

# **EE8602 - PROTECTION AND SWITCHGEAR**

## **UNIT I**

### **PROTECTION SCHEMES**

#### **PART A**

**1. How does the over voltage surge affect the power system?**

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.

**2. What are symmetrical components?**

It is a mathematical tool to resolve unbalanced components into balanced components. The symmetrical components of three phase system are, i) Positive sequence components. ii) Negative sequence components iii) Zero sequence components.

**3. Define negative sequence component.**

It has three vectors equal in magnitude and displaced from each other by an angle 120 degrees and has the phase sequence in opposite to its original phasors.

**4. State the essential qualities of protection.**

i) Reliability ii) Selectivity iii) Fastness of operation and iv) Discrimination.

**5. Give the consequences of short circuit or What are the effects of short circuit faults in power system if uncleared? (Nov/Dec 2018)**

When a short-circuit occurs, the current in the system increases to an abnormally high value while the system voltage decreases to a low value. The heavy current due to short-circuit causes excessive heating which may result in fire or explosion. Sometimes short-circuit takes the form of an arc and causes considerable damage to the system. If the voltage remains low for even a few seconds, the consumer's motors may shut down and generators on the power system may become unstable.

**6. What is the need of relay coordination?**

The operation of a relay should be fast and selective, i.e., it should isolate the fault in the shortest possible time causing minimum disturbance to the system. Also, if a relay fails to operate, there should be sufficiently quick backup protection so that the rest of the system is protected. By coordinating relays, faults can always be isolated quickly without serious disturbance to the rest of the system.

**7. Define: energizing quantity.**

The electrical quantity i.e., current or voltage either alone or in combination with other electrical quantities required for the functioning of the relay. The quantity either current or voltage which is the input to the relay energizes the trip coil of the relay which in turn trips the circuit in case of faults.

**8. What is protected zone? (Apr/May 2015)**

Protected zones are those which are directly protected by a protective system such as relays, fuses or switchgears. When a fault occurs in a zone, it can be immediately detected and isolated by a protection scheme which is dedicated to that particular zone. To limit the extent of the fault, power system protection is arranged in zones. Ideally, the zones of protection should overlap, so that no part of the power system is left unprotected.

**9. What are the various faults that would affect an alternator?**

i)Phase to phase faults ii) Phase to earth faults iii) Inter turn faults iv) Earth faults v)Fault between turns vi) Loss of excitation due to fuel failure vii) Over speed viii) Loss of drive ix) Vacuum failure resulting in condenser pressure rise, resulting in shattering of the turbine low pressure casing.

**10. State the significance of double line fault.**

Double line to ground fault occurs when two lines are short circuited and is in contact with the ground. This type of fault occurrence ranges from 15 to 25%. It has no zero sequence component and the positive and negative sequence networks are connected in parallel. Since zero sequence components are absent there is no circulating current.

**11. What is primary protection? (Nov/Dec 2017)**

Primary protection 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 defense.

**12. What are the different types of earthing ? (Apr/May 2015)**

- i) Resistive earthing
- ii) Reactance earthing
- iii) Resonant earthing

**13. State the significance of single line to ground fault.**

In single line to ground fault all the sequence networks are connected in series. All the sequence currents are equal and the fault current magnitude is three times its sequence currents.

**14. Differentiate between a fuse and a circuit breaker.**

Fuse is a low current interrupting device. It is a copper or an aluminum wire. Circuit breaker is a high current interrupting device and it act as a switch under normal operating conditions.

**15. What is surge absorber? How do they differ from surge diverter? (Nov/Dec 2011)**

Surge absorber is a device designed to protect electrical equipment from transient high voltage to limit the duration and amplitude of the following current. Surge diverter discharges the impulse surge to the earth and dissipates energy in the form of heat.

**16. Define the term “insulation coordination” (Nov/Dec 2011)**

The selection of the insulation strength of equipment in relation to the voltages, which can appear on the system for which the equipment is intended and taking into account the service environment and the characteristics of the available protective device.

**17. What are the various types of faults occurring in a power system (May/June 2017 ) (Nov/Dec 2017)**

Series Fault: a) One open conductor fault b) Two open conductor fault Shunt Fault: (a) Symmetrical or balanced fault (i) Three phase Fault (LLLG) (b) Unsymmetrical or unbalanced fault ( i) Line to line fault(LL)(ii) Line to ground fault (LG)(iii) Double line to ground fault.(LLG).

**18. How are arcing grounds avoided? (May/June 2012)**

The presence of inductive and capacitive currents in the isolated neutral system leads to formation of arcs called as arcing grounds. The surge voltage due to arcing ground can be removed by using the arc suppression coil or Peterson coil. The arc suppression coil has an iron cored tapped reactor connected in neutral to ground connection. The reactor of the arc suppression coil extinguishes the arcing ground by neutralizing the capacitive current.

**19. What are the effects of power system faults? (Nov/Dec 2012)**

Increase in current above rated value, Insulation failure, Equipment damage.

**20. What is back up protection? (Nov/Dec 2012)**

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

**21. What is meant by pick-up current? (May/June 2013)(Nov/Dec 2014)**

The minimum current at which the relay armature is attracted to close the trip circuit is called pick-up current. In most of the relays, the pick up current is also indicated with the relay.

**22. Write the sources of fault power. (Nov/Dec 2013)**

The fault power can be originated from the generation (faults in alternator) or transmission (short circuit) or from the distribution side (loads). Also the fault power can be from external sources like lightning.

**23. List out the duties of fault limiting reactors. (Nov/Dec 2013)**

The duties of fault limiting reactors are to limit the fault current and to eliminate the arcing ground.

**24. What are the functions of protective relays? (May/June 2013) (Apr/May 2015)**

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

**25. What is the necessity for earthing? (Nov/Dec 2014) (Nov/Dec 2015)**

When earthing is provided it ensures the safety of personnel against electrical shocks and avoids accidents. The potential of earthed body does not reach to dangerously high value above earth since it is connected to earth. Also the earth fault current flows through the earthing and may cause operation of fuse or an earth relay.

**26. What is the difference between short circuit and an overload?(Nov/Dec2015)(May/June2016)**

On the occurrence of short circuit, the voltage at the point of fault falls to zero and the current in the network increases abnormally to a higher value. But in the case of overload reduction in the terminal voltage of the equipment occurs but the voltage will never fall to zero. Similarly the current also increases to a higher value but not as high as in the case of short circuit.

**28. What is the difference between primary and back up protection? (May/June 2016)**

Primary protection 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 defense. Instantaneous relays are used. Back up protection is the second line of defense, which operates if the primary protection fails to activate within a definite time delay. Relays with definite time lag is used.

**29. Why earth wire is provided in overhead transmission lines? (May/June 2016)**

Earthing wire usually consists of a Low Resistance wire connected to earth or buried into Earth. It's nothing but a Low Resistance path. Whenever there is a fault or abnormal operation or any external activities, the current flows through the earth wire and charges are discharged into the ground. If a fault occurs, current follows through earth wire first and the electrical equipment is protected.

**30. What do you mean by dead spot in zones of protection?**

In practice, various protective zones are overlapped. The overlapping of protective zones is done to ensure complete safety of each and every element of the system. The zone which is unprotected is called dead spot. The zones are overlapped and hence there is no chance of existence of a dead spot in a system. If there are no overlaps, then dead spot may exist which means the circuit breakers lying within the zone may not trip even though the fault occurs. This may cause damage to the healthy system.

**30. State the difference between circuit breaker and switch. (May/June 2017)**

<b>Circuit breaker</b>	<b>Switch</b>
A mechanical switching device capable of making , carrying and breaking currents under normal conditions and abnormal conditions like short circuit. It is an automatic device	A mechanical switching device capable of making , carrying and breaking currents under normal conditions but not breaking under abnormal conditions such as short circuit. A switch is operated manually.

