ЭЛЕКТРОТЕХНИКА

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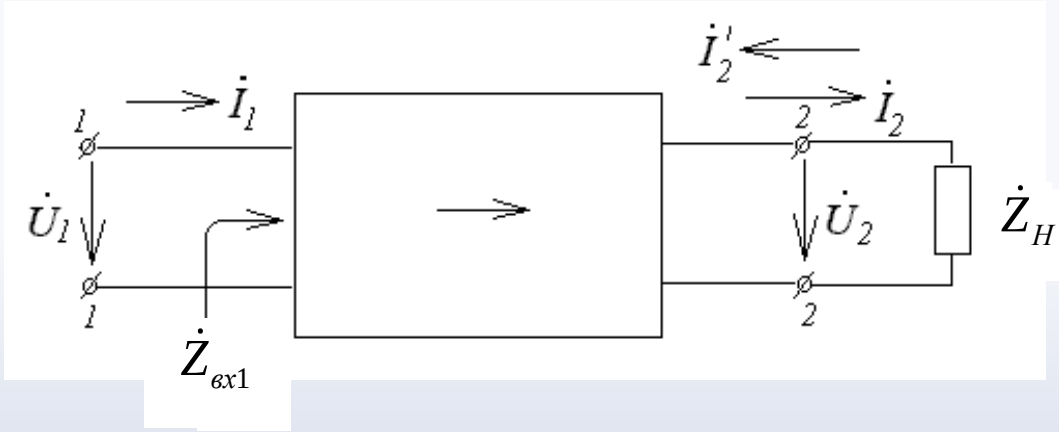
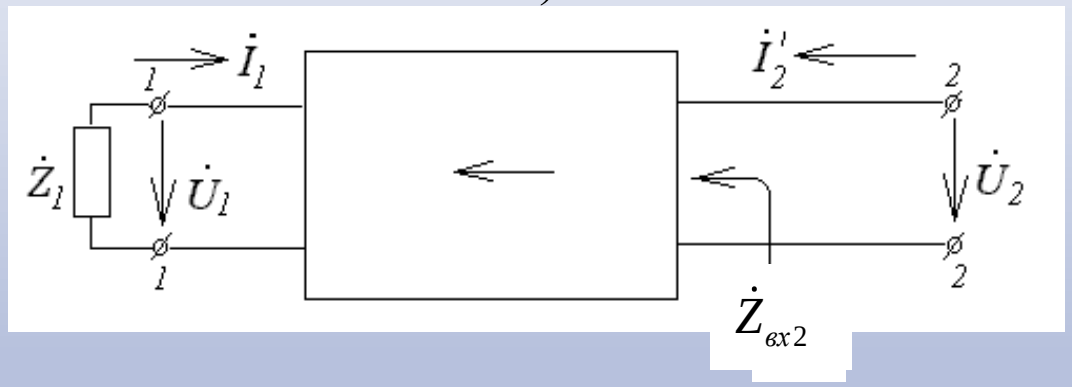
Входные сопротивления четырехполюсника



$$\dot{Z}_{вх1} = \frac{\dot{U}_1}{\dot{I}_1}$$

а)



$$\dot{Z}_{вх2} = \dot{Z}_{вых} = \frac{\dot{U}_2}{\dot{I}_2'}$$

б)

$$\dot{Z}_{вх1} = \frac{\dot{U}_1}{\dot{I}_1} = \frac{\dot{A}_{11}\dot{U}_2 + \dot{A}_{12}\dot{I}_2}{\dot{A}_{21}\dot{U}_2 + \dot{A}_{22}\dot{I}_2} = \frac{\dot{A}_{11}\dot{Z}_H + \dot{A}_{12}}{\dot{A}_{21}\dot{Z}_H + \dot{A}_{22}},$$

$$\dot{Z}_H = \dot{U}_2 / \dot{I}_2$$

$$\dot{Z}_{1XX} = \frac{\dot{A}_{11}}{\dot{A}_{21}}, \quad Z_{1K3} = \frac{\dot{A}_{12}}{\dot{A}_{22}}$$

$$\dot{Z}_{2XX} = \frac{\dot{A}_{22}}{\dot{A}_{21}}, \quad Z_{2K3} = \frac{\dot{A}_{12}}{\dot{A}_{11}}$$

$$\dot{Z}_{вх1} = \frac{\dot{A}_{11}}{\dot{A}_{21}} \frac{\frac{\dot{A}_{12}}{\dot{A}_{11}} + \dot{Z}_H}{\frac{\dot{A}_{22}}{\dot{A}_{21}} + \dot{Z}_H} = \dot{Z}_{1XX} \frac{\dot{Z}_{2K3} + \dot{Z}_H}{\dot{Z}_{2XX} + \dot{Z}_H},$$

$$\dot{Z}_{вх2} = \dot{Z}_{2XX} \frac{\dot{Z}_{1K3} + \dot{Z}_1}{\dot{Z}_{1XX} + \dot{Z}_1}$$

