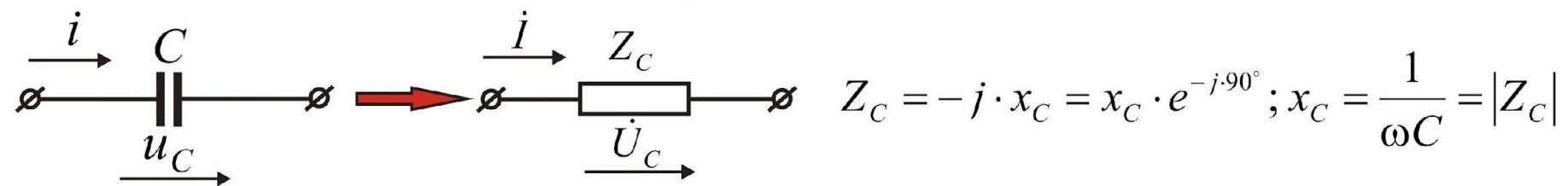
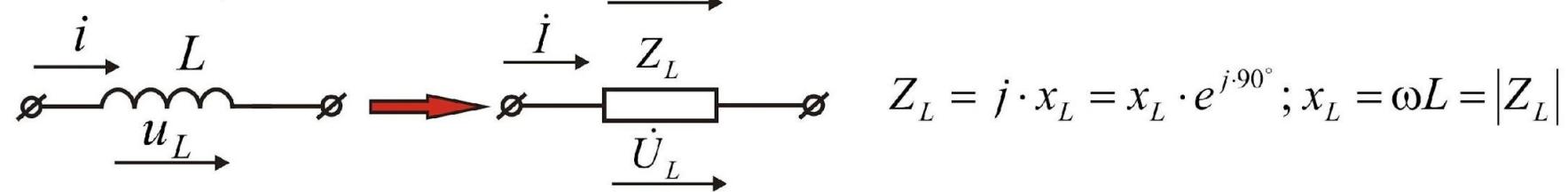
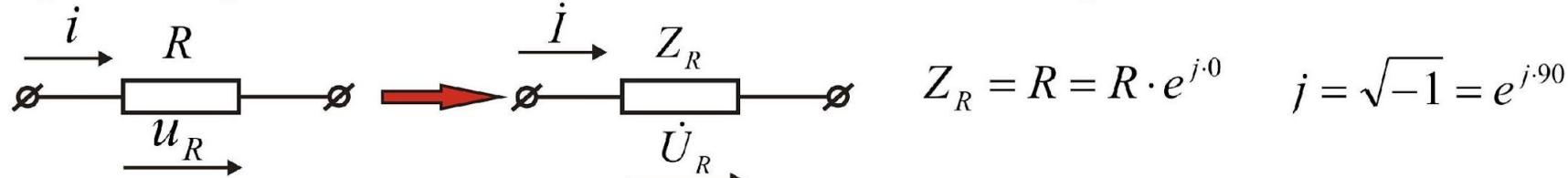


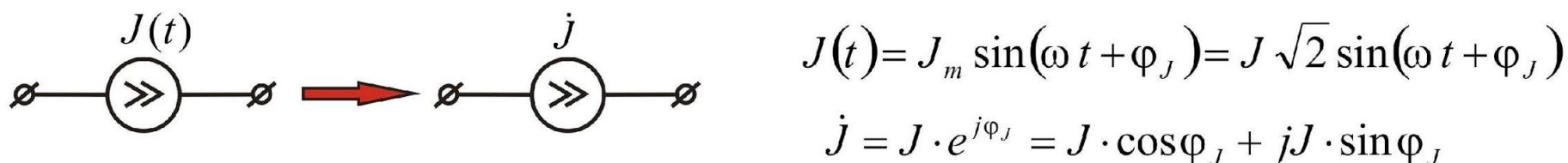
# Расчет линейных цепей синусоидального тока комплексным методом

1

Правила перевода пассивных элементов и источников из временной области в комплексную



$$Z = r + j(\omega L - \frac{1}{\omega C}) = r + jx. \quad Z = z e^{j\varphi} = z \angle \varphi. \quad z = |Z| \quad z = \sqrt{r^2 + x^2}; \varphi = \arctg \frac{x}{r}.$$



