JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE	Jaipur Engineering college and research centre, Shri Ram ki Nangal, via Sitapura RIICO Jaipur- 302 022.	**Academic year- 2020-21**

DEPARTMENT OF ELECTRICAL ENGINEERING

Syllabus
Power System Protection

III Year - VI Semester: B. Tech. (Electrical Engineering)

1. Introduction: Objective, scope and outcome of the course.

2. Introduction and Components of a Protection System: Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers.

3. Faults and Over-Current Protection: Review of Fault Analysis, Sequence Networks. Introduction to over current Protection and over current relay co-ordination.

4. Equipment Protection Schemes: Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes.

5. Digital Protection: Computer-aided protection, Fourier analysis and estimation of Phasors from DFT. Sampling, aliasing issues.

6. Modeling and Simulation of Protection Schemes: CT/PT modeling and standards, Simulation of transients using Electro-Magnetic Transients (EMT) programs. Relay Testing.

7. System Protection: Effect of Power Swings on Distance Relaying. System Protection Schemes. Under-frequency, under-voltage and df/dt relays, Out-of- step protection, Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems.

Power System Protection
Lecture Notes
Unit -II

A good electric power system should ensure the availability of electrical power without any interruption to every load connected to it. Generally power is transmitted through high voltage transmission line and lines are exposed, there may be chances of their breakdown due to storms, falling of external objects, and damage to the insulators etc. These can result not only mechanical damage but also in an electrical fault.

Protective relays and relaying systems detect abnormal conditions like faults in electrical circuits and automatically operate the switchgear to isolate faulty equipment from the system as quick as possible. This limits the damage at the fault location and prevents the effects of the fault spreading into the system. The switch gear must be capable of interrupting both normal currents as well as fault current. The protective relay on the other hand must be able to recognize an abnormal condition in the power system and take suitable steps so that there will be least possible disturbance to normal operation. Relay does not prevent the appearance of faults. It can take action only after the fault has occurred. However, there are some devices which can anticipate and prevent major faults. For example, Buchholz relay is capable of detecting the gas accumulation produced by an incipient fault in a transformer.

Nature and causes of faults The nature of fault simply implies any abnormal condition which causes a reduction in the basic insulation strength between phase conductors, between phase conductor and earth or any earth screen surrounding the conductors. The reduction of the insulation is not considered as a fault until it produces some effect on the system i.e. until it results either in an excess current or in the reduction of the impedance between the conductors, between the conductor and earth to a value below the lowest load impedance normal to the circuit.

Power systems mainly consist of generator; switch gear, transformer and distribution system. The probability of failure is more on the power system due to their greater length and exposure to atmosphere.

(a) Breakdown at normal voltage may occur on account of:

(i) The deterioration of insulation

(ii) Damage due to unpredictable causes such as perching of birds, accidental short circuiting by snakes, tree branches, etc.

(b) Breakdown may occur because of abnormal voltages: This may happen because of

(i) switching surges

(ii) surges caused by lightning

The present practice is to provide a high insulation level of the order 3 to 5 times the normal voltage, but still:

(i) The pollution on an insulator string caused by deposited soot or cement dust in industrial area.

(ii) Salt deposited wind borne see spray in coastal area. These will initially lower the insulation resistances and causes a small leakage current to be diverted, thus hastening the deterioration.

Secondly, even if the insulation is enclosed, such as sheathed and armoured, the deterioration of the insulation occurs because of: (a) Ageing (b) Void formation in the insulation compound of underground cable due to unequal expansion and contractions caused by the rise and fall of temperature.

Thirdly, insulation may be subjected to transient over voltages because of switching operation.

The voltage which rises at a rapid rate may achieve a peak value which approaches three times phase to neutral voltages. • Lightning produces very high voltage surges in the power system in the order of million volts. These surges travel with the velocity of light in the power circuit. The limiting factors are the surge impedance and the line resistance.

Essential Qualities of Protection

Every protective system which isolates a faulty element must satisfy four basic requirements:

1. Reliability

2. Selectivity

3. Fastness of operation

4. Discrimination.

Reliability : Reliability is a qualitative term. It can be expressed as a probability of failure.

