8

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 17 DECEMBER 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. (a) For the circuit shown in Fig Q1, determine EACH of the following:

(i) the current through the 10 Ω resistor; (8)

(ii) the p.d. across each resistor. (4)

(b) The 10 Ω resistor is now disconnected from the circuit.

Calculate the voltage V_{AB}. (4)

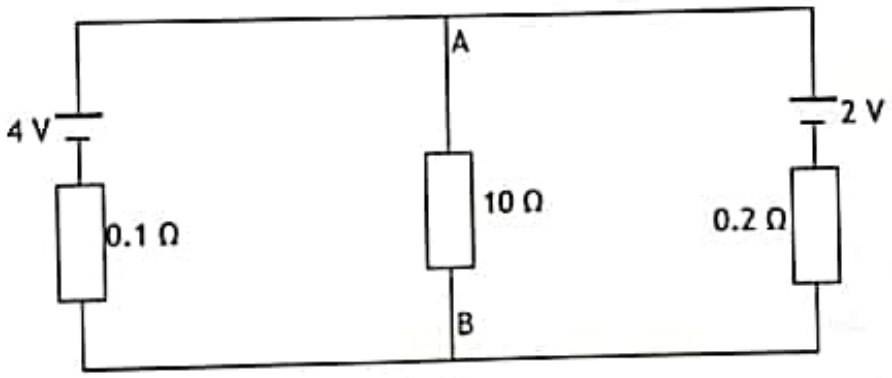

Fig. Q1

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2. A 120 μF capacitor is charged through a 4.7 kΩ resistor from a 12 V d.c. power supply.

(a) Calculate the instantaneous charging current at switch on. (2)

(b) State the expression for the capacitor charging voltage and determine its value 2 seconds after switch on. (4)

(c) Calculate the energy stored in the capacitor 2 seconds after switch on. (2)

(d) After 2 seconds of charging the supply is switched off and the capacitor is discharged through a 1.2 kΩ resistor.

(i) Determine the time taken during discharge for the capacitor voltage to fall to 5 V. (4)

(ii) Sketch a clearly labelled graph to show how a capacitor voltage changes over charge/discharge cycle. (4)

3. (a) THREE identical coils of impedance Z are to be connected to a balanced three-phase a.c. power supply of line voltage V_L. When the coils are star connected, the line currents are one third of the line currents when delta connected.

Using relationships for balanced three-phase circuits, show that this ratio is correct. (4)

(b) Three identical coils connected in delta across a three-phase, 415 V, 50 Hz power supply have a total power demand of 12 kW with line current of 25 A.

(i) Calculate the supply power factor. (2)

(ii) Determine the resistance and inductance of each coil. (6)

(c) The supply frequency is now raised to 60 Hz while the voltage remains constant.

Calculate the new line current and the total power supplied. (4)

4. A three-phase, four-pole induction motor has the following operating parameters:

Parameter	Value	Parameter	Value
Voltage	440 V	Frequency	50 Hz
Line current	120 A	Output power	50 kW
Power factor	0.7 lag	Speed	24 rev/s
Stator winding losses	3 kW	Rotational losses	4 kW

Calculate EACH of the following:

(a) the rotor winding loss; (8)

(b) the stator core loss; (6)

(c) the efficiency. (2)

