#6 PW 2.32: 4 MVAR minimizes the real power line losses to .336 MW; 4.5 MVAR minimizes the apparent power flow into the feeder to 8.34 MVA.

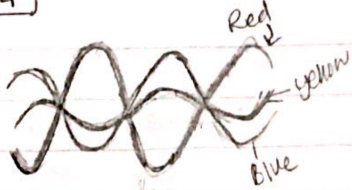
PW 2.33: See graph attached

PW 2.34: @ Q_{cap} = 5.0 Mvar, the load is 10 MW/5 MVAR. we have the least feeder losses at .525 MW & 1.050 MVAR.
@ Q_{cap} = 5.5 Mvar, the load is 20 MW/10 Mvar & 7.206 MW is the lowest feeder losses. & 4.413 MVAR, since these are the lowest feeder losses then they must produce the lowest average feeder losses.
Q_{cap} should be set between 5–5.5 Mvar.

* I worked with Matt Flynn.

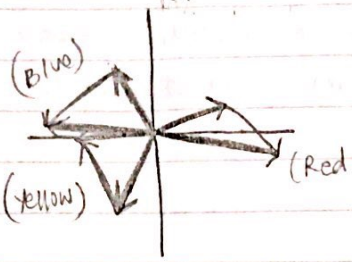
HW 4

#1 A)

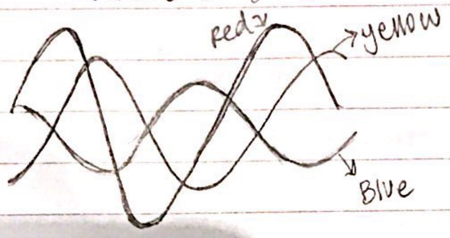


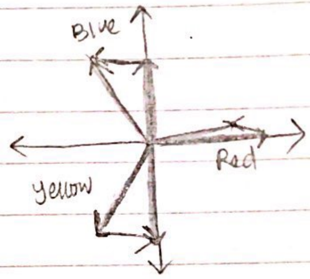
The red component has the highest amplitude, then blue followed by yellow.

The Blue & yellow vectors are in phase with each other.



b) Current Diagram:





The Blue & yellow currents are out of phase with each other by 180 degrees

c) If I move the relative angle to the right, the magnitude of the red phasor decreases while the magnitude of the yellow & blue components increase.

#2 a) Real power: 137 W Apparent power: 137 VA

b) $THD_I = \dfrac{\sqrt{\sum_{k=2}^{\infty} I_{krms}^2}}{I_{1rms}} \times 100 = \dfrac{\sqrt{(.5A)^2}}{1A} .100\% = 50\%$

$V_{rms} = V_{1rms}\sqrt{1+(THD_V/100)^2} = 276\ V$

$I_{rms} = (1A)\sqrt{1+(50/100)^2} = 1.12\ A$

$P_{avg} = \sum_{k=1}^{\infty} V_{krms} I_{krms} \cos(\varphi_k - \theta_k) = (276\ V)(.50\ A)\cos(0) + 0 + (0V)(.5A)\cos(0-0)$

$P_{avg} = 138\ W$

$Pf_{true} = \dfrac{P_{avg}}{V_{1rms} I_{1rms}}\left(\dfrac{1}{\sqrt{1+(THD_I/100)^2}}\right) = \dfrac{138\ W}{(276V)(.5A)} \dfrac{1}{\sqrt{1+(50/100)^2}} = .89$

$P = (276V)(.5A)(.89) = 122.82\ W$

$S = (276V)(.5A) = 138\ VA$

c) The third Harmonic of the current is the only contributor to THD.

The true p.f. is affected by the harmonics & power transferred to the load.

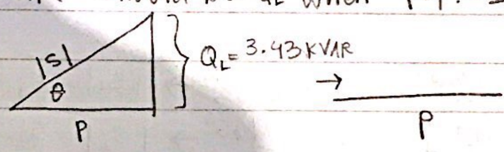
3 a) The customer & the neighbors will be concerned because non-linear loads do not present a constant impedance. A non-constant impedance will distort current waveform, causing current harmonics which in turn cause voltage harmonics.

b) If the source impedance is resistive, there will be less harmonics. If it's inductive the harmonics will be larger.

#4 a) $|S| = (20A)(240V) = 4{,}800\ VA$

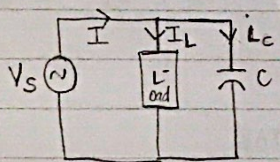
$$\cos\theta = \frac{3.36\ kW}{4800\ VA} = .7 \text{ lagging}$$

b) KVAR should be $-Q_L$ when p.f. = 1 since $\sin(\cos^{-1}(1)) = 0$.



After adding Q_c, Q_L reduces completely. $Q_{cap} = Q_L = 3.43\ KVAR$

c)



$$I_L = \frac{P}{V_{RMS}\cos\theta} = \frac{3.36\ kW}{(240\ V)(1)} = 14 \text{ amps}$$

$$I_C = I - I_L = 20\ A - 14\ A = 6\ A$$

d) 20 Amps

e) The capacitor only adds reactance / reduces the reactance of the load. It doesn't change total current.

