higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T470(E)(A7)T

APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

7 April 2014 (Y-Paper)
13:00–16:00

REQUIREMENTS: Graph paper

Calculators may be used.

This question paper consists of 6 pages and 2 formula sheets.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTROTECHNICS N4
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly.

QUESTION 1

1.1 Two batteries having an EMF of 30 V and 20 V and an internal resistance of 0,2 ohms and 1,2 ohms respectively are to be charged by a DC-generator with an EMF of 40 V and an internal resistance of 0,4 ohms.

Use Kirchhoff's laws to calculate the value of the current:

1.1.1 Supplied by the generator (4)

1.1.2 Through battery A (2)

1.1.3 Through battery B (2)

1.2 An unknown resistor is connected in parallel across a rheostat with a value of 5 Ω which is then connected in series with a heater element of 2 000 W.

What must the value of the unknown resister be so that the heater draws 20 A when the whole circuit is connected across a 150 V supply? (7)

1.3 On which factors does the magnitude of the hysteresis loss depend? (3)

1.4 For what reasons are certain alloys used in the manufacturing of standard resistors for use in measuring instruments? (2)

[20]

QUESTION 2

2.1 A 4 microfarad capacitor and an unknown capacitor are connected in series across a 20 volt supply.

Determine:

2.1.1 The value of the unknown capacitor if the total capacitance is 3 microfarads (2)

2.1.2 The potential difference across each capacitor (4)

2.2 How can a magnetic field of a solenoid be strengthened? (3)

2.3 An aluminium conductor, 200 m long, is connected in parallel to a copper conductor of the same length. When a current of 250 A passes through the combination, it is found that the current through the copper conductor is 150 A. The diameter of the aluminium conductor is 12 mm.

Calculate:

2.3.1 The diameter of the copper conductor if the resistivity of copper is 0,017 micro-ohm metres and the resistivity of aluminium is 0,028 micro-ohm metres. (7)

2.3.2 The voltage drop across the conductors (1)

2.4 The temperature coefficient of a conductor is 0,004 per degree Celsius.

Calculate the resistance at 100° C if the resistance decreases from 300 ohms at 150°C. (3)

[20]

QUESTION 3

3.1 The open-circuit characteristics of a separately excited DC-generator is as follows:

Terminal voltage (V)	40	80	130	155	160	165
Field current (A)	2	4	9	17	20	24

Plot a graph and determine:

3.1.1 The voltage to which the machine will excite on no-load when shunt-connected, if the total field resistance is 8 ohms (8)

3.1.2 The value of the critical resistance (2)

3.2 A short shunt compound generator supplies a load current of 100 A. It has a shunt field resistance of 50 ohms, an armature resistance of 0,1 ohms and a series field resistance of 0,5 ohms.

Calculate the armature EMF if the terminal voltage is 250 V. (5)

3.3 How can the field coils of DC machines be connected with self-excitation? (3)

3.4 What is the chief purpose of a DC motor starter? (2)

[20]

QUESTION 4

4.1 A single-phase 50/500 V transformer has a net area of 20 cm² and a maximum flux density of 0,75 tesla. The primary winding has 150 turns.

Calculate:

4.1.1 The frequency (4)

4.1.2 The number of turns in the secondary winding (2)

4.2 A sinusoidal AC-supply has a RMS value of 212,1 V and a frequency of 60 Hz.

Calculate:

4.2.1 The maximum value of the voltage

4.2.2 The periodic time in milliseconds

(2 x 1) (2)

4.3 In a certain circuit of three parallel branches, the instantaneous branch currents are represented by:

$$i_1 = 45Sin(wt - \frac{180}{4})A$$

$$i_2 = 60Sin(wt + \frac{180}{3})A$$

$$i_3 = 30Sin(wt + \frac{180}{4})A$$

4.3.1 Calculate the magnitude of the supply current and write it in the form

$$i = I_{max} Sin(wt + \theta)$$ (5)

4.3.2 Represent these currents by drawing a phasor diagram. (2)

4.4 An impedance of 9 + j9 ohms and an impedance of 3 - j6 ohms are connected in series across a 371,08 V, 50 Hz supply.

Calculate:

4.4.1 The current flowing in the circuit (4)

4.4.2 The power factor of the circuit (1)

[20]

QUESTION 5

5.1 A 500 V DC supply is connected across the circuit of a 100 ohm resistor connected in series with a resistor of unknown value. A voltmeter with a resistance of 500 ohms is connected across the 100 ohm resistor and shows a reading of 50 volts.

