (R_L) is given by $P_L = I_L^2 R_L$

$$P_L = \left(\frac{V}{r + R_L}\right)^2 R_L$$

$$P_L = \frac{V^2}{(r + R_L)^2} \times R_L$$

$$P_L = \underbrace{V^2}_{\text{constant}} \left[\frac{R_L}{(r + R_L)^2}\right] \quad -②$$

Here V, & r are constant ∴ P_L can be change by changing the value R_L

For P_L to be maximum, $\frac{dP_L}{dR_2} = 0$

Maximum power will be delivered by the DC voltage source by mathematic ~~f~~ function defferentiation put equal to zero

	② Differentiating Eq ② both sides wrt R_L & Equating it to zero we get $P_L = V^2\left[\frac{R_L}{(r+R_L)^2}\right]$ $\frac{u}{v}$ $\frac{dP_L}{dR_L} = V^2\left[\frac{(r+R_L)^2 \cdot 1 - R_L \cdot 2(r+R_L) \cdot 1}{((r+R_L)^2)^2}\right] = 0$ $r = \text{const}$ $P_L = \text{const}$ $= (r+R_L)^2 - 2R_L(r+R_L) = 0$ if $y = \frac{u}{v}$ $= \cancel{r^2 + R_L^2 + 2rR_L - 2R_L r - 2R_L^2} = 0$ $\frac{dy}{dx} = \frac{d}{dx}\frac{u}{v}$ $= r^2 + R_L^2 + 2\cancel{R_L} r - 2\cancel{R_L} r - 2R_L^2 = 0$ $\frac{dy}{dx} = \frac{v\frac{d}{dx}u - u\frac{d}{dx}v}{v^2}$ $r^2 + R_L^2 - 2R_L^2 = 0$ $r^2 - R_L^2 = 0$ $r^2 = R_L^2$ $\boxed{r = R_L}$ ∴ This is the Condition of max Power transfer
83	Derive the equivalent resistance for series and parallel circuits.

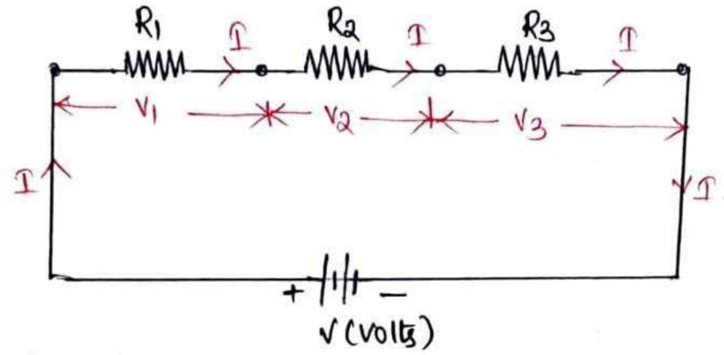
(3) Derive the ~~series~~ equivalent resistance for series parallel circuits.

Ans: Resistance in series: The resistance R_1, R_2 and R_3 are said to be in series. The combination is connected across a source of voltage 'V' volts.

Naturally, the current flowing through all the ~~cir~~ resistance is same, indicated as I ampere.

Let V_1, V_2, V_3 be the voltages across the terminals of resistance R_1, R_2 and R_3 respectively.

$V = V_1 + V_2 + V_3$.



According to ohm's law

$V_1 = IR_1, \quad V_2 = IR_2; \quad V_3 = IR_3$

current through all of them is same i,e I.

$$V = IR_1 + IR_2 + IR_3$$

$$V = I(R_1 + R_2 + R_3)$$

Apply ohm's law

$$V = I R_{eq}.$$

where R_{eq} = Equivalent resistance of the circuit.

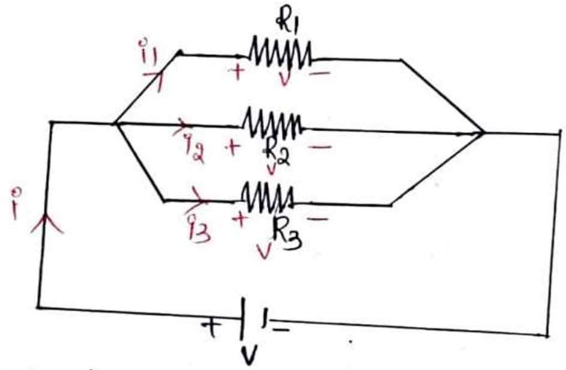
$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

for 'n' of resistance in series.

$$\boxed{R_{eq} = R_1 + R_2 + R_3 + \cdots + R_n.}$$

Resistance in parallel:

The three resistances R_1, R_2 and R_3 are connected in parallel and combination is connected across a source voltage 'V' volts.

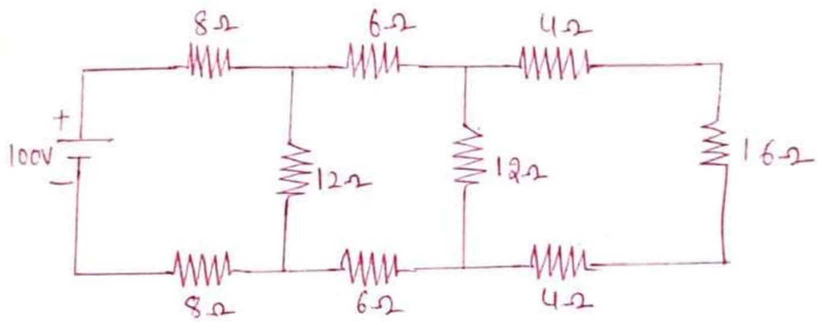
	(6) The Total current is I. There are 3 paths for this current, one through R_1, second through R_2 and third through R_3. The individual currents are I_1, I_2, I_3. while the voltage across the two ends of each resistances R_1, R_2 and R_3 is the same and equals the supply voltage 'V'  Apply ohm's law for the each resistance. $V = I_1 R_1$; $V = I_2 R_2$, $V = I_3 R_3$ $I_1 = \frac{V}{R_1}$; $I_2 = \frac{V}{R_2}$; $I_3 = \frac{V}{R_3}$ $I = I_1 + I_2 + I_3$; $\frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$ ohm's law is applied $V = I R_{eq}$. and $I = \frac{V}{R_{eq}}$ R_{eq} = Total (or) Equivalent resistance of the circuit. $\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ If 'n' of resistances connected in parallel. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}$; $\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$ → for 2 resistance connected.
84	Calculate a) The equivalent resistances across the terminals of the supply, b) Total current supplied by the source and c) Power delivered to 16 Ω in the circuit shown in the figure

Calculate;

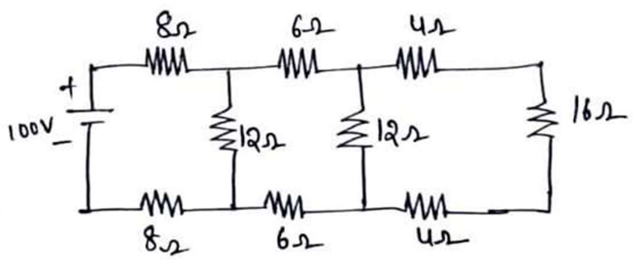
a) The equivalent resistance across the terminals of the Supply,

b) Total current supplied by the source and

c) power delivered to 16 ohm resistor in the circuit shown in below.



Sol



from the above circuit

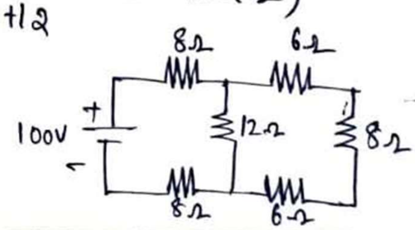
4Ω, 16Ω, 4Ω are in series.

4ohms + 16ohms + 4 ohms = 24 ohms (Ω)

Now, 24ohms(Ω) are parallel with 12Ω (ohms)

$24(\Omega) \| 12(\Omega)$

$= \dfrac{24 \times 12}{24 + 12} = 8 \text{ ohms} (\Omega)$



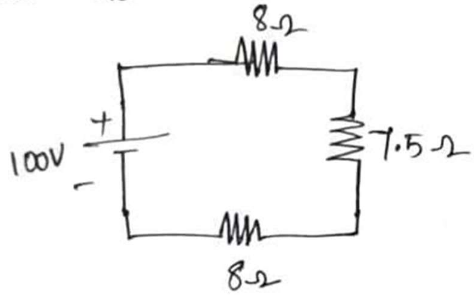
Now, 8 ohms(Ω), 6ohms(Ω), 6 ohms (Ω) are in series

$$8\Omega + 6\Omega + 6\Omega = 20\Omega.$$

Now 20Ω is parallel with 12Ω

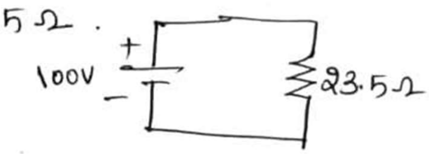
$$20 \| 12. \Rightarrow \frac{20\times12}{20+12} = 7.5\Omega$$

Now the circuit is deducted by.



Now, 7.5Ω, 8Ω, 8Ω are in series.

then $7.5 + 8 + 8 = 23.5\Omega$.



$\therefore$

a) The equivalent resistance across the terminals of supply is $R_{eq} = 23.5\Omega$

b) The total current supplied by source is

$$I = V/R_{eq} = 100/23.5 = 4.2 \text{ Amps}$$

c) power delivered to 16 ohms resistance is

$$I_{16ohms(\Omega)} = \frac{12}{(12+4+16+4)} \times 4.2 = 1.39 \text{ Amps}.$$

$$P_{16 ohms(\Omega)} = I^2R = (1.39)^2 \times 16 = 30.9136 \text{ watts}$$

85 Define Active and passive elements and write the voltage and current relationship of passive elements.

Active Elements: - Active elements are the elements with supply power or energy to the networkEg: Voltage source, Current sources

Passive Elements: - Passive elements are the elements which either store energy or dissipate energy in the formof heat.
Eg: Inductor and capacitor can store energy, resistor dissipates energy in the form of heat

1.11 Voltage Current Relationships for Passive Elements

The voltage current relationships for the passive elements resistance (R), inductance (L) and capacitor (C) are given in the Table 1.3.

Element	Basic relation	Voltage across, if current known	Current through, if voltage known	Energy
R	$R = \frac{v}{i}$	$v_R(t) = R\, i_R(t)$	$i_R(t) = \frac{1}{R} v_R(t)$	$w = \int_{-\infty}^{t} i_R(t)\, v_R(t)\, dt$
L	$L = \frac{N\phi}{i}$	$v_L(t) = L \frac{di_L(t)}{dt}$	$i_L(t) = \frac{1}{L} \int_{-\infty}^{t} v_L(t)\, dt$	$w = \frac{1}{2} L\, i^2(t)$
C	$C = \frac{q}{v}$	$v_C(t) = \frac{1}{C} \int_{-\infty}^{t} i_C(t)\, dt$	$i_C(t) = C \frac{dv_C(t)}{dt}$	$w = \frac{1}{2} C\, v^2(t)$

87 Discuss voltage-current relationships for passive elements.

1.11 Voltage Current Relationships for Passive Elements

The voltage current relationships for the passive elements resistance (R), inductance (L) and capacitor (C) are given in the Table 1.3.

Element	Basic relation	Voltage across, if current known	Current through, if voltage known	Energy
R	$R = \frac{v}{i}$	$v_R(t) = R\, i_R(t)$	$i_R(t) = \frac{1}{R} v_R(t)$	$w = \int_{-\infty}^{t} i_R(t)\, v_R(t)\, dt$
L	$L = \frac{N\phi}{i}$	$v_L(t) = L \frac{di_L(t)}{dt}$	$i_L(t) = \frac{1}{L} \int_{-\infty}^{t} v_L(t)\, dt$	$w = \frac{1}{2} L\, i^2(t)$
C	$C = \frac{q}{v}$	$v_C(t) = \frac{1}{C} \int_{-\infty}^{t} i_C(t)\, dt$	$i_C(t) = C \frac{dv_C(t)}{dt}$	$w = \frac{1}{2} C\, v^2(t)$

88 A 100w ,250 volts bulb is put in series with a 40w ,250-volt bulb across 500 volts supply. What will be the power consumed by each bulb.

	Problem:- 1) A 100W, 250V bulb is put in series with a 40W, 250V bulb across a 500V supply. What will be the power consumed by each bulb? Will such a Combination work? **Sol:-** For bulb 1, $P_1 = 100W$, $V_1 = 250V$ For bulb 2, $P_2 = 40W$, $V_2 = 250V$ $\Rightarrow P_1 = \frac{V_1^2}{R_1} \Rightarrow R_1 = \frac{V_1^2}{P_1} = \frac{250 \times 250}{100} = 625\Omega$ $R_1 = 625\Omega$ $P_2 = \frac{V_2^2}{R_2} \Rightarrow R_2 = \frac{V_2^2}{P_2} = \frac{250 \times 250}{40} = 1562.5\Omega$ Two bulbs are in series $I = \frac{V}{R_1 + R_2} = \frac{500}{625 + 1562.5}$ $I = 0.22857A$ Hence actual power consumption by each bulb is, $P_1 = I^2 R_1 = (0.22857)^2 \times 625 = 32.653W$ $P_2 = I^2 R_2 = (0.22857)^2 \times 1562.5 = 81.6316W$ But actual power consumption by bulb 2 is 81.6316W which has rating of 40W. Hence practically this combination "will not work"
89	Explain the voltage division rule and current division rule.

1.14.1 Resistors in Series

Current same voltage division

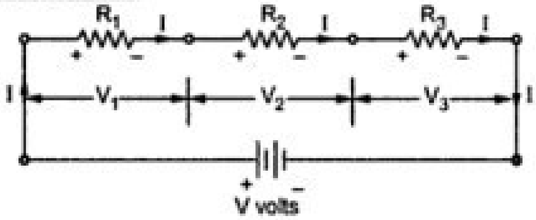


Fig. 1.21 A series circuit

Consider the resistances shown in the Fig. 1.21.

The resistance R_1, R_2 and R_3 are said to be in series. The combination is connected across a source of voltage V volts. Naturally the current flowing through all of them is same indicated as I amperes. e.g. the chain of small lights, used for the decoration purposes is good example of series combination.

Now let us study the **voltage distribution.**

Let V_1, V_2 and V_3 be the voltages across the terminals of resistances R_1, R_2 and R_3 respectively

Then, $$V = V_1 + V_2 + V_3$$

Now according to Ohm's law, $$V_1 = I R_1, \; V_2 = I R_2, \; V_3 = I R_3$$

Current through all of them is same i.e. I

$$\therefore \quad V = I R_1 + I R_2 + I R_3 = I(R_1 + R_2 + R_3)$$

Applying Ohm's law to overall circuit,

$$V = I R_{eq}$$

where R_{eq} = Equivalent resistance of the circuit. By comparison of two equations,

$$R_{eq} = R_1 + R_2 + R_3$$

i.e. total or **equivalent resistance** of the series circuit is arithmetic sum of the resistances connected in series.

For n resistances in series, $$\boxed{R = R_1 + R_2 + R_3 + \ldots\ldots + R_n}$$

1.14.1.1 Characteristics of Series Circuits

1) The same current flows through each resistance.
2) The supply voltage V is the sum of the individual voltage drops across the resistances.

$$V = V_1 + V_2 + \ldots\ldots + V_n$$

3) The equivalent resistance is equal to the sum of the individual resistances.
4) The equivalent resistance is the largest of all the individual resistances.

i.e $$R > R_1, \; R > R_2, \; \ldots\ldots R > R_n$$

1.15.1 Resistors in Parallel

Consider a parallel circuit shown in the Fig. 1.24.

In the parallel connection shown, the three resistances R_1 , R_2 and R_3 are connected in parallel and combination is connected across a source of voltage 'V '.

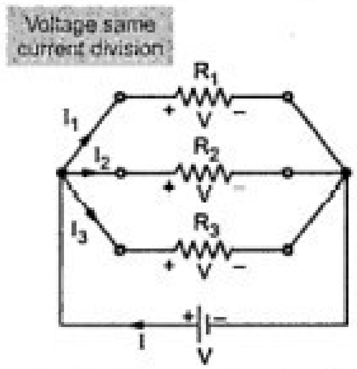


Fig. 1.24 A parallel circuit

In parallel circuit current passing through each resistance is different. Let total current drawn is say ' I ' as shown. There are 3 paths for this current, one through R_1, second through R_2 and third through R_3. Depending upon the values of R_1 , R_2 and R_3 the appropriate fraction of total current passes through them. These individual currents are shown as I_1 , I_2 and I_3. While the voltage across the two ends of each resistances R_1 , R_2 and R_3 is the same and equals the supply voltage V.

Now let us study current distribution. Apply Ohm's law to each resistance.

$$V = I_1 R_1 , \quad V = I_2 R_2 , \quad V = I_3 R_3$$

$$I_1 = \frac{V}{R_1}, \quad I_2 = \frac{V}{R_2}, \quad I_3 = \frac{V}{R_3}$$

$$I = I_1 + I_2 + I_3 = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$= V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right] \quad \ldots (1)$$

For overall circuit if Ohm's law is applied,

$$V = I R_{eq}$$

and $$I = \frac{V}{R_{eq}} \quad \ldots (2)$$

where R_{eq} = Total or **equivalent resistance** of the circuit.

Comparing the two equations,

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

where R is the equivalent resistance of the parallel combination.

In general if 'n' resistances are connected in parallel,

$$\boxed{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots + \frac{1}{R_n}}$$

1.17 Voltage Division in Series Circuit of Resistors

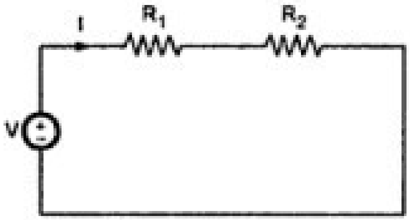


Fig. 1.33

Consider a series circuit of two resistors R_1 and R_2 connected to source of V volts.

As two resistors are connected in series, the current flowing through both the resistors is same, i.e. I. Then applying KVL, we get,

$$V = I R_1 + I R_2$$

$$\therefore \quad I = \frac{V}{R_1 + R_2}$$

Total voltage applied is equal to the sum of voltage drops V_{R1} and V_{R2} across R_1 and R_2 respectively.

$$\therefore \qquad V_{R1} = I \,.\, R_1$$

$$\therefore \qquad \boxed{V_{R1} = \frac{V}{R_1 + R_2} \cdot R_1 = \left[\frac{R_1}{R_1 + R_2}\right] V}$$

Similarly, $\quad V_{R2} = I \,.\, R_2$

$$\therefore \qquad \boxed{V_{R2} = \frac{V}{R_1 + R_2} \cdot R_2 = \left[\frac{R_2}{R_1 + R_2}\right] V}$$

So this circuit is a **voltage divider circuit.**

Key Point : *So in general, voltage drop across any resistor, or combination of resistors, in a series circuit is equal to the ratio of that resistance value to the total resistance, multiplied by the source voltage.*

1.18 Current Division in Parallel Circuit of Resistors

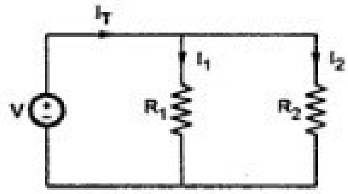


Fig. 1.34

Consider a parallel circuit of two resistors R_1 and R_2 connected across a source of V volts.

Current through R_1 is I_1 and R_2 is I_2, while total current drawn from source is I_T.

$\therefore \quad I_T = I_1 + I_2$

But $\quad I_1 = \dfrac{V}{R_1}, \quad I_2 = \dfrac{V}{R_2}$

i.e. $\quad V = I_1 R_1 = I_2 R_2$

$$\therefore \quad I_1 = I_2 \left(\frac{R_2}{R_1}\right)$$

Substituting value of I_1 in I_T,

$$\therefore \quad I_T = I_2\left(\frac{R_2}{R_1}\right) + I_2 = I_2\left[\frac{R_2}{R_1}+1\right] = I_2\left[\frac{R_1+R_2}{R_1}\right]$$

$$\therefore \quad \boxed{I_2 = \left[\frac{R_1}{R_1+R_2}\right] I_T}$$

$$\text{Now} \quad I_1 = I_T - I_2 = I_T - \left[\frac{R_1}{R_1+R_2}\right] I_T$$

$$\therefore \quad I_1 = \left[\frac{R_1+R_2-R_1}{R_1+R_2}\right] I_T$$

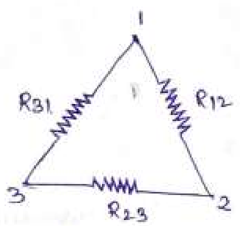
$$\therefore \quad \boxed{I_1 = \left[\frac{R_2}{R_1+R_2}\right] I_T}$$

Key Point : *In general, the current in any branch is equal to the ratio of opposite branch resistance to the total resistance value, multiplied by the total current in the circuit.*

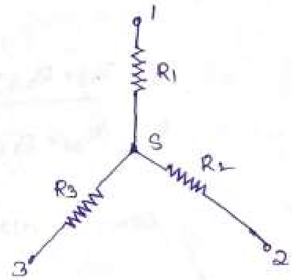
90	Derive the expressions to convert Delta to Star Network.

