higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T550**(E)**(A9)T

NATIONAL CERTIFICATE

ELECTROTECHNICS N6

(8080096)

9 April 2019 (X-Paper)
09:00–12:00

This question paper consists of 5 pages and a formula sheet of 5 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRONICS N6
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. Sketches must be large, neat and fully labelled.

5. Write neatly and legibly.

QUESTION 1: DC MACHINES

1.1 Name FOUR methods which may be used to control the speed of a DC motor. (4)

1.2 A 250 V, DC shunt motor has a shunt field resistance of 250 Ω and an armature resistance of 0,25 Ω.

For a given load torque and no additional resistance included in the shunt field circuit, the motor runs at 1 500 r/min, drawing an armature current of 20 A.

If a resistance of 250 Ω is inserted in series with the field, the load torque remains the same.

Calculate the following:

1.2.1 The armature current drawn (5)

1.2.2 The new speed (3)

1.3 Draw a neat diagram of a pair of two identical shunt motors mechanically coupled to the same load and connected in parallel. (2)

1.4 Draw the torque characteristic curve with respect to the armature current for the shunt motors described in QUESTION 1.3 above. (1)
[15]

QUESTION 2: AC CIRCUIT THEORY

A balanced 3-phase star-connected load of (8 + j6) ohms per phase is connected to a three-phase 230 V supply.

Calculate the following:

2.1 The line-current (5)

2.2 The power factor (2)

2.3 The active power (2)

2.4 The reactive power (2)

2.5 The total volt-amperes (2)
[13]

QUESTION 3: TRANSFORMERS

3.1 Name TWO effects of harmonic currents in transformers. (2)

3.2 Define the term *voltage regulation of a transformer*. (2)

3.3 A 250 kVA, 2 500/250 V, single-phase transformer has a percentage impedance of (1,2 + 3,5)%.

Calculate the following at a power factor of 0,8 lagging.

3.3.1 The full-load efficiency if the iron losses amount to 0,23 kW (4)

3.3.2 The maximum efficiency (2)

3.3.3 The applied primary voltage to circulate full-load current on short-circuit (3)

3.3.4 The percentage regulation (2)
[15]

QUESTION 4: AC MACHINES - ALTERNATORS

4.1 Calculate the power/load angle when a 1 500 kVA, 6,6 kV, three-phase, Y-connected alternator having a resistance of 0,4 ohms and a reactance of 6 ohms per phase delivers full-load current at normal rated voltage and 0,8 power factor lagging. (9)

4.2 Explain the term *armature reaction*, as applied to alternators. (2)

4.3 Explain the term *synchronous impedance of an alternator*. (2)
[13]

QUESTION 5: AC MACINES - SYNCHRONOUS MOTORS

5.1 Explain what is meant by the term *hunting of a synchronous motor,* and how it may be minimised. (4)

5.2 A 380 V single-phase synchronous motor has an armature resistance of 0,2 ohms and a synchronous reactance of 3 ohms. The motor has an output of 36,5 kW at 0,8 power factor leading. The efficiency is 80%.

Calculate the following:

5.2.1 The armature current (3)

5.2.2 The EMF to which the machine is excited (6)

5.3 Name TWO methods of starting a three-phase synchronous motor. (2)
[15]

QUESTION 6: AC MACHINES - INDUCTION MOTORS

6.1 A three-phase induction motor is wound for 4-poles and is supplied from a 50 Hz system.

Calculate the following:

6.1.1 The synchronous speed (2)

6.1.2 The speed of the rotor when the slip is 4% (3)

6.1.3 The rotor frequency when the speed of the rotor is 600 r/min (3)

6.2 Define the term *synchronous watt*. (2)

6.3 Name FOUR methods of starting an induction motor. (4)
[14]

QUESTION 7: GENERATION AND DISTRIBUTION OF AC

7.1 State TWO effects of a low power factor. (2)

7.2 State TWO advantages that power factor improvement may have for the consumer. (2)

7.3 A 3-phase, 50 Hz, transmission line having a resistance of 5 Ω per phase and an inductance of 30 mH per phase, supplies a load of 1000 kW at a power factor of 0,8 lagging and 11 kV at the receiving end.

