LEARNING MATERIAL OF

SWITCHGEAR & PROTECTIVE DEVICE

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Switch gear & protective DEVICE.

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1.	Introduction to switch gear
2.	fault calculation
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5.	Protective relays
6.	protection of electrical — Power equipment lines.
7.	protection against over voltage — and lightning
8.	static relay

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PRAKASH KUMAR IV/EL-64

Introduction to switch gear CH-I

04/01/2016

Switch gear :-

The apparatus used for switching, controlling & protecting the electrical ckts and equipment is known as switch gear

Ex- switch, Air break switch, Isolator (singe or double break) fuses, circuit breakers, Relays etc

Essential features of switch gear :- IMP...

The essential features of switch gear are -

(i) Complete reliability :- ✓

when fault occurrs on any part of power system the switch gear must reliable to operate to isolet the faulty sect^n from the remainder ckt

(ii) Absolute Certain discriminat^n :- ✓

when fault occurrs on any sect^n of the power system the switch gear must be able to discriminate bet^n the fault sect^n & the healthy sect^n

(iii) Quick operation :-

when fault occurrs on any part of the power system the switch gear must operate quickly so the no damage occurrs to generator, and other equipment by the short ckt current.

(iv) provision for manual control :-

It must have be provision for manual control

Switch gear Equipment

(i) - Switch :- A switch is a device which is to open or closed an electrical ckt easily.

(ii) Air break switch :- (A B) switch

It is an air switch and it design to open a ckt under load

(iii) Isolator or Dis Connecting switch :-

It is a knife shape and is design to open a ckt under NO load.

(iv) Oil switches :-

In oil switch the contact of switches are open under oil (usually TF oil)

(v) fuses :- A fuse is a short piece of a wire or thin strip which melts when excessive current flows through it for sufficient time

(vi) Circuit Breaker.

A circuit breaker is an equipment which can open or close a circuit under all conditions. i.e NO load, full load, fault condit'ns

(vii) Relay.

A relay is a device which detects the fault and supply information to the breaker for ckt Interruption

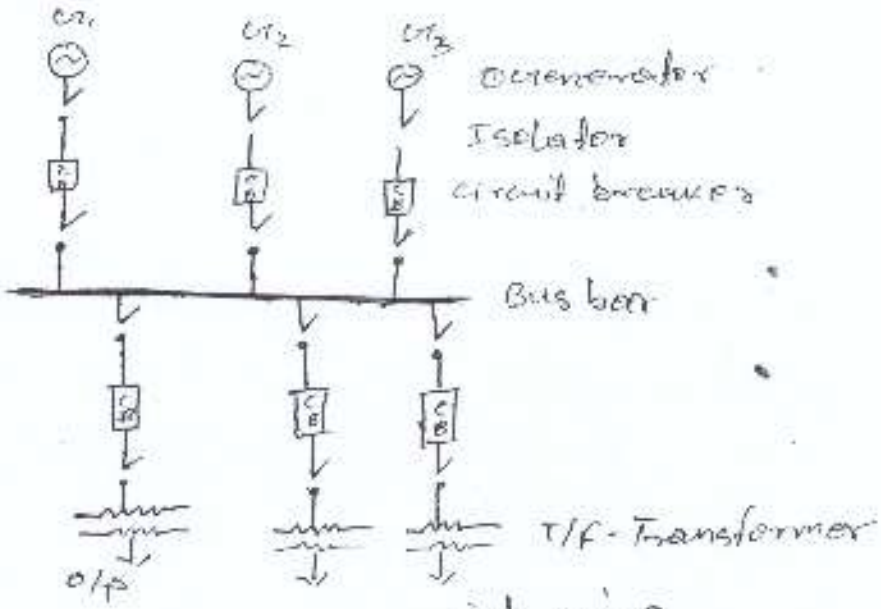
BUS - Bar arrangement

05/01/2017

(i) Single bus bar arrangement.

Bus-bars are copper rods or thin walled tubes and operate at constant voltage.

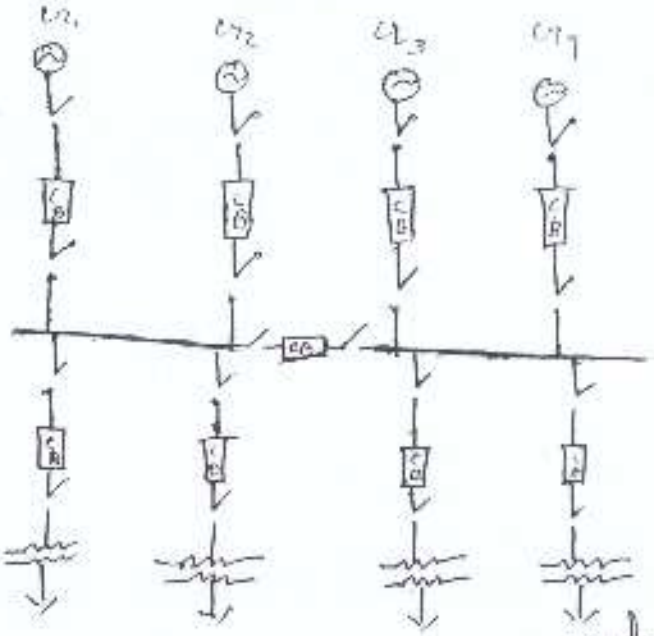
(ii) Single bus bar system.



* Here only one bus is used
* It is simple in design
* It has low initial cost
* It has less maintainance & simple operatn
* If fault occurs on the bus bar itself, there is Complet interruption of supply.
* In this arrangemnt the bus bar can't be cleaned, repair or tested

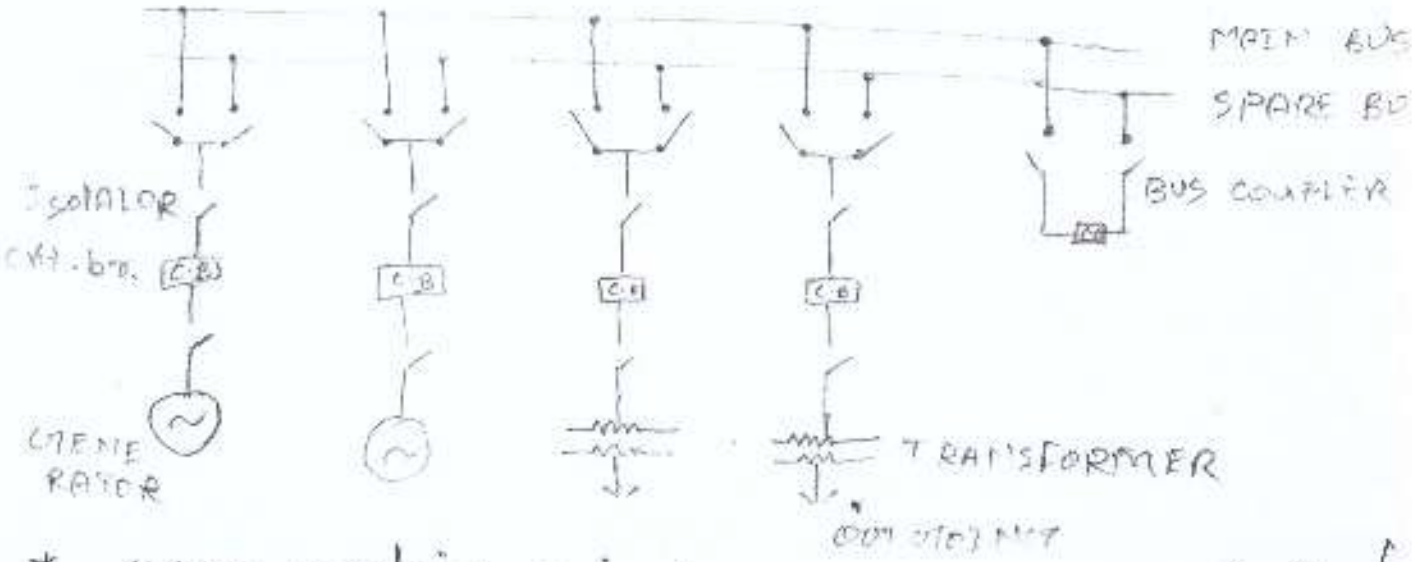
(iii)

(ii) Single bus bar section with sectionalizat^{n}



* It is employeding large generating 06-01-2017 stat^{n}
* Here the bus bar divided in to two sect^{n}s Connected by a ckt breaker & Isolator.
* If fault ocurrs on any section of the bus bar that sect^{n} can be isolated without affecting the supply to the other sect^{n}. in this
* In this sect^{n} bus bar maintenance & repair is simple.

(iii) Duplicate bus-bar system :-



* Here contain main bus, spare bus & a bus Coupler employed.
* This arrangement is difficult in nature.
* Each generator, feeder may be Connected to eighther bus bar with the help of bus Coupler which consist of CB. & Isolator
* It will too expenssive in nature
* Repair & maintenance of main bus bar easily with out interrupting the supply.
* If fault ocurrs on the bus bar the Continuity of the supply can be maintent by transforming it to the other bus bar

Switch gear Accomodat' 9-1-17

Depending up on the voltage to be handled switchgear may be broadly at classified in to.

i) outdoor type.

ii) In door type.

1. outdoor type

voltage above 66 kV, switch gear equipment are installed in outdoor is called as outdoor type accomodat^n

· Indoor type

for voltage below 66 kV. Switch gr. equipment are installed in indoor, this type of accomodat^n is called as indoor type.

Short Circuit

when ever a fault occurs on a network such that a large current flows in one or more phases, a short circuit is said to have occured

faults in power system:

A fault in an electrical equipment in defined as a differt in the electrical ckt due to which current is diverted in to the fault path

Fault's are two types such as-

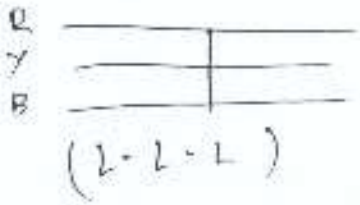
(i) symmetrical faults

ii) unsymmetrical faults.

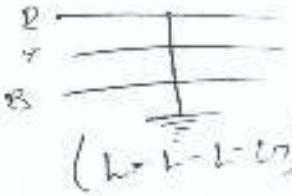
(i) symmetrical fault:

The fault which gives rise to symmetrical fault currents (equal fault currents with 120° displacement) is called a symmetrical fault

Ex:- All three lines to ground & all three lines to be shorted. This fault occurs may be 2 to 3 %.



(L-L-L)



(L-L-L-G)

(ii) Unsymmetrical fault:-

The faults which gives rise to unsymmetrical current (i.e unequal line current with un equal displacements) are called unsymmetrical faults. This occurs 70 to 75 %.

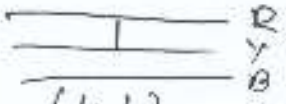
Again unsymmetrical faults are -

→ Single line to ground

(70 % occurs)

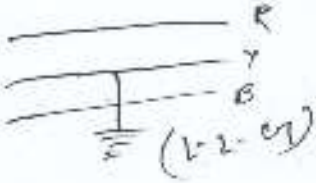
(L-G)

→ Line to line



(L-L)

→ Line to line & ground



(L-L-G)

→ Line to Line & 3rd phase to ground.

(L-L & 3rd G)

formulae :-

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

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

(3) $I_{SC} = I \times \left(\frac{100}{\%X}\right)$

(4) short ckt KVA = Base KVA $\times \frac{100}{\%X}$

(5) %X at base KVA =

$$\frac{\text{Base KVA}}{\text{Rated KVA}} \times \%X \text{ rate KVA.}$$

(1502 SBI)

short q.:-

17/02/2017.

1) Define switch gear.

Ans switch gear is the apparatus which use for switching, controlling & protecting the electrical ckt and equipment is known as switch gear.

2) Define bus bar?

Bus bars are copper rods or thin walled tubes and operated at constand vatage.

3) The fuse is a which device?

Ans fuse is a protective device.

4) An isolator is design to open a circuit under which Condit^n

Ans under no load condition an isolator is design to open a ckt

5) what do u mean by indoor switch gear arrangement

Ans Indoor switch gear means which switch gear range from below 66 KV

6) What do u mean by symmetrical fault?

Ans The fault which gives rise symmetrical fault current (equal fault current which 120 displacement is called S.F.

Long. Qs:

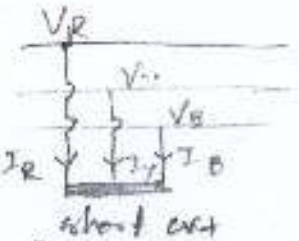
1) write down the essential feature of switch gear
2) Explain the types of bus bar arrangements.

Fault Calculation

Symmetrical faults on 3-ϕ system:—

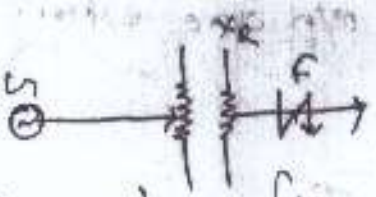
That faults on the power system which gives rise to symmetrical fault current (i.e equal fault currents in the lines with 120° displacement) is called a symmetrical fault

The symmetrical fault occurs when all the three ~~phases~~ of Conductors of a 3-ϕ line a brought together simultaniously



This fault is more dangerous in nature

Limitatn of Fault current:—



As shown in above fig, the fault occurs on the feeder at point ~~a~~F

* After that the short ckt current flows
* That short ckt current is limitade by the impedance of the system up to the point of fault
* Thats why the knowledge of impedance of the

Various equipment of the ckt in the line of the system is very important when calculating the short ckt current

Percentage Reactance.

It is the percentage of the total phase voltage droped in the ckt when full load current is flowing

$$\% X = \frac{IX}{V} \times 100 \quad \text{---(1)}$$

where,

I = Full load current, A

V = phase voltage.

X = Reactance in Ω/ph

from equⁿ (1)

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

Multiplying & dividing the Right hand expression by V

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

$$X = \frac{\% X \times V^2}{V \times I \times 100}$$

when the voltage and the o/p are expressed in KV & KVA respectively then

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

$$= \frac{(\% X) \times KV \times KV}{KV \times KA \times 100} \Rightarrow \frac{(\% X)\, KV^2 \times 1000}{KV \times A \times 100} = \frac{(\% X)(KV)^2 \times 10}{KVA}$$

$$\boxed{\% X = \frac{(X) \times KVA}{10 (KV)^2}} \quad \text{Important.}$$

If X is the only reactance element in the ckt, then short circuit current is given by

$$I_S = \frac{V}{X} \quad \text{---(1)}$$

from equation (1)

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

now this $\frac{V}{X}$ put in equn (2)

$$I_S = I \times \frac{100}{\% X}$$ important.

Percentage Reactance & Base KVA:

We know that $\% X = \frac{(KVA)X}{10(KV)^2}$

From above we see that % X depends upon the KVA rating

* The common KVA rating amount among the all equipments used in power system is know as base KVA

* A base KVA may be choosen in the following manner —

(i) Any arbitary value equal to the KVA rating of the largest unit connected in the network

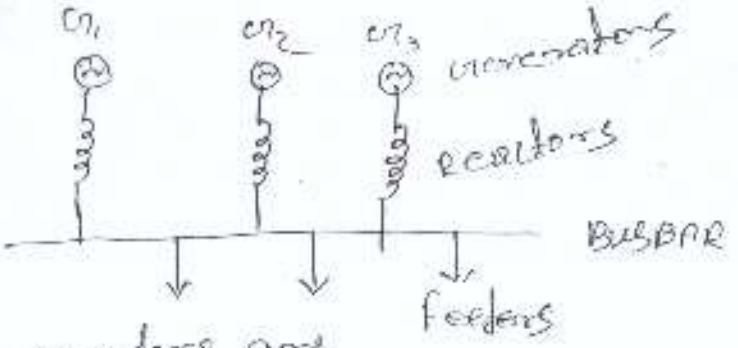
(ii) - Equal to the sum of the KVA ratings of all the units connected in the network

NB

% age reactance at base KVA

$= \frac{\text{Base KVA}}{\text{Rated KVA}} \times$ % reactance at rated KVA

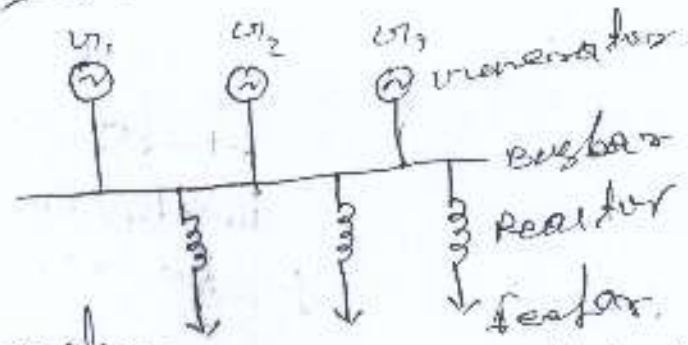
important



when the reactors are connected in series with each gen
They are known as generator reactors.

