# UNIT III

# APPARATUS PROTECTION

## PROTECTION OF FEEDERS

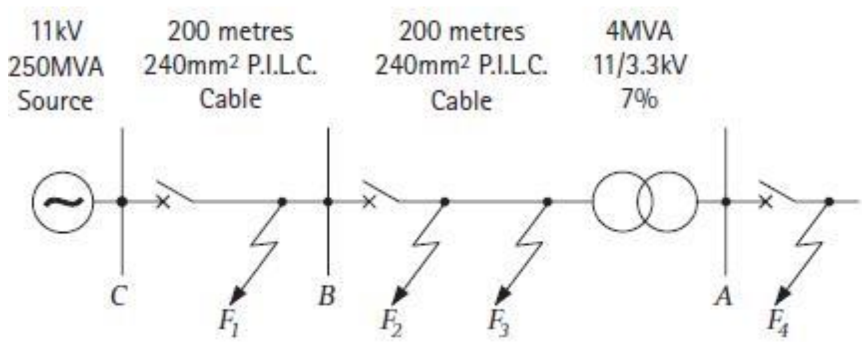
### 3.1 Over current and earth fault protection

It is customary to have two elements of over current and one element of earth fault protection system in the most elementary form of protection of three phase feeders. Different types of feeders employ the over current protection along with the directional relay so that proper discrimination of an internal fault is possible. Some examples are illustrated below.

### Application of directional relays to parallel feeders

It may be seen from the below given parallel feeders that the relays placed at the load side of both the lines use directional element which respond to a direction away from the bus bars. Similarly, the relays placed at the source side do not require any directional element.

A similar concept of discrimination is also utilized in the below given ring main feeder and a feeder fed from both the sides. It can be observed that relays placed near the bus connecting the sources, don not have any directional feature, where as the rest of the buses, respond to a direction always away from the source. It is good practice to locate a fault any where among different sections of the feeders and check whether that particular section only is isolated without disrupting the power flow in other sections.

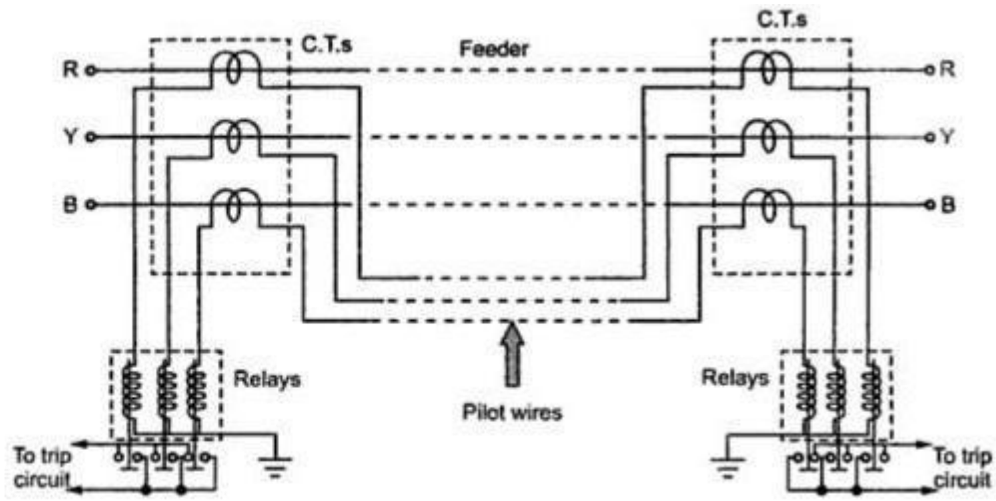



### Pilot wire schemes for feeder protection

In differential protection scheme, the current entering at one end of the line and leaving from other end of the line is compared. The pilot wires are used to connect the relays. Under normal working condition, the two currents at both ends are equal and pilot wires do not carry any current, keeping relays inoperative. Under an internal fault condition, the two currents at both the ends are no longer same, this causes circulating current flow through pilot wires and makes the relay to trip. The various schemes used with this method of protection are, 1. Merz-Price Voltage Balance System 2. Translay Scheme

**Merz-Price Voltage Balance System**

The figure below shows Merz-Price voltage balance system used for the three phase feeders.




Under normal condition, current entering the line at one end is equal to current leaving from the other end. Therefore, equal and opposite voltages are induced in the secondaries of C.T.s. at the two ends resulting in no current flow, through the relay. Under fault condition, two currents at the two ends are different. Thus the secondary voltages of both the end C.T.s differ from each other. This circulates a circulating current through the pilot wires and the relays. Thus the relays trip the circuit breakers to isolate the faulty section.

**The advantages of this method are as follows**

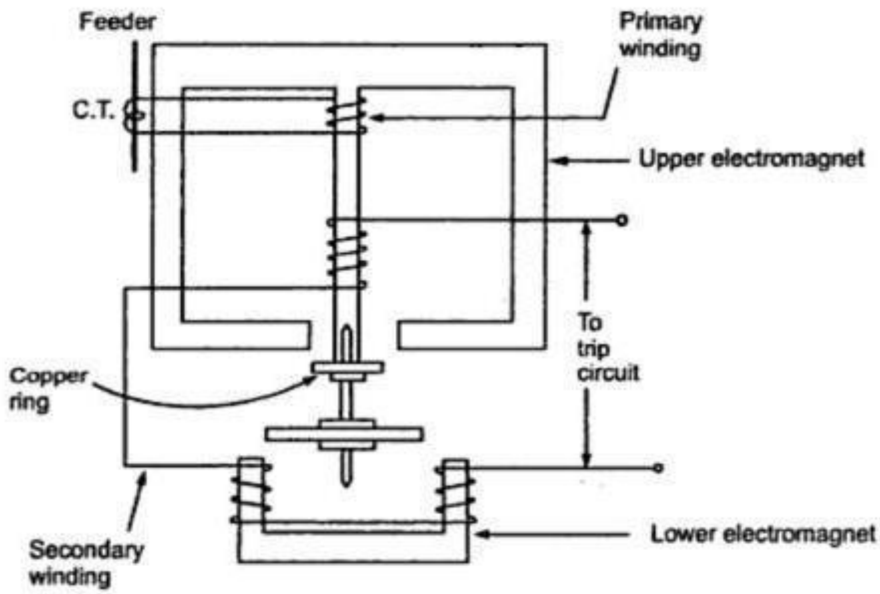
1. It can be used for parallel as well as ring main system.
2. It provides instantaneous protection to ground faults.

**The limitations of this method are as follows**

1. The C.T.s used must match accurately.
2. The pilot wires must be healthy without discontinuity.
3. Economically not suitable as the cost is high due to long pilot wires.
4. Due to long pilot wires, capacitive effects adversely bias the operation of the relays.
5. The large voltage drop in the pilot wires requiring better insulation.

