higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T510(E)(A9)T

APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

9 April 2013 (X-Paper)
09:00–12:00

REQUIREMENTS: Graph paper

Calculators may be used.

This question paper consists of 6 pages and a 2-page formula sheet.

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 50 V and 40 V and an internal resistance of 0,1 ohm and 0,6 ohm respectively, are to be charged by a DC generator having an EMF of 60 V and internal resistance of 0,2 ohm.

Use Kirchhoff's laws 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 (8)

1.2 A 50-ohm resistor is connected across a rheostat in parallel which is then connected in series with a heater element of 1 000 W. What must the value of the rheostat be so that the heater draws 10 A when the whole circuit is connected across a 200 V supply? (7)

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

1.4 What is the reason that certain alloys are used in the manufacturing of standard resistors for the use in measuring instruments? (2)
[20]

QUESTION 2

2.1 Two capacitors of 3 microfarads and 6 microfarads respectively, are connected in series across an 18-volt supply.

Determine the following:

2.1.1 The total capacitance (2)

2.1.2 The PD across each capacitor (4)

2.2 State *Lenz's law.* (3)

2.3 An aluminium conductor 100 m long is connected in parallel with a copper conductor, having the same length. When a current of 150 A passed through the combination it is found that the current through the copper conductor is 50 A. The diameter of the aluminium conductor is 9 mm.

Calculate the following:

2.3.1 The 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 (6)

2.3.2 The voltage drop across the conductors (2)

2.4 The resistance of a coil of wire increases from 200 ohms at 110 °C to 232 ohms at 150 °C.

Calculate the temperature coefficient of the conductor at 110 °C. (3)
[20]

QUESTION 3

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

Terminal voltage (V)	80	160	260	310	320	330
Field current (A)	4	8	18	34	40	48

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 ohm

3.1.2 The value of the critical resistance (10)

3.2 A short shunt compound generator supplies a load current of 50 A. It has a shunt field resistance of 25 ohms, an armature resistance of 0,2 ohm and a series field resistance of 0,8 ohm.

Calculate the armature EMF if the terminal voltage is 260 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 480/48 V-, 50 Hz transformer has a net area of 10 cm² and a maximum flux density of 1, 8 tesla.

Estimate the number of turns in each winding. (6)

4.2 A sinusoidal AC supply has a maximum value of 339,463 V and a frequency of 50 Hz.

Determine the following:

4.2.1 The RMS value of the voltage (1)

4.2.2 The periodic time in milliseconds (1)

4.3 4.3.1 In a certain circuit of three parallel branches, the instantaneous branch currents are represented by:

$$i_1 = 25Sin(wt - \frac{\pi}{7,2})A$$

$$i_2 = 50Sin(wt + \frac{\pi}{3,6})A$$

$$i_3 = 75Sin(wt + \frac{\pi}{2,4})A$$

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

$$i = Imax^{Sin(wt+\theta)}$$ (5)

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

4.4 An impedance of 15 + j9 ohms and an impedance of 9 – j6 are connected in series across a 242 V/50 Hz supply.

Calculate the following:

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 600 V-DC supply is connected across a circuit of a 200 ohms resistor in series with a resistor of unknown value. A voltmeter having a resistance of 600 ohms is connected across the 200-ohms resistor and shows a reading of 60 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 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 30 kVA transformer has 3 000 primary turns and 150 secondary turns. The primary windings are connected to a 3 kV/50 Hz supply.

Calculate the following:

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

ELECTROTECHNICS N4

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

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

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

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

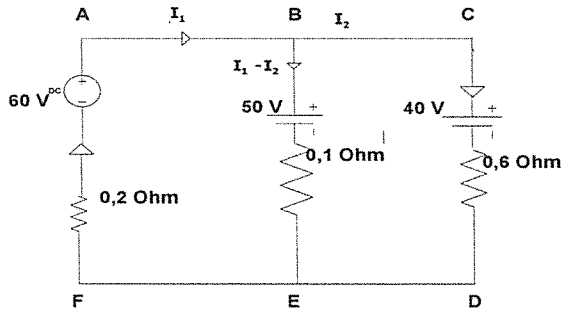
ELECTROTECHNICS N4

9 APRIL 2013

This marking guideline consists of 7 pages.

