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Subject Name & Code:
Basic Electrical Engineering- BE01000051

Marks

Q.1 (a) Apply and illustrate KCL on star connected circuit. **03**

Answer:

Kirchhoff's Current Law (KCL):
KCL states that *the algebraic sum of currents entering a junction (or node) in an electrical circuit is zero*. Mathematically,

$$\sum I_{\text{in}} = \sum I_{\text{out}} \quad \text{or} \quad \sum I = 0$$

Application of KCL in Star Connected Circuit:
In a **star (Y) connected circuit**, three loads (or impedances) are connected to a common neutral point. Let the line currents be IR,IY,IB corresponding to phases R, Y, and B.

At the neutral point (junction), the currents from all three phases meet. Applying **KCL** at this point:

IR+IY+IB=0

This means the **vector sum** (phasor sum) of the three phase currents in a balanced star-connected system is **zero**.

Illustration:
Consider a balanced 3-phase star-connected load with the following currents:

- $I_R = I\angle 0^\circ$
- $I_Y = I\angle -120^\circ$
- $I_B = I\angle +120^\circ$

Then,

$$I_R + I_Y + I_B = I\angle 0^\circ + I\angle -120^\circ + I\angle 120^\circ = 0$$

So, the sum of currents at the neutral point is zero, satisfying KCL.

Conclusion:
In a star-connected circuit, Kirchhoff's Current Law is verified at the neutral point by showing that the sum of incoming and outgoing currents is zero.

(b) Compute Rth and Vth for thevenin theorem. Assume necessary circuit for the same. **04**

Answer:

Assumed Circuit:
Let us consider the following simple circuit for analysis:
- A voltage source V=12 V
- Two resistors in series: R1=4 Ω, R2=6 Ω
- Load resistor RL=3 Ω connected across terminals A and B (across R2)

1. To Find Vth (Thevenin Voltage):
- Vth is the **open-circuit voltage across terminals A and B**.
- Remove the load resistor RL, and find the voltage drop across R2.

Using voltage division:

$$V_{th} = V_{AB} = \frac{R_2}{R_1 + R_2} \times V = \frac{6}{4+6} \times 12 = \frac{6}{10} \times 12 = 7.2\,V$$

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2. To Find Rth (Thevenin Resistance):
- Deactivate all **independent sources**:
  - Replace voltage source with a **short circuit**.
- Then, find **equivalent resistance** seen from terminals A and B.

Now the resistors R1 and R2 are in **parallel**:

$$R_{th} = R_1 \parallel R_2 = \frac{R_1 \cdot R_2}{R_1 + R_2} = \frac{4 \times 6}{4+6} = \frac{24}{10} = 2.4\,\Omega$$

Final Answer:
- **Thevenin Voltage, Vth=7.2 V**
- **Thevenin Resistance, Rth=2.4 Ω**

(c) Explain star to delta conversion with neat and clean diagram. **07**

Answer:

Star to Delta Conversion
In electrical circuits, especially in three-phase systems, it is often necessary to convert a star (Y) connected network into an equivalent delta (Δ) connected network and vice versa. This conversion simplifies circuit analysis.

Star (Y) to Delta (Δ) Conversion
Let the three star-connected resistors be:
- RA between terminal A and neutral N
- RB between terminal B and neutral N
- RC between terminal C and neutral N

We want to find equivalent delta-connected resistors:

- RAB between terminals A and B
- RBC between terminals B and C
- RCA between terminals C and A

Formula for Star to Delta Conversion

$$R_{AB} = \frac{R_A + R_B + R_A R_B / R_C}{1}$$

$$R_{BC} = \frac{R_B + R_C + R_B R_C / R_A}{1}$$

$$R_{CA} = \frac{R_C + R_A + R_C R_A / R_B}{1}$$

Or in simplified form:

$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$R_{CA} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B}$$

Where:

- RAB,RBC,RCA are the delta resistances.
- RA,RB,RC are the star resistances.

Application

- Star-delta conversions are widely used in electrical circuit analysis to simplify complex resistive networks.
- Especially useful in power systems and when solving bridge networks.

Conclusion

By converting a star network to its delta equivalent (or vice versa), we can analyze circuits more efficiently using basic series-parallel laws. This method plays a crucial role in three-phase electrical systems.

Q.2 **(a)** Explain the concept of active, reactive and apparent power. **03**

Answer:

In an AC circuit, especially with inductive or capacitive loads, power is classified into three types:

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1. Active Power (P):

- It is the actual power consumed by the load to do useful work like lighting, heating, or running motors.

- It is measured in **Watts (W)** or **kilowatts (kW)**.
- Formula:

$$P = V\, I \cos \phi$$

where ϕ is the phase angle between voltage and current.
- It represents the **real power** used by the circuit.

