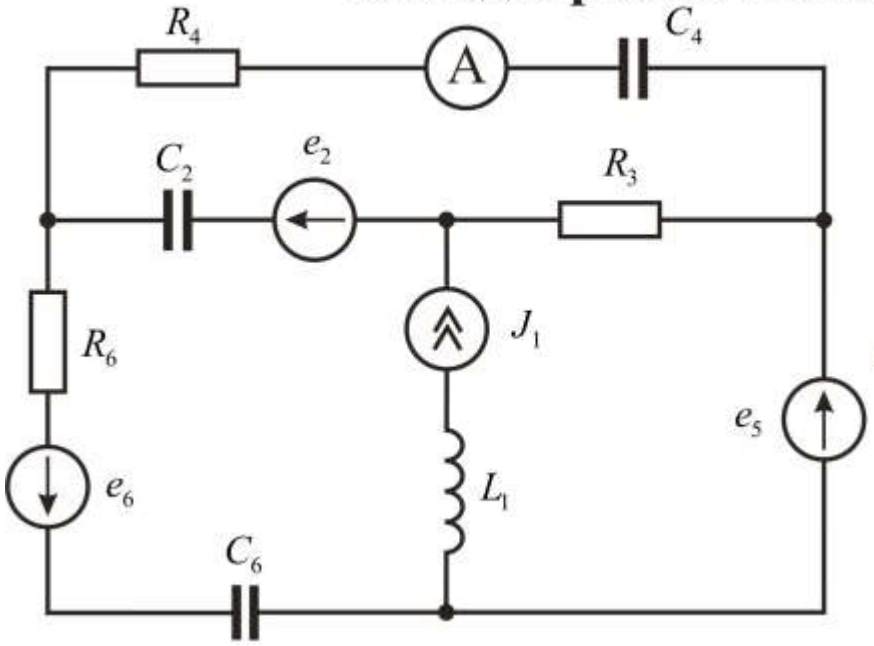
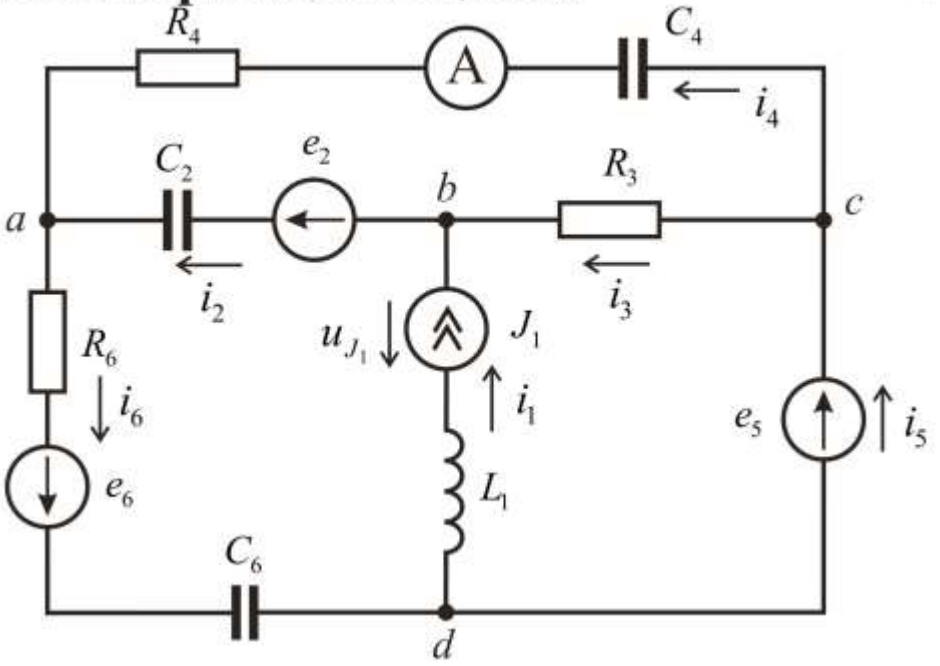
Методы расчета линейных электрических цепей





$J_1(t) = 7{,}1\sin(1000t + 2{,}498)$; $e_2(t) = 563{,}0\sin(1000t - 0{,}202)$;