Diagram → from part b, we don't have an angle anymore because the powerfactor is 1. From the triangle, to a flat line as in b.

f) The best KVAR rating would have been 3.43 KVAR

#5 Power Transfer

a) $Z = jX$

$$I_{12} = \frac{V_1 - V_2}{Z}$$

$S_1 = I_{12}^* V_1$ $\quad P_1 = |S_1| \cos(\theta)$ $\quad P_{12} = P_1 + P_2$

$S_2 = I_{12}^* V_2$ $\quad P_2 = |S_2| \cos(\theta)$ $\quad Q_{12} = Q_1 + Q_2$

$Q_1 = |S_1| \sin(\theta)$

$Q_2 = |S_2| \sin(\theta)$

b) For maximum power transfer to occur, one of sources must generate x amount of real power and the other source must consume x amount of real power.

c) $V_1 = 10\angle 30°$

$V_2 = 10\angle 0°$

$X = 1\,\Omega$

$$I_{12} = \frac{10\angle 30° - 10\angle 0°}{1\angle 90°} = \frac{8.66 + j5 - (10)}{1\angle 90°} = \frac{-1.34 + j5}{1\angle 90°} = \frac{5.176\angle -75}{1\angle 90°}$$

$I_{12} = 5.176\angle -165°$

$S_1 = [5.176\angle 165°][10\angle 30°] = 51.76\angle 195° \rightarrow |S_1| = 51.76$

$S_2 = [5.176\angle 165°][10\angle 0°] = 51.76\angle 165° \rightarrow |S_2| = 51.76$

$P_1 = (51.76)\cos(195) = -50$ W

$P_2 = (51.76)\cos(165) = -50$ W

$Q_1 = (51.76)\sin(195) = -13.39$ VAR

$Q_2 = (51.76)\sin(165) = 13.39$ VAR

Yes it all adds up. Machine 1 generates 50 W & supplies reactive power of 13.39 VAR. Machine 2 consumes energy at the rate of 50 W and supplies reactive power of 13.39 VAR. Supplied reactive power is 26.78 VAR which is required by the inductive reactance of $1\,\Omega$. Since the impedance is purely reactive, no real power is consumed by the impedance, and all the watts generated by machine 1 are transferred to machine 2.

d) $\delta_1 = 45°$ $V_1 = 10\angle 45°$ $V_2 = 10\angle 0°$

$$I_{12} = \frac{10\angle 45° - 10\angle 0°}{1\angle 90°} = \frac{10\cos(45) + j10\sin(45) - 10}{1\angle 90°}$$

$$I_{12} = \frac{7.07 + 7.07j - 10}{} = \frac{-2.92 + j7.07}{1\angle 90°} = \frac{7.65\angle -67.55°}{1\angle 90°}$$

$I_{12} = 7.65\angle -157.55°$

$S_1 = (7.65\angle 157.55°)(10\angle 45°) = 76.5\angle 202.55°$

$S_2 = (7.65\angle 157.55°)(10\angle 0°) = 76.5\angle 157.55°$

$P_1 = 76.5\cos(202.55°) = -70.65$ W

$P_2 = 76.5\cos(157.55°) = -70.70$ W

$Q_1 = 76.5\sin(202.55°) = -29.33$ VAR

$Q_2 = 76.5\sin(157.55°) = 29.21$ VAR

The current's magnitude increases, while the angle decreases. Machine 1 generates 70.65 watts while Machine 2 consumes 70.70 watts. Machine 1 supplies + 29.33 VARs & Machine 2 supplies 29.21 VaRs. The powers (reactive & real) do not completely cancel out.

e) $V_1 = 8.36\angle 30°$ $V_2 = 4.18\angle 0°$

$$I_{12} = \frac{8.36\angle 30° - 4.18\angle 0°}{1\angle 90°} = \frac{7.24 + j4.18 - 4.18}{1\angle 90°}$$

$$I_{12} = \frac{3.06 + j4.18}{1\angle 90°} = \frac{5.18\angle 53.79°}{1\angle 90°} = 5.18\angle 88.94°$$

$S_1 = (5.18\angle 88.94°)(8.36\angle 30°) = 43.3\angle 118.94°$

$S_2 = (5.18\angle 88.94°)(4.18\angle 0°) = 21.65\angle 88.94°$

$P_1 = 43.3\cos(118.94°) = -20.95$ W

$P_2 = 21.65\cos(88.94°) = .4$ W

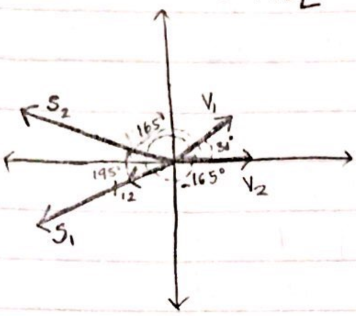
$Q_1 = 43.3\sin(118.94°) = 37.89$ VAR

$Q_2 = 21.65\sin(88.94°) = 21.65$ VAR

Everything changes except for the reactance.

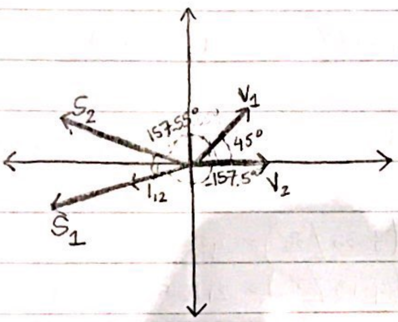
f) Part c: $V_1 = 10\angle 30°$ $V_2 = 10\angle 0°$ $I_{12} = 5.176\angle -165$

$S_1 = 51.76\angle 195°$ $S_2 = 51.76\angle 165°$



Part d: $V_1 = 10\angle 45°$ $V_2 = 10\angle 0°$ $I_{12} = 7.65\angle -157.55$

$S_1 = 76.5\angle 202.55°$ $S_2 = 76.5\angle 157.55°$



Part e: $V_1 = 8.36\angle 30°$ $V_2 = 4.18\angle 0°$ $I_2 = 5.18\angle 88.94°$

$S_1 = 43.3\angle 118.94°$ $S_2 = 21.65\angle 88.94°$