Module 10: Transmission and Distribution

30 Important Questions and Answers

1. Transmission and Distribution Basics

Q1. What is transmission and distribution? Describe the layout of a power system.

Ans: Transmission carries bulk power from the generating station to load centres, and distribution delivers it from the substations to consumers. Layout: generating station (11 kV to 33 kV), step-up transformer, primary transmission, receiving substation (step-down), secondary transmission, distribution substation (11 kV), distribution transformer and consumer supply (415 V / 230 V).

Q2. Why is electric power transmitted at high voltage?

Ans: For the same power, P = V x I, a higher voltage means a smaller current. Line loss (I^2R) then falls with the square of the current, so conductor size and cost are lower, and voltage drop and regulation improve.

Q3. 1000 kW is sent over a single-phase line of 5 ohm resistance at unity power factor. Compare the line loss at 11 kV and at 110 kV.

Ans: At 11 kV: I = 1,000,000 / 11,000 = 90.9 A, loss = 90.9^2 x 5 = approx. 41.3 kW. At 110 kV: I = 9.09 A, loss = 9.09^2 x 5 = approx. 0.41 kW. Ten times the voltage cuts the loss to one-hundredth.

Q4. What are the commonly used transmission and distribution voltages in India?

Ans: Primary transmission: 132, 220, 400 and 765 kV. Secondary transmission: 66 kV and 33 kV. Primary distribution: 11 kV (6.6 kV in some places). Secondary distribution: 415 V three-phase and 230 V single-phase.

Q5. What is a grid? State its advantages.

Ans: A grid is a network of interconnected power stations and load centres. It gives better reliability, lets stations share load and reserve capacity, allows the most economical plants to run, and lets surplus power flow between regions.

2. Overhead Transmission Lines

Q6. Name the main components of an overhead line.

Ans: Conductors, supports (poles or towers), insulators, cross-arms, earth (guard) wire, stay wires, vibration dampers, lightning arresters and danger plates or anti-climbing devices.

Q7. What materials are used for line conductors? What is ACSR?

Ans: Copper (best conductivity but costly and heavy), aluminium (light and cheap but weaker) and galvanised steel (strong, poor conductivity, used for earth wire and rural lines). ACSR (aluminium conductor steel reinforced) has aluminium strands around a steel core: aluminium carries the current, and steel gives strength for long spans.

Q8. Name the types of supports used for overhead lines.

Ans: Wooden poles (temporary or low voltage), RCC and steel tubular poles (distribution and up to about 33 kV), and lattice steel towers for high voltages and long spans. Selection depends on voltage, span, cost and terrain.

Q9. What are the types of insulators? What materials are used?

Ans: Insulators keep the live conductor insulated from the support. Types: pin, suspension (disc), strain, shackle and stay insulators. Pin type is used at lower voltages (up to about 33 kV) and suspension type above that. Materials: porcelain, toughened glass and polymer.

Q10. What is sag in an overhead line? On what factors does it depend? Find the sag for a 100 m level span, weight 1 kg/m and tension 500 kg.

Ans: Sag is the vertical distance between the point of support and the lowest point of the conductor. It increases with span, conductor weight and temperature, and decreases with tension. $S = w \times l^2 / (8 T) = 1 \times 100^2 / (8 \times 500) = 2.5$ m.

Q11. What is corona? How can it be reduced?

Ans: When the voltage gradient at the conductor surface exceeds the breakdown strength of air (about 30 kV/cm peak), the air ionises, producing a violet glow, hissing noise, power loss, and radio interference. It is reduced by using larger-diameter or bundled conductors and greater spacing.

Q12. What are skin effect and transposition of conductors?

Ans: Skin effect: AC tends to flow near the surface of a conductor, raising its effective resistance; it increases with frequency and conductor size and is absent in DC. Transposition: interchanging the positions of the three conductors at intervals to balance inductance and capacitance and reduce interference.

3. Underground Cables

Q13. Describe the construction of an underground cable.

Ans: Stranded conductor (copper or aluminium), insulation (PVC, XLPE or paper), metallic sheath (lead or aluminium), bedding, armouring (steel wire or tape) and an outer serving.

Q14. Compare underground cables with overhead lines.

