GOVT. POLYTECHNIC, BALANGIR

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SWITCH GEAR AND PROTECTIVE DEVICES

ELECTRICAL ENGG.

F16110002003

6th SEM.

2020/5/2

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CH-1

Switchgear

The apparatus used for switching, controlling and protecting the electrical circuit. Those equipments are known as switchgear.

Essential features of switchgear :-

Reliability :-

→ It is added to the power system to improve the reliability. ~~When~~

→ When fault is occur then isolate from the faulted area for other circuit.

Absolute discrimination :-

→ When fault occur in any ~~par~~ power system then it should be discriminate between the faulted area and healthy section.

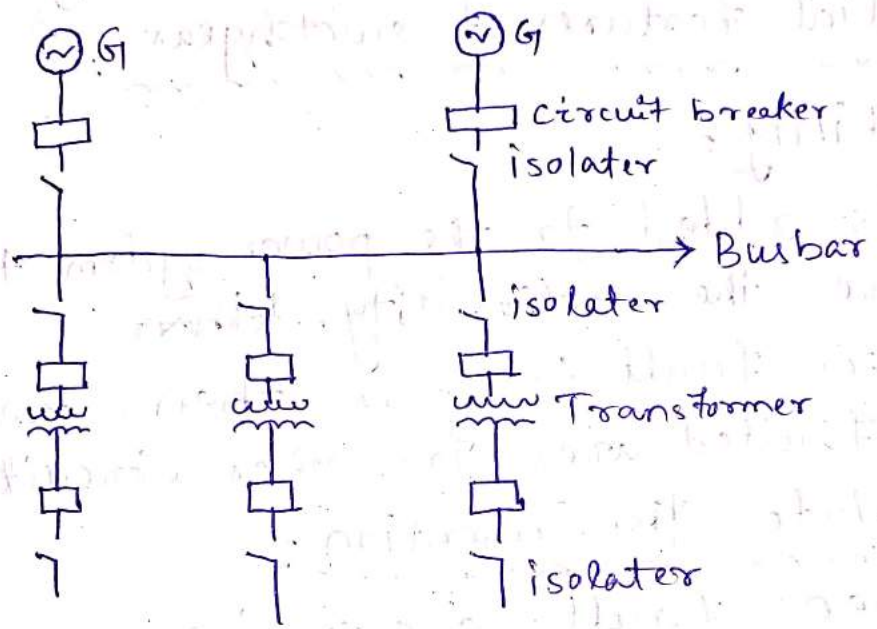
Quick operation :-

When fault occur in any part of power system the switchgear operate quickly so that no damage is done to any other part by the short ckt current.

Manually

Busbar :-

A conductor or a group of conductor used for collecting electric power from the incoming feeder and distribute to outgoing feeder.



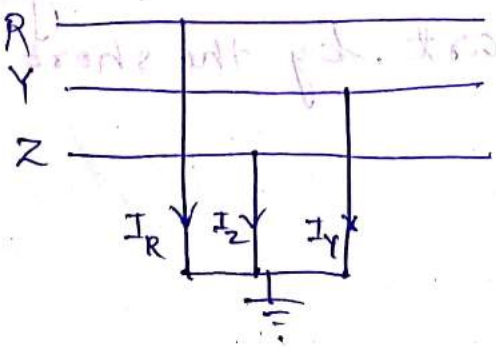
Fault are of two types:-

(i) Symmetrical fault

(ii) Unsymmetrical fault

Symmetrical fault :-

→ All the phases are short circuited to each other.



Unsymm

→ Fault

→ It is

(i) Single

(ii) Line

(iii) Doubl

Three

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Unsymmetrical fault

→ Fault occur in only one or two phase.

→ It is of three types :-

(i) Single line to ground fault (LG)
(ii) Line to line fault (LL)
(iii) Doubble line to ground fault (LLG)
Three phase to ground fault

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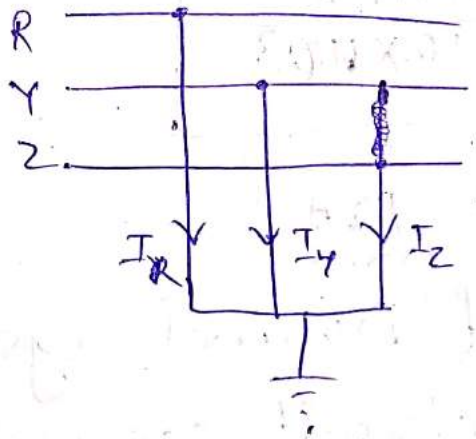
Fault calculation

→ The symmetrical fault occur when all the three conductor of a 3-ϕ line are brought together into a short circuit condition.



Percentage reactance

→ It is the percentage of the total voltage drop in the circuit, when full load current is their.

$$\therefore \%X = \frac{IX}{V} \times 100.$$

I = Full load current

X = reactance in ohm per phase

V = Phase voltage

$$\% X = \frac{IX}{V} \times 100$$

$$\Rightarrow X = \frac{(\% X)V}{I \times 100}$$

$$\Rightarrow X = \frac{(\% X)\left(\frac{V}{1000}\right) \times \left(\frac{V}{1000}\right) \times 1000}{100 \times \left(\frac{V}{1000}\right) \times I}$$

$$\Rightarrow X = \frac{\% X\ (KV)^2 \times 1000}{100 \times KVA}$$

$$\Rightarrow X = \frac{\% X\ (KV)^2 \times 10}{KVA}$$

$$\Rightarrow \boxed{\% X = \frac{KVA\ X}{10 \times (KV)^2}}$$

2mg

Short circuit KVA

The product of normal system voltage and short circuit current and the point of fault expressed in KVA

Reactor control of short circuit current

→ In order to control short circuit current circuit breaker can handle along with that additional reactance

known as reactor, are connected in series with the system.

→ Reactor is a coil of no: of turns designed to have a large inductance.

Advantages

(i) Reactance limit the flow of short circuit current thus protect the equipment over heating.

(ii) Increase the chance of continuity of supply.

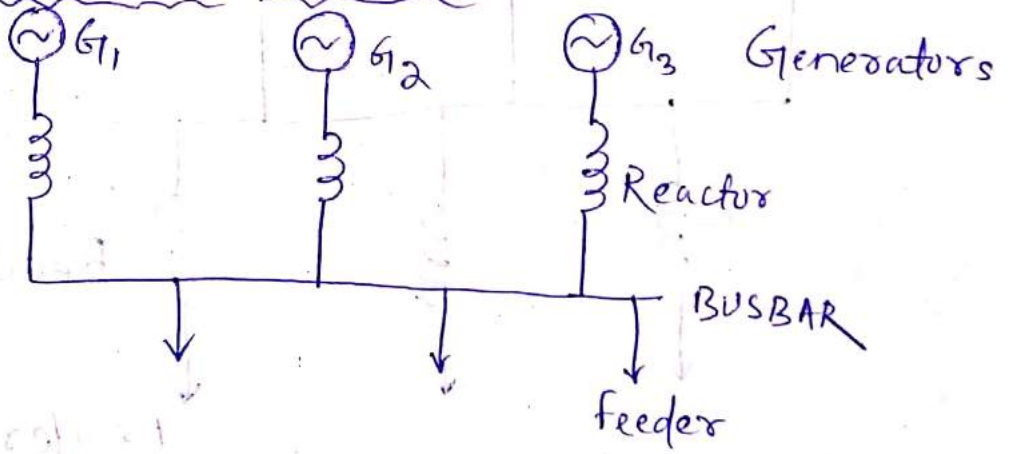
Location reactor

→ In series with each generator.

→ In series with each feeder.

→ In series with each busbar.

(i) Generator reactor



→ When the reactor are connected in series with each generator is known as generator reactor.

Disadvantages

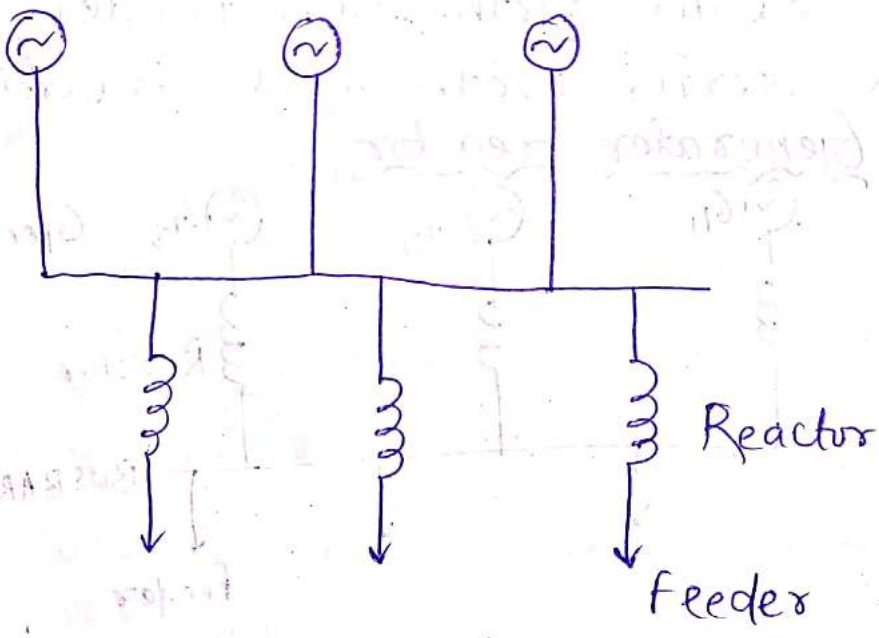
i) There is a constant voltage drop and power loss. even during normal operation.

ii) If busbar or feeder fault occur the voltage at busbar will reduced to a low value. That may lead to failure in generator.

iii) If no of generator is increase, size of feeder reactor will have to increase.

Feeder reactor

→ Most of the short circuit occur in feeder so large no. of reactor are used for each circuit.



→ If fault occur in any feeder the voltage drop in it's reactor will not affect to the busbar voltage.

→ If fault occur in any feeder it can easily remove for maintainance purpose.

and will not effect the other feeder.

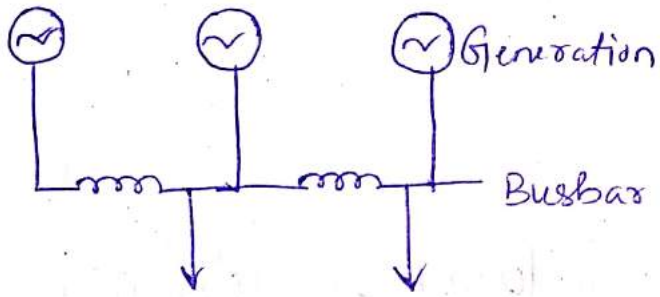
Busbar reactor

→ In above two method of locating reactor it's suffer from disadvantage i.e. voltage drop and power loss in the reactor during normal condition or operation.