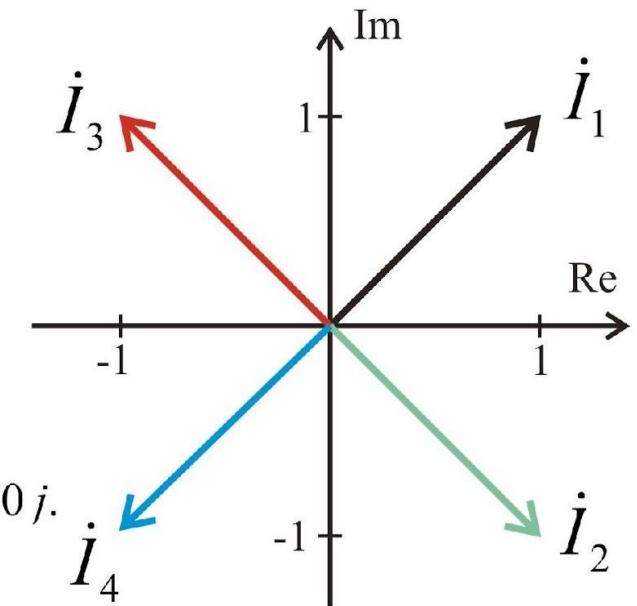
**Перевести из временной области в комплексную**

$$e(t) = 100 \sin \omega t \Rightarrow \dot{E} = \frac{100}{\sqrt{2}} \cdot e^{j0} = 50\sqrt{2}(\cos 0 + j \sin 0) = 50\sqrt{2};$$

$$u(t) = 100 \sin(\omega t + \frac{\pi}{4}) = \frac{100}{\sqrt{2}} \cdot e^{j\frac{\pi}{4}} = 50\sqrt{2}\left(\frac{\sqrt{2}}{2} + j\frac{\sqrt{2}}{2}\right) = 50 + 50j;$$

$$i(t) = 5\sqrt{2} \sin(\omega t - \frac{\pi}{2}) = \frac{5\sqrt{2}}{\sqrt{2}} \cdot e^{-j\frac{\pi}{2}} = 5(0 - j \cdot 1) = -5j;$$

$$u(t) = 100 \sin(\omega t - 135^\circ) = \frac{100}{\sqrt{2}} \cdot e^{-j135^\circ} = 50\sqrt{2}\left(-\frac{\sqrt{2}}{2} - j\frac{\sqrt{2}}{2}\right) = -50 - 50j.$$



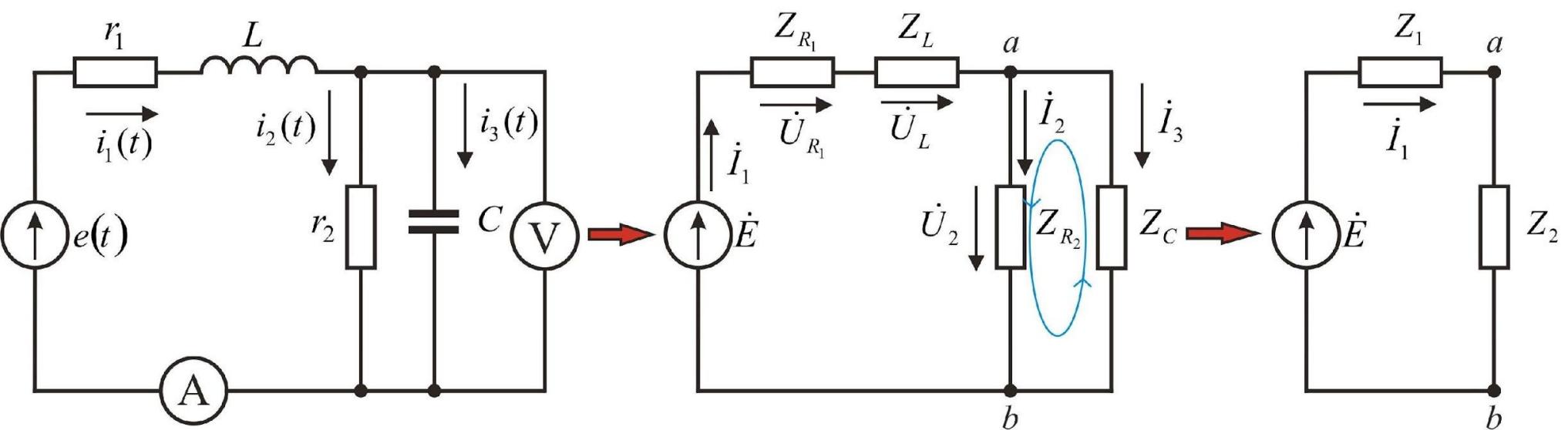
**Перевести из комплексной области во временную**

