higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T490(E)(A13)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

13 April 2015 (Y-Paper)
13:00–16:00

REQUIREMENTS: **Graph paper**

Calculators may be used.

This question paper consists of 6 pages and 1 formula sheet of 2 pages.

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 The field coil of a motor has a resistance of 300 Ω at 75 °C.

Calculate the final resistance if the temperature is 200 °C. Take the temperature coefficient of resistance as 0,004 °C at 75 °C. (4)

1.2 Distinguish between a positive and a negative temperature coefficient of resistance. (3)

1.3 A coil having 1 500 turns of conductor with a combined cross-sectional area of 300 mm² and a mean length per turn of 400 mm, has an inductance of 3 H.

Calculate the following:

1.3.1 The resistance of the winding if the resistivity (specific resistance) of the conductor is 4 μΩ.m (5)

1.3.2 The average value of the EMF induced in the coil when a current of 60 A reversed in 15 seconds (2)

1.4 Two capacitors connected in series have voltage readings of 40 V and 10 V respectively. The total charge equals 400 μC.

Calculate the following:

1.4.1 The total capacitance (2)

1.4.2 The value of each capacitor (4)

[20]

QUESTION 2

2.1 Explain Kirchhoff's first law. (2)

2.2 Two batteries of EMF 65 V and 50 V and internal resistance of 0,3 Ω and 0,6 Ω respectively, are connected in parallel to supply a load resistance of 2,8 Ω.

Use Kirchhoff 's laws and calculate the following:

2.2.1 The current supplied by each battery (7)

2.2.2 The voltage across the load (2)

2.3 Define a *farad.* (3)

2.4 A resistor of unknown value R is connected in parallel with a resistance of 180 Ω. This combination is connected in series with a resistance of 25 Ω. The circuit is then connected across a 280-V DC-supply.

Calculate the following:

2.4.1 The value of the resistor R when a 4-A current is drawn from the supply (5)

2.4.2 The power dissipated in the circuit (1)
[20]

QUESTION 3

3.1 The open-circuit characteristics of a shunt-excited DC motor are as follow:

Terminal voltage (V)	200	400	500	580	610	620
Field current (A)	10	20	30	50	65	75

Using the above values, plot a graph and determine the following:

3.1.1 The voltage which the motor will excite on no-load when shunt connected if the total field resistance is 10 Ω. (8)

3.1.2 The critical resistance (2)

3.2 A long-shunt compound-wound DC motor has an armature resistance of 0,3 Ω, a series-field resistance of 0,1 Ω and a shunt-field resistance of 48 Ω. The motor draws a current of 210 A from a 480-V DC supply.

Calculate the EMF generated in the armature. (5)

3.3 What is the purpose of a pole shoe in a DC motor? (2)

3.4 Name any THREE types of capacitors. (3)
[20]

QUESTION 4

4.1 What can be done to improve the power factor in a circuit? (2)

4.2 A 50 Hz sinusoidal voltage has an RMS value of 424,2 V.

Calculate the following:

4.2.1 The time for the voltage to reach a value of 300 V from zero for the first time (4)

4.2.2 Draw a phasor diagram and show the waveform of this voltage. (2)

4.3 A coil with a resistance of 200 Ω and an inductance of 0,3183 H is connected in series with a 10,61-μf capacitor. This circuit is connected across a 565/-685 V, 50 Hz supply.

Calculate the voltage drop across the following:

4.3.1 The coil (7)

4.3.2 The capacitor (1)

4.3.3 Draw the phasor diagram to represent the distribution of the voltage and the current in the circuit. (4)

[20]

QUESTION 5

5.1 The value of a resistor is measured by the voltmeter-ammeter method. The internal resistance of the voltmeter is 800 Ω. When the voltmeter is connected directly across the resistor to be measured, the ammeter reads 1,25 A and the voltmeter 200 V.

Calculate the value of the unknown resistor as follows:

5.1.1 Approximately (1)

5.1.2 Accurately (3)

5.1.3 The percentage error in the value of the resistor (2)

5.2 The no-load current of a 3 000/150-V single-phase transformer is 25 A at a power factor of 0,3. The primary winding has 150 turns and the supply frequency is 60 Hz.

Calculate the following:

5.2.1 The maximum value of the flux in the core

5.2.2 The power loss on no-load

5.2.3 The value of the magnetising current

(2 x 3) (6)

5.3 Name THREE types of power stations used to generate electricity. (3)

5.4 Why is the rotor bars of an induction motor skewed? (2)

5.5 Name the THREE main parts of an induction motor. (3)

[20]

TOTAL: 100

ELECTROTECHNICS N4

FORMULA SHEET

Any applicable formula may also be used.

