UNIT 1 INTRODUCTION

Protective relaying is one of the several features of the power system design. It is used to give an alarm or to cause prompt removal of any element of power system from service when a fault occurs. It minimizes the damage to the equipment & improve the quality of service.

Factors affecting the choice of protection:-

1. type & rating of equipment
2. Location of the equipment
3. Type of Faults
4. Abnormal Conditions
5. Cost.

Protective relaying scheme:-

includes protective current transformers, Voltage transformers, Protective relays, time delay relays, auxiliary relays, secondary circuits, trip circuits etc.

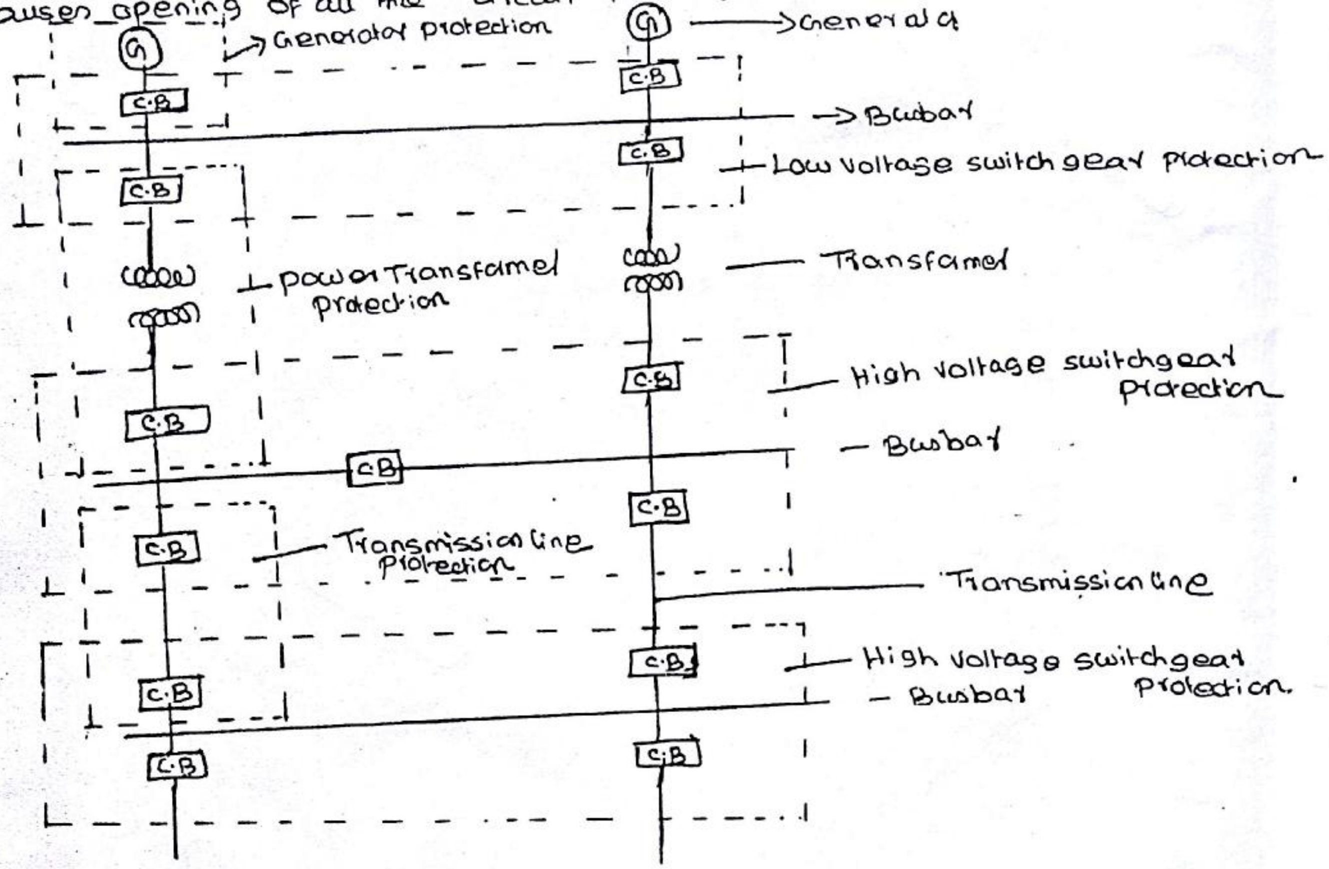
Functions of protective relaying:-

1. To remove the component which is behaving abnormally by sending signal to the trip circuit of circuit breaker or to sound an alarm.
2. To disconnect abnormally operating part from the healthy part, to prevent subsequent faults & to minimize the damage to the fault part itself.
3. To improve the system performance, system reliability, system stability & service continuity.

Thus faults cannot be prevented, but can be minimised.

Protective zones:-

It is a separate zone which is established around each system element. The significance of such a protective zone is that any fault occurring within a given zone will cause tripping of relays which causes opening of all the circuit breakers located within that zone.



The boundaries of protective zones are decided by the locations of the current transformers. In practice, various protective zones are overlapped. The overlapping of protective zones is done to ensure complete safety of each and every element of the system.

Dead spot:-

The zone which is unprotected is called dead spot. Due to overlapping, the existence of a dead spot in a system can be avoided. The probability of the failures in the overlapped region is very low.

Each protective zone has certain protective scheme and each scheme has number of protective systems.

Primary protection:- (Main protection)

