

**Electrical Engineering Department**

**EE 360**

**Term 071**

**Major Examination II**

**Date** January 1, 2008  
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**Instructor Name** Dr. Ibrahim El-Amin

**Sequence Number #**

**Student Id #**

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<b>Q1</b>	
<b>Q2</b>	
<b>Q3</b>	
<b>Total</b>	

Q1

(a) Three single phase transformers are connected as Y- $\Delta$  three phase transformer bank to deliver a power 400 kVA at 34.5/13.8 kV. Find the rating of each unit ( high voltage, low voltage, turns ration and power rating

(b) A 1.0-kVA 230/115-V transformer has been tested to determine its parameters. All tests were taken on the 230-V side. The test results are as show:

Test	Voltage(V)	Current(A)	Power(W)
Open circuited	230	0.95	80
Short circuited	11.2	5.0	20.1

- (i) Find the equivalent circuit parameters referred to the low voltage side.  
 (ii) Determine the transformer voltage regulation at rated load and 0.8 power factor leading.

a) Power per phase =  $\frac{400}{3} = 133.33 \text{ kW}$   
 $V_{1 \text{ phase}} = \frac{34.5}{\sqrt{3}} = 19.92 \text{ kV}$  - Connected  
 $V_{2 \text{ phase}} = 13.8 \text{ kV}$   $\Delta$ - Connected  
 $a = \frac{1.44}{1} ; I_1 = 6.69 \text{ A} ; I_2 = 9.66 \text{ A}$

b)  $Y_{oc} = \frac{0.95}{230} = 4.13 \times 10^{-3} \text{ S}$   
 $\theta_{oc} = -\cos^{-1}\left(\frac{80}{230(0.95)}\right) = -68.5^\circ$  ;  $Y_{oc} = \frac{4.13 \times 10^{-3} \angle -68.5^\circ}{1.51 \times 10^{-3} - j 3.84 \times 10^{-3}}$   
 $R_c = 1/G = 662.25 \Omega$  ;  $X_m = \frac{1}{B} = 260.4 \Omega$   
 $Z_{s/c} = \frac{11.2}{5} = 2.24 \Omega$  ;  $\theta_{sc} = \cos^{-1}\left(\frac{20.1}{11.2 \times 5}\right) = 68.96^\circ$   
 $R = 2 \cos \theta_{sc} = 0.804 \Omega$  ;  $X_{sc} = 2.09 \Omega$   
 $a = 2 ; a^2 = 4$   
 $R_{ca} = \frac{662.25}{4} = 165.56 \Omega$  ;  $X_m = 65.1 \Omega$   
 $V_p = 115 \angle 0 + 8.7 \angle 36.8 (2.24 \angle 68.96) = 113.8 \angle 2.36$   
 $\%r = \frac{V_p - V_s}{V_s} = -1.04\%$

**Q2 (a)** A 10-HP 230-V Series DC motor has a line current of 37 A and a rated speed of 1200 rpm. The motor has following parameters:

Armature resistance = 0.4 Ohms

Series field resistance = 0.2 Ohms

The total brush-drop = 2 V

Calculate the speed at a line current of 20-A.

**(b)** A 20-HP, 230-V 1150 rpm shunt motor has 4 poles and its armature winding is lap-connected with 882 conductors. The armature resistance is 0.188 Ohms. At rated speed and rated output, the armature current is 73 A and the field current is 1.6 A. Calculate:

(i) the torque developed

(ii) the flux per pole

(iii) the rotational losses

(iv) the motor efficiency

(v) the output torque.

a

$$E_1 = V_t - I_a(R_s + R_f) - \text{brush} = 230 - 37(0.4 + 0.2) - 2 = \underline{205.8 \text{ V}}$$

$$E_2 = V_t - 20(0.4) - 2 = \underline{216 \text{ V}}$$

$$\frac{E_2}{E_1} = \frac{k \phi_2 n_2}{k \phi_1 n_1} = ; n_2 = \frac{E_2 \cdot I_{a1} \cdot n_1}{E_1 \cdot I_{a2}}$$

$$n_2 = \frac{216 \cdot 37 \cdot (1200)}{205.8 \cdot 20} = \underline{2330 \text{ RPM}}$$

(b)

$$E = 230 - 73(0.188) = \underline{216.3 \text{ V}}$$

$$\omega_n = \frac{2\pi n}{60} = 120 \text{ Rad/sec}$$

$$(i) T_a = \frac{E I_a}{\omega} = \frac{216.3(73)}{120} = \underline{132 \text{ N-m}}$$

$$(ii) E = k \phi n = \frac{P Z \phi n}{a 60} = \frac{4(882) \phi (1150)}{4(60)}$$

$$\therefore \phi = \underline{0.0128 \text{ Wb}}$$

$$(iii) P_{\text{rot}} = P_{\text{dev}} - P_{\text{ent}} = E I_a - 120(746) = 15770 - 14920 = \underline{870 \text{ W}}$$

$$(iv) \text{Losses} = P_{\text{rot}} + I_a^2 R_a + V_t I_f = 870 + 73^2(0.188) + 230(1.6) = \underline{2240 \text{ W}}$$

$$\eta = 1 - \frac{\text{Loss}}{\text{input}} = \underline{0.867}$$

$$T_o = P_o / \omega = \underline{124 \text{ N-m}}$$

**Q3 (a) Choose the correct answer**

(i) The frequency of the generated voltage of a synchronous generator having six poles and running at 1200 rpm is:

- a. 50 Hz      b. 60 Hz  
c. 100 Hz     d. 120 Hz

(ii) A 60-Hz synchronous motor that runs at 1200 rpm has a number of poles that is equal to:

- a. 4              b. 8  
c. 6             d. 12

(b) A 9-kVA 208-V 1200 rpm 3-phase Y-connected synchronous generator has an impedance of  $0.3 + j5.0$  Ohms per phase. The generator operates at full load and 0.8 power factor lagging. The rotational losses are 500 W. Determine:

- (i) voltage regulation  
(ii) the efficiency

$$\textcircled{b} \quad V_t = \frac{208}{\sqrt{3}} = 120 \text{ V}; \quad I_a = \frac{9000}{\sqrt{3}(208)} = 25 \angle -\cos^{-1}(0.8)$$

$$E = 120 \angle 0 + I_a (0.3 + j5.0) = \underline{222.534 \angle 25.14^\circ}$$

$$VR = \left( \frac{222.534 - 120}{120} \right) \times 100 = \underline{85.45\%}$$

$$P_{\text{out}} = 3(120)(25)(0.8) = \underline{7200 \text{ W}}$$

$$\text{Losses} = 3I_a^2 R + 500 = 562.5 + 500 = \underline{1062.5 \text{ W}}$$

$$P_{\text{in}} = \underline{8262.5 \text{ W}}; \quad \eta = \frac{P_{\text{out}}}{P_{\text{in}}} = \underline{87.14\%}$$