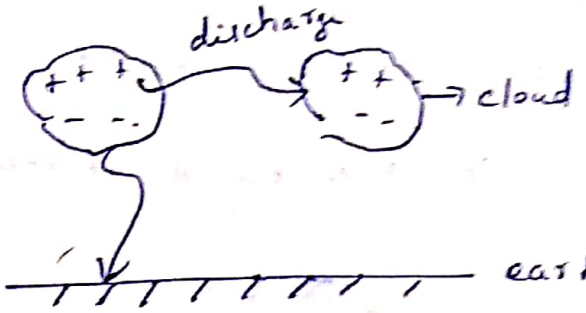
UNIT - I

1) Define Lightning phenomenon.

Lightning phenomenon is a peak discharge in which charge accumulated in the cloud discharge into a neighbouring cloud or to the ground.



2) List some sources causing switching surges.

→ Opening & closing of switchgear.
→ damped normal frequency voltage component
→ Restriking & Recovery voltage with successive reflected waves from termination

3) Define Isokeraunic Level.

It is defined as the No. of days in a year when thunder is Recorded in a particular location. The traditional method of designing thunderstorm activity by mean of Isokeraunic Level.

$N_g = (0.1 \text{ to } 0.2)\ TD / \text{strokes} / km^2\text{-year}$.

value of TD in India = 30 to 50

4) A transmission Line of surge impedance 250Ω is connected to a cable of surge impedance 50Ω at the other end, if a surge of 400 kV travels along the Line to the junction point. Find the voltage build at the junction.

$Z_1 = 250\Omega$, $Z_2 = 50\Omega$, $V = 400$ kV.

Voltage build at the junction $= V + V_1$

$= 400 + 166.67$

$= 566.67$ kV.

5) An overhead Line with surge impedance of 400Ω is connected to cable having a surge impedance of 50Ω. calculate the transmission coefficient in to the cable.

$Z_1 = 400\Omega$, $Z_2 = 50\Omega$.

Reflection $b = \frac{Z_2 - Z_1}{Z_1 + Z_2} = -0.7778$.

Transmission $a = 1 + (b) = 1 - 0.7778$

$= 0.2222$.

6) Mention the causes for internal overvoltage and give their Magnitude & frequency.

→ power frequency oscillation (or) harmonics

→ switching over voltage.

7) What are the techniques to be adopted for controlling the switching over voltage?

→ one or multistep energization of Lines by inserting Resistor.

→ phase controlled closing of CB with proper sensors.

→ using shunt reactor

→ using Lightning arrester or surge diverters

8) What is surge arrester?

Surge arrester or Lightning arrester is a device used to protect the power system against transient voltage due to Lightning & switching surges.

9) Why a simple spark gap cannot offer full protection against over voltage.

→ uniform field spark gap will always have a spark over voltage within a known tolerance under constant Atmospheric condition.

→ Measurement is reliable.

→ Accuracy is less.

10. Mention the different kinds of overvoltage

→ Internal → Switching
→ Temporary

→ External → Lightning overvoltage.

11. write some application of High voltage

→ cathode ray tubes
→ particle accelerator
→ Xerography
→ Electrostatic precipitator
→ Nuclear Research.

UNIT-II

1) Define uniform & non uniform field and give example of each.

Uniform	Non uniform.
→ voltage across the gap increases & ionization process take place & breakdown of gap in the form of a spark occur eg Sphere plane gap.	→ voltage across the gap increases & causes a discharge in the gap at sharp points whose electrode is curved. eg SF_6 & N_2.

2) define flashover.

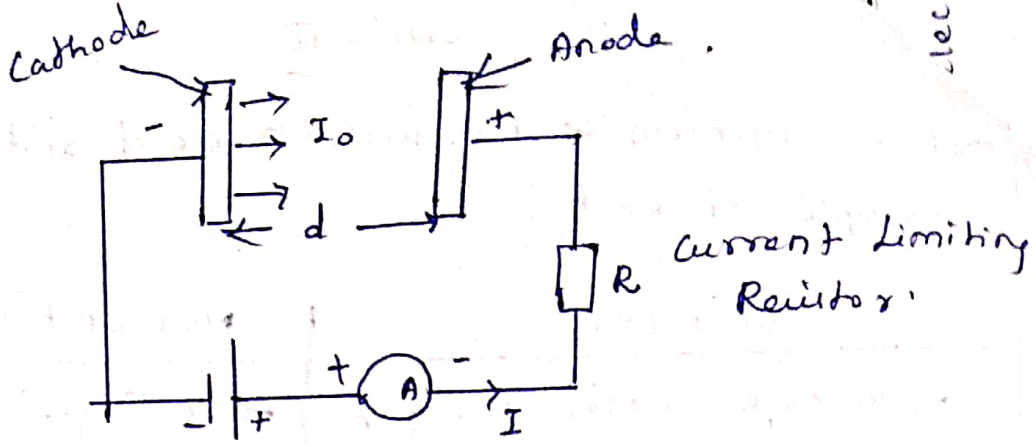
When a discharge take place between two electrodes in gas or a liquid over a solid surface in air, it is called flashover.

