CURS 13

Cuadripoli

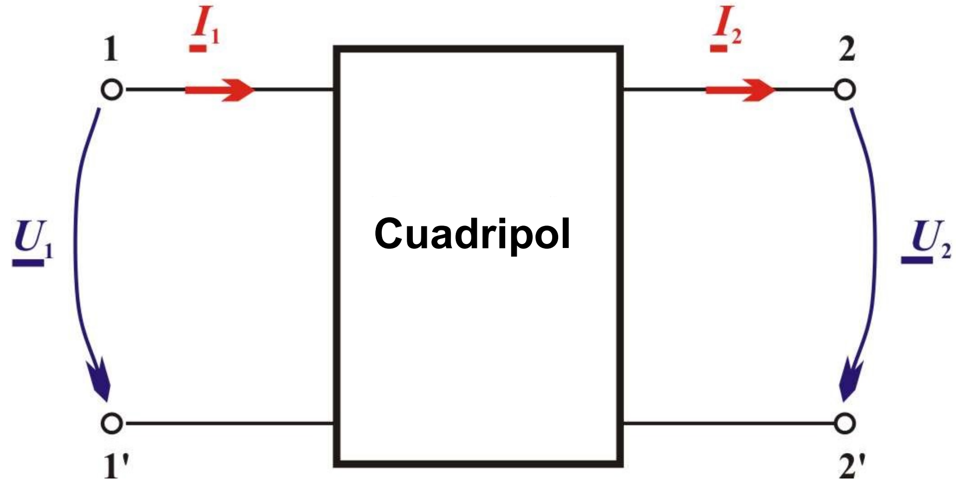
CUADRIPOLI

Circuit cu **patru** borne de acces

Poartă:

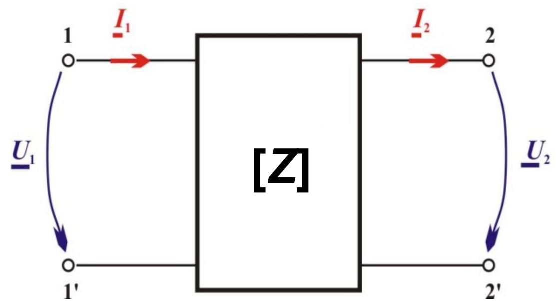
→ O pereche de borne care are **suma curenţilor zero**;

→ O pereche de borne pe la care circuitul **primeşte sau cedează energie**



Poartă de intrare:	**bornele 1-1'**	**primeşte energie**
Poartă de ieşire:	**bornele 2-2'**	**cedează energie**
Cuadripol activ:	conţine surse	
Cuadripol pasiv:	nu conţine surse	

PARAMETRI CUADRIPOLILOR



Parametrii impedanţă *Z*

$$\begin{cases} \underline{U}_1 = \underline{Z}_{11} \cdot \underline{I}_1 + \underline{Z}_{12} \cdot \underline{I}_2 \\ \underline{U}_2 = \underline{Z}_{21} \cdot \underline{I}_1 + \underline{Z}_{22} \cdot \underline{I}_2 \end{cases}$$

Matricial: $[\underline{U}] = [\underline{Z}] \cdot [\underline{I}]$

$$\begin{bmatrix} \underline{U}_1 \\ \underline{U}_2 \end{bmatrix} = \begin{bmatrix} \underline{Z}_{11} & \underline{Z}_{12} \\ \underline{Z}_{21} & \underline{Z}_{22} \end{bmatrix} \cdot \begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \end{bmatrix}$$

Impedanţa de intrare la mersul în gol

$$\underline{Z}_{11} = \left. \frac{\underline{U}_1}{\underline{I}_1} \right|_{\underline{I}_2 = 0}$$

Impedanţa de transfer la mersul în gol

$$\underline{Z}_{21} = \left. \frac{\underline{U}_2}{\underline{I}_1} \right|_{\underline{I}_2 = 0}$$

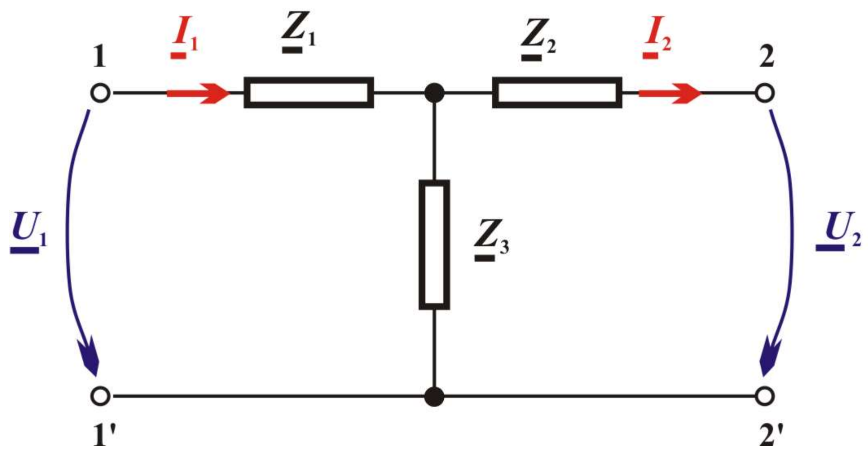
Impedanţa de transfer la mersul în gol

$$\underline{Z}_{12} = \left. \frac{\underline{U}_1}{\underline{I}_2} \right|_{\underline{I}_1 = 0}$$

Impedanţa de ieşire la mersul în gol

$$\underline{Z}_{22} = \left. \frac{\underline{U}_2}{\underline{I}_2} \right|_{\underline{I}_1 = 0}$$

Exemplu: cuadripol-T



Impedanţa de intrare la mersul în gol

$$\underline{Z}_{11} = \left.\frac{\underline{U}_1}{\underline{I}_1}\right|_{\underline{I}_2=0} = \underline{Z}_1 + \underline{Z}_3$$

Impedanţa de transfer la mersul în gol

$$\underline{Z}_{21} = \left.\frac{\underline{U}_2}{\underline{I}_1}\right|_{\underline{I}_2=0} = \underline{Z}_3$$