1. *Principles of electricity*

$$E = V + Ir$$

$$V = IR$$

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

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

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

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

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

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

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

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

$$F = B\ell I$$

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

$$E = B\ell v$$

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

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

$$Q = VC$$

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

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

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

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

2. *Direct-current motors*

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

$$c = 2a$$

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

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

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

3. *Alternating-current motors*

$$E_m = 2\pi BANn$$

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

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

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

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

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

$$\omega = 2\pi f$$

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

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

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

$$S = VI$$

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

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

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

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13 APRIL 2015

This marking guideline consists of 7 pages.

QUESTION 1

1.1

$$R_t = R_{20}[1+\alpha_\theta(t-\theta)]$$
$$= 300[1+0{,}004(200-75^\circ)]$$
$$= 300[1+0{,}004(125^\circ)]$$
$$= 300(1{,}5)$$
$$= 450\ \Omega$$

(4)

1.2

- Positive temperature coefficient of resistance refers to materials whose resistance rises when the temperature increases. √
- Negative temperature coefficient of resistance refers to materials√ whose resistance falls when the temperature increases. √

(3)

1.3 1.3.1 L = 1 500 x 0,4 = 600 m √

$$R = \frac{\rho \times L}{A} \quad \surd\surd$$
$$= \frac{4\times10^{-6} \times 600}{300 \times 10^{-6}} \quad \surd\surd$$
$$= 8\ \Omega$$

(5)

1.3.2

$$E = \frac{LI}{t} \times 2 \ \surd$$
$$= \frac{3 \times 60}{15} \times 2$$
$$= 24\ V \ \surd$$

(2)

1.4 1.4.1 C = Q/V = 400/40 & = 400/10
= 10 <u>µF</u> √√ & = <u>40 µF</u> √√

(2)

1.4.2

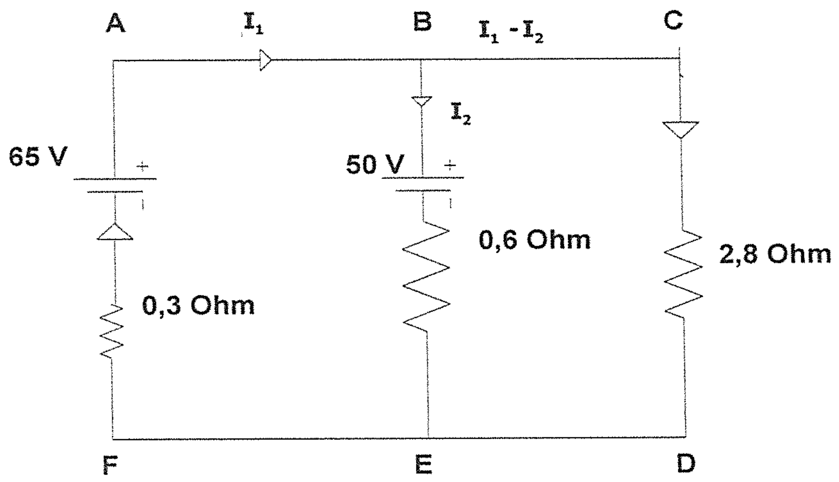
$$C_s = \frac{1}{\frac{1}{10}+\frac{1}{40}} = 8\ \mu F \ \surd\surd$$

(4)
[20]

QUESTION 2

2.1 The sum of the currents flowing towards a junction is equal to the sum of the currents flowing away from that junction √√ (2)

2.2



√

2.2.1 Consider loop/Vanaf lus:ABEFA

$\sum E - \sum IR = 0$

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

$(65 - 50) - (0{,}3I_1 + 0{,}6I_2) = 0$ √

$15 - 0{,}3I_1 - 0{,}6I_2 = 0$..........(1)

:loop/lus:ACDFA

$\sum E - \sum IR = 0$

$(E_1 - (I_1R_1 + R_3(I_1 - I_2)) = ($

$65 - (0{,}3I_1 + 2{,}8I_1 - 2{,}8I_2$

$65 - 3{,}1I_1 + 2{,}8I_2 = 0$......

Eq./Verg. (1)x4,667 = $70 - 1{,}4I_1 - 2{,}8I_2 = 0$ ....(3) √

Eq./Verg.(2) + (3) = $\underline{135 - 4{,}5I_1 = 0}$√

Thus/Dus: $I_1 = 135/4{,}5 = \underline{30\ A}$

Substitute/Vervang $I_1 = 30$ A into/in Eq./Verg. (1)

$15 - 0{,}3(30) = 0{,}6I_2$

$I_2 = 15 - 9/\ 0{,}6 = -6/0{,}6 = \underline{10\ A}$

$I_1 - I_2 = 30 - 10 = 20\ A$ √

Current across 65-V Battery = 30 A √

Current across 50-V Battery = 10 A √ (7)