**Translay Scheme**

The translay relay is another type of differential relay. The arrangement is similar to overcurrent relay but the secondary winding is not closed on itself. Additionally copper ring or copper shading bands are provided on the central limb as shown in the figure below.



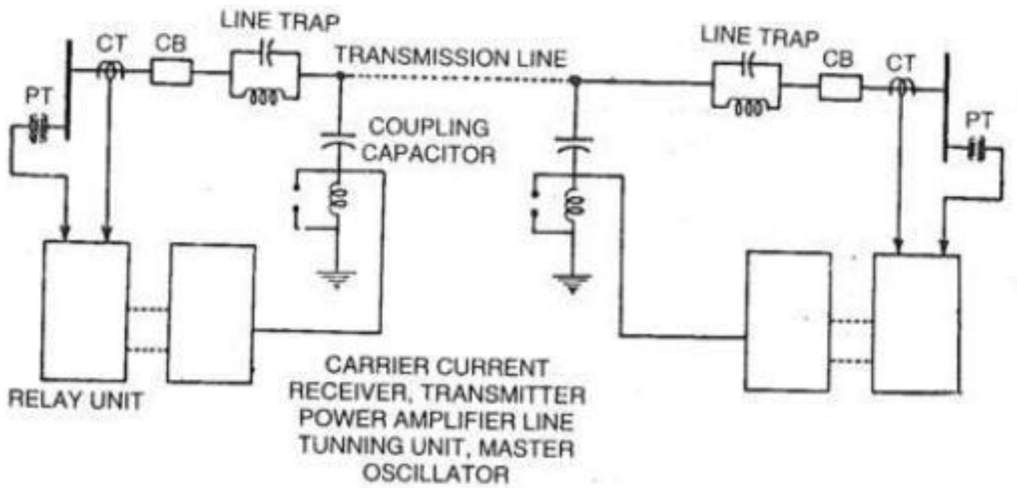

**Role of copper ring**:

Mainly relays may operate because of unbalance in the current transformers. The copper rings are so adjusted that the torque due to current induced in the copper ring due to primary winding of relay is restraining and do not allow the disc to rotate. It is adjusted just to neutralize the effect of unbalance existing between the current transformers. The copper rings also neutralize the effect of pilot capacitive currents. Though the feeder current is same at two ends, a capacitive current may flow in the pilots. This current leads the secondary voltage by 90o. The copper rings are adjusted such that no torque is exerted on the disc, due to such capacitive pilot currents. Therefore in this scheme the demerits of pilot relaying scheme is somewhat taken care of.

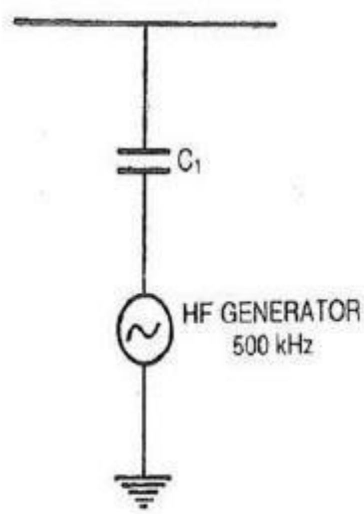
The **advantages** of this scheme are,

1. Only two pilot wires are required.
2. The cost is very low.
3. The current transformers with normal design can be employed.
4. The capacitive effects of pilot wire currents do not affect the operation of the relays.

**Carrier Current unit protection system**




Schematic diagram of the carrier current scheme is shown below. Different basic components of the same are discussed below. The Coupling capacitor These coupling capacitors (CU) which offer low reactance to the higher frequency carrier signal and high reactance to the power frequency signal. Therefore, it filters out the low ( power) frequency and allows the high frequency carrier waves to the carrier current equipments. A low inductance is connected to the CU, to form a resonant circuit.




$$Z = \frac{1}{\omega C_1}$$

$= 1.5$ mega ohms for 50 Hz.

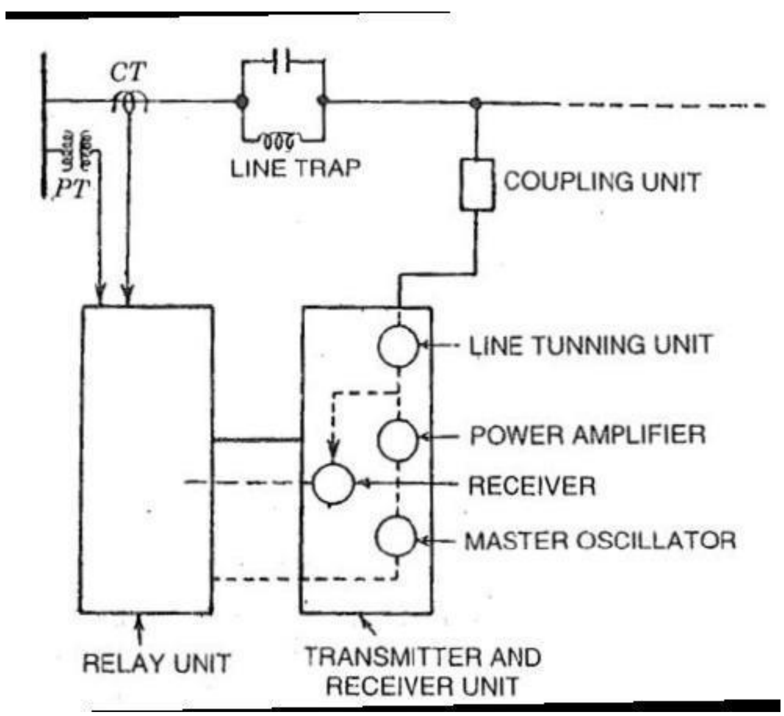
$= 150$ ohms for 500 kHz.

**Wave Traps**

The Wave traps ( also known as Line Trap) are inserted between the busbar and the connection of the CU. These traps are L and C elements connected in parallel, and they are tuned in such a manner that they offer low reactance to the power frequency signals and high reactance to the carrier waves. They ensure that neither of these different frequency signals get mixed up before being received at the bus bar. Both the CU and the Wave traps are protected from switching and lightening surges, with the help suitably designed Spark Gaps or Varistors. Frequency spacing Different frequencies are used in adjacent lines and the wave traps ensure that carrier signals of other lines do not enter a particular line section. Therefore, proper choice of frequency bands for different lines are adopted.

**Transmitter Unit**

In a Transmitter unit, the carrier frequency in the range of 50 to 500 KHz of constant magnitude is generated in the oscillator, which is fed to an amplifier. Amplification is required to overcome any loss in the coupling equipments, weather conditions, Tee connections in the lines of different size and length. The amplifier and the oscillators are constantly energized and a connection is made between the two with the help of a control unit.




