CONTENTS

1.Fault:
Common type of faults in both overhead and underground systems- symmetrical/ unsymmetrical faults – Single line to ground fault - double line to ground fault - Three-phase to ground fault open circuit-simple problems relating to fault finding.

2.Switch Gears
Purpose of protective gear- Difference between switch, isolator and circuit breakers- Function of isolator and circuit breaker.- Making capacity and breaking capacity of circuit breaker (only definition)
- Circuit breakers - Types of circuit breakers - bulk and minimum oil circuit breakers - air SF6 circuit breaker - Principles of Arc extinction blast circuit breakers in OCB and ACB - Constructional features
of OCB, ACB, and their working- Method of arc extinction - Miniature circuit breakers MCB, MCCB, ELCB, for distribution and transmission

3.Protection Devices
Fuses; function of fuse. Types of fuses, HV and LV fuses, rewire-able, cartridge, HRC Relays: a) Introduction - types of relays. Electromagnetic and thermal relays, their construction and working b) Induction type over-current, earth fault relays, instantaneous over current relay c) Directional over-current, differential relays, and their functions

4.Protection Scheme
Relays for generator protection Relays for transformer, protection including Buchholtz relay protection Protection of feeders and bus bars, Over current and earth fault protection. Distance protection for transmission system Relays for motor protection

5. Over-voltage Protections
Protection of system against over voltages, causes of over voltages, utility of ground wire Lightning arrestors, rod gap, horn gap, metal oxide type. Transmission Line and substation protection against over-voltages and lightning

6.Various Types of Tariffs

Concept of Tariffs Block rate, flat rate, maximum demand and two part tariffs Simple problems

1 UNIT

Faults

A power system operates under balanced conditions. When the system becomes unbalanced due to the failures of insulation at any point or due to the contact of live wires, a short–circuit is said to occur. Faults may occur in the power system due to the number of reasons like natural disturbances (lightning, high-speed winds, earthquakes), insulation breakdown, falling of a tree,
Effects: Over current flow, Danger to operating personnel Loss of equipment, Disturbs interconnected active circuits, Electrical fires, bird shorting, etc.
Causes: Weather conditions, Equipment failures, Human errors, Smoke of fires
Fault limiting devices: Fuse, Circuit breaker, Relay, Lighting power protection devices

1.1 Types of Faults

Faults in overhead lines

Symmetrical faults are line to line to line to ground (L-L-L-G), line to line to line (L-L-L)

Unsymmetrical faults are line to ground (L-G), line to line (L-L) and double line to ground (LL- G) faults

Faults in Underground Cables

Short-circuit fault (L-L)
When an insulator fails, it is due to the 2 conductors of a multi-core cable coming in contact with each other electrically, which indicates short-circuit failure. For this again, a megger is used. In this type, the 2 terminals of the megger are connected to any 2 conductors. Fault is indicate d when the megger gives zero reading between the electricity conductors. The Same process can be repeated by taking other 2 conductors at a time.

Earth Fault (L-G):
If a cable's conductor comes in contact with the earth (ground), then it is called as earth fault. In order to identify this fault, the two terminals of the megger are connected to the conductor and to the earth, respectively. Earth fault can be studied if the megger indicates zero reading. The Same procedure is applied to the cable's other conductors.

Steps for Symmetrical Fault Calculations
It has already been discussed that 3-phase short-circuit faults result in symmetrical fault currents *i.e.* fault currents in the three phases are equal in magnitude but displaced 120^0electrical from one another. Therefore, problems involving such faults can be solved by considering one phase only as the same conditions prevail in the other two phases. The procedure for the solution of such faults involves the following steps:

(i) Draw a single line diagram of the complete network indicating the rating, voltage and percentage reactance of each element of the network.

(ii) Choose a numerically convenient value of base kVA and convert all percentage reactances to this base value.

(iii) Corresponding to the single line diagram of the network, draw the reactance diagram showing one phase of the system and the neutral. Indicate the % reactances on the base kVA in the reactance diagram. The transformer in the system should be represented by a reactance in series.

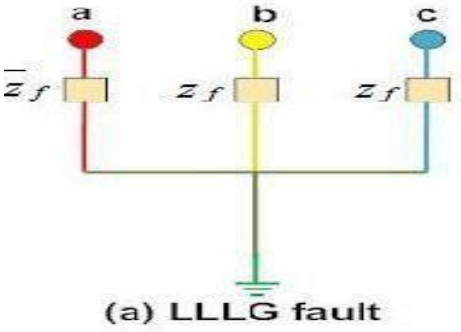
(iv) To find the total % reactance of the network up to the point of fault. Let it be X%.

(v) Find the full-load current corresponding to the selected base kVA and the normal system voltage at the fault point. Let it be I.

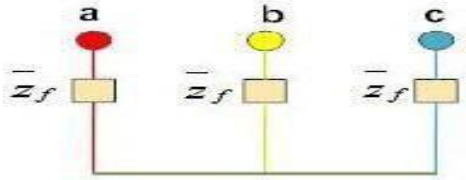
(vi) Then various short-circuit calculations are: Short-circuit current, $I_{SC} = I \times 100/\%X$ Short-circuit kVA = Base kVA × 100/ %X

1.3 Symmetrical faults

- That fault on the power system which gives rise to symmetrical fault currents (i.e. equal fault currents in the lines with 120◦ displacement) is called a symmetrical fault.
- These are very severe faults and occur infrequently in the power systems. These are also called as balanced faults and are of two types namely line to line to line to ground (L-L-L-G) and line to line to line (L-L-L).
- Only 2-5 percent of system faults are symmetrical faults.



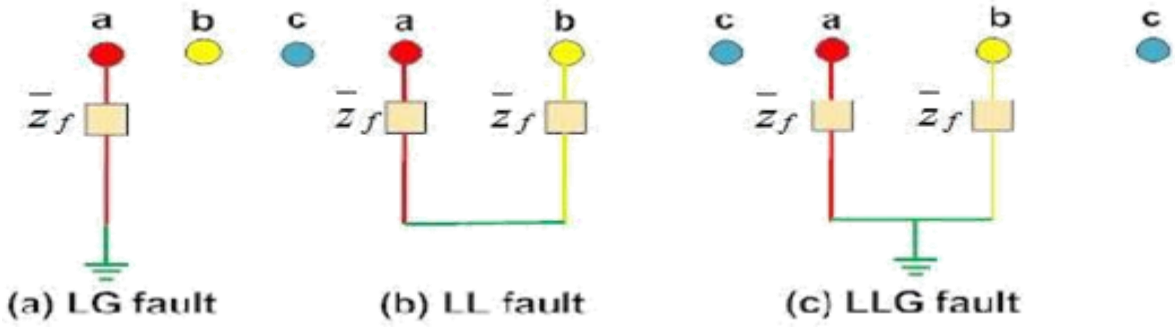
(a) LLLG fault



(b) LLL fault

1.4 Unsymmetrical faults

- Those faults on the power system which give rise to unsymmetrical fault currents (i.e. unequal fault currents in the lines with unequal phase displacement) are known as unsymmetrical faults
- These are very common and less severe than symmetrical faults. There are mainly three types namely line to ground (L-G), line to line (L-L) and double line to ground (LL-G) faults.
- Line to ground fault (L-G) is most common fault and 65-70 percent of faults are of this type. 15 to 20 percent of faults are double line to ground



Unsymmetrical fault components

- The solution of unsymmetrical fault problems can be obtained by either
- (*a*) Kirchhoff's laws or (*b*) Symmetrical components method. The latter method is preferred because of the following
- (b) Symmetrical Components Method: In 1918, Dr. C.L. Fortescue, an American scientist, showed that any unbalanced system of 3-phase currents (or voltages) may be regarded as being composed of three separate sets of balanced vectors –
- (i) A balanced system of 3-phase currents having positive (or normal) phase sequence. These are called *positive phase sequence components.*
- (ii) A balanced system of 3-phase currents having the opposite or negative phase sequence are called *negative phase sequence components*.
- (iii) A system of three currents equal in magnitude and having zero phase displacement. These are called *zero phase sequence components* The positive, negative and zero phase sequence components are called the *symmetrical components*
- The unbalanced 3-phase system has been resolved into three sets of balanced (or symmetrical) components. The subscripts 1, 2 and 0 are generally used to indicate positive, negative and zero phase sequence components respectively
- In unsymmetrical fault calculations, each piece of equipment will *have three values of impedance*—one corresponding to each sequence current *viz.*
  (i) Positive sequence impedance (*Z*1)
  (ii) Negative sequence impedance (*Z*2)
  (iii) Zero sequence impedance (*Z*0)

