Radial Feeder Protection

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What is a Feeder?

- Overhead lines or cables which are used to distribute the load to the customers. They interconnect the distribution substations
- This is an electrical supply line, either overhead or underground, which runs from the substation, through various paths, ending with the transformers. It is a distribution circuit, usually less than 69,000 volts, which carries power from the substation. with the loads.

Types of feeders

- Radial feeder
- Ring main feeder
- Parallel feeder

Radial feeder

- It has only one path between each customer and the substation.
- The power flows exclusively away from the substation and out to the customer along single path, which if interrupted results in complete loss of power to the customer.

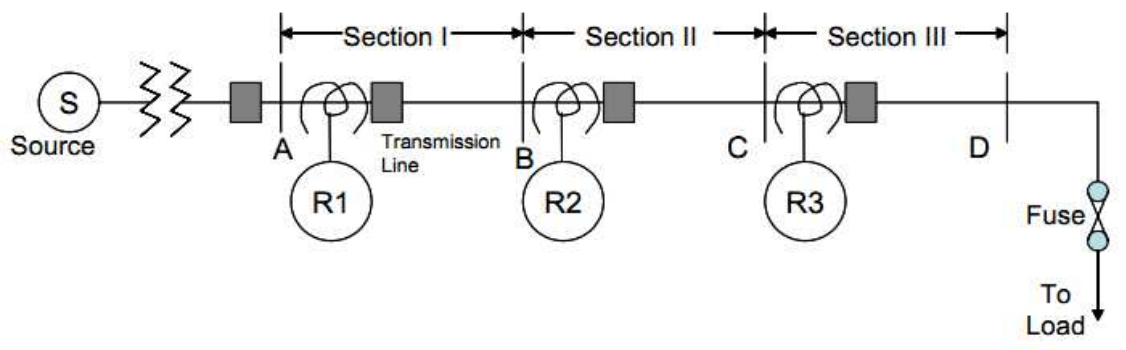


Fig. 1.1. A Typical Radial Transmission Line

Why Protection Is Important?

- The modern age has come to depend heavily upon continuous and reliable availability 0f electricity and a high quality of electricity too. Computer and telecommunication networks, railway networks, banking and continuous power industries are a few applications that just cannot function without highly reliable power source.
- No power system cannot be designed in such a way that they would never fail. So, protection is required for proper working.

Basic Requirements of Protection

- A protection apparatus has three main functions:
  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
- Protection must be reliable which means it must be:
  1. ***Dependable****: It must trip when called upon to do so.*
  2. ***Secure****: It must not trip when it is not supposed to.*

Basic Requirements of Protection

- These requirements are necessary for early detection and localization of faults and for prompt removal of faulty equipment from service.
  - ***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.

What Is Fault?

- A fault is defined as defect in electrical systems due to which current is directed away from its intended path.

- It is not practical to design and build electrical equipment or networks to eliminate the possibility of failure in service. It is therefore an everyday fact that different types of faults occur on electrical systems, however infrequently, and at random locations.

Classification of faults

- Faults can be broadly classified into two main areas which have been designated as
- Active faults
- Passive faults

Active Faults

- The ‘active’ fault is when actual current flows from one phase conductor to another (phase-to-phase), or alternatively from one phase conductor to earth.

- This type of fault can also be further classified into two areas
    - Solid Fault
    - Incipient Fault

Passive Faults

- Passive faults are not real faults in the true sense of the word, but are rather conditions that are stressing the system beyond its design capacity, so that ultimately active faults will occur. Typical examples are:
- Overloading leading to over heating of insulation
- *Overvoltage*
- *Under frequency*
- *Power swings*

