Unit: 1

General Concept of Protection System.

* Switchgear:

Switchgear is the combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment.

One of the basic functions of switchgear is protection, which is interruption of short-circuit and overload fault currents while maintaining service to unaffected circuits. Switchgear also provide isolation of circuits from power supplies. Switchgear is also used to enhance system reliability.

1.1 Nominal ratings & abnormal conditions of electrical equipment.

The term rating of electrical equipment stands for rated capacity, installed capacity or nameplate capacity of electrical equipment/plant, and is the capacity of equipment intended ~~for~~ for maximum continuous rating (MCR) for full-load output. This is maximum capacity specified for operation of equipment for continuous output/load. Thus it is the rating which considered for input (V, I, f etc) as well as output from the equipment & for continuous operation.

Machines if operated beyond and below the Nominal ratings will have shortened life due to unintended excess load for more than normal time. Thus output extraction from equipment differing from Nominal rating operation is abnormal conditions of/for electrical equipment.

Unit-1

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Abnormal Conditions of Electrical Equipments

Equipments Connected to electric power System gets affected during following two Conditions:

i) Short-circuit faults.

ii) Open-circuit faults.

S-C's harmful effects

O-C's "

* Causes of Short Circuit.

Causes of short circuit faults are as follows:

i) Internal effects:

Internal effects are caused by breakdown of equipment or transmission lines, from deterioration of insulation in a generator, transformer etc. Such problems may be due to ageing of insulation, inadequate design or improper installation.

ii) External effects

External effects causing short-ckt include insulation failure due to lighting surges, overloading of equipment causing excessive heating, mechanical damage by public etc.

* Requirements of Good protective Scheme:

Characteristics

Need of: P.S.Prot

(i) Reliability:

The system should be highly reliable i.e. Should be idle for periods extending into years and required to operate with fast response as intended the first time.

(ii) Selectivity:

The System should be able to detect and isolate any fault element or Section of the system leaving the healthy phase in operation.

(iii) Sensitivity:

The system should be highly sensitive to abnormal Conditions due to fault. It should be highly Sensitive for operation even in boarderline situation when the operation was planned.

(iv) Discriminating Capability:

-> The protective scheme should be able to discriminate abnormalities due to faults or short circuits and that due to abnormal but harmless Conditions such as Switching transients or Sudden changes in loads.

-> The System should not respond these switching transients which are normal in large integrated power networks.

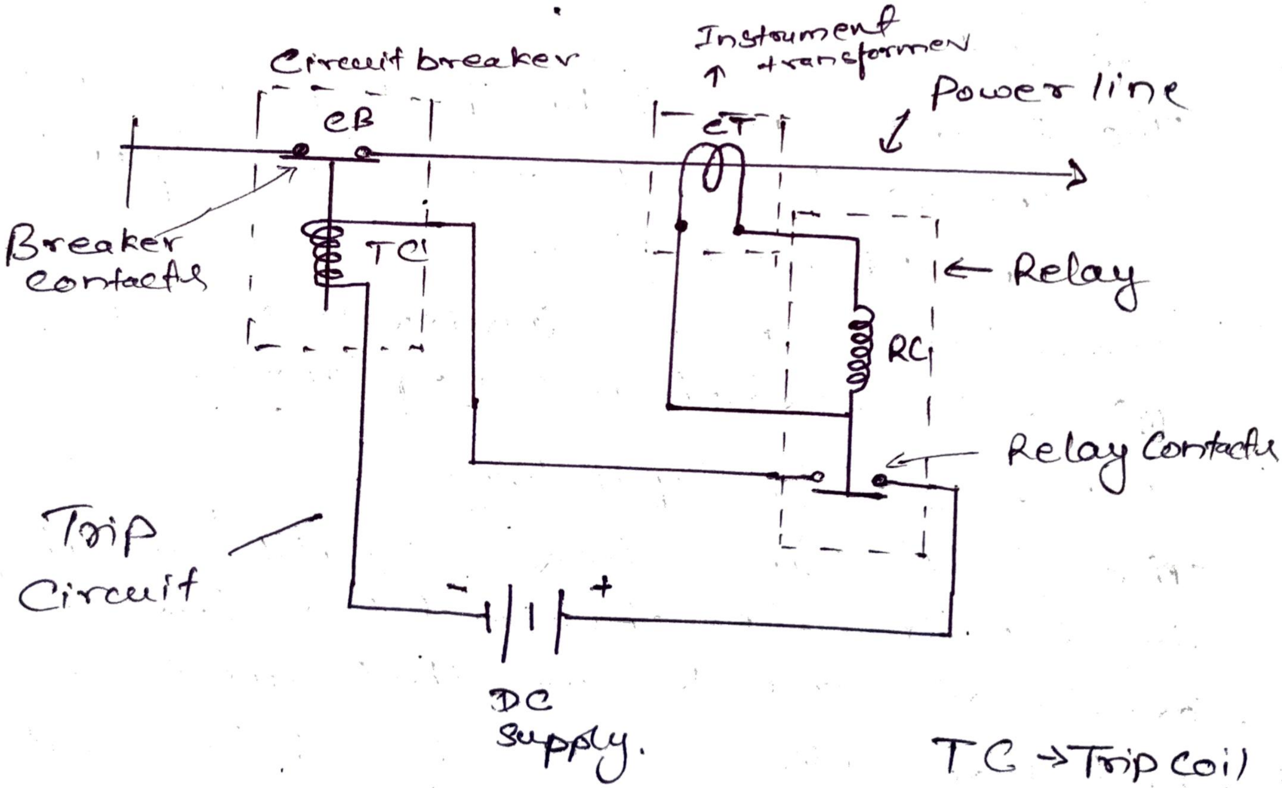
(v) Speed:

The system should be able to open the faulty section as quick as possible which prevents damages of the equipments.