• Quality of personnel mistakes by personnel are most likely causes of failure.

• High contact pressure.

• Dust free enclosures Records show that the order of likelihood of failure is relays, breakers, wiring, current transformers, voltage transformers and battery. When relays using transistors are considered, the failure rate goes up still further.

Selectivity: The property by which only the faulty element of the system is isolated and the remaining healthy sections are left intact. Selectivity is absolute if the protection responds only to faults within its own zone and relative if it is obtained by grading the setting of protections of several zones which may respond to a given fault. The systems of protection which in principle are absolutely selective are known as unit system. The systems which selectivity is relative are non unit system.

Fastness of Operation: Protective relays are required to be quick acting due to the following reasons:

(a) Critical clearing time should not be exceeded.

(b) Electrical apparatus may be damaged, if they are made to carry fault currents for a long time.

(c) A persistent fault will lower the voltage resulting in crawling and overloading of industrial drives.

Discrimination:

• Protection must be sufficiently sensitive to operate reliably under minimum fault condition for a fault within its own zone while remaining stable under maximum load i.e. a relay should be able to distinguish between a fault and an overload.

- In the case of transformers, the inrush of magnetising current may be comparable to the full current, being 5 to 7 times the full load current. The relay should not operate for inrush current.

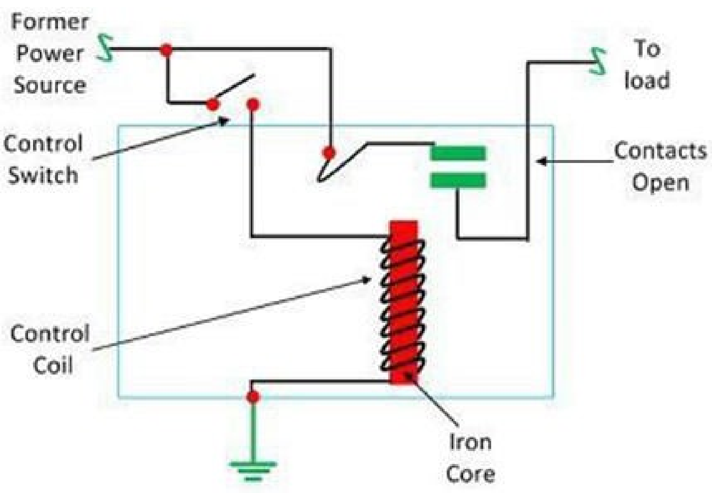
- In interconnected systems, there will be power swing, which should also be ignored by the relay.

Protective Relay

Definition: A protective relay is a device that detects the fault and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system. The relays detect the abnormal conditions in the electrical circuits by constantly measuring the electrical quantities which are different under normal and fault conditions. The electrical quantity which may change under fault conditions are voltage, current, frequency and phase angle, thus protects the system from damage.

Working Principle of Relay

It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energises the electromagnetic field which produces the temporary magnetic field.



This magnetic field moves the relay armature for opening or closing the connections. The small power relay has only one contacts, and the high power relay has two contacts for opening the switch.

The inner section of the relay is shown in the figure. It has an iron core which is wound by a control coil. The power supply is given to the coil through the contacts of the load and the control switch. The current flows through the coil produces the magnetic field around it.

Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Hence close the circuit, which makes the current flow through the load. If the contact is already closed, then it moves oppositely and hence open the contacts.

