SWITCHGEAR

&

PROTECTIVE DEVICES

(Diploma 6TH SEM)

Education for a World Stage

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PROCTION AGAINST OVERVOLTAGE AND LIGHTING

Voltage surge

A sudden rise in voltage for a very short duration on the power system is known as a voltage surge or transient voltage

Transients or surges are of temporary nature and exist for a very short duration (a few hundred sec) but they cause over voltages on the power system.

Causes of over voltage GATE-5 what are the causes of over voltage

The over voltages on a power system may be broadly divided into two main categories

1) Internal causes
   a) switching surges b) Insulation failure.
   c) Arcing ground d) Resonance.

2) External causes i.e lighting

Internal causes of over voltage

a) switching surges:

The over voltages produced on the power system due to switching operations are known as switching surges.

A few causes will be discussed by way of illustration

1) Case of an Open line

During switching operations of an unloaded line, travelling waves are set up which produce overvoltages on the line

When the unloaded line is connected to the voltage source, a voltage wave is set up which travels along the line. On reaching the terminals point 'A' it is reflected back to the supply end without change of sign. This causes voltage doubling i.e voltage on the line becomes twice the normal value.

If E_{rms} is the supply voltage, the instantaneous voltage which the line will have to withstand will be $2\sqrt{2}E$.

→ This overvoltage is of temporary nature. It is because the line losses attenuate the wave and in a very short time, the line settle down to it's normal supply voltage E.

Case of a loade line :-

Over voltages will be produced during the switching operations of a load line. Suppose a load line is suddenly interrupted. This will setup a voltage of $2Z_n i$ across the break

i = Instantaneous value of current at the time of opening of line

Z_n = Natural impedance of the line.

Current chopping :-

Current chopping results in the production of high voltage transients across the contacts of the air blast CB.

Insulation failure :-

The most common case of insulation failure in a power system is the grounding of conductor (i.e insulation failure between line and earth) which may cause overvoltage in the system.

Arcing Ground :- The phenomenon of intermittent arc taking place in line to ground fault of a 3ϕ system with consequent production of transient is know as arcing ground.

Arcing ground can be prevented by earthing the neutral

Resonance:- Resonance in an electrical system occurs when inductive reactance of the circuit becomes equal to capacitive reactance. Under resonance condition the impedance of the circuit is equal to resistance of the circuit and the p.f is unity. Resonance causes high voltage in the electrical system.

Lightning:- What is lightning

An electronic discharge between cloud and earth, between clouds or between the charge centers of the same cloud is known as lightning.

CLO-3

Explain concept of lightning phenomenon:-

→ Lightning is a huge spark and takes place when clouds are charged to such a high potential (+ve or -ve) w.r.t earth or a neighbouring cloud that the dielectric strength of neighbouring medium (air) is destroyed

→ There are several theories which exist to explain how the cloud acquire charge.

→ The most accepted one is that during the upruth of warm moist air from earth, the friction between the air and the tiny particles of water causes the building up of charges.

→ When drops of water are formed, the larger drops become +vely charged and the smaller drops become -vely charged.

→ When the drops of water accumulate, they form clouds and hence cloud may possess either +ve or -ve charge depending upon the charge drops of water they contain.

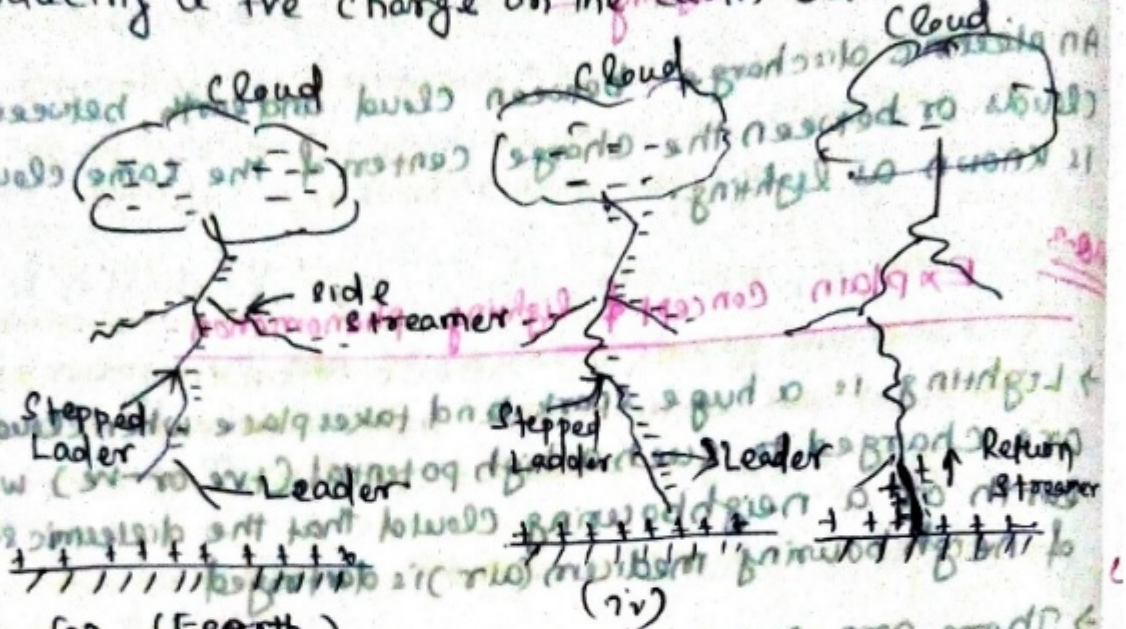
→ The charge on a cloud may become so great that it may discharge to another cloud or to earth and we call this discharge as lightning

Mechanism of Lightning Discharge

Q-1 Explain in details mechanism of lightning discharge.

→ When a charged cloud passes over the earth it induces equal and opposite charge on the earth below.

→ The below figure shows a negatively charge cloud inducing a +ve charge on the earth below. It.



→ As the charge acquired by the cloud increases, the potential between cloud and earth increases and therefore gradient in the air increases.

→ When the potential gradient is sufficient (5 kV/cm to 10kV/cm) to break down the surrounding air the lightning stroke starts.

→ The mechanism of the stroke are,

1) As soon as the air near the cloud breaks down, a streamer called lader streamer or pilot streamer starts from the cloud towards the earth and carries charge with it. The leader streamer will continue its journey towards earth as long as the cloud from which originates feeds enough charge to maintain gradient at the tip of the lader streamer above the strength of air. If the gradient is not maintained the leader streamer stops and the charge is dissipated without the formation of complete stroke.

ii) In many cases the lader streamer continues its journey towards earth [in fig (ii)] until it makes contact with earth or some object on the earth. As the leader streamer moves towards earth it is accompanied by points & luminescence which travel in jumps giving rise to stepped laders.

It may be noted that stepped leaders have sufficient luminosity and give rise to first visual phenomenon of discharge

iii) The path of lader streamer is a path of ionisation and therefore of complete breakedown of insulation. As the leader streamer reaches near the earth a return streamer shoots up from the earth to the cloud, following the same path as the main channel of the downward leader. This action can be compared with the closing of a switch between the +ve and -ve terminals: the downward leader having -ve charge and return streamer the +ve charge. This phenomenon causes a sudden spark which we call lighting.

GA Q-1 Most of the lighting strokes result from which type of charged cloud - Ans - negatively charged cloud

Types of Lighting strokes:-

GA Q-2 What are the different types of lighting strokes.

There are two main ways in which a lighting may strike the power system namely

1- Direct stroke ii) Indirect stroke.

Direct stroke:-

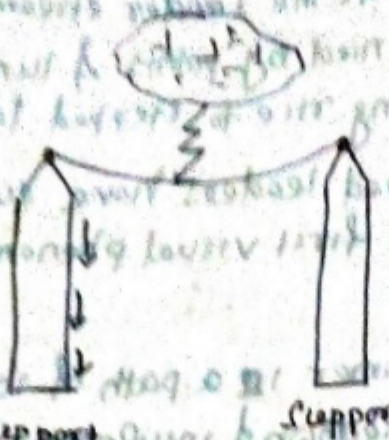
In the direct stroke, the lighting discharge (i.e Current path) is directly from the cloud to the subject equipment i.e on overhead line. From the line, the current path may be over the insulators down the pole to the ground. The over voltage set up due to the stroke may be large enough to flashover this path directly to the ground.

The direct stroke can be of two types

① Stroke A

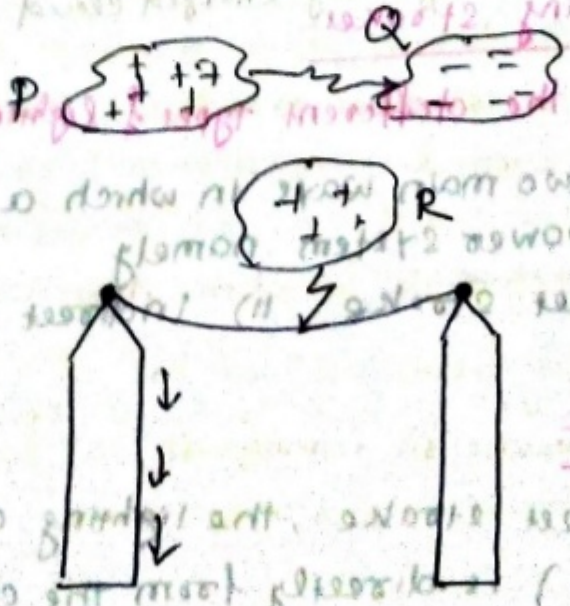
② Stroke B

Stroke A



In stroke A, the lighting discharge is from the cloud to the subject equipment i.e an over head lines in this case as shown in above figure. The cloud will induce a charge of opposite sign on the tall object. When the potential between the cloud and line exceeds the breakdown value of air the lighting discharge occurs between the cloud and the line.

