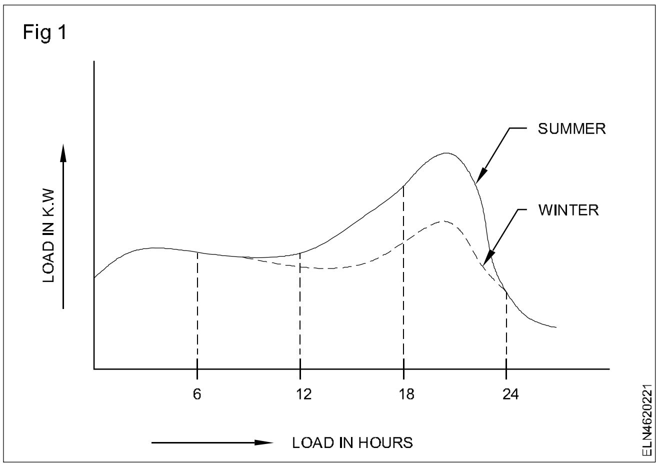


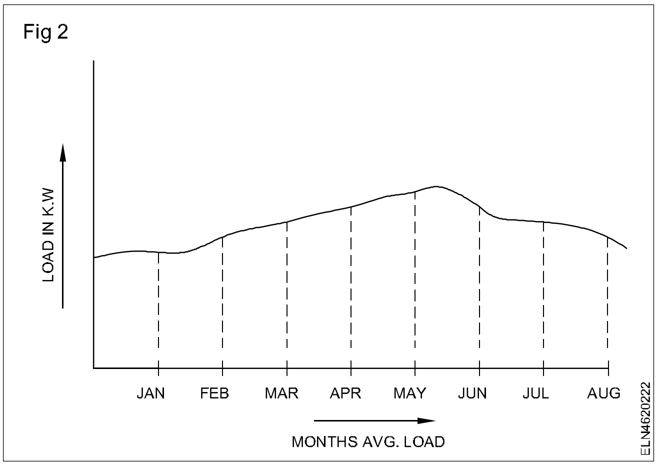

$$\text{Demand factor} = \frac{\text{Max. Demand}}{\text{Connected load}}$$

Usually it always less than one. The knowledge of demand factor is vital in determining the capacity of the plant equipment.

**Average demand**

It is the total demand in a month divided by number of days in that time period.

The average demand in a month taken to find the load requirement for a certain period is in Fig 2. It is evident that average load requirement is not uniform among all the months consumption as it depend on the environmental conditions; such as Winter, Summer, Monsoon seasons.




**Load factor**

In electrical engineering the load factor is defined as the total load divided by the peak load in specified time period. It is a measure of the utilization rate, or efficiency of electrical energy usage; a low load factor indicates that load is not putting a strain on the electric system, whereas consumers or generators that put more of a strain on the electric distribution will have a high load factor.

$$f_{Load} = \frac{\text{Total load}}{\text{Maximum load in given time period}} \text{ or } \frac{\text{Total load}}{\text{Peak load.}}$$

An example, using a large commercial electrical bill:

- peak demand = 436 KW
- use = 57 200 kWh
- number of days in billing cycle = 30

Hence:

- load factor = { 57 200 kWh/ (30 d x 24 hours per day x 436 kW) } x 100% = 18.22%

It can be derived from the load profile of the specific device or system. Its value is always less than one because maximum demand is always higher than average demand, since facilities likely never operate at full capacity for the duration of an entire 24 hours day. A high load factor means power usage is relatively constant. Low load factor shows that occasionally a high demand is set. To service that peak, capacity while remaining idle for long periods, thereby imposing higher costs on the system. Electrical rates are designed so that customers with high load factor are charged less over all per kWh.

The load factor is closely related to and often confused with demand factor.

$$f_{Demand} = \frac{\text{Maximum load in given time period}}{\text{Maximum possibe load}}$$

The major difference to note is that the denominator in the demand factor is fixed depending on the system. Because of thiss the demand factor cannot be derived from the load profile but needs the addition of the full load of the system in question.

