Q4 Explain briefly role of protection in power system. (S-16, S-15)

Ans :- An electrical power system consist of generators, transformers, transmission & distribution lines etc.

- An electrical power system should supply electrical power to the load without any interruption. When electrical power supply is extended to remote villages the power system would consist of several thousand kilometers of distribution lines.

- The high voltage x^n lines carrying bulk power could extend over several hundred kilometers.
- Since all these lines are overhead lines and are exposed, there are many chances of their breakdown due to storms, falling of external objects, damage to insulators etc.
These can result not only in mechanical damage but also in an electrical fault.
- Short circuit & other abnormal conditions often occurs on power system. The heavy current associated with short ckt cause damage to equipment
- If S.C. persists on a system for a longer, it may cause damage to some important sections of the system. A heavy S.C. current may cause a fire. It may spread in the system. The system voltage may reduce to a low value and individual generators in a power system station may loose synchronism. Thus an uncleared heavy S.C. may cause the total failure of the system.

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If faults occurs in an element of a power system, an automatic protective device is needed to isolate the faulty element as quickly as possible to keep the healthy section of system in normal operation. The fault must be cleared within a fraction of a second.

A protective system includes circuit breakers, Transducers (C.T. & P.T.), protective relays, trip ckt to isolate the faulty section of power system from healthy section.

- Transducers are used to reduce currents & voltages to lower values and to isolate protective relays from high voltages of power system.
- The function of protective relay is to detect and locate a fault and issue a command to the ckt breaker to disconnect the faulty element. It is a device which senses abnormal conditions on power system by constantly monitoring electrical quantities of system which differ under normal & abnormal conditions. The basic electrical quantities which are likely to change during abnormal conditions are currents, voltages, phase angle (direction) & frequency.
- Protective relays utilize one or more of these quantities to detect abnormal conditions on a power system.
- Protective relay does not preserve the occurance of fault, rather it takes action only after fault has occurred.

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Q4. Why should protective zones overlap around a circuit breaker? Show with required circuit breaker. OR [W-18, W-17, S-17, S-16]
Describe with neat sketch the different protective zones in a typical power system. Why the adjoining protective zone should overlap? How the overlapping is achieved in practice? [7M]

Ans :-

Protective Zones :-

- A power system contains generators, transformers, bus bars, transmission & distribution lines etc. There is seperate protective scheme for each piece of equipment or element of the power system, such as generator protection, transformer protection, transmission line protection, bus bar protection etc.

- Thus a power system is divided into a no. of zones for protection.

- A protective zone covers one or at the most two elements of power system.

- The protective zones are planned in such a way that the entire power system is collectively covered by them, and thus no part of the system is left unprotected.

- A part of system protected by a certain protective scheme is called protective zone or zone of protection.

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The various protective zones of a Typical power system are shown in fig. 1(a).

- Adjacent protective zones must overlap each other, so that no 'dead spot' are left in the protected system.

- If adjacent protective zones are not overlapped then the fault on the boundary of the zones may not lie in any of the zones and hence no circuit breaker would trip.

