10

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 MARCH 2024

0915 - 1215 hrs

Materials to be supplied by examination centres

Candidate's examination workbook
Graph paper

Examination Paper Inserts

Worksheet Q9

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. For the circuit shown in Fig Q1, determine EACH of the following:

(a) the currents I_1, I_2 and I_L; (12)

(b) the total power dissipated; (2)

(c) whether the batteries are charging or discharging. (2)

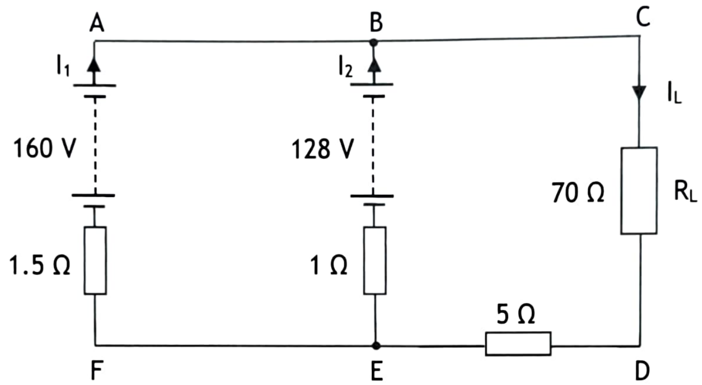

Fig Q1

2. A relay starts to operate when the current is 250 mA, 0.4 ms after connection to a 24 V d.c. supply. The relay time constant is 3 ms.

(a) Calculate EACH of the following:

(i) the final value of relay current; (3)

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

(b) A 56 Ω resistor is connected in series with the relay coil. Calculate the new operating time. (5)

(c) Sketch a current/time graph for the relay to show the rise of current from switch-on before the resistor is connected.

Indicate EACH of the following:

- the operating current and rise time;
- the final current and approximate rise time. (4)

3. Three loads are connected in star to a three-phase, 4-wire, 440 V supply. The load impedance values are:

$Z_R = 50\ \Omega$, 0.866 lag $\quad$ $Z_S = 90\ \Omega$, 0.866 lead $\quad$ $Z_T = 33\ \Omega$, unity

(a) Calculate the current in each load. (5)

(b) Calculate the magnitude and phase angle of the neutral current with respect to the R phase voltage. (6)

(c) Sketch, approximately to scale, a labelled phasor diagram to show the relationship between the phase voltages, load currents and neutral current. (5)

4. (a) With reference to a three phase generator with static excitation:

(i) sketch and label the electrical system diagram; (4)

(ii) describe the response of the electrical system sketched in Q4(a)(i) when a large induction motor is started direct on line. (2)

(b) The generator referred to in Q4(a) is to be synchronised with an identical generator already on load.

Sketch and label a circuit diagram to show how three lamps are connected to detect synchronism. (4)

(c) With reference to Q4(b), state EACH of the following:

(i) the ideal conditions of the incoming generator before closing the circuit breaker; (2)

(ii) the indication from the synchronising lamps when ideal conditions have been achieved; (2)

(iii) the immediate effect on the existing generator current if the incoming generator is running slow when the circuit breaker is closed. (2)

5. A three-phase, 2 MVA, 6.6 kV/690 V, star/delta transformer has a full-load efficiency of 96% at 0.8 lag. Maximum efficiency occurs at $^3/_4$ full-load.

(a) Calculate EACH of the following:

(i) the core loss; (6)

(ii) the maximum efficiency when the load power factor is 0.6 lag; (2)

(iii) the primary and secondary phase currents at $^2/_3$ full-load. (7)

(b) State the vector group symbol for this transformer if the primary to secondary phase shift is −30°. (1)

6. Two, three-phase, four-pole generators share a total ship's load. The active and reactive loading is 1800 kW and 1260 kVAr lagging respectively. The governor and AVR characteristics are linear and have settings as shown in Table Q6.