$$\dot{I} = 10 + 20j \Rightarrow I = \sqrt{10^2 + 20^2} = 22,36 \Rightarrow I_m = I\sqrt{2} = 31,5; \varphi = \arctg \frac{20}{10} \Rightarrow i(t) = 31,5 \sin(\omega t + \arctg 2);$$

$$\dot{U} = -10j \Rightarrow U = \sqrt{0^2 + (-10)^2} = 10 \Rightarrow U_m = 10\sqrt{2}; \varphi = \arctg \frac{-10}{0} = -\frac{\pi}{2} \Rightarrow u(t) = 10\sqrt{2} \sin(\omega t - \frac{\pi}{2});$$

$$\dot{I}_1 = 1 + j; \dot{I}_2 = 1 - j; \dot{I}_3 = -1 + j; \dot{I}_4 = -1 - j \Rightarrow I_1 = I_2 = I_3 = I_4 = \sqrt{2}; I_{1m} = I_{2m} = I_{3m} = I_{4m} = 2;$$

$$i_1(t) = 2 \sin(\omega t + 45); i_2(t) = 2 \sin(\omega t - 45); i_3(t) = 2 \sin(\omega t + 135); i_4(t) = 2 \sin(\omega t - 135).$$



$$e(t) = 446 \sin(1000t + 18,5^\circ);$$

$$\dot{E} = \frac{446}{\sqrt{2}} \cdot e^{j18,5} = 316,2(\cos 18,5 + j \sin 18,5) = 300 + 100j$$

$$r_1 = 10; r_2 = 40; L = 0,01; C = 25 \cdot 10^{-6} \quad Z_{R_1} = 10; Z_{R_2} = 40; x_L = \omega L = 10 \Rightarrow Z_L = 10j; x_C = \frac{1}{\omega C} = 40 \Rightarrow Z_C = -40j.$$

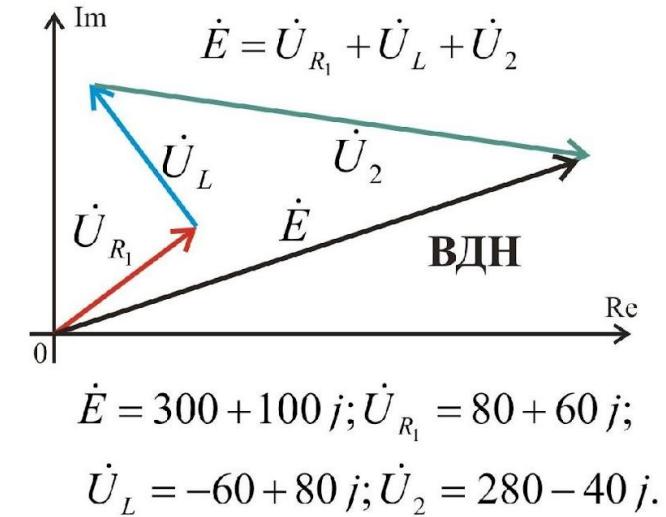
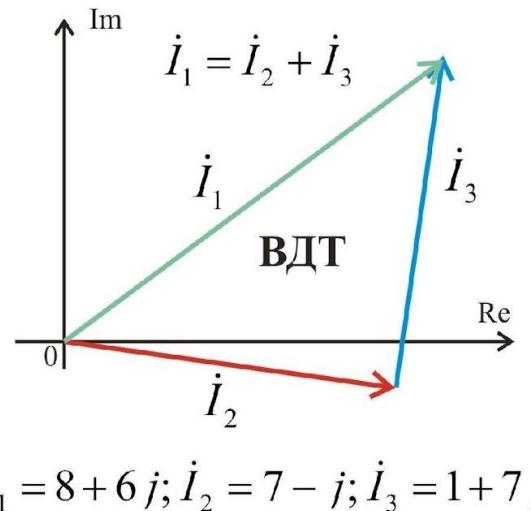
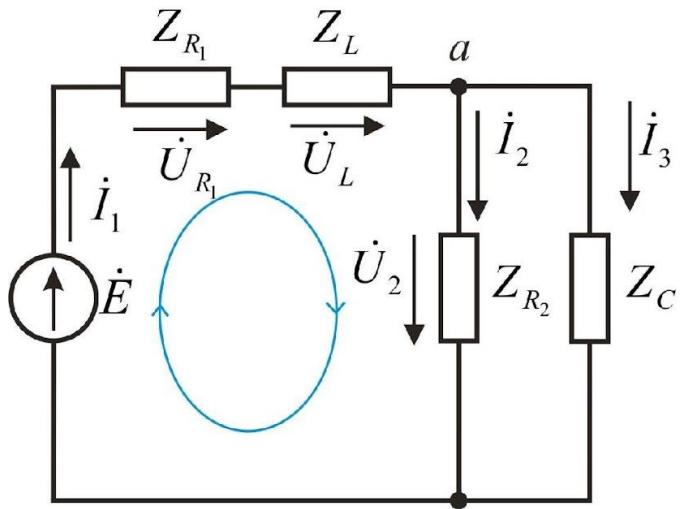
$$Z_1 = Z_{R_1} + Z_L = 10 + 10j \quad Z_2 = \frac{Z_{R_2} \cdot Z_C}{Z_{R_2} + Z_C} = \frac{40 \cdot (-40j)}{40 - 40j} = \frac{(-40j)}{1-j} = \frac{(-40j)(1+j)}{(1-j)(1+j)} = \frac{40 - 40j}{2} = 20 - 20j$$

