<u>Short question and answer[each carrying 2 marks]</u>

1. **Which types relay is used for long distance very high voltage transmission line?**

Ans: MHO relay is used for long distance very high voltage transmission line

2. **What are the advantage and disadvantage of electromagnetic relay?**

Ans: **advantage:**

- Electromagnetic relays have fast operation and fast reset
- They can be used for both ac and dc systems for protection of ac and dc equipments
- Electromagnetic relays operating speeds which has the ability to operate in milliseconds are also can be possible
- They have the properties such as simple, robust, compact and most reliable disadvantage
- High burden level instrument transformers are required (CTs and PTs of high burden is required for operating the electromagnetic relays compared to static relays)
- The directional feature is absent in electromagnetic relay
- Requires periodic maintenance and testing unlike static relays

3. **What are the advantages of static relay over electromagnetic relay?**

The advantages of static relay over electromagnetic relay

- The static relay consumes very less power because of which the burden on the measuring instruments decreases and their accuracy increases.
- The static relay gives the quick response, long life, high reliability and accuracy and it is shockproof.
- The reset time of the relay is very less.
- It does not have any thermal storage problems.
- The relay amplifies the input signal which increases their sensitivity.

4. **What is reach of relay**?

Ans: distance relay operates whenever the impedance seen by the relay is less than pre-specified value. This impedance or the corresponding distance is known as reach of relay. Reach may be defined as the limiting distance covered by the protection.

5. **What would be the PSM of relay when the fault current is 120A and plug setting is 1.2 and ct ratio is 50:1?**

Ans: fault current in relay coil =120x$\frac{1}{50}$ =2.4 A

PSM=$\frac{\text{FAULT CURRENT IN RELAY COIL}}{\textit{RATED SECONDARY CURRENT OF CTXCURRENT SETTING}}$ =2

6. **What is the limitation of merz price protection**?

Ans: The limitations of merz price protection are

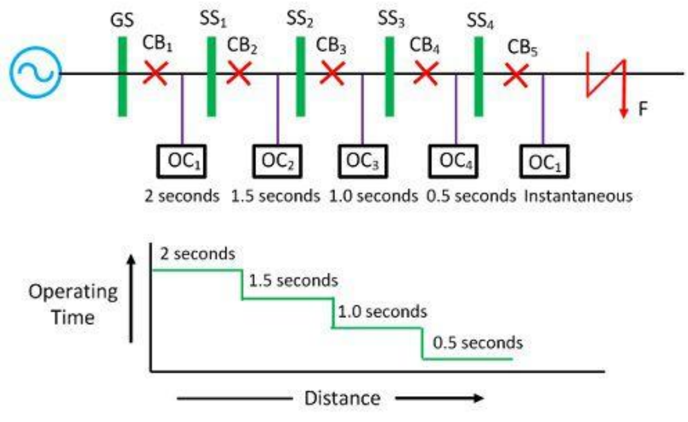
- The impedance of the pilot cable generally cause a slight difference between the current at the two end of the section to be protected
- Pilot cable capacitance cause incorrect operation of relay when large current flows.
- Accurate matching of current transformer cannot be achieved due to pilot circuit impedance.

7. **What is the meaning of under reach of relay?**

Ans: **under reach:** the extra impedance introduce by the arc into the fault loop affect the distance measured by the relay and cause it to under reach .underreach is just reverse of overreach. And may be defined as the failure of distance relay to operate within the set protected distance.

8. **What do you understand time grading. Give example**.

This is a scheme in which the time setting of relays is so consecutive that in the event of a fault, the smallest possible part of the system is isolated.