Impedanţa de transfer la mersul în gol

$$\underline{Z}_{12} = \left.\frac{\underline{U}_1}{\underline{I}_2}\right|_{\underline{I}_1=0} = \underline{Z}_3$$

Impedanţa de ieşire la mersul în gol

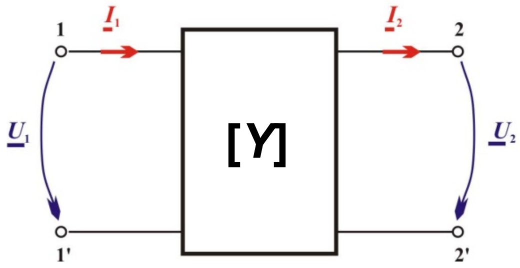
$$\underline{Z}_{22} = \left.\frac{\underline{U}_2}{\underline{I}_2}\right|_{\underline{I}_1=0} = \underline{Z}_2 + \underline{Z}_3$$

$$\underline{Z}_{12} = \underline{Z}_{21} = \underline{Z}_3$$

$$\underline{Z}_{11} - \underline{Z}_{21} = \underline{Z}_1$$

$$\underline{Z}_{22} - \underline{Z}_{21} = \underline{Z}_2$$

Parametri admitanţă, $\underline{Y}$



$$\boxed{\begin{cases} \underline{I}_1 = \underline{Y}_{11} \cdot \underline{U}_1 + \underline{Y}_{12} \cdot \underline{U}_2 \\ \underline{I}_2 = \underline{Y}_{21} \cdot \underline{U}_1 + \underline{Y}_{22} \cdot \underline{U}_2 \end{cases}}$$

Matricial: $[\underline{I}] = [\underline{Y}] \cdot [\underline{U}]$

$$\begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} \underline{Y}_{11} & \underline{Y}_{12} \\ \underline{Y}_{21} & \underline{Y}_{22} \end{bmatrix} \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{U}_2 \end{bmatrix}$$

Admitanţa de intrare la mersul în scurtcircuit

$$\underline{Y}_{11} = \left.\frac{\underline{I}_1}{\underline{U}_1}\right|_{\underline{U}_2=0}$$

Admitanţa de transfer la mersul în scurtcircuit

$$\underline{Y}_{21} = \left.\frac{\underline{I}_2}{\underline{U}_1}\right|_{\underline{U}_2=0}$$

Admitenţa de transfer la mersul în scurtcircuit

$$\underline{Y}_{12} = \left.\frac{\underline{I}_1}{\underline{U}_2}\right|_{\underline{U}_1=0}$$

Admitanţa de ieşire la mersul în scurtcircuit

$$\underline{Y}_{22} = \left.\frac{\underline{I}_2}{\underline{U}_2}\right|_{\underline{U}_1=0}$$

Relaţiile dintre parametri *Z* şi *Y*

$$\begin{cases} \underline{U}_1 = \underline{Z}_{11} \cdot \underline{I}_1 + \underline{Z}_{12} \cdot \underline{I}_2 \\ \underline{U}_2 = \underline{Z}_{21} \cdot \underline{I}_1 + \underline{Z}_{22} \cdot \underline{I}_2 \end{cases} \qquad \begin{cases} \underline{I}_1 = \underline{Y}_{11} \cdot \underline{U}_1 + \underline{Y}_{12} \cdot \underline{U}_2 \\ \underline{I}_2 = \underline{Y}_{21} \cdot \underline{U}_1 + \underline{Y}_{22} \cdot \underline{U}_2 \end{cases}$$

Rezolvând pentru $\underline{I}_1$ şi $\underline{I}_2$:

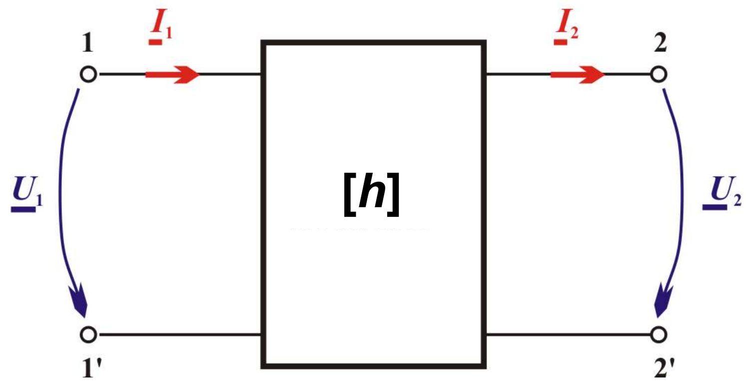
$$\underline{I}_1 = \frac{\begin{vmatrix} \underline{U}_1 & \underline{Z}_{12} \\ \underline{U}_2 & \underline{Z}_{22} \end{vmatrix}}{\begin{vmatrix} \underline{Z}_{11} & \underline{Z}_{12} \\ \underline{Z}_{21} & \underline{Z}_{22} \end{vmatrix}} \qquad \underline{I}_2 = \frac{\begin{vmatrix} \underline{Z}_{11} & \underline{U}_1 \\ \underline{Z}_{21} & \underline{U}_2 \end{vmatrix}}{\begin{vmatrix} \underline{Z}_{11} & \underline{Z}_{12} \\ \underline{Z}_{21} & \underline{Z}_{22} \end{vmatrix}}$$

$$\underline{I}_1 = \frac{\underline{Z}_{22}}{\Delta_Z} \cdot \underline{U}_1 - \frac{\underline{Z}_{12}}{\Delta_Z} \cdot \underline{U}_2 \qquad \underline{I}_2 = -\frac{\underline{Z}_{21}}{\Delta_Z} \cdot \underline{U}_1 + \frac{\underline{Z}_{11}}{\Delta_Z} \cdot \underline{U}_2$$

Comparând cu sistemul pentru ***Y***:

$$\begin{bmatrix} \underline{Y}_{11} & \underline{Y}_{12} \\ \underline{Y}_{21} & \underline{Y}_{22} \end{bmatrix} = \begin{bmatrix} \dfrac{\underline{Z}_{22}}{\Delta_Z} & -\dfrac{\underline{Z}_{12}}{\Delta_Z} \\ -\dfrac{\underline{Z}_{21}}{\Delta_Z} & \dfrac{\underline{Z}_{11}}{\Delta_Z} \end{bmatrix}$$