* In this arrangement generators are protected in the case of any short cut beyond the reactors
* There is a constant voltage drop and power loss in the reactors even during normal operation

Feeder Reactors.

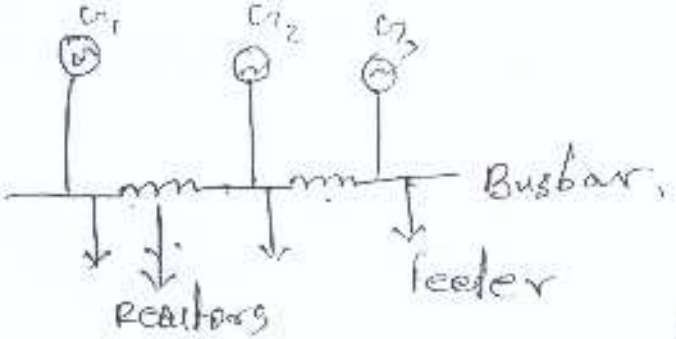


when the reactors are are connected in series with each feeder these are known as feeder reactors
* feeders are protected very safely
* Bus bar voltage should be constant even if fault on any feeders

Buss bar Reactors.

Buss bar reactors are two types

(i) Ring system.
(ii) Tie-bar system.

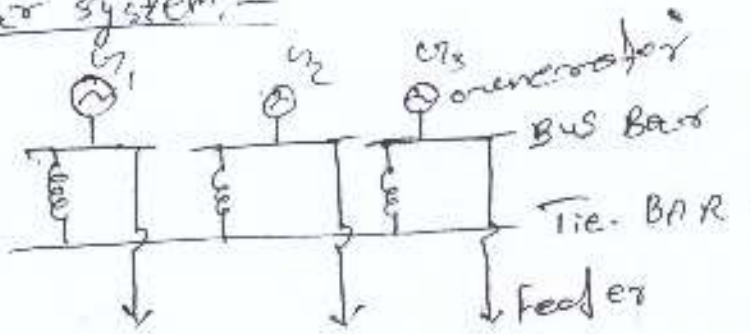


19-1-17

In this system bus bar is divided in to sections & those sections are connected through reactor.

→ There is little power loss & voltage drough in the reactor.

(ii) Tie-Bar system:-



In this system the additional bus bar i.e Tie bar is employed. There are effectively two reactors in series between the sections.

Step for symmetrical fault calculation

→ Draw a single dig. of the network indicating the rating, voltage & represent reactance of each elements of the network

→ Choose the value of base KVA & convert all represted reactance to the base value.

→ According to single line dig. draw the reactance dig.

→ Find the total percentage reactance of the network up to point of fault & let it be X%.

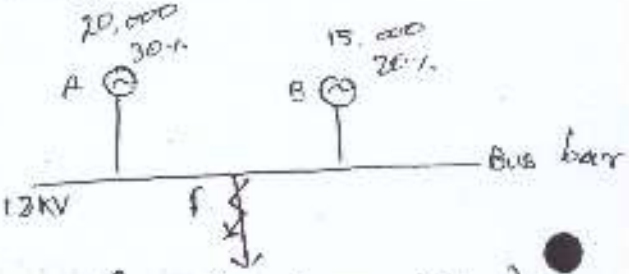
* Find the load current corresponding to the selected base KVA & the normal system voltage at the point of fault. Let it be 'I'

* Then find out various short ckt. calculation. Here short ckt current, $I_{sc} = I \times \frac{100}{\%\,x}$

* short ckt KVA = Base KVA $\times \frac{100}{\%\,x}$

Problem

In a 3-ϕ ckt consist of 2 alternators 20-1-17
20,000 KVA, 30% reactance and 15,000, 20% reactance respectively. This two alternator are connected to a bus bar having voltage 12 KV. Find out the I_{sc} & short ckt KVA when fault occurs a feeder which is connected to the bus bar (This fault is symmetrical)



(Single line dig.)

* Let the base KVA be 10,000

* Now we convert the rated reactance value of alternator A into base value.

$\therefore x_A = \frac{\text{Base value}}{\text{Rated value}} \times x$ at rated value.

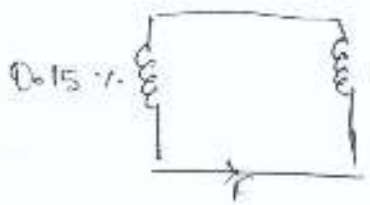
$= \frac{10000}{20,000} \times 30\% = 0.15\%$

Now we convert the rated reactance of alter. B in to base value.

$\therefore x_B = \frac{10000}{15,000} \times 20\% = 13.33\%$

Now we find line current corresponding to 11 kV side

$$I_L = \frac{kVA}{\sqrt{3} \times kV} = \frac{10000 \times 10^3}{\sqrt{3} \times 11 \times 10^3} = 481.125 \text{ A}$$



Reactance dig.

Now find out the total % reactance from neutral to fault point 'f'

$$\%X_T = \frac{\%X_A + \%X_B}{\%X_A + \%X_B} = \frac{15\% \times 13.33\%}{15\% + 13.33\%} = 7.053\%$$

Now find short ckt current

$$I_{SC} = I \times \frac{100}{\%X} = 481.125 \times \frac{100}{7.053} = 6824.46 \text{ A}$$

Short ckt KVA.

$$\text{Base KVA} \times \frac{100}{\%X} = 10000 \times \frac{100}{7.053} = 141703.27 \text{ KVA}$$

Q) A 3-Ø transmission line operating at 10 kV & having a resistance of 1Ω and reactance of 4Ω is connecting to the generating station bus-bars through 5 MVA step up transformer having a reactance of 5%. The bus bars are supplied by a 10 MVA alternator having 10% reactance calculate the short ckt KVA fed to symmetrical fault bet^n phases if it occurs

(i) At the load end of transmission line

(ii) and the high voltage terminal of the T/F

21-01-2017.

Given

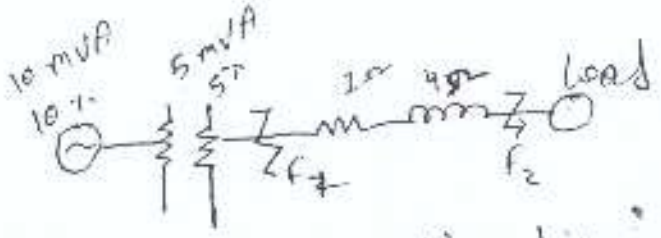
* 3-ϕ T/F contain:
  10 KV, R = 1, X = 4
* bus bar - 5 Ω
* step up T/F having

{ 10 MVA, 10 Ω.

{ 5 MVA, 5 Ω.

{ 1Ω, 4Ω, 10 KVA.

{ line operating 10 KV



Line dig:

Let base KVA = 10000

* Now alternator % reactance convert in to base MVA.

$$\%X_A = \frac{10000}{10 \times 10^3} \times 10\% = 10\%.$$

* Then % of T/F reactance convert in to base MVA

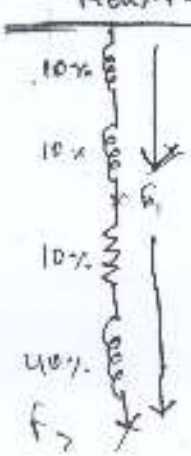
$$\%X_T = \frac{10000}{5 \times 10^3} \times 5\% = 10\%$$

* Now convert resistance & reactance of transmission line in terms of percentages by the base value.

$$\%R_L = \frac{R \times KVA}{10 \times (KV)^2} = \frac{1 \times 10000}{10 \times (10)^2} = 10\%$$

$$\%X_L = \frac{4 \times 10000}{10 \times (10)^2} = 40\%.$$

24/02/2017



(reactance dig.)

Now we have to calculate short cut KVA at point F_1 so total % age reactance from generator neutral to F_1

$\% X_T = 10 + 10 = 20\%$

short cut KVA = Base KVA $\frac{100}{\% X_T} = 10000 \times \frac{100}{20} = 50000$ KVA

Now total ~~reactance~~ % age of impedance from generator neutral to fault point F_2, so $R = 10\%$ & $X_L = 40\% + 20\% = 60\%$

$\% Z = \sqrt{10^2 + 60^2} = 60.83\%$

∴ short cut KVA at point F_2 = Base KVA $\times \frac{100}{\% Z}$

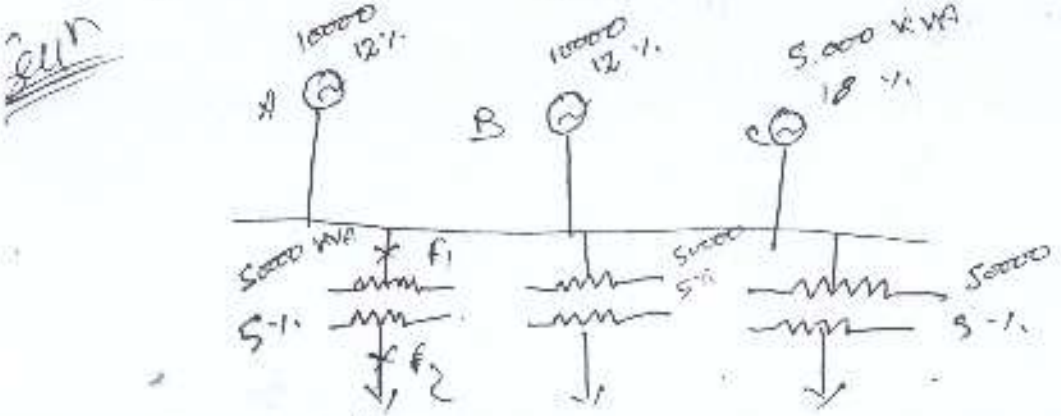
$= 10000 \times \frac{100}{60.83} = 16439.25$ KVA (approx)

b) The plant capacity of a 3-φ generating station consist of two 10000 KVA generators of reactance 12 % each and one 5000 generator of reactors 8 %. The generators are connected to the station bus bar from which load is taken through three 5000 KVA step up T/F each having a reactance of 5 %. Determine the max^m fault MVA which the cut breaker ON

(i) Low voltage side..

(ii) High voltage may have to deal with.

25/01/2017



Single line dig.

Now calculated rated % age of reactance of generator and T/F in to base KVA. Let base be 20000 KVA.

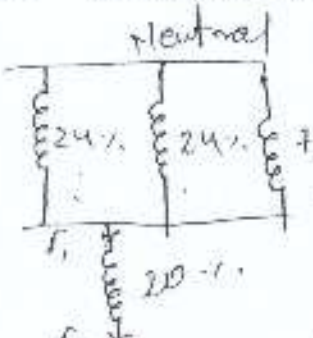
$\% X_A = \frac{20000}{10000} \times 12\% = 24\%$

$\therefore X_B = 24\%$

$X_C = \frac{20000}{50000} \times 18\% = 72\%$

$\% X_T = \frac{20000}{50000} \times 5\% = 20\%$

Now draw reactance dig.



From generator neutral to fault point f_1 total reactance is

$\% X = 24 \,||\, 24 \,||\, 72\%$

$= 12\% \,||\, 72\% = 10.28\%$

Short ckt mVA at point f_1, $= \frac{20000}{1000} = 20$ KVA to mVA

$\therefore$ Base mVA $\frac{100}{\% X} = 20 \times \frac{100}{10.28} = 194.55$

f_2 = Total generators reactance

$= 10.28 + 20 = 30.28\%$

$= 20 \times \frac{100}{30.28} = 66.05$ mVA.

Ch. 3

25/01/2017

Fuses

A fuses is a short piece of metal in shorted in the ckt which melts when excessive current flows through it and those breaak the ckt.

Desirable.

characteristic of fuse element :-

The fuse element should have the following charact.

i) Low melting point i.e. tin, lead.

ii) High conductivity ie silver, Copper.

iii) Free for deterioration due to oxidatn ie silver.

iv) Low cost ie lead, tin, Copper.

fuse element materials :-

* The most commonly used materials for fuse element are, lead, tin, copper, Zincs silver etc.

* for small current upto 10 amper tin or an alloy of lead and tin (lead 37%, tin 63%) is used for backing the fuse element.

* For large current copper or silver is employed.

Important Terms

The following terms are must used in the analysis of fuses.

(i) Current rating of fuse element

It is the current which the fuse element can normally carry with out over heating or melting.

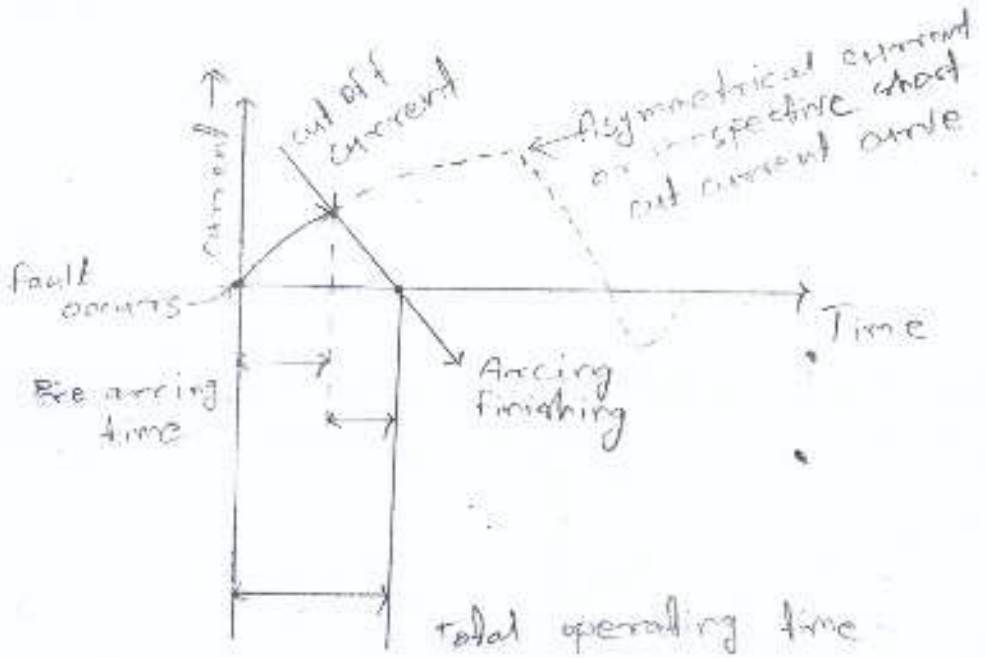
(ii) fusing current

It is the minimum current at which the fuse element melts and thus disconnect the ckt protected by it.

(iii) fusing factor :- It is the ratio of minimum fusing current to the current rating of the fuse element

$$\text{fusing factor} = \frac{\text{minimum fusing current}}{\text{current rating of fuse}}$$

(iv) Prospective current :-



It is the RMS Value of the 1st loop of all current obtained if the fuse is replace by an ordinary conductor of negligible resistance

03/02/2017

(v) cut off current

It is the maxm value of current actuall reachg before the fuse melt

(vi) pre-arcing time

It is the time betn the commencement of fault and the instant when cut off occurs

(vii) Arcing time :- This is the time betn the end of pre arcing time and instant when the arc is finished

(viii) Total operating Time :-

It is the sume of pre arcing & arcing times

Types of fuses:-

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

(i) Low voltage fuse

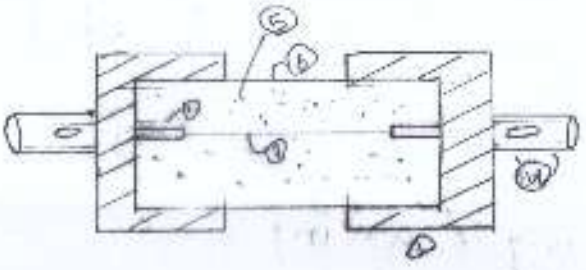
Low voltage fuses are two types

(a) rewireable fuse / kit-kat type
(b) High rupturing capacity (HRC) Cartridge type.

a) Rewireable fuse / kit-kat

* Rewireable fuse also known as kit-kat type fuse
* It consist of a base and a fuse carrier
* The base is of procelain and carries the fixed contact to which the incoming and out going phase wires are connected.
* The fuse carrier is also made up procelains holds the fuse element (tinned copper wire) between its terminals
* when a fault occurs the fuse element is blown out and the blown out fuse element is preplaced by the new one
* The fuse carrier is them reinserted in the base to restore the supply /

b) High rupturing capacity (HRC) cartridge type



① outer element
② FUSE ELEMENT
③ BRASS END PLATE
④ Fuse Link Contact
⑤ Filling Powder
⑥ Cartridge (made up of ceramic)

* It consisting of a heat resisting ceramic body having met
end caps
* The filling (chalk, plaster of parries, quartz, all marbal
dust) pack on the cartridge.
* fused element places on the cartidge betn outdoor
element
* under normal condit^n the fuse element carries the
normal current with out over heating.
* when a fault occurs the fuse elements melts due to
increase in current in the ckt and then the ckt is
interrupted.