It is the first line of defence and is responsible to protect all the power system elements from all the types of faults.

Reasons for failure of primary protection

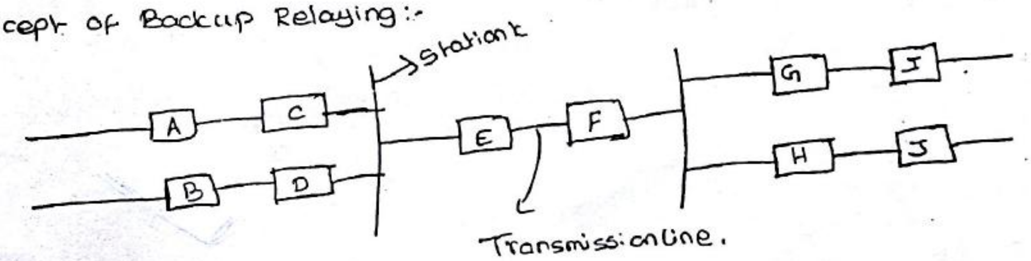
1. Failure in CB
2. Failure in protective relay
3. Failure in tripping circuit
4. Failure in d.c. tripping voltage.
5. Loss of voltage or current supply to the relay.

Backup protection :-

All the protective equipments will be same as primary protection but it will come into operation when the primary protection fails. If backup protection is absent & if primary protection fails, then there is a possibility of severe damage to the system.

When the primary protection is made inoperative for the maintenance purpose, the backup protection acts like a main protection. The arrangement of backup protection should be such that if any fault occurs in primary protection, it should not affect the backup protection. From the cost & economy point of view, the backup protection is employed only for the protection against short circuit & not for any other abnormal conditions.

Concept of Backup Relaying :-



relays C, D, G & H are primary relays
relays A, B, I, J are backup relays

Normally backup relays are tripped if primary relay fails. So if the primary relay E fails to trip, then backup relays A and B get tripped. The backup relays A and B provide backup protection for fault at station x. Also the backup relays at A and F provide the backup protection for the faults in line DB. The important requirement of backup relaying is that it must operate with sufficient time delay so that the primary relaying is given a chance to operate. When fault occurs, both the type of relays start relaying operation but primary is expected to trip first and backup will then reset without having had time to complete its relaying operation.

Methods of Backup protection :-

1. Relay Backup Protection :- In this scheme, a single breaker is used by both primary as well as backup protection, but the two protective systems are different.