Характеристические параметры

(вторичные)

$\dot{Z}_i$ - *внутреннее сопротивление генератора,*

$\dot{Z}_H$ - *сопротивление нагрузки*

Если $\begin{cases} \dot{Z}_i = \dot{Z}_{вх1} \\ \dot{Z}_{вх2} = \dot{Z}_H \end{cases}$ согласованный режим 4П

$$\dot{Z}_{вх1} = \frac{\dot{A}_{11}\dot{Z}_H + \dot{A}_{12}}{\dot{A}_{21}\dot{Z}_H + \dot{A}_{22}} = \dot{Z}_i, \quad \dot{Z}_{вх2} = \frac{\dot{A}_{22}\dot{Z}_1 + \dot{A}_{12}}{\dot{A}_{21}\dot{Z}_1 + \dot{A}_{11}} = \dot{Z}_H.$$

Характеристические сопротивления

$$\dot{Z}_{вх1} = \dot{Z}_i = \dot{Z}_{1C}$$

$$\dot{Z}_{вх2} = \dot{Z}_H = \dot{Z}_{2C}$$

$$\dot{Z}_{1C} = \frac{\dot{A}_{11}\dot{Z}_{2C} + \dot{A}_{12}}{\dot{A}_{21}\dot{Z}_{2C} + \dot{A}_{22}}, \qquad \dot{Z}_{2C} = \frac{\dot{A}_{22}\dot{Z}_{1C} + \dot{A}_{12}}{\dot{A}_{21}\dot{Z}_{1C} + \dot{A}_{11}}.$$

$$\dot{Z}_{1C} = \sqrt{\frac{\dot{A}_{11}\dot{A}_{12}}{\dot{A}_{21}\dot{A}_{22}}}, \qquad \dot{Z}_{2C} = \sqrt{\frac{\dot{A}_{22}\dot{A}_{12}}{\dot{A}_{21}\dot{A}_{11}}}.$$

$$\frac{\dot{A}_{11}}{\dot{A}_{21}} = \dot{Z}_{1XX}, \quad \frac{\dot{A}_{12}}{\dot{A}_{22}} = \dot{Z}_{1K3}, \quad \frac{\dot{A}_{22}}{\dot{A}_{21}} = \dot{Z}_{2XX}, \quad \frac{\dot{A}_{12}}{\dot{A}_{11}} = \dot{Z}_{2K3}$$

$$\dot{Z}_{1C} = \sqrt{\dot{Z}_{1XX}\dot{Z}_{1K3}}, \qquad \dot{Z}_{2C} = \sqrt{\dot{Z}_{2XX}\dot{Z}_{2K3}}.$$

Если 4П согласован с нагрузкой

$$\dot{Z}_H = \frac{\dot{U}_2}{\dot{I}_2} = \dot{Z}_{2C} = \sqrt{\frac{\dot{A}_{22}\dot{A}_{12}}{\dot{A}_{21}\dot{A}_{11}}},$$

$$\begin{cases} \dot{U}_1 = \dot{A}_{11}\dot{U}_2 + \dot{A}_{12}\dfrac{\dot{U}_2}{\dot{Z}_{2C}}, \\ \dot{I}_1 = \dot{A}_{21}\dot{Z}_{2C}\dot{I}_2 + \dot{A}_{22}\dot{I}_2. \end{cases}$$

$$\begin{cases} \dot{U}_1 = \dot{U}_2\left(\dot{A}_{11} + \sqrt{\dfrac{\dot{A}_{12}\dot{A}_{21}\dot{A}_{11}}{\dot{A}_{22}}}\right), \\ \dot{I}_1 = \dot{I}_2\left(\dot{A}_{22} + \sqrt{\dfrac{\dot{A}_{12}\dot{A}_{21}\dot{A}_{22}}{\dot{A}_{11}}}\right). \end{cases}$$

$$\begin{cases} \dfrac{\dot{U}_1}{\dot{U}_2}\cdot\sqrt{\dfrac{\dot{A}_{22}}{\dot{A}_{11}}} = \sqrt{\dot{A}_{11}\dot{A}_{22}} + \sqrt{\dot{A}_{12}\dot{A}_{21}}, \\ \dfrac{\dot{I}_1}{\dot{I}_2}\cdot\sqrt{\dfrac{\dot{A}_{11}}{\dot{A}_{22}}} = \sqrt{\dot{A}_{11}\dot{A}_{22}} + \sqrt{\dot{A}_{12}\dot{A}_{21}}. \end{cases}$$

$$\sqrt{\frac{\dot{A}_{11}}{\dot{A}_{22}}} = \sqrt{\frac{\dot{Z}_{1C}}{\dot{Z}_{2C}}} = n_T$$

