Module 6: AC Motors and Starters

30 Important Questions and Answers

1. AC Motors

Q1. How are AC motors classified?

Ans: Induction motors (single-phase and three-phase; the three-phase type is squirrel cage or slip ring), synchronous motors, and the universal (AC series) motor.

Q2. State the advantages of an induction motor.

Ans: Simple and rugged construction, low cost, no commutator or brushes (squirrel cage), low maintenance, good efficiency and runs directly on the AC supply.

Q3. Define synchronous speed and slip. Write the formulas.

Ans: Synchronous speed is the speed of the rotating magnetic field: Ns = 120 x f / P rpm. Slip is the fraction by which the rotor speed N falls short of it: s = (Ns - N) / Ns, often stated in percent.

Q4. A 4-pole, 50 Hz induction motor runs at 1440 rpm. Find the synchronous speed and slip.

Ans: Ns = 120 x 50 / 4 = 1500 rpm. Slip = (1500 - 1440) / 1500 = 0.04, that is 4%.

2. Three-Phase Induction Motor

Q5. Explain the working principle of a three-phase induction motor.

Ans: A three-phase supply in the stator winding produces a rotating magnetic field at synchronous speed. It cuts the rotor conductors and induces an EMF and current in them (Faraday's law). By Lenz's law the rotor tries to follow the field to reduce the relative motion, so a torque is produced and the rotor turns.

Q6. Name the main parts of a three-phase induction motor.

Ans: Stator (frame, laminated core and three-phase winding), rotor (squirrel cage or wound), shaft, bearings, cooling fan, end shields and terminal box.

Q7. Compare the squirrel cage and slip ring induction motors.

Ans: Squirrel cage: rotor bars shorted by end rings; rugged, cheap, low maintenance; high starting current and low starting torque. Slip ring: wound rotor connected through slip rings and brushes to external resistance; high starting torque and low starting current, speed control possible; costlier and needs more maintenance.

Q8. Why does an induction motor never run at synchronous speed? How is its direction of rotation reversed?

Ans: At synchronous speed there would be no relative motion between the field and the rotor, so no EMF, current or torque would be produced. Direction is reversed by interchanging any two of the three supply lines.

3. Single-Phase AC Motors

Q9. Why is a single-phase induction motor not self-starting?

Ans: A single-phase winding produces a pulsating field, not a rotating one. At standstill it can be viewed as two equal and opposite rotating fields, so the net starting torque is zero. Once started by some means, it keeps running.

Q10. Explain the split-phase method of starting.

Ans: The stator has a main winding and an auxiliary (starting) winding displaced 90 electrical degrees. Making the two currents differ in phase, using resistance or a capacitor, creates a rotating field. A centrifugal switch disconnects the starting winding at about 75-80% of full speed.

Q11. Describe capacitor-start and capacitor-start capacitor-run motors.

Ans: Capacitor-start: a capacitor is in series with the starting winding, giving high starting torque, and the centrifugal switch cuts it out; used for compressors, pumps, refrigerators and washing machines. Capacitor-start capacitor-run: a second capacitor stays in the circuit after starting, giving better power factor and smooth running.

Q12. Describe the permanent split capacitor (PSC) and shaded-pole motors, with their uses.

Ans: PSC: the capacitor and auxiliary winding remain connected during running, with no centrifugal switch; used in ceiling fans, blowers and small pumps. Shaded-pole: a copper shading ring on part of each pole creates a moving field; simple and cheap with low starting torque; used in small table fans, hair dryers and exhaust fans.

Q13. What is a universal motor? Give its uses.

Ans: A series-wound commutator motor that can run on both AC and DC. It has high starting torque and high speed, but needs brush maintenance. Uses: mixers and grinders, vacuum cleaners, portable drills and sewing machines.

Q14. How is the direction of a single-phase induction motor reversed?

Ans: By reversing the connections of either the starting (auxiliary) winding or the main winding, but not both together.

4. Starters for AC Motors

Q15. Why is a starter needed for an AC induction motor?

Ans: At start the rotor is at rest (slip = 1), so the rotor current is high and the motor draws 5 to 8 times its full-load current. This causes voltage dips and heating. A starter limits this starting current by supplying reduced voltage or adding rotor resistance.