Basic Fault Clearing Mechanism

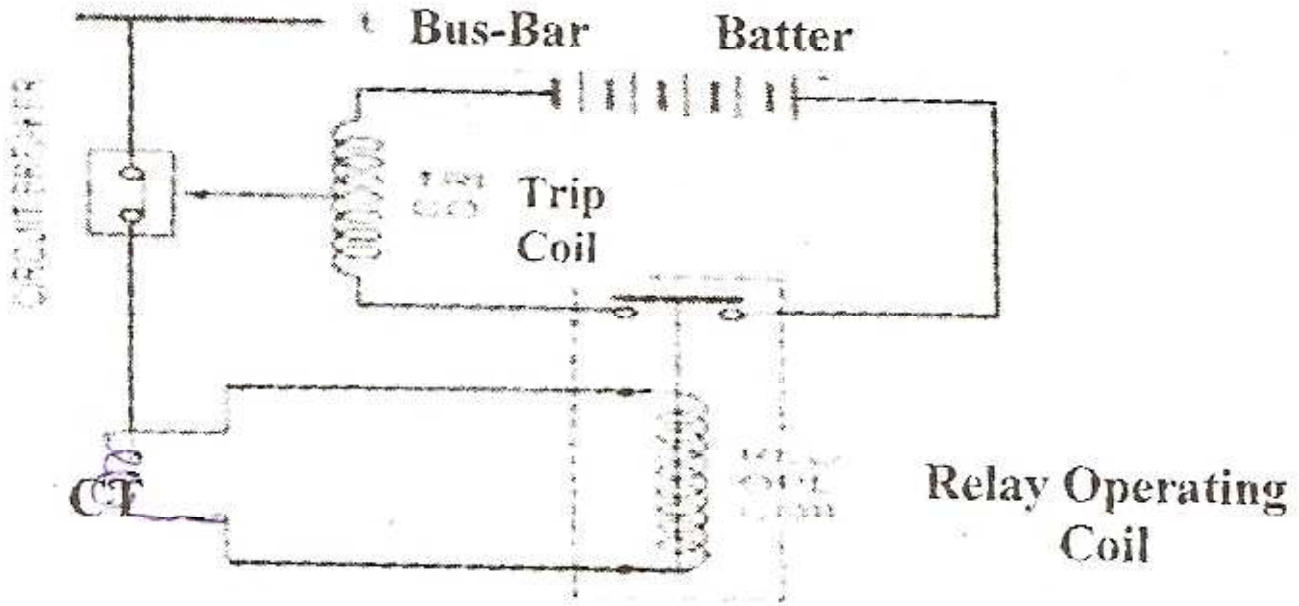


Figure 8.2 Typical Relay Circuit.

- The main requirement of line protection is

1. In the event of short circuit, the circuit breaker near to fault should open and all other circuit breakers remain in closed position.
2. If the circuit near to fault fail to trip, back up protection should be provided by the adjacent circuit breaker.
3. The relay operating should be the smallest possible in order to preserve system stability without unnecessary tripping of circuits.

Types of protection

- The need to analyze protection schemes has resulted in the development of protection coordination programs. Protection schemes can be divided into two major groupings:
- Unit schemes
- Non-unit schemes

Non unit type protection

- The non unit type protection system includes following schemes:
  - Time graded over current protection
  - Current graded over current protection
  - Distance or Impedance Protection

Over current protection

- This is the simplest of the ways to protect a line and therefore widely used.
- It owes its application from the fact that in the event of fault the current would increase to a value several times greater than maximum load current.
- It has a limitation that it can be applied only to simple and non costly equipments.