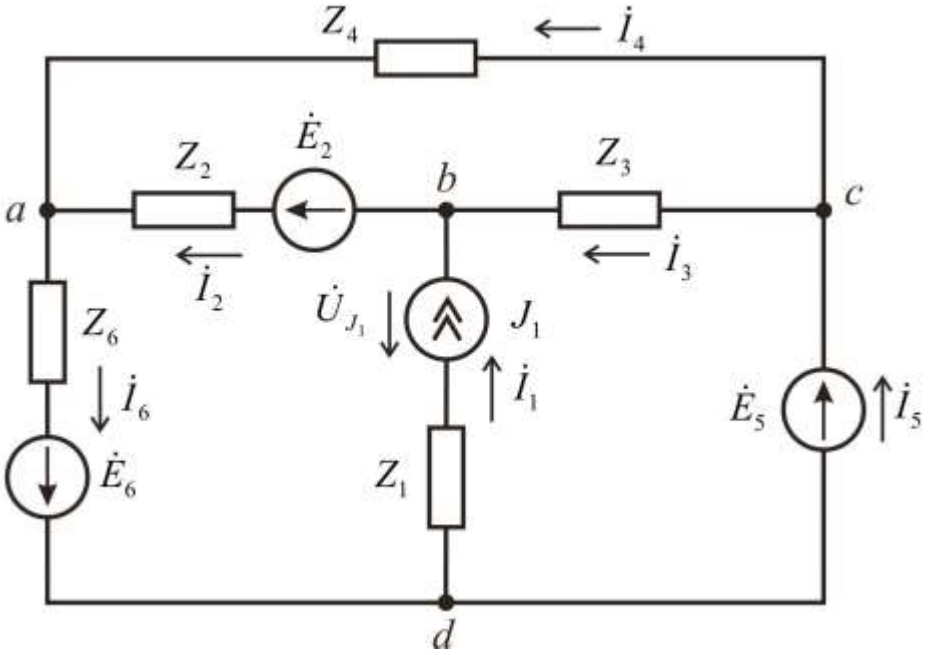
$e_5(t) = 282{,}8\sin(1000t - 1{,}571)$; $e_6(t) = 1214{,}3\sin(1000t + 2{,}029)$;

$L_1 = 10$ mH; $C_2 = 33{,}3$ μF; $R_3 = 50$ Ohm; $C_4 = 10{,}0$ μF;

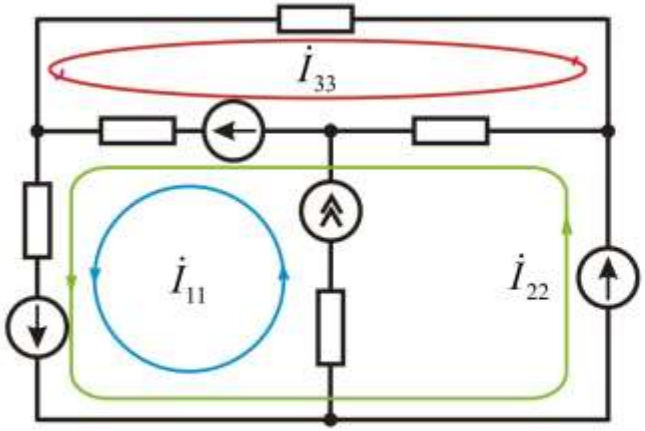
$R_4 = 40$ Ohm; $C_6 = 11{,}1$ μF; $R_6 = 20$ Ohm.

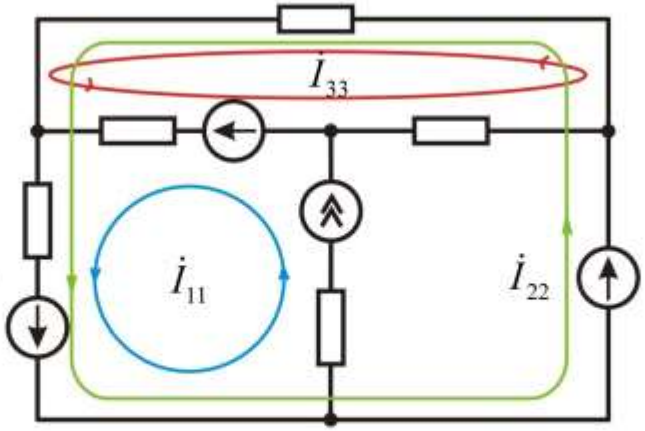
$Z_1 = 10\,j$; $Z_2 = -30\,j$; $Z_3 = 50$; $Z_4 = 40 - 100\,j$; $Z_6 = 20 - 90\,j$;