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2. Reactive Power (Q):
- It is the power that oscillates between the source and reactive components (inductors or capacitors).
- It does **not** perform any useful work.
- It is measured in **Volt-Ampere Reactive (VAR)** or **kVAR**.
- Formula:

$$Q = V\, I \sin \phi$$

- It accounts for the **energy stored and released** by inductive and capacitive elements.

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3. Apparent Power (S):
- It is the total power supplied by the source.
- It is the combination of both active and reactive power.
- It is measured in **Volt-Amperes (VA)** or **kVA**.
- Formula:

$$S = VI$$

Or

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

Power Triangle:
The relationship among the three powers can be represented using a right-angled triangle:

$$(\text{Apparent Power})^2 = (\text{Active Power})^2 + (\text{Reactive Power})^2$$

Conclusion:
- **Active Power (P)**: Useful power (in kW)
- **Reactive Power (Q)**: Non-working power (in kVAR)
- **Apparent Power (S)**: Total power (in kVA)

(b) Analyze voltage and current relations in three phase star connection. **04**

Answer:

In a **three-phase star (Y) connection**, the **similar ends** (either all starts or all finishes) of the three phase windings are connected at a common point called the **neutral (N)**, and the other ends are connected to the supply lines.

Voltage Relations:
Let:
- VL = Line Voltage
- Vph = Phase Voltage

In star connection:

$$V_L = \sqrt{3} \cdot V_{ph}$$

- Line voltage is **√3 times the phase voltage**.
- Line voltage is the voltage between any two lines.
- Phase voltage is the voltage between any line and the neutral.

Current Relations:
Let:

- IL = Line Current
- Iph = Phase Current

In star connection:

IL=Iph

- Line current is **equal to the phase current**.
- Same current flows through both line and phase in star connection.

Conclusion:
In star connection:

- **Line voltage is √3 times the phase voltage**
- **Line current equals phase current**

This configuration is commonly used for **long-distance transmission**, as it provides a **neutral point** and allows both **line-to-line and line-to-neutral loads**.

(c) Compare series and parallel resonance. **07**

Answer:

Comparison between Series and Parallel Resonance

Point of Comparison	Series Resonance	Parallel Resonance
1. Circuit Type	RLC elements are connected in **series**.	RLC elements are connected in **par**
2. Resonance Condition	Occurs when $X_L = X_C$ (i.e., $\omega L = \frac{1}{\omega C}$)	Same condition: $X_L = X_C$, but a parallel.
3. Impedance at Resonance	Impedance is **minimum** and equals the resistance (Z = R).	Impedance is **maximum**.
4. Current at Resonance	**Maximum current** flows through the circuit.	**Minimum current** is drawn from th
5. Power Factor	Power factor is **unity** (1).	Power factor is also **unity** (1).
6. Bandwidth	Bandwidth is $\mathrm{BW} = \frac{R}{2\pi L}$.	Bandwidth is $\mathrm{BW} = \frac{1}{2\pi RC}$.
7. Quality Factor (Q)	$Q = \frac{\omega_0 L}{R}$ — higher Q means sharper resonance.	$Q = R\sqrt{\frac{C}{L}}$ — lower Q in compa
8. Voltage and Current Behavior	High voltage across inductor or capacitor; current is in phase with voltage.	High circulating current between L and low input current.
9. Applications	Used in **tuned circuits**, radios, and filters.	Used in **filter circuits**, induction heatin etc.

OR

(c) Illustrate the Phasor diagram of RC series circuit and explain its development. **07**

Answer:

Phasor Diagram of RC Series Circuit and Its Development
An **RC series circuit** consists of a **resistor (R)** and a **capacitor (C)** connected in **series** across an alternating voltage source.

Phasor Diagram Development
Let:

- V be the total supply voltage
- VR be the voltage across the resistor
- VC be the voltage across the capacitor
- III be the current flowing through the circuit (same through R and C as they are in series)

Step-by-step Construction of the Phasor Diagram

1. **Current as Reference**:
   - In phasor diagrams, **current is taken as the reference** and drawn along the horizontal axis (0° angle).
2. **Voltage across Resistor (VR)**:
   - Since the voltage across the resistor is **in phase** with the current, draw VR along the same direction as current phasor.
3. **Voltage across Capacitor (VC)**:
   - The voltage across a capacitor **lags the current by 90°**.
   - So, draw VC **downward**, perpendicular to the current phasor.
4. **Resultant Voltage (V)**:
   - The total voltage V is the **vector sum** of VR and VC
   - It is obtained by drawing the **diagonal** of the right-angled triangle formed by VR (horizontal) and VC(vertical, downward).