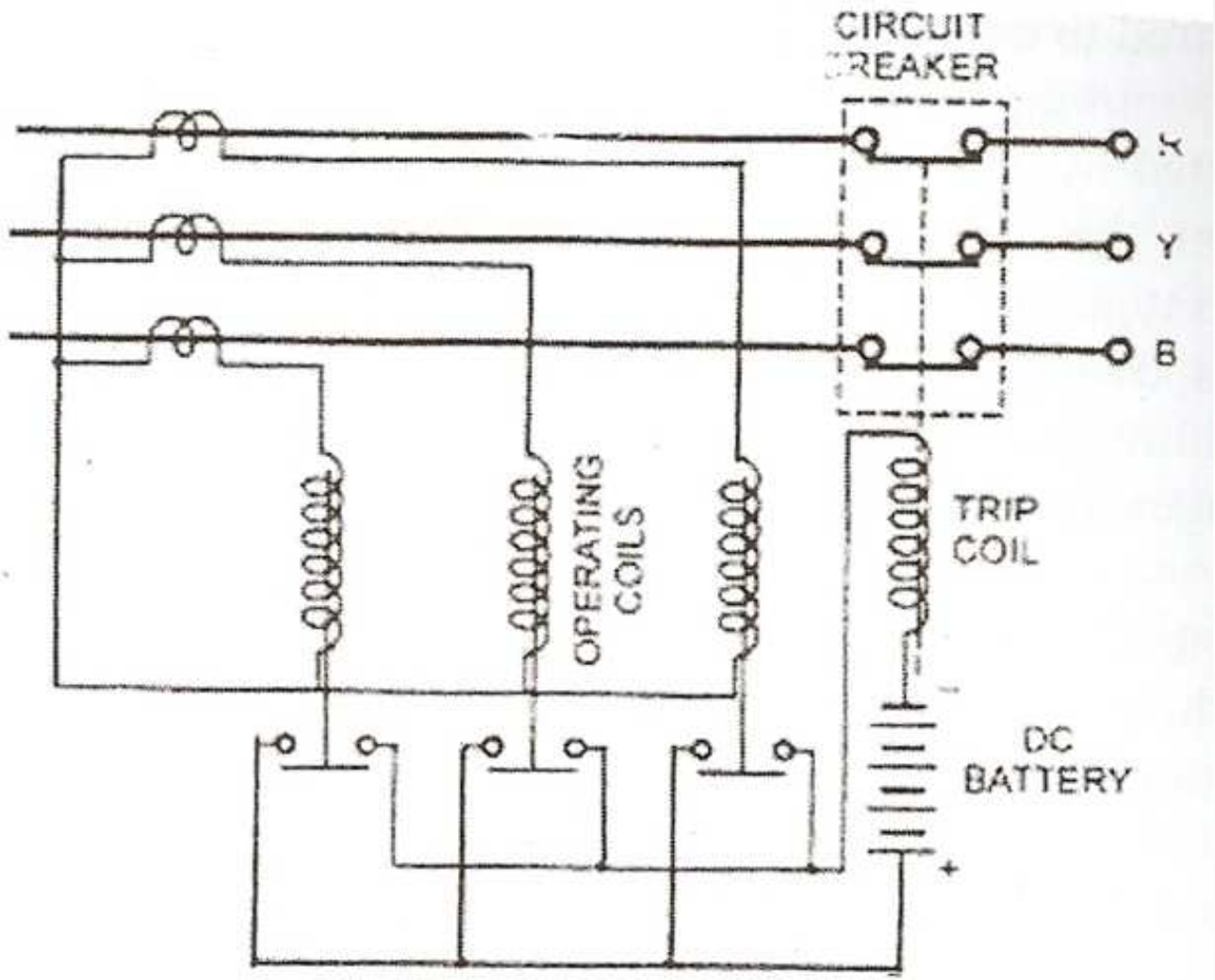


Figure 8.3 Overload Protection.

Earth fault protection

- The general practice is to employ a set of two or three over current relays and a separate over current relay for single line to ground fault. Separate earth fault relay provided makes earth fault protection faster and more sensitive.
- Earth fault current is always less than phase fault current in magnitude. Therefore, relay connected for earth fault protection is different from those for phase to phase fault protection.