Stroke B

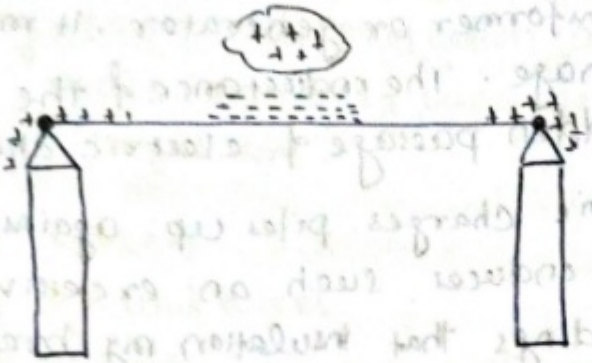


These are three clouds P, Q and R having +ve, -ve and +ve charges respectively. The charge on cloud Q is bound by the cloud R. If the cloud P shifts too near the cloud Q, then lighting discharge will occure between them and charges on both these clouds disappear quickly. The result is that charge on cloud R suddenly becomes free and it then discharge rapidly to earth, ignoring tall object.

→ Stroke A will always occur on tall objects and hence protection can be provided against it.

→ Stroke B completely ignores the height of the object and can even stroke the ground therefore it is not possible to provide protection against stroke B.

Indirect Stroke :-



→ In direct strokes result from the electrostatically induced charge on the conductors due to the presence of charged clouds.

→ A +ve charged cloud is above the line induces a -ve charge on the line by electrostatic induction.

→ This -ve charge however will be only on that portion of the line right under the cloud and the portions of the line away from it will be +ve charged.

→ The induced +ve charge leaks slowly to earth via the insulator. When the cloud discharges to earth or to another cloud. the -ve charge on the wire is isolated as it cannot flow quickly to earth over the insulator.

→ The result is that -ve charge rushes along the line in both directions in the form of travelling wave. It may worthwhile to mention here that majority of the surges in the transmission line are caused by indirect light strokes.

Harmful effect of lighting (99,70, W9.9, W09)

1) The travelling waves produced due to lightning will shatter the insulator and may even wreck poles.

II) If the travelling waves produced due to Lighting hit the windings of a transformer or generator, it may cause considerable damage. The inductance of the windings opposes any sudden passage of electric charge through it. Therefore the electric charges piles up against the transformer or generator. This induces such an excessive pressure between the windings that insulation my breakdown, resulting in the production of arc.

While the normal voltage between the turns is never enough to start an arc, once the insulation has broken down and an arc has been started by a momentary over voltage, the line voltage is usually sufficient to maintain the arc long enough to severely damage the machine.

III) If the arc is initiated in any part of the power system by the lighting stroke, this arc will set up very disturbing oscillations in the line. This may damage other equipment connected to the line.

GAQ-6 State two harmful effect of lighting:-

Ans:- 1) It shatter the insulators and may even wreck poles

2) Damage the transformer or generator.

GAQ-E What is a Surge Absorber.

Ans:- A surge absorber is a protective device which reduces the steepness of wave front of a surge by absorbing surge energy.

Protection Against lightning - UBB-5

→ The lightning surges may cause serious damage to the expensive equipment in the power system either by direct strokes on the equipment or by strokes on the transmission lines that reach the equipment as travelling waves

→ It is necessary to provide protection against both kind of surges. The most commonly used devices for protection against lightning surges are.

(i) Earthing screen
(ii) Overhead ground wires
(iii) Lightning arresters or surge diverters.

(i) Earthing screen provides protection to power station and sub-stations against direct strokes whereas overhead ground wires protect the transmission lines against direct lightning stroke.

(ii) However lightning arresters or surge diverters protect the station apparatus against both direct strokes and the strokes that come into the apparatus as travelling waves.

Lightning Arrester:-

UBB-5

A Lightning Arrester ~~or surge diverter~~ is a protective device which conducts the high voltage surges on the power system to the ground.

Types of Lightning Arresters:-

There are several types of lightning arresters in general use. but operates on the same principle i.e providing low resistance path for the surges to the ground

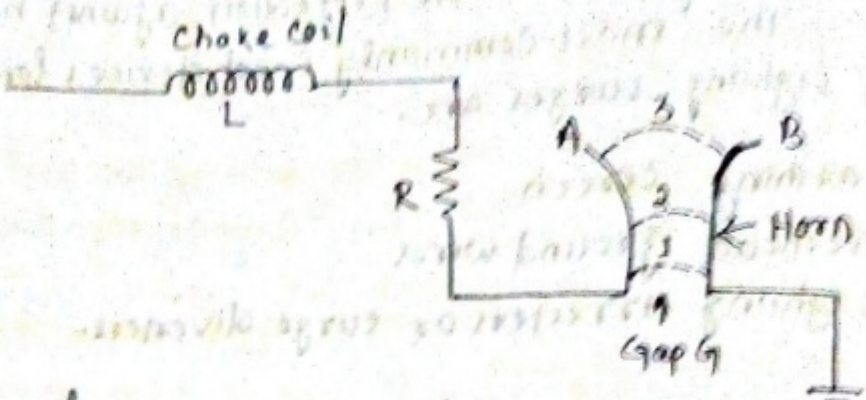
i) Rod gap arrester
ii) Horn gap arrester
iii) Valve type lightning Arrester.

Horn Gap Arrester

Explain with neat sketch horn gap type arrester

With neat sketch explain about horn gap type arrester

Diagram



Construction

→ It consists of two horn shaped metal rods A and B seperated by a small arc gap

→ The horns are so constructed that distance between them gradually increases towards the top as shown in the figure

→ The horns are mounted on porcelain insulators.

→ One end of horn is connected to the line through a resistance R and choke coil 'L' while the other end is effectively grounded.

→ The resistance 'R' helps in limiting the ~~following~~ follow current to a small value.

→ The choke coil is so designed that it offers small reactance at normal power frequency but a high reactance at transient frequency. Thus the choke does not allow the transients to enter the apparatus to be protected.

→ The gap between the horns is so adjusted that normal supply voltage is not enough to cause an arc across the gap.

Working:

→ Under normal conditions the gap is non-conducting i.e normal supply voltage is insufficient to initiate the arc between the gap.
→ On occurance of an over voltage, spark-over takes place across the small gap 'G'.
→ The heated air around the arc and the magnetic effect of the arc cause the arc to travel up the gap.
→ The arc moves progressively into position 1, 2 and 3.
→ At position 3 of the arc the distance may be too great for the voltage maintain the arc. Consequently the arc is extinguished.
→ The excess charge on the line is thus conducted through the arrester to the ground.

Advantages:

i) The arc is self-clearing. Therefore this type of arrester does not cause short ckt of the system after the surge is over as in the case of rod gap
ii) Series resistance helps in limiting the follow current to a small value.

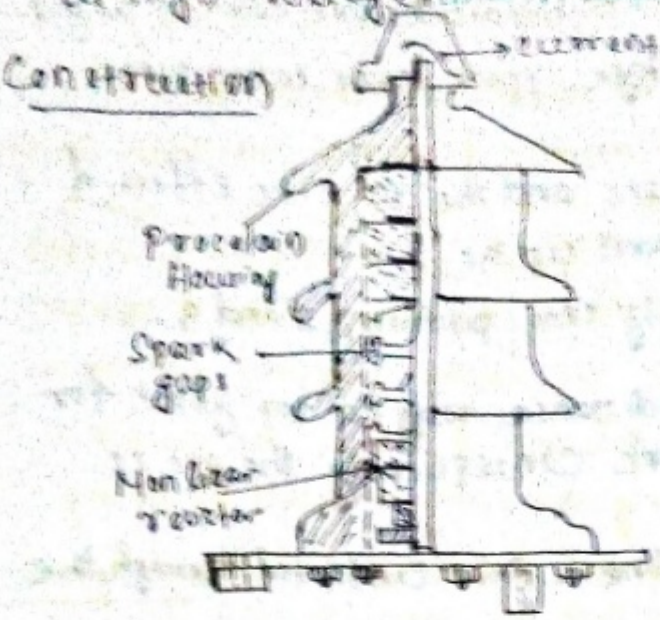
Limitations:

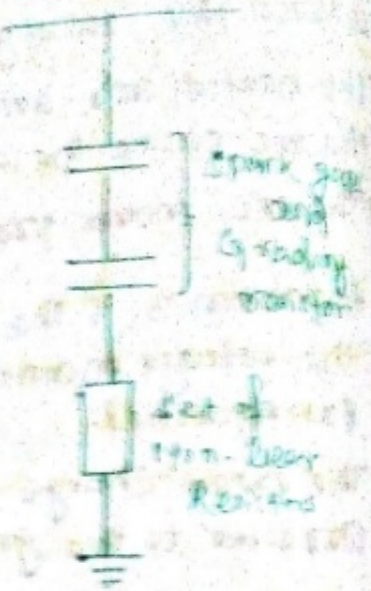
i) The Bridging of gap by some external agency (i.e birds) can render the device useless
ii) The setting of horn gap is likely to change due to corrosion or pitting. This adversely affects the performance of the arrester
iii) The time of operation is comparatively long, say about 3 seconds. In view of the very short operating time of modern protective gear for feeders this time is far long.

Valve type Arrester:

→ Valve type arrester are used on systems operating at high voltage.

Construction





Construction

It consists of two assemblies

① series spark gaps and ② non-linear resistor discs (made of material such as thyrite) in series. The non-linear elements are connected in series with the spark gaps. Both the assemblies are accommodated in tight porcelain container.

