higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N5

21 April 2021

This marking guideline consists of 7 pages.

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QUESTION 1

1.1
- Back EMF is when the EMF generated due to the movement of the armature conductors
- through the main magnetic flux between the field poles
- and the generated EMF acts against the applied voltage. (3)

1.2 $E_1 = 450 – (48 \times 0,42)$
$= 450 – 20,16$
$= 429,84$ V✓

$\phi_1 = \phi_2$ ✓
$T_2 = 0,78\ T_1$

$0,78 = I_{a2}/48$✓
$I_{a2} = 0,78 \times 48$
$= 37,44$ A✓
$N_2 = 0,75\ N$✓

$E_2 / 429,84 = 0,75$ ✓
$E_2 = 0,75 \times 429,84$
$= 322,38$ V✓

$E_2 = V – I_{a2}(R_a + R_X)$
$322,38 = 450 – 37,44(0,42 + R_X)$✓
$37,44(0,42 + R_X) = 127,62$✓
$R_X = 3,409 – 0,42$
$= 2,989\ \Omega$ ✓ (10)

1.3 $I_L = 54 \times 10^3 / 250$✓
$= 216$ A ✓

$AT(s)_{\text{NO LOAD}} = 3,8 \times 800 = 3\ 040$ At(s)✓
$AT(s)_{\text{LOAD}} = 4,8 \times 800 = 3\ 840$ At(s)✓

$AT(s)_{\text{SERIES FIELD}} = 3\ 840 – 3\ 040 = 800$ At(s)✓

$T_{\text{SERIES}} = 800/216$✓ $= 3,704$
$= 4$ turns✓ (7)
[20]

QUESTION 2

2.1 2.1.1 $I_T = P_T / (V_S \cos \Theta)$
$= 4\,400 / (220 \times 0,87)$
$= 22,989 < -29,54$ ✓
$= 20 - j11,334$

$X_A = (2\pi \times 60 \times 210 \times 10^{-6})^{-1}$
$= 12,631\ \Omega$

$Z_A = 4,5 + j12,631$
$= 13,512 < 69,19\ \Omega$ ✓

$I_A = 220 < 0 / 13,512 < 69,19$
$= 16,282 < -69,19$ ✓
$= 5,785 - j15,219$

$I_B = I_T - I_A$
$= 20 - j11,334 - 5,785 - j15,219$ ✓
$= 14,215 + j3,885$
$= 14,736 < 15,29$ A ✓ (5)

2.1.2 $Z_B = 220 < 0 / 14,736 < 15,29$
$= 14,929 < -15,29\ \Omega$ ✓ (1)

2.2 $Z_1 = 4 - j3 = 5 < -36,87\ \Omega$√
$Z_2 = 5 + j3 = 5,831 < 30,96\ \Omega$√
$Z_3 = 3 + j4 = 5 < 53,13\ \Omega$√
$Z_4 = 5 + j6 = 7,81 < 50,19\ \Omega$√

$V_1 = I_1 Z_1$
$= 12 < 0 \times 5 < -36,87$
$= 60 < -36,87$ V ✓

$V_1 = V_2 = V_{P1} = 60 < -36,87$ V

$I_2 = V_1 / Z_2 = 60 < -36,87 / 5,831 < 30,96$ ✓
$= 10,287 < 67,83$ A ✓

$I_3 = I_1 + I_2 = 12 + j0 + 3,883 + j9,52$ ✓
$= 15,883 + j9,528$
$= 18,522 < 30,95$ A ✓

$V_3 = I_3 Z_3 = 18,522 < 30,95 \times 5 < 53,13$
$= 92,61 < 84,08$ V ✓

$V_T = V_1 + V_3 = 47,999 - j36 + 9,552 + j92,116$✓
$= 57,551 + j56,116$
$= 80,381 < 44,28$ V ✓

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$V_T = V_4 = V_2 + V_3 = 80,381 < 44,28$ V

$I_4 = V_T / Z_4$
$= 80,381 < 44,28 / 7,81 < 50,19$ ✓
$= 10,292 < -5,91$ A ✓

$I_T = I_3 + I_4$
$= 15,883 + j9,528 + 10,237 – j1,059$ ✓
$= 26,12 + j8,469$
$= 27,459 < 17,96$ A ✓ (14)
[20]

QUESTION 3

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

3.2 3.2.1

$I_1 = S / V_1$
$= 12 \times 10^3 / 3\,000$
$= 4$ A ✓

$V_2 / 3\,000 = 1/5$
$V_2 = 3\,000/5$
$= 600$ V ✓

$R_{E1} = R_1 + R_2(N_1/N_2)^2$
$= 4 + 0,3(5)^2$
$= 11,5\ \Omega$ ✓

$X_{E1} = X_1 + X_2(N_1/N_2)^2$
$= 8 + 0,43(5)^2$
$= 18,75\ \Omega$ ✓

$V_{REG} = 4[(11,5 \times 0,8) + (18,75 \times 0,6)] / 3\,000$ ✓
$= 4(9,2 + 11,25) / 3\,000$
$= 0,0273$ p.u. OR 2,73%✓

$0,0273 = (600 – V_{2FL}) / 600$
$V_{2FL} = 600 – (600 \times 0,0273)$✓
$= 600 – 16,38$
$= 583,62$ V ✓ (8)

3.2.2

$V_{REG} = 4[(11,5 \times 0,8) + (18,75 \times 0,6)] / 3000$ ✓
$= 4(9,2 – 11,25) / 3000$
$= -2,733 \times 10^{-3}$ p.u OR – 0,002733 p.u ✓
$- 0.002733 = (600 – V_{2FL}) / 600$
$V_{2FL} = 600 + (600 \times 0,002733)$ ✓
$= 601,639$ V ✓ (4)