Earth fault protection

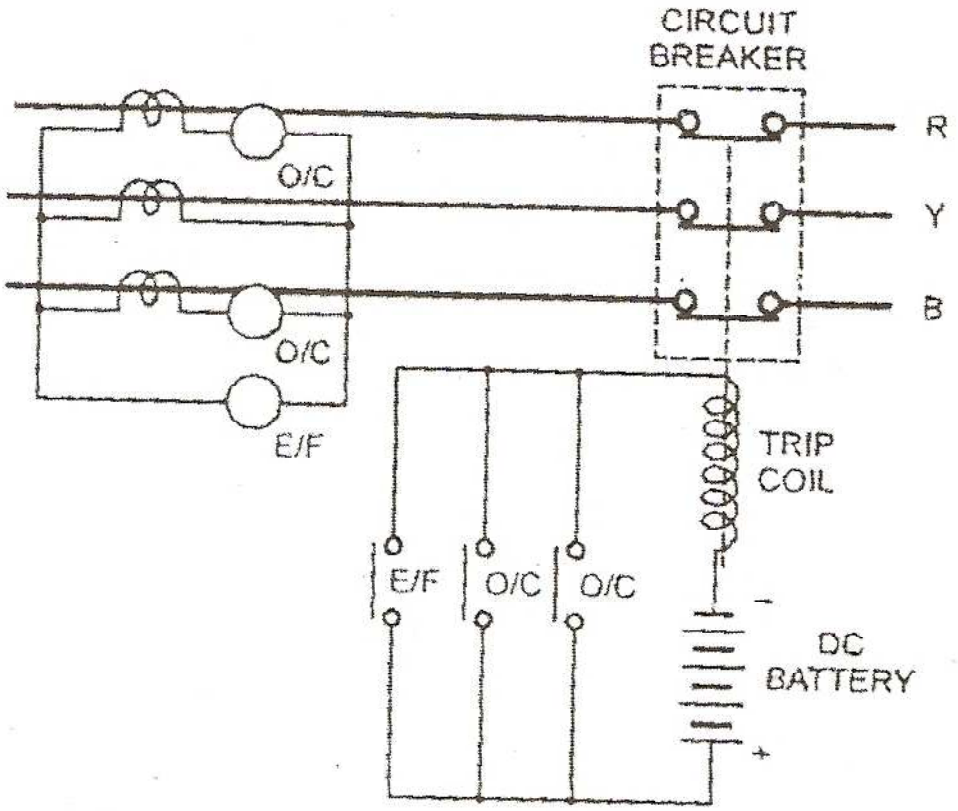


Figure 8.5 Over-current and Earth Fault Protection Scheme.

Time graded protection

- This is a scheme of over current protection is one in which time discrimination is incorporated. In other words, the time setting of the relays is so graded that minimum possible part of system is isolated in the event of fault.
- We are to discuss the application of the time graded protection on
  - Radial feeder

Protection of radial feeder

- The main characteristic of the radial feeder is that power can flow in one direction only from generator to supply end of the load line.
- In radial feeder number of feeders can be connected in series and it is desired that smallest part of the system should be off in the event of fault.
- This is achieved by time graded protection.
- In this system time setting time setting of a relay is so adjusted that farther the relay from the generating system lesser the time of operation.