The Receiver unit consists of an attenuator and a Band pass filter, which restricts the acceptance of any unwanted signals. The unit also has matching transformer to match the line impedance and that of the receiver unit.

## 3.2 TRANSFORMER PROTECTION

INTRODUCTION

• The power transformer is one of the most important links in a power transmission and distribution system.

• It is a highly reliable piece of equipment. This reliability depends on
• adequate design
• careful erection
• proper maintenance
• application of protection system.

**PROTECTION EQUIPMENT INCLUDES**

1. Surge diverters
2. Gas relay: It gives early warning of a slowly developing fault, permitting shutdown and repair before severe damage can occur.
3. Electrical relays.

• The choice of suitable protection is also governed by economic considerations. Although this factor is not unique to power transformers, it is brought in prominence by the wide range of transformer ratings used( few KVA to several hundreds MVA)

• Only the simplest protection such as fuses can be justified for transformers of lower ratings.

• for large transformers best protection should be provided.

**TYPES OF FAULTS AFFECTING POWER TRANSFORMER**

- THROUGH FAULTS

  a) Overload conditions.
  b) External short-circuit conditions.

The transformer must be disconnected when such faults occur only after allowing a predetermined time during which other protective gears should have operated.

- INTERNAL FAULTS

The primary protection of a power transformer is intended for conditions which arises as a result of faults inside the protection zone.

1. Phase-to-earth fault or phase- to- phase fault on HV and LV external terminals
2. Phase-to-earth fault or phase-to- phase fault on HV and LV windings.
3. Interturn faults of HV and LV windings.
4. Earth fault on tertiary winding, or short circuit between turns of a tertiary windings.

5. So called „incipient" faults which are initially minor faults, causing gradually developing fault. These types of faults are not easily detectable at the winding terminals by unbalance current or voltage.

**NATURE & EFFECT OF TRANSFRMER FAULTS**

A faults on transformer winding is controlled in magnitude by

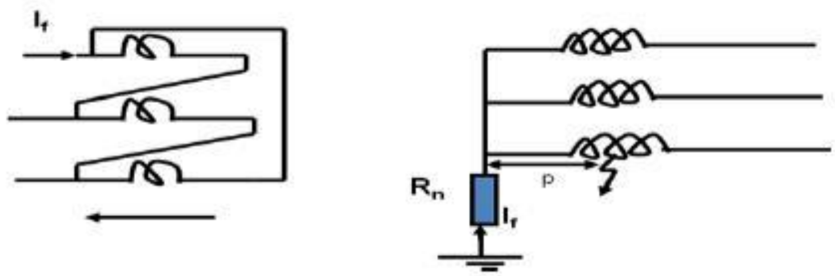
a) Source & neutral earthing impedance

b) Leakage reactance of the transformer

c) Position of the fault on the winding.

Following distinct cases are examined below (1) Star connected winding with neutral point earthed through an impedance

Earth fault on resistance earthed star winding




**Transformer differential protection**

Basic discussions related to the Merz-Price Scheme and its limitations which are taken care by the biased differential scheme, are omitted for repetition

**Basic considerations**

**a. Transformation ratio**

- The nominal currents in the primary and secondary sides of the transformer vary in inverse ratio to the corresponding voltages. This should be compensated for by using different transformation ratios for the CTs on the primary and secondary sides of the transformer.

**b. Current Transformer Connections**

- When a transformer is connected in star/delta, the secondary current has a phase shift of 300 relative to the primary
- This phase shift can be offset by suitable secondary CT connections

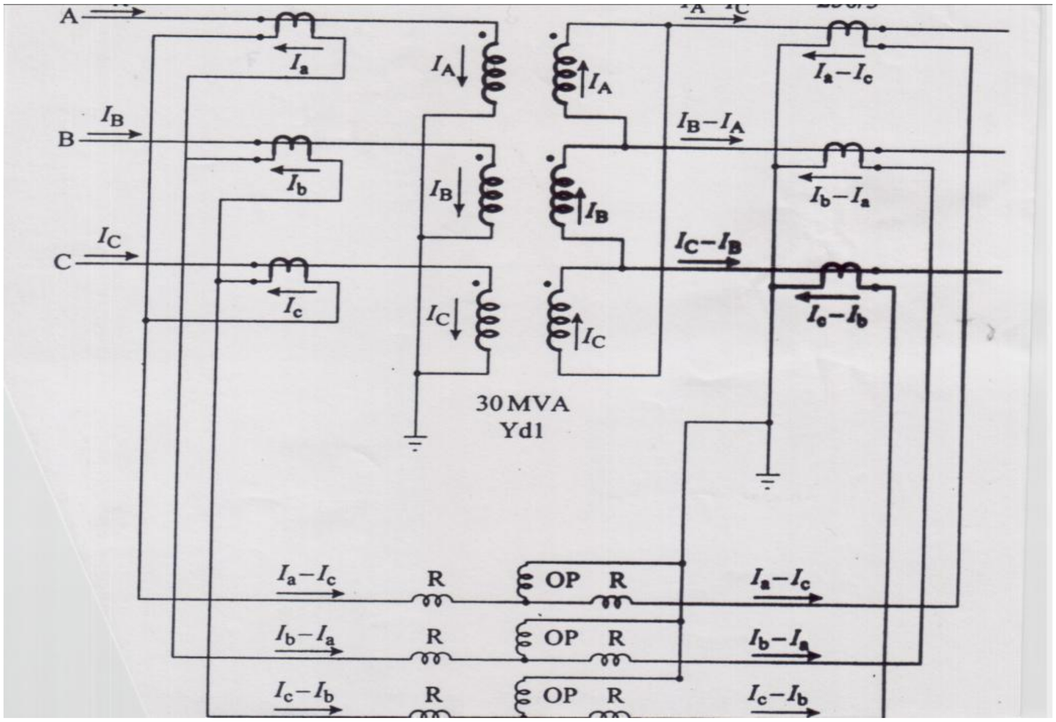
- The zero-sequence currents flowing on the star-side of the transformer will not produce current outside the delta on the other side. The zero sequence current must therefore be eliminated from the star-side by connecting the CTs in delta.
- • The CTs on delta side should be connected in star in order to give 300 phase shift.
- • When CTs are connected in delta, their secondary ratings must be reduced to 1/3 times the secondary ratings of the star-connected transformer, in order that the currents outside the delta may balance with the secondary currents of the star-connected CTs.
- • If transformers were connected in star/star, the CTs on both sides would need be connected in delta-delta.