→ The spark gap is a multiple assembly consisting of a number of identical spark gaps in series. Each gap consists of two electrodes with a fixed gap spacing. The voltage distribution across the gaps is linearized by means of additional resistance elements (called grading resistors) across the gaps. The spacing of the series gaps is such that it will withstand the normal circuit voltage. However on over voltage it will cause the gap to breakdown, causing the surge current to ground via the non-linear resistor.

→ The non-linear resistor discs are made of an inorganic compound such as Thyrite. Thin discs are connected in series. The non-linear resistor have the property of offering a high resistance to current flow when normal system voltage is applied but a low resistance to the flow of high surge current. In other words the resistance of these

non-linear elements decreases with the increase in current through them and vice-versa.

Working :-

Under normal conditions, the normal system voltage is insufficient to cause the breakdown of arc gap assembly. On the occurrance of an over voltage, the breakdown of the series spark gap takes place and the surge current is conducted to earth via the non-linear resistor. Since the magnitude of surge current is very large, the non-linear elements will offer a very low resistence to the passage of surge. The result is that the surge will rapidly go to earth instead of being sent back over the line. When the surge is over the non-linear resistors assume high resistance to stop the flow of current.

Advantages :-

i) It provides very effective protection against surges

ii) They operate very rapidly taking less than a second.

Limitations :-

i) They may fail to check the surge if very steep wave front from reaching the terminal apparatus. This calls for additional steps to check steep-fronted waves.

ii) Their performance is adversely affected by the entry of moisture into the enclosure. This necessitates effective sealing of the enclosure at all time.

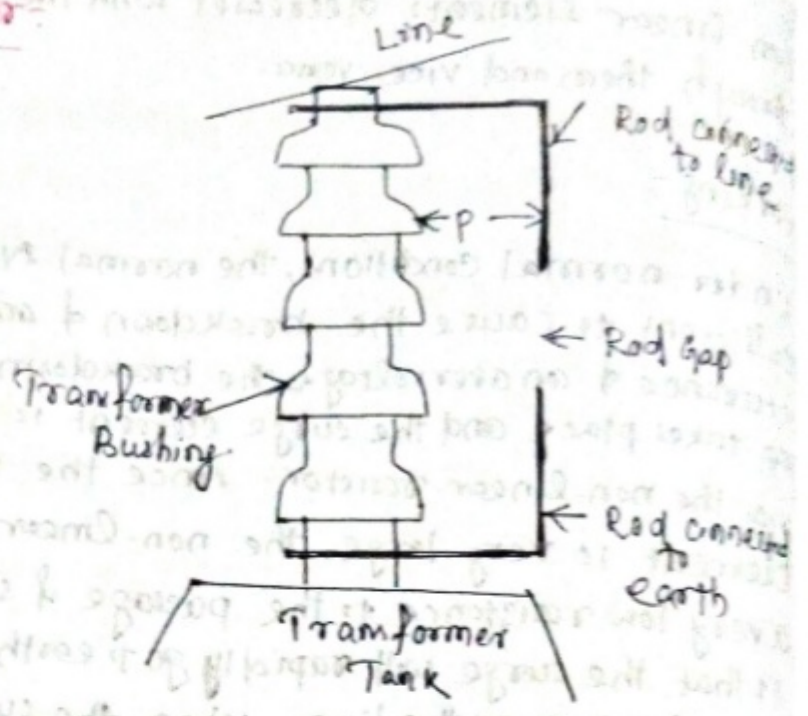
Applications :- According to the application, the valve type arresters are classified as

(i) station type (ii) line type.

The station type arresters are generally used for the protection of important equipments in the power stations operating on voltage upto 220kV or higher

The line type arresters are also used for stations handling voltage upto 66 kV.

Rod Gap Arrester:



Construction:

→ It is a very simple type diverter and consists of two L-shaped Rods which are bent at right angles with a gap in between as shown in the figure

→ One rod is connected to the line ckt and the other rod is connected to earth

→ The distance between gap and insulator (i.e distance p) must not be less than one-third of the gap length so that the arc may not reach the insulator and damage it.

→ The string of insulators for an overhead line on the bushing of transformer has frequently a rod gap across it.

Working

Under normal operating conditions the gap remains non-conducting. On the occurance of a high voltage surge on the line, the gap sparks over and the surge current is conducted to earth. In this way excess charge on the line due to the surge is harmlessly conducted to earth

Limitations:

(i) After the surge is over, the arc in the gap is maintained by the normal supply voltage leading to a short ckt on the system

(ii) The rods may melts or get damaged due to excessive heat produced by the arc

(iii) Rain, humidity, temperature affect the performance of rod gap arrester

(iv) The polarity of the surge also affects the performance of this arrester

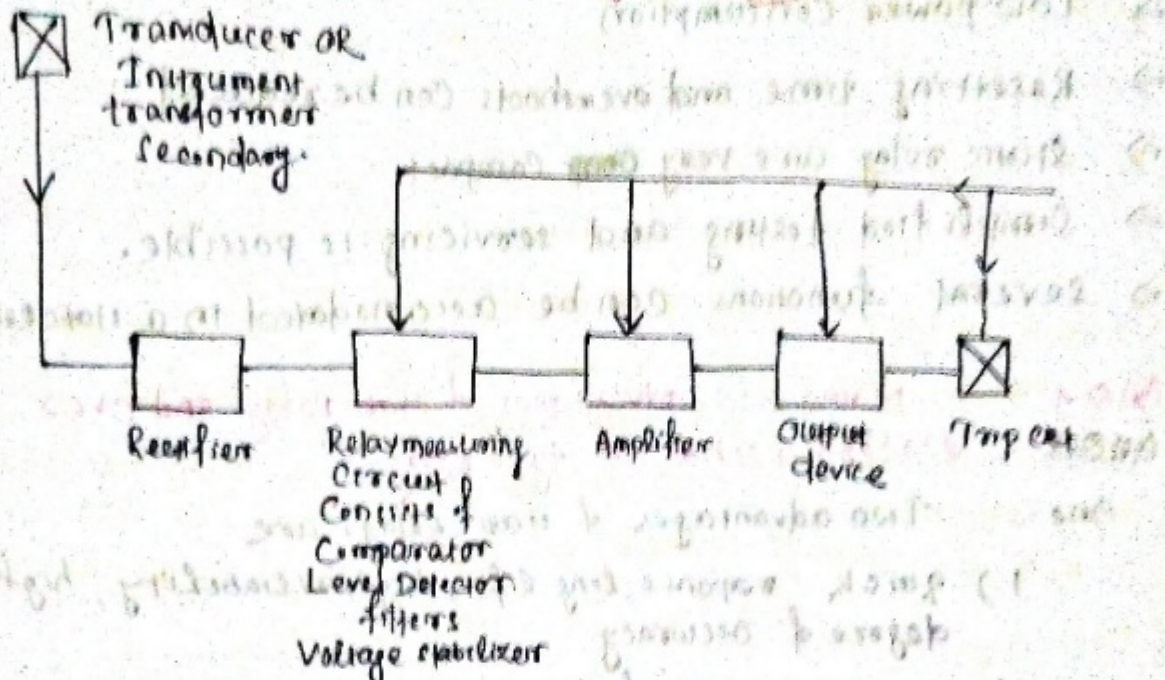
Static Relay

GAQ2

What do you mean by Static Relay

Static Relay (Solid State Relay) is an electrical Relay in which the response is developed by electronic/magnetic/optical or other components, without mechanical motion of components.

Explain about static relay with block diagram (GQ3)



→ The above block diagram shows the essential components in a static relay.

The output of CTs and PTs or transducers is rectified in rectifier

→ The rectified o/p is fed to the measuring unit. the measuring unit comprises comparators, level detectors, filters, logic circuits.

→ The o/p is initiated when input reaches the threshold value

→ The o/p of measuring unit is amplified by Amplifier

→ The amplified output is given to the o/p unit which energizes the trip coil only when relay operates.

Applications of static Relay GAQ6

→ These Relays are used in over current and earthfault protection schemes

→ These are used in pilot - high speed protection schemes EHVAC lines like using distance protection.

The advantages of static Relay are

→ The moving parts and the contacts are greatly reduced. the only moving parts are those of the actual tripping ckt

→ A high degree of Accuracy

→ A high speed of operation

→ Low power Consumption

→ Resetting time and overshoots can be reduced

→ Static relay are very ~~Comp~~ Compact

→ Simplified testing and servicing is possible.

→ several functions can be accomodated in a static Relay.

GBQ-4 Name two advantages of static Relay ~~and over~~ over GBQ-5 electro mechanical type Relay :-

Ans :- Two advantages of static Relay are

1) quick response, long life, high reliability, high degree of accuracy

2) Due to absence of moving Contacts associated problems of arcing, contact bounce, erosion and replacement of contacts ~~are~~ are absent.

GBQ-2 Compare static relay with electromagnetic Relay

Electromagnetic Relay :-

Ans :- → For simple protective functions and for protection of simple low power equipment, electromagnetic relays are preferred.

→ Electromagnetic units are also be used as Component of total predominantly static relay ~~n~~ e for auxiliary relay functions, output functions

Static Relay

For Complex protective functions requiring accurate Characteristics for various protective functions and for protection of costly, large equipments / machines, static relays are preferred. These may be hard-wired ~~and~~ or programmed

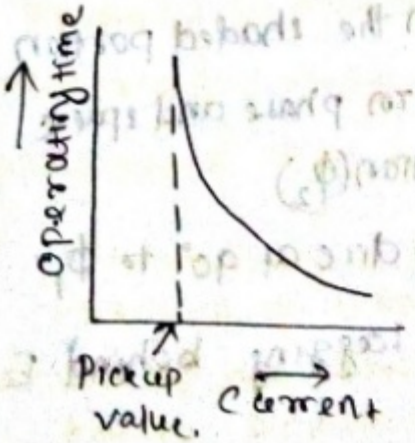
→ For integrated protection and monitoring systems programmable microprocessor controlled static relays are preferred.

