CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 12 DECEMBER 2019

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Worksheet Q4

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 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 fed into the ring main in each direction; (6)

   (b) the lowest voltage across any of the three loads; (6)

   (c) the total power loss in the ring main. (4)

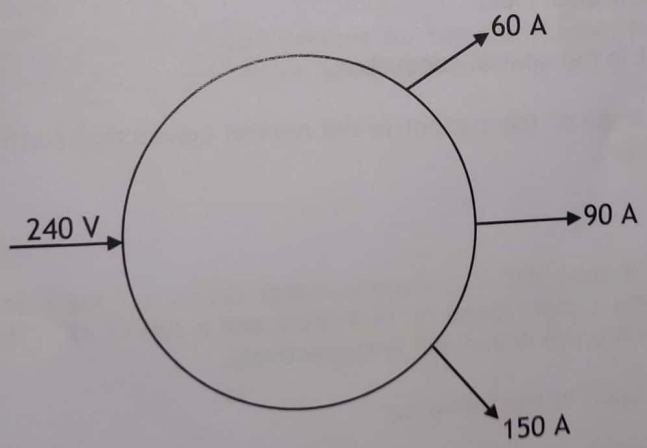

Fig Q1

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2. A 600 μF capacitor is charged from a 30 V d.c. supply via a 250 Ω resistor. When fully charged the capacitor is disconnected from the supply and connected across a 25 Ω resistor in order to be discharged.

Calculate EACH of the following:

(a) the initial charging current; (2)

(b) the capacitor voltage after 137 ms; (4)

(c) the time taken for the capacitor to charge to 22 V; (3)

(d) the initial discharge current; (2)

(e) the discharge current after 30 ms; (3)

(f) the resistor voltage after 30 ms of discharge. (2)

3. A three-phase, 415 V, 4-wire power supply has the following unity power factor loads:

- R-N: 24 kW
- S-N: 18 kW
- T-N: 12 kW

Calculate EACH of the following:

(a) the current in each load; (4)

(b) the current in the neutral conductor; (10)

(c) the phase angle of the current in the neutral conductor relative to the red phase voltage. (2)

4. A three-phase, 8 pole, 440 V, induction motor drives a 7 kW load at a power factor of 0.8 with a shaft speed of 14.4 rev/s and a slip of 4%. The stator and rotational losses are 600 W and 400 W respectively.

(a) Determine EACH of the following:

(i) the supply frequency; (4)

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

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

(iv) the supply current. (2)

(b) Insert the power values on the power-flow diagram provided in Worksheet Q4. (4)

5. Two 440 V, three-phase, a.c. generators supply the following loads:

- 1111 kVA at a power factor of 0.9 lagging
- 500 kW at unity power factor
- 500 kW at a power factor of 0.9 leading
- 1000 kVA at a power factor of 0.8 lagging

The load on No. 1 generator is 1300 kW at a power factor of 0.96 lagging.

Determine EACH of the following:

(a) the kW load delivered by generator No. 2; (5)

(b) the power factor of generator No. 2; (5)

(c) the total load current; (3)

(d) the current supplied by generator No. 2. (3)

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

(b) A three-phase, 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 an automatic voltage regulator (AVR) for ship's a.c. generators:

(a) explain why it is needed; (3)

(b) state the acceptable performance limits following a 15% voltage dip; (2)

(c) sketch a clearly labelled block diagram; (6)

(d) describe the operation of the block diagram sketched in Q7(c). (5)

8. With reference to shipboard three-phase electrical distribution systems:

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

(b) explain the term *protective earthing* of electrical equipment, stating how it is achieved; (4)

(c) sketch a clearly labelled circuit diagram of one arrangement for detecting phase to earth faults in an earthed neutral system; (5)

(d) calculate the ohmic 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 generator. (5)

9. Fig Q9 shows a single-transistor amplifier. The voltage between the transistor base and emitter is 0.6 V and the d.c. voltage at the output terminals is 8 V.

(a) Calculate EACH of the following, assuming that the base current is small enough to be neglected:

(i) the voltage between the collector and the emitter of the transistor; (4)

(ii) the power dissipated in the emitter resistor; (3)

(iii) the power dissipated in the transistor. (3)

(b) Sketch a clearly labelled circuit diagram, shown in Fig Q9, to show the additional components needed to make the circuit suitable for amplifying a.c. signals. (3)

(c) State the purpose of the additional components shown in Q9(b). (3)

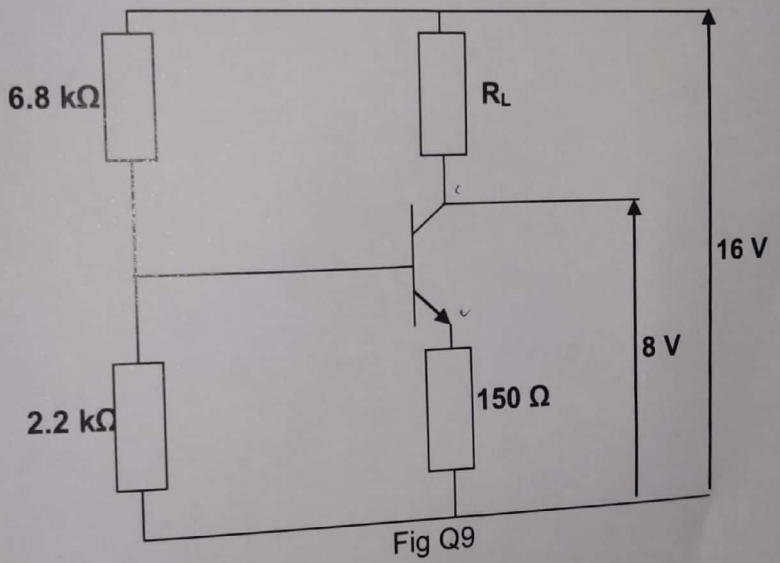

Fig Q9