higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

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This marking guideline consists of 6 pages.

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QUESTION 1

1.1
- They facilitate collection of current from the armature conductors.
- They convert the alternating EMF (AC) induced in the armature conductors into unidirectional EMF (DC). (2)

1.2 1.2.1
$E = V - I_aR_a$
$= 480 - (45 \times 0,36)$
$= 463,8$ V✓

$\phi = 60\ cE/2\ PNZ$
$= (60 \times 4 \times 463,8)/(2 \times 2 \times 980 \times 2\ 050)$✓
$= 111\ 312 / 8\ 036\ 000$
$= 0,01385$ Wb✓
$= 13,852$ mWb

1.2.2
$T = 0,318\ I_a\ ZP\ \phi/c$
$= (0,318 \times 45 \times 2\ 050 \times 2 \times 0,01385)$✓/4✓
$= 203,148$ Nm✓

(2 × 3) (6)

1.3
$E_1 = V - I_aR_a$
$= 500 - (110 \times 0,25)$✓
$= 472,5$ V✓

$T_2 = 0,8\ T_1$
$N_2 = 0,75\ N_1$
$\phi_2 = \phi_1$✓

$E_2/E_1 = \phi_2\ N_2/\phi_1\ N_1$
$E_2 = 0,75 \times 472,5$✓
$= 354,375$ V✓

$T_2/T_1 = \phi_2\ I_{a2}/\phi_1\ I_{a1}$
$0,8 = I_{a2}/110$ ✓
$I_{a2} = 0,8 \times 110$ ✓
$= 88$ A ✓

$E_2 = V - I_{a2}\ (R_a + R_X)$
$354,375 = 500 - 88(0,25 + R_X)$✓
$1,655 = 0,25 + R_X$
$R_X = 1,405\ \Omega$✓ (10)

1.4
- Fairly constant speed
- Poor starting torque (2)

[20]

QUESTION 2

2.1 2.1.1 $Z = 844 < 45/12 < -45$
$= 70,333 < 90°$✓

Magnitude:
$X_L = 70,333\ \Omega$✓

Nature:
Pure inductance✓ (3)

2.1.2 $314 = 2\pi f$
$F = 314/(2\pi)$
$= 49,975$ Hz✓

$T = 1/f$
$= (49,975)^{-1}$
$= 0,02$ s
$= 20$ ms✓ (2)

2.2 2.2.1 $P_T = V_T I_T \cos \Theta$
$I_T = P_T/(V_T \cos \Theta)$
$= 3\ 300/220$✓
$= 15$ A
$= 15 < 0$ A✓

$X_B = (2\pi \times 50 \times 145 \times 10^{-6})^{-1}$
$= 21,952\ \Omega$✓
$Z_B = 5 - j21,952$
$= 22,514 < -77,17\ \Omega$✓

$I_B = 220 < 0°/22,514 < -77,17$✓
$= 9,772 < 77,17$ A ✓

$I_A = I_T - I_B$
$= 15 + j0 - 2,169 - j9,528$✓
$= 12,831 - j9,528$✓
$= 15,982 < -36,59$ A✓

$Z_A = V_T / I_A$
$= 220 < 0/15,982 < -36,59$✓
$= 13,765 < 36,59\ \Omega$✓
$= 11,052 + j8,205$
$X_A = 8,205\ \Omega$✓
$R_A = 11,052\ \Omega$✓

OR

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$Z_T = V_T/I_T$
$= 220 < 0/15 < 0$✓
$= 14{,}667 < 0^0\ \Omega$✓

$Z_A = Z_T Z_B/(Z_B - Z_T)$
$= 14{,}667 < 0 \times 22{,}514 < -77{,}17$✓$/(5 - j21{,}952 - 14{,}667 - j0)$✓
$= 330{,}213 < -77{,}17$ ✓$/(-9{,}667 - j21{,}952)$✓
$= 330{,}213 < -77{,}17/23{,}986 < -113{,}77$✓
$= 13{,}767 < 36{,}6\ \Omega$✓
$= 11{,}052 + j8{,}208$✓
$R_A = 11{,}052\ \Omega$✓
$X_A = 8{,}208\ \Omega$✓ (13)

2.2.2 $\cos \Theta = \cos 36{,}59$✓
$= 0{,}803$, lagging✓ (2)
[20]

QUESTION 3

3.1
- The same voltage ratio
- The same per unit or percentage impedance
- The same polarity
- The same phase sequence and zero relative phase displacement (4)

3.2 Yes
The current in the primary winding provides a very small power component to supply the iron loss in the core. (2)

3.3 3.3.1 $S_T = P_T/\cos \Theta$
$= 1{,}2 \times 10^6/0{,}85$✓
$= 1\ 411{,}765$ kVA✓

$Z_1 = (2{,}5 + j5{,}5)\ 1\ 800/1\ 400$
$= 3{,}214 + j7{,}071$
$= 7{,}767 < 65{,}56\ \Omega$✓