Construction of Relay

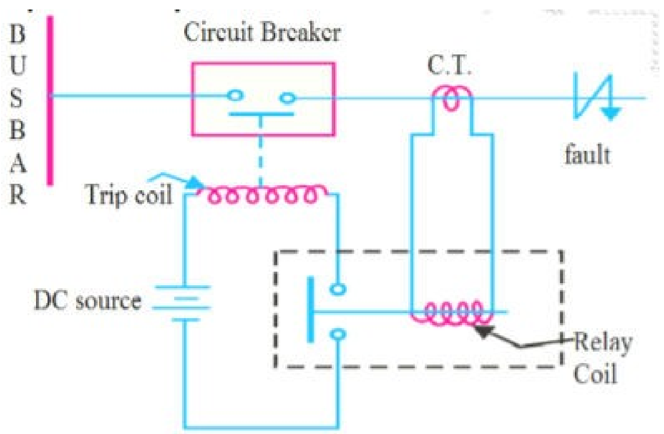
The relay operates both electrically and mechanically. It consists electromagnetic and sets of contacts which perform the operation of the switching. The construction of relay is mainly classified into four groups. They are the contacts, bearings, electromechanical design, terminations and housing.

Contacts – The contacts are the most important part of the relay that affects the reliability. The good contact gives limited contact resistance and reduced contact wear. The selection of the contact material depends upon the several factors like nature of the current to be interrupted, the magnitude of the current to be interrupted, frequency and voltage of operation.

Bearing – The bearing may be a single ball, multi-ball, pivot-ball and jewel bearing. The single ball bearing is used for high sensitivity and low friction. The multi-ball bearing provides low friction and greater resistance to shock.

Electromechanical design – The electromechanical design includes the design of the magnetic circuit and the mechanical attachment of core, yoke and armature. The reluctance of the magnetic path is kept minimum for making the circuit more efficient. The electromagnet is made up of soft iron, and the coil current is usually restricted to 5A and the coil voltage to 220V.

Terminations and Housing – The assembly of an armature with the magnet and the base is made with the help of spring. The spring is insulated from the armature by molded blocks which provide dimensional stability. The fixed contacts are usually spot welded on the terminal link.



(i) First part is the primary winding of a current transformer (C.T.) which is connected in series with the line to be protected.

(ii) Second part consists of secondary winding of C.T. and the relay operating coil. The relay coil makes the trip circuit when it is energized sufficiently high to drag the arm to close the contacts of the trip circuit

(iii) Third part is the tripping circuit which may be either a.c. or d.c. It consists of a source of supply, the trip coil of the circuit breaker and the relay stationary contacts.

Basic requirements of protective relaying: The following requirements must be considered while designing the protective relaying to protect the power system components. They are (SSSRSE):

a. Speed: protective relaying should disconnect a faulty element as quickly as possible. That results in

- To improve power system stability.
- To decrease the amount of damage incurred.
- Decrease the total outage time for power consumers.
- Decreases the development of additional faults due to one fault.
- Permits rapid re-closure of CB to restore service to customers.

b. Selectivity: It is the ability of the protective system to detect the point at which the fault occurs and selects the nearest circuit breaker to clear the fault with minimum or no damage to the system. This selectivity led to division of power system into protective zones where minimum part of the system is disconnected while interrupting the fault. The system is mainly divided into the following protective zones: i. Generators or generator transformer units. ii. Transformers iii. Bus bars iv. Transmission lines v. Distribution circuits.

c. Sensitivity: It is the capability of the relaying to operate reliably under the actual conditions that produce the least operating tendency. It is desirable to have the protection as sensitive as possible in order that it shall operate for low values of actuation quantity. The complexity in circuitry increases as the sensitivity increases.

d. Reliability: The protective relaying must be ready to function correctly and efficiently in operation at all times under any kind of fault and abnormal conditions of the power system for which it has been designed.

e. Simplicity: The main factor influencing the protective relaying are – • Good quality of relay. • Correctness of design. • Installation • Maintenance and supervision If these factors of protective scheme are maintained simpler, less number of CBs, Relays, CTs, PTs, etc can be adopted and hence improving the reliability. Simpler the protective scheme grater is the reliability.

f. Economy: Cost is the main consideration in designing and installing a power system. And too much protection is too bad. If we reduce the protection at undesired areas the cost can be reduced.

Types of protection: Power system is divided into various zones of protection, if fault occurs at a particular zone; it is the duty of the relays and CBs to isolate the faulty section Protective relaying is classified into two. They are (a) primary protection and (b) Backup protection.