**Diversity factor**

Diversity factor (Or simultaneity factor $K_S$) is a measure of the probability that a particular piece of equipment will turn on coincidentally to another piece of equipment. For aggregate system it is defined as the ratio of the sum of the individual non - coincident maximum loads of various sub divisions of the system to the maximum demand of the complete system.

$$\text{Diversity factor} = \frac{\text{Sum of individual max Demands}}{\text{Maximum Demand}}$$

The diversity factor is almost always larger than 1 since all components would have be on simultaneously at full load for it to be one. The aggregate load is time dependent as well being dependent upon equipment characteristics. The diversity factor recognizes that the whole loads does not equal the sum of its parts due to this time interdependence (i.e. diverseness). For example, we might have ten air conditioning units that are 20 tons each at a facility. We typically assume that the average full load equivalent operating hours for the units are 2000 hours per year. However, since tha units are each thermostatically controlled, we do not known exactly when each unit turns on. If the ten units are substantially bigger than the facility's actual peak A/C load, then fewer than all ten units will likely come on at once. Thus, even though each unit run a total of 2000 hours a year, they do not all come on at the same time to affect the facility's peak load. The diversity factor gives us a correction factor to use, which results in a lower total kW load for the ten A/C units. If energy balance we do for this facility comes out within reasons, but the demand balance shows far to many kW for the peak load, then we can use the diversity factor to bring the kW into line with facility's true peak load. The diversity factor does not affect the kWh; it only affects the kW.

**Plant utility factor**

The utility factor or use factor is the ratio of the time that a piece of equipment is in use to total time that it could be in use. If is often averaged over time in the definition such that the ratio becomes the amount of energy used divided by the maximum possible to be used. These definitions are equivalent.

The utility factor, $K_u$, is the ratio of the maximum load which could be drawn to rated capacity of the system. This is closely related to the concept of load factor. The factor is the ratio of the load that piece of equipment actually draws (time averaged) when it is in operation to the load it could draw (which we call full load.

$$\text{Utility Factor} = \frac{\text{Ratio of maximum power}}{\text{Plant capacity}} \times 100$$

For example, an oversized motor - 15 kW - drives a constant 12 kW load whenever it is on. The motor load factor is then 12/15 = 80%. The motor above may only be used for eight hours a day, 50 weeks a year, The hours of operation would then be 2800 hours, and the motor use factor for a base of 8760 hours per year would be 2800/ 8760 = 31.96%. With a base of 2800 hours per year, the motor use factor would be 100%.

In power plant utility factor various according to the demand on the plant from the electricity market.

# Line protective relays - types - operation

**Objectives:** At the end of this lesson you shall be able to
- **state the classification of relays**
- **list the types of relays and their uses**
- **explain the principle of operation of over current, differential, earth fault, distance and non directional relays**
- **state the characteristics of relays**
- **explain the principle of operation of a over voltage end under voltage relay**
- **state the necessity of time multiplier setting of relay.**

**Introduction**

The relays is the element that senses as abnormal condition in the circuit and commands the operation of the breaker. It interpret the fault quantities ie, CT output current and PT output voltage and sending the command to the tripping circuits of breaker for operation in accordance with the characteristic set in the relay and the value of the time multiplier setting.

**Classification of Relays**

**Relays are classified mainly in three categories; they are according to:**

1 **Quantity sensed :** Current, Voltage, active power, reactive power & impedance

2 **Tripping :** Instantaneous trip, delayed trip inverse time response and definite time

3 **Operating principle:** Electro magnetic relays, Induction relays, Thermal relays and static or digital relays

**Types or relays :** Various types of relays are used as per the requirement; they are:

1 Over current relay

2 Over voltage relay

3 Under voltage relay

4 Differential relay

5 Earth fault relay

6 Distance relay

7 Impedance relay

8 Admittance relay

9 Reactance relay

Relay is one of the main device used for switch gear protection networks to protect the transmission lines, transmission equipments and sub station equipments. The equipments used for transmission and in substation for distribution such as transformers, lightening arrestors,earth switches, isolators, CTs & PTs etc; are very costly and needs continuous protection from damage. Replacement or repairs are not easy and to provide an uninterrupted supply to consumers. So, protection of these devices/equipments are very essential

Reasons for over current, Over voltage and under voltage fault:

Many reasons constituted for over current, over and under voltage or earth faults; type of fault and the cause effect is listed in Table 1.

