VETRI VINAYAHA COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

IV YEAR/VIII SEMESTER EEE

EE6002- POWER SYSTEM TRANSIENTS

QUESTION BANK (PART A&B)

UNIT-I INTRODUCTION AND SURVEY

1. **Define Power System Transient**.

The power system transient is the outward manifestation of a sudden change in circuit conditions as when a switch opens or closes or a fault occurs on system. The transient is very short.

2. **Define switching transients.**

The switching transient is initiated whenever there is sudden change of circuit conditions. This transient is most frequently developed due to switching operations such as the closing of a switch (or) circuit breaker to energies a load. The opening of a circuit breaker to clear a fault.

3. **Give the relation between time constant of parallel and series circuit.**

Time constant of parallel circuit Tp=RC
Time constant of series circuit Ts=L/R

4. **The product of there time constants is the square of the angular period of the undamped circuit which is given by**

TpTs=LC =T2

5. **What is the need of resistance switching.**

The shunt resistors connected across circuit breaker have two functions.
To distribute the transient recovery voltage more uniformly across the several breaks.
To reduce the severity of transient recovery voltage at the time of interruption by introducing damping into oscillations.

6. **Define power system transients**.

The power system transient is the outward manifestation of a sudden change in circuit conditions as when a switch opens are closes are fault occurs on a system the transient period is very short.

7. **Mention the sources of power system transient**.

- Internal sources

- Switching surges, insulation failure, arching ground, ferro resonance.

- External sources.
- Lightning.

8. **What are the causes of switching surges?**

The making and breaking of electric circuits with switch gear may result in abnormal transients over voltages in a power system having large inductance and capacitance.

9. **What is meant by arcing ground?**

The phenomena of intermittent arc taking place in line to ground fault of a three phase system with consequent production of transients is known as arcing ground. It can be prevented by earthing the neutral.

10. **What is meant by lightning?**

An electric discharge between cloud and earth, between clouds or between charges centres of the same cloud is known as lightning.

11. What are the types of lightning?

- Direct stroke

- Indirect stroke.

12. **What are the types of power system transient?**

Ultrafast transients

Medium fast transients

Slow transients.

13. **What are the effects of lightning?**

Lightning produces a steep fronted voltage wave on the line. The voltage of this may rise from zero to peak value in about 1μs and decay to half the peak value in about 5μs.

14. **What is meant by insulation failure?**

The insulation failure between line to earth which cause high voltage in the system. Suppose a line at potential V is earthed at point C, the earthing of line causes to equal voltages-V travel along the main wire and return wire. Due to insulation failure, the current to earth is twice the ratio of voltage to impedance.

15. **What is meant by subsidence transients?**

When a disturbance such as fault occurs on the primary of transformer, then subsidence transient is produced. Due to this sudden reduction of voltage produced on the primary.

PART-B (16MARKS)

16. What are the sources and effects of transients on power system? Explain in detail.

17. Explain the various types of power system transients with illustration.

18. Explain the significance of transient studies in power system planning.

19. Discuss about the various sources and types of electrical transients in power system.

20. Write short notes on Double frequency transients?

21. Explain the resistance switching?

UNIT-II SWITCHING TRANSIENTS

PART-A (2-MARKS)

1. Define load switching.

The frequent functions performed by switching devices are to switch on and switch off load(ie)load switching which is represented by a parallel RL circuit.Low power factor loads are inductive and high power factor loads are resistive.When a high pf load is switched off, the effective capacitance of load becomesimportant in determining the form of transient produced.

2. What is meant by current chopping?

When breaking low currents(ie)unloaded transformer or reactor magnetizing current, the powerful deionizing effect of air blast circuit breaker(CB) causes the current abrupbtly to zero well before the natural current zero is reached.

3. Define capacitance switching.

The shunt capacitors are employed to correct a lagging power factor, or in some cases, to provide voltage support for the system. In some applicationsthey are switched in and out quite frequently as the system load varies and the system fluctuates. The switching operations are nontrival and should be carefully considered when designing capacitor banks and their associated switching equipment.

4. What is meant by ferroresonance?

Resonance causes high transient voltage in the power system. In usual transmission lines the capacitance is very small so that resonance rarely occurred in power system at normal frequency.

