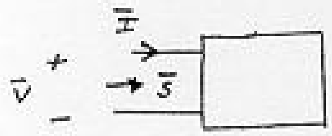
Question #1: (30 pts, no partial credit)

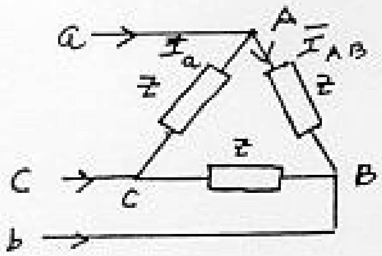
1. The r.m.s. phasor for $v_1(t) = 20\cos(\omega t - 45^0)$ is $\frac{20}{\sqrt{2}}\angle -45^\circ = 14.14\angle -45^\circ$
2. The r.m.s. phasor for $v_2(t) = 10\sin(\omega t + 60^0)$ is $\frac{10}{\sqrt{2}}\angle -30^\circ = 7.07\angle -30^\circ$
3. $v_1(t)$ lags $v_2(t)$ by 15°
4. $v_1(t) + v_2(t) =$ $29.8\cos(\omega t - 40^\circ)$
5. Given $\bar{V} = 100\angle 15^0, \bar{I} = 4\angle -105^0, \bar{S} =$ $400\angle 120^\circ = -200 + j346$



6. An electrical load absorbs 8KW at a lagging P.F of 0.8. The complex power is $8 + j6$ kVA $= 10\angle 36.87$
7. Two loads L_1 and L_2 are in parallel, L_1 is 5kVA at 0.8 P.F lag, L_2 is 10kW at 0.8 P.F lead. The total complex power $L_1 + L_2$ is $14 - j4.5$ kVA $= 14.71\angle -17.82^\circ$

$(4+j3) + \frac{10}{.8}(.8 - j.6)$

8. For the phase sequence a-b-c if $\bar{I}_{AB} = 15\angle 38^0$ the phasor $\bar{I}_a$ is $\sqrt{3}\times 15\angle 38^\circ - 30^\circ = 25.98\angle 8^\circ$

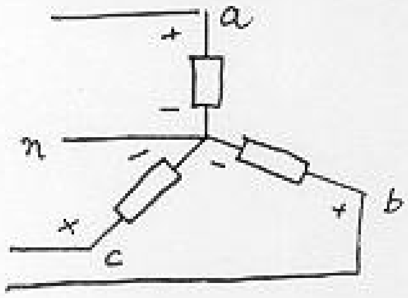


$\bar{I}_a$ lags $\bar{I}_{AB}$ by 30°

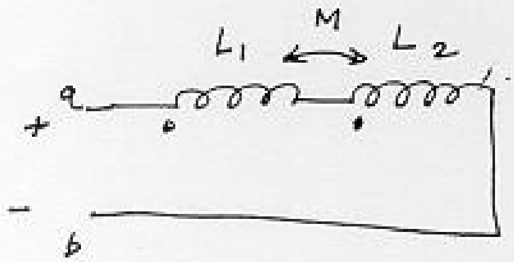
9. In (8) if $\overline{V}_{AB} = 10\angle 8^0$, the total three phase complex power $\overline{S}_T$ is $450\angle -30^\circ$

$3(\overline{V}_{AB})\,\overline{I}_{AB}^{*} = \quad = 346.4 - j225$ VA

10. For a-b-c phase sequence if $\overline{V}_{ab} = 120\angle 60^0$, the phasor $\overline{V}_{bc}$ is $120\angle -60^\circ$



11. What is the inductance at "ab" $L_1 + L_2 + 2M$.



$V_{ab} = L_1 \frac{d}{dt} i + L_2 \frac{d}{dt} i + M \frac{d}{dt} i + M \frac{di}{dt}$

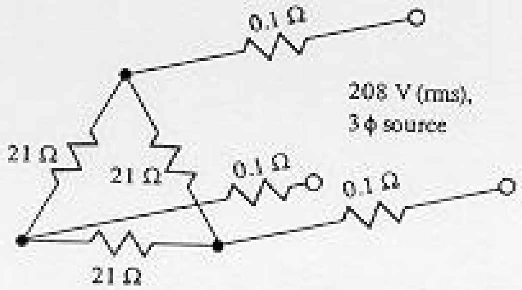
$= (L_1 + L_2 + 2M)\frac{di}{dt}$

12. Two three phase loads L_1 = 15kVA at 0.8 P.F lag and L_2 = 36KW at 0.6 P.F lead are connected in parallel. What is the KVAr needed to make total PF = 1.0 + 39 kVAr