3) define sparkover.

The voltage that causes a spark over at each or its application under specified condition when applied to surge arrestor. (test object).

4. What is meant by Townsend's discharge?.

The process of emitting an electron from a gas molecule with the simultaneous production of positive ion is called ionization.



5) State Paschan's Law.

$$V = f(Pd).$$

The breakdown varies as the product of Pd varies. The breakdown voltage of an uniform field gap is an unique function of the product of gas pressure p and gap length d for a particular gas & electrode material. This relation is known as paschen's Law.

6) What are the different theories related with Liquid dielectrics?

→ Suspended particle

→ cavitation & bubble

→ Stressed oil volume.

7) Distinguish between Insulator & dielectric.

Insulator: The maximum voltage applied to the insulation at moment of breakdown eg procelain.

dielectric → high mechanical & breakdown strength.

eg Transformer oil.

8) What is a composite dielectric

different dielectric materials can be in parallel with each other or in series with one another. such insulating system are called composite dielectric.

9) What is treeing

The spreading of spark channel during tracking, in the form of the branch of tree is called treeing.

10) What is tracking?

When voltage is applied, a formation of continuous conducting paths across the surface of the insulation due to surface erosion is called tracking.

11) What is tracking index?

Numerical value of voltage that initiates tracking is called tracking index.

UNIT 1- TWO MARKS

1.What are the types of source of transients?

- Lightning
- Switching
- Temporary voltage
- Very fast transient voltage.

2.Define Isokeraunic level or thunderstorm days. (u)

It is defined as the number of days in a year when the thunder is heard or recorded in a particular location. Often it does not distinguish between the ground strokes and the cloud-to-cloud strokes .

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

3.State the factors influence the lightning induced voltages on transmission lines.

The ground conductivity, the leader stroke current and the corona.

4. State the attenuation and distortion of travelling waves.

The decrease in the magnitude of the wave as it propagates along the line is called attenuation. The elongation or change of wave shapes that occur is called distortion

5.What are the disadvantages of MOCB over a mechanism of lighting strokes?

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

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

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

7. Write some applications of high voltage?

Cathode ray tubes, particle accelerators, Xerography, Electrostatic precipitators, Nuclear Research

8. What are the causes of over voltages in a power system? (UV - Nov/Dec 2014)

Lightning and Switching surges are the causes of overvoltages.

9. What are the theories associated with the formation of charges in clouds?

- Wilson 's theory • Simpson's theory • Reynold's and mason's theory

10. What are the types of lightning strokes

• Direct stroke • Indirect stroke

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 .

Indirect 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

11. What are the sources of switching surges?

- De-energizing of the lines, cables and shunt capacitors
- Disconnection of unloaded transformers and reactors
- Opening and closing of the protective devices
- Arcing ground

12. What are the factors to be considered for switching over voltages in EHV and UHV system?

- Interruption of low inductive currents by high speed circuit breakers
- Ferro resonance condition
- Interruption of fault current when the fault is cleared
- Single pole closing of Circuit breakers.

- Resistance switching used in circuit breakers.
- Sparking of the lightning arrestors located in the receiving end of the line.

13. What are the methods to control overvoltage due to switching and power frequency?

- One or multi-step energization of lines by inserting resistors.
- Phase controlled closing of Circuit breakers with proper sensors.
- Drain the trapped charges before reclosing the lines
- Using shunt reactors
- By using lightning arrestors or surge arrestors.

14. Write the causes of power frequency overvoltages.

- Sudden load rejection
- Disconnection of inductive and capacitive loads
- Ferranti effect • Saturation in transformers
- Tap changing operation

15. What are the various methods of protecting the power system from lightning?

- Using Ground wires
- Using ground rods
- Using counter poise wires
- Using protective devices like rod gap, expulsion and valve type surge arrestors.

16. What are the uses of ground wires?

It is used for direct stroke protection of lines for voltages of 110 kv and above and from attenuation of travelling waves in the line.