For line (*R*-phase)-to-ground fault :

$$\vec{I}_R = \text{Fault current} = \frac{3\vec{E}_R}{\vec{Z}_1+\vec{Z}_2+\vec{Z}_0} \;;\; \vec{I}_Y = 0 \;;\; \vec{I}_B = 0$$

$$\vec{V}_R = 0$$

$$\vec{V}_Y = \vec{V}_0 + a^2\vec{V}_1 + a\vec{V}_2$$

$$\vec{V}_B = \vec{V}_0 + a\vec{V}_1 + a^2\vec{V}_2$$

Summary of Results. For line-to-line fault (Blue and Yellow line

(*i*) $\vec{I}_R = 0 \;;\; \vec{I}_Y = -\vec{I}_B = \frac{-j\sqrt{3}\,\vec{E}_R}{\vec{Z}_1+\vec{Z}_2}$

(*ii*) $\vec{V}_Y = \vec{V}_B = -\frac{\vec{Z}_2}{\vec{Z}_1+\vec{Z}_2}\vec{E}_R$ and $\vec{V}_R = \frac{2\vec{Z}_2}{\vec{Z}_1+\vec{Z}_2}\vec{E}_R$

Multiple Choice Questions

Q1 various power system faults in increasing order of severity

are *a) LG,LL,LLG,LLLG*

b) LLLG,LLG,LG,LL

c) LLG,LLLG,LL,LG

d) LL,LG,LLLG,LLG

Q2 Oil immersed type reactor has the advantage

of *a)Higher safety against flashover*

b) Smaller size with large thermal capacity

c) Limiting the fault voltage

d) Both (a) and (b) above

Q3 **which of the following method of protection is used to achieve earth fault operation?**

a) Core balance method

b) Relay connected with neutral to ground

c) Frame leakage method

d) None of these

Q4 **Minimum faults occur in which of the following power system equipment?**

a) Transformer

b) Switch gear

c) CT, PT

d) Alternator

a) Mho and ohm relays

b) Horn gap and temperature relay

c) Merz Price percentage differential relay

d) Earth fault and positive sequence relay

Q6 When a line-to-line fault occurs, the short circuit current of an alternator depends upon its

a) Sub transient reactance

b) Transient reactance

c) Synchronous reactance

d) Short circuit reactance

Short Answer type Questions

Q1 What are symmetrical and unsymmetrical faults?

Q2 What is fault how does it occur?

Long Answer type questions

Q1 Explain various types of faults in power system in detail

2. UNIT

Power-system protection

Power-system protection is a branch of electrical power engineering that deals with the protection of electrical power systems from faults through the isolation of faulted parts from the rest of the electrical network. The objective of a protection scheme is to keep the power system stable by isolating only the components that are under fault Protection systems usually comprise five components Current and voltage transf orm ers to step down the high voltages and currents of the electrical power system to convenient levels for the relays to deal with Protective relays to sense the fault and initiate a trip, or disconnection, order; Circuit breakers to open/close the system based on relay and auto recloser commands; Batteries to provide power in case of power disconnection in the system. Communication channels to allow analysis of current and voltage at remote terminals of a line and to allow remote tripping of equipment.

2. Switchgear

One of the basic functions of switchgear is protection, which is interruption of short -circuit and overload fault currents while maintaining service to unaffected circuits

Switchgear has two types of components:

- Power conducting components, such as switches, circuit breakers, fuses, and lightning arrestors, that conduct or interrupt the flow of electrical power
- Control components as control panels, current transformers, potential transformers, protective relays, and associated circuitry, that monitor, control, and protect the power conducting components

2.1 Circuit Breaker

It is a switching device which can be operated manually and automatically for controlling and protection of electrical power system

The circuit breaker mainly consists of fixed contacts and moving contacts. In normal "ON" condition of 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 switching signal is given to the breaker

All circuit breaker have operating coils (tripping coils and close coil)
A circuit breaker is a piece of equipment which can

(i) make or break a circuit either manually or by remote control under normal conditions (*ii*) break a circuit automatically under fault conditions

Arc Voltage - It is the voltage that appears across the contacts of the circuit breaker during the arcing period, circuit either manually or by remote control under fault conditions

Restriking voltage- It is the transient voltage that appears across the contacts at or near current zero during arcing period

Recovery voltage- It is the normal frequency (50 Hz) r.m.s. voltage that appears across the contacts of the circuit breaker after final arc extinction. It is approximately equal to the system voltage.

2.2 Classification of Circuit Breaker

- There are several ways of classifying the circuit breakers. However, the most general way of classification is on the basis of medium used for arc extinction. The medium used for arc extinction is usually oil, air, Sulphur hexafluoride (SF6) or vacuum.

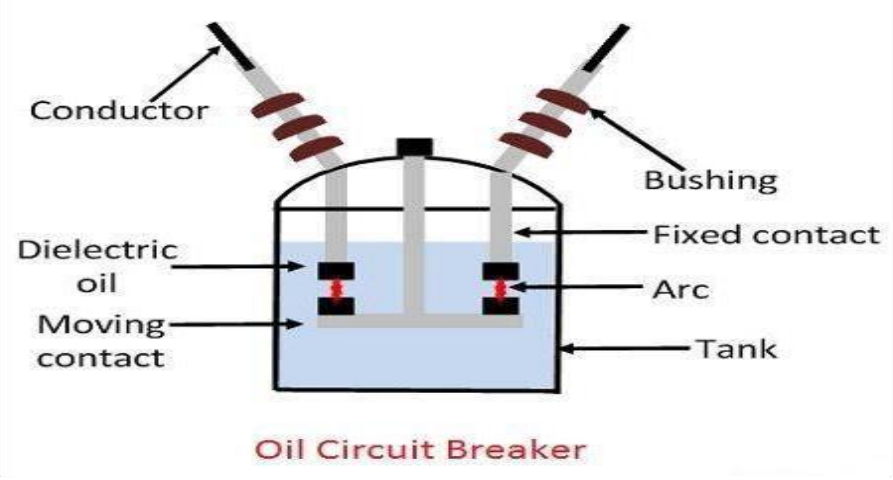
- (*i*) *Oil circuit breakers* which employ some insulating oil (*e.g.*, transformer oil) for arc extinction.
- (*ii*) *Air-blast circuit breakers* in which high pressure air-blast is used for extinguishing the arc.
- (*iii*) *Sulphur hexafluroide circuit breakers* in which sulphur hexafluoride (SF6) gas is used for arc extinction.
- (*iv*) *Vacuum circuit breakers* in which vacuum is used for arc extinction
-

2.3 Oil Circuit Breaker

- In such circuit breakers, some insulating oil (*e.g.*, transformer oil) is used as an arc quenching medium. The contacts are opened under oil and an arc is struck between them. The heat of the arc evaporates the surrounding oil and dissociates it into a substantial volume of gaseous hydrogen at high pressure
- *Oil circuit breaker is divided into* - Bulk oil circuit breaker, low oil circuit breaker
- *Bulk oil circuit breakers* which use a large quantity of oil.

The oil has to serve two purposes. Firstly, it extinguishes the arc during opening of contacts and secondly, it insulates the current conducting parts from one another and from the earthed tank. Such circuit breakers may be classified into : (*a*) Plain break oil circuit breakers (*b*) Arc control oil circuit breakers.