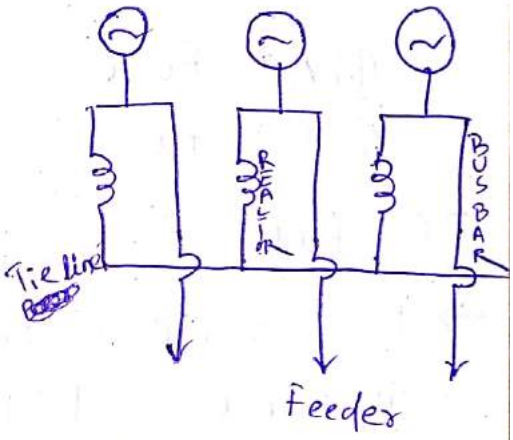
→ This disadvantages can be overcome by locating the reactor in busbar

Bus bars are of two types:-

i) Ring system



(ii) Tie bar system



→ One feeder is fed from one generator.

→ At a normal operating condition each generator will supply it's own section of the load and little power will be fed by other generator. Result in low voltage drop and low power loss.

~~ii) Tie bar system~~ ~~Advantages~~

→ i) Additional generator may be connected to the system without requiring change in

existing reactor.

CH-2 FUSE D-01-02-2019

Fuse

→ It is a device that protect a circuit from an over current condition or short circuit.

Advantages

① Less maintenance
② Low cost
③ Easily replacement for repairing
④ No noise

Fuse are of two types:-

① AC Fuse
② DC Fuse

DC fuse

→ DC fuse are produced by the direct current. It is very dibbicult to extinct. Because there are no zero current flow in the circuit for reducing the dc fuse arcing the electrode are placed more distance apart due to which the size of fuse increases as compaired to AC fuse.

Ac fuse

→ It is of two types

(i) Low voltage fuse
(ii) High voltage fuse

2020/5/2

Low voltage AC fuse

(i) Semi enclosed
(ii) Totally enclosed
(iii) Dropout fuse
(iv) Striker fuse
(v) Switch fuse

Semi enclosed fuse

Mostly used in domestic purpose.

→ It is also divided into two types :-

(a) D - type
(b) Bolted type

VSMP

HRC :- (High Rupturing Capacity)

→ Fuse element carrying the fault current for a long duration. If fault is not clear then the fuse element will melt and open the circuit.

→ The major advantages of HRC fuse is that it clear the low as well as High fault current.

→ For increasing the breaking capacity of the fuse two or more silver wire is joint in parallel with each other.

→ This wire are adjusted in such a way so that only one wire is melt at a time.

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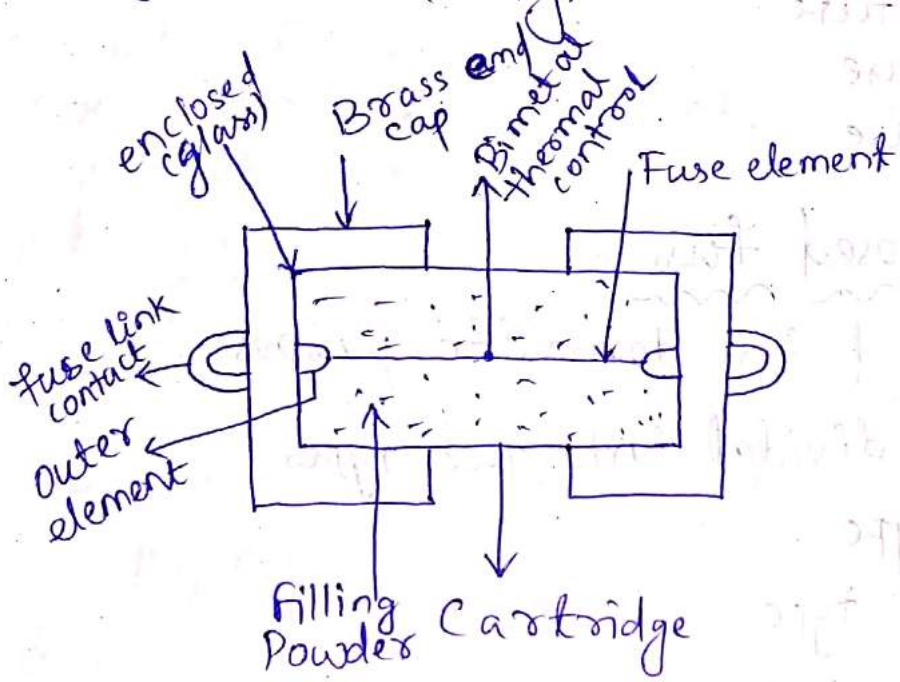
→ HRC fuse is two types :-

(a) Knife blade type HRC fuse

(b) Bolted type HRC fuse



[HRC Fuse]

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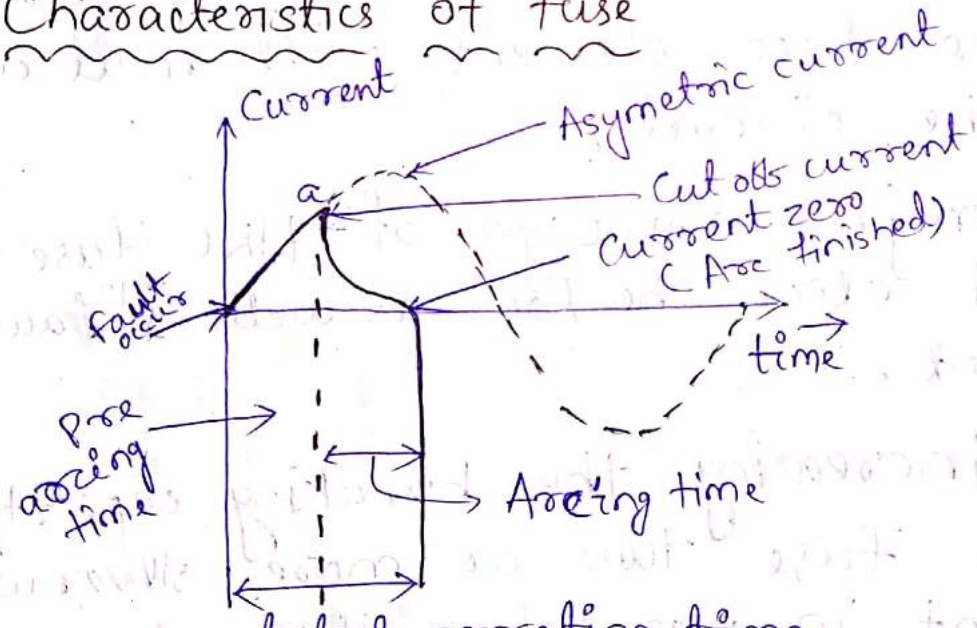
Characteristics of fuse



Fusing current

The minimum current at which the fuse element melt and thus disconnect the

circuit protected by it.

$$I = kd^{3/2}$$

k = constant
d = diameter

Cutoff current

→ It is the maximum value of fault current actually reached before the fuse melt.

→ Cut off current depends on
(i) Current rating of fuse
(ii) Value of prospetive current
(iii) Asymetry of short circuit current

→ When fault occur, the fault current raises rapidly and generate heat in the fuse element. As the fuse current reached the cut off value the fuse element melt and an arc generate.

→ The time from the start of the fault to the instant the arc is initiated is knowns as pre arcing time.

→ Pre arcing time is generally small a typical value being 0.001 sec.

→ This is the time between the end of pre arcing time and the

instant when the arc is extinguished.

→ The sum of the pre arcing time and arcing time is called total operating time.

Vsmi

Difference between fuse and circuit breaker

Fuse	Circuit breaker
(i) Fuse work on the principle of electrical & thermal properties of conducting material.	i) Circuit breaker work on the electromagnetism and switching principle.
ii) Fuses once used can not be reused again	(ii) But circuit breaker can be reused hence their is no need to change the circuit breaker after any fault.
iii) fuse can not be used as an on/off switch	III) Where as circuit breaker used as an on/off switch.
iv) Fuse are dependent of temperature.	iv) But circuit breaker is independant of temperature.
v) fuse provide protection against over load	(v) Where as circuit breaker provide protection for both power over load & short circuit.
vi) Breaking capacity of fuse is low as compaired to circuit breaker.	

2020/5/2

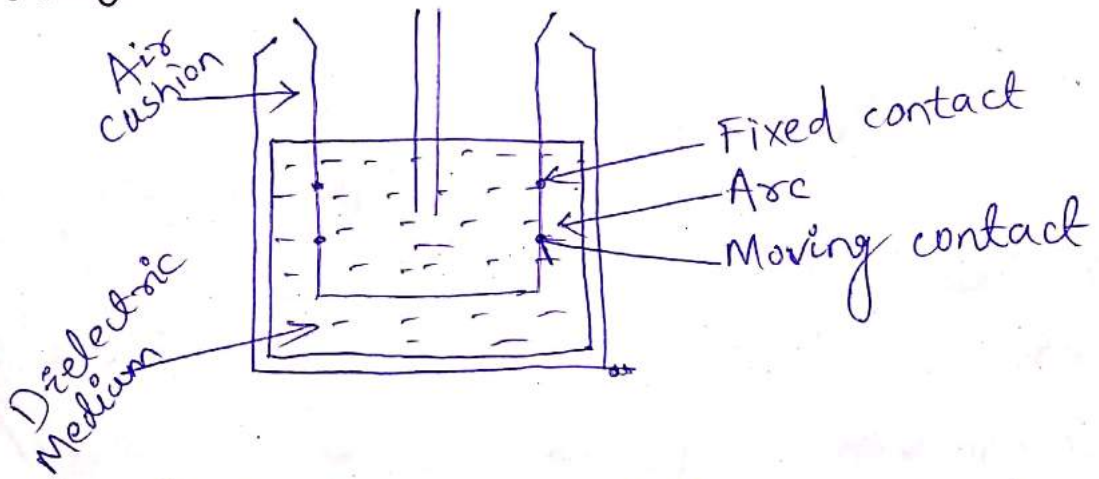
vii) operating time of fuse is about 0.002 sec.	vii) operating time of ckt breaker 0.002 to 0.005 sec
viii) The mode of operation of fuse is automatic	viii) Where ckt breaker can be operated manually as well as automatically with the help of relay system.
viv) Cost of fuse is low	viii) Where as ckt breaker is costly or expensive.

CH-4

CIRCUIT BREAKER

→ The circuit breaker is a switching device, when fault is occure it will be sence by the help of relay and it will trip, then no current is flow to another circuit and which does not damage the electrical equipment.

