

# Osnove teorije četvoropola

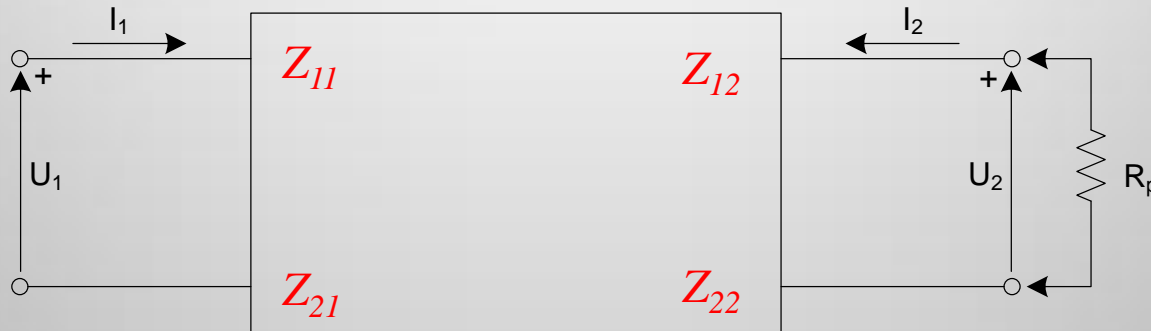
Prirodno-matematički fakultet u Nišu  
Departman za fiziku



- Linerna električna mreža sa četiri kraja (četiri pristupa, izvoda) može se opisati na više načina preko napona i struja na svojim krajevima.
- Takva električna mreža poznata je kao ČETVOROPOL.

**Uvod**  
**Modeli pojačavača**  
**Osnove teorije četvoropola**

Definicija četvoropola  
 "Z" - parametri  
 "h" - parametri  
 Strujno pojačanje  
 Ulazna otpornost  
 Naponsko pojačanje  
 Izlazna otpornost



$$U_1 = z_{11}I_1 + z_{12}I_2$$

$$U_2 = z_{21}I_1 + z_{22}I_2$$

Unutrašnja otpornost kola:  $R_u = \frac{U_1}{I_1}$

Naponsko pojačanje:  $A_u = \frac{U_2}{U_1}$

Strujno pojačanje:  $A_s = \frac{I_2}{I_1}$

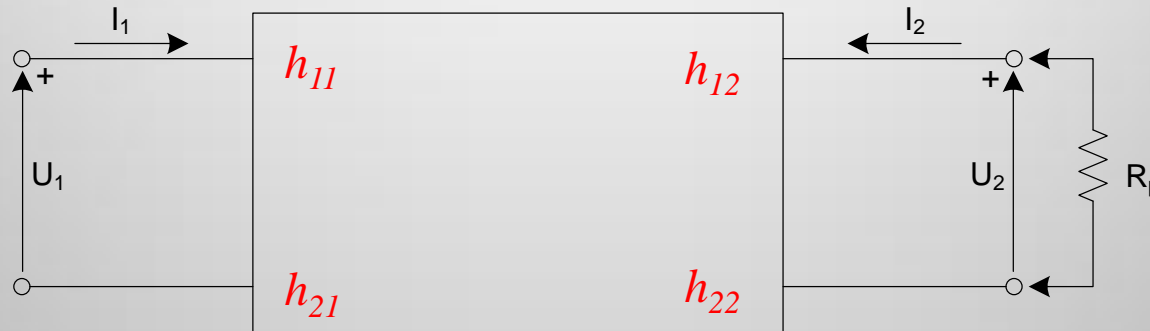
Izlazna otpornost kola:  
 (po Nortonovoj teoremi)  $R_i = \frac{\lim_{R_p \rightarrow \infty} U_2}{\lim_{R_p \rightarrow 0} I_2}$

$$z_{11} = \left. \frac{U_1}{I_1} \right|_{I_2=0} ; z_{12} = \left. \frac{U_1}{I_2} \right|_{I_1=0}$$

$$z_{21} = \left. \frac{U_2}{I_1} \right|_{I_2=0} ; z_{22} = \left. \frac{U_2}{I_2} \right|_{I_1=0}$$