**31. Why protection scheme is required for power system? (April/May 2018)**

An electrical power system consists of generators, transformers, transmission lines and distribution stations etc., Short circuits and other abnormalities often occur in power systems which cause heavy short circuit currents. The heavy current associated with short circuits will cause damage to the equipment if suitable protective relays and circuit breakers are not provided.

**32. Write down the importance of symmetrical components for fault current calculation. (April/May 2018)**

The method of symmetrical components is used to simplify fault analysis by converting a three-phase unbalanced system into two sets of balanced phasors and a set of single-phase phasors, or symmetrical components. These sets of phasors are called the positive-, negative-, and zero-sequence components. These components allow for the simple analysis of power systems under faulted or other unbalanced conditions. Once the system is solved in the symmetrical component domain, the results can be transformed back to the phase domain.

### **33. How protective relays are classified based on functions? (Nov/Dec 2018)**

The protective relays are classified in the following few categories.

- Directional Over current Relay
- Distance Relay
- Over voltage Relay
- Differential Relay
- Reverse Power Relay

### **PART B**

1. What do you understand by a zone of protection? Discuss various zones of protection. **(Nov/Dec 2015) (April/may 2018) (Nov/Dec 2018)**
2. (i) Discuss briefly the role of protective relays in a modern power system.  
(ii) Describe the essential qualities of protective relaying system **(May/June 2012)**
3. Explain the essential qualities of protection and explain them in detail. **(May/June 2012)**
4. Briefly explain the various methods of overvoltage protection of overhead transmission line.
5. What is a Peterson coil? Explain the protective function performed by this device with necessary diagram. **(May/June 2016)**
6. Discuss the need and compare various methods of neutral earthing? **(Nov/Dec 2019)**
7. Classify the different types of faults in power system. Which of these are more frequent? **(Nov/Dec 2015)**
8. Explain the overlapping of protective zones with neat sketch. **(May/June 2016)**
9. (i) Explain in detail about the need and different types of earthing scheme.  
(ii) A 132kV, 3 phase, 50 cycles, overhead line, 50km, long has a capacitance to earth for each line of 0.0157  $\mu\text{F}/\text{km}$ . Determine the inductance and kVA rating of the arc suppression coil. **(Nov/Dec 2016)**
10. Explain the method of calculating fault current using symmetrical components.
11. i) Explain in detail about different protection schemes. **(May/June 2017)**
12. Explain arc suppression coil earthing with neat diagram. **(May/June 2017)**
13. Explain the various methods of neutral grounding. **(Nov/ Dec 2017)**
14. Briefly discuss the nature of occurrence and types of fault in the power system.

## UNIT II

### ELECTROMAGNETIC RELAYS

#### PART A

**1. Name the different kinds of over current relays.**

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

**2. Define operating time of a relay.**

It is the time which elapses from the instant at which actuating quantity exceeds the relay pick up value to the instant at which the relay closes its contacts.

**3. Define resetting time of a relay.**

It is the time which elapses from the moment the actuating quantity falls below its reset value to the instant when the relay comes back to its normal (initial) position.

**4. What is 'Time grading' of relays. (Nov/Dec 2018)**

It is the setting of time of operation of various relays protecting the different sections of a line. It is set so that the relay which is nearest to the fault location alone will operate first and clear the fault.

**5. What are over and Under current relays?**

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

**6. What is biased differential beam relay?**

The biased beam relay is designed to respond to the differential current in terms of its fractional relation to the current flowing through the protected zone. It is essentially an over-current balanced beam relay type with an additional restraining coil. The restraining coil produces a bias force in the opposite direction to the operating force.

**7. Give the limitations of Merz Price protection.**

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.

**8. Why is an under frequency relay required in a power system?(May/June 2012) (Nov/Dec 2013) (Nov/Dec2014)**

An under frequency relay is one which operates when the frequency of the system (usually an alternator or transformer) falls below a certain value. Under frequency relays are used to shed automatically certain portion of load whenever the system frequency falls to such a low level which threatens the stability of the power system.

**9. What are the features of directional relay?**

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

**10. What is static relay?**

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.

**11. What is a programmable relay?**

A static relay which has one or more programmable units such as microprocessors or microcomputers embedded in its circuit is called a programmable relay.

**12. What are the advantages of static relay over electromagnetic relay? (Nov/Dec 2011) (May/June 2014) (Nov/Dec 2014)**

- i) Low power consumption as low as 1mW
- ii) No moving contacts; hence associated problems of arcing, contact bounce, erosion, replacement of contacts
- iii) No gravity effect on operation of static relays. Hence can be used in vessels ie, ships, aircrafts etc.
- iv) 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
- v) Static relay is compact.

**13. What are the different types of over current relays**

- i) Definite time
- ii) Inverse definite minimum time (IDMT)
- iii) Very Inverse
- iv) Extremely Inverse.

**14. What is earth fault protection?**

A ground fault (earth fault) is any failure that allows unintended connection of power circuit conductors with the earth. Such faults can cause objectionable circulating currents, or may energize the housings of equipment at a dangerous voltage. Under such condition residual current flowing to the ground is calculated. Such a protective scheme used for the protection of an element of a power system against earth faults is called as earth fault protection.

**15. List out the applications of static relays. (Nov/Dec 2012) ) (May/June 2016)**

- i) Protection of generators
- ii) Protection of transformers
- iii) Protection of transmission lines, and

iv) Protection of motors.

**16. What is meant by directional relay? (May/June 2012)**

A directional relay detects the whether the point of fault lies in the forward or reverse direction with respect to relay location. The relay which is able to sense the direction of power flow and act for a particular direction of power flow is called directional relay.

**17. What is meant by differential relay? (May/June 2013) (Apr/May 2015)**

A differential relay is one that operates when the phasor difference of two or more similar electrical quantities exceeds a predetermined value. It has two coils viz., operating coil which produces operating torque and restraining coil which produces restraining torque.

**18. What are the types of fuses? (Nov/Dec 2013)**

- a) Low voltage fuses i) Semi-enclosed rewirable fuse ii)HRC fuse
- b) High voltage fuses i) cartridge type ii)liquid type iii)metal clad type.

**19. List out the different types of distance relay.(May/June 2014)**

Dependent on the ratio of V and I there are three types of distance relays which are  
i) Impedance relay which is based on measurement of impedance Z ii) Reactance relay which is based on measurement of reactance X iii)Admittance or Mho relay which is based on measurement of component of admittance Y.

**20. In what way distance relay is superior to over current protection? (Nov/Dec 2015)**

Distance relays are preferred to overcurrent relays because they are not nearly so much affected by changes in short-circuit-current magnitude as overcurrent relays are, and, hence, are much less affected by changes in generating capacity and in system configuration. This is because distance relays achieve selectivity on the basis of impedance rather than current.

**21. Where are negative sequence relays employed?**

Negative sequence relays are employed for negative sequence protection of generators against the unbalanced load condition. The negative phase sequence filter along with the over current relay provides the necessary protection against the unbalanced loads.

**22. Write the effects of arc resistance.**

The effect of arc resistance is most significant on short lines where the reach of the relay setting is small. It can be a problem if the fault occurs near the end of the reach. High fault-arc resistances tend to occur during midspan flashovers to ground on transmission lines carried on wood poles without earth wires. These problems can usually be overcome by using relays having different shaped characteristics.

**23. What is the significance of PSM and TSM? (Nov/Dec 2016)**

Time setting multiplier TSM: TSM determines the operating time of the relay. Lower the value of TSM, lower will be the operating time.

Plug setting multiplier PSM: The plug position ensures the current setting value of the relay.

Plug setting multiplier (PSM) indicates the severity of the fault.