**c. Bias to cover tap-changing facility and CT mismatch**

- • If the transformer has the benefit of a tap changer, it is possible to vary its transformation ratio for voltage control.
- • The differential protection system should be able to cope with this variation.
- • This is because if the CTs are chosen to balance for the mean ratio of the power transformer, a variation in ratio from the mean will create an unbalance proportional to the ratio change. At maximum through fault current, the spill output produced by the small percentage unbalance may be substantial
- • Differential protection should be provided with a proportional bias of an amount which exceeds in effect the maximum ratio deviation. This stabilizes the protection under through fault conditions while still permitting the system to have good basic sensitivity.

**d. Magnetization Inrush**

- The magnetizing inrush produces a current flow into the primary winding that does not have any equivalent in the secondary winding. The net effect is thus similar to the situation when there is an internal fault on the transformer.
- Since the differential relay sees the magnetizing current as an internal fault, it is necessary to have some method of distinguishing between the magnetizing current and the fault current using one or all of the following methods.
- Using a differential relay with a suitable sensitivity to cope with the magnetizing current, usually obtained by a unit that introduces a time delay to cover the period of the initial inrush peak.
- • Using a harmonic-restraint unit, or a supervisory unit, in conjunction with a differential unit.
- • Inhibiting the differential relay during the energizing the transformer.




Compared to the differential protection used in generators, there are certain important points discussed below which must be taken care of while using such protection for the power transformers.

1. In a power transformer, the voltage rating of the two windings is different. The high voltage winding is low current winding while low voltage winding is high current winding. Thus there always exists difference in current on the primary and secondary sides of the power transformer. Hence if C.T.s of same ratio are used on two sides, then relay may get operated through there is no fault existing.

To compensate for this difficulty, the current ratios of C.T.s on each side are different. These ratios depend on the line currents of the power transformer and the connection of C.T.s. Due to the different turns ratio, the currents fed into the pilot wires from each end are same under normal conditions so that the relay remains inoperative. For example if K is the turns ratio of a power transformer then the ratio of C.T.s on low voltage side is made K times greater than that of C.T.s on high voltage side.

2. In case of power transformers, there is an inherent phase difference between the voltages induced in high voltage winding and low voltage winding. Due to this, there exists a phase difference between the line currents on primary and secondary sides of a power transformer. This introduces the phase difference between the C.T. secondary currents, on the two sides of a power transformer. Through the turns ratio of C.T.s are selected to compensate for turns ratio of transformer, a differential current may result due to the phase difference between the currents on two sides. Such a different current may operate the relay though there is no fault. Hence it is

necessary to correct the phase difference. To compensate for this, the C.T. connections should be such that the resultant currents fed into the pilot wires from either sides are displaced in phase by an angle equal to the phase shift between the primary and secondary currents. To achieve this, secondaries of C.T.s on star connected side of a power transformer are connected in delta while the secondaries of C.T.s on delta connected side of a power transformer are connected in star.

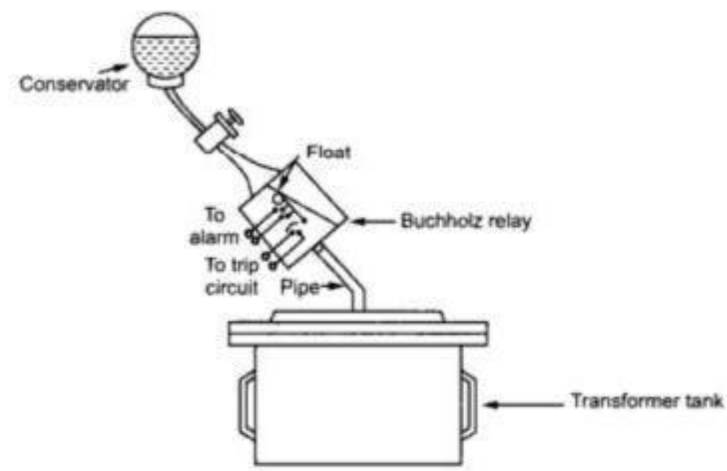
**Buchholz relay**

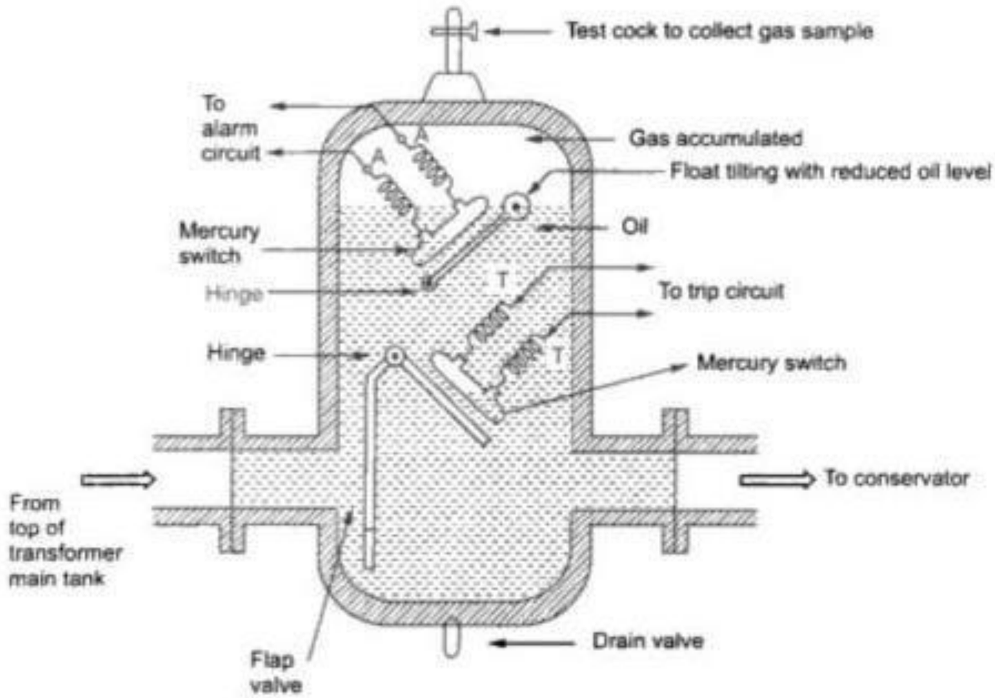
All faults below the oil in transformer result in the localized heating & breakdown of the oil, some degree of arcing will always take place in a winding fault & the resulting decomposition of it will release gases such as hydrogen, carbon monoxide & hydrocarbons.

• When the fault is of a very minor type, such as hot joints gas is released slowly, but a major fault involving severe arcing causes rapid release of large volumes of gas as well as oil vapour.

• Such incipient faults of smaller or larger magnitudes can be detected by a gas actuated relay known as Bucholtz Relay.

The Bucholtz Relay is contained in a cast housing which is connected as shown below between the conservator tank and main tank of the transformer.