Delta- Star Transformation.

Consider the three resistances R_{12}, R_{23}, R_{31} connected in Delta. as shown in fig. The terminals between which these are connected in Delta are named as 1, 2, and 3



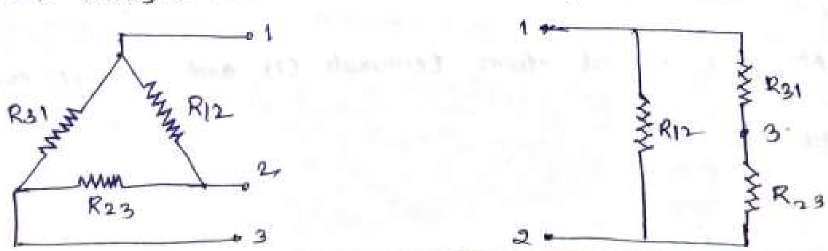
Given Delta



Equivalent Star.

Now it is always possible to replace these delta connected resistances by three equivalent star connected resistances R_1, R_2, R_3 between the same terminals 1, 2 and 3. Which is called as Star of Delta connected Resistances

Let us analyse delta connection first,



Now consider the terminals (1) and (2). Let us find equivalent resistance between (1) and (2).

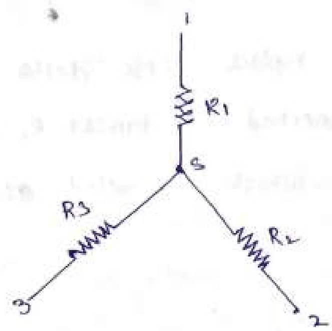
Now terminal '3' we are not considering, so between terminals (1) and (2), we get the combination as

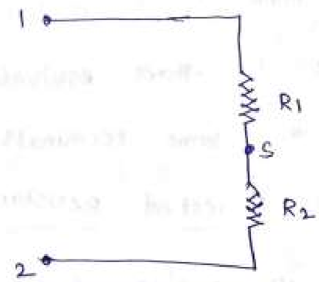
R_{12} parallel with $(R_{13}+R_{23})$ as R_{31} and R_{23} are in series

∴ Between (1) and (2) the resistance is,

$$= \frac{R_{12}(R_{13}+R_{23})}{R_{12}+(R_{31}+R_{23})} \qquad (1)$$

Now consider the same two terminals of equivalent star connection shown in fig.





Now as viewed from terminals (1) and (2). we can redraw the network.

Resistance between (1) and (2) is = $R_1 + R_2$ —— (2)

Two of them found to be in series across the terminals (1) and (2) while (3) found to be open

The resistances calculated between (1) and (2) in both the cases should be equal and hence equating equations (1) and (2)

$$\frac{R_{12}(R_{31}+R_{23})}{R_{12}+(R_{31}+R_{23})} = R_1 + R_2 \quad \text{—— (3)}$$

Similarly if we find the equivalent resistance as viewed through terminals (2) and (3); and (3) and (1) in both cases and equating, we get.

$$\frac{R_{23}(R_{12}+R_{31})}{R_{23}+(R_{12}+R_{31})} = R_2 + R_3 \quad \text{—— (4)}$$

$$\frac{R_{31}(R_{12}+R_{23})}{R_{31}+(R_{12}+R_{23})} = R_3 + R_1 \quad \text{—— (5)}$$

Subtracting equation (4) from (3)

$$R_1 + R_2 - (R_2 + R_3) = \frac{R_{12}(R_{31}+R_{23})}{R_{12}+(R_{31}+R_{23})} - \frac{R_{23}(R_{12}+R_{31})}{R_{12}+(R_{31}+R_{23})}$$

$$R_1 - R_3 = \frac{R_{12}R_{31} + \cancel{R_{12}R_{23}} - \cancel{R_{23}R_{12}} - R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}$$

$$R_1 - R_3 = \frac{R_{12}R_{31} - R_{23}R_{31}}{R_{12}+R_{23}+R_{31}} \quad \text{—— (6)}$$

Adding equation (5) and (6)

$$R_1 + \cancel{R_3} + R_1 - \cancel{R_3} = \frac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} + \frac{R_{12}R_{31} - R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}$$

Adding equation (5) and (6)

$$R_1 + \cancel{R_3} + R_1 - \cancel{R_3} = \frac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} + \frac{R_{12}R_{31} - R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}$$

$$2R_1 = \frac{R_{31}R_{12} + \cancel{R_{31}R_{23}} + R_{12}R_{31} - \cancel{R_{23}R_{31}}}{R_{12}+R_{23}+R_{31}}$$

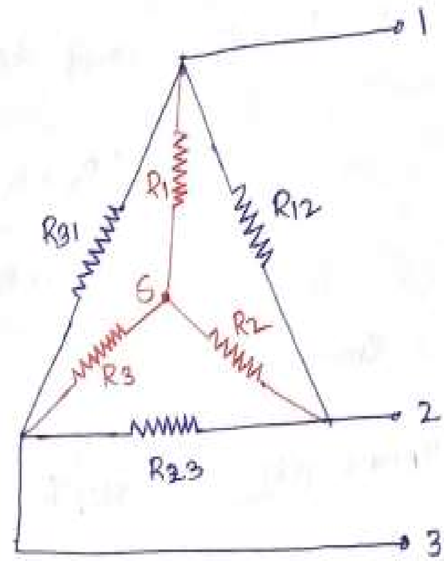
$$2R_1 = \frac{2R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}$$

$$\boxed{R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}}$$

Similarly

$$\boxed{R_2 = \frac{R_{12}R_{23}}{R_{12}+R_{23}+R_{31}}}$$

$$\boxed{R_3 = \frac{R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}}$$



Delta and equivalent Star

S.NO	Unit-II (LAQ's)
91	Derive the Average and RMS value of current for sinusoidal waveform.

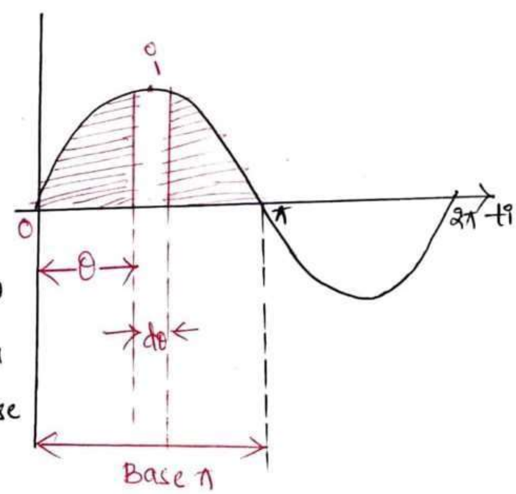
1(a) Derive the Average and RMS value of current for sinusoidal waveform.

Sol: Derivation of Average value:

Consider sinusoidally varying current

$I = I_m \sin\theta$

Consider the elementary interval of instant '$d\theta$'.



The average value can be obtained by the taking ratio of area under curve over a half cycle to length of the base for half cycle.

$$I_{av} = \frac{\text{Area under curve for half cycle}}{\text{Length of base over half cycle.}}$$

$$I_{av} = \frac{\int_0^{\pi} i\,d\theta}{\pi} = \frac{1}{\pi}\int_0^{\pi} i\,d\theta = \frac{1}{\pi}\int_0^{\pi} I_m \sin\theta\,d\theta = \frac{I_m}{\pi}\int_0^{\pi} \sin\theta\,d\theta$$

$$= \frac{I_m}{\pi}\left[-\cos\theta\right]_0^{\pi} = \frac{I_m}{\pi}\left[-\cos\pi + \cos 0\right] = \frac{I_m}{\pi}(2) = \frac{2I_m}{\pi} = 0.637 I_m$$

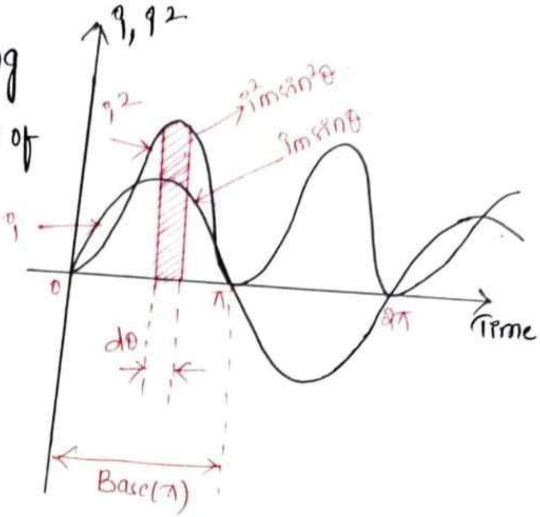
$$\boxed{I_{av} = 0.637 I_m}$$

For purely sinusoidal waveform, the average value is expressed interms of maximum values as

$$\boxed{I_{av} = 0.637 I_m \quad \text{and} \quad V_{av} = 0.637 V_m}$$

RMS (Root mean Square) Value:

Consider sinusoidally varying alternating current and square of current shown in figure.



Step I The current $i = I_m \sin\theta$

Step-II

Square of current

$$i^2 = I_m^2 \sin^2\theta$$

Area of square curve over half cycle $= \int_0^{\pi} i^2 d\theta$ and length of the base π

step III : Average value of square of the current over half cycle is;

$$\frac{\text{Area of curve over half cycle}}{\text{Length of base over half cycle}} = \frac{\int_0^{\pi} i^2 d\theta}{\pi} = \frac{1}{\pi}\int_0^{\pi} i^2 d\theta$$

$$= \frac{1}{\pi}\int_0^{\pi} I_m^2 \sin^2\theta \, d\theta = \frac{I_m^2}{\pi}\int_0^{\pi}\left[\frac{1-\cos 2\theta}{2}\right] d\theta = \frac{I_m^2}{2\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^{\pi}$$

$$= \frac{I_m^2}{2\pi}(\pi) = \frac{I_m^2}{2}$$

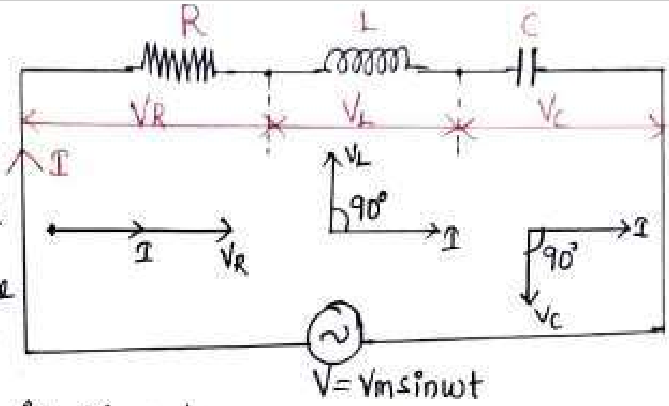
Step IV: Root mean square value (RMS value) can be calculated as

$$I_{rms} = \sqrt{\text{mean (or) Average of square of current}} = \sqrt{\frac{I_m^2}{2}} = \frac{I_m}{\sqrt{2}}$$

$$\boxed{\begin{aligned} I_{rms} &= \frac{I_m}{\sqrt{2}} = 0.707 I_m \\ V_{rms} &= \frac{V_m}{\sqrt{2}} = 0.707 V_m. \end{aligned}}$$

92	Derive Expression for Series RLC AC Circuit with phasor diagram.

Consider a circuit consisting of resistance R ohms, pure inductance L henries, and capacitance C farads connected in series with a.c supply is given by;



$$V = V_m \sin\omega t$$

The circuit draws a current I, due to current I, there are different voltage drop across R, L and C which are.

a) Drop across resistance R is $V_R = IR$

b) Drop across inductance L is $V_L = IX_L$

c) Drop across capacitance C is $V_C = IX_C$

The characteristics of three drops are,

a) V_R is in phase with current I.

b) V_L is leads with current I by 90°.

c) V_C is lags with current I by 90°

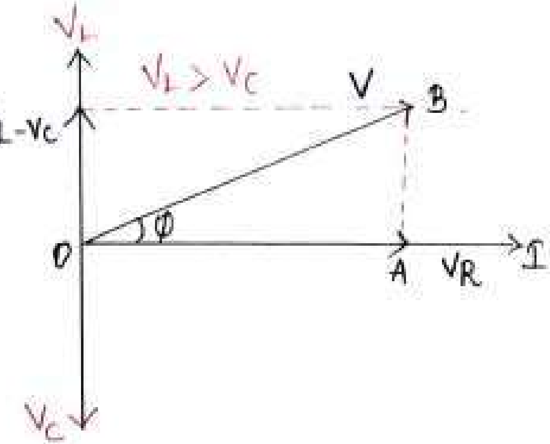
According to Kirchoff's laws, we can write.

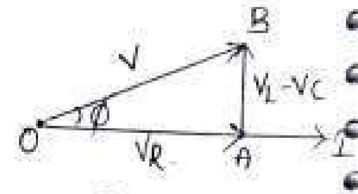
$$\boxed{\bar{V} = \bar{V}_R + \bar{V}_L + \bar{V}_C}$$

Case(i) ; $X_L > X_C$

when $X_L > X_C$, obviously IX_L i,e: V_L is greater than IX_C i,e V_C. So resultant of V_L and V_C will be directed towards V_L. i,e: leading current I.

current I will lag the resultant of V_L and V_C i.e. $(V_L - V_C)$ then the circuit is said to be inductive in nature. The phasor sum of V_R and $(V_L - V_C)$ gives the resultant supply voltag V.





I lags V.

from the voltage triangle,

$$V = \sqrt{(V_R)^2 + (V_L - V_C)^2} = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

$$V = IZ$$

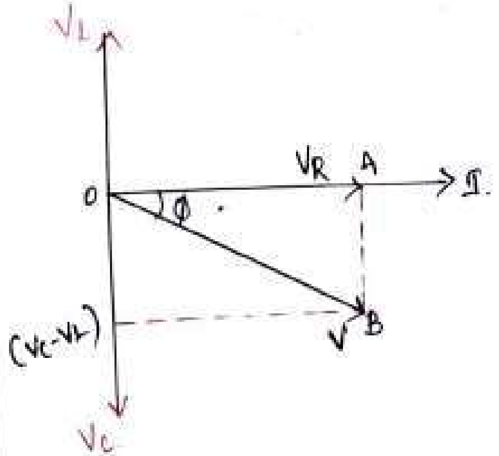
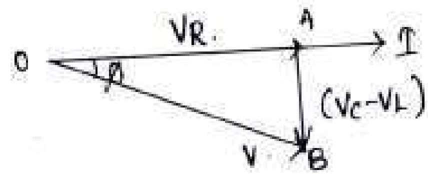
where $Z = \sqrt{R^2 + (X_L - X_C)^2}$

So, if $V = V_m \sin \omega t$, then $i = I_m \sin(\omega t - \phi)$

as current lags voltage by angle ϕ for $X_L > X_C$.

Case(ii): $X_L < X_C$

when $X_L < X_C$, obviously, IX_L i.e V_L is less than IX_C i.e V_C, so the resultant of V_L and V_C will be directed towards V_C. current I will leads $(V_C - V_L)$, then the circuit is said to be capacitive in nature.

	The phasor sum of V_R and (V_C-V_L) gives the resultant supply voltage V.   I leads V. from the voltage triangle, $V = \sqrt{(V_R)^2 + (V_C-V_L)^2} = \sqrt{(IR)^2 + (IX_C - IX_L)^2}$ $= I\sqrt{R^2 + (X_C - X_L)^2}$ $V = IZ$ where $Z = \sqrt{R^2 + (X_C - X_L)^2}$ So, if $v = V_m \sin \omega t$, then $i = I_m \sin(\omega t + \phi)$ as current leads voltage by angle ϕ for $X_L < X_C$
93	A series RC circuit is connected across 200V, 50Hz AC supply draws a current of 20A when the frequency of the supply is increased to 100Hz, the current increases to 23.4082A. calculate the value of resistance and capacitance of the circuit.

	(1)(b) A series RC circuit is connected across 200V, 50Hz ac supply draws a current of 20A. when the frequency of the supply is increased to 100Hz, the current increases to 23.4082A. Calculate the value of resistance and capacitance of the circuit. Sol Given data: Voltage (V) = 200V. frequency (f_1) = 50Hz current (I_1) = 20A. Increased frequency (f_2) = 100Hz. Increased current (I_2) = 23.4082A. When frequency is 50Hz; f_1=50Hz. $\|Z_1\| = \frac{V}{I_1} = \frac{200}{20} = 10\Omega$ when frequency is 100Hz; f_2= 100Hz. $\|Z_2\| = \frac{V}{I_2} = \frac{200}{23.4082} = 8.544\Omega$ $Z_1 = \sqrt{R^2+(X_{C_1})^2} = (10)^2 = R^2+(X_{C_1})^2$ —(1) $Z_2 = \sqrt{R^2+(X_{C_2})^2} = (8.544)^2 = R^2+(X_{C_2})^2$ —(2) Subtracting equations (1) and (2) $\Rightarrow (X_{C_1})^2-(X_{C_2})^2 = 27$ $\left(\frac{1}{2\pi f_1 C}\right)^2 - \left(\frac{1}{2\pi f_2 C}\right)^2 = 27$ $\frac{1}{4\pi^2 \times 50^2 \times C^2} - \frac{1}{4\pi^2 \times 100^2 \times C^2} = 27$ $\frac{1}{C^2}(7.6\times10^{-6}) = 27.$ $C^2 = 2.814\times10^{-7}.$ $C = 5.305\times10^{-4}$ F from equation no(1) R = 8Ω.
94	A 100 V, 1- ϕ 50 Hz AC supply is applied across series connection of R = 500 Ω, C = 0.5μF. calculate impedance, current, power factor, active power, reactive power, VR, VC.

A 100 V, 1-ϕ 50 Hz AC supply is applied across series connection of $R = 500\,\Omega$, $C = 0.5\,\mu F$. Calculate impedance, current, power factor, active power, reactive power, V_R, V_C.

Given data $V = 100V$

$f = 50Hz$

$R = 500\Omega$

$C = 0.05\,\mu F$ $\quad X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 0.05 \times 10^{-6}}$

$= \cancel{0404}\ 63661.97$

Impedance $Z = \sqrt{R^2 + (X_C)^2}$

$= \sqrt{(500)^2 + (63661)^2}$

$= \cancel{500}\ 6385$

Current $(I) = \frac{V}{Z} = \frac{100}{6385}$

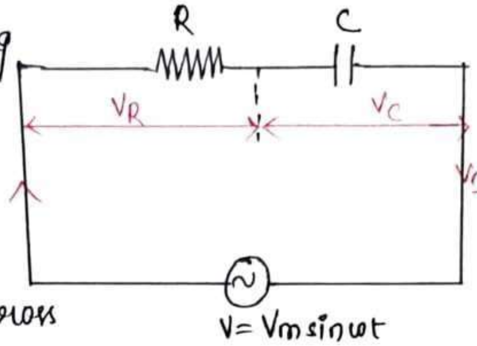
$I = 0.015$

Power factor $\cos\phi = \frac{R}{Z} = \frac{500}{6385}$

$= 0.07$

	active power $(P) = VI\cos\phi$ $= 100 \times 0.015 \times 0.07$ $= 0.105$ Reactive power $(Q) = VI\sin\phi$ $= 100 \times 0.015 \times 0.99$ $= 1.485$ $\cos\phi = 0.07$ $\phi = \cos^{-1}(0.07)$ $= 85.98$ $\sin(85.98)$ $= 0.99$ $V_R = IR$ $= 0.015 \times 500$ $= 7.5$ $V_C = I X_C$ $= 0.015 \times 6366$ $V_C = 95.49$
95	Derive the expression for Series RC AC Circuit with phasor diagram.

3) Derive expression for Series R-C, AC circuit with phasor diagram.



Consider a circuit consisting of pure resistance R-ohms and connected in series with a pure capacitor of C-farad's is connected across a.c supply given by

$$\boxed{V = V_m \sin \omega t}$$

Circuit draws a current I, there are two voltage drops,

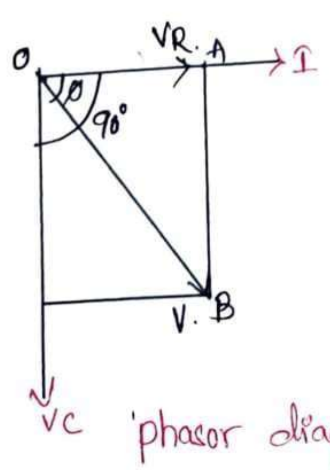
a) Drop across pure resistance $V_R = I \times R$

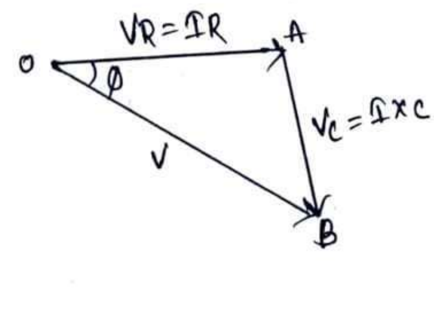
b) Drop across pure capacitance $V_C = I X_C$

The Kirchoff's voltage law can be applied to get,

$$V = \overline{V_R} + \overline{V_C} = \overline{IR} + \overline{IX_C}$$

Let us draw the phasor diagram, current I is taken as reference as it is common to both the elements.





phasor diagram.

