

CH-1

INTRODUCTION TO SWITCH GEAR

ASSIGNMENT

1. Fill in the blanks by inserting appropriate words/figures.

- (i) A fuse is a device.
- (ii) A circuit breaker is a device.
- (iii) An isolator is designed to open a circuit under
- (iv) When a switch is opened, is produced.
- (v) Under normal operating conditions, the contacts of the circuit breaker remain
- (vi) Under fault conditions, supplies information to the circuit breaker to open.
- (vii) If a fault occurs on the bus itself in a single bus-bar system, then there is complete
- (viii) The sectionalised bus-bar system gives fault current than that of unsectionalised bus-bar.
- (ix) For greater flexibility, bus-bar system is used.
- (x) The outdoor type switchgear is generally used for voltages beyond kV.

2. Pick up the correct words/figures from brackets and fill in the blanks.

- (i) A fuse performs functions.
(both detection and interruption, interruption)
- (ii) The circuit breaker performs function. (detection, circuit interruption)
- (iii) For voltages beyond 66 kV, switchgear equipment is installed
(indoor, outdoor)
- (iv) Bus-bars operate at voltage. (constant, variable)
- (v) Isolator is an switch. (air, oil)

ANSWERS

- 1. (i) protective (ii) circuit interrupting (iii) no load (iv) arc (v) closed (vi) relay (vii) shut down (viii) lower (ix) duplicate (x) 66
- 2. (i) both detection and interruption (ii) circuit interruption (iii) outdoor (iv) constant (v) air

CHAPTER ASSIGNMENT

- 1. What do you understand by switchgear ?
- 2. Discuss the various types of switches.
- 3. What is the difference between
 - (i) a switch and circuit breaker
 - (ii) a fuse and circuit breaker ?
- 4. Discuss the different types of bus-bar arrangements.
- 5. Explain the various methods of accommodating high-voltage switchgear.

QUESTIONS

1. What are the limitations of a fuse ?
2. Why do we use C.T. in the relay circuit ?
3. What is the necessity of bus-bar ?
4. Why do we use isolators on both sides of the circuit breaker ?
5. Why are isolators not opened on load ?
6. Which faults ____ symmetrical or unsymmetrical ____ are more frequent in power system and why ?
7. Suddenly a circuit carries a current 20 times the normal current. Is there possibility of short-circuit or overload ?

CH-2 FAULT CALCULATION

ASSIGNMENT

- 1.** A 3-phase, 30 MVA, 33 kV alternator has internal reactance of 4% and negligible resistance. Find the external reactance per phase to be connected in series with the alternator so that steady current on shortcircuit does not exceed 10 times the full load current. **[2·178 W]**
- 2.** A 3-phase transmission line operating at 33 kV and having a resistance of 5 W and reactance of 20 W is connected to the generating station through 15,000 kVA step-up transformer. Connected to the bus-bar are two alternators, one of 10,000 kVA with 10% reactance and another of 5000 kVA with 7·5% reactance. Calculate the short-circuit kVA fed to the symmetrical fault between phases if it occurs
(i) at the load end of transmission line
(ii) at the high voltage terminals of the transformer
[(i) 44,500 kVA (ii) 100,000 kVA]
- 3.** The plant capacity of a 3-phase generating station consists of two 8 MVA generators of reactance 14·5% each and one 4 MVA generator of reactance 9·5%. These are connected to a common bus-bar from which loads are taken through a number of 3 MVA step-up transformers each having 4% reactance. Determine the MVA rating of the circuit breakers on (i) L.V. side and (ii) H.V. side. Reactances given are based on the MVA of each equipment. **[(i) 15·24 MVA (ii) 50·25 MVA]**
- 4.** The 33 kV bus-bar of a station are in two sections *A* and *B* separated by a reactor. Section *A* is fed from four 10 MVA generators each having 20% reactance and section *B* is fed from the grid through 50 MVA transformer of 10% reactance. The circuit breakers have rupturing capacity of 500 MVA. Find the reactance of the reactor to prevent the circuit breakers being overloaded if a symmetrical short-circuit occurs on an outgoing feeder connected to it. **[1·45 W]**
- 5.** A generating station has five section bus-bar connected with a tie-bar through 7·5% reactors rated at 3000 kVA. Each generator is of 3000 kVA with 10% reactance and is connected to one section of the bus-bar. Find the total steady input to a dead short-circuit between the lines on one of the sections of the bus-bars (i) with and (ii) without reactors. **[(i) 55·3 MVA (ii) 150 MVA]**
- 6.** A generating station has four bus-bar sections. Each section is connected to tie-bar though 20% reactors rated at 200 MVA. Generators of total capacity 100 MVA and 20% reactance are connected to each busbar section. Calculate the MVA fed to a fault under short-circuit condition one one of the bus-bars. **[1000 MVA]**

