(5)

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY - MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 21 JULY 2022

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 ring main of total length 1000 m and resistance (go + return) of 0.002 Ω/m. The ring main is supplied with 240 V d.c. and the following loads are connected to the ring at distances measured clockwise from the supply point:

   - 60 A at 200 m
   - 90 A at 500 m
   - 150 A at 700 m

   Calculate EACH of the following:

   (a) the currents in sections AB and AD; **(6)**

   (b) the lowest voltage across any of the three loads; **(5)**

   (c) the total power loss in the ring main. **(5)**

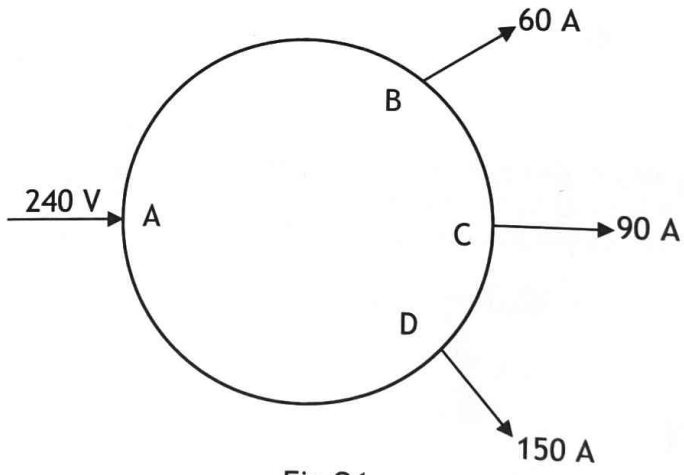

Fig Q1

2. A relay has a time constant of 5 ms and starts to operate 0.52 ms after connection to a 20 V d.c. supply.

(a) If the instantaneous current is 200 mA, calculate EACH of the following:

(i) the final steady state relay current; (6)

(ii) the resistance and inductance of the relay coil. (4)

(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. (6)

3. A balanced, three-phase, star connected load of 200 kW takes a leading current of 160 A from a 1.1 kV, 60 Hz supply.

Calculate EACH of the following:

(a) the resistance per phase; (6)

(b) the capacitance per phase; (3)

(c) the power factor; (2)

(d) the power consumed if the same load is connected in delta. (5)

4. A three-phase, 440 V, 60 Hz, 6 pole induction motor runs at a power factor of 0.82 lag and drives a load of 11 kW at a speed of 19.6 rev/s. The stator loss is 1.3 kW and the rotational losses (windage and friction) amount to 1.0 kW.

Calculate EACH of the following:

(a) the synchronous speed; (3)

(b) the rotor copper loss; (6)

(c) the input power to the motor; (4)

(d) the motor current. (3)

5. A three-phase, 440 V, 60 Hz shaft-generator supplies the following loads:

- incandescent lighting and heating 80 kW at unity pf
- fluorescent lighting 60 kW at 0.9 pf lagging
- navigation aids and miscellaneous 45 A at 0.85 pf lagging
- induction motors 240 kW at 0.8 pf lagging

(a) Determine the total kW, kVAr, kVA and the overall power factor of the ship's load. (10)

(b) A three-phase synchronous motor which takes 70 kW is now connected to the power system.

Determine EACH of the following:

(i) the required power factor of this motor to cause the shaft generator to operate at unity power factor; (3)

(ii) the current taken by the synchronous motor. (3)

6. A 250 kVA single-phase transformer has iron losses of 1.8 kW. The full load copper loss is 2 kW.

Calculate EACH of the following:

(a) efficiency at full load, 0.8 lagging p.f.; (6)

(b) kVA supplied at maximum efficiency; (4)

(c) maximum efficiency at 0.7 lagging p.f. (6)

7. With reference to shipboard electrical distribution systems:

(a) describe the meaning of the term *earth fault*; (2)

(b) explain the term *earth bonding* of electrical equipment, stating how it is achieved; (3)

(c) sketch a circuit diagram of one arrangement for detecting phase to earth faults in a shipboard high voltage three-phase system; (6)

(d) calculate the value of a neutral earthing resistor (NER) to limit the earth fault current to the full load rating of a 2 MW, 0.8 p.f., 3.3 kV, three-phase neutral earthed a.c. generator. (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 single-phase, 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 EACH of the following:

(i) the bridge input voltage; (2)

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

(iii) the load current. (2)