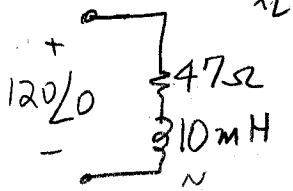
EE369/394J, Test #1, Sept. 3, 2004. Name KEY

One sheet of notes permitted. Show all steps.

Problem 1. A load consists of a 47Ω resistor and 10mH inductor in series. The load is energized by a 120V, 60Hz voltage source. The phase angle of the voltage source is zero.

a. Determine the phasor current
b. Determine the load P, pf, Q, and S.
c. Find an expression for instantaneous p(t)

$X_L = 2\pi fL = (2\pi)(60)(10\times10^{-3}) = 1200\pi\times10^{-3} = 3.77\Omega$



$Z_L = 47 + j3.77\Omega = 47.2\angle 4.59^\circ$

a) $\tilde{I} = \frac{\tilde{V}}{Z_L} = \frac{120\angle 0}{47.2\angle 4.59}$

$\tilde{I} = 2.54\angle -4.59$ A(RMS)

b) $S = VI^* = (120\angle 0)(2.54\angle -4.59)^* = 305\angle 4.59^\circ$ VA

$P = Re\{S\} = 305\cos(4.59^\circ) = 304$W

$Q = Im\{S\} = 305\sin(4.59^\circ) = 24.4$ VAr

$pf = \cos(4.59^\circ) = 0.997$

Also, $P = |I|^2 R = (2.54)^2(47) = 303$W

$Q = |I|^2 X_L = (2.54)^2(3.77) = 24.3$ VAr

$|S| = 305$, $Q = 24.4$, $P = 304$

c) $p(t) = V_p\cos(\omega t + \theta_V) I_p\cos(\omega t + \theta_I) = \frac{V_p I_p}{2}\left[\cos(\theta_V - \theta_I) + \cos(2\omega t + \theta_V + \theta_I)\right]$

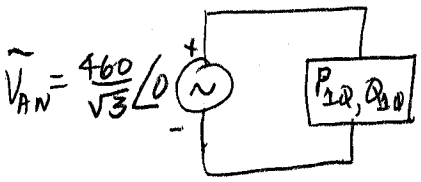
$p(t) = 305\left[0.997 + \cos(754t - 4.59^\circ)\right]$ (Note, $P = 305(0.997) = 304$W)

Problem 2. A three-phase, 460V motor draws 5kW with a power factor of 0.80 lagging.

Assuming that $\tilde{V}_{an}$ has phase angle zero,

a. Find phasor currents $\tilde{I}_a$ and $\tilde{I}_{ab}$ (note – $\tilde{I}_{ab}$ is inside the motor delta windings)
b. Find the three phase motor Q and S
c. How much capacitive kVAr (three-phase) should be connected in parallel with the motor to improve the net power factor to 0.95?

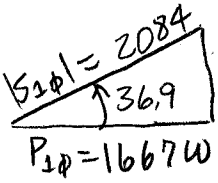
a) Draw a one-line diagram



$P_{1\phi} = \frac{P_{3\phi}}{3} = \frac{5000}{3} = 1667$W

$Q_{1\phi} = P_{1\phi}\sqrt{\left(\frac{1}{pf}\right)^2 - 1} = 1250$ VAr

$S_{1\phi} = \frac{P_{1\phi}}{pf}\angle\cos^{-1}(pf) = \frac{1667}{0.80}\angle 36.9^\circ = 2084\angle 36.9$ VA



a) $S_{1\phi} = V_{AN}(I_A)^* \Rightarrow I_A = \frac{S_{1\phi}^*}{V_{AN}^*} = \frac{2084\angle -36.9}{\frac{460}{\sqrt{3}}\angle 0} = 7.85\angle -36.9$ A

$\tilde{I}_{ab} = \frac{\tilde{I}_a}{\sqrt{3}}\angle 30^\circ = \frac{7.85\angle -36.9}{\sqrt{3}}\angle 30 = 4.53\angle -6.9^\circ$ A $= \tilde{I}_{ab}$

b) $Q_{3\phi} = 3Q_{1\phi} = 3750$ VAr

$\left(Q_{3\phi} = P_{3\phi}\sqrt{\left(\frac{1}{pf}\right)^2 - 1} = 3750\right)$

$S_{3\phi} = 3S_{1\phi} = 6252\angle 36.9$ VA

c) $Q_{NET}^{3\phi} = P_{NET}^{3\phi}\sqrt{\left(\frac{1}{pf_{NET}}\right)^2 - 1} = 5000\sqrt{\left(\frac{1}{0.95}\right)^2 - 1} = 1643$ VAr

$Q_{NET}^{3\phi} = Q_{MOT}^{3\phi} + Q_{CAP}^{3\phi}$, $Q_{CAP}^{3\phi} = 1643 - 3750 = -2107$ VAr