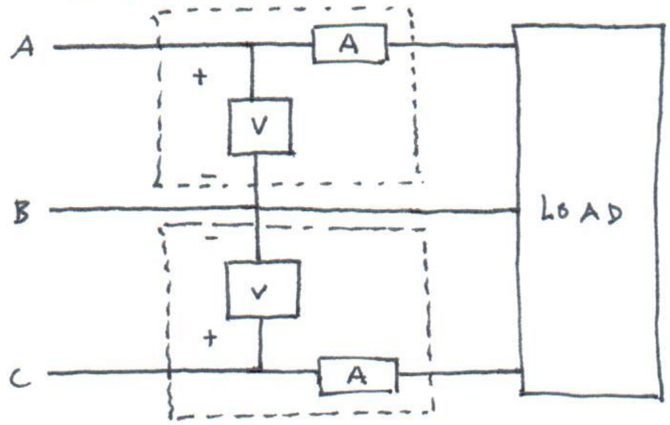
ECE431 (SPRING 2014) MIDTERM #1 SOLUTION

#1 Balanced 3ϕ, 4160 $V_{ll\,RMS}$, 3ϕ Load w/ $Z = (1.2 + j5)\ \Omega$/phase

(a) Two Watt-meter method

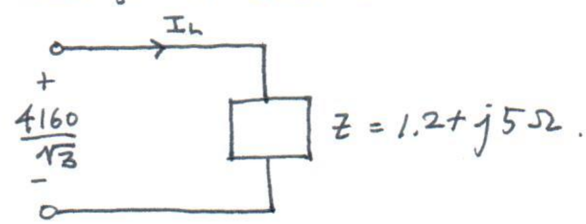
7pts



10pts

(b) Voltage, Current, and Power readings in each wattmeter.

Per-Phase Eq. Ckt



$\Rightarrow I_L = \dfrac{4160/\sqrt{3}}{(1.2+j5)} = 467.092 \angle -76.5° \quad \Rightarrow \theta = 76.5°$

Then $P_1 = (4160)(467.092)\cos(30 + 76.5)$

$P_2 = (4160)(467.092)\cos(30 - 76.5)$

$$\boxed{\begin{aligned} V_{AB} &= V_{CB} = 4160\,V \\ I_A &= I_C = 467.092A \\ P_1 &= -551.871\,kW \\ P_2 &= 1337.543\,kW \end{aligned}}$$

(c) Unity Power factor ($\theta = 0$)

8pts

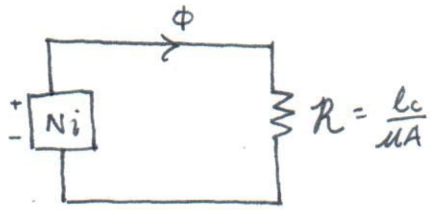
Then, $P_1 = P_2 = \dfrac{P_{total}}{2} = \dfrac{(-551.871) + (1337.543)}{2}$

$$\boxed{P_1 = P_2 = 392.836\,kW}$$

#2 $N = 400$, $A = 2\,cm^2$, $l_c = 10\,cm$

(a) Inductance of the coil

9pts



$$Ni = \mathcal{R}\phi$$

$$\phi = \frac{Ni}{\mathcal{R}}$$

$$\lambda = N\phi = \frac{N^2 i}{\mathcal{R}} = Li$$

$$\therefore L = \frac{N^2}{\mathcal{R}} = \frac{(400)^2 (400\mu_0)(2\times10^{-4}\,m^2)}{10\times10^{-2}\,m} = \boxed{0.161\,H}$$

9pts

(b) Max current the inductor can be run and remain below saturation

$$\phi_{sat} = B_{sat} A$$

$$\Rightarrow N i_{max} = \mathcal{R}\phi_{sat} = \mathcal{R} B_{sat} A$$

$$\Rightarrow i_{max} = \frac{\mathcal{R} B_{sat} A}{N} = \frac{l_c B_{sat} A}{\mu A N} = \frac{(10\times10^{-2})(1.5)}{400\mu_0 (400}$$

$$= \boxed{0.746\,A}$$

(c) Energy for this maximum current

7pts

$$\text{Energy} = \frac{1}{2} L i_{max}^2 = \frac{1}{2}(0.161)(0.746)^2$$

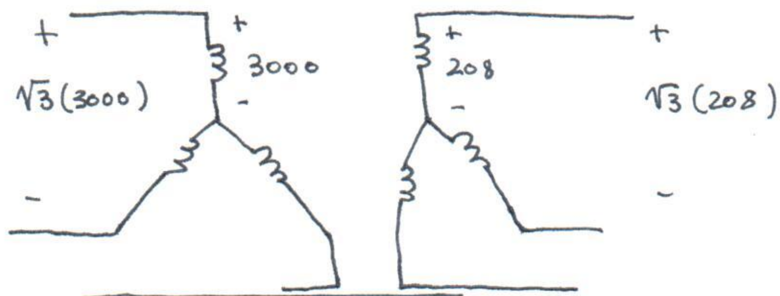
$$= \boxed{0.0448\,J}$$

#3 Three single ϕ transformers, each rated 3000 V : 208 V, 200 kVA.
Series impedance of 2Ω referred to high side.

