

SHORT QUESTIONS AND ANSWERS

UNIT I

INTRODUCTION

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 extending 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.

16 Marks Questions

1. (a) What are the causes of over voltage on a power system? (8)
(b) Why is it necessary to protect the lines and other equipment of the power system against over voltages? (8)
2. Describe the phenomenon of lightning. (16)
3. What protective measures are taken against lightning over voltages? (16)
4. (a) What is tower-footing resistance? (4)
(b) Why is it required to have this resistance as low as economically possible? (4)
(c) What are the methods to reduce this resistance? (8)
5. (a) What is necessity of protecting electrical equipment against traveling waves? (6)
(b) Describe in brief the protective devices used for protection of equipment against such waves? (10)
6. Describe the protection of stations and sub-stations against direct lightning stroke. (16)
7. Describe the construction and principle of operation of
 - (i) expulsion type lightning arrester, (8)
 - (ii) Valve type lightning arrester. (8)
8. What is Peterson coil? What protective functions are performed by this device? (16)
9. Write short notes on the following.
 - (i) klydonograph and magnetic link (4)
 - (ii) Rod gap (4)
 - (iii) Arcing horns (4)
 - (iv) Basic impulse insulation level (4)
10. What are the requirements of a ground wire for protecting power conductors against direct lightning stroke? Explain how they are achieved in practice. (16)
11. Determine the inductance of Peterson coil to be connected between the neutral and ground to neutralize the charging current of overhead line having the line to ground capacitive of $0.15\mu\text{f}$. If the supply frequency is 50Hz and the operating voltage is 132 KV, find the KVA rating of the coil. (16)

12. (a) Explain the term insulation coordination. (8)
(b) Describe the construction of volt-time curve and the terminology associated with impulse-testing. (8)
13. Explain the operation of various types of surge absorbers (16)

UNIT II

OPERATING PRINCIPLES AND RELAY CHARACTERISTICS

14. 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.

15. 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.

16. What are the various faults to which a turbo alternator is likely to be subjected?

Failure of steam supply; failure of speed; overcurrent; over voltage; unbalanced loading; stator winding fault .

17. 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.

18. Define the term pilot with reference to power line protection.

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

19. 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

20. 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.

21. 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.

22. 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.

23. 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.

24. 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.

16 Marks Questions

1. What are the different types of electromagnetic relays? Discuss their field of applications. (16)
2. What are the various types of over current relays? Discuss their area of application. (16)
3. Describe the operating principle, constructional features and area of applications of reverse power or directional relay. (16)
4. Describe the construction and principle of operation of an induction type directional over current relay. (16)
5. Explain the working principle of distance relays. (16)
6. Write a detailed note on differential relays. (16)
7. Describe the realization of a directional over current relay using a microprocessor. (16)
8. Derive a generalized mathematical model of distance relays for digital protection. (16)
9. (a) How can digital distance relaying algorithm be implemented on the 8086 Micro processor? (8)
(b) It is possible to implement these algorithms on the 8085micro processor? (8)
10. Explain with sketches and their R-X diagrams for the following distance relays.
 - (i) Impedance relay (5)
 - (ii) Mho relay (5)
 - (iii) Reactance relay (6)
11. (a) Explain the applications of microprocessors in power system protection. (8)
(b) Explain microprocessor based inverse time over current relay. (8)

UNIT III

APPARATUS PROTECTION

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

Definite time relay and inverse-definite time relay.

26. 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

27. 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.

28. What is the backup protection available for an alternator?

Overcurrent and earth fault protection is the backup protections.

29. What are faults associated with an alternator?

- (a) External fault or through fault
- (b) Internal fault
 - 1, Short circuit in transformer winding and connection
 - 2, Incipient or slow developing faults

30. What are the main safety devices available with transformer?

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

31. 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.

32. 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.

33. 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.

34. 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.

35. 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.

36. What are the merits of carrier current protection?

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

37. What are the errors in CT?

- (a) Ratio error
Percentage ratio error = $[(\text{Nominal ratio} - \text{Actual ratio})/\text{Actual ratio}] \times 100$
The value of transformation ratio is not equal to the turns ratio.
- (b) Phase angle error:
Phase angle $\alpha = 180 / \pi [(I_m \cos \alpha - I_1 \sin \alpha) / n I_s]$

38. What is field suppression?

When a fault occurs in an alternator winding even though the generator circuit breaker is tripped, the fault continues to feed 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.

39. 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.

40. 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.

41. 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.

42. 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.

43. What is a programmable relay?

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

44. What is CPMC?

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

45. 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

- 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.

16 Marks Questions

1. Enumerate the relaying schemes which are employed for the protection of a modern alternator. (16)
2. (a) What is transverse or split phase protection of an alternator? (4)
(b) What type of fault is this scheme of protection employed? (4)
(c) With a neat sketch discuss the working principle of this scheme. (8)
3. What type of a protective device is used for the protection of an alternator against overheating of its (i) stator (ii) rotor? Discuss them in brief. (8+8)
4. What type of a protective scheme is employed for the protection of the field winding of the alternator against ground faults? (16)
5. Discuss the protection employed against loss of excitation of an alternator. (16)
6. (a) What do you understand by field suppression of an alternator? (8)
(b) How is it achieved? (8)
7. Briefly discuss the protection of an alternator against.
(i) Vibration of distortion of motor (4)
(ii) Bearing overheating (4)
(iii) Auxiliary failure (4)
(iv) Voltage regulator failure (4)
8. What type of pilot protection is used for EHV and UHV transmission lines. (16)
9. (a) What is carrier protection? (4)
(b) For what voltage range is it used for the protection of transmission line? (4)
(c) What are its merits and demerits? (8)
10. (a) What is carrier aided distance protection. (4)
(b) What are its different types? (4)
(c) Discuss the permissive under-reach transfer tripping scheme of protection. (8)
11. (a) Draw and explain the merz-price protection of alternator stator winding. (10)
(b) A generator is protected by restricted earth fault protection. The generator ratings are 13.2kv, 10MVA. The percentage of winding protected against phase to ground fault 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. (6)

UNIT IV

THEORY OF CIRCUIT INTERRUPTION

46. 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.