$L_1 + L_2 = 15(.8 + j.6) + \frac{36}{.6}(.6 - j.8)$

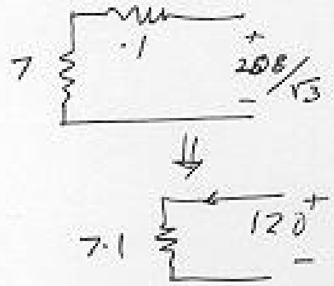
$= 48 - j39$ kVA.

13. Compute the total 3ϕ power supplied by the source.



Per Phase

Power = 6093.8 W



$$P = 3\frac{(120)^2}{7.1} = 6093.8$$

14. A 50kVA, 2400/240 V transformer supplies a 50kVA load at rated current and rated voltage at 0.8 P.F. Core losses are 190W and copper losses are 620W. Find the efficiency when the load current is one fourth the rated current.

η = 97.76

output at $\frac{1}{4}$ rated current $= 12.5 \times .8 = 10$ kW.

copper losses $= 620\left(\frac{1}{4}\right)^2 = 38.75$ W

$$\eta = \frac{10 \times 10^3}{10 \times 10^3 + 190 + 38.75} = 97.76$$

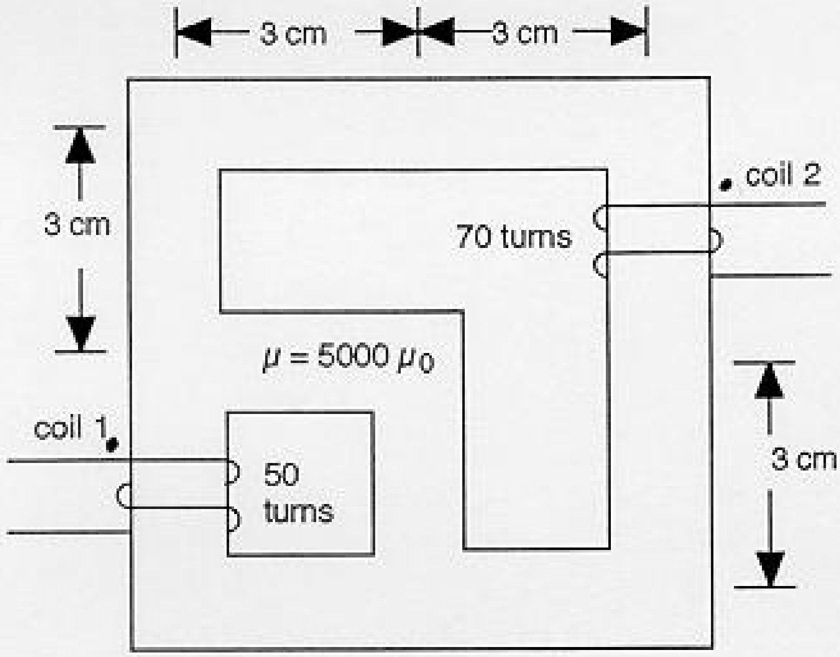
15. Two mutually coupled coils L_1 and L_2 have self inductances of 2 and 3 mH respectively. If the coefficient of coupling is 0.95, what is the mutual inductance?

$$\frac{M}{\sqrt{L_1 L_2}} = .95$$

$$M = .95\sqrt{6 \times 10^{-6}}$$

$$= \boxed{2.33 \text{ mH}}$$

Question #2 (35 pts.)