Advantages

They are capable of clearing high as well as low fault
current.
* They don't deteriorate with age.
* They have high speed of operat^n
* They provide reliable discriminat^n
* They required no maintenance

Disadvantages

They have to replace after each operation.
* Heat produced by the arc may affect the associated
switch

High voltage cartridge type switch

This is the similar construction as the low voltage
cartridge type.
* Here only some special design arranged that there
are two fuse element in parallel one of low
resistance (silver wire) & other of high resistance (tungsta
wire) under
* under normal condit^n the low resistance elemen

Carries the normal current.

* when a fault occurs the low resistance is blown out and the high resistance element reduces the short cut current and finally breaques the cct.

Current Carring Capacity of fuse element

The current carring capacity of a fuse element depends up on the following factors.

(a) Material of fuse element
(b) Length
(c) Diameter
(d) size & Locatn of terminal's

when the fuse element attains steady temp^r,

Heat produced = heat Lost per sec by Convectn, conductn & radiatn

I^2R = Constant × effective area

$I^2\rho\frac{l}{a}$ = Constant × $\pi d \times l$

$I^2\rho\frac{l}{a}$ = Cont. × $d \times l$

$I^2 = K \times d^3$

$\boxed{I = K d^{3/2}}$ Impart called the

where, K is a Constant ^ fuse Constant, Its value depends up on the metal of which the fuse element is made

Difference bet" a fuse & ckt breaker

08
07
04/02-2017

Sl NO fuse

Sl no	Particulars	fuse	ckt breaker
1	Function	It perform both detection & interrupt" funct"	It performs interrupt" fun. The detect" of fault is make by relay system
2	operat"	Completly automatic	For complet auto matic, relays are used
3	Breaking capacity	small	very large
4	operating time	very small	comparatively large
5	Replacement	Required replacement after every operat"	No replacement after every ope

Short &

① write down the name of fuse element ?

The name of fuse elements are, lead, tin, Copper, silver, alloy of lead & tin etc.

② Define fusing current ?

~~It is the~~ The fusing current is definet as the minum current at which the fuse element melts and thus disconnect the ckt protected by it

③ Define fusing factor ?

Fusing factor is the ratior of minimum fusing current to the current rating of the fuse element.

Long &

① Explain about HRC cartridge type fuse

② writedow the difference bet" fuse & ckt breaker

CH-4

Circuit Breaker

Circuit Breaker

A circuit breaker is a piece of equipment which can make or break a circuit either manually or by remote control under normal condition break a ckt automatically under fault condit^n, make a ckt either manually or by remote control under fault condition

Operating principle:-

A ckt breaker consist of fixed and moving contacts under normal operating condit^n these contact remain closed posit^n. These contacts can be open manually or by remote control whenever desired. when a fault occurs on any part of the system, the trip coils of the ckt breaker get energised and the moving contact are pulled apart by some mechanism, thus opening ckt

ARC PHENOMENON

* when short ckt occurs, a heavy current will flows through the contact of ckt breaker before open.
* After the contact open, the heat will produced in the medium (oil or air) bet^n contacts.
* That heat is sufficient to ionised the air of vapourise and ionise the oil
* The ionised air or vapour acts as conductor and an arc is formed bet^n the contacts

Principle of Arc extinction

These are two factors which are responsible for maintain arc bet^n the contacts as follows below

→ potential difference (P.D) bet^n the contacts

→ Ionised particle bet" Contacts

Methods of Arc extinction

There are two methods of extinguishing the arc in the cut breakers,

(i) → High resistance

(ii) → Low resistance / current zero method.

(i) High resistance method :-

In this method the arc resistance is made to increase with time so as the current is reduce to a Value insufficient to maintain arc,

* Consiquently the current is interrupted of the arc is extinguishing.

The resistance of the arc may be increased by,

→ Lengthening the arc

→ Cooling the arc

→ Reducing cross-section of arc ...

→ splitting the arc

$\therefore R = \rho \frac{l}{A}$

(ii) low resistance / current zero method

In this method the arc resistance is kept low, until current is zero, where the arc extinguishes naturally and is prevented from restriking inspite of the rising voltage across the contact;

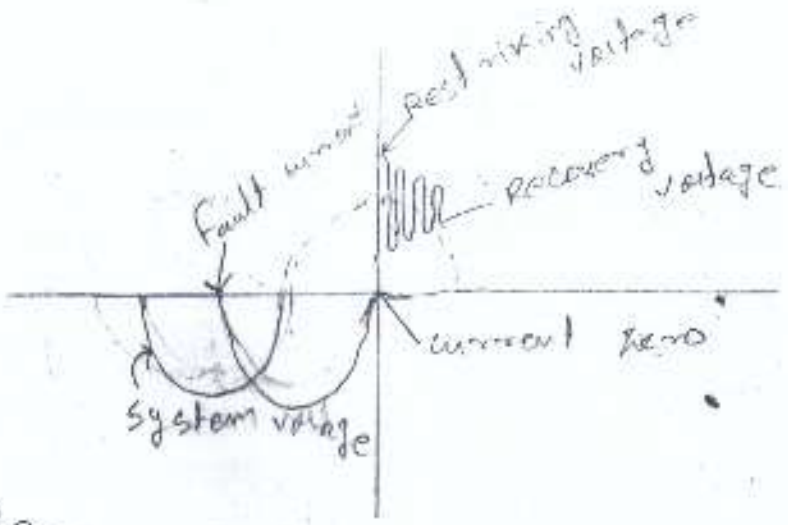
* In this method the dielectric strength of the medium bet" Contacts increased suddenly after current zero

* The rapped increased of dielectric strength (insulating properties) of the medium near zero can be done

hu

→ Lengthening of the gap.
→ High pressure
→ Cooling, Blast effect

Imp. terms



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Arc Voltage.

It is the voltage that appears across the contacts of the ckt breaker during the arcing period

Restriking voltage

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

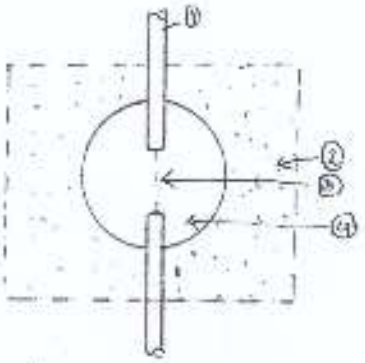
Recovery voltage -

It is the normal frequency (50 Hz) rms voltage that appears across the contacts of the ckt breaker after final arc extinction. It is approximately equal to the system voltage.

Classification of cut breaker:

Accordingly on the basic of medium used for arc extinction, cut breaker may be classified in to

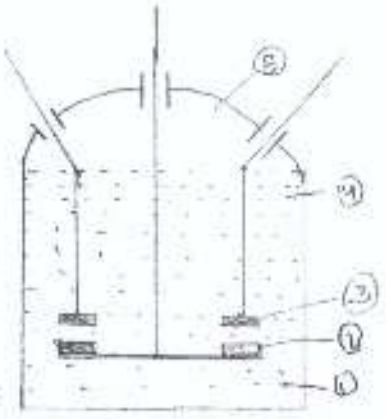
(i) oil cut breaker
(ii) Air blast cut breaker.
(iii) sulphur hexa ~~chloride~~ hexafluoride cut breaker (SF_6)
(iv) Vacuum cut breaker
(v) oil cut breaker:



① parting contact
② oil
③ Arc
④ Bubble of oil vapour

* In oil cut breaker, there are two contacts one is moving contact another is fixed contact
* The T/F oil is used for arc quenching medium
* The contacts are open under oil and an arc is struck betn them.
* The heat of the arc evaporates the sounding oil).
* Then the oil dissociates in to a substantial volume (1000 times)
* Therefore the oil is pushed away from the arc thus the arc extinction take place and cut current interrupted.

Plain brear oil ckt breaker



5) T/f oil
4) moving Contact
3) fixed Contact
2) oil level
1) Air cushion

Construction

- It has a strong wheather tight tank
* The tank Contains T/f oil upto a certain level
* The air cushion present above the oil level
* The fixed Contact & moving Contact enclosed in the tank.

operation

under normal operating Conditions the fixed & moving Contact remain closed and the breaker carries the normal ckt current. when fault occurs, the moving Contacts are pull down by the ~~powerful~~ system and an arc is strike which vapourise the oil mainly in to hydrogen. The hydrogen place vital role to extinguishing the arc and the ckt current is interrupted.

Arc Control oil ckt breaker

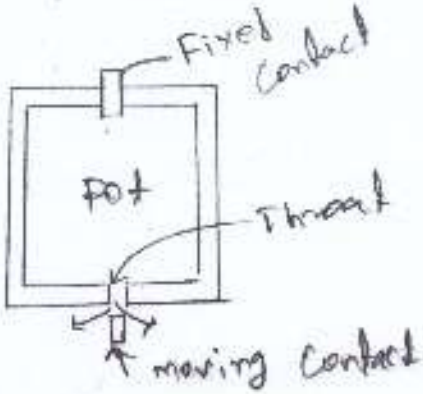
In arc Control oil ckt breakers special arc Control devices are employed for arc extinct^n purposes efficient is possible

There are two types of such breaker mainly.

→ Self-blast oil ckt breaker
→ forced blast oil ckt breaker.

Self-blast oil circuit breaker.

* In self-blast oil ckt breaker arc control is provided by internal means, that is arc it self is employed for ifs own extination efficiently.
* An insulating rigid pressure chamber or pot is installed surrounding the contact.
* Here the arc gases is restricted by the chamber, a very high pressure is developed to pas forced oil and gas through or arround the arc to extinguishing.
* The magnitude of the pressure developed depends up on the value of fault current to be interrupted



Forced blast oil ckt breaker:-

* Here pressure is generated by the mechanically
* That means oil pressure is created by the piston cylinder arrangement
* when fault occurs the contacts get seperated by the protective system and an arc is struck

16/02/2017

then the piston forces a jet of oil towards the contact gap to extinguish the arc.
* finally the cut current the current should be interrupted.

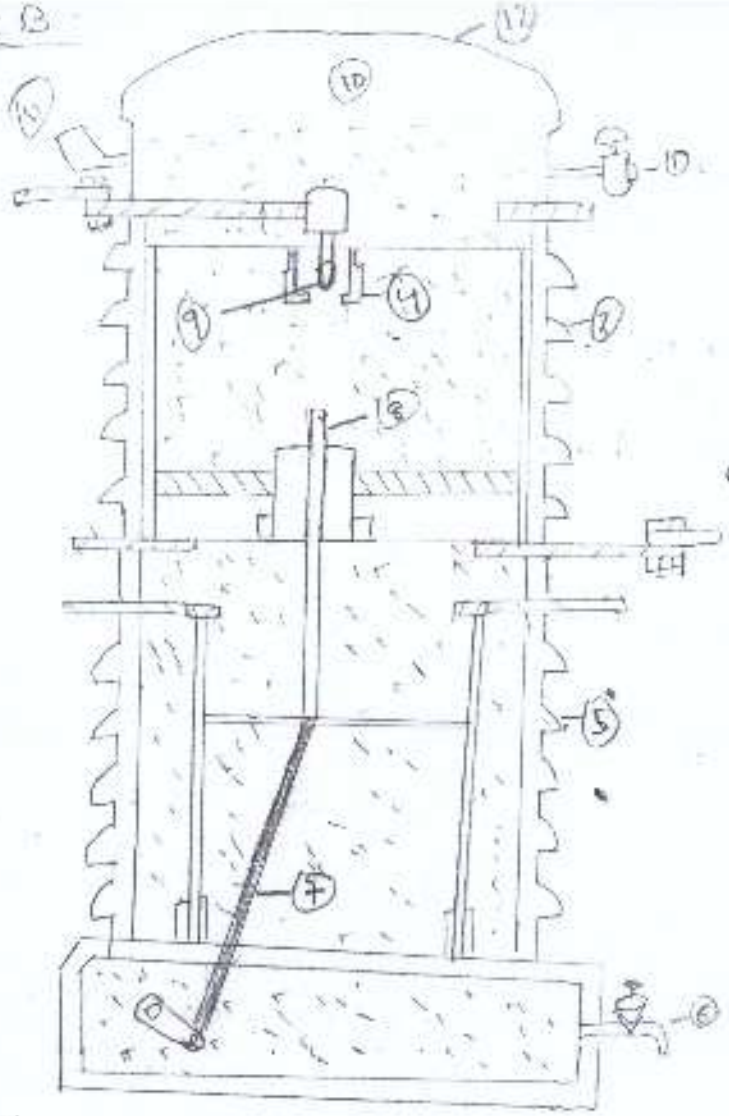
Maintenance of oil cut breaker

* check the current carrying parts and arcing contacts.
* If burning is severe the contact should be refleced.
* check the oil level.
* check the dielectric strength of the oil. If the oil is badly discoloured it should be changed or reconditioned.
* check the insulation for possible damage, clean the surface & remove carbon deposits with a strong and dry fabric
* Breather
* check closing and tripping mechanism

Low oil cut breaker.

→

Low OCB



1- Breather
2- arc breaking chamber
4- Fault extinction device or Turbulator
5- supporting chamber
6- Drain valve
7- operating rod
8- Moving contact
9- Fixed contact
10- oil level
11- Gas vent
12- Top chamber

Construction

* The low OCB has the following parts

(i) supporting chamber :-

* It is a porcelain chamber mounted on a metal chamber.
* It is filled with oil which is physically seperated from the oil in the arc breaking compartment.
* The oil inside the supporting chamber is employed for insulat^{n} purposes only

(ii) arc breaking chamber :-

* It is a porcelain encloser mounted on the top of the supporting compartment
* It is filled with oil
* It has following parts

(a) operend lower fixed contact
(b) Moving Contact
(c) Arc turbulator
(iii) Top Chamber:-
* It is a metal chamber
* It is mounted on the ckt breaking chamber
* It is provide expanssion space for the oil in the ckt breaking Compartment.

operation

17/02/2017

● Under normal operating Condition, The moving Contact & fixed Contact are closed with each other.
* when a fault occurs the moving Contact is pulled down by the tripping spring and an arc is struck.
* The arc energy Vapourises the oil and produces gases under high pressure.
* The high pressure gas is spreaded seriesly to the arc by turbulator, Thus arc is extinguished. Then the ckt current is interrupted.

Air blast ckt breakers.

* These breakers employes high pressure air glass
* as an quenching medium.
* The air glass puls the arc and keeps away the arcing product to the atmosphere
* This rappidely increases the dielectric strength of the medium bet^n Contact and prevents from re-establishing the arc

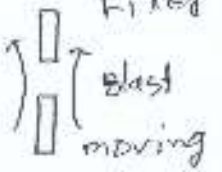
* Consiquently the arc is extinguished and flow of current is interrupted.

Types of air blast cut breaker:

Depending upon the direct^{n} of air blast in relat^{n} to the arc, air blast cut breaker are classified in to.

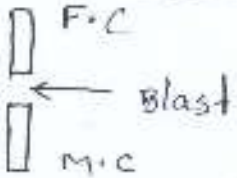
(i) Axial-blast type
(ii) Cross-Blast type.
(iii) Radial-Blast type.

(i) Axial-Blast type



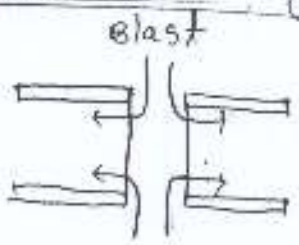
Here the air blast directed along the arc path

(ii) Cross-Blast type.