However if generator emf wave is distorted, the trouble of resonance may occur due to 5th (or)higher harmonics. This phenomenon is referred as ferro resonance, since the inductance involved is usually iron cored.

5. What is meant by abnormal switching transients?

Due to some other circumstances like transients the voltage and current magnitude may rise high. The transients occur due to the trapping of energy and its subsequent release somewhere in the circuit. Such transients are referred as abnormal current and voltage transients.

6. Define arcing ground.

If the neutral of three phase wires was not earthed in long enough voltage transmission lines a serious problems called arching ground is produced. The arching ground produces severe oscillations of three to four times the normal voltage. The phenomenon of intermittent arc takes place in line to ground fault of a three phase system with consequent production of transients is known as arching ground.

7. What is meant by resistance switching?

A deliberate connection of a resistance in parallel with the contact space (arc) is made to overcome the effect of transient recovery voltage. This is known as resistance switching.

8. Define switching transients.

The switching transient is initiated whenever there is sudden change of circuit conditions. This transient is most frequently developed due to switching operations such as the closing of a switch (or) circuit breaker to energies a load. The opening of a circuit breaker to clear a fault.

9. Give the relation between time constant of parallel and series circuit.

Time constant of parallel circuit Tp=RC
Time constant of series circuit Ts=L/R

10. **State the principle of superposition.**

According to the superposition principle, in any linear system if a stimulus produces S1 produce a response R1 and a stimulus S2 produces a response R2 then S1 and S2 applied simultaneously will evoke a response R1+R2.
The principle is not restricted to two stimuli but is true for any finite number.

11. **Mention the limitations of superposition principle.**

The super position principle can be applied only in linear circuits. For the non linear devices such as saturable devices like iron cored reactor, and unloaded transformer, this is not applicable.

12. **What is current chopping?**

Current chopping is the production of high voltage transient across the contacts of air blast circuit breaker. When breaking low current, ie., unloaded transformer or reactor magnetizing current, the powerful deionizing effect of air blast causes the current zero well before the natural current zero is reached. This phenomenon is called current chopping and produces high voltage transients across the breaker circuits.

13. **What are the causes of switching surges?**

The making and breaking of electric circuits with switch gear may result in abnormal transient over voltages in a power systems having large inductances and capacitances. The different situations under which happens are summarized as,

1. Interruption of low inductive currents by high speed circuit breaker.
2. Interruption of small capacitance currents.
3. Ferro resonance.
4. Energisation of loaded line.

14. What are the types of power system transients?

a) Ultra fast transients
b) Medium fast transients
c) Slow transients.

15. Why the air blast circuit breakers are more sensitive to restriking voltage transient?

In air blast circuit breaker it is observed that the rate at which dielectric strength of the gap increases is lower than the oil C.B. Since air has a much lower dielectric strength than the gases at the same temp and pressure in oil CB. The dielectric strength of a gas increases with pressure. Thus the air blast CB is more sensitive to the restriking voltage transient.

PART-B (16MARKS)

16. Explain resistance switching with equivalent circuit.

17. Explain with appropriate waveform (a) current suppression (b) current chopping (c) ferro resonance condition.

18. Explain load switching with equivalent circuit.

19. What is capacitance switching? Explain in brief the effect of source regulation and capacitance switching with a restrike.

20. Write short notes on ferroresonance effect.

21. Explain the appropriate waeform, the capacitance switching with one and multiple restrikes.

22. Explain the switching in both normal and abnormal conditions with neat sketches.

23. Describe about the Current chopping phenomenon in ac system?

24. Explain how can switching surges affects the capacitive circuits.

UNIT-III LIGHTNING TRANSIENTS

1. **What are the causes of over voltages in power systems?**

   Over voltages on power systems are do various cases. The voltage stresses due over voltages can be so high that may become dangerous to both the lines as well as connected equipment and may cause damage, unless some productive measures against these voltages are taken.

2. **Define over voltage protection factor or Amplitude factor.**

   Transient over voltages arising on power system are assessed by an over voltage protection. This is defined as ratio of peak overvoltage to the rated peaks system frequency phase voltage.

3. **Define lightning.**

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

4. **What are the different types of strokes?**

   - Direct stroke.
   - Indirect stroke.

5. **Write the direct lightning strokes**.

   When the thundercloud directly discharged on to a transmission line tower or line wires is called direct stroke.This is the most severe form if the stroke. However for bulk of the transmission systems the direct strokes are rare.