* Basic Components of a protective Scheme:

The basic components of any power system protection scheme are:

(i) Instrument transformer (ii) Relays (iii) Circuit breakers and (iv) Fuses.



TC → Trip coil

RC → Relay coil

fig: Schematic diagram of Protective Scheme

Cond...

Figure shows a typical arrangement of a protective scheme where a power line feeder is protected with the help of protective devices consisting of instrument transformer (CT), relay and circuit breaker.

Signals proportional to power system variables i.e. current or voltage magnitude is obtained through instrument transformers. The output of instrument transformer (CT) at the fault condition will be sufficient to operate the relay contacts, thereby energising the trip coil of the circuit breaker, which then opens the power line.

The power supply to energize the trip coil of the circuit breaker is provided by a seperate source usually dc from storage batteries.

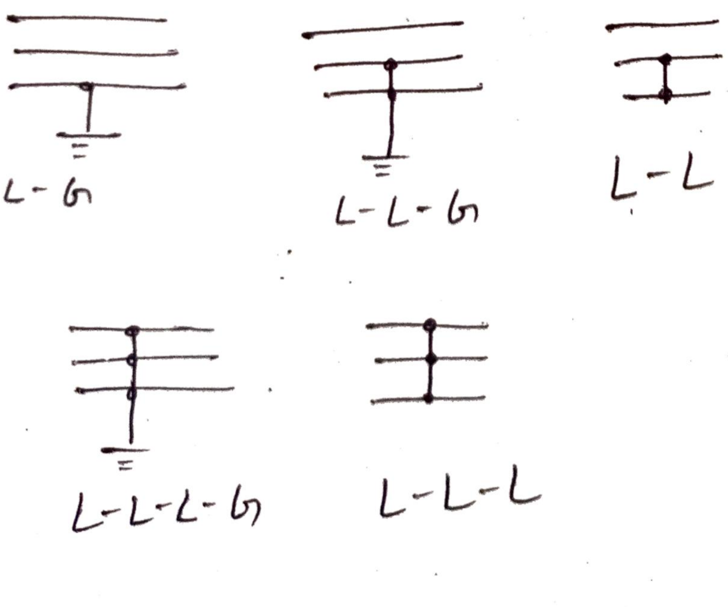
Short Circuit faults

* Short - Circuit fault:

The most common and dangerous faults that occur in a power system is short - circuit fault or shunt fault. They occur as a result of breakdowns in the insulation of current carrying phase conductors relative to earth or in the insulation between phases, In 3 - ϕ ac power circuit the short - circuit fault can be classified as

Unsymmetrical
(i) Single Line to ground (L-G) fault
(ii) Phase to phase (L-L) fault
(iii) two phases to ground (L-L-G) fault

Symmetrical fault
(iv) All three phases to ground (L-L-L-G) fault
(v) All 3-phases short circuited fault.



1.1 NEED FOR A POWER SYSTEM CONTROL AND PROTECTION

Extensive use of energy in the form of electrical in all the areas of energy use has led to the tremendous growth of electrical energy generation and distribution system. The system has become extremely large by virtually any measure: capital invested, physical size, amount of energy delivered and so on. As the system becomes large so also the conditions of faults and abnormalities increased and grow complicat[ed] and therefore the system has to incorporate a good control and protecti[on] scheme to sustain the safety, reliability and availability of the syste[m].

The causes of faults in the system can be many. They include lightnin[g], severe wind and storms, trees falling across lines, vehicles colliding with towers or poles, insulations breakdowns, and so on. And the fault[s] in the system out of these causes can damage and disrupt it severely in the following ways :

(a) The electrical faults typically allow abnormally large current to flow in the system resulting in overheating of the system components.

(b) The fault is usually a short-circuit (grounded) and exists as electric arc. The extremely high temperature in an arc will vaporize any substance causing equipment destruction and fire.

(c) Faults can lower or raise system voltages outside of their acceptable ranges.

(d) Faults can cause the three phase system to become unbalanced causing three-phase equipment to operate improperly.

(e) Faults block the flow of power to the load.

(f) Faults can cause the system to become unstable and finally br[illegible] completely.

Thus to prevent the damages and disruptions due to faults and to en[illegible] a healthy, reliable and safe system, a power system has to incorpor[illegible] a control and protection scheme.

1.2 REQUIREMENTS OF A GOOD PROTECTIVE SCHEME

An efficient protective scheme should have the following characteri[illegible]

(a) Reliability :- The system should be highly reliable. The si[illegible] may be that the protection system may have to be idle for per[illegible] extending into years and then be required to operate with fa[illegible] response as intended for the first time over the years. The[illegible] for failure to operate properly may run into heavy damages o[illegible] equipment and cost of life.

(b) Selectivity :- The system should be able to detect and isola[illegible] only faulty element or section of the system leaving the heal[illegible] sections in operation. It should be able to keep as much of [illegible] system interconnected as possible avoiding unnecessary operat[illegible] of protective devices.

1.4 DEFINITIONS AND TERMINOLOGY

Switchgear :- Any device or combination of devices capable of mak and breaking a circuit is called a switchgear. Circuit breakers, isolators, oil switches, switchfuse units, contactors etc. are al different forms of switchgears.

Circuit Breaker :- A circuit breaker is a switching device capabl making and breaking a circuit under all conditions including when system is faulted and the currents in the circuit are at their hig values.

Fuse :- A fuse is a protective device used for protecting a circu against damage from an exceeding current due to fault or overloadi The circuit is interrupted by fusing or melting.

Isolator :- It is a manual device for breaking and making a circu at no load condition. However, it should be able to carry fault cu for short time (2-3 secs) during which the fault shall be cleared b other interrupting device (fuse or breaker) elsewhere in the system.