Q8

Q8-1

What is IDMT Relay :-

The full form of IDMT relay is Inverse Definite Minimum Time Relay. In this relay the time of operation is approximately inversely proportional to fault current near Pickup value



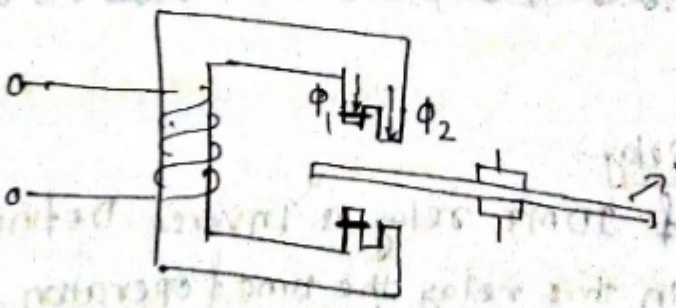
Explain the principle of IDMT Relay

The IDMT Relay works on the principle, where a aluminium or copper disc rotates between the poles of an electromag → and a damping magnet. The fluxes induce eddy currents → in the disc which interact and produce rotational torque → The disc rotates to a point where it operates a pair → of contacts that break the circuit and remove the fault condition.

With Neat sketch explain about IDMT Relay

→ In this type of relay a metal disc is allowed to rotate between two electromagnet. The electromagnets are energized by alternating currents. The field produced by the two magnets are displaced in space and phase.

→ The torque is developed by the interaction of the flux of one of the magnets and the eddy current induced in the disc by the other.

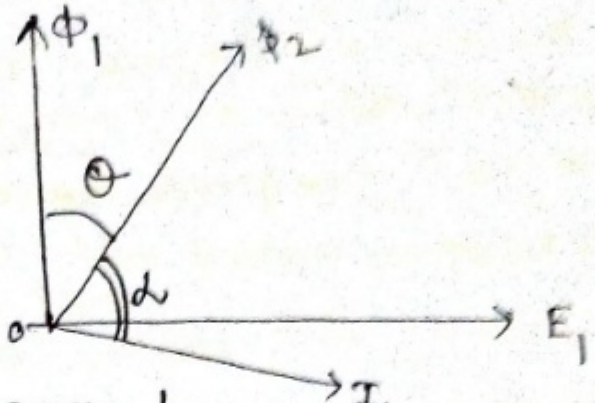


The shading ring is a copper band or a coil effect of shading ring is to produce flux in the shaded portion of the magnet ϕ_1 which is displaced in phase and space from the flux in the remaining portion (ϕ_2)

The flux ϕ_1 induces e.m.f E_1 in the disc at 90° to ϕ_1

The e.m.f E_1 produces current I_1 lagging behind E_1 by a small angle α.

The interaction between I_1 and ϕ_2 produces torque, which is proportional to $\phi_2 I_1 \cos\alpha$ where $I_1 \cos\alpha$ is component of I_1 in phase with ϕ_2. greater the angle α greater is the torque.



Torque equation

$$T = K_1 I^2 - K_2$$

T = Net torque

ϕ_1 = flux in shaded portion of magnet

ϕ_2 = " " unshaded " " "

E_1 = e.m.f induced in the disc due to ϕ_1

I_1 = Current in the disc induced by E_1

Torque $\propto \phi_2 I_1 \cos\alpha$

α is the angle between ϕ_2 and I_1

I Current in the relay coil

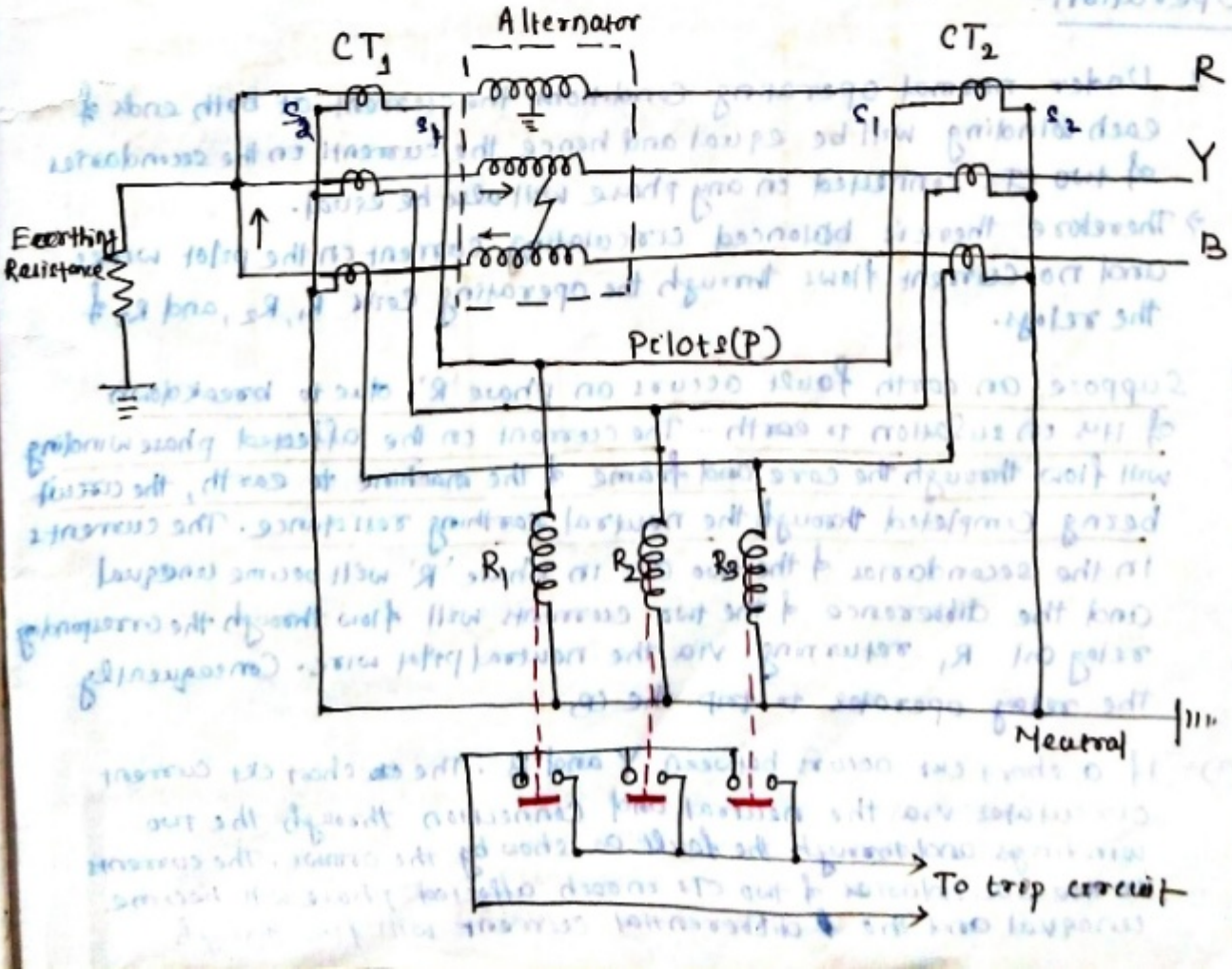
K_1, K_2 = Constants.

PROTECTION OF ALTERNATOR:- Before studing the protection of alternator we should know the import faults in alternator. Some of the important faults which may occur on an alternator are.

I) Failure of prime-mover
II) Failure of field
III) Overcurrent
IV) Overspeed
V) Over voltage
VI) Unbalanced loading
VII) Stator winding faults.

Differential protection of Alternator: Or (Merz - Price protection)

8- Write short notes on Differential protection of alternator.
7 - Explain one scheme of protection of alternator
2 - Explain merz - price protection system applied to generator.
2. What is biased circulating current protection system of generator?



The most common system used for the protection of stator winding faults employs circulating current principle. This form of protection is known as Merz-Price circulating current scheme.

Schematic Arrangement:

-> Identical current transformer pairs CT_1 and CT_2 are placed on either side of each phase of the stator windings.

-> The secondaries of each set of CT are connected in star, the two neutral points and the corresponding terminals of the two star groups being connected together by means of a four-core pilot cable.

-> Thus there is an independent path for the currents circulating in each pair of current transformers and the corresponding pilot wire.

-> The relay coils are connected in star, the neutral point being connected to the current transformer common neutral and the outer ends one to each of the other three pilots.

-> In order that burden on each current transformer is the same the relays are connected across equipotential points of the three pilot wires and these equipotential points would naturally be located at the middle of the pilot wires.

-> The relays are generally electromagnetic type and are arranged for instantaneous action since fault should be cleared as quick as possible.

Operation:

(i) -> Under normal operating conditions the current at both ends of each winding will be equal and hence the currents in the secondaries of two CTs connected in any phase will also be equal.

-> Therefore there is balanced circulating current in the pilot wires and no current flows through the operating coils R_1, R_2, and R_3 of the relays.

(ii) Suppose an earth fault occurs on phase 'R', due to breakdown of its insulation to earth. The current in the affected phase winding will flow through the core and frame of the machine to earth, the circuit being completed through the neutral earthing resistance. The currents in the secondaries of the two CTs in phase 'R' will become unequal and the difference of the two currents will flow through the corresponding relay coil R_1 returning via the neutral pilot wire. Consequently the relay operates to trip the CB.

