# EE6702 PROTECTION AND SWITCHGEAR

## UNIT I

## INTRODUCTION

## Part-A

**1. What are the functions of protective relays?**

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.

**2. Give the consequences of short circuit.**

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.

**3. Define protected zone.**

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.

**4. What are unit system and non unit system?**

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.

**5. What is 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 defence.

**6. What is back up protection?**

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

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

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

**8. Define energizing quantity.**

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

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

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

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

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.

**11. What are over and under current relays?**

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)

**12. Mention any two applications of differential relay.**

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

**13. What is biased differential bus zone reduction?**

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.

**14. 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.

**15. What are symmetrical components?**

It is a mathematical tool to resolve unbalanced components into balanced components.

**16. State the three sequence components.**

Positive sequence components, negative sequence components and zero sequence components.

**17. Define positive sequence component.**

It has 3 vectors equal in magnitude and displaced from each other by an angle 120 degrees and having the phase sequence as original vectors.

**18. Define zero sequence components.**

They has 3 vectors having equal magnitudes and displaced from each other by an angle zero degrees.

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

It has no zero sequence component and the positive and negative sequence networks are connected in parallel.

**20. Define negative sequence component.**

It has 3 vectors equal in magnitude and displaced from each other by an angle 120 degrees and has the phase sequence in opposite to its original phasor.

**21. State the different types of faults.**

Symmetrical faults and unsymmetrical faults and open conductor faults.

**22. State the various types of unsymmetrical faults.**

Line to ground, line to line and double line to ground faults

**23. Define single line diagram.**

Representation of various power system components in a single line is defined as single line diagram.

## PART-B

**1. (i)Summarize the importance of protective schemes employed in power system(ii)Show the essential quantities of protection**

**2. Discuss the symmetrical components method to analyze an unbalanced system.**

**3. Discuss about three-phase symmetrical fault? Also discuss the different types of unsymmetrical faults that can occur on a three-phase system.**

**4. Explain and draw the sequence network for the following type of faults: a. Single-line-to-ground fault b. Double- line-to-ground fault c. Line-to-line fault.**

**5. In a 3-phase 4 wire system, the current R,Y and B under abnormal condition of loading are as under IR=100 30o A, IY=50 300o A, IB= 30 180o A. Calculate the positive, negative and zero-sequence currents in R line and return current in the neutral wire.**

**6. (i)Explain different types of earthing the neutral point of the power system (ii)Formulate an expression for the reactance of the peterson coil in terms of capacitance of the protected line.**

**7. Describe in detail about the Peterson coil? List the protective functions performed by this device**

**8. Discuss and compare the various methods of netural earthing**

**9. (i)Explain the overlapping of protective zones with neat sketch. (ii)Describe the different faults in power system. Which of these are more frequents?**

**10.(i)Describe the fundamental requirements of protective relaying (ii)Differentiate between surge diverter and surge absorber.Also explain the characteristics of an ideal surge diverter**

**11.(i)List the causes of over voltage? (ii)Describe the protection scheme employed to protect from lighting and switching effects**

**12.(i)List the causes of short circuits due to failure of insulation on overhead conductors? (ii)Briefly explain about resistance earthing and reactance earthing.**

## UNIT-II
## ELECTROMAGNETIC RELAY

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

The operation of a relay should be fast and selective, ie, 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.

**2. Mention the short comings of Merz Price scheme of protection applied to a power transformer.**

In a power transformer, currents in the primary and secondary are to be compared. As these two currents are usually different, the use of identical transformers will give differential current, and operate the relay under no-load condition. Also, there is usually a phase difference between the primary and secondary currents of three phase transformers. Even CT's of proper turn-ratio are used; the differential current may flow through the relay under normal condition.

**3. 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 loading; stator winding fault.

**4. What is an under frequency relay?**

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

**5. Define the term pilot with reference to power line protection.**

Pilot wires refer 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.

**6. Mention any two disadvantage of carrier current scheme for transmission line only.**

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

**7. 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.

**8. What are the causes of over speed and how alternators are protected from it?**

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.

**9. What are the main types of stator winding faults?**

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

**10. 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.

**11. 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 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.

**12. Define a over current relay.**

Relay which operates when the current ia a line exceeds a predetermined value.

**13. Define an undercurrent relay?**

Relays which operates whenever the current in a circuit drops below a predetermined value.