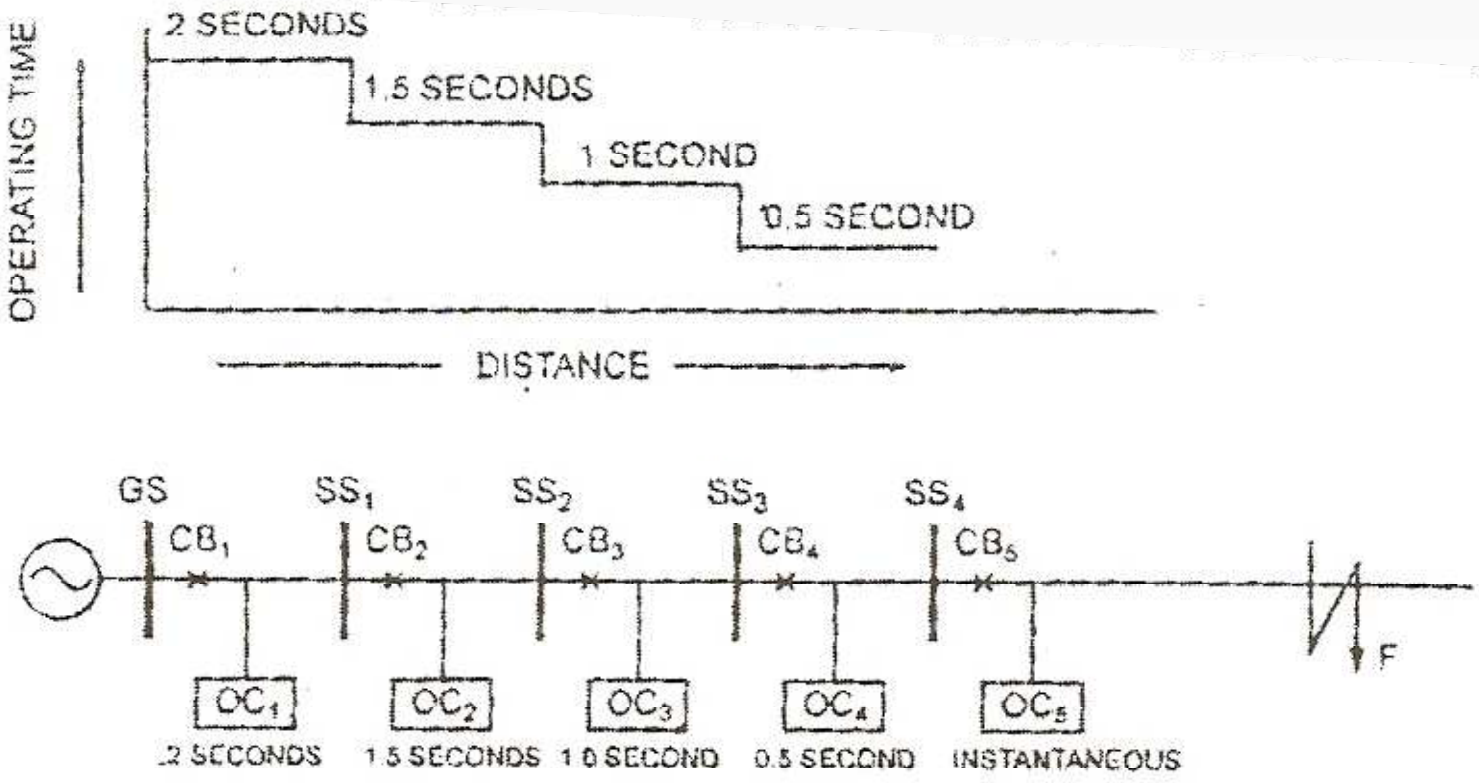


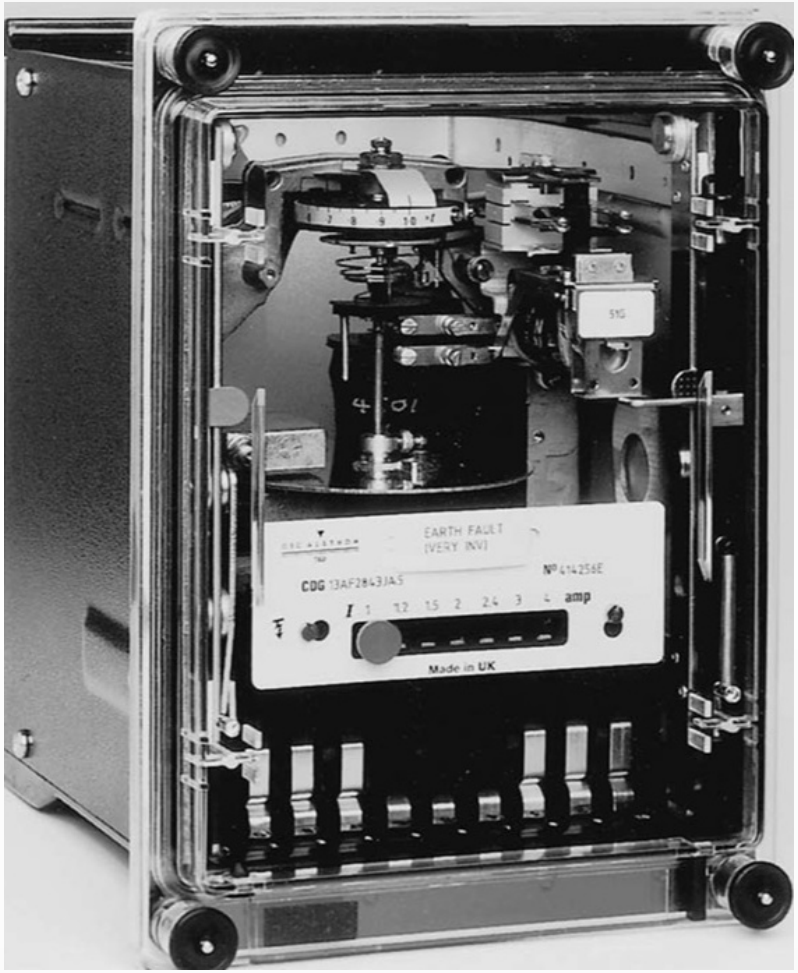
Figure 8.6 Time-Graded Protection for Radial Feeders.

Drawbacks of time graded protection

- The drawbacks of graded time lag over current protection are given below:
  - The continuity in the supply cannot be maintained at the load end in the event of fault.
  - Time lag is provided which is not desirable in on short circuits.
  - It is difficult to co-ordinate and requires changes with the addition of load.
  - It is not suitable for long distance transmission lines where rapid fault clearance is necessary for stability.

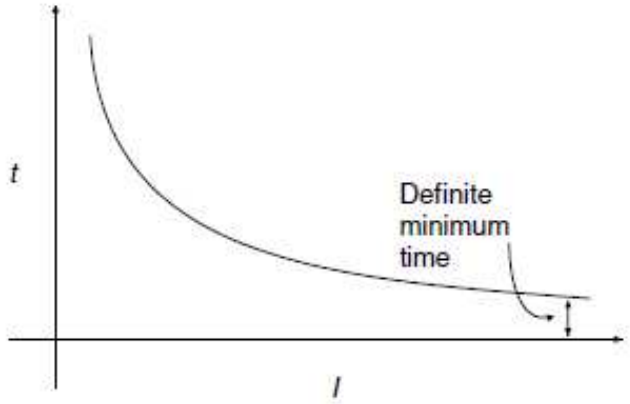
IDMT Relay

- In time graded protections IDMT (Inverse definite minimum time) relays are used.
- As the name implies, it is a relay monitoring the current, and has inverse characteristics with respect to the currents being monitored. This relay is without doubt one of the most popular relays used on medium- and low-voltage systems for many years, and modern digital relays' characteristics are still mainly based on the torque characteristic of this type of relay.