(15)

From the voltage triangle,

$$V = \sqrt{(V_R)^2 + (V_C)^2} = \sqrt{(IR)^2 + (IX_C)^2}$$

$$= I\sqrt{R^2 + (X_C)^2}$$

$$V = IZ$$

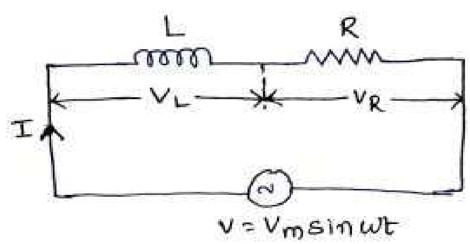
where $Z = \sqrt{R^2 + X_C^2}$

It can be seen that current leads voltage by angle ϕ

hence, $\boxed{v(t) = V_m \sin \omega t}$, and $\boxed{i(t) = I_m \sin(\omega t + \phi)}$.

96 Derive the expression for Series RL AC Circuit with phasor diagram.

A.C through Series R-L Circuit.



Consider a circuit consisting of pure resistance R ohms connected in series with a pure inductance of L henries as shown in the fig.

The series combinations is connected across a.c supply given by $V = V_m \sin \omega t$. Circuit draws a current I then there are two voltage drops,

a) Drop across pure resistance, $V_R = I \times R$

b) Drop across pure inductance, $V_L = I \times X_L$

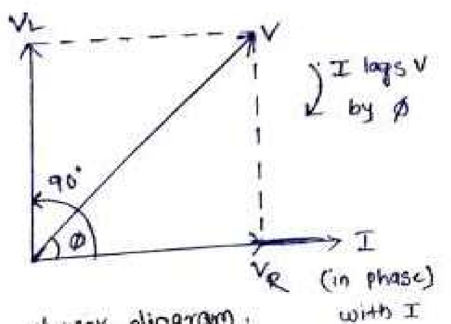
where $X_L = 2\pi f L$

I = r.m.s value of current drawn

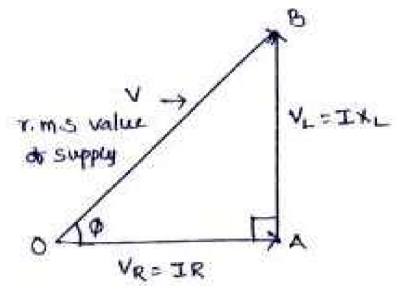
V_R, V_L = r.m.s value of the voltage drops.

The Kirchhoff's voltage law can be applied to the a.c circuit.

$$V = \bar{V}_R + \bar{V}_L = \bar{I}R + \bar{I}X_L$$



phasor diagram.



voltage triangle

From the voltage triangle, we can write

$$V = \sqrt{(V_R)^2 + (V_L)^2} = \sqrt{(IR)^2 + (IX_L)^2} = I\sqrt{R^2 + X_L^2}$$

$$V = IZ$$

where $\boxed{Z = \sqrt{R^2 + X_L^2}}$

The impedance Z is measured in ohms.

It can be seen that current lags voltage by angle ϕ

$$\boxed{\therefore\ v(t) = V_m \sin \omega t \ \text{ and } \ i(t) = I_m \sin(\omega t - \phi)} \qquad (\omega t - \phi)$$

97 Explain the difference between a balanced polyphase system and an unbalanced polyphase system. What conditions typically cause a polyphase system to become unbalanced?

A balanced polyphase system is a power distribution system in which the magnitudes of the voltages or currents of each phase are equal and the phases are separated by 120 degrees. In a balanced system, the line currents are equal and opposite, so the net current is zero. This means that the net power being transmitted is the same for each phase, and the system is considered to be in balance.

An unbalanced polyphase system, on the other hand, is a power distribution system in which the magnitudes of the voltages or currents of one or more phases are different from the others. This can result in unequal distribution of power between the phases and can cause a net current to flow in the system. This can lead to a reduction in system efficiency and can cause damage to equipment over time.

There are several conditions that can cause a polyphase system to become unbalanced, including:

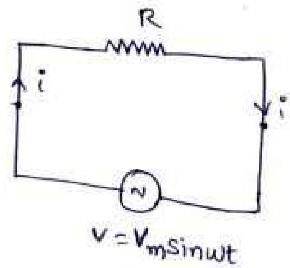
1. Unbalanced load distribution: If the load connected to a polyphase system is not evenly distributed across the phases, it can cause an imbalance in the system.
2. Phase-to-ground faults: If one phase of a polyphase system is grounded, it can cause an imbalance in the system.
3. Line impedance unbalance: If the impedance of one phase is different from the others, it can cause an imbalance in the system.
4. Open or broken phase conductors: If one phase conductor is open or broken, it can cause an imbalance in the system.
5. Phase shifting transformers: If phase shifting transformers are not properly configured, they can cause an imbalance in the system.

In general, unbalanced polyphase systems are less efficient and can cause damage to equipment if not corrected. It is important to regularly monitor the balance of a polyphase system and to take steps to correct any imbalances as soon as they are detected.

98 Explain the concept of AC through pure resistance.

A.C through Pure Resistance.

Consider a simple circuit consisting of a pure resistance 'R' ohms connected across a voltage $v = V_m \sin\omega t$. The circuit is shown in fig.



According to ohm's law, we can find the equation for the current i as,

$$i = \frac{V}{R} = \frac{V_m \sin\omega t}{R} = \left(\frac{V_m}{R}\right)\sin\omega t$$

This is the equation giving instantaneous value of the curren

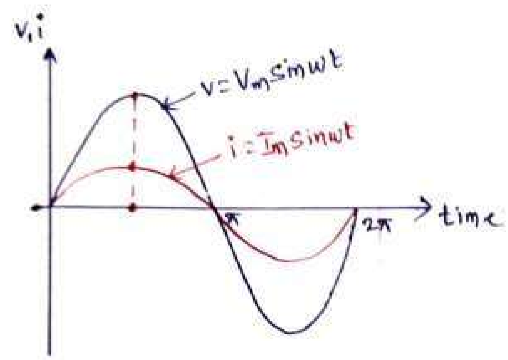
Comparing this with standard equation, $i = I_m \sin(\omega t + \phi)$

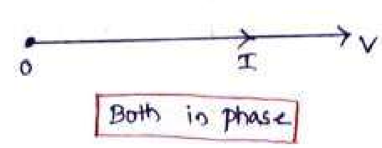
$$\boxed{I_m = \frac{V_m}{R} \quad \text{and} \quad \phi = 0^\circ}$$

So, maximum value of alternating current, i is $I_m = \frac{V_m}{R}$ while as $\phi = 0$, it indicates that it is in phase with the applied voltage.

NOTE:-

In purely resistive circuit, the current and the voltage applied a in phase with each other.





99 Explain the concept of AC through pure inductance.
Or
Show that the current lags voltage by 90° in a pure inductive circuit. Draw the necessary waveforms.

This is the equation giving instantaneous value of the Curren

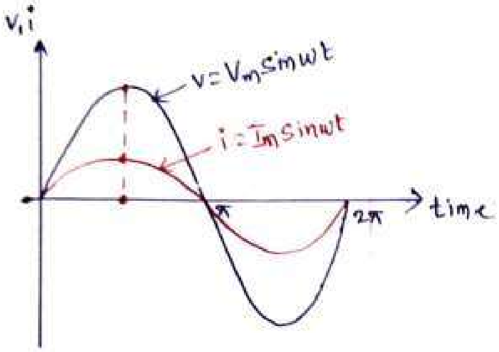
Comparing this with standard equation, $i = I_m \sin(\omega t + \phi)$

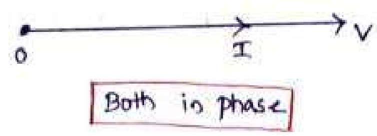
$$\boxed{I_m = \frac{V_m}{R} \quad \text{and} \quad \phi = 0^\circ}$$

So, maximum value of alternating current, i is $I_m = \frac{V_m}{R}$ while as $\phi = 0$, it indicates that it is in phase with the applied voltage.

NOTE:-

In purely resistive circuit, the current and the voltage applied a in phase with each other.





At all the instant, applied voltage, v is equal and opposite to the self induced e.m.f., e.

$$v = -e = -\left[-L\frac{di}{dt}\right]$$

$$v = L\frac{di}{dt} \quad \text{i.e} \quad V_m \sin \omega t = L\frac{di}{dt}$$

$$di = \frac{V_m}{L}\sin \omega t \, dt$$

$$i = \int di = \int \frac{V_m}{L}\sin \omega t \, dt = \frac{V_m}{L}\left[\frac{-\cos \omega t}{\omega}\right]$$

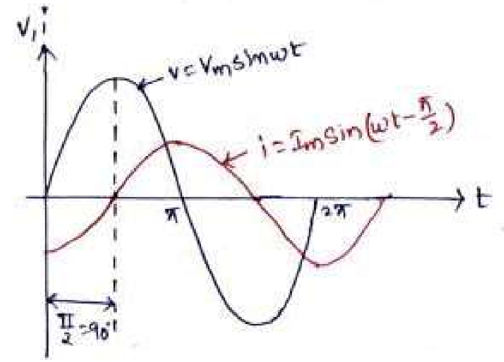
$$= \frac{-V_m}{\omega L}\cos \omega t = \frac{-V_m}{\omega L}\sin\left(\frac{\pi}{2} - \omega t\right)$$

$$= \frac{V_m}{\omega L}\sin\left(\omega t - \frac{\pi}{2}\right)$$

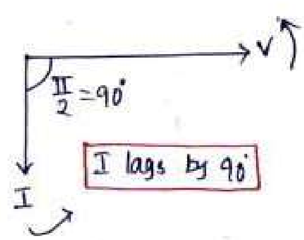
$$\boxed{i = I_m \sin\left(\omega t - \frac{\pi}{2}\right) \quad \text{where } I_m = \frac{V_m}{\omega L} = \frac{V_m}{X_L} \quad \text{and } X_L = \omega L = 2\pi f L \ \Omega}$$

The above equation clearly shows that the current is purely sinusoidal and having phase angle of $-\frac{\pi}{2}$ radians i.e -90°. This means that the current lags voltage applied by 90°.

The negative sign indicates lagging nature of the current.



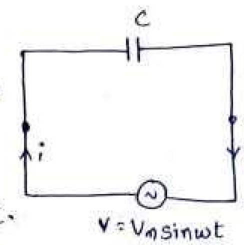
V and I are r.m.s value.



100 Explain the concept of AC through pure capacitance.

AC through pure capacitance.

Consider a simple circuit consisting of a pure capacitor of C-farads, connected across a voltage $v = V_m \sin \omega t$ as shown in fig.



The current i charges the capacitor C. The instantaneous charge 'q' on the plates of the capacitor is given by.

$$q = Cv = CV_m \sin \omega t$$

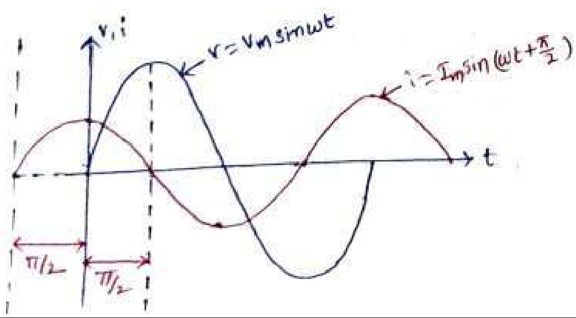
current is rate of flow charge.

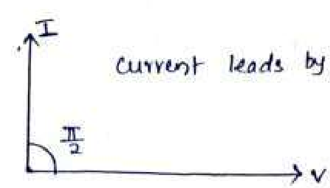
$$i = \frac{dq}{dt} = \frac{d}{dt}(CV_m \sin \omega t) = CV_m \frac{d}{dt} \sin \omega t = CV_m \omega \cos \omega t$$

$$i = \frac{V_m}{1/\omega C} \sin\left(\omega t + \frac{\pi}{2}\right) = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$

Where $\boxed{I_m = \frac{V_m}{X_C} \text{ and } X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}\ \Omega}$

The above equation clearly shows that the current is purely sinusoidal and having phase angle of $+\frac{\pi}{2}$ radians i.e $+90°$. This means current leads voltage applied by $90°$. The positive sign indicates leading nature of the current.





current leads by 90°

101	Show that VL = √3 Vph in 3-phase balanced star connected system with the help of phasor diagram.

4(a) Show that $V_L = \sqrt{3}\, V_{ph}$ in 3-phase balanced star connected system with the help of phasor diagram.

Ans: Three-phase balanced star connected system: The circuit diagram for a three-phase balanced star connected system with phase sequence RYB is shown below figure.

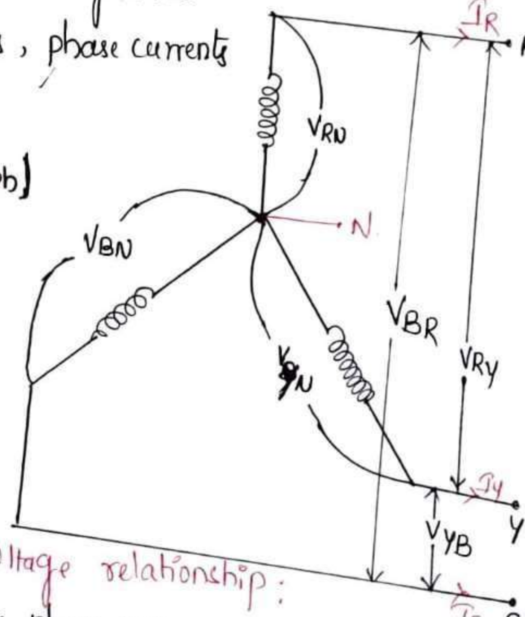
In a balanced system, all the magnitude of phase voltages, line voltages, phase currents and line currents are equal.

$|\bar{V}_{RN}| = |\bar{V}_{YN}| = |\bar{V}_{BN}| = |\bar{V}_{ph}|$

$|\bar{V}_{RY}| = |\bar{V}_{YB}| = |\bar{V}_{BR}| = |\bar{V}_L|$

$|\bar{I}_R| = |\bar{I}_Y| = |\bar{I}_B| = |\bar{I}_L|$;

$|\bar{I}_{BY}| = |\bar{I}_{YB}| = |\bar{I}_{BR}| = |\bar{I}_{ph}|$



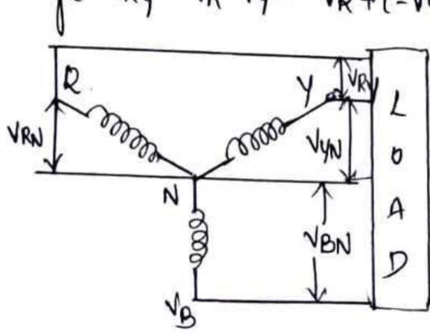
Phase voltage and line voltage relationship:

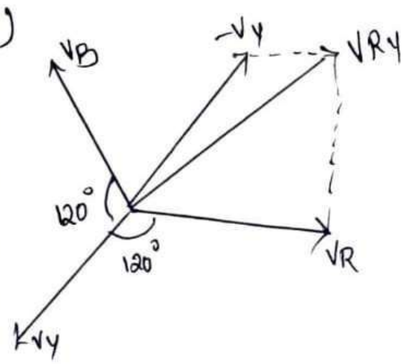
$V_{ph} = V_R, V_Y, V_B$ are phase voltages

$V_L = V_{RY}, V_{YB}, V_{RB}$ line voltages

→ for star connection; line current (I_L) = phase current

line voltage $V_{RY} = V_R - V_Y = V_R + (-V_Y)$





	$V_{RY} = \sqrt{V_R^2 + V_Y^2 + 2V_RV_Y \cos(V_R \wedge V_Y)}$ $= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph} \cdot V_{ph} \cos(60^\circ)}$ $= \sqrt{V_{ph}^2 + V_{ph}^2 + \cancel{2}V_{ph}^2 \times \frac{1}{\cancel{2}}}$ $= \sqrt{3V_{ph}^2}$ $\boxed{V_L = \sqrt{3}\, V_{ph}}$
102	A 220v , 1-Ø 50HZ AC supply is applied across series connections of R=10Ω, L=0.1H. Calculate impedance , Current ,Vr ,VL, Power Factor , Active power and Reactive power Given a 220V, 1-phase 50Hz AC supply applied across a series connection of a resistor (R) and an inductor (L), the following can be calculated: Impedance (Z): The impedance of a series R-L circuit is given by the equation: $$z = \sqrt{R^2 + (x_L - x_C)^2}$$ Where Xl is the inductive reactance, which is given by the equation: $$x_L=2 * \pi * f * L$$ And Xc is the capacitive reactance, which is zero in this case as there is no capacitor present. So, the impedance can be calculated as follows: $$z = \sqrt{R^2 + (x_L)^2}$$ $$z = \sqrt{10^2 + (2 * \pi * 0.1)^2}$$ $$= 10.5\ \Omega$$ Current (I): The current can be calculated using Ohm's law, which states that the current is equal to the voltage divided by the impedance: $$I = \frac{v}{z} = \frac{200v}{10 \cdot 5\Omega} = 21A$$ Voltage across the resistor (Vr): The voltage across the resistor can be calculated using Ohm's law, which states that the voltage is equal to the current times the resistance: Vr = I * R = 21A * 10 Ω = 210V Voltage across the inductor (Vl): The voltage across the inductor can be calculated using the equation: $V_L = I * x_L = 21A * 2 * \pi * 50 * 0.1 = 31.42V$ Power Factor (PF): The power factor is the ratio of active power (P) to apparent power (S), and is given by the equation:

$$PF = \frac{P}{S} = \frac{P}{\sqrt{P^2 + Q^2}}$$

Where P is the active power and Q is the reactive power.

Active Power (P): The active power can be calculated using the equation:

P = V * I * PF = 220V * 21A * PF

Reactive Power (Q): The reactive power can be calculated using the equation:

Q = √(S^2 - P^2) = √((220V * 21A)^2 - (220V * 21A * PF)^2)

$$Q = \sqrt{S^2 - P^2}$$

$$Q = \sqrt{((220V * 21A)^2 - (220V * 21A * P.F)^2)}$$

Note that the power factor is a dimensionless value between 0 and 1, so to calculate the active and reactive power, it is necessary to measure or calculate the power factor first.

103 A 10Ω resistor, 10-mH inductor, and 10-µF capacitor are connected in series with a 10-kHz voltage source. The rms current through the circuit is 0.20 A. Find the rms voltage drop across each of the 3 elements.