**Uvod**  
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Definicija četvoropola  
"Z" - parametri  
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Strujno pojačanje  
Ulazna otpornost  
Naponsko pojačanje  
Izlazna otpornost



$$U_1 = h_{11}I_1 + h_{12}U_2$$

$$I_2 = h_{21}I_1 + h_{22}U_2$$

$h_{11}$  Ima dimenzije ulazne otpornosti pri kratko spojenim izlazima

$h_{12}$  Neimenovani broj, prenos napona pri otvorenim ulaznim krajevima

$h_{21}$  Neimenovani broj, prenos struje pri kratko spojenim izlaznim krajevima

$h_{22}$  Ima dimenzije izlazne provodnosti pri otvorenim ulaznim krajevima

$$h_{11} = \left. \frac{U_1}{I_1} \right|_{U_2=0} \quad ; \quad h_{12} = \left. \frac{U_1}{U_2} \right|_{I_1=0}$$

$$h_{21} = \left. \frac{I_2}{I_1} \right|_{U_2=0} \quad ; \quad h_{22} = \left. \frac{I_2}{U_2} \right|_{I_1=0}$$

$$U_1 = h_{11}I_1 + h_{12}U_2$$

$$I_2 = h_{21}I_1 + h_{22}U_2$$

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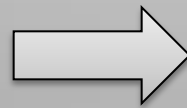
$$U_2 = -R_p I_2$$

$$U_1 = h_{11}I_1 - h_{12}R_p I_2$$

$$I_2 = h_{21}I_1 - h_{22}R_p I_2$$

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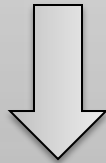
$$I_2 = -\frac{h_{21}}{1 + h_{22}R_p} I_1$$



$$A_s = \frac{I_2}{I_1} = \frac{h_{21}}{1 + h_{22}R_p}$$

$$R_u = \frac{U_1}{I_1} = \frac{h_{11}I_1 - h_{12}R_p I_2}{I_1} = h_{11} - h_{12}R_p A_s = h_{11} - h_{12}R_p \frac{h_{21}}{1 + h_{22}R_p}$$

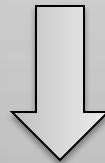
$$R_u = \frac{h_{11} + h_{11}h_{22}R_p - h_{12}h_{21}R_p}{1 + h_{22}R_p} = \frac{h_{11} + R_p(h_{11}h_{22} - h_{12}h_{21})}{1 + h_{22}R_p}$$



$$R_u = \frac{h_{11} + hR_p}{1 + h_{22}R_p}$$

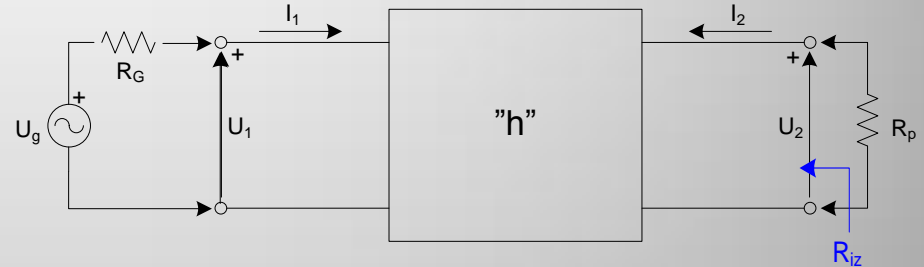
$$h = h_{11}h_{22} - h_{12}h_{21}$$

$$A_u = \frac{U_2}{U_1} = \frac{-R_p I_2}{U_1} = \frac{-R_p h_{21} I_1}{U_1 (1 + h_{22} R_p)} = -\frac{R_p h_{21}}{1 + h_{22} R_p} \frac{1}{R_u}$$
$$A_u = \frac{-R_p h_{21}}{1 + h_{22} R_p} \frac{1 + h_{22} R_p}{h_{11} + h R_p} = -\frac{R_p h_{21}}{h_{11} + h R_p} \quad R_u = \frac{h_{11} + h R_p}{1 + h_{22} R_p}$$



$$A_u = -\frac{h_{21}}{h_{11} + h R_p} R_p$$

$$R_{iz} = ? \quad \begin{cases} U_g = 0 \\ U_1 = -R_g I_1 \end{cases}$$

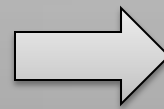


$$U_1 = h_{11}I_1 + h_{12}U_2 = -R_g I_1$$

$$I_2 = h_{21}I_1 + h_{22}U_2$$

$$I_1 = \frac{-h_{12}}{h_{11} + R_g} U_2$$

$$I_2 = \frac{-h_{21}h_{12}}{h_{11} + R_g} U_2 + h_{22}U_2$$



$$R_{iz} = \frac{U_2}{I_2} \bigg|_{\substack{R_p \rightarrow \infty \\ U_g \rightarrow 0}} = \frac{R_g + h_{11}}{h + h_{22}R_g}$$

Kao da je ovde priključen idealni naponski generator napona  $U_2$  i struje  $I_2$