

- 1- In every electrical substation, there are generally various indoor and outdoor switchgear equipments. **Illustrate** with a basic pattern of electrical switchgear scheme the function of each equipment.
- 2- While selecting a circuit breaker for a special application such as capacitor switching, line switching ...etc. relevant types, relevant ratings and relevant tests certificate should be checked. Explain with short notes the following:
  - a. The different types of circuit breakers and their applications.
  - b. The different Ratings of circuit breakers.
  - c. The different tests necessary to prove the ratings of circuit breakers.
- 3- Explain using appropriate waveforms the different stages occurs from the instant of the short circuit start up to final arc extinction.
- 4- What is happening to the voltage between the C.B contacts before and after the separation of C.B contacts, Support your answer with appropriate waveforms?
- 5- Derive an expression for the following terms and then show the dependence of them on the oscillation frequency:
  - a. The rate of rise of restriking voltage (R.R.R.V).
  - b. The time for maximum resriking voltage.
  - c. The peak resriking voltage across the C.B.
  - d. The average rate of rise of restriking voltage ( $R.R.R.V_{avg}$ ).
  - e. The time for maximum rate of rise of restriking voltage.
  - f. The maximum rate of rise of restriking voltage ( $R.R.R.V_{max}$ ).
- 6- Explain the meaning of the following Terms using the drawing if possible:
  - a. The rated short circuit breaking current.
  - b. The rated short circuit making current.
  - c. The restriking voltage or transient recovery voltage (TRV).

- d. The recovery voltage.
  - e. The rate of rise of transient recovery voltage (R.R.R.V).
  - f. The prospective current.
- 7- In a system, the R.M.S voltage is 19.1 kV, the inductance of 10 mH and the capacitance is 0.02 micro-farad. Determine the average rate of rise of restriking voltage (R.R.R. $V_{avg}$ ) when the C.B opens.
- 8- A 50 cycle, 3-Ph alternator with grounded neutral has inductance of 1.6 mH per phase and is connected to busbar through a C.B. the capacitance to earth between the alternator and the C.B is 0.003 micro-farad per phase. The C.B opens when the RMS value of the current is 7500A, Specify the type of this current and then determine the following:
- a. The time for maximum resriking voltage.
  - b. The peak resriking voltage across the C.B.
  - c. The average rate of rise of restriking voltage (R.R.R. $V_{avg}$ ).
  - d. The time for maximum rate of rise of restriking voltage.
  - e. The maximum rate of rise of restriking voltage (R.R.R. $V_{max}$ ).
  - f. The frequency of restriking voltage transient.
- 9- A 3-Ph alternator has the line voltage of 11 kV. The generator is connected to busbar through a C.B. the inductive reactance up to the C.B is 5 ohm per phase and the distributed capacitance up to the C.B between the phase and the neutral is 0.003 micro-farad. Determine the following:
- a. The time for maximum resriking voltage.
  - b. The peak resriking voltage across the C.B.
  - c. The average rate of rise of restriking voltage (R.R.R. $V_{avg}$ ).
  - d. The time for maximum rate of rise of restriking voltage.
  - e. The maximum rate of rise of restriking voltage (R.R.R. $V_{max}$ ).