**14. Mention any 2 applications of differential relays.**

Protection of generator and generator-transformer unit: protection of large motors and bus bars

## PART-B

**1. Develop the different inverse time characteristics of over current relays and mention how the characteristics can be achieved in practice for an EM relay?**

**2. Explain the general working of a relay and derive the fundamental torque equation**

**3. Discuss the construction details and principle of operation of induction type directional over current relay.**

**4. Discuss the construction and principle of operation of non-directional induction-disc relay.**

**5. Discuss the construction and operating principle of over current relay with directional scheme**

**6. Describe the operating principle, constructional features and area of applications of directional relay. How do you implement directional feature in the over current relay.**

**7. (i)Explain the construction details and principle of operation of directional induction cup relay (ii) Explain with the help of neat diagram the construction and working of induction type directional power relay.**

**8. Show the MHO relay characteristic on the R-X diagram. Discuss the range setting of various distance relays placed on a particular location**

**9. Show in what way distance protection is superior to over current protection for the protection of transmission line**

**10.Explain the principle of working of distance relays. Describe with neat sketchs the following types of relays (i)Impedance relay (ii)Reactance relay (iii) Mho relayIndicate the difference on RX diagrams and show where each type is suitable.**

**11.Describe the operating principles and characteristic of impedance , admittance and mho relays**

**12.Describe the principle of percentage biased differential relay with necessary diagrams. Also discuss its applications**

**13.Describe the principle of (i) Negative Sequence Relay(8) (ii) Under Frequency relay**

**14.Explain the construction and working principle of negative sequence relay with a neat diagram.(16)**

## UNIT III

## APPARATUS PROTECTION

**1.What are the types of graded used in line of radial relay feeder?**

Definite time relay and inverse-definite time relay.

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

(a) Stator faults
1, Phase to phase faults
2, Phase to earth faults
3, Inter turn faults
(b) 1, Earth faults
2, Fault between turns
3, Loss of excitation due to fuel failure
(c) 1, Over speed 2,
Loss of drive
3, Vacuum failure resulting in condenser pressure rise, resulting in shattering of the turbine low pressure casing
(d) 1, Fault on lines
2, Fault on busbars



**3. Why neutral resistor is added between neutral and earth of an alternator?**

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

**4.What is the backup protection available for an alternator**

Overcurrent and earth fault protection is the backup protections.

**5.What are faults associated with an alternator?**

External fault or through fault
Internal fault
1, Short circuit in transformer winding and connection
2, Incipient or slow developing faults

**6. What are the main safety devices available with transformer?**

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

**7.What are the limitations of Buchholz relay?**

(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.

**8.What are the problems arising in differential protection in power transformer and how are they overcome?**

1. 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.

2. 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.

3. 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.

4. Magnetizing inrush current appears wherever a transformer is energized on its primary side producing harmonics. No current will 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.

**9.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.

**10. What is over fluxing protection in transformer?**

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.

**11.Why busbar protection is needed?**

(a)Fault level at busbar is high

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

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

**12.What are the merits of carrier current protection?**

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



**13. What are the errors in CT?**

(a) 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.

(b) Phase angle error:

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

**14. What is field suppression?**

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.

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

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

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

- 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.

## PART-B

**1.Compare CT & PT. What are the applications of CT & PT**

**2. Briefly discuss the protective devices used for the protection of large transformer**

**3. Classify different protection schemes normally used for protection of a power transformer from internal faults? Discuss one of them in brief**

**4. (i)Explain the Merz-price circulation current scheme of protection used for power transformer. (8) ( BTL-4) (ii)A three phase transformer of 220/11000 line volts is connected in star/delta. The protective transformers on 220V side have a current ratio of 600/5 . Calculate the current transformer ratio on 11000V side**

**5. A 3 phase transformer having line voltage ratio of 440 V / 11 kV is connected in star – delta. The protection transformer on the LV side has a ratio of 500 / 5. Estimate the ratio of the protection transformer connected on HV side?**

**6. (i)Describe the differential protective scheme of transformer (ii)Show the protective scheme employed for the bus bar**

**7. (i)Describe the construction and working of Buchholz relay (ii) Explain the use of impedance relay on transmission line protection.**

**8. Discuss the principle of percentage biased differential protection with necessary diagrams. Also discuss its applications**

**9. Describe the differential pilot wire method of protection of feeder**

**10.A star connected 3-phase,20MVA,11KV Alternator has a per phase reactance of 0.75 ohms/phase .It is protected by Merz price circulating current principle which is to operate for fault currents not lessthan 175A. Formulate the value of earthing resistance to be provided in order to ensure only 10% of the alternator winding remains unprotected**

**11.Describe the types of protective schemes employed for the protection of field winding and loss excitation of alternator**

**12.Describe the types of protective schemes employed for the protection of Busbar**

**13.Explain the types of protective schemes employed for the protection of Transmission line**

**14.Show the different types of feeder and the protective schemes employed for the protection of feeder**



## UNIT-IV
## STATIC RELAY AND NUMERICAL RELAYS

**1. 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.

**2. What is power swing?**

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.