Under normal conditions, the Buchholz relay is full of oil. It consists of a cast housing containing a hinged hollow float. A mercury switch is attached to a float. The float being rotated in the upper part of the housing. Another hinged flap valve is located in the lower part which is directly in the path of the oil between tank and the conservator. Another mercury switch is attached to a flap valve. The float closes the alarm circuit while the lower flap valve closes the trip circuit in case of internal faults.

**Operation**

There are many types of internal faults such as insulation fault, core heating, bad switch contacts, faulty joints etc. which can occur. When the fault occurs the decomposition of oil in the main tank starts due to which the gases are generated. As mentioned earlier, major component of such gases is hydrogen. The hydrogen tries to rise up towards conservator but in its path it gets accumulated in the upper part of the Buchholz relay. Through passage of the gas is prevented by the flap valve.

When gas gets accumulated in the upper part of housing, the oil level inside the housing falls. Due to which the hollow float tilts and closes the contacts of the mercury switch attached to it. This completes the alarm circuit to sound an alarm. Due to this operator knows that there is some incipient fault in the transformer. The transformer is disconnected and the gas sample is tested. The testing results give the indication, what type of fault is started developing in the transformer.

Hence transformer can be disconnected before grows into a serious one. The alarm circuit does not immediately disconnect the transformer but gives only an indication to the operator. This is because sometimes bubbles in the oil circulating system may operate the alarm circuit even though actually there is no fault. However if a serious fault such as internal short circuit between phases, earth fault inside the tank etc. occurs then the considerable amount of gas gets generated. In that case, due to a fast reduction in the level of oil, the pressure in the tank increases. Due to this the oil rushes towards the conservator. While doing so it passes through the relay where flap valve is present. The flap valve gets deflected due to the rushing oil and operates the mercury switch, thereby energizing the trip circuit which opens the circuit breaker of transformer is totally disconnected from the supply. The connecting pipe between the tank and the conservator should be as straight as possible and should slope upwards conservator at a small angle from the horizontal. This angle should be around 100. For the economic considerations, Buchholz relays are not provided for the transformer having rating below 500 KVA.

**Advantages**

The various advantages of the Buchholz relay are,

1. Normally a protective relay does not indicate the appearance of the fault. It operates when fault occurs. But Buchholz relay gives an indication of the fault at very early stage, by anticipating the fault and operating the alarm circuit. Thus the transformer can be taken out of service before any type of serious damage occurs.

2. It is the simplest protection in case of transformers.

**Limitations**

The various limitation of the Buchholz relay are,

1. Can be used only for oil immersed transformers having conservator tanks.
2. Only faults below oil level are detected.
3. Setting of the mercury switches cannot be kept too sensitive otherwise the relay can operate due to bubbles, vibration, earthquakes mechanical shocks etc.
4. The relay is slow to operate having minimum operating time of 0.1 seconds and average time of 0.2 seconds.

**Applications**

The following types of transformer faults can be protected by the Buchholz relay and are indicated by alarm:

1. Local overheating
2. Entrance of air bubbles in oil
3. Core bolt insulation failure
4. Short circuited laminations
5. Loss of oil and reduction in oil level due to leakage

6. Bad and loose electrical contacts
7. Short circuit between phases
8. Winding short circuit
9. Bushing puncture
10. Winding earth fault.

## 3.3 Generator protection

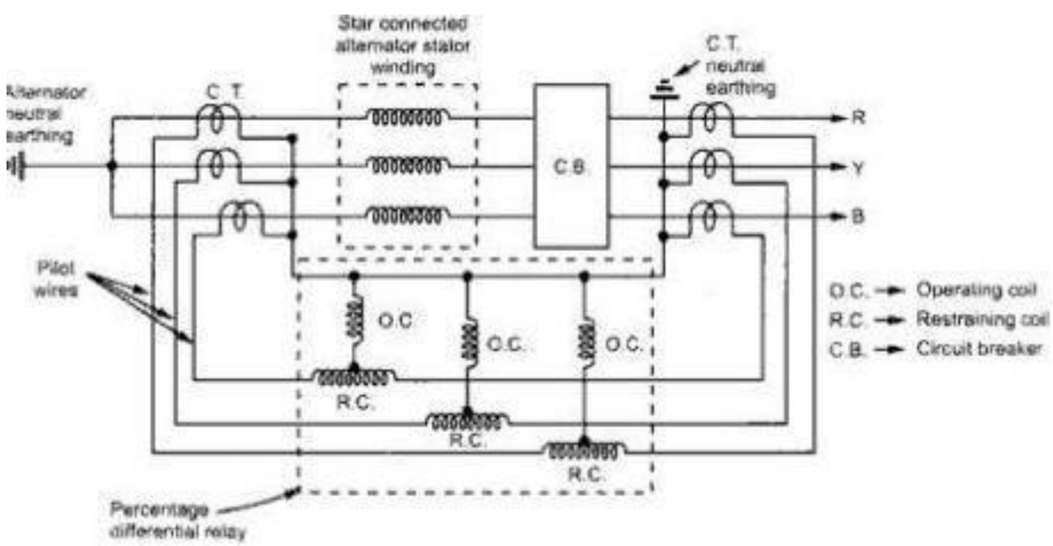
### INTRODUCTION

- The range of size of generators extends from a few hundred KVA to more than 500MVA
- Small and Medium sized sets may be directly connected to the distribution system

A larger unit is usually associated with an individual transformer, through which the set is coupled to the EHV transmission system. No switchgear is provided between the generator and transformer, which are treated as a unit.

**Biased Differential scheme (Merz-Price Scheme) for protection of Generators.**

This is most commonly used protection scheme for the alternator stator windings. The scheme is also called biased differential protection and percentage differential protection. The figure below shows a schematic arrangement of Merz-Price protection scheme for a star connected alternator.




The differential relay gives protection against short circuit fault in the stator winding of a generator. When the neutral point of the windings is available then, the C.T.s may be connected in star on both the phase outgoing side and the neutral earth side, as shown in the above figure. But, if the neutral point is not available, then the phase side CTs are connected in a residual connection, so that it can be made suitable for comparing the current with the generator ground point CT secondary current. The restraining coils are energized from the secondary connection of C.T.s in each phase, through pilot wires. The operating coils are energized by the tappings from restraining coils and the C.T. neutral earthing connection.

The similar arrangement is used for the delta connected alternator stator winding, as shown below.