QUESTION 1

1.1



Consider loop:ABEFA **:loop:ACDFA**

$\Sigma E - \Sigma IR = 0$ $\Sigma E - \Sigma IR = 0$

$(E_1 - E_2) - (I_1R_1 + (I_1R_2 - I_2R_2)) = 0$

$(60 - 50) - (0,2I_1 + (0,1I_1 - 0,1I_2) = 0$ √

$10 - 0,3I_1 + 0,1I_2 = 0 \ldots\ldots\ldots\ldots\ldots (1)$

$(E_1 - E_3) - [I_1R_1 + R_3I_2] = 0$

$(60 - 40) - (0,2I_1 +, 06I_2) = 0$ √

$20 - 0,2I_1 - 0,6I_2 = 0 \ldots\ldots\ldots\ldots\ldots (2)$

Eq.(1) x (6) = $\underline{60 - 1,8I_1 + 0,6I_2 = 0}$ √.....(3)

Add (2) and (3) $= 80 - 2I_1 = 0$

Thus: $I_1 = 80/2 = \underline{40\ A}$√

Substitude $I_1 = 40$ A into Eq. (1)

$10 - 0,3(40) + 0,1I_2 = 0$

$-I_2 = 10 - 12/0,1 = -2/0,1$

$-I_2 = \underline{-20\ A}$ Thus √

$I_2 = \underline{20\ A}$

$I_1 - I_2 = 20A$

1.1.1 = 40 A from pos. to neg.√

1.1.2 from neg. to pos. √

1.1.3 = 20 A from neg. to pos.√ (8)

1.2 $P = I^2R$

$1000 = 100\ R$

$R = \underline{10\ \Omega}$ √x

$\therefore$ $V_{SE} = IR_{SE}$ $V_P = V_T - V_{SE}$ $I = V/R$

$= 10x10$ $= 200 - 100$ $= 100/50$

$= \underline{100V}$√ $= \underline{100\ V}$ √ $= \underline{2\ A}$√

$I = 10 - 2 = 8\ A$ √

BUT $V_P = 100\ V$

$\therefore \quad R_{RHEOST.} = \frac{V_P}{I} = \frac{100}{8} = 12{,}5\ \Omega \surd\surd$ (7)

1.3 The type of material used, √ and the heat treatment √ and the mechanical handling to which the specimen has been subjected. √ (3)

1.4 They are almost unaffected by temperature. √√ (2)
[20]

QUESTION 2

2.1 2.1.1 $C_S = \frac{1}{\frac{1}{3}+\frac{1}{6}} = 2\ \mu F \quad \surd\surd$ (2)

2.1.2 $Q_T = Q_1 = Q_2 = VC = 18 \times 2\ \mu F = \underline{36\ \mu C} \quad \surd\surd$

V = Q/C = 36/3 en 36/6
=12 V √ en 6 V √ (4)

2.2 The direction of <u>an induced e.m.f.</u> is always such that it tends to set up <u>a current opposing</u> the motion or <u>the change of flux</u> responsible for inducing that e.m.f. √√√ (3)

2.3 2.3.1 $I_a = I_T - I_C$
$= 150 - 50 \ \surd$
$= 100\ A$

$A_a = \frac{\pi d_a^2}{4} = \frac{\pi(9x10^{-3})^2}{4} = 6{,}3617251x10^{-5} m^2 \surd\surd$

$R_a = \frac{P_a x L_a}{A_a}$ but

$= \frac{0{,}028x10^{-6}x100}{6{,}3617251x10^{-5}} \ \surd$

$= 0{,}044013218\Omega$

$d = \sqrt{\frac{4P_cL_c}{\pi R_c}} = \sqrt{\frac{4x0{,}017x10^{-6}x100}{\pi(0{,}088026437)}} = 4{,}959\ mm \surd\surd$ (6)

2.3.2 $V_a = I_a R_a$
$= 100x0{,}044013218 \ \surd$
$= 4{,}401321883\ V$

$R_C = \frac{V_C}{I_C} = \frac{4{,}4013}{50} = 0{,}088026437\ \Omega \surd$ (2)

