1. In the 60Hz circuit shown in Figure 1, $V_S = 240.0\,\text{V} \angle 30^\circ$ and $I_1 = 38.8\,\text{A} \angle -36.2^\circ$.

$$R_1 = 2.5\,\Omega \quad L_1 = 0.015\,\text{H}$$

a) Determine the phasor currents, $I_S$ and $I_2$, and the impedance $Z_2$.

b) Calculate the apparent power delivered by the source and the apparent powers consumed by the resistor, the inductor and the impedance $Z_2$. Show that the conservation of power principle holds true for this circuit.

$$I_1 = \frac{V_S}{Z_1} = \frac{240.0\,\text{V} \angle 30^\circ}{2.5\,\Omega + j(377\,\text{rad/s})(0.015\,\text{H})} = 38.8\,\text{A} \angle -36.2^\circ = (31.3 - j22.9)\,\text{A}$$

$$I_2 = I_1 - I_1 = (35.0\,\text{A} \angle 15^\circ) - (38.8\,\text{A} \angle -36.2^\circ) = (2.5 + j32.0) = 32.1\,\text{A} \angle 85.5^\circ$$

$$Z_2 = \frac{V_S}{I_2} = \frac{240.0\,\text{V} \angle 30^\circ}{32.1\,\text{A} \angle 85.5^\circ} = 7.48\,\Omega \angle -55.5^\circ = (4.23 - j6.17)\,\Omega$$

$$S_{\text{Source}} = V_S I_1^* = (240\,\text{V} \angle 30^\circ)(35.0\,\text{A} \angle -15^\circ) = 8400\,\text{VA} \angle 15^\circ = 8114\,\text{W} + j2174\,\text{VAR}$$

$$P_{R_1} = I_1^2 R_1 = (38.8\,\text{A})^2 (2.5\,\Omega) = 3767\,\text{W}$$

$$Q_{X_1} = I_1^2 X_1 = (38.8\,\text{A})^2 (377\,\text{rad/s} \cdot 0.015\,\text{H}) = 8520\,\text{VAR}$$

$$S_{Z_2} = I_2^2 Z_2 = (32.1\,\text{A})^2 (4.23 - j6.17)\,\Omega = 4347\,\text{W} - j6346\,\text{VAR}$$

$$S_{\text{Load}} = P_{R_1} + jQ_{X_1} + S_{Z_2} = 3767\,\text{W} + j8520\,\text{VAR} + 4347\,\text{W} - j6346\,\text{VAR} = 8114\,\text{W} + j2174\,\text{VAR}$$
2. A three phase wye-connected balanced load is supplied by a balanced three-phase delta connected source with ‘abc’ sequence. The following source voltage and load impedance are given:

\[ V_{ab} = 11.6 \text{kV} \angle 0^\circ \quad Z_{bn} = 250 + j300 \, \Omega \]

a) Find the phase currents \( I_{an}, I_{bn}, \) and \( I_{cn}, \) and the neutral current \( I_n. \)

b) Draw separate phasor diagrams for the line voltages, phase voltages, and the line currents of part a).

At the source:
\[ V_{line} = V_{phase} = V_{ab} = 11.6kV \angle 0^\circ \]

At the load, using the phasor diagram to determine the phase angles:
\[ V_{phase(\text{load})} = V_{an} \]
\[ V_{an} - V_{bn} = V_{ab} \]
\[ V_{an} = \frac{V_{ab}}{\sqrt{3}} \angle -30^\circ = 6697 \angle -30^\circ \]

The load current:
\[ I_{an} = \frac{V_{an}}{Z_{an}} = \frac{6697V \angle -30^\circ}{(250 + j300)\Omega} = 17.15A \angle -80^\circ = I_{line} \]

At the source:
\[ I_{phase(\text{source})} = I_{ab} \]
\[ I_{ab} - I_{ca} = I_a \]
\[ I_{ab} = \frac{I_a}{\sqrt{3}} \angle +30^\circ = 9.90A \angle -50^\circ \]