higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

12 April 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

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

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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. Questions may be answered in any order, but subsections of questions must not be separated.
5. Start each question on a new page.
6. Use only a black or blue pen.
7. Write neatly and legibly.

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QUESTION 1: PRINCIPLES OF ELECTRICITY

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (1.1.1-1.1.10) in the ANSWER BOOK.

1.1.1 To gain insight into the nature of electric currents, it is necessary to consider the structure of the atom.

1.1.2 In a DC circuit, power is the product of the applied voltage and the resulting current.

1.1.3 The strands of conductors make it impossible for cables to bend to a certain degree.

1.1.4 A positive temperature coefficient of resistance means the higher the temperature, the higher the resistance of the material.

1.1.5 Kirchhoff's first law states that the algebraic sum of the voltage drop in any closed circuit is equal to the algebraic sum of the applied EMFs.

1.1.6 According to Norton's theorem, any network that has two terminals and consists of resistances, voltage sources and current sources cannot be replaced by a single current source.

1.1.7 When two magnets are placed very close to each other, like poles attract each other and unlike poles repel each other.

1.1.8 The two principal laws of electromagnetism are known as Faraday's laws.

1.1.9 Any two conductors separated by an insulating material is defined as capacitors.

1.1.10 When capacitors are connected in series, each capacitor has the same applied voltage.

(10 × 1) (10)

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1.2 Two cells are connected in series and the circuit is completed by means of two parallel coils of resistances, 7 Ω and 5 Ω respectively. One cell has an EMF of 1,5 V and an internal resistance of 1,2 Ω and the other cell an EMF of 1,1 V and an internal resistance of 0,7 Ω.

Calculate:

1.2.1 The current through each cell. (4)

1.2.2 The current through each coil. (3)

1.2.3 The terminal voltage of each coil. (2)

1.3 The field current of a shunt connected generator is 4,1 A, with the initial temperature of the coil being 20 ºC. The generator supplies full-load current at a terminal voltage of 230 V. Just before the generator is stopped, the temperature of the coil reaches 60 ºC. Calculate the drop in the field current if the temperature coefficient of resistance at 20 ºC is 0,004/ºC. (5)

1.4 A 15-microfarad capacitor is charged from a 60 V, DC supply. After being disconnected, it is immediately connected in parallel with a discharged capacitor of 5 microfarad.

Calculate:

1.4.1 The PD across the combination. (4)

1.4.2 The charge across each capacitor. (2)

[30]

QUESTION 2: DC MACHINES

2.1 Define *armature reaction*. (2)

2.2 A six-pole lap wound DC generator supplies a load of 50 A at 240 V. Calculate the speed of the prime-mover if the machine is shunt-connected and the armature has 864 conductors with a resistance of 0,1 Ω. The field has a resistance of 120 ohms with a flux per pole of 50 mWb. (7)

2.3 A short-shunt, compound-wound generator supplies a load with 65 A at a terminal voltage of 400 V. The series field, shunt field and armature resistances are 0,1 Ω, 220 Ω and 0,15 Ω, respectively. Calculate the brush contact voltage drop if the magnitude of the generated EMF is 420 V. (8)

2.4 A 500-volt DC motor has an armature resistance of 0,2 Ω and draws a full load armature current of 100 amps. Calculate the starting resistance required if the overloads are set to trip at 125% of full load current. (3)

[20]

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QUESTION 3: AC THEORY

3.1 Explain the *effective value of an alternating current.* (2)

3.2 A circuit consist of coil A (36 Ω resistor and an inductance of 200 mH) connected in parallel with (30 Ω resistor in series with a capacitance of 55 µF). The combination is then connected in series with coil B (20 Ω resistor and an inductance of 100 mH). The circuit is supplied by 200 V/50 Hz.

Determine the following:

3.2.1 The total current drawn by the circuit (12)

3.2.2 The voltage drop across the two coils (4)

3.2.3 The current through each branch of the parallel circuit (2)

[20]

QUESTION 4: TRANSFORMERS

4.1 What are the TWO types of single-phase transformer windings? (2)

4.2 A single-phase 50 Hz transformer has 20 primary turns and 273 secondary turns. The net cross-sectional area of the core is 400 cm². If the primary winding is connected to a 220 V supply, calculate:

4.2.1 The peak value of the flux density in the core (4)

4.2.2 The voltage induced in the secondary winding (2)

4.2.3 The voltage per turn (2)

[10]

QUESTION 5: AC MACHINES

5.1 Explain what the *end plates* of a motor are. (3)

5.2 Name THREE types of a single-phase, induction motors. (3)

5.3 Discuss briefly the differences that exists between the starting and running windings of a split-phase motor. (4)

[10]

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QUESTION 6: GENERATION AND SUPPLY OF AC POWER AND MEASURING INSTRUMENTS

6.1 Beside hydro power stations, what are the other TWO power stations that depend on vast quantities of water for their operation? (2)

6.2 Give THREE reasons why coal-fired power stations are built near coal mines. (3)

6.3 You have a 0,25 Ω resistor, a 15 kΩ resistor and a galvanometer with an internal resistance of 300 Ω that gives a full-scale deflection when 13,5 mA passes through it.

Determine the maximum current and voltage that the instrument can be used to measure. (5)

[10]

TOTAL: 100

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FORMULA SHEET

Any applicable formula may also be used.

1. *Principles of electricity*

$$E = V + Ir$$

$$V = IR$$

$$R_{se} = R_1 + R_2 + ... R_n$$

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

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

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

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

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

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

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

$$F = B\ell I$$

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

$$E = B\ell v$$

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

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

$$Q = VC$$

$$Q_{se} = Q_t = Q_1 = Q_2 ... = Q_n$$

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

$$Q_p = Q_1 + Q_2 + ... Q_n$$

$$C_p = C_1 + C_2 + ... C_n$$

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*

$$E_m = 2\pi BANn$$

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

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

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

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

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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

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

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

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