2. Breaker Backup Protection:-

In this method, separate breakers are provided for primary and backup protection. Both the types of breakers are at the same station.

3. Remote Backup protection:-

In this method, separate breakers are provided for primary and backup protection. The two types of breakers are at the different stations and are completely isolated and independent of each other.

4. Centrally Co-ordinated Backup Protection:-

In this method, primary protection is at various stations. There is a central control room and backup protection for all the stations is at central control room. Central control continuously inspect the load flow and frequency in the system. If any element or any part of the system fails, load flow gets affected which is sensed by the control room. The control source consists of a digital computers which decides the proper switching action. This method is also called centrally controlled backup protection.

Essential Qualities of Protective Relaying:-

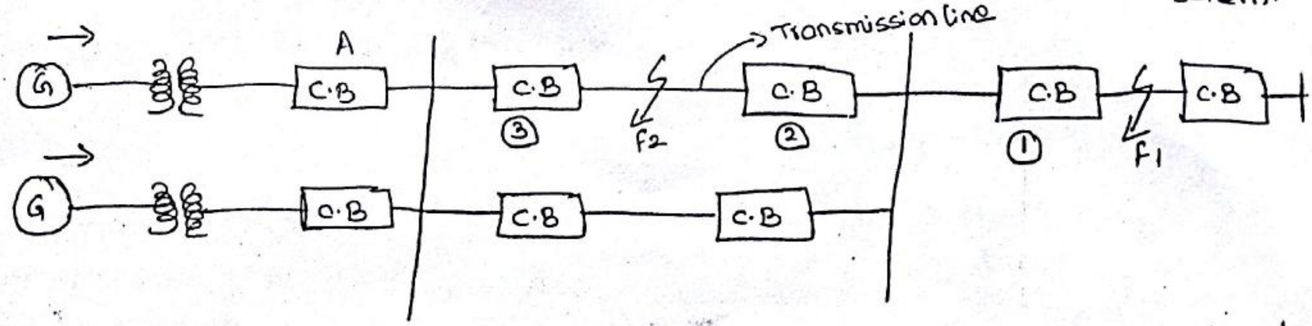
1. Reliability:-

The basic quality of protective relaying is reliability. It indicates the ability of the relay system to operate under the predetermined conditions. Various components like circuit breakers, relays, C.T's, P.T's, Cables, trip circuits etc are employed in protective relaying & the reliability of the protective system depends on the reliability of all those components. Reliability can be achieved by the factors like

1. Simplicity
2. Robustness
3. High contact pressure
4. Dust free enclosure
5. Good contact material
6. Good workmanship
7. Careful maintenance

2. Selectivity and Discrimination:-

The selectivity is the ability of the protective system to identify the faulty part correctly and to disconnect that part without affecting the rest of the healthy part of the system. The discrimination is the ability to distinguish between normal condition and abnormal condition and also whether the fault occurs within protective zone or not. Thus the protective system should select the faulty part and disconnect only the faulty part without disturbing the healthy part of the system.



If fault F_2 occurs on transmission line then the C.B's ② & ③ should operate and disconnect the line from the remaining system. It should not operate for fault F_1 which occurs beyond its protection zone.

3. Speed and Time:-

A protective system must disconnect the faulty system as fast as possible. If the faulty system is not disconnected for a long time, then

1. The devices carrying fault currents may get damaged.
2. The failure leads to reduction in system voltage. Such low voltage may affect the motors and generators running on the consumer side.
3. If fault persists for long time, then subsequently other faults may get generated.

The fault clearing time should be as small as possible to have high speed operation of the protective system. A fast protective system is an important quality which minimises the damage & it improves the overall stability of the power system.

Though a small fault clearing time is preferred, in practice certain time lag is provided. This is because

1. To have clear discrimination between primary and backup protection
2. To prevent unnecessary operation of relays under the conditions such as transients, starting inrush of current etc.