(iii) If a short ckt occurs between Y and B. The short ckt current circulates via the neutral and connection through the two windings and through the fault as show by the arrows. The currents in the secondaries of two CTs in each affected phase will become unequal and the differential current will flow through

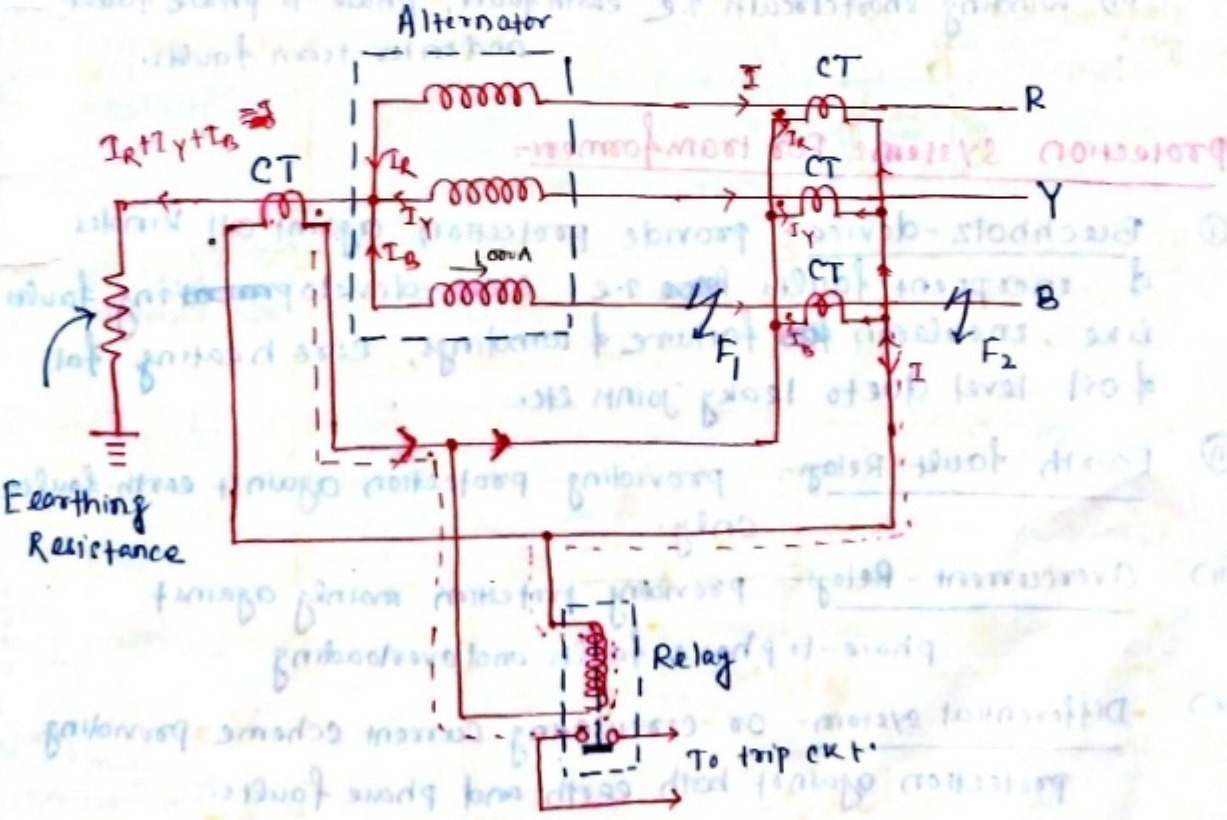
the operating coils of the relay i.e R_2 and R_3 connected on these phases. The relay then closes its contacts to trip the CB.

→ In some cases the alternator is located at a considerable distance from the switchgear. As the relays are located close to the CB therefore it is not convenient to connect the relay coils to the actual physical mid-point of pilots. Under these circumstances balancing resistances are inserted to the shorter lengths of the pilots so that the relay tapping points divide the whole secondary impedance of two sets of CTs into equal portions.

Balanced Earth-Fault Protection of Alternator:-

→ In small size alternators the neutral ends of the three-phase windings are often connected internally to a single terminal. Therefore it is not possible to use Merz-price circulating current principle because there are no facilities for accomodating the necessary CTs in the neutral connections of each phase winding.

→ Under these circumstances it is considered efficient to provide protection against earth-faults only by the use of balanced earth-fault protection scheme.



Schematic Arrangement:-

It consists of three line CTs, one mounted on each phase, having their secondaries connected in parallel with that of a single current transformer in the conductor joining the star point of the alternator to earth. A relay is connected across the CTs secondaries. The protection against earth faults is limited to the region between the neutral and the line CTs.

Operation :-

→ Under normal operating conditions, the currents flowing in the alternator leads and hence the currents flowing in secondaries of the line CTs add to zero and no current flows through the relay.

→ If an earth fault develops at F_2 external to the protected zone, the sum of the currents at the terminals of the alternator is exactly equal to the current in the neutral connection and hence no current flows through the relay.

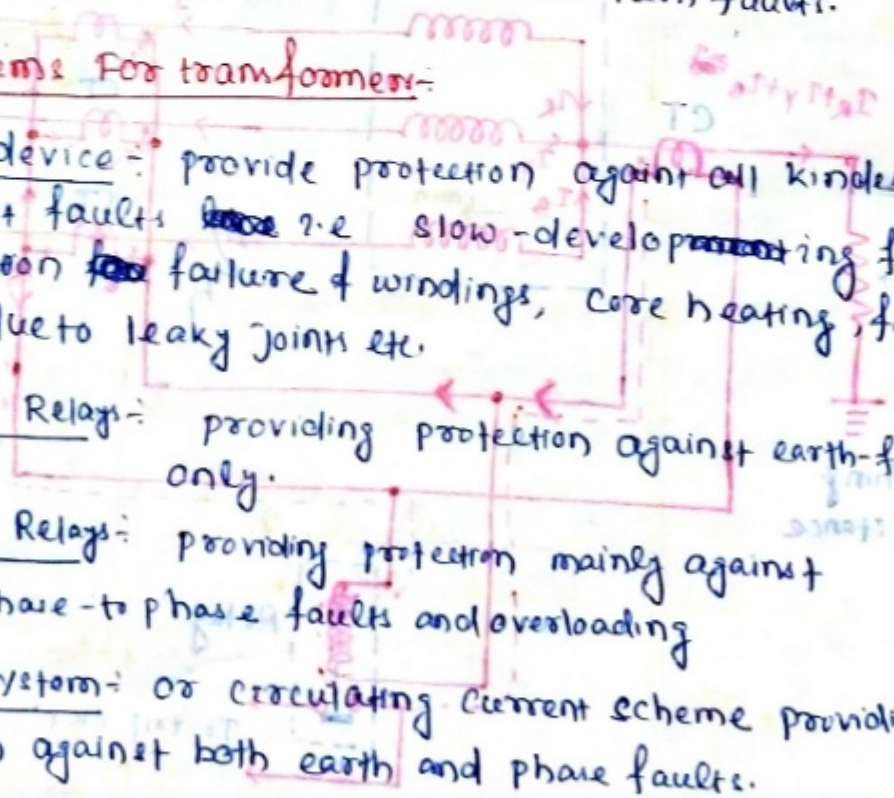
→ When an earth fault occurs at F_1 or within the protected zone these currents are no longer equal and the differential current flows through the operating coil of the relay. The relay then closes its contacts to disconnect the alternator from the system.

Protection of Transformer :-

Common transformer faults :-

i) Open circuits.
ii) Overheating
iii) Winding short circuits i.e earth fault, phase-to phase faults and inter-turn faults.

Protection systems For transformer :-



① **Buchholz-device** :- provide protection against all kinds of incipient faults i.e slow-developing faults like, insulation failure of windings, core heating, fall of oil level due to leaky joints etc.

(ii) **Earth fault Relays** :- providing protection against earth-faults only.

(iii) **Overcurrent Relays** :- providing protection mainly against phase-to phase faults and overloading

(iv) **Differential system** :- or circulating current scheme providing protection against both earth and phase faults.

Buchholz Relay :-

Qc 5 Describe the construction and working of a Buchholz Relay

GB Q1 Write short notes on buchholz Relay.

