CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 30 MARCH 2023

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 d.c. distribution system. The main feeder cable has a resistance (go + return) of 1.45×10^{-3} Ω/m, and the load cables have a resistance (go + return) of 2.3×10^{-3} Ω/m.

   (a) Calculate EACH of the following:

      (i) the voltage at load A; (3)

      (ii) the power dissipated at load B; (6)

      (iii) the voltage at the main switchboard. (3)

   (b) Calculate the length of main feeder cable required to supply an additional 300 V, 350 A load at its rated values directly from the main switchboard. (4)

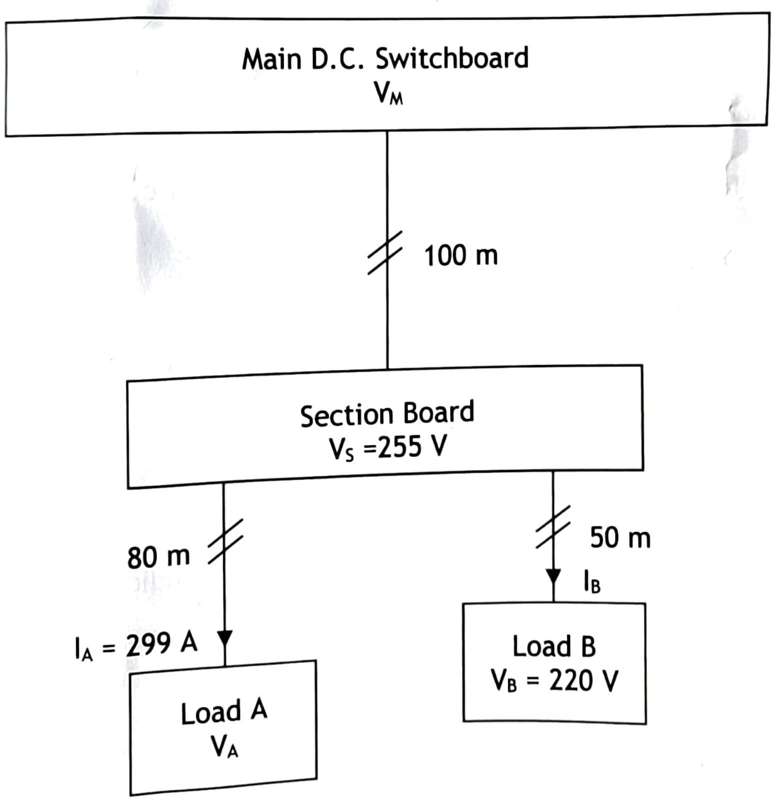

Fig Q1

2. A relay coil has a resistance of 275 Ω and operates when the coil current is 75 mA. When the coil is connected to a 24 V d.c. supply the relay takes 20 ms to operate.

(a) Calculate EACH of the following for the relay coil:

(i) the final value of current; (2)

(ii) the time constant; (4)

(iii) the inductance. (3)

(b) A 33 Ω resistor is connected in series with the relay coil.

Calculate the new operating time for the relay. (7)

3. THREE resistive loads are connected in star to a three-phase, 4-wire, 220 V supply. The load values are:

$R_R = 56\ \Omega$ $R_S = 91\ \Omega$ $R_T = 33\ \Omega$

(a) Calculate EACH of the following:

(i) the current in EACH load; (4)

(ii) the current in the neutral; (5)

(iii) the total power supplied. (3)

(b) Sketch, approximately to scale, a labelled phasor diagram of the load and neutral currents. (4)

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

(a) explain why the rotor power factor is very low at start; (2)

(b) explain why the rotor core losses are negligible when the motor is running; (2)

(c) sketch and label a typical torque/speed characteristic and indicate:

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

(d) explain, with the aid of a labelled sketch, how a shaped, deep-bar rotor design increases starting torque; (6)

(e) state ONE additional advantage of a shaped, deep-bar rotor. (1)