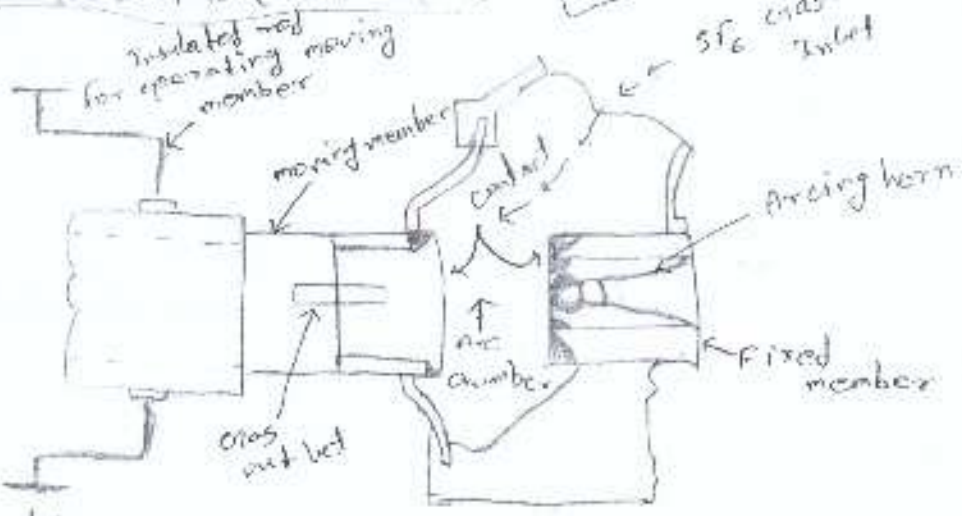
Here the air blast is directed at right angles to the arc path

(iii) Radial Blast type.



Here the air blast is directed radially to the arc path

Sulphur Hexafluoride (SF_6)



Construction

It consist of fixed & moving contact/members enclosed in a chamber.

* Fixed member is a hollow cylindrical coil current carring contact heated with an arc horn
* The moving member is also a hole cylinder with rectangular holes

27th feb 17

* The tips of fixed member & arcing horn are coated with copper tungston are resistance materian
* The enclose chamber called arc interruption chamber containing SF_6 gas.
* This chamber is connected to a SF_6 gas reserver

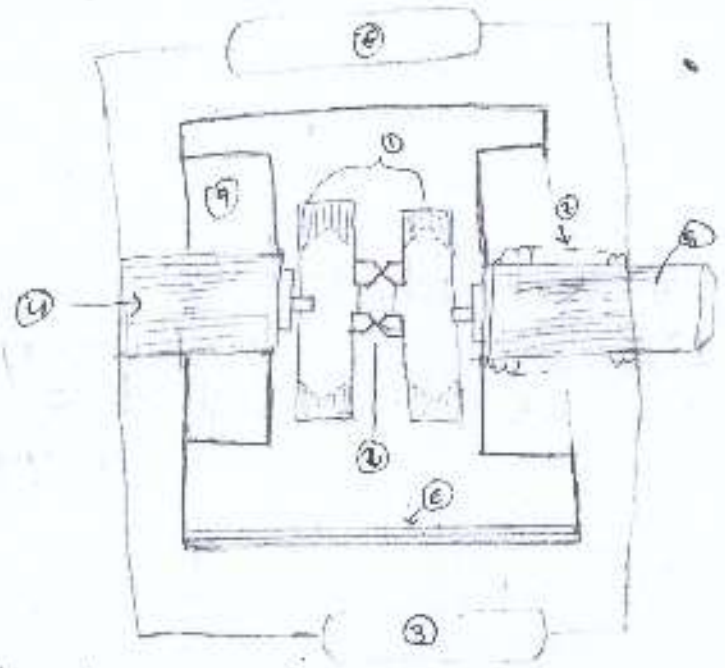
* Working

under normal operating condition the contacts are remain closed and surrounded by SF_6 gas.
* when breaker operates, the moving member is pulled apart and an arc is struck bet" the contacts
* The movement of the moving member is connected with the opening of a valve which permits SF_6 gas at 14 kg/cm² pressure from the reserver to the

are interruption chamber.

* The high pressure flow of SF_6 rapidly absorbs the free of electrons in the arc path to form immobile negative ions which are ineffective as charge carrier.
* The result is that the medium betn the contact quickly builds up high dielectric strength and causes the extinction of the arc.
* Finally current is interrupted in the ckt.

Vacuum ckt breaker.



1- Arcing range
2- Contact
3- Insulating vessel
4- fixed member
5- moving member
6- Main arc shield
7- Arc shield bellows
8- Insulating vessel
9- Arc field

Construction

It Consists of fixed member, moving members arc shield mounted inside a vacuum chamber

* The movable member is Connected to the Control mechanism by stainless steel bellows.
* This enables the permanent ceiling of the Vacuum Chamber, so as to eliminate the possibility of leak
* A glass/ceramic vessel is used as the outer insula body
* The arc sheeted prevent the deterioration of the

Vapours falling on the inside surface of the outer insulating cover

Working:

* Under normal condition fixed member & moving member are in closed
* when breaker operates the moving member separates from the fixed member & an arc is struck betn the Contact.
* The producth of arc is due to ionisation of metal ions and depends very much upon the material of Contacts.
* The arc is quicly extinguishes because the metalic vapours, electrons & ions produced during arc are defused in a short time and sheezed by the surface of moving & fixed members & shields.
* Finally current interrupted in the circuit

Switch gear Components

The following are some important Components Common to most of the ckt breaker

1 → Bushing
2 → Circuit breaker Contact
3 → Instrument T/F
4 → Buss bars & Conductors

1 → Bushing

When a high voltage passes through a metal sheet/frame which is at earth potential, the necessary insulat^n is provided in the form of bushing.

2 → Ckt Breaker Contacts

The ckt breaker Contacts are required to carry norm as well as short ckt current.

ckt breaker Contacts are following types.

(i) Tulip type Contact
(ii) Finger & wedge contact
(iii) Butt Contact

3 → Instrument T/F

* For measuring high voltage, high current & the relay, operation instrument T/F is Connected to ckt breakers.

The instruments T/F are two types.

(i). Current transformer
(ii) potential "

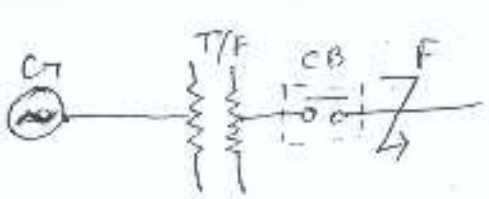
4 → Buss bars & Conductors :-

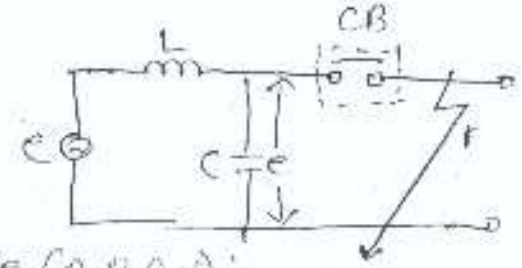
The current carrieng member in a ckt breaker Consist of fixed & moving Contacts and the Conductors Connectin these two the points external to the breaker.

* If the switch gear is of outdoor type this Connection are Connected directly to the overhead line.

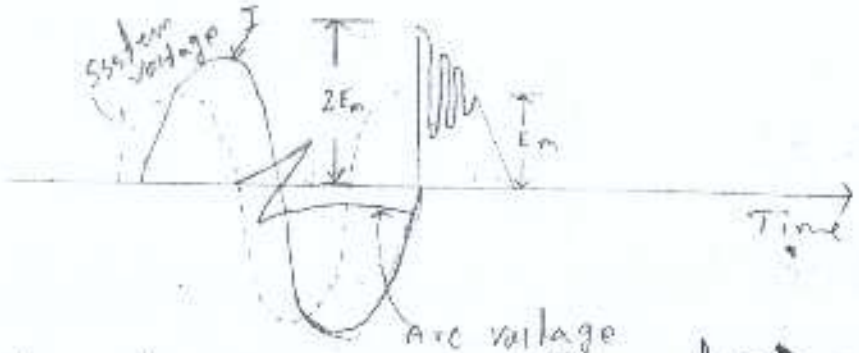
* In Case of Indoor switch gear the incoming Conduct to the ckt breaker are Connected to the bus bar

Problems at CKt Interruption





i) Rate of Rise of restriking voltage (R-R R-V):-



It is the rate of increase of restriking voltage.

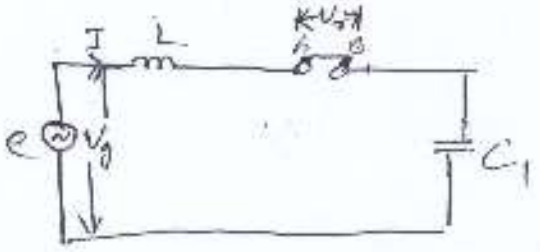
* The unit of RRRV is kV/μsec

ii) Current chopping

* It is the phenomenon of current interruption before the natural current zero is reached

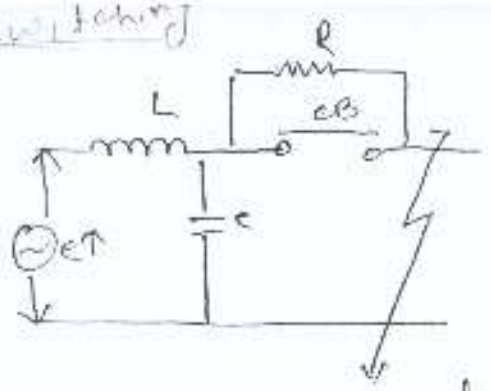
(iii) Capacitive current Breaking

27th feb-17



: Another cause of excessive voltage surges in the ckt breakers is the interruption of capacitive current, *Examples of sub instances are opening of an unloaded long transmission line, disconnecting a capacitive bank used for power factor improvement

Resistance switching



* In a ckt breaker current chopping capacitive current breaking etc. gives rise to ~~surge~~ severe voltage oscillations. These excessive voltage surges during circuit interruption can be prevented by the use of shunt resistance ~~are~~ 'R' connected across the ckt breaker contacts as shown in above equivalent ckt. This is known as resistance switching.

Ckt Breaker Rating :-

(i) Breaking Capacity :-

It is the current (RMS) that a ckt breaker is capable of breaking at a given recovery voltage and under specify conditions.

(ii) Short time rating.

It is the period for which a ckt breaker is able to carry fault current while remaining closed

(iii) Making Capacity :-

* The peak value of current (including dc component) during the first cycle of current wave after the closure of ckt breaker is known as making capacity

28th Feb - 17

Short Q:

a) Define re-striking voltage ?—

Ans: It is the transient voltage appeare across the contact at or near current zero during arcing period

b) Define recovery voltage.

It is the normal frequency (50 H_z) r.m.s voltage that appeare across the contact of the ckt breaker after final arc extinction. It is approximately equal to the system voltage.

c) Define RRRV ?

Ans: It is the rate of increase of restriking voltage.

* The unit of is kv/μsec.

d) Define making capacity of ckt breaker ?

Ans: The peak value of current (including dc component) during the first cycle of current wave after the closing of ckt breaker is called making capacity of ckt breaker.

e) Define current chopping ?

It is the phenomenon of current interruption before the natural current zero, is reached

Long Q:

1. Explain about ABCB with neat sketch ?
2. " " VCB " " "
3. " " OCB " " "
4. " " Sulphur hexafluoride CB with neat sketch

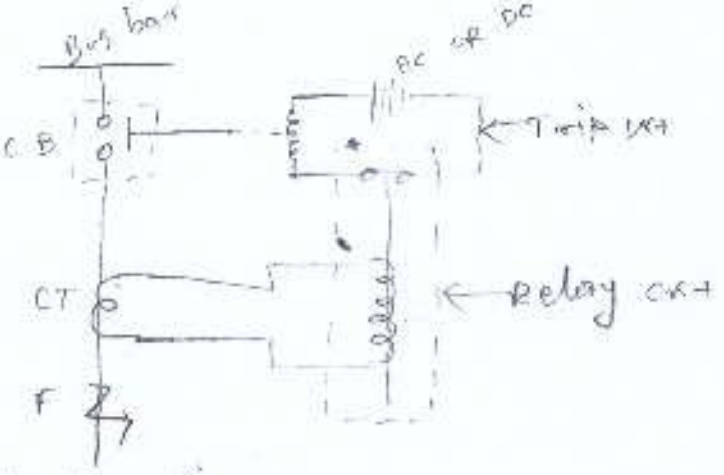
CH-5

Protective Relay

1st Mar 17

Protective Relay :-

Protective relay is a device that detects the fault and initiate the operat^n of the ckt breaker to isolate the diffective system.



Fundamental Requirement of protective Relay

* The following are the main funct^n of the protective relay —

i. Selectivity

The ability of the protective system to select correctly that part of the system in trouble and disconnect the fulty part with out disturbing the rest of the system

ii. Speed

The relay system should disconnect the faulty sect^n as fast as possible

iii Sensitivity

* It is the ability of relay system to operate

low of value of actuating quantity

Reliability

It is the ability of relay system to operate under the predetermined conditions.

v. Simple ctly

The relay system should be simple so that it can be easyly maintain.

vi. Economy

The protective relay system must be in low cost

Basic Relay operat^{n}

* The basic relays are work on the following two main operating principle

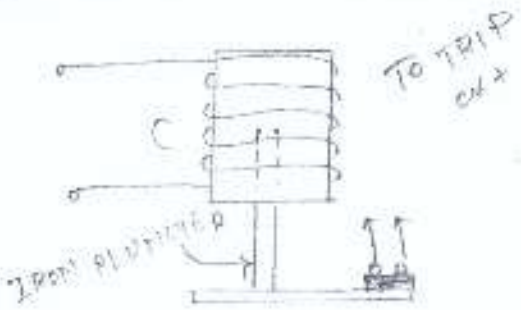
1. Electro magnetic attract^{n} type
2. " " Induct^{n} "

1. Electro magnetic attract^{n} type relays

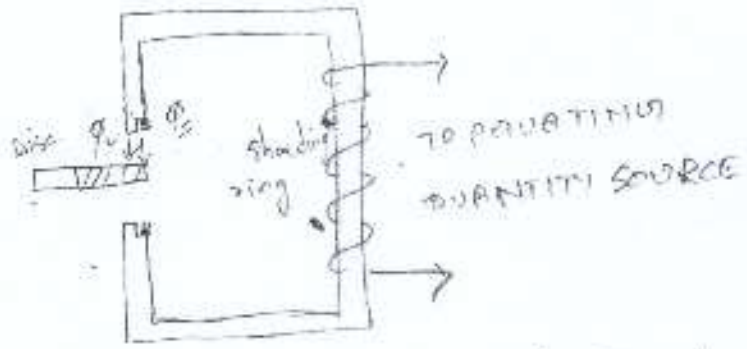
* E.M.A Relays operate on the principle of an armature being attracted to the poles of an electromagnet.
* This relay may be actuated by Ac or Dc quantities

Important types of electromagnetic attract^{n} relays are

a) Attracted armature type
b) Solenoid type relay
c) Balance beam type relay



2. Electromagnetic Induct^{n} relay.



* E.M.I relays operate on the principle of mutual induct
* This relay operate on the Ac quantities.
* An induct^{n} relay can be Consist of a pivoted alumi
disc placed in the magnetic field
* There are three types of structure Commonly used in induct^{n} relay as follows below.

1. shaded pole structure
2. Watt-hour meter structure
3. Induct^{n} cup structure

Importance terms :—

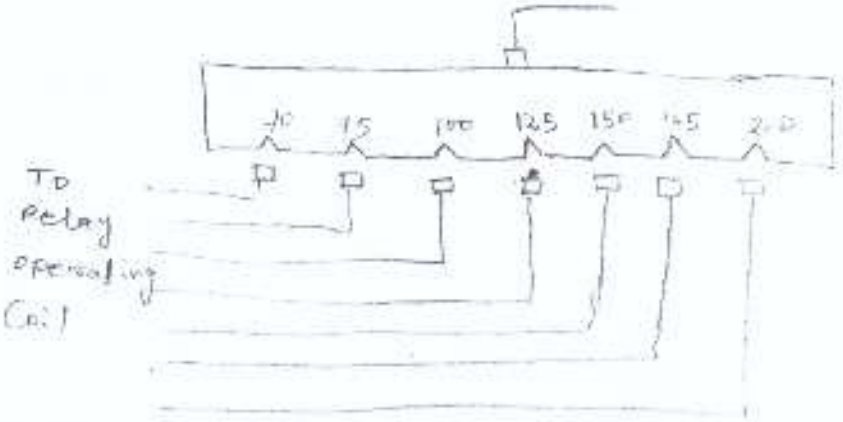
Pick up current

It is the minimum current in the relay coil at whic the relay starts to operate is know as pick up curre

Current setting

2nd mtd - 17

The adjustment of the pickup current to any required value is known as current setting.