Contactor :- A contactor is an automatic switching device which op under the action of an electromagnet for repeatedly breaking and mak of an electric circuit.

Protective Relay :- A relay is an electrical device designed to per switching action to energize the trip coil of a circuit breaker or t operate an alarm signal in the event of abnormal conditions or fault in the system.

Instrument Transformers :- These are the transformers of special design used for the purpose of processing the signals for the relay to operate in the event of abnormal conditions or faults in the system.

Trip Coil :- Trip coil of a circuit breaker operates the release mechanism of the breaker and opens it after energizing through the supply obtained via relay contacts and the d.c. source (Refer Fig.1.1).

Trip Circuit :- The circuit which supplies current (usually d.c. from battery source) to energize the trip coil of the breaker through relay contacts is called the trip circuit (Refer Fig.1.1).

Relay Contacts :- Relays may have one or more contacts which are closed or opened during the switching actions in the event of fault or abnormal operating conditions of the system. The supply to the trip coil of the breaker is obtained through these contacts. They may be normally open (NO) or normally close (NC) type (Refer Fig.1.1).

Opening Time :- This term is usually used in case of circuit breaker and is the time interval lapsed from the energization of the trip coil to the instant of contact separation of the breaker. It is also called the pre-arcing time of the breaker.

Arcing Time :- The time interval from contact separation of the breaker to the extinction of the arc is called the Arcing Time.

Total Break Time :- The sum of the opening or pre-arcing time and arcing time is called the Total Break Time of the breaker.

Energizing Quantity :- The electrical quantity, i.e. current or voltage, either alone or in combination with other electrical quantities required for the functioning of the relay is called its energizing quantity.

(iv) **Characteristic Quantity :-** The quantity to which the relay is designed to respond is called its characteristic quantity, i.e. current in an over-current relay, impedance in an impedance relay, phase angle in a directional relay, etc. Some relays have response to more than one quantity and such quantities are called the characteristic quantities of the relay.

Setting :- The setting value of the relay is the actual value of the energizing or characteristic quantity at which the relay is designed to operate under given conditions.

Power Consumption (burden) :- The power consumed by the circuits of the relay at the rated current or voltage is called the burden of the relay on the power circuit.

Pickup Value :- A relay is said to pickup when it moves from the off-position to the on-position. The value of the characteristic quantity at which the relay just picks up to operate is called the pickup value of the relay.

Reset Value :- A relay is said to reset when it moves from the on-position to the off-position. The value of the characteristic quantity below which this occurs is known as drop out or reset value.

Operating Time :- The time interval between the relay picks up its pick-up value and the operation of its contacts is called the operating time of the relay.

Resetting Time :- The time which the operated relay takes to come back to its off-position after operation is called the Resetting Time of the relay.

Primary Relays :- If the relays are connected directly in the power circuit without instrument transformers, then they are called primary relays.

Secondary Relays :- If the relays are connected to the power circuits through instrument transformers like CT's and PT's, then they are called secondary relays.

Auxiliary Relays :- Relays which operate in response to the opening or closing of the main circuit breaker to perform other functions are called Auxiliary Relays.

Backup Relays :- A relay which operates after a slight time delay if the main relay fails to operate is called the Backup Relay. A Backup relay acts as the second line of defense.

Flag or Target :- A device used for indicating the operation of relay is called Flag or Target. It is usually spring or gravity operated.

SAMPLE QUESTIONS/EXERCISES :

1. Explain briefly why power system has to be controlled and protected. Give reasons.

Chap - 2

Short Circuit faults

Short-Circuit fault:

The most common and dangerous faults that occur in a power system is short-circuit fault or shunt fault. They occur as a result of breakdowns in the insulation of current carrying phase conductors relative to earth or in the insulation between phases. In 3-ϕ ac power circuit the short-circuit fault can be classified as

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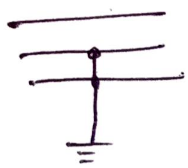
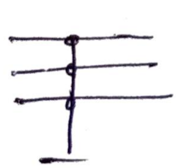
(v) All 3-phases short circuited fault.

L-G

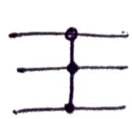


L-L-G

L-L



L-L-L-G



L-L-L

Harmful effects of Short-Circuit faults

* Damages due to fault (S/C):

(i) The heavy current due to short-circuit causes excessive heating which may result in fire or explosion.

(ii) Onsymmetrical short circuit fault causes the currents of the network unbalanced.

(iii) The stability of the power system may be adversely affected and even the complete shut down of the power system

(iv) The damages of the equipment may be caused due to overheating.

(v) There may be interruption in power supply to consumers.

(vi) There may be a considerable reduction in voltage on healthy feeders connected to the system having fault.

* Representation of Power System:

A balanced 3-ϕ system can be conveniently solved on single phase basis.
It can be represented by a single phase only omitting neutral.

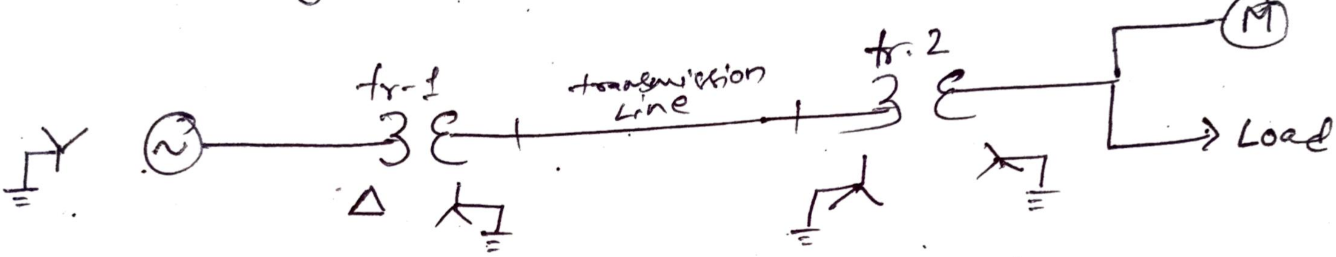


fig: single line representation

Each component of the system can also be represented by their impedances.