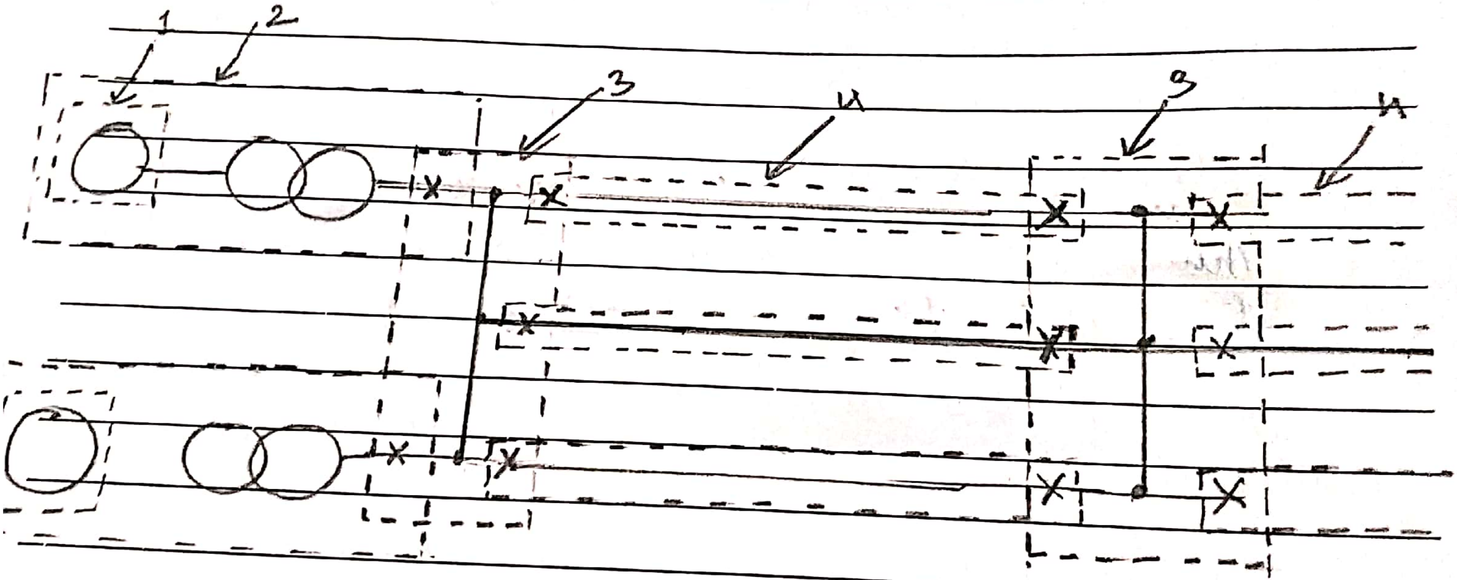

fig. 1(a). Explaining protective zones

where,

x → circuit breaker plus Isolators

1 → Generator P. zone

2 → Generator transformer unit protective zone

3 → Bus bar protective zone

4 → Transmission line protective zone

.... → Boundary of P. zones decided by location of CT's

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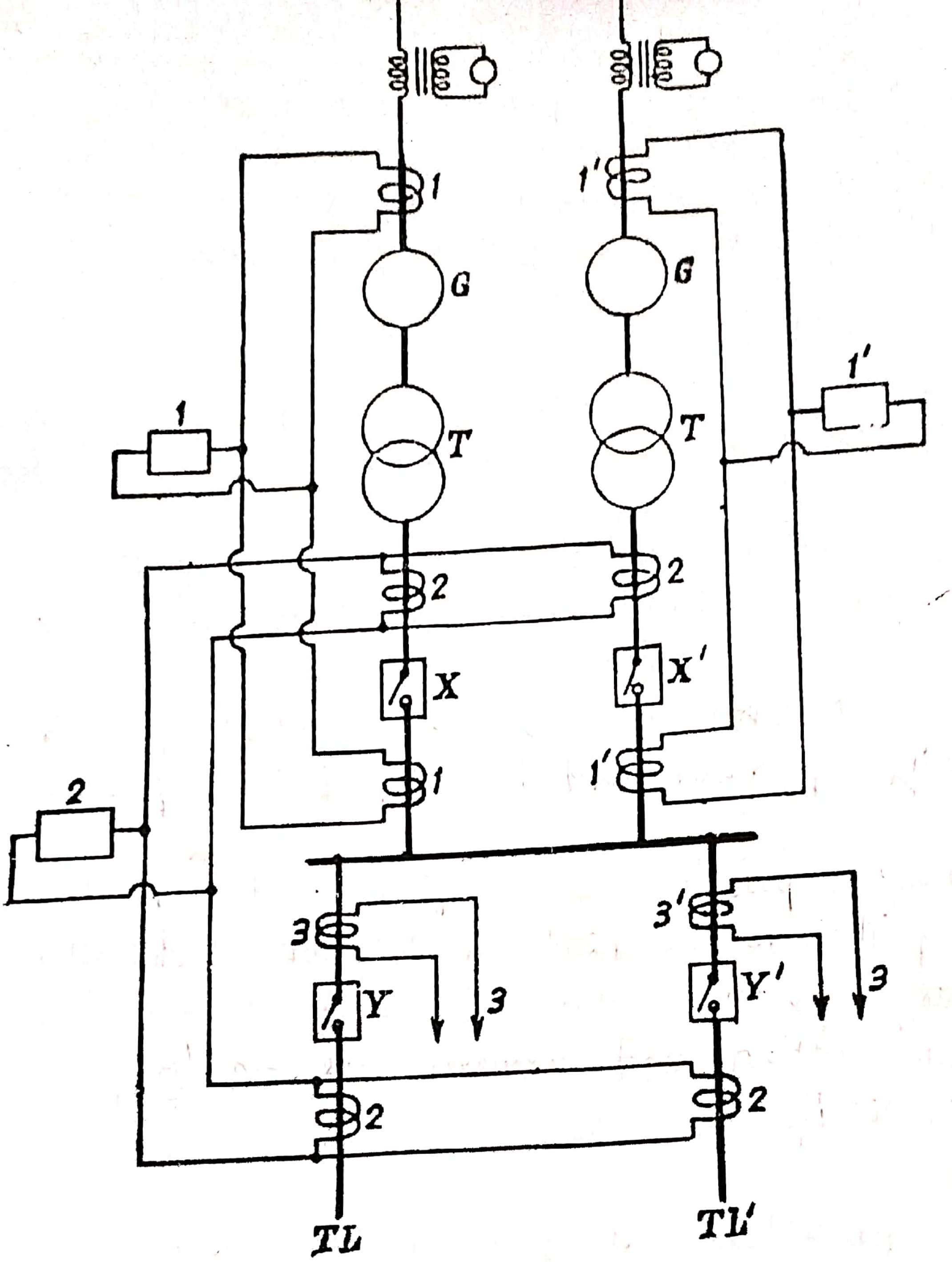

G Generator

T Main transformer of unit

TL Transformer Lines

1,1′ Subscript for generator-transformer unit protection system covering circuit-breakers *X*, *X*′ respectively

2 Subscript for Main Bus Protecting System covering circuit- breaker *X*, *X*′ and also *Y*, *Y*′

3,3′ Subscript for transmission line protection systems Covering circuit-breakers *Y*, *Y*′

Fig. (*b*) Explaining overlapping of neighbouring protective zones in a generation station

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Q4 What do you mean by primary & Back up protection? (S-18, W-17, W-16, S-17, S-16, W-15, S-15)

Ans: Justify the necessity of Back up protection and Explain different types of Back up protection.

Ans:

Primary Protection :

1) Two sets of relays primary & Back up are usually provided for each zone of protection.

2) Primary or main protection is the essential protection provided for protecting an equipment/machine.

3) As a precautionary measure, an additional protection is generally provided and is called 'Back up protection'

4) The primary protection is the first to act and the back up protection is next in the line of defence. If primary protection fails, the back up protection comes into action and removes the faulty part from the healthy system.

Back up protection is provided for foll. reasons :-

Necessity of Back up protection :-

If due to some reason, the main protection fails, the Back up protection serves the purpose of protection. Main protection can fail due to failure of one of the components in the protective system such as relay, auxilliary relay, CT, PT, Trip circuit, ckt breaker etc.

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2) If the primary protection fails, there must be an additional protection otherwise the fault may remain uncleared, resulting in a disaster.

3) When main protection is made inoperative for the purpose of maintenance, testing etc. the back-up protection acts like main protection.

4) As a measure of economy, back-up protection is given against short circuit protection and not for other abnormal conditions.

5) The extent to which back-up protection is provided, depend upon economic and technical considerations.

The methods of Back-up protection can be classified as:

1) Relay Back-up
2) Breaker Back-up
3) Remote Back-up
4) Centrally Co-ordinated Back up.

1) Relay Back-up: This is a kind of a local back-up in which same ckt breaker is used by both main & back-up protection but the protective systems are different. Seperate trip coils may be provided for the same breaker. (separate relay) Though such a back-up costly, it can be recommended where remote back up is not possible.

2) Breaker Back-up: This is also a kind of local back up. This type of back up is necessary for a bus bar system where a number of C.B. are connected to it.

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When a protective relay operates in response to a fault but the C.B. fails to trip, the fault is treated as a bus-bar fault. In such a situation it becomes necessary that all other ckt breakers on that bus-bar should trip.
Different breakers are provided for main and back-up protection, both the breakers being in the same station.

3) Remote Back up :- When back-up relays are located at a neighbouring station, they back up the entire primary protection scheme which includes the relay, ckt breaker, CT, VT (PT) and other elements, in case of failure of the primary protective scheme.
The main & back-up protection are provided at different stations and are completely independent.
It is the cheapest & simplest form of back up protection and is widely used back up protection for transmission lines.

4) Centrally co-ordinated Back-up :- The system having central control can be provided with centrally controlled back-up.
- Central control continuously supervises the load flow and frequency in the system.
- The information about load flow & frequency is assessed continuously.
If one of the components in any part of the system fails (e.g. a fault on a transformer, in some station) the load flow in the system is affected.

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- The central co-ordinating station receives information about the abnormal condition through high frequency carrier signals. The stored programme in the digital computer determines the correct switching operation, as regards severity of fault, system stability, etc.
- Main protection is at various stations and Back-up protection for all stations is at central control centre.
- The centrally co-ordinated back up is a team-work of protective relaying equipment, high frequency carrier current equipment and digital computer.

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Q4. What do you mean by reach of the relay? Explain over reaching & under-reaching of the relay with suitable example. (S-18, W-16) (6M or 7M)

Ans:-

1) Reach of the Relay : (Reach of Relay) : The limiting distance covered by the protection, the faults beyond which are not within the reach of the protection & should be covered by other relay.

2) Over-reach : Operation of (distance) relay for a faults beyond its set protected distance (say 130 %)

3) Under-reach : Failure of distance relay to operate within the set protected distance (say 90 %)

Over-reach and under reach of relay signify the accuracy and co-ordination setting of the relay.

For ex: In distance relay protection, when a relay over-reac over reaches beyond its pre-set setting (the distance upto which it should protect the line) it is said to have over-reached & similarly it is not able to detect the fault within its defined reach and detects only upto a lesser (nearer) point then it is said to be have under-reached.