1. Fill in the blanks by inserting appropriate words/figures.

- (i) When a short-circuit occurs, a current flows through the system.
- (ii) The most serious result of a major uncleared short-circuit fault is the
- (iii) When all the three phases are short-circuited, it gives rise to currents.
- (iv) The rating of a circuit breaker is generally determined on the basis of short circuit currents.
- (v) The most common type of fault in overhead lines is
- (vi) The short-circuit fault gives very heavy duty on the circuit breaker.
- (vii) If the % age reactance upto the fault point is 20%, then short-circuit current will be times the full-load current.
- (viii) A 1000 kVA transformer with 5% reactance will have a reactance of at 2000 kVA base.
- (ix) Short-circuit kVA is obtained by multiplying the base kVA by
- (x) Reactors are used at various points in the power system to

2. Pick up the correct words/figures from the brackets and fill in the blanks.

- (i) fault gives rise to symmetrical fault currents.
(single phase to ground, phase to phase, 3-phase short-circuit)
 - (ii) Percentage reactances as they are referred through transformers.
(remain unchanged, are changed)
- Symmetrical Fault Calculations
- (iii) If the % age reactance of the system upto the fault point is 20% and the base kVA is 10,000, then short-circuit kVA is (50,000, 10,000, 2,000)
 - (iv) The use of reactors permits installation of circuit breakers of ratings. (lower, higher)
 - (v) A 20,000 kVA transformer with 10% reactance will have a reactance of at 10,000 Kva base. (5%, 20%, 10%)

ANSWERS TO SELF-TEST

- 1. (i) heavy (ii) fire (iii) symmetrical fault (iv) symmetrical (v) phase-to-ground fault (vi) 3-phase (vii) 5 (viii) 10% (ix) 100/% X (x) limit short-circuit current
- 2. (i) 3-phase short-circuit (ii) remain unchanged (iii) 50,000 (iv) lower (v) 5%

CHAPTER ASSIGNMENT

1. What do you understand by a short-circuit ? Discuss the possible causes of short-circuit in the power system.
2. Explain the harmful effects of short-circuit fault on the power system.
3. What is the importance of short-circuit calculations ?
4. Discuss the possible faults on overhead lines.
5. What do you understand by percentage reactance ? Why do we prefer to express the reactances of various elements in percentage values for short-circuit calculations ?
6. What is the importance of base kVA in short-circuit calculations ?
7. Why do we use reactors in the power system ? Discuss their advantages.
8. Explain the various methods of connecting short-circuit current limiting reactors in the power system.

ASSIGNMENT QUESTIONS

1. Why do we choose a base kVA in short-circuit calculations ?
2. What is the advantage of expressing reactances in percentage values ?
3. Why do we decide the rating of a circuit breaker on the basis of symmetrical short-circuit currents ?
4. Will the value of short-circuit current change if we take different base kVAs' ? Explain your answer.
5. Can feeder reactors permit the use of circuit breakers of lower ratings ?

CH-3

FUSE

ASSIGNMENT

1. Fill in the blanks by inserting appropriate words/figures

- (i) Fuses are generally used in circuits where operations are not expected.
- (ii) The minimum time of operation of a fuse is than that of a circuit breaker.
- (iii) A fuse element should have melting point.
- (iv) The disadvantages of tin fuse element is that its vapour tends to when it blows out.
- (v) The value of fusing factor is always than unity
- (vi) Semi-enclosed rewirable fuses have breaking capacity.
- (vii) A fuse has time current characteristics.

- (viii) The action of a fuse is completely automatic.
(ix) The fuse element is generally made of
(x) The fuse melts well the first peak of fault current is reached.

2. Pick up the correct words/figures from the brackets and fill in the blanks.

- (i) A fuse is than other circuit interrupting device of equal breaking capacity.
(*cheaper, costlier*)
(ii) For the same material, heavy-current fuse wires must have diameters than for smaller currents. (*larger, smaller*)
(iii) A fuse performs functions. (*both detection and interruption, interruption*)
(iv) A fuse has breaking capacity as compared to a circuit breaker. (*low, high*)

ANSWERS

1. (i) frequent (ii) smaller (iii) low (iv) maintain the arc (v) more (vi) low (vii) inverse (viii) inherently (ix) silver (x) before
2. (i) cheaper (ii) larger (iii) both detection and interruption (iv) low

CHAPTER ASSIGNMENT

1. What is a fuse ? Discuss the advantages and disadvantages of a fuse.
2. Why do we prefer silver as a fuse element ?
3. Define and explain the following terms :
(i) fusing current (ii) cut off current (iii) operating time (iv) breaking capacity
4. Write short notes on the following :
(i) Semi-enclosed rewirable fuse
(ii) H.R.C. cartridge fuse
(iii) Difference between a fuse and circuit breaker

CHAPTER QUESTIONS

1. Why are circuit breakers preferred to fuses ?
2. Why fuses cannot provide adequate discrimination on heavy short-circuit ?
3. Why fuses can interrupt heavy short-circuit currents successfully ?