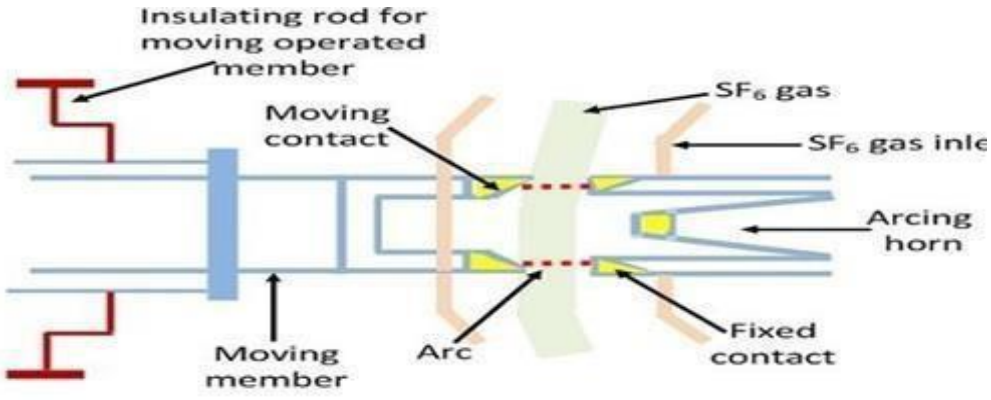
Low oil circuit breakers which use minimum amount of oil. In such circuit breakers, oil is used *only* for arc extinction; the current conducting parts are insulated by air or porcelain or organic insulating material



Oil Circuit Breaker

2.4 Sulphur Hexafluoride (SF6) Circuit Breaker

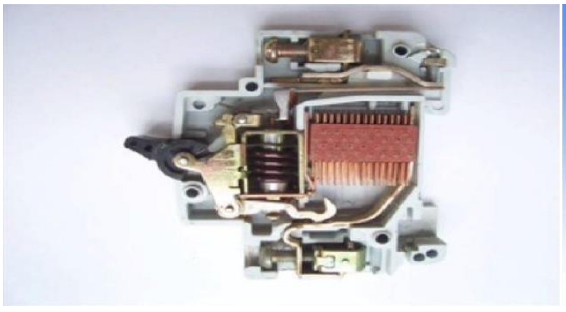
- A circuit breaker in which SF_6 under pressure gas is used to extinguish the arc is called SF_6 circuit breaker. SF_6 (sulphur hexafluoride) gas has excellent dielectric, arc quenching, chemical and other physical properties which have proved its superiority over other arc quenching mediums such as oil or air.
- It consists of fixed and moving contacts enclosed in a chamber (called arc interruption chamber) containing SF6 gas at a pressure of about 2·8 kg/cm



Interrupter Unit of SF6 Circuit Breaker

2.5 Miniature circuit breaker

- A miniature circuit breaker automatically switches off electrical circuit during an abnormal condition. If the circuit is overloaded for a long time, the bi-metallic strip becomes overheated and deformed. This deformation of Bi-metallic strip causes displacement of latch point. The moving contact of the MCB is arranged by means of spring pressure, with this latch point, that a little displacement of latch causes, release of spring and makes the moving contact to move for opening the MCB.



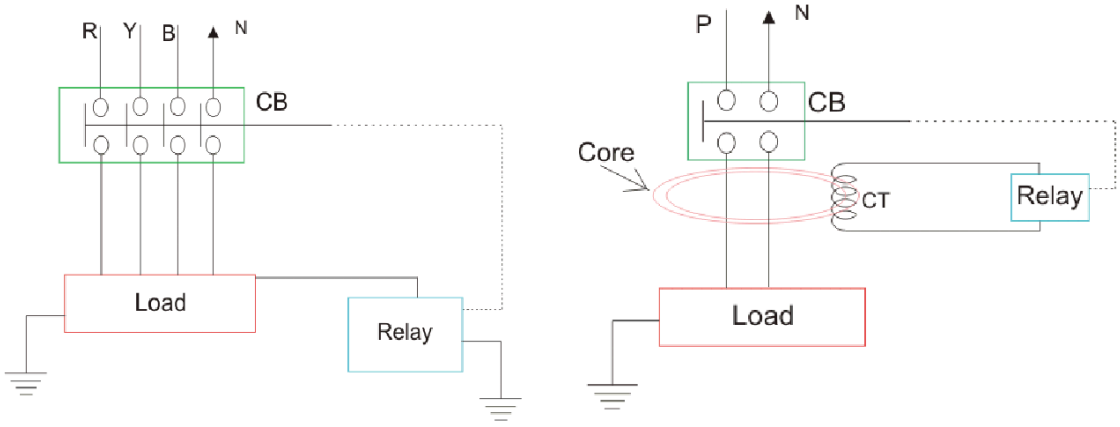
2.6 MCCB-Molded Case Circuit Breaker

- The MCCB is used to control electric energy in distribution n/k and is having short circuit and overload protection. This circuit Breaker is an electromechanical device which guards a circuit

from short circuit and over current. They offer short circuit and over current protection for circuits ranges from 63 Amps-3000 Amps. MCCB has a higher capacity than an MCB

2.7 ELCB -Earth Leakage Circuit Breaker

- The ELCB is used to protect the circuit from the electrical leakage. When someone gets an electric shock, then this circuit breaker cuts off the power at the time of 0.1 secs for protecting the personal safety and avoiding the gear from the circuit against short circuit and overload.
- Types of earth leakage circuit breaker, one is voltage ELCB and other is current ELCB.



Multiple Choice Questions

Q1 Circuit breakers usually operate under

a. Steady short circuit current
b. *Sub transient state of short circuit current*
c. Transient state of short circuit current
d. None of these

Q2 what is the actuating quantity for the relays?

a. Magnitude
b. Frequency
c. Phase angle
d. *All of these*

Q3 What is the making capacity of the circuit breaker?

a. Less than the asymmetrical breaking capacity of the breaker
b. *Greater than the asymmetrical breaking capacity of the breaker*
c. Equal to the asymmetrical breaking capacity of the breaker **d.**
Equal to the symmetrical breaking capacity of the breaker

Q4 SF_6 is which type of gas?

a. Electro positive
b. Electro negative

c. *Both (a) and (b)*

d. None of these

Q6 Which circuit breaker is preferred to be installed in extra high voltage AC system?

a. Bulk oil type circuit breaker

b. Air blast circuit breaker

c. *SF_6 circuit breaker*

d. Vacuum circuit breaker

Q7 Which of the following circuit breakers has the lowest operating voltage?

a. SF_6 circuit breaker

b. *Air break*

c. Air blast

d. Minimum oil circuit breaker

Q8 Plug setting of a electromagnetic relay can be altered by

varying *a.* *Number of ampere turns*

b. Air gap of magnetic path

c. Adjustable back stop

d. None of these

Q9 What is the major cause of the failure of the circuit breaker?

a. Trip circuit open

b. Trip latch defective

c. Spring defective

d. *All of these*

Short Answer type Questions

Q1 what do you understand by a switchgear? What is its function?

Q2 Give difference between circuit breaker and relay **Long answer type Questions**

Q1 Explain construction and working of oil circuit breaker.

Q2 Explain construction and wprking of SF_6 circuit breaker.

Q3 Write short notes on: a) ELCB b) MCB

3 Protection Devices

Fuse

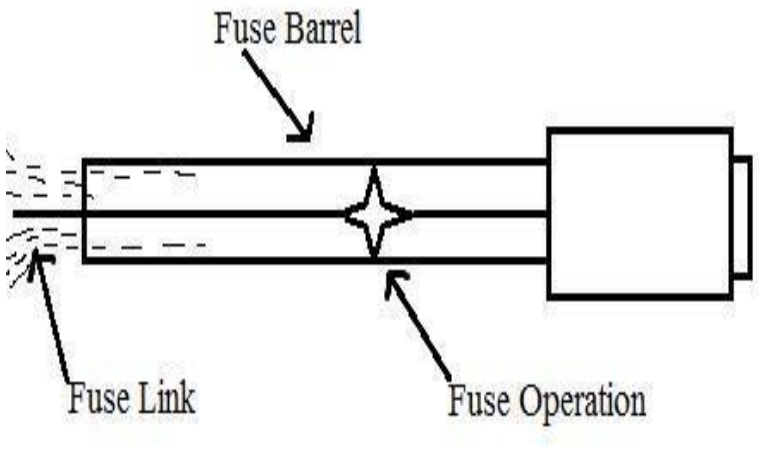
- A fuse is a short piece of metal, inserted in the circuit, which melts when excessive current flows through it and thus breaks the circuit. Fuses are used for the prevention of home appliances from the short circuit and damage by overload or high current etc.
- The fuses work on the principle of the heating effect of the current.