5. Fig Q5 shows a one-line diagram of a ship's electrical power system:

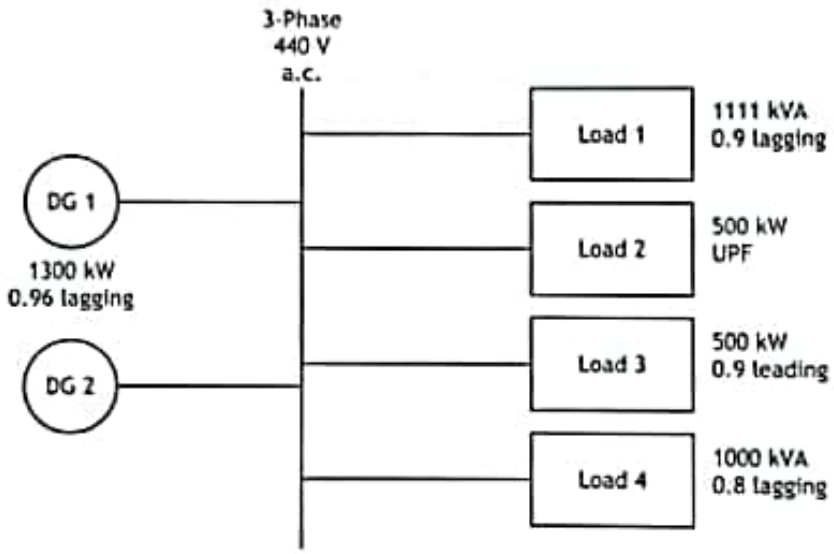

Fig Q5

Calculate EACH of the following:

(a) the kW load delivered by DG2; (5)

(b) the power factor of DG2; (5)

(c) the total load current; (3)

(d) the current supplied by DG2. (3)

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6. (a) With reference to a single-phase autotransformer:

(i) sketch a labelled diagram; (3)

(ii) describe how this autotransformer is different to an ordinary power transformer; (3)

(iii) state FOUR advantages compared to an ordinary power transformer; (4)

(iv) state ONE shipboard application of an autotransformer. (1)

(b) An autotransformer is used to supply a single-phase, 230 V, 2 kW, unity power factor load from a 400 V supply.

Calculate EACH of the following, neglecting losses:

(i) the current in the turns not connected across the load; (4)

(ii) the current in the turns connected across the load. (1)

7. (a) State the *function* of an AVR. (2)

(b) State FOUR conditions external to a generator that cause its terminal voltage to drop. (4)

(c) Sketch and label a typical AVR response curve, identifying the application of load, recovery time, maximum acceptable voltage dip, and the permissible steady-state voltage regulation. (6)

(d) State the function of an AVR trimming potentiometer for EACH of the following cases:

(i) when a generator operates in standalone mode; (2)

(ii) when a generator operates in parallel. (2)

8. With reference to a THREE-phase brushless generator system:

(a) sketch a clearly labelled circuit diagram showing the essential features; (8)

(b) describe the system sketched in Q8(a). (8)

9. (a) State the conditions necessary to *turn on* and *turn off* a thyristor ('SCR'). (4)

(b) Describe the operation of the circuit shown in Fig Q9. (8)

(c) Sketch a clearly labelled load-voltage waveform for EACH of the following trigger delay angles:

(i) 60°; (2)

(ii) 120°. (2)

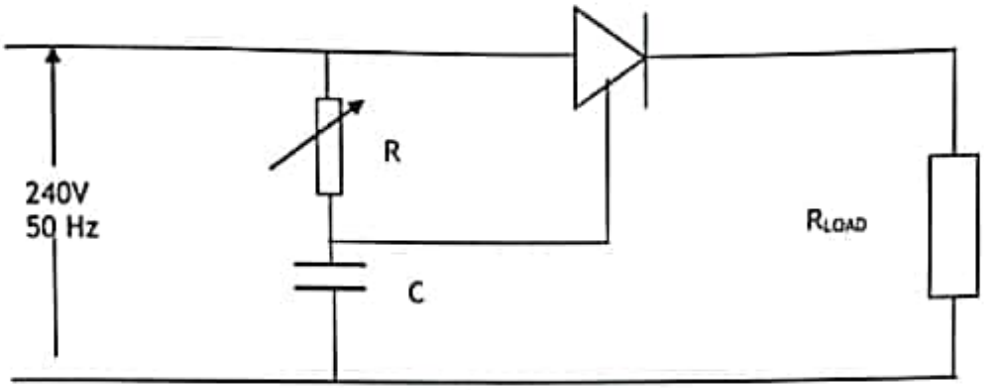

Fig Q9