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Qu. Give the classification of protective scheme. Explain them in brief. (W-18, S-18, W-16)
(6M or 7M)

Ans:-

Following are the main (common) protective schemes which are used for the protection of a modern power system.

i) Overcurrent Protection
ii) Distance Protection
iii) Carrier - current Protection
iv) Differential protection

i) Overcurrent Protection : This scheme of protection is used for the protection of distribution lines, large motors, equipment etc. It includes one or more overcurrent relays. An overcurrent relay operates when the current exceeds its pick-up value.

ii) Distance Protection : Distance protection is used for the protection of transmission or sub-transmission lines: usually 33kV, 66kV and 132kV lines. It includes number of distance relays of the same or different types. A distance relay measures the distance between the relay location and the point of fault in terms of impedance, reactance or V/I ratio. The relay operates if the point of fault lies within the protected section of the line. There are various kinds of distance relays. The important types are impedance, reactance and mho type.

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An impedance relay measures the line impedance between the fault point & relay location; a reactance relay measures the reactance, and a mho relay measures a component of admittance.

iii) Carrier-Current Protection :- This scheme of protection is used for the protection of EHV and UHV lines, generally 132kV and above. A carrier signal in the range of 50-500 kHz is generated for the purpose. A transmitter & receiver are installed at each end of a transmission line to be protected. Information regarding the direction of the fault current is transmitted from one end of the line section to the other. Depending on the information, relays placed at each end trip if the fault lies within their protected section. Relays do not trip in case of external faults. The relays are of distance type and their tripping operation is controlled by the carrier signal.

iv) Differential Protection :- This scheme of protection is used for the protection of generators, transformers, motors of very large size, bus zones etc. CTs are placed on both sides of each winding of machine. The output of their secondaries are applied to the relay coils. The relay compares the current entering a machine winding and leaving the same. Under normal conditions or during any external fault, the current entering the winding is equal to the current

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leaving the winding. But in the case of an internal fault on the winding, these are not equal. This difference in the current actuates the relay. Thus, the relay operates for internal faults and remains inoperative under normal conditions or during external faults. In case of bus zone protection, CTs are placed on both the sides of bus box.

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Q1. Describe the essential properties of good protective relaying. (W-18, S-18, W-17, S-17, W-16, S-16, W-15) (6M/7M)

Ans:

The essential properties or qualities of good protective relaying are

i) Selectivity
ii) Reliability
iii) Stability
iv) Sensitivity
v) Speed / Fast operation
vi) Adequateness
vii) Discrimination

i) **Selectivity** :- Protective relay should be selective in protecting meaning.

Selectivity is the ability of protective devices (relay) to isolate only the faulty part of power system from healthy part to maintain normal power supply to rest of the power system.

It is devided into two ways - a) Unit system of prot
b) Non unit syst. of Prot

> Unit system of Protection :- It means the one in which the protection responds only to faults within its own zone and does not make note of the

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conditions elsewhere. In unit protection, selectivity is absolute.

b) Non-unit system of Protection :- It is the one in which selectivity is obtained by grading the time/current setting of the relay at different locations. All of which may respond to a given fault. In Non-unit system, the selectivity is not exact.

ii) Reliability :- Protective system must operate reliably when a fault occurs in its zone of protection.

- The failure of protective system may be due to the failure of any one or more elements of the protective system. Its important elements are the protective relays, circuit breaker, trip circuit, CT, PT, wiring, battery etc.

- To achieve high degree of reliability, great attention should be given to the design, installation, maintenance and testing of the various elements of the protective system.

- Robustness & simplicity of the relaying equipments also contribute to reliability.

- The contact pressure, contact material of the relay and prevention of contact contamination are also very important from the reliability point of view.

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iii) Stability :- A protective system should remain stable even when a large current is flowing through its protective zone due to an external fault, which does not lie in its zone.
- The concerned C.B. is supposed to clear the fault. But the protective system will not wait indefinitely, if the protective scheme of the zone in which fault has occurred fails to operate.
- After the preset delay, the relay will operate to trip the C.B.

iv) Sensitivity :- It is the ability of protective device to operate correctly to the fault or abnormal conditions inside the zone of protection. It refers to the minimum level of the fault current at which the protection device operates.
- The sensitivity factor usually determines the sensitivity of protective relay, which depends on the parameters of protective elements and operating condition of the power system.

v) Speed / Fast Operation :- A protective system should be fast enough to isolate the faulty element of the system as quickly as possible to minimise damage to the equipment and to maintain the system stability.

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- For modern power system, the stability criteria is very important and hence the operating time of the protective system should not exceed the critical clearing time to avoid loss of synchronism.

- The operating time of protection relay is usually one cycle. Half cycle relays are also available. For distribution system, the operating time may be more than one cycle.

VI) Adequateness :-

- There can be many abnormal conditions and providing protection against every abnormal condition is economically impossible. However protection provided for machine should be adequate. The adequateness is judged by considering following aspects :-

1) Rating of Protected machine
2) Location of protected machine
3) Probability of abnormal condition due to internal & external causes.
4) Cost of Machine
5) Continuity of supply is affected by failure of machine.

For low voltage machine / equipment, at the re end of the system, an elaborate and co protective system is not necessary.

For Ex. → Distribution transformers below say 500 KVA are protected simply by drop out fuses.

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- Motors below 100 kW are protected by thermal overload relays and HRC fuses. In these cases, the cost of CTs & protective relays, circuit breakers etc. is not judged.
Whereas for large machine, say generator, a very complex protective scheme is necessary.

i) Discrimination :-

Discriminating quality of protection relaying enable it to distinguish between the normal condition and abnormal condition.
The protective system should operate only during abnormal condition and should not operate under normal condition.
In other words, the protective relaying system should discriminate between normal condition and abnormal condition. It should select & disconnect only faulty part without disconnecting remaining healthy part.

protective relay is not selective & operates fault beyond its protection zones, a larger portion of the system gets disconnected unnecessarily, causing embarrassment to supplier & consumer.

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Qu. Explain nature & causes of faults. Discuss the consequences of faults on a power system & Removal of faults. [W-18 W-17, S-17, S-16, S-15] (6M/7M)

Ans :-

Nature of fault :- Nature of fault simply implies any abnormal condition which causes a reduction in the basic insulation strength between phase conductors or between phase conductors & earth.

Actually reduction of the insulation is not considered as a fault until it produces some effects on the system, that is until it results either in an excess current or in the reduction of impedance between conductors or between conductors & earth to a value below that of the lowest load impedance normal to the circuit.

Due to fault, current is diverted from intended path.

Causes of faults :- There are several causes of faults in power system.

a) Breakdown may occur at normal voltage on account of :

i) Deterioration of insulation (Insulation failure)

ii) Damage due to unpredictable causes such as perching of birds, accidental short circuiting by snakes, kites, strings, tree branches etc.

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b) Breakdown may occur because of abnormal voltages.
This may happen because of either
i) Switching surges
ii) Surges caused by lightning

→ Most of the faults on transmission & distribution lines are caused by overvoltages due to lightning or switching surges or by external conducting objects falling on overhead lines.
It causes flashover on the surface of insulators resulting in short circuits.

