Final Exam Solution Spring 1996

#1 Assume ABC sequence: $\bar{V}_{AB} = 230\angle 30^\circ$, $\bar{I}_A = I\angle -\phi$

$wm = 230 I \cos(30 - (-\phi)) = 1320$. With B & C reversed, it reads $\bar{V}_{AC} = 230\angle -30^\circ$, $\bar{I}_A = I\angle -\phi$

$wm = 230 I \cos(-30 - (-\phi)) = 575$, so $\cos(30+\phi) = 2.296\cos(30-\phi)$

$\cos 30\cos\phi - \sin 30\sin\phi = 2.296\cos 30\cos\phi + 2.296\sin 30\sin\phi$

$-1.122\cos\phi = 1.648\sin\phi$ Cannot be for induction motor.

Assume ACB sequence: $\bar{V}_{AB} = 230\angle -30^\circ$, $\bar{I}_A = I\angle -\phi$

$wm = 230 I \cos(-30 - (-\phi)) = 1320$. With B & C reversed, it reads $\bar{V}_{AC} = 230\angle +30^\circ$, $\bar{I}_A = I\angle -\phi$

$wm = 230 I \cos(30 - (-\phi)) = 575$, so $\cos(30-\phi) = 2.296\cos(30+\phi)$

$\cos 30\cos\phi + \sin 30\sin\phi = 2.296\cos 30\cos\phi - 2.296\sin 30\sin\phi$

$1.648\sin\phi = 1.122\cos\phi$ $\phi = 34^\circ$, ok so ACB

$230 I\cos(-30+34) = 1320$ $I = 5.75\,A$ $pf = 0.829$ lag

#2 (a) $|\bar{Z}_{01}| = \frac{345}{1.39} = 248.2\,\Omega$ $\%t = \frac{248.2\times 100}{7200/1.39} = 4.8\%$

(b) $I_{sc} = \frac{100}{4.8}\times\frac{10{,}000}{120} = 1736\,A$

#3 $T = \frac{P_{to\ rotor}}{\omega_{sync}} = \frac{3\times|\bar{I}_r'|^2 r_r'/s}{2\pi 60\times\frac{2}{4}}$ $\left|\bar{I}_r'\right|_{s=1} = \left|\frac{208/\sqrt{3}}{1.7+j2}\right| = 45.75$

(a) $T_{start} = \frac{3\times(45.75)^2\times 0.7}{2\pi 60/2} = 23.3\,Nm$

(b) $\frac{0.7}{s} = |1+j2| = \sqrt{5}$ $s = .313$ $|\bar{I}_r|_{s=.313} = \left|\frac{208/\sqrt{3}}{3.236+j2}\right| = 31.6\,A$

$T_{max} = \frac{3\times 31.6^2\times 0.7/.313}{2\pi 60/2} = 35.5\,Nm$

#4 $k\omega \times 2.8 = \frac{230}{\sqrt{3}}$ $\quad k\omega = 47.4$

$$-2400 = \frac{3\times\frac{230}{\sqrt{3}}47.4\times 3.2}{X_s}\sin(-\delta) \qquad 0 = \frac{3\times\left(\frac{230}{\sqrt{3}}\right)^2}{X_s} - \frac{3\times\frac{230}{\sqrt{3}}\times 47.4\times 3.2\cos(-\delta)}{X_s}$$

$$0 = \frac{230}{\sqrt{3}} - 47.4\times 3.2\cos(-\delta)$$

$\delta = 28.9°$ $\quad \underline{X_s = 12.2\,\Omega}$

#5 $k\times 830\times\frac{240}{124} = 240 \qquad k = 0.1494$

want 1200 rpm $\quad 0.1494\times 1200\times I_f = 240$

$I_f = 1.3386\,A \qquad R_{tot} = 179\,\Omega \qquad \underline{R = 55\,\Omega}$

#6 (a) $\delta(.01) = -\pi/6 + (377-377).01 = -\pi/6$

$\omega(.01) = 377 + (-10+10).01 = 377$

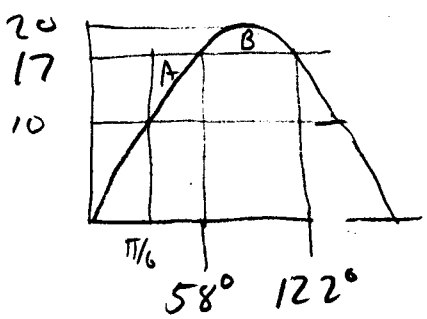
$\delta(.02) = -\pi/6 + (377-377).01 = -\pi/6$

$\omega(.02) = 377 + (-17+10).01 = 376.93$

$\delta(.03) = -\pi/6 + (376.93-377).01 = -.5243$ rad

$\omega(.03) = 377 + (-17+10).01 = 376.86$ r/s

(b)



want $A - B > 0$

$$A = \int_{30°}^{58°}(17-20\sin\delta)\,d\delta \qquad B = \int_{58°}^{122°}(20\sin\delta-17)\,d\delta$$

$$A-B = \int_{30°}^{122°}(17-20\sin\delta)\,d\delta = 17\left(122-30\right)\frac{\pi}{180} + 20\cos\delta\Big|_{30}^{122°}$$

$= 27.3 - 10.6 - 17.3 = -.6$ so $\underline{\text{Yes}}$

#7 To avoid saturation...

$$V = \frac{d\lambda}{dt} \qquad \lambda = N\phi = NAB = NAB_{max}\cos\omega t$$

$$V = -\omega NAB_{max}\sin\omega t$$

$$B_{max} \propto \frac{V}{\omega}$$

Ok for increases in ω because this would lower B_{max}