**SRI VIDYA COLLEGE OF ENGINEERING & TECHNOLOGY, VIRUDHUNAGAR**

**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**SHORT ANSWER QUESTIONS AND ANSWERS**

**EE 6701 –HIGH VOLTAGE ENGINEERING**

**UNIT-I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS**

**PART – A**

1. What are the chief causes of over voltages in electric power system?
   1) Lightning over voltages (Natural causes)
   2) Switching over voltages (system oriented causes)

2. How are switching over voltages originated in a power system?

   Switching over voltages originate in the system itself by the connection and disconnection of circuit breaker contacts or due to initiation or interruptionof faults.

3. What are switching over voltages?

   Switching over voltages are highly damped short duration over voltages. They are temporary over voltages of power frequency or its harmonic frequencies.
   - They are sustained or weakly damped
   - They originate in switching and fault clearing process.

4. For ultra high voltages, perhaps, switching surges may be the chief condition for design considerations. Why?

   The magnitudes of lighting voltages appearing on a transmission line do not depend on line design hence lightning performance does not improve with increasing insulation level, that is, the system voltage. On the other hand switching over voltages is proportional to operating voltage. Hence for ultra high voltages switching surges may he the chief condition for consideration.

5. State the parameters and characteristics of the lightning strokes:
   1. Amplitude of currents
   2. The rate of rise.
   3. The probability distribution
   4. Wave shape of the lightning voltage and current.
   5. Time to peak value.

6. How are lightning strokes on transmission lines classified.
   1) Direct strokes
   2) Inducted strokes

Direct stroke:

- When thunder cloud directly discharges on to a transmission line tower or line wires, it is called direct stroke. This is the most severe form and this occurs rarely.

Inducted Stroke:

- . When thunder storm generates negative charges at its ground end. The transmission line and Tower develop induced positive charges.
- Normally lines are unaffected, because they are insulated by string insulators.

However, because of the high field gradients involved, the positive charge leak from the Tower along the insulator surfaces to the live conductors, after a few micro seconds, (say). When the cloud discharges through some earthed objects other than the transmission line, huge concentration of positive charge is left with.

- The transmission line and earth act as a huge capacitor.
- This may result in a stroke and hence the name inducted lightning stroke.

7. What is Back Flashover?

Some times when a direct lightning stroke occurs on tower if the tower footing resistance is considerable, the potential of the tower rises to a large value, in view of the huge lightning stroke current, steeply with respect to the line and consequently a flash over may take place, along the insulator string. This is known as Back Flash over.

8. Give the mathematical Model for lightning:

Let Io – lightning current (current source)
Zo – source impedance(of the cloud )
Z - object Impedance
V - Voltage built across the object

Tr line : 300 to 500 ohms
Ground wire : 100-150ohms
Tower : 10-50 ohms
Therefore Z/Zo=less and can be neglected.
Therefore V= Io.Z
Where Io = lightning stroke current
Z = surge impedance.

9. A lightning stroke 10KA strikes a line of 400 ohms surge Impedance. (I) What is the over Voltage caused?(II) If a direct stroke occurs over the top of the unshielded Tr line what is the over voltage?

Case :I

V = Io . Z
= 10KA .400 = 4000 kv

Case II

V = Io (Z/2) = 10 x 400 KV =2000KV

10. What is Thunder storm days?

Thunder storm days (TD) (is known as the Iso Keraunic level) is defined as the number of days in a year when thunder is heard or recorded in a particular location,

- The incidence of lightning strikes on Tr. Line / substation in related to T.D.
- . T.D is =5 to 10 in Brittan
  30 to 50 in USA
  30 t0 50 in India

11. What are the Causes for Switching surges?

(1) Making and Breaking of electric circuits.
(2) Initiation or termination of faults.
(3) Energisation and de energisation of cables, capacitors, transformer, Reactors, load etc.

12. What are the effects Switching surges on power system:

. Power system has large Inductance and capacitance.