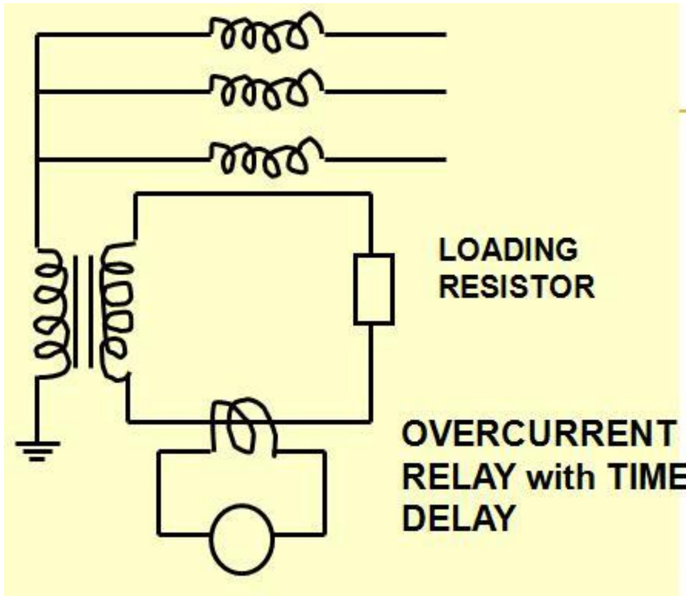
This scheme provides very fast protection to the stator winding against phase to phase faults and phase to ground faults. If the neutral is not grounded or grounded through resistance then additional sensitive earth fault relay should be provided. The advantages of this scheme are,

1. Very high speed operation with operating time of about 15 msec. 2. It allows low fault setting which ensures maximum protection of machine windings. 3. It ensures complete stability under most severe through and external faults. 4. It does not require current transformers with air gaps or special balancing features.

**Earth fault protection of Generators**

The neutral point of the generator is usually earthed, so as to facilitate the protection of the stator winding and associated system. Impedance is inserted in the earthing lead to limit the magnitude of the earth fault current. Generators which are directly connected to the transmission or distribution system are usually earthed through a resistance which will pass approximately rated current to a terminal earth fault. In case of generator-transformer unit, the generator winding and primary winding of a transformer can be treated as an isolated system that is not influenced by the earthing requirements of the transmission system. Modern practice is to use a large earthing transformer (5-100 KVA) – the secondary winding which is designed for 100-500V is loaded with a resistor of a value, which when referred through the transformer ratio, will pass a suitable fault current. The resistor is therefore of low value and can be of rugged construction. It is important that the earthing transformer never becomes saturated, otherwise a very undesirable condition of ferro resonance may occur.

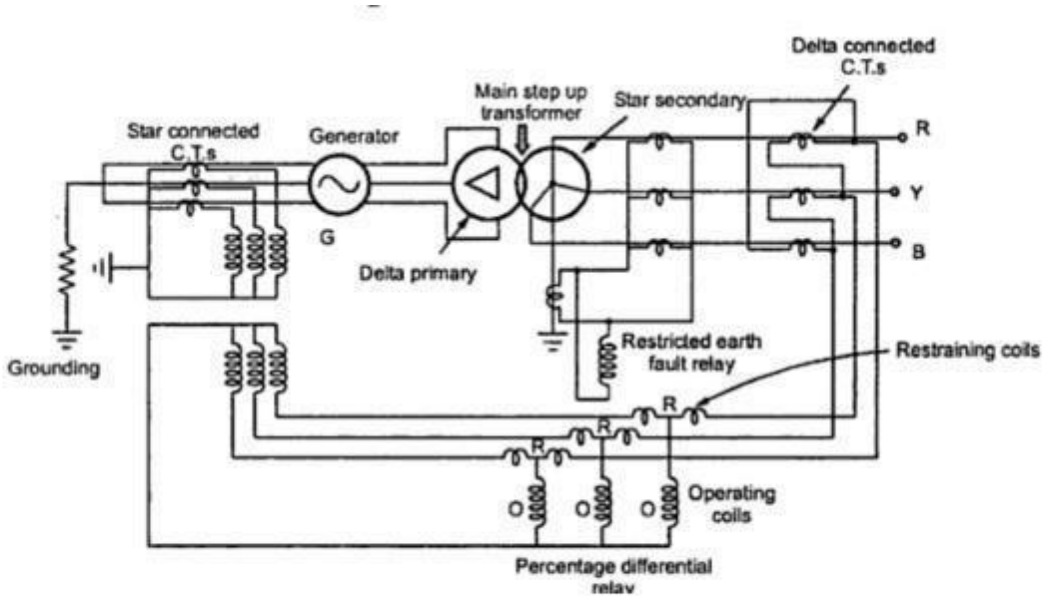
Earth fault protection can be obtained by applying a relay to measure the transformer secondary current by connecting a voltage measuring relay in parallel with the load resistor




**Generator and Transformer Unit Biased Differential Protection**

In a high voltage transmission system, the bus bars are at very high voltages than the generators. The generators are directly connected to step up transformer to which it is connected, together from a generator transformer unit. The protection of such a unit is achieved by differential protection scheme using circulating current principle. While providing protection to such a unit, it is necessary to consider the phase shift and current transformation in the step up transformer. The figure in the following page, shows a biased differential protection scheme used for generator transformer unit. The zone of such a scheme includes the stator windings, the step up transformer and the intervening connections. The transformer is delta-star hence the current transformers on high voltage side are delta connected while those on generator side are star connected. This cancels the displacement between line currents introduced by the delta connected primary of the transformer. Where there is no fault, the secondary currents of the current transformer connected on generator side are equal to the currents in the pilot wires from the secondaries of the delta connected current transformers on the secondary of main transformer. When a fault occurs, the pilot wires carry the differential current to operate the percentage differential relay.

For the protection against the earth faults, an earth fault relays is put in the secondary winding of the main step up transformers as shown. In such a case, differential protection acts as a backup protection to the restricted earth fault protection. This overall differential protection scheme does not include unit transformer as a separate differential scheme is provided it.




