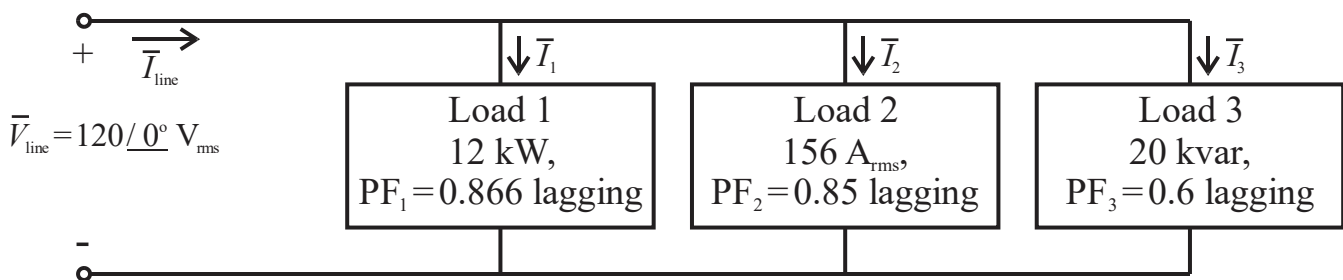


It is desired to correct the overall power factor of the prior problem to unity by connecting a reactive load in parallel with loads 1 – 3. a) Will the reactive load need to be an inductor or capacitor? Explain. b) Determine the value of the reactive load (i.e., L or C) required, reactive power used, and phasor current (rms) supplied to the reactive load. c) Determine the new complex power and phasor current (rms) supplied by the source. By what percent was the source current magnitude reduced (e.g., $|I_{\text{old}} - I_{\text{new}}| / I_{\text{old}} * 100\%$)?

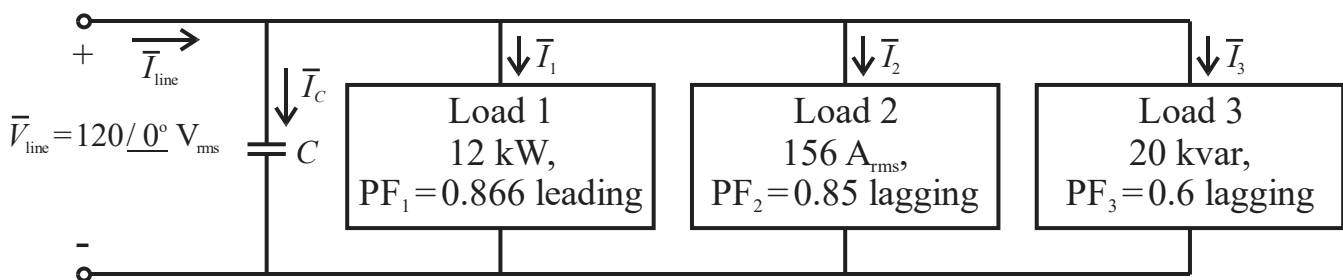
A 60 Hz, 120 V_{rms} single-phase source (assume 0° phase angle) is connected to three loads connected in parallel. Load 1 consumes 12 kW of power and has a power factor $pf_1 = 0.866$ leading. Load 2 draws 156 A_{rms} of current and has $pf_2 = 0.85$ lagging. Load 3 uses 20 kvar of reactive power and has a power factor $pf_3 = 0.6$ lagging. Determine: a) the complex power consumed, phasor current (rms) drawn by, and impedance of load 1, b) repeat for load 2, c) repeat for load 3, d) the total complex power and phasor current (rms) supplied by the source, and e) the overall power factor ‘seen’ by the source.



From prior problem solution: $\bar{S}_{\text{line}} = 48,655.24 \angle 28.12^\circ \text{ (VA)} = 42,912 + j22,932 \text{ (VA)}$,
 $\bar{I}_{\text{line}} = 405.46 \angle -28.12^\circ \text{ (A}_{\text{rms}})$, and $\text{PF}_{\text{line}} = 0.882 \text{ lagging}$.

a) Since the overall PF was found to be lagging (i.e., resistive-inductive load)

⇒ parallel reactive load needs to be a capacitor.



b) For a PF = 1, the desired overall phase angle is $\text{PF} = 1 = \cos(\theta_{\text{des}}) \Rightarrow \theta_{\text{des}} = 0^\circ$.

From the class notes, $C = \frac{P_1 [\tan(\theta_1) - \tan(\theta_2)]}{\omega V^2}$ where P_1 is the power consumed by the load(s), θ_1 is phase angle of the original load(s), θ_2 is the desired overall phase angle, $\omega = 2\pi f$ is the radian frequency, and V is the rms line voltage.

The capacitance needed is

$$C = \frac{42,912 [\tan(28.12^\circ) - \tan(0^\circ)]}{2\pi(60)120^2} \Rightarrow \underline{C = 4.2243 \times 10^{-3} \text{ F} = 4.22 \text{ mF.}}$$

$$\text{From notes, } |Q_C| = \omega C V^2 = 2\pi(60)0.0042243(120)^2 \Rightarrow \underline{Q_C = -22,932 \text{ var.}}$$

$$\text{By Ohm's Law, } \bar{I}_C = 120 \angle 0^\circ (j2\pi(60)0.0042243) \Rightarrow \underline{\bar{I}_C = 191.103 \angle 90^\circ (\text{A}_{\text{rms}}).}$$

$$\begin{aligned} \text{c) The new complex power is } \bar{S}_{\text{line,corr}} &= \bar{S}_{\text{line}} + \bar{S}_C = (42,912 + j22,932) - j22,932 \\ &\Rightarrow \underline{\bar{S}_{\text{line,corr}} = 42,912 (\text{VA}) = 42,912 (\text{W}).} \end{aligned}$$

$$\begin{aligned} \text{The new phasor current is } \bar{I}_{\text{line,corr}} &= \bar{I}_{\text{line}} + \bar{I}_C = 405.46 \angle -28.12^\circ + 191.103 \angle 90^\circ \\ &\Rightarrow \underline{\bar{I}_{\text{line,corr}} = 357.6 \angle 0^\circ (\text{A}_{\text{rms}}).} \end{aligned}$$

$$\begin{aligned} \% \text{ reduction of current} &= |I_{\text{old}} - I_{\text{new}}| / I_{\text{old}} * 100\% = |405.46 - 357.6| / 405.46 * 100\% \\ &\Rightarrow \underline{\% \text{ reduction of current} = 11.8\%.} \end{aligned}$$