CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 22 OCTOBER 2020

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Notes for the guidance of candidates:

1. Examinations administered by 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.

All formulae used must be stated and the method of working and all intermediate steps must be made clear in the answer.

1. Fig. Q1 represents a ring main system of total length 620 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; (5)

   (b) the currents supplied at each end of the distributor cable; (6)

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

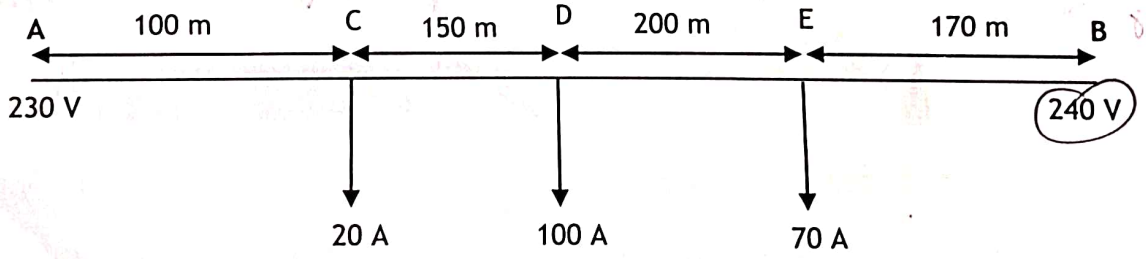

Fig Q1

Not to scale

2. When connected to a 20 V d.c. supply a relay starts to operate 0.52 ms after switching on the supply at which time the instantaneous current is 200 mA. The relay coil has a time constant of 5 ms.

(a) Calculate EACH of the following:

(i) the final steady state relay current;

(ii) the resistance of the relay coil;

(iii) the inductance of the relay coil.

(b) To increase the operating time a 40 Ω resistor is connected in series with the relay coil.

Calculate the new operating time for the relay assuming the instantaneous current is 200 mA. (7

3. THREE identical coils are star-connected across a three-phase, 440 V, 60 Hz power supply and consume a total power of 3 kW at a power factor of 0.8 lagging.

(a) Determine the resistance and inductance of each coil. (8)

(b) Calculate the current in each line if one coil is:

(i) short-circuited; (5)

(ii) open-circuited. (3)

4. A THREE-phase, star-connected, eight-pole induction motor has the following operating parameters:

Parameter	Value	Parameter	Value
Supply voltage	415 V	Supply frequency	50 Hz
Full load current	57 A	Output power	24 kW
Power factor	0.707 lag	Speed	12 rev/s
Rotational losses	1 kW	Stator resistance	0.1 Ω per phase

Calculate EACH of the following:

(a) the output torque; (2)

(b) the rotor winding loss; (5)

(c) the stator winding loss; (2)

(d) the stator core loss; (5)

(e) the efficiency. (2)

5. A THREE-phase, 440 V, shaft-driven generator shares the total electrical load of a ship with an auxiliary diesel generator. An over-excited synchronous motor is used in the supply system for kVAr compensation.

The ship's consumer load is 1 MW at 0.83 power factor lagging and the synchronous motor takes 40 kW.

(a) Sketch a single-line diagram of the power system. (3)

(b) The shaft-generator is loaded to its rated output of 650 kW at unity power factor; the diesel generator is operated at a power factor of 0.9 lagging.

Determine EACH of the following:

(i) the kW and kVAr loading of the diesel generator; (5)

(ii) the load current supplied by the diesel generator; (2)

(iii) power factor of the synchronous motor. (6)

6. A single-phase, 50 Hz transformer has 144 primary turns and 432 secondary turns, and a maximum flux of 7.5 mWb. The no-load input is 0.24 kVA at 0.26 power factor lagging. The transformer supplies a 1.2 kVA load at a power factor of 0.8 lagging.

Calculate EACH of the following:

(a) the magnetising current; (5)

(b) the primary current; (9)

(c) the primary power factor. (2)

7. With reference to propulsion-shaft driven generators:

(a) State TWO advantages of their application. (2)

(b) State ONE disadvantage of their application. (1)

(c) Sketch a labelled diagram of a shaft generator scheme that employs a frequency converter. (8)

(d) Describe the operation of the system sketched in Q7 (c). (5)

8. (a) With reference to the principle of operation of a synchronous motor, explain how it differs from that of an induction motor. (4)

(b) Explain why a synchronous motor is unable to produce starting torque. (6)

(c) State how an electronic converter is used to start a synchronous motor. (3)

(d) State THREE shipboard applications of synchronous motors. (3)

9. With reference to a full wave bridge rectifier:

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

(b) explain the circuit operation; (4)

(c) sketch labelled waveforms to show the relationships between the following:

(i) the bridge input voltage; (2)

(ii) the current through each diode; (4)

(iii) the load current; (2)