Working principle of circuit breaker



→ A circuit breaker essentially consists of fixed and moving contacts, called electrodes. Under normal operating conditions, these contacts

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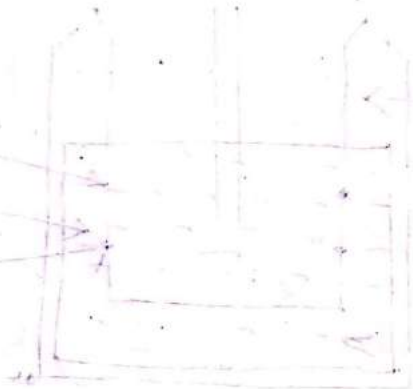
remain closed and will not open automatically untill and unless the system become faulty.

→ When a fault occurs on any part of the system, the trip coils of the circuit breaker get energised and the moving contacts are pulled apart by some mechanism, thus opening the circuit.

→ When the contacts of a circuit breaker are separated under fault conditions, an arc is struck between them.

→ The production of arc not only delays the current interruption process but it also generates enormous heat which may cause damage to the system or to the ckt breaker itself.

→ Therefore, the main problem in a circuit breaker is to extinguish the arc within the shortest possible time so that heat generated by it may not reach a dangerous value.



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Methods of arc extinction

(a) High resistance method
(b) Low resistance method or zero current method

(a) High resistance method

→ Arc resistance is made to increase with time so that current is reduced to a value that insufficient to maintain the arc.

→ It is employed only in dc circuit breaker and low capacity ac circuit breaker, because heat dissipation is very large.

→ Method of increases high resistance

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(i) Lengthing of arc
(ii) Cooling of arc
(iii) reducing cross-section area of arc
(iv) Spitting the arc

Lengthing of arc

Resistance is directly proportional to length. The arc can be increased by increasing the gap between the two contact (i.e fixed contant & moveable contact

As increasing in length resistance is also increases then it helps for protecting the arc.

(ii) Cooling of arc

→ Cooling help in the deionisation other medium between the contact this increases the arc resistance.

→ Cooling may be obtained by a gas blast directed along the arc.

(iii) Reducing cross-section area

→ If the area of cross-section of arc is reduced voltage necessary to maintained the arc is increase. Due to which resistance of the arc path is increase.

(iv) Spilting the arc

→ The ~~distan~~ resistance can be increased by spilting the arc into a number of small arc in series.

→ Each one of this arc experience effect of ~~lengthing~~ lengthening and cooling.

→ The arc may be spilt by interducing some conducting places between the contact.

(b) Low resistance method or current zero method :-

→ Arc resistance is kept Low untill current is zero.

→ In an ac system current drop to zero after every half cycle and at every current zero arc extinguishes.

→ The deionisation of the medium can be acheived by

(i) Lengthening of gap

Dielectric strength of medium is proportional to the length of the gap between contact. Therefore, by opening the contact rapidly higher dielectric strength of the medium can be acheived.

(ii) High pressure

If the pressure of the arc increase, the density of the particles discharge also increase. The increased density of the particle thus higher rate deionisation and consequently the dielectric strength of the medium between the contact is increased.

(iii) Cooling

Natural ~~communication~~ combination of ionised particle take place more rapidly if their allowed to cool. The dielectric strength of the medium bet the contact can be increased by cooling the arc.

(iv) Blast effect

→ If the ionised particle between the contact swept away and replaced by an ionised particle.

→ The dielectric strength of the medium can be increased considerably this may be achieved by a gas blast directly along the discharge or by forcing oil into the contact space.

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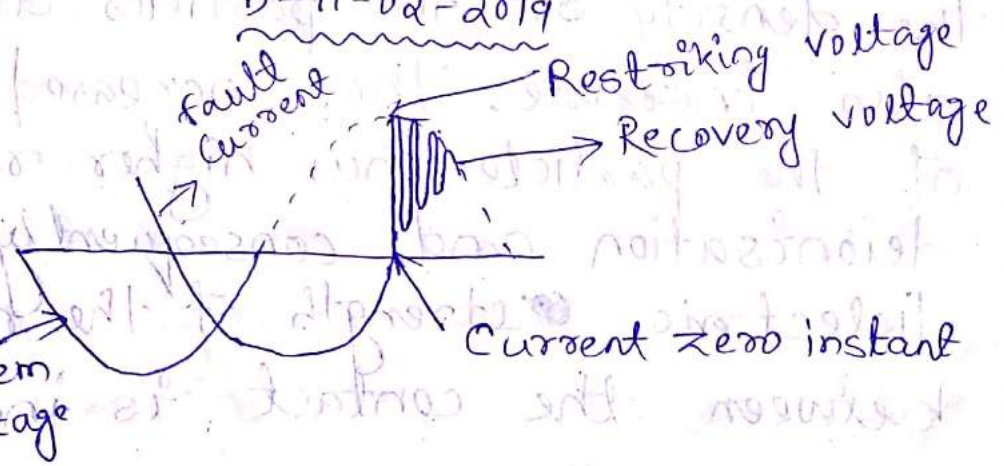

Arc voltage

→ It is the voltage that appear across the contact of the circuit breaker during the arcing period.

→ Restriking voltage

It is the transient voltage that appear across the contact at or near current zero during arcing period.

Transient voltage :-

Short duration ~~~~ surge of electrical energy and result of the sudden release of energy.

Recovery voltage :-

It is the normal frequency (i.e. 50 Hz) rms voltage that appear across the contact of the circuit breaker after final arc extinction. (ନିବିଦ୍ଧିକା)

It is approximatly equal to system voltage.

Graph :-

→ At current zero, the arc voltage rise repitly to peak value and this voltage maintai the current flow in the form of arc.

→ Current interroption of in the circui depend upon this voltage.

→ If the restriking voltage raises more rapidly then the dielectric strength of the medium between the contact. The arc will persist for another half cycle.

Principle of arc extinction

→ Factor responsible for the maintainance of arc between the contact.

(i) Potential difference between the contact.
(ii) Ionised between the contact

Potential difference between the contact

→ When the contact have a small separation the potential difference betⁿ them each sufficent to maintain the arc. One way to extinguish the arc is to separate the contact to such a distance that potential difference become inadequite to maintain the arc.

Ionised between the contact

→ If the arc path is deionised then the arc will be extinction. This may be acheive by cooling the arc or by removing the ionised particle from the

space between the contact.

Classification of circuit breaker

→ Circuit breaker is classified on the basic of medium use for arc extinction :-

(i) Oil circuit breaker
(ii) Air blast circuit breaker
(iii) Shulphur hexa chloride (SF_6) circuit breaker.
(iv) Vaccum circuit breaker

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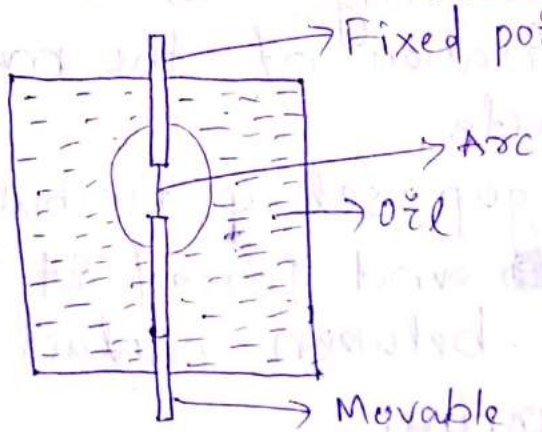
Oil circuit breaker (OCB)



→ It contain some insulating oil for arc extinction. Oil is used here because when arc is produced it may lead to fire hazard and oil is behave as a insulator, dielectric strength is more and check continuity.

→ When arc produced it evaporate the sourrounding oil

and dissociate it into a substaintial volume of gas. Mainly hydrogen gas is produced as a result of oil dicomposition and small amount of methen, Ethen is also generate at high pressure.

→ It aqupied a large space as compaired to oil decompose and formation of hydrogen gas bubbles sourrounding the arc ~~vision~~ region.

→ The arc extinction facilitated in two way

(a) Hydrogen gas has high heat conductivity thus adding the deionisation of the medium between contacts.

(b) The gap set up turbulence in the oil and forced it into the space between contact thus elimint the arcing.

Advantages

(i) It absorbs the arc energy to decompose the oil into gases which have excellent cooling properties.

(ii) It act as an insulator.

(iii) Sourrounding oil present cooling surface to the arc.

Disadvantages

(i) It is inflammable and their is a risk of fire.

(ii) It may formed and exclusive mixture with air.

Types of oil circuit breaker

(1) Bulk (Large) oil circuit breaker
   (i) Plain break oil circuit breaker
   (ii) Arc control " " "

(2) Low oil circuit breaker.

(1) Bulk oil circuit breaker

Which used a large quantity of oil. Oil has to serve two purposes
   (i) It extinguishes the arc during opening of contact
   (ii) It insulate the current conducting part from one another.

It may also classified into two types:-
   (a) Plain break oil circuit breaker
   (b) Arc control " " "

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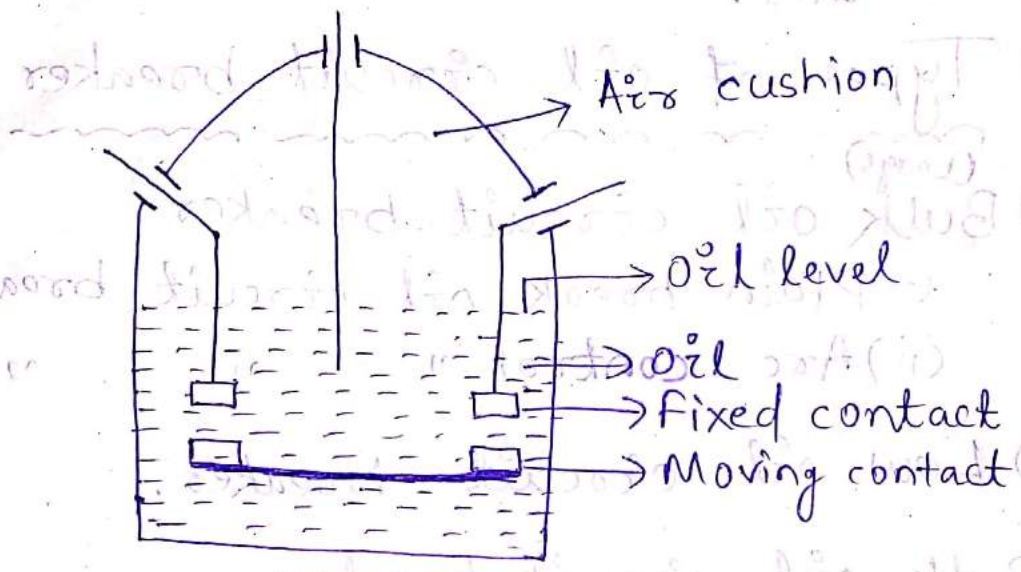
Plain break oil circuit breaker

→ A plain break oil circuit breaker involved the simple process of separting the contact. Under the whole of the oil in the tank.

→ There is no special system for arc control other than the increase in length causes by the separation of contact.