Parametri hibrizi; *h*



$$\begin{cases} \underline{U}_1 = \underline{h}_{11} \cdot \underline{I}_1 + \underline{h}_{12} \cdot \underline{U}_2 \\ \underline{I}_2 = \underline{h}_{21} \cdot \underline{I}_1 + \underline{h}_{22} \cdot \underline{U}_2 \end{cases}$$

matricial:

$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} \underline{h}_{11} & \underline{h}_{12} \\ \underline{h}_{21} & \underline{h}_{22} \end{bmatrix} \cdot \begin{bmatrix} \underline{I}_1 \\ \underline{U}_2 \end{bmatrix}$$

Impedanţa de scurcircuit la poarta 1

$$\underline{h}_{11} = \left. \frac{\underline{U}_1}{\underline{I}_1} \right|_{\underline{U}_2 = 0}$$

Raportul de transformare al curenţilor

$$\underline{h}_{21} = \left. \frac{\underline{I}_2}{\underline{I}_1} \right|_{\underline{U}_2 = 0}$$

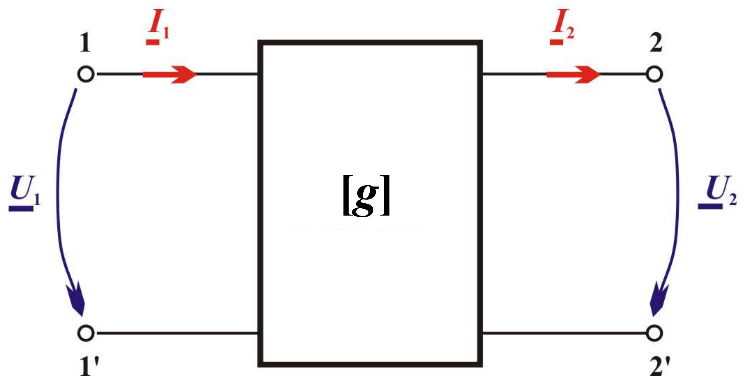
Raportul de transformare al tensiunilor

$$\underline{h}_{12} = \left. \frac{\underline{U}_1}{\underline{U}_2} \right|_{\underline{I}_1 = 0}$$

Admitanţa de mers în gol la poarta 2

$$\underline{h}_{22} = \left. \frac{\underline{I}_2}{\underline{U}_2} \right|_{\underline{I}_1 = 0}$$

Parametri hibrizi; *g*



$$\boxed{\begin{cases} \underline{I}_1 = \underline{g}_{11} \cdot \underline{U}_1 + \underline{g}_{12} \cdot \underline{I}_2 \\ \underline{U}_2 = \underline{g}_{21} \cdot \underline{U}_1 + \underline{g}_{22} \cdot \underline{I}_2 \end{cases}}$$

Matricial:

$$\begin{bmatrix} \underline{I}_1 \\ \underline{U}_2 \end{bmatrix} = \begin{bmatrix} \underline{g}_{11} & \underline{g}_{12} \\ \underline{g}_{21} & \underline{g}_{22} \end{bmatrix} \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{I}_2 \end{bmatrix}$$

Admitanţa de mers în gol la poarta 1

$$\underline{g}_{11} = \left.\frac{\underline{I}_1}{\underline{U}_1}\right|_{\underline{I}_2=0}$$

Raportul de transformare al tensiunilor

$$\underline{g}_{21} = \left.\frac{\underline{U}_2}{\underline{U}_1}\right|_{\underline{I}_2=0}$$

Raportul de transformare al curenţilor

$$\underline{g}_{12} = \left.\frac{\underline{I}_1}{\underline{I}_2}\right|_{\underline{U}_1=0}$$

Impedanţa de scurt circuit la poarta 2

$$\underline{g}_{22} = \left.\frac{\underline{U}_2}{\underline{I}_2}\right|_{\underline{U}_1=0}$$

Relaţiile dintre parametri *h* şi *Z*

Pentru parametri *Z*:

$$\begin{cases} \underline{U}_1 = \underline{Z}_{11} \cdot \underline{I}_1 + \underline{Z}_{12} \cdot \underline{I}_2 \\ \underline{U}_2 = \underline{Z}_{21} \cdot \underline{I}_1 + \underline{Z}_{22} \cdot \underline{I}_2 \end{cases}$$

Pentru parametri *h*:

$$\underline{h}_{11} = \left.\frac{\underline{U}_1}{\underline{I}_1}\right|_{\underline{U}_2=0} \quad \underline{h}_{12} = \left.\frac{\underline{U}_1}{\underline{U}_2}\right|_{\underline{I}_1=0} \quad \underline{h}_{21} = \left.\frac{\underline{I}_2}{\underline{I}_1}\right|_{\underline{U}_2=0} \quad \underline{h}_{22} = \left.\frac{\underline{I}_2}{\underline{U}_2}\right|_{\underline{I}_1=0}$$

Înlocuim $\underline{U}_2 = 0$ în ecuaţia 2:

$$0 = \underline{Z}_{21} \cdot \underline{I}_1 + \underline{Z}_{22} \cdot \underline{I}_2 \quad \Rightarrow \quad \frac{\underline{I}_2}{\underline{I}_1} = -\frac{\underline{Z}_{21}}{\underline{Z}_{22}} = \underline{h}_{21}$$

Substituim $\frac{\underline{I}_2}{\underline{I}_1}$ în ecuaţia 1:

$$\underline{U}_1 = \underline{Z}_{11} \cdot \underline{I}_1 + \underline{Z}_{12} \cdot \left(-\frac{\underline{Z}_{21}}{\underline{Z}_{22}} \underline{I}_1 \right) \quad \Rightarrow \quad \frac{\underline{U}_1}{\underline{I}_1} = \underline{Z}_{11} - \frac{\underline{Z}_{12} \cdot \underline{Z}_{21}}{\underline{Z}_{22}} = \underline{h}_{11}$$

sau

$$\underline{h}_{11} = \frac{\underline{Z}_{11} \cdot \underline{Z}_{22} - \underline{Z}_{12} \cdot \underline{Z}_{21}}{\underline{Z}_{22}} = \frac{\Delta_Z}{\underline{Z}_{22}}$$

unde:

$$\Delta_Z = \underline{Z}_{11} \cdot \underline{Z}_{22} - \underline{Z}_{12} \cdot \underline{Z}_{21}$$