3.1 Desirable Characteristics of Fuse Element

(i) Low melting point *e.g.*, tin, lead.
(ii) High conductivity *e.g.*, silver, copper.
(iii) Free from deterioration due to oxidation *e.g.*, silver.
(*iv*) Low cost *e.g.*, lead, tin, copper.

The most commonly used materials for fuse element are lead, tin, copper, zinc and silver. For small currents up to 10 A, tin or an alloy of lead and tin (lead 37%, tin 63%) is used for making the fuse element. For larger currents, copper or silver is employed.

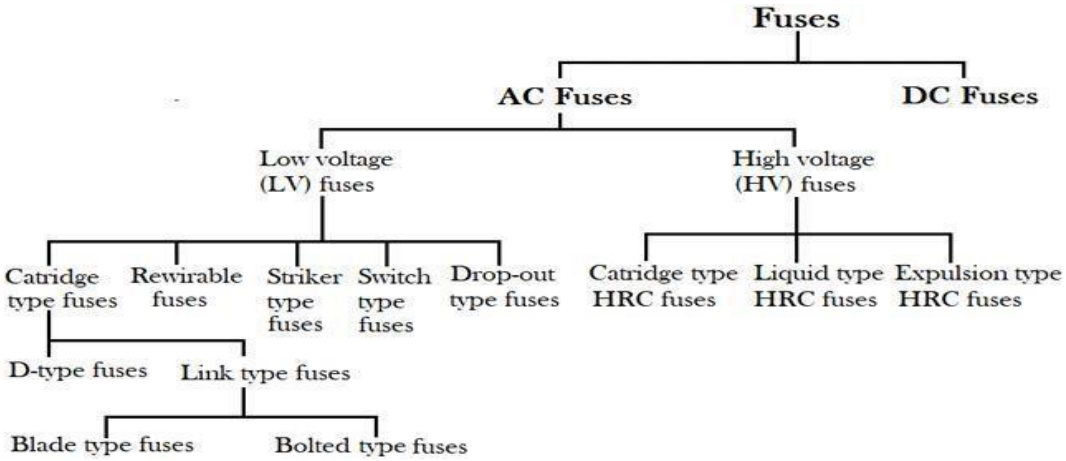
Fuses may be classified into : (*i*) Low voltages fuses (*ii*) High voltage fuses



Characteristics of Fuses

- *Current Rating:* The continuously conducting maximum amount of current holds the fuse without melting it is termed as current ratings. *Current(Cin)=75%Current (rating)*
- *Voltage Rating:* In this characteristic, the voltage connected in series with fuse does not increase voltage rating V *(fuse) >V(open ckt)*
- I^2t *Rating:* It measures the heat energy (energy due to current flow) of fuse & it is generated when fuse has blown.
- *Interrupting or Breaking Capacity:* It is the maximum rating of current without harm interrupt by the fuse is known as breaking or interrupting capacity of the fuse. *Breaking capacity > maximum rated voltage*

- *Temperature:* In this, the operating temperature will be higher, therefore the current rating will be lesser, so the fuse melts
- *Fusing factor:* It is the ratio of minimum fusing current to the current rating of the fuse Element

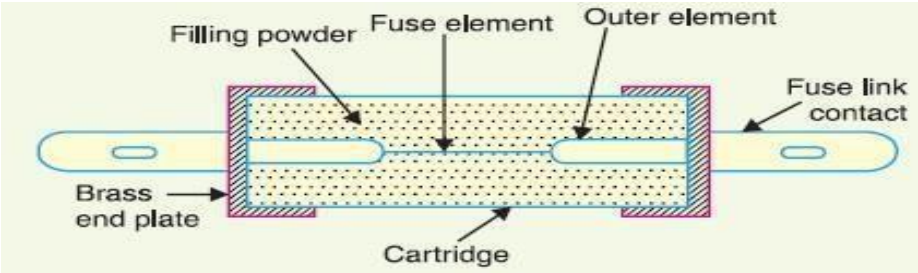


3.2 Low voltage fuses

Low voltage fuses can be subdivided into two Classes *viz*., (*i*) semi-enclosed rewire able fuse (*ii*) high rupturing capacity (H.R.C.) cartridge fuse.

***Semi-enclosed Rewireable fuse*:** Rewireable fuse (also known as kit-kat type) is used where low values of fault current are to be interrupted. It consists of (*i*) a base and (*ii*) a fuse carrier. The base is of porcelain and carries the fixed contacts to which the incoming and outgoing phase wires are connected. The fuse carrier is also of porcelain and holds the fuse element (tinned copper wire) between its terminals

- High-Rupturing capacity (H.R.C.) cartridge fuse: It consists of a heat resisting ceramic body having metal end-caps to which is welded silver current-carrying element. The space within the body surrounding the element is completely packed with a filling powder. The filling material may be chalk, plaster of paris, quartz or marble dust and acts as an arc quenching and cooling medium.



High voltage cartridge fuses are used upto 33 kV with breaking capacity of about 8700 A at that voltage. Rating of the order of 200 A at 6·6kV and 11 kV and 50 A at 33 kV are also available

Types of Relays

The relay may be defined as an electrical device interposed between the main circuit and the circuit breaker in such a manner that any abnormality in the circuit acts on the relay, which in turn if the fault is dangerous then it causes the circuit breaker to isolate and so to remove the faulty element. The relay ensures the safety of the circuit equipment from any damage which might be otherwise caused by the fault.

The electrical protective relay can be broad, classified into two categories (i) Electromagnetic Relay and (ii) Static Relay. According to the principle of operation and construction, the relay may be classified such as the electromagnetic attraction type, electromagnetic induction type, electrodynamic type, moving coil type, electro-thermal type, physics electric type, and static relays.

Electromagnetic Relays

Electromagnetic attraction relays are of two types, namely attracted armature type and solenoid type. In an attracted armature type relay operation depends on the movement of an armature under the influence of attractive force due to magnetic field set up by the current flowing through the relay winding.

While in a solenoid type operation depends on the movement of an iron plunger, attracted armature hinged, and balanced beam types of relays fall under this category. Such relays are actuated by DC or AC quantities.

Electromagnetic Induction Relays

Its operation depends on the movement of a metallic disc or cylinder free to rotate by the interaction of the induced currents and the alternating magnetic fields producing them. Electromagnetic induction relays are most generally used relays. It involves only AC quantities for the protective relaying purpose.

These relays operate on the simple principle of split-phase induction motors. Actuating force is developed on a moving element, by the interaction of electromagnetic fluxes with eddy currents that are induced in the rotor by these fluxes.

Electrodynamic Type Relays

In an electrodynamic type relay moving member consists of a coil free to rotate in an electromagnetic field as in the case of a moving coil instrument.

Moving Coil Type Relays

In a moving coil type relay moving member consists of a coil free to rotate in the air gap of a permanent magnet. In this relay, the magnetic coil freely rotates in the magnetic field of a permanent magnet. The torque is developed by the interaction between the field of the permanent magnet and the coil field developed due to the flow of actuating current into the coil.

The time-current characteristic of such relay is an inverse time characteristic. The operating torque is proportional to the actuating current. Such a relay has uniform torque for different positions of the coil

and therefore, can be accurately set.

Electro-thermal Relays

In electro-thermal relay, the movement depends on the action of the heat produced by the current flowing through the element of the relay. These relays operates on the principle of thermal effect of electric current. It is most widely used for the protection of low-voltages squirrel cage induction motors or dc motors of lower output ratings.

Static Relays

A static relay refers to a relay in which there is no moving contacts and response is developed by thermionic valves, transistor or amplifiers. It is combination of both static and electromagnetic units. In static relays, the sensing is taken out by static circuits consisting of comparators, detectors, filters etc.

