National University of Singapore

Department of Electrical & Computer Engineering

EE-1002:Introduction to Circuits and Systems

Tutorial - 6 (Power for AC Circuits)

Year 2013-14

Q.1 The supply voltage phasor is given by

$$\mathbf{V} = 1000\sqrt{2}\angle 0^0$$

The phasor for the phase current through the resistive branch is given by

$$I_R = \frac{\mathbf{V}}{\mathbf{R}} = \frac{1000\sqrt{2}\angle 0^0}{100\angle 0^0} = 10\sqrt{2}\angle 0^0$$

The phasor for the phase current through the inductive branch is given by

$$I_L = \frac{\mathbf{V}}{X_L} = \frac{1000\sqrt{2}\angle 0^0}{377 \times 0.5\angle 90^0} = 5.3\sqrt{2}\angle -90^0$$

Thus, the total current phasor is given by

$$\mathbf{I} = I_R + I_L = 10\sqrt{2}\angle 0^0 + 5.3\sqrt{2}\angle -90^0 = 11.3\sqrt{2}\angle -27.92^0$$

The active power is given by

$$P = V_{rms}I_{rms}cos(\theta) = 1000 \times 11.3cos(27.92) = 10\, kW$$

The reactive power is given by

$$Q = V_{rms}I_{rms}sin(\theta) = 1000 \times 11.3sin(27.92) = 5.29\, kVAR$$

The apparent power is given by

$$S = V_{rms}I_{rms} = 1000 \times 11.3 = 11.3\, kVA$$

The power factor is given by

$$cos\theta = cos(27.92) = 0.88\, lagging$$

Q.2 The phasor for the current is given by

$$\mathbf{I} = \frac{V_A - V_B}{\mathbf{Z}} = \frac{260\sqrt{2}\angle 50^0 - 220\sqrt{2}\angle 30^0}{5 + j12} = 7.1\sqrt{2}\angle 37.3^0$$

The active power P_A supplied by source-A is given by

$$P_A = V_{rms}I_{rms}cos(\theta) = 260 \times 7.1cos(50 - 37.3) = 1.798\, kW$$

The reactive power Q_A supplied by source-A is given by

$$Q_A = V_{rms} I_{rms} sin(\theta) = 260 \times 7.1 sin(50 - 37.3) = 0.405\, kVAR$$

The active power P_B consumed by source-B is given by

$$P_B = V_{rms} I_{rms} cos(\theta) = 220 \times 7.1 cos(30 - 37.3) = 1.547\, kW$$

The reactive power Q_B consumed by source-B is given by

$$Q_B = V_{rms} I_{rms} sin(\theta) = 220 \times 7.1 sin(30 - 37.3) = -0.198\, kVAR$$

The active power P_R consumed by the resistor, R is given by

$$P_R = {I_{rms}}^2 \times R = 7.1^2 \times 5 = 0.251\, kW$$

The reactive power Q_{X_L} consumed by the inductor, X_L is given by

$$Q_{X_L} = {I_{rms}}^2 \times X_L = 7.1^2 \times 12 = 0.604\, kVAR$$

Q.3 The active power P_A consumed by load-A is given by

$$P_A = 10.0\, kW$$

The reactive power Q_A consumed by load-A is given by

$$Q_B = \frac{P_A}{0.9} \times sin(cos^{-1}(0.9)) = \frac{10kW}{0.9} \times sin(cos^{-1}(0.9)) = 4.84\, kVAR$$

The active power P_B consumed by load-B is given by

$$P_B = S_B \times cos(\theta_B) = 15kVA \times 0.8 = 12\, kW$$

The reactive power Q_B consumed by load-B is given by

$$Q_B = S_B \times sin(cos^{-1}(0.8)) = 15kVA \times (0.6) = 9\, kVAR$$

The total active power, P_S supplied by the source is

$$P_S = P_A + P_B = 10\, kW + 12\, kW = 22\, kW$$

The total reactive power, Q_S supplied by the source is

$$Q_S = Q_A + Q_B = 4.84\, kVAR + 9\, kVAR = 13.84\, kVAR$$

The total apparent power supplied by the source, is given by

$$S_S = \sqrt{{P_S}^2 + {Q_S}^2} = \sqrt{22\, kW^2 + 13.84\, kVAR^2} = 26\, kVA$$

The power factor of the over all load is given by

$$cos\theta = tan^{-1}\left(\frac{Q_S}{P_S}\right) = tan^{-1}\left(\frac{13.84\, kVAR}{22\, kW}\right) = 0.846\, lagging$$

Q.4 The load power is 100 kW and the phase angle is given by

$$\theta = cos^{-1}(0.25) = 75.5^0$$

The rms value of the load current is given by

$$I_{rms} = \frac{P_{load}}{V_{rms} \times cos(\theta)} = \frac{100\,kW}{1000\,V \times 0.25} = 400\,A$$

Thus, the current phasor is given

$$\mathbf{I} = 400\sqrt{2}\angle{-75.5^0}$$

The reactive power consumed by the load is given by

$$Q = P \times sin(\theta) = 100kW \times sin(75.5) = 387.3\,kVAR$$

Thus, the value of the reactive power supplied by the capacitor should be 387.3 kVAR in order to make the overall load power factor unity.

Thus, the value of the capacitance required to make the reactive power supplied by teh capacitor to ne 387.3 kVAR is

$$X_C = \frac{{V_{rms}}^2}{Q_C} = \frac{1000^2}{387.3\,kVAR} = 2.58\,\Omega \Rightarrow C = 1.02\,mF$$

Thus, the new current phasor is given

$$\mathbf{I} = \frac{P_{Load}}{V_{rms}} = \frac{100\,kW}{1000\,V} = 100\angle 0^0$$

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