- f. The frequency of restriking voltage transient.
- 10- In a short circuit test on a 3 pole, 110kV circuit breaker, the power factor of the fault was 0.4, the recovery voltage was 0.95 times full line value. The breaking current was symmetrical. The frequency of oscillation of restriking voltage was 15000 cycle per second. The neutral is grounded and the fault involves earth. Neglect the first pole to clear factor and Estimate the following:
- The time for maximum resriking voltage.
  - The peak resriking voltage across the C.B.
  - The average rate of rise of restriking voltage (R.R.R. $V_{avg}$ ).
  - The time for maximum rate of rise of restriking voltage.
  - The maximum rate of rise of restriking voltage (R.R.R. $V_{max}$ ).
- 11- In a short circuit test on a circuit breaker, the time to reach the peak resriking voltage of 100 kV is 70 micro-second on a frequency transient. Determine the following:
- The average rate of rise of restriking voltage (R.R.R. $V_{avg}$ ).
  - The time for maximum rate of rise of restriking voltage.
  - The maximum rate of rise of restriking voltage (R.R.R. $V_{max}$ ).
  - The frequency of restriking voltage transient.
- 12- In a short circuit test on a circuit breaker, the following readings are obtained on a frequency transient: The time for maximum rate of rise of restriking voltage is 35 micro-second and the peak resriking voltage is 100 kV. Determine the following:
- The time to reach the peak of restriking voltage.
  - The average rate of rise of restriking voltage (R.R.R. $V_{avg}$ ).
  - The maximum rate of rise of restriking voltage (R.R.R. $V_{max}$ ).
  - The frequency of restriking voltage transient.

- 13- Explain the influence of the following on the transient recovery voltage:
- The circuit power factor.
  - The armature reaction.
  - The first pole to clear.
- 14- In a system of 132kV, the circuit phase to ground capacitance is 0.01 micro-farad, the inductance is 6 H. calculate the voltage appearing across the poles of C.B if a magnetizing current of 10 amps is interrupted (instantaneous). Calculate the value of critical damping resistance.
- 15- Explain with the drawing the trip circuit operation.
- 16- Explain the function of the auxiliary contacts of the circuit breaker.
- 17- Explain the meaning of the following Terms:
- Protective relaying.
  - Fault clearing process.
  - Fault clearing time.
  - Switching Resistance.
  - Opening Resistance.
  - Critical Damping Resistance for Restriking voltage transient.

1. **Compare** between isolator, load break switch and earth switch?
2. There are several ways in which the switching equipment can be connected in the electrical layout of generating station, receiving station or switchgear in a distribution system, **Discuss** the different arrangements of Bus-bar in Switchyards?
3. In a 132/11 KV substation the following equipments are to be connected:  
(Two) Overhead 132 KV Lines,  
(Four) 132 KV Circuit Breakers,  
(Two) 132/11KV- 45 MVA Transformers,  
(Six) 11KV Circuit-Breakers,  
(Two) Lightning arresters 132 KV,  
(Four) 11KV feeders.  
**Draw** a diagram of electrical scheme, show isolators and earthing switches where necessary. Then **write** the specifications required for each switchgear equipments used for the above-mentioned substation.
4. How to isolate feeder for maintenance?
5. How to isolate transformer for maintenance?
6. In case of a complete 220/66 kV substation is tripped by Bus-bar protection, **what** are the procedures required to be taken?
7. In case of a complete 220/66 kV substation is tripped without any protection relaying operated, **what** are the procedures required to be taken?
8. In case of two feeders are connected in parallel tripped from one side and one of them tripped by distance relay from other side, **what** are the procedures required to be taken?
9. In case of SF<sub>6</sub> gas leakage on load break switch compartment or C.B quenching chamber, **what** are the procedures required for blocking the operation of isolator and C.B in case of maintenance if the pressure decreases to 1.5 bar?
10. Feeder tripped from one side while earth fault relay operated from two sides, the circuit breaker tripped side was oil circuit breaker and the non tripped side was an SF<sub>6</sub> circuit breaker.  
By checking the SF<sub>6</sub> C.B. found that the SF<sub>6</sub> pressure below the allowed, therefore the SF<sub>6</sub> C.B. operation blocked.
  - Increase the SF<sub>6</sub> pressure to the allowed.
  - Isolate the feeder by the same way of Prob 4.
  - Repair the feeder and closed back to normal.

11. **Explain** with drawing how to make maintenance to UHV TL without disconnecting the live?
12. In case of air blast substation, **what** are the procedures required for blocking the operation of isolator and C.B in case of maintenance?
13. **Explain** how the electrical interlock operates with the dc supply energized the coil of interlock?
14. **What** are the origin of trapped charge and how to measure it?