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CH-4 CIRCUIT BREAKERS

ASSIGNMENT

1. Fill in the blanks by inserting appropriate words/figures.

- (i) A circuit breaker opens when a fault occurs on the system.
- (ii) A circuit breaker can the circuit immediately after automatic operation.
- (iii) When the contacts of a circuit breaker are opened on the occurrence of a fault, an is struck.
- (iv) An a.c. circuit is more easily interrupted than a d.c. circuit because alternating current provides..... .
- (v) If the length of the arc increases, its resistance is

- (vi) If dielectric strength of the medium between contacts builds up more rapidly than the re-striking voltage, then arc will be
- (vii) In an oil circuit breaker, is used as the arc quenching medium.
- (viii) The quantity of oil needed for arc control oil circuit breakers is than that of plain break oil circuit breaker.
- (ix) Current chopping mainly occurs in circuit breakers.
- (x) Capacitive current breaking results in

2. Pick up the correct words/figures from the brackets and fill in the blanks.

- (i) Cross jet explosion pot breaker can interrupt short circuit currents efficiently. (*heavy, low*)
- (ii) In forced blast oil circuit breakers, the extinguishing force is the fault current to be interrupted. (*dependent upon, independent of*)
- (iii) In low oil circuit breakers, is used for insulation purposes. (*solid material, oil*)
- (iv) Forced-blast circuit breakers have speed of circuit interruption. (*low, high*)

ANSWERS

1. (i) automatically (ii) remake (iii) arc (iv) natural current zeros (v) increased (vi) extinguished (vii) some mineral oil (viii) less (ix) air-blast (x) voltage surges
2. (i) heavy (ii) independent of (iii) solid material (iv) high

CHAPTER ASSIGNMENT

1. What is a circuit breaker ? Describe its operating principle.
2. Discuss the arc phenomenon in a circuit breaker.
3. Explain the various methods of arc extinction in a circuit breaker.
4. Define and explain the following terms as applied to circuit breakers :
 - (i) Arc voltage
 - (ii) Restriking voltage
 - (iii) Recovery voltage
5. Describe briefly the action of an oil circuit breaker. How does oil help in arc extinction ?
6. Discuss the advantages and disadvantages of oil circuit breakers.
7. Explain with neat sketches the construction and working of the following circuit breakers :
 - (i) Plain explosion pot

- (ii) Cross jet explosion pot
(iii) Self-compensated explosion pot
8. Explain the difference between bulk oil circuit breakers and low-oil circuit breakers.
9. Discuss the constructional details and operation of a typical low-oil circuit breaker ? What are its relative merits and demerits ?
10. Discuss the principle of operation of an air-blast circuit breaker. What are the advantages and disadvantages of using air as the arc quenching medium ?
11. Explain briefly the following types of air-blast circuit breakers :
- (i) Axial-blast type
(ii) Cross-blast type
12. What are the important components common to most of circuit breakers ? Discuss each component briefly.
13. Write a short note on the rate of re-striking voltage indicating its importance in the arc extinction.
14. Discuss the phenomenon of
- (i) Current chopping
(ii) Capacitive current breaking
15. Write short notes on the following :
- (i) Resistance switching
(ii) Circuit breaker ratings
(iii) Circuit interruption problems

CHAPTER QUESTIONS

1. Why do plain break oil circuit breakers have a low speed of circuit interruption ?
2. Is it logical to express the breaking capacity of a circuit breaker in MVA ? Discuss.
3. Why is current interruption easier in an a.c. circuit than in a d.c. circuit ?
4. Why are circuit breakers designed to have a short-time rating ?
5. Is arc production in a circuit breaker unfortunate manifestation ?

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CH-5 PROTECTIVE RELAY

ASSIGNMENT

1. Fill in the blanks by inserting appropriate words/figures.

- (i) A relay performs the function of
- (ii) The relay operating coil is supplied through
- (iii) A 1 VA relay is sensitive than a 3 VA relay.
- (iv) The minimum relay coil current at which the relay operates is called.....
- (v) Induction relays be used with d.c. quantities.
- (vi) An overcurrent relay having a current setting of 125% is connected to a supply circuit through a current transformer of ratio 400/5. The pick-up value will be

- (vii) The pick-up value of a relay is 7.5 A and fault current in relay coil is 30A. Its plug-setting multiplier is
- (viii) Back-up protection functions when

2. Pick up the correct words/figures from brackets and fill in the blanks.

- (i) Most of the relays on service on electric power system are relays.
(*electronic, electro-mechanical*)
- (ii) Induction relays are used with quantities. (*a.c., d.c., both a.c. and d.c.*)
- (iii) Back-up protection is generally employed for protection against faults.
(*short-circuit, other than short-circuit*)
- (iv) Back-up protection is generally of type. (*unit, non-unit*)

ANSWERS

1. (i) fault detection (ii) instrument transformers (iii) more (iv) pick-up value (v) cannot
(vi) 6.25A (vii) 4 (viii) primary protection fails
2. (i) electro-mechanical (ii) a.c. (iii) short-circuit (iv) non-unit.