$$\sum_k \pm \dot{U}_k = \sum_k \pm \dot{E}_k \Rightarrow \dot{I}_1 \cdot Z_1 + \dot{I}_1 \cdot Z_2 = \dot{E} \Rightarrow \dot{I}_1 = \frac{\dot{E}}{Z_1 + Z_2} = \frac{300 + 100j}{30 - 10j} = \frac{(30 + 10j)(3 + j)}{(3 - j)(3 + j)} = 8 + 6j$$

$$\dot{I}_1 = \dot{I}_2 + \dot{I}_3; \dot{I}_2 \cdot Z_{R_2} - \dot{I}_3 \cdot Z_C = 0 \Rightarrow \dot{I}_2 = \dot{I}_1 \frac{Z_C}{Z_{R_2} + Z_C} = (8 + 6j) \frac{(-40j)}{40 - 40j} = 7 - j; \dot{I}_3 = \dot{I}_1 - \dot{I}_2 = 1 + 7j.$$

$$\dot{U}_{R_1} = \dot{I}_1 \cdot Z_{R_1} = 80 + 60j; \dot{U}_L = \dot{I}_1 \cdot Z_L = -60 + 80j; \dot{U}_2 = \dot{I}_2 \cdot Z_{R_2} = \dot{I}_3 \cdot Z_C = 280 - 40j;$$

$$A = I_1 = |\dot{I}_1| = \sqrt{8^2 + 6^2} = 10; V = U_2 = |\dot{U}_2| = \sqrt{280^2 + 40^2} = 282,8$$



### Баланс мощности в комплексной форме

$$\sum \tilde{S}_{\text{ист}} = \sum \tilde{S}_{\text{потр}} \Rightarrow \sum P_{\text{ист}} = \sum P_{\text{потр}}; \sum Q_{\text{ист}} = \sum Q_{\text{потр}}.$$

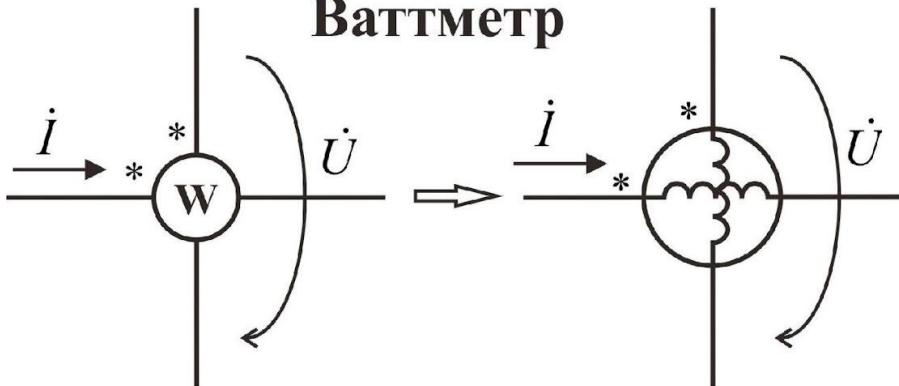
$$\left\{ \begin{array}{l} \tilde{S}_{\text{ист}} = \sum_{k=1}^n \dot{E}_k \cdot \overset{*}{I_k} + \sum_{k=1}^n \dot{U}_k \cdot \overset{*}{I_k} \\ \tilde{S}_{\text{потр}} = \sum_{k=1}^n \dot{E}_k \cdot \overset{*}{I_k} + \sum_{k=1}^n \dot{U}_k \cdot \overset{*}{I_k} + \sum_{k=1}^n I_k^2 \cdot Z_k \end{array} \right\}. \quad I_k^2 = \dot{I}_k \cdot \overset{*}{I_k}.$$