Înlocuim $\underline{I}_1 = 0$ in ec. 1 şi 2:

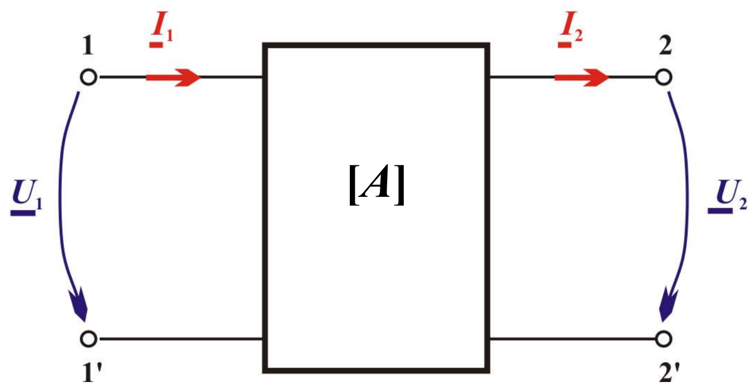
$$\begin{cases} \underline{U}_1 = \underline{Z}_{12} \cdot \underline{I}_2 \\ \underline{U}_2 = \underline{Z}_{22} \cdot \underline{I}_2 \end{cases}$$

$$\underline{h}_{12} = \left.\frac{\underline{U}_1}{\underline{U}_2}\right|_{\underline{I}_1=0} = \frac{\underline{Z}_{12}}{\underline{Z}_{22}}$$

$$\underline{h}_{22} = \left.\frac{\underline{I}_2}{\underline{U}_2}\right|_{\underline{I}_1=0} = \frac{1}{\underline{Z}_{22}}$$

$$\begin{bmatrix} \underline{h}_{11} & \underline{h}_{12} \\ \underline{h}_{21} & \underline{h}_{22} \end{bmatrix} = \begin{bmatrix} \dfrac{\Delta_Z}{\underline{Z}_{22}} & \dfrac{\underline{Z}_{12}}{\underline{Z}_{22}} \\ -\dfrac{\underline{Z}_{21}}{\underline{Z}_{22}} & \dfrac{1}{\underline{Z}_{22}} \end{bmatrix}$$

PARAMETRI FUNDAMENTALI



$$\boxed{\begin{cases} \underline{U}_1 = \underline{A} \cdot \underline{U}_2 + \underline{B} \cdot \underline{I}_2 \\ \underline{I}_1 = \underline{C} \cdot \underline{U}_2 + \underline{D} \cdot \underline{I}_2 \end{cases}}$$

matricial:

$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_1 \end{bmatrix} = \begin{bmatrix} \underline{A} & \underline{B} \\ \underline{C} & \underline{D} \end{bmatrix} \cdot \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix}$$

Raportul de transformare al tensiunilor

$$\underline{A} = \left.\frac{\underline{U}_1}{\underline{U}_2}\right|_{\underline{I}_2 = 0}$$

Admitanţa de transfer la mers în gol

$$\underline{C} = \left.\frac{\underline{I}_1}{\underline{U}_2}\right|_{\underline{I}_2 = 0}$$

Impedanţa de transfer la mers în scurtcircuit

$$\underline{B} = \left.\frac{\underline{U}_1}{\underline{I}_2}\right|_{\underline{U}_2 = 0}$$

Raportul de transformare al curenţilor

$$\underline{D} = \left.\frac{\underline{I}_1}{\underline{I}_2}\right|_{\underline{U}_2 = 0}$$

Relaţiile dintre *parametri fundamentali* şi parametri *Z*

$$\begin{cases} \underline{U}_1 = \underline{Z}_{11} \cdot \underline{I}_1 + \underline{Z}_{12} \cdot \underline{I}_2 \\ \underline{U}_2 = \underline{Z}_{21} \cdot \underline{I}_1 + \underline{Z}_{22} \cdot \underline{I}_2 \end{cases}$$

$$\begin{cases} \underline{U}_1 = \underline{A} \cdot \underline{U}_2 + \underline{B} \cdot \underline{I}_2 \\ \underline{I}_1 = \underline{C} \cdot \underline{U}_2 + \underline{D} \cdot \underline{I}_2 \end{cases}$$

$$\underline{U}_2 = \underline{Z}_{21} \cdot \underline{I}_1 + \underline{Z}_{22} \cdot \underline{I}_2 \quad \Rightarrow \quad \underline{I}_1 = \frac{\underline{U}_2}{\underline{Z}_{21}} - \frac{\underline{Z}_{22}}{\underline{Z}_{21}} \cdot \underline{I}_2$$

$$\underline{U}_1 = \underline{Z}_{11} \cdot \underline{I}_1 + \underline{Z}_{12} \cdot \underline{I}_2 \quad \Rightarrow \quad \underline{U}_1 = \underline{Z}_{11} \cdot \left(\frac{\underline{U}_2}{\underline{Z}_{21}} - \frac{\underline{Z}_{22}}{\underline{Z}_{21}} \cdot \underline{I}_2 \right) + \underline{Z}_{12} \cdot \underline{I}_2$$

rezultă:

deci: $$\underline{U}_1 = \frac{\underline{Z}_{11}}{\underline{Z}_{21}} \cdot \underline{U}_2 - \frac{\underline{Z}_{11} \cdot \underline{Z}_{22} - \underline{Z}_{21} \cdot \underline{Z}_{12}}{\underline{Z}_{21}} \cdot \underline{I}_2 = \frac{\underline{Z}_{11}}{\underline{Z}_{21}} \cdot \underline{U}_2 - \frac{\Delta_Z}{\underline{Z}_{21}} \cdot \underline{I}_2$$

$$\underline{A} = \frac{\underline{Z}_{11}}{\underline{Z}_{21}}; \qquad \underline{B} = -\frac{\Delta_Z}{\underline{Z}_{21}}$$

similar, $$\underline{I}_1 = \frac{\underline{U}_2}{\underline{Z}_{21}} - \frac{\underline{Z}_{22}}{\underline{Z}_{21}} \cdot \underline{I}_2$$