- Switching surges may create abnormal over voltages (six times)
- Switching surges with a high rate of rise of voltage may cause repeated restriking of the arc between the CB contacts and damage the contacts.
- They have high Natural frequency components and damped normal frequency component.

13) Explain the Mechanism of Switching over voltage in EHV system:

Switching over voltage are generated when there is a sudden release of internal energy

stored in either in the electrostatic form (in the capacitance) or in the electromagnetic from in the inductance). This happens where

(1) Low inductive current is interrupted (Transformers and reactors)
(2) Small capacitive current interrupted (Unloaded lines)
(3) Ferro resonance condition
(4) Energisation long EHV lines.

14. What are the measures taken to control/ reduce the switching over voltages?
    1. One step or multi step energisation of lines by pre insertion of resistors
    2. Phase controlled closing of circuit Breakers with proper systems.
    3. Drainage of Trapped charges on long lines (by discharging) before the closing of the lines.
    4. Limiting over voltage by surge diverters.

15. What are the causes for power frequency over voltage in a system:
    1. Sudden loss of loads.
    2. Disconnection of inductive loads.
    3. Ferranti effects and unsymmetrical faults.
    4. Saturation in Transformers

16. Name the various methods for protection of Transmission lines against lightning over voltages:
    1. Shielding the over head line using ground wires.
    2. Using ground rods and counterpoise wires
    3. Using protective devices like expulsion gap, protector tubes, surge diverters at appropriate places.

17. What is a ground wire in a Transmission System:
    - Ground wire is a conductor run parallel to the main conductors of the transmission line supported on the same tower and earthed every equally and regularly spaced towers.
    - It is run above the main conductors.
    - It shields the line conductors from induced charges and lightning discharges.
    - The shielding angle should be less than 30.

18. Distinguish between an expulsion gap and a protector tube/ value type LAS.
    In the expulsion gap type there is no non linear resistance.

19. What is the purpose of Insulation coordination:
    1. Electric Power supply should ensure reliability and continuity
    2. At the same time cost should be low
    3. A gradation of system Insulation and protective devices operation is needed, keeping in view of the importance and cost of equipments, duration of interruption etc.Hence the need for insulation coordination.

20. The volt ampere characteristics of a non linear resistor used in a surge arrester is given by:

    $V = K I^n$

    Where K and n are constants

    n = 0.5 to 0.6 for silicon carbide

    n = 0.02 to 0.03 for ZnO

    For Silicon carbide n=0.5 to 0.6, which is not enough to limit the power frequency follow on current within limit. Hence spark gaps are used. Whereas for ZnO, the characteristics is such that even without the spark gap, the current value can be limited within the value (gapless lightning arrestors)

21. Give the wave shape of a standard lightening impulse and a standard switching impulse voltage:

Standard lightning impulse voltage
1) Vp = Peak value, Tolerance ±3%
2) Tf = front time1.2 μs }30%
3) Tt = tail time: 50 μs }20%

Standard switching impulse voltage
1) Vp : Tolerance ±3%
2) Tf : 250 ± 20%
3) Tt : 2500 ± 60%

22. For proper protection how should the ground wire be positioned?

1. They should be positioned at a height above line conductors such that they intercept the lightning stroke.
2. The phase Conductor should be in the protected Zone: within a quarter circle with the radius = the ground clearance and centre at ground wire
3. The shielding angle should be <300
4. There should be no side Flash over
5. Tower footing resistance should be low to prevent back Flesh over.

23. What are counter poise wires ?

- Horizontal wires buried at a depth of 1m in the ground, they may be parallel to the conductors or radial from the tower footing
- They are to reduce tower footing resistance.

