

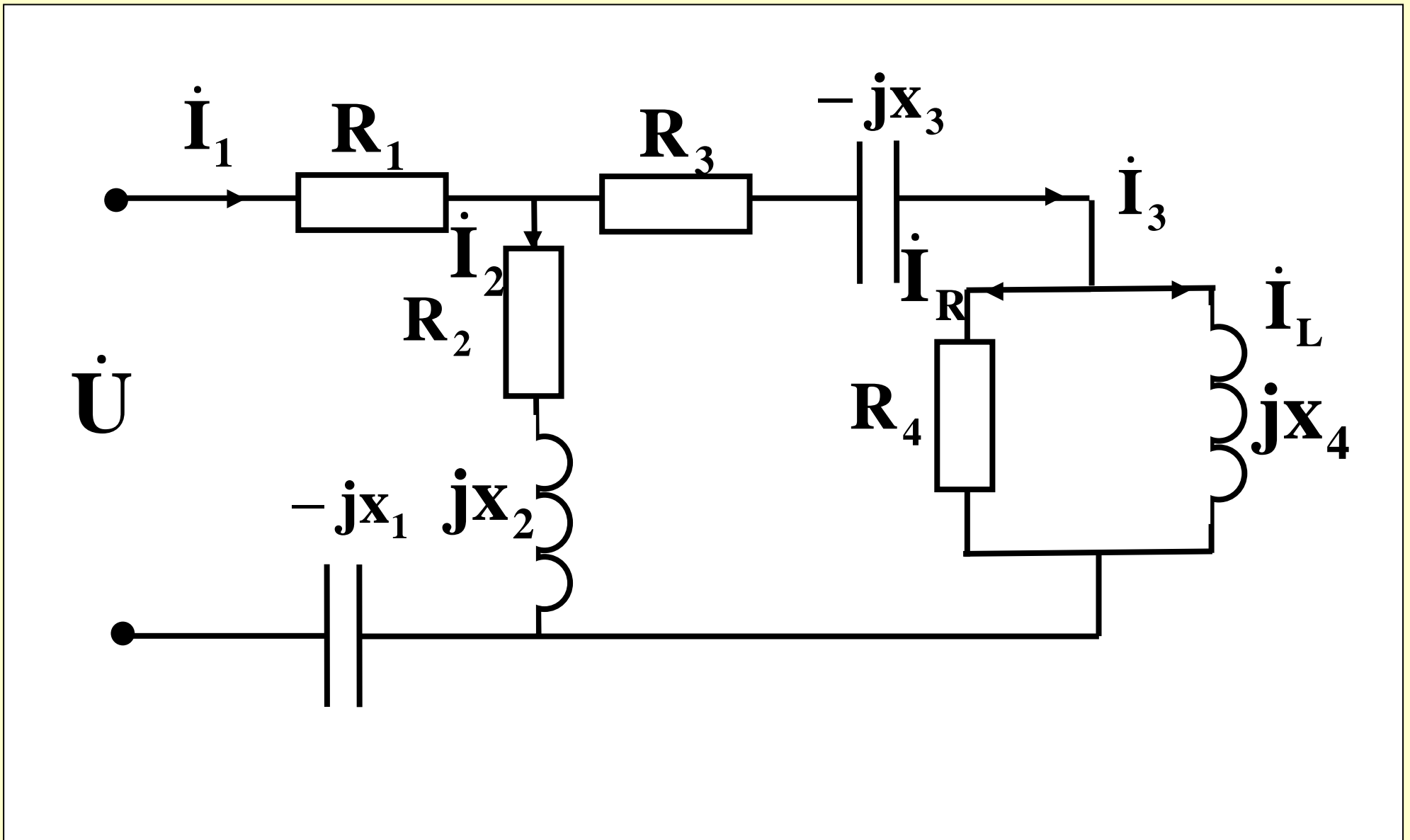
Пример решения

Дано: $u(t) = 127 \sin(\omega t + 45^\circ)$, В

$R_1 = 30 \text{ Ом}$, $R_2 = 10 \text{ Ом}$, $R_3 = 20 \text{ Ом}$, $R_4 = 10 \text{ Ом}$

$x_1 = 10 \text{ Ом}$, $x_2 = 10 \text{ Ом}$, $x_3 = 15 \text{ Ом}$, $x_4 = 20 \text{ Ом}$

