ECE330
Exam #1
Fall 2003

Name Solution
(Print Name)

Section: (Circle One) 10 MWF (Sauer) 10TT (Krein)

Problem 1 _______ Problem 2 _______ Problem 3 _______ TOTAL: _______

USEFUL INFORMATION

$\sin x = \cos(x - 90^\circ)$ $\qquad$ $\bar{Z}_Y = \frac{1}{3}\bar{Z}_\Delta$

$\bar{S}_{3\phi} = \sqrt{3}\, V_L I_L \angle\theta$ $\qquad$ $I_L = \sqrt{3}\, I_\phi$ (delta)

$\oint_C \underline{H}\cdot \underline{dl} = \int_S \underline{J}\cdot\underline{n}\, da$ $\qquad$ $\oint_C \underline{E}\cdot\underline{dl} = -\frac{d}{dt}\int_S \underline{B}\cdot\underline{n}\, da$

$\oint_S \underline{B}\cdot\underline{n}\, da = 0$ $\qquad$ $R = \frac{l}{\mu A}$ $\qquad$ $mmf = Ni = \phi R$

$\lambda = N\phi = Li$ $\qquad$ $\mu_0 = 4\pi \times 10^{-7}\ H/m$ $\qquad$ $k = \frac{M}{\sqrt{L_1 L_2}}$

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Problem 1 (42 pts.) (No partial credit - 6 points each)

a) A single-phase load has a voltage of 157 cos (377t + 15°) Volts with a current into the positive terminal of 12 sin (377t + 70°) Amps.

$\bar{V} = 111.03 \angle 15^\circ \qquad \bar{I} = 8.49 \angle -20^\circ$

$\bar{S} = 942 \angle 35^\circ$

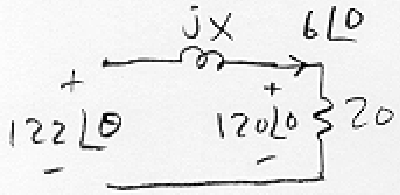
The real power absorbed by this load is 772 Watts.

b) Two loads in parallel consume the complex powers of 100+j100 kVA and 50-j20 kVA.

$\bar{S} = 150k + j80k = 170k \angle 28^\circ$

The power factor of the total load is 0.88 (specify lead / lag circle one)

c) A single-phase load resistor of 20 Ohms is being served through a line with an inductive reactance of value X. The source voltage magnitude is 122 Volts and the load voltage magnitude is 120 Volts.



$122 \angle \theta = j6X + 120$

$122 \cos\theta = 120 \qquad \theta = 10.4^\circ$

$122 \sin\theta = 22 = 6X$

The value of X is 3.67 Ohms.

d) A 3 phase, delta connected load has a line to line voltage of 480 V. The complex power per phase is 2,000+j700 VA.

$\bar{S}_{3\phi} = 6000 + j2100 = 6357 \angle 19^\circ = \sqrt{3} \times 480\, I_L \angle \theta$

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The magnitude of the line current is 7.65 A.

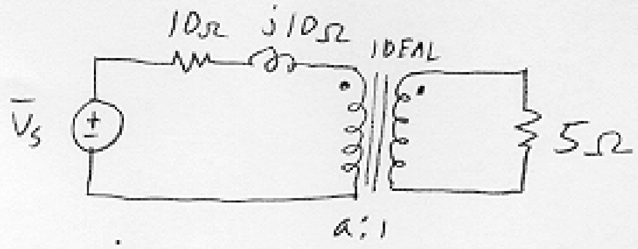
e) A coil of 300 turns is wound on an iron core whose cross sectional area is 0.002 square meters. The applied voltage is $120\sqrt{2}\cos(2\pi 60t)$ Volts.

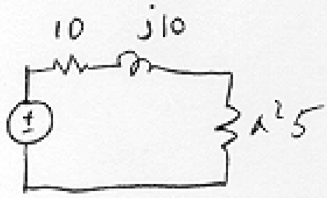
$$120\sqrt{2}\cos(2\pi 60t) = 300\frac{d\phi}{dt} \qquad \phi = \frac{120\sqrt{2}}{300 \times 2\pi 60}\sin 2\pi 60t$$

$$B = \frac{\phi}{A} = \frac{120\sqrt{2}}{.002 \times 300 \times 2\pi 60}\sin 2\pi 60t$$

The peak value of the magnetic flux density is 0.75 Tesla.

f) Find the turns ratio "a" to maximize the power absorbed by the 5Ω load in the impedance matching circuit shown below:

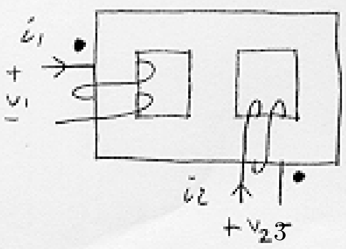




$$a^2 5 = \sqrt{10^2 + 10^2}$$

The turns ratio "a" should be 1.68.

g) Put the polarity dot markings on the two coils shown below.