Коэффициент трансформации

Входное сопротивление согласованного 4П

$$\dot{Z}_{вх1} = \dot{Z}_{1C} = n_T^2 \dot{Z}_{2C} = n_T^2 \dot{Z}_H,$$

g – постоянная передачи

$$\frac{1}{n_T}\frac{\dot{U}_1}{\dot{U}_2} = n_T \frac{\dot{I}_1}{\dot{I}_2} = \sqrt{\dot{A}_{11}\dot{A}_{22}} + \sqrt{\dot{A}_{12}\dot{A}_{21}} = e^{\dot{g}}$$

Для симметричного 4П $\dot{A}_{11} = \dot{A}_{22},\ \dot{Z}_{1C} = \dot{Z}_{2C},\ n_T = 1,$

$$\dot{g} = \ln\frac{\dot{U}_1}{\dot{U}_2} = \ln\frac{\dot{I}_1}{\dot{I}_2} = \ln\left(\sqrt{\dot{A}_{11}\dot{A}_{22}} + \sqrt{\dot{A}_{12}\dot{A}_{21}}\right),$$

В случае согласованности с нагрузкой

$$\dot{Z}_H = \dot{Z}_{2C},$$
$$\dot{Z}_{2C}\dot{I}_2 = \dot{U}_2,$$
$$ch\dot{g} + sh\dot{g} = e^{\dot{g}}$$

$$\begin{cases} \dot{U}_1 = \sqrt{\dfrac{\dot{Z}_{1C}}{\dot{Z}_{2C}}}\dot{U}_2 e^{\dot{g}}, \\ \dot{I}_1 = \sqrt{\dfrac{\dot{Z}_{2C}}{\dot{Z}_{1C}}}\dot{I}_2 e^{\dot{g}} \end{cases}$$

Постоянная передачи

$$\dot{g} = a + jb.$$

$$\dot{U}_1 = \left|\dot{U}_1\right| e^{j\varphi_{U1}}, \quad \dot{U}_2 = \left|\dot{U}_2\right| e^{j\varphi_{U2}}, \quad \dot{Z}_{1C} = \left|\dot{Z}_{1C}\right| e^{j\varphi_{1C}},$$

$$\dot{I}_1 = \left|\dot{I}_1\right| e^{j\varphi_{I1}}, \quad \dot{I}_2 = \left|\dot{I}_2\right| e^{j\varphi_{I2}}, \quad \dot{Z}_{2C} = \left|\dot{Z}_{2C}\right| e^{j\varphi_{2C}}.$$

$$\begin{cases} \left|\dot{U}_1\right| e^{j\varphi_{U1}} = \left[\sqrt{\dfrac{\left|\dot{Z}_{1C}\right|}{\left|\dot{Z}_{2C}\right|}}\left|\dot{U}_2\right| e^{a}\right] e^{j\varphi_{U2}} e^{j\frac{1}{2}(\varphi_{1C}-\varphi_{2C})} e^{jb}, \\ \left|\dot{I}_1\right| e^{j\varphi_{I1}} = \left[\sqrt{\dfrac{\left|\dot{Z}_{2C}\right|}{\left|\dot{Z}_{1C}\right|}}\left|\dot{I}_2\right| e^{a}\right] e^{j\varphi_{I2}} e^{j\frac{1}{2}(\varphi_{2C}-\varphi_{1C})} e^{jb}. \end{cases}$$

$$\varphi_{U1}-\varphi_{U2}=\frac{1}{2}\left(\varphi_{1C}-\varphi_{2C}\right)+jb,\quad \varphi_{I1}-\varphi_{I2}=\frac{1}{2}\left(\varphi_{2C}-\varphi_{1C}\right)+jb.$$

Для симметричного 4П

$$\begin{cases}\left|\dot{U}_1\right|e^{j\varphi_{U1}}=\left|\dot{U}_2\right|e^{a}e^{j\varphi_{U2}}e^{jb},\\ \left|\dot{I}_1\right|e^{j\varphi_{I1}}=\left|\dot{I}_2\right|e^{a}e^{j\varphi_{I2}}e^{jb}.\end{cases}$$

b - коэффициент *фазы (радиан* или *градус)*:

$$b=\varphi_{U1}-\varphi_{U2}=\varphi_{I1}-\varphi_{I2}.$$

a – собственный коэффициент затухания:

$$a=\ln\frac{\left|\dot{U}_1\right|}{\left|\dot{U}_2\right|}=\ln\frac{\left|\dot{I}_1\right|}{\left|\dot{I}_2\right|}$$ *(непер)*.

$$a(бел) = \lg \frac{U_1 I_1}{U_2 I_2} = \lg \frac{S_1}{S_2}.$$

$$\frac{S_1}{S_2} = \frac{U_1^2}{U_2^2} = \frac{I_1^2}{I_2^2} \quad \Longrightarrow \quad a(бел) = 2\lg \frac{U_1}{U_2} = 2\lg \frac{I_1}{I_2}.$$

$$a(дб) = 20\lg \frac{U_1}{U_2} = 20\lg \frac{I_1}{I_2} = 10\lg \frac{S_1}{S_2}.$$

$$1\,дб \approx 0{,}115\,неп; \qquad 1\ неп \approx 8{,}7 дб.$$