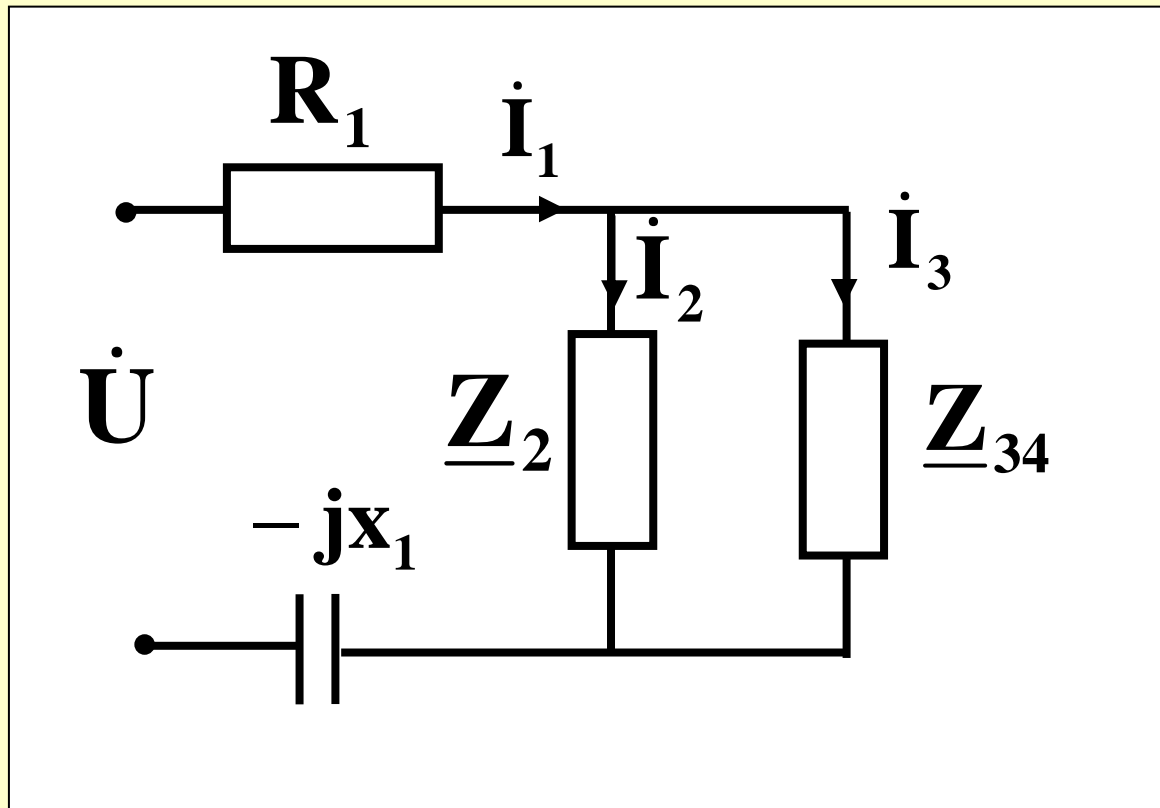
Найти все токи схемы



$$\underline{\mathbf{Z}}_4 = \frac{\mathbf{R}_4 \cdot \mathbf{jX}_4}{\mathbf{R}_4 + \mathbf{jX}_4} = \frac{10 \cdot 20\mathbf{j}}{10 + 20\mathbf{j}} = \frac{200e^{\mathbf{j}90}}{22.36e^{\mathbf{j}63.4}} = 8.944e^{\mathbf{j}26.6} \text{O}_M$$

$$\begin{aligned} \underline{\mathbf{Z}}_{34} &= \mathbf{R}_3 - \mathbf{jX}_3 + \underline{\mathbf{Z}}_4 = 20 - 15\mathbf{j} + 8.944e^{\mathbf{j}26.6} = \\ &= 20 - 15\mathbf{j} + 8.944 \cos(26.6) + \mathbf{j} \sin(26.6) = \\ &= 20 - 15\mathbf{j} + 8 + 4\mathbf{j} = 28 - 11\mathbf{j} = \sqrt{28^2 + 11^2} e^{\mathbf{j} \arctan \frac{-11}{28}} = \\ &= 30e^{-\mathbf{j}21.4} \text{O}_M \end{aligned}$$

$$\underline{Z}_2 = 10 + 10j = \sqrt{10^2 + 10^2} \cdot e^{j \arctan \frac{10}{10}} = 14.1 e^{j45} \text{ O}_M$$



