higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T420**(E)**(N24)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

(8080085)

24 November 2016 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 5 pages and 1 formula sheet of 2 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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NATIONAL CERTIFICATE
ELECTROTECHNICS N5
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 Can a series motor be started without some mechanical load on it? Give a reason for your answer (2)

1.2 A DC motor can be self-regulating due to back EMF.

Briefly explain this statement. (4)

1.3 A six-pole generator has a lap-connected armature with 600 conductors. The ratio of the pole arc per pole pitch is 0,8.

Calculate the ampere-turns per pole of a compensating winding to give uniform air gap density when the total armature current is 790 A. (4)

1.4 An 88 kW, 435 V shunt generator has 1 800 turns on each pole of its field winding. On no-load a current of 6,5 A in the field winding produces a terminal voltage of 435 V, but on full-load the shunt current has to be increased to 10,5 A for the same terminal voltage at the same speed.

Calculate the number of series field turns per pole required for level compounding. (8)

1.5 Explain the practical applications of lap and wave windings with reference to DC machines. (2)

[20]

QUESTION 2

2.1 A constant voltage at a frequency of 0,84 MHz is applied across a circuit consisting of an inductor in series with a variable capacitor. When the capacitor is adjusted to 380 pF, the current has its maximum value. When the capacitance is reduced to 350 pF, the current is at 0,707 of its maximum value.
Find the inductance and resistance of the inductor. (10)

2.2 A resonant circuit comprising of a coil of inductance 375 μH and a resistance of 33 Ω in parallel with a variable capacitor is connected in series with a resistor of 6400 Ω. The supply across this circuit is 120 V with a frequency of 3 MHz.

Calculate the following:

2.2.1 Value of capacitor at resonance (5)

2.2.2 The impedance of the parallel circuit (2)

2.2.3 Current in each branch (3)

[20]

QUESTION 3

3.1 State FOUR methods of reducing leakage flux in transformers. (4)

3.2 Two single-phase transformers are connected in parallel to a load of 1000 A, at a power factor of 0,8 lagging.

Test data :

Open–circuit : 12000 / 2800 V for each transformer

Short–circuit with high-voltage winding short-circuited:

Transformer A: secondary input 330 V, 380 A, 20 kW

Transformer B : secondary input 180 V, 380 A, 25 kW

Calculate the following:

3.2.1 Sending voltage (10)

3.2.2 Output and power factor of transformer A (3)

3.2.3 Output and power factor of transformer B (3)

[20]

QUESTION 4

4.1 Calculate the total resistance, inductance and capacitance of a single-phase, 31 km overhead line with solid conductors of 1,6 cm diameter and spaced 0,90 m between centres. Take resistivity of conductor material as 1,7 $\mu\,\Omega$ cm. (8)

4.2 A THREE-phase induction motor has an output of 21,5 kW when operating at 80% efficiency and a power factor of 0,7 lagging.

Calculate the readings on EACH of the TWO (2) watt-meters connected to read the input power. (8)

4.3 TWO to measure the power input to a three watt-meter used phase motor, indicates 35 kW and 390 kW.

Calculate the following:

4.3.1 Input power (1)

4.3.2 Power factor (3)

[20]

QUESTION 5

5.1 Can an induction motor develop torque when running at synchronous speed? Explain your answer. (4)

5.2 Two similar three-phase, star-connected alternators are operating in parallel. Each machine has a synchronous reactance of 9,6 Ω per phase and negligible resistance, and is excited to generate an EMF of 3430 V per phase. The machines have a phase displacement of 30 electrical degrees relative to each other.

Calculate the following:

5.2.1 circulating current (5)

5.2.2 terminal voltage per phase (2)

5.2.3 power supplied from one machine to another (3)

5.3 A star-connected, three-phase alternator at a speed of 1000 rpm must generate a voltage of 645 V at 50 Hz on open circuit. The stator has two slots per pole per phase and four conductors per slot.

Assume all the conductors per phase to be series connected and coils to be full-pitched (kd = 0,96).

Calculate the following:

5.3.1 Number of poles (2)

5.3.2 Useful flux per pole (4)
[20]

TOTAL: 100

ELECTROTECHNICS N5

FORMULA SHEET

Armature ampere-turns/pole $= \frac{1}{2} \cdot \frac{I_a}{C} \cdot \frac{Z}{2P}$

$$E = V \pm I_a R_a$$

$$E = \frac{2pNZ\Phi}{60c}$$

$$T = 0{,}318 \frac{I_a}{c} ZP\Phi$$

$$k = n\sqrt{\frac{R_1}{r_m}}$$

$$r_1 = R_1 \left[\frac{k-1}{k}\right]$$

$$r_1 = R_s \frac{1-y}{1-y^m}$$

$$R_1 = bR_1\ (k-1) \times \frac{1-b^n}{1-b} + r_m$$

$$y = \frac{I_2}{I_1}$$

$$r_1 = bR_1\ (k-1)$$

$$\frac{E_1}{E_2} = \frac{K\Phi_1 N_1}{K\Phi_2 N_2}$$

$$\frac{T_1}{T_2} = \frac{K\Phi_1 I_{a1}}{K\Phi_2 I_{a2}}$$

$$I_{ave/gem} = \frac{i_1 + i_2 + i_3 + \dots i_n}{n}$$

$$I_{rms/wgk} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + \dots + i_n^2}{n}}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2}$$

$$P = \sqrt{3} I_L V_L \, Cos\,\phi$$

$$P_1 = V_L I_L \, Cos\,(30 - \phi)$$

$$P_2 = V_L I_L \, Cos\,(30 + \phi)$$

$$\tan\phi = \frac{\sqrt{3}\,(P_2 - P_1)}{(P_2 + P_1)}$$

% Voltage regulation
$$= I_1 \frac{(R_e \, Cos\phi \pm X_e \, Sin\phi)}{v_1} \times \frac{100}{1}$$

$$Z_e = \sqrt{R_e^2 + X_e^2}$$

$$\%Z_e = \frac{I\,Z_e}{V} \times \frac{100}{1}$$

$$S_1 = S \frac{Z_2}{Z_1 + Z_2}$$

$$E = 2{,}222 \; k_d k_p \; Z\Phi f$$

$$I_r = \frac{E_r}{Z_r}$$

$$E_o = V_p \frac{Z_r}{Z_s}$$

$$Cos\phi_r = \frac{R}{Z_r}$$

$$s = \frac{2\pi T(n_s - n_r)}{2\pi T \; n_s}$$

$$L = 0{,}05 + 0{,}2 \; Lin \frac{d}{r}$$

$$C = \frac{1}{36 Lin \dfrac{d - r}{r}}$$

$$C = \frac{1}{18 Lin \dfrac{de}{r}}$$

% Regulation
$$= \frac{V_s - V_R}{V_R} \times \frac{100}{1}$$