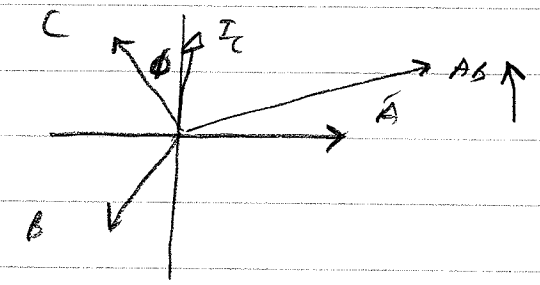
Solution Final Exam
Spr 2000

#1 $W_M = V_{LL} I_L \cos(\angle V_{AB} - \angle \bar{I}_C)$



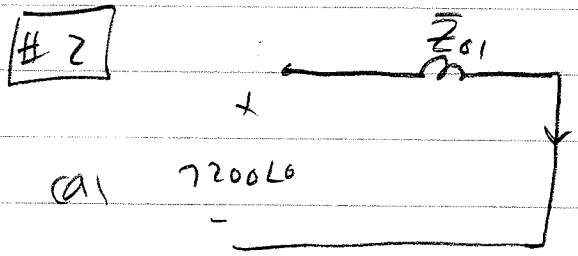
$= V_{LL} I_L \cos(30° - (120 - \phi))$

$= V_{LL} I_L \cos(\phi - 90°)$

$= V_{LL} I_L \sin\phi = Q_{3\phi}/\sqrt{3}$

$= \boxed{866 \text{ watts}}$ ✓

#2

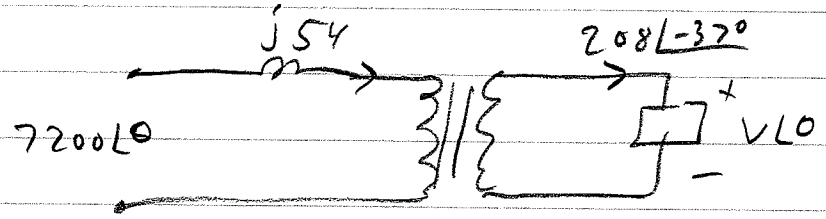


$|\bar{Z}_{01}| = 54\,\Omega$.

(a) $Z_{1\text{pu}} = \dfrac{7200}{50\text{k}/7200} = 1037\,\Omega$

$|Z_{01\text{pu}}| = .052 \rightarrow \boxed{5.2\%}$ ✓

(b)



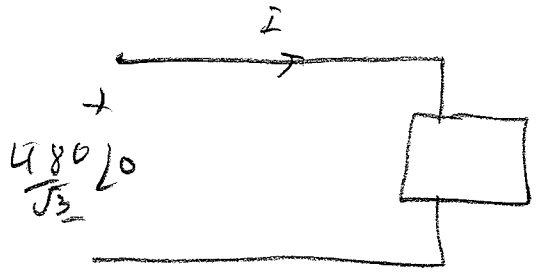
$7200\angle\theta = j54\left(208 \times \frac{240}{7200}\angle -37°\right) + \frac{7200}{240} V_{LO}$

$7200\cos\theta = 374\cos 53° + 30V$

$7200\sin\theta = 374\sin 53° \rightarrow \theta = 3°$

$7190 = 225 + 30V \rightarrow \boxed{V = 232V}$ ✓

#3



(a) $(27\angle 0)\,\bar{I}^* = 2000\angle +37°$ $\quad |\bar{I}| = 7.22\,A$

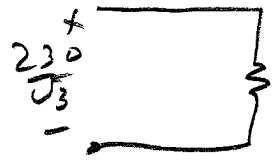
(b) $Q_{load} = 1204/phase = \frac{480^2}{2\pi 60 C}$ $\quad C = 14\,\mu F$

(c) $27\angle 0\ \bar{I}^* = 2000 \times .8 = 1600$ $\quad |\bar{I}| = 5.8\,A$

#4

(a) $f_r = 5 f_s = \frac{1200-1100}{1200} \times 60 = 5\,Hz$

(b)