$$\tilde{S}_{\text{ист}} = \dot{E} \cdot \overset{*}{I_1} = (300 + 100j) \cdot (8 - 6j) = 3000 - 1000j$$

$$I_1^2 = (8 + 6j)(8 - 6j) = 100; I_2^2 = (7 - j)(7 + j) = 50; I_3^2 = (1 + 7j)(1 - 7j) = 50$$

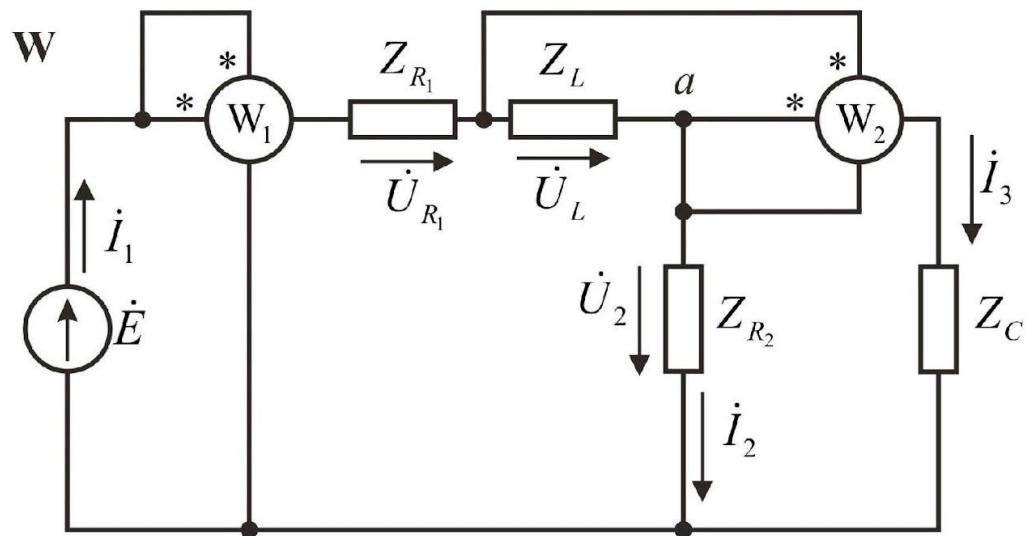
$$\tilde{S}_{\text{потр}} = I_1^2 \cdot Z_{R_1} + I_1^2 \cdot Z_L + I_2^2 \cdot Z_{R_2} + I_3^2 \cdot Z_C = 100 \cdot 10 + 100 \cdot 10j + 50 \cdot 40 + 50 \cdot (-40j) = 3000 - 1000j$$

## БАТТМЕТР



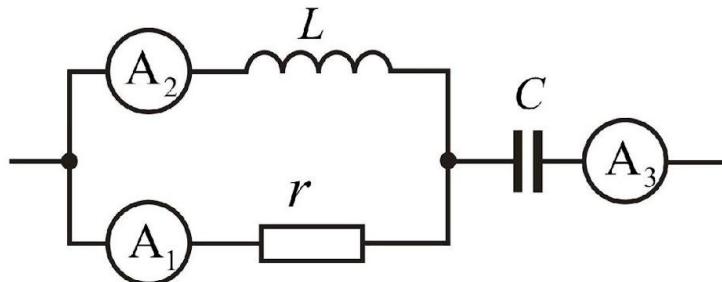
$$\tilde{S} = \dot{U} \cdot \overset{*}{I} = P + jQ; P = U \cdot I \cdot \cos\varphi;$$

$$Q = U \cdot I \cdot \sin\varphi; W = P = \operatorname{Re}(\tilde{S})$$

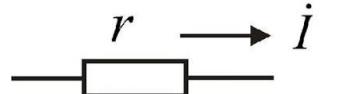


$$W_1 = \operatorname{Re}(\tilde{S}_1) = \operatorname{Re}(\dot{E} \cdot \overset{*}{I}_1)$$

$$W_2 = \operatorname{Re}(\tilde{S}_2) = \operatorname{Re}(\dot{U}_L \cdot \overset{*}{I}_3)$$