- Same current pass through each component since they are connected in series.
- Then the potential drop across each is given by

1. For the resistor,

$$V_R = IR = 0.20A \times 10^4\Omega$$
$$= \mathbf{2000V}$$

2 , For the inductor,

$$|V_L| = I\omega L = 2\pi f L \cdot I$$
$$= 2\pi \times (10^4 s^{-1}) \times (10 \times 10^{-3} H) \times 0.2A$$
$$= \mathbf{125.66V}\text{[leading the current by 90deg.]}$$

3, For the capacitor,

$$|V_c| = \frac{I}{\omega C} = \frac{I}{2\pi f C}$$
$$= \frac{0.2A}{2\pi \times 10^4 s^{-1} \times 10 \times 10^{-6} F}$$
$$= \mathbf{0.318V}\text{[lagging the current by 90 deg.]}$$

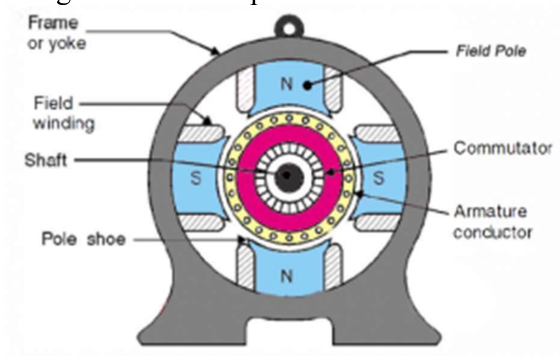
104	An alternating voltage is given by V = 141.4 sin 314tV. Find (1) frequency (ii) rms value (iii) maximum value (iv) average value and (v) instantaneous value at t=5ms Given: $V = 141.4 \sin 314t$ On complaining with, $V = Vm \sin 2\pi ft$ $Weget, 2\pi f = 314$ $\therefore f = 314/2\pi = 50Hz$ $Vm(\text{Peak value}) = 141.4V$ $\therefore Vrms = Vm/\vee 2 = 141.4V/\vee 2 = 100V$ $Vavg = 0.63Vm = 0.63 * 1414V = 89V$ At t= rms $V(t) = 141.4 \sin(314 * 3 * 10 - 3)$ $= 141.4 \sin(0.942 rod)$ $= 141.4 \sin(0.942 * 180)$ $= 141.4 \sin(53.97)\pi$ $= V(t) = 114.36V$
105	A series R-C circuit is connected across 220v,50Hz a.c supply draws a current of 20A. when the frequency of the supply is increased to 100Hz the current increases to 23.4082A. calculate the value of resistance and capacitance of the circuit. The given circuit is an R-C series circuit, which means that it consists of a resistor and a capacitor connected in series. Let's first find the reactance of the capacitor at 50 Hz and 100 Hz: Reactance of capacitor at 50 Hz, $$x_C = \frac{1}{2\pi fC} = \frac{1}{2\pi * 50 * C}$$ Reactance of capacitor at 100 Hz, $$x_C = \frac{1}{2\pi fC} = \frac{1}{2\pi * 100 * C}$$ Let's assume the value of the resistance in the circuit is R, and the value of the capacitance is C. At 50 Hz, the impedance of the circuit is given by: Z = $\sqrt{}(R^2 + Xc^2)$ At 50 Hz, the current drawn by the circuit is 20 A, so the impedance can be calculated as: Z = 220 V / 20 A = 11 Ω Substituting the value of Xc from above, we get:

	$11 = \sqrt{(R^2 + (1/(2\pi \times 50 \times C))^2)}$ Squaring both sides, we get: $R^2 + (1/(2\pi \times 50 \times C))^2 = 121$ Similarly, at 100 Hz, the impedance of the circuit is given by: Z = 220 V / 23.4082 A = 9.4 Ω Substituting the value of Xc from above, we get: $9.4 = \sqrt{(R^2 + (1/(2\pi \times 100 \times C))^2)}$ Squaring both sides, we get: $R^2 + (1/(2\pi \times 100 \times C))^2 = 88.36$ We now have two equations with two unknowns, R and C. Let's solve them simultaneously: $R^2 + (1/(2\pi \times 50 \times C))^2 = 121$ --- equation 1 $R^2 + (1/(2\pi \times 100 \times C))^2 = 88.36$ --- equation 2 Subtracting equation 2 from equation 1, we get: $(1/(2\pi \times 50 \times C))^2 - (1/(2\pi \times 100 \times C))^2 = 32.64$ Simplifying, we get: $1/(2\pi \times C) = 0.0001458$ Therefore, capacitance, $C = 1/(2\pi \times 0.0001458) = 1093.9$ microfarads Substituting the value of C in equation 1, we get: $R^2 + (1/(2\pi \times 50 \times 1093.9 \times 10^{-6}))^2 = 121$ Simplifying, we get: R = 11.43 ohms Therefore, the value of resistance in the circuit is approximately 11.43 ohms, and the value of capacitance is approximately 1093.9 microfarads.
S.NO	Unit-III (LAQ's)
106	Explain ta he construction of a DC machine with a neat diagram. A DC machine is an electro mechanical energy alteration device. The working principle of a DC machine is when electric current flows through a coil within a magnetic field, and then the magnetic force generates a torque that rotates the dc motor. The DC machines are classified into two types such as DC generator as well as DC motor. DC Machine

The main function of the DC generator is to convert mechanical power to DC electrical power, whereas a DC motor converts DC power to mechanical power. The AC motor is frequently used in industrial applications for altering electrical energy to mechanical energy. However, a DC motor is applicable where good speed regulation & an ample range of speeds are necessary like in electric-transaction systems.

Construction of DC Machine

The construction of the DC machine can be done using some of the essential parts like Yoke, Pole core & pole shoes, Pole coil & field coil, Armature core, Armature winding otherwise conductor, commutator, brushes & bearings. Some of the parts of the DC machine is discussed below.



Construction of DC Machine

Yoke

Another name of a yoke is the frame. The main function of the yoke in the machine is to offer mechanical support intended for poles and protects the entire machine from moisture, dust, etc. The materials used in the yoke are designed with cast iron, cast steel otherwise rolled steel.

Pole and Pole Core

The pole of the DC machine is an electromagnet and the field winding is winding among pole. Whenever field winding is energized then the pole gives magnetic flux. The materials used for this are cast steel, cast iron otherwise pole core. It can be built with the annealed steel laminations for reducing the power drop because of the eddy currents.

Pole Shoe

Pole shoe in the DC machine is an extensive part as well as to enlarge the region of the pole. Because of this region, flux can be spread out within the air-gap as well as extra flux can be passed through the air space toward armature. The materials used to build pole shoe is cast iron otherwise cast steed, and also used annealed steel lamination to reduce the loss of power because of eddy currents.

Field Windings

In this, the windings are wounded in the region of pole core & named as field coil. Whenever current is supplied through field winding than it electromagnetics the poles which generate required flux. The material used for field windings is copper.

Armature Core

Armature core includes a huge number of slots within its edge. The armature conductor is located in these slots. It provides the low-reluctance path toward the flux generated with field winding. The materials used in this core are permeability low-reluctance materials like iron otherwise cast. The lamination is used to decrease the loss because of the eddy current.

Armature Winding

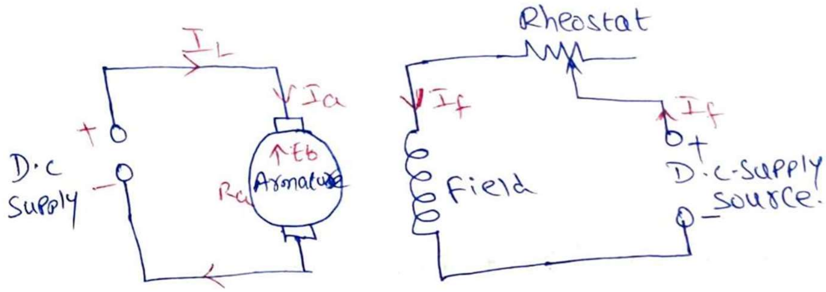
The armature winding can be formed by interconnecting the armature conductor. Whenever an armature winding is turned with the help of prime mover then the voltage, as well as magnetic flux, gets induced within it. This winding is allied to an exterior circuit. The materials used for this winding are conducting material like copper.

Commutator

The main function of the commutator in the DC machine is to collect the current from the armature conductor as well as supplies the current to the load using brushes. And also provides-

	directional torque for DC-motor. The commutator can be built with a huge number of segments in the edge form of hard drawn copper. The Segments in the commutator are protected from the thin mica layer. Brushes Brushes in the DC machine gather the current from the commutator and supply it to the exterior load. Brushes wear with time to inspect frequently. The materials used in brushes are graphite otherwise carbon which is in rectangular form.
107	Explain the different types of DC motors write its voltage equations. Explain The different types of D.C. motors and D.C. generators write it's voltage and current equations. s) :- Types of D.C motors 1. Separately excited d.c. motor 2. Series wound d.c. motor 3. Shunt wound d.c. motor 4. Compound wound d.c. motor. Relation Between currents and voltages of d c motor I_L = Load current amperes (A) I_{se} = Series field current in amperes (A) I_{sh} = Shunt field current in amperes (A) I_a = Armature current in amperes (A) R_{se} = Series field resistance in ohms (Ω) R_{sh} = Shunt field resistance in ohms (Ω) R_a = Armature resistance in ohms (Ω) V = Applied voltage in volts (V) E_b = Back e.m.f in volts (V)

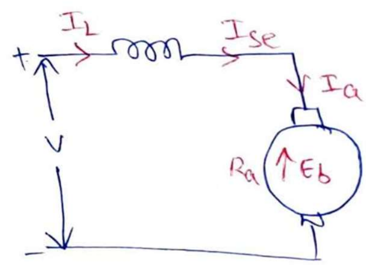
Seperately Excited D.C motor



$$I_L = I_a$$

$$E_b = V - I_a R_a$$

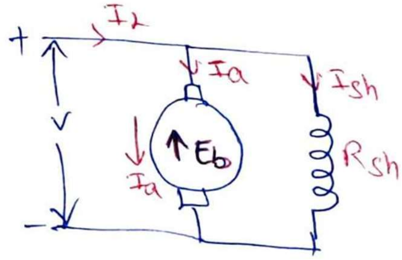
D.C. series motor :-



$$I_L = I_{se} = I_a$$

$$E_b = V - I_a(R_a + R_{se})$$

D.C. shunt motor :-



$$I_{sh} = \frac{V}{R_{sh}}$$

$$I_a = I_L - I_{sh}$$

$$E_b = V - I_a R_a$$

$$V = E_b + I_a R_a$$

108	Derive the EMF equation of D.C generator.

(3) (a) Derive EMF Equation of D.C. generator

(Ans): The Derivation of EMF Equation for D.C. generator has TWO Parts.

1. Induced EMF of one Conductor

2. Induced EMF of The generator.

Derivation for Induced EMF of one Armature Conductor

For one revolution of The Conductor,

Let,

ϕ = flux Produced by Each Pole in weber(wb)

and

P = number of Poles In The DC generator

$\therefore$ Total flux Produced by all The Poles $= \phi \times P$.

and

Time taken to Complete one revolution $= \frac{60}{N}$

where

N = Speed of The Armature Conductor In rpm.

Now, According to faraday's Law of Induction, The Induced emf of The Armature Conductor is denoted by 'e'

$$\therefore \; e = \frac{d\phi}{dt} \text{ and } e = \frac{\text{total flux}}{\text{time taken}} = \frac{\phi P}{\frac{60}{N}} = \phi P \frac{N}{60}$$

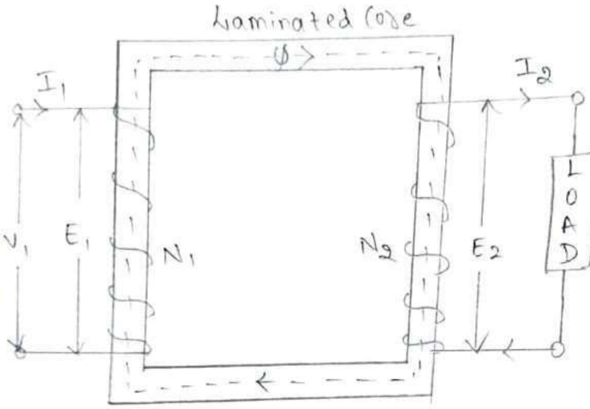
	Derivation for Induced Emf for D.C. generator Z = total numbers of Conductor A = number of Parallel Paths. Then $\frac{Z}{A}$ = number of Conductors Connected in series Induced emf of DC generator(E) = emf of one Conductor, number of Conductor Connected in series. Induced emf of DC generator is Lap Type winding. $\boxed{e = \phi P \frac{N}{60} \times \frac{Z}{A} \text{ volts}}$ In Lap winding $P = A$ In wave winding $A = 2$ Induced emf of DC generator is wave Type winding $\boxed{e = \frac{\phi P N}{60} \times \frac{Z}{2} = \frac{\phi P N Z}{120} \text{ volts}}$
109	A 6-pole lap wound armature has 1200 conductors and flux per pole of 0.02 Wb. Determine the generated EMF when running at 600 rpm.

	(3) (b) A 6 Pole Lap wound armature has 1200 Conductors and flux/Pole of 0.02 wb. Determine The generated EMF when running at 600 rpm. (Ans) : <u>given data</u> : No. of. Poles $P = 6$ No. of. Conductors $Z = 1200$ flux per Pole ϕ/Pole $= 0.02$ wb. speed $N = 600$ rpm. $e = ?$ $\boxed{(e) = \frac{\phi Z N}{60} \times \frac{P}{A}}$ Lap winding Type $\therefore P = A$ $\boxed{\begin{aligned}(e) &= \frac{0.02 \times 1200 \times 600}{60} \times \frac{6}{6} \\ &= 240 \text{ Volts}\end{aligned}}$
110	Derive the EMF equation of a single-phase transformer.

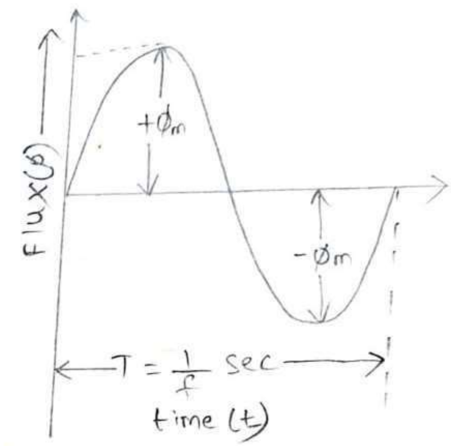
4(b)

Q EMF Equation of A Single Phase Transformer

(ANS):



(a) schematic diagram



(b) Vector diagram.

V_1 = Primary a.c. supply voltage in volts

I_1 = Primary current In ampere

E_1 = Induced e.m.f in Primary (volts)

N_1 = No. of turns in Primary winding

N_2 = No. of turns in Secondary winding

E_2 = Induced e.m.f in Secondary

I_2 = Secondary current in Amperes.

V_2 = Secondary voltage in volts

ϕ_m = maximum flux in core in webers

f = frequency of a.c. supply in hertz (Hz)

The magnetic flux is Increases from zero to maximum value 'ϕ_m' in one-forth of cycle in $\frac{1}{4}f$ second.

$\therefore$ Average rate of change of flux w.r.s.p.t Time (or) change In time (dt)

$$\boxed{\frac{d\phi}{dt} = \frac{\phi_m}{\frac{1}{4f}} = 4f\phi_m \text{ wb/s}} \text{ (or) volts}$$

$\therefore$ Average e.m.f/turn $= 4f\phi_m$

$$\boxed{\text{Form factor} = \frac{\text{R.m.s Value}}{\text{average value}} = 1.11}$$

The R.m.s value of e.m.f induced is obtained by multiplying The average value with form factor 1.11

$\therefore$ $\boxed{\text{Rms value of e.m.F/turn} = 1.11 \times \text{Average e.m.f/turn}}$

$= 1.11 \times 4f\phi_m = 4.44 f\phi_m$

R.m.s value of e.m.f induced in Primary winding

$E_1 =$ e.m.f induced/turn × No.of Primary turns

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

$$\boxed{= \underbrace{4.44\, f N_1 B_m A}_{\text{(volts)}} \quad \left(\because B_m = \frac{\phi_m}{A}\right)}$$

R.m.s value of e.m.f Induced in Secondary winding

$E_2 =$ e.m.f Induced/turn × No.of Secondary turns

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

$$\boxed{= 4.44\, f N_1 B_m A \text{ (volts)}}$$

112	Differentiate Ideal and Practical Transformers.

	Q- Difference between Ideal and Practical transformer? (ANS) <table><tr><th>Ideal Transformer</th><th>Practical / Real Transformer</th></tr><tr><td>The primary and secondary winding resistance and the Power / energy lost in them are considered to be zero</td><td>The primary and secondary windings offer some resistance and there is power lost in them</td></tr><tr><td>Same amount of flux links both primary and secondary side of the transformer (as in, there is no leakage flux).</td><td>There is a definite leakage flux inside the transformer and the flux connecting the secondary side and the primary side is not the same</td></tr><tr><td>Efficiency is 100%.</td><td>Efficiency is lower than 100%.</td></tr><tr><td>Permeability of core is considered infinite</td><td>Permeability of core is finite</td></tr><tr><td>There are no power losses (for example, eddy current losses or hysteresis losses)</td><td>There are power losses</td></tr></table>
113	Explain the different types of DC generator write its voltage equations.

Types Of D.C Generators:-

(a) Separately excited D.C Generators and

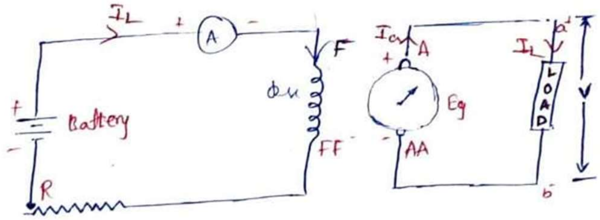
(b) Self-excited D.C Generators:-

i) Series Wound Generator

ii) Shunt wound Generator

iii) Compound wound Generator

a.) Separately Excited D.C Generator:-



$E_g = V + I_a R_a$

$I_{Line} = I_{Field}$

$I_a = I_{Load}$

V = Terminal voltage - volts

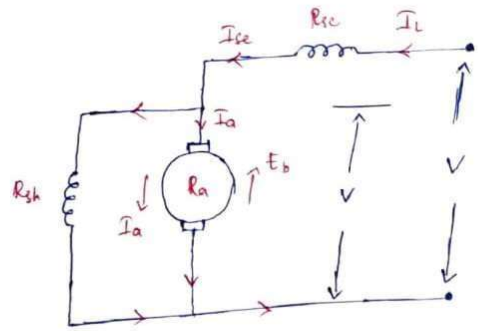
I_a = armature current - A

R_a = armature resistance Ω

E_g = generated emf - volts

R_{se} = Series field resistance.

Short Shunt D.C Compound Motor :-

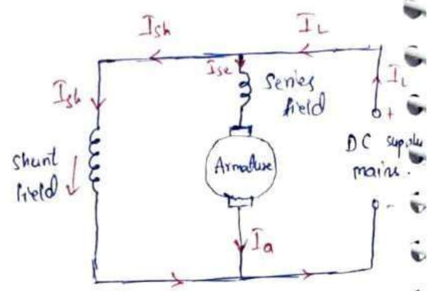


$$I_{sh} = \frac{V}{R_{sh}}$$

$\Rightarrow$ $I_a = I_L - I_{sh}$.

$\Rightarrow$ $E_b = V - I_a R_a - I_{se} R_{se}$ - brush drop

Long Shunt D.C Compound Motor :-



$$I_{sh} = \frac{V}{R_{sh}}$$

$$I_a = I_L - I_{sh}$$

$$E_b = V - I_a(R_a + R_{se}) - \text{brush drop}$$

RELATION BETWEEN CURRENT AND VOLTAGES OF D.C

GENERATORS :-

I_a = Armature current in ampere (A)

I_{sh} = Shunt field current in ampere (A)

I_{se} = series field current in ampere (A)

I_L = Load current in ampere (A)

R_a = Armature resistance in ohms (Ω)

R_{sh} = Shunt field resistance in ohms (Ω)

R_{se} = series field resistance in ohms (Ω)

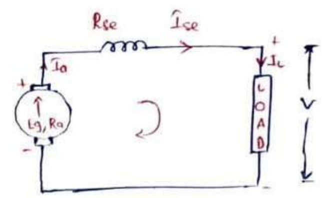
V = Terminal voltage in volts (V)

E_g = e.m.f generated in volts (V)

D.C Series Generator :-

$$E_g = V + I_a R_a + I_{se} R_{se} \text{ volt}$$

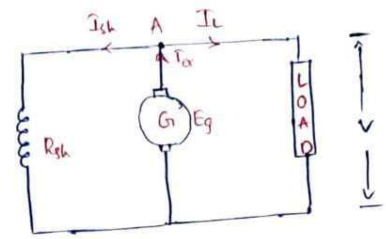
$$I_a = I_{se} = I_L$$



D.C Shunt Generator :-

$$I_{sh} = \frac{V}{R_{sh}}$$

$$I_a = I_L + I_{sh}$$



$$E_g = V + I_a R_a + \text{brush contact drop}$$

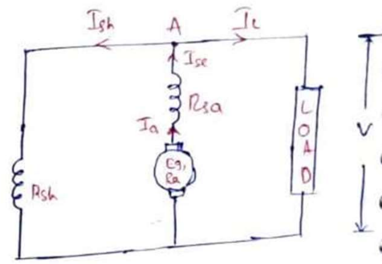
D.C Long Shunt Compound Generator:-

$$I_a = I_{se}$$

$$I_{sh} = \frac{V}{R_{sh}}$$

$$I_a = I_L + I_{sh}$$

$$E_g = V + I_a (R_a + R_{se}) + \text{brush contact drop}$$



D.C short shunt compound Generator:-

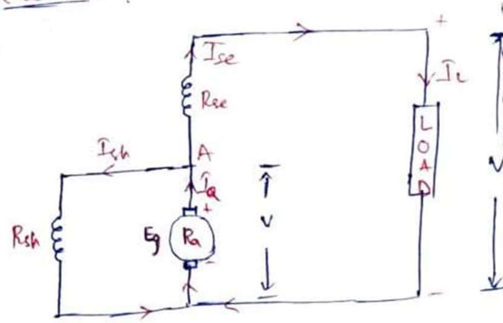
$$I_{se} = I_L$$

$$v = V + I_{se} R_{se}$$

$$I_{sh} = \frac{V}{R_{sh}}$$

$$I_a = I_L + I_{sh}$$

$$E_g = V + I_a R_a + \text{brush contact drop}$$



114 A transformer is rated at 100 kVA.at full load copper loss is 1200W and iron loss is 960W.Calculate

The efficiency at full load, UPF

Efficiency at half load ,0.8pf

The efficiency at 75% full load,0.7pf lag

Load kVA at which maximum efficiency occurs.