Pickup Current = rated secondary current of CT × current setting

Ex- If current setting is = 125% = 1.25, C.T having ratio 400:5

∴ Pickup current = 5 × 1.25 = 6.25 A.

plug setting multiplier (P.S.M)

It is the ratio of fault current in relay coil to the pickup current.

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

$$= \frac{\text{Fault current in relay coil}}{\text{rated secondary current of CT} \times \text{current setting}}.$$

Ex - suppose that a relay is connected to a 400:5 CT & set up 150%, with a primary fault current of 2400 A

find out P.S.M

Sol^n

Pickup current = $5 \times 1.50 = 7.5$ A.

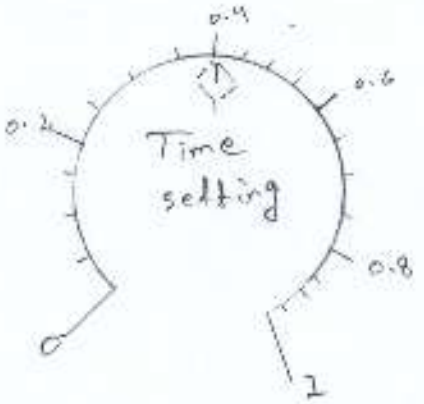
fault current in relay Coil = $2400 \times \frac{5}{400} = 30$ A.

$\therefore$ P.S.M = $\frac{\text{fault current in relay Coil}}{\text{pick up current.}}$

$= \frac{30}{7.5} = 4$ ←

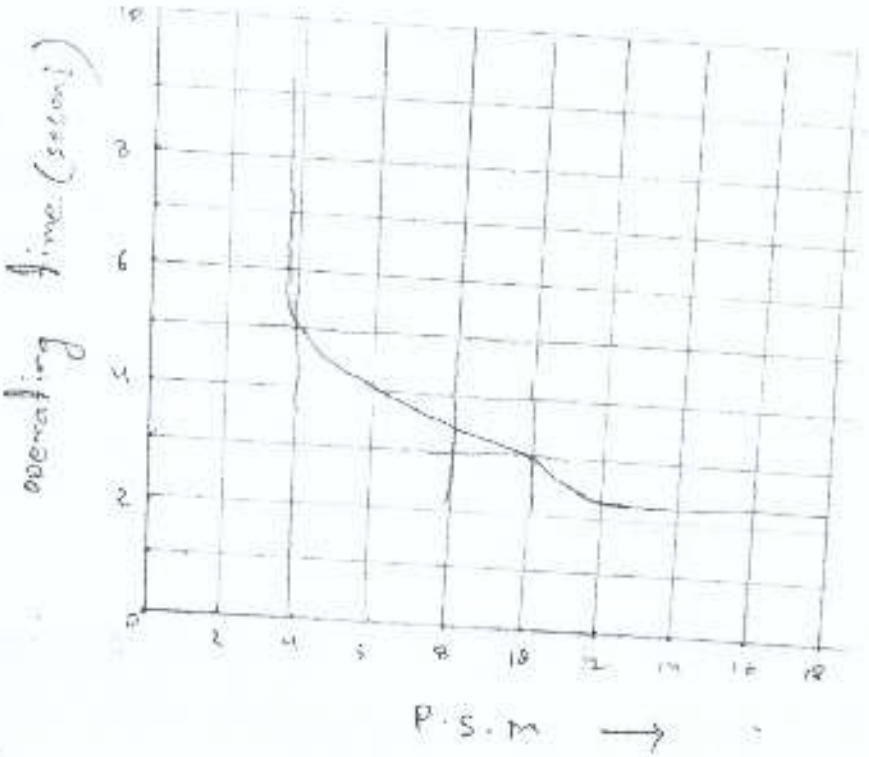
Time setting multiplier.

The adjustment of Control of time operat^n is know as time setting multiplier.



Time/plug setting multiplier (P.S.M) curve

The curve betn time of operat^n and plug setting multiplier of a typical relay is known as time psm curve.



Ex- In an over current relay the time setting is 0.1 and the time obtained from the time/P.S.M curve is 3 second. find the actual relay operating time

Soln

Actual relay operating time = Time setting × Time obtained from the Tim/PS.M curve

$= 0.1 \times 3 = 0.3$ sec

2) Determine the time of operat^n of 5A 3 second over current relay having a current setting of 125% Time setting multiplier of 0.6 Connected to supply ckt through a 400:5 ct when a ckt Carries fault current of 4000 A (time obtained from time/P.S.M curve is 3.5 sec)

Soln Rated secondary current is CT = 5 A.

Current setting $= \frac{125\%}{100} = 1.25$

Pick up current $= 5 \times 1.25 = 6.25$ A.

Fault current in relay coil = $\frac{4000 \times 5}{400}$ = 50 A.

We know,

Actual relay operating time = Time setting × time obtained from the Time / PSM

$\Rightarrow$ Time setting = $\frac{\text{Actual relay operating time}}{\text{Time obtained from the Time / PSM}}$ =

PSM = $\frac{50}{6.25} = 8$

We know from given data that time PSM curve = 3.5

Actual relay operating time = 0.6 × 3.5 = 2.1 Sec Ans

3rd mar 17

Classificatn of Functional Relay

According to the funct of power system relays are following types.

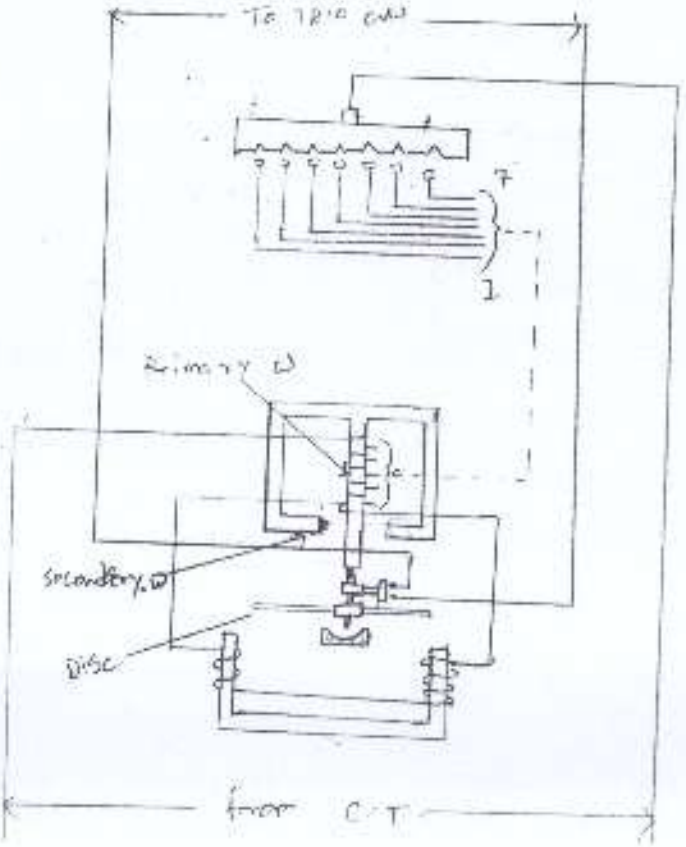
i → Induction type over current relays

ii → " " Reverse Power relays

iii → Distance Relays

iv → Differential Relays

i. Inductn type over Current relays ✓



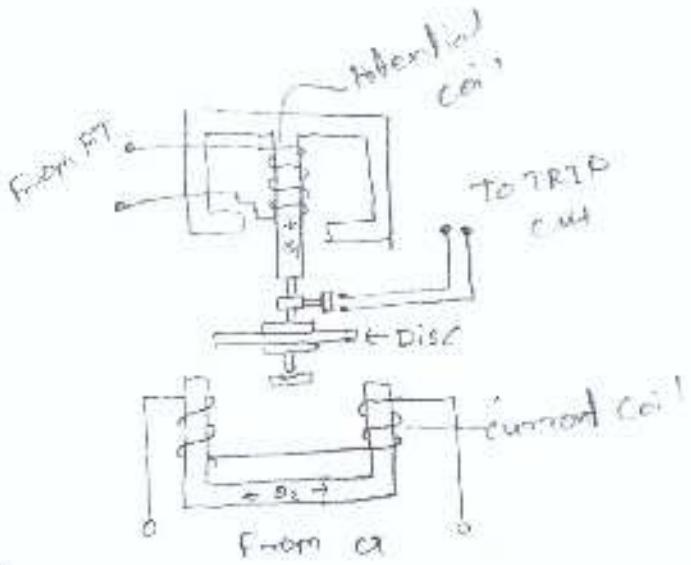
* This relay works under the principle of mutual induction
* The actuating source of fault current
* It has two electro magnet. Called as upper & lower electro magnet
* Secondary winding is connected series with the lower electro magnet winding
* Tapping are provided in the primary winding which are connected to a plug bridge or plug setting & C.T
* Time setting is provided by adjusting the moving contact of disc.
* A metalic or aluminium disc which is free to rotate in between the poles of two electro magnet

Operation :-

Under normal operating conditions, restraining torque is greater than the driving torque produced by the relay coil current.

* Therefore the aluminium disc remains stationary
* when fault occurs the current in the protective ckt exceed the preset value, the driving torque become greater than restraining torque
* Hence the disc rotate and the moving contact reaches the fixed contact.
* After that trip ckt operates the ckt breaker

Induct" type directional power relay

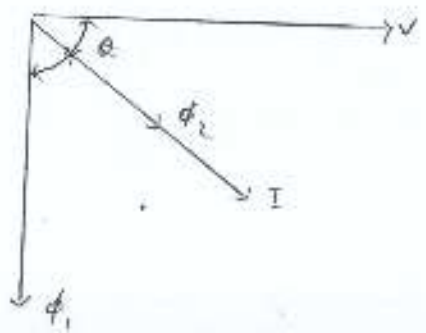


Construct"

It works under the principle of mutual induct?

* It Consist of two electromagnet called as upper & lower electro magnet.
* upper electro magnet winding energised through P.T (Called potential Coil)
* Lower electro magnet energised through a CT (Called current Coil).
* It Consist of a aluminium disc free to rotate in betⁿ two poles of electromagnet.
* The tapping are provided in current Coil 'c, c' which are Connected to plug setting bridge

Operation.



from vector dig. we see that

$T \propto VI \sin(90° - \theta)$

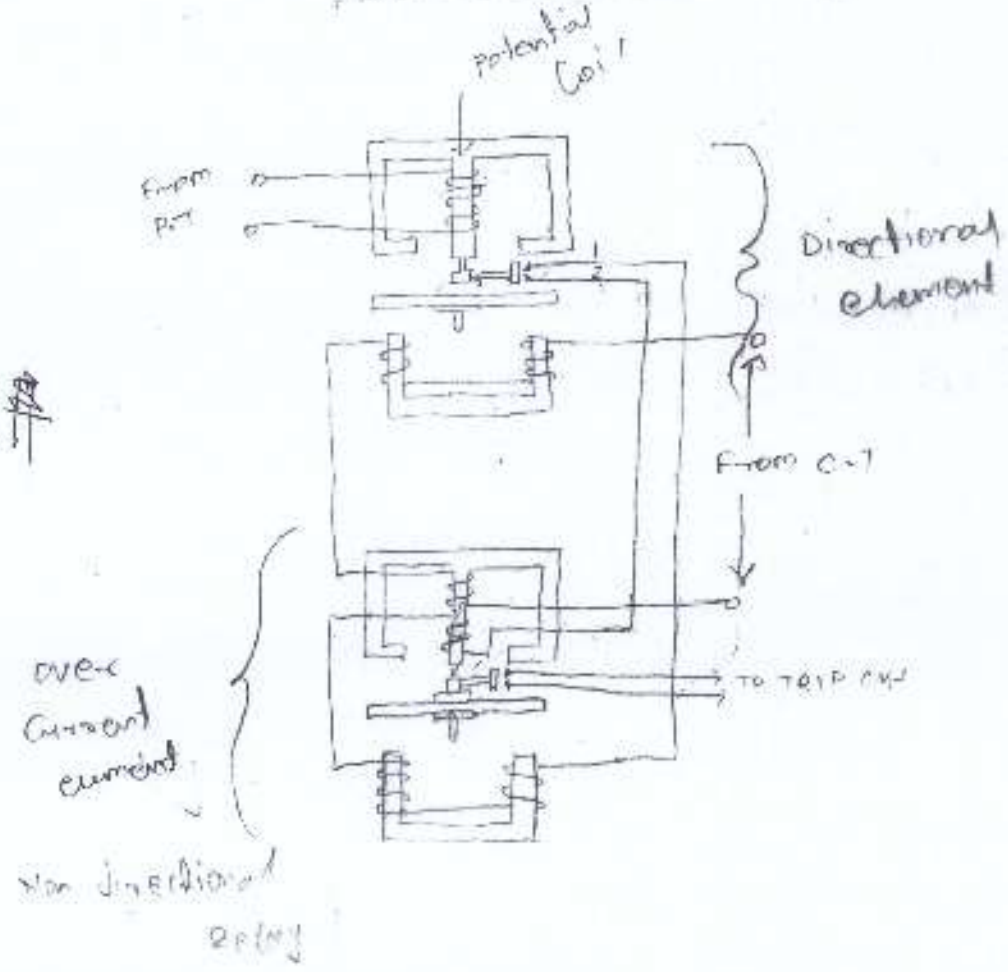
$\propto VI \cos\theta$

$\propto$ power in the ckt

* Under normal Condition the power will flow in the normal direct^n and the aluminium disc remains stationary.
* In abnormal Condit^n the disc rotate and the moving Contact closes the trip ckt.
* This Causes the operat^n of ckt breaker which disConnect the fulty sect^n

7th marc - 17

Induct^n type directional over current relay.



Construction.

9th mar - 17

It consist of two relay elements mounted on a common case that is

i. directional element.

ii. Non directional element.

* The directional element consist of upper & Lower electro magnet & consist of aluminium disc.
* The directional element energised from P.T & C.T.
* non directional element consist of upper magnet (primary winding & secondary winding), lower magnet & an aluminium disc.
* The non directional element energised from C.T and the trip contact of directional element.
* The non directional element aluminium disc trip Contact Connect to trip ckt

Operation

Under normal condition the two alumium disc remain stationary

* when fault occurs the trip contact of directional element closes the ckt of lower magnet's winding of non directional element trip ~~contact~~ the ckt and hence operate the ckt breaker which isolate the faulty section.

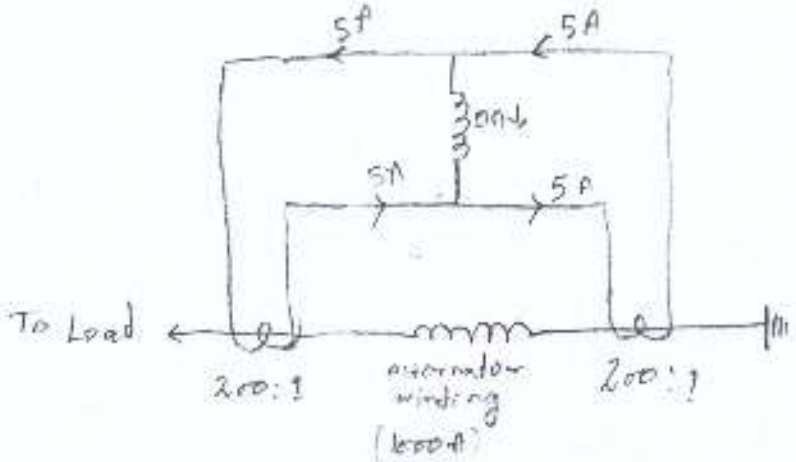
Differential Relays

A differential relay is one that operates when the phase difference of two or more similar electrical quantities exceeds a predetermined value.