According to the connection of sensing elements, relays are classed as primary and secondary relays. Primary relays are those whose sensing elements are directly connected in the circuit or element they protect, while the secondary relays are those whose measuring elements are connected to the circuit they protect through instrument transformers.

Normally secondary relays are used in power system protection because of high values of line voltages and current. According to applications the relay may be classified as

Overvoltage, Overcurrent, and Overpower Relay – The relay operates when the voltage, current or power arises above a specified value.

Undervoltage, Undercurrent, and Underpowe r Relay – The relays operate when the voltage, current or power falls below a specified value.

Directional or Reverse Current Relay – The relay operates when the applied current assumes a specified phase shift on the supply voltage and the relay is compensated for the fall in voltage.

Directional or Reverse Power Relay – The relay operates when the applied voltage and current assumed specified space displacement and no compensation is allowed for fall in voltage.

Differential Relay – The relays operate when some specified phase or magnitude difference between two or more electrical quantities occurs.

Distance Relay – In this relay operation depends on the ratio of the voltage to the current.

According to timing characteristic, the relays can be divided into the following classes.

Instantaneous Relays – These relays employed after a small time duration from the incidence of the current or other quantity resulting in operation. The times require for the operation of such relays is less than 0.2 seconds.

Definite Time Lag Relays – In these relays, the time of operation is sensibly independent of the magnitude of the current or other quantity causing operation.

Inverse Time Lag Relays – In this relay, the magnitude of the current or other quantity causing operation is inversely equal to the time requires for the operation.

Inverse Definite Minimum Time Lag Relays – In these relays the time of operation is approximately equal to the lesser values of current or other quantity like voltage, frequency, etc., causing operation and tends to be a specific minimum time as the value rises without limit.

Multiple Choice Questions

Q1 What should be the value of fusing factor?

a. Equal to zero
b. Equal to one
c. *Less than one*
d. More than one

Q2 Which among these are the main characteristics of a fuse element?

a. Low melting point
b. High conductivity
c. Least deterioration due to oxidation
d. All of the above

Q3 For a current upto 10A which material is used as the fusing element?

a. Copper
b. Silver
c. Alloy of lead and tin
d. Zinc

Q4 What is fusing factor?

a. The ratio of current rating of the fuse to the minimum fusing current. *b. The ratio of minimum fusing current to the current rating of the fuse.* c. The ratio of maximum fusing current to the current rating of the fuse. d. The ratio of minimum fusing current to the voltage rating of the fuse

Q5 What is the typical value of the pre arcing time?

a. 0.1
b. 0.01
c. 0.001
d. 0.0001

Short Answer Questions

Q1 Define fuse with its various characteristics.

5 Over-voltage Protections

This portion of our website covers almost everything related to **protection system in power system** including standard lead and device numbers, mode of connections at terminal strips, color codes in multi-core cables, Dos and Don'ts in execution. It also covers principles of various power system protection relays and schemes including special **power systemprotection** schemes like differential relays, restricted earth fault protection, directional relays and distance relays etc. The details of transformer protection, generator protection, transmission line protection and protection of capacitor banks are also given. It covers almost everything about **protection of power system**.
The switchgear testing, instrument transformers like current transformer testing, voltageor potential transformer testing and associated protection relay are explained in detail.
The close and trip, indication and alarm circuits different of circuit breakers are also included and explained.
The following are the top five causes of over voltage .

1. **Power system surges**. Due to poor regulation of the power source or power utility company, voltage fluctuations either over or under may occur. This may cause serious damage especially to electronic orcomputer controlled equipment. In this case, special attention should be given to these equipment to ensure safe usage. Relay devices, AVRs, auto-transformer type regulators may be used.
2. **Insulation Failure.** The most common form of insulation failure is when there is grounding of the conductor. Failure takes place when there is no insulation between the line and the earth. So, the part of the conductor that is grounded to the earth allows the current to flow downward.
3. **Arcing Ground.** This happens when there is presence of a sporadic arc in line-to-ground fault belonging to three-phase system. Here, short-live oscillations are produced in the system due to some changes in the voltage and the current load. This phenomenon may lead to serious problems like breakdown of the insulation and may harm equipment connected to the power system.
4. **Resonance.** This one occurs when the value of the inductive resistance in the power system becomes equal with the value of capacitive resistance.
5. **External causes.** Although many cases of over-voltage result from the internal causes as listed above, studies show that the highest surges are still contributed by some external causes. Lightning is one good example, which has already been cited as responsible for high magnitude of surges, leading to very serious failures. This is because an external factor such as lightning is capable of increasing the voltage by many times higher that the normal value. This is the reason why power systems and appliances should be protected with voltage protectors

Lightning stroke is the direct discharge of an electrical charge between the atmosphere and the object of earth. It is a sudden flow of electric charge between the electrical charge area of a cloud also called intra-cloud and another cloud called (CC lightning) or between the charged cloud and the ground (CG lightning

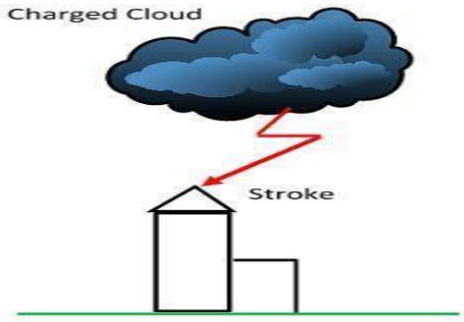
Types of Lightning Stroke
The lightning stroke affects the lines in two ways

1. Direct stroke
2. Electrostatic induction.

3. **1. Direct Stroke**

4. In the direct lightning strokes, the cloud attains a large amount of charge and induces an opposite charge on taller objects such as temple, churches or mosques. When the intensity of

electrostatic field becomes sufficiently great to ionise the neighbouring air, the air break down and discharge takes place between the cloud and the object. Such types of discharge take a long time to produce, and it strikes the highest and the most sharply pointed building in the neighbourhood.



Objective of Power System Protection

The objective of **power systemprotection** is to isolate a faulty section of electrical powersystem from rest of the live system so that the rest portion can function satisfactorily without any severe damage due to fault current.
Actually circuit breaker isolates the faulty system from rest of the healthy system and these circuit breakers automatically open during fault condition due to its trip signal which comes from protection relay. The main philosophy about protection is that no protection of power system can prevent the flow of fault current through the system, it only can prevent the continuation of flowing of fault current by quickly disconnect the short circuit path from the system. For satisfying this quick disconnection the protection relays should have following functional requirements.
Overvoltage Protection

When the voltage in a system, raised beyond its rated voltage, then it is known as overvoltage. This overvoltage may be of transient or persistent nature. The main cause due to which overvoltage is produced in the power system may be conveniently grouped into two categories, namely, internal and external. Internal overvoltage has got their origin within the system itself, whereas external overvoltage is because of lightning on the lines.

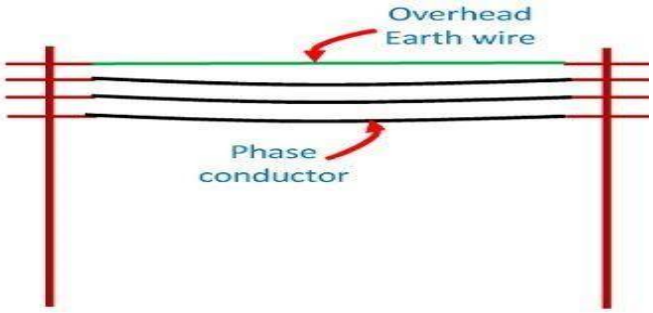
This over voltage may cause damage to insulators and substation equipment. It is, therefore, necessary to provide a means to protect the insulators and other apparatus from the harmful effect of overvoltage. Some devices are available to reduce the amplitude and front steepness of surges. The following will be described here

1. Rod gap
2. Surge Diverter
3. Overhead Earth Wire

Overhead Earth Wire

An overhead earth wire or ground wire is one of the most common devices used to protect the lines against lightning. It is the wire carried the line supports and runs over the phase conductors. The

purpose of the earth wire is to block the direct lightning strokes, which would otherwise strike the phase conductors. The waves of lightning reach the adjoining towers which pass them to earth safely.