→ Sometimes, certain foreign particals such as cement dust or soot in industrial areas or salt in coastal areas or any dirt in general, accumulates on the surface of string & pin insulators. This reduces their insulation strength & causes flashover.

If conductors are broken, there is failure of conducting path and the conductor becomes open circuited. If the broken conductor falls on the ground, it results in a short circuit.

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Consequences of faults (Effects of faults) :-

The most common type of fault which is also the most dangerous one is the short circuit which may have any of the following consequences :-

i) A great reduction of the line voltage over a major part of the power system. This will lead to the breakdown of the electrical supply to the consumer and may produce wastage in production.

ii) Damage caused to the elements of the system by the electrical arc during the short ckt.

iii) Damage to the other equipments in the system due to overheating and due to abnormal (High) mechanical forces set up. (due to heavy current)

iv) Disturbances to the stability of the electrical system and this may even lead to a complete shut down of the power system.

v) A marked reduction in the voltage which may sometimes be so great that relay having pressure coils tend to fail.

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✪ Removal of Faults :-

Faults can be removed to some extent by taking the following measures.

i) Improvement in the quality of machines, equipments, installation, etc. by improvement in design, manufacturing techniques, materials, quality control, adequate testing, research & development.

ii) Improvement in system design, correct lay out, choice of equipment

iii) Adequate & reliable protection systems, control

iv) Regular & detailed maintenance by trained personnel.

v) Trained personal for operation and management of electrical plant.

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Qn. Give the classification of various types of faults that occurs on 3Φ system. (6M)

W-17

Ans :- The various types of faults that occurs on a 3Φ system are

i) L-G fault (85%) → (Single phase to ground fault)

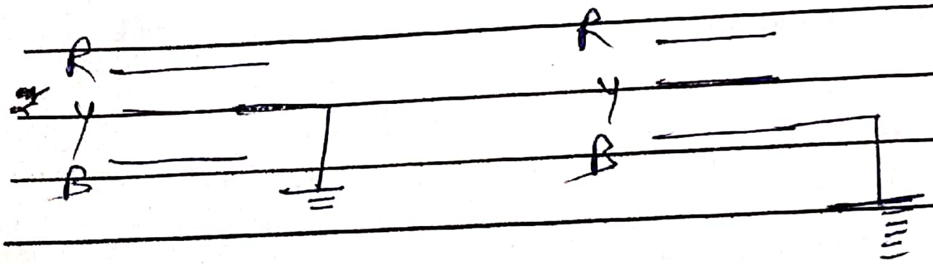
Three phase faults are mainly divided into 2 types i.e. 1) Asymmetrical fault
2) Symmetrical fault

1) Asymmetrical fault : It is again divided into 3 types i.e.

i) L-G fault
ii) L-L fault
iii) L-L-G fault

1) L-G Fault :- (85%) (Single phase to grd. fault)

On a three phase system the breakdown of insulation between one of the phases and earth is known as L-G fault. (Short circuit between one of the phases & earth)



2) L-L fault :- (8%) (Phase to phase fault)

The breakdown of insulation between either of two phases is known as L-L fault.

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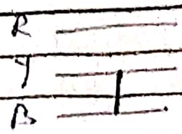


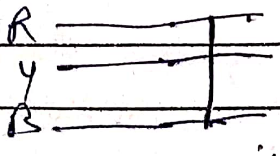
L-G fault L-G fault

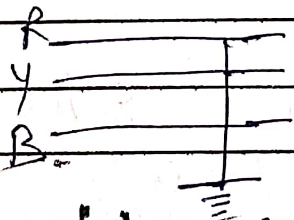
3) L-L-G fault :- (5%) (Two phase to ground fault) The insulation breakdown between two phases & earth is known as L-L-G fault or double line to gnd. fault.

2) Symmetrical faults :- It is again divided into 2 types - i) L-L-L Fault
ii) L-L-L-G Fault

i) L-L-L fault :- (2%) → Breakdown of insulation between any the three phases (lines) is known as L-L-L fault. (3φ fault)

ii) L-L-L-G Fault :- → Breakdown of insulation bet^n any 3 phases & if these phases connected to ground, then the fault is called L-L-L-G fault.





L-L-L fault L-L-L-G fault.

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Sub:- Switchgear & Protection
UNIT :- V - Introduction to static Relay

Q4. Compare electromagnetic and static relays
OR Compare static relays with conventional electromagnetic relay. (electromechanical)

Ans:-

Static Relays	Electromagnetic Relay
1) Static relays provide less burden on CTs & PTs as compared to conventional electromagnetic relays.	1) Electromagnetic relays provide more burden on CTs & PTs as compared to conventional static relays.
2) No moving contacts and therefore no associated problems of arcing, contact bounce, erosion, replacement of contacts etc.	2) Due to moving contacts there is problem of arcing, contact bounce, erosion etc.
3) Fast response	3) Slow response
4) It has longer life	4) Comparatively small life
5) Effect of vibrations & shocks is less as compared to electromagnetic relays & hence are suitable for earthquake prone areas, aeroplanes etc.	6) Effect of vibrations and shocks is more as compared to static relays.

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Static relay	Electromagnetic relay
(i) For complex protection system, static relays are preferred technically & economically.	(i) For simple protective functions, conventional electromagnetic relays provide economic & satisfactory choice.

Q4. What are the merits & demerits of static relays ?

Ans :-

Advantages / merits of static relays :-

i) No moving part in measuring circuit, hence no effect of vibrations, shocks, dust etc.
ii) Faster operation 20 ms, 40 ms, 60 ms.
iii) Less burden. e.g. burden on CT : 0.8 VA to 4.2 VA during normal & short ckt conditions respectively. Burden of PT : 2.2 to 12 VA during normal & S.C. condn respectively.
iv) Greater adaptability due to large range of adjustments & characteristics.
v) Versatile range of relays available for various specific applications.
vi) Better stability under power swing conditions.
vii) Suitable for long heavily loaded lines, cables, even distribution lines.
viii) It consumes very less power thus provide less burden on CTs & PTs.
ix) Reset time of relay is very less.

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x) The chance of unwanted tripping is less in this relay.

xi) It does not have any thermal storage problem.

Disadvantage / demerits of static Relays :-

1) The components used by static relays are very sensitive to the electrostatic discharges.

2) The relay is sensitive to vtg. spikes or vtg. transients & is easily affected by the high vtg. surges.

3) The relay has less overloading capacity.

4) The static relay is more costly as compared to the electromagnetic relay.

5) The construction of the relay is easily affected by the surrounding interference.

6) Static relay are temperature dependence, since the characteristics of semiconductor are Influenced by ambient temperature.

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Q4. Write a short note on the foll. with block diagram.

a) Static overcurrent Relay.
b) Integrating type phase relay comparator.

Ans:-

a) Static overcurrent Relay:

The static overcurrent relay consist of a rectifier unit which converts the ac signal to d.c. levels, followed by overload level detector, timing ckt, level detector and a tripping ckt.

Fig. below shows the block diagram of static overcurrent relay.

