higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T470(E)(A4)T
AUGUST EXAMINATION

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

4 August 2014 (Y-Paper)
13:00–16:00

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

ENGINEERING

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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. Write neatly and legibly.

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QUESTION 1

1.1 A coil having 2 500 turns of conductor with a cross-sectional area of 625 mm² and a mean length per turn of 250 mm, has an inductance of 4 henry.

Determine the following:

1.1.1 The resistance of the winding if the specific resistance of the conductor is 2 micro-ohm metres. (3)

1.1.2 The average value of the EMF induced in the coil when a current of 40 A reversed in 20 seconds (2)

1.2 A resistor of unknown value R is connected in parallel with a resistance of 30 ohms. This combination is connected in series with a resistance of 20 ohms. The circuit is then connected across a 120 V DC-supply.

Calculate the following:

1.2.1 The value of the resistor R when a 3 A current is drawn from the supply (5)

1.2.2 The power dissipated in the circuit (1)

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

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

If the resistance increases by 150 ohms when running, what temperature would be attained when running?

Take the temperature coefficient of resistance as 0,004 per degree Celsius at 75 °C (4)

1.5 Explain Kirchhoff's first law. (2)
[20]

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QUESTION 2

2.1 If a magneto motive force of 250 A is required to produce a flux of 5 mWb in a magnetic circuit; what must the reluctance be? (2)

2.2 Two batteries of EMF 35 V and 100 V and internal resistance of 0,5 ohms and 0,5 ohms respectively, are connected in parallel to supply a load resistance of 2 ohms.

Use Kirchhoff 's laws to 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 the farad. (3)

2.4 Two capacitors are connected in series and have respective voltage readings of 20 V and 5 V. If the total charge equals 240 µC;

Calculate the following:

2.4.1 The total capacitance (2)

2.4.2 The value of each capacitor (4)
[20]

QUESTION 3

3.1 The open-circuit characteristics of a shunt-excited DC machine are as follows:

Terminal voltage (V)	200	400	500	580	610	620
Field current (A)	1	2	3	5	6,5	7,5

Plot a graph and determine:

3.1.1 The voltage to which the machine will excite on no-load when shunt connected if the total field resistance is 100 ohm (8)

3.1.2 The critical resistance (2)

3.2 A long-shunt compound-wound DC-machine has a armature resistance of 0,5 ohms, a series field resistance of 0,02 ohms, and a shunt field resistance of 35,2 ohms. The machine draws a current of 110 A from a 352 V DC- supply when run as a motor.

Calculate the EMF generated in the armature. (5)

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

3.4 Make a neat sketch to illustrate magnetic fringing, leakage flux and useful flux. (3)
[20]

QUESTION 4

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

4.2 A 60 Hz sinusoidal voltage has a RMS value of 353,5 V.

4.2.1 Calculate the taken time for the voltage to reach a value of 250 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 300 ohms and an inductance of 1, 06 103 henry is connected in series with a 4,42 microfarad capacitor. This circuit is connected across a 1 000 V, 60 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 500 ohms. When the voltmeter is connected directly across the resistance to be measured, then the ammeter reads 2 A and that of the voltmeter 250 V.

Calculate the value of the unknown resistor:

5.1.1 Approximately (1)

5.1.2 Accurately and (3)

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

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5.2 The no-load current of a 2 500/50 V single-phase transformer is 15 A at a power factor of 0,2. The primary winding has 125 turns and the supply frequency is 50 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

(3 x 2) (6)

5.3 What device is used on a transformer that serves as a protection system and what does it also activate? (2)

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

5.5 Name any FOUR disadvantages of a single-phase motor compared to a three-phase motor. (4)

[20]

TOTAL: 100

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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 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

$$E_m = 2\pi BANn$$

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

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

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

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

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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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MARKING GUIDELINE

NATIONAL CERTIFICATE

AUGUST EXAMINATION

ELECTROTECHNICS N4

4 AUGUST 2014

This marking guideline consists of 7 pages.