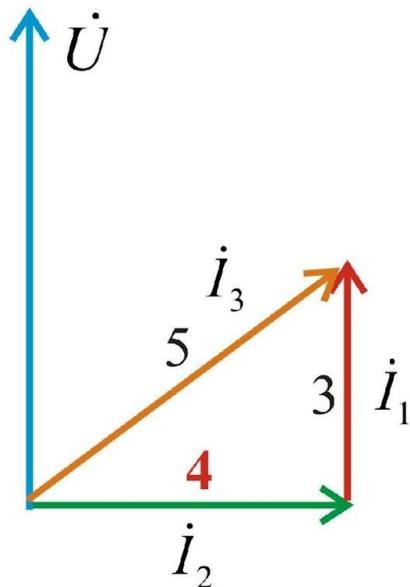
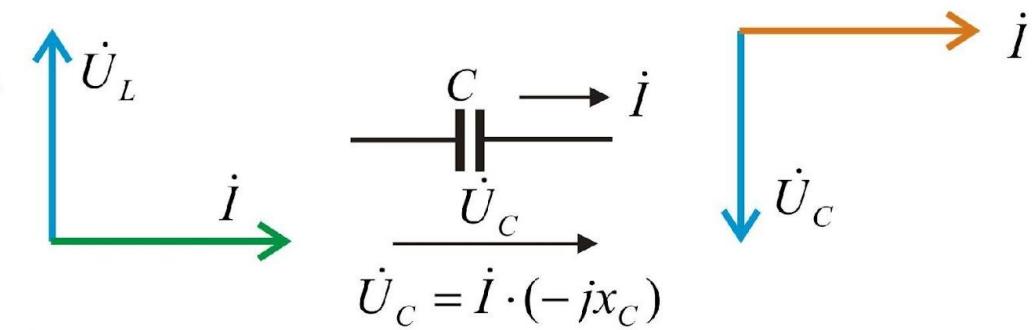
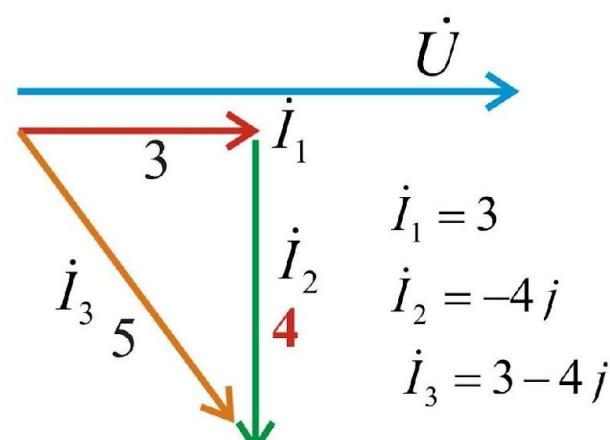
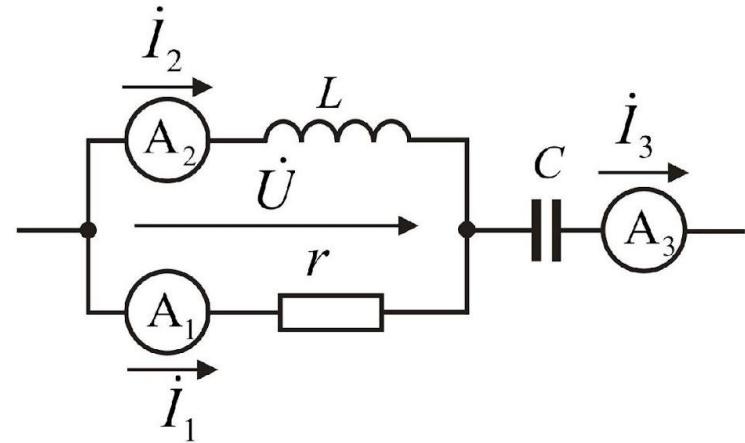
$$A_1 = 3; A_3 = 5; A_2 = ?$$



$$\dot{U}_R = \dot{I} \cdot r$$



$$\dot{U}_L = \dot{I} \cdot jx_L$$



$$\begin{aligned}\dot{I}_1 &= 3j \\ \dot{I}_2 &= 4 \\ \dot{I}_3 &= 4 + 3j\end{aligned}$$