higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

6 AUGUST 2018

This marking guideline consists of 7 pages.

Copyright reserved

QUESTION 1

1.1 Pole pitch is the centre-to-centre distance between two adjacent poles. (1)

1.2 Commutating poles are used to improve commutation, while compensating windings are used to minimise armature reaction. (1 + 1) (2)

1.3 By using interpoles (1)

1.4 1.4.1 $E^O = P \times M^O$
$= 2 \times 3$
$= 6°$✓

Demag AT/P = $0,5 \times I_a / C \times Z/2P \times 4\Theta/360$
$= 0,5 \times 150/2 \times 860/4 \times (4 \times 6/360)$✓
$= 537,5$ AT/P✓

Cross-mag AT/P = $0,5 \times 150/2 \times 860/4 \times [1 – (4 \times 6/360)]$✓
$= 8\,062,5 \times 0,933$
$= 7\,524,73$ AT/P✓ (5)

1.4.2 MMF = N I
I = MM/N
= 537,5/1 100✓
= 0,49 A✓ (2)

1.5 1.5.1 Emf = $V + I_a R_a$
$= 350 + (70 \times 0,6)$✓
= 392 V✓ (2)

1.5.2 $\phi = 60 E c/2 P N Z$✓
$= (60 \times 392 \times 6)$✓$/(2 \times 3 \times 1\,300 \times 11)$✓
= 0,0164 Wb✓
= 16,448 MWb✓ (4)

1.5.3 $T = 0,318 I_a Z P \phi/c$✓
$= (0,318 \times 70 \times 1\,100 \times 3 \times 0,164)$✓$/6$✓
= 2 007,852 Nm✓ (3)
[20]

QUESTION 2

2.1 2.1.1 $X_C = X_L$
$= 2 \pi f L$
$= 2 \pi \times 1,8 \times 10^6 \times 430 \times 10^{-6}$
$= 4\,863,185\ \Omega$✓

$C = (2 \pi f X_C)^{-1}$
$= (2 \pi \times 1,8 \times 10^6 \times 4\,863,185)^{-1}$✓
$= 1,818 \times 10^{-11}$✓
$= 18,181 \times 10^{-12}$
$= 18,181\ pF$✓

$Z_P = L/CR$
$= 430 \times 10^{-6}/(18,181 \times 10^{-12} \times 35)$✓
$= 675\,744,694\ \Omega$
$= 675,745\ k\Omega$✓ (6)

2.1.2 $I_T = V_T/Z_T$
$= 80/(675\,744,694 + 8\,400)$✓
$= 0,117\ mA$✓

$V_{COIL} = I_T Z_P$
$= 0,117 \times 10^{-3} \times 675\,744,694$
$= 79,018\ V$✓ (3)

2.2 2.2.1 $Z_1 = 6,403 < 38,66\ \Omega$
$Z_3 = 4,472 < -63,43\ \Omega$
$V_3 = I_T Z_3$
$V_3 = 24,149 < 32,32 \times 4,472 < -63,43$
$= 107,994 < -31,11\ V$✓

$V_P = V_T - V_3$
$= 100 + j0 - 92,462 + j55,799$✓
$= 7,538 + j55,799$
$= 56,306 < 82,31\ V$✓

$I_1 = V_P/Z_1$
$= 56,306 < 82,31/6,403 < 38,66$✓
$= 8,794 < 43,65\ A$✓

$I_2 = I_T - I_1$
$= 20,408 + j12,911 - 6,363 - j6,07$
$= 14,045 + j6,841$
$= 15,622 < 25,97\ A$✓ (6)

2.2.2 $PF = \cos\Theta$
$= \cos(25,97)$
$= 0,899$ leading✓ (1)

2.2.3 $Z_2 = V_P/I_2$
$= 56,306 < 82,31/15,622 < 25,97$✓
$= 3,604 < 56,34\ \Omega$✓
$= 1,996 + j2,999$

$R_2 = 1,996\ \Omega$✓
$X_2 = 2,999\ \Omega$✓ (4)
[20]

QUESTION 3

3.1
- To keep the coils cool
- To provide additional insulation not obtainable when the transformer is left in the air (2)

3.2 $R_{E1} = R_1 + R_2 (V_1/V_2)^2$
$= 11 + 0,016 (5\ 800/220)^2$✓
$= 22,121\ \Omega$✓

$I_1 = S/V_1$
$= 25 \times 10^3/5\ 800$
$= 4,31\ A$✓

% reg $= I_1 (R_{E1} \cos\phi + X_{E1} \text{SIN}\ \phi)/V_1$
$= 4,31 [(22,121 \times 0,8) + (24 \times 0,6)]/5\ 800$✓
$= (138,337/5\ 800) \times 100$✓
$= 2,385\%$✓ (6)

3.3 $Z_A = 2\ 000/1\ 400\ (2 + j8)$✓
$= 1,429\ (2 + j8\ )$
$= 2,858 + j11,432$
$= 11,784 < 75,96\ \Omega$✓

$Z_B = 1,4 + j7$
$= 7,139 < 78,69\ \Omega$✓

$Z_A + Z_B = (2,858 + j11,432\ ) + (1,4 + j7)$
$= 4,258 + j18,432$
$= 18,917 < 76,99$✓