We know that the transformer's rating is 100 kVA, and its losses are as follows:

Copper loss = 1200 W

Iron loss = 960 W

Let's use these values to calculate the transformer's efficiency at full load and unity power factor (UPF):

At full load, the apparent power is equal to the rating of the transformer, which is 100 kVA. Therefore, the real power is:

P = 100 kVA x 1 = 100 kW

The total losses are:

Losses = Copper loss + Iron loss = 1200 W + 960 W = 2160 W

The efficiency is given by:

$$Efficiency = \frac{(\text{Real power output})}{(\text{Real power output} + \text{Losses})}$$

Substituting the values, we get:

$$Efficiency = \frac{100\ \text{kW}}{(100\ \text{kW} + 2160\ \text{W})}$$

Efficiency at full load, UPF =

$$Efficiency = \frac{100\ \text{kW}}{(100\ \text{kW} + 2160\ \text{W})}$$

= 97.81%

Now let's calculate the transformer's efficiency at half load and 0.8 power factor:

At half load, the apparent power is 50 kVA. The real power can be calculated using the power factor:

P = 50 kVA x 0.8 = 40 kW

The total losses are the same as before:

Losses = 1200 W + 960 W = 2160 W

The efficiency is:

$$Efficiency = \frac{(\text{Real power output})}{(\text{Real power output} + \text{Losses})}$$

Substituting the values, we get:

Efficiency at half load, 0.8pf =

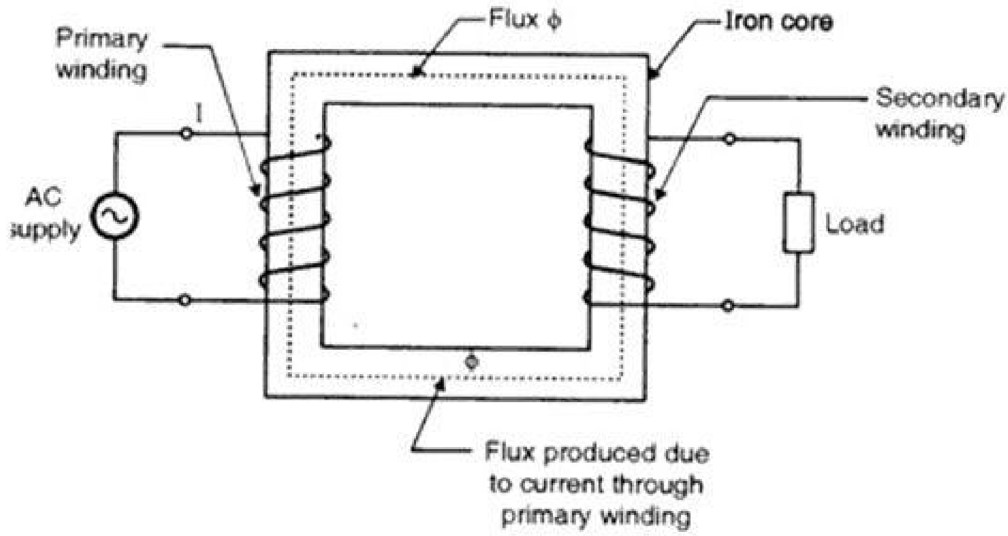
$$Efficiency = \frac{(40\ \text{kW})}{(40\ \text{kW} + 2160\ \text{W})}$$

= 94.34%

Now let's calculate the transformer's efficiency at 75% full load and 0.7 power factor lagging:

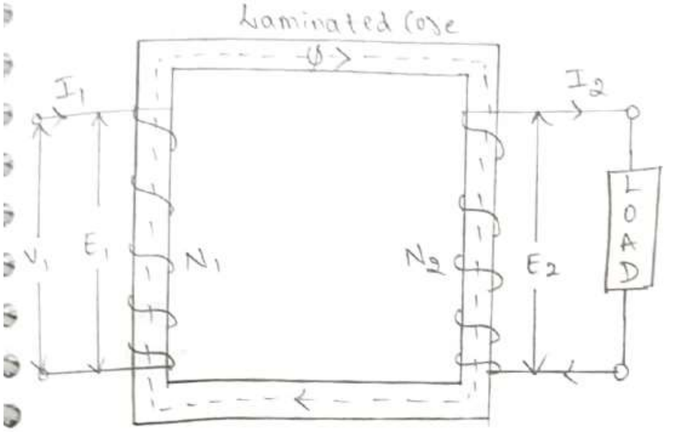
	At 75% full load, the apparent power is 75 kVA. The real power can be calculated using the power factor: P = 75 kVA x 0.7 cos (-0.84) = 45.12 kW (Here, we have used the phasor method for power calculation) The total losses are the same as before: Losses = 1200 W + 960 W = 2160 W The efficiency is: $$Efficiency = \frac{(\text{Real power output})}{(\text{Real power output } + \text{ Losses})}$$ Substituting the values, we get: Efficiency at 75% full load, 0.7pf lag $$Efficiency = \frac{(45.12\text{ kW})}{(45.12\text{ kW } + \text{ 2160 W})}$$ = 95.47% Now let's find the load kVA at which maximum efficiency occurs. The efficiency of the transformer can be expressed as: Efficiency = (Real power output) / (Apparent power input) = P / S where S is the apparent power input. The real power output can be expressed as: P = S - Losses Substituting this expression in the equation for efficiency, we get: Efficiency = (S - Losses) / S = 1 - (Losses / S) We can see that the efficiency is a function of the losses and the apparent power input. Therefore, the efficiency is maximum when the losses are minimum, which occurs at no-load. At no-load, the transformer's losses are equal to the iron losses, which are given as 960 W. Therefore, the apparent power input is equal to the iron losses divided by the power factor at no-load. Let's assume that the power factor at no-load is unity: Apparent power input at no-load = Iron losses / Power factor at no-load = 960 W
115	Explain the significance of back EMF. Back EMF (Electromotive Force) is a voltage that is generated in an inductive load (such as a motor or transformer) when the current passing through it changes. It is called "back" EMF because its direction is opposite to the applied voltage that caused the current to flow in the first place. The back EMF is significant for several reasons:

	Protection of the power supply: The back EMF opposes the applied voltage and reduces the current flowing through the load. This helps to protect the power supply from overloading and damage. For example, in a DC motor, the back EMF is generated as the motor rotates, and this reduces the current flowing from the power supply, thus protecting it from excessive current draw. Control of the load: The back EMF can be used to control the load, for example in a DC motor, by varying the applied voltage. As the motor speed increases, the back EMF also increases, which reduces the current flowing through the motor, and hence its torque. This allows the motor to be controlled to maintain a desired speed or torque. Efficiency: The back EMF reduces the power consumed by the load, by reducing the current flowing through it. This improves the efficiency of the load, for example in a motor, by reducing the losses in the motor windings and improving the overall efficiency. Indication of motor health: By measuring the back EMF in a motor, it is possible to determine the motor's health, as changes in the back EMF can indicate problems such as bearing wear or winding faults. the back EMF is a significant and useful phenomenon in electrical systems, as it provides protection to power supplies, allows for control of loads, improves efficiency, and can be used to diagnose issues with the system.
116	State with the reason the area of application of various DC generators used. DC generators are widely used in a variety of applications where a stable and reliable DC voltage supply is required. The different types of DC generators are designed for specific applications based on factors such as voltage regulation, power output, and operating conditions. Here are some of the common types of DC generators and their areas of application: Series-wound DC generators: These generators have a high output voltage and are often used in applications that require high starting torque, such as in cranes, hoists, and elevators. They are also used in electric traction systems and in welding machines. Shunt-wound DC generators: These generators have good voltage regulation and are often used in applications where a stable DC voltage supply is required, such as in battery charging, electroplating, and in electric motors. Compound-wound DC generators: These generators have both series and shunt windings, and can provide good starting torque as well as stable voltage regulation. They are often used in applications that require a combination of both high starting torque and stable voltage regulation, such as in rolling mills and machine tools. Permanent magnet DC generators: These generators have a simple construction and are often used in small portable devices that require a low power supply, such as in small motors, electric vehicles, and small wind turbines. Separately-excited DC generators: These generators have an independent field winding, which allows for greater control over the output voltage. They are often used in applications that require precise control of the output voltage, such as in laboratory equipment and test systems. In summary, the choice of DC generator for a particular application depends on the specific requirements of the application, such as voltage regulation, power output, and operating conditions. By selecting the appropriate type of DC generator, it is possible to achieve reliable and efficient operation of the electrical system.
117	Explain the constructional details and principle of operation of 1-Φ transformer.

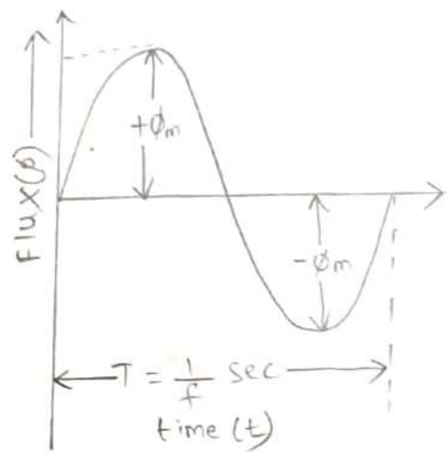
	A 1-Φ transformer, also known as a single-phase transformer, is an electrical device that is used to transfer electrical energy from one circuit to another through electromagnetic induction. It is called a single-phase transformer because it operates with a single alternating current (AC) input and output.  Constructional Details: A 1-Φ transformer consists of two coils of insulated wire wound on a laminated iron core. The coils are wound around the core, with one coil connected to the AC input voltage, known as the primary winding, and the other coil connected to the output circuit, known as the secondary winding. The core is made of thin sheets of iron or steel that are insulated from each other to reduce eddy current losses. Principle of Operation: The principle of operation of a 1-Φ transformer is based on Faraday's law of electromagnetic induction. When an AC voltage is applied to the primary winding of the transformer, it creates a changing magnetic field around the coil. This changing magnetic field induces an electromotive force (EMF) in the secondary winding, which results in a current flow in the secondary circuit. The voltage induced in the secondary winding is proportional to the turns ratio of the two coils. Therefore, by changing the number of turns on the primary and secondary coils, it is possible to step-up or step-down the voltage in the secondary circuit. The key features of a 1-Φ transformer are: 1. The voltage on the primary and secondary windings is alternating in nature. 2. The primary and secondary windings are electrically isolated from each other, which makes it possible to transfer energy from one circuit to another without any physical connection. 3. The transformer is highly efficient, with energy losses due to resistance and magnetic hysteresis in the core being minimized by the use of laminated iron or steel cores. a 1-Φ transformer is a simple and efficient device for transferring electrical energy from one circuit to another. Its constructional details are relatively simple, and it operates on the principle of electromagnetic induction, which makes it ideal for a wide range of applications where a stable and reliable voltage supply is required.
118	Derive the EMF equation of 1-Φ transformer.

Q EMF Equation OF A Single Phase Transformer

(ANS):



(a) schematic diagram



(b) Vector diagram.

V_1 = Primary a.c. supply voltage in volts

I_1 = Primary current in ampere

E_1 = Induced e.m.f in Primary (volts)

N_1 = No. of turns in Primary winding

N_2 = No. of turns in secondary winding

E_2 = Induced e.m.f in secondary

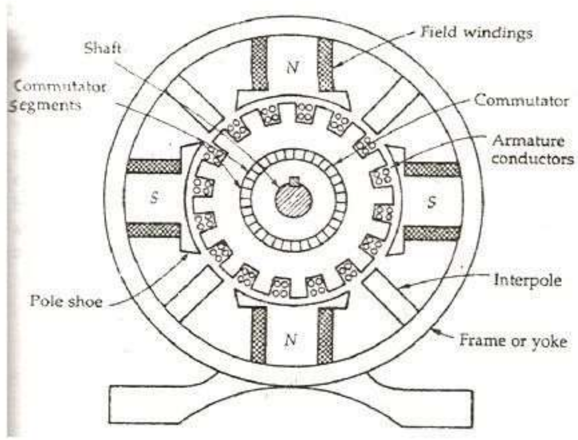
I_2 = secondary current in Amperes.

V_2 = secondary voltage in volts

ϕ_m = maximum flux in core in webers

f = frequency of a.c. supply in hertz (Hz)

	The magnetic flux is Increases from zero to maximum value 'ϕ_m' in one-forth of cycle in $\frac{1}{4}f$ second. ∴ Average rate of change of flux w.r.s.p.t Time (or) change In time (dt) $$\boxed{\frac{d\phi}{dt} = \frac{\phi_m}{\frac{1}{4f}} = 4f\phi_m \ wb/s} \text{ (or) volts}$$ ∴ Average e.m.f/turn $= 4f\phi_m$ $$\boxed{\text{Form factor} = \frac{\text{R.m.s value}}{\text{average value}} = 1.11}$$ The R.m.s value of e.m.f induced is obtained by multiplying The average value with form factor 1.11 ∴ $\boxed{\text{Rms value of e.m.F/turn} = 1.11 \times \text{Average e.m.f/turn}}$ $= 1.11 \times 4f\phi_m = 4.44 f\phi_m$ R.m.s value of e.m.f induced in Primary winding E_1 = e.m.f induced/turn × No. of Primary turns $= 4.44f\phi_m \times N_1 = 4.44f\phi_m N_1$ $$\boxed{= 4.44\, f N_1 B_m A \ (\text{volts}) \quad \left(\because B_m = \frac{\phi_m}{A}\right)}$$ R.m.s value of e.m.f Induced in Secondary winding E_2 = e.m.f Induced/turn × No. of Secondary turns $= 4.44 f\phi_m \times N_2 = 4.44 f\phi_m N_2$ $$\boxed{= 4.44 f N_1 B_m A \ (\text{volts})}$$
119	Explain the working principle of DC generator. With neat diagram.



A DC generator, also known as a dynamo, is an electrical machine that converts mechanical energy into electrical energy using the principle of electromagnetic induction. It generates a direct current (DC) output, which can be used to power various electrical devices. Let us understand the working principle of a DC generator with the help of a neat diagram.

Working Principle:

The basic working principle of a DC generator can be explained using the following steps:

Step 1: Conversion of Mechanical Energy to Rotational Motion

The mechanical energy is provided to the DC generator by an external prime mover such as a steam turbine or a diesel engine. The prime mover drives the generator shaft, which rotates the armature of the generator.

Step 2: Generation of Electromagnetic Induction

The armature of the DC generator consists of a set of coils wound on a laminated iron core. The core is used to reduce eddy current losses and hysteresis losses. The armature is mounted on the shaft and rotates within a magnetic field produced by the field poles.

The magnetic field is produced by the field poles, which are stationary and are located outside the armature. The field poles are electromagnets that produce a magnetic field when a DC current is passed through them.

As the armature rotates, the coils on the armature cut across the magnetic field produced by the field poles. This creates a voltage in the coils, according to Faraday's law of electromagnetic induction. The magnitude and direction of the induced voltage depend on the speed of the armature rotation, the number of turns in the coil, and the strength of the magnetic field.

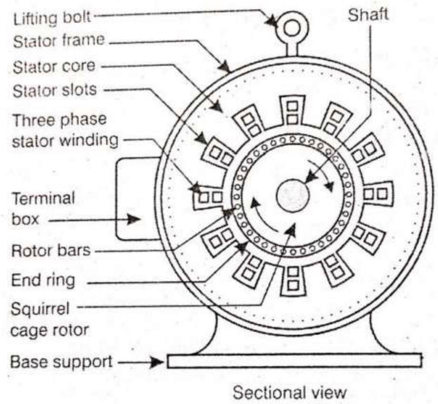
Step 3: Commutation

The DC voltage generated in the coils is alternating in nature, which means it changes direction every half-cycle. To convert this AC voltage into DC voltage, the generator uses a commutator. The commutator is a split-ring device that rotates with the armature and connects the coils to the external circuit.

The commutator consists of a set of copper segments, which are insulated from each other by mica sheets. The segments are connected to the ends of the coil, and they are arranged in such a way that the polarity of the voltage across the coils is maintained. The brushes are made of carbon or graphite and are in contact with the commutator segments.

	As the armature rotates, the commutator segments pass under the brushes. When the coil is in the position where the brushes are in contact with the commutator segments, the current flows in one direction. When the coil moves to the position where the brushes are no longer in contact with the commutator segments, the current stops flowing. The commutator segments and the brushes ensure that the voltage generated in the coils is rectified and results in a DC output voltage. Step 4: Regulation of Voltage The voltage produced by the DC generator depends on the speed of the armature rotation and the strength of the magnetic field. To regulate the output voltage, the generator uses a voltage regulator. The voltage regulator is an electronic device that maintains the output voltage at a constant level by controlling the current flow in the field poles. In summary, a DC generator converts mechanical energy into electrical energy using the principle of electromagnetic induction. It consists of an armature, field poles, a commutator, and a voltage regulator. As the armature rotates, the coils on the armature cut across the magnetic field produced by the field poles, which creates a voltage in the coils. The commutator rectifies the AC voltage into DC voltage, and the voltage regulator maintains the output voltage at a constant level.
120	8-pole lap wound DC generator has120 slots having 4 conductors per slot. If each conductor can carry 250A and if flux/pole is 0.05wb calculate the speed of a generator for giving 240V on open circuit. If the voltage drops to 220V on full load, find the rated output of the machine.

	Answer : Given that, A lap wound D.C generator No. of poles, $P = 8$ Since it is a lap wound generator. Therefore No. of parallel paths in armature, $A = P = 8$ No. of slots = 120 No. of conductors/slot = 4 Current across each condcutor, $I = 250$ A Flux, $\phi = 0.05$ Wb Generated voltage, $E_g = 240$ V Full load voltage, $V = 220$ V To determine, (i) Speed of the generator, $N = ?$ (ii) Rated output of the machine, $P = ?$ **(i) Speed of Generator** The EMF equation of a DC generator is given as, $E_g = \frac{P\phi ZN}{60A}$ Since, we know that, The total number of conductors, Z = number of slots × number of conductors/slot $\therefore \quad Z = 120 \times 4 = 480$ Substitute given values in equation (1), we get, $\Rightarrow \quad 240 = \frac{8 \times 0.05 \times 480 \times N}{60 \times 8}$ $\Rightarrow \quad N = \frac{240 \times 60}{480 \times 0.05} = 600$ rpm $\therefore$ Speed, $N = 600$ rpm **(ii) Rated Output of the Machine** The total current at full-load, I = Current in each parallel path × No. of parallel paths = 250 × 8 = 2000 A [$\because$ No. of parallel paths = 8] The rated of the machine, $P = V \times I = 220 \times 2000$ = 440000 W = 440 kW
S.NO	Unit-IV (LAQ's)
121	Explain working principle of three phase induction motor with neat diagram. The working principle of a three-phase induction motor is based on the phenomenon of electromagnetic induction, as described by Faraday's law. In a three-phase induction motor, an alternating current (AC) is supplied to the stator winding, which creates a rotating magnetic field. This rotating magnetic field induces a current in the rotor, which in turn creates a magnetic field. The interaction between the magnetic fields of the stator and rotor causes the rotor to rotate, thus generating mechanical energy. Here is a diagram that illustrates the working principle of a three-phase induction motor:



Stator: The stator is the stationary part of the motor and consists of a series of laminated steel cores with windings of copper wire.

Rotor: The rotor is the rotating part of the motor and is usually made of a cast iron core with windings of copper wire, or it may be a squirrel cage rotor made of copper bars.

Stator winding: The stator winding is connected to a three-phase AC power supply and creates a rotating magnetic field in the air gap between the stator and rotor.

Rotor winding: The rotor winding is induced with an electromotive force (EMF) by the rotating magnetic field of the stator and creates its own magnetic field.

Air gap: The air gap between the stator and rotor is where the rotating magnetic field of the stator induces an EMF in the rotor winding.

Slip: The slip is the difference between the synchronous speed of the magnetic field and the actual speed of the rotor.

Torque: The interaction between the magnetic fields of the stator and rotor creates a torque that causes the rotor to rotate, thus generating mechanical energy.

In conclusion, the working principle of a three-phase induction motor is based on the interaction between the rotating magnetic field of the stator and the induced magnetic field of the rotor, which results in the generation of mechanical energy and rotation of the rotor.

122 A4-pole,50Hz squirrel cage induction motor runs on load at shaft speed of 1440 rpm. Calculate

i) Percentage slip

ii) The frequency of the induced current in the rotor

Given:

- Shaft speed = 1440 rpm
- Frequency of supply = 50Hz

i) Percentage Slip: The synchronous speed of a 4-pole induction motor is given by the formula:

Ns = (120 * f) / p

where ns is the synchronous speed (in RPM), f is the frequency (in Hz), and p is the number of poles.

So, for the given motor, the synchronous speed is:

ns = (120 * 50) / 4 = 1500 RPM

The slip of an induction motor is defined as the difference between the synchronous speed and the actual shaft speed, expressed as a percentage of synchronous speed. It is given by the

formula: s = (Ns - N) / Ns * 100%

where s is the percentage slip, n is the actual shaft speed (in RPM), and

Ns is the synchronous speed (in RPM).