GENERATOR	GOVERNOR		AVR	
	No-load (rev/min)	Droop (rev/min/kW)	No-load (V)	Droop (V/kVAr)
G1	1925	0.05	470	0.025
G2	1900	0.03	450	0.04

Table Q6

(a) Determine EACH of the following:

(i) the load power factor; (2)

(ii) the busbar frequency; (5)

(iii) the busbar voltage. (3)

(b) Assuming the governor and AVR droop settings are not changed, describe the throttle and excitation setting adjustments required to achieve equal active and reactive loading of the generators at 60 Hz, 440 V. (6)

7. For the three-phase induction motor shown in Fig Q7:

(a) identify the numbered parts; (5)

(b) describe how torque is produced; (4)

(c) explain the meaning of *pull-out* torque; (2)

(d) sketch and label torque/speed characteristics on the same axes, to show the effect of three increasing rotor resistance values R_1, R_2 and R_3, indicating EACH of the following:

- the characteristic for each of the three rotor resistances;
- *pull-out* torque;
- synchronous speed.

(5)

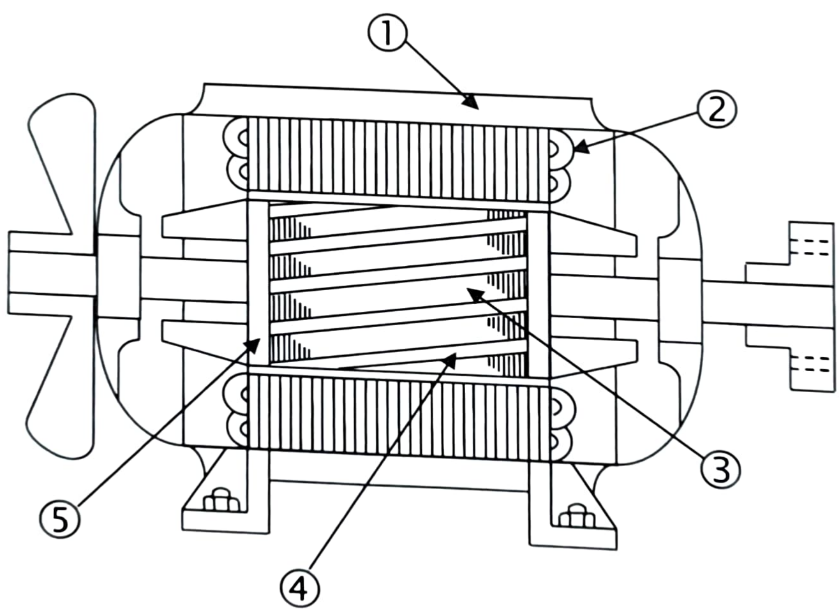

Fig Q7

8. With reference to three-phase, insulated neutral marine electrical distribution systems:

(a) explain the meaning of *insulated neutral*; (2)

(b) state the advantage of this system compared to an earthed neutral system; (2)

(c) sketch a labelled circuit diagram of ONE arrangement for detecting phase to earth faults; (5)

(d) describe the indication from the arrangement sketched in Q8(c) for EACH of the following conditions:

- no earth fault;
- a phase to earth fault. (4)

(e) explain the voltage stress experienced by the insulation of the two healthy phases while there is an earth fault on the other phase. (3)

9. (a) A full-wave bridge rectifier is fed from a 110 V, single-phase supply via a 4:1 step down transformer. A 100 Ω resistive load is connected to the bridge rectifier.

(i) sketch and label a circuit diagram; (4)

(ii) calculate the average d.c. load voltage and current, ignoring diode volt drop. (5)

(b) Using worksheet Q9, indicate EACH of the following on the rectified waveforms:

(i) the r.m.s. load voltage; (1)

(ii) the average d.c. load voltage; (1)

(iii) which diodes conduct during each half cycle. (2)

(c) A smoothing capacitor is connected in parallel with the load for the circuit sketched in Q9(a). Using worksheet Q9:

(i) sketch on the rectified waveform the load voltage waveform after connecting the capacitor; (2)

(ii) indicate the average d.c. voltage after smoothing. (1)