Problem 2 (29 pts)

The following three-phase balanced loads are connected in parallel across a three-phase wye- connected, 60 Hz source of 4,160 V (line to line)

Load #1	120 kVA at 0.8 PF lag (Wye connected)
Load #2	180 kW at 0.7 PF lag (Wye connected)
Load #3	13 Amps phase current, unity power factor (Delta connected)

a) Find the total complex power consumed by the three loads
b) Find the total source line current (magnitude).
c) Find the CAPACITANCE needed per phase (for a delta connection) so that the overall power factor is 0.95 lag.
d) Find the new source line current with the 3-phase bank of capacitors installed.

a) $\bar{S}_{3\phi} = 120k\angle 37^\circ + \frac{180k}{0.7}\angle 46^\circ + 3\times13\times4160\angle 0$

$= 95.8k + j72.2k$
$+ 180k + j185k$
$+ 162k$

$\boxed{438k + j257k \text{ VA}}$

b) $\sqrt{(438k)^2 + (257k)^2} = \sqrt{3}\times4160\, I_L$ $\quad \boxed{I_L = 70 \text{ Amps}}$

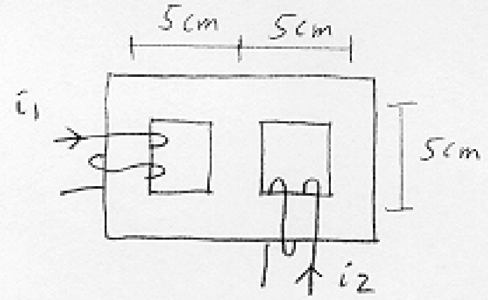
c) $\frac{438K}{0.95} = 461 kVA$ $\quad \bar{S}_{new} = 461k\angle 18^\circ$ $\quad Q_{new} = 142 \text{ KVAR}$

$Q_{add} = (257-142)K = 115K = 3\times4160^2\times2\pi60\, C$

$\boxed{C = 5.88\mu F}$

d) $461K = \sqrt{3}\times4160\, I_L$ 4 $\boxed{I_{L_{new}} = 64 \text{ Amps}}$

Problem 3 (29 pts)



$\mu = 1000\ \mu_0$

$N_1 = 50$ turns
$N_2 = 25$ turns

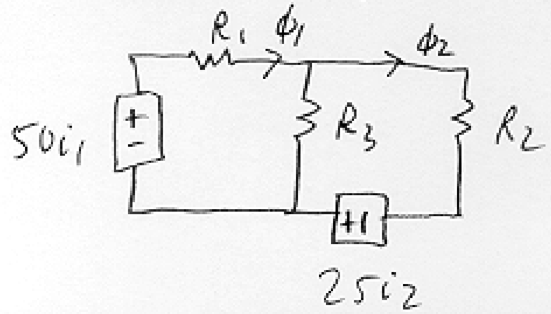
$A = 10\ cm^2$ everywhere

Neglect leakage flux, coil resistance and core losses.

a) Find the coil self inductances (L_1 and L_2) plus the mutual inductance (M)

b) Find the flux density (B) in each vertical leg if the current $i_1 = 5$ Amps (DC), and the current $i_2 = -10$Amps (DC).

a)



$$R_1 = R_2 = \frac{.15}{1000 \times 4\pi \times 10^{-7} \times .001}$$

$$= 119{,}366$$

$$R_3 = \frac{R_1}{3} = 39{,}789$$

$$-50i_1 + 119{,}366\phi_1 + 39{,}789(\phi_1 - \phi_2) = 0$$

$$-25i_2 + 119{,}366\phi_2 + 39{,}789(\phi_2 - \phi_1) = 0$$

$$\begin{bmatrix} 159{,}155 & -39{,}789 \\ -39{,}789 & 159{,}155 \end{bmatrix} \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} = \begin{bmatrix} 50i_1 \\ 25i_2 \end{bmatrix}$$

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$$\begin{bmatrix}\phi_1\\ \phi_2\end{bmatrix} = \frac{\begin{bmatrix}159{,}155 & 39{,}789\\ 39{,}789 & 159{,}155\end{bmatrix}}{2.375\times 10^{10}}\begin{bmatrix}50i_1\\ 25i_2\end{bmatrix}$$

$$\phi_1 = 335\times10^{-6} i_1 + 41.8\times10^{-6} i_2$$

$$\phi_2 = 83.8\times10^{-6} i_1 + 167\times10^{-6} i_2$$

$$\lambda_1 = 50\phi_1 = 0.01675 i_1 + 0.0021 i_2$$

$$\lambda_2 = 25\phi_2 = 0.0021 i_1 + 0.004175 i_2$$

$$\boxed{\begin{array}{ll} L_1 = 0.01675\ H & \\ & m = 0.0021\ H \\ L_2 = 0.004175\ H & \end{array}}$$

b) $B_1 = \frac{\phi_1}{A} = \frac{335\times10^{-6}\times5}{.001} - \frac{41.8\times10^{-6}\times10}{.001} = 1.258\ T$

$B_2 = \frac{\phi_2}{A} = \frac{83.8\times10^{-6}\times5}{.001} - \frac{167\times10^{-6}\times10}{.001} = -1.251\ T$

$B_3 = B_1 - B_2 = 2.5\ T$

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