Explanation

- The current in an RC circuit **leads the voltage** (since capacitor causes leading behavior).
- The angle between V and I is the **phase angle ϕ**, given by:

$$\tan(\phi) = \frac{V_C}{V_R} = \frac{1}{\omega CR}$$

- The phasor diagram helps visualize the **phase relationship** between voltage and current and the individual voltage drops.

Conclusion
The phasor diagram of an RC series circuit shows that the **current leads the voltage**, and the voltage across the capacitor **lags** the current. This diagram is essential in analyzing the phase difference and calculating impedance and power factor in AC circuits.

Q.3 **(a)** Describe concept of MMF. **03**

Answer:

MMF (Magneto Motive Force) is the magnetic equivalent of electromotive force (EMF) in an electrical circuit. It is the force that **drives magnetic flux** through a magnetic circuit, just like EMF drives electric current through an electric circuit.

Definition:

MMF is defined as the **force responsible for creating magnetic flux** in a magnetic material.

Formula:

$$MMF = N \times I$$

Where:

- N = Number of turns of the coil
- I = Current flowing through the coil (in amperes)
- MMF is measured in **Ampere-Turns (AT)**

Explanation:

When an electric current flows through a coil of wire wound around a magnetic core, it produces a magnetic field. The strength of this magnetic field depends on the **amount of current** and the **number of turns** in the coil. This product (N × I) is called **Magneto Motive Force**.

Electrical Quantity	Magnetic Equivalent
EMF (Voltage)	MMF (Ampere-Turns)
Current (I)	Magnetic Flux (Φ)
Resistance (R)	Reluctance ($\Re$)

Conclusion:

MMF is the cause of magnetic flux in a magnetic circuit, similar to how voltage causes current in an electric circuit. It is measured in Ampere-Turns and is given by the product of the number of turns and current.

(b) Define flux, flux density, reluctance and permeability. **04**

Answer:

1. Magnetic Flux (ϕ):

- Magnetic flux is the **total magnetic field** passing through a given area.
- It represents the **quantity of magnetic lines of force**.
- Unit: **Weber (Wb)**
- Symbol: **ϕ**

$$\phi = B \times A$$

Where,
B = Flux density (Wb/m²),
A = Area (m²)

2. Flux Density (B):

- Flux density is the **magnetic flux per unit area** perpendicular to the direction of the magnetic field.
- It indicates the **concentration of magnetic field lines**.
- Unit: **Weber per square meter (Wb/m²)** or **Tesla (T)**
- Symbol: **B**

$$B = \phi / A$$

3. Reluctance ($\mathscr{R}$):

- Reluctance is the **opposition offered by a material** to the passage of magnetic flux, similar to resistance in an electric circuit.
- Unit: **Ampere-Turns per Weber (AT/Wb)**
- Symbol: $\mathscr{R}$

$$R = l / \mu A$$

Where,
l = Length of magnetic path (m),
μ = Permeability (H/m),
A = Cross-sectional area (m²)

4. Permeability (μ):

- Permeability is the **measure of the ability of a material to conduct magnetic flux**.
- Higher permeability means the material allows more flux to pass through.
- Unit: **Henry per meter (H/m)**
- Symbol: **μ**

$$\mu = \mu 0 \cdot \mu r$$

Where,
μ0 = Permeability of free space
μr = Relative permeability of the material

(c) Compare Split phase and Capacitor start motors. **07**

Answer:

Comparison between Split Phase Motor and Capacitor Start Motor

Point of Comparison	Split Phase Motor	Capacitor Start Motor
1. Starting Mechanism	Uses an auxiliary winding with higher resistance.	Uses an auxiliary winding with a **capacitor in series**.
2. Phase Difference	Produces a small phase difference (~30°) between windings.	Produces a large phase difference (~80° to 90°), improving torque.
3. Starting Torque	**Low starting torque** (1.5 to 2 times full-load torque).	**High starting torque** (3 to 4.5 times full-load torque).
4. Capacitor Usage	**No capacitor** is used.	Uses a **capacitor** only during starting (disconnected later).
5. Centrifugal Switch	Disconnects the auxiliary winding after starting.	Disconnects both auxiliary winding and capacitor after starting.
6. Cost and Construction	Simpler and cheaper.	Slightly more expensive due to the capacitor.
7. Applications	Suitable for **fans, blowers, small tools**.	Suitable for **compressors, pumps, refrigerators** where high starting torque is needed.

8. Efficiency and Performance	Moderate performance and efficiency.	Better performance due to improved starting characteristics.

