

Ass 5.

1.  $A = 10^4 \text{ mm}^2$

[4.5] 55-kVA, 50 Hz, 3.3 kV/220 V

$B_m = 1.6 \text{ T}$

from  $V = 4.44 f N B_m A$

(a)  $N_1 = \frac{V_1}{4.44 f B_m A} = \frac{3300}{4.44 \times 50 \times 1.6 \times 10^{-4} \times 10^{-6}} = 929$  [5]

(b)  $N_2 = \frac{V_2}{4.44 f B_m A} = \frac{220}{4.44 \times 50 \times 1.6 \times 10^{-4} \times 10^{-6}} = 62$  [5]

$I_{\text{rated}} = \frac{S_{\text{rated}}}{V_{\text{rated}}}$

(c)  $I_{\text{rated}} = \frac{55000}{3300} = 16.7 \text{ A}$  [5]

(d)  $I_{2 \text{ rated}} = \frac{55000}{220} = 250 \text{ A}$  [5]

(e)  $S = \frac{\mu_0 L}{\mu A} = 63,662 \text{ At/Wb}$

$L = \frac{N^2}{S} = 13.6 \text{ H}$

$LE = ND \rightarrow I = \frac{ND}{L} = \frac{929 \times 3.3}{13.6} = 1.096 \text{ A}$

(f)  $X_0 = \frac{V_1}{I_{\text{mag}}} = \frac{3300}{1.096} = 3010 \Omega$  [5]

(g)  $V_1 I_{\text{loss}} = 1000 \rightarrow I_{\text{loss}} = 0.3 \text{ A}$  [5]

(h)  $R_0 = \frac{V_1}{I_{\text{loss}}} = \frac{3300}{0.3} = 10800 \Omega$  [5]

(i)  $I_1 = I_2' + I_0 = I_2 \left( \frac{N_2}{N_1} \right) + (I_{\text{mag}} + I_{\text{loss}}) = \left| \frac{220 \times 220}{3300} \angle 0^\circ + 0.3 + j \right| 1.096 = 14.2 \text{ A}$  [5]

2.  $P_{\text{core}} = 600 \text{ W}$ ;  $P_{\text{Fe}} = 300$ ; (a)  $x = \sqrt{\frac{300}{600}} = 0.7$  [3.0]

[2.5] (b) @ 0.8 P.f lag and  $x = \frac{1}{2}$ ;  $\eta = \frac{0.7 \times 60 \times 10^3}{0.7 \times 60 \times 10^3 + 300 + 300} = 0.986$  [5]

$\eta = \frac{\frac{1}{2} 60 \times 10^3 \times 0.7}{\frac{1}{2} 60 \times 10^3 \times 0.7 + 300 + \left(\frac{1}{2}\right)^2 600} = 0.979$  [10]

3.  $R_T = 2 \Omega$ ,  $X_T = 3 \Omega$ ,  $I_2 = 10 \text{ A}$ ,  $I_2' = 10 \times \frac{100}{220} = 4.5 \text{ A}$

$Z_T = \sqrt{2^2 + 3^2} = 3.6 \Omega$ ,  $\phi_T = \tan^{-1} \frac{3}{2} = 56.3^\circ$

$\text{Reg} = \frac{I_2' Z_T}{V_1} \cos(\phi_T - \phi_L)$

(a) Zero p.f lag,  $\phi_L = 90^\circ$

$\text{Reg} = \frac{4.5 \times 3.6}{220} \cos(56.3^\circ - 90^\circ) = 0.061$

(b) At unity p.f,  $\phi_L = 0$

$\text{Reg} = \frac{4.5 \times 3.6}{220} \cos(56.3^\circ - 0) = 0.041$

[30]

(c) Zero p.f lead,  $\phi_L = -90^\circ$

$\text{Reg} = \frac{4.5 \times 3.6}{220} \cos(56.3^\circ + 90^\circ) = -0.061$

(d)  $\phi_L = \phi_T = 56.3^\circ \rightarrow \text{P.f} = 0.56 \text{ Lag}$

(e) Max reg,  $\rightarrow \phi_L = \phi_T = 56.3^\circ$   
 $\text{Reg}_{\text{max}} = \frac{4.5 \times 3.6}{220} = 0.0736$

(f) Zero reg p.f:  
 $\phi_L - \phi_T = 90^\circ$ ,  $\phi_L = 90^\circ + \phi_T = 90^\circ + 56.3^\circ = 143^\circ$ ;  $\text{P.f} = \cos 143^\circ = -0.832 \text{ Lead}$