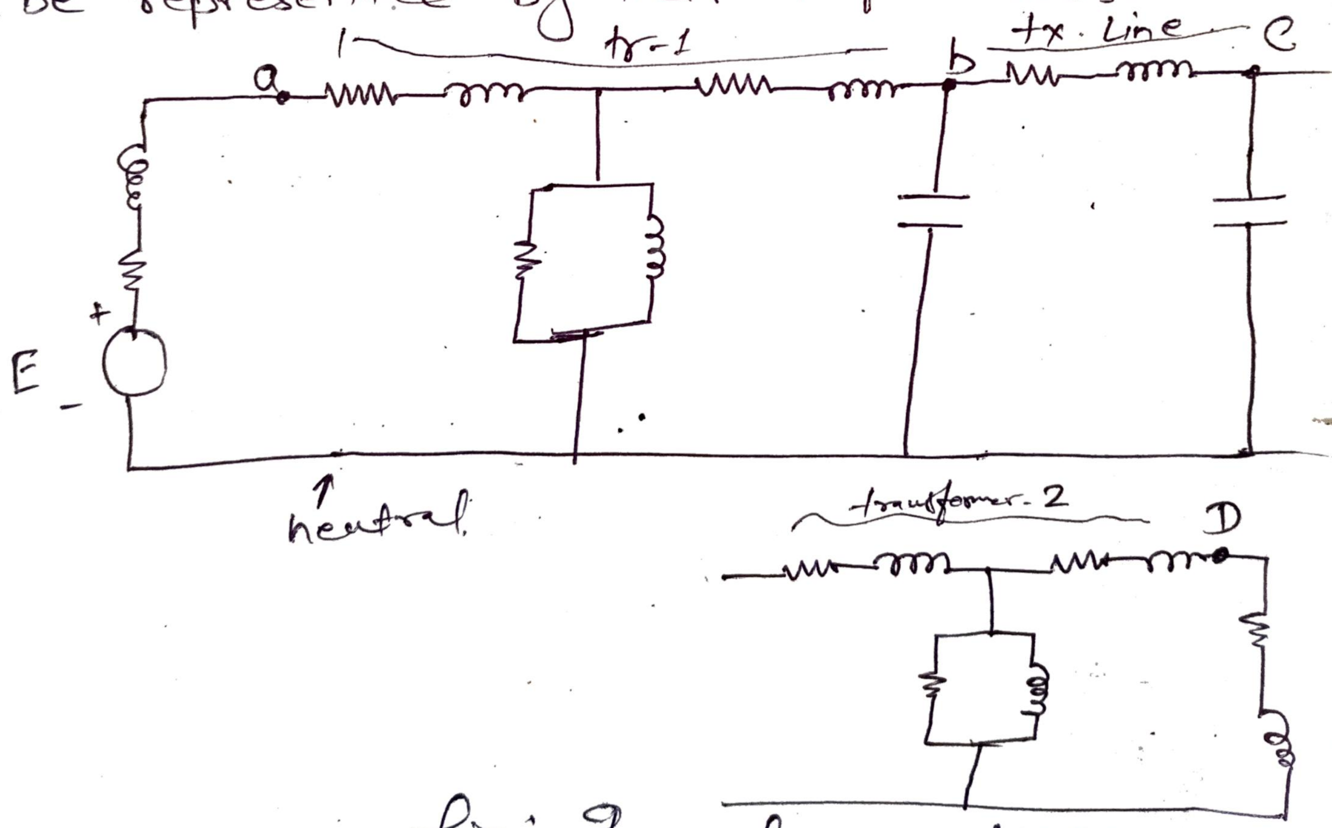


fig: Impedance diagram.

The resistances and capacitances can be neglected further for fault calculations. Then the above diagram reduces to reactance diagram.

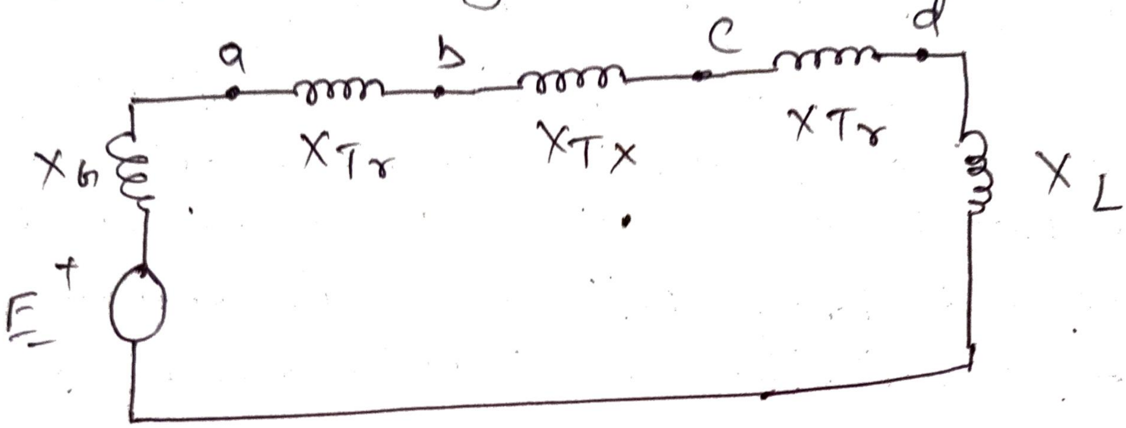


fig: Reactance diagram.

