ECE 333

FINAL EXAM SOLUTION

SPRING 1991

Solution #1

$$T_{FL} = \frac{2 \times 746}{1180 \times \frac{2\pi}{60}} = 12.07 \text{ Nm} \qquad S_{FL} = \frac{1200 - 1180}{1200} = .01667$$

Estimate T vs slip linear $\quad 12.07 = \dfrac{3 \times \left(\frac{230}{\sqrt{3}}\right)^2 \times .01667}{\frac{2\pi 60}{3} r_r'}$

$r_r' = 0.58\Omega \qquad \underset{\text{rotor start}}{P_{TO}} = 3 \times |\bar{I}_r'|^2 r_r'$

Assume $|I_r'| \approx 20$ amps $\qquad \underset{\text{rotor start}}{P_{TO}} = 696 \text{ w}$

$$T_{start} = \frac{696}{\frac{2\pi 60}{3}} = 5.5 \text{ Nm}$$

Solution #2

O.C. TEST $\quad K_f w_s = \frac{120}{2} = 60$

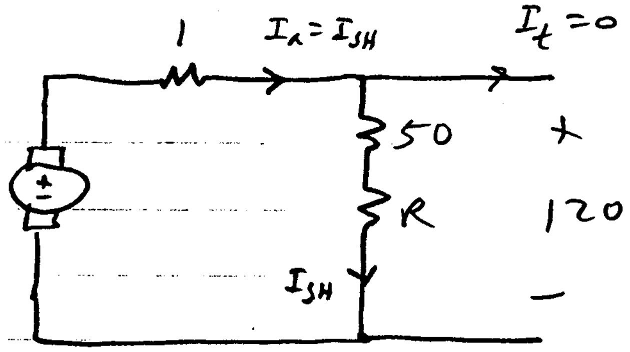
S.C. TEST $\quad K_f w_s \times 1 = 6 \times X_s \qquad X_s = 10\Omega$