Time Graded Protection for Radial Feeders

9. Define following term (i)burden (ii) pick up (iii) reset (iv) operating time

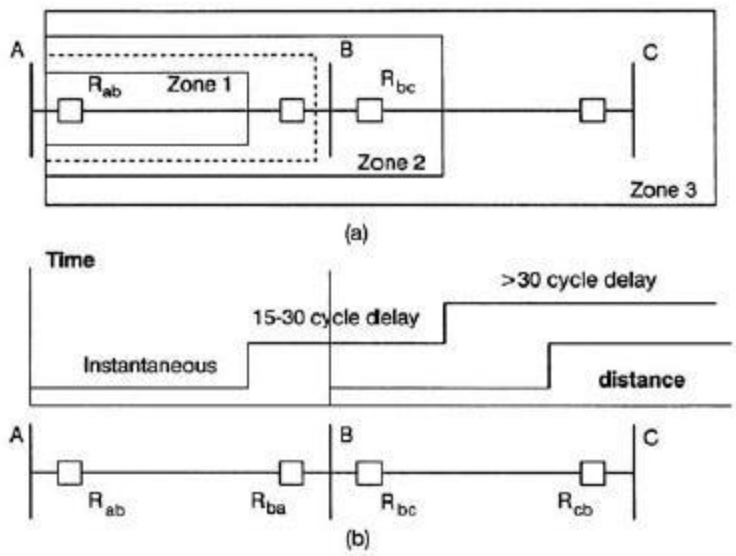
Ans: burden: it is the value of power consumed by the relay circuit at the rated current and voltage and is expressed in VA for ac and watt for dc.

Pick up: a relay is said to pickup when it moves from off position to on position. The value of characteristic quantity above which the change occurs is known as pickup value.

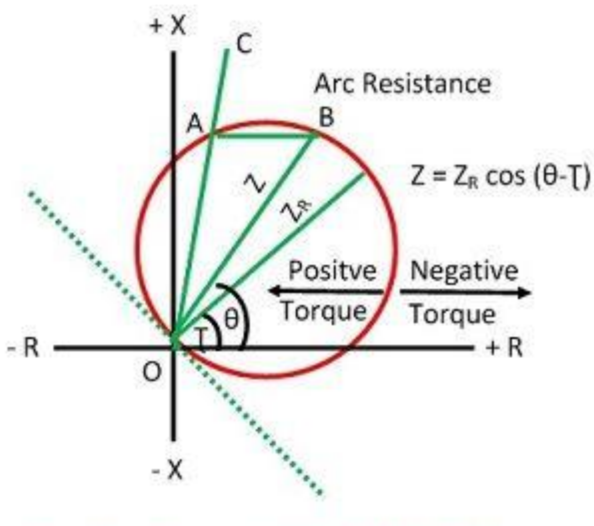
Reset: the relay is said to be reset when it moves from on position to off position.

Operating time: It is defined as the time period extended from the occurrence of the fault through the relay detecting the fault to the operation of the relay.

10.Draw the scheme of three stepped distance protection



11. Draw the typically characteristic of mho relay.



Operating Characteristic of Mho Relay

12. **What is the concept of unit and non unit protection**?

Ans: A unit protective system is one in which the protection scheme responds to faults in the

Protected zone alone whereas non-unit system does not have exact zone boundaries. Each zone has certain protective scheme and each protective scheme has several protective systems.

13. Distinguish the term OVER VOLTAGE and OVER CURRENT.

Ans: **OVER VOLTAGE:** When the voltage in a circuit or part of it is raised above its upper design limit, this is known as overvoltage. The conditions may be hazardous. Depending on its duration, the overvoltage event can be transient—a voltage spike—or permanent, leading to a power surge.

OVER CURRENT: current beyond rated value is known as over current

What is the full form of IDMT relay and where such relay is used?

ANS: the full form of IDMT is inverse definite minimum time and is used in protection of radial or loop feeder

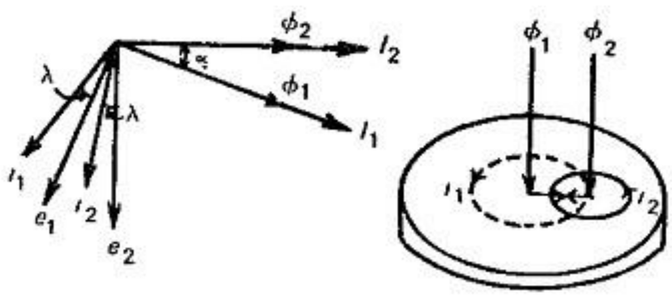
14. What is the limitation of over current relay used for the protection of transmission line?