So, for the given motor, the percentage slip is:

s = (1500 - 1440) / 1500 * 100% = 4%

ii) Frequency of the Induced Current in the Rotor: The frequency of the induced current in the rotor is equal to the slip frequency, which is given by the formula:

fr = s * f

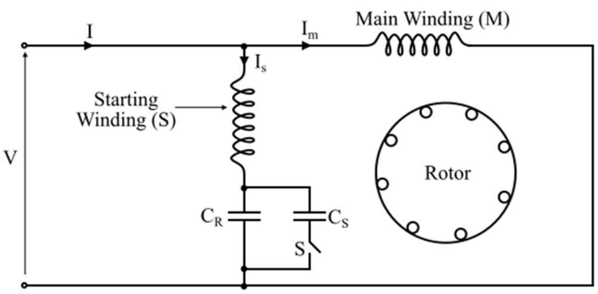
where f_r is the frequency of the induced current in the rotor (in Hz), s is the percentage slip, and f is the frequency of the supply (in Hz).

So, for the given motor, the frequency of the induced current in the rotor is:

fr = 4% * 50Hz = 2Hz

123 Describe the construction and working of capacitor start and capacitor run induction motor. And list out its applications.

The capacitor-start capacitor-run motor is a type of single-phase induction motor. The capacitor-start capacitor-run induction motor is also known as two value capacitor motor. The schematic diagram of a capacitor-start capacitor run induction motor is shown below.



The capacitor-start capacitor-run induction motor consists of a squirrel cage rotor and its stator has two windings, viz. the starting or auxiliary winding and the main or running winding. The two windings are displaced by an angle of 90° in the space.

This motor uses two capacitors − the starting capacitor (CS) and the running capacitor (CR). The two capacitors are connected in parallel at the instant of starting.

In order to obtain a high starting torque, a large starting current is required. For this, the capacitive reactance in the starting winding should be low.

Since the reactance of the starting capacitor is given by,

$$X_S = \frac{1}{\omega C_S}$$

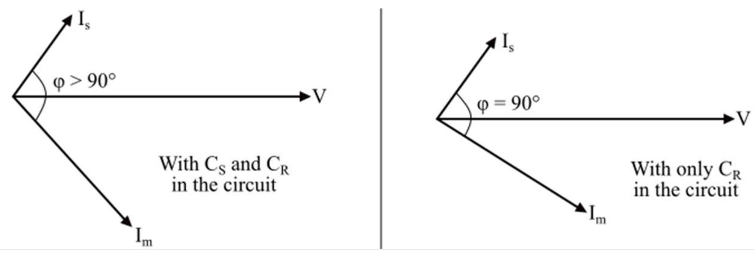
Hence, for XS to be small, the value of starting capacitor (CS) should be large. The starting capacitor CS is a short-time rated electrolytic capacitor. During the normal operation of the motor, the rated line current should be smaller than the starting current. Therefore, the capacitive reactance of the running capacitor should be high and is given by,

$$X_R = \frac{1}{\omega C_R}$$

Hence, for XR to be high, the value of the running capacitor (CR) should be small. The running capacitor is a long-time rated capacitor and is usually of oil-filled paper construction.

As the motor attains the normal speed, the starting capacitor (CS) is disconnected from the motor circuit by a centrifugal switch (S) and the running capacitor (CR) remains permanently connected in the circuit. Since one capacitor (CS) is used only at starting and the other capacitor (CR) for continuous running, the motor is known as capacitor-start capacitor-run motor.

The phasor diagram of the capacitor-start capacitor-run motor is shown below. At starting both the capacitors are in the circuit, therefore, the phase angle φ is greater than 90°. When the starting capacitor (CS) is disconnected from the circuit, then the phase angle becomes 90° electrical.



Characteristics of Capacitor-Start Capacitor-Run Induction Motor

Following are the primary characteristics of a capacitor-start capacitor-run induction motor −

- These motors have quiet and smooth-running operation.
- They have high efficiency.
- These motors produce constant torque and not a pulsating torque.
- Because of the constant torque, the motor is vibration free.

Applications of Capacitor-Start Capacitor-Run Motor

The capacitor-start capacitor-run motors are used for driving the loads of high inertia requiring frequent starts where the pull-out torque and the efficiency required are high such as −

- Air compressors
- Refrigerators
- Pumping equipment
- Hospitals, studios and at other places where silence is important, etc.

124 Describe working principle and construction details of synchronous generator with neat diagrams.

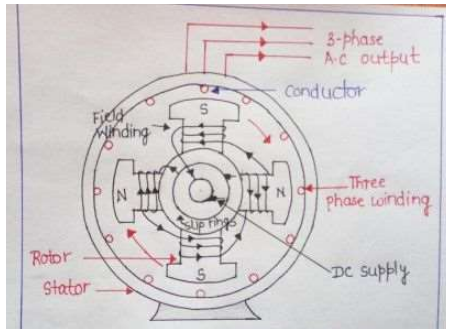
Working principle: The working principle of a synchronous generator is based on Faraday's law of electromagnetic induction, which states that a changing magnetic field within a coil of wire induces a voltage across the coil. In a synchronous generator, this principle is utilized by rotating a magnetic field within a set of stationary coils of wire, thereby inducing an alternating current in the coils.

Construction: The construction of a synchronous generator typically consists of the following components:

1. Rotor: The rotor is the rotating component of the generator and is typically made of a solid steel core with field windings that create a magnetic field. The rotor rotates within the stator, which is the stationary component of the generator.
2. Stator: The stator is the stationary component of the generator and consists of a set of stationary coils of wire that are positioned around the rotor. The stator windings are connected in a closed loop and are wound in slots along the inner circumference of the stator.
3. Excitation system: The excitation system provides the magnetic field for the rotor. It typically consists of a direct current (DC) generator or rectifier that converts AC power from the generator into DC power, which is then used to excite the rotor windings.
4. Bearings: The generator rotor is supported by bearings, which allow it to rotate freely.

5. Voltage regulator: The voltage regulator controls the excitation system, ensuring that the voltage produced by the generator remains constant.
6. Slip rings and brushes: The slip rings and brushes allow the DC power from the excitation system to be supplied to the rotor windings.

The diagram below provides a simplified representation of the construction of a synchronous generator:



In conclusion, the synchronous generator is an important component of the electrical power system, converting mechanical energy into electrical energy through the principle of electromagnetic induction. The construction and working of the synchronous generator are critical to its efficiency and effectiveness in producing a constant and stable AC power supply.

125 Derive the EMF equation of an alternator.

8.10 E.M.F. Equation of an Alternator

Let

ϕ = Flux per pole, in Wb

P = Number of poles

N_s = Synchronous speed in r.p.m.

f = Frequency of induced e.m.f. in Hz

Z = Total number of conductors

Z_{ph} = Conductors per phase connected in series

$\therefore \quad Z_{ph} = \frac{Z}{3}$ as number of phases = 3.

Consider a single conductor placed in a slot.

The average value of e.m.f. induced in a conductor

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

For one revolution of a conductor,

$$e_{avg} \text{ per conductor} = \frac{\text{Flux cut in one revolution}}{\text{Time taken for one revolution}}$$

Total flux cut in one revolution is $\phi \times P$.

Time taken for one revolution is $\frac{60}{N_s}$ seconds, as speed is N_s r.p.m.

$$\therefore \quad e_{avg} \text{ per conductor} = \frac{\phi P}{\left(\frac{60}{N_s}\right)}$$

$$= \phi \frac{PN_s}{60} \qquad \ldots(1)$$

But

$$f = \frac{PN_s}{120}$$

$$\frac{PN_s}{60} = 2f$$

Substituting in (1),

$$e_{avg} \text{ per conductor} = 2f\,\phi \quad \text{volts}$$

$f = \frac{\phi N_s}{60} \times 2f$

Assume full pitch winding for simplicity i.e. this conductor is connected to a conductor which is 180° electrical apart. So these two e.m.f.s will try to set up a current in the same direction i.e. the two e.m.f.s are helping each other and hence resultant e.m.f. per turn will be twice the e.m.f. induced in a conductor.

$$\therefore \quad \text{e.m.f. per turn} = 2 \times (\text{e.m.f. per conductor})$$

$$= 2 \times (2f\,\phi)$$

$$= 4\,f\,\phi \quad \text{volts}$$

$$K_f = \frac{\text{R.M.S.}}{\text{Average}} = 1.11 \qquad \text{for sinusoidal}$$

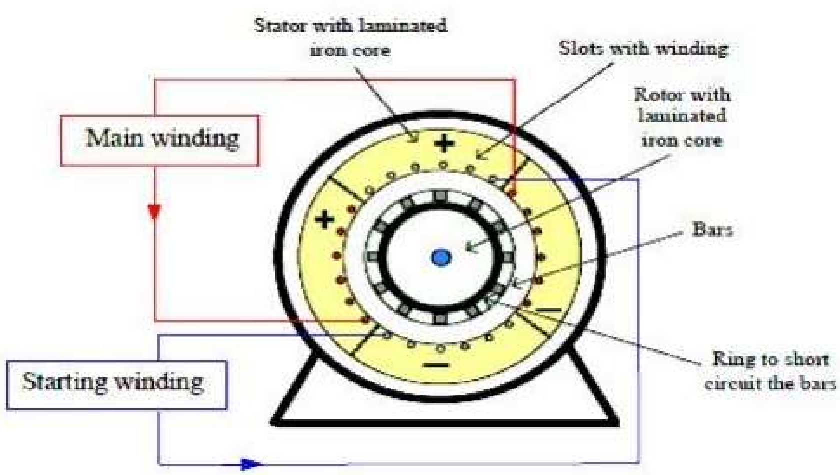
$$\therefore \quad \text{R.M.S. value of } E_{ph} = K_f \times \text{Average value}$$

$$E_{ph} = 1.11 \times 4\,f\,\phi\,T_{ph}$$

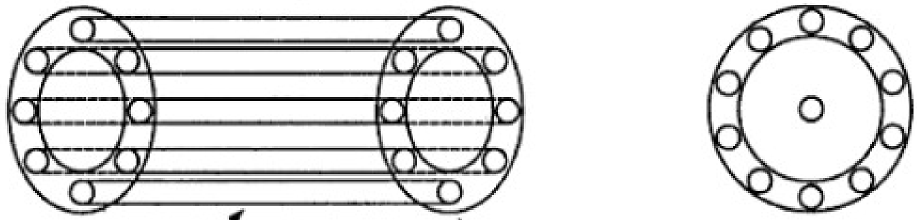
$$\boxed{E_{ph} = 4.44\,f\,\phi\,T_{ph} \quad \text{volts}}$$

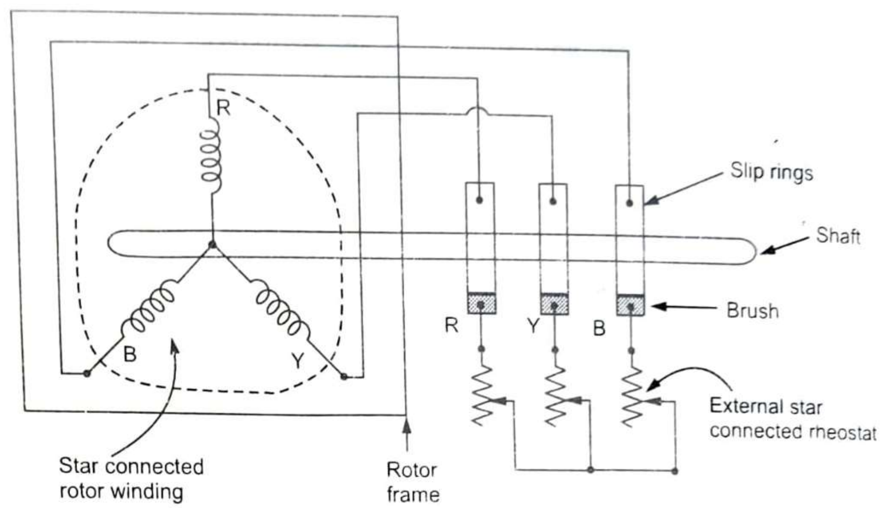
126 Explain the construction details and principle of operation of single-phase induction motor.

A single-phase induction motor is a type of AC motor that operates on a single-phase power supply. It is commonly used in applications where a simple, reliable, and efficient motor is required, such as in small household appliances and power tools.



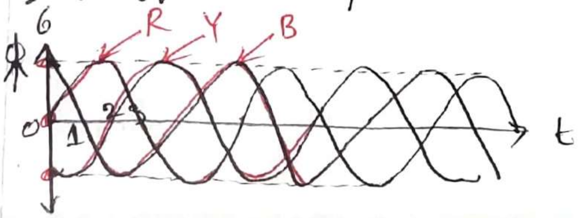
	Construction: The construction of a single-phase induction motor typically consists of the following components: 1. Stator: The stator is the stationary component of the motor and consists of a set of coils that are wound around a core. When supplied with AC power, these coils produce a magnetic field that rotates around the axis of the motor. 2. Rotor: The rotor is the rotating component of the motor and is typically made of a solid core or a laminated core with short-circuited windings. The rotor is positioned within the stator and is separated from the stator windings by a small air gap. 3. Bearings: The rotor is supported by bearings, which allow it to rotate freely. 4. Fan: A fan is often mounted on the shaft of the rotor to provide cooling and to increase the life of the motor. Principle of operation: The principle of operation of a single-phase induction motor is based on the phenomenon of electromagnetic induction. When an AC voltage is applied to the stator windings, a rotating magnetic field is produced. This rotating magnetic field induces an electromotive force (EMF) in the rotor, which in turn generates a current in the rotor windings. The interaction between the magnetic field produced by the stator and the current generated in the rotor creates a torque on the rotor, causing it to rotate. The rotor rotates in the same direction as the rotating magnetic field, and the speed of rotation is proportional to the frequency of the AC voltage applied to the stator. The current in the rotor is often referred to as "induced current" or "induced rotor current." It is this current that generates the torque and causes the rotor to rotate. In conclusion, the single-phase induction motor is a simple and efficient motor that operates on the principle of electromagnetic induction. Its construction consists of a stator with windings that produce a rotating magnetic field and a rotor with windings that generate a current in response to the magnetic field, resulting in a torque that drives the rotor to rotate.
127	Explain the construction details and principle of operation of squirrel cage induction motor. A Squirrel Cage Induction Motor is a type of asynchronous AC motor that is widely used in industrial and household applications due to its simplicity, reliability, and low cost. Principle of Operation: The basic operating principle of the Squirrel Cage Induction Motor is based on the interaction between the magnetic field created by the stator and the induced currents in the rotor. The stator windings are supplied with a three-phase AC current, which creates a rotating magnetic field that rotates at the same speed as the supply frequency. When this magnetic field passes through the rotor, it induces a current in the rotor bars, which in turn creates a magnetic field that opposes the field of the stator. This interaction between the magnetic fields produces a torque that causes the rotor to rotate, thereby driving the motor's load. Construction: Stator: The stator is the stationary part of the motor that houses the windings. It is typically made of a laminated steel core with a rectangular cross-section and is placed inside a metal frame. The stator windings are arranged in slots around the circumference of the core, and the windings are connected in a specific pattern to create a polyphase system (most commonly a three-phase system). Rotor: The rotor is the rotating part of the motor and is mounted on the shaft. It consists of a cylindrical core made of laminated steel that is surrounded by a cage made of aluminum or copper bars. The bars are short-circuited at both ends and are arranged symmetrically around the rotor's

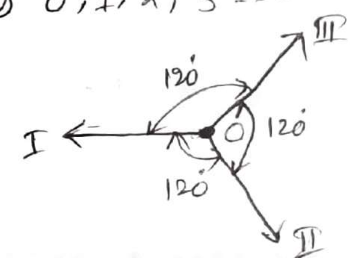
	circumference. The rotor is also referred to as the squirrel cage because of its similarity to a cage used for squirrels.  (a) Cage type structure of rotor (b) Symbolic representation **Fig. 5.7 Squirrel cage rotor** the Squirrel Cage Induction Motor operates based on the principles of electromagnetic induction and magnetic attraction. Its simple design and reliable operation make it a popular choice for a wide range of applications.
128	Explain the construction details and principle of operation of slip ring induction motor. A Slip Ring Induction Motor is a type of asynchronous AC motor that is used in high-power industrial applications where a constant torque is required over a wide range of speeds. The key difference between a Slip Ring Induction Motor and a Squirrel Cage Induction Motor is the type of rotor used in the motor. Principle of Operation: The operating principle of a Slip Ring Induction Motor is similar to that of a Squirrel Cage Induction Motor, but with the added feature of external resistance control. When the stator is supplied with a three-phase AC current, a rotating magnetic field is created, which induces currents in the rotor windings. These induced currents create a magnetic field that interacts with the magnetic field of the stator, producing a torque that drives the motor's load. Construction: Stator: The stator of a Slip Ring Induction Motor is similar to that of a Squirrel Cage Induction Motor, consisting of a laminated steel core with windings arranged in slots around its circumference. The stator windings are connected to form a three-phase system. Rotor: The rotor in a Slip Ring Induction Motor is more complex than the rotor in a Squirrel Cage Induction Motor. It consists of a cylindrical core made of laminated steel with a winding arrangement similar to the stator. The rotor windings are connected to slip rings, which are metal rings that are mounted on the shaft and are connected to an external resistance. The rotor windings can be connected in either a wye or delta configuration, depending on the desired motor characteristics.

	 **Fig. 7.8 Slip rings or wound rotor** However, the added external resistance in the rotor circuit allows for control of the rotor speed and thus the motor's torque output. By adjusting the resistance in the rotor circuit, the speed of the rotor can be varied, and the motor can operate at a constant torque over a wide range of speeds. This makes the Slip Ring Induction Motor well-suited for applications where constant torque is required, such as crane and hoist systems, elevators, and conveyor systems. the Slip Ring Induction Motor operates based on the same principles of electromagnetic induction and magnetic attraction as a Squirrel Cage Induction Motor, but with the added feature of external resistance control in the rotor circuit. This allows for more precise control of the motor's speed and torque output, making it a popular choice for high-power industrial applications.
129	Explain the generation of rotating magnetic field in three phase induction motor.

A uniform magnetic flux which rotates at a constant rate can easily be produced if three phase supply is given to stationary coils, which are wound for 3-ϕ system. The 3-ϕ winding, displaced in space by 120° with a three phase current, displaced in time by 120° is the production of a resultant magnetic flux which rotates in space in a manner comparable to actual magnetic poles being rotated mechanically. ϕ_{max}, max flux value and ϕ_r, resultant flux at any instant, is given by the vector sum of the individual fluxes ϕ_1, ϕ_2, ϕ_3 due to the 3-phases.

$\frac{1}{6}$ th of the time period marked as 0, 1, 2, 3 ---





1. When $\theta = 0^\circ$, corresponding to point 0.

$$\phi_1 = 0$$
$$\phi_2 = -\frac{\sqrt{3}}{2}\phi m$$
$$\phi_3 = \frac{\sqrt{3}}{2}\phi m$$

$$\phi\text{resultant } (\phi r) = \frac{3}{2}\phi m$$

(or)

$$\boxed{\phi_r = \frac{m}{2}\phi m} \quad \because (m = \text{no. of phases})$$

2. when $\theta = 60^\circ$: corresponding to point 1.

$$\phi_1 = \frac{\sqrt{3}}{2}\phi m$$
$$\phi_2 = -\frac{\sqrt{3}}{2}\phi m$$
$$\phi_3 = 0$$

$$\therefore \phi_r = 2 \times \left(\frac{\sqrt{3}}{2}\right)\phi m \cos 30^\circ = \frac{3}{2}\phi m$$

3. $\theta = 120^\circ$: corresponding to point 2.

$$\phi_1 = \frac{\sqrt{3}}{2}\phi m$$
$$\phi_2 = 0$$
$$\phi_3 = -\frac{\sqrt{3}}{2}\phi m$$

It can be proved that $\boxed{\phi r = \frac{3}{2}\phi m}$

4. when $\theta = 180^\circ$: corresponding to point 3.

$$\phi_1 = 0$$
$$\phi_2 = \frac{\sqrt{3}}{2}\phi m$$
$$\phi_3 = -\frac{\sqrt{3}}{2}\phi m$$

The resultant is $\frac{3}{2}\phi m$ and has rotated clockwise through an additional angle of 60° or through an angle of 180° from the initial position.

(i) The value of the resultant flux is always constant and equal to $\left(\frac{3}{2}\right)\phi m$. i.e 1.5 times the maximum value of flux due to any phase.

(ii) The resultant flux rotates around the stator at synchronous speed which is given by $\boxed{N_s = \frac{120f}{P} \text{ rpm}}$.

As it is visible, the resultant flux phasor is at the positions shown at the intervals of 60° only. The field that is produced by the resultant flux rotates in a clockwise direction.

130 Describe the construction details of resistor start or split phase induction motor with neat diagrams. Mention the application.

The Resistor Start or Split Phase Induction Motor is a type of single-phase induction motor that is commonly used in low-power applications such as small fans, blowers, and pumps. This type of motor has a simplified construction compared to other types of induction motors and is designed to be more cost-effective and efficient.