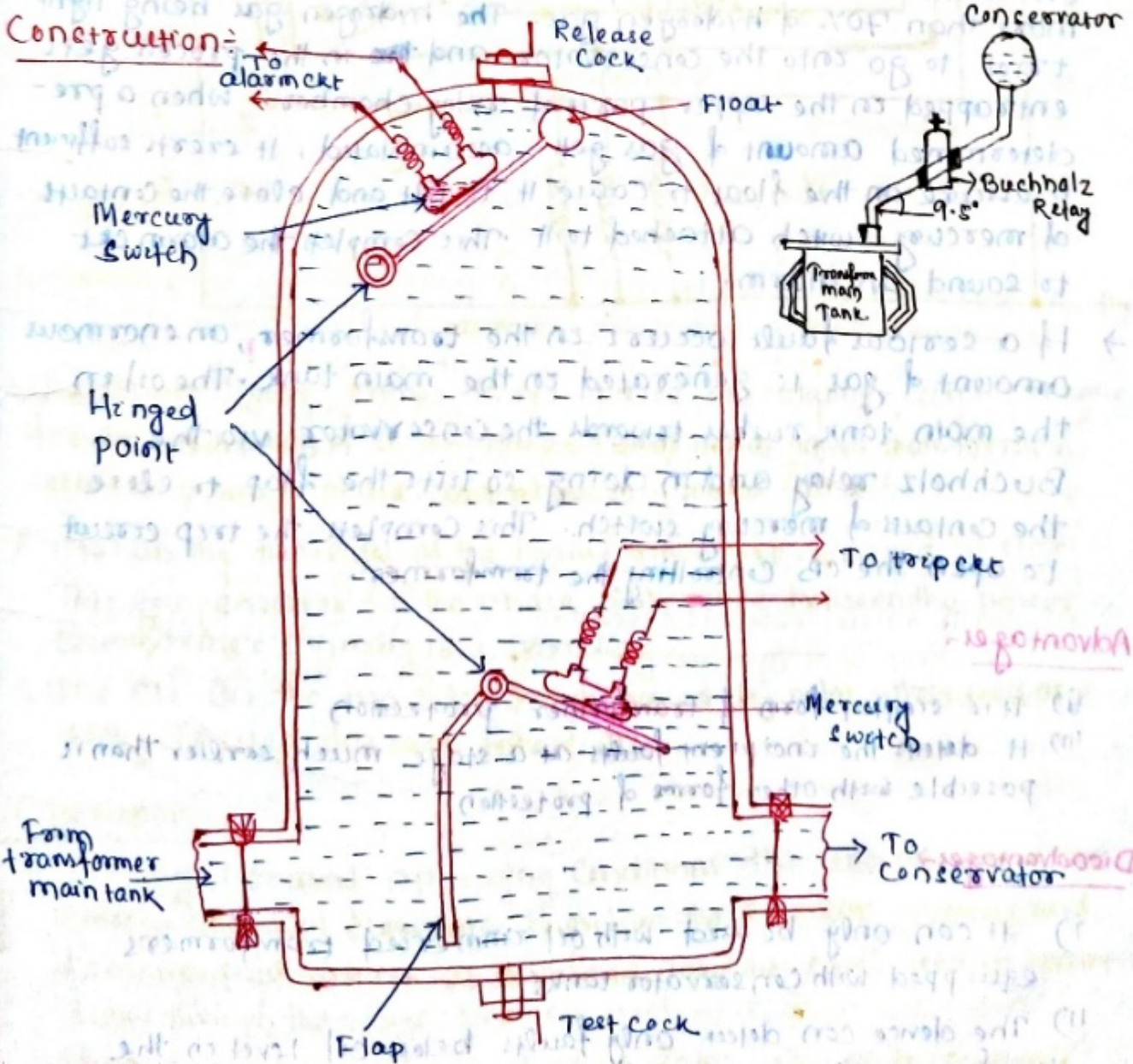
→ Buchholz Relay is a gas-actuated relay installed in oil-immersed transformers for protection against all kinds of incipient faults (i.e slow developing faults)

→ It is used to give an alarm in case of faults in the transformer and to disconnect the transformer from supply.

→ It is usually installed in the pipe connecting the conservator to the main tank.

→ It is used for oil immersed transformers of rating more than 750 KVA is generally economical.

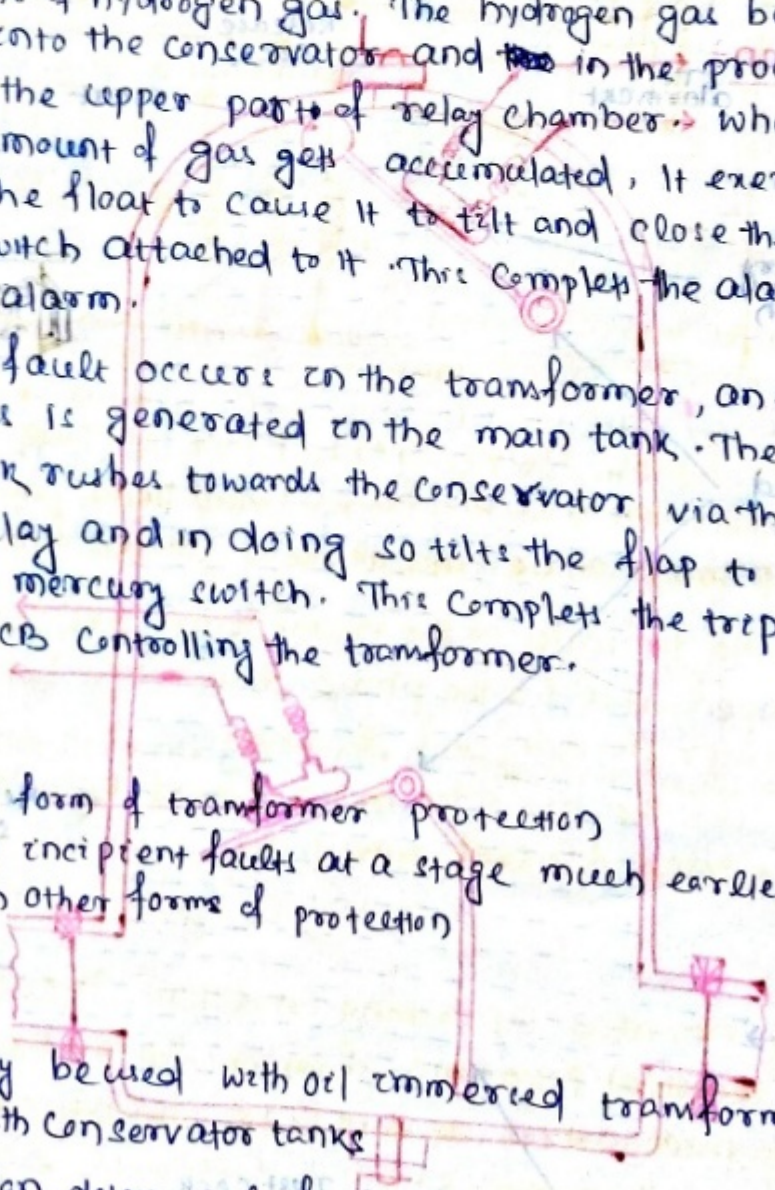
Construction :-



→ It takes the form of a domed vessel placed in the connecting pipe between the main tank and the conservator.
→ The device has two elements. The upper element consists of a mercury type switch attached to a float. The lower element contains a mercury switch mounted on a hinged type flap located in the direct path to the flow of oil from the transformer to the conservator.
→ The upper element closes an alarm ckt during fault whereas the lower element is arranged to trip the CB in case of severe internal fault.

Operation:

→ In case of incipient faults within the transformer, the heat due to fault causes the decomposition of some transformer oil in the main tank. The products of decomposition contain more than 70% of hydrogen gas. The hydrogen gas being light tries to go into the conservator and in the process gets entrapped in the upper part of relay chamber. When a predetermined amount of gas gets accumulated, it exerts sufficient pressure on the float to cause it to tilt and close the contacts of mercury switch attached to it. This completes the alarm ckt to sound an alarm.
→ If a serious fault occurs in the transformer, an enormous amount of gas is generated in the main tank. The oil in the main tank rushes towards the conservator via the Buchholz relay and in doing so tilts the flap to close the contacts of mercury switch. This completes the trip circuit to open the CB controlling the transformer.



Advantages:

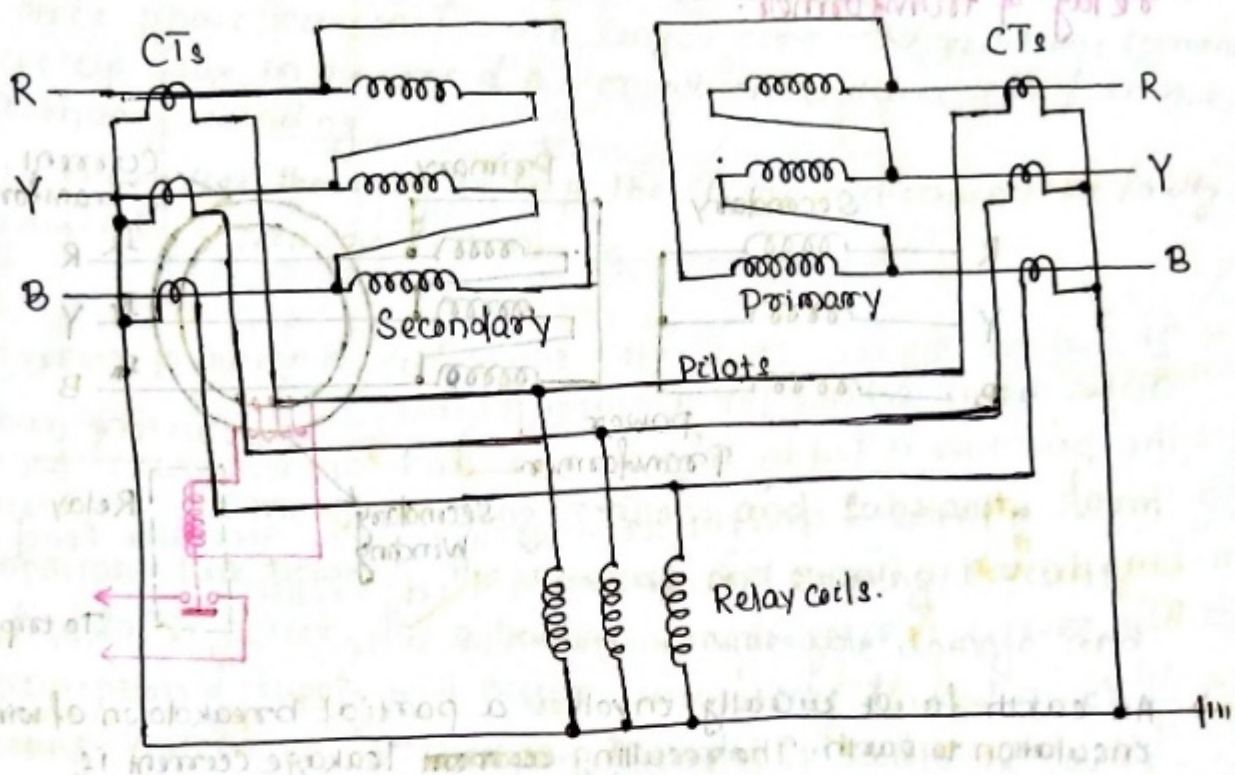
(i) It is simplest form of transformer protection
(ii) It detects the incipient faults at a stage much earlier than is possible with other forms of protection

Disadvantages:

i) It can only be used with oil immersed transformers equipped with conservator tanks
ii) The device can detect only faults below oil level in the transformer. Therefore seperate protection is needed for connecting Cables.