Table 1

| SI No | Type of Fault | Cause | Effect |
|---|---|---|---|
| 1 | Phase to neutral short | - Insulation failure<br>- Components failure<br>- Human error | - High current flow in line.<br>- Fire |
| 2 | Phase to phase short in transmission lines | - Tree branches falls on line<br>- Snakes crossing on tower lines and<br>- Birds falls<br>- Strong winds<br>- Natural calamities<br>- Riots, and human made faults | - Very high current flows<br>- Fire<br>- Extensive damage of equipments |
| 3 | Phase to ground fault | - Insulation failure<br>- Component failure | - High current flow in line<br>- Fire<br>- Low voltage |

| Sl No | Type of Fault | Cause | Effect |
|---|---|---|---|
| 4 | Lightening storm etc; | - Natural calamities | - Very high current flows<br>- Fire<br>- High voltage spikes |
| 5 | Sudden removel of heavy load | - Fuse failure | - High voltage |
| 6 | Increasing Load beyond the rated level | - Human Error | - Low voltage in line<br>- Over loading the line |

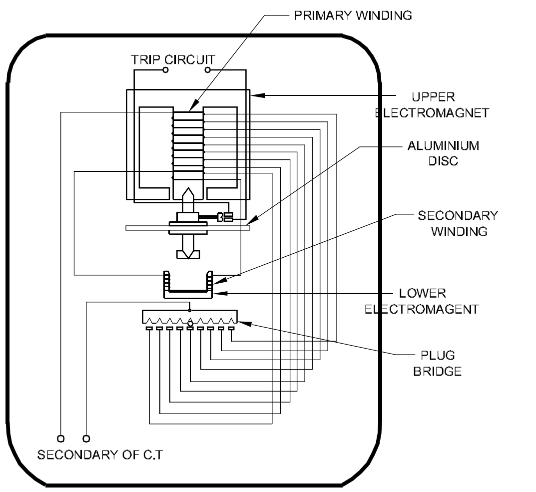
**Sensors used for Relays**

The relay cannot accept the total line voltage or load current. A small part of the electrical quantity is supplied to the relay through sensors. A current transformer popularly known as CT and a potential transformer PT, is serves the purpose of sensors in current relay and voltage relay. Various input and output ratios are in practice to supply the sensing quantity to the relays according to the load conditions.

**Working principle of current relay**

The electro magnetic relay widely using in the substation and transmission lines are serves the protection from the disaster conditions. The latest version of modern static or digital relays are now a days out dated the conventional electro magnetic relays, because of their many of advancements compare to electro magnetic relay. (Fig 1)

Fig 1




INDUCTION TYPE NON-DIRECTIONAL OVERCURRENT RELAY

Fig 2 shows the front panel setting of a electric magnetic relay.

Fig 2


1 Time multiplier setting (TMS)

2 Trip flag

3 Aluminium rotating disc

4 Percentage fault quantity time reference dial

5 Tap setting plug

6 Input fault quantity ($V_{ONI}$)

7 Contact plug terminals

An induction type over current relay giving inverse time operation with a definite minimum time characteristic is in Fig 1. It consists essentially of an ac energy meter mechanism with slight modification to give required characteristics. The relay has two electromagnets. The upper electromagnet has two windings, one of these is primary and is connected to the secondary of a CT in the line to be protected and is tapped at intervals.

The tappings are connected to a plug setting bridge by which the number of turns in use can be adjusted, thereby giving the desired current setting. The plug bridge is usually arranged to give seven sections of tappings to give over current range from 50% to 200% in steps of 25%. If the relay is required to response for earth fault the steps are arranged to give a range from 10% to 70% or 20 to 80% in steps of 10%. The values assigned to each tap are expressed in terms of percentage of full-load rating of CT with which the relay is associated and represents the value above which the disc commences to rotate and finally closes the trip circuit.

Thus pick-up current equals the rated secondary current of CT multiplied by current setting. For example suppose