**24. A relay is connected to 400/5 ratio current transformer with current setting of 150%. Calculate the plug setting multiplier when circuit carries a fault current of 4000A. (Nov/Dec 2016)**

Fault Current = 4000A

C.T. ratio = 400/5

Fault current in the relay coil =  $4000 * (5/400) = 50A$

Plug Setting Multiplier (PSM) = Fault Current in the relay coil / (Rated secondary C.T. Current \* Current setting)

Plug Setting Multiplier (PSM) =  $50 / (5 * 1.5) = 6.667$

**25. Why shaded ring is provided in induction disc relay? (May/June 2017)**

In the induction disc relay, a metal disc is allowed to rotate between two electromagnets. The shaded pole structure is generally actuated by current flowing in a single coil on a magnetic structure containing an air gap. The air gap flux produced by this current is split into two out-of-phase components by a so called “shading ring” generally of copper, that encircles part of the pole face of each pole at the air gap.

**26. Give the principle of negative sequence relay. (Nov/Dec 2017)**

A relay which protects the electrical system from negative sequence component is called a negative sequence relay or unbalance phase relay. The actuating quantity is negative sequence current. When the negative sequence current exceeds a certain value, the relay operates. This is used to protect electrical machines against overheating due to unbalanced currents.

**27. Write the torque equation of the universal relay. (Nov/Dec 2017)**

$$T = K_1 I^2 + K_2 V^2 + K_3 VI \cos(\theta - \tau) + K_4$$

where  $K_1$ ,  $K_2$ ,  $K_3$  are the tap setting or constant of Voltage  $V$  and current  $I$ . The  $K_4$  is the mechanical restraint due to spring or gravity.

**28. Mention the principle of operation of distance relay. (April/may 2018)**

There is one voltage element from PT and a current element fed from CT of the system. The deflecting torque is produced by secondary current of CT and restoring torque is produced by voltage of potential transformer. In normal operating condition, restoring torque is more than deflecting torque. Hence relay will not operate. But in faulty condition, the current becomes quite large whereas voltage becomes less. Consequently, deflecting torque becomes more than restoring torque and dynamic parts of the relay starts moving which ultimately close the No contact of relay. Hence clearly operation or working principle of distance relay depends upon the ratio of system voltage and current.

**29. Determine the plug setting multiplier of a 5 ampere, 3 second over current relay having a current setting of 125% and a time setting multiplier of 0.6 connected to supply circuit through a 400/5 current transformer when the circuit carries a fault current of 4000A. (April/may 2018)**

Plug Setting Multiplier = Fault current in relay coil / (Rated CT secondary current \* Current Setting)

Fault current in relay coil =  $4000 * (5/400) = 50A$ . Therefore,  $PSM = 50 / (5 * 1.25) = 8$

**30. What are the factors affecting the performance of differential relays? (Nov/Dec 2018)**

- Phasor sum of currents
- CT ratio
- Polarity of transformers

**PART- B**

1. Describe the construction and operation of over current relay with directional Scheme. **(June 2014) (Nov/Dec 2015). (May/June 2016)**
2. i) Discuss the operating principle, constructional features area of applications of directional relay. How do you implement directional feature in the over current relay.
3. (i) What are the different inverse-time characteristics of over current relays and mention how to characteristics can be achieved in practice for an electromagnetic relay? **(Nov/Dec 2018)**
4. Explain the principle of percentage biased differential relay with necessary diagrams. Also discuss its application. **(May/June 2012)**
5. Describe the Principle, of operation of various differential relays with neat sketches. **(Nov/Dec 2019).**
6. i) With neat block diagram, explain the construction and operating principle of electromagnetic relay. ii) Describe the operation of over current relay with directional feature. **(Nov/Dec 2013) (Nov/Dec 2018)**
7. Describe the operating principles and characteristics of impedance and mho relays. **(Nov/Dec 2013)**
8. Explain the operation of i) Negative sequence relay ii) Static relay. iii) under frequency relay **(Apr/May 2015) (April/may 2018)**
9. Explain in what way distance protection is superior to over current protection for the protection of transmission lines. **(Nov/Dec 2013,2014) (May/June 2014)**
10. i) Explain with the help of neat diagram the construction and working of induction type directional power relay. **(Nov/Dec 2015).**
11. What is universal torque equation? Using this equation derive the following operating characteristics. i) Impedance relay ii) Reactance relay iii) Mho relay. **(May/June 2013) (Nov/Dec 2015)(May/June 2016)**
12. Draw and explain about differential protection of transmission lines. **(Apr/May 2015) (April/may 2018)**
13. Explain the construction and operating principle of impedance type distance relay with R-X diagram. **(May/June 2017) (April/may 2018)**
14. With necessary sketches discuss in detail about electromagnetic attraction type relays. **(May/June 2017) (Nov/ Dec 2017)**
15. Describe the construction and principle of operation of non-directional induction type over current relay. **(Nov/ Dec 2017) (Nov /Dec 2019)**
16. Explain MHO relay characteristic on the R- X diagram. Discuss the range setting of various distance relays placed on a particular location. **(May/June 2016)**

## UNIT III

### APPARATUS PROTECTION

#### PART A

**1. What are the causes of over speed and how alternators are protected from it? (April/may 2018)**

Sudden loss of all or major part of the load causes over-speeding in alternators. Modern alternators are provided with mechanical centrifugal devices mounted on their driving shafts to trip the main valve of the prime mover when a dangerous over- speed occurs.

**2. What are the uses of Buchholz's relay?**

Bucholz relay is used to give an alarm in case of incipient (slow-developing) faults in the transformer and to disconnect 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.

**3. What are the various faults that would affect an alternator? (May/June 2013) (Apr/May 2015) )(May/June 2016)**

(a) Stator faults i) Phase to phase faults ii) Phase to earth faults iii) Stator inter turn faults (b) Rotor faults i)Rotor earth faults ii)Field over loading iii) Heating of rotor c)Abnormal Running Conditions i) Over speeding ii) Over loading iii) Unbalanced Loading iv)Over voltage v)Failure of Prime mover.

**4. What are faults associated with a transformer?**

a) Overheating b) Winding Faults i)phase to phase fault ii) Earth fault iii) Interturn faults c)Open circuits d)Through faults e)Over fluxing.

**5. What are the main safety devices available with transformer? (May/June 2012)**

Oil level gauge, sudden pressure delay, oil temperature indicator, winding temperature indicator.

**6. What are the limitations of Buchholz relay? (May/June 2017)**

- (a) Only fault below the oil level are detected.
- (b) Mercury switch setting should be very accurate, otherwise even for vibration; there can be a false operation.
- (c) The relay is of slow operating type, which is unsatisfactory.

**7. What are the problems arising in differential protection in power transformer and how are they overcome? (May/June 2012) (Nov/Dec 2015)**

i) 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. ii) 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.iii) 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. iv) Magnetizing inrush current will be identified as short circuit current. A harmonic restraining unit is added to the relay which will block it when the transformer is energized.

**8. What is REF relay?**

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.

**9. What is over fluxing protection in transformer? (Nov/Dec 2016)**

If the turn's 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.

**10. Why bus-bar protection is needed? (May/June 2013)**

(i) Fault level at bus-bar is high (ii) The stability of the system is affected by the faults in the bus zone.(iii) A fault in the bus bar causes interruption of supply to a large portion of the system network.

**11. What are the causes of bus zone faults?**

i) Failure of support insulator resulting in earth fault ii) Flashover across support insulator during over voltage iii ) Heavily polluted insulator causing flashover iv) Earthquake, mechanical damage etc.

**12. What are the problems in bus zone differential protection?**

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

**13. What are the disadvantages of time graded protection?**

i) Time lag is not desirable on short circuits ii) Not suitable for ring main distribution iii) Difficult to coordinate & needs changes with new connection iv) Not suitable for long distance relaying.

**14. How does the over voltage surge affect the power system?**

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.

