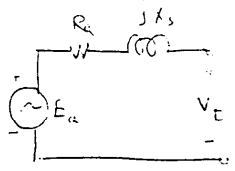
1) a) $E_a = \frac{6920}{\sqrt{3}} = 4000\ V$

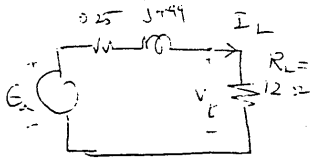


$R_a = \frac{5}{2(10)} = 0.25\ \Omega$ /phase

$Z = \frac{E_a}{I_{sc}} = \frac{4000}{800} = 5\ \Omega$ /phase

$X_s = \sqrt{Z^2 - R_a^2} = \sqrt{(5)^2 - (0.25)^2} = 4.993\ \Omega$ /phase

b) $I_L = \frac{E}{Z_T} = \frac{E}{\sqrt{(12.25)^2 + (4.993)^2}} = \frac{4000}{\sqrt{(12.25)^2 + (4.993)^2}} =$



$= 302.37$ Amp

$V_t = I_L R_L = 12(302.37) = 3628.5$ Volt (phase voltage)

$\Rightarrow$ the line voltage is $3628.5\sqrt{3} = 6284.74\ V$

c) $\%\ VR = \frac{4000 - 3628.5}{3628.5} \times 100$

$= 10.2\%$

From the open-circuit + short circuit tests

$$|Z_s| = \frac{E_{oc(ph)}}{I_{sc(phase}} = \frac{}{377} = 1.378\ \Omega$$

From the Dc-test:

$$R_{dc} = \frac{V_{dc}}{2I_{dc}} = \frac{32}{200} = 0.16\ \Omega$$

$$R_a = 1.5 \times R_{dc} = 0.24\ \Omega$$

$$X_s = \sqrt{Z_s^2 - R_a^2} = \sqrt{(1.378)^2 - (0.24)^2} = 1.36\ \Omega$$

$$\% VR = \frac{E_a - V_{t\,F.L}}{V_{t\,F.L}} \times 100\%$$

$$E_a = \sqrt{\left(V_t \cos\theta + I_{a\,F.L} R_a\right)^2 + \left(V_t \sin\theta \pm I_a X_s\right)^2} \quad \text{---(A)}$$

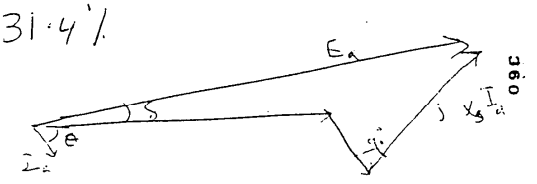
(lagging p.f; leading p.f)

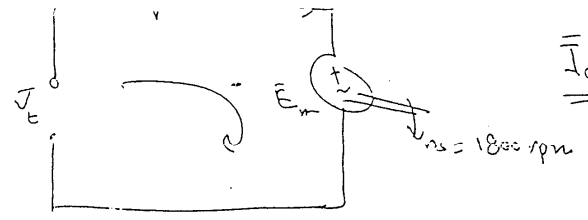
$$I_{a\,F.L} = \frac{1500 \times 10^3}{\sqrt{3}\ 2300} = 377\ A \quad ; \quad V_t = 2300/\sqrt{3} = 1328\ V$$

at 0.8 p.f lagg:

$$E_a = \sqrt{(1328 \times 0.8 + 377 \times 0.24)^2 + (1328 \times 0.6 + 377 \times 1.36)^2} = 1745\ V$$

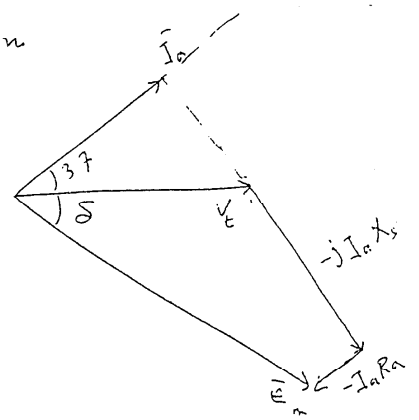
$$\% VR = \frac{1745 - 1328}{1328} \times 100\% = 31.4\%$$





