Quiz 2 6.685 12/4/13

Problem 1:

Experiment $T = p\lambda_0 I = 10$ when $p=2$ and $I=10$

so $\lambda_0 = \frac{1}{2}$

Running $T = \frac{3}{2}\frac{p}{\omega}\frac{VE}{X} = \frac{3}{2}\frac{p}{\omega}\frac{V\omega\lambda_0}{\omega L}$

$= \frac{3}{2} \cdot \frac{2}{200} \cdot \frac{100 \times \frac{1}{2}}{.005} = \frac{3}{2} \times \frac{.5}{.005} = \frac{3}{2} \times 100 = 150$

$P = \Omega T = 100\, T = 15000 = 15\,kW$

Problem 2

To make max torque: $I_d = -\frac{10}{\sqrt{2}}$ $I_q = \frac{10}{\sqrt{2}}$

1. $T = -\frac{3}{2}p(L_q - L_d)I_d I_q = 3 \times .009 \times 50 = 150 \times .009$

$= 1.35$ N-m

2. $V_d = -\omega L_q I_q = -12 \times \frac{10}{\sqrt{2}}$

$V_q = \omega L_d I_d = -3 \times \frac{10}{\sqrt{2}}$

$P = \frac{3}{2}(V_d I_d + V_q I_q) = \frac{3}{2}(12 \times 50 - 3 \times 50) = \frac{3}{2} \times 9 \times 50$

$= 1.5 \times 450 = 675$ W

3. $Q = \frac{3}{2}(V_q I_d - V_d I_q) = \frac{3}{2}(3 \times 50 + 12 \times 50) = 1.5 \times 15 \times 50$

$= \frac{3}{2} \times 750 = 1{,}125$ VAR

Problem 3

$$I_s = \frac{P}{3\times 1000} = \frac{10^6}{3\times 1000} = \frac{1000}{3} \cong 333.3 \text{ A}$$

$N = 900$ RPM $\quad s = .25 \qquad N = 1500$ RPM $\quad s = -.25$

So $\quad P_r = 250\text{kW} \quad$ or $\quad -250\text{kW}$

Reactive Power

$$Q_2 = 3\times\left(\frac{1000}{3}\right)^2 \times (X_1 + X_2) \qquad \text{and } X_1 + X_2 = 1\Omega$$

so $Q_2 = 3\times \frac{10^6}{9} = \frac{10^6}{3}$ VARs

$$Q_R = |s| \times Q_2 = \frac{10^6}{12} \cong 83\tfrac{1}{3} \text{ kVAR for both speeds}$$

2. Voltages

$$V_2 = 1000 + j\,\frac{1000}{3}$$

$$V_r = s\times 3\times V_2 = \frac{3}{4} V_2 = 750 + j250 \qquad \text{at } s = .25$$

$$V_r = -750 + j250 \qquad s = -.25$$

(remember phase sequence reverses!)

$I_r = \frac{1}{3} I_2$ and $I_2 = \frac{1000}{3}$ for all slip

so

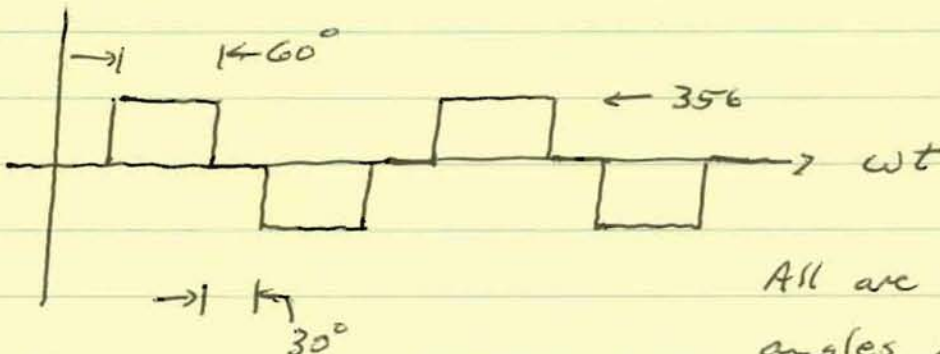
$$I_r = \frac{1000}{9} \cong 111.11 \text{ A} \quad \text{both cases}$$

Problem 4 $|V| = 2\omega_m R \ell N_a B_r$ and $B_r = \frac{4}{4.5} = \frac{8}{9}\,T$

$\omega_m = 500$ Rad/sec

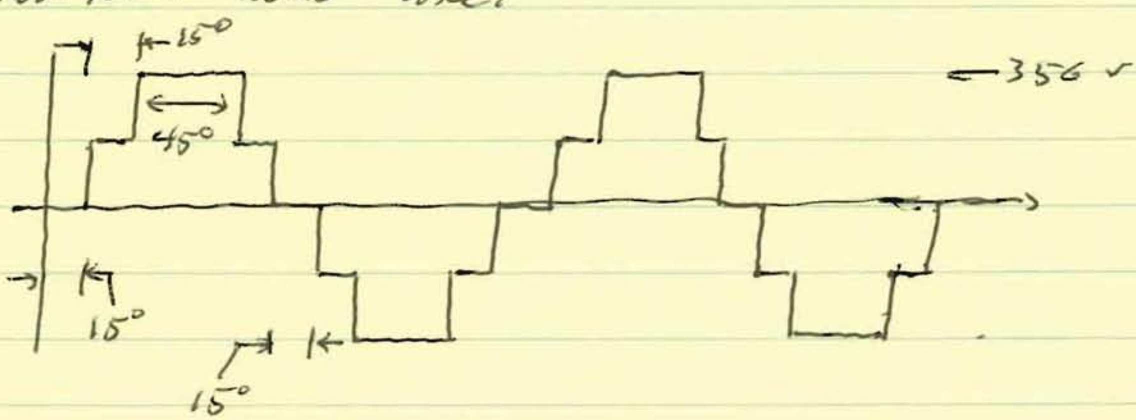
So $|V| = 500 \times .1 \times .2 \times 20 \times 2 = 356$ V

For a full-pitch winding, the voltage would have the form



All are mechanical angles!

For the 5/6 pitch winding the two coil halves are 15° (mechanical) apart, and the waveform looks like:



6.685 Electric Machines
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