**15. What is the general connection rule for Current transformers in differential protection?**

If the windings of the power transformer are delta connected then the current transformers are star connected and if the windings of the power transformer are star connected then the current transformers are delta connected.

**16. Write the coordination equation for inverse over-current relay?**

$$T_A = T_B + CBB + OA + F$$

Where  $T_A$  operating time of relay at station A,  $T_B$  operating time of relay at station B,  $CBB$  operating time of circuit breaker at station B,  $OA$  over travel time of relay at station A,  $F$  factor of safety.

**17. Explain why secondary of current transformer should not be open. (Nov/Dec 2011)(Dec 2014) (Apr/May 2015) (May/June 2016)**

Current transformers generally work at a low flux density. Core is then made of very good metal to give small magnetizing current. On open-circuit, secondary impedance now becomes infinite and the core saturates. This induces a very high voltage in the primary upto approximately system volts and the corresponding volts in the secondary will depend on the number of turns. Since secondary of CT has more turns compared to the primary, the voltage generated on the open-circuited CT will be high, leading to flashovers. Hence as a safety precaution, CT secondary should not be open-circuited.

**18. What is meant by time graded system protection? (Nov/Dec 2018)**

In a time graded system, the operating time of the relay is increased from the far end of protected circuit towards the generating source. Definite time over current relays are used which after a preset time will trip the circuit. The difference in time setting of the two adjacent relays are kept at 0.5s. This difference is to cover the operating time of CB and errors in CT and relay.

**19. Write the function of earth fault relay. (Nov/Dec 2012)**

Earth fault relay is used for the protection of an element of a power system against earth faults. Earth relay calculates the residual current. If the residual current is zero the relay will not operate. Restricted earth fault relay is used in differential protection which will not operate for external faults.

**20. What is meant by relay operating time? (Nov/Dec 2012)**

It is the time which elapses from the instant at which actuating quantity exceeds the relay pick up value to the instant at which the relay closes its contacts.

**21. What are the different types of zones of protection? (Nov/Dec 2013)**

i) Primary protection and ii) backup protection and Unit and Non-Unit protection.

**22. State the methods of protection of busbars. (Nov/Dec 2014) (Nov/Dec 2016)**

i) Frame leakage protection of bus bar ii) Circulating current protection of bus bar  
iii) High impedance differential protection of bus bar

**23. List the applications of current transformer. (May/June 2014)**

i) To supply the stepped down current to the relay coil in the event of any overloading or short-circuiting of the equipment lines.  
ii) To measure power of a load in conjunction with a wattmeter. The secondary of the CT is connected to the current coil of the wattmeter.  
iii) To measure large currents in conjunction with medium/Small range meters.

**24. Give examples of Unit and Non – Unit Protection Schemes (Nov/Dec 2015)**

The concept of 'Unit Protection', whereby sections of the power system are protected individually as a complete unit without reference to other sections.  
eg. Differential Protection, Overcurrent Protection. eg. Non – Unit Protection: Distance Protection.

**25. What are the difficulties encountered through differential protection? (May/June 2017)**

Though the saturation in Current transformer is avoided, there exist difference in the C.T. characteristics due to ratio error at high values of short circuit currents. This causes an appreciable difference in the secondary currents which can operate the relay. So the relay operates for external faults. Due to the difference in lengths of the pilot wires on both sides, the unbalance condition may result. Due to the magnetizing current inrush current in transformers which may be as great as 10 times the full load current of the transformer, the differential relay may operate falsely.

**26. What is the need of instrumentation transformer? (May/June 2017)**

Instrument transformers are high accuracy electrical devices used to isolate or transform voltage or current levels. The most common usage of instrument transformers is to measure high voltage or high current (with common meters) by safely isolating secondary control circuitry from the high voltages or currents.

**27. Why secondary of a transformer should not be opened? (Nov/Dec 2017)**

The secondary side of a current transformer should never be kept in open condition because, when kept open, there is a very high voltage found across the secondary side. This high voltage causes a high magnetizing current to build up on the secondary side which in turn causes high flux and makes the core to saturate.

**28. List the types of bus bar protection. (Nov/Dec 2017)**

Frame-Earth Protection  
Differential Protection for Sectionalized Bus bars High-Impedance Differential Protection Low-Impedance Differential Protection Digital Bus bar Protection

**29. What are the protection methods used for transmission lines?(April/may 2018)**

Over current protection; Simple Impedance Relay; Mho relay; Reactance relay

**30. In the event of fault in generator windings, the field excitation should be suppressed as early as possible. Why? (Nov/Dec 2018)**

Failure of excitation that is failure of field system in the generator makes the generator run at a speed above the synchronous speed. In that situation the generator or alternator becomes an IG which draws magnetizing current from the system. Although this situation does not create any problem in the system immediately but over loading of the stator and overheating of the rotor due to continuous operation of the machine in this mode may create problems in the system in long-run. Therefore special care should be taken for rectifying the field or excitation system of the generator immediately after failure of that system. The generator should be isolated from rest of the system till the field system is properly restored.

**31. Which type of protection is used for EHV and UHV lines? (Nov/Dec 2018)**

Carrier current protective scheme Pilot wire protective scheme

**PART- B**

1. Discuss how the generator is protected against an inter turn fault with necessary diagram.
2. Explain what is meant by distance protection and why it is superior to other types of protection for an overhead transmission line.
3. i) Describe the construction and working of Buchholz relay. (April/may 2018)  
ii) Discuss the time graded over current protection for parallel feeders.
4. i) Explain with the neat diagram the application of Merz-price circulating current principle for protection of alternator. (Apr/May 2015)  
ii) What is the role of instrument transformer in protective schemes? (May 2013)
5. i) Describe the differential protective schemes of transformer (May/June 2014)  
ii) Enumerate the protective scheme employed for the bus bar. (Nov/Dec 2013)
6. Briefly discuss the protective devices used for the protection of a large transformer.
7. Explain impedance relay characteristics on the R-X diagram. Also discuss the range setting of three impedance relays placed at a particular location. (Nov/Dec 2014)
8. Explain about carrier aided protection of transmission lines and various relays associated with it (Apr/May 2015) (Nov/Dec 2015)
9. Why is harmonic restrained differential relay used for protecting large size transformer? Describe its working and construction. (Nov/Dec 2015) (Nov/Dec 2018)
10. With neat sketches, explain the different types of protective schemes for transmission lines. (May/June 2016)
11. Draw and explain protection scheme of an A.C. induction motor. (Nov/Dec 2016)
12. (i) A generator is protected by restricted earth fault protection. The generator ratings are 13.2kV, 10 MVA. The percentage of winding protected against phase to ground is 85%. The relay setting is such that it trips for 20% out of balance. Calculate the resistance to be added in the neutral to ground connection.  
(i) Explain a protection scheme for protection of transformer against incipient fault.
13. Give a detailed explanation for protection of transformer using differential protection which includes associated faults. (May/June 2014) (Nov/ Dec 2017)
14. Give a detailed explanation about CT's and PT's and its application to power systems.
15. Give a brief account on the protection of generator using differential and biased differential protection scheme. (Nov/ Dec 2017)
16. With neat sketches, explain the different types of protective schemes for motors.
17. A star connected, 3 phase, 10 MVA, 6.6 kV alternator has a per phase reactance of 10%. It is protected by Merz-price circulating current principle which is set to operate for fault currents not less than 175A. Calculate the value of earthing resistance to be provided in order to ensure that only 10% of the alternator winding remains unprotected. (April/may 2018)

18. An alternator rated at 10kV protected by the balanced circulating current system has its neutral grounded through a resistance of 10ohms protective relay is set to operate when there is an out of balance of 1.8A in the pilot wires which are connected to the secondary windings of 1000/5 CT ratio. Determine the percentage of windings which remain unprotected and minimum value of earthing resistance to protect 80% of the winding. (Nov/Dec 2018)
19. Identify and explain the different protection schemes necessary for the protection of 3 phase alternators with suitable circuit diagram. (Nov/ Dec 2012) (Apr/May 2015)
20. i) Explain the factors which cause difficulty in applying Merz-Price circulating current principle to a power transformer.  
(ii) A three phase transformer of 220/11000 line volts is connected in star/delta. The protective transformers on 220 V side have a current ratio of 600/5. What should be the current transformer ratio on 11000 V side? (Nov/Dec 2011)
21. i) With aid of neat schematic diagram, describe the percentage differential Protection scheme of a transformer and generator. (Nov/Dec 2014).  
(ii) Describe the differential pilot wire method of protection of feeder.