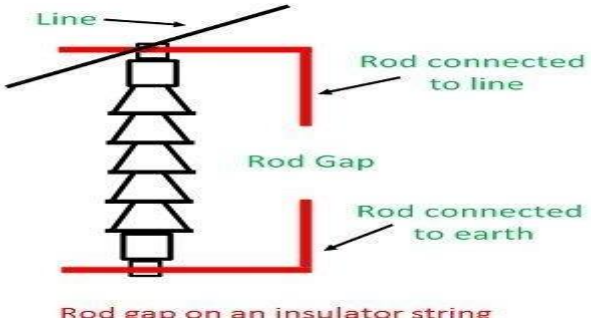
Overhead earth wire

In case the resistance of electrical tower or ground is small, the lighting will be raised to very high voltage, which will cause a flash over from the tower to one or more phase conductors. Such a flashover is known as black flash over. Back flash over on the line can be minimized by reducing the tower footing resistance using driven rods and counterpoise where soil resistivity is high.

Rod gap

The rod gap is one of the most common frames of protective devices. It is an air gap between the ends of two rods. The gap setting should be such that it should break under all conditions before the equipment to be protected is affected. The chief merits of this device are simplicity, reliability and cheapness.

Rod gap has a some restrictions like they are unable to prevent the flow of power which flows in the gap after the breakdown. It is used in the places where continuity of supply is not of much importance. In such cases (where continuity is important) , automatic reclosing circuit breakers are used.



Rod gap on an insulator string

Surge diverters

Surge-diverters or lightning arrester is a device used for distracting abnormal high voltage to ground without affecting the continuity of supply. Surge diverters are three types

1. Expulsion-type surge diverter

2. Valve-type surge diverter
3. Metal-oxide surge diverter

The name surge diverters appear to be correct than lightning arreste

Lightning Arrester

Definition: The device which is used for the protection of the equipment at the substations against travelling waves, such type of device is called lightning arrester or surge diverter. In other words, lightning arrester diverts the abnormals high voltage to the ground without affecting the continuity of supply. It is connected between the line and earth, i.e., in parallel with the equipment to be protected at the substation.

When a travelling wave reaches the arrestor, its sparks over at a certain prefixed voltage as shown in the figure below. The arrestor provides a conducting path to the waves of relatively low impedance between the line and the ground. The surge impedance of the line restricts the amplitude of current flowing to ground.

The lightning arrester provides a path of low impedance only when the travelling surge reaches the surge diverter, neither before it nor after it. The insulation of the equipment can be protected if the shape of the voltage and current at the diverter terminal is similar to the shape shown below.

The lightning arrester is located close to the equipment that is to be protected. They are usually connected between phase and ground in an AC system and pole and ground in case of the DC system. In an AC system, separate arrester is provided for each phase.

7 Electricity Tariffs

Definition: The amount of money frame by the supplier for the supply of electrical energy to various types of consumers in known as an electricity tariff. In other words, the tariff is the methods of charging a consumer for consuming electric power. The tariff covers the total cost of producing and supplying electric energy plus a reasonable cost.

The actual tariffs that the customer pay depends on the consumption of the electricity. The consumer bill varies according to their requirements. The industrial consumers pay more tariffs because they use more power for long times than the domestic consumers. The electricity tariffs depends on the following factors

- Type of load
- Time at which load is required.
- The power factor of the load.
- The amount of energy used.

The total bill of the consumer has three parts, namely, fixed charge D, semi-fixed charge Ax and running charge By.

$$C = Ax + By + D$$

where, C – total charge for a period (say one month)
x – maximum demand during the period (kW or kVA)
y – Total energy consumed during te period (kW or kVA)
A – cost per kW or kVa of maximum demand.
B – cost per kWh of energy consumed.
D – fixed charge during each billing period.
This is known as three-part electricity tariff, and it is mainly applied to the big consumer.

Factors Affecting the Electricity Tariffs

The following factors are taken into accounts to decide the electricity tariff:

- **Types of Load –** The load is mainly classified into three types, i.e., domestic, commercial, or industrial. The industrial consumers use more energy for a longer time than domestic consumers, and hence the tariff for the industrial consumers is more than the domestic consumers. The tariff of the electric energy varies according to their requirement.
- **Maximum demand –** The cost of the electrical energy supplied by a generating station depends on the installed capacity of the plant and kWh generated. Increased in maximum capacity increased the installed capacity of the generating station.
- **The time at which load is required –** The time at which the maximum load required is also essential for the electricity tariff. If the maximum demand coincides with the maximum demand of the consumer, then the additional plant is required. And if the maximum demand of the consumers occurs during off-peak hours, the load factor is improved, and no extra plant capacity is needed. Thus, the overall cost per kWh generated is reduced.
- **The power factor of the load –** The power factor plays a major role in the plant economics. The low power factor increases the load current which increases the losses in the system. Thus, the regulation becomes poor. For improving the power factor, the power factor correction equipment is installed at the generating station. Thus, the cost of the generation increases.

1. Simple Tariff

In this type of tariff, a fixed rate is applied for each unit of the energy consumed. It is also known as a uniform tariff. The **rate per unit of energy does not depend upon the quantity** of energy used by a consumer. The price per unit (1 kWh) of energy is constant. This energy consumed by the consumer is recorded by the energy meters.

2. Flat Rate Tariff

In this tariff, different types of consumers are charged at different rates of cost per unit (1kWh) of electrical energy consumed. Different consumers are grouped under different categories. Then, each category is charged money at a fixed rate similar to Simple Tariff. The different rates are decided according to the consumers, their loads and load factors**.**

3. Block Rate Tariff

In this tariff, the first block of the energy consumed (consisting of a fixed number of units) is charged at a given rate and the succeeding blocks of energy (each with a predetermined number of units) are charged at progressively reduced rates. The rate per unit in each block is fixed.
For example, the first 50 units (1st block) may be charged at 3 rupees per unit; the next 30 units (2nd block) at 2.50 rupees per unit and the next 30 units (3rd block) at 2 rupees per unit.

4. Two Part Tariff

In this tariff scheme, the total costs charged to the consumers consist of two components: fixed charges and running charges. It can be expressed as:
Total Cost=[A(kW)+B(kWh)] Rs. Where, A = charge per kW of max demand (i.e. A is a constant which when multiplied with max demand (kW) gives the total fixed costs.)
B = charge per kWh of energy consumed (i.e. B is a constant which when multiplied with units consumed (kWh), gives total running charges.)

5 Maximum Demand Tariff

In this tariff, the energy consumed is charged on the basis of maximum demand. The units (energy) consumed by him is called maximum demand. The max demand is calculated by a maximum demand meter. This removes any conflict between the supplier and the consumer as it were the two part tariff. It is similar to two-part tariff.

6 Three Part Tariff

In this scheme, the total costs are divided into 3 sections: Fixed costs, semi-fixed costs and running costs.
Total Charges = [A + B (kW) + C (kWh)]
Where, A = fixed charges,
B = charge per kW of max demand (i.e. B is a constant which when multiplied with max demand (kW) gives the total fixed costs.)
C = charge per kWh of energy consumed (i.e. C is a constant which when multiplied with units consumed (kWh), gives total running charges.)

Question 1. What Are The Functions Of Protective Relays?

Answer : To detect the fault and initiate the operation of the circuit breaker to isolate the defective element from the rest of the system, thereby protecting the system from damages consequent to the fault.

Question 2. Give The Consequences Of Short Circuit?

Answer :

Whenever a short-circuit occurs, the current flowing through the coil increases to an enormous value. If protective relays are present , a heavy current also flows through the relay coil, causing it to operate by closing its contacts. The trip circuit is then closed , the circuit breaker opens and the fault is isolated from the rest of the system. Also, a low voltage may be created which may damage systems connected to the supply.

Question 3. Define Protected Zone?

