Ejemplos resueltos de Potencia compleja

EXAMPLE 17–2 For the *RL* circuit of Figure 17–7(a), $I = 5$ A. Determine P and Q.

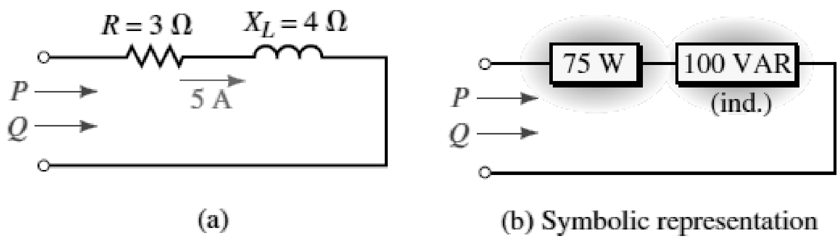


FIGURE 17–7 From the terminals, P and Q are the same for both (a) and (b).

Solution

$$P = I^2R = (5\text{ A})^2(3\ \Omega) = 75\text{ W}$$

$$Q = Q_L = I^2X_L = (5\text{ A})^2(4\ \Omega) = 100\text{ VAR (ind.)}$$

These can be represented symbolically as in Figure 17–7(b).

EXAMPLE 17–3 For the *RC* circuit of Figure 17–8(a), determine P and Q.

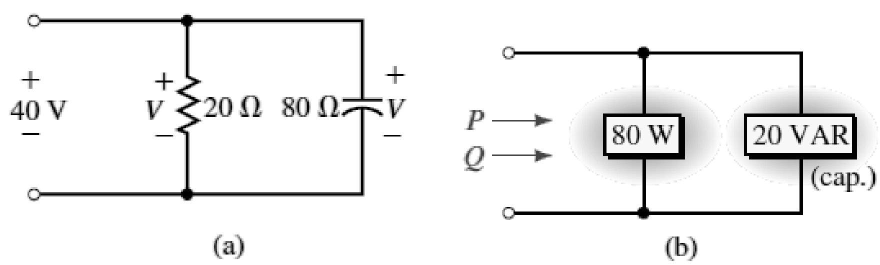


FIGURE 17–8 From the terminals, P and Q are the same for both (a) and (b).

Solution

$$P = V^2/R = (40\text{ V})^2/(20\ \Omega) = 80\text{ W}$$

$$Q = Q_C = V^2/X_C = (40\text{ V})^2/(80\ \Omega) = 20\text{ VAR (cap.)}$$

These can be represented symbolically as in Figure 17–8(b).

EXAMPLE 17–4

a. For Figure 17–9(a), compute P_T and Q_T.

b. Reduce the circuit to its simplest form.

