Module 7: Instruments and Transformers

30 Important Questions and Answers

1. Measuring Instruments (Indicating Type)

Q1. How are electrical measuring instruments classified?

Ans: Absolute instruments (give the value from the instrument constants, e.g. tangent galvanometer) and secondary instruments (calibrated against absolute ones). Secondary instruments are of three kinds: indicating, recording and integrating.

Q2. What are indicating, recording and integrating instruments? Give examples.

Ans: Indicating: show the instantaneous value by a pointer on a scale (ammeter, voltmeter, wattmeter). Recording: draw a continuous record on paper (chart recorder). Integrating: add up the quantity over time (energy meter).

Q3. What are the three essential torques in an indicating instrument?

Ans: Deflecting torque (moves the pointer), controlling torque (opposes it and fixes the final position) and damping torque (stops the pointer oscillating and brings it quickly to rest).

Q4. How are an ammeter and a voltmeter connected, and what should their resistances be?

Ans: An ammeter is connected in series and should have very low resistance. A voltmeter is connected in parallel and should have very high resistance. A shunt extends the ammeter range and a multiplier (series resistance) extends the voltmeter range.

2. Deflecting Type Instruments

Q5. What is deflecting torque? How are instruments classified by the way it is produced?

Ans: It is the torque that moves the moving system from its zero position, produced by the quantity being measured. Types: moving coil (PMMC), moving iron (attraction and repulsion), dynamometer, induction, thermal (hot wire) and electrostatic instruments.

Q6. Describe the PMMC (permanent magnet moving coil) instrument.

Ans: A coil carrying current is placed in the field of a permanent magnet and experiences a torque proportional to the current. It works on DC only, has a uniform scale, high accuracy and sensitivity, and uses eddy-current damping.

Q7. Describe the moving iron instrument.

Ans: A soft iron piece is attracted into, or repelled inside, a coil carrying the current. It works on both AC and DC, is cheap and rugged, but has a non-uniform scale (crowded at the low end) and is less accurate because of hysteresis.

Q8. Where are the dynamometer and induction type instruments used?

Ans: Dynamometer type (fixed and moving coils) is used as a wattmeter, and works on AC and DC. Induction type instruments work on AC only and are used as energy meters.

3. Controlling Torque and Damping Torque

Q9. What is the purpose of controlling torque? Name the methods.

Ans: It opposes the deflecting torque so the pointer settles at a value that indicates the measured quantity, and it returns the pointer to zero when the quantity is removed. Methods: spring control and gravity control.

Q10. Compare spring control and gravity control.

Ans: Spring control uses spiral hair-springs; it gives a uniform scale in PMMC instruments and does not need levelling. Gravity control uses an adjustable weight on the moving system; it is cheap and does not fatigue, but the scale is crowded and the instrument must be kept level (vertical).

Q11. What is damping torque? Name the methods of damping.

Ans: It acts only while the pointer moves and opposes the motion, so the pointer settles quickly without overshooting (critical damping). Methods: air friction damping, fluid (oil) friction damping and eddy-current damping.

Q12. Which damping method is the most effective? Where is each used?

Ans: Eddy-current damping is the most effective and is used in PMMC instruments and energy meters (aluminium former or braking magnet). Air friction damping is used in moving iron and dynamometer instruments.

4. Transformer Principle and EMF Equation

Q13. What is a transformer?

Ans: A static device without moving parts that transfers electrical energy from one circuit to another at the same frequency, usually with a change in voltage, by mutual induction.

Q14. State the working principle of a transformer and name its main parts.

Ans: When AC is applied to the primary winding, an alternating flux is set up in the core, and it links with the secondary winding and induces an EMF in it (mutual induction). Main parts: laminated silicon-steel core, primary and secondary windings, and, in oil-immersed types, the tank, oil, conservator and breather.

Q15. What are the types of transformers?

Ans: Step-up and step-down; core type and shell type; single-phase and three-phase; and by use, power, distribution, instrument (CT, PT) and auto-transformers.

Q16. Write the EMF equation of a transformer and the transformation ratio.