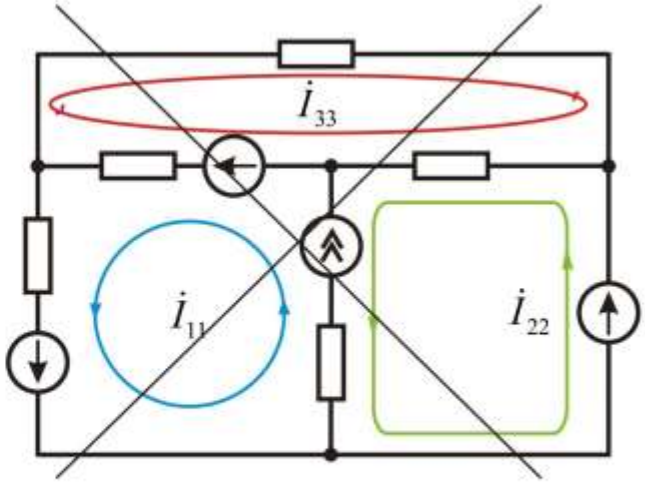
$\dot{J}_1 = -4 + 3\,j$; $\dot{E}_2 = 390 - 80\,j$; $\dot{E}_5 = -200\,j$; $\dot{E}_6 = -380 + 770\,j$

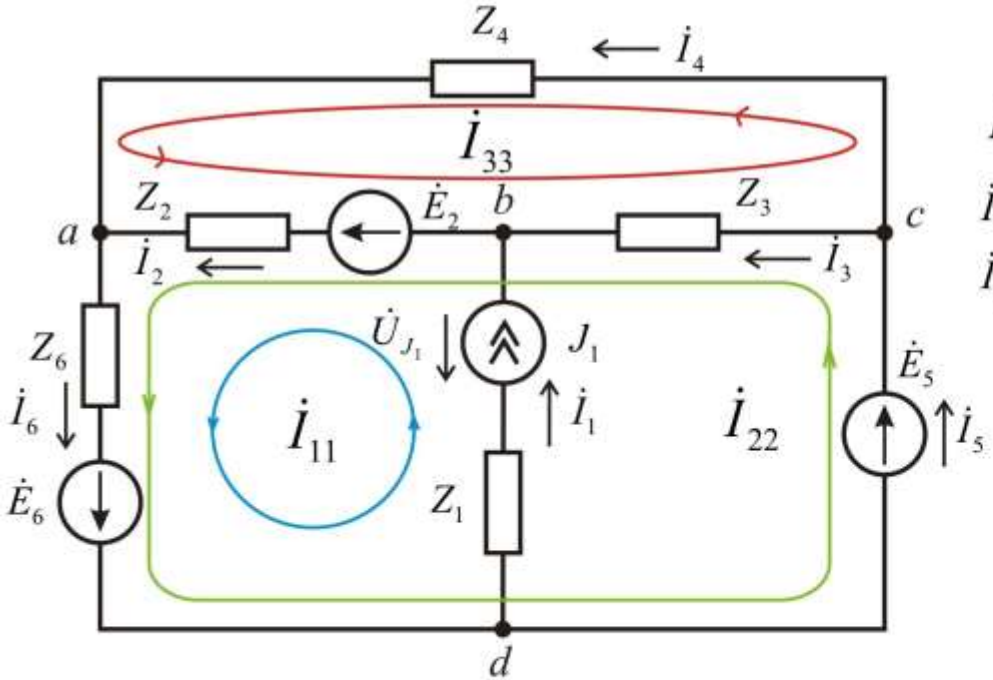


Метод контурных токов









$$\dot{I}_{11} = \dot{J}_1 = -4 + 3j.$$

$$\dot{I}_{22}(Z_2 + Z_3 + Z_6) + \dot{I}_{11}(Z_2 + Z_6) - \dot{I}_{33}(Z_2 + Z_3) = \dot{E}_2 + \dot{E}_5 + \dot{E}_6$$

$$\dot{I}_{33}(Z_2 + Z_3 + Z\ ) - \dot{I}_{11}Z_2 - \dot{I}_{22}(Z_2 + Z_3) = -\dot{E}_2$$

$$\dot{I}_{11} = \dot{J}_1 = -4 + 3j;\ \dot{I}_{22} = -1 - 3j;\ \dot{I}_{33} = -2 - 2j;$$

$$\dot{I}_1 = \dot{I}_{11} = -4 + 3j;\ \dot{I}_2 = \dot{I}_{11} + \dot{I}_{22} - \dot{I}_{33} = -3 + 2j;$$