## UNIT IV

### STATIC RELAYS AND NUMERICAL PROTECTION

#### PART-A

#### **1. Define static relay? (Nov/Dec 2017)**

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.

#### **2. What is CPMC?**

It is combined protection, monitoring and control system incorporated in the static system. For example static relays employ microprocessor units which incorporate protection principles such as over current, inverse time etc., in their operation. Also these units sense the fault current each and every time. The fault current can also be controlled by changing the code embedded into the processor.

#### **3. What are the advantages of static relay over electromagnetic relay? (Nov/Dec 2018)**

- 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
- Simplified testing and servicing. Can convert even non-electrical quantities to electrical in conjunction with transducers.

#### **4. What is pick up value?**

It is the minimum current in the relay coil at which the relay starts to operate. The relay should not operate when the current does not exceed the pick up value.

**5. Define target.**

It is the indicator used for showing the operation of the relay. This helps the operator to know the cause of tripping of the circuit breaker.

**6. Define blocking.**

Blocking is preventing the relay from tripping due to its own characteristics or due to additional relays. False operation of relay may lead to unnecessary opening of circuit.

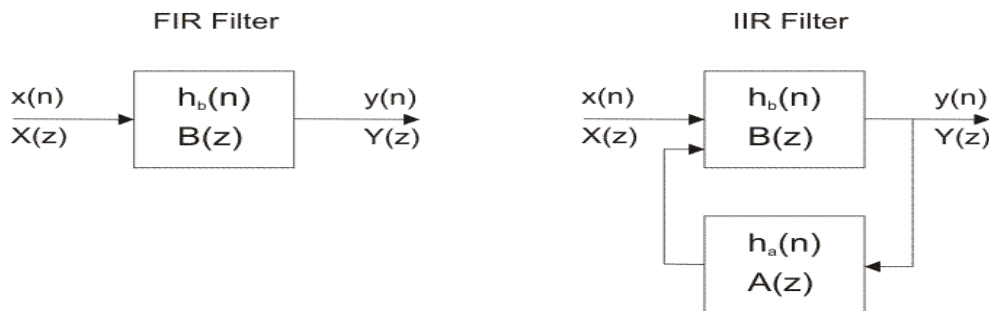
**7. What are the advantages of numerical relays over conventional relays? (May/June 2014) (May/June 2015) (Nov/Dec 2016)**

No moving parts and therefore no friction Easy to replace and service. Numeric relays are not affected by gravity Are compact and has modular arrangement Various characteristics can be obtained.

**8. What are the drawbacks of analogue and active analogue filters? (May/June 2014)**

They are bulky, especially inductors require large space; High precision components are needed making them expensive; Their characteristics drift with respect to time and temperature; Filters for very low frequencies need impracticably high component values; They are not programmable and adaptable.

**9. Draw the block diagram of FIR and IIR filter**



**10. Compare FIR and IIR filters**

S.No	FIR Filter	IIR Filter
1.	Difficult to control and have no particular phase	Always make a linear phase.
2.	FIR is always stable	IIR can be unstable
3.	FIR has no limited cycles	Can have limited cycles
4.	FIR has no analog history	IIR is derived from analog.
5.	FIR can always be made casual	IIR filters make polyphase implementation possible
6.	FIR filters are Finite IR filters which are required for linear-phase characteristics.	IIR is infinite and used for applications where linear characteristics are not of concern.

**11. What is Fourier analysis?**

The analysis of a complex waveform expressed as a series of sinusoidal functions, the frequencies of which form a harmonic series. If a function is periodic, then it can be written as a discrete sum of trigonometric or exponential functions with specific frequencies.

**12. What is discrete Fourier transform?**

As the name implies, the Discrete Fourier Transform (DFT) is purely discrete: discrete-time data sets are converted into a discrete-frequency representation. This is in contrast to the DTFT that



uses discrete time, but converts to continuous frequency. Since the resulting frequency information is discrete in nature, it is very common for computers to use DFT calculations when frequency information is needed.

**12. What is Aliasing?**

Aliasing is a phenomenon where the high frequency components of the sampled signal interfere with each other because of inadequate sampling. It results in loss of signal and its place will be taken by a different lower frequency wave.

**13. What is sampling?**

Sampling is the process of converting a signal (for example, a function of continuous time or space) into a numeric sequence (a function of discrete time or space).

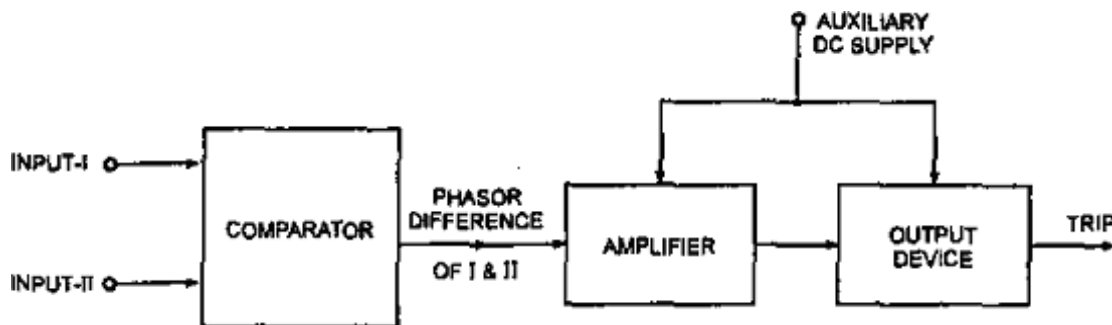
**14. What is sample and hold circuit?**

A sample and hold circuit is an analog device that samples (captures, grabs) the voltage of a continuously varying analog signal and holds (locks, freezes) its value at a constant level for a specified minimum period of time. Sample and hold circuits and related peak detectors are the elementary analog memory devices. They are typically used in analog-to-digital converters to eliminate variations in input signal that can corrupt the conversion process.

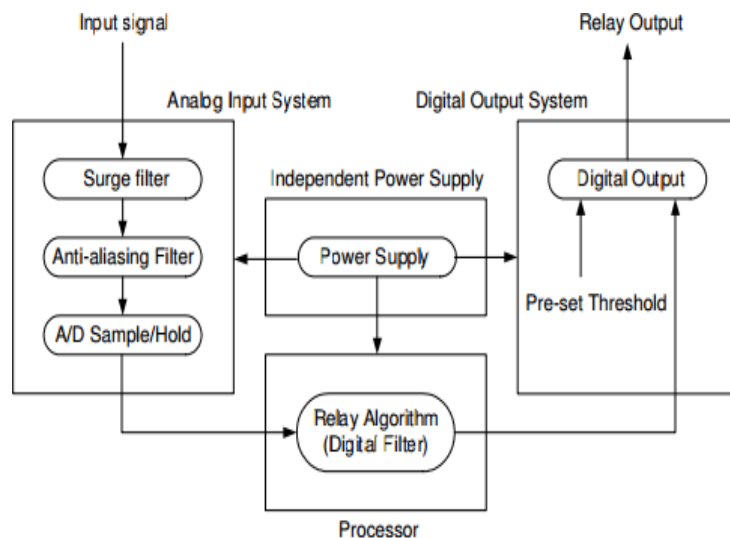
**15. What is digital filter?**

In signal processing, a digital filter is a system that performs mathematical operations on a sampled, discrete-time signal to reduce or enhance certain aspects of that signal.

