CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 16 DECEMBER 2021

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 represents a ring main system of total length 1300 m and resistance (go + return) of 0.002 Ω/m.

Calculate EACH of the following:

(a) the cable resistances for AC, CD, DE, and EB; (4)

(b) the current at EACH end of the feeder; (6)

(c) the voltage at each load point; (5)

(d) show that the voltage at B equals 240 V. (1)

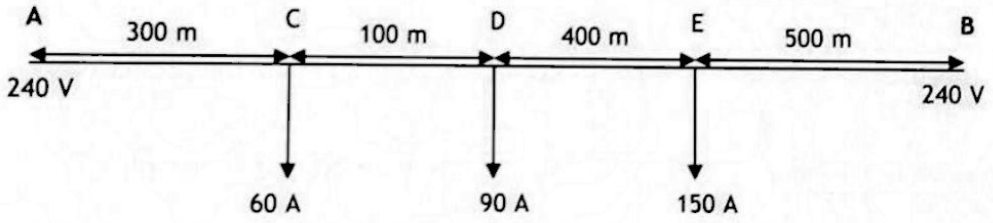

Fig Q1

Not to scale

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2. A d.c. relay coil has an inductance of 400 mH and a time-constant of 1.6 ms. The current rises to 86.5 mA after 3.2 ms from switch on.

Calculate EACH of the following:

(a) the coil resistance; (2)

(b) the maximum current; (3)

(c) the supply voltage; (2)

(d) the current 4 ms after switch on; (3)

(e) the time taken for the current to reach 70 mA; (4)

(f) the final value of the stored energy. (2)

3. A three-phase 4-wire unbalanced system has a current in the *R* phase of 5 A U.P.F. and a current in the *S* phase of 8 A lagging by 30°.

(a) If the current in the neutral line is 1.93 A in phase with V_{RS}, calculate EACH of the following:

(i) the *T* phase current; (9)

(ii) the phase angle of the *T* phase current with respect to the *T* phase voltage. (3)

(b) Calculate the total power drawn by the three-phase system if the phase voltage is 240 V. (4)

4. A three-phase, induction motor is operating at the following parameters:

Parameter	Value	Parameter	Value
Supply voltage	440 V	Number of Poles	8
Supply frequency	60 Hz	Output power	7 kW
Power factor	0.8 lag	Speed	14.4 rev/s
Rotational losses	0.4 kW	Stator loss	0.6 kW

(a) Determine EACH of the following:

(i) the slip; (2)

(ii) the frequency of the rotor emf; (2)

(iii) the input power to the motor; (7)

(iv) the motor line current. (2)

(b) Sketch a labelled power-flow diagram for the motor indicating kW value at EACH stage. (3)

5. Two, six-pole, three-phase a.c. generators operating in parallel supply a total load of 2000 kVA at a power factor of 0.8 lagging.

The generator load characteristics are linear with the test results given in Table Q5.

Generator	Speed/kW	Voltage/kVAR
No. 1	1440 rev/min on No-load 1200 rev/min on 1200 kW	500 V on No-load 415 V on 1000 kVAR
No. 2	1360 rev/min on No-load 1180 rev/min on 900 kW	490 V on No-load 425 V on 800 kVAR

Table Q5

Determine EACH of the following:

(a) the supply frequency; (6)

(b) the bus-bar voltage; (6)

(c) the kVA output of each generator; (2)

(d) the operating power factor of each generator. (2)

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6. (a) State the disadvantages of operating electrical circuits at a lower power factor. (2)

(b) A three-phase, 6600 V/440 V, 80 kVA transformer supplies a unity power factor load of 15 kW and an inductive load of 55 kW at 0.67 power factor.

Determine the minimum kVAR rating of a capacitor bank to ensure that the supply transformer is not overloaded. (7)

(c) Calculate the value of output current for the transformer in Q6(b) before and after power factor correction being applied. (7)

7. With reference to shipboard three-phase generators:

(a) describe, with the aid of a sketch, EACH of the following:

(i) an insulated neutral distribution system; (3)

(ii) an earthed neutral distribution system. (3)

(b) explain the effect of a single earth fault on each of the systems in Q7(a); (6)

(c) state TWO causes of earth faults. (4)

8. With reference to a three-phase, cage rotor induction motor:

(a) sketch a labelled cross-section of the motor; (8)

(b) describe how the motor develops torque; (5)

(c) explain why the motor cannot run at synchronous speed. (3)

9. A single-phase, 230 V, 50 Hz, 3:1 step-down transformer has a secondary winding resistance of 1 Ω and supplies a half-wave rectifier circuit. The rectifier circuit has a resistive load of 680 Ω and the diode has a forward resistance of 14 Ω.

(a) Sketch EACH of the following:

(i) the circuit diagram; (3)

(ii) the load voltage waveform indicating maximum and average voltage levels. (3)

(b) Calculate EACH of the following load values:

(i) the maximum current; (4)

(ii) the average current; (3)

(iii) the average voltage. (3)