There are two fundamental system of differential or balance protection —

i Current balance protection
ii Voltage balance protection.

i. Current balance protection



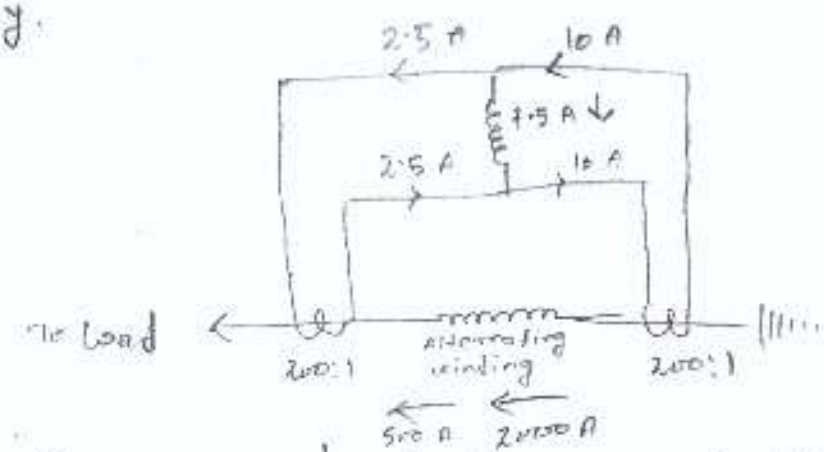
A pair of identical current T/f are fitted on either end of the sectn to be protected.

* The secondary of current T/F's are connected in series is such a way that they carry induced current in the same direction.
* The operating coil of the over current relay is connected across the C.T secondary ckt

operation

Under normal operating conditions suppose alternator winding carrised a normal current of 1000 A. Then the current in the two secondaries are

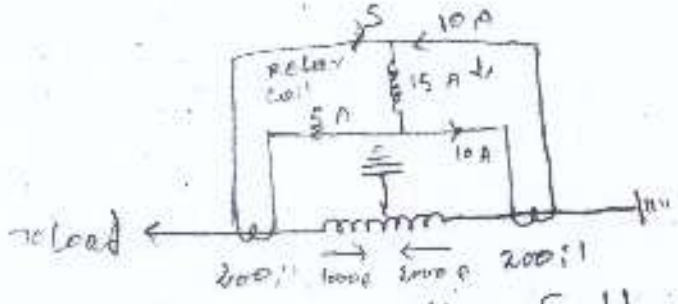
equal. Thes current will circulate bet the two current T/f and no current will flow through the differential relay.



* If a ground fault occurs on the alternator windi Two secondary currents will not be equal and the current flows the operating coil of the relay, Causing the relay to operate.

i— If some current (500 A in this case) flowes out of one side while a larger current (2000 A enters the other sides as shown in above, then the difference of the current T/f secondary current that is

10 − 2·5 = 7·5 A will flow through the relay.

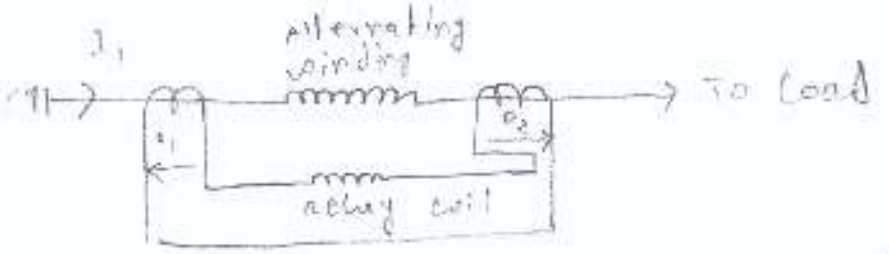


If current flows to the fault from both sides as shown in above dig. The the sum of CT secondary currents i.e - 10+5 = 15 A will flow through the relay

Va

Voltage balance ~~Differential~~ relay.

Voltage balance differential



9th mar 17

* In this scheme protection of two similar current T/F are connected at either end the element to be protected i.e (by an alternating windings) by means of pilot wire.
* The secondaries of current T/F's are connected in series with relay in such a way that under normal condition there an induced emf are in ~~operat~~ opposition

operation

Under healthy conditions equal currents ($I_1 = I_2$) Flow in both primary windings.
* Therefore the ~~rela~~ secondary voltages of two T/F's are balanced against each other and no current will flow through the relay operating coil
* when fault occurs in the protected zone the current in the two primary will differ from ($I \neq I_2$) and their secondary voltage will no longer be in

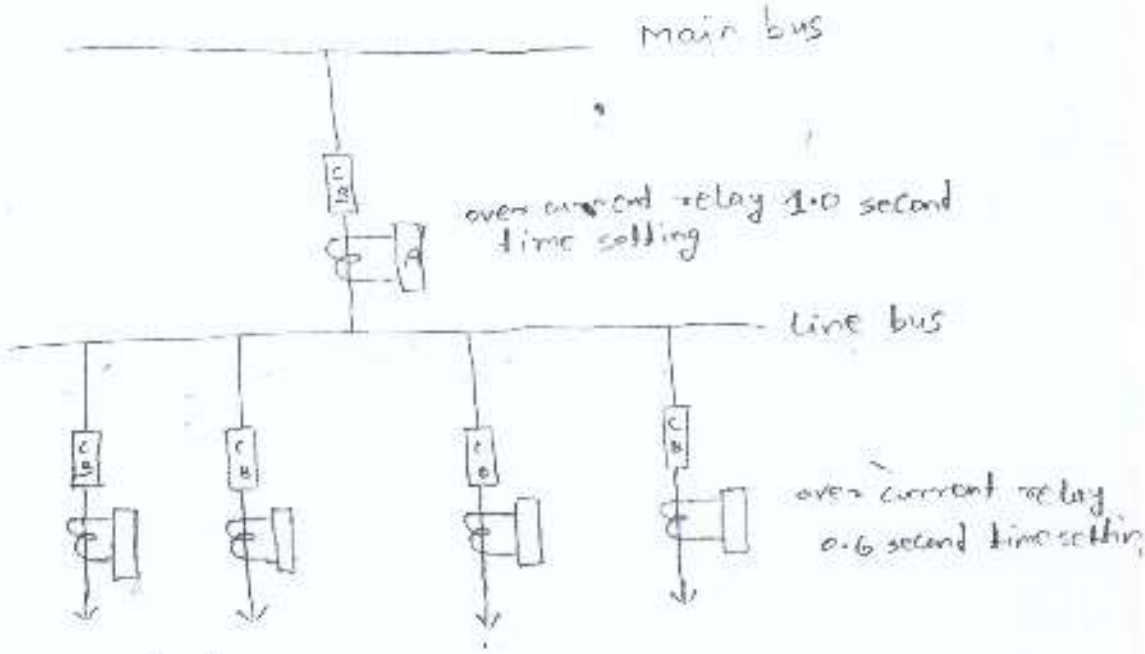
balance

* This voltage difference will cause a to flow through the operating coil of the relay which closes the trip out

Types of protection

Protection schemes are two types:-

* Primary protection
* Back-up protection



Primary protection.

It is the protectⁿ scheme which is design to protect the component part of the power system.

* In above fig. each line hage an over current relay that protect the line.
* If fault occur in any line it will be cleared by it's relay & ckt breaker
* This forms the primary all main protection and serves as the 1st line of diffence

Back-up protection

It is the 2nd line of difference in case of failure of the primary protection

* It is design to operate with sufficient time relay so that primary relaying will be given enough time to funct^n if it is able to.

* In above fig. relay 'A' provide back-up protection for each of the four lines
* If a line fault is not clear, by it's relay and breaker, the relay 'A' on the group breaker will operate after a definite time relay and clear entair group of lines.

Short question

1. Define pick-up current ?

⇒ It is the minimum current in the relay coil at which the relay starts to operate is known as Pick-up current

2. Define current setting ?

⇒ The adjustment of the pick-up current to any required value is known as current setting.

3. Define P.S.M ?

⇒ It is the ratio of fault current in the relay coil to the pickup current.

4. Define time setting multiplier ?

⇒ The adjustment the control of time operat^n in the relay is known as time setting multiplier

5. Define differential relays?

A differential relay is one that operates when the phasor difference of two or more similar electrical quantites exceeds a predetermined value.

Long:

1. Write down the fundamental requirement of Protective relay?
2. Explain about induction type over current nondirectional relay with neat sketch
3. With neat sketch describe about types of protection scheme in a Power system.
4. Explain with neat sketch about the differential relay system
5. Describe about induction type directional over current relay with neat sketch
6. Prot

CH-6 { Protection of Electrical Power equipments and Lines:-

20 marks

10th mar - 17

Protection of alternator:-

There are the some important faults occur on an alternator are follows below:-

i) failure of prime mover
ii) failuere of field
iii) over current
iv) over speed
v) over voltage
vi) unbalanced loading
vii) stator winding faults

i:- failure of primemover

*The failuer of primemover in an alternator is very rair

* The prime mover of an alternator mechanically coupled to the turbine.
* If prime mover failuer occur the m/c can be safely isolated by the control room attendant
* Therefore the automatic & electrical protect" is not required

ii:- failuere of field.

*The chance of field failure of an alternator undoutly very rair
* If field failure occur then the alternator can run for a short period
* This short period allowed control room attendant to disconnect the faulty alternator manually from the system has here

(iii) over current

The ~~over~~ current overcurrent occur of an alternator due to over load ~~of~~ the supply system and partial break down of winding insulation

* for protect^{n} of alternator from over current the m should be designed with high values of internal impedanc and can be disconnect manually. by attendant

(iv) over speed

10th mar - 17

The chief cause of over speed, is the sudden loss of a or the measure part of load on the alternator

* Morden alternator usually provided with mechanica centrifugal devices mounted on their driving shaft to trip the main valve of the primemover when o dangerous over speed occurs

(v) over voltage

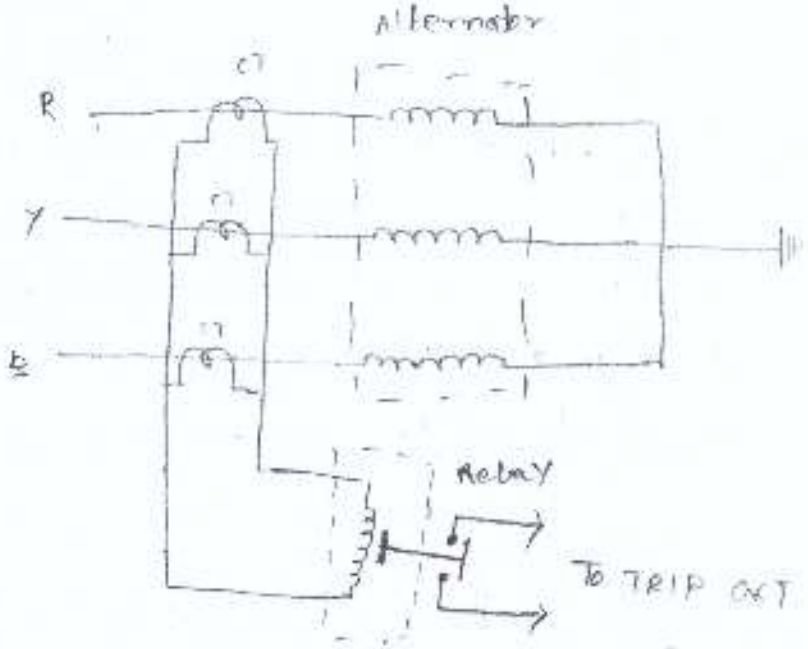
over voltage in an alternator occurs when the speed of the prime mover increases due to sudden loss of the alternator load.

* Controler governors (steam turbine) exercise a continious check on over speed and thus prevent the occurance of overvoltage on generating unit

(vi) un balance loading

Un balance load means that different phase current in the alternator.

* unbalance loading arrises from faults to earth or fault bet^{n} phase on the ckt external to the alternator



The ckt dig above shows the protect^n of alt. against un balance loading.

(viii) stator winding faults.

This faults occurs mainly due to the insulat^n failuer of the stator winging.

* The main types of stator winding faults are

a) Fault's bet^n phase & ground

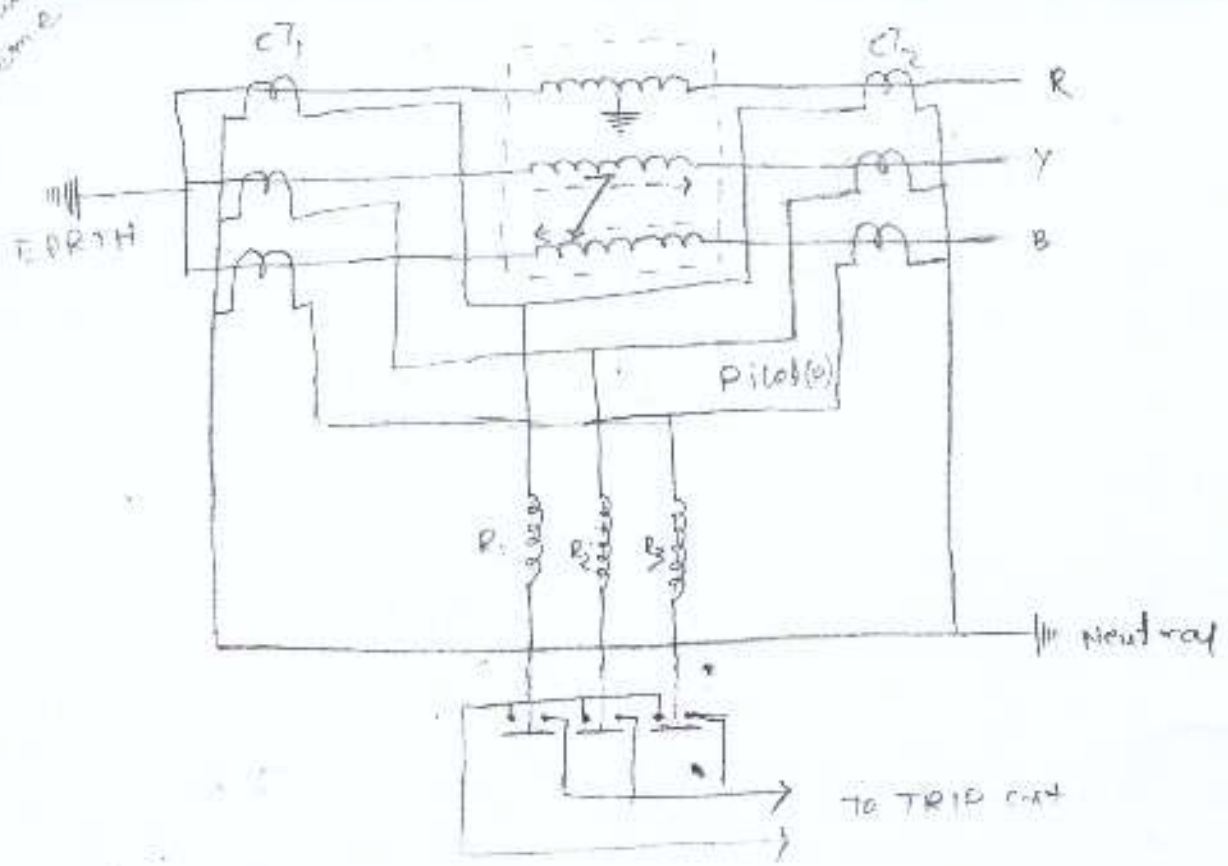
b) " " phases

c) Interteon faults involving terrs of the same phase winding.

* for protect^n of alternator against such above faults differential methad's of protection (also means merz price system) is employed

Differential protect^n of alternators (merzprice circulating current scheme)

Merz Price circulating scheme



Schematic arrangement.