Calculate the value of the unknown resistor. (5)

5.2 What is the function of a Buchholz device on a transformer? (2)

5.3 What is the purpose of the capacitor in a single-phase capacitor motor? (3)

5.4 Which crystals are commonly used in the breather of a transformer and what is their purpose? (2)

5.5 5.5.1 Name TWO types of feeders used in transmission systems. (2)

5.5.2 In which system does failure of one interconnecting feeder interrupt the supply to any of the other substations? (1)

5.6 An ideal 50 kVA transformer has 50 primary turns and 500 secondary turns. The primary windings are connected to a 5 kV, 50 Hz supply.

Calculate:

5.6.1	The secondary voltage	(1)
5.6.2	The value of the secondary and the primary currents on full load	(2)
5.6.3	The maximum core flux	(2)
		[20]

TOTAL: 100

FORMULA SHEET

Any applicable formula may also be used.

1. Principles of electricity

$$E = V + Ir$$

$$V = IR$$

$$R_{se} = R_1 + R_2 + \dots R_n$$

$$R_p = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \dots \frac{1}{R_n}}$$

$$R = \rho \frac{\ell}{a}$$

$$\frac{R_1}{R_2} = \frac{1 + \alpha_o T_1}{1 + \alpha_o T_2}$$

$$R_t = R_\theta \left[1 + \alpha_\theta \left(t - \theta\right)\right]$$

$$P = VI = I^2 R = \frac{V^2}{R}$$

$$\Phi = \frac{mmf}{S} = \frac{IN}{S}$$

$$H = \frac{IN}{\ell}$$

$$F = B\ell I$$

$$E = \frac{\Delta\Phi}{\Delta t} . N$$

$$E = B\ell v$$

$$E = \frac{L\Delta I}{\Delta t}$$

$$L = \frac{\Delta\Phi}{\Delta I} . N$$

$$Q = VC$$

$$Q_{se} = Q_t = Q_1 = Q_2 \dots = Q_n$$

$$C_{se} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \dots \frac{1}{C_n}}$$

$$Q_p = Q_1 + Q_2 + \dots Q_n$$

$$C_p = C_1 + C_2 + \dots C_n$$

2. Direct-current machines

$$E = \frac{2Z}{c} . \frac{Np}{60} . \Phi$$

$$c = 2a$$

$$E_{gen} = V + I_a R_a$$

$$E_{mot} = V - I_a R_a$$

$$R_{start} = \frac{(V - E)}{I_a} - R_a$$

3. Alternating-current machines

$$E_m = 2\pi BANn$$

$$e = E_m \sin\left(2\pi f . t \times 57{,}3\right)^\circ$$

$$E_{ave} = 0{,}637\ E_m$$

$$E_{rms} = 0{,}707\ E_m$$

$$T = \frac{1}{f}$$

$$f = \frac{Np}{60}$$

$$\omega = 2\pi f$$

$$Z_L = R + j\omega L$$

$$Z_c = R - j\frac{1}{\omega C}$$

$$pf = \cos\phi = \frac{R}{Z}$$

$$S = VI$$

$$P = V.I\cos\phi = I^2R$$

$$Q = V.I\sin\phi$$

4. *Transformers*

$$E = 4{,}44\ f\ \Phi_m\ N$$

$$k_t = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

5. *Measuring instruments*

$$R_{SH} = \frac{i_m\ R_m}{I_{sh}}$$

$$R_{se} = \frac{V}{i_m} - R_m$$