4. Sensitivity:-

The sensitivity of the system is the ability of the relay system to operate with low value of actuating quantity. It indicates the smallest value of the actuating quantity at which the protection starts operating in relation with the minimum value of fault current in the protected zone.

The relay sensitivity is the function of the volt-amperes input to the relay coil necessary to cause its operation. Smaller the value of volt-ampere input, more sensitive is the relay. Thus 1VA input relay is more sensitive than 5VA input relay

Sensitivity Factor is the ratio of minimum short circuit current in the protected zone to the minimum operating current required for the protection to start.

$$k_s = I_s / I_o$$

k_s = sensitivity factor

I_s = minimum short circuit current in the zone

I_o = minimum operating current for the protection.

5. Stability :-

It is the quality of the protective system due to which the system remains inoperative and stable under certain specified conditions such as transients, disturbance etc. For providing the stability, certain modifications like time delays, Filter circuits, mechanical and electrical bias are required in the system design.

6. Adequateness :-

There are variety of faults and disturbances that arises practically in a power system. It is not possible to provide protection against each and every abnormal condition that exist, due to economical reasons. But the protection system must provide adequate protection for any element of the system. Adequateness of the system is assessed by

1. Ratings of various equipments
2. Cost of the equipments
3. Locations of the equipments
4. Probability of abnormal condition due to internal and external causes.
5. Discontinuity of supply due to failure of the equipment.

7. Simplicity and Economy :-

It is necessary that the cost of the system should be well within limits. As a rule, the protection cost should not be more than 5% of the total cost. But if the equipments to be protected are very important, the economic constraints can be relaxed.

The protective system should be as simple as possible so that it can be easily maintained. The complex system are difficult from the maintenance point of view. The simpler systems are always more reliable.

Terminologies used in Protective Relaying :-

Protective Relay :-

It is an electrical relay, which closes its contacts when an actuating quantity reaches a certain preset value. Due to closing of contacts, relay initiates a trip circuit of circuit breaker or an alarm circuit.

Relay Time:-

It is the time between the instant of Fault occurence and the instant of closure of relay contacts.

Breaker Time:-

It is the time between the instant at circuit breaker operates and opens the contacts, to the instant of extinguishing the arc completely.

Fault clearing Time:-

The total time required between the instant of Fault and the instant of final arc interruption in the circuit breaker is Fault clearing time. It is the sum of the relay time and circuit breaker time.

Pickup :-

A relay is said to be picked up when it moves from the 'off' position to 'on' position.

Pickup Value:-

It is the minimum value of an actuating quantity at which relay starts operating. In most of the relays actuating quantity is current in the relay coil & pickup value of current is indicated along with the relay.

Dropout or Reset:-

A relay is said to dropout or reset when it comes back to the original position. The value of an actuating quantity current or voltage below which the relay resets is called reset value of that relay.

Time Delay:-

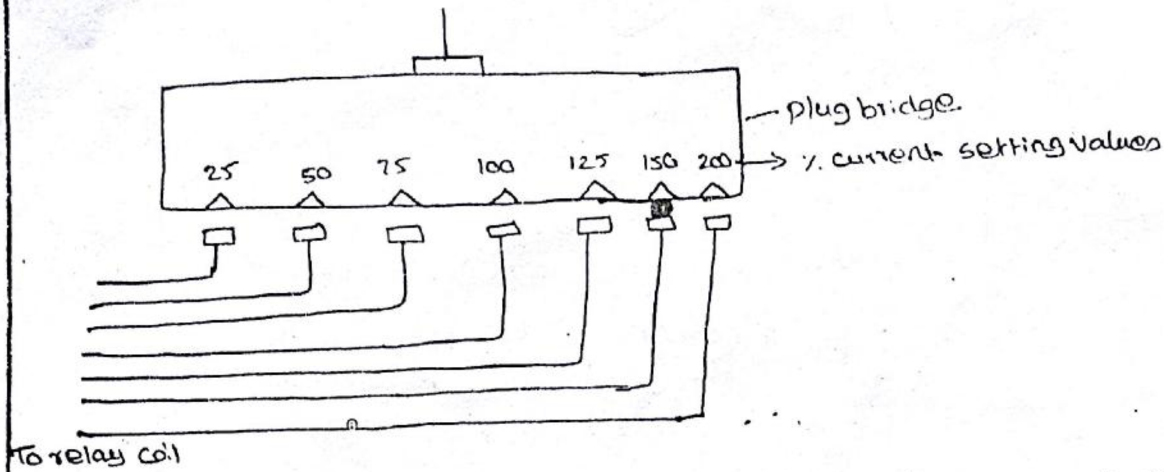
The time taken by relay to operate after it has sensed the fault is called time delay of relay. Some relays are instantaneous while in some relays intentionally a time delay is provided.