Ans: as the fault in transmission line and source impedance are unpredictable and variable, proper selection cannot be made and loss of selectivity can lead to danger to the stability of the line and to the power system. Large fluctuation of load may cause improper synchronization of relay.

FOCUSED TYPE SHORT QUESTION AND ANSWER

1. Discuss the theory of induction relay torque with mathematical derivations.

Ans: In Induction Relay Torque Equation, Two magnetic fluxes Φ_1 and Φ_2 differing in time phase penetrate through a disc. These alternating fluxes induce emfs e_1 and e_2 in the disc which lag their respective fluxes by 90°. These emfs lead to the flow of eddy currents i_1 and i_2. By the interaction of Φ_1 with i_2 and Φ_2 with i_1 a driving torque is produced. The currents i1 and i2 lag the voltages e1 and e2 by the impedance angle λ of the disc. Figure shows the vector diagram.



Principle of induction relay torque.

$$\phi_1 \propto |I_1| \sin \omega t$$
$$\phi_2 \propto |I_2| \sin (\omega t + \alpha)$$
$$e_1 \propto \frac{d\phi_1}{dt} \propto \omega |I_1| \cos \omega t$$
$$e_2 \propto \frac{d\phi_2}{dt} \propto \omega |I_2| \cos (\omega t + \alpha)$$
$$i_1 \propto \omega |I_1| \cos (\omega t - \lambda)$$
$$i_2 \propto \omega |I_2| \cos (\omega t + \alpha - \lambda)$$

Therefore, the resultant torque is given by.

$$T \propto \phi_2 i_1 - \phi_1 i_2$$
$$\propto \omega |I_1||I_2| [\sin (\omega t + \alpha) \cos (\omega t - \lambda) - \sin \omega t \cos (\omega t + \alpha - \lambda)]$$
$$\propto \omega |I_1||I_2| \sin \alpha \cos \lambda$$
$$T \propto \omega |I_1||I_2| \sin \alpha$$

Thus the induction relay is a sine comparator in which the maximum torque is developed when α is 90° or 270° and zero torque when α is 0° or 180°.

2. Analyze phase comparator with proper equation

Let us first derive the general threshold equation assuming that there are two input signals $S_1$and S_2 such that when the phase relationship or magnitude relationship fulfills pre-determined threshold conditions, tripping is initiated. The input signals are derived from the system through instrument transformers (CTs and/or PTs). In case the two quantities to be compared are different (i.e., voltage and current), some form of mixing device, such as current voltage transformer is required.

Let the two input signals be represented as –

$$\left.\begin{aligned} \mathbf{S}_1 &= \mathbf{K}_1\mathbf{A} + \mathbf{K}_2\mathbf{B} \\ \mathbf{S}_2 &= \mathbf{K}_3\mathbf{A} + \mathbf{K}_4\mathbf{B} \end{aligned}\right\} \quad \text{and} \quad \ldots(3.1)$$

Where, A and B are the primary system quantities, K_1 and K_3 are the scalar numbers and $|K_2|$and $|K_4|$ are the complex numbers with angles θ_2 and θ_4 respectively. Taking A as the reference phasor and phasor B to lag A by an angle ϕ. Then the above equation can be rewritten as –

$S_1 = K_1 |A| + |K_2||B| \{\cos(\theta_2 - \phi) + j \sin(\theta_2 - \phi)\}$

And $S_2 = K_3|A| + |K_4||B| \{\cos(\theta_4 - \phi) + j \sin(\theta_4 - \phi\}$ … (3.2)

Analysis for Amplitude Comparator:

If the operating criterion is given by $|S_1| \geq |S_2|$ then at the threshold of operation-

$$|S_1| = |S_2|$$

$$\text{or} \quad \{K_1|A| + |K_2||B| \cos(\theta_2 - \phi)\}^2 + \{|K_2||B| \sin(\theta_2 - \phi)\}^2$$
$$= \{K_3|A| + |K_4|^2 |B| \cos(\theta_4 - \phi)\}^2 + \{|K_4|^2 |B| \sin(\theta_4 - \phi)\}^2$$