Construction



→ It has a very simple construction. It consists of fixed and moving contact enclosed in a strong weather tight earthed tank contain oil upto a certain level and an air cushion above the oil level.

→ The air cushion allow the arc gases without generation of unsafe pressure in the dome of the circuit breaker.

Working principle

→ Under normal operating condition the fixed and moving contact remain closed and the breaker carries the normal

circuit current, when a fault occur, the moving contact are ~~pulled down~~ ~~cool down~~ pulled down by the protective system and an arc is struck which vaporised the oil ~~remaining~~ mainly into hydrogen gas.

⇒ The arc extinction is followed by various process

(i) The hydrogen gas bubble generated around the arc cools the arc column and deionised the medium between the contact.

(ii) The gas set up turbulences in the oil and helps in eliminating the arcing product from the arc path.

(iii) As the arc ~~lengthing~~ lengthening due to the separating contacts, the dielectric strength of the medium is increased. * The result of this action is that at some critical gap length, the arc is extinguished and circuit current is interrupted.

Disadvantages

* There is no special control over the arc other than increasing the length by separating the moving contact.

Therefore interruption, long arc length is necessery.

* These breaker have long an inconsistant arcing time.
* These breaker do not permit high speed interruption. Due to this disadvantages plain oil circuit breaker are used only for the low voltage application where high breaking capacity are not important
* It is usually practice to use such a breaker for low capacity installation for voltage not exceeding 11KV.

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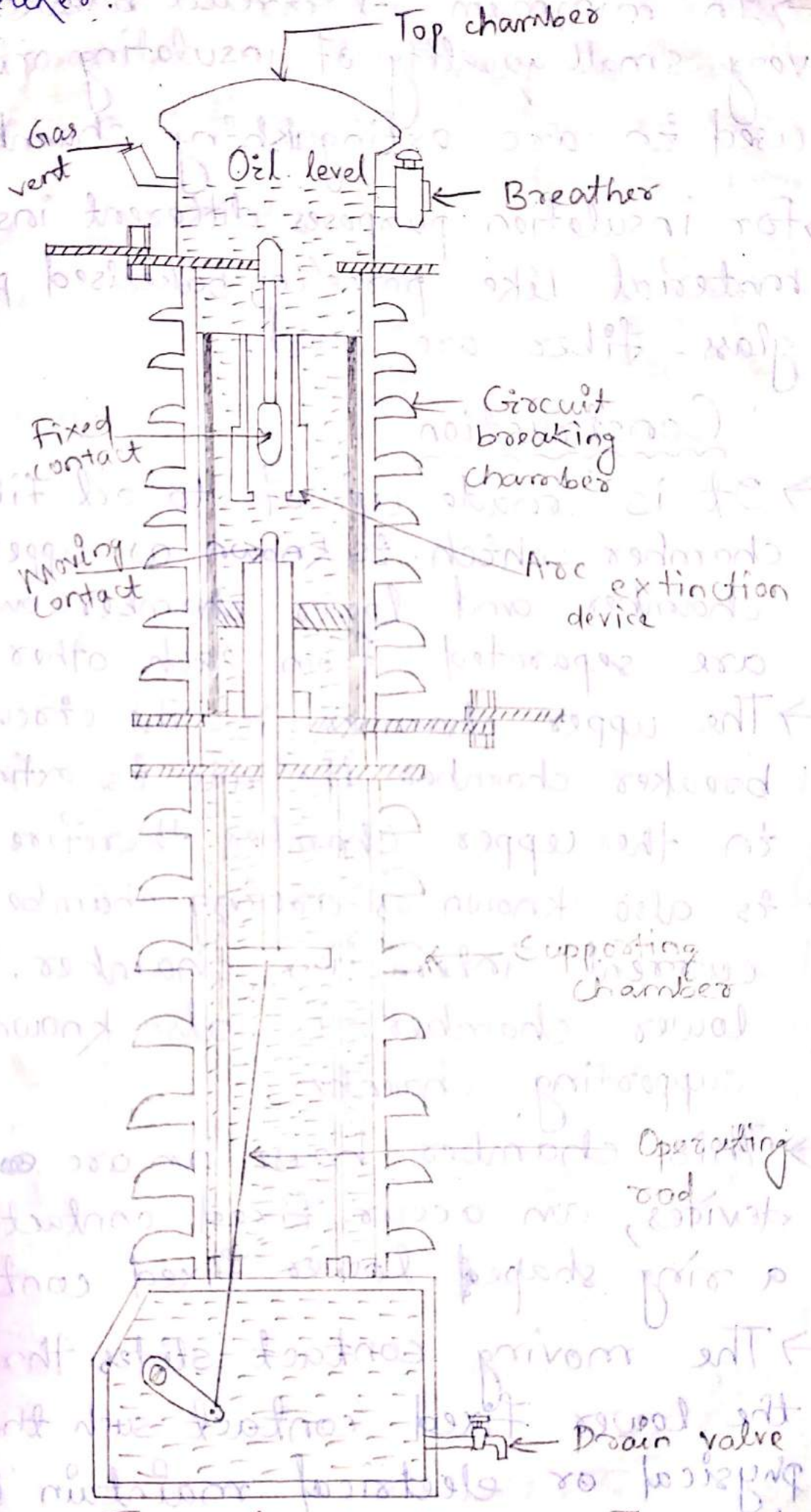
✓ Low oil circuit breaker

→ In above discussion it has been found that only a small percentage of oil is actually used for arc extinction. While the major part is utilised for insulation purposes.

→ On the bais of this fact, low or minimum oil circuit breaker has been developed. It is also known as miniature oil circuit breaker or live tank circuit

breaker.



[Low oil circuit breaker].

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→ In minimum oil circuit breaker very small quantity of insulating oil is used in arc extinguishing chamber.

→ For insulation purposes different insulating material like porcelin, bakelised paper, glass-fiber are used.

Construction

→ It is made up of to oil filled chamber which is known as upper chamber and lower chamber and are separated from each other.

→ The upper chamber is the circuit breaker chamber the arc is extinguished in the upper chamber therefore it is also known as arcing chamber or current interaction chamber. The lower chamber is also known as supporting chamber.

→ This chamber house an arc controlling devices, an accur fixed contact and a ring shaped lower fixed contact.

→ The moving contact slides through the lower fixed contact such that a physical or electrical maintain between them.

→ The lower chamber oil used for insulation purposes not involved in arc extinction. So low chamber is also known as dielectric supporting chamber.

→ The operating rod which is permantely fixed to the moving contact which provide vertical motion in order to make and broake the circuit.

Operating principle

→ Under normal operating condition the moving contact remain engaged with the upper fixed contact.

→ When the fault occur the moving contact is pulled down by a tripping strings and arc is struck. The arc energy evaporised the oil and produces gases under high pressure.

→ The gases formed will expand and so that the pressure inside the chamber rises, hence the gases will move upward by which the contacts cool down and the arc splits.

→ The gap between the contact will be filled with fresh oil. This oil will also be decomposed and relased gases will

expand so the pressure will be increased again. Hence the gas will move upward and again fresh oil will entered.

Advantages

(i) It required smaller space.
(ii) It required lesser quantity of oil.
(iii) Maintainance problems are reduces.

Disadvantages

(i) Due to the smaller quantity of oil, degree of carbonisation is increased.
(ii) There is difficulty of removing the gases form the contact space in time.

Application

* In indoor application it is used upto 36KV.
* In outdoor application it is used in line voltage of 220KV.

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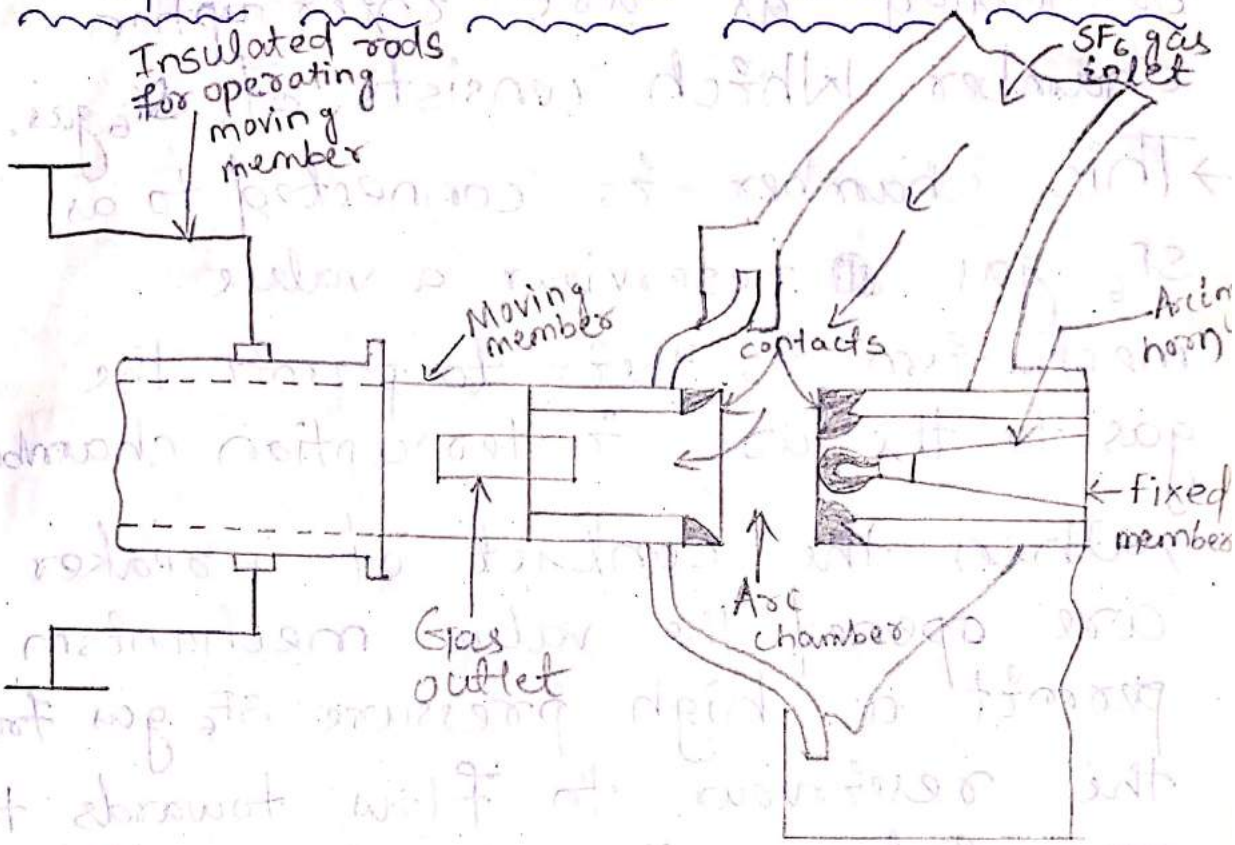
Sulphur Hexa chloride circuit breaker



(Sulphur Hexafluoride (SF_6) Circuit breaker)

→ SF_6 gas is used as the arc quenching medium.

