CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

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

041-33 - ELECTROTECHNOLOGY

THURSDAY, 15 DECEMBER 2016

0915 - 1215 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.

2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph paper

ELECTROTECHNOLOGY

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. A non-linear element is connected in series with a resistor across 240 V. d.c. supply.

   The non-linear element is governed by the law $I = kV^2$. When the resistor is set to 10 Ω the supply current is 12 A.

   (a) Calculate EACH of the following:

      (i) the resistance value required to reduce the current to 8 A; (8)

      (ii) the resistance of the non-linear element when the current is 8 A. (2)

   (b) The supply voltage is reduced to 159 V. Calculate the power dissipated in the non-linear element if the series resistor is reset to 10 Ω. (6)

2. A 120 uF capacitor is charged through a resistance from a 12 V d.c. supply and the instantaneous charging current at switch-on is 2.55 mA.

   (a) Calculate EACH of the following:

      (i) the value of the charging resistance; (2)

      (ii) the time constant; (2)

      (iii) the voltage across the capacitor after 2 s of charging; (3)

      (iv) the energy stored after 2 s. (2)

   (b) After 2.5 s of charging the supply is switched off and the capacitor is discharged through a 1.2 kΩ resistor.

      Calculate EACH of the following:

      (i) the new time constant; (2)

      (ii) the voltage across the capacitor after 124 ms; (3)

      (iii) the discharge current at 124 ms. (2)

[OVER

3. An unstabilised d.c. power supply voltage which varies between 10 V and 60 V is connected across a stabiliser circuit comprising a 520 Ω resistor in series with a 8.2 V zener diode. The zener diode has a slope resistance of 12 Ω and requires a minimum operating current of 1 mA. The arrangement supplies a variable load current of 0-40 mA.

(a) Draw a circuit diagram of the arrangement. (2)

(b) Calculate EACH of the following:

(i) the load voltage when the load current is zero and the supply p.d. is 10 V; (4)

(ii) the load voltage when the load current is 40 mA and the supply p.d. is 50 V; (3)

(iii) the minimum value of the supply p.d. to give a stabilised load voltage for a load current of 40 mA; (3)

(iv) the power dissipated in the zener diode when the supply is 60 V and the load current is 30 mA. (4)

4. A series circuit comprising a pure resistor 'R', a coil having resistance and inductance and a capacitor is connected in series across a 60 V variable frequency supply. When the supply frequency is 400 Hz the current reaches its maximum value of 0.8 A and the voltages across the pure resistor 'R' and the capacitor are 40 V and 200 V respectively.

Calculate EACH of the following:

(a) the value of the pure resistor 'R'; (2)

(b) the value of the capacitor; (2)

(c) the resistance and inductance of the coil; (6)

(d) the p.d. across the coil; (3)

(e) the coil power factor. (3)

5. (a) State two disadvantages of operating electrical circuits at a low power factor. (2)

(b) A 3-ph, 440 V, 80 kVA transformer supplies a unity power-factor load of 15 kW and an inductive load of 55 kW and power-factor of 0.67.

Determine the minimum kVAR rating of a load capacitor bank to ensure that the supply transformer is not overloaded. (10)

Calculate the current supplied by the transformer in EACH of the following:

(i) prior to the power factor correction being applied; (2)

(ii) after the power factor correction is applied. (2)

6. (a) Describe the principle of operation of a 1-ph, a.c. power transformer. (6)

(b) A 500 kVA power transformer has a full load copper loss of 4 kW and iron loss of 2.5 kW.

Calculate EACH of the following:

(i) the kVA load at maximum efficiency; (5)

(ii) the maximum efficiency for a load power factor of 0.75 lagging at this kVA rating in Q6(b)(i). (5)

7. (a) Explain the reasons for using instrument transformers in a ship's electrical distribution system. (4)

(b) Sketch a circuit diagram of a voltmeter, an ammeter and a wattmeter connected to a 1-ph, a.c. circuit utilising appropriate current transformers and voltage transformers on a set of a.c. switchboard instruments. (6)

(c) Explain why the secondary windings of instrument transformers are connected to earth. (4)

(d) A voltmeter, ammeter and wattmeter, connected to a 1-ph, a.c. circuit, recorded the following readings:

440 V, 570 A and 240 kW

Calculate the power factor of the circuit. (2)

8. (a) State two advantages and two disadvantages of the wound rotor method of starting an induction motor. (4)

(b) Sketch a circuit diagram showing the rotor/slip rings and starting resistors connection for a three phase wound rotor induction motor. (6)

(c) A three phase 4 pole wound rotor induction motor has a rotor induced e.m.f. of 230 V, 60 Hz between the slip rings at standstill.

Calculate EACH of the following:

(i) the rotor e.m.f. and rotor frequency at a slip of 0.05 p.u.; (4)

(ii) the synchronous speed. (2)

9. (a) Draw a circuit diagram illustrating how a single thyristor ('silicon controlled rectifier') may be used to provide a variable voltage d.c. output from a single phase a.c. supply. (8)

(b) Explain how the *firing angle* of the thyristor is varied. (4)

(c) Sketch waveforms for the output voltage when the firing angle is:

(i) 60°; (2)

(ii) 120°. (2)