Zones of Protection

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

The circuit breakers are placed at the appropriate points such that any element of the entire power system can be disconnected for repairing work, usual operation, and maintenance requirements and also under abnormal conditions like short circuits. Thus a protective covering is provided around rich element of the system.

The various components which are provided with the protective zone are generators, transformers, transmission lines, bus bars, cables, capacitors etc. No part of the system is left unprotected. The figure below shows the various protective zones used in a system.

Various protective zones

The boundaries of protective zones are decided by the locations of the current transformer. 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. The zone which is unprotected is called dead spot. The zonesare overlapped and hence there is no chance of existence of a dead spot in a system. For the failures within the region where two adjacent protective zones are overlapped, more circuit breakers get tripped than minimum necessary to disconnect the faulty element.

If there are no overlaps, then dead spot may exist, means the circuit breakers lying within the zone may not trip even though the fault occurs. This may cause damage to the healthy system.

The extent of overlapping of protective zones is relatively small. The probability of the failures in the overlapped regions is very low; consequently the tripping of the too many circuit breakers will be frequent. The figure shows the overlapping of protective zones in primary

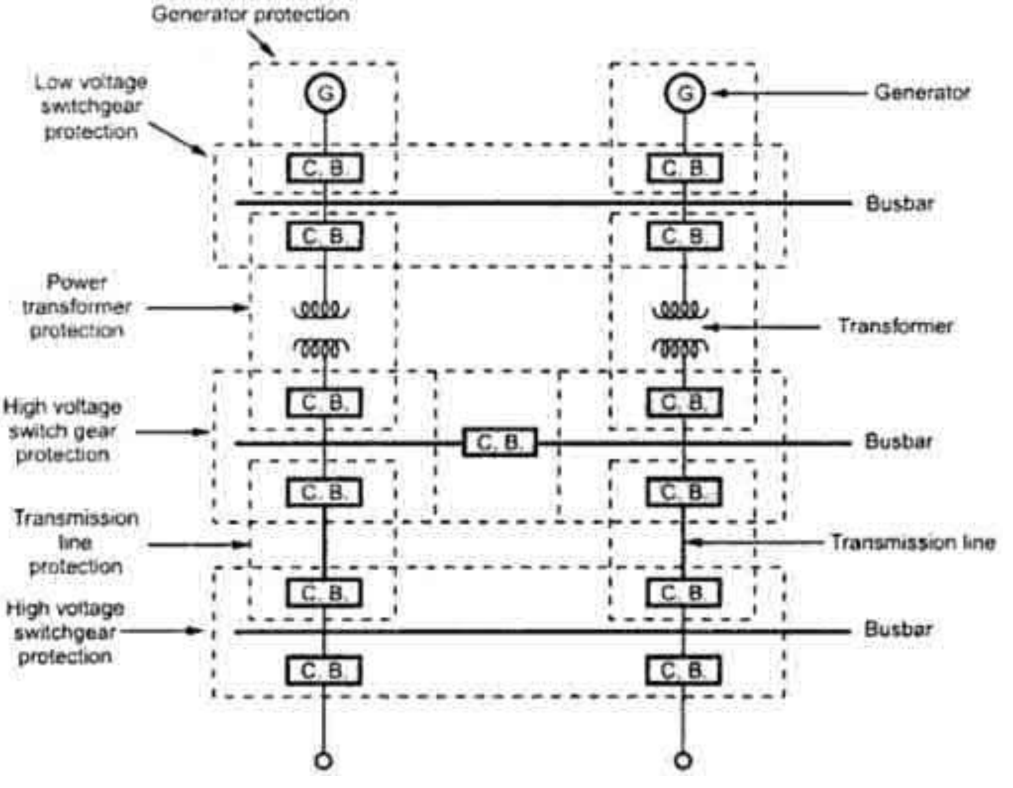

Figure shows Overlapping zones in primary relaying. It can be seen from the figure that the circuit breakers are located in the connections to each power system element. This provision makes it possible to disconnect only the faulty element from the system.

Occasionally for economy in the number of circuit breakers, a breaker between the two adjacent sections may be omitted but in that case both the power system are required to be disconnected for the failure in either of the two. Each protective zone has certain protective scheme and each scheme has number of protective systems.

