ECE 333

Exam II Solution Spring 1991

#1 Open circuit test: $K_f \omega_s = \frac{120}{2} = 60$

Short circuit test: $K_f \omega_s \times 1 = 5 \times X_s \qquad X_s = 12\,\Omega$

(a) $60 I_f \angle\delta = j12(5\angle 0) + 120\angle 0 = 120 + j60$ $\quad \boxed{I_f = 2.24\,A}$

(b) $\frac{1}{\sqrt{2}} \frac{N_f}{N_s} L_{ms} \omega_s = 60$, $\omega_s (L_{ls} + \frac{3}{2} L_{ms}) = 12$

$\omega_s L_{ms} = 8\,\Omega$ so $\boxed{\frac{N_f}{N_s} = 10.6}$

#2

$$\omega_t \frac{d\omega_t}{dt} = \omega_t (5 - k_2 \sin\delta)$$

$$\int_0^{\hat{t}} \omega_t \frac{d\omega_t}{dt}\, dt = \int_0^{\hat{t}} (5 - k_2 \sin\delta) \frac{d\delta}{dt}\, dt$$

$$\int_0^{\omega_t(\hat{t})} \omega_t\, d\omega_t = \int_{\delta(0)}^{\hat{\delta}} (5 - k_2 \sin\delta)\, d\delta$$

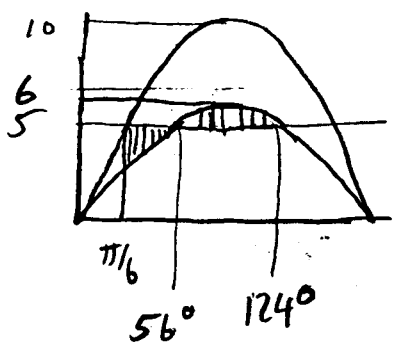
$$\frac{1}{2}\omega_t^2(\hat{t}) = \int_{\delta(0)}^{\hat{\delta}} (5 - k_2 \sin\delta)\, d\delta$$

A $\hat{\delta}$ must exist so that $\omega_t(\hat{t}) = 0$

or, $$\int_{\delta(0)}^{\hat{\delta}} (5 - k_2 \sin\delta)\, d\delta = 0$$

For the problem given:

Can $\int_{30^\circ}^{\hat{\delta}} (5 - 6\sin\delta)\,d\delta \overset{?}{=} 0$ for $t > 0$



$$A = \int_{30^\circ}^{56^\circ} (5 - 6\sin\delta)\,d\delta$$

$$= 5\left(\frac{56\pi}{180} - \frac{\pi}{6}\right) + 6\cos(56^\circ) - 6\cos 30^\circ = 0.43$$

$$B = \int_{56^\circ}^{124^\circ} (6\sin\delta - 5)\,d\delta = -6\cos(124^\circ) + 6\cos(56^\circ) - 5\left(\pi - \frac{56\pi}{180} - \frac{56\pi}{180}\right) = 0.78$$

Yes it can be done.

#3 $$2000 = \frac{3 \times 120 \times 0.23 \times 2\pi 60 \times I_f}{10}\sin\delta = 3121 I_f \sin\delta$$

$$Q_{3\phi} = 3121\cos\delta - \frac{3 \times 120^2}{10} = 3121 I_f \cos\delta - 4320$$

$$|\bar{I}_{as}| = \frac{|\bar{S}_{3\phi}|}{3 \times |\bar{V}_{as}|} = \frac{\sqrt{2000^2 + Q^2}}{360}$$

1. minimum field current is at $\delta = 90°$

$2000 = 3121\, I_{f_{min}}$ $\quad I_{f_{min}} = 0.64\,A$

$Q = 0 - 4320 \qquad |S| = \sqrt{2000^2 + 4320^2} = 4760$

$|I_{as}| = \frac{4760}{3 \times 120} = 13.2$

2. minimum armature current is at $Q = 0$

$2000 = 3121\, I_f \sin\delta$
$0 = 3121\, I_f \cos\delta - 4320$
$\Big\} \; 3121^2 I_f^2 = 2000^2 + 4320^2$

$I_f = 1.53\,A$

$|S| = 2000 \qquad |\bar{I}_{as}| = \frac{2000}{3 \times 120} = 5.56\,A$

3. maximum armature current is $|I_{as}| = 20A$

So $|S| = 3 \times 120 \times 20 = 7200$ so $Q = \sqrt{7200^2 - 2000^2}$
$= 6916$

$2000 = 3121\, I_f \sin\delta$
$6916 = 3121\, I_f \cos\delta - 4320$
$\Big\} \; 3121^2 I_f^2 = 2000^2 + 11236^2$

$I_f = 3.66\,A$