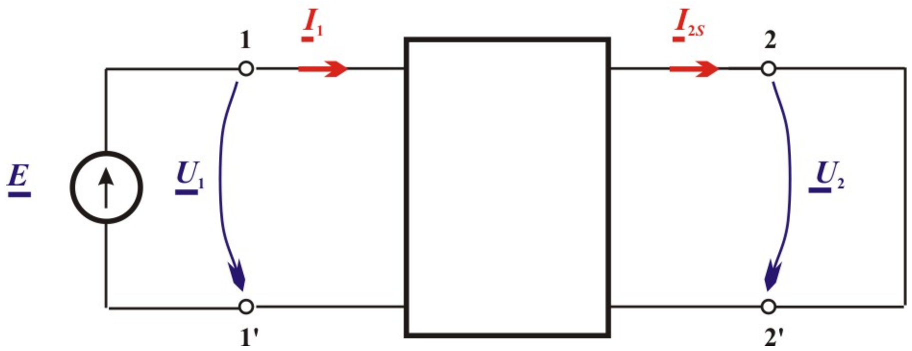
$$\underline{C} = \frac{1}{\underline{Z}_{21}}; \qquad \underline{D} = -\frac{\underline{Z}_{22}}{\underline{Z}_{21}}$$

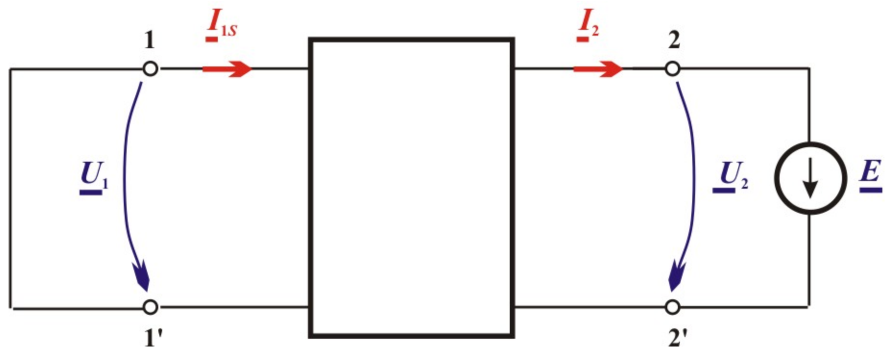
$$\underline{A} \cdot \underline{D} - \underline{B} \cdot \underline{C} = -\frac{\underline{Z}_{11}}{\underline{Z}_{21}} \cdot \frac{\underline{Z}_{22}}{\underline{Z}_{21}} + \frac{1}{\underline{Z}_{21}} \cdot \frac{\underline{Z}_{11} \cdot \underline{Z}_{22} - \underline{Z}_{21} \cdot \underline{Z}_{12}}{\underline{Z}_{21}} = -\frac{\underline{Z}_{12}}{\underline{Z}_{21}}$$

$$\boxed{\text{Dacă} \quad \underline{Z}_{12} = -\underline{Z}_{21} \qquad \text{atunci} \qquad \underline{A} \cdot \underline{D} - \underline{B} \cdot \underline{C} = 1}$$

Teorema reciprocităţii

Un cuadripol este reciproc: **Dacă se aplică o tensiune la una dintre porţi curentul de scurcircuit de la cealaltă poartă este acelaşi indiferent de poarta la care se aplică tensiunea.** *Condiţia este posibilă numai pentru cuadripoli pasivi.*





$\underline{U}_1 = \underline{E}$ $\quad$ $\underline{U}_2 = 0$ $\quad$ $\underline{U}_1 = 0$ $\quad$ $\underline{U}_2 = -\underline{E}$

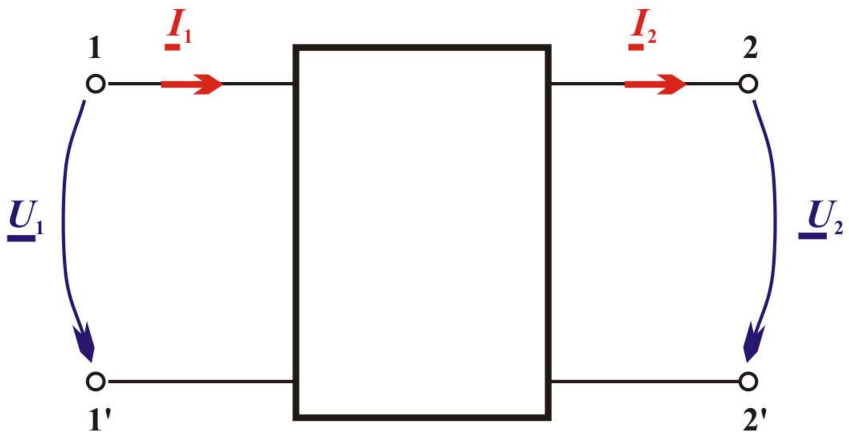
$$\begin{cases} \underline{U}_1 = \underline{A}\cdot\underline{U}_2 + \underline{B}\cdot\underline{I}_2 \\ \underline{I}_1 = \underline{C}\cdot\underline{U}_2 + \underline{D}\cdot\underline{I}_2 \end{cases} \qquad \begin{cases} \underline{U}_1 = \underline{A}\cdot\underline{U}_2 + \underline{B}\cdot\underline{I}_2 \\ \underline{I}_1 = \underline{C}\cdot\underline{U}_2 + \underline{D}\cdot\underline{I}_2 \end{cases}$$

$$\begin{cases} \underline{E} = \underline{B}\cdot\underline{I}_{2S} \\ \underline{I}_1 = \underline{D}\cdot\underline{I}_{2S} \end{cases} \qquad \underline{I}_{2S} = \frac{\underline{E}}{\underline{B}}$$