Answer :

Are those which are directly protected by a protective system such as relays, fuses or switchgears.If a fault occurring in a zone can be immediately detected and or isolated by a protection scheme dedicated to that particular zone.

Question 4. What Are Unit System And Non Unit System?

Answer :

A unit protective system is one in which only faults occurring within its protected zone are isolated.Faults occurring elsewhere in the system have no influence on the operation of a unit system.A non unit system is a protective system which is activated even when the faults are external to its protected zone.

Question 5. What Is Primary Protection?

Answer :

Is the protection in which the fault occurring in a line will be cleared by its own relay and circuit breaker.It serves as the first line of defence.

Question 6. What Is Back Up Protection?

Answer :

Is the second line of defence , which operates if the primary protection fails to activate within a definite time delay.

Question 7. Name the Different Kinds Of Over Current Relays?

Answer :

Induction type non-directional over current relay,Induction type directional over current relay & current differential relay.

Question 8. Define Energizing Quantity?

Answer :

It refers to the current or voltage which is used to activate the relay into operation.

Question 9. Define Operating Time Of A Relay?

Answer :

It is defined as the time period extended from the occurrence of the fault through the relay detecting the fault to the operation of the relay.

Question 10. Define Resetting Time Of A Relay?

Answer :

It is defined as the time taken by the relay from the instant of isolating the fault to the moment when the fault is removed and the relay can be reset.

Question 11. What Are Over And Under Current Relays?

Answer :

Overcurrent relays are those that operate when the current in a line exceeds a predetermined value. (eg: Induction type non-directional/directional overcurrent relay, differential overcurrent relay)whereas undercurrent relays are those which operate whenever the current in a circuit/line drops below a predetermined value.(eg: differential over-voltage relay)

Question 12. Mention Any Two Applications Of Differential Relay?

Answer :

Protection of generator & generator transformer unit; protection of large motors and bus bars .

Question 16. What Are The Various Faults To Which A Turbo Alternator Is Likely To Be Subjected? failure Of Steam Supply; Failure Of Speed; Overcurrent; Over Voltage; Unbalanced

Answer :

loading; stator winding fault

Question 17. What Is An Under Frequency Relay?

Answer :

An under frequency relay is one which operates when the frequency of the system (usually an alternator or transformer) falls below a certain value.

Question 18. Define The Term Pilot With Reference To Power Line Protection.

Answer :

Pilot wires refers to the wires that connect the CT's placed at the ends of a power transmission line as part of its protection scheme. The resistance of the pilot wires is usually less than 500 ohms.

Question 19. Mention Any Two Disadvantage Of Carrier Current Scheme For Transmission Line Only.

Answer :

The program time (ie, the time taken by the carrier to reach the other end-upto .1% mile); the response time of band pass filter; capacitance phase-shift of the transmission line .

Question 20. What Are The Features Of Directional Relay?

Answer :

High speed operation; high sensitivity; ability to operate at low voltages; adequate short-time thermal ratio; burden must not be excessive.

Question 21. What Are The Main Types Of Stator Winding Faults?

Answer :

Fault between phase and ground; fault between phases and inter-turn fault involving turns of the same phase winding.

Question 22. Give The Limitations Of Merz Price Protection?

Answer :

Since neutral earthing resistances are often used to protect circuit from earth-fault currents, it becomes impossible to protect the whole of a star-connected alternator. If an earth-fault occurs near the neutral point, the voltage may be insufficient to operate the relay. Also it is extremely difficult to find two identical CT's. In addition to this, there always an inherent phase difference between the primary and the secondary quantities and a possibility of current through the relay even when there is no fault.

Question 23. What Are The Uses Of Buchholz's Relay?

Answer :

Bucholz relay is used to give an alarm in case of incipient(slow-developing) faults in the transformer and to connect the transformer from the supply in the event of severe internal faults. It is usually used in oil immersion transformers with a rating over 750KVA.

Question 24. Why Neutral Resistor Is Added Between Neutral And Earth Of An Alternator?

Answer :
In order to limit the flow of current through neutral and earth a resistor is introduced between them.

Question 25. What Is The Backup Protection Available For An Alternator? Overcurrent And Earth Fault Protection Is The Backup Protections. What Are Faults Associated With An Alternator?
Answer :
External fault or through fault

Internal fault

1. Short circuit in transformer winding and connection

2. Incipient or slow developing faults

Question 26. What Are The Main Safety Devices Available With Transformer?
Answer :
Oil level guage, sudden pressure delay, oil temperature indicator, winding temperature indicator .

Question 27. What Are The Limitations Of Buchholz Relay?
Answer :
Only fault below the oil level are detected.

Mercury switch setting should be very accurate, otherwise even for vibration, there can be a false operation.

The relay is of slow operating type, which is unsatisfactory.

Question 28. What Are The Problems Arising In Differential Protection In Power Transformer And How Are They Overcome?
Answer :
Difference in lengths of pilot wires on either sides of the relay. This is overcome by connecting adjustable resistors to pilot wires to get equipotential points on the pilot wires.

Difference in CT ratio error difference at high values of short circuit currents that makes the relay to operate even for external or through faults. This is overcome by introducing bias coil.

Tap changing alters the ratio of voltage and currents between HV and LV sides and the relay will sense this and act. Bias coil will solve this.

Magnetizing inrush current appears wherever a transformer is energized on its primary side producing harmonics. No current wi**l** be seen by the secondary. CT's as there is no load in the circuit. This difference in current will actuate the differential relay. A harmonic restraining unit is added to the relay which will block it when the transformer is energized.

Question 29. What Is Ref Relay?
Answer :
It is restricted earth fault relay. When the fault occurs very near to the neutral point of the transformer, the voltage available to drive the earth circuit is very small, which may not be sufficient to activate the relay, unless the relay is set for a very low current. Hence the zone of protection in the winding of the transformer is restricted to cover only around 85%. Hence the relay is called REF relay.

Question 30. What Is Over Fluxing Protection In Transformer?
Answer :
If the turns ratio of the transformer is more than 1:1, there will be higher core loss and the capability of the transformer to withstand this is limited to a few minutes only. This phenomenon is called over fluxing.

Question 31. Why Busbar Protection Is Needed?
Answer :

Fault level at busbar is high.

The stability of the system is affected by the faults in the bus zone.

A fault in the bus bar causes interruption of supply to a large portion of the system network.

Question 32. What Are The Merits Of Carrier Current Protection?

Answer :

Fast operation, auto re-closing possible, easy discrimination of simultaneous faults .

Question 33. What Are The Errors In Ct?

Answer :

Ratio error

Percentage ratio error = [(Nominal ratio – Actual ratio)/Actual ratio] x 100 The value of transformation ratio is not equal to the turns ratio.

Phase angle error:

Phase angle =180/π[(ImCos δ-I1Sin δ)/nIs]

Question 34. What Is Field Suppression?

Answer :

When a fault occurs in an alternator winding even though the generator circuit breaker is tripped, the fault continues to fed because EMF is induced in the generator itself. Hence the field circuit breaker is opened and stored energy in the field winding is discharged through another resistor. This method is known as field suppression.

Question 35. What Are The Causes Of Bus Zone Faults?

Answer :

- Failure of support insulator resulting in earth fault
- Flashover across support insulator during over voltage Heavily polluted insulator causing flashover Earthquake, mechanical damage etc.

Question 36. What Are The Problems In Bus Zone Differential Protection?

Answer :

- Large number of circuits, different current levels for different circuits for external faults.
- Saturation of CT cores due to dc component and ac component in short circuit currents. The saturation introduces ratio error.
- Sectionalizing of the bus makes circuit complicated.
- Setting of relays need a change with large load changes.

Question 37. What Is Static Relay?

Answer :

It is a relay in which measurement or comparison of electrical quantities is made in a static network which is designed to give an output signal when a threshold condition is passed which operates a tripping device.

Question 38. What Is Power Swing?

Answer :

During switching of lines or wrong synchronization surges of real and reactive power flowing in transmission line causes severe oscillations in the voltage and current vectors. It is represented by curves originating in load regions and traveling towards relay characteristics.

Question 39. What Is A Programmable Relay?