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

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

**4. What is CPMC?**

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

**5. What are the advantages of static relay over electromagnetic relay?**

- 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

**6. What is pick up value?**

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

**7. Define target.**

It is the indicator used for showing the operation of the relay.

**8. Define reach.**

It is the distance upto which the relay will cover for protection.

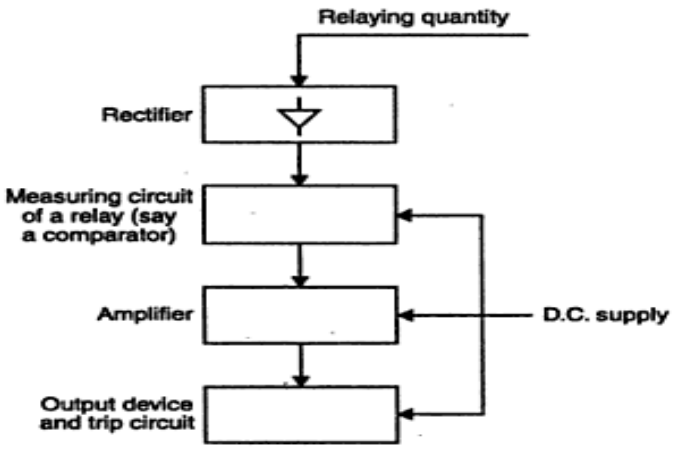
**9. Define blocking.**

It means preventing the relay from tripping due to its own characteristics or due to additional relays.

**10.What is a Static Relay?**

It is a relay that uses solid state components like transistors and diodes for the measurement or comparison of electrical quantities

**11.Block Diagram of a Static Relay**




**12.Define Comparator**

The magnitude of voltage & current and phase angle between them may change when a fault occurs.

**13.Define Amplitude Comparator**

- It compares the magnitude of two input quantities irrespective of the angle between them.
- The two quantities are operating quantity and restraining quantity.
- When the magnitude of the operating quantity is greater than the restraining quantity, the relay sends trip signal to C.B.

**14.Define Circulating current Comparator**

$i_O$ and $i_r$ are operating and restraining currents. Under no fault condition, $i_r > i_O$. The differential current flows through the relay in -ve direction. During a fault, $i_o > i_r$. Hence the differential current flows through the relay in +ve direction to trip C.B

**15.Define Opposed Voltage Comparator**

$V_O$ and $V_r$ are operating and restraining voltages.Under no fault condition, $V_r > V_O$. The differential current flows through the relay in -ve direction. During a fault, $V_o > V_r$. Hence the differential current flows through the relay in +ve direction to trip C.B.

**16.Define Phase Comparator**

Period of coincidence of +ve polarity of 2 signals are compared with a reference angle. (usually 90 degree). If the 2 signals have a phase difference of $\phi$, then the angle of coincidence $\psi = 180 - \phi$. If $\phi < 90^0$, then $\psi > 90^0$. The phase comparator may be designed to trip the C.B, when $\psi > 90^0$. The period of coincidence is measured by different techniques.

**17. What are the types of Phase Comparator**

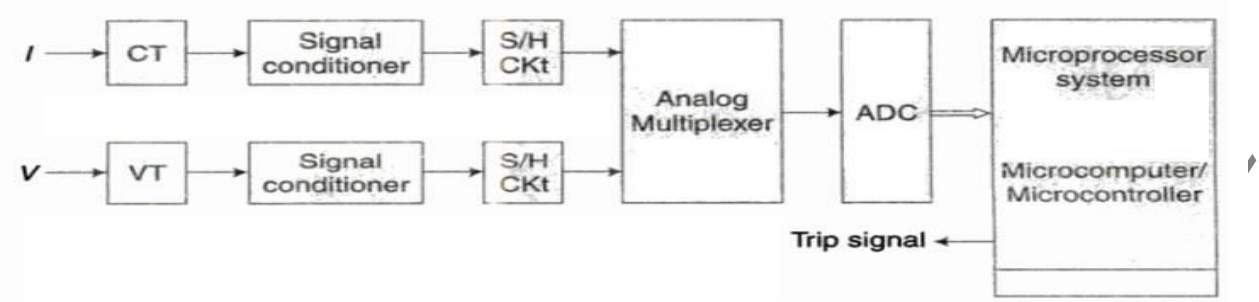
- Vector product P.C

a) Hall effect P.C
b) Magneto-resistivity P.C

- 1.2.2 Coincidence type P.C

a) Block spike P.C
b) Phase-splitting type P.C
c) Integrating type P.C
d) Rectifier bridge type P.C