→ SF_6 gas is an electro negative gas and has a strong tendency to absorb free electrons.

→ SF_6 circuit breaker having found to be very effective for high power and high voltage service.

Construction

→ SF_6 circuit breaker consists of a fixed and moving contacts ~~enclosed~~

enclosed in a chamber this chamber is called as arc interruption chamber. Which consists of SF_6 gas.

→ This chamber is connected to as SF_6 gas reservior a value mechanism is their to permit the gas to the arc interruption chamber.

→ When the contact of breaker are opened the value mechanism permit a high pressure SF_6 gas from the reservrour to flow towards the arc interruption chamber.

→ The fixed contact is a hollow cylinderical current carrying contact fitted with an arcing horn then the moving contact is also a hollow cylinderical with regular hole in the side. The hole permit the sulphur hexa flouride gas to left out through them after flowing along and across the arc.

→ The tips of fixed contacts, moving contacts and arcing horn are ~~protect~~ coated with copper tungesten arc resistance material.

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Working

→ The working of an SF_6 circuit breaker is similiar to the working of a normal circuit breaker in normal operating condition the contact of the breaker are closed. When the fault current in the system occur the contact are pulled apart and an arc is struck between them. The displacement of the moving contact is synchronised with the valve which entered the high pressure SF_6 gas in the arc interruption chamber, at a pressure about 14 kg/cm^2.

→ The SF_6 gas absorb the free electron in the arc path and forms ions which do not act as a charge carrier. These ions increase dielectric strength of the gas and hence the arc is extinguish.

Advantages

(i) SF_6 gas has excellent insulating, arc extinguishing and many other perporties which are greatest advantages of SF_6 circuit breaker.

(ii) The gas is non-inflamable and chemically stable that decomposition product are not expolsive and hence their is no risk of fire.

(iii) Electric clearance is much reduced because of high dielectric strength of SF_6.

(iv) It gives noise less operation and their is no over voltage problem because the gas is extinguish at natural zero current.

(v) It requires less maintanance and no costly compressed air system required.

Disadvantages

(i) SF_6 gas is suffocating to some extent. In the case of leakage in the breaker tank the SF_6 gas being heavier than air, and hence SF_6 are settled in ther sourrounding and lead to suffocation of the operating portion.

(ii) The entrance of moisture in the SF_6 breaker tank is very harmful to the breaker and it cause several failure.

(iii) The special facility required for transportation & maintainance of quality of gas

Vaccum circuit breaker

→ Vaccum offer the highest insulating strength.

→ The operation of switching ON and closing of current carrying contacts and inter related arc interruption take place in a vaccum chamber. In the breaker which is called vaccum interupture. It is used in 11 KV to 33 KV transmission line and tripping time is less than 1 and max 3 sec.

Construction

→ The material used for current carrying contacts play an important role in the performance of the vaccum circuit breaker. The alloy like copper bismuth or copper chroome are the ideal material to make VCB contact.

→ The VCB is consists of a fixed contact, a moving contact at a vaccum interupture. The moving contact is connected to a control

mechanism by stainless steel. The arc shield are supported to the insulating housing such that they covered on this shield and is prevented from condensing on the insulating encloser.

→ The possibility of leak is eliminated due to permanet sealing of vaccum chamber for that a glass vessel or ceramic vessel is used as the outer insulating body.

Working D-20-02-2019

→ When breaker operates, the moving contact separate from fixed contact andanarc is struck between the contact.

→ The production of arc is due to the ionisation of metal ions and depend on the material of contact.

→ The arc is quickly extinguish because the metalic vapour, electrons and ion produced during arc defuse in a short time.

→ Since a vaccum has very fast rate of recovery of dielectric strength, arc extinguistion in a vaccum breaker occur with a short contact separation.

Advantages

(i) The vaccum circuit breaker has a long life span.

(ii) No fire hazard.

(iii) Vaccum circuit breaker is fast in operation so ideal for fault clearing.

(iv) VCB is suitable for repeated operation.

(v) VCB are almost maintainance free.

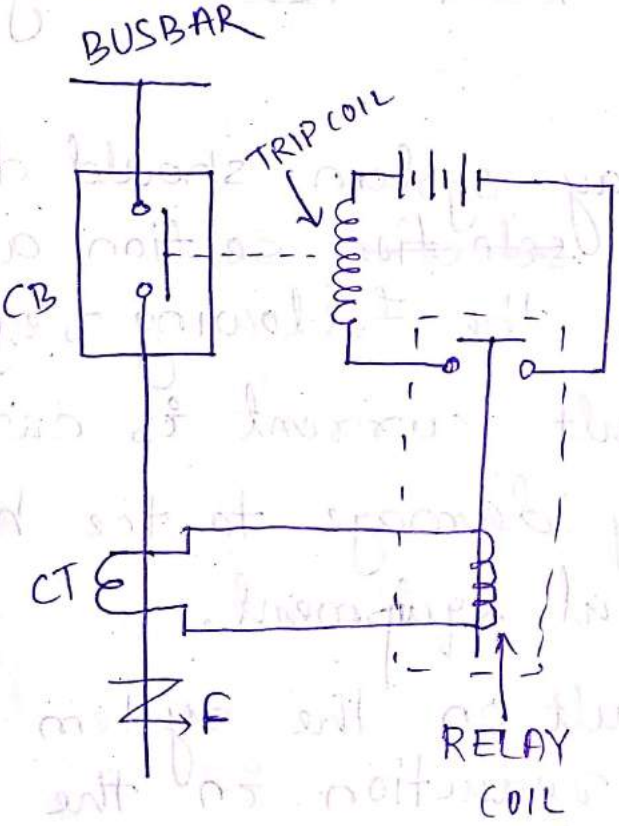
(vi) No exhaust of gas to the atmosphere and noises operation.

CH-5 Protective Relays

→ A protective relay is a relay device designed to trip a circuit breaker when a fault is detected.

→ It is a electromagnetic device.

→ Relaying on coil operating on moving part to provide detection of abnormal operating condition. Such as over current, over voltage & over frequency.



V.I.M.P

Essential quality of good protective system

OR

Fundamental requirement of protective relay

→ In order that protective relay system may perform following qualities;

(i) Selectivity :-

→ It is the ability of the protective system to select correctly that part of the system in trouble disconnect the faulty part from the healthier portion from the power system.

→ Generator, Transformer, Transmission line, Low tension Switchgear.

(ii) Speed :-

→ The relay system should disconnect the faulty section as fast as possible for the following region

(a) If fault current is carry then it may damage to the healthy electrical equipment.

(b) A fault on the system lead to a grade reduction in the system voltage.

(iii) Sensitivity :-

→ It is the ability of the realy system to operate with low value of actuating quantity.

→ It is desirable that relay system should be sensitive, so that it operate with low value of volt/ampere input.

(iv) Reliability :-

→ It is the ability of the relay system to operate under pre determine condition without reliability.

(v) Simplicity :-

→ The relaying system should be simple so that it can easily maintained.

→ Reliability is closely related to simplicity.

→ The simpler the protection scheme the greater will be reliability.

Basic relay D-22-02-2019 (P-501)

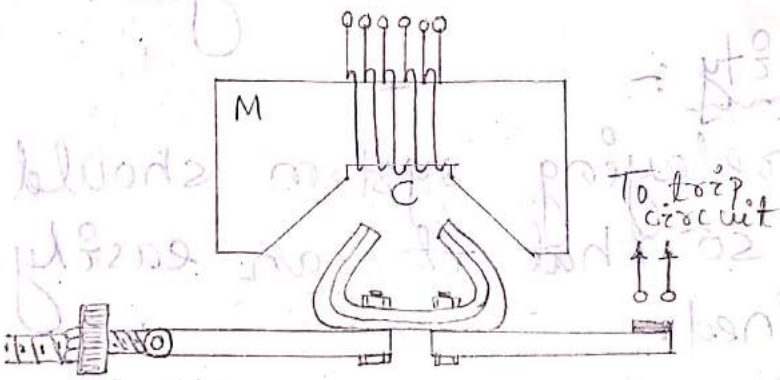
→ Most of the relay used in power system operates by virtue of the current/voltage supplied by current and voltage transformer, present in various combination to the system is to be protected.

→ Most of the relay in service on electrical power system today are ~~electromagnet~~ electromechanical type.

→ Two main operating principle are
(i) Electro-magnetic attraction
(ii) Electro-magnetic induction

(i) Electro-magnetic attraction relay

✱ Attracted armature type relay :-



→ It consists of a laminated electro-magnet M carrying coil C and a pivoted laminated armature.

→ The armature is balanced by a counter weight and carrying a pair of spring contact finger at it's free end.

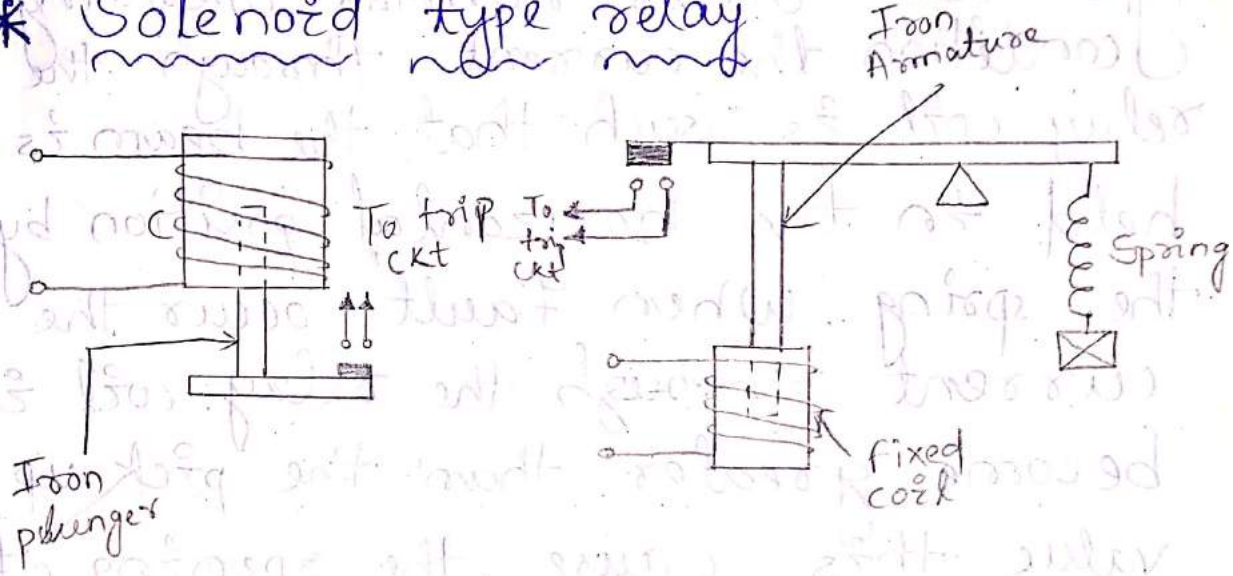
→ When short circuit occur the current through the armature is attracted upward this complete a trip circuit which result in the opening of the circuit breaker and therefore it

2020/5/2 10:32

disconnect the fault circuit.