Primary and Back up protection

Primary Protection

The primary protection scheme ensures fast and selective clearing of any fault within the boundaries of the circuit element, that the zone is required to protect. Primary Protection as a rule is provided for each section of an electrical installation. However, the primary protection may fail. The primary causes of failure of the Primary Protection system are enumerated below.

1. Current or voltage supply to the relay.
2. D.C. tripping voltage supply
3. Protective relays
4. Tripping circuit
5. Circuit Breaker

Back-up Protection

Back-up protection is the name given to a protection which backs the primary protection whenever the later fails in operation. The back-up protection by definition is slower than the primary protection system. The design of the back-up protection needs to be coordinated with the design of the primary protection and essentially it is the second line of defence after the primary protection system.

Concept of back up relay

The backup relaying schemes provide this extra reliability to the system. Backup relays are extra relaying schemes attached to the equipment or part of the network with their own relaying system. The main function of backup relay, to operate in any failure of tripping of circuit breaker due to main relays. The relay attached to the system may fail due to

- Mechanical defect of moving parts of the main relay,
- Failure of DC supply to the relay,
- Failure of tripping pulse to the breaker from relay,
- Failure of current or voltage to the relay from CT or PT circuits etc.

In this typical situation there should be another line of protection called back up relaying. Hence, back up relaying essentially have everything separate from main relaying scheme. This is because backup relay must not fail to operate in the event of failure of main relays.

There are some situations when we have to disconnect main relays from the system for preventive maintenance or trouble shootings. In those cases due to presence of back up relays, we do not have to interrupt the equipment or circuit. During this time back up protection scheme takes care of the protection of the system. As the back relaying is second line of protection it must be slow in action than main relay so that it can only be operated when the main relaying scheme of the system/equipment fails.

Methods of Back up protection

The methods of back-up protection can be classified as follows :

1. Relay Back-up
2. Breaker Back-up
3. Remote back-up
4. Centrally Coordinated Back-up

Relay Back-up

Same breaker is used by both main and back-up protection, but the protective systems are different. Separate trip coils may be provided for the same breaker.

Breaker Back-up

Different breakers are provided for main and back-up protection, both the breakers being in the same station

Remote back-up

The main and back-up protections provided at different stations and are completely independent.

Centrally Coordinated Back-up

The system having central control can be provided with centrally controlled back-up. Central control continuously supervises the load flow and frequency in the system. The information about load flow and frequency is assessed continuously. If one of the components in any part of the-system fails, (e.g. a fault on a transformer, in some station) the load flow in the system is affected. The central coordinating station receives information about the abnormal condition through high frequency carrier signals. The stored programme in the digital computer determines the correct switching operation, as regards severity of fault, system stability,

Essential qualities of protection

The essential qualities of protection are

1. Reliability
2. Selectivity and Discrimination
3. Speed and Time
4. Sensitivity
5. Stability
6. Adequateness
7. Simplicity and Economy

1. Reliability

A protective relaying should be reliable is its basic quality. It indicates the ability of the relay system to operate under the predetermined conditions. There are various components which go into the operation before a relay operates. Therefore every component and circuit which is involved in the operation of a relay plays an important role. The reliability of a protection system depends on the reliability of various components like circuit breakers, relays, current transformers (C.T.s), potential transformers (P.T.s), cables, trip circuits etc. The proper maintenance also plays an important role in improving the reliable operation of the system. The reliability cannot be expressed in the mathematical expressions but can be adjusted from the statistical data. The statistical survey and records give good idea about the reliability of the protective system. The inherent reliability is based on the design which is based on the long experience. This can be achieved by the factors like,

i) Simplicity ii) Robustness
iii) High contact pressure iv) Dust free enclosure
iv) Good contact material vi) Good workmanship and
vii) Careful Maintenance

2 Selectivity and Discrimination

The selectivity id the ability of the protective system to identify the faulty part correctly and disconnect that part without affecting the rest of the healthy part of system. The discrimination means to distinguish between. The discrimination quality of the protective system is the ability to distinguish between normal condition and abnormal condition and also between abnormal condition within protective zone and elsewhere. The protective system should operate only at the time of abnormal condition and not at the time of normal condition. Hence it must clearly discriminate between normal and abnormal condition. Thus the protective system should select the fault part and disconnect only the faulty part without disturbing the healthy part of the system.