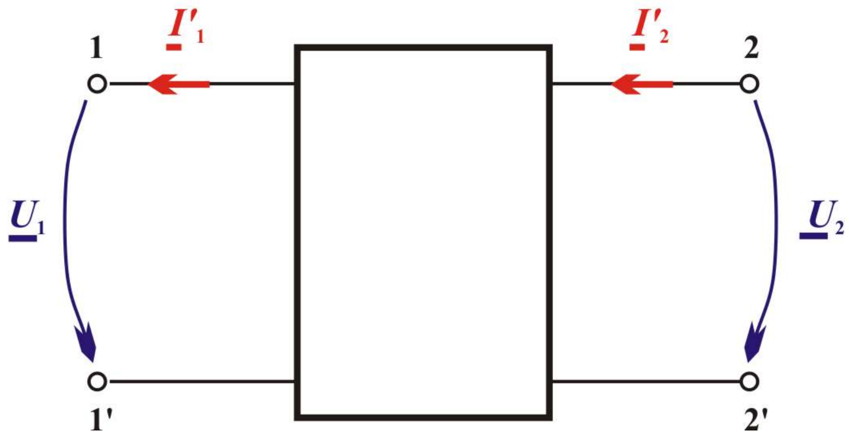
$$\begin{cases} 0 = -\underline{A}\cdot\underline{E} + \underline{B}\cdot\underline{I}_2 \\ \underline{I}_{1S} = -\underline{C}\cdot\underline{E} + \underline{D}\cdot\underline{I}_2 \end{cases} \qquad \underline{I}_{1S} = \frac{\underline{E}\cdot\left(\underline{A}\cdot\underline{D} - \underline{B}\cdot\underline{C}\right)}{\underline{B}}$$

$$\underline{I}_{1S} = \underline{I}_{2S} \qquad \Rightarrow \qquad \boxed{\underline{A}\cdot\underline{D} - \underline{B}\cdot\underline{C} = 1}$$

Teorema simetriei



Alimentare directă



Alimentare inversă

$$\begin{cases} \underline{U}_1 = \underline{A} \cdot \underline{U}_2 + \underline{B} \cdot \underline{I}_2 \\ \underline{I}_1 = \underline{C} \cdot \underline{U}_2 + \underline{D} \cdot \underline{I}_2 \end{cases}$$

Se rezolvă sistemul considerând ca necunoscute $\underline{U}_2$ şi $\underline{I}_2$:

$$\begin{cases} \underline{U}_2 = \underline{D} \cdot \underline{U}_1 - \underline{B} \cdot \underline{I}_1 \\ -\underline{I}_2 = \underline{C} \cdot \underline{U}_1 - \underline{A} \cdot \underline{I}_1 \end{cases}$$

Comparând sensurile curenţilor putem scrie:

$$\begin{cases} \underline{I}_1^{'} = -\underline{I}_1 \\ \underline{I}_2^{'} = -\underline{I}_2 \end{cases}$$

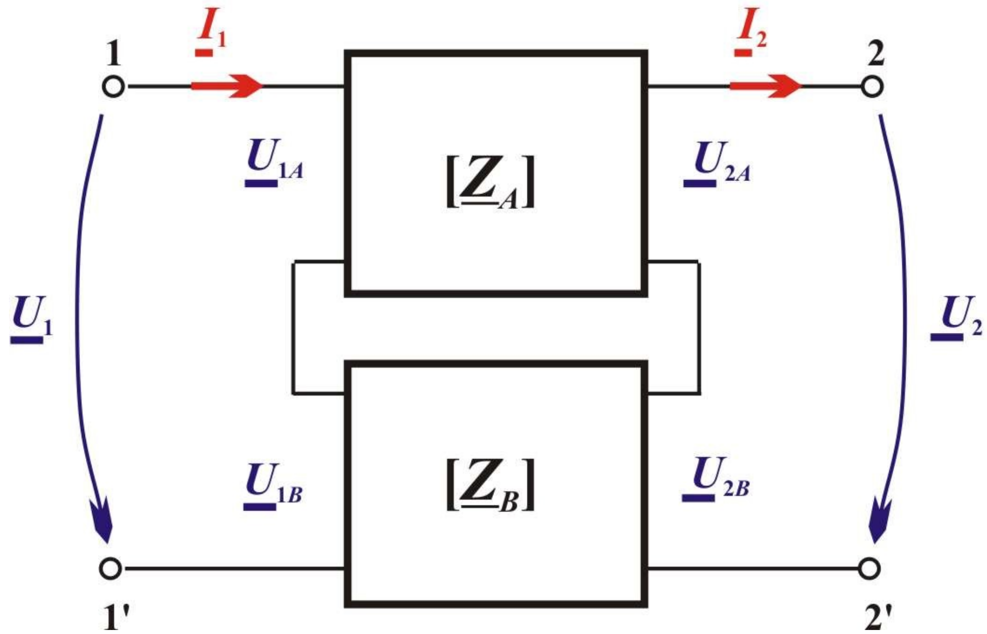
Pentru alimentare inversă rezultă sistemul:

$$\begin{cases} \underline{U}_2 = \underline{D} \cdot \underline{U}_1 + \underline{B} \cdot \underline{I}_1^{'} \\ \underline{I}_2^{'} = \underline{C} \cdot \underline{U}_1 + \underline{A} \cdot \underline{I}_1^{'} \end{cases}$$

În cazul în care $\underline{A} = \underline{D}$ coeficienţii sistemului vor fi identici pentru alimentare inversă. **Un cuadripol care îndeplineşte condiţia $\underline{A} = \underline{D}$ este simetric.**