OR

Q.3 **(a)** Describe Construction and working of brushless DC motor. **03**

Answer:

1. Construction of Brushless DC Motor:

A **Brushless DC (BLDC) motor** consists of the following main parts:

- **Stator:**
    - The stator is the stationary part and has **windings** placed in slots.
    - It is similar to the stator of a 3-phase induction motor.
    - The windings are connected to an **electronic controller**.
- **Rotor:**
    - The rotor is the rotating part and carries **permanent magnets**.
    - The number of poles may vary (2-pole, 4-pole, etc.).
- **Position Sensors (Hall Sensors):**
    - These detect the rotor position and send signals to the controller for proper switching.
- **Electronic Controller:**
    - It replaces the mechanical commutator and brushes.
    - It uses signals from position sensors to energize stator windings in sequence.

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2. Working of Brushless DC Motor:

- When DC supply is given to the **electronic controller**, it converts DC into a controlled three-phase supply for the stator.
- Based on the **rotor position**, the controller energizes specific stator windings.
- This creates a **rotating magnetic field** in the stator.
- The permanent magnets on the rotor align with the rotating field, causing the rotor to turn.
- As the rotor moves, the position sensors continuously update the controller to switch the stator phases at the correct time, ensuring **smooth rotation**.

Conclusion:

A **BLDC motor** operates without brushes and uses an electronic controller for commutation. It is efficient, requires less maintenance, and is widely used in fans, electric vehicles, drones, and industrial machines.

(b) Examine construction of single phase induction motor. **04**

Answer:

A **single-phase induction motor** is widely used in domestic and small industrial applications. It operates on **single-phase AC supply** and consists of two main parts: the **stator** and the **rotor**.

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1. Stator:

- The **stator** is the **stationary part** of the motor.
- It is made up of **laminated steel sheets** and has **slots** on the inner periphery to accommodate the **stator winding**.
- The winding is connected to a **single-phase AC supply**.
- In split-phase or capacitor-type motors, **auxiliary windings** are also provided for starting.

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2. Rotor:

- The **rotor** is the **rotating part**, placed inside the stator.
- Most commonly, it is a **squirrel cage type** rotor made of laminated iron core with aluminum or copper bars short-circuited at both ends by end rings.
- The rotor does **not have any external electrical connection**; it rotates by the action of the rotating magnetic field induced by the stator.

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3. Shaft and Bearings:

- The rotor is mounted on a **shaft**, supported by **ball bearings** on both ends, to reduce friction and ensure smooth rotation.

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4. Fan and Casing:

- A **cooling fan** is often fitted at the non-driving end to keep the motor from overheating.
- The entire assembly is enclosed in a **protective casing** made of metal or strong plastic.

Conclusion:
The simple and robust construction of a single-phase induction motor makes it **cost-effective, reliable, and easy to maintain**, suitable for fans, pumps, washing machines, and other household appliances.

(c) Explain B-H Curve and Hysteresis Loop in detail. **07**

Answer:

B-H Curve and Hysteresis Loop
The **B-H curve** (Magnetization curve) and **Hysteresis Loop** describe how a magnetic material responds to an external magnetic field. These are fundamental in understanding the magnetic behavior of materials used in electrical machines like transformers, motors, etc.

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1. B-H Curve

- The **B-H curve** is a graph between:
  - Magnetic flux density **(B)** on the vertical axis
  - Magnetic field strength **(H)** on the horizontal axis
- It shows how **magnetization (B)** of a material increases with applied magnetizing force **(H)**.

Development of the Curve

- Initially, when H increases, B increases rapidly and **almost linearly**.

- As H continues to increase, B **saturates** (i.e., further increase in H causes very little increase in B).
- This curve shows how easily a material can be magnetized.

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2. Hysteresis Loop
When the magnetic field (H) is varied cyclically (positive to negative and back), the B-H curve forms a **loop**, known as the **hysteresis loop**.
Key Points on the Loop

1. **Initial Magnetization**: Starting from zero, when H is increased, B increases and follows a curve until **saturation**.
2. **Retentivity (or Remanence)**: When H = 0 after saturation, some B remains. This value of B is called **retentivity**.
3. **Coercivity**: The negative value of H required to bring B back to zero is called **coercivity**.
4. **Negative Saturation**: On increasing H in the negative direction, the material reaches **negative saturation**.
5. **Loop Formation**: The same process in reverse completes the loop.

3. Importance of Hysteresis Loop

- **Soft magnetic materials** (like silicon steel):
  - Narrow loop → **low hysteresis loss**, used in transformers.
- **Hard magnetic materials** (like Alnico):
  - Wide loop → **high retentivity and coercivity**, used in permanent magnets.

Conclusion
The **B-H curve** shows how a material responds to magnetization, while the **hysteresis loop** indicates **magnetic memory** and **energy loss** in magnetic materials. This concept is crucial for the design of electrical machines and magnetic devices.