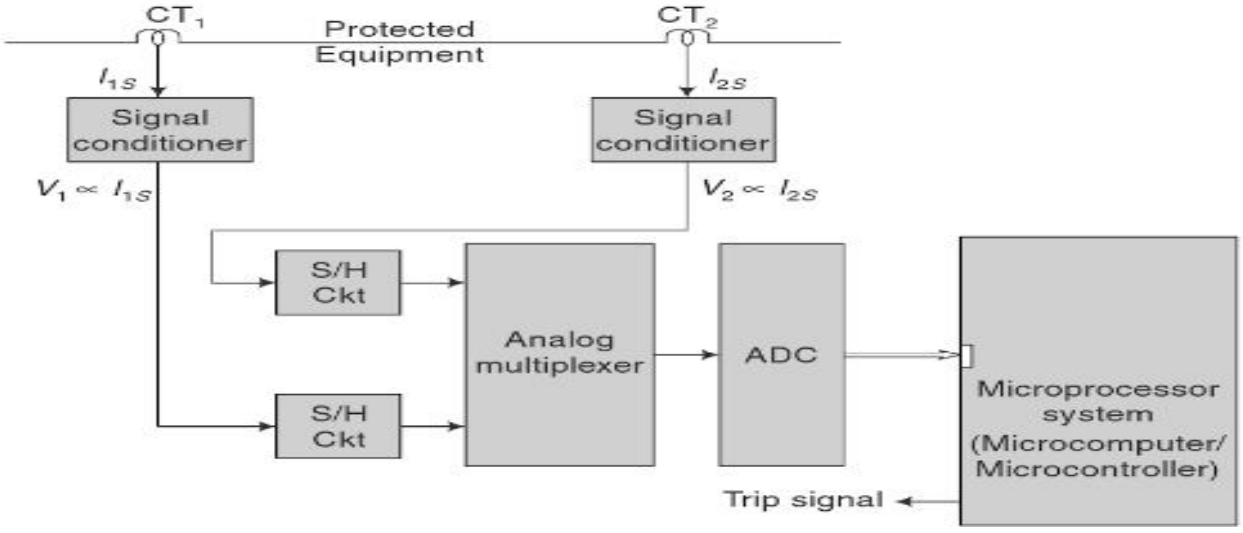
**18. Block diagram of Numerical Relay**



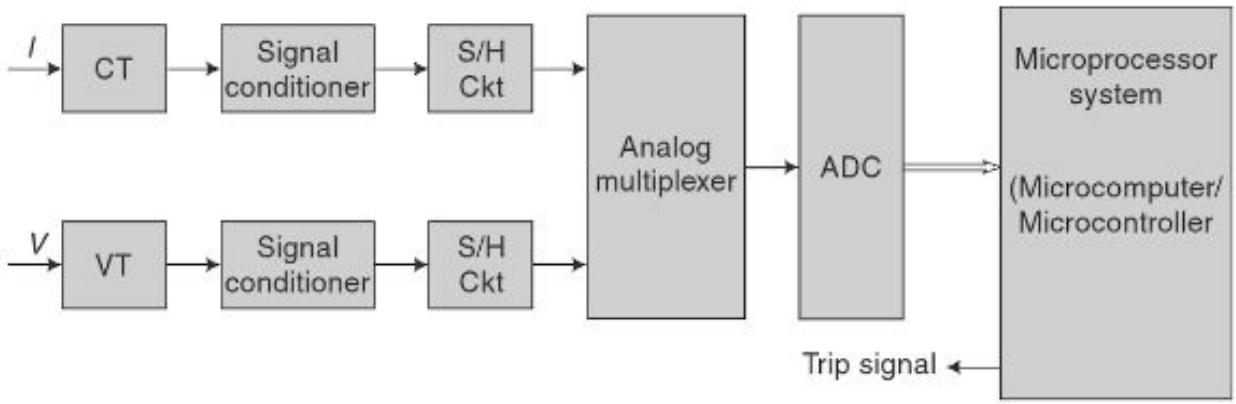

**19.Define Numerical Relay**

Numerical is the relay in which the measured AC quantities are sequentially sampled and converted into numerical data that is mathematically and/or logically processed to make trip decisions