All legs have cross sections 1 cm by 1 cm

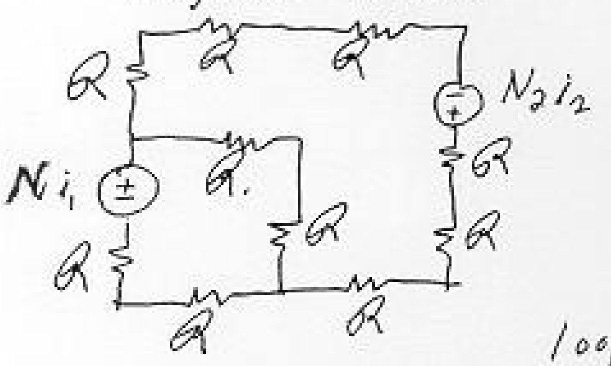
c) What is the mutual inductance between the coils

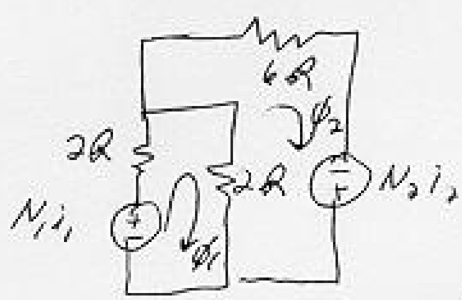
a) In the magnetic circuit shown above, put polarity dots on the coils so that the mutual inductance is positive.

b) What is the self inductance of coil 1?

$$\mathcal{R} = \frac{l}{\mu A} = \frac{3\times10^{-2}}{(5000)(4\pi\times10^{-7})(10^{-4})} = 47746$$

magnetic circuit





$N_1 = 50$

$N_2 = 70$

loop equations $N_1 i_1 = 2\mathcal{R}\phi_1 + 2\mathcal{R}(\phi_1 - \phi_2)$

$N_2 i_2 = 2\mathcal{R}(\phi_2 - \phi_1) + 6\mathcal{R}\phi_2$

add 4x 1st eqn to 2nd eqn to get

$14\mathcal{R}\phi_1 = 4N_1 i_1 + N_2 i_2$

$$\phi_1 = \frac{N_1 i_1}{7/2\,\mathcal{R}} + \frac{N_2 i_2}{14\mathcal{R}}$$

$$\lambda_1 = N_1\phi_1 = \frac{N_1^2}{\frac{7}{2}\mathcal{R}} i_1 + \frac{N_1 N_2}{14\mathcal{R}} i_2$$

$= L_1 i_1 + M i_2$

$$L_1 = \frac{N_1^2}{7/2\,\mathcal{R}} = 15\,mH$$

c) $$M = \frac{N_1 N_2}{14\mathcal{R}} = 5.2\,mH$$

Question #3 (35 pts.)

A 240/120-V, 4.8-kVA, 60-Hz, single-phase transformer is used to supply a 4.8-kVA resistive load (i.e., the load has a power factor of 1.0) at rated voltage of 120 V.

a) If you assume the transformer is ideal, what would be the magnitude of the expected primary side (240 Volt side) current?

b) Again, if you assume the transformer is ideal, what is the apparent impedance of the load viewed from the primary side of the transformer?

Next, the transformer is tested to determine its parameters. Surprisingly, during the open circuit, $I_{oc} = 0$ and $P_{oc} = 0$. During the short circuit test, in which a voltage is applied to the primary (high side) in order to get rated current to flow in the secondary, $V_{sc} = 20$ Volts and $P_{sc} = 100$ W.

c) What are R_{eq} and X_{eq} (referred to the primary)?

d) What are X_m and R_c (referred to the primary)?

e) Using the model values determined from the test data, what voltage must be applied to the primary in order to supply the 4.8-kVA resistive load at a rated voltage of 120 V?

a) $I_s = \frac{4800}{120} = 40A$ $a = 2$ $I_p = 20\ A$

b) $\frac{240^2}{4800} = 12\ \Omega$

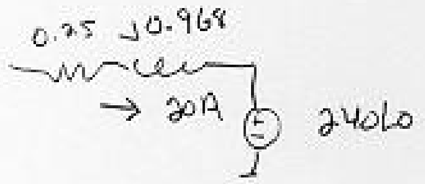
c) I in secondary = 40A, so I in primary = 20 A

$100 = I^2 r_{eq}$ $r_{eq} = \frac{100}{20^2} = 0.25\ \Omega$

$X_{eq} = \sqrt{1 - 0.25^2} = 0.968\ \Omega$

d) No current so X_m & R_c are infinite

e)



$V_{supply} = 245 + j19.38$

$|V_{supply}| = 245.8\ V$