3.3 3.3.1 $V_{L1} = \sqrt{3}\ V_P$
$V_{P1} = V_{L1} / \sqrt{3}$
$= 3\ 300 / \sqrt{3}$
$= 1\ 905{,}256$ V ✓

$V_{P2} = (30 \times 1\ 905{,}256) / 420$
$= 136{,}089$ V ✓

3.3.2 $V_{P2} = (30 \times 3\ 300) / 420$
$= 235{,}714$ V ✓

$V_{L2} = \sqrt{3}\ V_{P2}$
$= \sqrt{3} \times 235{,}714$
$= 408{,}269$ V ✓

(2 × 2) (4)
[20]

QUESTION 4

4.1 $P_{IN} = P_O / \eta$
$= 32 \times 10^3 / 0{,}88$
$= 36\ 363{,}636$ W ✓
$P_1 + P_2 = 36\ 363{,}636$ W ✓ .....(1)

$\text{Tan}\ \Theta = \sqrt{3}(P_2 - P_1) / (P_1 + P_2)$
$\text{Tan}\ 45{,}57 = \sqrt{3}\ (P_2 - P_1) / 36\ 363{,}636$ ✓
$P_2 - P_1 = (36\ 363{,}636 \times 1{,}02) / \sqrt{3}$
$= 21\ 416{,}49$ ✓ .....(2)

ADD: (1) and (2)
$2P_2 = 57\ 780{,}126$ ✓
$P_2 = 57\ 780{,}126 / 2$
$= 28\ 890{,}063$ W
$= 28{,}89$ kW ✓

Subst: $P_2 = 28\ 890{,}126$ W into (1)
$28\ 890{,}126 + P_1 = 36\ 363{,}636$ ✓
$P_1 = 7\ 473{,}573$ W
$= 7{,}474$ kW ✓ (8)

4.2 4.2.1 $I_P = P / (\sqrt{3} \times V_L \times \text{Cos } \Theta)$
$= 0,55 \times 10^6 / (\sqrt{3} \times 11 \times 10^3 \times 0,8)$
$= 36,084 \text{ A}$ ✓

$V_r = 11\,000 / \sqrt{3} (\text{Cos } \Theta + j\text{Sin } \Theta)$
$= 6\,350,853(0,8 + j0,6)$ ✓
$= 5\,080,682 + j3810,512$ ✓

$V_d = I_P Z_P$
$= 36,084(25 + j45)$
$= 902,1 + j1623,78$ ✓

$V_S = V_r + V_d$
$= 5\,080,682 + j3810,512 + 902,1 + j1623,78$
$= 5\,982,782 + j5434,292$ ✓
$= 8\,082,401 < 42,25 \text{ V}$ ✓

$V_{S\,LINE} = \sqrt{3} \times 8\,082,401$
$= 13\,999,129 \text{ V}$
$= 13,999 \text{ kV}$ ✓ (7)

4.2.2 $\text{Reg} = (V_S - V_r) / V_r$
$= (8\,082,401 - 6\,350,85) / 6\,350,85$ ✓
$= 0,273 \times 100$
$= 27,265\%$ ✓ (2)

4.3 $C_{Ph} = 65 / \{ 18 \text{ In } [(300 - 12,5) / 12,5] \}$ ✓
$= 65 / (18 \text{ In } 23)$ ✓
$= 65 / 56,439$
$= 1,152 \mu\text{F}$ ✓ (3)
[20]

QUESTION 5

5.1
- The EMF of the alternators must be equal to the busbar voltage.
- The EMF of the alternators must be in phase with the busbar voltage.
- The frequencies of the alternators must be the same. (Any 2 × 1) (2)

5.2
- Sudden changes in the 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)

5.3 5.3.1 $F = N_S P / 60$
$50 = 4 \times N_S / 60$
$N_S = 750$ r/min ✓

$S = (N_S - N_r) / N_r$
$0,04 = (750 - N_r) / N_r$
$0,04 N_r = 750 - N_r$ ✓
$N_r = 750 / 1,04$
$= 721,154$ r/min ✓ (3)

5.3.2 $P_{GROSS} = 30 \times 10^3 + 280$
$= 30\,280$ W ✓

$P_{GROSS} = 2\pi N_r T / 60$
$30\,280 = (2\pi \times 721,154 \times T) / 60$
$T = 400,958$ Nm ✓

Rotor input $= 2\pi N_S T / 60$
$= (2\pi \times 750 \times 400,958) / 60$
$= 31\,491,168$ W ✓

Rotor Cu. Loss = S × Rotor input
$= 0,04 \times 31\,491,168$
$= 1\,259,647$ W ✓ (4)

5.4 5.4.1 $E_R = 0 + j1980 - (1980 \text{ Sin } 20 + j1980 \text{ Cos } 20)$ ✓
$= 0 + j1980 - (677,199 + j1714,73)$
$= -677,199 + j265,27$ ✓
$= 727,301 < 158,61$ V
$= 727,301$ V ✓

$I_P = E_R / (2 X_S)$
$= 727,301 / 10$ ✓
$= 72,73$ A ✓ (5)

5.4.2 $V_{TERM} = 1\,980 \text{ Cos } (20 / 2)$ ✓
$= 1\,949,919$ ✓ (2)

5.4.3 $P = 3 I_P V_P$
$= 3 \times 72,73 \times 1\,949,919$ ✓
$= 425\,452,855$ W
$= 425,453$ W ✓ (2)
[20]

TOTAL: 100

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