## PHASE FAULT

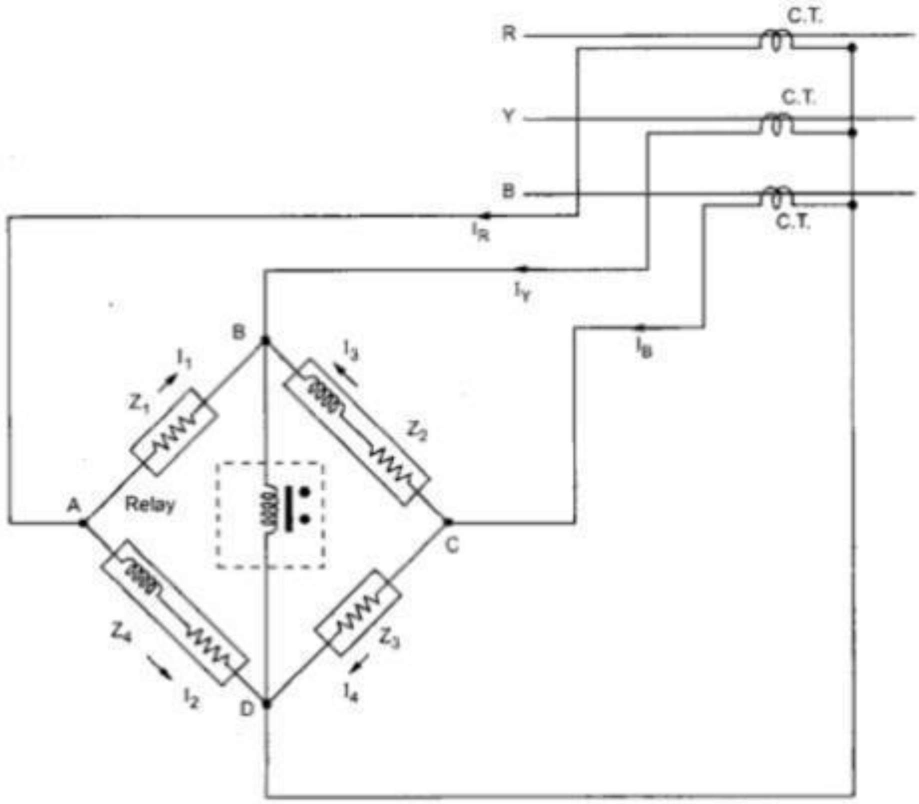
- Phase-phase faults clear of earth are less common. They may occur on the end portion of stator coils or in the slots if the winding involves two coil sides in the same slot. In the later case the fault will involve earth in a very short time.
- Phase fault current is not controlled by the method of earthing the neutral point.

## INTERTURN FAULTS

- Interturn faults are also uncommon, but not unknown
- A greatest danger arising from failure to deal with interturn faults quickly is fire. A large portion of the insulation is inflammable

### Negative sequence protection

The negative sequence component can be detected by the use of a filter network. Many negative sequence filter circuits have been evolved. One typical negative sequence filter circuit is as follows




Basically it consists of a resistance bridge network as depicted in the first figure showing the circuit connection. The magnitudes of the impedances of all the branches of the network are equal. The impedances Z1 and Z3 are purely resistive while the impedances Z2 and Z4 are the combinations of resistance and reactance. The currents in the branches Z2 and Z4 lag by 60o from the currents in the branches Z1 and Z3. The vertical branch B-D basically consists of an over current element with inverse time characteristics having negligible impedance compared to the bridge impedances.

**3.4 protection of bus bars**

The protection scheme for a power system should cover the whole system against all probable types of faults. Unrestricted forms of line protection such as over current and distance systems, meet this requirement, although faults in the Bus bar zone are cleared only after some time delay. If unit protection is applied to feeder and plant the bus bars are not inherently protected. Bus bars have been left without specific protection. Different bus bar faults are as follows. BUSBAR FAULTS

- Majority of bus faults involve one phase and earth, but faults arise from many causes and a significant number are inter-phase clear of earth.
- With fully phase-segregated metal clad gear, only earth faults are possible ,and a protective scheme need have earth fault sensitivity only.

- For outdoor busbars , protection schemes ability to respond to inter-phase faults clear of earth is an advantage

**TYPES OF PROTECTION SCHEMES**

- System protection used to cover bus bars
- Frame –earth protection
- Differential protection

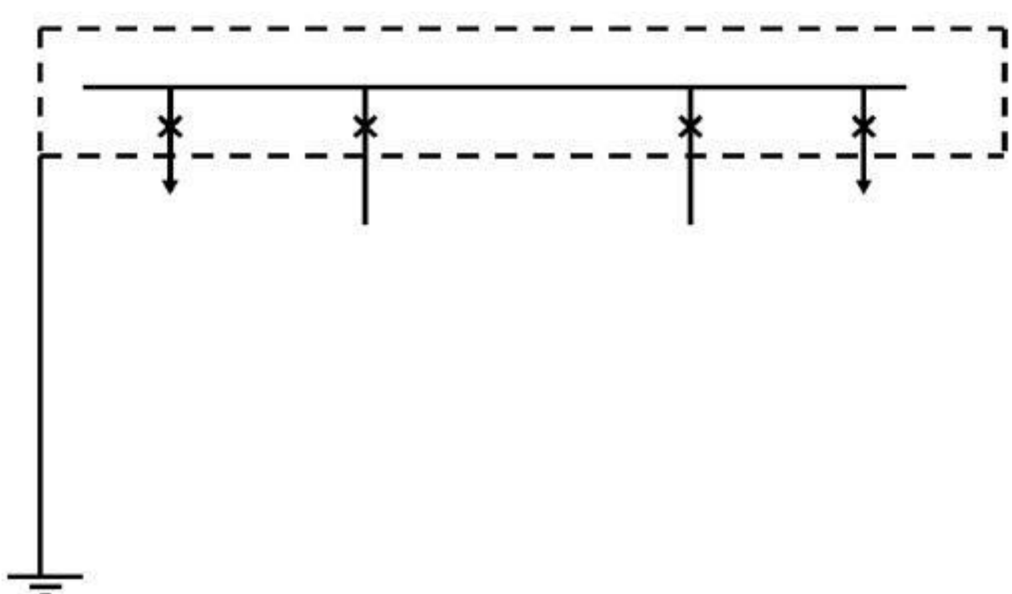
**SYSTEM PROTECTION**

- A system protection that includes over current or distance systems will inherently give protection cover to the bus bars.
- Over current protection will only be applied to relatively simple distribution systems, or as a back-up protection set to give considerable time delay. Distance protection will provide cover with its second zone.
- In both cases, therefore ,the bus bar protection so obtained is slow

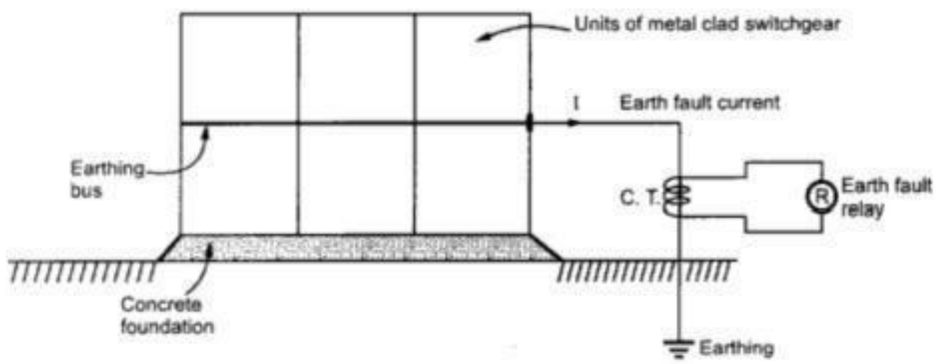
**Frame-earth Protection**

- This is purely an earth fault system, and in principle involves simply measuring the fault current flowing from the switchgear frame to earth. To this end a current transformer is

mounted on the earthing conductor and is used to energize a simple instantaneous relay.