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QUESTION 1

1.1 1.1.1 $L = 2\,500 \times 0{,}25 = 625 \text{ m} \surd$

$$R = \frac{\rho x L}{A} \quad \surd\surd$$

$$= \frac{2x10^{-6} x\, 625}{625 \times 10^{-6}} \quad \surd\surd$$

$$= 2\,\Omega$$

(3)

1.1.2 $$E = \frac{LI}{t} \times 2 \surd$$

$$= \frac{4 \times 40}{20} \times 2$$

$= 16 \text{ V} \surd$

(2)

1.2 1.2.1 $V_{SE} = IR_{SE} = 3x20 = \underline{60 \text{ V}} \surd$

$$R_P = \frac{V_P}{I_T} = \frac{60}{3} = 20\ \Omega \surd$$

$V_T = V_{SE} + V_P$

$120 = 60 + V_P$

$V_P = \underline{60 \text{ V}} \surd$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R}$$

$$\frac{1}{R_x} = \frac{1}{R_P} - \frac{1}{R_1} \surd$$

$$= \frac{1}{20} - \frac{1}{30}$$

$= 0{,}0167$

$R_X = \underline{60\ \Omega} \surd$

(5)

1.2.2 $P = V I = 120 \times 3 = \underline{360 \text{ W}} \surd$

(1)

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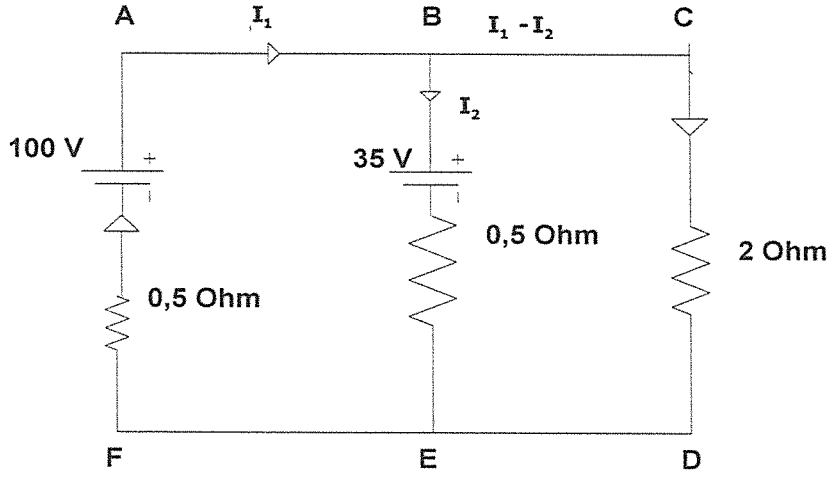
1.3 Positive temperature coefficient of resistance refers to materials whose resistance rises when the temperature increases. √
Negative temperature coefficient of resistance refers to materials whose resistance falls when the temperature increases. √ (3)

1.4
$$R_t = R_{20}[1+\alpha_\theta(t-\theta)]$$
$$450 = 300[1+0,004(t-75°)]$$
$$450/300 = [1+0,004(t-75°)]$$
$$1,5-1 = 0,004(t-75°)$$ √√√√
$$0,5/0,004 = t-75°$$
$$t-75° = 125$$
$$t = 125+75°$$
$$t = 200°C$$ (4)

1.5 That the sum of the currents flowing towards a junction is equal to the sum of the currents flowing away from that junction √√ (2)
[20]

QUESTION 2

2.1 **Mmf = ΦxS =**
S = Mmf/Φ
= 250/0,005
= 50 000 A/Wb √√ (2)