$Z_2 = 1{,}6 + j3{,}5$
$= 3{,}848 < 65{,}43\ \Omega$✓
$Z_1 + Z_2 = 4{,}814 + j10{,}571 = 11{,}616 < 65{,}52\ \Omega$✓

$S_1 = (1\ 411{,}765 < -31{,}79 \times 3{,}848 < 65{,}43)$✓$/11{,}616 < 65{,}52$
$= 5\ 432{,}472 < 33{,}64/11{,}616 < 65{,}52$
$= 467{,}672 < -31{,}88$ kVA
$= 467{,}672$ kVA✓
$\cos \Theta = \cos 31{,}88 = 0{,}849$ lagging✓ (8)

3.3.2 S_2 = (1 411,765 < -31,79 x 7,76 < 65,56) ✓/11,616 < 65,52✓
= 10 955,296 < 33,77 ✓/11,616 < 65,52
= 943,121 < -31,75 kVA
= 943,121 kVA✓

Cos Θ = Cos 31,75 ✓= 0,85 lagging✓ (6)
[20]

QUESTION 4

4.1 4.1.1 $X_L = 2\pi \times 50 \times 0,04 = 12,566\ \Omega$✓
$Z_P = 12 + j12,566 = 17,375 < 46,32\ \Omega$✓

$I_P = V_P/Z_P$ = 415 < 0/17,375 < 46,32✓
= 23,885 < -46,32 A ✓
$I_L = \sqrt{3}\, I_P = \sqrt{3} \times 23,885$ ✓ = 41,369 A✓ (6)

4.1.2 CosΘ = Cos 46,32 = 0,691 lagging✓ (1)

4.1.3 $P = \sqrt{3}\, V_L\, I_L \cos\Theta = \sqrt{3} \times 415 \times 41,369 \times 0,691$✓
= 20 547,633 W = 20,548 kW✓ (2)

4.2 4.2.1 $V_P = 12 \times 10^3/\sqrt{3} = 6\,928,203$ V✓

$V_R = V_P(\cos\Theta + j\sin\Theta) = 6\,928,203(0,78 + j0,626)$
= 5 403,998 + j4 337,055✓

$I_P = S/\sqrt{3}\, V_L = 3 \times 10^6/(\sqrt{3} \times 12 \times 10^3) = 144,338$ A✓

$V_d = I_P Z = 144,338(5 + j10) = 721,688 + j1\,443,38$✓

$V_S = V_R + V_d$ = 5 403,998 + j4 337,055 + 721,688 + j1 443,38✓
= 6 125,686 + j5 780,435 = 8 422,438 < 43,34 V✓

Reg = $(V_S - V_R)/V_R$ = (8 422,438 – 6 928,203) /6 928,203 × 100✓
= 21,567%✓ (8)

4.2.2 Losses = $3 (I_P)^2 R_P = 3(144,338)^2 \times 5 = 312\,501,874$ W
= 31,25 kW✓

$\eta = P_O/(P_O + \text{loss}) = 2,34 \times 10^6/(2,34 \times 10^6 + 31,25 \times 10^3)$✓
= 98,682%✓ (3)
[20]

QUESTION 5

5.1 Hunting is a sudden change of load on synchronous motors, sometimes set up oscillations that are superimposed upon the normal rotation, giving rise to periodic variations in speed of a very low frequency. (2)

5.2 $N_S = 60f/p = (60 \times 50)/4$ ✓ $= 750$ r/min✓

$S = (N_S - N_R)/N_S$

$0,04 = (750 - N_R)/750$✓

$N_R = 750 - (750 \times 0,04)$

$= 720$ r/min✓ (4)

5.3 5.3.1 $E_R = E_A + E_B < (180 - \alpha) = 1\,910 < 0 + 1\,800 < 150$

$= 1\,910 + j0 - 1\,558,846 + j900$✓

$= 351,154 + j900$

$= 966,079 < 68,69$ V✓

$Z_R = 0,4 + j9 = 9,009 < 87,46\ \Omega$ ✓

$I_R = E_R/Z_R = 966,079 < 68,69/9,009 < 87,46$✓

$= 107,235 < -18,77$ A✓ (5)

5.3.2 $V_{TER} = (E_A + E_B)/2 = (1\,910 + j0 + 1\,558,846 - j900)$ ✓/2

$= (3\,468,846 - j900)/2$

$= (3\,583,698 < -14,54)/2$

$= 1\,791,849 < -14,54$ V✓

$V_L = \sqrt{3} \times 1\,791,849 = 3\,103,574$ V✓ (3)

5.4 5.4.1 $E_O = 110/\sqrt{3} = 63,509$ V✓

$Z_O = 2,6 + j7,5 = 7,938 < 70,88\ \Omega$✓

$I_R = E_O/Z_O = 63,509/7,938 = 8$ A✓ (4)

5.4.2 $\text{Cos}\Theta = \text{Cos}\ (70,88)$✓ $= 0,328$✓

OR

$\text{Cos}\Theta = \text{Cos}[\tan^{-1}\ (7,5/2,6)]$✓ $= 0,328$✓ (2)

[20]

TOTAL: 100

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