* Per Unit method (PU):

The quantities voltage (V), current (I), KVA, impedance are often expressed as percentage or PU of their selected bases. Such method simplifies the calculations.

for this process, first of all base value is assumed. As a rule, only two bases ~~are~~ should be selected first and from these two, the remaining bases should be calculated. This is so because kV, KVA, I and Z are interrelated.

eg: select base kV and Base KVA

$$PU\ kV = \frac{\text{Actual kV}}{\text{Base kV}}$$

$$\text{Base current } I \ (A) = \frac{\text{Base KVA}}{\text{Base kV} \ (\times\sqrt{3})} \text{ for phase voltage}$$

$$\text{Base impedance } Z = \frac{\text{Base kV} \times 1000}{\text{Base current}}$$

$$= \text{Base kV} \times \frac{\text{Base kV} \times 1000}{\text{Base KVA}}$$

$$= \frac{\text{Base kV}^2 \times 1000}{\text{Base KVA}}$$

$$= \frac{\text{Base kV}^2}{\text{Base MVA}}$$

PU impedance $= \dfrac{\text{actual impedance}}{\text{base impedance}}$

$= \text{actual } Z \times \dfrac{\text{Base kVA}}{(\text{Base kV})^2 \times 1000}$

PU impedance referred to new base

$= \text{Old PU impedance} \times \left(\dfrac{\text{Base kV old}}{\text{Base kV new}}\right)^2$

$\times \dfrac{\text{Base kVA new}}{\text{Base kVA old}}$

$Z_{pu} = \dfrac{Z(\Omega)}{Z_{base}}$

Chap - 2

Synime Short ckt. fault Calculation
Per Unit Method.

Fault MVA and Fault current:

Per unit fault (or short circuit current).

$$I_{sc} \cdot pu = \frac{\text{PU voltage at Fault point}}{\text{PU } X_{eq}}$$

Per Unit fault (MVA) = $\sqrt{3}$ × P.U fault current ($I_{sc}Pu$) × PerUnit Voltage Source

or,

$$\text{Fault MVA} = \frac{\text{Base MVA}}{\text{PU } X_{eq}} \text{ MVA}$$

$$\text{Fault Current } I_{sc} = \frac{\text{Fault MVA} \times 10^3}{\sqrt{3} \times \text{Base KV}}$$

$$\text{Fault current } I_{sc} = I_{sc}\, pu \times I_B$$

Fault apparent Power = $I_{sc}pu$ × Per Unit fault -Voltage

$$\text{Short ckt. MVA or Fault level} = \frac{\text{Base MVA}}{X_{eq}\ \text{P.U.}}$$

Q. A Symmetrical 3-ϕ Short Circuit occurs on 22 kV bus-bars of the Circuit shown as one line diagram in fig ①. Calculate the fault current and fault apparent power & fault MVA.

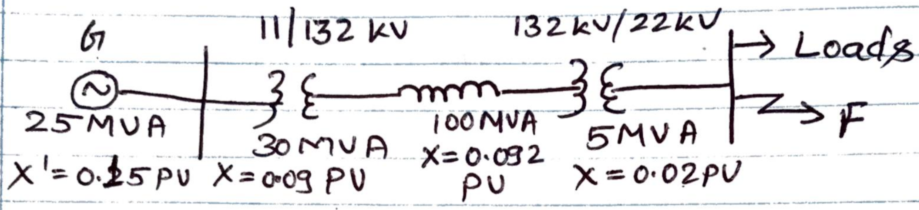


Fig ①

Sol^n.

Let base MVA For Complete System be 100 MVA (largest)
Let " kV " generator Side = 11 kV
" " " Feeder Side = 132 kV
" " " Load Side = 22 kV

For generator :-

$$X_{PU\ old} = 0.15\ PU$$

For new base, P.U reactance of generator

$$X_{PU.\ new} = X_{PU\ old} \times \left(\frac{KVA_{new}}{KVA_{old}}\right) \times \left(\frac{KV_{old}}{KV_{new}}\right)^2$$

$$= 0.15 \times \left(\frac{100}{25\text{ - given}}\right) \times \left(\frac{11\text{ - given}}{11\text{ - nPani}}\right)^2$$

$$= 0.6\ PU$$

For Transformer :-

T_1, P.U reactance of tr-er,

$$X_{PU.\ new} = 0.09 \times \left(\frac{100}{30}\right) \times \left(\frac{11}{11}\right)^2$$

$$= 0.3\ P.U.$$

T_2 =

$$X_{PU\ new} = 0.02 \times \left(\frac{100}{5}\right) \times \left(\frac{132}{132}\right)^2$$

$$= 0.4\ P.U.$$

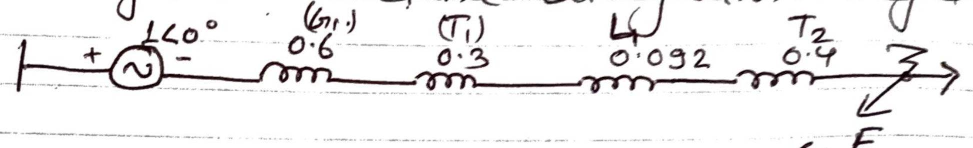
P.U reactance of tr. line = 0.092 P.U

$$X_{P.U.new} = X_{PU old} \times \left(\frac{KVA_{new}}{KVA_{old}}\right) \times \left(\frac{KV_{old}}{KV_{new}}\right)^2$$

$$= 0.092 \times \left(\frac{100}{100}\right) \times \left(\frac{132}{132}\right)^2$$

$$= 0.092 \text{ PU}$$

Drawing, P.U reactance diagram, we get



Assuming fault point voltage be $1\angle 0°$

$$X_{eq\,PU} = (0.6 + 0.3 + 0.092 + 0.4) = 1.392 \text{ PU}$$

or, $j1.392$ (inductive)

or $1.392\angle 90°$

Per Unit fault current $I_{sc\,P.U} = \dfrac{\text{P.U. Fault voltage}}{\text{P.U reactance}}$

$$= \frac{1\angle 0°}{1.392\angle 90°}$$

$$= 0.7184\angle -90° \text{ P.U.}$$

We know,

Base current $(I_B) = \dfrac{\text{Base MUA} \times 1000}{\sqrt{3} \times \text{base kV}}$

$$I_B = \frac{100 \times 1000}{\sqrt{3} \times 22} \text{ (Line)} = 2624 \text{ A}$$