**20.Numerical Relay for Differential Protection**




**21.Numerical Relay for Distance Protection**




## PART-B

**1.Define static relay? What are the merits and demerits of static relays over electromagnetic relays also mention its applications.**

**2. i) Define the Duality Between Amplitude and Phase Comparators.(8) ii) Define the type of Amplitude and Phase Comparators.**

**3. Discuss the Synthesis of Various Distance Relays Using Static Comparators**

**4. Explain with neat block diagram of the function of Synthesis of Mho Relay Using Static Phase Comparator**

**5. Explain with neat block diagram of the function of Synthesis of Reactance Relay Using Cosine-type Phase Comparator**

**6. Distinguish briefly about the Phase Comparators and write its types**

**7. Illustrate and Explain with neat Block diagram of Numerical relays**

**8. Compose the problems arising in differential protection in power transformer and how are they overcome?**

**9. Explain with neat block diagram of the function of Synthesis of Simple Impedance Relay Using Amplitude Comparator**

**10. Assess the factors cause spill current on external fault in case of transformer Differential protection?**

**11. Illustrate with neat Block diagram of Numerical Transformer Differential Protection**

**12. Discuss with Neat Block diagram of different methods of Numerical Distance Protection of Transmission Line.**

**13. Define the Over Current Protection and Explain its types briefly**

**14. Define i) definite time over-current relay ii) Inverse Time Over-current Relay**

## UNIT V

## CIRCUIT BREAKER

**1. What is resistance switching?**

- 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.

**2. What do you mean by current chopping?**

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.

**3.What are the methods of capacitive switching?**

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

**4. 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.

**5. Give the two methods of arc interruption?**

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.

**6. What is restriking voltage?**

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

**7. What is meant by 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.



**6. What is RRRV?**

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

**7. What is circuit breaker?**

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.

**8.Write the classification of circuit breakers based on the medium used for arc extinction?**

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

**9. 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.

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

- Short contact life
- Frequent maintenance
- Possibility of explosion
- Larger arcing time for small currents
- Prone to restricts

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

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



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

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

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

- Arial-blast type
- Cross blast
- Radial-blast

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

- 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

**15. What is meant by electro negativity of SF6 gas?**

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.

**16. What are the characteristic of SF6 gas?**

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.

**17. Write the classifications of test conducted on circuit breakers.**

- Type test
- Routine test
- Reliability test
- Commissioning test

**18. What are the indirect methods of circuit breaker testing?**

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



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

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. This method does not give a proper estimate of the breaker performance.

**20. What are arcing grounds?**

The presence of inductive and capacitive currents in the isolated neutral system leads to formation of arcs called as arcing grounds.

## PART-B

**1.Define the principle of arc extinction. What are the methods of arc extinction? Describe them in detail. (16) (BTL-1)**

**2. i)Explain the arc interruption methods used in circuit breakers ii)Explain Resistance switching for arc extinction in circuit breakers**

**3. i) compose and Draw the schematic of a HVDC Circuit Breaker and explain its function ii) Compose the problem of direct current interruption**

**4. i) Explain how arc initiated and sustained when the circuit breaker contactsbreak ii) Explain in detail the various methods of arc extinction in circuit breaker)**

**5. i) Show an expression for Restriking voltage and rate of rise of restriking voltage (RRRV) in a C.B.) ii) Illustrate the current chopping? Explain how can the effect of current chopping be minimized?**

**6. i) Solve the RRRV of 132 kV circuit breaker with neutral earthed circuit breaker data as: broken current is symmetrical, restriking voltage has frequency of 20 kHz, and power factor is 0.15. Assume fault is also earthed. (8) (BTL-3) (ii) Illustrate the selection of circuit breakers for different ranges of system voltages**

**7 . i) Define resistance switching. ii) Describe the operating principle of DC circuit breaker.**

**8. Discuss with neat sketch, the construction and working of minimum oil circuit breaker. Also gives its merits and demerits.**

**9. Describe the constructional details of SF6 circuit breaker and its operation. Give its advantages and disadvantages**

**10. Discuss the different arc control mechanisms with suitable diagrams in bulk oil CB.**

**11. Describe the principle constructional features of all types of air blast CB.Give its advantages and disadvantages.**

**12. Describe the constructional details of vacuum CB and explain its principle of operation and working.**

**13. Explain rupturing capacity, making capacity and short time rating and rated current of the circuit breaker.**

**14. Compare the performance and characteristics of different types of CB.List out their merits and demerits**