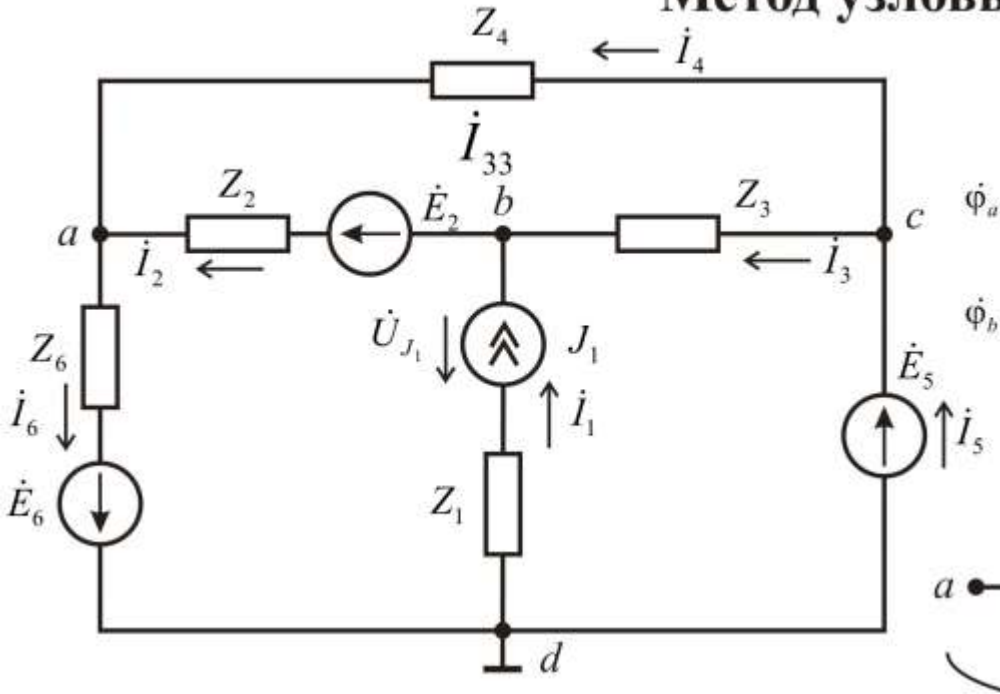
$$\dot{I}_3 = \dot{I}_{22} - \dot{I}_{33} = 1 - j;\ \dot{I}_4 = \dot{I}_{33} = -2 - 2j;$$

$$\dot{I}_5 = \dot{I}_{22} = -1 - 3j;\ \dot{I}_6 = \dot{I}_{11} + \dot{I}_{22} = -5.$$

$$Z_1 = 10j;\ Z_2 = -30j;\ Z_3 = 50;\ Z_4 = 40 - 100j;\ Z_6 = 20 - 90j;$$

$$\dot{J}_1 = -4 + 3j;\ \dot{E}_2 = 390 - 80j;\ \dot{E}_5 = -200j;\ \dot{E}_6 = -380 + 770j$$

Метод узловых потенциалов

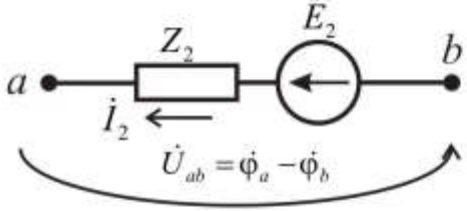


$\dot\varphi_d = 0; \dot\varphi_c = \dot E_5$

$$\dot\varphi_a \cdot \left(\frac{1}{Z_4} + \frac{1}{Z_2+0} + \frac{1}{Z_6}\right) - \dot\varphi_d \cdot \frac{1}{Z_6} - \dot\varphi_b \cdot \frac{1}{Z_2} - \dot\varphi_c \cdot \frac{1}{Z_4} = \frac{\dot E_2}{Z_2} - \frac{\dot E_6}{Z_6};$$

$$\dot\varphi_b \cdot \left(\frac{1}{Z_1+\infty} + \frac{1}{Z_2+0} + \frac{1}{Z_3}\right) - \dot\varphi_a \cdot \frac{1}{Z_2+0} - \dot\varphi_d \cdot \frac{1}{Z_1+\infty} - \dot\varphi_c \cdot \frac{1}{Z_3} = \dot J_1 - \frac{\dot E_2}{Z_2}.$$