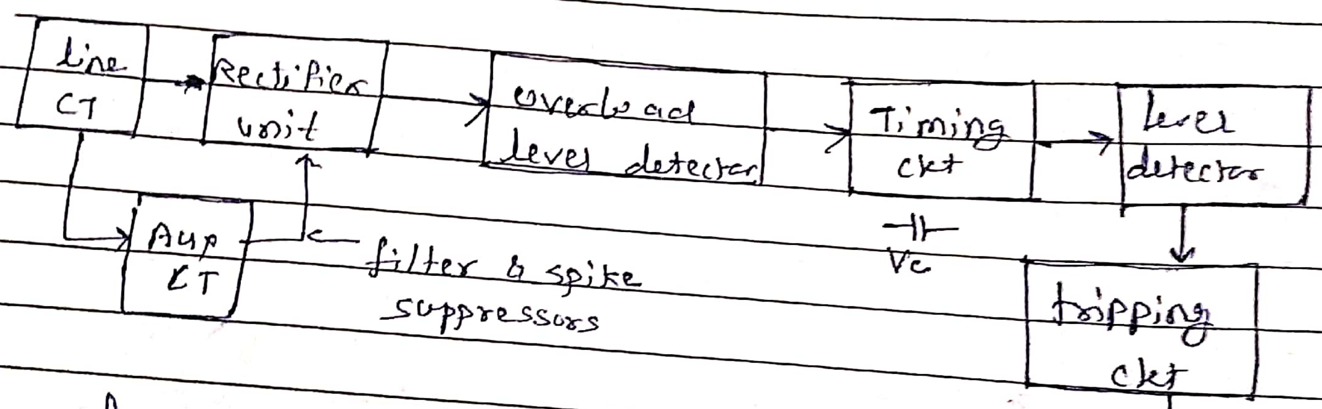

Fig:- Block diagram of static overcurrent relay

The secondary current from a line CT is generally not suitable for static relay operation. It is higher. The current from the line CT is reduced by an auxiliary CT.

The auxiliary CT has taps on the primary for selecting the desired pick up and current range.

The alternating current derived from auxiliary CT may contain harmonics particularly under S.C. condition.

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- The high vtg. spikes in the waveform are harmful to the semiconductor devices in static relay. Hence filter & spike suppressors are provided in the input stage of the static relay.
- The current is rectified in the rectifier unit and is supplied to an overload level detector and an RC timing circuit.
- When the vtg. on the timing capacitor has reached the value for triggering the level detector, tripping occurs.
- The auxiliary dc supply is necessary for level detectors, amplifiers o/p stage of static relay.

b) Integrating type phase comparator :-

- In this method the time overlap of the two sinusoidal inputs is measured for each cycle by integrating the o/p of an AND gate through which they are fed.
- The period of coincidence is measured and only if it exceeds 90° (for a symmetrical comparator), the o/p is obtained so that, the condition is $-90° \leq \theta \leq 90°$.

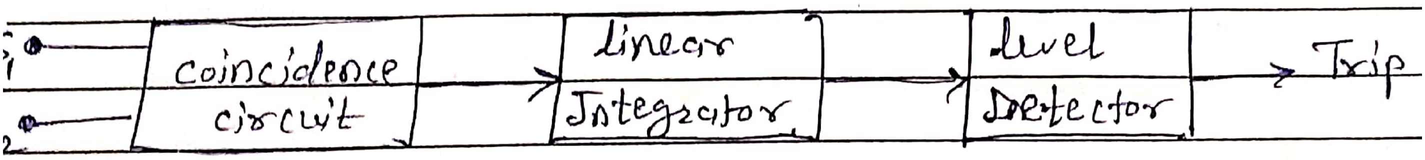
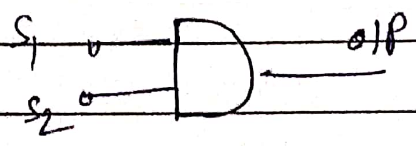


fig (1): Block Schematic for Integrating phase comparator



time overlap of S_1 & S_2 } is measured for each cycle.

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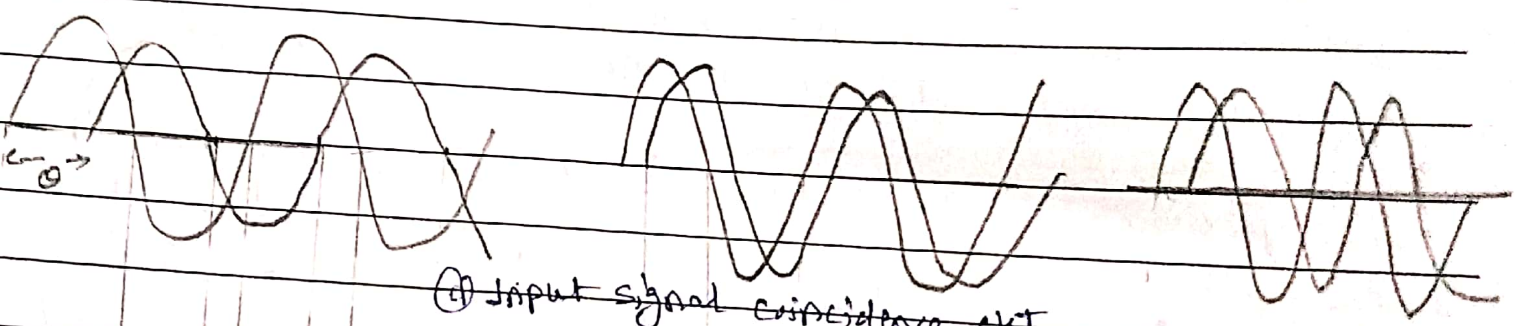
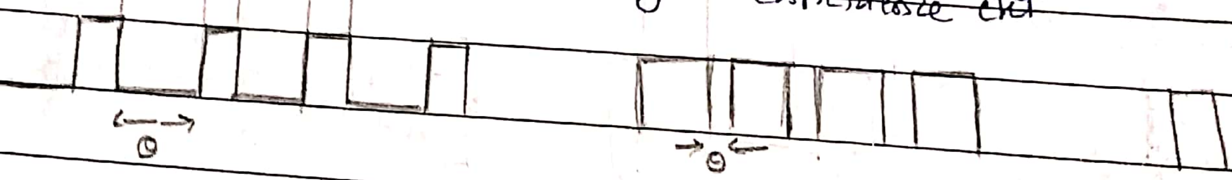
- This fig ① shows the basic arrangement of the integration of coincidence blocks.
- The input S_1 & S_2 are compared in coincidence ckt producing standard o/p pulses which are +ve when S_1 & S_2 are of the same polarity and -ve when they are of opposite polarity.
- The pulses are applied to an integrating ckt whose o/p increases linearly during the time when the pulse is +ve & falls at the same rate when the polarity reverses.
- The level detector switches when the integrator o/p exceeds some preset value & resets when the o/p falls below some second value.
- The operation resulting from different coincidence periods are illustrated in fig. ② below.