IDMT relay

It can be seen that the operating time of an IDMTL relay is inversely proportional to function of current, i.e. it has a long operating time at low multiples of setting current and a relatively short operating time at high multiples of setting current.



Current graded protection

- It is an alternative to time graded protection and is used when the impedance between two substations is sufficient.
- It is based on the fact that short circuit current along the length of protected length of the circuit decreases with increase in distance between the supply end and the fault point.
- If the relays are set to operate at a progressively higher current towards the supply end of the line then the drawback of the long time delays occurring in the graded time lag system can be partially overcome.

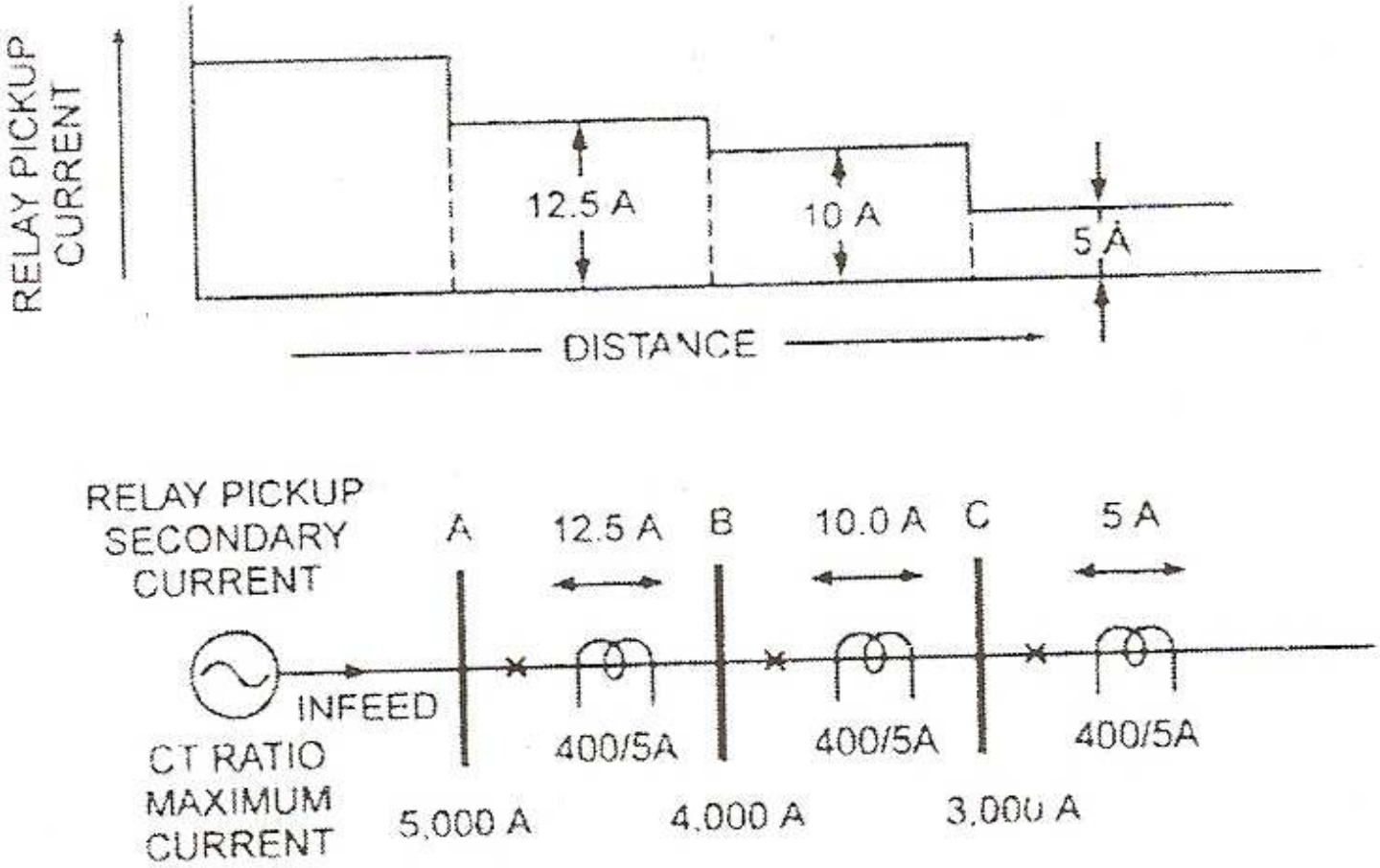
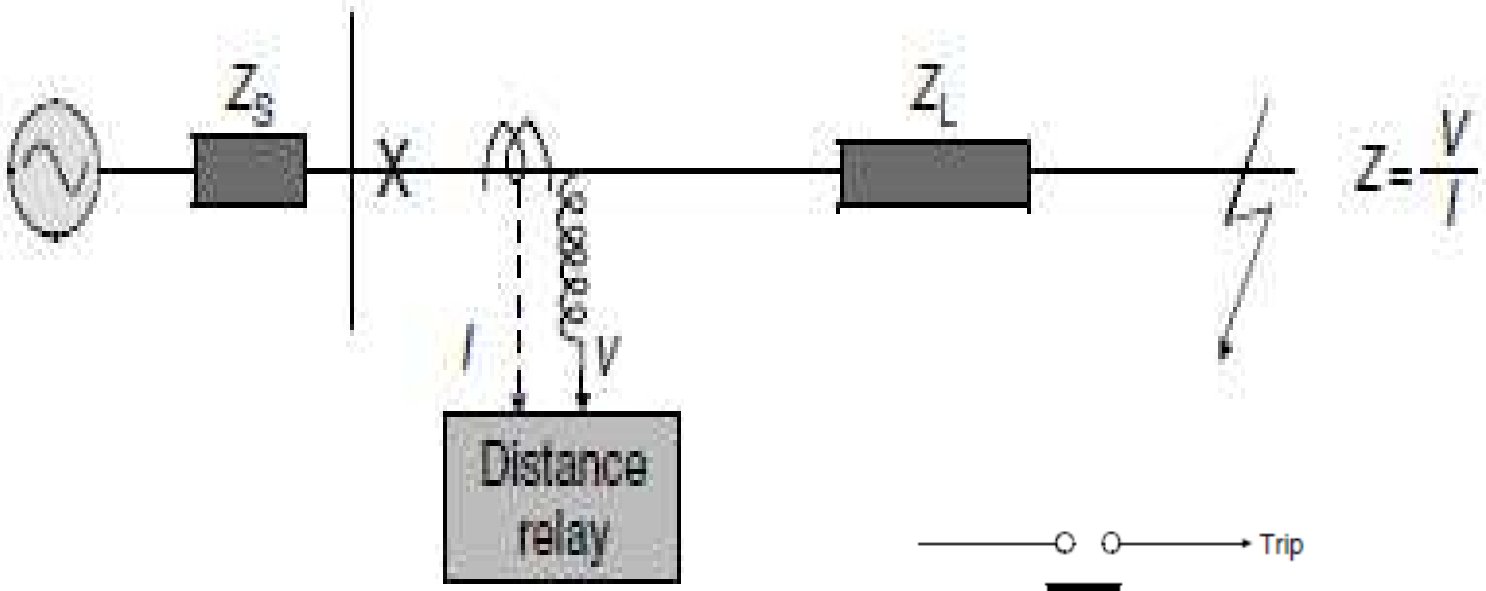