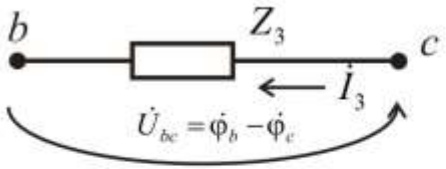
$\dot\varphi_a = 280 - 320\,j; \dot\varphi_b = -50 - 150\,j; \dot\varphi_c = -200\,j; \dot\varphi_d = 0.$



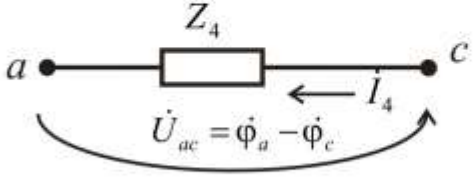
$\dot I_2 Z_2 + \dot U_{ab} = \dot E_2 \Rightarrow \dot I_2 = \dfrac{\dot E_2 - \dot U_{ab}}{Z_2} = -3 + 2\,j$

$Z_1 = 10\,j; Z_2 = -30\,j; Z_3 = 50; Z_4 = 40 - 100\,j; Z_6 = 20 - 90\,j;$

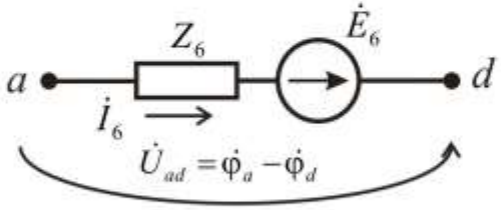
$\dot J_1 = -4 + 3\,j; \dot E_2 = 390 - 80\,j; \dot E_5 = -200\,j; \dot E_6 = -380 + 770\,j$



$\dot I_3 Z_3 + \dot U_{bc} = 0 \Rightarrow \dot I_3 = \dfrac{-\dot U_{bc}}{Z_3} = 1 - j$

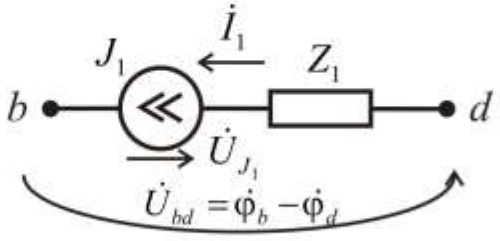


$\dot I_4 Z_4 + \dot U_{ac} = 0 \Rightarrow \dot I_4 = \dfrac{-\dot U_{ac}}{Z_4} = -2 - 2\,j$



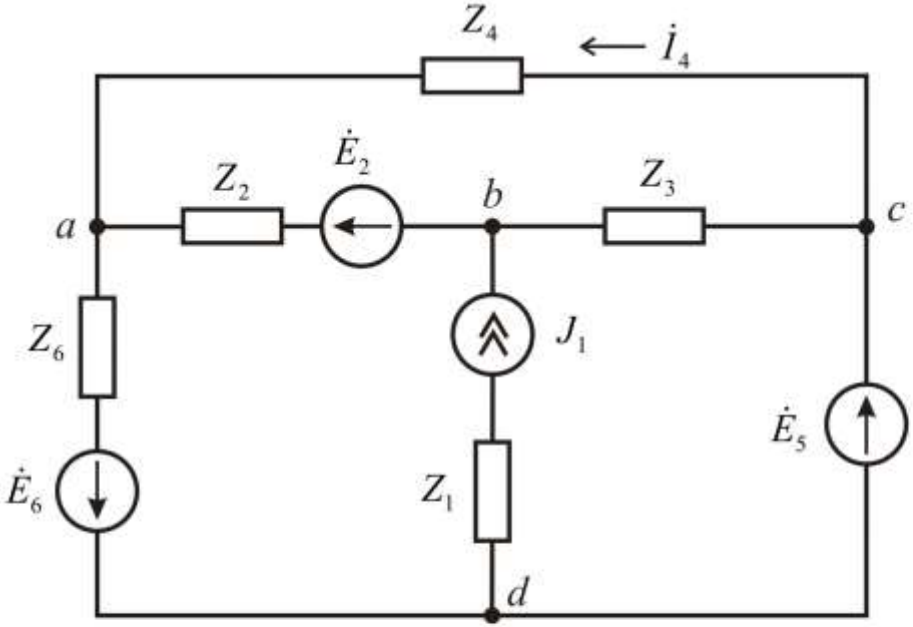
$-\dot I_6 Z_6 + \dot U_{ad} = -\dot E_6 \Rightarrow \dot I_6 = \dfrac{\dot E_6 + \dot U_{ad}}{Z_6} = -5$