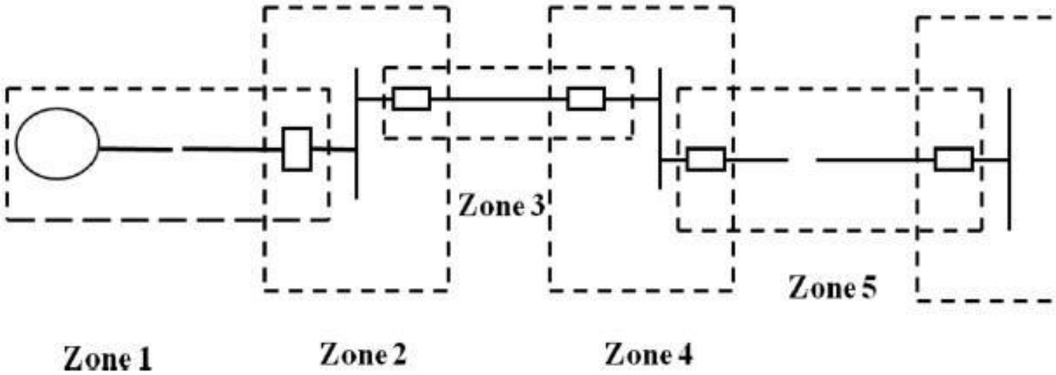
This protection is nothing but the method of providing earth fault protection to the bus bar assembly housed in a frame. This protection can be provided to the metal clad switchgear. The arrangement is shown in the figure below. The metal clad switchgear is lightly insulated from the earth. The enclosure of the frame housing different switchgears and bus bars is grounded through a primary of current transformer in between. The concrete foundation of switchgear and the other equipments are lightly insulated from the ground. The resistance of these equipments with earth is about 12 ohms. When there is an earth fault, then fault current leaks from the frame and passes through the earth connection provided. Thus the primary of C.T. senses the current due to which current passes through the sensitive earth fault relay, thereby operating the relay.




**3.5 Zones and types of Protection system**

**Zones of Protection system**

- An electric power system is divided into several zones of protection. Each zone of protection, contains one or more components of a power system in addition to two circuit breakers.
- When a fault occurs within the boundary of a particular zone, then the protection system responsible for the protection of the zone acts to isolate (by tripping the Circuit Breakers) every equipment within that zone from the rest of the system.
- The circuit Breakers are inserted between the component of the zone and the rest of the power system. Thus, the location of the circuit breaker helps to define the boundaries of the zones of protection.
- Different neighbouring zones of protection are made to overlap each other, which ensure that no part of the power system remains without protection. However, occurrence of the fault with in the overlapped region will initiate a tripping sequence of different circuit breakers so that the minimum necessary to disconnect the faulty element




**Types of Protection (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 cause of failure of the Primary Protection system are enumerated below.

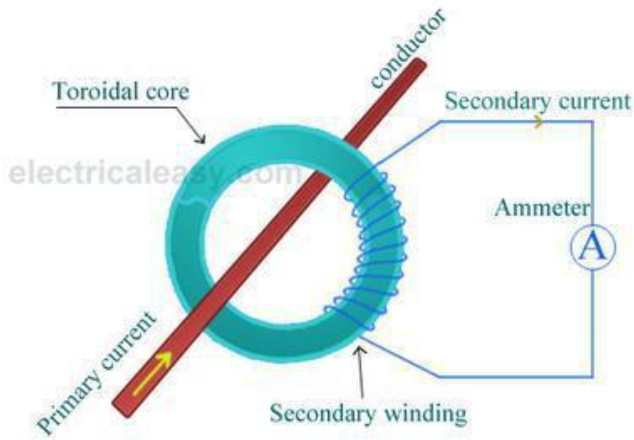
1. Current or voltage supply to the relay.
2. D.C. tripping voltage supply
3. Protective relays
4. Tripping circuit
5. Circuit Breaker

**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.

**3.6 CTs and PTs and their applications in protection schemes.**

Current transformers are generally used to measure currents of high magnitude. These transformers step down the current to be measured, so that it can be measured with a normal range ammeter. A Current transformer has only one or very few number of primary turns. The primary winding may be just a conductor or a bus bar placed in a hollow core (as shown in the figure). The secondary winding has large number turns accurately wound for a specific turns ratio.

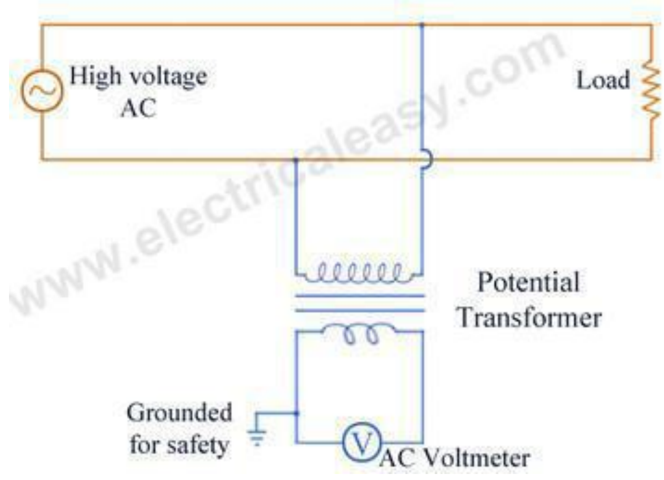



Thus the current transformer steps up (increases) the voltage while stepping down (lowering) the current. Now, the secondary current is measured with the help of an AC ammeter. The turns ratio of a transformer is NP / NS = IS / IP

- UPS systems
- Transfer switches
- Motor-generator sets
- Commercial sub-metering,
- CT 's in one package for 3-phase metering
- Accurate measuring for metering/WATT/VAR
- Current sensing, recording, monitoring & control
- Control panels and drives
- Standard CT used as measuring standard for comparison
- Winding temperature indicator (WTI) for power transformers
- Summation current transformers.

**Potential Transformer (PT)**

Potential transformers are also known as voltage transformers and they are basically step down transformers with extremely accurate turns ratio. Potential transformers step down the voltage of high magnitude to a lower voltage which can be measured with standard measuring instrument. These transformers have large number of primary turns and smaller number of secondary turns. A potential transformer is typically expressed in primary to secondary voltage ratio. For example, a 600:120 PT would mean the voltage across secondary is 120 volts when primary voltage is 600 volts.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AC
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for safety
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