Primary protection: It is the first line of defense. They clear the faults in the protected section as fast as possible, as the CTs, PTs and CBs may not be 100% reliable and so sometimes they fail to clear the fault that leads to the damage of the power system equipments and instability in power system. To avoid this we require some backup to protect the system and maintain the stability.

Backup protection: It is the second line of defense which comes into action if the primary protection fails. They cover not only the local section but also the next section. There are three types of back up protection they are

(a) Remote Backup
(b) Relay Backup &
(c) Breaker Backup.

(a) Remote backup: it is the cheapest and simplest form of backup. They are located at neighboring station and backup the entire primary protective scheme (relay, CT, PT, and CB etc). They are widely used backup for transmission lines.

(b) Relay back up: it is a kind of local backup. Additional relay is provided for backup that trips the same CB if primary relay fails. This operation takes place without delay. The principles of operation are selected that are different from those of primary; they are activated using separate CTs and PTs. They are costlier and they are used where remote backup is not possible.

(c) Breaker back up: it is also a kind of local back up where number of CBs connected are more i.e., mainly Bus-bar system. When primary relay activates but the CB fails the fault is treated as Busbar fault. So, all the CBs on that Bus-bar should trip. If proper CB doesn't open n specified time after the trip coil is energized, after some time delay the main relay closes the contacts of the backup relay resulting in opening of all other CBs.

Relay Terminology:

Plug Setting Multiplier (PSM): It is the ratio of fault current in the relay coil to the pickup current.

$$\text{PSM} = \frac{Fault\ Current\ in\ Relay\ Coil}{Pick\ up\ value\ of\ current}$$

$$\text{PSM} = \frac{Fault\ Current\ in\ Relay\ Coil}{Rated\ secondary\ current\ X\ Current\ setting}$$

Time setting Multiplier (TSM): adjusting the time of operation of the relay using time setting dial is called time setting multiplier. The dial is calibrated in steps; these values are multipliers to be used to convert the time curve into the actual operating time.

Classification of Relays:

Based on the construction and principle of operation:

1. **Electromagnetic relays.** They are activated by A.C. or D.C. quantities.
2. **Electro-thermal relays.** Thermal protection using Bi-metallic strip.
3. **Static relays.** use solid state devices for their operation.
4. **Microprocessor based relays.** Use VLSI technology.

Based on their application:

1. **Over current relays.** Operate when the activating quantity (current) rises above a specified value.
2. **Under voltage relay.** Operates when the activating quantity (voltage) falls below a specified value.
3. **Distance relays.** Its operation depends upon ratio.
4. **Differential relays.** Its operation depends upon comparison of two or more electrical quantities.
5. **Directional relays.**
6. **Under frequency relays.**

Based on time of operation:

1. **Instantaneous relays.** Operation takes place after a small interval of time that is negligible.
2. **Definite time relays.** Its operation is independent of magnitude of activating quantity.
3. **Inverse time relays.** Their time of operation is inversely proportional to the magnitude of the activating quantity.

Instruments Transformers

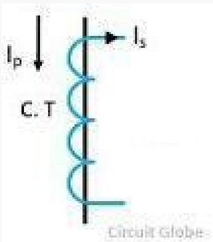
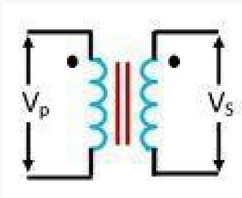
Current Transformer (CT) & Potential Transformer (PT)

The electrical instruments are not directly connected to the meters or control apparatus of high voltage for safety purpose. The instrument transformers like voltage transformer and current transformer are used for connecting the electrical instruments to the measuring instruments. These transformers reduce the voltage and current from high value to the low value which can be measured by conventional instruments.

The construction of the current and potential transformer is similar as both have the magnetic circuit in their primary and secondary winding. But they are different in the method of working. There are several types of differences between the voltage and the current transformer.

