CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 25 MARCH 2021

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Worksheet Q9

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 1300 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; (4)

   (b) the currents fed into the ring main in each direction; (7)

   (c) the voltage at each load point; (4)

   (d) show that the voltage at B equals 240 V. (1)

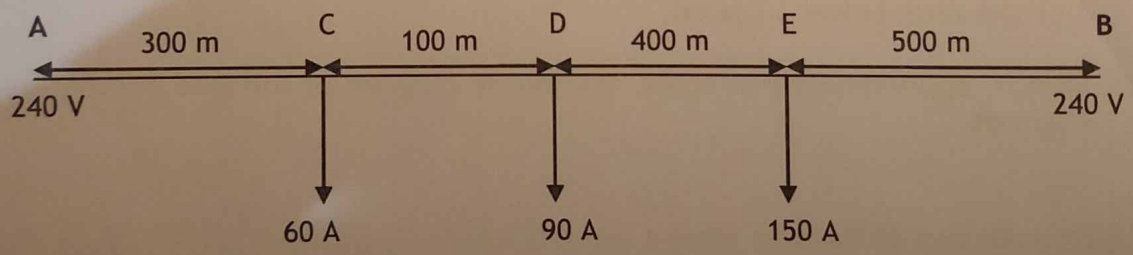

Fig Q1

Not to scale

2. A d.c. relay coil of 400 mH inductance has a time constant of 1.6 ms. It takes 3.2 ms for the current to rise to 86.5 mA after switch on.

Calculate EACH of the following:

(a) the coil resistance; (2)

(b) the maximum current; (3)

(c) the supply voltage; (2)

(d) the current 4 ms after switch on; (3)

(e) the time taken for the current to reach 70 mA; (4)

(f) the final value of the stored energy. (2)

3. Three resistive loads of 50 Ω, 40 Ω, and 30 Ω are connected respectively in star to the R, S, and T phases of a three-phase, 4-wire, 415 V, power supply.

(a) Determine EACH of the following:

(i) the current in each load; (5)

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

(iii) the total power supplied. (2)

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

4. A three-phase electrical load of 800 kW is operating at a power factor of 0.68 lagging. It is desired to improve the power factor to 0.92 lagging by connecting a synchronous motor driving a load of 200 kW with an efficiency of 91%.

Determine EACH of the following:

(a) the kVA rating of the synchronous motor; (13)

(b) the power factor of the synchronous motor. (3)

5. Two, six-pole, three-phase a.c. generators operating in parallel supply a total load of 2000 kVA at a power factor of 0.8 lagging.

The generator load characteristics are linear with the test results given in Table Q5.

Generator	Speed/kW	Voltage/kVAR
No. 1	1440 rev/min on No-load 1200 rev/min on 1200 kW	500 V on No-load 415 V on 1000 kVAR
No. 2	1360 rev/min on No-load 1180 rev/min on 900 kW	490 V on No-load 425 V on 800 kVAR

Table Q5

Determine EACH of the following:

(a) the supply frequency; (6)

(b) the bus-bar voltage; (6)

(c) the kVA output of each generator; (2)

(d) the operating power factor of each generator. (2)

6. (a) With reference to three-phase transformers, sketch labelled diagrams for EACH of the following connection types indicating line and phase voltages and line currents:

(i) star-star; (4)

(ii) delta-star. (4)

(b) A three-phase, step-down transformer has a turns ratio of 12 and takes 10 A when it is connected to a 6600 V supply. If the transformer is star-delta connected, calculate EACH of the following:

(i) the secondary line voltage; (3)

(ii) the secondary line current; (3)

(iii) the output kVA. (2)

7. With reference to the parallel operation of alternators:

(a) state FOUR ideal conditions that must be met prior to closing the circuit breaker of an incoming machine onto a live busbar; (4)

(b) sketch a labelled block diagram of an auto-synchronizer; (6)

(c) describe the operation of the auto-synchronizer sketched in Q7(b). (6)

8. (a) State THREE reasons why switchboard instruments are supplied via instrument transformers from the power circuits which they monitor. (3)

(b) Explain why it is hazardous to open circuit a current transformer whilst its primary is still energised. (4)

(c) Sketch a circuit diagram showing an ammeter, a voltmeter and a wattmeter fed from a single phase supply via current and voltage transformers. (5)

(d) An ammeter, a voltmeter and a wattmeter monitoring a single phase supply read 40 A, 240 V and 8 kW respectively.

Calculate the power factor of the circuit. (4)

9. A transistor with the characteristics shown on Worksheet Q9 is used in a common emitter amplifier circuit with a 14 V d.c. supply and a 2 kΩ resistive load. The base bias current is 80 mA for a sinusoidal input signal current of ±60 mA.

(a) Draw the load line on Worksheet Q9. (2)

(b) Determine the values of the collector d.c. voltage and current. (4)

(c) Determine the R.M.S. values of EACH of the following:

(i) the a.c. load current; (4)

(ii) the a.c. output voltage. (4)

(d) Calculate the a.c. signal current gain of the amplifier. (2)