Q.4 **(a)** List components of low tension switchgear. **03**

Answer:

Low Tension (LT) switchgear is used for electrical systems operating at voltages up to 1000 volts AC. It is used to protect, control, and isolate electrical equipment in low voltage power distribution.

The main components of LT switchgear are:

1. **Switches:**
   - Used to manually open or close an electrical circuit.
   - Types include air break switches and isolators.
2. **Fuses:**
   - Protect electrical circuits from overcurrent by melting the fuse element when current exceeds the rated value.
3. **Miniature Circuit Breakers (MCB):**
   - Automatically switch off the circuit in case of overcurrent or short circuit.
   - Used in residential and commercial installations.
4. **Moulded Case Circuit Breakers (MCCB):**

- Used for higher current ratings than MCBs.
- Provide protection against overload, short circuit, and earth fault.

5. **Earth Leakage Circuit Breaker (ELCB) / Residual Current Circuit Breaker (RCCB):**
   - Detect leakage current to earth and disconnect the supply to prevent electric shock.
6. **Contactors:**
   - Electrically operated switches used for controlling large loads like motors.
7. **Relays:**
   - Sense fault conditions and send signals to circuit breakers for disconnection.
8. **Distribution Boards (DB):**
   - House the protective devices and help in organized power distribution to various circuits.

(b) Define types of lamps for industrial and residential premises. **04**

Answer:

Different types of lamps are used in **industrial** and **residential** premises based on requirements like intensity, efficiency, color, and cost.

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1. Incandescent Lamp:
- Produces light by heating a tungsten filament until it glows.
- Used in **residential** premises for low-cost and warm lighting.
- **Low efficiency**, short life span.

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2. Fluorescent Lamp (Tube Light):
- Works on the principle of **gas discharge** and **phosphor coating**.
- Common in both **residential and industrial** premises.
- **More efficient** and **longer life** than incandescent lamps.

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3. Compact Fluorescent Lamp (CFL):
- Miniature version of tube light, with integrated electronic ballast.
- Used widely in **homes and offices**.
- Consumes **less energy**, fits into standard bulb sockets.

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4. LED Lamp (Light Emitting Diode):
- Uses semiconductors to emit light when current passes through.
- Popular in both **residential and industrial** applications.
- **Highly energy-efficient**, long life, and low heat production.

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5. Mercury Vapor Lamp:
- High-intensity lamp used in **industrial areas**, warehouses, and street lighting.
- Emits bright light; takes time to start.

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6. Metal Halide Lamp:
- Used in **industrial lighting**, stadiums, and outdoor spaces.
- Provides **high-intensity white light** and good color rendering.

7. Sodium Vapor Lamp:

- Common in **street lighting and industrial yards**.
- **High efficiency**, emits yellow-orange light.

Conclusion:
Selection of lamps depends on the **purpose**, **brightness requirement**, **energy efficiency**, and **cost** considerations.
LEDs and CFLs are preferred for residential use, while mercury vapor, metal halide, and sodium vapor lamps are more suitable for industrial settings.

(c) Explain Lumen requirements for different categories. **07**

Answer:

Lumen Requirements for Different Categories

Lumen is a unit of **luminous flux**, which measures the total quantity of visible light emitted by a source. The **lumen requirement** for a given area depends on the **type of activity** and the **illumination level** required.

Illumination is measured in **lux** (lumens per square meter), and the number of lumens required is based on the **standard lighting recommendations** for different environments.

Typical Lumen Requirements by Category

Category	Application Area	Illumination Level (in lux)	Required Lumens per sq. meter
1. Residential Areas	Living room, Bedroom	100 – 300 lux	100 – 300 lumens
2. Kitchens / Bathrooms	Where detail work is done	300 – 500 lux	300 – 500 lumens
3. Offices	General office work, reading, writing	300 – 500 lux	300 – 500 lumens
4. Schools / Classrooms	Study, reading, writing	300 – 500 lux	300 – 500 lumens
5. Laboratories / Workshops	Precision and technical work	500 – 1000 lux	500 – 1000 lumens
6. Hospitals / Clinics	Patient rooms	100 – 300 lux	100 – 300 lumens
	Operating theaters	1000 – 2000 lux	1000 – 2000 lumens
7. Industrial Areas	Assembly lines, manufacturing	300 – 750 lux	300 – 750 lumens
8. Corridors / Stairways	Pathways and general movement	75 – 150 lux	75 – 150 lumens
9. Libraries	Reading areas	300 – 500 lux	300 – 500 lumens
10. Outdoor Lighting	Streets, parking, security	10 – 100 lux	10 – 100 lumens

Key Points

- **Higher lux** is required where **detailed or precision tasks** are performed.
- **Lower lux** is acceptable in areas like corridors, lobbies, or restrooms.
- Proper lumen selection enhances **visual comfort**, reduces **eye strain**, and improves **efficiency and safety**.