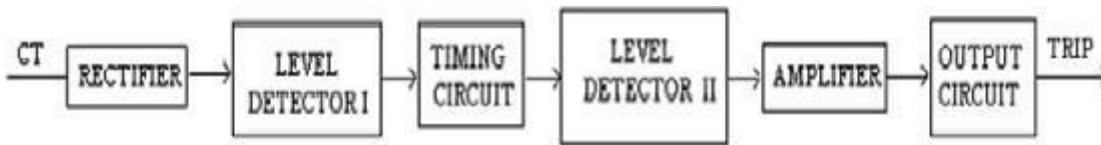
**16. Draw the block diagram of static differential relay**



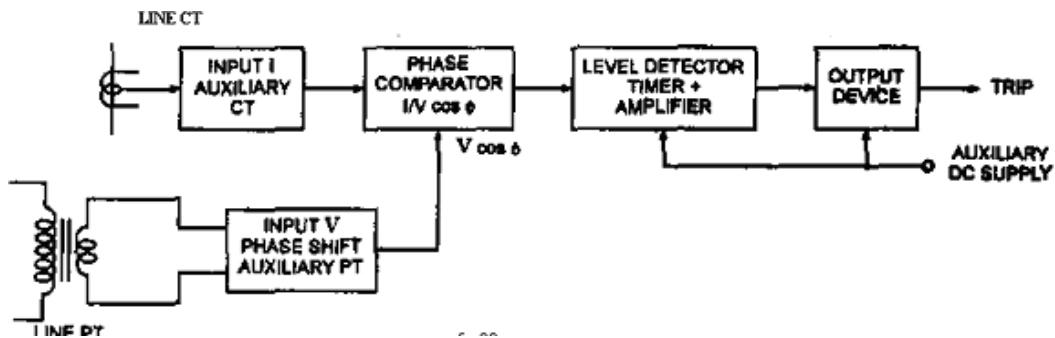
**17. Draw the block diagram of numerical relay**



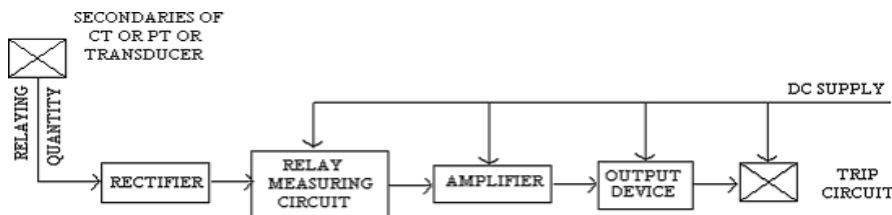
**18. Draw the block diagram of static directional relay**



**19. Draw the block diagram of static over current relay**



**20. Draw the block diagram of static relay**



**21. What are the building blocks of static relay? or What are the basic circuits in static relay? (April/may 2018)**

Rectifier, Comparator, Amplifier, Transducer are some of the building blocks of static relay.

**22. What is least error squared technique? (May/June 2015)**

The least error squared technique is directly related to the Fourier technique. If a given function were to be synthesized by using a dc component, a sine wave of fundamental frequency and harmonics of this fundamental, then the amplitudes of various components given by the Fourier analysis are the ones which give the least squared error. We can directly find out the amplitudes of the components by using the LES technique.

**23. List out the applications of static relays. (Nov/Dec 2016) (May/June 2016)**

- Ultra high speed protection of EHV AC transmission lines utilizing distance protection.
- In over current and earth fault protection schemes
- As main element in differential relay

**24. State Nyquist–Shannon sampling theorem (May/June 2017)**

If a function  $x(t)$  contains no frequencies higher than  $B$  hertz, it is completely determined by giving its ordinates at a series of points spaced  $1/(2B)$  seconds apart. A band limited signal can be

reconstructed exactly if it is sampled at a rate atleast twice the maximum frequency component in it.  
 $f_s \geq 2f_m$  where  $f_s$  = sampling frequency;

$f_m$  = frequency of the signal which is reconstructed.

**25. Write about numerical transformer differential protection. (May/June 2017)**

It provides fast and selective tripping for two winding transformer. It quickly discriminates between faults that occur in the protected zone and those occurring outside this zone and thus provides selective and fast tripping. The faults within protected zone are short circuit between turns, windings and cables and earth faults inside transformer housing and protected zone. It discriminates between above internal faults and the operational conditions like inrush, over-fluxing and faults external to protected zone using numerical algorithms.

**26. What is phase comparator? (Nov/Dec 2017)**

A phase detector or phase comparator is a frequency mixer, analog multiplier or logic circuit that generates a voltage signal which represents the difference in phase between two signal inputs. It is an essential element of the phase-locked loop (PLL).

**27. List out the general characteristics of numerical protection. (April/may 2018)**

- The numerical relay relies on one system for all approach and use indication on LCD for relay activation, ensuring less space.
- Since the numerical relay system relies on software, customized modifications can be made for getting the desired protection features. This saves the cost of replacing hardware. Fewer interconnections ensure reliability.
- The range of operation of traditional models is narrow while numerical relays are diverse and evolution adaptable.
- It also has the feature of auto resetting and self-diagnosis.
- The benefit of using microprocessor based relays in the numerical system is that it gives minimum burden on the instrument transformers. The sensitivity of the system is pretty nifty and boasts a high pickup ratio.

**PART B**

1. Explain in detail the numerical over current protection of transmission line. Derive the necessary equations. **(May/June 2015)**
2. Explain with a neat diagram the numerical transformer differential protection scheme.
3. **(May/June 2015)**
4. How will you synthesize a mho relay using static phase comparator? **(Nov. 16)**
5. Explain the numerical over current protection and numerical transformer differential protection. **(Nov/Dec 2016)**
6. With a neat sketch discuss in detail about the synthesis of reactance relay using phase comparator. **(May/June 2017)**
7. Explain with neat block diagram the operation static relay and list its advantages and disadvantages. **(Nov/ Dec 2017)**
8. Describe the operation of static instantaneous over current relay with neat diagram. **(Nov/ Dec 2019)**
9. (a) Compare static relays with numerical relays. (b) Explain the advantages of numerical relays. **(April/may 2018)**
10. Describe the construction, working principle and operation of static over current relay.
11. Discuss in detail, integrating and instantaneous type static amplitude comparators.
12. Illustrate your answer with appropriate circuits and waveforms. **(Nov/Dec 2018)**
13. How static over current relays are different from electromechanical relays?
14. Explain how the operation of instantaneous relay is achieved using electronic relays?

## UNIT V

### CIRCUIT BREAKERS

#### PART A

**1. What is dielectric test of a circuit breaker?**

It consists of over voltage withstand test of power frequency lightning and impulse voltages. Tests are done for both internal and external insulation with switch in both open and closed conditions.

**2. Define composite testing of a circuit breaker.**

In this method the breaker is first tested for its rated breaking capacity at a reduced voltage and afterwards for rated voltage at a low current. It is the combination of both field type testing station and laboratory type testing station. This method does not give a proper estimate of the breaker performance.

**3. What is making capacity? (Nov/Dec 2015)**

It is the capacity of the circuit breaker to be closed onto a short circuit.

It is expressed as  $1.414 \times 1.8 \times$  symmetrical breaking capacity =  $2.55 \times$  symmetrical breaking capacity.

**4. What are the advantages of synthetic testing methods?**

i) The breaker can be tested for desired transient recovery voltage and RRRV.

ii) Both test current and test voltage can be independently varied. This gives flexibility to the test

iii) The method is simple iv) With this method a breaker capacity (MVA) of five times of that of the capacity of the test plant can be tested.