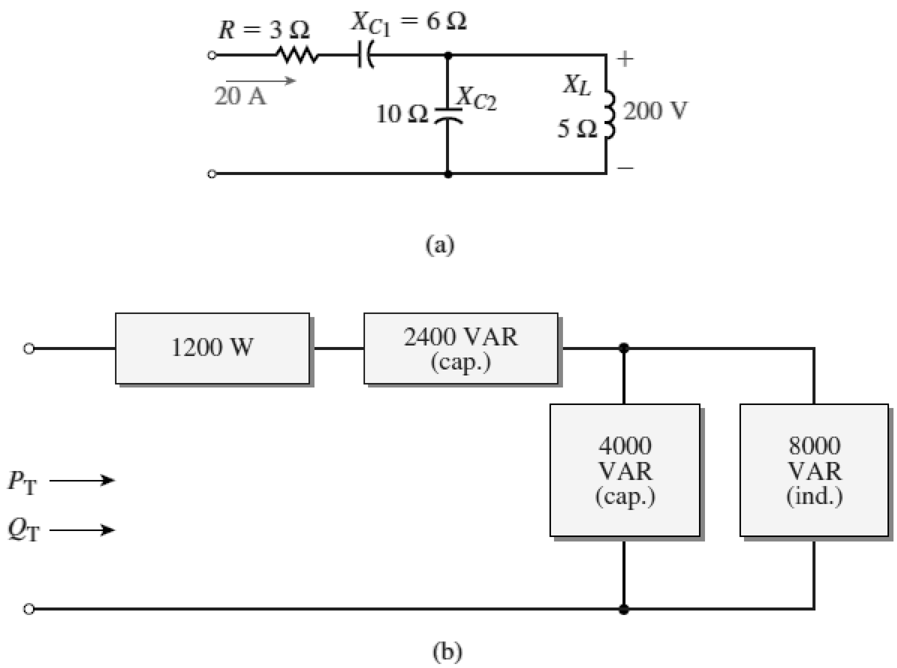


FIGURE 17–9

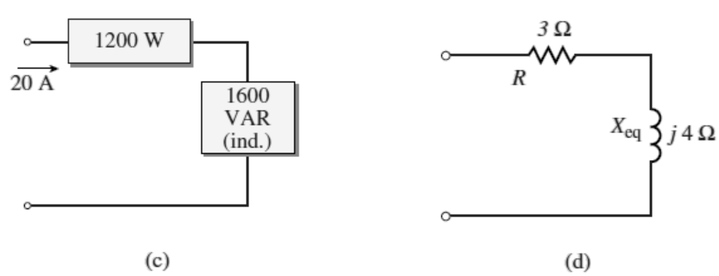


FIGURE 17–9 Continued.

Solution

a. $P = I^2R = (20\text{ A})^2(3\ \Omega) = 1200\text{ W}$

$Q_{C_1} = I^2X_{C_1} = (20\text{ A})^2(6\ \Omega) = 2400\text{ VAR (cap.)}$

$$Q_{C_2} = \frac{V_2^2}{X_{C_2}} = \frac{(200\text{ V})^2}{(10\ \Omega)} = 4000\text{ VAR (cap.)}$$

$$Q_L = \frac{V_2^2}{X_L} = \frac{(200\text{ V})^2}{5\ \Omega} = 8000\text{ VAR (ind.)}$$

These are represented symbolically in part (b). $P_T = 1200$ W and $Q_T = -2400\text{ VAR} - 4000\text{ VAR} + 8000\text{ VAR} = 1600\text{ VAR}$. Thus, the load is net inductive as shown in (c).

b. $Q_T = I^2X_{eq}$. Thus, $X_{eq} = Q_T/I^2 = (1600\text{ VAR})/(20\text{ A})^2 = 4\ \Omega$. Circuit resistance remains unchanged. Thus, the equivalent is as shown in (d).

EXAMPLE 17–7 For the circuit of Figure 17–18(b), a capacitance with $Q_C = 160$ kVAR is added in parallel with the load as in Figure 17–19(a). Determine generator current I.

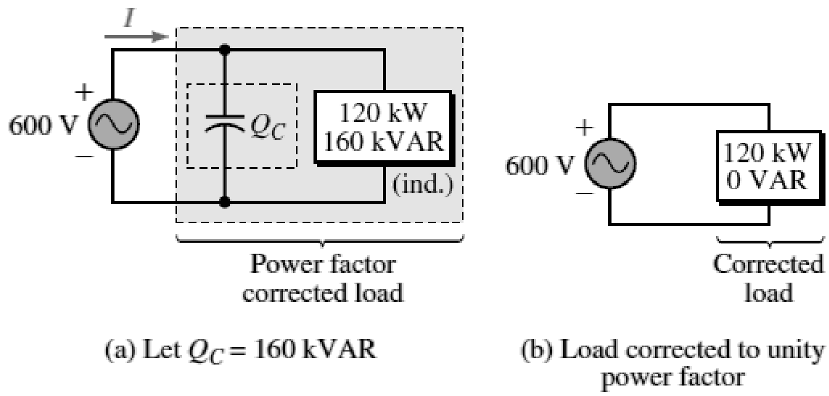


FIGURE 17–19 Power factor correction. The parallel capacitor greatly reduces source current.

Solution $Q_T = 160\text{ kVAR} - 160\text{ kVAR} = 0$. Therefore, $\mathbf{S}_T = 120\text{ kW} + j0\text{ kVAR}$. Thus, $S_T = 120$ kVA, and $I = 120\text{ kVA}/600\text{ V} = 200$ A. Thus, the generator is no longer overloaded.

EXAMPLE 17–8 An industrial client is charged a penalty if the plant power factor drops below 0.85. The equivalent plant loads are as shown in Figure 17–20. The frequency is 60 Hz.

a. Determine P_T and Q_T.
b. Determine what value of capacitance (in microfarads) is required to bring the power factor up to 0.85.
c. Determine generator current before and after correction.