Q.9

Explain how transformer can be protected by circulating current scheme.



→ The above figure shows Merz-price circulating-current scheme for the protection of a 3-phase Delta/Delta power transformer against phase to phase and phase to ground fault

→ CTs on the two sides of the transformer are connected in star. This compensates for the phase difference between the power-transformer primary and secondary.

→ The CTs on the two sides are connected by pilot wires and one relay is used for each pair of CTs.

Operation:-

→ During normal operating conditions the secondaries of CTs carry identical currents. Therefore the currents entering and leaving pilot wires at both ends are the same and no current flows through the relays.

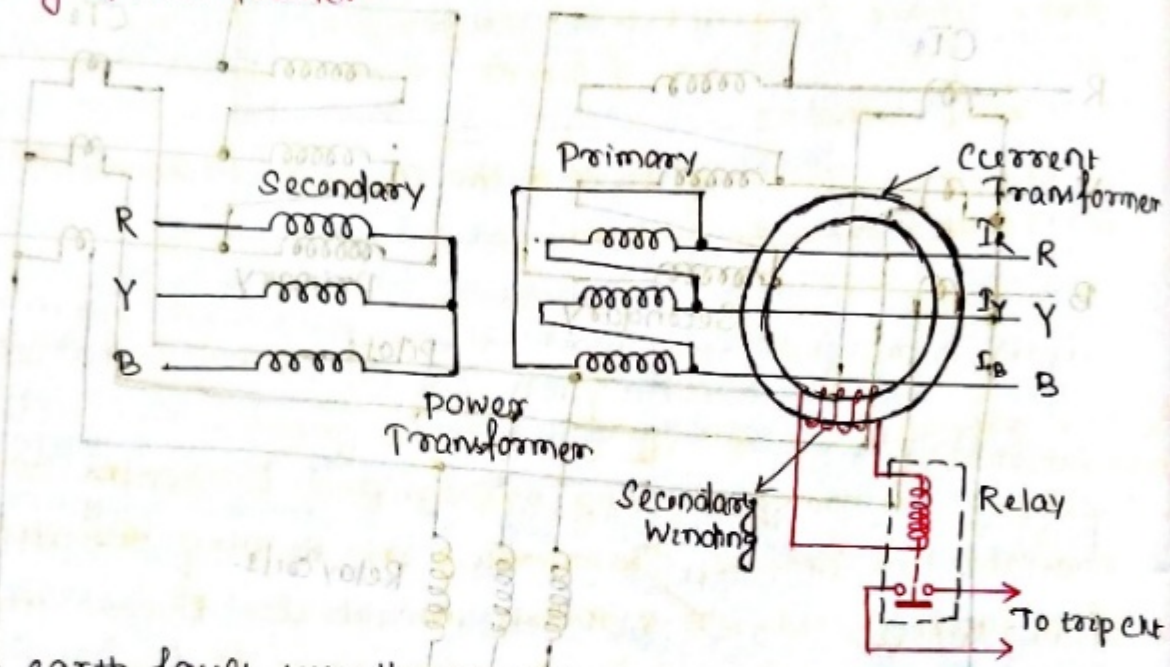
→ If a ground or phase-to-phase fault occurs the currents in the secondaries of CTs will no longer be the same and the differential current flowing through the relay circuit will clear the breaker on ~~the~~ both sides of the transformer

→ The protected zone is limited to the region between CTs on the high voltage side and the CTs on the low voltage side of the power transformer.

Earth fault or Leakage protection of Transformer

qc

1 With a neat circuit explain the working of a earth-fault relay of transformer.



→ An earth fault usually involves a partial breakdown of winding insulation to earth. The resulting leakage current is considerably less than the short-circuit current.

→ The earth fault may continue for a long time and cause considerable damage before it ultimately develops into a short-circuit and removed from the system. Under these circumstances it is profitable to employ earth fault relays in order to ensure the disconnection of earth fault or leak in the relay stage

→ An earth fault relay is essentially an over current relay of low setting and operates as soon as an earth fault or leak develops.

→ One method of protection against earth-faults in transformer is the core-balance leakage protection

Schematic Arrangement :-

→ The three leads of the primary winding of power transformer are taken through the core of a current transformer which carries a single secondary winding.

→ The operating coil of a relay is connected to this secondary

Operation:-

Under normal conditions, (i.e no fault to earth), the vector sum of the three phase currents is zero and there is no resultant flux in the core of current transformer no matter how much the load is out of balance. Consequently no current flows through the relay and it remains inoperative.

→ However on the occurance of an earth fault the vector sum of three phase currents is no longer zero. The resultant current sets up flux in the core of the CT which induces e.m.f in the secondary winding

→ This energises the relay to trip the CB and disconnect the faulty transformer from the system.

Busbar protection:-

→ Busbars in the generating stations and substations form important link between the incoming and outgoing circuits.

→ If a fault occurs on a busbar considerable damage and disruption of supply will occur unless some form of quick-acting automatic protection is provided to isolate the faulty-bus bar.

→ The bus-bar zone, for the purpose of protection includes not only the busbars themselves but also the isolating switches, CBs and the associated connections.

The two most commonly used schemes for bus-bar protection are

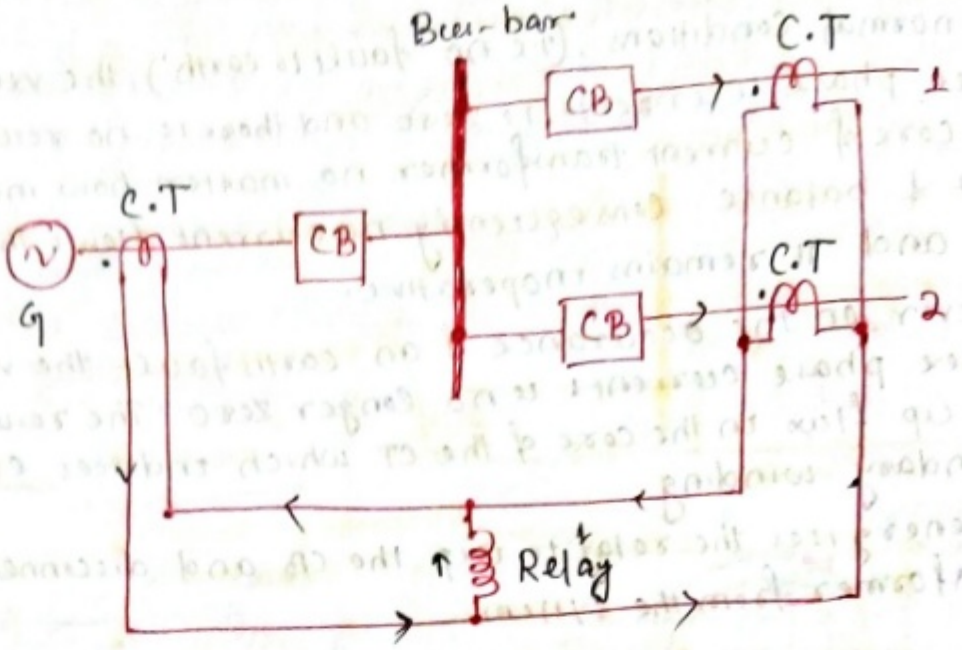
1) Differential protection
2) Fault bus-protection.

Differential protection

→ The basic method for bus-bar protection is the differential scheme in which currents entering and leaving the bus are totalised

→ During normal load conditions, the sum of these currents is equal to zero.

→ When a fault occurs the fault current upsets the balance and produces a differential current to operate a relay.



→ The above figure shows the single line diagram of current differential scheme for a station busbar.

→ The bus-bar is fed by a generator and supplies load to two lines

→ The secondaries of current tramformers in the generator load in line 1 and in line 2 are all connected in parallel.

→ The protective relay is connected across this parallel connections

→ All CTs must be of the same ratio in the scheme regardless of the capacities of the various circuits

→ Under normal load conditions or external fault conditions the sum of currents entering the bus is equal to those leaving it and no current flows through the relay.

→ If a fault occurs within the protected zone, the currents entering the bus will no longer be equal to those leaving it.

→ The difference of these currents will flow through the relay and cause the opening of the generator, CB and each of the line CBs.