Rearranging the terms we have

$$(K_1^2 - K_3^2)|A|^2 + 2|A||B| \{K_1|K_2| \cos(\theta_2 - \phi) - K_3|K_4| \cos(\theta_4 - \phi)\}$$
$$+ |K_2|^2 |B|^2 \cos^2(\theta_2 - \phi) - |K_4|^2 |B^2| \cos^2(\theta_4 - \phi)$$
$$+ |B|^2\{|K_2|^2 \sin^2(\theta_2 - \phi) - |K_4|^2 \sin^2(\theta_4 - \phi)\} = 0$$

$$\text{or} \quad (K_1^2 - K_3^2)|A|^2 + 2|A||B| \{K_1|K_2| \cos(\theta_2 - \phi) - K_3|K_4| \cos(\theta_4 - \phi)\} + (|K_2|^2 - |K_4|^2)|B^2| = 0 \quad \ldots(3.3)$$

Dividing by $(|K_2|^2 - |K_4|^2)\,|A|^2$ and rearranging the terms we have

$$\left|\frac{B}{A}\right|^2 + 2\left|\frac{B}{A}\right| \frac{(K_1|K_2|\cos\theta_2 - K_3|K_4|\cos\theta_4)\cos\phi + (K_1|K_2|\sin\theta_2 - K_3|K_4|\sin\theta_4)\sin\phi}{|K_2|^2 - |K_4|^2} + \frac{K_1^2 - K_3^2}{|K_2|^2 - |K_4|^2} = 0$$

$$\text{or} \quad \left|\frac{B}{A}\right|^2 + 2\left|\frac{B}{A}\right| (A_0 \cos\phi + B_0 \sin\phi) + C_0 = 0 \quad \ldots(3.4)$$

$$\text{where } A_0 = \frac{K_1|K_2|\cos\theta_2 - K_3|K_4|\cos\theta_4}{|K_2|^2 - |K_4|^2};$$

$$B_0 = \frac{K_1|K_2|\sin\theta_2 - K_3|K_4|\sin\theta_4}{|K_2|^2 - |K_4|^2}$$

$$\text{and } C_0 = \frac{K_1^2 - K_3^2}{|K_2|^2 - |K_4|^2}$$

Equation (3.4) represents the equation of a circle on the β-plane having $\left|\frac{B}{A}\right| \cos\phi$ and $j\left|\frac{B}{A}\right| \sin\phi$ as coordinates. This circle has radius

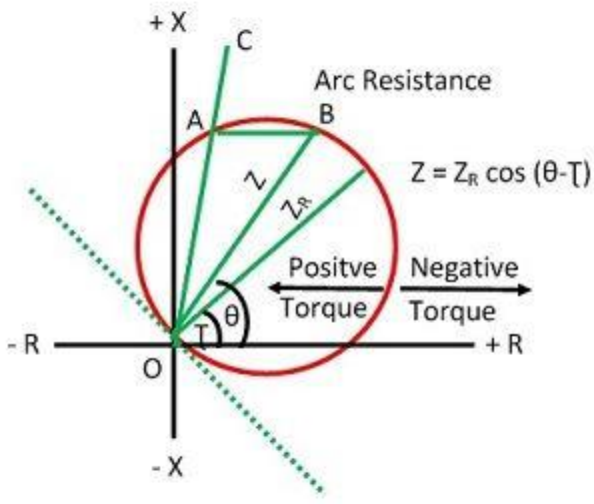
$$r = \frac{\sqrt{K_1^2 |K_4|^2 + |K_2|^2 K_3^2 - 2K_1 |K_2| K_3 |K_4| \cos(\theta_2 - \theta_4)}}{|K_2|^2 - |K_4|^2}$$

and coordinates of the centre are (c, ϕ) where

$$c = \frac{\sqrt{K_1^2 |K_2|^2 + K_3^2 |K_4|^2 - 2K_1 |K_2| K_3 |K_4| \cos(\theta_2 - \theta_4)}}{|K_2|^2 - |K_4|^2}$$