$\dot I_5 = \dot I_3 + \dot I_4 = -1 - 3\,j$



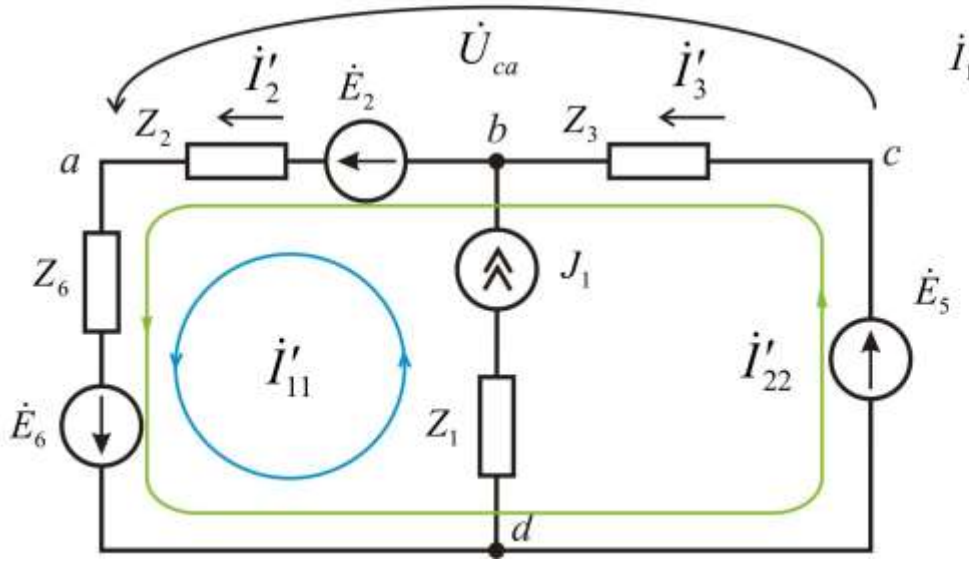
$\dot U_{bd} + \dot I_1 Z_1 - \dot U_{J_1} = 0$