V3

$\bar{I}_a = 70 \angle 37°$ A



overexcited

$$\bar{E}_m = \bar{V}_t - \bar{I}_a(R_a + jX_s)$$

$$\bar{E}_m = 3810\angle 0 - 70\angle 37\,(2 + j20)$$

$$\boxed{\bar{E}_m = 4697 \angle -14.8° \text{ V}}$$

c) $E_{Lin} = \sqrt{3} * 4697 \Rightarrow \boxed{E_L = 8136 \text{ V}}$

b) $\delta = 14.8°$ electrical degrees

or $\delta = \frac{14.8}{2} = 7.4$ mechanical degrees

d) $P_d = P_{in} - 3I_a^2 R_a \Rightarrow P_{in} = \sqrt{3} V_t I_L \cos\theta = \sqrt{3}(6600)(70) * 0.8$

$= 3 V_t I_a \cos\theta = 3(3810)(70) \times 0.8$

$P_{in} = 640.16$ KW

$P_{rstala} = 3 * (70)^2 * (2) = 29.4$ KW

$P_d = 640.16\text{K} - 29.4\text{K} \Rightarrow \boxed{P_d = 610.76 \text{ KW}}$

$T_d = \frac{P_d}{\omega_s} = \frac{P_d}{2\pi \frac{n_s}{60}}$, $n_s = \frac{120 * f}{p} = \frac{120 * 60}{4} = 1800$ rpm

$\omega_s = \frac{2\pi * 1800}{60} = 188.5$ rad/sec

$\bar{T}_d = \frac{610.76 \times 10^3}{188.5} \Rightarrow \boxed{T_d = 3240.2 \text{ N-m}}$

e) $\eta = \frac{P_o}{P_{in}} * 100$, $P_o = P_d - P_{Rot} = 610.76\text{K} - 30\text{K}$

$P_o = 580.76$ KW

$\eta = \frac{580.76}{640.16} * 100 \Rightarrow \boxed{\eta = 90.7\%}$

f) $T_o = \frac{P_o}{\omega_s} = \frac{580.76 * 10^3}{188.5} \Rightarrow \boxed{T_o = 3080.9 \text{ N-m}}$

a) $E_a = V_t - j X_s I_a = \frac{6600}{\sqrt{3}} - j30(100 \angle 25.84)$

$= 5787 \angle -27.8^\circ$ Volt.

b) Rated torque $= \frac{\sqrt{3}\ 6600\ (100)(0.9)}{2\pi\left(\frac{50}{3}\right)} = 9827$ Nm

c) For maximum torque of 25000 Nm, we have:

$$25\,000 = 3\,\frac{6602}{\sqrt{3}}\,\frac{E_a}{30} \cdot X\,\frac{1}{2\pi\left(\frac{50}{3}\right)}\sin -90$$

$$\boxed{E_a = 6870\ V}$$

d) for the new excitation:

$$9827 = -3\,\frac{6600}{\sqrt{3}}\,\frac{6870}{30}\,\frac{\sin\delta}{2\pi\,(50/3)}$$

$$\Rightarrow \quad \sin\delta = -0.393 \quad \text{or} \quad \boxed{\delta = -23.1^\circ}$$

$$I_{a,new} = \frac{6600/\sqrt{3} - 6870(0.92 - j\,0.393)}{j30} = 122.9 \angle 42.9^\circ$$

$\Rightarrow \cos\theta = 0.732$ lead

e) for rated torque at reduced voltage

$$9827 = \frac{3\,V_t}{\sqrt{3}}\,\frac{6870}{30}\,\frac{\sin 90}{2\pi\,(50/3)}$$