$\therefore$ Fault current, $I_{sc} = I_{sc\,P.U.} \times I_B = 0.7184 \times 2624$

$$= 1885.3 \text{ A}$$

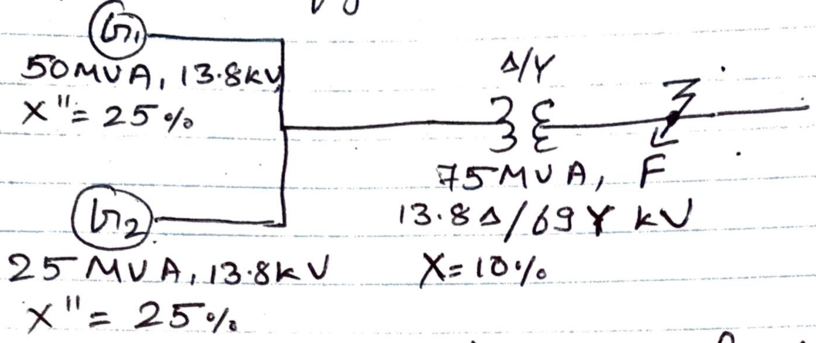
Fault MUA = I_{sc} PU × Base MUA

$= 0.7184 \times 100$

$= 71.84$ MU.A

↳ Fault apparent Power.

Q. Two generators are connected in parallel to the L.V side of 3-ϕ Δ-Y transformer as shown in fig ①.



Before the fault occurs, the voltage on H.T side of tr-er is 66kV eff. Find the fault current & subtransient current in G_1 & G_2 when fault occurs on H.T side of Tr-er.

Soln: Let 50 MVA be the base MVA; Base kV on gen-side or LT side of tr-er = 13.8 kV & on feeder side be 69 kV.

For Generator G_1,

$$X_{p.u\,new} = X_{p.u\,old} \times \left(\frac{KVA_{new}}{KVA_{old}}\right) \times \left(\frac{KV_{old}}{KV_{new}}\right)^2$$

$$= 0.25 \times \left(\frac{50}{50}\right) \times \left(\frac{13.8}{13.8}\right)^2 = 0.25\,P.U$$

For G_2,

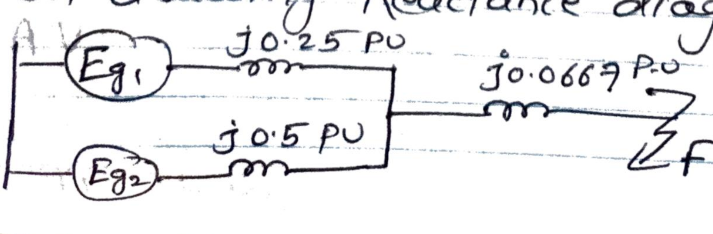
$$X_{pu\,new} = 0.25 \times \left(\frac{50}{25}\right) \times \left(\frac{13.8}{13.8}\right)^2 = 0.5\,P.U.$$

For Tr-er, (LT)

$$X_{pu\,new} = 0.1 \times \left(\frac{50}{75}\right) \times \left(\frac{13.8}{13.8}\right)^2 = 0.0667\,P.U$$

L.T

Now, on drawing Reactance diagram,



$\therefore X_{eq_{P.U.}} = (0.25 \parallel 0.5) + 0.0667$
$= 0.2333$ PU

Per Unit Fault Current $= \dfrac{\left(\frac{66}{69}\right)}{0.2333}$
$(I_{SC\,P.U})$

$\left[\because\ \text{Trg kV at Fault} = 66\,kV\right]$

$= 4.1$ PU

Base Current $(I_B) = \dfrac{\text{Base MVA} \times 1000}{\sqrt{3} \times \text{Base kV}}$

$= \dfrac{50 \times 1000}{\sqrt{3} \times 69}$

$= 418.36$ A

Fault Current $= I_{SC\,PU} \times I_B$

$= 4.1 \times 418.4$

$= 1715$ A

Sub transient Current in G_1

$= \dfrac{0.5}{0.25+0.5} \times \dfrac{69}{13.8} \times 1715$

$= 5716$ A

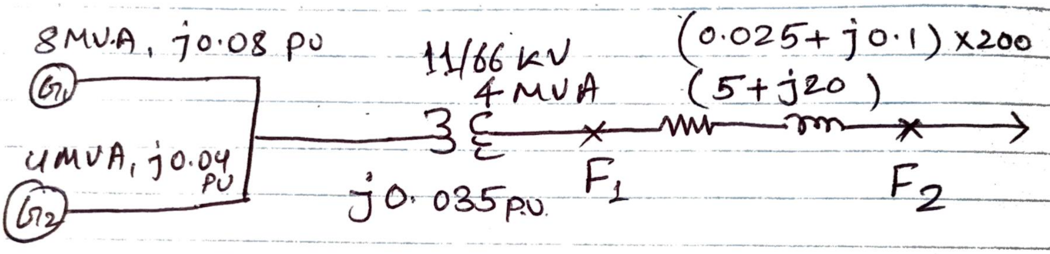
Sub transient Current in G_2

$= 1715 \times \dfrac{0.25}{0.25+0.5} \times \dfrac{69}{13.8}$

$= 2858$ A

Q. Two 3-ϕ 11kV generators of capacities 8MVA and 4MVA and subtransient reactance of 8% and 4% respectively operate in parallel. The generating station is connected to a tr-line of 200km length, through a step-up tr-er of capacity 4MVA and having % reactance of 3.5%. The resistance & reactance of tr-line per km length are 0.025 Ω & 0.1 Ω respectively & it is operated at 66 kV. (200km) Calculate the short circuit MVA for phase to phase fault at the receiving end of the transmission line and at the sending end.