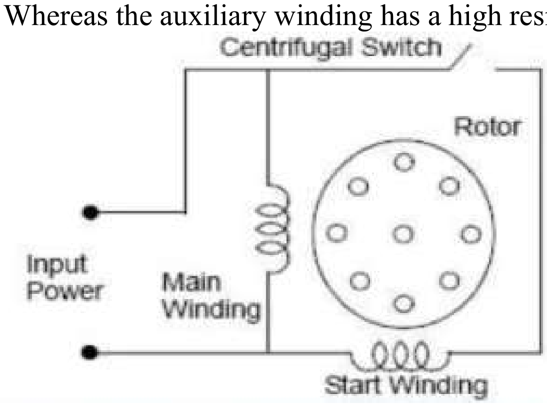
A split phase induction motor consists of two main parts: -

I. Stator
II. Rotor

The stator is provided with single phase windings

III. Main winding
IV. Auxiliary winding

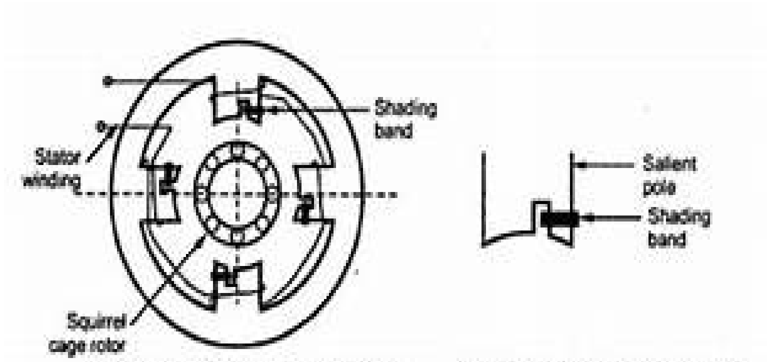
The two winding are placed 90 degrees electrical apart & are connected in parallel across the single-phase AC supply. Whereas the auxiliary winding has a high resistance & low reactance.



Applications of Split phase motor

These motors are suitable where a moderate starting torque is required and where starting periods are infrequent e.g., to drive:

Fans

	washing machines oil burners Small machine tools etc. The power rating of such motors generally lies between 60 W and 250 W.
131	Describe working principle and construction details of shaded pole induction motor with neat diagrams. Mention the application. A shaded pole motor has a stator consisting of salient poles & a squirrel cage rotor. The main winding is wound on the entire pole section. When the ac supply is given to the stator winding of shaded pole motor, due to shading provided on the salient poles, a rotating magnetic field is produced.  (a) 4 - pole shaded pole construction (b) Salient pole with shading band These motors are only suitable for low power applications e.g., to drive: Small fans Toys Hair driers Desk fans etc. The power rating of such motors is up to about 30 W.
132	Describe working principle and construction details of synchronous generator with neat diagrams. synchronous generator (alternator) works on the principle of Faraday's Laws of electromagnetic induction. In the alternator, the armature is stationary and field rotates ⇒ An e.m.f is induced whenever the flux linkage between conductor coils changes. ⇒ The amount of induced emf in a conductor coil is directly proportional to the rate of change of flux linked by the coil. ⇒ When there is a relative motion between the conductors and the flux, emf gets induced in the conductors. ⇒ The direction of the emf due to electromagnetic induction, as per the Lenz's law, is such that the current set up by it tends to oppose the change which causes the induced emf.

The nature of the induced e.m.f. against the time is alternating.

The equation below is a combination of the Faraday's and Lenz's Law:

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

Where: e = Induced e.m.f (voltage)

T = No. of turns in the coil (N).

$d\phi$ = change in the flux.

dt = time taken for the change to occur.

in other form.

$$\boxed{\text{induced e.m.f} = Blv \sin\theta}$$

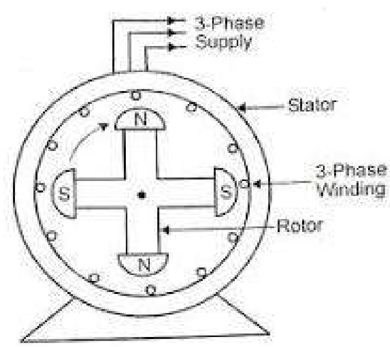
Where: e = induced emf in watt

B = Flux density in Tesla

l = length of the conductor in (mtr)

v = velocity of the conductor in (mtr/sec)

θ = angle by which the conductor cuts magnetic field.



	Construction of synchronous generator:- ⇒ The alternator should be operated at a constant speed, which is called synchronous speed. Therefore these are also called as synchronous generators. The major parts are; (i) stator (ii) Rotor (iii) Exciter. ① stator:- stator is a stationary part made up of silico steel. The stator core uses a laminated construction. slots (angi the stator are mutually insulated with the help of varnish or a paper. The laminated construction reduces the eddy curre loss in the stator.
133	4-pole, 50Hz squirrel cage induction motus runs on load. at a shaft speed of 1440 rpm calculate is i) Percentage slip ii)The frequency of induced current in the rotor. sol:- given data: poles (P) = 4 supply frequency $(f_s) = 50\,Hz$ rotor speed $(N_r) = 1440$ rpm synchronous speed $\boxed{(N_s) = \frac{120 \times f}{P}}$ $N_s = \frac{120 \times 50}{4} = 1500$ rpm ∴ ① slip percentage: $\boxed{\% S = \frac{N_s - N_r}{N_s} \times 100}$ $= \frac{1500-1440}{1500} \times 100$ $= \frac{60}{1500} \times 100 = 4\%$ $\boxed{\therefore \% slip = 4\%}$ (or) slip (S) = 0.04 (ii) rotor frequency (f_r):- ∴ $\boxed{f_r = (S) f_s}$ $= 0.04 \times 50$ $= 2\,Hz$ ∴ $\boxed{f_{rotor} = 2\,Hz}$
134	Describe working principle and construction details of Alternator with neat diagrams.

synchronous generator (alternator) works on the principle of Faraday's Laws of electromagnetic induction.

In the alternator, the armature is stationary and field rotates.

⇒ An e.m.f is induced whenever the flux linkage between conductor coils changes.

⇒ The amount of induced emf in a conductor coil is directly proportional to the rate of change of flux linked by the coil.

⇒ When there is a relative motion between the conductors and the flux, emf gets induced in the conductors.

⇒ The direction of the emf due to electromagnetic induction, as per the Lenz's law, is such that the current set up by it tends to oppose the change which causes the induced emf.

The nature of the induced e.m.f. against the time is alternating.

The equation below is a combination of the Faraday's and Lenz's Law:

$$* \boxed{e = -N\frac{d\phi}{dt}} *$$

Where: e = Induced e.m.f (voltage)

T = No. of turns in the coil (N).

$d\phi$ = change in the flux.

dt = time taken for the change to occur.

in other form.

$$* \boxed{\text{induced e.m.f} = Blv\sin\theta} *$$

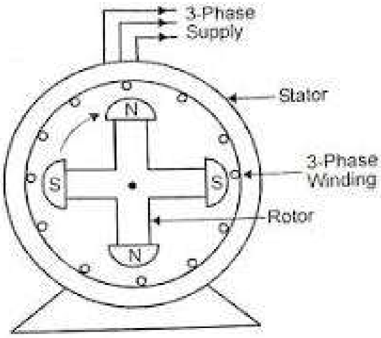
Where: e = induced emf in watt

B = Flux density in Tesla

l = length of the conductor in (mtr)

v = velocity of the conductor in (mtr/sec)

θ = angle by which the conductor cuts magnetic field.



Construction of synchronous generator:-

⇒ The alternator should be operated at a constant speed, which is called synchronous speed. Therefore these are also called as synchronous generators.

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the stator are mutually insulated with the help of varnish or
a paper. The laminated construction reduces the eddy curro
loss in the stator.

steel is used to minimize the hysteresis losses. The entire core is fabricated in a frame made of steel plates. The core has slots on its periphery for housing the armature conductors. Frame does not carry (current) any flux and serves as a support to the core.

In alternators less KVA, the alternating current is obtained at the armature by the slip rings.

For alternators of greater KVA, the 3-ϕ alternating current is obtained from the terminals in the terminal box.

To provide cooling in the stator, axial and radial ventilating ducts are provided.

slots for these ducts can be prepared: such as

(i) Open slots:- (ii) Semi-closed/semi-open slots.

(iii) Closed slots.

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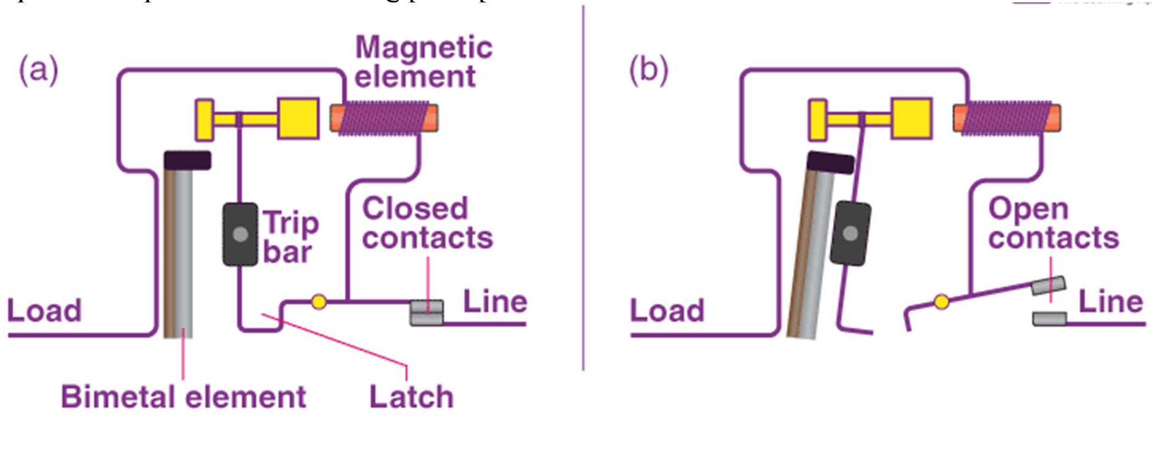
(iii) Closed slots.

135	Difference between Synchronous and Asynchronous Motor.

Point of Comparison	Synchronous Motor	Asynchronous Motor
Definition	The AC motor which runs at synchronous speed is known as synchronous motor.	The type of AC motor which runs at speed less than the synchronous speed is known as asynchronous motor.
Principle of operation	The operating principle of the synchronous motor is based on the principle of magnetic interlocking between the magnetic fields of stator and rotor.	The asynchronous motor works on the principle of electromagnetic induction between the stator magnetic field and rotor circuit.
Expression of speed (Rotor)	Synchronous speed, $N_s = \frac{120f}{P}$ Where, f is the supply frequency and P is the number of stator poles.	Rotor speed, $N_r = N_s(1-s)$ Where, s is the slip and Nr < Ns
Dependency of speed	Speed of the synchronous motor depends upon the frequency of input AC supply and the number of poles on stator.	Speed of an asynchronous motor depends upon the mechanical load, rotor circuit resistance and slip in the motor. In actual practice, the speed of the asynchronous motor is always less than synchronous speed.
Slip	In case of synchronous motor, there is no slip, i.e., both stator and rotor rotate at the same speed.	There is slip in an asynchronous motor and it is always greater than 0 and less than 1.
Effect of load on speed	The speed of the synchronous motor does not vary with the variation in the load.	The speed of an asynchronous varies with the change in the load.
Starting	The synchronous motors are not self-starting. They require some external mean of starting.	The asynchronous motors are self-starting.
Rotor supply	The rotor of the synchronous motor requires an extra input supply to produce rotor magnetic field.	In case of asynchronous motor, if the rotor is squirrel cage type, then there is no need of rotor supply but the wound type rotor needs extra supply input.
Type of rotor supply	DC supply is given to the rotor of the synchronous motor.	AC supply (in wound type rotor) is fed to the rotor circuit.
Need of slip ring and brushes	Synchronous motor requires slip rings and brushes to supply DC to its rotor circuit.	Asynchronous motor with squirrel cage rotor does not require slip rings. However, with the wound type rotor, slip rings are used.
Speed control	The speed of the synchronous motor is controlled by changing the supply frequency using VFD (variable frequency drive).	The speed of an asynchronous motor can be controlled either by using variable rotor resistance or VFD.
Effect of supply voltage on speed and torque	The supply voltage does not affect the speed and torque of a synchronous motor.	By changing the supply voltage, the torque and speed of an asynchronous motor can be changed.
Capital cost	The capital cost of synchronous motor is higher.	The initial cost of an asynchronous motor is comparatively lower.
Efficiency	A synchronous motor has high efficiency.	
Operating speed	The synchronous motors are best suited for low speed (constant) applications, below 300 RPM.	Asynchronous motors are best suited for high speeds, more than 600 RPM.
Power factor	Synchronous motor can be operated at lagging leading or unity power factor by varying the excitation.	The asynchronous motors always operate at lagging power factor.
Applications	Synchronous motor can be used for driving mechanical loads as well as power factor correction (by operating at leading power factor).	Asynchronous motor can only be used for driving mechanical loads.

S.NO	Unit-V (LAQ's)
136	Explain the operation and working principle of MCB. 

Working Principle of MCB

Miniature circuit breaker is an electro-mechanical device. Which operates and disconects the particular circuit. These which operates and are widely used in all the domestic, commercial and industrial applications. It can be used in case of fuses. Under normal operating condition MCB can be operated as a switch to switch the circuit ON or OFF.

During overload or any other type of fault, it gets activated and isolates the faulty circuit from the supply. MCB is a high-fault capacity thermal/magnetic, current-limiting trip-free automatic-switching device with just magnetic tripping.

The thermal operation uses a bimetallic strip, which deflects when heated by any excessive current flowing through it. When short circuit fault occurs, the rising current energizes the solenoid operating the plunger to strike the trip level causing an immediate release of the latch mechanism.

In MCB there is no serviceable part, the whole unit should be replaced. It will normally operate at 1·25 times more than its rated current.

137	Explain the operation and working principle of MCCB.

Ans:

Moulded Case Circuit Breaker (MCCB)

It is an electromechanical device, which provides protection under overload and short circuit conditions. MCCB automatically goes in off state when current in the circuit flows more than its limited value. It has two elements (thermal element and magnetic element) which are used for over current and short circuit protection respectively. MCCB's are available in the range of 63A, 100A, 250A, 450A, 630A, 800A, 500V, 50 Hz. They are widely used in circuit protection in branch feeders, transformer secondary distribution system, D.C circuits and capacitor switching.

In case of fault when current is less than 10 times its pre-set value, the breaker trips due to thermal release and if the current is more than 10 times to its pre-set value than the breaker trips due to magnetic release.

Some important features of MCCB are,

1. The MCCB is independent of manual operation and its operating mechanism is "quick-make, quick-break".
2. The outer structure of MCCB is made of heat resistant insulating material. All the parts are enclosed in this structure except the toggle switch, which is accessible externally.
3. Whenever a fault occurs on any one phase, all phases are disconnected.
4. To quench the arc rapidly high arc resistance silver alloy contacts are used.

These contacts have long electrical life.

138 Explain the operation and working principle of ELCB.

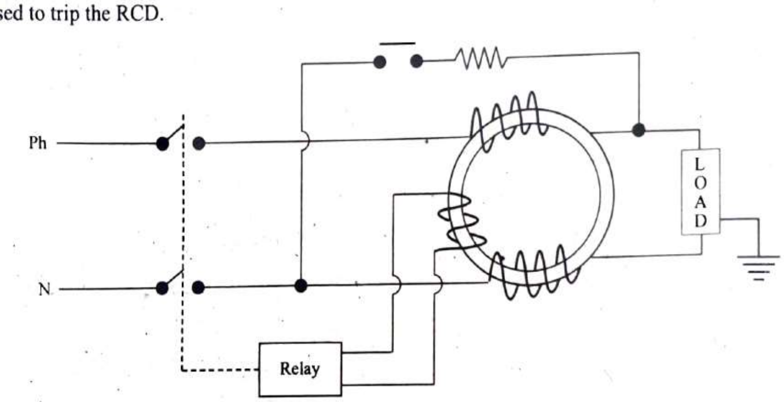
Ans:

Earth Leakage Circuit Breaker

ELCB is also known as residual current circuit breaker. (RCCB). It is a residual current device (RCD) which is designed to provide a protection against electrical fire. ELCB goes in off state when it sense a leakage of electric current in a circuit.

The operating principle of RCD can be explained by using figure. It consists current transformer, relay and sensing coil. When RCD is connected between supply and a load, the phase and neutral wire is connected to the load through primary winding of the transformer and secondary winding is connected to the relay which can be used as sensing coil.

When phase and neutral currents are equal and opposite then there is no current generated in the sensing coil. But when phase and neutral current are not equal, imbalance flux is created which will include a current in the secondary winding (sensing coil) which is used to trip the RCD.



Figure

139 Describe the different types of cables used for domestic wiring.

	Electrical wiring is all about connecting wires and cables to various equipment and devices like appliances, switches, lights, receptacles and so on the main distribution board. A cable is the combination of two or more wires, assembled using a single jacket. In modern homes, the NM (nonmetallic cable is the most comman type. This consisting of two or more individual wires wrapped inside a protective plastic sheathing and conteins:

	• One (or) more "hot" (current-carrying) wires. • a neutral wire • a ground wire ① NM Cable: The most common type of home electrical wiring The Nonmetallic cable contain three or more individual conductors This type of cable is generally used for dry, interior home wiring and fixtures, switches, and outlets. Cable comes in different colors to indicate the wire gauge. • 6-gauge, 55-Amp black sheathing • 8-gauge – 40 Amp. black sheathing • 10-gauge – 30 Amp. --- etc. orange sheathing * Gray sheathing is reserved for underground (UG) cable. ② Armored cable:- This cable designed with flexible metallic sheathing, which offers extra protection for the conductors inside. In commercial buildings or residential constructions with more than three stories, AC can't be used. ③ Underground feeder Cable: (UF) is specially designed for wet locations and direct ground burial. Another option electricians choose is using pvc conduit underground and pulling wires through, This type of Cable can be used for major circuit wiring. ④ Low voltage wire (LV):- used for Vtg less than 50V like door bells, thermostats, sprinkler systems on landscape lighting. LV wiring varies from 12 to 22-gauge
140	What do you understand by power factor? Explain the necessity of improving power factor.

	powerfactor (P.F) is an indicator of efficient utilization of power. In an AC (Alternating current) electrical power system, p.f is defined as the ratio of real power flowing to the load, to the apparent power in the circuit and is a dimensionless number. In order to have an "efficient" system, we want pf to ~~the~~ be as close to 1.0 (i.e 100%) as possible.

Inductive loads, which are sources of Reactive power, are mainly responsible for Low p.f. These constitute a major portion of power consumed in industrial complexess and include:
Transformers, Induction motors, High intensity Discharge lighting etc

Why improve Low p.f?
Some of the benefits of improving p.f includes:
* Lesser Electricity bill. by
(a) Reducing peak billing demand: By improving p.f. peak billing demand lowers, which results in savings in bill if the contract Demand is decided judiciously.
* Increased capacity and reduced losses: In electrical system Low p.f causes Losses in distribution system. By improving p.f Losses can be reduced which is in turn can enhance the capacity to bear additional load in your system.

moreover, low p.f not only causes unnecessary increase in generation and transmission capacity of the utility, in a broader perspective, it actually increases amount of greenhouse gases that get released into the atmosphere

How to improve p.f :- Installing Capacitors (KVAR Generators)
(a) install capacitors close to the motors/load.
(b) switch on or off the capacitor in tandem with motor/load. this will maximise reactive compensation and provide relief to your internal electrical network. To avoid manual operation. you may install Automatic power Factor controller (APFC).
(c) we must be take the help of "Capacitor Bank.

To understand p.f :

Active power (KW) : $P = VI\cos\phi$ (real power)

Reactive power (KVAR) : $Q = VI\sin\phi$

Apparent power (KVA) : $S = VI$

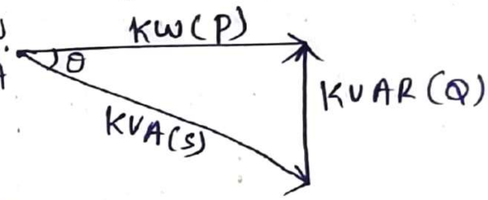
Note:- KVAR: It is the power that magnetic equipment (Transformer, motor and relay) needs produce the magnetic flux)

p.f :- The cosine angle between voltage and current.

$$\boxed{\cos\phi = \frac{P}{VI} = \frac{P}{S}} = \frac{KW}{KVA} \text{ (or) } \frac{\text{working power}}{\text{Apparent power}}.$$

The power triangle

$$p.f(\cos\theta) = \frac{KW}{KVA}$$



141	Discuss the different types of wires.

The wires are used for general electrical purposes can be divided into the following:

⇒ Rubber covered, taped, braided and compounded or V.I.R wires.

⇒ lead alloy sheathed wires.

⇒ Tough Rubber sheathed (T.R.S)/cab Tyre sheathed (C.T.S) wires.

⇒ weather proof wires

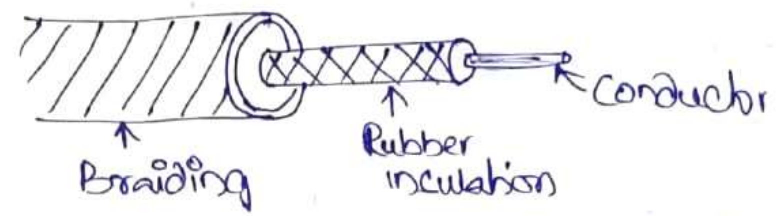
⇒ flexiable wires

⇒ P.V.C (poly vinyl chloride) wires.