2.4 $R_t = R\,[1 + \alpha\,(t_1 - t_2)]$

$232 = 200[1 + \alpha(150° - 110°)]$ √√√

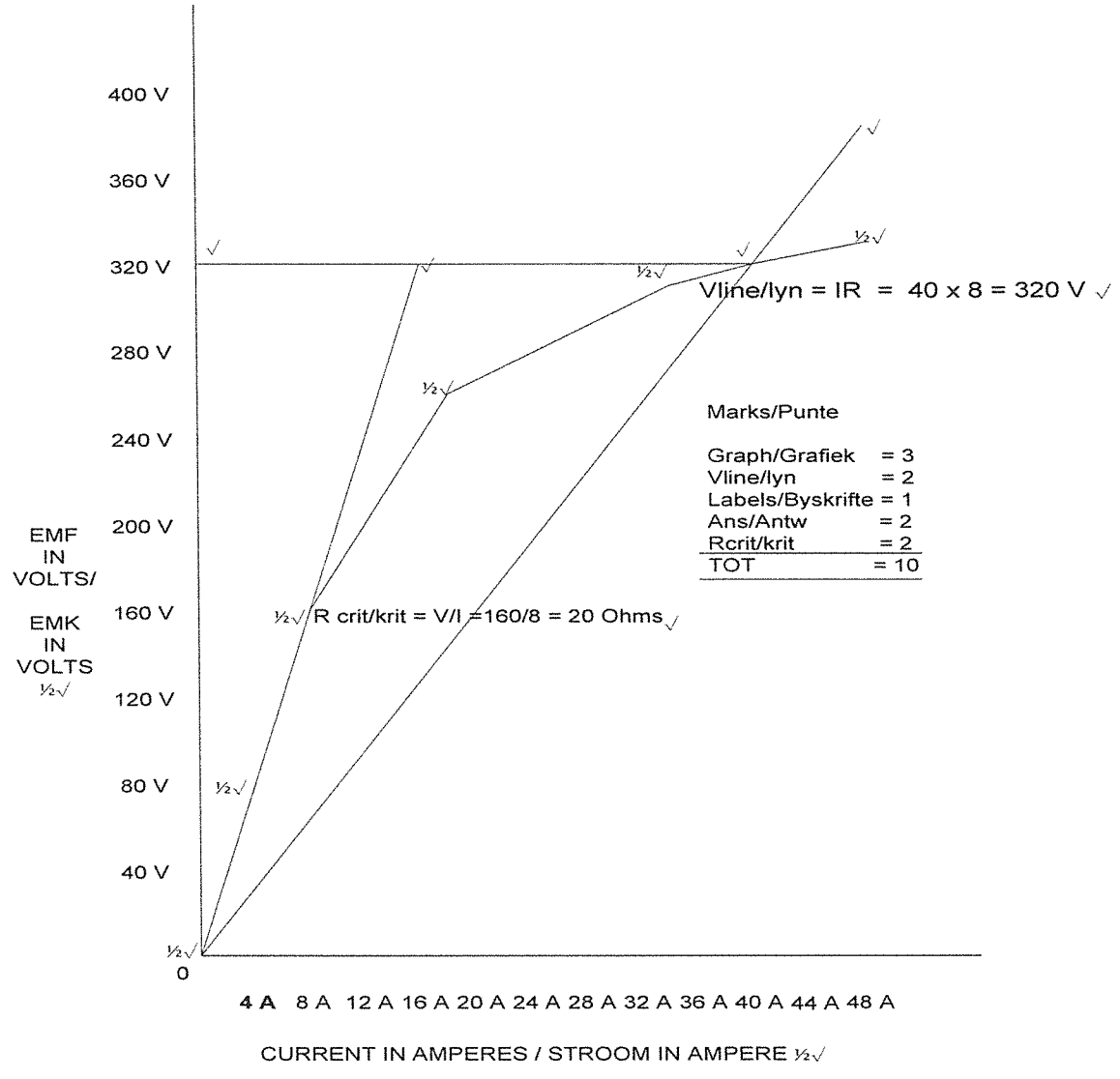
$232 = 200[1 + \alpha(40)]$

$\alpha = 0{,}004$ per degree C (3)

[20]

QUESTION 3

3.1



(10)

3.2

$$I_{SH} = \frac{V + I_L R_{SE}}{R_{SH}}$$

$$= \frac{260 + (50x0,8)}{25} \surd\surd$$

$$= \frac{300}{25}$$

$$= 12\ A$$

$I_a = I_L + I_{SH}$ $= 50 + 12 \surd$ $= 62\ A$

$E = V + I_a R_a + I_L R_{SE}$ $= 260 + (62x0,2) + 50(0,8) \surd\surd$ $= 312,4\ V$