One of the major difference between them is that the current transformer converts the high value of current into low value whereas the potential or voltage transformer converts the high value of voltages into low voltage. Some other differences between the current and the potential transformer are explained below in the comparison chart.

Comparison Chart

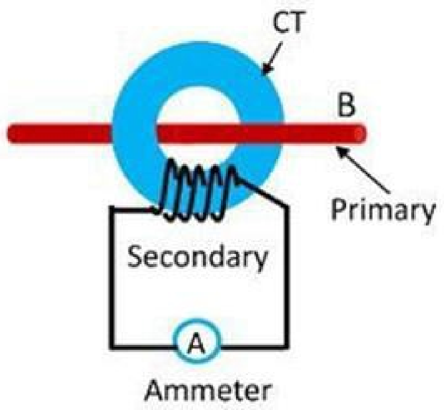
Basis for Comparison	**Current Transformer**	**Potential Transformer**
Definition	Transform the current from high value to the low value.	Transform the voltage from high value to the low value.
Circuit Symbol		
Core	Usually built up with lamination of silicon steel.	It is made up of with high quality steel operating at low flux densities

Primary Winding	It carries the current which is to be measured	It carries the voltage which is to be measured.
Secondary Winding	It is connected to the current winding of the instrument.	It is connected to the meter or instrument.
Connection	Connected in series with the instrument	Connected in parallel with the instrument.
Primary Circuit	Has a small number of turns	Has a large number of turns
Secondary	Has a large number of turns and	Has a small number of turns
Basis for Comparison	**Current Transformer**	**Potential Transformer**
Circuit	cannot be open circuit.	and can be open circuit.
Range	5A or 1A	110v
Transformation Ratio	High	Low
Burden	Does not depends on secondary burden	Depends on the secondary burden
Input	Constant current	Constant Voltage
Full line current	The primary winding consists the full line current.	The primary winding consists the full line voltage.
Types	Two types (Wound and Closed Core)	Two types (Electromagnetic and Capacitor voltage)

Impedance	Low	High
Applications	Measuring current and power, monitoring the power grid operation, for operating protective relay,	Measurement, power source, operating protective relay,

Definition of Current Transformer

A current transformer is a device which is used for the transformation of current at a higher value to a lower value with respect to the earth potential. It is used with the AC instruments for measuring the high value of current.

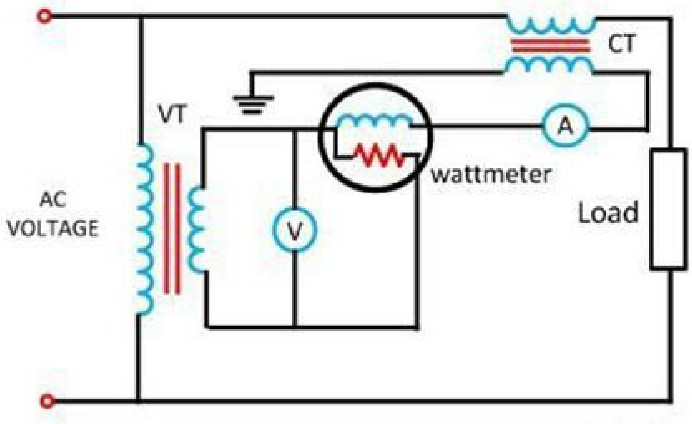


The line current is too high, and it is very difficult to measure them directly. Thus, the current transformer is used which decrease the high value of current into a fractional value which is easy to measure by the instrument.

The primary of the current transformer is connected directly to the line whose value is to measure. The secondary of the current transformer is connected to the ammeter or meter which measured the line value regarding fractions.

Definition of Potential Transformer

A voltage transformer is the type of instrument transformer which is used for the transformation of the voltage from a higher value to a lower value.



The primary terminal of the potential transformer is connected to the line for measuring the line voltage. The potential transformer reduced the high value of voltage into the small value which can easily be measured by the voltmeter or meter.