24. What are ground rods ?

Additional rods provided driven into the ground near the tower footing and connected to the tower footing to reduce the tower footing resistance [15 mm dia, 3.0 m long, 10 to 16 rods]

25. What are the characteristics of an ideal surge diverter?

1) When the line voltage is less than the limiting value the leakage current should be zero.
2) When the line voltage exceeds the limit, it should offer zero impedance irrespective of the wave shape, so that the surge voltage is by passed.
3) Immediately after the passing of surge, and immediately after Normal voltage is returned, it should act again as a perfect insulator.

26. What are the design considerations for LAS for EHV application:

1. Rate of rise of voltage
2. The type of system, whether effectively earthed or grounded through an insulator etc.
3. The operating condition of the arrester.

27. What is valving off voltage?

Below this voltage, the LAS will not conduct. Valving off voltage should be greater than the Normal voltage (power frequency). Otherwise there will be continuous flow of power frequency run current and hence heat and destruction.

28) What is the Mechanism of generation of switching over voltage:

- Making and breaking of electric circuits of large capacitance and Inductance for example Transmission line.

- De energisation of reactive loads like power transformer (unloaded) reactors in (inductance)
- The above constitute, sudden release of internal energy stored in Electrostatic form ( in capacitance) and in Electromagnetic form (in Inductance) and causes switching surge

Amplitude : 2 to 3.3 pu

Duration : 1 to 10 ms

The over voltage has high Natural frequency component and damped normal frequency component.

29. What are the purposes of providing ground wire protection for transmission lines?

1. Ground wires are placed above Transmission line, suitable shielding angle is provided, when the thunder clouds come near the Tr line, since the base of the cloud has –ve charges, +ve charges are induced in the ground wire. These induced charges are drawn to the ground since ground wires are earthed periodically. Consequently potential rise will be small and hence induced lightning stroke can be prevented. Hence the frequency of lightning stroke is reduced.

2. When lightning strokes, takes place traveling waves are generated, they move. Correspondingly over voltages are induced in the ground wires, which will oppose the traveling waves and Flattening of the High voltage curve on the transmission line.

30. Why ground rods are provided?

1) To reduce Tower footing Resistance

2) A number of rods of 15mm dia , 2.5 m to 3.0 m long driven to the ground up to say 50m, in hard soils

3) They are interconnected and connected to the tower footing

4) Reduction in tower footing resistance reduces the surge impedance of the Tower and back flash over.

31. Give the equivalence circuit of a surge diverter

VTh - Open circuit voltage at junctions.

Zth - Thevinins equivalent Impedance

S - Surge diverter.

32. What are the disadvantages of spark gap surge diverter?

1. Depends on atmosphere conditions

2. Arc cleaning to be done after surge flow.

3. For the same voltage peak, the gap to be set for lightning over voltage is lesser than the gap to be set for switching over voltage and hence if we set a spark gap surge diverter for lightning over voltage, frequent flashover occurs for switching surge even if the peak voltage is lesser than the set value.

33. What are the characteristics of an ideal surge diverter?

1. When the line voltage is less than the limiting value, leakage current should be zero. Perfect insulator and impedance is infinite.

2. When the line voltage exceeds the limit, it should offer zero impedance and irrespective of the voltage shape it should by pass the voltage.

3. After the surge is bypassed & immediately after normal voltage is restored, once again is should act as an insulator.

34) How are the above characteristics are obtained in practice?

. One or more air gaps with a suitable non linear resistance can produce the above characteristics.

**PART – B**

1. Draw the cross sectional view of non linear resistor lightning arrester (valve type) and explain its operation in detail and its V-I characteristics.

2. Discuss mechanism of lightning stroke and over voltages on transmission lines and give its mathematical model.

3. Write short notes on:

(i) Rod gaps used as protective devices

(ii) Ground wires for protection of overhead lines.

4. Explain different theories of charge formation in clouds.

5. Explain different methods employed for lightning protection of overhead lines.

6. (i) Draw & Explain the procedure to draw Bewley Lattice Diagram for a two substations system .

(ii) Explain briefly about expulsion type arrester.