6. What are the factors contributing to good transmission line design?

First we try to keep the incidence of stokes to the system to a minimum.

The objective of good design is to reduce the number of outages caused by lightning.

Tall towers are more vulnerable than low goal post like structures. In order to prevent the lightning, some adequate clearences must be provided

High ground impedance or tower footing resistance are to be avoided.

High surge impedance in ground wires, tower structures are to be avoided.

7. Write the significance of tower footing resistance?

Tower footing resistance is the resistance offered by tower footing to the disipstion of current. The effective wire depends to a large extended on the tower footing resistance. The tower top potential depends on the resistance.

Significance:

A low value of tower footing resistance results in less voltage stresses across line insulation.A tower footing resistance of 20Ω for EHV lines and 10 Ω for HV lines provides sufficient lightning protection.

Depends on

Type of electrode configuration employed.
Soil resistivity.

8. What is the necessity of insulation co-ordination.

Power system have components with different withstand voltages and volt time characteristics. Insulation co-ordination arms to correlating the insulation of these various components with the characteristics of protective devices so that the equipment is protected from over voltages.

9. What are the basic steps involved in insulation co-ordination.

Selection of standard insulation level. Making sure that every equipment has a breakdown strength equal to higher than insulation level.

10. What are the types of over voltages?

Lightning over voltages, switching over voltages.

11. Explain the various regions of the cloud.

The upper regions of the cloud are positively charged, whereas the lower region and the base are predominantly negative except the local region near the base and the head which is possible.

12. Mention the different theories of charge formation.

Simpson's theory, Reynold's theory and mason's theory**.**

13. What does a thunder cloud consist?

A thunder aloud consists of supercooled water droplets moving upwards and large hailstones moving downwards.

14. What is back flashover?

When a direct lightning stroke occurs on a tower, the tower has to carry huge impulse currents. If the tower footing resistance is considerable, the potential of the tower rises to a large value, steeply with respect to the line and consequently a flahover may take place along the insulator strings.

15. State the parameters and the characteristics of the lightning strokes.

Amplitude of the current, the rate of rise, the probability distribution of them and the waveshapes of the lightning voltages and currents.

16. Define isokeraunic level Or thunderstorm days.

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

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

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

18. What is ground wire?

Ground wire is a conductor run parallel to the main conductor of the transmission line supported on the same tower and earthed at every equally and regularly spaced towers. It is run above the main conductor of the line.

19. What is the use of ground wire?

It shields the transmission line conductor from induced carges, from clouds as well as from a lightning discharge.

20. Define basic impulse level.

It is defined as the minimum insulation impulse withstand voltage of any power equipment or apparatus. The BIL of a power system is usually chosen as 25% to 30%more than the protective level offered by the protective devices.

21. Mention the various insulation levels in a substation.

The busbar insulation is the higher to ensure the continuity of supply in a substation. The circuit breakers, isolator, instrument and relay transformers are given the next lower limit level. The power transformers are the costliest and sensitive device and the insulation level for it is the lowest.

22. What does the selection of BIL level for lines depend?

Atmospheric conditions, lightning activity, insulation pollution and acceptable outage of the line.

PART-B (16MARKS)

1. Explain with neat sketches the mechanism of lightning discharge.

2. Explain with neat diagrams the two different theories of charge generation and operator in a thunder cloud.

3. Explain the mechanism by which lightening strokes develop and induce over voltages on overhead power lines.

4. Give the mathematical model for lightning discharges and explain them.

5. Explain the interaction between lightning and power system.

6. Explain lightening phenomenon.

7. Explain in detail how the charges are formed in the clouds.

8. Derive the mathematical model for lightning and also give its iteration with power systems.

9. What are the factors that contribute good line design? Explain the protection offered by ground wires.

10. Explain about the tower footing resistance.

11. Explain the importance of switching over voltage in EHV power systems? How is protection against over voltage achieved?

12. Explain with suitable figure the principles and functioning of a) expulsion gaps, (b) protector tubes.

13. Discuss the various theories related to lightning phenomena?
14. List out the factors for good line design?

15. Discuss the various techniques of protection of power system against lightning?

16. Explain the mathematical model of lightning?

UNIT-IV

TRAVELLINING WAVES ON TRANSMISSION LINE AND COMPUTATION OF TRANSIENTS.

