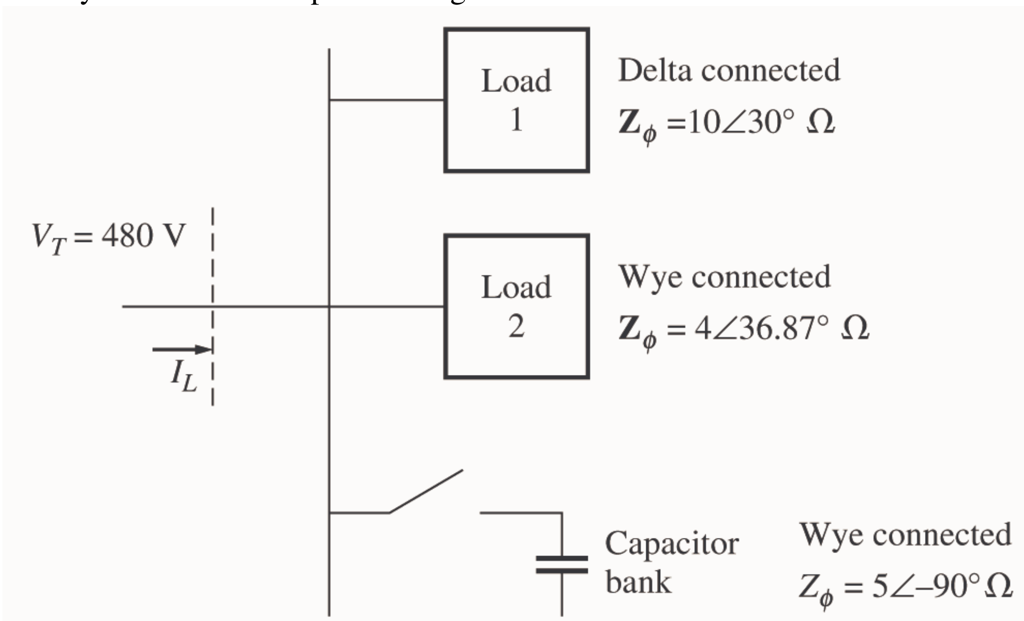
P1: La figure ci-dessous montre un système de distribution de 480V. On assume que les lignes du système ont des impédances égales à zéro.



a) Si l'interrupteur est ouvert, dérives la puissance réelle, réactive et apparente du système. Trouvez le courant total délivré au système.
b) Répétez la question (a) avec l'interrupteur fermé.
c) Qu'arrive-t-il au courant délivré et pourquoi?

SOLUTION

(a) With the switch open, the power supplied to each load is

$$P_1 = 3\frac{V_\phi^2}{Z}\cos\theta = 3\frac{(480\text{ V})^2}{10\ \Omega}\cos 30° = 59.86\text{ kW}$$

$$Q_1 = 3\frac{V_\phi^2}{Z}\sin\theta = 3\frac{(480\text{ V})^2}{10\ \Omega}\sin 30° = 34.56\text{ kvar}$$

$$P_2 = 3\frac{V_\phi^2}{Z}\cos\theta = 3\frac{(277\text{ V})^2}{4\ \Omega}\cos 36.87° = 46.04\text{ kW}$$

$$Q_2 = 3\frac{V_\phi^2}{Z}\sin\theta = 3\frac{(277\text{ V})^2}{4\ \Omega}\sin 36.87° = 34.53\text{ kvar}$$

$$P_{\text{TOT}} = P_1 + P_2 = 59.86\text{ kW} + 46.04\text{ kW} = 105.9\text{ kW}$$

$$Q_{\text{TOT}} = Q_1 + Q_2 = 34.56\text{ kvar} + 34.53\text{ kvar} = 69.09\text{ kvar}$$

The apparent power supplied by the utility is

$$S_{\text{TOT}} = \sqrt{P_{\text{TOT}}^2 + Q_{\text{TOT}}^2} = 126.4\text{ kVA}$$

The power factor supplied by the utility is

$$\text{PF} = \cos\left(\tan^{-1}\frac{Q_{\text{TOT}}}{P_{\text{TOT}}}\right) = \cos\left(\tan^{-1}\frac{69.09\text{ kvar}}{105.9\text{ kW}}\right) = 0.838\text{ lagging}$$

The current supplied by the utility is

$$I_L = \frac{P_{\text{TOT}}}{\sqrt{3}\,V_T\,\text{PF}} = \frac{105.9\text{ kW}}{\sqrt{3}\,(480\text{ V})\,(0.838)} = 152\text{ A}$$

(b) With the switch closed, P_3 is added to the circuit. The real and reactive power of P_3 is

$$P_3 = 3\frac{V_\phi^{\,2}}{Z}\cos\theta = 3\frac{(277\text{ V})^2}{5\,\Omega}\cos(-90°) = 0\text{ kW}$$

$$P_3 = 3\frac{V_\phi^{\,2}}{Z}\sin\theta = 3\frac{(277\text{ V})^2}{5\,\Omega}\sin(-90°) = -46.06\text{ kvar}$$

$$P_{\text{TOT}} = P_1 + P_2 + P_3 = 59.86\text{ kW} + 46.04\text{ kW} + 0\text{ kW} = 105.9\text{ kW}$$

$$Q_{\text{TOT}} = Q_1 + Q_2 + Q_3 = 34.56\text{ kvar} + 34.53\text{ kvar} - 46.06\text{ kvar} = 23.03\text{ kvar}$$