Above fig. shows of schematic arrangement of current differential protection for a 3-ϕ alternate

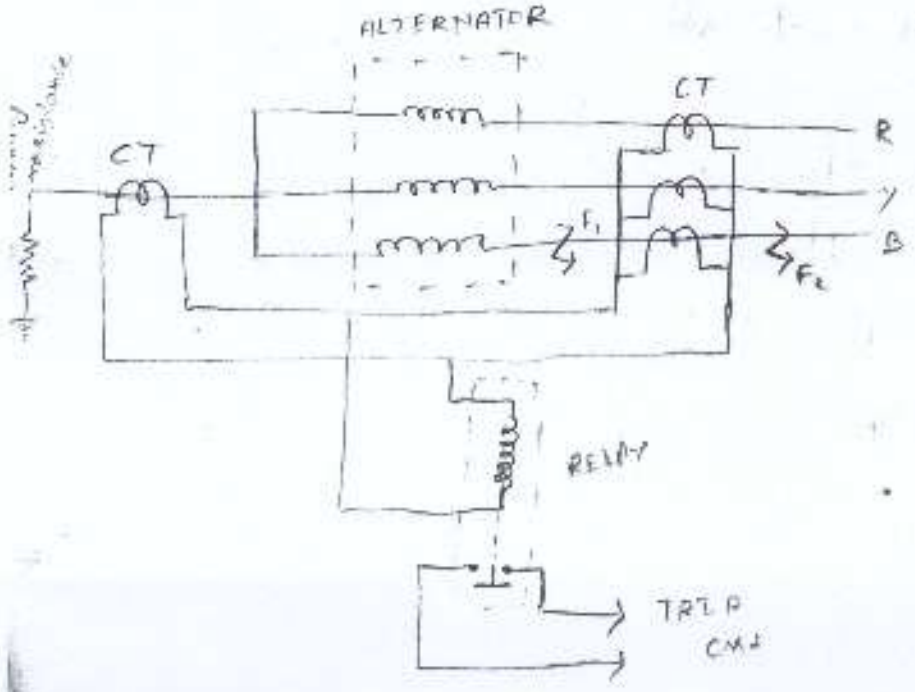
* Identical current T/F pairs CT_1 & CT_2 are placed a eighter side of each phase of the stator winding.
* The secondary of each set of current T/F are connected in Y
* There are two star groups i.e stator winding & CT secondary. Hence there is neutral point
* The terminals of the two star groups being Connected together by means of a 4 core Pilot(9) Cable.

operatn

15th mar-17

Under normal operating Conditn the current at both ends of each winding will be equal hence the current in the secondary of two CT's are Connected in any phase will also be equal. Therefore there is balanced circulating current in the pilot wires and no current close through the operating coils (R_1, R_2 & R_3) of the relays when an earth fault or phase to phase fault occurs this Conditn no longer exists coil's could and the differential current flowing through the relay ckt operate the relay to trip the ckt breaker

Balanced Earth fault Protection.



Schematic Arrangement :-

It consist of 3-line CT, one mounted in each phase.

* An other CT is connected in the star point of the alternator to the earth
* The secondary of three current T/F are connected in parallel with that of a single CT
* A relay is connected across the T/F secondaries

operation

Under normal conditio equal currents flow through the different phase of the alternator and their algebric sum is zero

* Therefore the sum of current flowing in the secondaries is also zero and no current flow thro the operating coil of the relay
* Under this condition the current in the neutral wire is zero and the secondary of the neutral CT supplyes no current to the relay.
* If an earth fault develops at f_2 external to the protected zone the sum of the current at H terminals of the alternator is exactly equal to the current flows through the relay and hence curren flow through the relay & trip the ckt breake

Protection systems for T/F

* The Common T/F's faults are :—

i. open ckt
ii. over heating
iii. winding short ckt
i.e phase to phase fault & interturn fault
earth fault etc,

The principal relay system used for T/F protections are :—

i) Buchholz devices providing protect" against all kinds of incipent faults
i.e slow developing faults such as :—
Isulat" failure of windings, Core heating, fall of oil level due to leaky joint's etc.

ii) Earth fault relays providing protect" against earth fault only

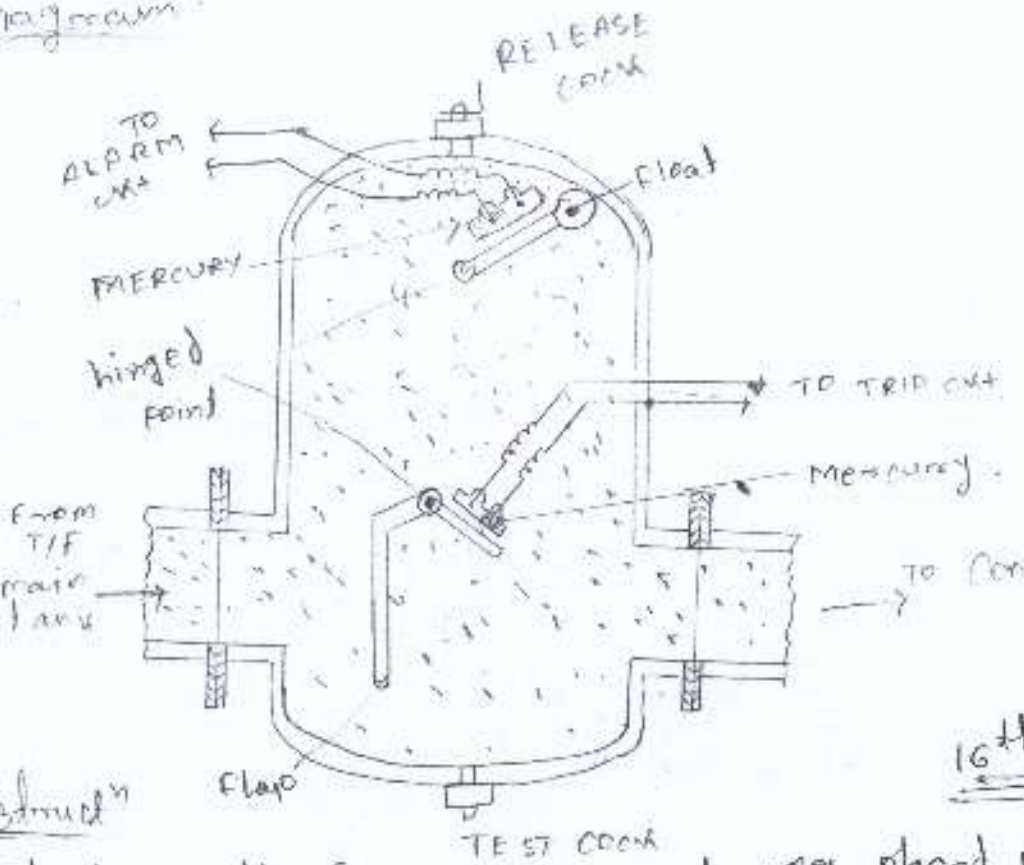
iii) over current relay's providing protect" mainly against phase to phase faults overloading

iv) Differential system (circulating current system) Providing protection against phase faults and earth faults

Buchholz Relay :-

It is a gas actuated relay, installed in oil immersed T/F's for protectn against all kinds of fau

Diagram :-



16th MAY 17

Constructn

* It takes the form of a domed vessel placed in the connecting pipe betn the main tank and Conservator.
* The device has 2 elements ie upper element & lower elem
* The upper element consist of a mercury type switch attach to a float
* The lower element consist a mercury switch mounted on a hinged pipe arm located in the direct path of the flow of oil from the T/F to the Conservator.
* The upper element closes an alarm ckt during incipent fault (slow developing fault)
* The lower element arrange to trip the ckt breaker in case of severe internal fault

Operation

The operat^{n} of Buchholz relay is as follows below

i) In case of incipent fault with in the T/F, the heat due to fault causes the decomposition of some T/F oil in the maintain. The product's of decomposit^{n} contain more than 70% of hydrogen gas. The hydrogen gas being light trajes to go in to the conservator. At that moment the gas get's deposited in the upper part of relay chamber. when a high amount of gas ~~get's deposited in the upper part of relay chamber. when a~~ get's accumulated it ~~exhs.~~ exerst sufficient pressure on the float to cause it, to tilt and close the Contact of mercury switch attach to it. This Complet the alarm ckt to sound or alarm.

ii) If a serious fault occurs in the T/F, and enormous amount of gas is generated in the main tank. The oil in the main tank rushes towards the Conservator through Buchholz relay and in doing so tilts the ~~the~~ flap to close the Contact of mercury switch. It complet the trip ckt to open the ckt breaker.

Protection of Busbars

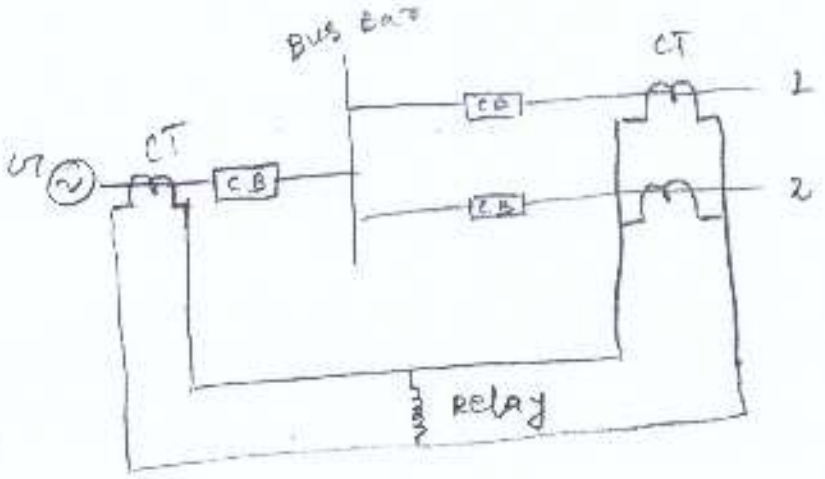
Bus bar in the generating stat^n & sub stat^n form important link bet^n the incoming & out going ckt

The two most commonly used schemes for bus bar protection are

i → Differential protection
ii → Fault bus protection

i- Differential protection

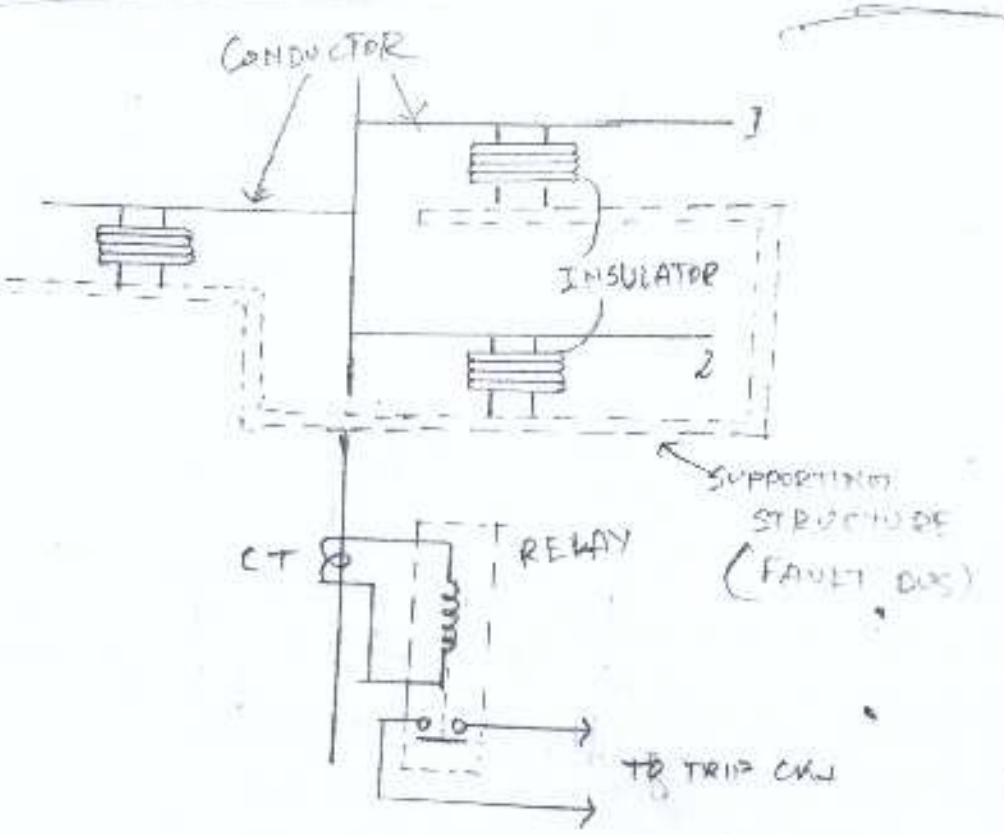
The basic method for bus bar protection is the differential scheme in which the currents entering and living the bus are totalized



During normal load condit^n the sum of these is equal to zero

* when a fault occurs the fault current upsets the balance and produces a differential current to operate the relay

Fault bus protection



Schematic arrangement

The metal supporting structure or fault bus is earthed through a CT

* A relay is connected across the secondary of the CT

operation:

Under normal operating condition there is no current flow from fault bus to ground and the relay remains in operating.

* The fault involving a ~~conductor~~ connection betⁿ a conductor and earth supporting structure will result in current flow to ground through

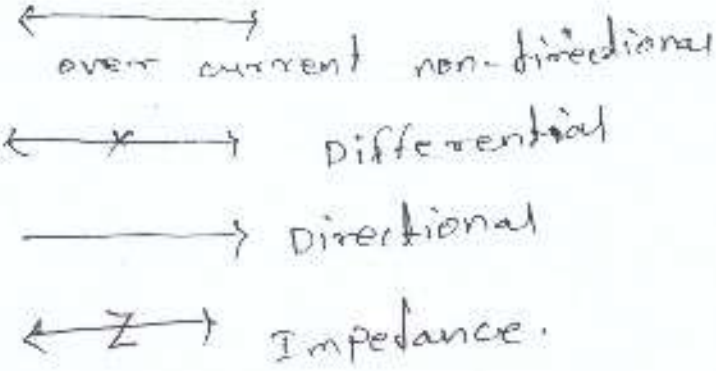
the fault bus causing the relay to operate.

* The operation of relay will trip all breakers connected equipment to the bus

Protection of Transmission lines

The common methods of line protection are

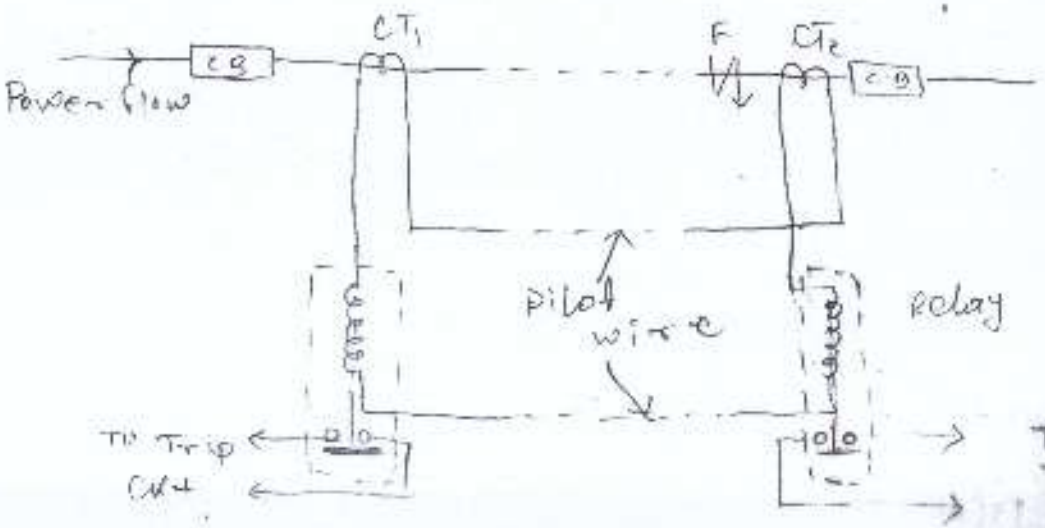
i) time graded over current protection
ii) Differential protection
iii) Distance protection



17th marx 17

Above symbol indicating the various types of relays

Differential pilot wire protection (Merlz-Pri Voltage balance system)



Schematic Arrangement

Above dig. shows the single line dig. of Merz Price voltage balance system for the protection of a 3-φ line.