47. 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.

48. What are the methods of capacitive switching?

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

49. 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.

50. 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 occurs 100 times a second in case of 50Hz power system frequency in ac.

51. What is restriking voltage?

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

52. 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.

53. 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.

16 Marks Questions

1. (a) What is resistance switching? (4)

- (b) Derive the expression for critical resistance. (12)
2. (a) Explain the phenomenon of current chopping in a circuit breaker. (12)
- (b) What measures are taken to reduce it? (4)
3. Discuss the problem associated with the interruption of
- (i) Low inductive current (5)
- (ii) Capacitive current and (5)
- (iii) Fault current if the fault is very near the substation. (6)
4. Explain in detail about RRRV. (16)

UNIT V

CIRCUIT BREAKERS

54. 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.

55. 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

56. 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.

57. What are demerits of MOCB?

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

58. 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

59. What are the hazards imposed by oil when it is used as an arc quenching medium?

There is a risk of fire since it is inflammable. It may form an explosive mixture with arc. So oil is preferred as an arc quenching medium.

60. 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

61. 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.

62. What are the types of air blast circuit breaker?

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

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

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

64. 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

65. 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.

66. 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.

67. Write the classifications of test conducted on circuit breakers.

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

68. What are the indirect methods of circuit breaker testing?

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

69. What are the advantages of synthetic testing methods?

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

70. How does the over voltage surge affect the power system?

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

71. What is pick up value?

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

72. Define target.

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

73. Define reach.

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

74. Define blocking.

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

75. Define an over current relay.

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

76. Define an under current relay?

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

77. Mention any 2 applications of differential relays.

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

78. Mention the various tests carried out in a circuit breaker at HV labs.

Short circuit tests, Synthetic tests & direct tests.

78. Mention the advantages of field tests.

The circuit breaker is tested under actual conditions like those that occur in the network. Special occasions like breaking of charging currents of long lines, very short line faults, interruption of small inductive currents etc... can be tested by direct testing only.

79. State the disadvantages of field tests.

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

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

81. State the various types of earthing.

Solid earthing, resistance earthing, reactance Earthing, voltage transformer Earthing and zig-zag transformer earthing.

82. 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.

83. What is arc suppression coil?

A method of reactance grounding used to suppress the arc due to arcing grounds.

84. 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.

85. What are symmetrical components?

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

86. State the three sequence components.

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

87. Define positive sequence component.

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

88. Define zero sequence component.

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

89. State the significance of double line fault.

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

90. 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 phasors.

91. State the different types of faults.

Symmetrical faults and unsymmetrical faults and open conductor faults.

92. State the various types of unsymmetrical faults.

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

93. Mention the withstanding current in our human body.

9mA

94. State the different types of circuit breakers.

Air ,oil,vacuum circuit breakers.

95. Define per unit value.

It is defined as the ratio of actual value to its base value.

96. Mention the inductance value of the peterson's coil.

$L=1/3wc^2$

97. Define single line diagram.

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

98. Differentiate between a fuse and a circuit breaker.

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

99. How direct tests are conducted in circuit breakers?

Using a short circuit generator as the source.

Using the power utility system or network as the source.

100. What is dielectric test of a circuit breaker?

It consists of overvoltage 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.

16 Marks Questions

1. Discuss the recovery rate theory and energy balance theory of arc interruption in a circuit breaker. (16)
2. Explain terms:
 - i) Restriking voltage (3)
 - ii) Recovery voltage (3)
 - iii) RRRV (3)
 - iv) Derive expressions for restriking voltage and RRRV. (3)
 - v) What measures are taken to reduce them? (4)
6. With neat sketch, describe the working principle of an axial air blast type circuit breaker. (16)
7. (a) Discuss the operating principle of SF₆ circuit breaker. (10)
(b) What are its advantages over other types of circuit breakers? (3)
(c) For what voltage range is it recommended? (3)
8. Describe construction, operating principle and application of vacuum circuit breaker. For what voltage range is it recommended? (16)
9. (a) What are the various types of operating mechanisms which are used for opening and closing of the contacts of a circuit breaker? (10)
(b) Discuss their merits and demerits. (6)
10. (a) Enumerate various types of ratings of a circuit breaker. (4)
(b) Discuss symmetrical and asymmetrical breaking capacity, (4)
(c) Making capacity (4)
(d) Short-time current capacity. (4)
11. What are the different methods of testing of circuit breakers? Discuss their merits and demerits. (16)

12. What is the difficulty in the development of HVDC circuit breaker? Describe its construction and operating principle. (16)
13. (a) What are the physical chemical and dielectric properties of SF₆ Gas (8)
- (b) Define switchgear. What are the essential features of switchgear (8)
14. A 3-phase alternator has the line voltage of 11kV. The generator is connected to a circuit breaker. The inductive reactance upto the circuit breaker is 5_/phase. the distributed capacitance upto circuit breaker between phase and neutral is 0.001 μF. Determine peak restriking voltage across the CB, frequency of restriking voltage, average rate of restriking voltage upto peak restriking voltage, maximum RRRV. (16)