Answer :

A static relay may have one or more programmable units such as microprocessors or microcomputers in its circuit.

Question 40. What Is Cpmc?

Answer :

It is combined protection, monitoring and control system incorporated in the static system.

Question 41. What Are The Advantages Of Static Relay Over Electromagnetic Relay?

Answer :

- Low power consumption as low as 1mW
- No moving contacts; hence associated problems of arcing, contact bounce, erosion, replacement of contacts
- No gravity effect on operation of static relays. Hence can be used in vessels ie, ships, aircrafts etc.
- A single relay can perform several functions like over current, under voltage, single phasing protection by incorporating respective functional blocks. This is not possible in electromagnetic relays
- Static relay is compact
- Superior operating characteristics and accuracy
- Static relay can think , programmable operation is possible with static relay
- Effect of vibration is nil, hence can be used in earthquake-prone areas o Simplified testing and servicing. Can convert even non-electrical quantities to electrical in conjunction with transducers.

Question 42. What Is Resistance Switching?

Answer :

It is the method of connecting a resistance in parallel with the contact space(arc). The resistance reduces the restriking voltage frequency and it diverts part of the arc current. It assists the circuit breaker in interrupting the magnetizing current and capacity current.

Question 43. What Do You Mean By Current Chopping?

Answer :

When interrupting low inductive currents such as magnetizing currents of the transformer, shunt reactor, the rapid deionization of the contact space and blast effect may cause the current to be interrupted before the natural current zero. This phenomenon of interruption of the current before its natural zero is called current chopping.

Question 44. What Are The Methods Of Capacitive Switching?

Answer :

- Opening of single capacitor bank
- Closing of one capacitor bank against another

Question 45. What Is An Arc?

Answer :

Arc is a phenomenon occurring when the two contacts of a circuit breaker separate under heavy load or fault or short circuit condition.

Question 46. Give The Two Methods Of Arc Interruption?

Answer :

High resistance interruption:-the arc resistance is increased by elongating, and splitting the arc so that the arc is fully extinguished

Current zero method:-The arc is interrupted at current zero position that occurs100 times a second in case of 50Hz power system frequency in ac.

Question 47. What Is Restriking Voltage?

Answer :

It is the transient voltage appearing across the breaker contacts at the instant of arc being extinguished.

Question 48. What Is Meant By Recovery Voltage?

Answer :

The power frequency rms voltage appearing across the breaker contacts after the arc is extinguished and transient oscillations die out is called recovery voltage.

Question 49. What Is Rrrv?

Answer :

It is the rate of rise of restriking voltage, expressed in volts per microsecond. It is closely associated with natural frequency of oscillation.

Question 50. What Is Circuit Breaker?

Answer :

It is a piece of equipment used to break a circuit automatically under fault conditions. It breaks a circuit either manually or by remote control under normal conditions and under fault conditions.

Question 51. Write The Classification Of Circuit Breakers Based On The Medium Used For Arc Extinction?

Answer :

- Air break circuit breaker Oil circuit breaker
- Minimum oil circuit breaker Air blast circuit breaker
- SF6 circuit breaker
- Vacuum circuit breaker

Question 52. What Is The Main Problem Of The Circuit Breaker?

Answer :

When the contacts of the breaker are separated, an arc is struck between them. This arc delays the current interruption process and also generates enormous heat which may cause damage to the system or to the breaker itself. This is the main problem.

Question 53. What Are Demerits Of Mocb?

Answer :

Short contact life

Frequent maintenance Possibility of explosion

Larger arcing time for small currents Prone to restricts

Question 54. What Are The Advantages Of Oil As Arc Quenching Medium?

Answer :

It absorbs the arc energy to decompose the oil into gases, which have excellent cooling properties

It acts as an insulator and permits smaller clearance between line conductors and earthed components

Question 55. What Are The Hazards Imposed By Oil When It Is Used As An Arc Quenching Medium? There Is A Risk Of Fire Since It Is Inflammable. It May Form An Explosive Mixture?

Answer :

with arc. So oil is preferred as an arc quenching medium.

Question 56. What Are The Advantages Of Mocb Over A Bulk Oil Circuit Breaker?

Answer :

- It requires lesser quantity of oil
- It requires smaller space
- There is a reduced risk of fire
- Maintenance problem are reduced

Question 57. What Are The Disadvantages Of Mocb Over A Bulk Oil Circuit Breaker?

Answer :

- The degree of carbonization is increased due to smaller quantity of oil
- There is difficulty of removing the gases from the contact space in time

- The dielectric strength of the oil deteriorates rapidly due to high degree of carbonization.

Question 58. What Are The Types Of Air Blast Circuit Breaker?

Answer :

- Arial-blast type
- Cross blast Radial-blast

Question 59. What Are The Advantages Of Air Blast Circuit Breaker Over Oil Circuit Breaker?

Answer :

- The risk of fire is diminished
- The arcing time is very small due to rapid buildup of dielectric strength between contacts
- The arcing products are completely removed by the blast whereas oil deteriorates with successive operations

Question 60. What Are The Demerits Of Using Oil As An Arc Quenching Medium?

Answer :

The air has relatively inferior arc quenching properties

The air blast circuit breakers are very sensitive to variations in the rate of rise of restriking voltage

Maintenance is required for the compression plant which supplies the air blast

Question 61. What Is Meant By Electro Negativity Of Sf6 Gas?

Answer :

SF6 has high affinity for electrons. When a free electron comes and collides with a neutral gas molecule, the electron is absorbed by the neutral gas molecule and negative ion is formed. This is called as electro negativity of SF6 gas.

Question 62. What Are The Characteristic Of Sf6 Gas?

Answer :

It has good dielectric strength and excellent arc quenching property. It is inert, non-toxic, noninflammable and heavy. At atmospheric pressure, its dielectric strength is 2.5 times that of air. At three times atmospheric pressure, its dielectric strength is equal to that of the transformer oil.

Question 63. Write The Classifications Of Test Conducted On Circuit Breakers?

Answer :

- Type test
- Routine test Reliability test
- Commissioning test

Question 64. What Are The Indirect Methods Of Circuit Breaker Testing?

Answer :

- Unit test
- Synthetic test
- Substitution testing o Compensation testing o Capacitance testing

Question 65. What Are The Advantages Of Synthetic Testing Methods?

Answer :

- The breaker can be tested for desired transient recovery voltage and RRRV.
- Both test current and test voltage can be independently varied. This gives flexibility to the test
- The method is simple With this method a breaker capacity (MVA) of five time of that of the capacity of the test plant can be tested.

Question 66. How Does The Over Voltage Surge Affect The Power System?

Answer :

The over voltage of the power system leads to insulation breakdown of the equipments. It causes the line insulation to flash over and may also damage the nearby transformer, generators and the other

equipment connected to the line.

Question 67. What Is Pick Up Value?

Answer :
It is the minimum current in the relay coil at which the relay starts to operate.

Question 68. Define Target?
Answer :
It is the indicator used for showing the operation of the relay.

Question 69. Define Reach?
Answer :
It is the distance upto which the relay will cover for protection.

Question 70. Define Blocking?
Answer :
It means preventing the relay from tripping due to its own characteristics or due to additional relays.

Question 71. Define A Over Current Relay?
Answer :
Relay which operates when the current ia a line exceeds a predetermined value.

Question 72. Define An Under Current Relay?
Answer :
Relays which operates whenever the current in a circuit drops below a predetermined value.

Question 73. Mention Any 2 Applications Of Differential Relays?
Answer :
Protection of generator and generator-transformer unit: protection of large motors and bus bars

Question 74. Mention The Advantages Of Field Tests?
Answer :
The circuit breaker is tested under actual conditions like those that occur in the network. Special occasions like breaking of charging currents of long lines ,very short line faults ,interruption of small inductive currents etc. can be tested by direct testing only.

Question 75. State The Disadvantages Of Field Tests?
Answer :

- The circuit breaker can be tested at only a given rated voltage and network capacity.
- The necessity to interrupt the normal services and to test only at light load conditions.
- Extra inconvenience and expenses in installation of controlling and measuring equipment in the field.