Ans: Cables are safer, more reliable (fewer faults from weather and lightning), tidier and cause less interference, but they cost much more, their faults are harder to locate and repair, and they have limited current capacity. Overhead lines are cheaper and easier to repair, but more exposed.

Q15. What are the methods of laying underground cables?

Ans: Direct burial (cable laid about 1 m deep in a trench with sand and brick or tile cover), draw-in system (cables drawn through ducts with manholes) and solid system (cables in troughs filled with bituminous compound).

4. Substations

Q16. What is a substation? How are substations classified?

Ans: A substation is a place where voltage is changed and power is controlled, switched and protected. By function: step-up, step-down, distribution and switching substations. By construction: indoor and outdoor.

Q17. List the main equipment of a substation.

Ans: Power transformer, circuit breaker, isolator, bus bars, current and potential transformers, relays, lightning arresters, earthing switch, capacitor bank and control panel.

Q18. What is the difference between an isolator and a circuit breaker?

Ans: A circuit breaker can open or close a circuit under load and fault current and clear faults automatically. An isolator only opens a circuit that carries no current (off-load) and is used to isolate equipment for maintenance. It is opened only after the breaker.

5. Distribution System

Q19. Define feeder, distributor and service mains.

Ans: Feeder: a conductor from the substation to the distribution area with no tapping in between. Distributor: a conductor along which tappings are given to consumers. Service mains: the small cable from the distributor to the consumer's premises.

Q20. How are distribution systems classified?

Ans: By current (AC or DC), by scheme (radial, ring main and interconnected), by construction (overhead or underground) and by voltage (primary at 11 kV and secondary at 415/230 V).

Q21. Describe the radial distribution system.

Ans: Separate feeders radiate from the substation, and each feeds a distributor at one end. It is simple and cheap, but a fault interrupts the supply beyond that point and the far-end voltage drop is high. Used in small and rural areas.

Q22. Describe the ring main distribution system.

Ans: The feeder forms a closed ring around the area, so each point can be fed from either side. It gives higher reliability and less voltage drop, and a faulty section can be isolated. It is costlier and is used in towns and cities.

Q23. Describe the three-phase four-wire distribution system.

Ans: Three phase wires and a neutral. Voltage between two phases is 415 V and between phase and neutral is 230 V. Single-phase loads are connected between phase and neutral, and three-phase motors use the three phases. The neutral is earthed at the substation.

6. Comparison of AC and DC Transmission

Q24. Why is AC generally used for transmission and distribution?

Ans: Power is generated as AC, voltage can easily be stepped up and down with transformers, switchgear and protection are simple, and AC networks can be interconnected into grids.

Q25. State the advantages of HVDC transmission.

Ans: Fewer conductors and smaller towers, lower line loss over long distances, no skin effect and no reactive power flow, no stability limit, and it can link grids of different frequencies. It is also suitable for long submarine cables, where AC has charging-current problems.

Q26. State the disadvantages of HVDC transmission.

Ans: Converter terminals (rectifier and inverter) are costly and complex, they produce harmonics that need filters, and they absorb reactive power. Voltage cannot be stepped up or down easily by a transformer, and DC circuit breakers are difficult to build.

Q27. Write the differences between AC and DC transmission.

Ans: 1) AC: uses transformers to change voltage; DC needs converters.
2) AC line: three conductors; DC line: two (bipolar) or one (monopolar).
3) AC has skin effect, corona and reactive power loss; DC has none of the first and less of the others.
4) AC terminals are cheap; DC terminals are costly.
5) AC suits short and medium distances; DC suits very long distances.

Q28. When is HVDC transmission preferred?

Ans: For very long overhead distances (beyond roughly 600 to 800 km, where lower line cost offsets terminal cost), for submarine cable links, for connecting grids with different frequencies or unsynchronised grids, and for bulk power from remote generation.

Q29. Name the main components of an HVDC transmission system.

Ans: Converter transformers, converters (a rectifier at the sending end and an inverter at the receiving end, using thyristor valves), smoothing reactors, harmonic filters, reactive power compensation, the DC line or cable, and earth electrodes.

Q30. What are monopolar, bipolar and homopolar HVDC links?

Ans: Monopolar: one conductor with earth or sea return. Bipolar: two conductors of opposite polarity (+ and -), and if one fails the other can run with earth return. Homopolar: two conductors of the same polarity with earth return.