ELECTROTECHNOLOGY

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. Fig Q1 shows a 240 V ring main. The cable resistance (go + return) is 2×10^{-3} Ω/m.

   Calculate EACH of the following:

   (a) the resistance of each cable section AB, BC, CD and DE; (4)

   (b) the current in each cable section; (7)

   (c) the voltage at each load; (4)

   (d) the potential difference between D and E. (1)

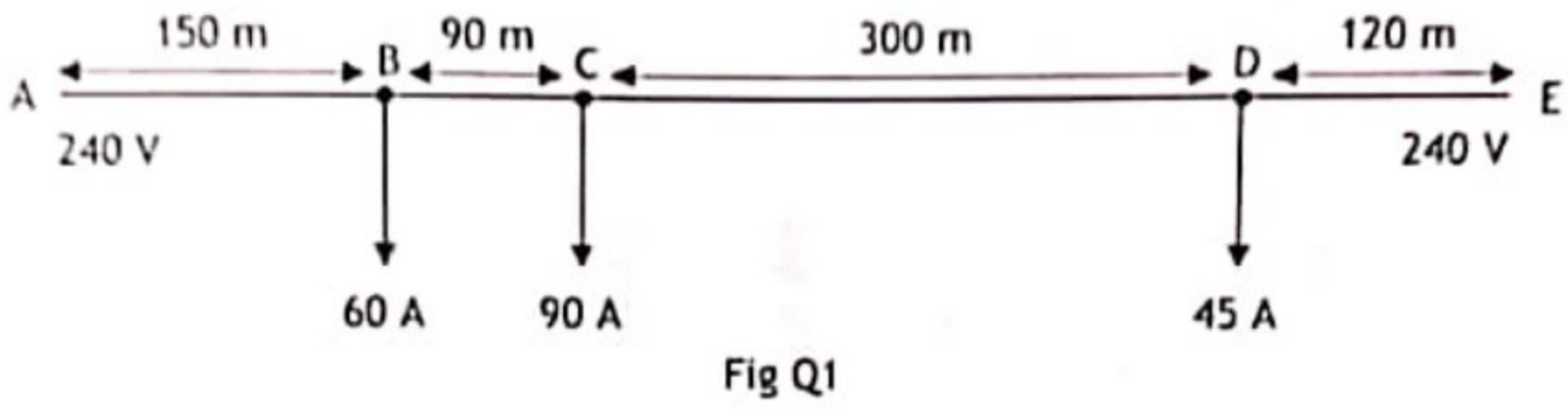

Fig Q1

2. A coil of inductance 0.25 H and resistance 100 Ω is connected to a 200 V d.c. supply via a changeover switch. When the switch is operated the coil is disconnected from the supply and connected in parallel with a 75 Ω resistor.

   Calculate EACH of the following for the coil in parallel with the resistor:

   (a) the energy stored in the coil; (4)

   (b) the induced e.m.f. at the instant of changeover; (2)

   (c) the time constant; (2)

   (d) the initial rate of decay of the current; (3)

   (e) the current after a time equal to one time constant; (2)

   (f) the time taken for the current to fall to one third of its original value. (3)

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3. A three-phase, 415 V, 4-wire, unbalanced load has currents as shown in Table Q3.

Current (A)		Reference
I_S	$20\angle -60°$	V_{SN}
I_T	$35\angle 48°$	V_{TN}
I_N	$40\angle 45°$	V_{RN}

Table Q3

(a) Sketch, approximately to scale, a labelled phasor diagram to show the relationship between the phase voltages and the currents given in Table Q3, include angles. (6)

(b) Calculate EACH of the following:

(i) the current in the R phase and its phase angle with respect to V_{RN}; (4)

(ii) the total load power. (4)

(c) Sketch and label the current phasor I_R on the diagram for Q3(a), and indicate the phase angle φ_R. (2)

4. A three-phase, 440 V, 60 Hz generator is tested using a delta connected load bank. Each phase of the load is a coil having a resistance of 1.3 Ω, and the generator load condition for the test is 200 kVA.

Calculate EACH of the following:

(a) the coil current; (4)

(b) the coil impedance; (2)

(c) the coil inductance; (4)

(d) the coil power factor; (2)

(e) the total load active power; (2)

(f) the total load reactive power. (2)

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5. (a) Describe EACH of the following power transformer losses and state how they are affected by supply frequency:

(i) hysteresis loss; (2)

(ii) eddy current loss. (2)

(b) Fig Q5 shows a simplified equivalent circuit for a single-phase transformer ignoring the no-load current.