Sol^n.



Fig① Single line diagram.

let 8MVA be the the base MVA of the complete system.
Base kV of gen side or L.T side of Tr-er be 11kV and transmission line side be 66 kV (H.T side of tr-er)

for G_1,

$$X_{pu\,new} = X_{p.u.old} \times \left(\frac{KVA_{new}}{KVA_{old}}\right) \times \left(\frac{KV_{old}}{KV_{new}}\right)^2$$

$$= j0.08 \times \left(\frac{8}{8}\right) \times \left(\frac{11}{11}\right)^2$$

$$= j0.08 \text{ p.u.}$$

for G_2,

$$X_{pu\,new} = j0.04 \times \left(\frac{8}{4}\right) \times \left(\frac{11}{11}\right)^2$$

$$= j0.08 \text{ p.u}$$

$$Z_{p.u} = \frac{Z_A}{Z_B} = \frac{Z_A}{\frac{(KV_B)^2}{MVA}} = Z_A \times \frac{MVA_B}{(KV_B)^2} \qquad Z_B = Z \times \frac{MVA_B}{(KV_B)^2}$$

For T_1,

$$X_{pu\,new} = j0.035 \times \left(\frac{8}{4}\right) \times \left(\frac{11}{11}\right)^2.$$

$$= j0.07 \text{ P.U.}$$

For,

Tr-line,

$$Z_A = 200\,(0.025 + j0.1)$$

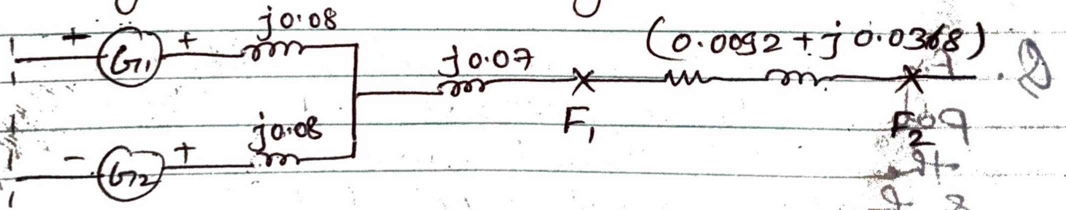
$$= (5 + j20)\ \Omega$$

$$Z_{pu} = Z_A \cdot \frac{(MVA)_{Base}}{(KV_B)^2}$$

$$= (5 + j20) \times \frac{8}{(66)^2}$$

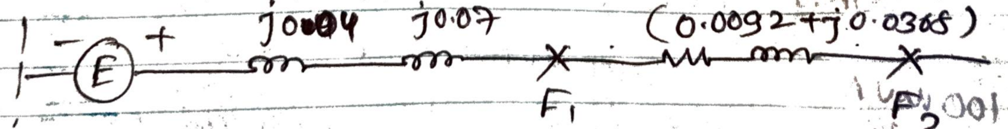
$$= 0.0092 + j\,0.0368 \text{ p.u}$$

① Drawing. Reactance diagram.



Reduced Reactance diagram.

$0.08 \parallel 0.08 = 0.04$



Case I For Fault at F_1, if fault occurs at H.T of Tr-er or sending end

$$X_{eq_{P.U.}} = j0.04 + j0.07 = j0.11 \text{ pu}$$

$$\text{Short ckt. MVA} = \frac{\text{Base MVA}}{X_{eq.\,P.u.}} = \frac{8}{0.11} = 72.73 \text{ MVA}$$

$$E_1 = a_1 + jb_1$$
$$E_1 = \sqrt{a_1^2 + b_1^2}$$
$$\phi = \tan^{-1}\frac{b_1}{a_1}$$

Case II F_2.

for 3-ϕ fault occurs at receiving end of tr-line.

$$X_{eq} = j0.04 + j0.07 + (0.0092 + j0.0368)$$
$$= (0.0092 + j0.1468)\ PU$$
$$= 0.1471 \angle 86.4^\circ$$

$$\text{Short ckt MVA} = \frac{\text{Base MVA}}{X_{eq}\ \text{P.U.}}$$
$$= \frac{8}{0.1471}$$
$$= 54.4\ \text{MVA}$$

Q. Fig. shows a generating station feeding power to a 132 kV system. Determine the total fault current, fault level & fault current supplied by each generator for a 3-ϕ fault at receiving end bus. The line is 200 km long.