$S_T = 1\ 100/0,85$
$= 1\ 294,118 < -31,79$ kVA✓

$S_A = S_T \times (Z_B/Z_A + Z_B)$
$= 1\ 294,118 < -31,79 \times (7,139 < 78,69/18,917 < 76,99)$✓
$= 9\ 238,708 < 46,9/18,917 < 76,99$
$= 488,381 < -30,09$ kVA✓

Pf $= \cos\Theta$
$= \cos(30,09)$
$= 0,865$ lagging✓

$S_B = S_T \times (Z_A/Z_A + Z_B)$
$= 1\,294{,}118 < -31{,}79 \times (11{,}784 < 75{,}96)/18{,}917 < 76{,}99$✓
$= 15\,249{,}887 < 44{,}17/18{,}917 < 76{,}99$✓
$= 806{,}147 < -32{,}82$ kVA✓

$Pf = \cos\Theta$
$= \cos(32{,}82)$
$= 0{,}84$ lagging✓ (12)
[20]

QUESTION 4

4.1 Regulation is the rise or fall in voltage at the receiving end when full load is switched off. The sending-end voltage remaining constant. (2)

4.2 $X_L = 2\,\pi\,f\,L$
$= 2 \times \pi \times 50 \times 0{,}02$
$= 6{,}283\ \Omega$✓
$X_C = (2\,\pi\,f\,C)^{-1}$
$= (2 \times \pi \times 50 \times 31{,}8 \times 10^{-6})^{-1}$
$= 100{,}097\ \Omega$✓
$V_P = V_L/\sqrt{3}$
$= 415/\sqrt{3}$
$= 239{,}6$ V✓
$Z_P = Z_1 Z_2 /(Z_1 + Z_2)$
$= 11{,}81 < 32{,}141$✓ $\times\ 100{,}097 < -90/(10 + j6{,}29 + 0 - j100{,}097)$
$= 1\,182{,}181 < -57{,}86/94{,}348 < -83{,}92$✓
$= 12{,}53 < 26{,}06\ \Omega$✓
$I_P = V_P/Z_P$
$= 239{,}6 < 0/12{,}53 < 26{,}06$
$= 19{,}122 < -26{,}06$ A✓
$I_P = I_L$
$= 19{,}122$ A✓ (8)

4.3 4.3.1 $V_P = V_L/\sqrt{3}$
$= 11\,000/\sqrt{3}$
$= 6\,350{,}853$ V✓

$I_L = S/(\sqrt{3}\,V_L$
$= 2\,500 \times 10^3/(\sqrt{3} \times 11\,000)$
$= 131{,}216$ A✓

$V_S = V_R < \Theta + I\,R < 0^0 + I \times < 90$

$V_R < \Theta = 6\,350{,}853 < 36{,}87$
$= 5\,080{,}676 + j3810{,}521$✓

$I\ R < 0^0$ = 3 × 131,216 < 0 = 393,648 + j0✓

1 × < 90 = 6 × 131,216 < 90
= 0 + j787,296

V_S = 5 474,324 + j4597,817
= 7 148,996 < 40,026 V✓
= $\sqrt{3}$ × 7148,996
% reg = 12 382,424 V✓
= $V_S - V_R/V_S$
= (7 148,996 – 6 350,853)/7 148,996
= 12,567%✓ (7)

4.3.2 P_R = ScosΘ
= 2 500 × 0,8
= 2 000 kW✓

Losses = 3 I^2 R_P
= 3(131,216)^2 × 3
= 154,959 kW✓

Eff = $P_R/(P_R$ + losses)
= 2 000/(2 000 + 154,959)
= 92,809%✓ (3)
[20]

QUESTION 5

5.1 When rotor speed equals synchronous speed, the slip is zero which means there is no cutting of magnetic flux by rotor bars and hence no torque is generated. To generate torque, rotor speed should always be less than synchronous speed. (3)

5.2 5.2.1 $E_{O(PH)}$ = 55/$\sqrt{3}$
= 31,754 V✓

Z_{PH} = (4 + j3) + (0,7 + j5)
= 4,7 + j8
= 9,278 < 59,566✓

I_O = E_{PH}/Z_{PH}
= 31,754 < 0/9,278 < 59,566
= 3,423 A✓ (3)

5.2.2 E_R = SE_O
= 0,05 × 31,754
= 1,588 V✓
X_R = SX_O
= 0,05 × 5
= 0,25 Ω✓
Z_R = 0,7 + j0,25
= 0,743 < 19,654 Ω✓
I_R = E_R/Z_R
= 1,588/0,743
= 2,137 A✓ (4)

5.3 5.3.1 P_{IN} = P_O/η
= 40 000/0,8
= 50 kW✓

I_L = $P_{IN}/(\sqrt{3}\ V_L \cos\Theta)$
= 50 000/($\sqrt{3}$ × 2 000 × 0,87)
= 16,591 A✓

I_{ALT} = 16,591 A✓

I_{MOT} = $I_L/\sqrt{3}$
= 16,591/$\sqrt{3}$
= 9,579 A✓ (4)

5.3.2 S = $\sqrt{3}\ V_L\ I_L$
= $\sqrt{3}$ × 2 000 × 16,591✓
= 57 472,909 A
= 57,473 kVA✓ (2)

5.4 Pitch factor (Kp) is the ratio of emf with short-pitch coil to emf with full-pitch coil, while distribution factor (Kd) is the ratio of emf with a distributed winding to emf with a concentrated winding. (2 + 2) (4)

[20]

TOTAL: 100

Copyright reserved