OR

Q.4 **(a)** Describe working of MCB. **03**

Answer:

MCB (Miniature Circuit Breaker) is an automatic switching device used to **protect electrical circuits from overcurrent and short circuits** in low-voltage systems. It trips (opens the circuit) when the current exceeds a safe limit.

Working of MCB:
An MCB operates using **two mechanisms**:

1. **Thermal Operation (for Overload Protection):**
    - A **bimetallic strip** is used inside the MCB.
    - When excess current flows for a longer duration, the strip **heats up and bends** due to the difference in expansion of the metals.
    - This mechanical movement **trips the latch** and opens the circuit, stopping the current flow.
2. **Magnetic Operation (for Short-Circuit Protection):**
    - A **solenoid coil** produces a magnetic field when very high current flows (such as in a short circuit).
    - The magnetic field pulls a **plunger or lever**, which **instantly trips** the MCB.
    - This provides **fast disconnection** during short-circuit faults.

Resetting:
- After the fault is cleared, the MCB can be **manually reset** without replacing any parts (unlike a fuse).

Conclusion:
MCB detects overcurrent due to overload or short circuit using thermal and magnetic mechanisms. It then automatically disconnects the power to protect electrical equipment and wiring.

(b) State different parts with neat and clean diagram of MCCB. **04**

Answer:

MCCB – Moulded Case Circuit Breaker:
An **MCCB** is an electrical protection device used to **protect circuits from overcurrent**, short circuits, and faults in both **industrial and commercial** systems.

Main Parts of MCCB:

1. **Frame (Moulded Case):**
   - Outer casing made of insulating material.
   - Provides **mechanical protection** and insulation.
2. **Operating Mechanism:**
   - Handle or toggle switch used to **manually turn ON or OFF** the MCCB.
3. **Contacts:**
   - Includes fixed and moving contacts.
   - **Closes or opens the circuit** when operated or during fault conditions.
4. **Arc Chute:**
   - Quenches the arc formed when the contacts open during fault.
   - Made of **metal plates or grids**.
5. **Trip Unit:**
   - Automatically opens the MCCB during **overload or short circuit**.
   - Can be **thermal**, **magnetic**, or **electronic** type.
6. **Terminal Connectors:**
   - For input and output **cable connection**.

Conclusion:
MCCBs are widely used for **high current protection**, **motor control**, and **industrial circuit protection**, providing reliable safety and manual control in power systems.

(c) Explain working principal of energy meter. **07**

Answer:

Working Principle of Energy Meter
An **energy meter** (also known as a **watt-hour meter**) is a device used to measure the **electrical energy consumed** by a residence, business, or electrically powered device. It measures energy in **kilowatt-hours (kWh)**.

Type of Meter:
For single-phase supply, the commonly used meter is an **induction-type energy meter**.

Working Principle:
The energy meter works on the **electromagnetic induction principle**.
It operates based on the interaction of magnetic fields produced by:

1. **Voltage Coil (Shunt Coil)**
2. **Current Coil (Series Coil)**

These coils produce magnetic fluxes that interact and induce eddy currents in a rotating aluminum disc. The **torque** produced by the interaction of these fluxes and eddy currents causes the disc to rotate.

Main Components and Their Functions:

Component	Function
Voltage Coil	Connected in parallel with the load; produces magnetic flux proportional to voltage.
Current Coil	Connected in series with the load; produces magnetic flux proportional to current.

Aluminum Disc	Rotates due to torque developed by eddy currents.
Permanent Magnet	Produces braking torque to control disc speed.
Gear and Dial System	Converts disc rotation into energy reading in kWh.

Operation in Detail:

- The **voltage coil** creates a flux that lags the voltage by 90°.
- The **current coil** produces a flux that is in phase with the current.
- The interaction of these two fluxes produces a **driving torque** proportional to the **power consumed**.
- The **aluminum disc** rotates due to this torque.
- The **number of revolutions** of the disc is proportional to the energy consumed.
- A **braking magnet** produces a braking torque proportional to speed, thus controlling rotation.

Equation:

$$\text{Energy Consumed} = \text{Power} \times \text{Time} = V \cdot I \cdot \cos\phi \cdot t$$

$$\text{Energy (in kWh)} = \frac{\text{Number of Revolutions}}{\text{Meter Constant (rev/kWh)}}$$

Conclusion:
An **energy meter** accurately measures the total energy used over time using **electromagnetic induction**. It is an essential instrument for utility companies to bill customers for electrical energy consumption.