→ The minimum current at which the relay armature is attracted to closed the trip circuit is called as pick up current.

* Solenoid type relay



→ It consists of a solenoid and a moving iron under normal operating condition the current through the relay coil is such that it hold the plunger. By gravity or spring.

→ When ~~hold current~~ fault occur the relay coil becomes more than the pickup value causing the plunger to be attracted to the solenoid.

→ The upward moment of the plunger closed the trip circuit, thus opening

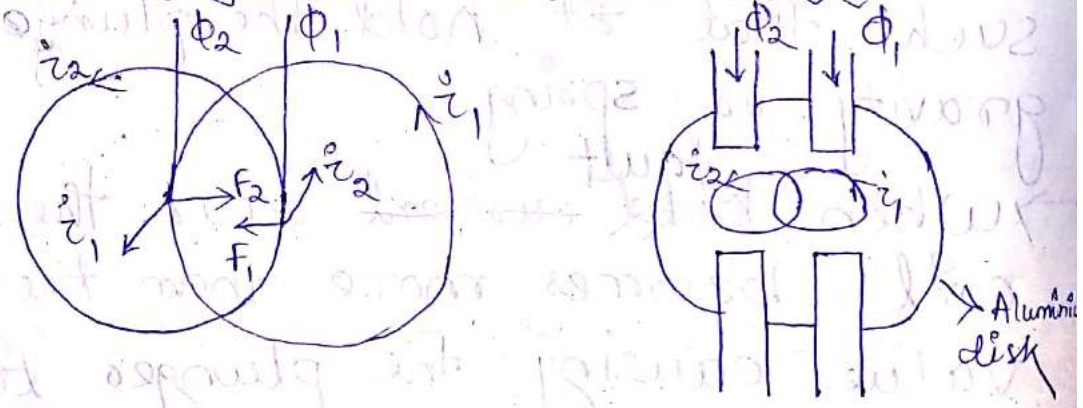
of the C.B and disconnect the fault ckt.

* Balanced beam type relay

→ It consists of an iron armature joined the two part to be a balanced beam type relay. Under normal operating condition the current through the relay coil is such that the beam is held in the horizontal position by the spring. When fault occur the current through the relay coil is become greater than the pick up value this cause the opening of the circuit breaker to isolate the fault circuit.

D-25-02-2019

Electro-magnetic induction relay



$$\phi_1 = \phi_1 \sin \omega t$$

$$\phi_2 = \phi_2 \sin (\omega t + \alpha)$$

$i_1 \propto \frac{d}{dt}\phi_1$

$= \frac{d}{dt}\phi_1 \sin \omega t$

$= \phi_1 \cos \omega t$

$i_2 \propto \frac{d}{dt}\phi_2$

$= \frac{d}{dt}\phi_2 \sin(\omega t + \alpha)$

$= \phi_2 \frac{d}{dt} \sin(\omega t + \alpha)$

$= \phi_2 \cos(\omega t + \alpha)$

$f_1 \propto i_2 \phi_1$

$f_2 \propto i_1 \phi_2$

$F \propto f_2 - f_1$

$\propto \phi_2 i_1 - \phi_1 i_2$

$= \phi_1 \phi_2 \cos \omega t - \phi_1 \phi_2 \cos(\omega t + \alpha)$

$= \phi_1 \phi_2 \cos \omega t - \phi_1 \phi_2 (\cos \omega t \cdot \cos \alpha - \sin \omega t \cdot \sin \alpha)$

$= \phi_1 \phi_2 \cos \omega t - \phi_1 \phi_2 \cos \omega t \cdot \cos \alpha + \phi_1 \phi_2 \sin \omega t \cdot \sin \alpha$

$= \phi_1 \phi_2 \cos \omega t (1 - \cos \alpha) + \phi_1 \phi_2 \sin \omega t \cdot \sin$

$\propto \phi_2 \sin(\omega t + \alpha) \cdot \phi_1 \cos\omega t - \phi_1 \sin\omega t \cdot \phi_2 \cos(\omega t + \alpha)$

$\propto \phi_1\phi_2 \{ \sin(\omega t + \alpha) \cdot \cos\omega t - \cos(\omega t + \alpha) \cdot \sin\omega t \}$

$\propto \phi_1\phi_2 \sin(\omega t + \alpha - \omega t)$

$\propto \phi_1 \phi_2 \sin\alpha$

$$F \propto \phi_1 \phi_2 \sin\alpha$$

D-27-02-2019

Induction Relay

→ Electromagnetic induction relay operates on the principle of induction motor and are widely used for protective relaying purposes.

→ It is used in A.C quantities, not use in d.c quantities.

→ An induction relay essentially consists of a pivoted alluminium field of the same frequency but displays in time & space.

→ The torque is produced in the disc by the interaction one of the magnetic field with the current induced in the disc by the other.

→ It is of 3 types:-

(a) Shaded pole structure
(b) Watt hour meter or double winding structure
(c) Induction cup structure

Shaded pole

→ It consists of a pivoted alluminium disc free to rotate in the air gap of an electromagnet. One half of each pole of the magnet is sourrounded by a ~~magnet~~ copper band known as shading ring.

→ Alternating flux ϕ_s is generated in the shaded portion of the pole lag behind the flux ϕ_u in the unshaded portion by an angle α. It produce an necessery torque i.e T.

$\therefore T \propto \phi_s \phi_u \sin\alpha$

$T \propto i^2 \sin\alpha$

(b) Watt-hour meter structure

→ It consists of a pivoted alluminium disc arranged to rotate freely betⁿ the pole of two electromagnet.

→ The upper electromagnet carries two winding i.e primary & secondary. The primary winding carry relay current i_1 where as secondary winding is connected to the winding of the lower magnet.

→ The primary current induced emf in the secondary and so circulation of current i_2 in it.

→ Flux ϕ_2 induced in the lower magnet by the current in the secondary that lag behind ϕ_2 by an angle α.

2020/5/2 10:34

$\therefore T \propto \phi_1 \phi_2 \sin\alpha$

→ It work on the principle of ~~induction~~ opening & closing of the circuit, if the ckt is opened then no flux can set by the lower magnet, no torquer will be produced. Therefore the relay can be make in operation of opening & closing of ckt in the secondary winding.

(c) Induction cup structure

→ Induction cup structure closely resembles and induction motor except the rotor iron is stationary and rotor conductor portion being free to rotate.

→ The moving element is a hollow cylindrical rotor the rotating field is produced by two pair of coil wound on four pole.

→ The rotating field induced current

produced torque. If ϕ_1 & ϕ_2 is flux produced in pole that torque is directly porportional to $\phi_1 \phi_2 \sin\alpha$.

$$T \propto \phi_1 \phi_2 \sin\alpha$$

where α is the phase difference between the two flux.

→ Induced cup structure are more efficient torque produce than either shade or watt-hour structure.

→ This relay has very high speed and may have an operating time less than 0.1 sec.

Important terms

i) Pick-up current

→ It is the minimum current in the relay coil at which the relay start to operate.

→ The current in the relay is less than the pick up value then the relay does not operate and the breaker is in closed position.

→ When the relay coil current is equal to or greater than pick up value, the relay operate to energised

the trip coil which open the circuit breaker.

(ii) Current setting

→ Current setting is the setting of current i.e pick up current in a relay at which we want to operate that relay.

→ It is ~~usually~~ usually achieved by the tapping on the relay operating coil. The taps are brought out to the plug bridge, it permit to alter the no of turns on the relay coil this change the torque as well as the time of operation of the relay.

∴ Pick up current = Rated secondary current of CT × current setting.

D-01-03-2019

Plug setting multiplier (P.S.M)

→ Plug setting multiplier is defined as ratio of fault current in relay coil through the pick up current of the relay.

$$P.S.M = \frac{\text{Fault current in relay coil}}{\text{Pick up current}}$$

$$= \frac{\text{Fault current}}{\text{Rated secondary current of CT} \times \text{Current setting}}$$

Time setting multiplier

→ A relay is generally with controls to adjust the time of operation this adjustment is known as time setting multiplier.

→ The time setting dial is celibrated from 0 to 1 in set of 0.05 sec

Function relay

→ Relay are generally classified according to there function

2020/5/2 10:34

(b) Induction type directional power relay

→ This type of relay operates when power in the circuit flows in a specific direction
→ It operate by the interaction of magnetic field derived from both voltage & current source of the ckt.

Construction

→ It consists of a alluminium disc which is free to rotate in between the pole of two electromagnet.

→ The upper electromagnet carries a winding called potential coil. which is connected through potential transformer to the circuit voltage source.

→ The lower electromagnet has a separate winding called current coil connected to the secondary of C.T.

→ The current coil is connected to plug setting bridge this permit to desire a current setting.

→ The disc is connected to a ~~spitender~~ spindle which rotate through a preset angle.

Working

→ The torque developed on the disc suspended between the two magnet is proportional to VI.

→ When the power flow in the normal direction the torque develop on the disc assist by the spring

tends to ~~rotate~~ turn away the moving contact from the fixed circuit contain. Thus the relay remain inoperade a reversal of current in the circuit reverse the torque produce on the disc and when this is large enough to ~~[illegible]~~ over ~~current~~ come the control spring torque, the disc rotate in the reverse direction and the moving contact closed to the trip circuit.

→ This cause the operation of the circuit breaker to disconnect the faulty circuit.

D-13-03-2024

Induction type directional overcurrent relay

→ When a short circuit occur, the system voltage fall to a low value and their may be insufficient torque develop in the relay to cause it's operation these difficulty is overcome

→ In the directional overcurrent relay which is designed to be almost independent of system voltage and power factor.

Construction

→ It consists of two relay mounted on a common case;

(i) Directional element
(ii) non-directional "

Directional element

→ Directional power relay which operates when power flow in a specific direction. The potential coil element is connected through a P.T to the system.

→ The current coil of the element is energised through C.T by the ckt current.

→ Current coil of the element is energised through C.T. and the winding is carried over the upper magnet of the non-directional element.

→ The trip coil (1,2) are connected in series with the secondary circuit of the overcurrent element.

(ii) Non-directional element

→ The spriodle of the disc of this element carries a moving contact which closed the fixed contact.

→ The plug setting bridge is also provided in the relay for current setting. The taping are provided on the upper magnet of overcurrent element and are connected to the bridge.

Working

→ Under normal operating condition, power flow in the normal direction. In the circuit protected by the relay.