Calculate the following:

7.3.1 The sending end voltage (6)

7.3.2 The power factor (1)

7.3.3 The transmission efficiency (2)

7.3.4 The regulation (2)
[15]

TOTAL: 100

FORMULA SHEET

GS-MASJIENE — *DC MACHINES*

$$E = V - Ia\,Ra$$

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

$$\frac{T_1}{T_2} = \frac{I_1\,\Phi_1}{I_2\,\Phi_2}$$

SPOEDBEHEER — ***SPEED CONTROL***

$$E = V - Ia\left(\frac{R\,Rse}{R + Rse} + Ra\right)$$

$$E = V - Ia\,Ra - Ise\,Rse$$

TOETSING DIREKTE METODE — ***TESTING DIRECT METHOD***

$$\eta = \frac{2\pi Nr\,(W - S)}{60\,IV}$$

SWINBURNE-METODE — ***SWINBURNE METHOD***

$$\eta_{motor} = \frac{IV - (Ia^2 Ra + Ia_o\,V + Is\,V)}{IV}$$

$$\eta_{generator} = \frac{IV}{IV + Ia^2\,Ra + Ia_o\,V + Is\,V}$$

HOPKINSON-RENDEMENTE DIESELFDE — HOPKINSON EFFICIENCIES THE SAME

$$\eta = \sqrt{\frac{I_1}{I_1 + I_2}}$$

YSTER-VERLIES — IRON LOSS

$$= I_2\,V - \left\{(I_1 + I_3)^2\,Ra + (I_1 + I_2 - I_4)^2\,Ra + (I_3 + I_4)\,V\right\}$$
$$= C$$

$$\eta_{generator} = \frac{I_1\,V}{I_1 V + (I_1 + I_3)^2\,Ra + I_3\,V + \frac{C}{2}}$$

$$\eta_{motor} = \frac{(I_1 + I_2)\,V - \left\{(I_1 + I_2 - I_4)^2\,Ra + I_4\,V + \frac{C}{2}\right\}}{(I_1 + I_2)\,V}$$

WS-BELASTING
STERSTELSELS

AC LOADS
STAR SYSTEMS

$$\bar{I}_R = \frac{V \underline{|0°}}{Z_{RN} \underline{|\phi_1}}$$

$\bar{V}rn$ = *VERWYSING REFERENCE*

$$\bar{I}_y = \frac{V \underline{|-120°}}{Z_{YN} \underline{|\phi_2}}$$

R-Y-B VOLGORDE SEQUENCE

$$\bar{I}_B = \frac{V \underline{|120°}}{Z_{BN} \underline{|\phi_3}}$$

$$\bar{I}_N = \bar{I}_R + \bar{I}_B + \bar{I}_Y$$

GEBALANSEERDE KRING $\bar{I}n = 0$ ***BALANCED CIRCUIT***

DELTASTELSELS ***DELTA-SYSTEMS***

$$\bar{I}_{RY} = \frac{\bar{V}_{RY}}{\bar{Z}_{RY}} \quad \bar{I}_R = \bar{I}_{RY} - \bar{I}_{BR}$$

$$\bar{I}_{YB} = \frac{\bar{V}_{YB}}{\bar{Z}_{YB}} \quad \bar{I}_Y = \bar{I}_{YB} - \bar{I}_{RY}$$

$$\bar{I}_{BR} = \frac{\bar{V}_{BR}}{\bar{Z}_{BR}} \quad \bar{I}_B = \bar{I}_{BR} - \bar{I}_{YB}$$

DRIEDRAAD-STELSELS ***THREE-WIRE SYSTEMS***

$$V_{sn} = \frac{\frac{\bar{V}_{an}}{\bar{Z}_1} + \frac{\bar{V}_{bn}}{\bar{Z}_2} + \frac{\bar{V}_{cn}}{\bar{Z}_3}}{\frac{1}{\bar{Z}_1} + \frac{1}{\bar{Z}_2} + \frac{1}{\bar{Z}_3}}$$

$$\bar{V}_{aN} = \bar{V}_{aS} + \bar{V}_{sN}$$

$$\bar{V}_{bN} = \bar{V}_{bS} + \bar{V}_{sN}$$

$$\bar{V}_{cN} = \bar{V}_{cS} + \bar{V}_{sN}$$

$$\bar{I}_a = \frac{\bar{V}_{aS}}{\bar{Z}_1}$$

$$\bar{I}_B = \frac{\bar{V}_{bS}}{\bar{Z}_2}$$

$$\bar{I}_C = \frac{\bar{V}_{cS}}{\bar{Z}_3}$$

KOMPLEKSE GOLFVORMS / ***COMPLEX WAVE FORMS***

$$e_1 = E_m \ Sin \ \omega t$$

$$e_2 = K_2 \ E_m \ Sin \ 2 \ \omega t$$

$$e_3 = K_3 \ E_m \ Sin \ 3 \ \omega t$$

$$e = E_m \ (Sin \ \omega t + k_2 \ Sin \ 2 \ \omega t + k_3 \ Sin \ 3 \ \omega t)$$