The winding resistances are assumed to be negligible, and the reactance of the secondary has been referred to the primary to give a value equivalent to the reactance effects of both windings.
The transformer has a turns ratio of 5:1 and delivers $105\angle -30°$ A at 86 V.

(i) Sketch a labelled phasor diagram to show all voltages, currents and angles. (4)

(ii) Calculate EACH of the following:

- the supply voltage V_1
- the voltage regulation. (8)

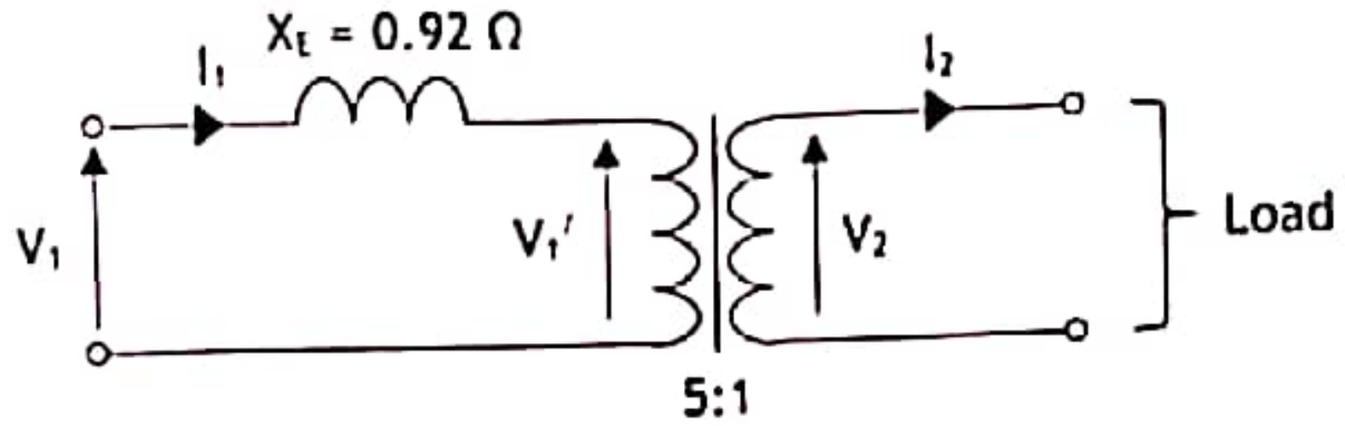

Fig Q5

6. Fig Q6 shows a power flow diagram for a three-phase, 2 pole, 6.6 kV, 60 Hz, induction motor. At full-load the motor efficiency and power factor are 94% and 0.88 lag respectively, the output power is 200 kW and slip is 1.2%.

(a) Calculate EACH of the following:

(i) the power input P_{IN}; (2)

(ii) the full-load current I_N; (2)

(iii) the stator, rotor and mechanical losses; (8)

(iv) the shaft torque. (2)

(b) State the two components of stator loss. (2)