3. Draw the characteristics of mho relay and shows the effect of arc resistance on reach of mho relay.

Ans: The operating characteristic of the mho relay is shown in the figure below. The diameter of the circle is practically independent of V and I, except at a very low magnitude of the voltage and current when the spring effect is considered, which causes the diameter to decrease. The diameter of the circle is expressed by the equation as $Z_R = K_1 / K_2$ = ohmic setting of the relay

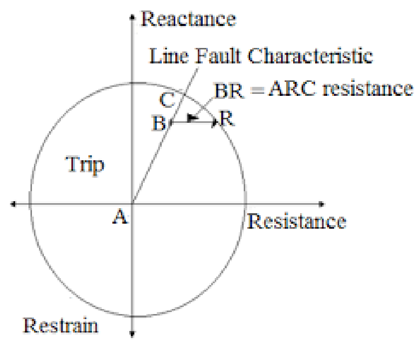


Operating Characteristic of Mho Relay

 The relay operates when the impedance seen by the relay within the circle. The operating characteristic showed that circle passes through the origin, which makes the relay naturally directional. The relay because of its naturally directional characteristic requires only one pair of contacts which makes it fast tripping for fault clearance and reduces the VA burdens on the current transformer.

The impedance angle of the protected line is normally 60º and 70º which is shown by line OC in the figure. The arc resistance R is represented by the length AB, which is horizontal to OC from the extremity of the chord Z. By making the τ equal to, or little less lagging than Θ, the circle is made to fit around the faulty area so that the relay is insensitive to power swings and therefore particularly applicable to the protection of long or heavily loaded lines.

Effect of arc resistance on reach of relay



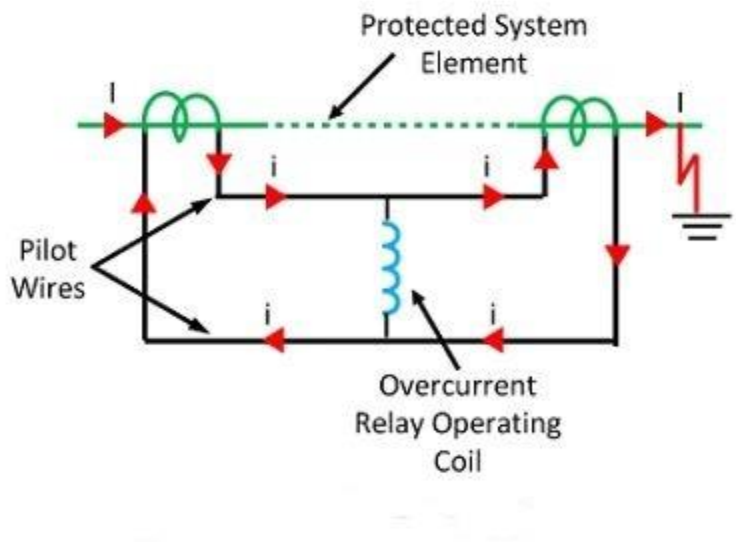
4. Write short notes on differential relay.

Definition: The relay whose operation depends on the phase difference of two or more electrical quantities is known as the differential protection relay. It works on the principle of comparison between the phase angle and the magnitude of the same electrical quantities.

The differential protection relay is used for the protection of the generator, transformer, feeder, large motor, bus-bars etc. The following are the classification of the differential protection relay.

- Current Differential Relay
- Voltage Differential Relay

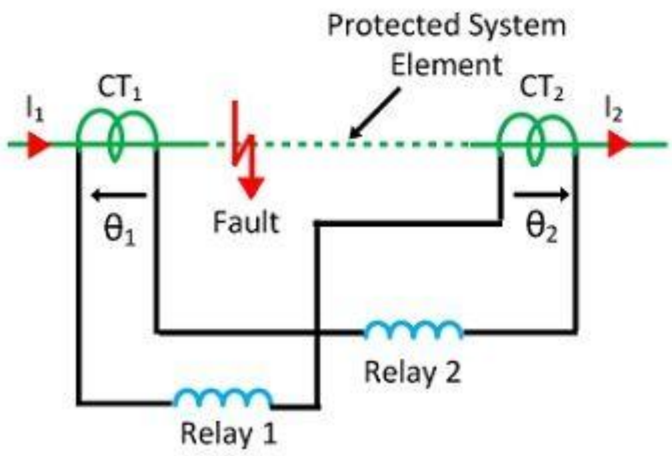
Current Differential Relay: A relay which senses and operates the phase difference between the current entering into the electrical system and the current leaving the electrical system is called a current differential relay. An arrangement of over current relay connected to operate as a differential relay is shown in the figure below.