MODURI DE CONECTARE ALE CUADRIPOLILOR

Conexiune serie-serie

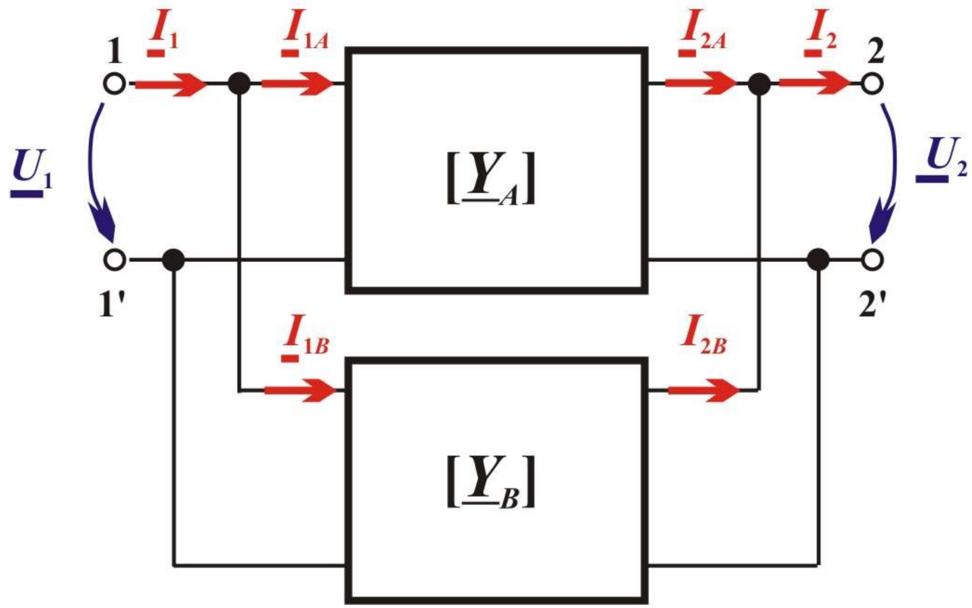


$$\begin{bmatrix}\underline{U}_1\\ \underline{U}_2\end{bmatrix}=\begin{bmatrix}\underline{U}_{1A}+\underline{U}_{1B}\\ \underline{U}_{2A}+\underline{U}_{2B}\end{bmatrix}=\begin{bmatrix}\underline{U}_{1A}\\ \underline{U}_{2A}\end{bmatrix}+\begin{bmatrix}\underline{U}_{1B}\\ \underline{U}_{2B}\end{bmatrix}=[\underline{Z}_A]\cdot\begin{bmatrix}\underline{I}_1\\ \underline{I}_2\end{bmatrix}+[\underline{Z}_B]\cdot\begin{bmatrix}\underline{I}_1\\ \underline{I}_2\end{bmatrix}=([\underline{Z}_A]+[\underline{Z}_B])\cdot\begin{bmatrix}\underline{I}_1\\ \underline{I}_2\end{bmatrix}$$

Rezultă:

$$\boxed{[\underline{Z}_{ECHIVALENT}]=[\underline{Z}_A]+[\underline{Z}_B]}$$

Conexiune paralel-paralel

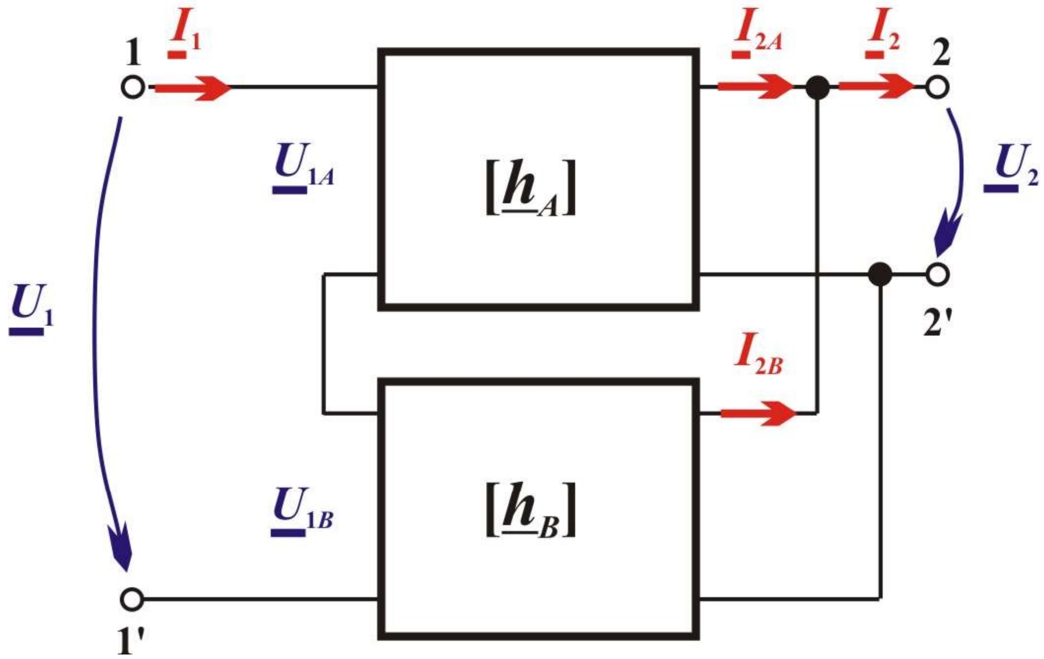


$$\begin{bmatrix} \underline{I}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} \underline{I}_{1A} + \underline{I}_{1B} \\ \underline{I}_{2A} + \underline{I}_{2B} \end{bmatrix} = \begin{bmatrix} \underline{I}_{1A} \\ \underline{I}_{2A} \end{bmatrix} + \begin{bmatrix} \underline{I}_{1B} \\ \underline{I}_{2B} \end{bmatrix} = [\underline{Y}_A] \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{U}_2 \end{bmatrix} + [\underline{Y}_B] \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{U}_2 \end{bmatrix} = ([\underline{Y}_A] + [\underline{Y}_B]) \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{U}_2 \end{bmatrix}$$

