CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-33 - ELECTROTECHNOLOGY

THURSDAY, 17 JULY 2025

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

1. Examinations administered by the SQA on behalf of the Maritime & Coastguard Agency.
2. Candidates should note that 96 marks are allocated to this paper. To pass, candidates must achieve 48 marks.
3. Non-programmable calculators may be used.
4. All formulae used must be stated and the method of working and all intermediate steps must be made clear in the answer.

Maritime & Coastguard Agency

SQA

ELECTROTECHNOLOGY

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. Fig Q1 shows a two-core distribution cable, its go + return section resistances and the supply voltages at A and E. The cable supplies three loads as shown.

Calculate EACH of the following:

(a) the current in each section of the cable; (5)

(b) the voltage at each load; (6)

(c) the power loss in the cable; (3)

(d) the total power supplied. (2)

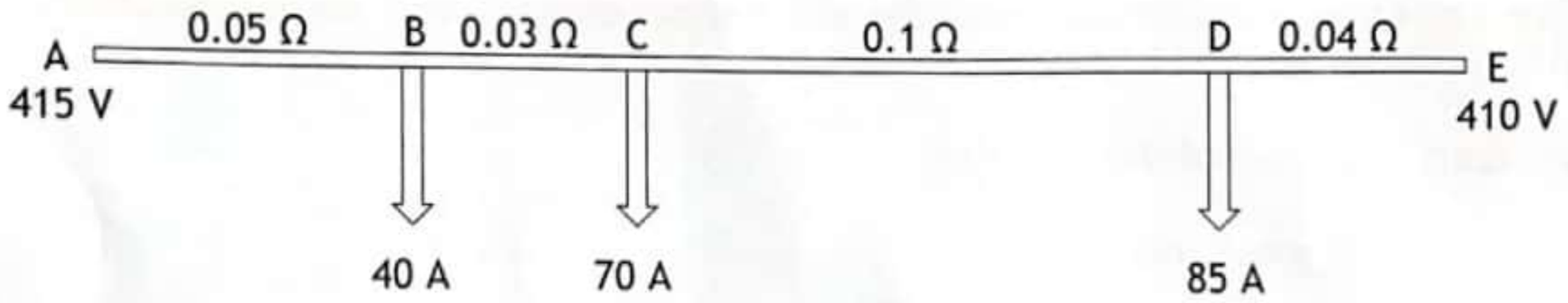

Fig Q1

[OVER

2. A 43 μF capacitor is connected in series with a 62 kΩ resistor across a 50 V d.c. supply via a changeover switch.

After the capacitor is fully charged, the switch is operated and the circuit is instantaneously disconnected from the supply and connected in parallel with a 22 kΩ resistor.

Calculate EACH of the following for the capacitor:

(a) the approximate time to become fully charged; (3)

(b) the energy stored; (2)

(c) the current at the instant of changeover; (2)

(d) the initial rate of voltage discharge; (3)

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

(f) the time taken for the voltage to fall to one quarter of its initial value. (4)

3. Three, star connected coils of resistance 50 Ω and inductance 0.25 H are supplied from a three-phase, 440 V, 60 Hz supply.

(a) Calculate EACH of the following:

(i) the line current; (6)

(ii) the active load power. (2)

(b) Three identical capacitors arranged in star are connected to the supply to raise the power factor to 0.95 lag.

Calculate the capacitor value. (8)

4. Fig Q4, shows a 1715 kVA, 3.3 kV generator with a stator earth fault protection scheme using four identical current transformers (CT) and a relay activated by the spill current.

(a) Explain the response of the earth fault protection scheme for EACH of the following conditions:

(i) no earth fault; (2)

(ii) earth fault F1; (3)

(iii) earth fault F2. (3)

(b) Ignoring winding reactance, calculate the value of the NER required to limit the maximum earth fault current to one-third of the generator full-load current. (5)

(c) If the relay has a minimum operating current of 1.0 A, and the CTs have a current ratio of 100:5, calculate the percentage of the generator phase winding which will not be protected. (3)