The protective system should not operate for the faults beyond its protective zone. For example, consider the portion of a typical power system shown in the Fig. 1.

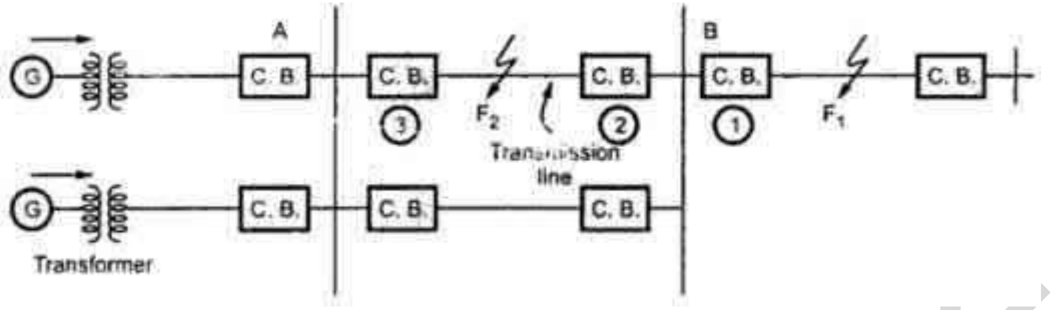

Fig. 1

It is clear from the Fig. 1 that if fault F_2 occurs on transmission line then the circuit breakers 2 and 3 should operate and disconnect the line from the remaining system. The protective system should be selective in selecting faulty transmission line only for the fault and it should isolate it without tripping the adjacent transmission line breakers or the transformer.

If the protective system is not selective then it operates for the fault beyond its protective zones and unnecessary the large part of the system gets isolated. This causes a lot of inconvenience to the supplier and users.

3 Speed and Time

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

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

The high speed protective system avoids the possibility of such undesirable effects.

The total time required between the instant of fault and the instant of final arc interruption in the circuit breaker is called fault clearing time. It is the sum of relay time and circuit breaker time. The relay time is the time between the instant of fault occurrence and theinstant of closure of relay contacts. The circuit breaker times is the time taken by the circuit breaker to operate to open the contacts and to extinguish the arc completely. The fault clearing time should be as small as possible to have high speed operation of the protective system.

Though the 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 relay under the conditions such as transient, starting inrush of current etc.

Thus fast protective system is an important quality which minimises the damage and it improves the overall stability of the power system.

4 Sensitivity

The protective system should be sufficiently sensitive so that it can operate reliably when required. 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 the 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 1 VA input relay is more sensitive than the 5VA input relay.

Mathematically the sensitivity is expressed by a factor called sensitivity factor . It is the ratio of minimum short circuit current in the protected zone to the minimum operating current required for the protection to start.

$$K_s = I_s/I_o$$

where K_s = sensitivity factor

I_s = minimum short circuit current in the zone

I_o = minimum operating current for the protection

5 Stability

The stability is the quality of the protective system due to which the system remains inoperative and stable under certain specified conditions such as transients, disturbance, through faults etc. For providing the stability, certain modifications are required in the system design. In most of the cases time delays, filter circuits, mechanical and electrical bias are provided to achieve stable operation during the disturbances.

6 Adequateness

There are variety of faults and disturbance those may practically exists in a power system. It is impossible to provide protection against each and every abnormal condition which may exist in practice, due to economical reasons. But the protective system must provide adequate protection for any element of the system. The adequateness of the system can be assessed by considering following factors,

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 the failure
of the equipment

6. 7Simplicity and

7. Economy

In addition to all the important qualities, it is necessary that the cost of the system should be well within limits. In practice sometimes it is not necessary to use ideal protection scheme which is economically unjustified. In such cases compromise is done. 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 constrains can be relaxed.

The protective system should be as simple as possible so that it can be easily maintained.The complex systems are difficult from the maintenance point of view. The simplicity and reliability are closely related to each other. The simpler system are always more reliable.