(a) For each case, determine ratings and per-phase (wye eq.)
12pts series impedance (referred to the high side)

* Power rating : $3 \times 200 = \boxed{600\text{kVA}}$ for each case

(i) <u>Wye-Wye</u>



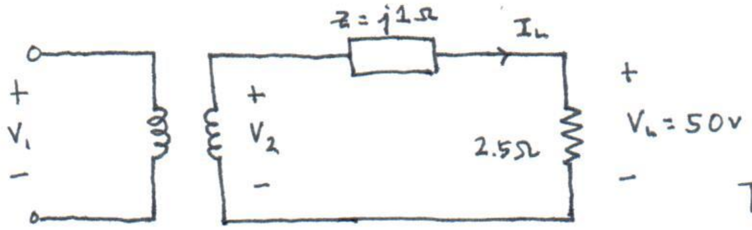
Voltage rating : $\boxed{5196.15 : 360.267\text{ V}}$
per-phase impedance : $\boxed{2\Omega}$

(ii) <u>Delta-Wye</u> since for Δ, $V_{ll} = V_\phi$,

Voltage rating : $\boxed{3000\text{V} : 360.267\text{ V}}$
Per-Phase impedance : $\boxed{\frac{2}{3}\Omega}$ (using Δ-Y transformation $R_Y = \frac{R_\Delta}{3}$)

(iii) <u>Delta-Delta</u>
Voltage rating : $\boxed{3000\text{V} : 208\text{V}}$
Per-phase impedance : $\boxed{\frac{2}{3}\Omega}$

(b)
13pts



To provide 50v with load $= 2.5\Omega$,
$I_L = \frac{50}{2.5} = 20\text{A}$.

Then $|V_2| = |(j1)(20) + 50|$
$= 53.85\text{V}$.

$\therefore V_1 = 53.85 \frac{240}{50} = \boxed{258.488\text{ V}}$

Load Regulation $= \dfrac{V_{L,\text{no load}} - V_{L,\text{load}}}{V_{L,\text{load}}} = \dfrac{53.85-50}{50} = \boxed{7.7\%}$

#4 6/8 reluctance machine, single excitation

(a) For clockwise rotation,

7pts

$\boxed{A \rightarrow B \rightarrow C}$

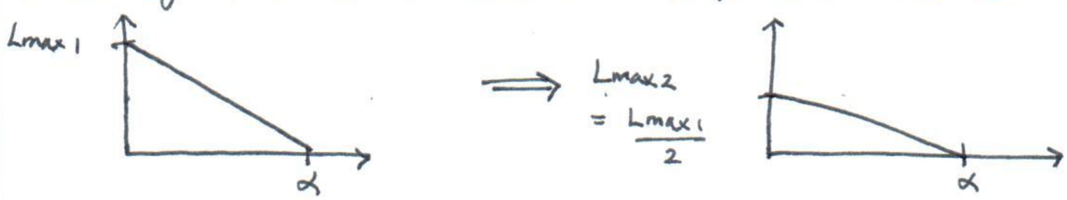
(b) $S = mN_r$ = (3 phases)(8 teeth on the rotor) = $\boxed{24 \text{ steps/rev}}$

7pts

(c) Air gap doubled.

6pts

When l_g is doubled, L_{max} is halved, then T_{max} will be halved

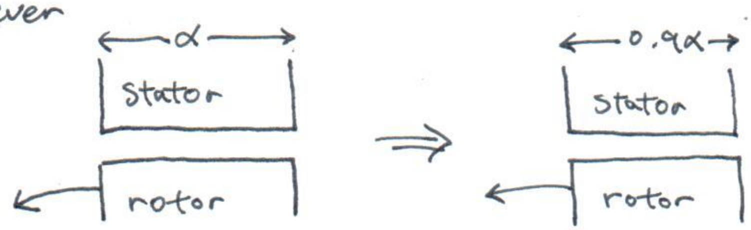


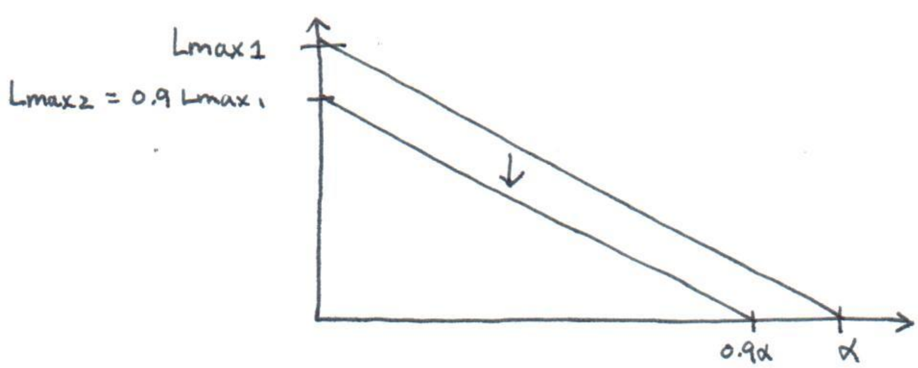
(d) Stator, rotor teeth reduced by 10%.

5pts

Then, L_{max} will be reduced by 10%.

However





⇒ Constant slope ⇒ T_{max} does not change