5. Fig Q5 shows ONE section of a high voltage distribution system.

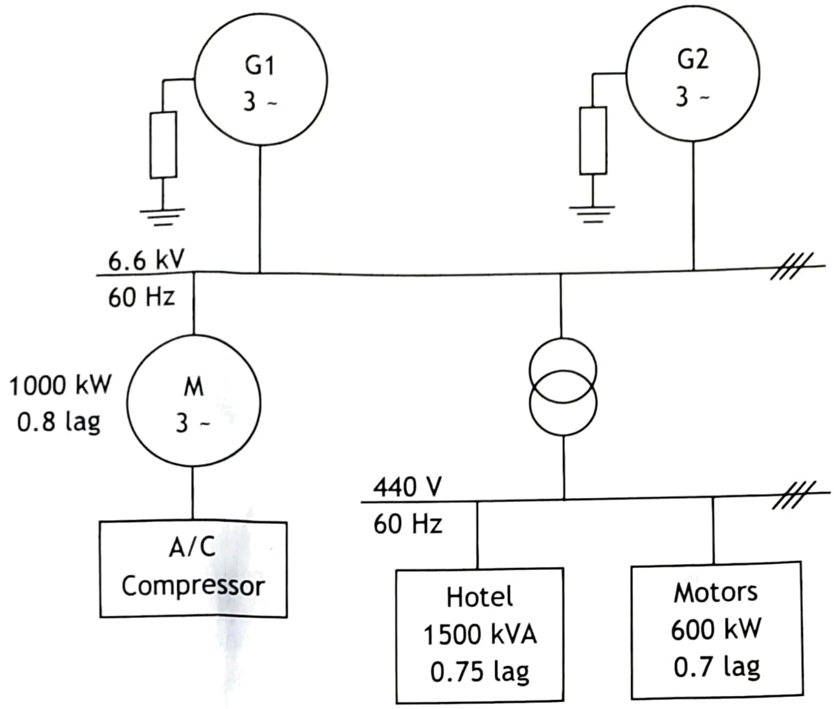

Fig Q5

(a) Calculate EACH of the following:

(i) the total active load (kW); (2)

(ii) the total reactive load (kVAr); (4)

(iii) the transformer primary and secondary current. (6)

(b) If the generators have identical loading. Calculate EACH of the following for the generators:

(i) the power factor; (3)

(ii) the apparent power (kVA). (1)

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6. A three-phase transformer nameplate shows the following information:

Rating (kVA)	2500
Voltage (volts) H.V	6600
L.V.	690
Frequency	60
Vector group	Yd11

The transformer has an efficiency of 97% at full-load unity power factor, and maximum efficiency occurs at $^2/_3$ full-load.

(a) Calculate EACH of the following:

(i) the core loss; (6)

(ii) the maximum efficiency when the load power factor is 0.7 lag; (2)

(iii) the primary and secondary phase currents at ½ full-load. (7)

(b) State the meaning of the vector group symbol. (1)

7. (a) With reference to a three-phase brushless generator:

(i) sketch a labelled system diagram; (6)

(ii) describe the operation of the system sketched in Q7(a)(i). (5)

(b) Sketch and label on common axes, the load characteristics for a three-phase generator operating at constant speed and excitation for EACH of the following load power factors:

- unity
- 0.7 lag
- 0.7 lead

(5)

8. (a) With reference to marine electrical distribution, explain EACH of the following terms:

(i) earth fault; (2)

(ii) insulated neutral; (2)

(iii) neutral earthing resistor. (3)

(b) Sketch a labelled circuit diagram to show how a d.c. voltage, derived from the three-phase supply, can be used to monitor the insulation resistance of the system. (5)

(c) Describe the indication obtained from the arrangement sketched in Q8(b) for EACH of the following situations:

(i) no earth faults; (2)

(ii) an earth fault on one line. (2)

9. (a) (i) Sketch the forward and reverse characteristics for a silicon diode and label the axes. (2)

(ii) Indicate on the sketch EACH of the following:

- a typical value for the forward volt drop across the diode;
- reverse breakdown. (2)

(b) For a single-phase, full wave rectifier which uses two diodes and a centre-tapped transformer to supply a load resistor:

(i) sketch a labelled circuit diagram; (4)

(ii) describe, with the aid of a labelled output voltage waveform, the operation of the circuit; (3)

(iii) indicate the d.c. output voltage on the waveform in Q9(b)(ii). (1)

(c) If the transformer of Q9(b) has a sinusoidal secondary voltage of 50 V, calculate the d.c load voltage. (4)