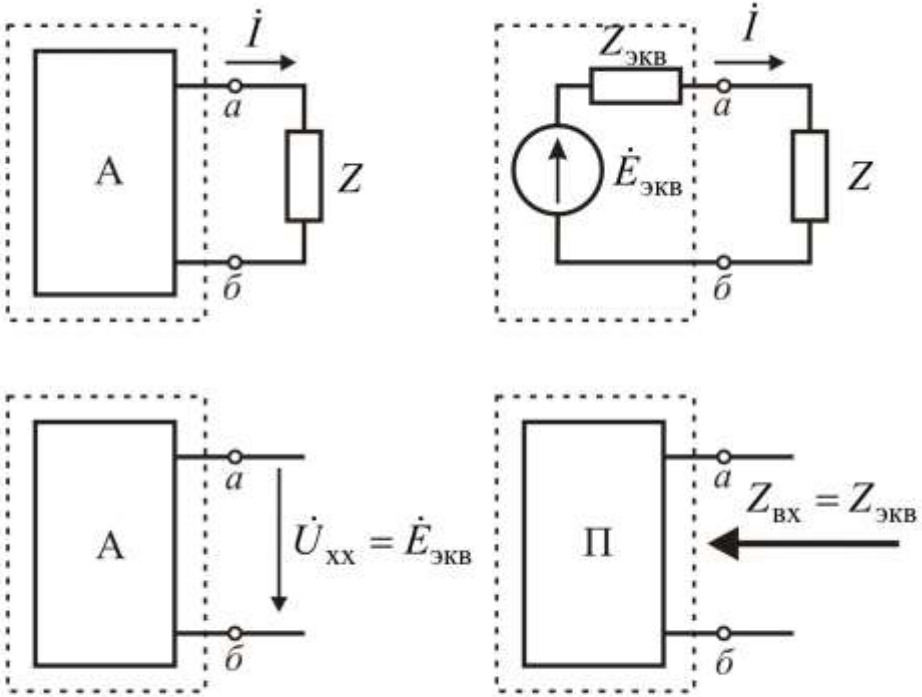
$\dot U_{J_1} = -80 - 190\,j$



$Z_1 = 10\,j;\ Z_2 = -30\,j;\ Z_3 = 50;\ Z_4 = 40 - 100\,j;\ Z_6 = 20 - 90\,j;$

$\dot J_1 = -4 + 3\,j;\ \dot E_2 = 390 - 80\,j;\ \dot E_5 = -200\,j;\ \dot E_6 = -380 + 770\,j$





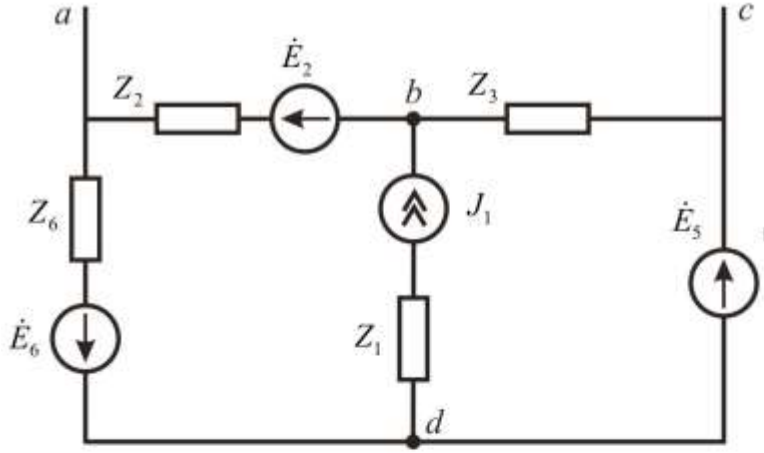
$$\dot I_{11}' = \dot J_1 = -4 + 3\,j;\ \dot I_{22}'(Z_2 + Z_3 + Z_6) + \dot I_{11}'(Z_2 + Z_6) = \dot E_2 + \dot E_5 + \dot E_6$$

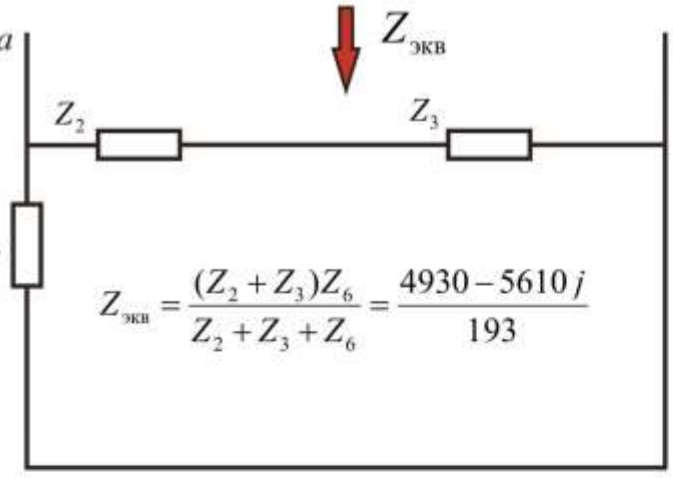
$$\dot I_{22}' = \frac{-129 - 359\,j}{193}$$

$$\dot I_3' = \dot I_{22}' = \frac{-129 - 359\,j}{193};\ \dot I_2' = \dot I_{11}' + \dot I_{22}' = \frac{-901 + 220\,j}{193}$$