Ans: $E = 4.44 \times f \times N \times phi_m$ volts, so $E_1 = 4.44\ f\ N_1\ phi_m$ and $E_2 = 4.44\ f\ N_2\ phi_m$. Transformation ratio $K = E_2 / E_1 = N_2 / N_1 = V_2 / V_1 = I_1 / I_2$.

Q17. A 50 Hz transformer has 500 primary and 100 secondary turns, and the primary is on 2000 V. Find the secondary voltage and the maximum flux.

Ans: $K = 100 / 500 = 0.2$, so $V_2 = 0.2 \times 2000 = 400$ V. $phi_m = E_1 / (4.44 \times f \times N_1) = 2000 / (4.44 \times 50 \times 500) = 0.018$ Wb.

5. Parallel Operation of Transformers

Q18. Why are transformers operated in parallel?

Ans: To meet a growing load without replacing the existing unit, to keep supply continuous when one transformer is taken out for maintenance or fails, and to run at better efficiency by switching units in or out with the load.

Q19. State the conditions for parallel operation of single-phase transformers.

Ans: Same polarity, same voltage ratio, same frequency, and the same percentage (per-unit) impedance, with a similar R/X ratio. Three-phase transformers also need the same phase sequence and the same phase-angle shift (vector group).

Q20. What happens if these conditions are not met?

Ans: Wrong polarity or phase sequence causes a dangerous short circuit. Unequal voltage ratios cause a circulating current even at no load. Unequal percentage impedances make the load share improperly, so one transformer may be overloaded.

Q21. Two transformers of 100 kVA and 200 kVA with equal percentage impedance supply 240 kVA. Find the load on each.

Ans: With equal percentage impedance, load is shared in proportion to ratings: 100 : 200 = 1 : 2. So the 100 kVA unit carries 80 kVA and the 200 kVA unit carries 160 kVA.

6. Cooling of Transformers

Q22. Why is cooling required in a transformer?

Ans: Core (iron) losses and copper losses turn into heat. This heat must be removed so that the winding and insulation stay within the permissible temperature rise, otherwise the insulation ages fast and the life of the transformer is cut short.

Q23. Name the cooling methods of transformers.

Ans: AN (air natural) for small dry types, AB or AF (air blast), ONAN (oil natural, air natural) for distribution transformers, ONAF (oil natural, air forced), OFAF (oil forced, air forced) and OFWF (oil forced, water forced) for large power transformers.

Q24. What are the functions of transformer oil? State its desirable properties.

Ans: It acts as insulation and as a coolant, carrying heat from the core and windings to the tank walls. It should have high dielectric strength, low viscosity, high flash point, and be free from moisture, acid and sludge.

Q25. What are the functions of the conservator and breather?

Ans: The conservator is a small tank above the main tank that takes up the expansion and contraction of oil. The breather holds silica gel, which absorbs moisture from the air entering the conservator. Silica gel is blue when dry and turns pink when it has absorbed moisture.

7. Protective Devices for Transformers

Q26. Why are protective devices needed for transformers?

Ans: To detect and clear overloads, short circuits, earth faults and internal faults quickly, so as to protect the transformer, the connected equipment and the people around it.

Q27. What is a Buchholz relay? Where is it fitted?

Ans: A gas-operated relay fitted in the pipe between the main tank and the conservator of an oil-filled transformer (generally above about 500 kVA). Slow gas build-up from a minor fault operates an alarm, while a violent oil surge from a major fault trips the circuit breaker.

Q28. What electrical protective devices are used with transformers?

Ans: HRC fuses or circuit breakers (MCCB, ACB, VCB), overcurrent and earth-fault relays, and differential relays, which compare primary and secondary currents to detect internal faults in large transformers.

Q29. Name the other protective and monitoring fittings of a transformer.

Ans: Oil temperature indicator, winding temperature indicator, oil level gauge, pressure relief (explosion) vent and a Buchholz relay.

Q30. What is the function of a lightning arrester and of earthing in a transformer installation?

Ans: A lightning arrester diverts lightning and switching surges to earth and protects the insulation. Earthing the tank body and the neutral keeps metal parts at earth potential, ensures protective devices operate on a fault and protects people from shock.