2.2.2 Voltage across the load = IR = 20 x 2,8 = 5<u>6 V</u>√ (2)

2.3 One farad is that capacitance which will accumulate a charge of 1 coulomb when connected across a voltage of 1 volt √√√ (3)

2.4 2.4.1 $V_{SE} = IR_{SE} = 4 \times 25 = \underline{100\ V}$ √

$R_P = \frac{V_P}{I_T} = \frac{180}{4} = 45\ \Omega$ √

$V_T = V_{SE} + V_P$

$280 = 100 + V_P$

$V_P = \underline{180\ V}$ √

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R}$ $\frac{1}{R_x} = \frac{1}{R_p} - \frac{1}{R_1}$ √ $= \frac{1}{45} - \frac{1}{180}$

$\frac{1}{R_x} = 0{,}0167$ ∴ $R_X = \underline{60\ \Omega}$ √

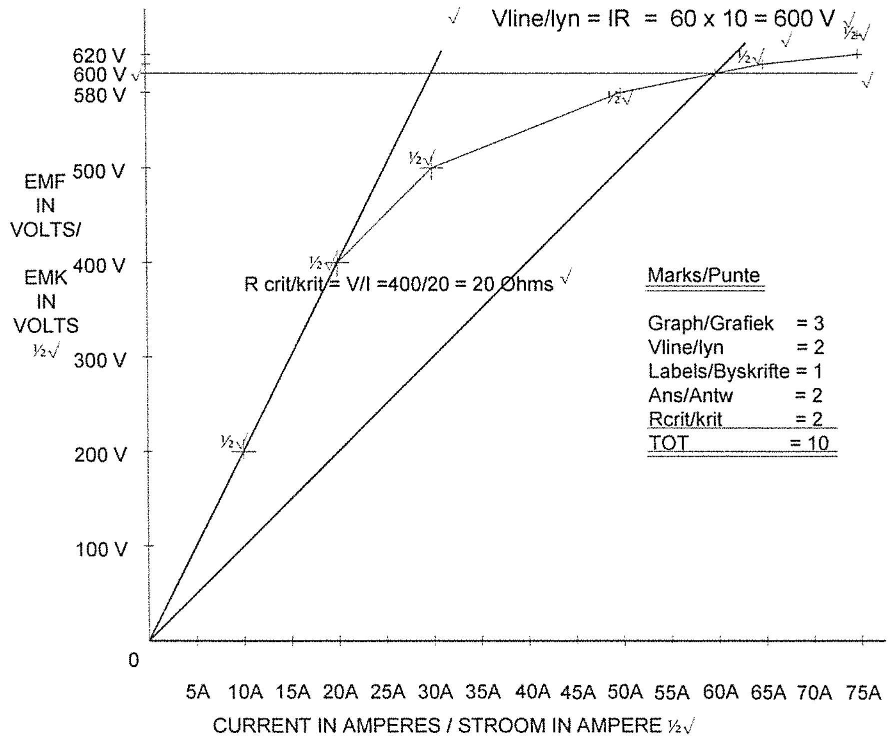
(5)

2.4.2 $P = VI = 280 \times 4 = \underline{1\ 120\ W}$ √ (1)

[20]

QUESTION 3

3.1



(10)

3.2

$I_{SH} = \frac{V}{R_{SH}} = \frac{480}{48}$ √ $= 10\ A$

$I_a = I_L - I_{SH} = 210 - 10$ √ $= 200\ A$

$E = V - I_aR_a + I_aR_{SE}$
$= 480 - [(200 \times 0{,}3) + (200 \times 0{,}1)]$ √√√
$= 480 - (60 + 20)$
$= 400\ V$

(5)

3.3 To hold the field windings in place and to increase the cross-sectional area √√ (2)

3.4
- Air√
- Paper√
- Mica√
- Ceramic
- Polycarbonate
- Electrolytic (Any 3 x 1) (3)

[20]

QUESTION 4

4.1 Making the circuit more capacitive √ To run a synchronous motor with little or no load with rotor over-excited by a high direct current√ By use of suitable corrective apparatus (machines) √ (Any 2 x 1) (2)

4.2 4.2.1

$$V_{rms/wgk} = 0{,}707 V_m$$

$$424{,}2 = 0.707 V_m \quad √$$

$$V_m = \frac{424{,}2}{0{,}707}$$

$$= 600\ V$$

$$v = V_m \sin 2\pi f t x \frac{180}{\pi}$$

$$300 = 600 \sin 2\pi 50\ t \frac{180}{\pi} \quad √√√√$$

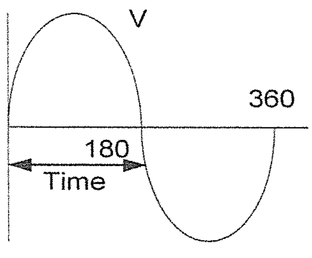
$$\frac{250}{500} = \sin 18\ 000\ t$$

$$1\ 8000t = \sin^{-1} 0{,}5$$

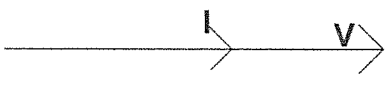
$$t = \frac{30}{1\ 8000} = 1{,}67\ ms$$

(4)

