EECS 215 Quiz #10 Solution Fall 2017

a) $X_{L_1} = L_1\omega = 54\times10^{-3}\times 2\pi\times f = 20\ \Omega$

$Z_{L_1} = jX_{L_1} = j20\ \Omega$

$X_{L_2} = L_2\omega = 13.5\ mH\times10^{-3}\times 2\pi f = 5\ \Omega$

$Z_{L_2} = jX_{L_2} = j5\ \Omega$

$Z_c = \frac{1}{jc\omega} = -j\frac{1}{c\omega} = -j\frac{10^6}{176\times 2\pi f} = -j15\ \Omega$

$S = \frac{1}{2}VI^* = V_{rms}\cdot I^*$

$S_1 = V_{rms}\cdot\frac{V_{rms}}{(10+j20)^*} = \frac{(120\ V)^2}{10-j20} = \frac{1440}{1-j2} = \frac{1440(1+j2)}{5}$

$S_1 = 288(1+j2) = 288+j576\ \ VA$

$S_2 = V_{rms}\cdot\frac{V_{rms}}{(5-j15)^*} = \frac{14400}{5(1+j3)} = \frac{14400(1-j3)}{50}$

$S_2 = 288(1-j3) = 288-j864\ \ VA$

$S_3 = \frac{14400}{(j5+5)^*} = \frac{14400}{5-j5} = 2880\frac{1+j}{2} = 1440(1+j)$

$S_3 = 1440+j1440\ \ VA$

$S_{total} = 2016\ W + j1152\ VAR = P+jQ$

$|S| = 2322\ \ VA$

b) $PF = \frac{P}{|S|} = \frac{2016\ W}{2322\ VA} = 0.868$

c) It is lagging, load is inductive.

d) A capacitor can be placed in parallel with the whole load to reduce reactive power to a new value

So that

$$Pf_{new} = 0.95 = \cos\varphi$$

$$\varphi = 18.2^{\circ}C$$

$$\tan\varphi = \frac{Q_{New}}{P} = 0.329$$

$$Q_{New} = 0.329\,P = 0.329 \times 2016 = 662.8 \text{ VAR}$$

$$Q_{New} = Q - Q_c \quad \text{or} \quad Q_c = Q - Q_{New}$$

$$Q_c = 1152 - 662.8 = 489.2 \text{ VAR}$$

In a capacitor $S = -jC\omega V_{rms}^2$

$\therefore$ $Q_c = C\omega V_{rms}^2$

$$C = \frac{Q_c}{\omega V_{rms}^2} = \frac{489.2 \text{ VAR}}{2\pi \times 60 \times (120)^2} = 90\,\mu F$$