Calculators may be used.

This question paper consists of 6 pages and a 5-page formula sheet.
DEPARTMENT OF EDUCATION
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
ELECTROTECHNICS N6
TIME: 3 HOURS
MARKS: 100

Answer ALL the questions.

INSTRUCTIONS AND INFORMATION

1. Write neatly and clearly.
2. Start each question on a NEW page.
3. Question numbers must be clearly indicated.
4. Answers to ALL calculations must be approximated accurately to THREE decimals.
5. Keep subsections of questions together.
6. Use the correct symbols and units.

QUESTION 1

1.1 Name TWO types of constant losses in a DC machine.

1.2 What is meant by normal speed of a DC machine?

When there is not External resistance in the armature or field resistance.
1.3 Two similar DC shunt machines are tested by means of the Hopkinson method and the following readings were obtained:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal voltage of each machine</td>
<td>250 V</td>
</tr>
<tr>
<td>Generator output current</td>
<td>328 A</td>
</tr>
<tr>
<td>Input current from the supply</td>
<td>60 A</td>
</tr>
<tr>
<td>Generator field current</td>
<td>8 A.</td>
</tr>
<tr>
<td>Motor field current</td>
<td>10 A</td>
</tr>
<tr>
<td>Armature circuit resistance of each machine</td>
<td>0.02Ω</td>
</tr>
</tbody>
</table>

Calculate the efficiency of the machine acting as a motor, assuming:

\[ (10) \]

1.3.1 The iron and friction losses are equal

1.3.2 Equal efficiency

\[ (2) \] \[ [18] \]

**QUESTION 2**

2.1 An EMF is represented by
\[
e = 120 \sin \alpha t + 25 \sin(3\alpha t + 30^\circ) + 12 \sin(5\alpha t - 15^\circ)
\] volts is applied to a series circuit having a resistance of 5 ohms and a capacitance of 412 \( \mu F \). The fundamental frequency is 50 Hz.

Calculate the expression for the instantaneous value of the current.

\[ (9) \]

2.2 The three line currents of an unbalanced, four-wire, three-phase, star-connected load is:

\[
I_R = 12.7 \angle 0^\circ A
\]

\[
I_T = 35.93 \angle -165^\circ A
\]

\[
I_B = 20.88 \angle 201^\circ A
\]

The line voltage is 440 V. Take \( V_{RN} \) as phasor reference and R-Y-B as phase rotation.

Calculate the load impedances \( Z_{RN}, Z_{YN} \) and \( Z_{BN} \).

\[ (7) \] \[ [16] \]
QUESTION 3

3.1 Name FOUR of the most common three-phase transformer connections. (4)

3.2 A 350 kVA, single-phase, 50 Hz transformer working at unity power factor has an efficiency of 90% at both half load and full load.

Calculate the following:

3.2.1 The iron loss and full-load copper loss $K_v$. (6)

3.2.2 The efficiency at 75% of full-load and 0.8 power factor lagging (12)

QUESTION 4

4.1 Show, with the aid of phasor diagrams, how the regulation of an alternator is affected by the following power factors of the load at:

4.1.1 Unity power factor (2)
4.1.2 Lagging power factor (2)
4.1.3 Leading power factor (2)

4.2 A 10 pole, 50 Hz, star-connected alternator has to develop 15 000 V on open circuit.

If there is a total of 90 slots on the armature, calculate:

4.2.1 The distribution factor (3)

4.2.2 The coil span factor when the coils are short chorded by one slot (2)

4.2.3 The number of armature conductors in series per phase when the flux per pole is 0.172 webers and the form factor is 1.2 (14)
QUESTION 5

5.1 How can the rotating flux of a three-phase induction motor be reversed? \hspace{1cm} (1)

5.2 A 4 pole, 50 Hz, three-phase induction motor has a rotor resistance of 0.2 ohm per phase and can develop a maximum torque of 193.4 N.m at a speed of 1380 r/min.

Calculate the following:

5.2.1 The slip at which maximum torque is produced \hspace{1cm} (2)
5.2.2 The standstill rotor reactance \hspace{1cm} (1)
5.2.3 The standstill rotor EMF \hspace{1cm} (6)
5.2.4 The starting torque \hspace{1cm} (2)

HINT: \[ T_{\text{start}} = \frac{3 \cdot S \cdot E_0^2 \cdot R_2}{2 \cdot \pi \cdot \eta \left( R_2^2 + \left[ S \cdot X_0 \right]^2 \right) \} \]

The slip is one at starting \hspace{1cm} [12]

QUESTION 6

6.1 State TWO advantages that a power factor improvement has for the consumer. \hspace{1cm} (2)

6.2 A synchronous motor is connected in parallel to a load of 1 000 kW at a power factor of 0.7 lagging. If the combined load has a power factor of 0.85 lagging and the synchronous motor takes 130 kW from the supply, calculate the following for the synchronous motor:

6.2.1 The kVA \hspace{1cm} (5)
6.2.2 The kVA \hspace{1cm} (1)
6.2.3 The power factor \hspace{1cm} (2)

[10]
QUESTION 7

7.1 Define regulation of a transmission line.

7.2 Use the 'T' method to determine the sending end current, voltage and power factor of a long transmission line delivering a load of 60 MVA, three-phase at a power factor of 0.8 lagging and a line voltage of 132 kV at 50 Hz.

Each conductor has a resistance of 25 ohms, inductance of 0.2 H and a capacitive reactance to neutral of 2122 ohms.

TOTAL: 100
ELECTROTECHNICS N6

GS-MASJIE NEN

DC MACHINES

\[ E = V - I_a R_a \]

\[ \frac{E_1}{E_2} = \frac{N_1 \Phi_1}{N_2 \Phi_2} \]

\[ \frac{T_1}{T_2} = \frac{I_1 \Phi_1}{I_2 \Phi_2} \]

SPOEDBEHEER

\[ E = V - I_a \left( \frac{R \cdot R_{se}}{R + R_{se}} + R_a \right) \]

\[ E = V - I_a R_a - I_{se} R_{se} \]

SPEED CONTROL

TOETSING

DIREKTE METODE

\[ \eta = \frac{2\pi n_r (W - S)}{60 IV} \]

TESTING

DIRECT METHOD

SWINBURNE-

METODE

\[ \eta_{\text{motor}} = \frac{IV - (I_a^2 R_a + I_{a_0} V + I_s V)}{IV} \]

\[ \eta_{\text{generator}} = \frac{IV}{IV + I_a^2 R_a + I_{a_0} V + I_s V} \]

SWINBURNE

METHOD

HOPKINSON-

RENDEMENTE

DIESELFDE

HOPKINSON

EFFICIENCIES

THE SAME

IRON LOSS

YSTER-

VERLIES

\[ I_2 V - \left\{ \left( I_1 + I_3 \right)^2 R_a + \left( I_1 + I_2 - I_4 \right)^2 R_a + \left( I_3 + I_4 \right) V \right\} = C \]

\[ \eta = \frac{I_1 V}{I_1 V + (I_1 + I_3)^2 R_a + I_3 V + \frac{C}{2}} \]

\[ \eta = \frac{(I_1 + I_2) V - \left\{ \left( I_1 + I_2 - I_4 \right)^2 R_a + I_4 V + \frac{C}{2} \right\}}{(I_1 + I_2) V} \]

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