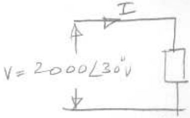
Problem 1 (30 pts.) (No partial credit)

a) A single-phase load takes a complex power of 100 $\angle 60°$ kVA and the voltage across the load is 2000 $\angle 30°$ V. The current in phasor form is $\underline{50\angle -30°}$ A.



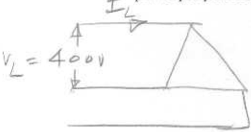
$$\bar{S} = \bar{V}\bar{I}^* \Rightarrow I = \left(\frac{\bar{S}}{\bar{V}}\right)^* = 50\angle -30° \text{ A}$$

$S = 100\angle 60°$ kVA

b) Two loads in parallel have the complex powers as 100+j100 kVA and 50+jQ kVA. The total complex power is 150-j50 kVA. The value of Q is $\underline{-150 \text{ kVA}}$ Is it **capacitive** or **inductive** (circle one)?

$$100 + j100 + 50 + jQ = 150 - j50 \Rightarrow Q = -150 \text{ kVA}$$

c) A 3 phase, delta connected load has a line to line voltage of 400 V. The complex power per phase is 1000+j500 VA. The magnitude of the line current is $\underline{4.84}$ A.



$$1000 + j500 = V_{ph} I_{ph}^* = 400\, I_{ph}^* \Rightarrow I_{ph} = (2.5 - 1.25j)\text{A} = 2.795\angle -26.56°$$

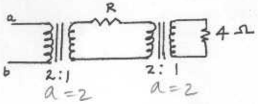
$$|I_L| = \sqrt{3}\,|I_{ph}| = 4.84 \text{ A}$$

d) A coil of 500 turns is wound on an iron core whose reluctance $\mathfrak{R} = 4.6 \times 10^6$ At/Wb The inductance of the coil is $\underline{53.35}$ mH.

$$L = \frac{N^2}{R} = \frac{500^2}{4.6 \times 10^6} = 53.35 \text{ mH}$$

$$\left(\lambda = N\phi = N\frac{Ni}{R} = \frac{N^2 i}{R} = Li \Rightarrow L = \frac{N^2}{R}\right)$$

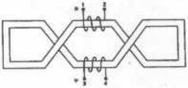
e) Input resistance at "ab" is 100Ω (R>0). The value of R is 9Ω.



Ideal transformers

$$100 = a^2(R + a^2 4)$$
$$\text{i.e. } 100 = 4(R + 16) \Rightarrow R = 9$$

e) Put the dot markings on the two coils.



Dots at 1 and 3

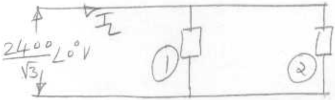
OR 2 and 4.

Problem 2 (35)

The following two three phase loads are connected in parallel across a three phase wye connected source of 2400 V (line to line)

Load #1 120 kVA at 0.8 PF lead
Load #2 180 kW at 0.6 PF lag

a) Find total complex power
b) Find the total line current (magnitude) from the source.
c) What kVAR of capacitor is needed to make the overall PF=0.8 lead



per phase equivalent circuit

a) Load #1 : $S_1 = 120(0.8 - j0.6) = 96 - j72$ kVA
#2 : $S_2 = \frac{180}{0.6}(0.6 + j0.8) = 180 + j240$ kVA

Total Power = $S_1 + S_2 = \underline{276 + j168}$ kVA

b) $PF = \cos(\tan^{-1}\frac{168}{276}) = 0.854$ lag

Now $276 = \sqrt{3}(2400) I_L (0.854)$

$\Rightarrow I_L = \underline{77.75\ A}$

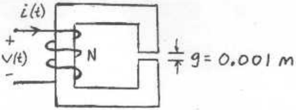
c) $Q_{new} = 276 \tan(\cos^{-1} 0.8) = -207$ kVAr. (−ve for capacitive)

$Q_{old} + Q_{cap} = Q_{new}$

$\therefore 168 + Q_{cap} = -207$ kVAr

$\Rightarrow Q_{cap} = \underline{-376}$ kVAr.

Problem 3 (35)



$v(t) = 120\sqrt{2}\cos(2\pi 60 t)$

$\sigma_{wire} = \infty$

Cross section area A=0.0016 m^2

Neglect fringing and leakage

a) Find the value of N so that the peak value of the flux density in the iron is 1.0 Tesla

b) Using this N, find the current $i(t)$ (if you cannot find N in a), just use the symbol N)

a) $120\sqrt{2}\cos 2\pi 60 t = N \dfrac{d\phi}{dt}$

$\phi = \dfrac{120\sqrt{2}\sin 2\pi 60 t}{2\pi 60 N}$. want $\dfrac{120\sqrt{2}}{2\pi 60 N} = (1.0)(0.0016)$

$\Rightarrow$ **N = 281 Turns**

b) $H_{gap}\, g = N i \Rightarrow i = \dfrac{H_{gap} \times 0.001}{281}$

$= \dfrac{0.001\, B_{gap}}{281 \times 4\pi \times 10^{-7}}$

ie $i = \dfrac{0.001}{281 \times 4\pi \times 10^{-7}} \dfrac{\phi}{A} = \dfrac{0.001 \times 120\sqrt{2}\sin 2\pi 60 t}{281 \times 4\pi \times 10^{-7} \times 2\pi 60 \times 281 \times 0.0016}$

$\therefore$ **$i = 2.8 \sin 2\pi 60 t$ A**