$$P = \frac{E_m^2 1 + E_m^2 2 + E_m^2 3 + ... + E_m^2 N}{2R}$$

$$P = \left(I_m^2 1 + I_m^2 2 + I_m^2 3 + ... + I_m^2 \ N \right) R$$

$$I = \sqrt{\frac{I_m^2 1 + I_m^2 2 + ... + I_m^2 N}{2}}$$

$$E = \sqrt{\frac{E_m^2 1 + E_m^2 2 + ... + E_m^2 N}{2}}$$

$$Cos \ \phi = \frac{I^2 \ R}{E \ I} = \frac{\frac{E^2}{R}}{E \ I}$$

TRANSFORMATORS / ***TRANSFORMERS***

$$\eta = \frac{S \ Cos \ \phi}{S \ Cos \ \phi + Po + Psc}$$

Enige waarde van belasting by k van vollas / *Any value of load at k of full-load*

$$\eta = \frac{k \ S \ Cos \ \phi}{k \ S \ Cos \ \phi + Po + k^2 \ Psc}$$

MAKSIMUM RENDEMENT / ***MAXIMUM EFFICIENCY***

$$K = \sqrt{\frac{Po}{Psc}}$$

$$\eta = \frac{k \ S \ Cos \ \phi}{k \ S \ Cos \ \phi + Po + k^2 \ Psc}$$

FORMULES ***FORMULAE***

$$\% R = \frac{I \text{ Re}}{V}$$

$$\% X = \frac{I \ Xe}{V}$$

$$\% Z_e = \% R_e + j \% X_e$$

$$V_{SC} = I \ Z_e$$

$$P_{SC} = I^2 \ R_e$$

$$Cos \ \phi_e = \frac{P_{SC}}{I_1 \ V_{SC}}$$

$$Reg = \frac{V_{SC} \ Cos \ (\phi_e \pm \phi_2)}{V}$$

$$Reg = \frac{I \ Z \ Cos \ (\phi_e \pm \phi_2)}{V}$$

$$Reg = \frac{I \ (\text{Re} \ Cos \ \phi_2 \pm Xe \ Sin \ \phi_2)}{V}$$

WS-MASJIENE ALTERNATORS ***AC MACHINES ALTERNATORS***

$$n = \frac{f}{p}$$

$$Kd = \frac{Sin \ \frac{n\alpha}{2}}{n \ Sin \ \frac{\alpha}{2}}$$

$$Kp = Cos \ \frac{\psi}{2}$$

$$E = 2 \ Kf \ \ Kd \ \ Kp \ \ f \ \ \Phi \ Z$$

$$E = \sqrt{(V \ Cos \ \phi + IR)^2 + (V \ Sin \ \phi \pm IX)^2}$$

$$E = V + IR \ Cos \ \phi \pm IX \ \ Sin\phi$$

$$\overline{E} = E \underline{|\phi} + IR \underline{|o} + Ix \underline{|90}$$

$$Reg = \frac{E - V}{V}$$

SINCHRONE MOTOR **SYNCHRONOUS MOTOR**

$$\overline{V} + \overline{E} = \overline{E}_R \qquad \overline{E}_R = \overline{IZ}$$

$$\overline{E} = V\,\underline{|-\phi} + IR\,\underline{|180^\circ} + IX\,\underline{|-90^\circ}$$

INDUKSIEMOTOR **INDUCTION MOTOR**

$$\frac{Eo}{V_1} = \frac{Zr}{Z_s} \qquad E_2 = SEo$$

$$X_2 = SXo \qquad I_2 = \frac{E_2}{Z_2}$$

$$Z_2 = \sqrt{R_2^2 + (SXo)^2} \qquad Io = \frac{Eo}{Zo}$$

$$Zo = \sqrt{R_2^2 + Xo^2}$$

$$I_2 = \frac{SEo}{\sqrt{R_2^2 + (SXo)^2}} \qquad Io = \frac{Eo}{\sqrt{R_2^2 + Xo^2}}$$

MAKSIMUM RENDEMENT **MAXIMUM EFFICIENCY**

$$R_2 = SXo$$

Rotorkoperverlies = S rotorinset
Rotor copper loss = S rotor input

$$S = \frac{N_1 - N_2}{N_1}$$

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

$$KVA = \sqrt{3}\, V_L\ I_L$$