CHAPTER ASSIGNMENT

1. What is protective relay ? Explain its function in an electrical system.
2. Discuss the fundamental requirements of protective relaying.
3. Describe briefly some important types of electromagnetic attraction relays.
4. Derive the equation for torque developed in an induction relay.
5. Write a brief note on relay timing.
6. Define and explain the following terms as applied to protective relaying :
(i) Pick-up value (ii) Current setting (iii) Plug-setting multiplier (iv) Time-setting multiplier
7. Sketch a typical time/P.S.M. curve.
8. Describe the various steps for calculating the actual relay operating time.
9. Explain with the help of neat diagram the construction and working of :
(i) Non-directional induction type overcurrent relay

(ii) Induction type directional power relay

10. Describe the construction and principle of operation of an induction type directional overcurrent relay.

11. Explain the working principle of distance relays.

12. Write a detailed note on differential relays.

13. Describe the Translay scheme of protection.

14. Write short notes on the following :

(i) Percentage differential relays (ii) Definite distance relays (iii) Time-distance relays

CHAPTER QUESTIONS

1. What is the difference between a fuse and a relay ?

2. What is the difference between an overcurrent relay and current differential relay ?

3. Back-up protection is not a good substitute for better maintenance. Discuss.

4. Why are differential relays more sensitive than overcurrent relays ?

5. What is the difference between a balanced voltage relay and a Translay relay ?

CH-7 PROTECTION AGAINST OVER VOLTAGE AND LIGHTING

ASSIGNMENT

1. Fill in the blanks by inserting appropriate words/figures :

(i) The most severe surges on the line are produced by

(ii) Lightning produces a fronted wave.

(iii) Transients on the power system due to current chopping are taken care of by

(iv) Arcing ground can be prevented by

(v) The lightning currents range from 10 kA to about kA.

(vi) For successful working of ground wire, the footing resistance of tower should be

(vii) A surge diverter should be located to the apparatus to be protected.

2. Fill in the blanks by picking correct words/figures from brackets :

(i) A $1/50 \mu\text{s}$ surge is harmful than $3/50 \mu\text{s}$ surge. Assume the same peak value.
(more, less)

(ii) The lightning strokes are very rare on the power system. (*direct, indirect*)

(iii) Most of the lightning strokes are due to charged clouds. (*negatively, positively*)

(iv) The stroke *A* will always occur on (*tallest object, earth*)

(v) cannot protect the equipment from the travelling waves reaching the equipment.
(*ground wires, lightning arrester*)

(vi) In sub-stations, the most commonly used type of arrester is arrester.
(*Thyrite, horn gap, rod gap*)

(vii) Surge absorbers are used to the steepness of wave front of the surge.
(reduce, increase)

ANSWERS

1. (i) lightning (ii) steep (iii) resistance switching (iv) earthing the neutral (v) 90 (vi) low (vii) close
2. (i) more (ii) direct (iii) negatively (iv) tallest object (v) ground wires (vi) thyrite (vii) reduce

CHAPTER ASSIGNMENT

1. What is a voltage surge ? Draw a typical lightning voltage surge.
2. Discuss the causes of overvoltages.
3. What is lightning ? Describe the mechanism of lightning discharge.
4. Describe the various types of lightning stroke.
5. What are the harmful effects of lightning ?
6. How do earthing screen and ground wires provide protection against direct lightning strokes ?
7. What is a surge diverter ? What is the basic principle of operation of a surge diverter ?
8. Write short notes on the following surge diverters :
 - (i) Rod gap diverter
 - (ii) Horn gap diverter
 - (iii) Expulsion type diverter
 - (iv) Multigap diverter
9. Discuss the construction, principle and working of a valve type arrester.
10. What is a surge absorber ? Write a short note on Ferranti surge absorber.

ASSIGNMENT QUESTIONS

1. Why are steep fronted surges more dangerous to power system equipment ?
2. Why is lightning accompanied by a thunder ?
3. Is the name lightning arrester appropriate ?
4. Why are surge diverters located very close to the equipment to be protected ?
5. Where will you use a surge absorber ?

CH-8

STATIC RELAY

ASSIGNMENT

- 1.What is the advantage of static relay?
- 2.What is instantaneous over current rely?
- 3.Explain Principle of IDMT relay?