(5)

3.3
- Shunt connected √
- Series connected √
- Compound connected √

(3)

3.4 To limit the initial starting current to an acceptable value √√ (2)

[20]

QUESTION 4

4.1 $E_1 = 4,44\Phi_m f N_1$

$N_1 = E_1 / 4,44 f \Phi_m$

$= 48/4,44x50x1,8x10x10^{-4}$

$= \underline{120,12\ Turns} \surd\surd\surd\surd$ (4)

$N_2 = \frac{V_2 x N_1}{V_1} = \frac{480x120.12}{48} = 1201,2\ Turns \surd\surd$ (2)

4.2 4.2.1 $V_{rms} = 0,707\ V_m$

$V_m = 0,707 \times 339,463 = 240\ V \surd$ (1)

4.2.2 $T = \frac{1}{f}$

$T = \frac{1}{50} = \underline{20\ ms} \surd$ (1)

4.3 4.3.1 $i_1 = 25\angle -25° = 22,658 - j10,565$

$i_2 = 50\angle 50° = 32,139 + j38,302$ √√

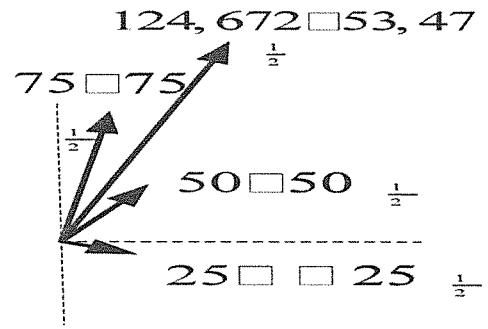
$i_3 = 75\angle 75° = 19,411 + j72,444 \surd$

Total current $= 74,209 + j\ 100,181$

$= 124,672\angle 53,471° \surd$

$i_T = 124,674 Sin(wt + 53,471°)A \surd$ (5)

4.3.2



(2)

4.4 4.4.1

$$Z_1 = 15 + j9 = 17,493\angle 30,964°$$
$$Z_2 = 9 - j6 = 10,817\angle -33,69°$$
$$Z_T = 24 + j3 \surd$$
$$Z_T = 24,187\angle 7,125°\Omega \surd$$
$$V = I\,Z$$
$$\therefore I = \frac{V}{Z}$$
$$= \frac{242\angle 0°}{24,187\angle 7,125°} = 10,005\angle -7,125° = \underline{10,005\ A}\ \surd\surd$$

(4)

4.4.2 p.f = Cos-7,125 lagging √
= 0,992

(1)
[20]

QUESTION 5

5.1

$$I_V = \frac{V}{R_V} = \frac{60}{600} = 0,1A\ \surd$$
$$I_A = \frac{V}{R_A} = \frac{60}{200} = 0,3\ A\ \surd$$
$$I_T = I_V + I_R = 0,1 + 0,3 = 0,4\ A\ \surd$$
$$V_X = V_T - V_R = 600 - 60 = 540\ A\ \surd$$

$$R_x = \frac{V_X}{I_X} = \frac{540}{0,4} = 1350\ \Omega\ \surd$$

(5)

5.2 It serves as a protection system and activates an alarm √√ (2)

5.3 It produces a constant torque and let the motor run quietly and ensures that it operates at a good power factor. √√√ (3)

5.4 Calcium chloride or silica gel; it extracts the moisture from the air √√ (2)

5.5 5.5.1 Radial and Ring Feeders √√ (2)

5.5.2 Radial Feeders √ (1)

5.6 5.6.1 $\frac{V_P}{V_S}=\frac{N_P}{N_S} \therefore V_S=\frac{V_P N_S}{N_P}=\frac{3\,000x150}{3\,000}=\underline{150\ V}\sqrt{}$ (1)

5.6.2 $S=VI \therefore I_S=\frac{S}{V}=\frac{30x1000}{150}=\underline{200\ A}\sqrt{}$

$S=VI \therefore I_P=\frac{S}{V}=\frac{30x1000}{3\,000}=\underline{10\ A}\sqrt{}$

(2)

5.6.3 $E=4{,}44\Phi_M fN \therefore \Phi_M=\frac{3\,000}{4{,}44x50x3\,000}=4{,}505\ mWb$ √√ (2)

[20]

TOTAL: 100