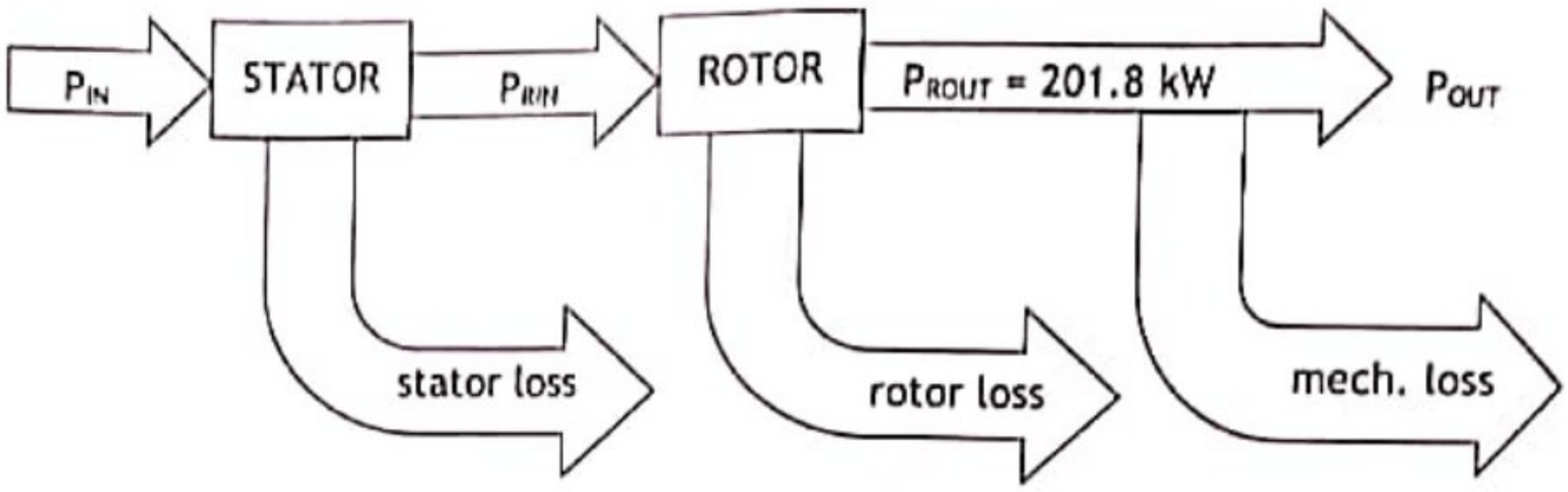

Fig Q6

7. With reference to a propulsion shaft generator system with a frequency converter and synchronous compensator:

(a) sketch a labelled block diagram; (8)

(b) describe the purpose of EACH block in the diagram for Q7(a); (5)

(c) the ship's load is 800 kW at 0.85 lag. Calculate the power factor of the synchronous compensator if it has an input of 30 kW. (3)

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8. Fig Q8 shows a circuit for earth fault monitoring lamps.

(a) Explain EACH of the following:

(i) why the circuit is necessary; (2)

(ii) why the lamps are supplied through transformers; (2)

(iii) why earth fault monitoring circuits must be connected to both primary and secondary of distribution transformers. (2)

(b) Describe the lamp indications for EACH of the following conditions:

(i) P/B open; (1)

(ii) P/B open, L2 open circuit; (1)

(iii) P/B closed, no earth fault; (1)

(iv) P/B closed, earth fault on T. (1)

(c) (i) Sketch a labelled circuit diagram to show how d.c. injection and an ohm meter are arranged to indicate earth faults. (4)

(ii) Describe the indication on the ohm meter in Q8(c)(i) for EACH of the following conditions:

- no earth fault (1)
- one earth fault (1)