~~(a) Input signal coincidence ckt~~



(b) output signal coincidence ckt

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Q4. Explain duality between amplitude & phase comparator.
OR
Explain duality bet^n the comparators giving suitable examples.
OR Discuss how an amplitude comparator can be converted into phase comparator & vice versa.

Ans:

Duality bet^n Amplitude & phase Comparator :-

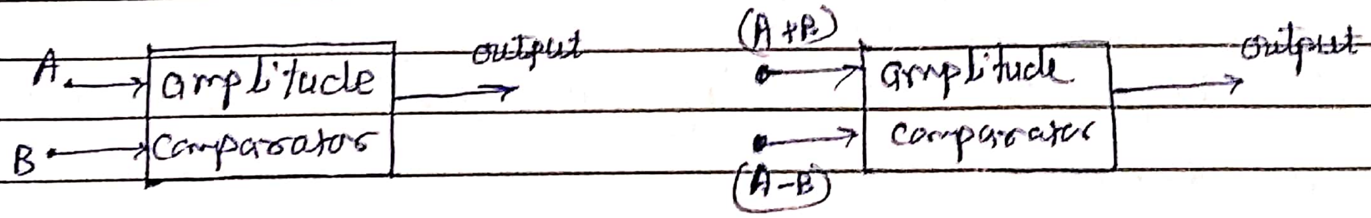
1) An amplitude comparator can be converted to phase comparator & vice-versa. if the input quantity to the comparator are modified.

2) The modified input quantities are the sum & difference of the ~~two~~ original two I/P quantities.

3)

fig. ① Consider the operation of an amplitude comparator with I/P signals A & B. It operates when |A| > |B|.

4) If the inputs are changed to (A+B) & (A−B) so th[e] it operates when |A+B| > |A−B|



Operates when |A| > |B|

(a)

Operates when |A+B| > |A−B|
This condition is satisfied when |∅ ...

fig:- ①

(b)

fig. 1.1 (a) Amplitude comparator
(b) Amplitude comparator used for phase comparison

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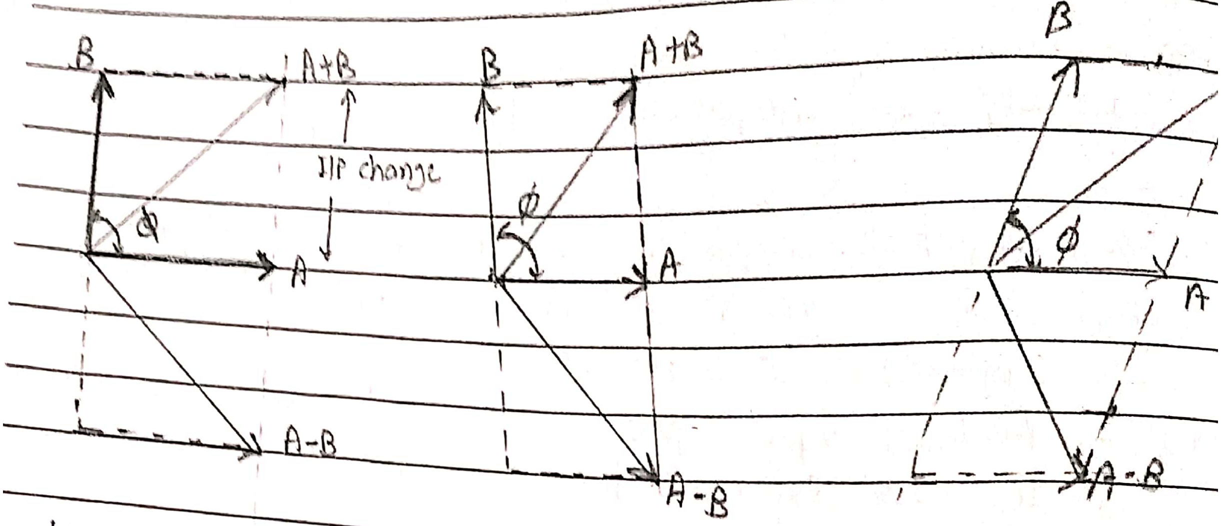
⇒ This condition will be satisfied only when the phase angle between A & B is less than 90°.

$|A+B| \geq |A-B|$

$\phi < 90°$



$|A+B| = |A-B|$	$|A+B| < |A-B|$	$|A+B| \geq |A-B|$
$\phi = 90°$	$\phi > 90°$	$\phi < 90°$
(Threshold)	(No)	(yes)
(a)	(b)	(c)

fig. ②

Phase comparator

fig. (1.2) Phase comparison using an amplitude comparator.

fig. ② ⇒

i) It has now become an inherent phase comparator as shown in fig. (1.2) vector diagram i.e. if the i/ps are changed to (A+B) & (A−B) the original amplitude comparator would compare phases of A & B.

fig. ③ ⇒ Similarly consider a phase comparator as shown fig. (1.3). It compares the phases of i/p signals A & B.

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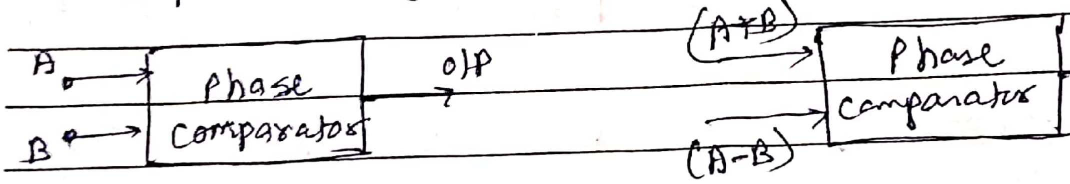
fig. ② ⇒ If the phase angle bet^n A & B i.e. angle ϕ is less than 90°, the comparator operates.

fig. ④ Now change the input signal to (A+B) & (A−B). With these changed input the comparator will operate when phase angle between (A+B) & (A−B) i.e. angle λ is less than 90°. This condition will be satisfied only when |A| > |B|. Such comparators are known as converted comparators.

→ In other words these phase comparator with changed i/ps has now become an amplitude comparator for the original i/p signal A & B. This has been illustrated with phasor diagram as shown in fig. (1.4) below.