Rezultă:

$$\boxed{[\underline{Y}_{ECHIVALENT}] = [\underline{Y}_A] + [\underline{Y}_B]}$$

Conexiune serie-paralel

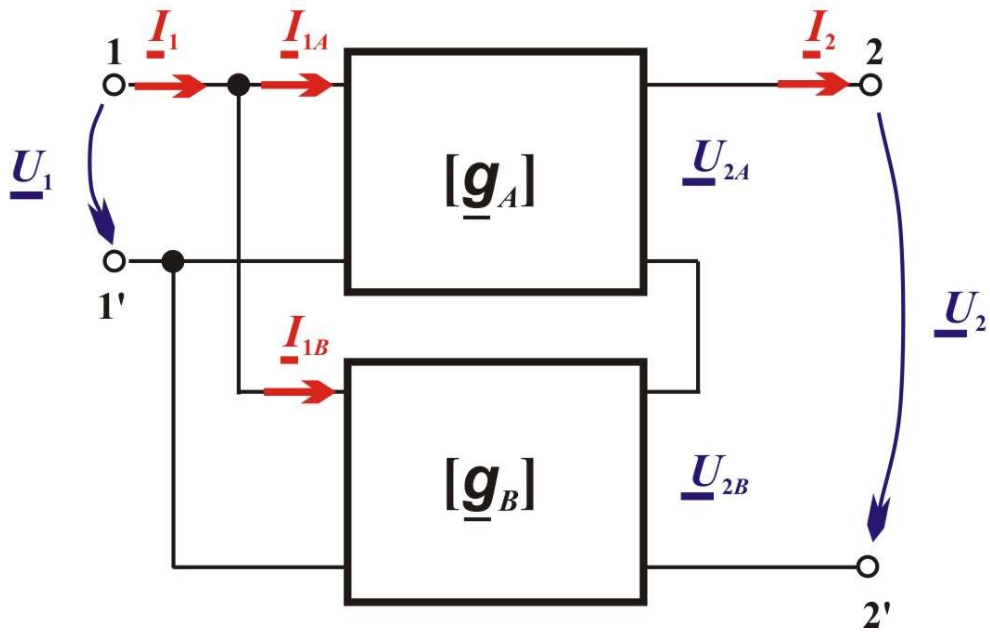


$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} \underline{U}_{1A} + \underline{U}_{1B} \\ \underline{I}_{2A} + \underline{I}_{2B} \end{bmatrix} = \begin{bmatrix} \underline{U}_{1A} \\ \underline{I}_{2A} \end{bmatrix} + \begin{bmatrix} \underline{U}_{1B} \\ \underline{I}_{2B} \end{bmatrix} = [\underline{h}_A] \cdot \begin{bmatrix} \underline{I}_1 \\ \underline{U}_2 \end{bmatrix} + [\underline{h}_B] \cdot \begin{bmatrix} \underline{I}_1 \\ \underline{U}_2 \end{bmatrix} = ([\underline{h}_A] + [\underline{h}_B]) \cdot \begin{bmatrix} \underline{I}_1 \\ \underline{U}_2 \end{bmatrix}$$

Rezultă:

$$\boxed{[\underline{h}_{ECHIVALENT}] = [\underline{h}_A] + [\underline{h}_B]}$$

Conexiune paralel-serie

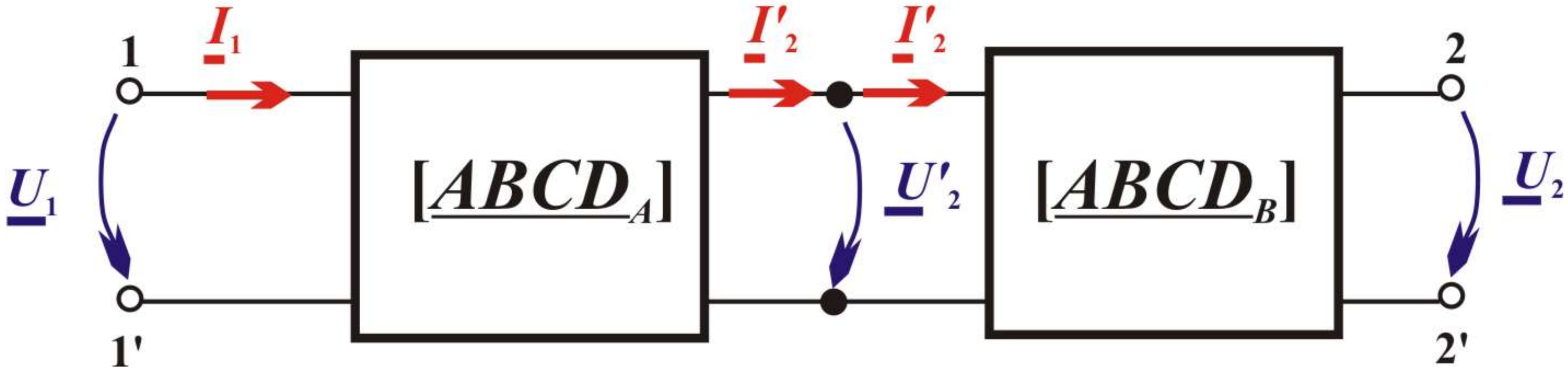


$$\begin{bmatrix} \underline{I}_1 \\ \underline{U}_2 \end{bmatrix} = \begin{bmatrix} \underline{I}_{1A} + \underline{I}_{1B} \\ \underline{U}_{2A} + \underline{U}_{2B} \end{bmatrix} = \begin{bmatrix} \underline{I}_{1A} \\ \underline{U}_{2A} \end{bmatrix} + \begin{bmatrix} \underline{I}_{1B} \\ \underline{U}_{2B} \end{bmatrix} = [\underline{g}_A] \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{I}_2 \end{bmatrix} + [\underline{g}_B] \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{I}_2 \end{bmatrix} = ([\underline{g}_A] + [\underline{g}_B]) \cdot \begin{bmatrix} \underline{U}_1 \\ \underline{I}_2 \end{bmatrix}$$

Rezultă:

$$\boxed{[\underline{g}_{ECHIVALENT}] = [\underline{g}_A] + [\underline{g}_B]}$$

Conexiune în cascadă



$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_1 \end{bmatrix} = [\underline{ABCD}_A] \cdot \begin{bmatrix} \underline{U}_2^{'} \\ \underline{I}_2^{'} \end{bmatrix} = [\underline{ABCD}_A] \cdot [\underline{ABCD}_B] \cdot \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix}$$

Rezultă:

$$\boxed{[\underline{ABCD}_{ECHIVALENT}] = [\underline{ABCD}_A] \cdot [\underline{ABCD}_B]}$$

Subiecte examen

1. Parametrii impedanţă Z: matrice, ecuatii.
2. Parametrii admitanţă, Y: matrice, ecuatii.
3. Parametrii hibrizi, h: matrice, ecuatii.
4. Parametrii hibrizi, g: matrice, ecuatii.
5. Cand un cuadripol este reciproc.
6. Cand un cuadripol este simetric.