Differences between Current and Potential Transformer

1. The current transformer transforms the high value of current into the low value so that it can conveniently measure by the instrument whereas the potential transformer converts the high value of voltage into low value.
2. The primary winding of the current transformer is connected in series with the transmission line whose current is to be measured whereas the potential transformer is connected in parallel with the line.
3. The core of the current transformer is built up with the laminations of the stainless steel. The core of the potential transformer is made up with high operating core operating at low flux densities.
4. The primary winding of the current transformer carries the current which is to be measured whereas the primary of the potential transformer carries the voltage.
5. The primary winding of the current transformers has a small number of turns, whereas in potential transformer the primary winding has a large number of turns.
6. The secondary of the current transformer has a large number of turns, and it cannot be open circuited when it is under the services. The secondary winding of the potential transformer has a small number of turns, and it can be open circuit during the services.
7. The normal range of the current transformer for measuring the current is 5A or 1A whereas the standard voltage at the secondary winding of the

potential transformer is up to 110V.

8. The transformation ratio of the current transformer is always remained high, whereas for the potential transformer its remains low.
9. The input of the current transformer is the constant current, whereas the input of the potential transformer is the constant voltage.
10. The primary winding of the current transformer does not depend on the burden of the secondary winding of the transformer; it depends on the current flows in the primary windings whereas the primary of the potential transformer depends on the burden of the secondary winding.
11. The primary winding of the current transformer is directly connected to the full line current whose current is to be measured whereas in potential transformer the full line voltage is directly connected to the primary terminal.
12. The impedance of the primary winding of the transformer is very low as compared to the secondary winding whereas in a potential transformer, the impedance of the primary winding is high.
13. The current transformer is mainly used for measuring such magnitude of current that the meter or instrument cannot conveniently be measured whereas the potential transformer is used for measuring the high voltage of the current.

What is Circuit Breaker?

An electrical circuit breaker is a switching device which can be operated manually and automatically for controlling and protecting an electrical power system. As the modern power system deals with huge currents, special attention should be given during designing of a circuit breaker to ensure it is able to safely interrupt the arc produced during the closing of a circuit breaker. This was the basic definition of circuit breaker.

Introduction to Circuit Breaker

The modern power system deals with huge power network and huge numbers of associated electrical equipment. During a short circuit fault or any other type of electrical fault (such as electric cable faults), a high fault current will flow through this equipment as well as the power network itself. This high current may damage the equipment and networks permanently.
For saving these pieces of equipment and the power networks, the fault current should be cleared from the system as quickly as possible. Again after the fault is removed, the system must come to its normal working condition as soon as possible for supplying reliable quality power to the receiving ends. In addition

to that for proper controlling of the power system, different switching operations are required to be performed.

So for timely disconnecting and reconnecting different parts of power system network for protection and control, there must be some special type of switching devices which can be operated safely under huge current carrying condition.
During the interruption of large current, there would be large arcing in between switching contacts, so care should be taken to quench these arcs in circuit breaker in a safe manner. The circuit breaker is the special device which does all the required switching operations during current carrying condition. This was the basic introduction to circuit breaker.

Working Principle of Circuit Breaker

The circuit breaker mainly consists of fixed contacts and moving contacts. In normal “ON” condition of the circuit breaker, these two contacts are physically connected to each other due to applied mechanical pressure on the moving contacts. There is an arrangement stored potential energy in the operating mechanism of circuit breaker which is released if the switching signal is given to the breaker.
The potential energy can be stored in the circuit breaker by different ways like by deforming metal spring, by compressed air, or by hydraulic pressure. But whatever the source of potential energy, it must be released during operation. The release of potential energy makes the sliding of the moving contact in a speedy manner.

All circuit breaker have operating coils (tripping coils and close coil), whenever these coils are energized by switching pulse, and the plunger inside them displaced. This operating coil plunger is typically attached to the **operating mechanism of circuit breaker**, as a result the mechanically stored potential energy in the breaker mechanism is released in forms of kinetic energy, which makes the moving contact to move as these moving contacts mechanically attached through a gear lever arrangement with the operating mechanism.
After a cycle of **operation of circuit breaker** the total stored energy is released and hence the potential energy again stored in the operating mechanism of the circuit breaker using spring charging motor or air compressor or by any other means.