1. What do you mean by travelling waves?

Any disturbance on a transmission line or system such as sudden opening or closing of line, a s.c or a fault results in the development of overvoltage or over current at that point. This disturbance propagates as travelling waves to the ends of the line or to a termination such as a substation usually these travelling waves are high frequency disturbances and travelling as waves. They may be reflected, transmitted, attenuated during propagation until the energy is absorbed.

2. What are the damages caused by the travelling waves?

The high peak (or) crest voltage of the surge may cause flashover in the internal winding their by spoil the windings insulation.

The steep wave front of the surge may cause internal flashover between inter turns of the transformer.

The high peak voltage of the surge may cause external flashover, between the terminals of the electrical equipment which may result in damage to insulators.

The steep wave front resulting into resonance and high voltage may cause internal or external flashover of an unpredictable nature causing building up of the oscillation in the electrical apparatus.

3. What is surge impedance of a line and why is it also called the natural impedance?)

The ratio of voltage to current which has the dimension of impedance is called as surge impedance of the line.

$E/I=\sqrt{(L/C)} = Zc = Zn$ (natural impedance)

It is also called the natural impedance because this impedance does not depend on load impedance but depends only on the line constants. The value of this impedance is 400Ω to 600Ω for an overhead line and 40 to 60Ω for a cable.

4. What is the application bewley's lattice diagram?

With the use of bewley's diagram one can know at a glance the position the direction of motion of every incidence of reflected and transmitted wave on the system at every instant of time.

5. What are the specifications of of travelling waves?

A travelling waves is characterized by the four specifications

Crest of a wave.

Front of a wave

Tail of a wave.

Polarity.

6. Define crest and front of a travelling wave.

Crest: The crest of the wave is the maximum amplitude of the wave and is usually expressed in KV or KA.

Front: the front of the wave is the proportion of the wave before crest and is expressed in time from beginning of the wave to the crest value in ms or μs.

7. Define tail and polarity of a wave.

Tail: Tail of a wave is the portion beyond the crest. It is expressed in time (μs) from beginning of the wave to the point where the wave has reduced to 50% of its value at crest.

Polarity: it is polarity of crest voltage or current. a positive wave of 500Kv crest, I μs front time and 25 μs tail time will be represented as +500/ 1.0/ 25.0

8. Why step waves are considered to be dangerous to the apparatus?

The simplest and most commonly used representation is the infinite rectangular or step wave. Such as wave jumps suddenly from zero to full value and is maintained at that value there after. As this wave has front causing maximum gradients ans sustained tail producing maximum oscillations in machine windings it is most dangerous to apparatus/ equipment. Hence the analysis based on it is liable to error on the safer side.

9. Write the expression for reflection coefficient and refraction coefficient.

Reflection coefficient: $a=(Zb - Za) / (Zb + Za)$ $-1<a<+1$.
Refraction coefficient $a = 2Zb / (Zb + Za)$
Where (Zb , Za) are the characteristic impedance of the line.

10. What is the effect of shunt capacitance at the terminal of a transmission lines?

The effect of shunt capacitance at the terminal of a transmission line is to cause the voltage at the terminal is to rise to full value gradually instead of abruptly. i.e, to cause flattening of the wave front which reduces the stress on the line end windings of transformer connected to the lines.

11. Why velocity of propogation over all overhead lines is same?

Velocity of propogation over all overhead lines is same because the product of l& c is same for all overhead lines.velocity of propogation $v = 1/\sqrt{LC}$

12. What is attenuation? How they are caused?

The decrease in the magnitude of the wave as a prorogates along the line is called attenuation. It is caused due to the energy loss in the line.

13. What is distortion?

The elongation or change of wave shape that occurs is called distortion.

14. What are the design principles observed in lattice diagram?

All waves travel down hill (i.e) in to the positive time. The position of the wave at any instant is given by the means of the time scale at the left of the lattice diagram.

15. How are the transmission lines classified?

These are classified as lines with no loss or ideal loss lines without distortion or distortion less lines. Lines with small loss Lines with infinite and finite length defined by all the four parameters.

16. What are standing waves?

A standing wave, also known as stationery waves, is a wave that remains constant position. This phenomenon can occur because the medium is moving in the opposite direction to the wave, or it can arise in a stationery medium as a result of interference between two waves travelling in opposite direction.

