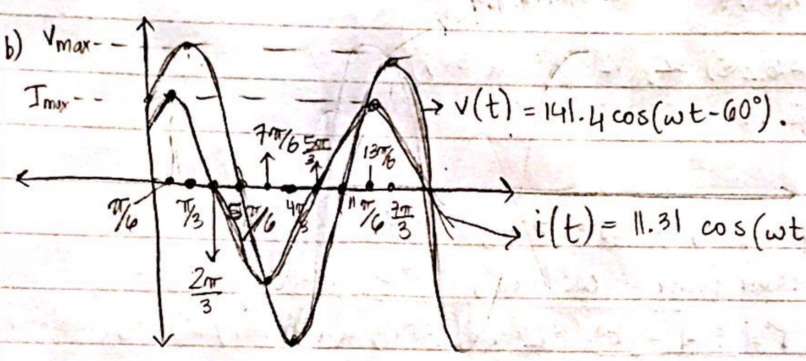
Homework #2

1 Phasors ; $v = 141.4\cos(\omega t - 60°)$ & $i = 11.31\cos(\omega t - 30°)$

a) $V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{141.4}{\sqrt{2}} = 99.98 \approx 100$ $\quad I_{rms} = \frac{I_{max}}{\sqrt{2}} = 7.997 \approx 8$

$V_{max} = 141.4$ $\quad I_{max} = 11.31$

b)



c) Voltage $= \frac{V_{max}}{\sqrt{2}} = \frac{141.4}{\sqrt{2}} = 99.98 \approx 100\angle{-60°} = 50 - j86.6$

current : $\frac{I_{max}}{\sqrt{2}} = \frac{11.31}{\sqrt{2}} = 7.997 \approx 8 \Rightarrow 8\angle{-30°} = 6.93 - j4$

d) $v = 141.4\cos(\omega t - \pi/3)$

$V = 141.4\cos(\omega t)$ (add $\pi/3 = 60°$) $= \frac{141.4}{\sqrt{2}} \approx 99.98 \approx 100\angle 0°$

$i = 11.31\cos(\omega t + 30°) = \frac{11.31}{\sqrt{2}} = 7.997378 \approx 8\angle 30°$

e) Capacitive since θ is $\varphi_v - \varphi_c = 0 - 30° = -30°$ (negative means current is leading)

f) $\mathbf{Z} = \frac{\mathbf{V}}{\mathbf{I}} = \frac{100\angle 0°}{8\angle 30°} = 12.5\angle{-30°} = (12.5)\cos(-30°) + j(12.5)\sin(-30°) = 10.82 - j6.25$

$R = 10.82\,\Omega$

$X = -6.25\,\Omega$

* 1) $Z_1 = \frac{1}{Y_{tot}} \Rightarrow Y_{tot} = \frac{1}{Z} = \frac{1}{12.5\angle -30^\circ} = .08\angle 30^\circ = (.08)\cos(30^\circ) + j(.08)\sin(30^\circ)$

$Y_{tot} = .06928 + j.04$

$Y_R = .06928 = \frac{1}{Z_R} \Rightarrow Z_R = \frac{1}{.06928} = 14.4\,\Omega = R$

$X = \frac{-B}{G^2+B^2} = \frac{-.04}{.006399718} = -6.25\ \Omega$

#2 a) $Z_1 = 10\angle 60^\circ\ \Omega = 10\cos(60^\circ) + j(10)\sin(60^\circ) = 5 + j8.66\ \Omega$

$R = 5\Omega$

Power factor $= \cos(+60^\circ) = .5$ lagging

$X_c = 8.66\Omega \rightarrow$

$|S| = \sqrt{(P^2)+(Q)^2} = \sqrt{(2879)^2+(4987)^2}$

$|S| = 5758$ VA

$V = 240\angle 0^\circ$

$I = \frac{240\angle 0^\circ}{10\angle 60^\circ} = 24\angle -60^\circ = (24)\cos(-60^\circ) + j(24)(\sin(-60^\circ)) = 12 - j20.78$

$P = I^2R = \left[\sqrt{(12)^2+(20.78)^2}\right]^2(5) = 2879$ W

$Q = I^2X_c = \left[\sqrt{(12)^2+(20.78)^2}\right]^2(8.66\Omega) = 4987$ VAR

b) $Q = +1250$ VAR

$Z_L = 5 + j8.66\Omega$

$Q_s = Q_L - Q_C = 4987 - 1250 = 3737$ VAR

Power doesn't change from a since the capacitor doesn't supply real power, so $P = 2879$ W

$Q_s = P\tan\theta_s$

$\tan^{-1}\left(\frac{Q_s}{P}\right) = \theta_s$

$\theta_s = 52.389^\circ$

$\cos(\theta_s) = .61$, lagging.