$$\underline{Z}_{234} = \frac{\underline{Z}_2 \cdot \underline{Z}_{34}}{\underline{Z}_2 + \underline{Z}_{34}} = \frac{14.1e^{j45} \cdot 30e^{-j21.4}}{10 + 10j + 28 - 11j} = \frac{423e^{j23.6}}{38 - 1j} =$$

$$= \frac{423e^{j23.6}}{38e^{-j1.5}} = 11.13e^{j25.1} \text{ O}_M$$

$$\underline{Z} = \underline{R}_1 - j\mathbf{x}_1 + \underline{Z}_{234} = 30 - 10j + 11.13e^{j25.1} =$$

$$30 - 10j + 10.07 + 4.72j = 40.07 - 5.28j =$$

$$= 40.41e^{-j7.5} \text{ O}_M$$

$$\dot{\mathbf{I}}_1 = \frac{\dot{\mathbf{U}}}{\underline{\mathbf{Z}}} = \frac{127e^{j45}}{40.41e^{-j7.5}} = 3.142e^{j52.5} \text{ A}$$

По правилу разброса:

$$\begin{aligned} \dot{\mathbf{I}}_2 &= \dot{\mathbf{I}}_1 \cdot \frac{\underline{\mathbf{Z}}_{34}}{\underline{\mathbf{Z}}_{34} + \underline{\mathbf{Z}}_2} = 3.142e^{j52.5} \cdot \frac{30e^{-j21.4}}{10 + 10j + 28 - 11j} = \\ &= \frac{94.26e^{j31}}{38e^{-j1.5}} = 2.48e^{j32.5} \text{ A} \end{aligned}$$

$$\begin{aligned}\dot{I}_3 &= \dot{I}_1 - \dot{I}_2 = 3.142e^{j52.5} - 2.48e^{j32.5} = \\ &= 1.173e^{j98.6} \text{ A}\end{aligned}$$

По правилу разброса:

$$\begin{aligned}\dot{I}_L &= \dot{I}_3 \cdot \frac{R_4}{R_4 + jX_4} = 1.173e^{j98.6} \cdot \frac{10}{10 + 20j} = \\ &= \frac{11.73e^{j98.6}}{22.3e^{j63.4}} = 0.526e^{j35.2} \text{ A}\end{aligned}$$

$$\begin{aligned}\dot{\mathbf{I}}_{\mathbf{R}} &= \dot{\mathbf{I}}_3 \cdot \frac{\mathbf{j}X_4}{\mathbf{R}_4 + \mathbf{j}X_4} = 1.173e^{j98.6} \cdot \frac{20j}{10 + 20j} = \\ &= \frac{23.46e^{j188.6}}{22.3e^{j63.4}} = 1.0526e^{j125.2} \text{ A}\end{aligned}$$

Составим баланс мощности

Мощность источника:

$$\begin{aligned}\dot{S} &= \dot{U} \cdot \dot{I}_1^* = 127e^{j45} \cdot 3.142e^{-j52.5} = \\ &= 399e^{-j7.5} = 395.6 - 52j \text{ ВА} = \\ &= P_{\text{И}} - jQ_{\text{И}}\end{aligned}$$

Мощность приемников:

$$\begin{aligned} P_{\Pi} &= I_1^2 \cdot R_1 + I_2^2 \cdot R_2 + I_3^2 \cdot R_3 + I_R^2 \cdot R_4 = \\ &= 3.142^2 \cdot 30 + 2.48^2 \cdot 10 + 1.173^2 \cdot 20 + \\ &+ 1.052^2 \cdot 10 = 396.2 \text{ Вт} \end{aligned}$$

$$\begin{aligned} Q_{\Pi} &= I_1^2 \cdot (-x_1) + I_2^2 \cdot x_2 + I_3^2 \cdot (-x_3) + I_L^2 \cdot x_4 = \\ &= 3.142^2 \cdot (-10) + 2.48^2 \cdot 10 + 1.173^2 \cdot (-15) + \\ &+ 0.526^2 \cdot 20 = -52.27 \text{ ВАР} \end{aligned}$$

Считаем погрешность:

$$\delta_P = \frac{|P_{\text{И}} - P_{\text{П}}|}{P_{\text{И}}} \cdot 100\% = 0.15 < 3\%$$

$$\delta_Q = \frac{|Q_{\text{И}} - Q_{\text{П}}|}{Q_{\text{И}}} \cdot 100\% = 0.5 < 3\%$$