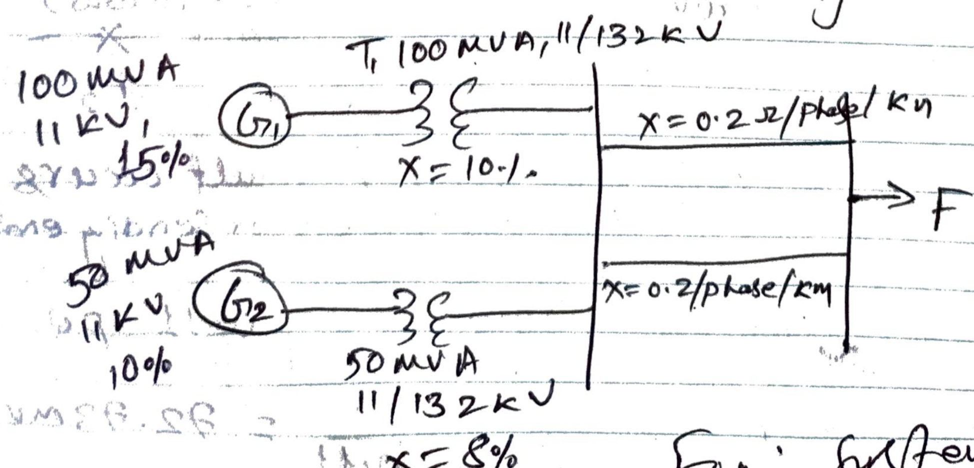


Fig: System for question

Solⁿ: let 100 MVA be the base MVA of complete system,
11 kV be base kV on L.T side &
132 kV at feeder side.

For G_1,
$X_{pu} = j0.15$ pu

For G_2, $X_{pu} = 0.1 \times \frac{100}{50} = j0.2$ p.u

For T_1 $X_{pu} = 0.1 \times \frac{100}{100} \times \left(\frac{11}{11}\right)^2 = j0.1$ pu

For, T_2 $X_{pu} = 0.08 \times \frac{100}{50} = j0.16$ pu

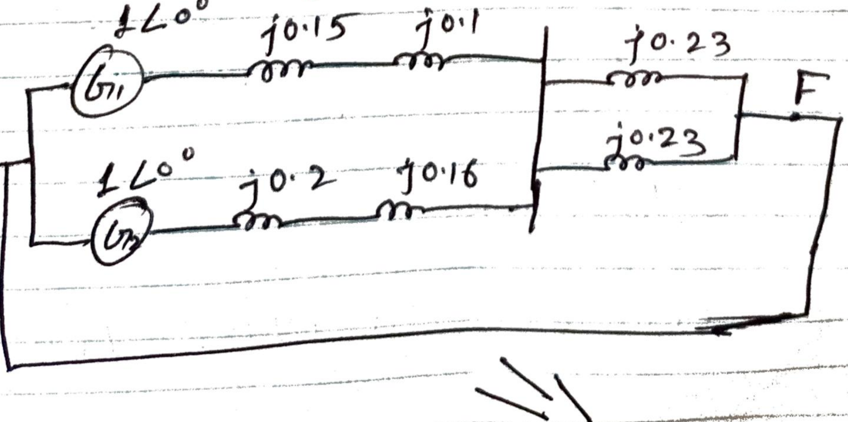
For line,
p.u reactance of each line

$= j0.2 \times 200 \times \frac{MVA_B}{(kV_B)^2}$

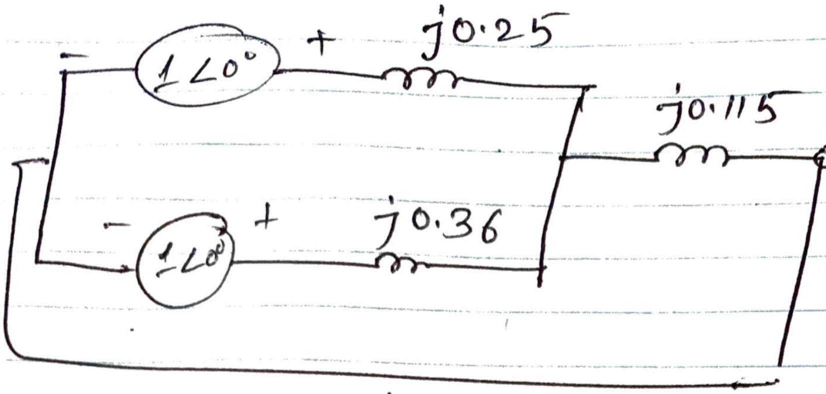
$= j0.2 \times 200 \times \frac{100}{(132)^2}$

$= j0.23$ p.u

Now, Drawing reactance diagram.



L to P

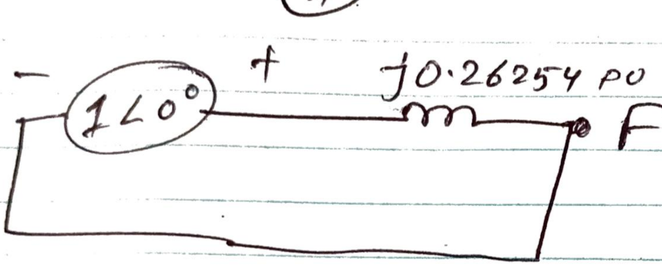


$\Downarrow$

$0.25 // 0.35 + 0.115$

$= 0.147 + 0.115$

$= 0.26254$



$$\text{Fault level} = \frac{\text{Base MVA}}{X_{eq}\ \text{PU}} = \frac{100}{0.26254} = 380.9\ \text{MVA}$$

$$\text{Total fault current} = \frac{\text{Fault level MVA} \times 1000}{\sqrt{3} \times \text{base kV of Feeder}}$$

$$= \frac{380.9 \times 1000}{\sqrt{3} \times 132}$$

$$= 1666\ \text{A}$$

Total fault Supplied by two gen.

= Fault current on feeder side × transformer ratio

$$= 1666 \times \frac{132}{11} = 19992\ \text{A}$$

Fault Current Supplied by G_1

$$I_{f_1} = \frac{j0.36}{j0.36 + j0.25} \times 19992$$

$$= 11799\ A$$

Fault Current Supplied by G_2.

$$I_{F_2} = 19992 \times \frac{j0.25}{j0.36 + j0.25}$$

$$= 8193.4\ A_{//}.$$

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Q. A Symmetrical three phase short circuit occurs on load B on single line diagram. Calculate the short circuit current & Fault MVA.