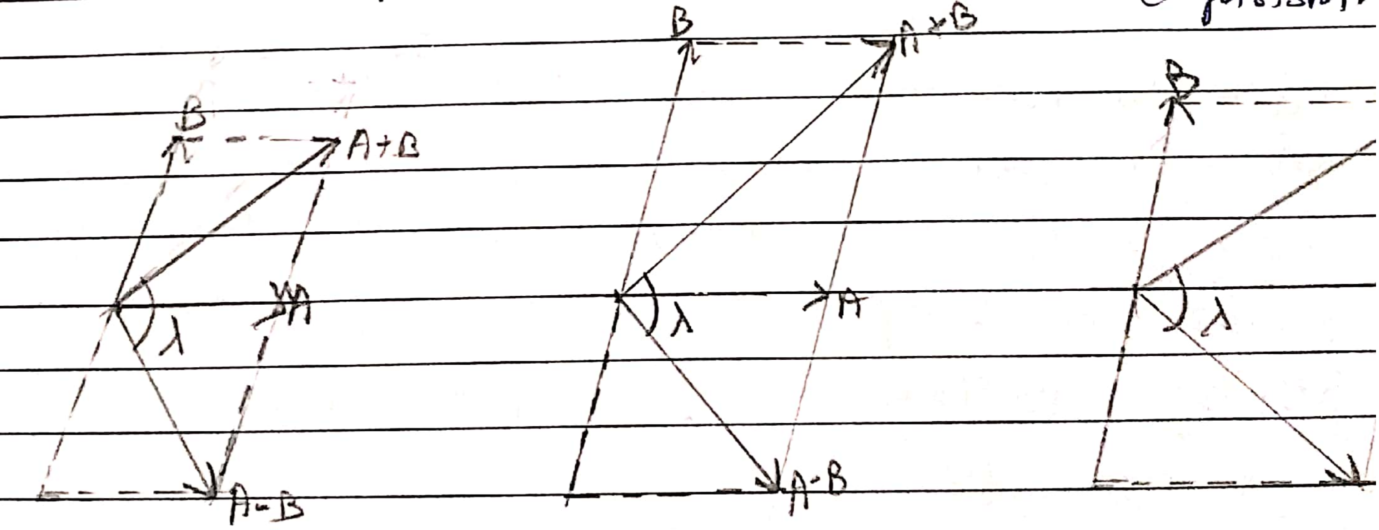


operates when ϕ < 90°
ⓐ

Operates when λ < 90°. This cond^n is satisfied when |A| > |B|.
ⓑ

fig. ③

fig: 1.3 ⓐ Phase comparator ⓑ Phase comparator used for amplitude comparision



|A| = |B|
λ = 90
(Threshold) ⓐ

|A| < |B|
λ > 90°
No ⓑ

|A| > |B|
λ < 90°
(Yes) ⓒ

fig. ④

fig 1.4 ⇒ Amplitude comparison using a phase comparator. Amp Comp

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Q4. Explain the comparison between the amplitude & phase comparator.

Ans:

Amplitude comparator	Phase comparator
1) An amplitude comparator compares the magnitudes of two i/p quantities irrespective of the angle bet' them.	1) A phase comparator compare two i/p quantities in phase angle irrespective of their magnitudes.
) The operation depends upon the amplitude of two similar electrical quantities.	2) The operation depends on the phase difference bet' two similar electrical quantitie
) Amplitude comparator can be changed to phase comparator	3) Phase comparator can be changed to amplitude comparator.
In amplitude comparator either magnitude of vtg/current are compared.	4) Phase angle between vtg. & current are measured.
When the magnitude of the operating quantity exceeds amplitude of the restraining quantity the relay sends a tripping signal.	6) when the phases of the operating quantity is less than 90°, the relays sends a tripping signals. phase (operating qty) < 90° → Relay trip.

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Qn What is meant by comparator? Explain any one type of phase comparator.

Ans:

Comparator: The part of circuitary which compares the two actuating quantities either in amplitude or phase is known as comparator. There are basically three types of comparator.

1) Amplitude Comparator
2) Phase comparator
3) Hybrid Comparator.

Comparator is also a basic from of multi-input device, although more than two i/ps increases, the range of complex characteristics so that the special characteristics of the form; ellipse, parabola, quadrilateral, parallelogram etc. can be obtained.

(Integrating type phase comparator is already explained in earlier question).

Qn. Show that mho relay characteristics can be obtained by using phase comparator.

Ans:

fig:- Mho relay characteristic using phase comparator

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$OA = |Z_{r1}| \rightarrow$ trip $\qquad AP = |Z_n - Z_{r1}|$

$OB = |Z_{r2}| \rightarrow$ Threshold $\qquad BP = |Z_n - Z_{r2}|$

$OC = |Z_{r3}| \rightarrow$ Restrain $\qquad CP = |Z_n - Z_{r3}|$

$$\text{Arg}\ \frac{|Z_n - Z_{r1}|}{|Z_{r1}|} = \angle RAP < 90^\circ \rightarrow \text{trip}$$

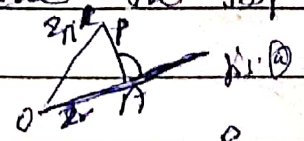
$$\text{Arg}\ \frac{|Z_n - Z_{r2}|}{|Z_{r2}|} = \angle CBP = 90^\circ \rightarrow \text{Threshold}$$

$$\text{Arg}\ \frac{|Z_n - Z_{r3}|}{|Z_{r3}|} = \angle DCP > 90^\circ \rightarrow \text{Restrain}$$

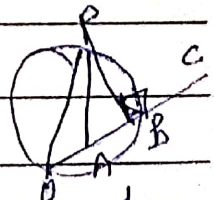
If $\text{Arg}\ \frac{|Z_n - Z_r|}{|Z_r|} < 90^\circ$, then trip

fig. ① : As shown in fig. above, the characteristic has circle passing through origin with diameter as phasor Z_n.

② Now, the impedance seen by the relay be Z_r, represented by point A. Since the impedance phasor lies within the trip region, the relay must issue the trip output.



③ It can be easily seen from the fig. that as the impedance seen by the relay moves towards the boundary bet^n the trip & restrain region, the angle bet^n $(Z_n - Z_r)$ & Z_r moves towards 90°.



④ When the phasor representing the impedance seen by the relay lies on the boundary, this angle is exactly 90° ($\angle PBC$)

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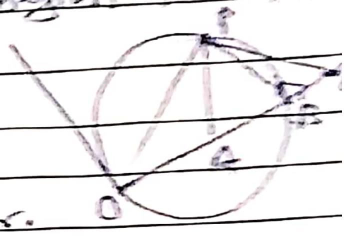
~~The fig shows that as the impedance~~

③ It can be easily seen from the fig. that the phasor $(Z_n - Z_r)$ represented by line AP. leads the phasor Z_r by an angle which is less than 90°

④ The fig shows that as the impedance seen by the relay moves towards the boundary betⁿ the trip & restrain region, the angle betⁿ $(Z_n - Z_r)$ & Z_r moves towards 90°

⑤ When the phasor representing the impedance seen by the relay lies on the boundary this angle is exactly 90° ($\angle PBC$).

⑥ For all impedances lying outside the trip region i.e. in the restraining region, the angle betⁿ $(Z_n - Z_r)$ & Z_r is always greater than 90°. $\angle PCD$. ⑦ Thus, the phasors $(Z_n - Z_r)$ & Z_r obey the law of cosine type phase comparator. Therefore. if $(Z_n - Z_r)$ & Z_r are used as i/p to a cosine comparator, the restraining resulting entity would behave exactly like mho relay.



⑧ But the comparator accepts only vtg. signals at its inputs. We therefore need to convert these 2 impedance phasors into vtg. signals.