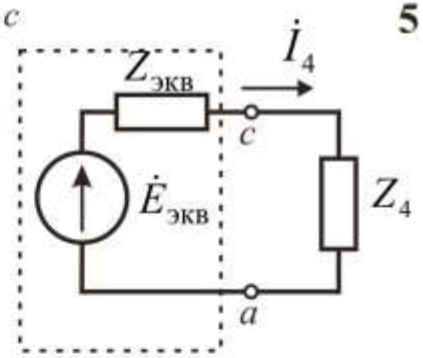
$$\dot U_{ca} - \dot I_2' Z_2 - \dot I_3' Z_3 = -\dot E_2 \Rightarrow$$

$$\dot E_{экв} = \dot U_{ca} = \dot I_2' Z_2 + \dot I_3' Z_3 - \dot E_2 = \frac{-75120 + 24520\,j}{193}$$





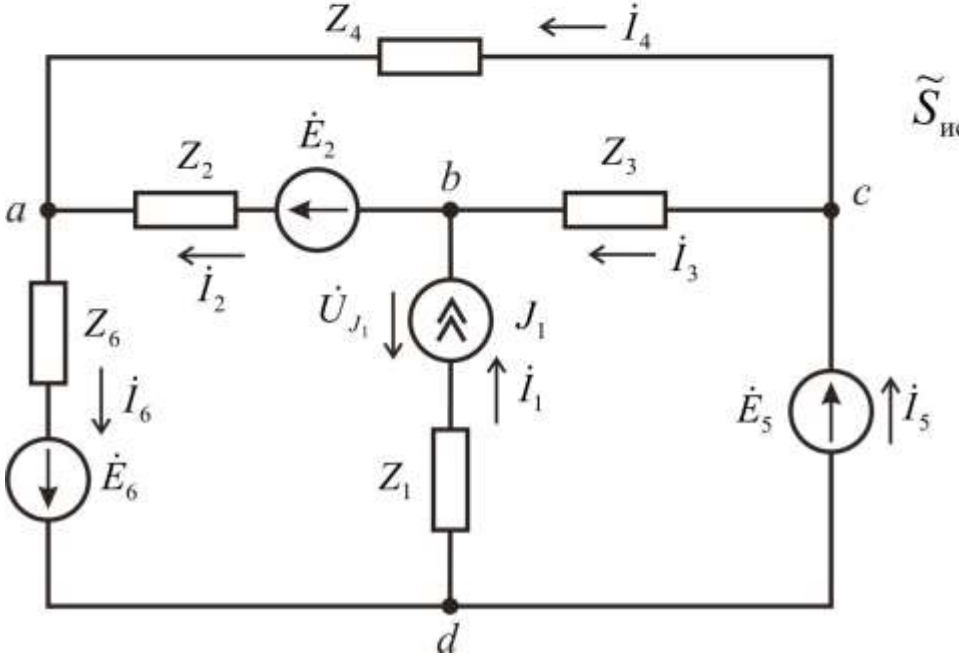
$$Z_{экв} = \frac{(Z_2 + Z_3)Z_6}{Z_2 + Z_3 + Z_6} = \frac{4930 - 5610\,j}{193}$$



$$\dot{I}_4 = \frac{\dot{E}_{экв}}{Z_{экв} + Z_4} = -2 - 2\,j$$

Баланс мощности

$$\left\{\widetilde{S}_{ист} = \sum_{k=1}^{n} \underline{\dot{E}_k} \cdot \overset{*}{\underline{I_k}} + \sum_{k=1}^{n} \underline{\dot{U}_k} \cdot \overset{*}{\underline{I_k}}\right\} = \left\{\widetilde{S}_{потр} = \sum_{k=1}^{n} \underline{\dot{E}_k} \cdot \overset{*}{\underline{I_k}} + \sum_{k=1}^{n} \underline{\dot{U}_k} \cdot \overset{*}{\underline{I_k}} + \sum_{k=1}^{n} I_k^2 \cdot Z_k\right\}. \qquad I_k^2 = \dot{I}_k \cdot \overset{*}{I}_k .$$



$$\widetilde{S}_{ист} = \dot{E}_2 \cdot \overset{*}{I}_2 + \dot{E}_5 \cdot \overset{*}{I}_5 + \dot{E}_6 \cdot \overset{*}{I}_6 + \dot{U}_{J_1} \cdot \overset{*}{I}_1 = 920 - 3190\,j$$

$$\widetilde{S}_{потр} = I_1^2 \cdot Z_1 + I_2^2 \cdot Z_2 + I_3^2 \cdot Z_3 +$$
$$+ I_4^2 \cdot Z_4 + I_6^2 \cdot Z_6 = 920 - 3190\,j$$