Solution

a. The components of power are as follows:

Lights: $P = 12\text{ kW}, \quad Q = 0\text{ kVAR}$

Furnace: $P = I^2R = (150)^2(2.4) = 54\text{ kW}$

$Q = I^2X = (150)^2(3.2) = 72\text{ kVAR (ind.)}$

Motor: $\theta_m = \cos^{-1}(0.8) = 36.9°$. Thus, from the motor power triangle,

$Q_m = P_m \tan\theta_m = 80 \tan 36.9° = 60\text{ kVAR (ind.)}$

Total: $P_T = 12\text{ kW} + 54\text{ kW} + 80\text{ kW} = 146\text{ kW}$

$Q_T = 0 + 72\text{ kVAR} + 60\text{ kVAR} = 132\text{ kVAR}$

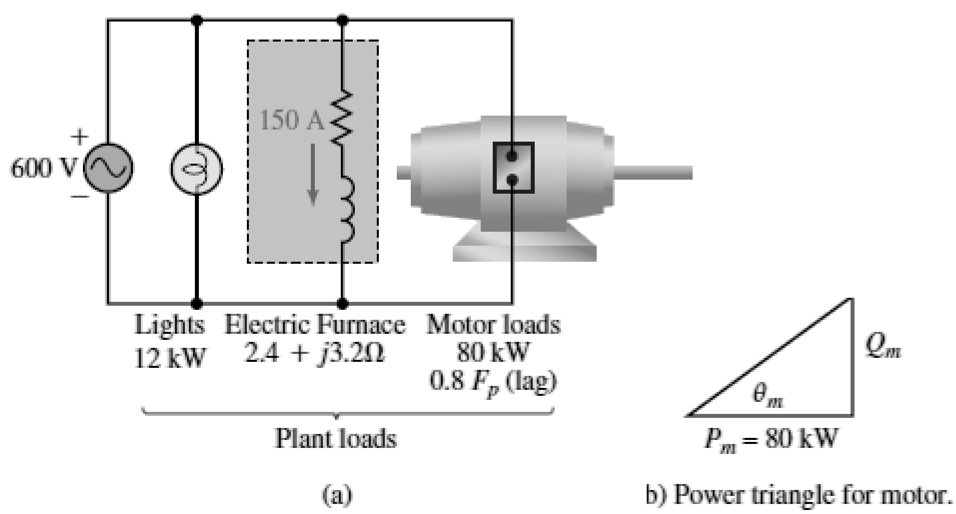
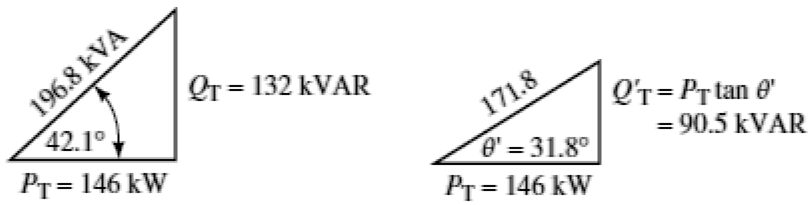


FIGURE 17–20

b. The power triangle for the plant is shown in Figure 17–21(a). However, we must correct the power factor to 0.85. Thus we need $\theta' = \cos^{-1}(0.85) = 31.8°$, where θ' is the power factor angle of the corrected load as indicated in Figure 17–21(b). The maximum reactive power that we can tolerate is thus $Q'_T = P_T \tan \theta' = 146 \tan 31.8° = 90.5$ kVAR.



(a) Power triangle for the plant

(b) Power triangle after correction

FIGURE 17–21 Initial and final power triangles. Note that P_T does not change when we correct the power factor.

Now consider Figure 17–22. $Q'_T = Q_C + 132$ kVAR, where $Q'_T = 90.5$ kVAR. Therefore, $Q_C = -41.5$ kVAR $= 41.5$ kVAR (cap.). But $Q_C = V^2/X_C$. Therefore, $X_C = V^2/Q_C = (600)^2/41.5\text{ kVAR} = 8.67\ \Omega$. But $X_C = 1/\omega C$. Thus a capacitor of

$$C = \frac{1}{\omega X_C} = \frac{1}{(2\pi)(60)(8.67)} = 306\ \mu\text{F}$$

will provide the required correction.

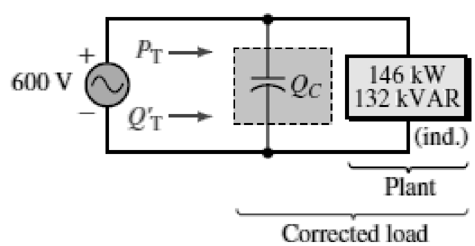


FIGURE 17–22

c. For the original circuit Figure 17–21(a), $S_T = 196.8$ kVA. Thus,

$$I = \frac{S_T}{E} = \frac{196.8\text{ kVA}}{600\text{ V}} = 328\text{ A}$$

For the corrected circuit 17–21(b), $S'_T = 171.8$ kVA and

$$I = \frac{171.8\text{ kVA}}{600\text{ V}} = 286\text{ A}$$

Thus, power factor correction has dropped the current by 42 A.