√

Consider loop/ Vanaf lus:ABEFA :loop/lus:ACDFA

∑E - ∑IR = 0 ∑E - ∑IR = 0

$(E_1-E_2)-(I_1R_1+I_2R_2)=0$ $(E_1-(I_1R_1+R_3(I_1-I_2)=0$

$(100-35)-(0,5I_1+0,5I_2)=0$ √ $100-(0,5I_1+2I_1-2I_2)=0$ √

$65-0,5I_1-0,5I_2=0.....(1)$ $100-2,5I_1+2I_2=0.....(2)$

Eq./Verg. (1)x4 = $260 - 2I_1 - 2I_2 = 0$ .....(3) √

Eq./Verg.(2) + (3) = $360 - 4,5I_1 = 0$√

Thus/ Dus: $I_1 = 360/4,5 = \underline{80\ A}$

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Substitute/Vervang $I_1 = 80$ A into/in Eq./Verg. (1)

$65 - 0{,}5(80) = 0{,}5I_2$

$I_2 = 65 - 40/\ 0{,}5 = -\ 25/0{,}5 = \underline{50\ A}$

$I_1 - I_2 = 80 - 50 = 30\ A$ √

2.2 2.2.1 Current across 100 V battery = 80 A √
Current across 35 V battery = 50 A √ (7)

2.2.2 Voltage across the load = IR = 30 x 2 = 60 V√ (2)

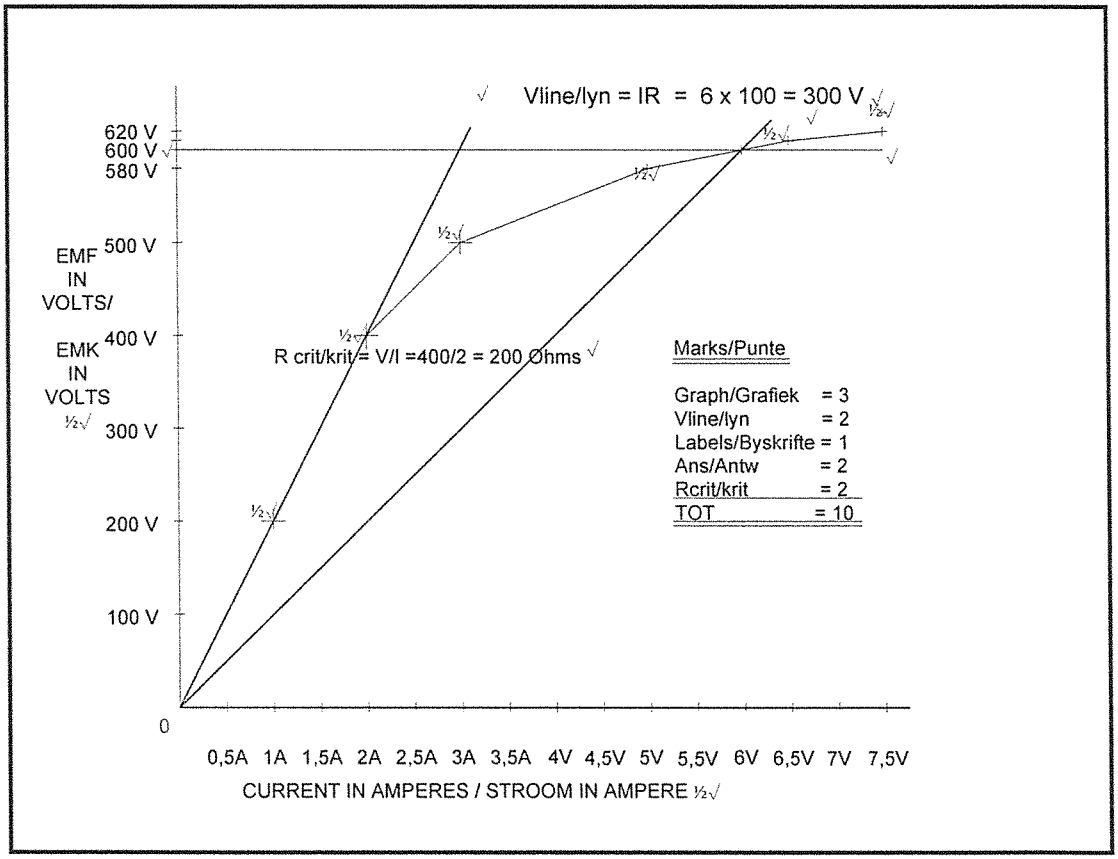
2.3 One farad is that capacitance which will accumulate a charge of one Coulomb when connected across a voltage of one volt √√√ (3)