The rubber covered, taped, braided and compounded wires are always single core but can be subdivided into two classes i.e, for voltages upto 250V or those upto 600V. All other types of wires either single core or double core or 3 core or twin core with Earth continuity conductor (E.C.C).

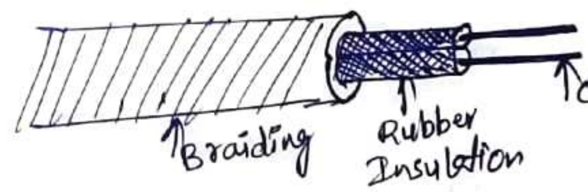
V.I.R Wires (Vulcanized India Rubber).

→ These are used for Ordinary electrical wiring in Casing-capping or Conduit wiring.



→ This type of wire Consists of the wire is shown in fig. These are always single core wires. The thickness of the rubber insulation depends upon the voltage for which the wire is required. It is for 250V or 600V.

Lead Alloy sheathed Wires:- This type of wire is used where the climatic condition is not dry, but has a little bit of moisture. The ordinary wires are covered with a continuous sheath of lead. These wires provides only a little mechanical protection.



Tough Rubber sheathed (T.R.S) or Cab Tyre sheathed (C.T.S) wires:

It provides additional insulation and protection against moisture, chemical fumes and wear and te

This type of wire is available in single core, twin core and three cores.

142	List out components of LT switchgear. And explain briefly about each component. Low-Voltage (LV) switchgear is a system that provides electrical protection, control, and distribution functions for electrical power systems at voltages below 1000V. The components of LV switchgear are: 1. Circuit Breaker: The circuit breaker is the main component of LV switchgear. It is used to interrupt the flow of electric current in case of an overload or short circuit. Circuit breakers can be either air, oil, or vacuum-based. 2. Contractor: The contactor is a switch used to control the flow of electric current. It is used to turn on and off electrical loads, such as motors and lights. 3. MCCB (Melded Case Circuit Breaker): The MCCB is a type of circuit breaker that is designed for use in LV switchgear. It is typically used to protect electrical circuits from overloading and short circuits. 4. RCCB (Residual Current Circuit Breaker): The RCCB is a type of circuit breaker that is designed to detect and interrupt the flow of electric current in the event of a fault, such as an earth fault. 5. MCB (Miniature Circuit Breaker): The MCB is a type of circuit breaker that is designed for use in LV switchgear. It is used to protect electrical circuits from overloading and short circuits. 6. Fuse: A fuse is a type of protective device that is designed to interrupt the flow of electric current in the event of an overload or short circuit. Fuses are used to protect electrical circuits from damage. 7. Isolator: An isolator is a type of switch that is used to isolate electrical circuits from the power supply. It is used to disconnect electrical loads for maintenance and repair. 8. Busbar: The busbar is a metal conductor used to distribute electrical power within a switchgear assembly. Busbars are typically made of copper or aluminium and are used to connect the various components of LV switchgear. these components of LV switchgear include circuit breakers, contactors, MCCBs, RCCBs, MCBs, fuses, isolators, and busbars. These components are used to provide electrical protection, control, and distribution functions for electrical power systems. The specific components used in a particular LV switchgear system will depend on the requirements of the application, such as the required level of electrical protection, control, and distribution.
143	Write a short note on power factor improvement using static Capacitors.

Static Capacitors

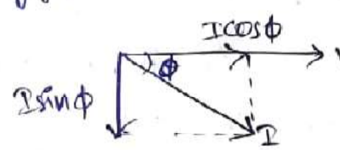
By connecting a capacitor across the load, the capacitor will draw a leading current and will help to neutralize the reactive or wattless component of the current drawn by the equipment. In this way, the power factor is improved.

Static capacitors can be connected in star (Y) or (Δ) delta

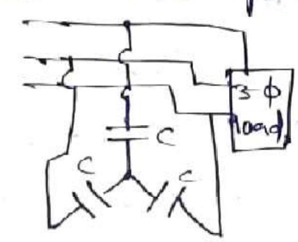
Static capacitors are used for p.f improvement because of the following reasons.

1. they have very small losses, higher efficiency (99.6%)
2. almost no maintenance
3. Low initial cost
4. Lighter in weight and easy installation.

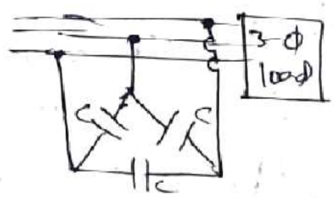
The current drawn by the Induction motors working at the lagging pf can be resolved into two components. shown below



By connecting a capacitor across the load, the capacitor will draw leading current and will help to neutralize the reactive power, the power factor is improved.



(Star-connection)



(Δ-connection)

144 Explain the different types of Batteries and its characteristics.

Batteries are devices that store and supply electrical energy. They come in a variety of sizes, shapes, and technologies, each with its own unique characteristics and applications. The different types of batteries include:

1. Lead-Acid Batteries: Lead-acid batteries are one of the oldest and most commonly used types of batteries. They consist of lead plates and a sulfuric acid electrolyte, and are commonly used in automotive applications, backup power systems, and for renewable energy storage. Lead-acid batteries have a relatively low energy density and a limited number of charge-discharge cycles, but are inexpensive and have a long service life.
2. Nickel-Cadmium (NiCad) Batteries: NiCad batteries are rechargeable batteries that use nickel oxide and cadmium electrodes. They have a relatively high energy density, good discharge characteristics, and a long service life. NiCad batteries are commonly used in portable power tools and electronic devices.

3. Nickel-Metal Hydride (NiMH) Batteries: NiMH batteries are rechargeable batteries that use nickel and hydrogen as the active materials. They have a higher energy density than NiCad batteries and are also more environmentally friendly. NiMH batteries are commonly used in portable electronic devices, such as mobile phones and laptops.
4. Lithium-Ion (Li-Ion) Batteries: Li-Ion batteries are rechargeable batteries that use lithium ions to store and release electrical energy. They have a high energy density, good discharge characteristics, and a long service life. Li-Ion batteries are commonly used in portable electronic devices, electric vehicles, and renewable energy storage systems.
5. Alkaline Batteries: Alkaline batteries are non-rechargeable batteries that use an alkaline electrolyte and zinc-manganese dioxide electrodes. They have a relatively low cost, good discharge characteristics, and a long shelf life. Alkaline batteries are commonly used in household appliances, toys, and flashlights.

In conclusion, batteries come in a variety of types, each with its own unique characteristics and applications. The type of battery selected for a particular application will depend on factors such as the required energy capacity, discharge characteristics, cost, service life, and environmental impact. It is important to consider the specific requirements of an application when selecting a battery type, to ensure that the best battery for the job is selected.

145 What is earthing? Why earthing is required? With the help of neat sketch explain the plate Earthing. Discuss the disadvantages of low power factor.

Ans:

The process of connecting non-current carrying metal parts of an electrical systems to earth is known as earthing of electrical equipment or equipment earthing. The need of earthing of electrical equipments is explained as follows,

1. **Protection from Shocks:** Earthing provides safety against electric shocks to any person or animal when they are in contact with the metal parts. Though some of the systems have fuses or circuit breakers for protection from the fault current or short circuit, the person may receive a shock at the operating point of fuse or breaker. Thus, earthing is necessary for the protection against shock.
2. **Controls Constant Line Voltage:** Earthing controls the constant line voltage in unbalanced load condition.
3. **Prevention of Equipment from Damage:** Without earthing the parts of the electrical equipment may damage either due to fault currents short circuits or the undetected part which causes fire.
4. **Protection against Lightning:** Earthing guards the buildings, towers, machines which are supplied from overhead transmission lines against lightning and thunder storms. Lightning arises because the surge current follows the path of two or more ground connections. The conductors of the lightning must have direct connection to earth in order to prevent from lightning.
5. **Achieves Required Performance:** The earthing installations ensure the desired performance of the earthing systems. It is cost effective process and achieves reliable and improved service. It also provides a drainage path for the currents which are undesirable.

Construction

Plate earthing consists of G.I plate or copper plate with nuts and bolts, charcoal, salt and earth wire. The size of the copper plate is (60 × 60 × 0.318) cm and the size of the G.I plate is (60 × 60 × 0.63) cm. The copper plates are efficient earth electrodes and are independent of the soil moisture. But G.I plate is more commonly used because of high material cost. For copper plate, the nuts and bolts should be made of copper whereas for G.I plate it should be made of galvanized iron. G.I pipe is also used in the construction with a funnel at its top. The cast iron frame with cement work used at the top of the G.I pipe to avoid from watering arrangement. The set up of plate earthing is shown in figure.

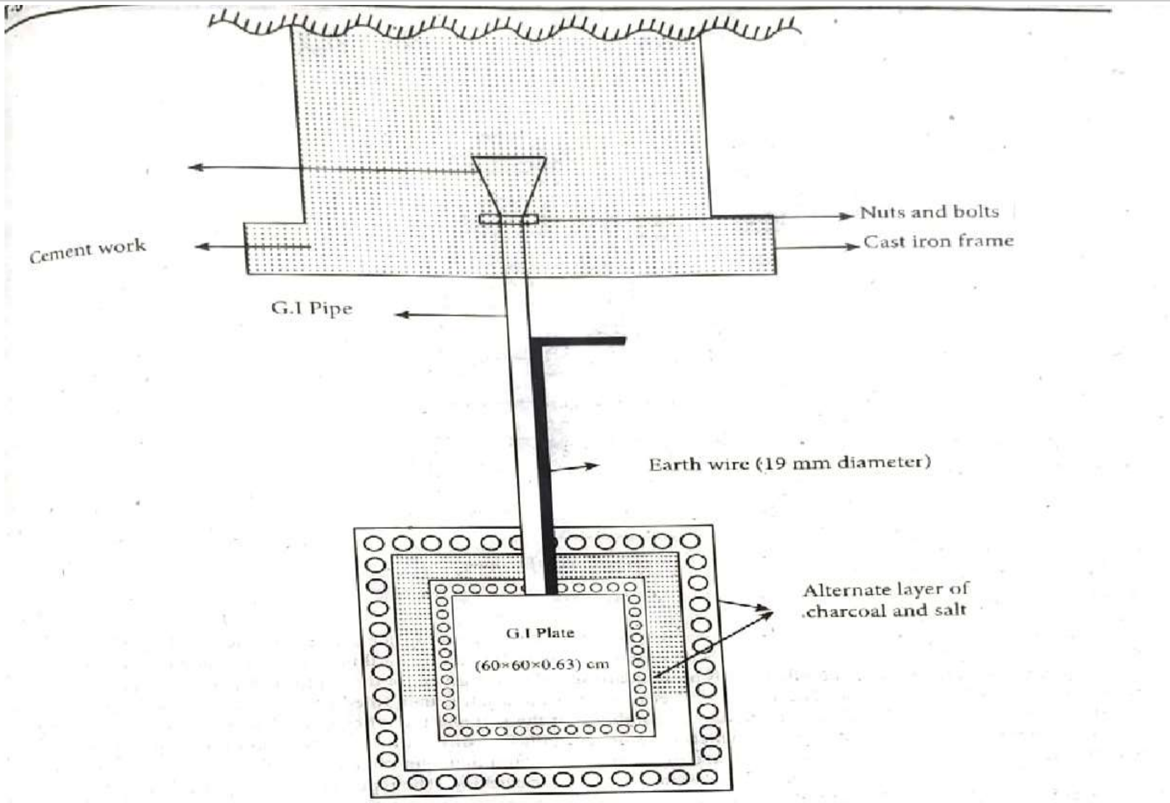


Figure: Plate Earthing

Working

Select the location for plate earthing. Make a hole in the soil of particular depth as per the requirement. The depth is usually not less than 3 m. The plate is then inserted vertically into the hole. Then the alternate layer of charcoal and salt is arranged in the surrounding area of G.I plate. Each layer is minimum of 15 cm in thickness. The mixture of charcoal and salt reduces the resistance of the earth. The earth wire is inserted in the soil through the G.I pipe and gets attached to G.I plate which is of 19 mm diameter and 60 cm below the soil. For performance of the earthing system, salt water is poured into the pipe through funnel periodically. The efficiency of the earthing increases with an increase in the cross-sectional area and depth of the plate. This method cannot check the performance by continuity tests.

146 Write the causes and disadvantages of low power factor.

Ans:

Disadvantages of Low Power Factor

Let the loads on a system are at low power factors. In this case, the load current drawn from the supply mains will be more, because for constant voltage and power, the load current is inversely proportional to the power factor.

$$\text{i.e.,} \quad I \propto \frac{1}{\cos\alpha} \qquad \text{... (1)}$$

$$\text{Since,} \quad I = \frac{P}{V\cos\phi} \quad \text{(For single-phase)}$$

$$\text{And} \quad I = \frac{P}{\sqrt{3}\,V\cos\phi} \quad \text{(For three-phase)}$$

Hence, from the above relationship (i.e., equation (1)), the disadvantages of low power factor can be framed as follows.

(i) High I^2R Losses

If the power factor of the system is poor then the load current drawn from the supply will be high due to which the copper losses or I^2R losses will be more as a result the efficiency of the system will be poor.

(ii) Greater Conductor Size

It has been seen in equation (1), that the load current is inversely proportional to the power factor. Hence, if the system is having low power factor, then for transmitting or distributing a fixed amount of power at constant voltage, the conductors will have to carry more amount of current and if suppose, that the power factor is high, then the same amount of power can be carried by conductors having less cross-sectional area. Therefore, low power factor requires greater conductor size which increases the cost of the system.

(iii) Effect on Voltage Regulation

In alternators, transmission lines, transformers and distributors, the large current at low lagging power factor causes very high voltage drops which leads to decrease in voltage at the consumer end and this may damage the devices at the consumer end. In order to overcome this, separate device such as voltage regulator is required which further increases the cost of the system.

(iv) Reduced Handling Capacity of System

For system having low lagging power factor, the reactive component of current prevents the full utilization of the system as a result the handling capacity of the element of the system will be reduced.

(v) Increased in Ratings of the Equipments

Another disadvantage of low power factor is that for a system having low power factor, the kVA and kW capacities of the equipment are lowered.

$$\text{i.e., } kVA = \frac{kW}{\cos\phi}$$

Hence, for same amount of power large kVA rating of the equipment is required which makes the equipment larger and also costlier.

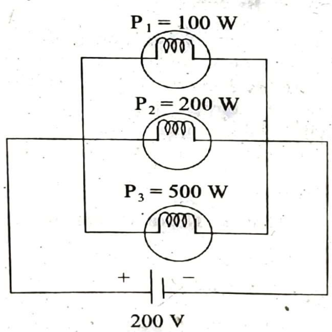
147 Explain the different methods to improve power factor of the system.

Power factor is a measure of the efficiency of an electrical power system, defined as the ratio of real power (measured in watts) to apparent power (measured in volt-amperes). Improving the power factor of a system is important because a low power factor indicates that a significant amount of the electrical energy consumed by the system is not being used to perform useful work, but is instead being wasted as heat in the electrical wiring and equipment.

There are several methods to improve the power factor of a system, including:

1. Power Factor Correction Capacitors: Power factor correction capacitors are devices that are connected in parallel with the electrical load to provide a leading current that compensates for the lagging current consumed by the load. This results in an increase in the power factor and a reduction in the amount of electrical energy wasted as heat in the electrical wiring and equipment.
2. Harmonic Filters: Harmonic filters are devices that are installed in electrical systems to reduce the amount of harmonic distortion, which can contribute to a low power factor. Harmonic filters can be installed at the source of the harmonic distortion, such as at individual loads, or at the point of common coupling (PCC), which is the point where the electrical distribution system connects to the utility grid.
3. Power Factor Regulators: Power factor regulators are devices that automatically adjust the magnitude and phase angle of the voltage supplied to a load to maintain a desired power factor. They are commonly used in industrial applications to improve the power factor and reduce energy costs.
4. Energy Efficient Equipment: The use of energy efficient equipment, such as energy efficient lighting, motors, and HVAC systems, can also contribute to an improvement in the power factor of a system. Energy efficient equipment typically consumes less reactive power and has a lower displacement power factor than less efficient equipment.
5. System Optimization: System optimization involves analysing the electrical distribution system to identify areas where the power factor can be improved, and making changes to the system to increase the power factor. This can include installing power factor correction capacitors, upgrading to energy efficient equipment, and modifying the electrical distribution system to reduce harmonic distortion.

In conclusion, there are several methods for improving the power factor of a system, including the use of power factor correction capacitors, harmonic filters, power factor regulators, energy efficient equipment, and system optimization. The specific method or combination of methods selected for a

	particular system will depend on the specific requirements of the application and the desired level of improvement in the power factor.
148	Three lamps of rating 230V,100W,200W, and 500W are connected in parallel across 220V supply. Calculate the power dissipation of each lamp. **Ans:** Given that, Rated voltage of each lamp, $V = 230$ V Supply voltage, $V_s = 200$ V Rating of lamp-1, $P_1 = 100$ W Rating of lamp-2, $P_2 = 200$ W Rating of lamp-3, $P_3 = 500$ W Power dissipation of each lamp = ?  **Figure** Resistance of each lamp can be calculated as, $R_1 = \frac{V^2}{P_1} = \frac{(230)^2}{100} = 529\ \Omega$ $R_2 = \frac{V^2}{P_2}$ $= \frac{(230)^2}{200} = 264.5\ \Omega$ $R_3 = \frac{V^2}{P_3}$ $= \frac{(230)^2}{500} = 105.8\ \Omega$ Power dissipation of each lamp, $P_1' = \frac{V_s^2}{R_1} = \frac{(200)^2}{529} = 75.61$ W $P_2' = \frac{V_s^2}{R_2} = \frac{(200)^2}{264.5} = 151.22$ W $P_3' = \frac{V_s^2}{R_3} = \frac{(200)^2}{105.8} = 378.07$ W
149	What is miniature circuit breaker and mention its use? Give the specification of miniature circuit breaker. **Ans:** **Miniature Circuit Breaker (MCB)** Miniature Circuit Breaker (MCB) is a type of circuit breaker which are used only at low voltages. It is an electro mechanical device which provides protection under overloads and short-circuit conditions. Unlike fuses, they do not need servicing and rewiring. They comes into operation when current in the circuit reaches predetermined value. MCB's are more efficient, faster and are easily manageable.

It other words, miniature circuit breakers or micro circuit breakers is a switch which automatically goes in off state when the current in the circuit flows more than the limited value. It detects the fault in an electrical circuit by interrupting the current flow.

Uses

Miniature circuit breakers are widely used nowadays by replacing the typical rewirable fuses. They find applications in the following areas,

1. Residentials
2. Shops
3. Distributions boards
4. Offices
5. Power loads
6. Industries
7. Lighting circuits
8. Control circuits
9. Sub-distribution circuits
10. Building applications etc.

Specifications

The required specifications of miniature circuit breakers are tabulated as follows,

	Function	Specification
1.	Number of poles	1 to 4
2.	Rated voltage	240/415 V
3.	Rated current	0.5, 1, 2, 6, 10, 16, 25, 32, 40 and 63 Amps
4.	Rated frequency	50 Hz
5.	Rated short circuit	3 kA, 9 kA and 25 kA
6.	Category of duty suppose,	
	M1	⇒ Current – 1000 A, Power factor – 0.85 - 0.9
	M 1.5	⇒ Current – 1500 A, Power factor – 0.8 - 0.85

150	Briefly write about switch fuse unit.

Ans:

Switch Fuse Unit

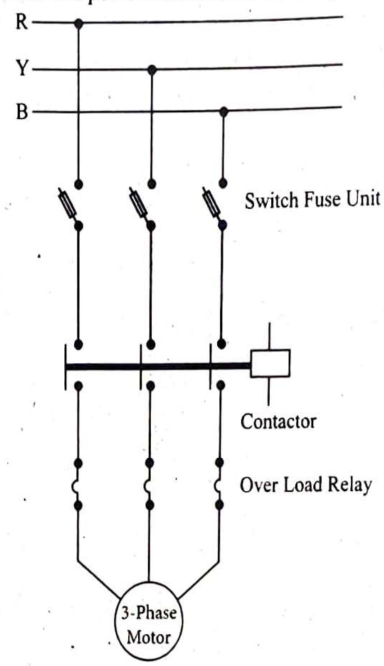
Switch fuse unit is formed when fuse base is integrated with switch. These units are available in three pole (TP) and three pole neutral (TPN) form up to a rating of 1000 A, 415 V with breaking capacity of 50 kA.

Switch fuse units are of two types,

(i) SFU where fuse is stationary and

(ii) SFU where fuse is mounted on moving assembly

Both the units are in use, however the unit with stationary fuse are more reliable and has less deterioration of electrical joints compare to the unit with movable fuse. The power circuit of motor using switch fuse unit is shown in figure.



Figure

Advantages

1. Less electrical points in the circuit
2. Less maintenance
3. Space required is also less.

Q24

**** END****