⑨ If we multiply both $(Z_n - Z_r)$ and Z_r by the current at the relay location I_r, then we get

$(I_r Z_n - I_r Z_r)$ & $Z_r I_r$

where $I_r Z_r = V_r$

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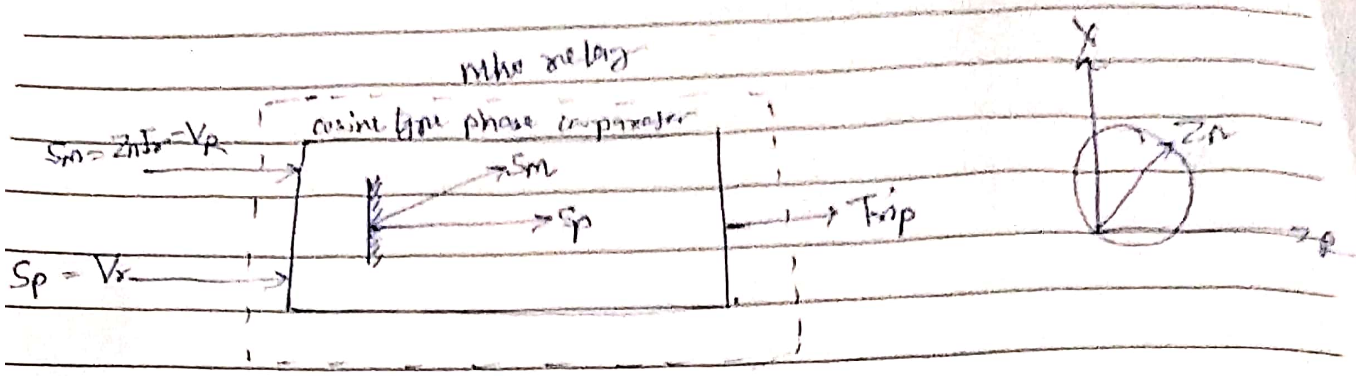

fig:- Deriving practical signals for mho relay.

Qs Explain the working of static mho relay using amplitude Comparator.

Ans:- Static mho Relay :-

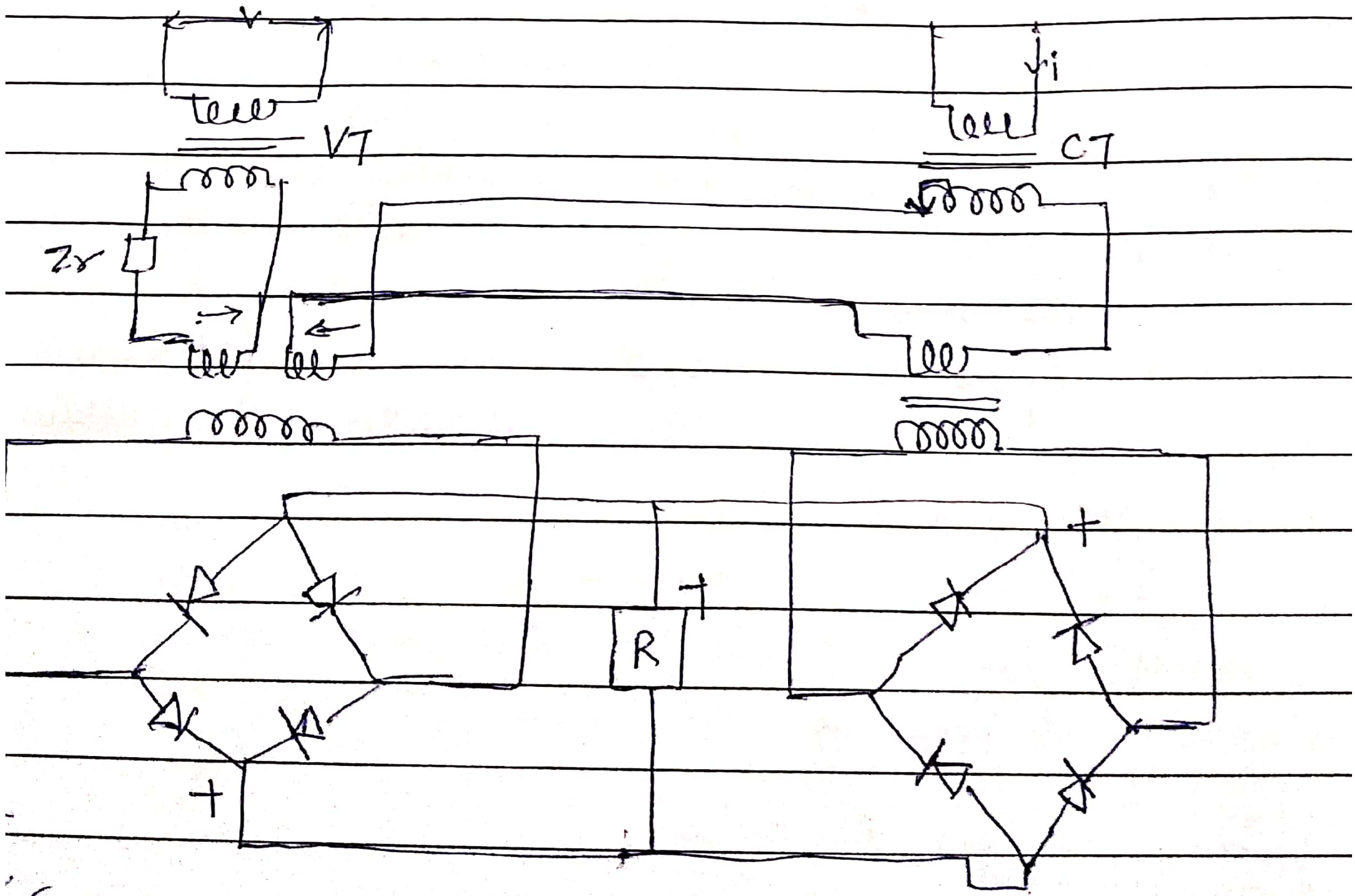

fig:- 1.1 Schematic diagram of a static mho relay

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fig. Mho characteristic

(1) fig. 1.1 shows a rectifier bridge type amplitude comparator to realise a mho characteristic.

(2) The actuating quantities to be compared are I & $\left(\frac{V}{Z_r} - I\right)$

- The relay will operate when $I > \left|\frac{V}{Z_r} - I\right|$

- Multiplying both sides by Z_r, we get

$$|IZ_r| > |V - IZ_r|$$

$Z_r \Rightarrow$ radius of circle = impedance of rly. ckt

Dividing both sides by I, we get.

$$|Z_r| > \left|\frac{V}{I} - Z_r\right| \quad \text{or}$$

$$|Z_r| > |Z - Z_r|$$

- When the above condition is satisfied, the characteristic obtained will be a mho chara. as shown in above fig.

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- Z_r is the radius of the mho circle which is equal to the impedance of the vtg. ckt
- If a fault point Z lies within the circle,

$$|Z_r| > |Z - Z_r|$$

- If a fault point lies on the circumference of the circle $|Z_r| = |Z - Z_r|$
- If the fault is outside the circle, $|Z_r| < |Z - Z_r|$
- The above conditions are also true if the point P is anywhere on AB.
- When the fault point is very close to the relay location (close-up fault), the relay may fail to operate.
- To overcome this difficulty, a vtg. called the polarising vtg. which is obtained from a pair of healthy phases is added to actuating quantity.

• fault pt. close to relay location ⇒ Relay fails to operate

To overcome this,

Polarising vtg ⇒ obtained from pair of healthy phases ⇒ Added to Actuating qty.

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