2.4 2.4.1 $C_s = \dfrac{1}{\frac{1}{12} + \frac{1}{48}} = 9{,}6\ \mu F$ √√ (2)

2.4.2 C = Q/V = 240/20 & = 240/5
= 12 µF √√ & = 48 µF √√ (4)
[20]

QUESTION 3

3.1



(10)

3.2

$$I_{SH} = \frac{V}{R_{SH}} = \frac{352}{35,2} \surd = 10\ A$$

$$I_a = I_L - I_{SH} = 110 - 10 \surd = 100\ A$$

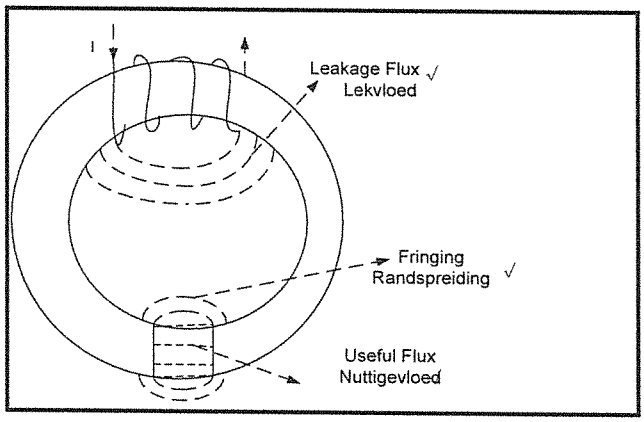
$$E = V - I_aR_a + I_aR_{SE} = 352 - [(100 \times 0,5) + (100 \times 0,02)] \surd\surd\surd = 352 - (50 + 2) = 300\ V$$

(5)

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

(2)

3.4



√√√ (3)
[20]

QUESTION 4

4.1 By 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 × 1) (2)

4.2 4.2.1

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

$$\surd \quad 353,5 = 0.707V_m$$

$$V_m = \frac{353,5}{0,707} = 500\ V$$

$$v = V_m \sin 2\pi ftx \frac{180}{\pi}$$

$$250 = 500 \sin 2\pi 60\ t \frac{180}{\pi} \quad \surd\surd\surd\surd$$

$$\frac{250}{500} = \sin 21\,600\ t$$

$$21\,600t = \sin^{-1} 0,5$$

$$t = \frac{30}{21\,600} = 1,389\ ms$$

(4)

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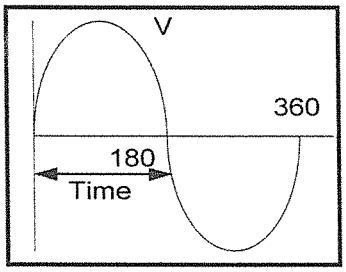
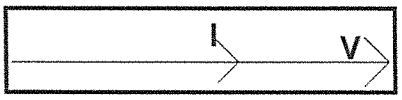
4.2.2





(2)

4.3 4.3.1 $X_L = 2\pi fL = 2\pi 60x1,06103 = 400,0\ \Omega$ √

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi 60x4,42x10^{-6}} = 600\ \Omega \surd$$

$$Z_{COIL} = \sqrt{R^2 + X_L{}^2} = \sqrt{300^2 + 400^2} = 500\ \Omega \surd$$

$$Z = \sqrt{R^2 + (X_C{}^2 - X^2{}_L)} = \sqrt{300^2 + (600-400)^2} = 360,5551275\ \Omega \surd$$

$$I = \frac{1000}{360,555} = 2,774\ A$$

$$\Theta = \text{Cos}^{-1}\frac{R}{Z} = \text{Cos}^{-1}\frac{300}{360,555} = 33,69° \surd$$