#3 $Z = 8 + j6$

a) $\sqrt{(8)^2+(6)^2} = 10$

$\theta = \tan^{-1}\left(\frac{6}{8}\right) = 36.86990 \approx 36.87°$

$\mathbf{Z} = 10\angle 36.87°$

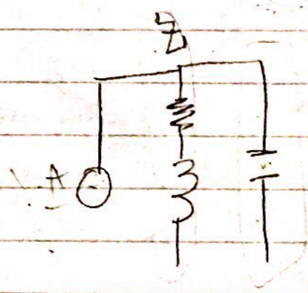
The inductor has an imaginary component attached to it so we can't just add the two numbers together.

* b) $j\omega L = j6$

$L = \frac{6}{\omega} = \frac{6}{(2\pi 60)} = 1.59 \times 10^{-2}$ H $= 15.9$ mH

$L = \frac{6}{\omega} = \frac{6}{2\pi(50)} = 1.91 \times 10^{-2}$ H $= 19.1$ mH

This will be used in part g.



c) Current Phasor: $\frac{\mathbf{V}}{\mathbf{Z}} = \frac{120\angle 0°}{10\angle 36.87°} = 12\angle -36.87°$

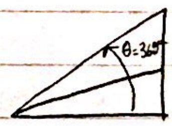
d) $\mathbf{S} = \mathbf{V}(^*\mathbf{I}) = (12\angle +36.87)(120\angle 0°) = 1440\angle 36.87°$

$I = 12(\cos(-36.87°)) + j(12)(\sin(-36.87))$

$I = 9.6 - j7.2$

$P = |I|^2 R = (9.6^2 + (-7.2)^2)\, 8 = 1152$ W

$Q = |I|^2 X_L = (9.6^2 + (-7.2)^2)\, 6 = 864$ VAR



e) $\theta = \cos^{-1}(.95) = 18.19°$

$Q_s = (1152\,W)\tan(\theta) = (1152\,W)(.3285) = 378.5$ VAR

$Q_c = Q_L - Q_s = 864 - 378.5 = 485.5$ VAR that the capacitor delivers.

$I_c = \frac{Q_c}{V\sin(\theta)} = \frac{485.5\text{ VAR}}{(120\text{ V})(\sin(18.19))} = 12.96$ A

$$\boxed{X_c = \frac{Q_c}{(I_c)^2} = \frac{485.5\text{ VAR}}{(12.96\text{ A})^2} = 2.89\,\Omega}$$

f) $X_C = 2.89\Omega = \dfrac{1}{\omega C}$

$$C = \frac{1}{\omega(2.89\Omega)} = 917.8\ \mu F$$

g) $V(t) = 169.7\cos(\omega t)$

$C = 917.8\ \mu F$ $\quad$ $f = 60\ Hz \rightarrow \text{period} = \dfrac{1}{f} = 1.67\times10^{-2}$

$L = 15.9\ mH$ $\quad$ Half cycle $= \dfrac{1}{2}\left[1.67\times10^{-2}\right] = 8.33\times10^{-3}$

$$E_C(t) = \frac{1}{2}C\left[V(t)\right]^2 = E_C(8.33\times10^{-3}) = \frac{1}{2}(917.8\times10^{-6}F)(169.7\cos(120(8.33\times10^{-3})))$$

$E_C(t) = 7.786\times10^{-2}$ J

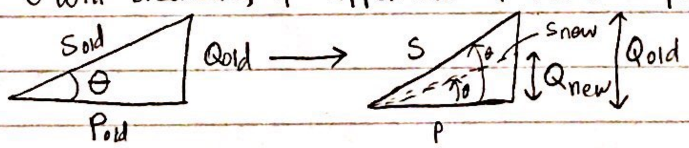
#4 a) The power-save unit increase the power factor, reduces the current usage, & therefore increase efficiency.

b) $\cos\theta = .60$

$P = (20A)(120V)(.60) = 1440$

Energy consumption: 1.44 KWh

c) The current drawn will decrease, the power factor will increase which inturn means θ will decrease, & apparent & reactive power will decrease.



d) $\dfrac{5 \text{ hours}}{1 \text{ day}}$ $\quad$ ER = .20/kWh

e) The claim is realistic for apparent power. The increase in the power factor will reduce apparent power, but it will not reduce real power and that's the power residential customers pay for.

f) Residential customers can save money by using Power-Save devices when it comes to back up energy systems. Correcting power factor allows residential customers to use a less expensive inverter since a larger power factor allows for a smaller VA rating

5 Imagine water falling on the ground from up high. The space from the ~~top~~ (where the water starts falling) to the ground makes up is the voltage. It can also be explained with people. Imagine bad people who want to be good. The more they want to be good the more the voltage.