Seal-on Relay or Sealing Relay or Holding Relay:-

The relay contacts are designed for light weight and hence they are therefore very delicate. when the protective relay closes its contacts, it is relieved from other duties such as time lag, tripping etc. These duties are performed by auxiliary relays which are also called seal-on Relays or holding relays.

Current Setting:-

The pickup value of current can be adjusted to the required levels in the relays which is called current setting of the relay. It is achieved by use of tappings on the relay coil, which are brought out to a plug bridge. The tap values are expressed in terms of percentage full load rating of C.T. with which the relay is associated.



Pickup current = % current setting X rated secondary current of CT.

eg: if CT is 500/10A & current setting is 150%.

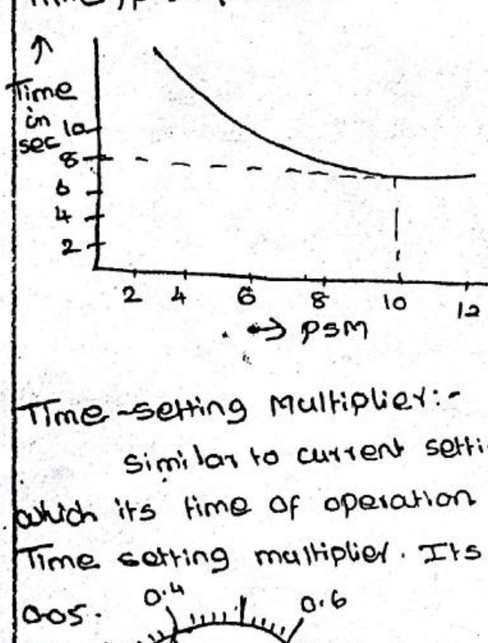
$$\text{Pickup current} = \frac{150}{100} \times 10 = 15A.$$

Plug setting Multiplier (PSM) :-

$$PSM = \frac{\text{Fault current in relay coil}}{\text{Pickup value}}$$

$$= \frac{\text{Fault current in relay coil}}{\text{\% current setting} \times \text{rated secondary current OF C.T.}}$$

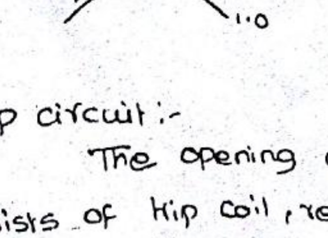
Time /P.S.M curve:-



For a relay, a curve showing relation between time and plug setting multiplier is provided which is called time /P.S.M curve. Using this curve and time-setting multiplier, the actual time of operation of a relay can be obtained.

Time-setting Multiplier:-

Similar to current setting, a relay is provided with a feature with which its time of operation can be controlled. This feature is known as Time setting multiplier. Its dial is calibrated from 0 to 1 in steps of 0.05.



eg: if time setting multiplier is 0.2, from curve time corresponding to P.S.M of 10 is 8 sec, then

Actual time of operation = time in seconds X time-setting multiplier
$= 8 \times 0.2 = 1.6$ seconds.

Trip circuit:-

The opening operation of C.B is controlled by a circuit which consists of trip coil, relay contacts, auxiliary switch, battery supply etc., which is called trip circuit.