The circuit breaker has to carry large rated or fault power. Due to this large power, there is always dangerously high arcing between moving contacts and fixed contact during operation of the circuit breaker. Again as we discussed

earlier the arc in circuit breaker can be quenching safely if the dielectric strength between the current carrying contacts of circuit breaker increases rapidly during every current zero crossing of the alternating current.
The dielectric strength of the media in between contacts can be increased in numbers of ways, like by compressing the ionized arcing media since compressing accelerates the deionization process of the media, by cooling the arcing media since cooling increase the resistance of arcing path or by replacing the ionized arcing media with fresh gasses. Hence some arc quenching processes should be involved in the operation of the circuit breaker.
Although circuit breakers perform their function independently and without supervision, there are also remote control circuit breakers which can be operated on demand at a distance.

Types of Circuit Breaker

According different criteria there are different types of circuit breaker. According to their arc quenching media the circuit breaker can be categorized as:

1. Oil circuit breaker.
2. Air circuit breaker.
3. SF6 circuit breaker.
4. Vacuum circuit breaker.

According to their services the circuit breaker can be categorized as:

1. Outdoor circuit breaker.
2. Indoor breaker.

According to the operating mechanism of circuit breaker they can be categorized as:

1. Spring operated circuit breaker.
2. Pneumatic circuit breaker.
3. Hydraulic circuit breaker.

According to the voltage level of installation types of circuit breaker are referred as:

1. High voltage circuit breaker.
2. Medium voltage circuit breaker.
3. Low voltage circuit breaker.

CLASSIFICATION OF CIRCUIT BREAKERS
(According to Arc Quenching Medium)

1.**Oil Circuit Breakers:** Employ some insulating oil(e.g., transformer oil) for arc extinction.

2. **Air-blast Circuit Breakers**: Utilize high pressure air-blast is used for extinguishing the arc.

3. **Sulphur Hexafluoride Circuit Breakers:** In which sulphur hexafluoride (SF6) gas is used for arc extinction.

4. **Vacuum Circuit Breakers:** Wherein vacuum is used for arc extinction.

High-voltage AC circuit breakers are routinely available with ratings up to 765 kV.

Classification of CBs according to their services

Classification of CBs according to their operating mechanism.

1. Spring operated circuit breaker
2. Pneumatic circuit breaker
3. Hydraulic circuit breaker

Classification of CBs according to their voltage level of installation.

1. High voltage circuit breaker (> 72 kV)
2. Medium voltage circuit breaker (1-72 kV)
3. Low voltage circuit breaker (< 1 kV)

Breaker Ratings

▪Plain-break air breakers are used in low voltage and medium voltage up to 15 kV.

▪For low and medium voltages fuses can be used, but the main disadvantage is that they must be replaced after fault clearing.

▪In medium voltage systems minimum oil, SF6 and vacuum breakers are also being used.

▪For high voltages minimum oil, SF6 and blast-air breakers are used, but always with multiple interrupters in series.

▪The maximum voltage per interrupter is 100 kV for air-blast andSF6 breakers, 170 kV for minimum oil breakers.

Zone of Protection:

The circuit breakers used to disconnect any element of the system for repairing work, usual operation and maintenance requirements and also under abnormal conditions like short circuits.