Q.5 **(a)** List various methods of earthing. **03**

Answer:

Earthing is the process of connecting the non-current carrying parts of electrical equipment or the neutral point of a power system to the ground to ensure safety and prevent electric shock.

The **various methods of earthing** are:

1. **Plate Earthing:**
   - A **copper or galvanized iron plate** is buried vertically in the ground.
   - Charcoal and salt are placed around the plate to maintain moisture and reduce resistance.
2. **Pipe Earthing:**
   - A **GI pipe (usually 38 mm in diameter and 2 m long)** is placed vertically into the ground.
   - This is the most common and efficient method of earthing.
3. **Rod Earthing:**
   - A **copper or GI rod** is driven into the earth.
   - It is a simple and economical method used for temporary installations.

4. **Strip or Wire Earthing:**
    - A **strip or wire** of copper or GI is buried in a horizontal trench.
    - Used in areas with rocky soil where other methods are not feasible.
5. **Earthing through Water Mains:** *(Not recommended now)*
    - The metallic water piping system is used for earthing.
    - This method is outdated and not reliable.

Conclusion:

The main methods of earthing include **plate earthing**, **pipe earthing**, **rod earthing**, and **strip earthing**, each chosen based on soil conditions, installation type, and cost.

(b) Describe the necessity of using electrical protective devices. **04**

Answer:

Necessity of Electrical Protective Devices:
Electrical protective devices are essential components in electrical systems to ensure **safety, reliability, and damage prevention**. Their use is necessary for the following reasons:

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1. Protection of Human Life:
- Prevents **electric shock**, **fire**, or injury caused by faults such as short circuits or leakage currents.
- Devices like **earth leakage circuit breakers (ELCB)** disconnect power during unsafe conditions.

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2. Protection of Equipment:
- Sensitive electrical equipment can be **damaged by overcurrent, voltage surges, or short circuits**.
- **Fuses**, **MCBs**, and **MCCBs** protect motors, transformers, and appliances from permanent damage.

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3. Prevent Fire Hazards:
- Excessive current or faulty wiring can lead to **overheating and fire**.
- Protective devices **interrupt the circuit** before it reaches dangerous levels.

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4. Maintain System Stability and Reliability:
- Ensures that **only the faulty section** is isolated without disturbing the entire system.
- Devices like **relays and circuit breakers** help in **coordinated protection** of the system.

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5. Compliance with Standards and Safety Codes:

- Use of protective devices is **mandatory** as per **IS/IEC standards** and government regulations for electrical installations.

Common Electrical Protective Devices:

- **Fuse**
- **MCB (Miniature Circuit Breaker)**
- **MCCB (Moulded Case Circuit Breaker)**
- **ELCB (Earth Leakage Circuit Breaker)**
- **Relays and Circuit Breakers**

Conclusion:

Electrical protective devices are **vital for safe and efficient operation** of electrical systems. They **protect life, property, and equipment** by quickly responding to abnormal conditions.

(c) Explain Pipe earthing. **07**

Answer:

Pipe Earthing

Pipe earthing is one of the most commonly used methods of **earthing** in electrical installations, especially in moist soil conditions. It is reliable, simple, and highly effective in providing a low-resistance path to ground for fault current.

Definition:

Pipe earthing is a method in which a **galvanized iron (GI) pipe** is used as the earth electrode. It is placed vertically in the ground to connect the non-current carrying metal parts of electrical equipment to the earth.

Construction Details:

- **Pipe Used:** Galvanized iron (GI) pipe of 38 mm diameter and 2 to 3 meters in length (longer for dry areas).
- **Depth of Installation:** The pipe is buried vertically in a pit of depth **2.5 to 3.0 meters** depending on soil moisture.
- **Soil Treatment:** The pit is filled with layers of **charcoal and salt** alternately around the pipe to maintain soil conductivity and reduce earth resistance.
- **Earthing Lead:** A **GI strip or wire** is connected to the top of the pipe to connect to the electrical system.
- **Watering Arrangement:** A **funnel with a mesh** is fitted at the top of the pipe to allow water to be poured in, keeping the surrounding soil moist and ensuring consistent earthing resistance.

Advantages of Pipe Earthing:

- Provides low earth resistance.
- Effective in **moist soil** conditions.
- Requires less space.
- Long-lasting and **low maintenance**.

Applications:

- Used in **residential buildings**, **substations**, **transformers**, and **industrial setups**.

- Ideal for places with **high soil resistivity** where plate earthing may not be effective.

Conclusion:
Pipe earthing is a highly effective method of earthing that ensures the **safety of equipment and personnel** by safely discharging fault currents to the ground. It is cost-effective, durable, and widely adopted in both domestic and industrial electrical systems.