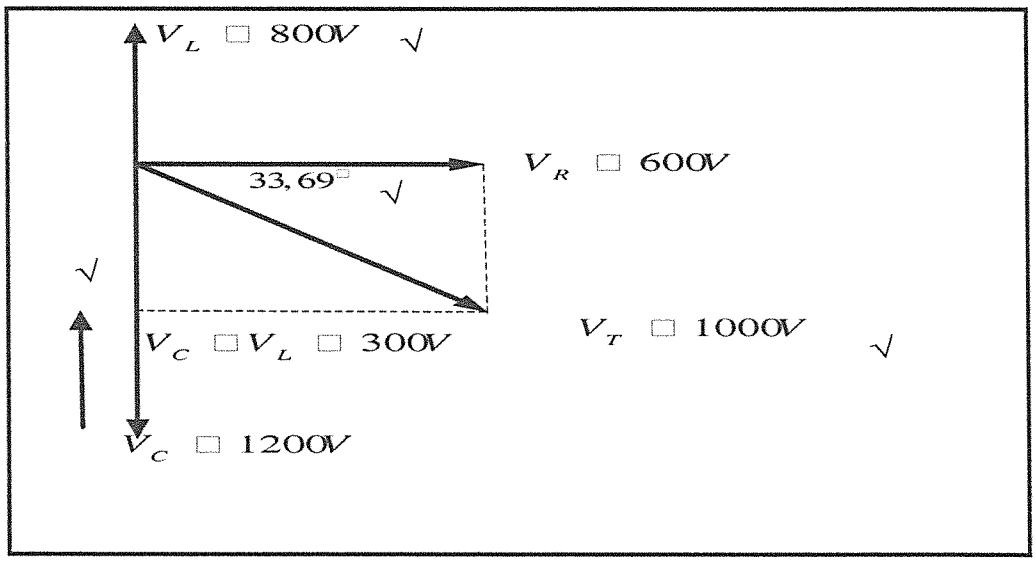
$V_{COIL} = IZ_{COIL} = 2,774 \times 500 = 1\ 387\ V$ √

(7)

4.3.2 $V_C = IX_C = 2,774 \times 600 = 1\ 664,4$ √

(1)

4.3.3



(4)
[20]

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QUESTION 5

5.1 5.1.1 $R_V = 500\Omega$ V = 250 V I = 2 A

$$I_V = \frac{V}{R_V} = \frac{250}{500} = 0,5A \quad \surd$$

$$R_{app} = \frac{V}{I} = \frac{250}{2} = 125\Omega \quad \surd \qquad (1)$$

5.1.2 $$R_X = \frac{V}{I - I_V} = \frac{250}{2 - 0,5} = 166,67\Omega \quad \surd\surd \qquad (3)$$

5.1.3

$$\% \text{ Error} = \frac{R_X - R_{app}}{R_X} = \frac{166,67 - 125}{166,67} = 25\% \quad \surd\surd \qquad (2)$$

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

$\Phi_m = E_1 / 4,44fN_1 = 2\ 500/4,44x50x125 = 0,09009 = 90$ mWb $\surd\surd$

5.2.2 $$Powerloss = V_1 I_0 Cos\phi_0 = 2500x15x0,2 = 7500W \quad \surd\surd$$

5.2.3 $$I_C = \frac{Coreloss}{V_P} = \frac{7500}{2500} = 3A \surd$$

$$I_M = \sqrt{I^2{}_O - I^2{}_C} = \sqrt{15^2 - 3^2} = 14,6969A \surd$$

(3 × 2) (6)

5.3 Buchholtz device which activates an alarm √ √ (2)

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

5.5 Lower efficiency √ Lower power factor √ Weaker torque √ More noisier √ √ Vibrates more √ (Any 4 × 1) (4)

[20]

TOTAL: 100

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