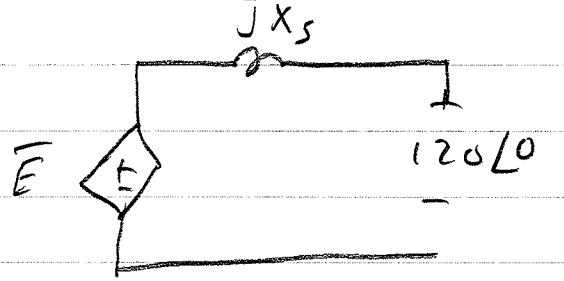


$$T = \frac{P_{TO\ Rotor}}{\omega_{sync}} = \frac{3 \times (230/\sqrt{3})^2 s/r_r'}{2\pi 60/3}$$

$$8 = \frac{52900\left(\frac{100}{1200}\right)}{\frac{377}{3} r_r'} \qquad r_r' = 4.38\,\Omega$$

$$I_{start} = \frac{230/\sqrt{3}}{4.38} = 30A$$

#5



(a)

$$P_{in} = \frac{3 \times 120 \times E}{X_s} \sin(-\delta) \qquad -3730 = \frac{3 \times 120 E}{X_s} \sin(-30^\circ)$$

$$\frac{E}{X_s} = 20.72$$

When $\delta = 0$, $|I| = 5$ Amps $\rightarrow$ $P = 0$, $Q_{in} = 600$/phase

$$Q_{in} = \frac{3 \times 120^2}{X_s} - \frac{3 \times 120 E}{X_s} \cos(-\delta) = 1800$$

$$\frac{3 \times 120^2}{X_s} - 3 \times 120 \times 20.72 = 1800$$

$$\frac{3 \times 120^2}{X_s} = 1800 + 7459$$

$$X_s = 4.66 \rightarrow E = 96.67$$

To make the pf = 1.0 with $P = 3730$,

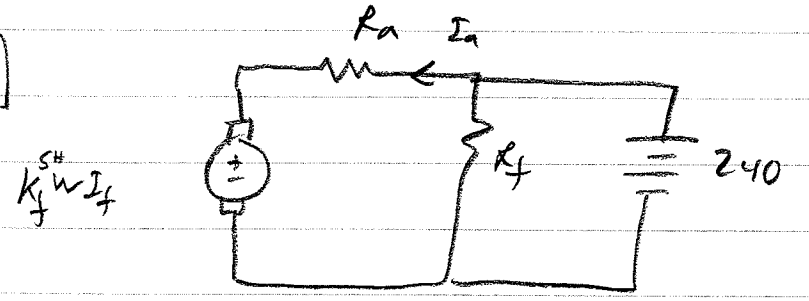
$$3730 = \frac{3 \times 120 \times E'}{4.66} \sin(-\delta) \qquad E \sin(-\delta) = 48.3$$

$$0 = \frac{3 \times 120^2}{4.66} - \frac{3 \times 120 E'}{4.66} \cos(-\delta) \qquad E \cos(-\delta) = 120$$

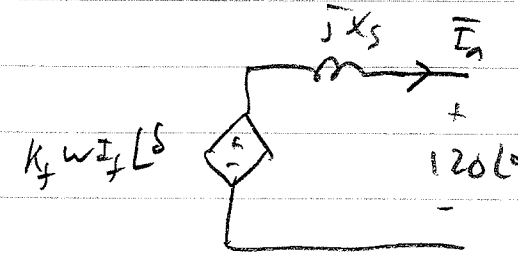
$$E^2 = 48.3^2 + 120^2 \qquad E = 129$$

$$\frac{129}{96.67} = 1.34 \quad (34\%)$$

#6



No load $I_a = 0$ $\quad K_f^{SH} \times \frac{377}{2} \times 3 = 240$ $\quad K_f^{SH} = 0.424\ H$



$K_f \frac{377}{2} 2 = 120$ $\quad K_f = 0.32\ H$

Full load = $5 \times 746 = 3730$ watts

Unity pf $\quad \bar{I}_a = \frac{3730}{3 \times 120} \angle 0 = 10\angle 0$

$I_f = 3$

$$0.32 \times \frac{377}{2} \times 3 \angle\delta = jX_s\, 10\angle 0 + 120\angle 0$$

$$181\angle\delta = 120 + j10X_s \qquad 10X_s = \sqrt{181^2 - 120^2} = 135$$

(b) $\boxed{X_s = 13.5\ \Omega}$

(a) $0.424 \times \frac{377}{2} \times 2.8\, I_a = 3730 W \qquad I_a = 16.7A$

$$240 = 16.7 R_a + .424 \times \frac{377}{2} \times 2.8$$

$\boxed{R_a = 0.97\ \Omega}$