→ Direction relay does not operate & overcurrent element ~~en~~ unenergised, when a short circuit occur

there is a tendency for the current or power to flow in reverse direction. Due to which disc is rotate and moving contact attached to trip ckt.

→ As two relay are connected in series so that torque is developed in lower part which is the region to rotate the disc and finally it trip the circuit.

Differential relay

→ In the above discussion relay are less sensitive because they can not make correct distingstion between heavy load condition and minor fault condition.

→ In order to overcome this difficulty differential relay are used.

→ Differential relay is one that operate when the phasor difference of two or more similar electrical quantites exceeds a pre-determined value.

→ There are two fundamental system of differential relay or balanced protection;

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(b) Vol

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(a) Current balanced protection / current differential relay

(b) Voltage balanced protection / Voltage differential relay

(a) Current differential relay

→ A relay which sense and operates the phases difference between the current entering into electrical system and the current leaving the electrical system is called current differential relay.

→ A pair of identical current T.f are fitted on either of the section to be protected (alternator winding or transformer winding).

→ The secondary of C.T's are connected in series in such a way that

they carry the induced current in the same direction.

→ The operating coil of the overcurrent relay is connected across the C.T's secondary circuit. In normal operating condition the magnitude of current in the secondary of the C.T's remain same. The zero current flow through the operating coil on the occurance of the fault, the magnitude of the current on secondary of the C.T's become unequal ($i_1 \neq i_2$). Because of which the relay start operating.

(i) Biased beam relay or percentage differential relay :-

→ This is the most used form of differential relay. There arrangement is same as that of current differential relay, the only difference is that this relay system consists of an additional restraining coil connected in the pilot wire.

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Beca
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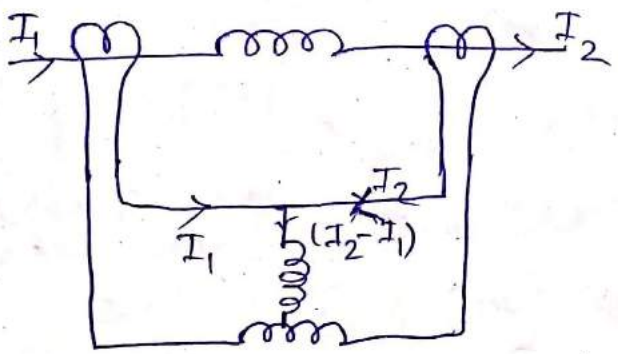
→ The operating coil connects in the center of the restraening coil. The restraening coil is produces a bias force in the opposite direction to the operating force. Under normal operating condition the bias-force due to restraening coil is greater than the operating force.

→ Therefore the relay remain inoperate. When falult occur, the operating force exceeds the bias-force, thus the trip current are closed to open the circuit breaker.

Because total ampere turns on restraing coil of N turns $\propto i_1 \frac{N_2}{2} + i_2 \frac{N}{2}$

$$\propto (i_1 + i_2) \frac{N}{2}$$

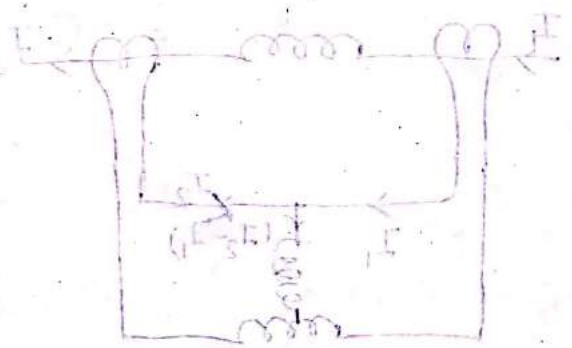
$$i_2 - i_1 \propto (i_1 + i_2) \frac{N}{2}$$



→ It is clear that greater the current flowing through the restraing coil, the higher the value of current required in the operating winding to trip the relay.

→ Under a heavy load greater differential current through the relay operating coil is required for operating then light load condition. This relay is called percentage relay because the operating current required to trip be expressed as a percentage of load current.

(b) Voltage balanced differential relay :-



→ The current differential is not suitable for the protection of feeder for the protection of feeder the voltage balanced differential relay are used.

→ To similar current transformer placed across the protective zone with the help of pilot wire.

→ The secondary of C.T are connected in series with the relay in a such way that under normal condition there induced emf are in opposition.

→ Under normal condition ($i_1 = i_2$) flow of current in both primary winding so no current is flow in relay coil and the relay coil is inoperate. But when fault is occur in the protected zone the current in the two primaries will differ from one another ($i_1 \neq i_2$) and their secondary voltage will no longer be in balance this voltage difference will cause a current to flow through the operating coil of the relay.

which close the trip ckt.

Disadvantage

i) A multi gap transformer construction is required to acheive the accurate balance betn the C.T pair.

ii) The system is suitable for protection of cable of ~~real~~ relatively short length due to the capacitance of pilot wire.

D-18-03-2019

CH-6

Protection of electrical power equipment and lines

Protection of alternator

→ Some of the important fault which may occur on an alternator are

(i) failure of primover :- when input of primover fails, the alternator runs as synchronous motor and draw some current from the supply it is known as "inverted running"

(ii) failure of field :- This failure is very rare if it occur no

immediate damage will cause to alternator and it allow to run without a field for a short period of time. The faulty alternator is disconnected by manually from the supply busbar.

(iii) Over current :- It occur mainly due to partial breakdown of winding insulation or due to over load on the supply system. Over current protection for alternator is necessary because of following region;

(a) The alternator should be designe with value of internal impedance so that the alternator can be disconnected manually when there is any short circuit or overload.

(iv) Over speed :- The cause of over speed is due to sudden loss of all or major part of load on the alternator.

Alternator are usually provided with mechanical configural device mounted on their driving shaft to trip the main value of prime over.

(v) Over voltage :- Over voltage in an alternator occur when speed of the prime over increases due to sudden loss of the alternator load.

(vi) Unbalanced loading :- (Difference phase current in the alternator)

→ Unbalanced loading arises from fault to earth or fault between the phase on the circuit external to the alternator.

→ The unbalanced current may burn the mechanical fixing of the rotor or damage the field winding.

(vii) Stator winding :- This fault occur mainly due to the insulation failure of the stator winding. Main type of stator winding fault are;

(a) Fault betn phase & ground
(b) Fault betn phases
(c) Inter turn fault involving turns of the same phase winding

2nd Differential protection of alternator (Merlz-price circulating current scheme)

→ It work on the principle of circulating current principle.

→ This system is used for the protection stator winding fault.

Construction

→ Two identical CTs pair are placed on either side of each phase of stator winding.

→ The secondary of each set of CT are connected in star, the two neutral

point and corresponding terminal of two star group are connected by means of four core pilot cable.

→ The relay coil are connected in star connection, the neutral point is connected to CTs of neutral and the outer end two each of the other three pilot wire.

→ The relay are connected across equi-potential point of the three pilot wire and are located the middle of pilot wire.

Operation

→ Under normal operating condition, the current at both the end of each winding will be equal. and hence current in the secondary of two CTs connected in any phase will also be equal & balanced circulating current in the pilot wire and no current is flow through the operating coil.

When an earth fault or phase to phase fault occur, differential current flowing through the relay

circuit operate the relay to trip the circuit breaker.

Limitation

D-20-03-2019

→ In order to limit the destructive effect of or fault current. In the situation it is impossible to protect the whole stator winding of star connected alternator during earth fault.

→ When an earth fault occur near the neutral point, their may be insufficient voltage across the short circuited portion to drive the necessary current ground the fault current to operate the relay. The magnitude of unprotected zone depend upon the value of earth resistance and relay setting.

Balanced (or Restricated) earth-fault protection.

→ It is mainly used for protection of small generator where differential and self balanced protection are not applicable.
→ It provide the protection against the stator winding of the earth fault in stator and does not operate in case of external earth fault.

Construction

→ It consists of three line CT, one mounted in each phase, having secondaries connected in parallel with single CT.
→ A relay connected across the transformer secondaries.

Operation

→ Under normal operating condition, the current flowing in secondaries of the line current transformer add to zero and no current flow through the relay.
→ The current in the neutral wire is zero and the secondary of neutral

CT supply no current to the relay.

→ Then when fault occur then the current are no longer equal and the differential current flows through the operating coil of the relay then trip coil work and it disconnect the alternator from the system.

Buchholz relay

Construction

→ It is a domped vessel placed in between the main tank and the conservator. The device has two element the upper elerment consists of a mercury type switch attached to a float. The lower element contain a mercury switch mounted on in hinged type flap located in the direct path of the flow of oil from transformer to the conservator.

→ The upper element closed an alaram ckt and the lower element is arranged to trip circuit.

Operation

→ When fault occur incipient (Going to start something) within the transformer the heat due to fault cause the decomposition of oil and it produce hydrogen gas which tries to go into the conservator and in the process get entrapped in the upper part of the relay chamber.

→ It exert sufficient pressure on the float to cause it to tilt (slop) and closed the contact of mercury switch attaced to it.

→ This complete the alaram circuit to sound an alaram.

→ If a serious fault occur in the TF huge amount of gase is generated in the main tank. The oil in the tank rushes towards the conservator through relay and it tilts the flap to closed the contact of mercury switch and the trip circuit open the circuit breaker controlling the transformer.

Advantages

(i) It is a simplest form of T.F protection.

(ii) It ditect the incipient fault at a stage much earlier than is possible with other form of protection

Disadvantages

(i) It can be only be used with oil immersed transformer equipped with

conservator tank.

(ii) The device can detect only fault below oil level in the transformer Therefore separate protection is necessary for connecting cable.

D - 25 - 03 - 2019

Protection of bus bar

→ The two most common used scheme for bus bar protection are

(i) Differential protection
(ii) Fault bus protection

Differential protection

→ The basic method of bus bar protection is the differential protection scheme.

Construction

→ The bus bar is connected to a generator and supply load to two line.

→ The secondary of CTs in the line 1 and 2 are connected in parallel the protecting relay is connected across parallel connection of CTs.

Operation

→ Under the normal operating condition or external fault condition

the sums of the current entering the bus is equal to those leaving it and no current is flow through the relay. If fault occur in the protected zone, the current entering the bus will no longer being equal to those leaving it.

→ The difference of these current will flow through the relay and cause the opening of the generator, circuit breaker and the protected equipement.

(ii) Fault bus protection

→ The fault i.e developed are mainly earth fault it can be achevied by providing earth metal barrior (fault bus) sourrounding each conductor through out its entire length.

→ Fault that might occur must involved a connection between a conductor & an earth metal path.

→ It is possible to detect the fault and determine thier location. This type of protection is known as fault bus protection.

→ A relay is connected across the secondary of CT under normal operating condition there is no current flow form fault bus to ground and relay remain inoperative.

→ When fault occur between a conductor and earth supporting will result in current flow to ground through the fault bus, causing relay to operate the operation of relay, trip all breaker connection and protected equipment from the bus.