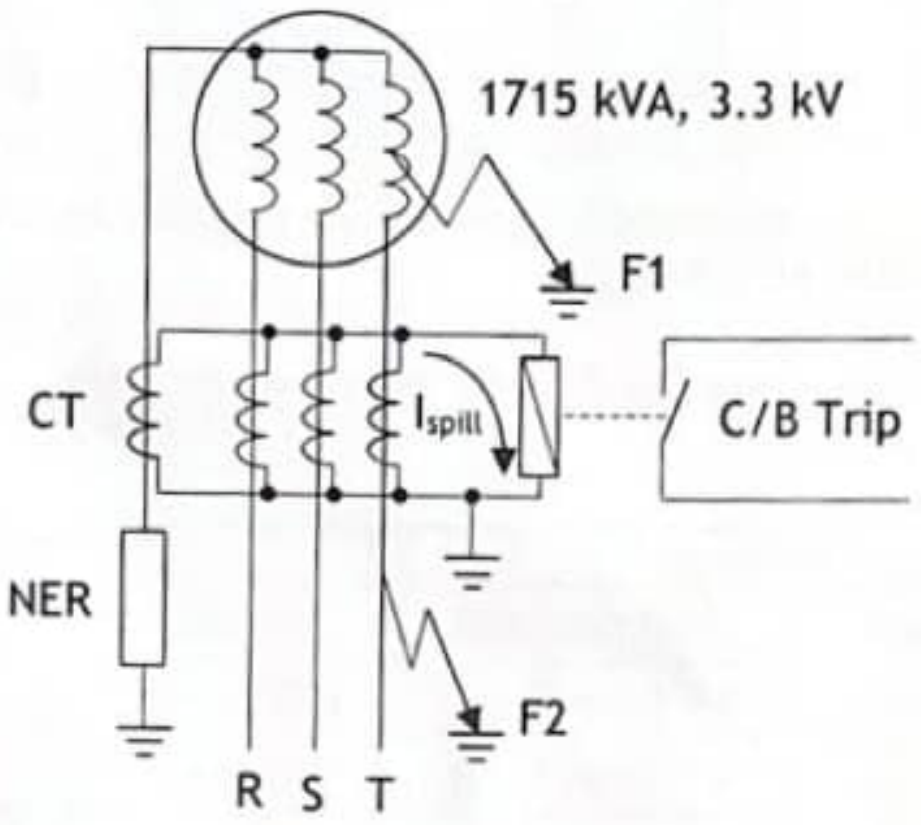

Fig Q4

5. A three-phase, delta connected, six-pole, 690 V, 60 Hz induction motor has the following operating parameters at full-load:

Supply Current (A)	Power Factor	Output Power (kW)	Rotational Losses (kW)	Shaft Speed (rev/min)
19.5	0.86 lag	18.4	0.22	1176

The stator has a winding resistance of 1.1 Ω/phase.

Calculate EACH of the following:

(a) the shaft torque; (2)

(b) the rotor winding loss; (5)

(c) the stator winding loss; (2)

(d) the stator core loss; (5)

(e) the motor efficiency. (2)

6. Two, six-pole, three-phase generators operate in parallel to share a total load of 2500 kVA at a power factor of 0.8 lag.

Table Q6 shows the governor and AVR test results for each generator, all characteristics are linear.

Generator	Governor		AVR	
G1	No-load	1500 rev/min	No-load	500 V
	1000 kW	1425 rev/min	1000 kVAr	460 V
G2	No-load	1475 rev/min	No-load	480 V
	800 kW	1425 rev/min	1200 kVAr	450 V

Table Q6

(a) Determine EACH of the following:

(i) the busbar frequency; (7)

(ii) the busbar voltage. (5)

(b) Assuming the governor and AVR droop settings are not changed, explain how to adjust the throttle and excitation settings to achieve equal active and reactive loading of the generators at 60 Hz, 440 V. (4)

7. (a) With the aid of labelled diagrams, describe the construction of EACH of the following types of single-phase transformer:

(i) core type; (6)

(ii) shell type. (5)

(b) A 200 kVA, 6600/440 V, single-phase transformer has a core loss of 3 kW. The primary and secondary windings have resistances of 0.5 Ω and 0.002 Ω respectively.

Calculate the full-load efficiency when the power factor is 0.8 lagging. (5)

8. (a) Using a labelled cross-sectional sketch show the constructional features of a four-pole salient rotor for a synchronous motor. (4)

(b) A three-phase, star connected, 11 kV synchronous motor has negligible stator winding resistance and synchronous reactance of 25 Ω/phase. The motor takes a current of 80 A at a power factor 0.866 lead.

(i) Sketch a labelled phasor diagram for one phase, to show the relationship between all voltages and the motor current, and indicate the phase and load angles. (5)

(ii) Calculate EACH of the following:

- the generated phase e.m.f.
- the load angle (7)

[OVER

9. (a) Explain, with the aid of a labelled circuit diagram, the operation of a single-phase, full-wave bridge rectifier. (6)

(b) For the full-wave rectifier circuit in Q9(a):

(i) sketch and label the input and output voltage waveforms, and indicate EACH of the following:

- which diodes conduct during each supply half cycle
- the average output voltage (4)

(ii) calculate the average output voltage if the a.c. input applied to the bridge is 14 V; (3)

(iii) add a smoothing capacitor to the circuit diagram sketched in Q9(a); (1)

(iv) add a waveform to the sketch in Q9(b)(i) to show the effect of capacitor smoothing on the output voltage, and indicate the average d.c. output voltage. (2)