15

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 31 MARCH 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. For the circuit shown in Fig Q1, calculate EACH of the following:

(a) the current in EACH battery; (10)

(b) the load voltage; (3)

(c) the load power. (3)

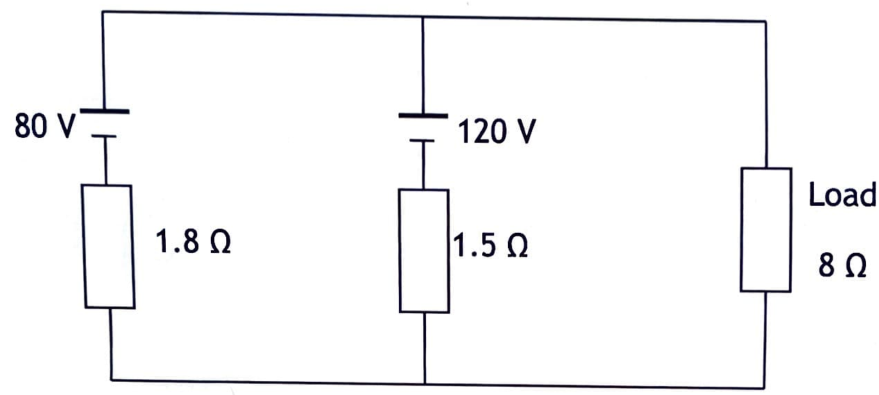

Fig Q1

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. THREE resistive loads of 50 Ω, 20 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; (3)

(ii) the current in the neutral wire; (6)

(iii) the total power supplied to the load. (3)

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

4. A 100 kW, three-phase, star-connected, induction motor is operating at the following parameters:

Parameter	Value	Parameter	Value
Supply voltage	6,600 V	Synchronous Speed	500 r.p.m
Supply frequency	60 Hz	Slip	1.7%
Power factor	0.86 lag	Stator winding loss	2.5 kW
Mechanical losses	1.3 kW	Stator core loss	3.5 kW

(a) Determine EACH of the following:

(i) the rotor winding loss; (3)

(ii) the line current; (5)

(iii) the efficiency. (2)

(b) Sketch a fully labelled power-flow diagram for the motor indicating power at EACH stage. (6)

5. A three-phase, 440 V, shaft-driven generator shares the total electrical load of a ship with an auxiliary diesel generator. An over-excited synchronous motor is used in the supply system for kVAr compensation.

The ship's total consumer load is 1 MW at 0.83 power factor lagging and the synchronous motor takes 40 kW.

(a) Sketch a single-line diagram of the power system. (3)

(b) The shaft-driven generator is loaded to its rated output of 650 kW at unity power factor. The diesel generator is operated at a power factor of 0.9 lagging.

Determine EACH of the following:

(i) the kW and kVAr loading of the diesel generator; (5)

(ii) the load current supplied by the diesel generator; (2)

(iii) the power factor of the synchronous motor. (6)

6. A three-phase, delta/star connected, step-down transformer has a turns ratio of 26:1 and supplies a 440 V, 450 kW load at a power factor of 0.82 lagging.

(a) Sketch a labelled circuit diagram showing line and phase voltages. (6)

(b) Calculate EACH of the following:

(i) secondary phase voltage; (2)

(ii) secondary phase current; (3)

(iii) primary phase voltage; (2)

(iv) primary line current. (3)

7. (a) Sketch and label the V/I characteristics of a three-phase generator operating at constant speed with EACH of the following load power factors:

(i) unity; (2)

(ii) 0.8 lagging; (2)

(iii) 0.8 leading. (2)

(b) Explain why it is recommended that TWO *identical* a.c. generators running in parallel should operate at similar power factors. (5)

(c) Explain how the power factor of paralled a.c. generators may be altered independently of the ship's load power factor. (5)

8. (a) State the main reasons why switchboard instruments are supplied via instrument transformers from the power circuits which they monitor. (4)

(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. (4)

(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. Fig Q9 shows a 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 the circuit diagram shown in Fig Q9, adding the additional components needed to make the circuit suitable for amplifying a.c. signals. (3)

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

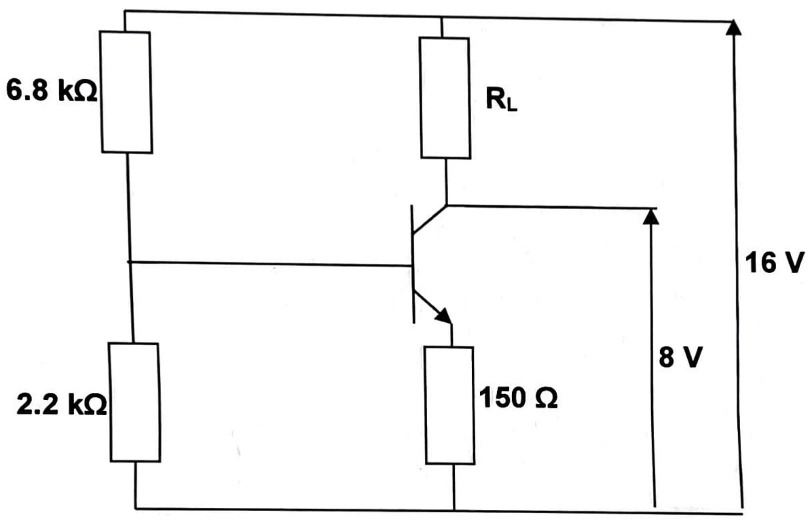

Fig Q9