CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 20 OCTOBER 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 220 V ring main. The cable resistance (go + return) is 0.003 Ω/m.

   Calculate EACH of the following:

   (a) the resistance of each cable section AB, BC, CD and DE; (4)

   (b) the current in each cable section; (8)

   (c) the voltage at each load. (4)

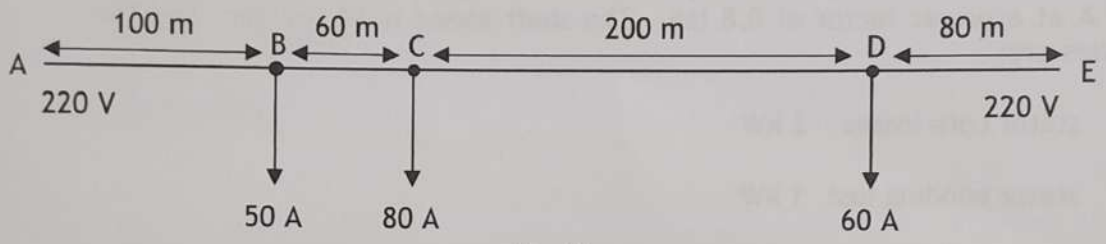

Fig Q1

2. A 56 μF capacitor and a 68 kΩ resistor are connected in series to a 15 V d.c. power supply.

   (a) Calculate EACH of the following:

   (i) the instantaneous current when the supply is switched on; (2)

   (ii) the capacitor voltage 3 seconds after switch-on; (3)

   (iii) the energy stored in the capacitor 3 seconds after switch-on. (2)

   (b) After 3 seconds of charging the supply is switched off and the capacitor is discharged through a 39 kΩ resistor.

   (i) Calculate the time taken for the capacitor voltage to fall to 6 V. (3)

   (ii) Using approximately scaled axes, sketch graphs of capacitor voltage against time for charge and discharge indicating:

   - the supply voltage and the voltage 3 seconds after switch-on
   - initial discharge voltage and the time when the voltage is 6 V (6)

3. A THREE-phase star connected load has a coil of inductance 0.2 H and resistance 30 Ω in EACH phase. The load is connected to a 415 V, 60 Hz supply.

(a) Calculate EACH of the following:

(i) the line current; (6)

(ii) the load power factor; (1)

(iii) the active load power. (2)

(b) THREE identical capacitors, arranged in delta, are connected to the supply to raise the power factor to unity.

Calculate the capacitor value. (7)

4. (a) Sketch and label a power flow diagram for an induction motor. (3)

(b) A THREE-phase, 440 V, 60 Hz, 6 pole induction motor draws a line current of 80 A at a power factor of 0.8 lag. The shaft speed is 19 rev/sec, and the losses are:

- stator core losses 2 kW
- stator winding loss 1 kW
- mechanical losses 1.5 kW

Calculate EACH of the following:

(i) the slip; (3)

(ii) the rotor winding loss; (6)

(iii) the shaft output power; (2)

(iv) the efficiency. (2)

7. (a) With reference to an incoming THREE-phase generator having the same phase sequence as an existing supply:

(i) list the THREE conditions which must be satisfied when synchronising the incoming generator; (3)

(ii) state how EACH condition required in Q7(a)(i) is controlled. (2)

(b) Two THREE-phase generators having identical AVR and governor characteristics operate in parallel.

Describe the effects resulting from EACH of the following:

(i) a faulty AVR causes a reduction in excitation of ONE generator; (7)

(ii) a faulty governor causes a loss of fuel supply to the prime mover of ONE generator. (4)

8. With reference to an electronic Variable Frequency Drive (VFD), which uses constant voltage/frequency (V/f) ratio to control the speed of a THREE-phase induction motor:

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

(b) describe the purpose of EACH block sketched in Q8(a); (4)

(c) explain why the V/f ratio needs to be constant; (3)

(d) describe Pulse Width Modulation (PWM), stating how this technique controls the voltage and the frequency of the motor waveform. (5)

9. The alarm circuit in Fig Q9 shows a silicon transistor, a relay and a klaxon.

(a) With reference to current flow, describe the operation of the circuit when S is closed. (4)

(b) State EACH of the following:

(i) the type of transistor; (1)

(ii) ONE marine application for this circuit. (1)

(c) S is closed and $V_{BE} = -0.7$ V, $V_{CE} = -0.3$ V.

Calculate EACH of the following:

(i) the power dissipated by the relay coil; (3)

(ii) the current gain of the transistor; (4)

(iii) the power supplied to the circuit. (3)

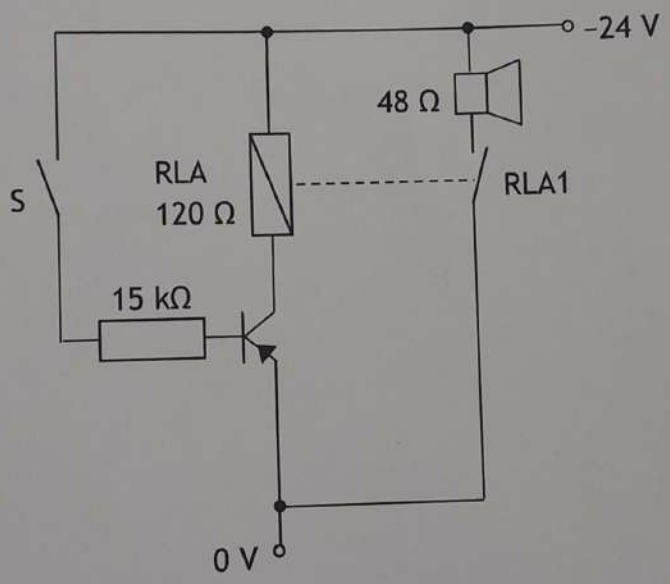

Fig Q9

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

- induction motors — 200 kW, 0.7 lag
- fluorescent lighting — 14 kVA, 0.86 lag
- incandescent lighting — 5 kW, u.p.f.
- navigation aids — 27 A, 0.9 lag

(a) Calculate EACH of the following:

(i) the total active power supplied; (4)

(ii) the generator power factor. (6)

(b) A THREE-phase synchronous motor is connected to the supply to raise the generator power factor to unity. The synchronous motor has an input power of 50 kW.

Calculate EACH of the following for the synchronous motor:

(i) the power factor; (4)

(ii) the current. (2)

6. A 440/220 V, single-phase transformer takes a no-load current of 3 A at 0.2 power factor lag. At full-load the primary current is 75 A at 0.6 power factor lag.

(a) Sketch a labelled phasor diagram to show the primary and secondary voltages and all currents (ignore winding impedance voltages). (5)

(b) Calculate EACH of the following:

(i) the full-load secondary current; (6)

(ii) the secondary power factor; (2)

(iii) the full-load efficiency. (3)