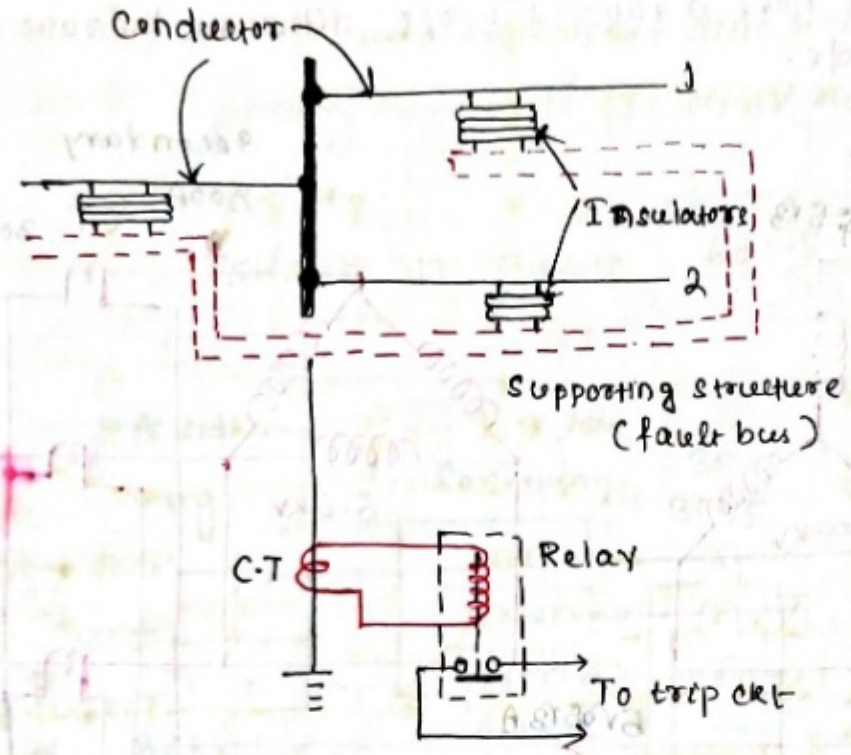
ii) Fault Bus protection:

→ It is possible to design a station so that the faults that develop are mostly earth-faults.

→ This can be achieved by providing earthed metal barrier (known as fault bus) surrounding each conductor throughout its entire length in the bus structure.

→ With this arrangement every fault that might occur must involve a connection between a conductor and an earthed metal part.

→ By directing the flow of earth fault current it is possible to detect the faults and determine their location. This type of protection is known as fault bus protection.



→ The metal supporting structure or fault bus is earthed through a current transformer

→ A relay is connected across the secondary of the CT.

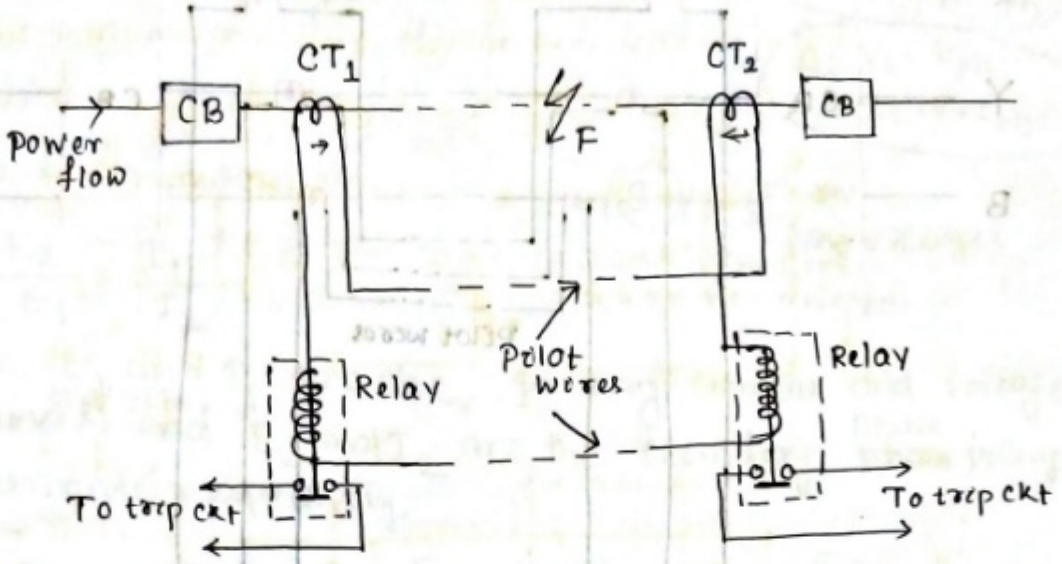
→ Under normal operating conditions, there is no current flow from fault bus to ground and the relay remains inoperative.

→ A fault involving a connection between a conductor and earthed supporting structure will result in current flow to ground through the fault bus, causing the relay to operate.

→ The operation of relay will trip all breakers connecting equipment to the bus.

6) With a neat diagram explain Merz-price voltage balance protection for 3-phase feeder:

Ans:-



→ The above diagram shows the single line diagram of Merz-price voltage balance system for the protection of a 3-phase line.

→ Identical current transformers are placed in each phase at both ends of the line.

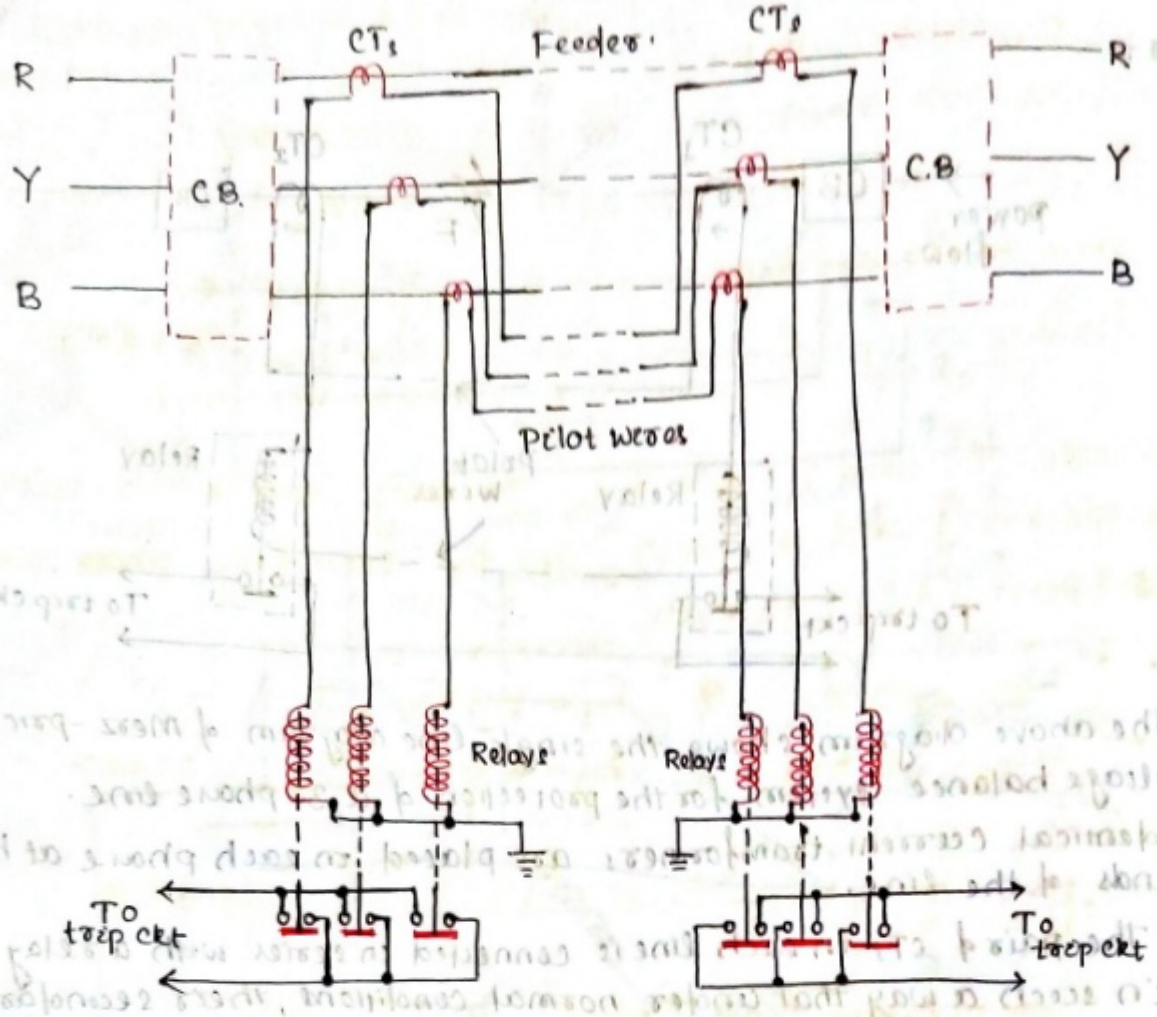
→ The pair of CT, in each line is connected in series with a relay in such a way that under normal conditions, their secondary voltages are equal and in opposition i.e they balance each other.

→ Under healthy conditions, current entering the line at one-end is equal to that leaving it at the other end

→ Therefore, equal and opposite voltages are induced in the secondaries of the CTs at the two ends of the line. The result is that no current flows through the relays

→ Suppose a fault occurs at point 'F' on the line shown in the above figure this causes a greater current to flow through CT_1 than through CT_2 consequently, their secondary voltages become unequal and circulating current flows through the pilot wires and relays.

→ The CBs at both ends of the line will trip out and the faulty line will be isolated.



Advantages:-

i) This system can be used for ring mains as well as parallel feeders.

ii) This system provides instantaneous protection for ground faults. This decreases the possibility of these faults involving other phases.

iii) This system provides instantaneous relaying which reduces the amount of damage to overhead conductors resulting from arcing faults.

Disadvantages:-

i) Accurate matching of current transformers is very essential

ii) If there is a break in the pilot wire ckt the system will not operate

iii) This system is very expensive owing to the greater length of pilot wires required

iv) In case of long lines, charging current due to pilot-wire - capacitance effects may be sufficient to cause relay operation even under normal conditions.

v) This system cannot be used for lines voltages beyond 33 KV because of constructional difficulties in matching the current transformers.