* Indentical CT's are placed in each phase at both end's of the line
* The pair of CT's in each line is Connected in series with a relay

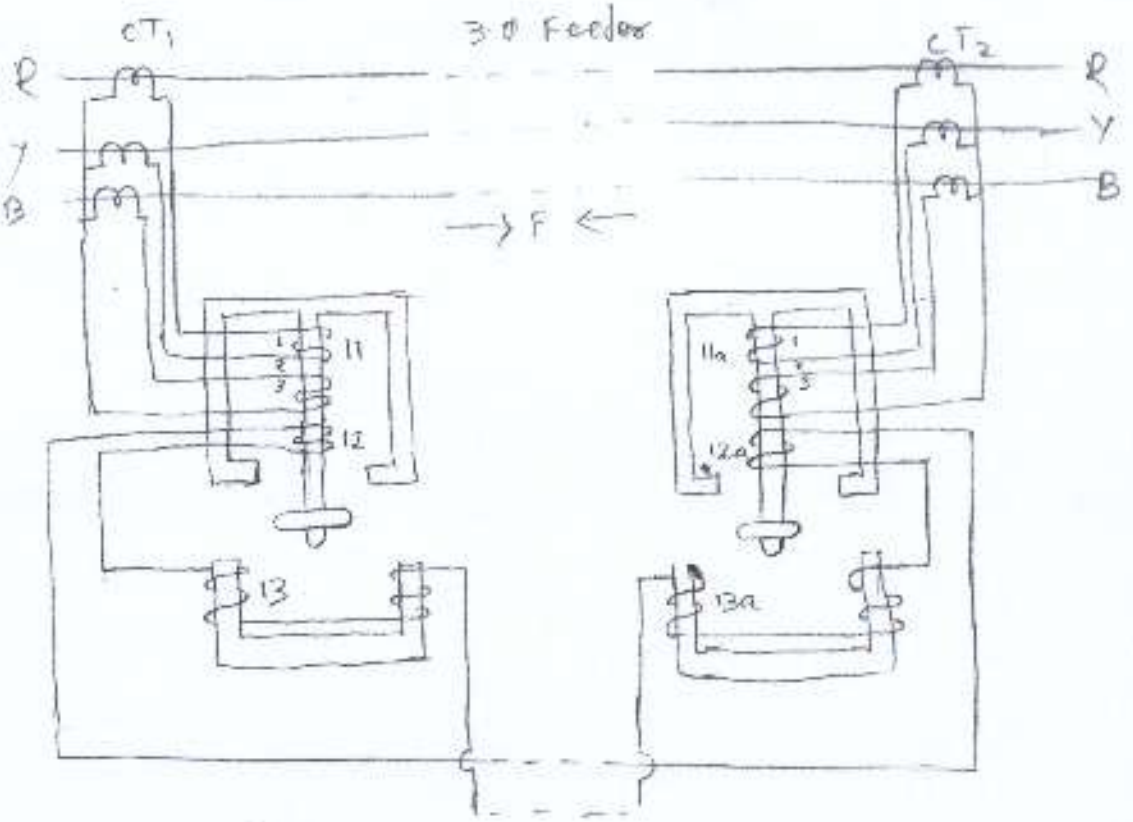
Operation:-

Under normal operating Condition current entering the line at one end is equal to that living it at the other end.

* There fore equal and opposit voltages are induced in the secondaries of the CT's at the two end's of the line.
* The result is that ~~no~~ No current flows through the relays
* Suppose a fault occurs at point 'F' on the line this will cause a grater current to flow though CT_1 then ~~the~~ through CT_2
* Finally above secondary voltage become unequal and circulating current flows through the pilot wires & relays
* The CB at both end's of be line will

trip out and [illegible] tuning line will be isolated

Explain protect" of feeder by over current & Earth fault relay



Schematic Arrangement :-

* The relays used in the scheme are essentially over current induction type relay
* Each relay has two electromagnetic elements
* The upper element carries a winding (11 or 11a) which is energised as a summation CT from the secondaries of the line CT's connected in the phases on the line to be protected.
* The upper element also carries a secondary winding (12 or 12a) which is connected in series with the operating winding with the operating

winding (13 or 13a) on the lower magnet.
* The secondary winding (12 or 12a) & operating winding (13 or 13a) are connected in series

Operation

when the feeder is sound, the current at it's two end's are equal so that secondary current on the both sides of CTs are equal.
* finally the currents flowing ~~and~~ in the relay primary winding (11 & 11a) will be equal and they induce equal voltages in the secondary windings (12 & 12a).
* Since these windings are connected in opposit^{n} no current flows in them or in the operating windings (13 & 13a)
* when fault occurs on the protected line, unequal current will be flow as a result the torque will be developed to rotate the disc
* Hence the CB should open the faulty sect^{n}.

27th may 17

UNIT-4 | Protect^{n} against overvoltages & lightning |

Voltage Surge:- 21-3-17

A sudden rise in voltage for a short durat^{n} on the power system is known as a voltage surge or traigent voltage.

Causes of over voltage:-

The Causes of over voltage of an power system devided in to two types i.e

1:- Internal Causes
   (i) Switching surges
   (ii) Insulat^{n} faillure
   (iii) Arcing ground
2:- External Causes
   i.e lightning

Internal Causes of over voltages:-

(i) Switching surges

The over voltage provided on the power system due to switching are known as switching surge

(ii) Insulat^{n} failluers:-

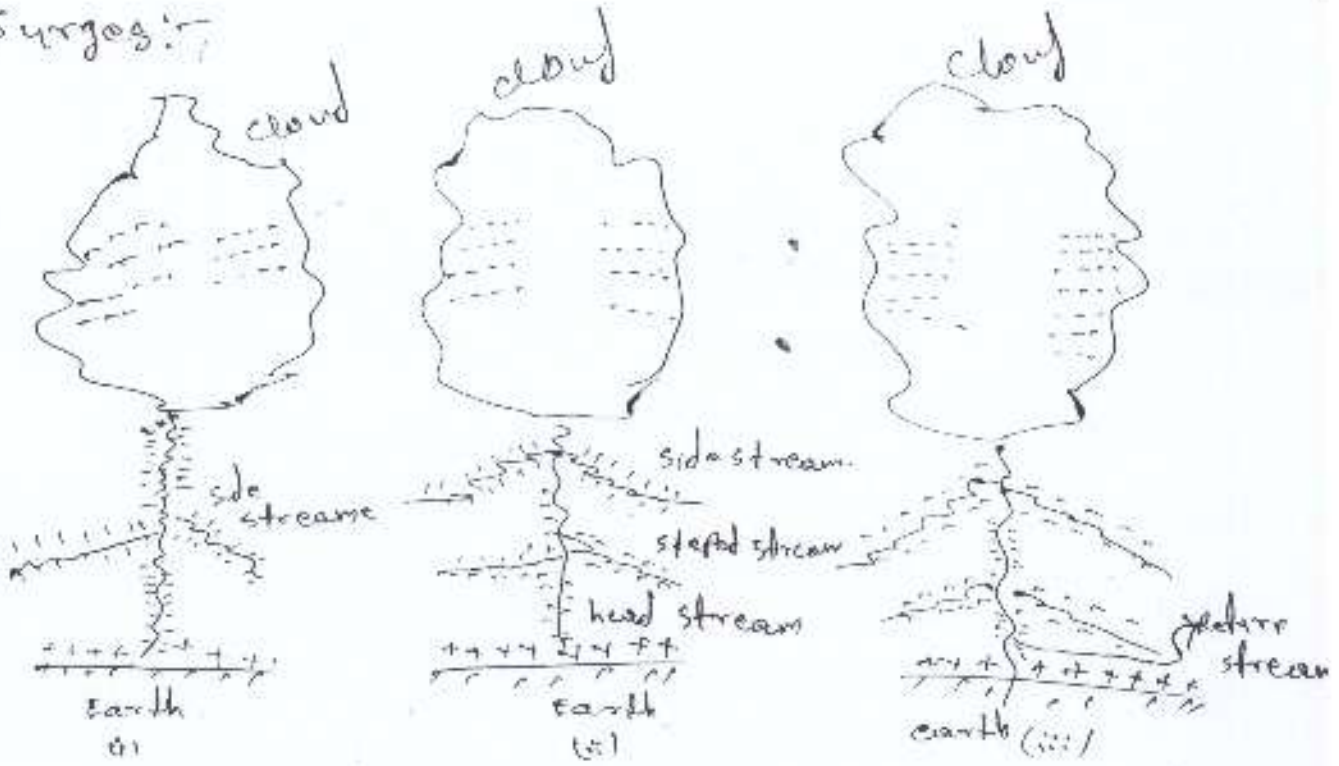
The over voltage produced on the power system due to insulat^{n} faillure bet^{n} Light & earth

* The earth fault acting ground.
* The phenomenon of arcing taking place in Line to ground fault of a 3-ϕ system with consiquent product^{n} of traingent is known as arcing ground

External Causes of over Voltage:

(Lightning) - when charge discharge bet" clouds & Earth

⇒ An electric discharge bet" cloud & earth, ~~bet~~ ~~cloud~~ or bet" the cloud charge centers of the same cloud is known as Clearing. mechanisms of lightning surges:



* In atmosphere the drops of water accumulate to f forms cloud's
* cloud main causes eighter a +ve or -ve, depending open the charge of the drops of water they Contain
* when charge cloud passes the over the earth it induces equal and opposite charge on the earth bel it.
* As soon as the air near the cloud breaches down the streamer called leader streamer or pilot streamer starts form the ground two wards the earth as shown in above fig.

* At that moment the return or leader streamer polarite with each other which is opposite in nature.

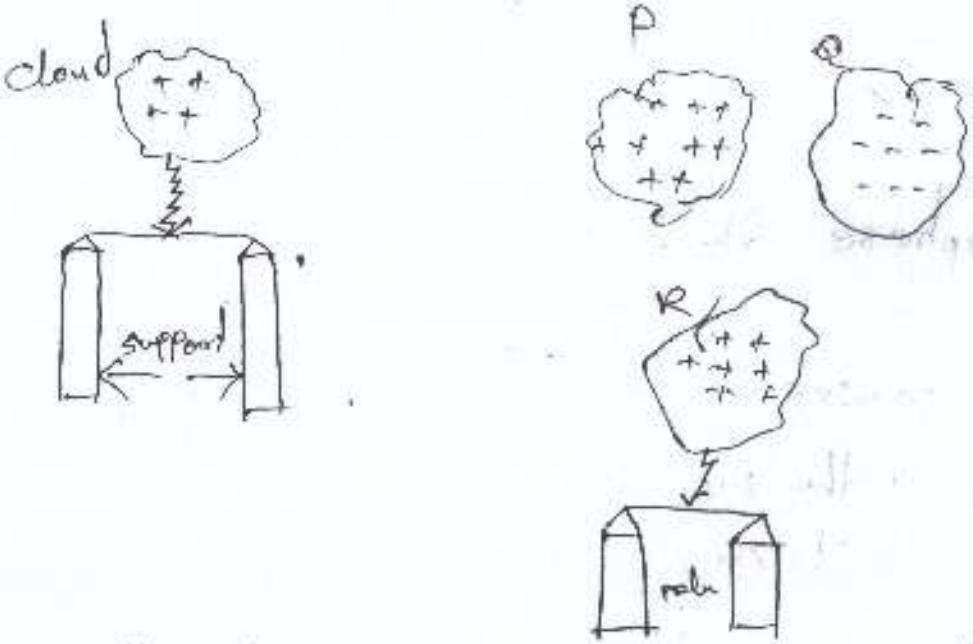
* This phenomenon cause a sudden spark which is called lightning.

Types of lightning stroke:-

There are two main way to which a lightning may strike the power system (i.e. over head lines; substation's, towers etc.) namely.

(i) Direct stroke
(ii) indirect stroke.

Direct stroke :-



* In direct stroke the lightning discharge (i.e current path) is directly form the cloud to the subject equipment i.e an overhead line.

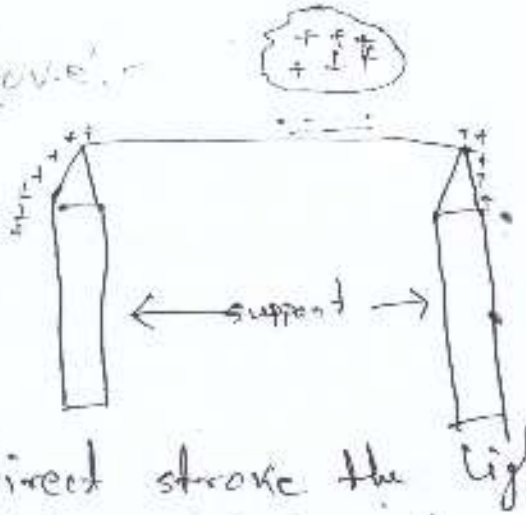
* Direct strokes are two types i.e stroke 'A'.

& Stroke 'B' which are shown in ab. fig.

* Direct stroke is very rair stroke 'A' will always occurs an tuo object's and hence the protect^{n} cant provided agnaist it.

* stroke 'B' compelly ignors the height of the objec and can even strike the ground and hence protec against stroke B can't be provided

Indirect stroke:-



* In the indirect stroke the lightning discharge (i.e current path) is not directly form the cloud to th subject equipment.

* The indirect stroke as shown in above fig.

* The majority of the surges in a transmission line are caused by indirect lightning stroke which moves as traveling waves in the power line.

Harmful effect of lightning:-

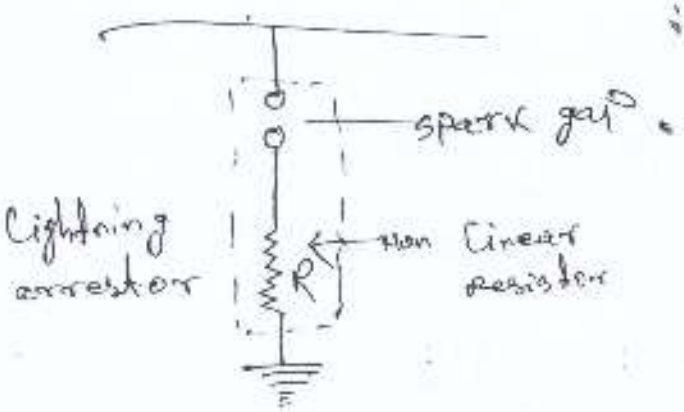
* clears the insulator in poles
* Damage the winding of the T/F and generator
* The insulat^{n} ~~perpet~~ properties of oil dicuses in the power equipment resulting in the product^{n} of earth

* The product of arc will setup very distributing disturbing distribution oscillation on the power line.

Lightning Arrester :-

* A lightning arrester or surge diverter is a protective device which conduct the high voltage source on the power system to the ground.

Cut fig.

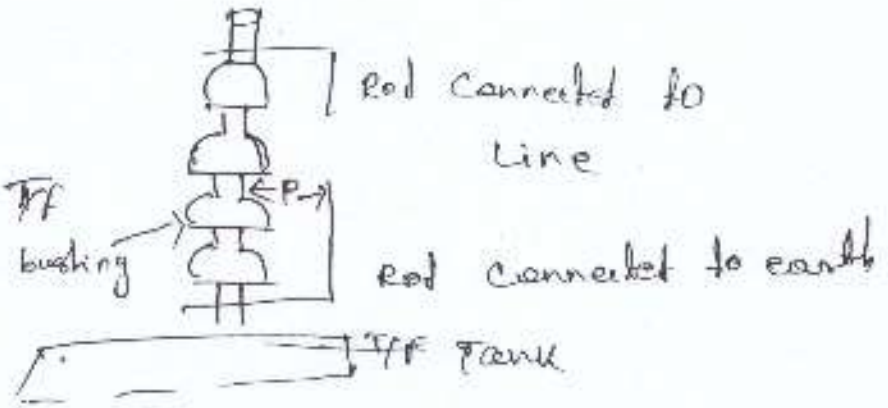


* Above fig. shows the basic form of a surge diverter
* It consist of spark gap in series with a non linear resistor.
* one end of the diverter is connected to the terminal of the equipment to be protected and the other end is effectively grounded
* the length of the gap is so set that normal line voltage is not enough to cause an earth gap. across the gap but a dangerously high voltage will breakdown the air insulation and form an arc

operation

* under normal condition the lightning arrestor is off the line & dark it conducts no current. to earth or gap is non-conducting.
* on the occurance of over voltage the air insulat" across the gap breaks down and is arc is formed providing the low resistance path for the surge to the ground.
* In this way the excessive charge on the line due to the surge is ~~harmlessly~~ conducted through the arrested to the ground instade of being send back over the line.

Rod gap arrestor



* It Consist of two 1.5 cm rod's which are bent right angle with a gap in bet" 'z'
* one rod of lightning arrestor is connected to the line & another rod connected to the earth.
* the distance bet" gap & insulator gap & insulat" (i.e distance (p)) at rod less than one third of the gap length.

operation

Under normal operating Condition the gap remain,

* The occurance of the high voltage surge on the line to the surge is born loss the conductor to earth.