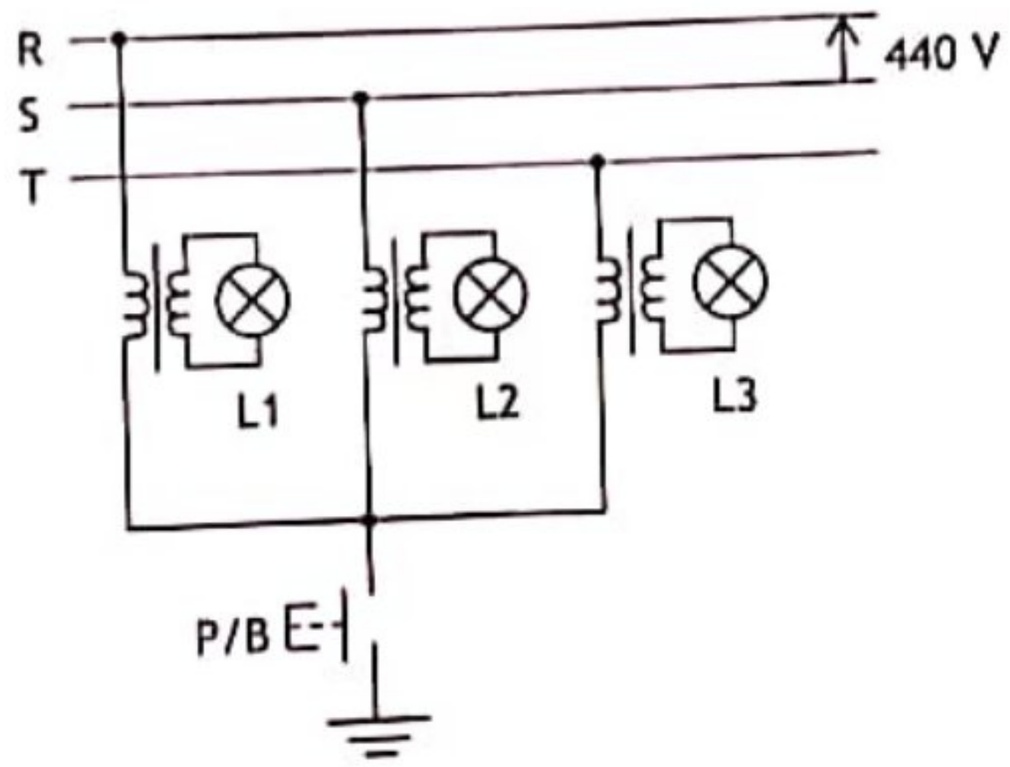

Fig Q8

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9. Fig Q9 shows a flame failure detector circuit which uses a light dependent resistor LDR, a light emitting diode LED, and a transistor switch. When the transistor is FULLY ON the collector current is 10 mA., the base current is negligible and the collector-emitter voltage V_{CEsat} is 0.15 V.

(a) Explain the operation of the circuit. (4)

(b) Calculate the minimum LDR resistance at which the transistor turns on. (3)

(c) Calculate EACH of the following when the transistor is FULLY ON:

(i) the voltage across the LED; (4)

(ii) the power supplied to the circuit. (4)

(d) Describe the change in circuit operation if the positions of LDR and R_1 are swapped. (1)

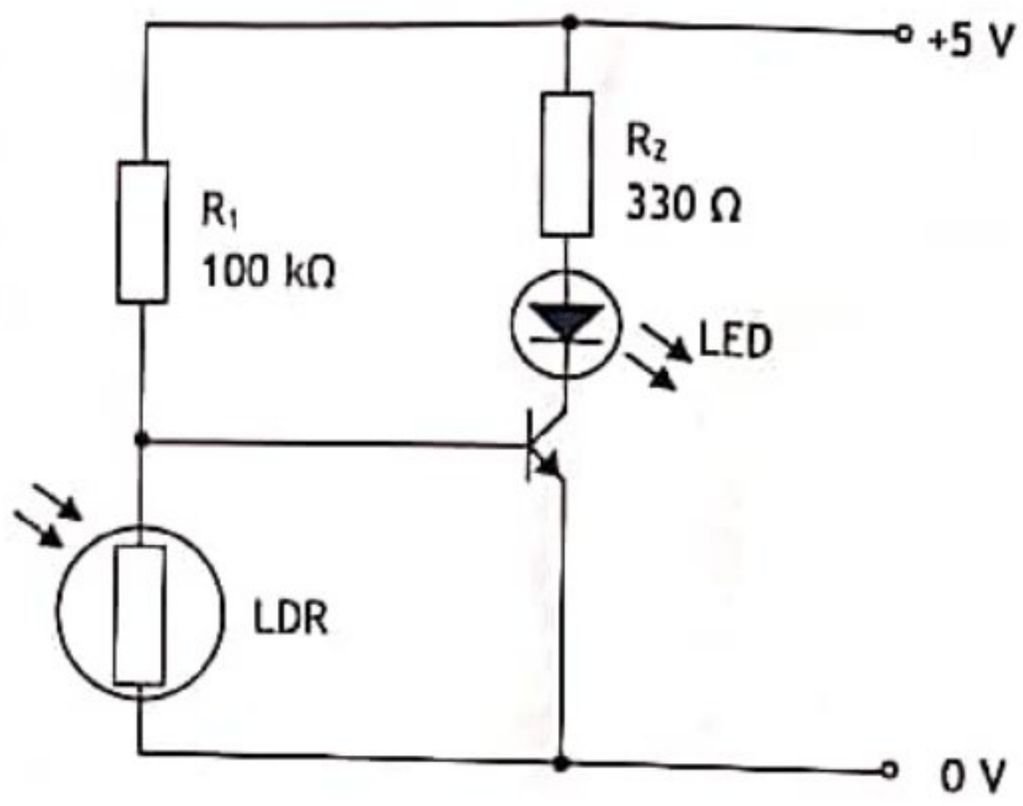

Fig Q9

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