Q16. Name the types of starters used for AC motors.

Ans: Direct-on-line (DOL), star-delta, auto-transformer and rotor resistance (slip ring motor) starters. Soft starters and variable frequency drives are also used.

5. Single-Phase and Three-Phase DOL Starters

Q17. What is a DOL starter? Where is it used?

Ans: It connects the motor directly to the full supply voltage through a contactor. It is simple, cheap and compact, but the starting current is high, so it is used for small motors (up to about 5 HP or 3.7 kW, depending on supply-authority rules).

Q18. Explain the parts and working of a three-phase DOL starter.

Ans: Parts: contactor, thermal overload relay, ON (green) and OFF (red) push buttons and an auxiliary hold-on contact. Pressing ON energises the contactor coil, its main contacts close and the auxiliary contact holds the coil. OFF, an overload trip or supply failure de-energises the coil and stops the motor (no-volt protection).

Q19. How does a single-phase DOL starter differ from a three-phase one?

Ans: It uses a two-pole contactor (phase and neutral) instead of a three-pole one, with a single overload element, and works on the same start-stop and hold-on principle. It is used for small single-phase motors such as pumps and compressors.

6. Star-Delta Starter

Q20. State the principle of a star-delta starter.

Ans: The stator winding of a motor rated for delta running is connected in star at starting, so each phase gets line voltage / 1.732 (about 58%). After the motor picks up speed, the winding is switched to delta and runs at full voltage. The motor needs six terminals brought out.

Q21. How much do the starting current and torque fall with a star-delta starter?

Ans: Starting line current and starting torque both become one-third of their DOL values.

Q22. Explain the working of an automatic star-delta starter.

Ans: It has three contactors (main, star and delta), a timer and an overload relay. On starting, the main and star contactors close. After the timer setting (a few seconds) the star contactor opens and the delta contactor closes. Star and delta contactors are interlocked to prevent a short circuit.

Q23. State the advantages and limitations of a star-delta starter.

Ans: Advantages: cheap, simple, no transformer, reasonable efficiency. Limitations: only for motors normally run in delta, needs six leads, starting torque is low (only for light-load starts such as fans, pumps and machine tools), and a current jerk occurs at changeover.

7. Slip Ring Motor Starter

Q24. Describe the rotor resistance starter for a slip ring motor.

Ans: A three-phase rheostat is connected to the rotor winding through slip rings and brushes. Full resistance is in the circuit at start and is cut out step by step as the speed rises, until the slip rings are short-circuited at full speed. The stator is connected directly to the supply.

Q25. State the advantages and uses of the rotor resistance starter.

Ans: It gives high starting torque with low starting current and allows some speed control. Uses: cranes, hoists, lifts, compressors and other loads that start under heavy load. The resistance must be fully in at the moment of starting.

8. Auto-Transformer Starter

Q26. Explain the working of an auto-transformer starter.

Ans: A three-phase auto-transformer applies reduced voltage from a tap (commonly 50%, 65% or 80%) to the squirrel cage motor at start. When the motor has picked up speed, the transformer is cut out and the motor is connected to full voltage. Motor current falls in proportion to the tap voltage, and the supply current and torque fall roughly as its square.

Q27. State the advantages and disadvantages of the auto-transformer starter.

Ans: Advantages: adjustable taps, better starting torque per amp of supply current than star-delta, and it suits large motors, including star-connected ones. Disadvantages: costly, bulky, needs more maintenance, and there may be a surge at changeover.

9. AC Motor Panel

Q28. What is an AC motor control panel?

Ans: A metal enclosure containing switchgear and control devices to start, stop, protect and monitor one or more AC motors.

Q29. List the main components of an AC motor panel.

Ans: Incoming isolator or MCCB, fuses or MCBs, contactors, thermal overload relay, timer (for star-delta), start-stop push buttons, indicating lamps, ammeter and voltmeter with selector switches, phase failure relay, control transformer, busbars and an earthing terminal.

Q30. What protections and safety measures are provided in a motor panel?

Ans: Overload protection (thermal relay), short-circuit protection (fuse or MCCB), single-phasing and under or over voltage protection, and earth-fault protection. The panel enclosure is earthed, labelled and kept closed, and the supply is isolated and locked off before maintenance.