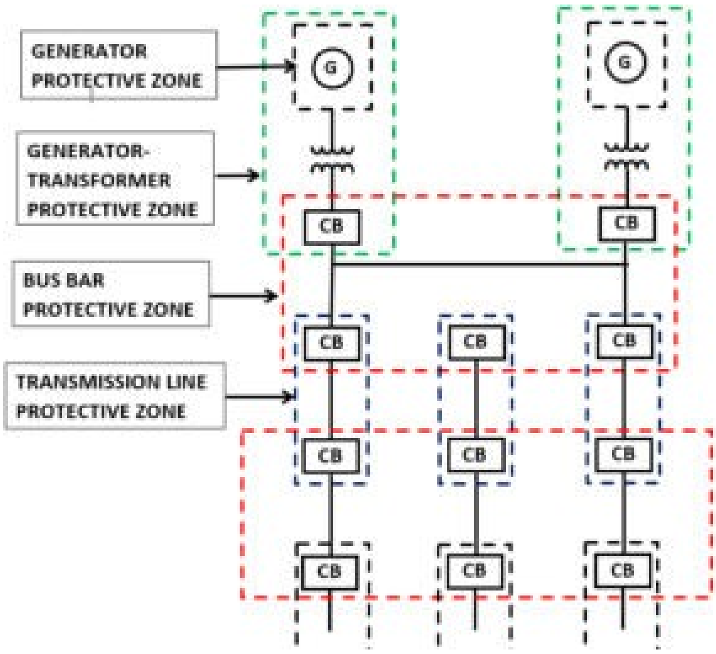
Protective Zones established around each system element. The significance of protective zones is any fault that occurs in a given zone will cause tripping of relays. And it will isolate that part of the system by opening the circuit breaker.

The various components provided with the protective zones, which are generators, transformers, bus bars, transmission lines, cables etc. There is not a single part that has no protection.

The edges of protective zones decided by the locations of the current transformers.

In practice, these zones overlapped to ensure the complete safety of all elements of the system. The part of the system which is unprotected, that known as a **dead spot** or **blind spot**. Hence, to avoid the dead spot, use overlapping of zones.

Overlapping of Protective Zones



The above figure shows the overlapping of zones. The circuit breakers are located in the connections to each power system element. because of this, at the time of the fault, only the faulty element will disconnect.

Due to overlapping of the protective zone, if a fault occurs in the overlapped area, more circuit breaker than the minimum necessary for the disconnection of fault region. So, there is a chance of unnecessary tripping of breaker, then also for security reasons, the overlapping done in the practical power system network. And also, there are very fewer chances that the fault occurs in this area.

The protection provided by the protective relaying equipment can be categorized into two types

- Primary Protection
- Backup Protection

Primary Protection

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

When the primary protection made inoperative for any reason, the backup protection has to sense the fault and trip an appropriate circuit breaker.

There are many conditions when the primary protection may not operate due to many reasons like,

- **Failure in circuit breaker:** The breaker cannot operate due to jammed contacts,
- **Failure in the protective relay:** The relay setting is not properly done. Hence it cannot sense the fault.
- **Loss of voltage and current supply to the relay:** Protective equipment supplied by DC battery bank. If there is a fault in this supply, the relay cannot generate a trip command to the breaker.
- **Failure in tripping circuit:** The tripping circuit used to transfer a signal from relay to breaker. If this system is failed to operate, then the breaker will not

open. So, these are the possibilities for failing the primary protection scheme.

Backup Protection

Backup protection is provided to protect the elements when the primary protection is failed to operate due to any reason.

Suppose, the back protection is not given to the element, in this case, if the primary protection failed to operate, it will create serious damage in the power system network. Therefore, it is necessary to implement the backup protection.

The arrangement of backup protection done in such a way that, the failure in primary protection should not cause the failure in backup protection. To avoid this, the backup protection is located at a different station from the primary protection.

Generally, the backup protection given to the costly equipment. For cost and economy consideration, the backup protection is employed only for the protection against short circuit and not for any other abnormal conditions.

Methods of Backup Relaying

Relay backup protection
A single breaker used by both primary as well as backup protection but the two protective systems are different.

Breaker backup protection

In this scheme, separate breakers provided for primary and backup protection. Both types of breakers are in the same zone.

Remote backup protection

Separate breakers provided for primary and backup protection. The two types of breakers are at different stations and are completely isolated and independent of each other.

Centrally coordinated backup protection

In this method, primary protection is at various stations. There are a central control room and backup protection controlled for all stations from the central control room. And the control room used to inspect and monitor the entire system. The load flow analysis done from the control room. The control room consists of digital computers that decide the proper switching action. The method also called controlled backup protection.