The apparent power supplied by the utility is

$$S_{\text{TOT}} = \sqrt{P_{\text{TOT}}^{\,2} + Q_{\text{TOT}}^{\,2}} = 108.4\text{ kVA}$$

The power factor supplied by the utility is

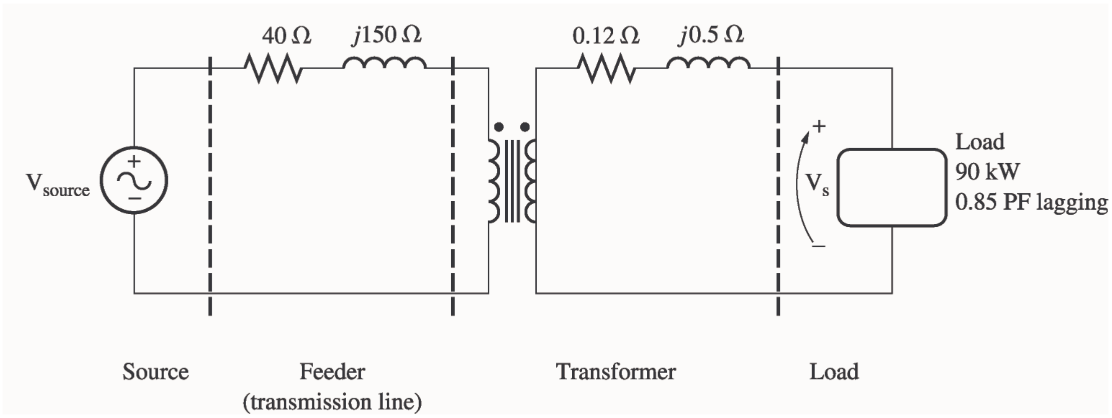
$$\text{PF} = \cos\left(\tan^{-1}\frac{Q_{\text{TOT}}}{P_{\text{TOT}}}\right) = \cos\left(\tan^{-1}\frac{23.03\text{ kVAR}}{105.9\text{ kW}}\right) = 0.977\text{ lagging}$$

The current supplied by the utility is

$$I_L = \frac{P_{\text{TOT}}}{\sqrt{3}\,V_T\,\text{PF}} = \frac{105.9\text{ kW}}{\sqrt{3}\,(480\text{ V})\,(0.977)} = 130.4\text{ A}$$

(c) The total current supplied by the power system drops when the switch is closed because the capacitor bank is supplying some of the reactive power being consumed by loads 1 and 2.

P2: la figure ci-dessous représente un système de puissance monophasé. La source alimente un 100kVA 14/2.4KV transformateur et le voltage aux bornes de la charge est de 2300V.



a) Dérivez le voltage au niveau de la source du système.
b) Dérivez le voltage de régulation (VR) du transformateur.
c) Dérivez l'efficacité totale du système.

SOLUTION

To solve this problem, we will refer the circuit to the secondary (low-voltage) side. The feeder's impedance referred to the secondary side is

$$Z_{line}' = \left(\frac{2.4 \text{ kV}}{14 \text{ kV}}\right)^2 (40\ \Omega + j150\ \Omega) = 1.18 + j4.41\ \Omega$$

The secondary current $\mathbf{I}_S$ is given by

$$I_S = \frac{90 \text{ kW}}{(2300 \text{ V})(0.85)} = 46.03 \text{ A}$$

$$\mathbf{I}_S = 46.03\angle -31.8° \text{ A}$$

(a) The voltage at the power source of this system (referred to the secondary side) is

$$\mathbf{V}_{source}' = \mathbf{V}_S + \mathbf{I}_S Z_{line}' + \mathbf{I}_S Z_{EQ}$$

$$\mathbf{V}_{source}' = 2300\angle 0° \text{ V} + (46.03\angle -31.8° \text{ A})(1.18 + j4.11\ \Omega) + (46.03\angle -31.8° \text{ A})(0.12 + j0.5\ \Omega)$$

$$\mathbf{V}_{source}' = 2467\angle 3.5° \text{ V}$$

Therefore, the voltage at the power source is

$$\mathbf{V}_{source} = (2467\angle 3.5° \text{ V})\frac{14 \text{ kV}}{2.4 \text{ kV}} = 14.4\angle 3.5° \text{ kV}$$

(b) To find the voltage regulation of the transformer, we must find the voltage at the primary side of the transformer (referred to the secondary side) under full load conditions:

$$\mathbf{V}_P' = \mathbf{V}_S + \mathbf{I}_S Z_{EQ}$$

$$\mathbf{V}_P' = 2300\angle 0° \text{ V} + (46.03\angle -31.8° \text{ A})(0.12 + j0.5\ \Omega) = 2317\angle 0.41° \text{ V}$$

There is a voltage drop of 17 V under these load conditions. Therefore the voltage regulation of the transformer is

$$\text{VR} = \frac{2317 - 2300}{2300} \times 100\% = 0.74\%$$

(c) The overall efficiency of the power system will be the ratio of the output power to the input power. The output power supplied to the load is P_{OUT} = 90 kW. The input power supplied by the source is

$$P_{IN} = V_{source}' I_S \cos\theta = (2467 \text{ V})(46.03 \text{ A}) \cos 35.3° = 92.68 \text{ kW}$$

Therefore, the efficiency of the power system is

$$\eta = \frac{P_{OUT}}{P_{IN}} \times 100\% = \frac{90 \text{ kW}}{92.68 \text{ kW}} \times 100\% = 97.1\%$$