**5. Write are the types of test conducted on circuit breakers. (May/June 2012) (Apr/May 2015)**

- Type test ii) Routine test iii) Reliability test iv) Commissioning test

Type test can be classified into mechanical performance test, thermal test, dielectric test and short circuit tests.

**6. What are the characteristic of SF<sub>6</sub> gas?**

It has good dielectric strength and excellent arc quenching property. It is inert, non- toxic, non inflammable 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.

**7. Give the advantage of SF<sub>6</sub> circuit breaker over air blast circuit breaker (May/June 2013) (Apr/May 2015) (May/June 2016)**

High electro negativity, compactness, reduced switching over voltages, reduced insulation time, superior arc interruption and increased safety.

**8. What is meant by electro negativity of SF<sub>6</sub> gas?**

SF<sub>6</sub> 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 SF<sub>6</sub> gas.

**9. What are the demerits of using oil as an arc quenching medium?**

i) The air has relatively inferior arc quenching properties

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

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

**10. What are the advantages of air blast circuit breaker over oil circuit breaker?**

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

**11. What are the types of air blast circuit breaker?**

- i) Air-blast type ii) Cross blast iii) Radial-blast

**12. What are the disadvantages of MOCB over a bulk oil circuit breaker?**

- i) The degree of carbonization is increased due to smaller quantity of oil
- ii) There is difficulty of removing the gases from the contact space in time
- iii) The dielectric strength of the oil deteriorates rapidly due to high degree of carbonization.

**13. What are the advantages of MOCB over a bulk oil circuit breaker?**

- i) It requires lesser quantity of oil
- ii) It requires smaller space
- iii) There is a reduced risk of fire
- iv) Maintenance problem are reduced.

**14. What are the advantages of oil as arc quenching medium?**

- 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

**15. What are demerits of MOCB?**

- i) Short contact life
- ii) Frequent maintenance
- iii) Possibility of explosion
- iv) Larger arcing time for small currents
- v) Prone to restricts

**16. Mention different types of circuit breakers? (May/June 2012)**

- i) Air break circuit breaker ii) Oil circuit breaker iii) Minimum oil circuit breaker
- iv) Air blast circuit breaker v) SF6 circuit breaker vi) Vacuum circuit breaker

**17. What are the different types of oil circuit breakers?**

- i) Plain break oil circuit breakers
- ii) Arc control circuit breakers
- iii) Minimum oil circuit breakers

**18. What are the advantages of using vacuum as an arc interrupting medium?**

Vacuum offers the utmost insulating strength. Interruption occurs in the first current zero. So it has superior arc quenching properties than any other medium. Also the dielectric strength of vacuum is superior to those of porcelain, oil, air and SF6.

**19. Write any two properties of contact material used in vacuum circuit breaker?**

- i) Good electrical conductivity to pass normal load currents without overheating.
- ii) Good thermal conductivity to dissipate rapidly the large heat generated during arcing.

**20. What are the basic requirements of circuit breaker? (Nov/Dec 2011)**

- i) To make or break a circuit either manually or by remote control under normal conditions ii) Break a circuit automatically under fault condition iii) Make a circuit automatically either manually or by remote control after the fault is cleared.

**21. Write the difference between fuse and circuit breaker. (Nov/Dec 2012)**

Fuse is a low current interrupting device. It is a copper or an aluminum wire. Circuit breaker is a high current interrupting device and it act as a switch under normal operating conditions.

- 22. Enumerate breaking capacity of circuit breaker. (Nov/Dec 2012) (Nov/Dec 2014)**  
 The capacity of the circuit breaker which can break under specified conditions of recovery voltage. The breaking capacity of a circuit breaker is expressed in MVA and given as  $1.732 X$  (rated voltage in kV)  $X$  (rated current in kA).
- 23. Write the ratings of the circuit breaker. (Nov/Dec 2013)**  
 Circuit breaker has three ratings. i) Breaking capacity ii) Making capacity and iii) Short time capacity.
- 24. Define the opening time of circuit breaker.(May/June 2014)**  
 The time interval which is passed in between the energization of the trip coil to the instant of contact separation is caused the opening times. It is dependent on fault current level.
- 25. What is meant by current chopping? (Nov/Dec 2014)**  
 At the time of interruption of a large fault current, the arc energy is high enough to keep ionized until the arc is interrupted at natural current zero. On the other hand, while interrupting small inductive currents such as unloaded currents of transformers and currents of shunt reactor, there is a possibility of overvoltage depending on the value of the chopping current. This small inductive current is interrupted just before natural current zero and thus induces high transient voltages, which is known as current chopping.
- 26. What is resistance switching? (Nov/Dec 2013)**  
 It is the method of connecting a resistance in parallel with the contact space (arc). The inserted resistance reduces the re striking voltage frequency and it diverts part of the arc current. It assists the circuit breaker in interrupting the magnetizing current and capacity current.
- 27. What is an arc?**  
 Arc is a phenomenon occurring when the two contacts of a circuit breaker separate under heavy load or fault or short circuit condition.
- 28. Give the two methods of arc interruption? (May/June 2012) (Apr/May 2015)**  
 i) High resistance interruption:-the arc resistance is increased by elongating, and splitting the arc so that the arc is fully extinguished. ii)Current zero method:-The arc is interrupted at current zero position that occurs 100 times a second in case of 50Hz power system frequency in AC.
- 29. What is restriking voltage? (Nov/Dec 2011) (May/June 2017)**  
 It is the transient voltage appearing across the breaker contacts at the instant of arc being extinguished.
- 30. What is meant by recovery voltage? (Nov/Dec 2011) (May/June 2013)**  
 The power frequency RMS voltage appearing across the breaker contacts after the arc is extinguished and transient oscillations die out is called recovery voltage.
- 31. Define the term RRRV? (May/June 2012) (Apr/May 2015)**  
 The transient voltage which appears across the circuit breaker contacts at the instant of arc extinction is called restriking voltage. RRRV is the Rate of Rise of Restriking Voltage, expressed in volts per microsecond. It is the rate at which the restriking voltage changes per microsecond. It is closely associated with natural frequency of oscillation.
- 32. What is the main problem of the circuit breaker?**

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.

**33. What are the factors the arc resistance depends upon?**

i) Degree of ionization ii) Length of the arc iii) Cross section area of the arc.

**34. Mention the details circuit breaker rating**

i) Rated voltage & rated current ii) Rated Frequency iii) Rated breaking capacity, symmetrical & asymmetrical iv) Rated making capacity v) Rated short time current vi) Rated operating duty.

**35. What are the factors the ARC phenomenon depends upon? (May/June 2013)**

i) The nature and pressure of the medium ii) The external ionizing and de-ionizing agent present iii) Voltage across the electrodes and its variation with time iv) The nature shape & separation of electrodes v) The nature and shape of vessel and its position in relation to the electrodes.

**36. Define symmetrical breaking capacity. (Nov/Dec 2017)**

The symmetrical value of breaking capacity is the value of the symmetrical breaking current which the circuit breaker is capable of breaking at the stated recovery voltage and restriking voltage under prescribed condition.

**37. What are the two theories explaining current zero interruption?**

i) Recovery rate theory or voltage race theory or Slepain's theory. ii) Energy balance theory or Cassie's theory.

**38. What are the factors the recovery voltage depends upon? (Nov/Dec 2011)**

i) Power factor, ii) Armature reaction & iii) Circuit condition.

**39. What is the basic requirement of DC circuit breaking?**

Lengthening of the arc is basic requirements of D.C circuit breaker. Loss of energy increases with increasing length of arc and more power will be required to maintain the arc.

**40. What are the problems associated with DC circuit breakers?**

i) Natural current zero does not occur as in the case of A.C circuit breakers. ii) The amount of energy to be dissipated during the short interval of breaking is very high as compared to conventional A.C circuit breakers.