Protection of line

→ The common method of line protection are :-

(a) Time greaded over current protection
(b) Differential protection
(c) Distance protection

(a) Time greaded over current protection

(i) Radial feeder system

→ The main characteristics of radial system is that power can flow only in one direction.

→ Time graded protection of radial feeder can be acheived by using
* Definite time relay
* Inverse time relay

* Definite time relay

→ The time of operation of each relay is fixed and independent of the operating current.

Disadvantages

(i) If there are no. of feeder in series the tripping time for fault near the supply end bechome high.

This disadvantages can be overcome by using inverse time relay

* Inverse time relay

→ Here the operating time is inversly proportional to operating current so the relay operating time is shorter.

D-27-03-2019

Parallel feeder

→ Two parallel feeder may be installed if a fault occur on one feeder, it can be disconnected from the system and continuity of supply can be maintained from the other feeder.

Ring main system

→ In this system various power station or sub-stations are inter connected by alternate routes thus forming a closed ring.

→ In case of damage to any section of the ring, that section may be disconnected for repairing, power will be supplied from both end of the ring.

Differential pilot wire protection :-

→ The differential pilot wire protection is based on the principle that under normal operating condition

current entering one end of a line is equal to that leaving the other end until fault occur. It is upto scheme system -

(a) Two scheme system :-

(i) Merz - price voltage balance system

(ii) Translay scheme

Merz - price voltage balanced system

→ Identical current transformer are placed in each phase at both end of the line.

→ The pair of CTs in each line is connected in series with a relay in such a way that under normal operating condition the secondary voltage at both the end is equal.

→ Under healthy condition current entering the line at one end is equal to that leaving it at the other end, therefore equal and opposite voltage are induced in the secondary of CTs as a result no current flow through the relay.

→ When fault occur the voltage become unequal and circulating current flow through the pilot wire to relay and this will occur the trip coil to operate and fault line will be isolated.

Advantages

i) This system can be used for ring main as well as parallel feeder.

ii) This will provide instantenous protection for ground fault.

(iii) This system provide instantenous relaying which reduce the amount of damage to over head conductor.

Disadvantage

(i) Accurate ~~matching~~ matching of CTs is very essential.

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

iii) This system is very expensive owing to the length of pilot wire.

2020/5/2

CH-7 Protection Against over voltage and lightning

Voltage surge :-

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

→ It is exist for a short duration but they cause over voltage on the power system.

Causes of over voltage :-

→ The over voltage on the power system may be broadly divided into two categories

(a) Internal cause
  (i) Switching surge
  (ii) Insulation failure
  (iii) Arcing ground
  (iv) Resonance

(b) External cause
  (i) Lightning

D-29-03-2019

Internal cause of over voltage

i) Switching surge

→ The over voltage produce on the power system due to switching operation

* Case of an open line :- When unloaded lines is connected to the voltage source a voltage wave is set up which travels along the line on reaching the terminal point it reflect back to the supply end without change of sign. It cause voltage doubling that is voltage becomes twice the normal value.

→ This over voltage is of temporary nature. It is because the line losses attenuate the wave and in a very short time.

* Case of loaded line :- Suppose a loaded line is suddenly interrupted due to which voltage reached to peak value at the switch.

(ii) Insulation failure

(iii) Arcing Ground

The phenomenon of intermitent at taking place in line to ground fault of a three phase system with consiquent production of transient is known as arcing ground.

→ The transient produce due to arcing ground are cumulative and may cause serious damage to the equipment in the power system by causing breakdown of insulation. Arcing ground can be prevented by earthing the neutral.

(iv) Resonance

→ Resonance is an electrical system occur when inductive reactance of the circuit become equal to capacitive reactance. Under resonance impedance of circuit is equal to the resistance of the circuit and power factor is unity.

→ Resonance cause high voltage in the electrical system.

D-05-04-2019

Types of lighting strokes

(i) Direct strokes
(ii) Indirect strokes

→ There are two main way in which a lighting stroke on power system occur.

(i) Direct strokes

→ In the direct strokes, the lightning discharge (current path) is directly from the cloud to the subject equipment (Overhead line, Tower, Substation etc.).

→ The over voltage set up due to the stroke may be large enough to flash over this path directly to the ground.

→ It is of two types

(a) Stroke - A

(b) Storke - B

Stroke - A

→ Lightining discharge is from the cloud to the subject.

→ The cloud will induce a charge of opposite sign on the object. It occur when the potential difference between the cloud and line exceed the breakdown value of air.

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→ It is always occur on tall object.

Stroke-B

→ If positive charge cloud shift near to negative charge cloud then lightning discharge will occur bet" them and charge on both this cloud disappear quickly the result is that charge on cloud near to the transmission line suddenly become free and it discharge rapidly to earth.

→ It does not depend on tall object.

(ii) Indirect stroke

that may lead to surge in transmission line caused by indirect lightning stroke.

Harmful effect of lightning

→ A direct or indirect stroke produce voltage wave on the line, it rises from 0 to peak value which lead to travelling wave along the line in both direction. Which depend upon L & C parameter of the line.

(i) The travelling wave produced due to lightning surge shatter the insulator and poles.

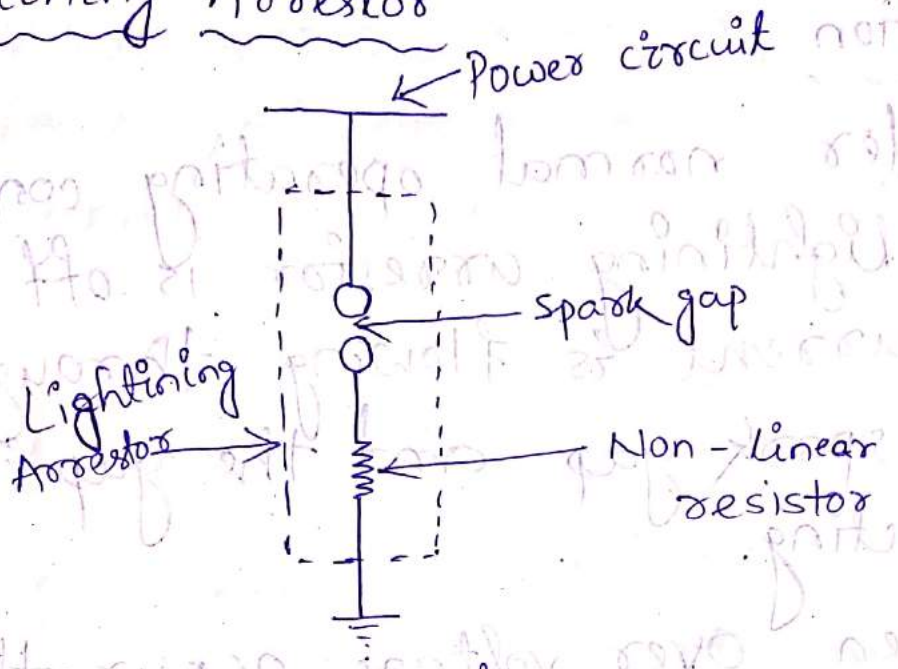
(ii) If the travelling wave produced due to lightning heat the winding of transformer or generator lead to damage.

(iii) If the arc is initiated in any point of power system by lightning stroke, this arc will set up very disturbing oscillation in the line. This may damage other equipment of line.

2020/5/2

D-08-04-2019

Lightining Arrestor



→ A lightining arrestor or surge divetor is a protective device which conduct the high voltage surge on the power system to the ground.

→ It consists of a spark gap in series with a non-linear resistor. One end of the divetor is connected to the terminal of the equipment to be protected and the other end is effectively grounded.

→ The length of the gap is so set that normal voltage not enough to cause an arc across the gap but a dangerous high voltage will break down the air insulation and formed an arc.

→ Non-linear resistance is used because the resistance decrease as the voltage or

current increased or vice versa.

Operation

→ Under normal operating condition the lightining arrestor is off therefore no current is flowing through the spark gap and the gap is non-conducting.

→ When over voltage occur the air insulation across the gap breakdown and an arc is formed and provide a low resistance path for the surge to the ground and harmless conducted surge pass through arrestor to ground instead of being send back over the line.

Types of lightining arrestor

① Rod gap arrestor
② Horn gap "
③ Valve type arrestor

① Rod ga

→ It is consists are be gap en

→ One circuit to ear insulato of the may damage

→ Under gap o occur on the the s earth

① Rod gap arrestor

→ It is a simple type of convetor consists of two 1.5 c.m rods which are bend at right angle with a gap in between two rods.

→ One rod is connected to the line circuit and the other rod is connected to earth the distance bet^n gap & insulator must not be less than 1/3rd of the gap length. So that the arc may not reach the insulator and damage it.

→ Under normal operating condition the gap remain non-conducting. On the occurance of high voltage surge on the line, the gap spark over and the surge current is conducted to earth.

Limitation

→ After the surge over, the arc in the gap is maintain by the normal supply voltage on the system.

→ The rod may melt or get damaged due to excessive heat produced by the arc.

→ The climatic condition affect the performance of rod gap arrestor.

D-15-04-2019

Horn gap

→ It consists of two horn shape metal rod separated by a small air gap the distance between them gradually increases towards the top.

→ One end of the horn is connected to the line through resistance and a choke coil and another end is grounded.

→ Resistance is used to flow current to a small value, choke is designed to offers small ~~resistan~~ reactance at normal power frequency but a small high reactance at transient frequency.

→ Thus transient frequency does not allow to enter into ~~or~~ choke. Under normal operating condition the gap is non-conducting there is normal supply voltage is insufficient to initiate the arc between the gap.

→ When over voltage produce spark over take place across the gap, the heating effect and magnetic effect arround the arc make the arc to travel of as the arc make up the distance be increased for the voltage to maintain the arc consequently the arc is extinguished and the excess charge on the line is conducted through the arrestor to the ground.

Advantages

Valve type arrestor

→ It consists of two ~~assebl~~ assembles
(i) Series spark gaps
(ii) Non-linear resistor disc

Series spark gaps :- It consists of no. of identical spark gap in series ~~es~~ each gap consists of two electrode with a fixed gap spacing.

→ The voltage distribution across the gap is linearised by mean of additional resistance element called ~~grading~~ graded resist

across the gap in the series withstand the normal circuit voltage when over voltage will cause the gap break down causing the surge current to ground via non-linear resistor.

ii) Non-linear resistor disc :-

Non-linear resistor disc are made of inorganic compound connected in series the non-linear element decreases with increase in current through them.

Working

→ Under normal operating condition the normal system voltage is sufficient to cause the break down of air gap when over voltage is occur the breakdown of the series spark gap take place and surge current is conducted to earth through non-linear resistor. Since the magnitude of surge current is very large, the non-linear element will offer a low resistance to the passage of surge. The result is that the surge will rapidly go to the earth instead of being send back over the line.

2020/5/2

Surge absorber

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