17. Define SWR.

Standing wave ratio is the ratio of the amplitude of partial standing waves at an antinode to the amplitude at an adjacent node is an electrical transmission line.

PART-B (16MARKS)

18. Drive the expressions for the voltage and current waves on long transmission line.

19. Explain the transient response of a system with series and shunt distributed lines.

20. Explain the transient response of a system with series and shunt and lumped parameters.

21. Explain the travelling wave concept with step response.

22. Describe the detail in terms: Attenuation, distortion of travelling waves.

23. Derive the expression for reflection coefficient and refraction coefficient and explain the behavior of travelling waves at short circuited lines.

24. Explain the behavior of travelling waves at open circuited lines.

25. Explain the behavior of travelling waves at reactive termination. (capacitance and inductance termination).

26. Explain the bewley's lattice diagram with an example.

27. Derive an expression for standing wave equation.

28. .Discuss about Bewleys lattice diagram?

29. Explain the phenomenon of current interruption in a lumped capacitive circuit and a distributed constant transmission lines?

UNIT -V

TRANSIENTS IN INTEGRATED POWER SYSTEM

1.**What is meant by kilometric fault?**

Kilometric fault is the fault located beyond the terminals and thus the current can be easily interrupted due to the added impedance of the line. This added impedance not only limits the current but also supports some of the system voltage.

2.**What are the causes of over voltage?**

i)the over voltage are induced when a ground fault occurs on one of the conductors.
ii)A line to ground fault can produce an overvoltage on an unfaulted phase as high as 2.1 times the normal line to neutral voltage on a three phase line.

3.**What is meant by switching surges?**

The disturbance produced by the switching operation in a system which sets up travelling waves which travel along the connected lines to and fro. These disturbances are called as switching surges.

4.**Define reflection coefficient.**

The reflection coefficient (a) is given by the ratio of the voltage of reflected wave to the voltage of incident wave of a transmission line due to the travelling waves caused by switching surges.

i. Reflection coefficient a = Vr/Vi

Where Vr = is the reflected wave. Vi= is the incident wave.

5.Define transmission coefficient.

It is defined as the ratio of voltage of transmitted wave to the voltage of incident wave.Transmission coefficient = Vt /Vi

6.**What is meant by EMTP?**

The EMTP is a comprehensive computer program designed to solve electrical transient problems in lumpy circuits, distributed circuits. This program is capable of solving steady-state circuit problems. Transients analysis can be carried out in circuits without any arbitrary configuration of lumped parameters (R, L, & C). Transmission lines with distributed parameters, transposed (or) untransposed, can be included in the network.

7.**What are the effects of load rejection in power systems?**

Sudden load rejection on large power systems causes the speeding up of generator prime movers. The speed governors and automatic voltage regulates will intervene to restore the normal conditions. Initially both the frequency and voltage increases.

8.**Write the network equation to model a transmission network for EMTP calculation.**

i. [G][V(T)] = [I(T)-[I]]

Where [G] is the nodal conductance matrix.
[V(T)] is the node voltages.
[I(T)] is the vector of current sources
[I] is the vector of past history terms.

9. **What are the effects of transients when a switch a switch is closed?**

When a switch is suddenly closed immediately prior to the circuit being completed, a certain voltage across the switch contacts. At the moment the contacts made by pre striking discharge, this voltage appears.

PART-B (16MARKS)

10. Explain the occurrence and effects of kilometric fault in a power system.

11. Explain in detail about the switching surges on an integrated power system.

12. Derive the reflection and transmission co-efficient in an integrated power system.

13. Explain the network modeling for EMTP calculation.

14. Explain the modeling of lumped parameters R, L & C for EMTP calculation.

15. Explain the computational procedure for EMTP calculation with a Neat flow chart.

16. Derive the expression for response and recovery voltage of a shorted line.

17. Explain the causes of transient on closing and reclosing of transmission line.

18. Explain and analyze the causes of over voltages induced by various faults occurring in power system.

19. Define the term:

    Transmission coefficient.
    Kilometric fault
    Switching surges
    Effects of load rejection

20. Explain the algorithm used for computation of transient voltages in EMTP.

21. Derive the expression for overvoltages caused by load rejection and line dropping.

22. Explain in detail about short line fault.

23. Discuss about the switching surges on integrated system with example.