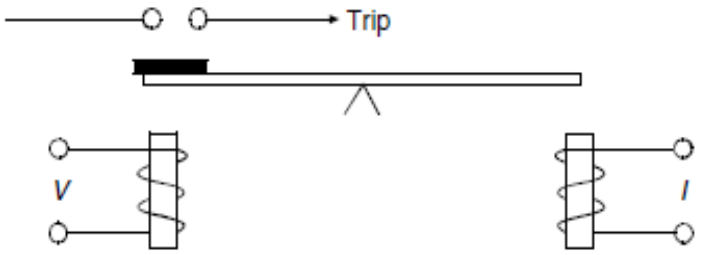
Figure 8.10 Current-Graded Protection Applied to a Radial Feeder.

DISTANCE OR IMPEDANCE PROTECTION

- A distance relay, as its name implies, has the ability to detect a fault within a pre-set distance along a transmission line or power cable from its location.
- **BASIC PRINCIPLE**

  The basic principle of distance protection involves the division of the voltage at the relaying point by the measured current. The apparent impedance so calculated is compared with the reach point impedance. If the measured impedance is less than the reach point impedance, it is assumed that a fault exists on the line between the relay and the reach point.





BASIC PRINCIPLE OPERATION OF IMPEDANCE RELAY

Three stepped distance protection

- **Zone 1**

  First step of distance protection is set to reach up to 80 to 90% of the length of the line section. This is instantaneous protection i.e. there is no intentional delay

- **Zone 2**

second zone is requires in order to provide primary protection to remaining 10 to 20% of the line and a cover up to 50% of the next line section. The operating time of this zone is delayed so as to be selective with zone 1.

Three stepped distance protection

- **Zone 3**

  The third zone is provided with an intention to give full back up to adjoining line section. It covers the line of the section, 100% of the next line section and reaches farther into the system. The motivation behind the extended reach of this step is to provide full back up to the next line section. Its operating time is slightly more than that of zone 2.

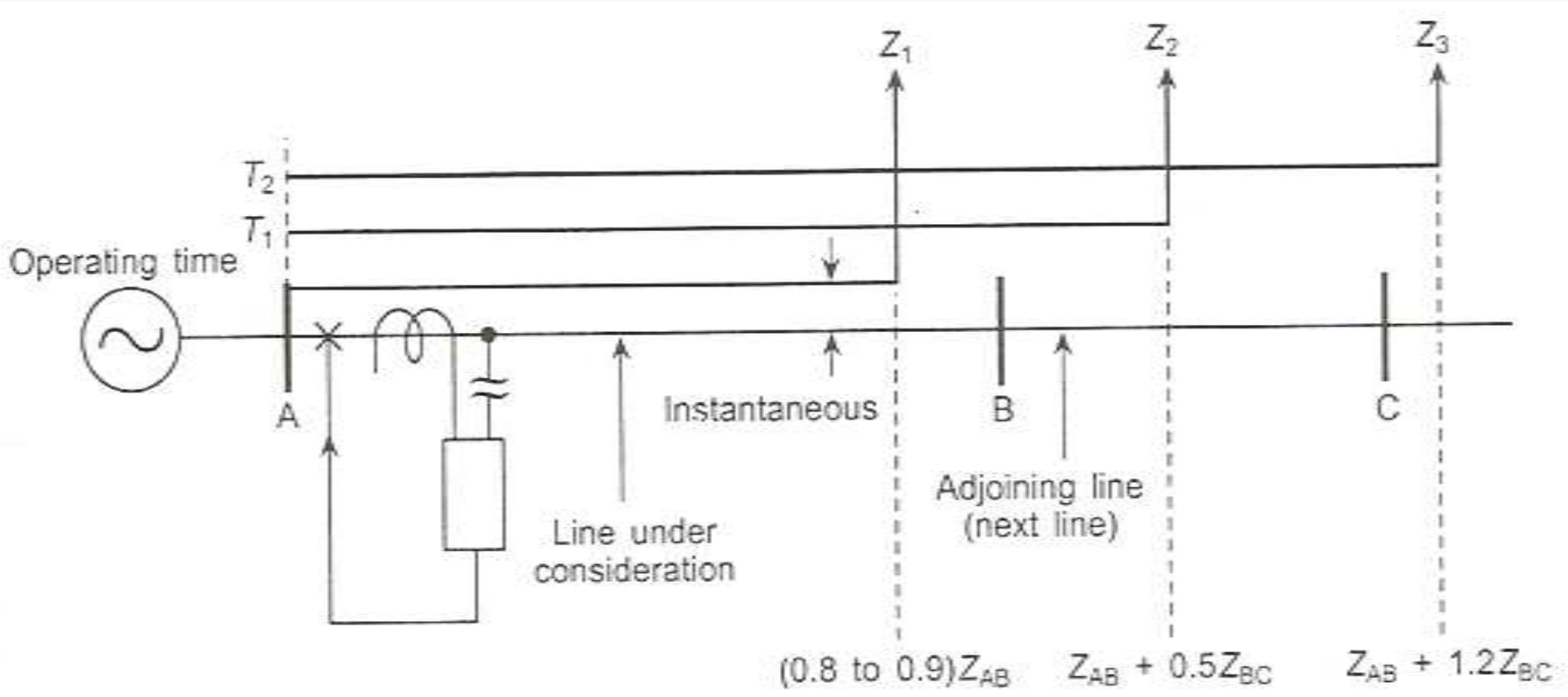


Figure 6.29(a) Three-stepped distance protection.

Figure 11.17 (a): First generation of static distance relay

Queries?