OR

Q.5 **(a)** State important characteristics of batteries. **03**

Answer:
A **battery** is a device that stores electrical energy in chemical form and supplies it as direct current (DC) when needed. The important characteristics of a battery are:

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1. Voltage (V):

- It is the **electrical potential difference** between the battery terminals.
- A single cell typically provides 1.5 V (dry cell) or 2 V (lead-acid cell).
- Battery voltage depends on the number of cells connected in series.

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2. Capacity (Ah or mAh):

- Battery capacity is the amount of **charge it can deliver** over time.
- Measured in **ampere-hours (Ah)** or **milliampere-hours (mAh)**.
- Indicates how long the battery can supply current.

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3. Efficiency:

- Ratio of output energy to input energy during a full charge-discharge cycle.
- It is expressed as a percentage (%).
- Depends on battery type and usage conditions.

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4. Internal Resistance:

- It is the **resistance offered by the battery's internal components** to current flow.
- A lower internal resistance means better performance and less heat loss.

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5. Shelf Life and Life Cycle:

- **Shelf life** is the time a battery can retain its charge when not in use.
- **Cycle life** is the number of charge-discharge cycles the battery can undergo before it degrades.

Conclusion:
Important battery characteristics include **voltage**, **capacity**, **efficiency**, **internal resistance**, and **life span**, all of which determine its suitability for different electrical applications.

(b) State safety precautions of electrical appliances. **04**

Answer:

To ensure the safe use of electrical appliances and to prevent accidents, the following **safety precautions** must be observed:

1. Use Proper Earthing:

- Always ensure electrical appliances are **properly earthed**.
- Prevents electric shock in case of insulation failure.

2. Avoid Wet Hands:

- **Do not operate electrical appliances with wet hands** or in damp conditions.
- Water conducts electricity and increases the risk of **electric shock**.

3. Do Not Overload Sockets:

- Avoid connecting **multiple high-power appliances** into a single socket.
- Overloading can cause **heating, fire, or fuse blowout**.

4. Use ISI Marked Appliances:

- Always use **quality-certified appliances (ISI marked)** that comply with safety standards.

5. Switch Off When Not in Use:

- **Always switch off appliances** after use and unplug them during maintenance or cleaning.
- Prevents unnecessary power consumption and accidents.

6. Regular Inspection:

- Periodically check for **damaged wires, loose plugs, or faulty switches**.
- Replace damaged cords immediately.

7. Keep Away from Flammable Materials:

- Keep electrical appliances away from **curtains, paper, or other flammable materials** to avoid fire hazards.

8. Use Correct Rating Fuse or MCB:

- Always use **fuses or MCBs of correct current rating** to protect the appliance from overcurrent.

Conclusion:
Following these safety precautions ensures **protection of life, property, and equipment** while using electrical appliances in homes, labs, and industries.

(c) Explain plate earthing. **07**

Answer:

Plate Earthing

Plate earthing is one of the conventional methods of earthing in which a metal plate is buried in the ground to safely dissipate the fault current into the earth. This method is commonly used in residential, commercial, and industrial electrical installations.

Definition:

Plate earthing is a method in which a **copper or galvanized iron (GI) plate** is buried vertically in the earth and connected to the electrical system to provide a **low-resistance path** for leakage or fault currents to the ground.

Construction Details:

- **Plate Used:**
  - **Copper Plate** of size **600 mm × 600 mm × 3.18 mm**, or
  - **GI Plate** of size **600 mm × 600 mm × 6.35 mm**
- **Depth of Burial:**
  The plate is buried **vertically** at a depth of **3.0 to 3.5 meters** from the ground level, depending on the soil condition.
- **Soil Treatment:**
  The pit is filled with alternate layers of **charcoal and salt** around the plate. This helps maintain **low earth resistance** by retaining moisture.
- **Earthing Lead:**
  A **GI strip** or **copper wire** is securely connected to the plate and brought up to ground level to connect with the electrical system.
- **Watering Arrangement:**
  A **GI pipe** is fitted vertically with a **funnel and mesh** on top, used to **pour water** to keep the surroundings of the plate moist.

Advantages:

- Provides a **safe discharge path** for fault current.
- Maintains **low resistance** over time, especially with regular watering.
- Simple and effective for both domestic and industrial setups.

Applications:

- Electrical installations in **residential buildings**.
- **Substations, transformers**, and **switchgear** installations.
- Places where **deep earthing** is possible and necessary.

Conclusion:

Plate earthing is a widely accepted and reliable method for earthing electrical installations. It ensures safety by discharging fault currents into the earth and preventing electric shock hazards and equipment damage.

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