T610(E)(A6)T
APRIL 2009

NATIONAL CERTIFICATE

ELECTROTECHNICS N4
(8080074)

6 April (X-Paper)
09:00 – 12:00

REQUIREMENTS: Graph paper

Calculators may be used.

This question paper consists of 5 pages and a 2-page formula sheet.
INSTRUCTIONS AND INFORMATION

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

QUESTION 1

1.1 Two batteries, A and B, having an EMF of 25 V and 15 V and an internal resistance of 0.2 ohm and 0.6 ohm respectively are to be charged by a DC generator with an EMF of 30 V and internal resistance of 0.1 ohm.

Use Kirchhoffs' law to determine the following:

1.1.1 The value of the current supplied by the generator
1.1.2 The value of the current through battery A
1.1.3 The value of the current through battery B

1.2 A 25 ohm resistor is connected in parallel across a rheostat which is then connected in series with a heater element of 250 W. What must the value of the rheostat be so that the heater draws 5 A when the whole circuit is connected across a 150 V supply?

1.3 On what does the magnitude of the hysteresis loss depend?

1.4 Why are certain alloys used in the manufacturing of standard resistors for use in measuring instruments?
QUESTION 2

2.1 Two capacitors of 5 microfarads and 20 microfarads respectively are connected in series across a 50 volt supply.

Calculate the following:

2.1.1 The total capacitance

2.1.2 The pd across each capacitor

2.2 State Lenz's law.

2.3 An aluminium conductor, 10 m long, is connected in parallel with a copper conductor of the same length. When a current of 15 A is passed through the combination, it is found that the current through the copper conductor is 5 A. The diameter of the aluminium conductor is 3 mm.

Calculate the following:

2.3.1 Diameter of the copper conductor if the resistivity of copper is 0.017 micro-ohm metres and that of the aluminium is 0.028 micro-ohm metres.

2.3.2 Voltage drop across the conductors

2.4 The resistance of a coil of wire increases from 100 ohms at 35 °C to 116 ohms at 75 °C. Find the temperature coefficient of the conductor.

QUESTION 3

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

<table>
<thead>
<tr>
<th>TERMINAL VOLTAGE (V)</th>
<th>40</th>
<th>80</th>
<th>130</th>
<th>155</th>
<th>160</th>
<th>165</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD CURRENT (A)</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>17</td>
<td>20</td>
<td>24</td>
</tr>
</tbody>
</table>

Plot a graph and determine the following:

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

3.1.2 The value of the critical resistance

(10)
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 ohm and a series field resistance of 0.4 ohm.

Calculate the armature EMF if the terminal voltage is 160 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? [20]

QUESTION 4

4.1 A single-phase 2400/240 V, 60 Hz transformer has a net core area of 100 cm² and a maximum flux density of 0.9 tesla. Estimate the number of turns in each winding. (6)

4.2 A sinusoidal AC supply has a maximum value of 240 V and frequency of 60 Hz.

Calculate the following:

4.2.1 The RMS value of the voltage

4.2.2 The periodic time in milliseconds (2)

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

\[ i_1 = 30 \sin\left(\omega t - \frac{\pi}{6}\right) \text{A} \]
\[ i_2 = 15 \sin\left(\omega t + \frac{\pi}{12}\right) \text{A} \]
\[ i_3 = 45 \sin\left(\omega t + \frac{\pi}{4}\right) \text{A} \]

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

\[ i = I_{\text{max}} \sin(\omega t + \theta) \]

4.3.2 Represent these currents by drawing a phasor diagram. (7)

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4.4 An impedance of 9 + j3 ohms and an impedance of 6 - j2 ohms are connected in series across a 240 V, 50 Hz supply.

Calculate the following:

4.4.1 The current flowing in the circuit

4.4.2 The power factor of the circuit [20]

QUESTION 5

5.1 A 350 V DC supply is connected in series across a circuit of a 300 ohms resistor with a resistor of unknown value. A voltmeter with a resistance of 500 ohms is connected across the 300 ohms resistor and shows a reading of 50 volt. 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 What crystals are commonly used in the breather of a transformer and what purpose do they serve? [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 20 kVA transformer has 1 600 primary turns and 80 secondary turns. The primary windings are connected to a 2 kV, 50 Hz supply.

Calculate the following:

5.6.1 Secondary voltage

5.6.2 Value of the secondary current and the primary currents on full load [5]

5.6.3 Maximum core flux [20]

TOTAL: 100
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FORMULA SHEET

Any applicable formula may also be used.

1. Principles of electricity

\[ E = V + Ir \]
\[ V = IR \]
\[ R_{se} = R_1 + R_2 + \ldots + R_n \]
\[ R_p = \frac{1}{ \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n} } \]
\[ R = \rho \frac{\ell}{a} \]
\[ \frac{R_1}{R_2} = \frac{1 + \alpha_1 T_1}{1 + \alpha_2 T_2} \]
\[ R_i = R_0 [1 + \alpha \theta (t - \theta)] \]
\[ P = VI = I^2 R = \frac{V^2}{R} \]
\[ \Phi = \frac{mmf}{S} = \frac{IN}{S} \]
\[ H = \frac{IN}{l} \]
\[ F = BlI \]
\[ E = \frac{\Delta \Phi}{\Delta t} \cdot N \]
\[ E = Blv \]
\[ E = \frac{I \Delta I}{\Delta t} \]
\[ L = \frac{\Delta \Phi}{\Delta M} \cdot N \]

2. Direct-current machines

\[ Q = VC \]
\[ Q_{se} = Q_1 = Q_2 = \ldots = Q_n \]
\[ C_{se} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}} \]
\[ Q_p = Q_1 + Q_2 + \ldots + Q_n \]
\[ C_p = C_1 + C_2 + \ldots + C_n \]

\[ E = \frac{2Z}{c} \cdot \frac{Np}{60} \cdot \Phi \]
\[ c = 2a \]
\[ E_{gen} = V + I_a R_a \]
\[ E_{mot} = V - I_a R_a \]
\[ R_{start} = \frac{(V - E)}{I_a} - R_a \]

3. Alternating current machines

\[ E_m = 2\pi BANn \]
\[ e = E_m \sin (2\pi f \cdot t \times 57,3)^\circ \]
\[ E_{ave} = 0,637 \cdot E_m \]
\[ E_{rms} = 0,707 \cdot E_m \]
\[ T = \frac{1}{f} \]

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\[ f = \frac{Np}{60} \]
\[ \omega = 2\pi f \]
\[ Z_L = R + j\omega L \]
\[ Z_C = R - j\frac{1}{\omega C} \]
\[ pf = \cos \phi = \frac{R}{Z} \]
\[ S = VI \]
\[ P = V.I \cos \phi = I^2R \]
\[ Q = V.I \sin \phi \]

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

\[ R_{SH} = \frac{i_m R_m}{I_{sh}} \]
\[ R_{se} = \frac{V}{i_m} - R_m \]