ELECTROTECHNOLOGY

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets

1. A 110 V battery with internal resistance of 0.3 Ω, is connected in parallel with a 120 V d.c. generator with internal resistance 0.5 Ω. This parallel combination supplies a 5 Ω load.

   (a) Sketch a labelled circuit diagram. (3)

   (b) Calculate EACH of the following:

   (i) the battery current; (8)

   (ii) the load current. (4)

   (c) State whether the battery is charging or discharging. (1)

2. (a) A 33 μF capacitor is charged from a 100 V d.c. supply via a 47 kΩ resistor for 3 seconds. This capacitor is then disconnected from the supply and a 68 μF capacitor is charged from the same supply via the same resistor for 5 seconds.

   Calculate EACH of the following:

   (i) the voltage to which each capacitor has charged; (8)

   (ii) the charge stored in each capacitor. (3)

   (b) The charged capacitors in Q2(a) are connected in parallel.

   Calculate the final voltage across the parallel circuit. (5)

3. An unbalanced, three-phase, star connected load is supplied from a four-wire, 440 V, 50 Hz supply. The current in EACH phase is:

- I_R = 7 A lagging VR by 30°
- I_S = 5 A in phase with V_S
- I_T = 9 A leading V_T by 60°

(a) Sketch, approximately to scale, a labelled phasor diagram showing phase voltages and currents. (3)

(b) Calculate EACH of the following:

(i) the neutral current; (5)

(ii) the phase angle of the neutral current with respect to the S phase voltage; (2)

(iii) the total power dissipated. (6)

4. (a) With reference to a three-phase synchronous motor:

(i) explain why the motor is not self-starting; (3)

(ii) describe ONE starting method; (2)

(iii) describe how the motor responds to increasing load if the excitation is constant; (3)

(iv) state the effect on motor power factor if the excitation is reduced. (1)

(b) A 50 kW synchronous motor operates at full-load with an efficiency of 90% and power factor 0.92 lead.

Calculate EACH of the following motor input values:

(i) active power (kW); (2)

(ii) reactive power (kVAr); (3)

(iii) apparent power (kVA). (2)

5. Two, three-phase, four-pole generators operate in parallel and share a 3200 kVA load with a power factor of 0.75 lag. Both generators have linear characteristics with test results as shown in Table Q5.

GENERATOR	SPEED/kW	VOLTAGE/kVAr
G1	1900 rev/min at no-load 1825 rev/min at 900 kW	460 V at no-load 450 V at 400 kVAr
G2	1875 rev/min at no-load 1850 rev/min at 400 kW	455 V at no-load 446 V at 1000 kVAr

Table Q5

Determine EACH of the following:

(a) the busbar frequency; (7)

(b) the busbar voltage; (6)

(c) the power factor of EACH generator. (3)

6. (a) Sketch a labelled circuit diagram for a 440V, step-down, star connected, three-phase autotransformer with 50%, 65% and 80% tappings. Indicate primary and secondary phase turns, voltages and currents. (5)

(b) State TWO advantages and the main disadvantage of an autotransformer compared to a double wound transformer. (3)

(c) A three-phase, 440 V induction motor having a full-load current of 75 A is connected to the 65% tappings of the autotransformer in Q6(a). The motor starting current is 6 x full-load when started D.O.L.

Calculate EACH of the following at start:

(i) the current in each section of the transformer phases; (4)

(ii) the voltage across each section of the transformer phases; (3)

(iii) the motor line voltage. (1)

7. (a) With the aid of a labelled cross-sectional sketch, describe the construction of a four pole salient rotor for a synchronous generator. (6)

(b) A three-phase, star connected, 500 kVA, 440 V generator has negligible stator winding resistance and synchronous reactance of 0.2 Ω/phase. The generator load demands full-load current at 0.8 power factor lag.

(i) Sketch a labelled phasor diagram to show the relationship between the generated e.m.f., the terminal voltage and the load current. (4)

(ii) Calculate the voltage regulation. (6)

8. (a) Referring to Fig Q8, which shows the cage rotor for a three-phase, 6 pole, 60 Hz induction motor:

(i) explain how torque is produced; (5)

(ii) state the direction of rotation of the rotor; (1)

(iii) explain why the rotor does not rotate at synchronous speed. (2)

(b) Sketch and label a torque/speed characteristic for the motor, and indicate EACH of the following:

- synchronous speed;
- pull-out torque;
- starting torque. (5)

(c) Calculate the rotor speed if the slip is 4%. (3)

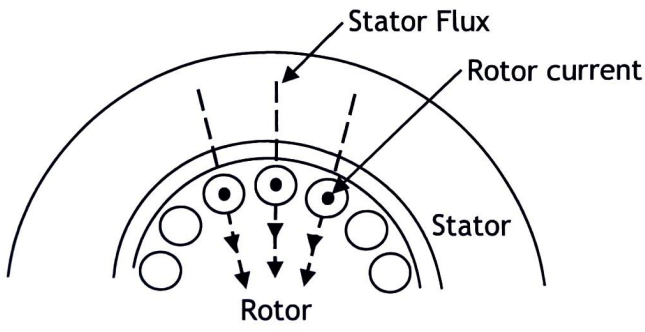

Fig Q8

9. (a) Sketch a labelled circuit diagram for a full wave three-phase rectifier supplying a load resistor. Indicate the polarity of the load terminals. (5)

(b) For the circuit sketched in Q9(a):

(i) summarise the circuit operation; (2)

(ii) state the diode conduction sequence for one cycle of the supply; (3)

(iii) sketch the output voltage waveform and indicate the average voltage; (3)

(iv) explain why a smaller value of capacitor is required to achieve the same peak-peak ripple compared to the value required for a single-phase, full wave rectifier, assuming the same supply frequency. (3)