The arrangement of the over current relay is shown in the figure below. The dotted line shows the section which is used to be protected. The current transformer is placed at both the ends of the protection zone. The secondary of the transformers is connected in series with the help of the pilot wire. Thereby, the current induces in the CTs flows in the same direction. The operating coil of the relay is connected on the secondary of the CTs.

Voltage Balance Differential Relay

The current differential relay is not suitable for the protection of the feeders. For the protection of the feeders, the voltage balance differential relays are used. The voltage differential relay uses two similar current transformer places across the protective zone with the help of pilot wire.
The relays are connected in series with the secondary of the current transformer. The relays are connected in such a way that no current flows through it in the normal operating condition. The voltage balance differential relay uses the air core CTs in which the voltages induces regarding current.



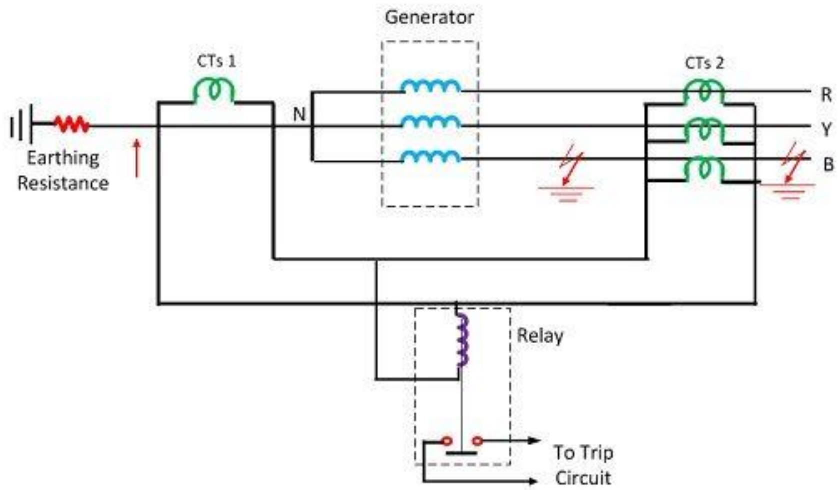
Balance Voltage Differential Protection

5.write short notes on balanced earth fault protection.

The balanced earth fault protection scheme is mainly used for protection of small generator where differential and self-balanced protection systems are not applicable. In a small generator, the neutral end of the three phase windings is connected internally to a single terminal. So the neutral end is not available, and protection against earth fault is provided by using the balanced earth protection scheme. Such scheme does not provide protection against phase-to-phase fault until and unless they develop into earth faults.

<u>Connection of Balanced Earth Fault Protection Scheme</u>

In this scheme, the current transformers are mounted on each phase. Their secondary is connected in parallel with that of CT mounted on a conductor joining the star point of the generator to earth. A relay is connected across the secondary of the CTs.



Balanced Earth Fault Protection

Working of Balanced Earth Fault Protection Scheme

When the generator is in a normal operating condition the sum of the currents flow in the secondary of the current transformers is zero and the current flow into secondary to neutral is also zero. Thus the relay remains de-energized. When the fault occurs in the protected zone (left of the line) the fault current flow through the primary of current transformers and the corresponding secondary current flow through the relay which trips the circuit breaker. When the fault develops external of the protective zone (right of the current transformer) the sum of the currents at the terminal of the generator is exactly equal to the current in the neutral connection. Hence, no current flows through the relay operating coil.

Drawback of Balanced Earth Protection Scheme

If the fault occurs near the neutral terminal or when grounding of the neutral is connected through a resistance or a distributing transformer then the magnitude of the fault current flow through the secondary of current transformer becomes small. This current is less than the pick-up current of the relay. Thus, the relay remains inoperative, and the fault current continues to persist in the generator winding which is highly undesirable