- 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.

17. What are the methods to vary the tower footing resistance?

- Varying the spacing of the rod.
- Varying the number of rods
- Varying the depth to which they are driven

19. What are the requirements of the lightning arrestor?

• Should not pass any current to the system component which to be protected abnormal condition.

• Should discharges the surge current without any damage.

• Should interrupt the power frequency follow current after the surge is discharged.

20. What are the advantages of rod gaps?

It is simple in construction and Cheap

21. What are the disadvantages of rod gaps?

It does not interrupt the power frequency follow current. Every operation of the ground rod results in a line to ground fault and the breaker must operate to isolate the faulty section.

22. What are the disadvantages of expulsion type lightning arrestor?

It has poor volt ampere characteristics.

23.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

24.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.

25.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.

26.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.

27.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.

28.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.

29.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 =2000 KV

Case II

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

30.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

31.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.

32.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.

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

V = K In 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)

34.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%

35. 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 Flash over

36.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

37.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]

38.Give the equivalence circuit of a surge diverter

VTh - Open circuit voltage at junctions.

Zth - Thevinins equivalent Impedance

S - Surge diverter

39.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.

40.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.

1) What are various abnormalities in a High Voltage System? APRIL/May 2015

→ The making & breaking of electric circuits with switchgear may result in abnormal overvoltage in power system having large inductance & capacitance.

→ The overvoltage thus generated last for longer duration & therefore are severe & more dangerous to the system.

UNIT-V

HIGH VOLTAGE TESTING AND INSULATION COORDINATION

1. What are the necessities of High voltage testing?

1. To check whether they are as per the design and as per specifications and standards.
2. To ensure that the HV equipment is able to withstand over voltages produced naturally or within the system.

2. What is the specialty of HV Testing?

1. The H.V. lab requires higher space.
2. Special equipments are required.
3. Special Techniques are required.

3. Name how standards for HV Testing

1. B I S - Bureau of Indian Standards.
2. I E C - International Electro Tech. Commission.
3. B S I - British Standard Institution.
4. I E E E - Instituting Electrical & Electronics Engineering.
5. I S O P - International Standards Organization.
6. A N S I - American Standards Institute
7. C I G R E - International Council on large electrical system.
8. ISS - Indian Standard Specifications

4. What is disruptive discharge voltage?

The Voltage that produces loss of dielectric strength of equipment is called disruptive discharge voltage. In solid-it is called puncture. In liquid or air-it is called Flashover.

5. What is Flashover?

When a loss of dielectric strength occurs inside a liquid or gaseous insulation or along the surface of a solid Insulation, it is called flashover.

6. What is Puncture?

When a loss of dielectric strength occurs inside a solid it is called puncture.

7. What are self restoring and Non self restoring insulation?

Insulation which completely regains its dielectric strength after a disruptive Discharge is called a self restoring insulation. Insulation which does not regain its insulating property after a disruptive discharge is a Non self restoring insulation.

8. What is withstand voltage

Withstand Test is a Test in which the specified voltage is applied to the test object under specified conditions to check whether the equipment withstands W/o. any discharge/ flash over . The test voltage which is applied to a Test object in a withstand Test is called withstand voltage. It is the voltage that the equipment is capable of withstanding under specified conditions.

9. Define 50% Flashover voltage

The Test voltage which has 50% probability for flashover is called 50% flashover voltage.

10. Define 100% Flashover voltage

The test voltage which causes flashover of the test object at each of its application.

11. Define Creepage Distance:

It is the shortest distance on the contour of the external surface of the insulator that is between the two metal fittings on the insulator

12. Define AC Test Voltage

Alternating current voltage of frequency 40 to 60 Hz, approximately sinusoidal (7% deviation is permitted) is called AC Test voltage.

13. Define Impulse voltage

It is a fast rising slow decaying voltage, characterized by its peak value, time to front and time to half value.

Standard Impulse Voltage

1. Peak : Tolerance ±3%
2. Time to Front : T f 1.2μsec ±30%
3. Time to half value : Tt 50μsec ±20%

Standard Switching Voltage

1. Peak : Tolerance ±3%
2. Time to Front : 250 μs ± 20%
3. Time to half value : 2500μs ± 60%

11. How are the Testing of insulators classified?

1. Type Test

Done whenever a new brand is introduced and a new design is adopted.

2. Routine Test

Whenever the quality of the individual equipment is to be established say at the time of purchase.

