1

Need for protection

1.1 Need for protective apparatus

A power system is not only capable to meet the present load but also has the flexibility to meet the future demands. A power system is designed to generate electric power in sufficient quantity, to meet the present and estimated future demands of the users in a particular area, to transmit it to the areas where it will be used and then distribute it within that area, on a continuous basis.

To ensure the maximum return on the large investment in the equipment, which goes to make up the power system and to keep the users satisfied with reliable service, the whole system must be kept in operation continuously without major breakdowns.

This can be achieved in two ways:

- The first way is to implement a system adopting components, which should not fail and requires the least or nil maintenance to maintain the continuity of service. By common sense, implementing such a system is neither economical nor feasible, except for small systems.
- The second option is to foresee any possible effects or failures that may cause long-term shutdown of a system, which in turn may take longer time to bring back the system to its normal course. The main idea is to restrict the disturbances during such failures to a limited area and continue power distribution in the balance areas. Special equipment is normally installed to detect such kind of failures (also called 'faults') that can possibly happen in various sections of a system, and to isolate faulty sections so that the interruption is limited to a localized area in the total system covering various areas. The special equipment adopted to detect such possible faults is referred to as 'protective equipment or protective relay' and the system that uses such equipment is termed as 'protection system'.

A protective relay is the device, which gives instruction to disconnect a faulty part of the system. This action ensures that the remaining system is still fed with power, and protects the system from further damage due to the fault. Hence, use of protective apparatus is very necessary in the electrical systems, which are expected to generate, transmit and distribute power with least interruptions and restoration time. It can be well recognized that use of protective equipment are very vital to minimize the effects of faults, which otherwise can kill the whole system.

1.2 Basic requirements of protection

A protection apparatus has three main functions/duties:

1. Safeguard the entire system to maintain continuity of supply
2. Minimize damage and repair costs where it senses fault
3. Ensure safety of personnel.

These requirements are necessary, firstly for early detection and localization of faults, and secondly for prompt removal of faulty equipment from service.

In order to carry out the above duties, protection must have the following qualities:

- *Selectivity*: To detect and isolate the faulty item only.
- *Stability*: To leave all healthy circuits intact to ensure continuity or supply.
- *Sensitivity*: To detect even the smallest fault, current or system abnormalities and operate correctly at its setting before the fault causes irreparable damage.
- *Speed*: To operate speedily when it is called upon to do so, thereby minimizing damage to the surroundings and ensuring safety to personnel.

To meet all of the above requirements, protection must be reliable which means it must be:

- *Dependable*: It *must* trip when called upon to do so.
- *Secure*: It must *not* trip when it is not supposed to.

1.3 Basic components of protection

Protection of any distribution system is a function of many elements and this manual gives a brief outline of various components that go in protecting a system. Following are the main components of protection.

- Fuse is the self-destructing one, which carries the currents in a power circuit continuously and sacrifices itself by blowing under abnormal conditions. These are normally independent *or* stand-alone protective components in an electrical system unlike a circuit breaker, which necessarily requires the support of external components.
- Accurate protection cannot be achieved without properly measuring the normal and abnormal conditions of a system. In electrical systems, voltage and current measurements give feedback on whether a system is healthy or not. Voltage transformers and current transformers measure these basic parameters and are capable of providing accurate measurement during fault conditions without failure.
- The measured values are converted into analog and/or digital signals and are made to operate the relays, which in turn isolate the circuits by opening the faulty circuits. In most of the cases, the relays provide two functions viz., alarm and trip, once the abnormality is noticed. The relays in olden days had very limited functions and were quite bulky. However, with advancement in digital technology and use of microprocessors, relays monitor various parameters, which give complete history of a system during both pre-fault and post-fault conditions.
- The opening of faulty circuits requires some time, which may be in milliseconds, which for a common day life could be insignificant. However, the circuit breakers, which are used to isolate the faulty circuits, are capable of

carrying these fault currents until the fault currents are totally cleared. The circuit breakers are the main isolating devices in a distribution system, which can be said to directly protect the system.

- The operation of relays and breakers require power sources, which shall not be affected by faults in the main distribution. Hence, the other component, which is vital in protective system, is batteries that are used to ensure uninterrupted power to relays and breaker coils.

The above items are extensively used in any protective system and their design requires careful study and selection for proper operation.

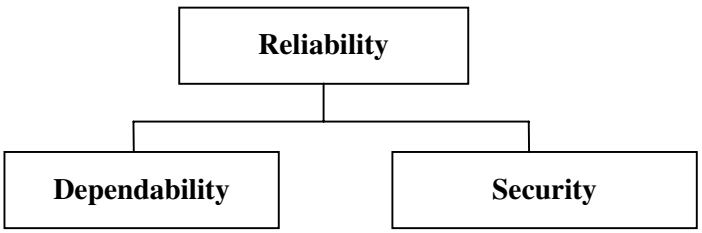
1.4 Summary

Power System Protection – Main Functions
1. To safeguard the entire system to maintain continuity of supply. 2. To minimize damage and repair costs. 3. To ensure safety of personnel.

Power System Protection – Basic Requirements
1. *Selectivity*: To detect and isolate the faulty item only. 2. *Stability*: To leave all healthy circuits intact to ensure continuity of supply. 3. *Speed*: To operate as fast as possible when called upon, to minimize damage, production downtime and ensure safety to personnel. 4. *Sensitivity*: To detect even the smallest fault, current or system abnormalities and operate correctly at its setting.

Power System Protection – Speed is Vital!!
The protective system should act fast to isolate faulty sections to prevent: • Increased damage at fault location. Fault energy = $I^2 \times R_f \times t$, where t is time in seconds. • Danger to the operating personnel (flashes due to high fault energy sustaining for a long time). • Danger of igniting combustible gas in hazardous areas, such as methane in coal mines which could cause horrendous disaster. • Increased probability of earth faults spreading to healthy phases. • Higher mechanical and thermal stressing of all items of plant carrying the fault current, particularly transformers whose windings suffer progressive and cumulative deterioration because of the enormous electromechanical forces caused by multi-phase faults proportional to the square of the fault current. Sustained voltage dips resulting in motor (and generator) instability leading to extensive shutdown at the plant concerned and possibly other nearby plants connected to the system.

Power System Protection – Qualities



1. *Dependability*: It MUST trip when called upon.
2. *Security*: It must NOT trip when not supposed to.

Power System Protection – Basic Components

1. *Voltage transformers and current transformers*: To monitor and give accurate feedback about the healthiness of a system.
2. *Relays*: To convert the signals from the monitoring devices, and give instructions to open a circuit under faulty conditions or to give alarms when the equipment being protected, is approaching towards possible destruction.
3. *Fuses*: Self-destructing to save the downstream equipment being protected.
4. *Circuit breakers*: These are used to make circuits carrying enormous currents, and also to break the circuit carrying the fault currents for a few cycles based on feedback from the relays.
5. *DC batteries*: These give uninterrupted power source to the relays and breakers that is independent of the main power source being protected.