CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-33 - ELECTROTECHNOLOGY

THURSDAY, 27 AUGUST 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. 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)

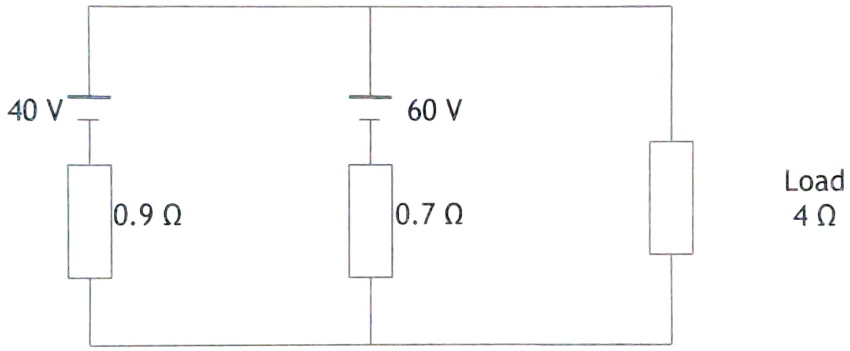

Fig Q1

2. A 73.5 μF capacitor is charged through a 6.8 kΩ resistor from a 24 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 1 second after switch on. (4)

(c) Calculate the energy stored in the capacitor 1 seconds after switch-on. (2)

(d) After 1.5 seconds of charging the supply is switched off and the capacitor is discharged through a 22 kΩ resistor.

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

(ii) Sketch a clearly labelled graph with approximately scaled axes to show the capacitor voltage changes over its charge/discharge cycle. (4)

3. A three-phase, 440 V, four-pole, star connected generator runs at a speed of 25 rev/s. It supplies a delta connected load, each branch of which has a resistance of 30 Ω in series with an inductance of 75 mH.

(a) Sketch a clearly labelled circuit diagram. (2)

(b) Determine EACH of the following:

(i) the supply frequency; (2)

(ii) the generator phase voltage; (2)

(iii) the load phase current; (6)

(iv) the generator phase current; (2)

(v) the generator power output. (2)

4. A three-phase, eight-pole, star connected induction motor runs on a 415 V, 50 Hz power supply. The stator resistance is 0.1 Ω per phase, the rotational losses (windage and friction) are 1 kW, the speed is 12 rev/s and the shaft output power is 24 kW.

If the input current is 57 A at a lagging power factor of 0.707, calculate EACH of the following:

(a) the output torque; (2)

(b) the rotor winding loss; (5)

(c) the stator winding loss; (2)

(d) the stator core loss; (5)

(e) the efficiency. (2)

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 1200 kW at 0.8 power factor lagging and the synchronous motor takes 70 kW.

(a) Sketch a clearly labelled single-line diagram of the power system. (2)

(b) The shaft-generator is loaded to its rated output of 750 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; (8)

(ii) the load current supplied by the diesel generator; (3)

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

6. A 440 V/110 V, single-phase transformer has a primary resistance of 0.68 Ω and a secondary resistance of 0.045 Ω. The transformer core loss is 250 W at rated voltage.

Calculate EACH of the following at maximum efficiency;

(a) the primary and secondary currents; (10)

(b) the power output when the load power factor is 0.8 lagging; (2)

(c) the value of efficiency when the load power factor is 0.8 lagging. (4)

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

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

(c) Sketch a clearly labelled, 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. (a) With reference to the principle of operation of a synchronous motor, explain how it differs from that of an induction motor. (5)

(b) Explain why a synchronous motor is unable to produce starting torque. (5)

(c) State how an electronic converter is used to start a synchronous motor. (3)

(d) State THREE shipboard applications of synchronous motors. (3)

9. A single-phase, 230 V, 50 Hz, 3:1 step-down transformer has a secondary winding resistance of 1 Ω and supplies a half-wave rectifier circuit. The rectifier circuit has a resistive load of 680 Ω and the diode has a forward resistance of 14 Ω.

(a) Sketch clearly labelled diagram for EACH of the following:

(i) a circuit diagram; (3)

(ii) the load voltage waveform indicating maximum and average voltage levels. (3)

(b) Calculate EACH of the following load values:

(i) the maximum current; (5)

(ii) the average current; (3)

(iii) the average voltage. (2)