**41. What is the purpose of protective spark gap?**

A protective spark gap can be used across the circuit breaker to reduce the size of commutation capacitor. The spark gap acts as an energy dissipating device for high frequency currents.

**42. List out the various methods of arc interruptions. (Nov/Dec 2012) (Apr/May 2015)**

i) High resistance interruption ii) Current zero method.

**43. How do you classify the circuit breakers? (Nov/Dec 2012) (Nov/Dec 2014)**

- Air break circuit breaker, ii) Oil circuit breaker, iii) Air blast circuit breaker iv) SF<sub>6</sub> circuit breaker, and v) Vacuum circuit breaker.

**44. What is meant by auto reclosing? (Nov/Dec 2013) (May/June 2016)**

In electric power distribution, an auto recloser is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a fault.

**45. Write the function of isolating switch. (Nov/Dec 2013) (May/June 2016)**

A disconnect, disconnect switch or isolator switch is used to ensure that an electrical circuit is completely de-energised for service or maintenance. The disconnect is usually not intended for normal control of the circuit, but only for safety isolation. Disconnect can be operated either manually or automatically (motorized disconnect).

**46. Mention any two advantages of vacuum circuit breakers.(Nov/Dec 2014)**

i) They are compact in size and have longer life. ii) There are no fire hazards.iii) No generation of gas during and after operation. iv) They require less maintenance and quiet in operation. v) They can successfully withstand lightning surges.

**47. Why current chopping is not required in MOCB?**

MOCB has superior arc quenching properties when compared to air blast circuit breakers due to the cooling oil and hence there is no special mechanism required for current chopping.

**48. How does a circuit breaker differ from a switch? (Nov/Dec 2015) (May/June 2016)**

Switches are not automatic as they need to be manually turned on or off while circuit breakers just trips off on certain conditions. Switches allow users to cut off power supply to a certain area or equipment while circuit breakers are more preventive in nature. Circuit breakers are essentially automatic off switches designed for a very specific purpose, which is to prevent unnecessary electrical circuit damage.

**49. Name the materials used for contacts of vacuum circuit breakers. (Nov/Dec 2015)**

Compounds of copper and Chromium are used most widely for making the contacts of circuit breakers.

**50. What is the difference between re-striking voltage and recovery voltage? (Nov/Dec 2016)**

Re-striking voltage: It is the transient voltage appearing across the breaker contacts at the instant of arc being extinguished. Recovery voltage: The power frequency RMS voltage appearing across the breaker contacts after the arc is extinguished and transient oscillations die out is called recovery voltage.

**51. State the difference between D.C. and A.C. circuit breaking. (Nov/Dec 2016)**

DC circuit breaker, like their name suggests, is used for the protection of electrical devices that operate with direct current. The main difference between direct current and alternating current is that in DC the voltage output is constant, while in AC it cycles several times per second.

**52. What is rupturing Capacity? (May/June 2017)**

Rupturing capacity is the current that a fuse, circuit breaker, or other electrical apparatus is able to interrupt without being destroyed or causing an electric arc with unacceptable duration. The prospective short-circuit current which can occur under short circuit conditions should not exceed the rated breaking capacity of the apparatus. This theory states that the rate at which positive ions and electrons recombine to form neutral molecules is compared with rate of rise of restriking voltage and if the restriking voltage rises more rapidly than the dielectric strength, gap space breaks down and arc strikes again persists.

**53. What are the factors responsible for increase in arc resistance? (April/may 2018)**

The arc resistance increases

- When ionized particle between contact decreases.
- As the separation between contact increases and length of the arc also increases.
- With decrease in cross section area of the arc.



**54. A circuit breaker is rated as 1500A, 1000MVA, 3second, 3 phase oil circuit breaker . Find the rated making current. (April/may 2018)**

Given:

Breaking capacity= 1000MVA; Breaking current = 1500A;

Soln:

Making current =  $2.55 \times \text{breaking current} = 2.55 \times 1500 = 3825\text{A}$ .

**55. Why rate of rise of restriking voltage plays an important role in circuit breaker operation? (Nov/Dec 2018)**

The rate of rise of restriking voltage denotes the rate at which transient voltage increases or decreases. This factor plays an important role in circuit breaker operation since it decides the interruption of current by the circuit breaker. Transient recovery voltage depends upon natural frequency and power factor.

**56. Why oil circuit breakers are not suitable for heavy current interruption at low voltages? (Nov/Dec 2018)**

Oil circuit breakers cannot be used for heavy current interruption because high current causes arc which produces flammability of oil. Thus it requires high maintenance.

### **PART B**

1. Explain with neat sketch, the construction and working of minimum oil circuit breaker. What are its main advantages and disadvantages? **(May/June 2016)**
  - i) Describe the various types of rating of circuit breaker **(May/June 2012) (May/June 2013)**
2. With a neat block diagram, explain the construction, operating principle and
3. applications of SF6 circuit breaker. What are its advantages over other circuit breaker? **(Apr/May 2015) (May/June 2014) (Dec 2014) (Nov/Dec 2015).**
4. With neat sketches, explain the construction and operating principle of air break and minimum oil circuit breaker. (16) **(Nov/Dec 2013) (Nov/Dec 2015)**
5. Compare the performance, characteristics and application of different types of circuit breaker.
6. What are the requirements of a contact material for a vacuum circuit breaker? Why current chopping is not a serious problem with this circuit breaker? **(May 2015)**
7. With neat sketch explain the principles of axial blast circuit breaker. Enumerate the advantages and disadvantages of air blast circuit breakers. **(Apr/May 2015) (Nov/Dec 2018)**
8. What are the various types of operating mechanism which are used for opening and closing of the contacts of a CB? Discuss their merits and demerits.
9. i) Explain how arc is initiated and sustained when the circuit breaker contacts break ii) What is current chopping? Explain how can the effect of current chopping be minimized?
10. Derive an expression for the rate of rise of restriking voltage in a circuit breaker ii) Describe the operating principle of DC circuit breaker.
10. Discuss the recovery rate theory and energy balance theory of arc interruption in a circuit breaker. **(Apr/May 2015)**
11. Discuss the problems associated with the interruptions of low inductive current and the fault occurs nearer to the substation. **(Nov/ Dec 2012) (Nov/Dec 2014) (Nov/Dec 2015)**
12. Explain the phenomenon of current chopping and capacitive current breaking with diagram and waveforms. (16) **(May/June 2016) (May/June 2017)**
13. Derive an expression for restriking voltage and RRRV in terms of system voltage, inductance up to the fault location and bushing to earth capacitance of the circuit breaker. **(Apr/May 2015) (Nov/Dec 2014) (May/June 2016) (Nov/Dec 2016)**
14. Explain the methods of arc interruption. **(May/June 2014) (Nov/Dec 2011)**
15. What are the comparative merits and demerits of circuit breaker? **(Apr/May 2015)**
16. Discuss the different types of rating of circuit breakers along with the significance

and features.

17. Explain about current zero interruption theories. **(May/June 2016)**
  - (i) With a neat sketch explain the principle of vacuum circuit breaker.
  - (ii) Explain the phenomenon of interruption of capacitive current in a circuit breaker.
18. In short circuit test on a 3 pole, 132kV, circuit breaker, the following observations are made. Power factor for fault = 0.4, recovery voltage 0.9 times full line value, the breaking current symmetrical, frequency of oscillation of restriking voltage 16kHz. Assume neutral is grounded and fault is not grounded. Determine RRRV. **(Nov/Dec 2016)**
19. With neat diagram explain the construction and working principle of Air blast Circuit breaker and Vacuum circuit breaker. **(May/June 2017) (April/may 2018)**
20. Write short notes on i) Current Chopping ii) Resistance switching. **(Nov/ Dec 2017)**