$$60\, I_f \angle\delta = j10(6\angle 0) + 120\angle 0 = 120 + j60$$

$$I_f = 2.24 \text{ A}$$

Solution #3

$$\frac{1200}{1160}\left(12+\frac{500 I_{SH}}{3+I_{SH}}\right)$$




$$\frac{1200}{1160}\left(12+\frac{500 I_{SH}}{3+I_{SH}}\right) = I_{SH} + 120$$

$$\frac{1200}{1160}(36+512 I_{SH}) = 360 + 123 I_{SH} + I_{SH}^2$$

$$I_{SH}^2 - 406.655 I_{SH} + 322.759 = 0$$

$$I_{SH} = 203.328 \pm 202.532 \qquad I_{SH} = 0.8\ A$$

$$120 = (50+R)0.8 \qquad \boxed{R = 100\,\Omega}$$

Neglecting $r_a$ gives

$$\frac{1200}{1160}\left(12+\frac{500I}{3+I}\right) = 120$$

$$36 + 512I = 348 + 116I$$

$$I = .788$$

$$R = 102$$

using 1160 gives with $r_a = 0$

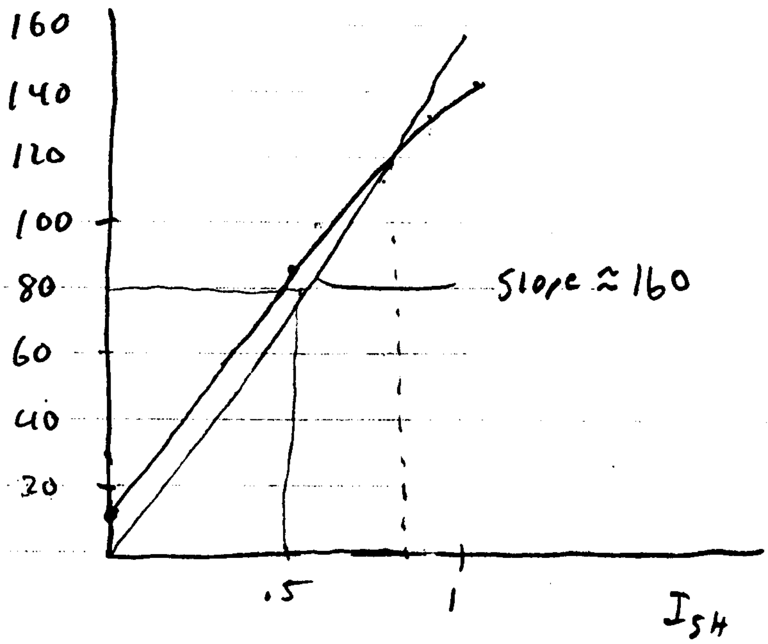
$$36 + 512I = 360 + 120I$$

$$I = 0.83$$

$$R = 95$$

OR

$V_{t_{oc}} \approx E_a$ at 1200




slope ≈ 160 so $R \approx 110\,\Omega$

Solution #4

$$125 = (30 + R_1) I_{SH_1} \qquad 125 = I_{a_1} + 10 + 100 I_{SH_1}$$

$$10 + 100 I_{SH_2} = I_{a_2} + 120 \qquad (30 + R_2) I_{SH_2} = 120$$

$$I_{a_2} = I_{SH_2} + \frac{120}{10}$$

$$10 + 100 I_{SH_2} = I_{SH_2} + 12 + 120 \qquad I_{SH_2} = 1.2323\ A$$

$$R_2 = 67.4\ \Omega$$

Assume lossless power transfer

$$E_{a_1} I_{a_1} = E_{a_2} I_{a_2}$$

$$(10 + 100 I_{SH_1}) I_{a_1} = \underbrace{(10 + 123.23)(1.2323 + 12)}_{1763}$$

$$125 = I_{a_1} + 10 + 100 I_{SH_1}$$

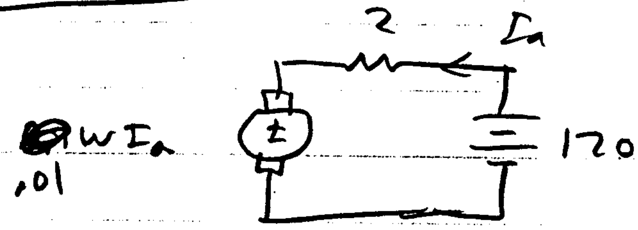
$$(10 + 100 I_{SH_1})(\underbrace{125 - 10}_{115} - 100 I_{SH_1}) = 133.23 \times 13.2323 = 1763$$

$$1150 - 1000 I_{SH_1} + 11500 I_{SH} - 10^4 I_{SH_1}^2 = 1763$$

$$I_{SH_1}^2 - 1.05 I_{SH_1} + .06 = 0 \qquad I_{SH_1} = .525 \pm .464 \qquad I_{SH_1} = 0.988$$

$$I_{a_1} = 16.2 \qquad R_1 = 96.5\ \Omega$$

Solution #5




$$120 = (2 + .01\omega) I_a \qquad I_a = \frac{120}{2 + 0.1\omega}$$

$$T = \frac{(0.01\omega I_a) I_a}{\omega} = .01 I_a^2$$

$$T = \frac{1440}{(2 + .01\omega)^2}$$

~~10 Nm~~

~~T = 50 Nm~~ ~~1000 + 5ω = 1440~~

~~5ω = 440~~

~~ω = 88~~

~~T = 20~~ ~~40~~

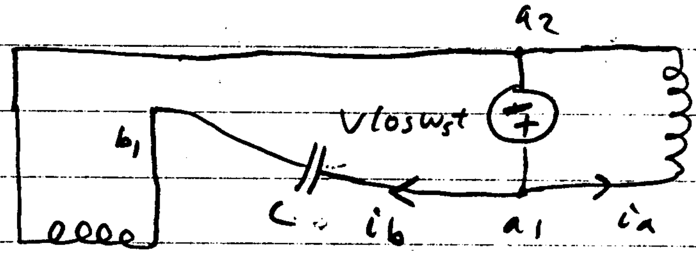
~~44 Nm ω = 125~~

## Solution #6

$$mmf = N_a \cos\alpha \, i_a + N_b \sin\alpha \, i_b$$

want mmf to contain $K\cos(\alpha \pm \omega_s t + \gamma)$ and possibly other terms which do not exactly cancel out the rotation.

Hook up capacitor as follows:




$$v\cos\omega_s t = r_a i_a + L_a \frac{di_a}{dt}$$

$$V\cos\omega_s t = v_c + r_b i_b + L_b \frac{di_b}{dt}$$

$$i_b = C\frac{dv_c}{dt}$$

In steady state, $V\angle 0 = (r_a + jx_a)\bar{I}_a$

$$V\angle 0 = \left(r_b + jx_b - j\frac{1}{\omega_s C}\right)\bar{I}_b$$

Proper C will give flexibility to design a phase shift into $i_b$ to get rotation of the field