4.2.2



√



(2)

4.3 4.3.1

$$X_L = 2\pi fL = 2\pi 50 \text{ x } 0,3183 = 100\ \Omega\ \surd$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi 50\text{x}1,061\text{x}10^{-6}} = 300\ \Omega\ \surd$$

$$Z_{COIL} = \sqrt{R^2 + X_L{}^2} = \sqrt{200^2 + 100^2} = 223,607\ \Omega\ \surd$$

$$Z = \sqrt{R^2 + (X_C{}^2 - X^2{}_L)} = \sqrt{200^2 + (300 - 100)^2} = 282,843\ \Omega\ \surd$$

$$I = V/Z = 565,685/282,843 = 2 \text{ A } \surd$$

$$\Theta = \text{Cos}^{-1}\frac{R}{Z} = \text{Cos}^{-1}\frac{200}{282,843} = 45°\ \surd$$

$$V_{COIL} = IZ_{COIL} = 2 \text{ x } 223,607 = 447,214 \text{ V } \surd$$

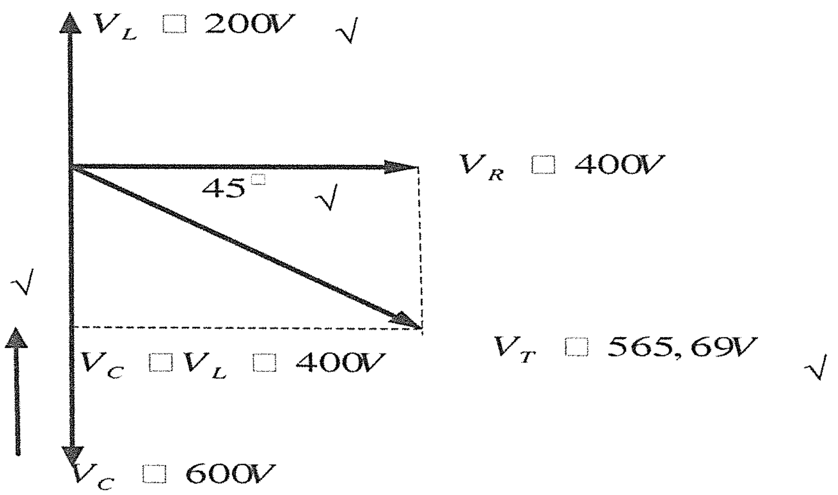
(7)

4.3.2

$$V_C = IX_C = 2 \text{ x } 300 = 600 \text{ V } \surd$$

(1)

4.3.3



(4)
[20]

QUESTION 5

5.1 5.1.1

$R_V = 800\Omega$ V = 200 V I = 1,25 A

$$R_{app} = \frac{V}{I} = \frac{200}{1,25} = 160A\ \surd$$

$$I_V = \frac{V}{R_V} = \frac{200}{800} = 0,25A\ \surd$$

(1)

5.1.2

$$R_X = \frac{V}{I - I_V} = \frac{200}{1,25 - 0,25} = 200\Omega\ \surd\surd$$

(3)

5.1.3

$$\% \text{ Error} = \frac{R_X - R_{app}}{R_X} = \frac{200 - 160}{200} = 20\%\ \surd\surd$$

(2)

5.2 5.2.1 $E_1 = 4{,}44\Phi_m fN_1$

$\Phi_m = E_1/4{,}44fN_1 = 3\,000/4{,}44 \times 60 \times 150 = 0{,}075075 = 75{,}075$ mWb√√

5.2.2 $Powerloss = V_1 I_0 Cos\phi_0 = 3000x25x0,3 = 22,5Kw$ √√

5.2.3 $I_C = \frac{Coreloss}{V_P} = \frac{22500}{3000} = 7,5A$ √

$I_M = \sqrt{I^2{}_O - I^2{}_C} = \sqrt{25^2 - 7,5^2} = 23,484A$ √

(3 x 2) (6)

5.3
- Coal-fired power station
- Hydro-electric power station
- Nuclear power station

(3)

5.4 To reduce magnetic noise and to eliminate variation in starting torque at different positions of the rotor √√ (2)

5.5
- Rotor
- Stator
- End plates

(3)
[20]

TOTAL: 100