12. What are the various High Voltage Tests done on insulators?

1. Power frequency Flashover Test Dry
2. Power frequency Flashover Test Wet
3. Power frequency Withstand Test (One Minute) Dry
4. Power frequency Withstand Test (One Minute) Wet
5. Impulse withstand Test Dry
6. Impulse Flashover TestDry
7. Pollution Test (Power Frequency)
8. Partial discharge Test
9. Radio Interference Test.

13. What is meant by atmospheric correction with reference to High Voltage Testing?

Normally HV Tests are done under Normal Temperature, pressure & humidity conditions and then the values are corrected to the following conditions.

Temp : $27^{o}C$

Pressure : 1013 Millibar 760 torr

Absolute humidity : $17gram/m^3$

This is done by applying the following correction factors.

h = humidity correction factor

d = air density correction factor

If Va = Voltage under Test conditions

& Vs = Voltage under reference atmospheric candidate

Then

$$Vs = Va \times h/d$$

$$d = 0.289\ b/(273+t)$$

Where

b = atmospheric Pressure in millibar

t = atmospheric temp in degree C.

h = Can be obtained form graph. (Humidity / Dry bulb thermometer reading)

14. What are the various HV Test done on Bushings?

1. Power frequency Tests
   - Power factor Test
   - Partial Discharge Test
   - 1 Minute W.S. Test
   - Visible discharge Test
2. Impulse Voltage Test

- Impulse with stand Test – Full wave (Positive & Negative Polarity)
- Impulse with stand Test – Chopped wave (Positive & Negative polarity)
- Switching surge Flashover Test
- Impulse Flash over Test under oil.

15. What are the steps for Impulse withstand Test on Power Transformer?

1. Apply one full Impulse of 75% BIL of Power Transformer
2. Apply one full Impulse of 100% BIL of Power Transformer
3. Apply Two chopped wave of 100% BIL
4. Apply one full wave of 100% BIL
5. Apply one full wave of 75% BIL

The Power Transformer stand. Then, it passes the Test.

16. What are the various HV Tests done one circuit Breakers?

1. Power frequency WS Test, 1 minute, dry.
2. Power frequency WS Test, wet
3. Impulse voltage WS Test, dry.
4. Switching impulse WS Test

(The above Tests are done with both circuit Breaker Open & closed condition).

17. What are the various Tests (HV Tests) done on surge diverters?

1. Insulation withstand test power frequency both dry and wet.
2. Power frequency voltage spark over Test.
3. Standard Impulse voltage spark over Test.
4. Front of wave voltage spark over Test.
5. Switching Impulse voltage spark over Test.
6. Residual voltage Test.

7. Current Impulse withstand Test.

- o High current
- o Long duration.

8. Pressure relief Test (When fitted)

9. Pollution Tests

18. What is the necessity for measurement of RIV?

Sometimes electrical equipment like power Transformers, conductors, rotating machines etc. produce unwanted electrical signals in the radio frequency range of 150k Hz to 30 M Hz, where as the power frequency being 50 Hz. These signals affect the communication systems & should be prevented. Hence RIV measurement is necessary.

19. What is meant by insulation co-ordination in EHV power system?

Insulation co-ordination is the grading of the insulation level of

(1) Various equipments in a power system

(2) Various parts of the equipments

(3) Protection devices in such a way that, in the event of a serious over voltage, less vital, less important, less costlier, easy to repair equipment part of equipment breaks down first and thereby avoiding major breakdown & interruption to consumers, cost of replacement etc.

For e.g.

1. In the event of an over voltage, a string insulator on Transmission line should breakdown before the bushing of a power Transformer.

2. The bushing of the power Tr. should breakdown first before the Breakdown of the winding of the Power Transformer.

20. What is system protection level and its selection depend on what factors?

In the power system, system protection level is established considering the,

1. Location of the station
2. Protection level of arrester
3. Line shielding

21. What is BIL?

The basic insulation levels are reference levels fixed by standards for each voltage levels. Basic impulse levels are reference levels expressed in terms of impulse crest voltage(Vp) with a standard lightning impuse voltage (1.2/50 miero seconds wave) for any apparatus the insulation level as demonstated by suitable tests should be greater than or equal to the BIL.

22. While selecting an equipment for a power system what should he its BIL when compared to the system protection level?

For any equipment insulation level should be more than the BIL.For proper insulation coordination its insulation level should be greater than the system protection level over the margin determined by the following factorS

1. Atmospheric Conditions
2. Station Location
3. Protection level of arresters.
4. Importance of the equipments etc.

Hence the system protection level should be less than BIL.