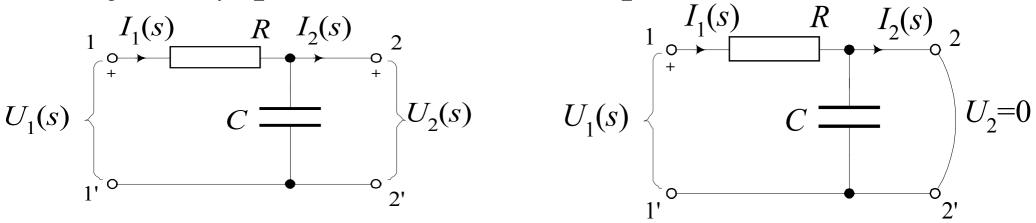
# Električni krugovi

Četveropoli-primjeri

Skripta: M. Plohl, Teorija četveropolnih sistema, 1987., I-dio

Primjer 1.: y-parametri RC četveropola

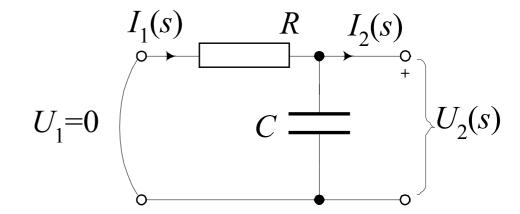


■ $U_2$ =0 → kratki spoj na 2-2'

$$y_{11} = \frac{1}{R}$$

$$y_{21} = \frac{1}{R}$$

•<u> $U_1$ </u>=0 → kratki spoj na 1-1'



$$y_{12} = \frac{1}{R}$$

$$y_{22} = \frac{1}{R} + sC$$

# Jednadžbe čvorišta

$$U_{1}(s) = \frac{1}{R} U_{1}(s) - \frac{1}{R} U_{2}(s)$$

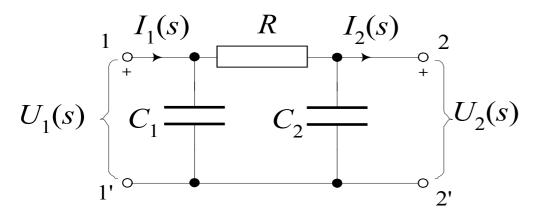
$$U_{2}(s) = \frac{1}{R} U_{1}(s) - \left(\frac{1}{R} + sC\right) U_{2}(s)$$

$$I_{2}(s) = \frac{1}{R} U_{1}(s) - \left(\frac{1}{R} + sC\right) U_{2}(s)$$

$$I_1 = U_1 y_{11} - U_2 y_{12} \qquad y_{11} = \frac{1}{R} \qquad y_{11}$$

$$\frac{I_2 = U_1 y_{21} - U_2 y_{22}}{y_{21}} \qquad y_{21} = \frac{1}{R} \qquad y_{22} = \frac{1}{R} + sC$$

Primjer 2.: y-parametri RC četveropola



$$y_{11} = \frac{I_1}{U_1} \bigg|_{U_1=0} = \frac{1}{R} + sC_1$$

$$y_{21} = \frac{I_2}{U_1} \bigg|_{U_2 = 0} = \frac{1}{R}$$

$$y_{12} = \frac{1}{R}$$

$$y_{22} = \frac{1}{R} + sC_2$$

# Jednadžbe čvorišta

$$U_{1}(s)$$
 $C_{1}$ 
 $C_{2}$ 
 $U_{2}(s)$ 
 $C_{2}$ 
 $C_{2}$ 
 $C_{2}$ 
 $C_{2}$ 

$$I_1 = U_1 y_{11} - U_2 y_{12}$$
$$I_2 = U_1 y_{21} - U_2 y_{22}$$

$$I_1(s) = \left(\frac{1}{R} + sC_1\right)U_1(s) - \frac{1}{R}U_2(s)$$

$$I_2(s) = \frac{1}{R}U_1(s) - \left(\frac{1}{R} + sC_2\right)U_2(s)$$

$$y_{11} = \frac{1}{R} + sC_1$$

$$y_{12} = y_{21} = \frac{1}{R}$$

$$y_{22} = \frac{1}{R} + sC_2$$

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Primjer 3.: z-parametri

$$U_{1}(s) = \begin{bmatrix} I_{1}(s) & R_{1} & R_{2} & I_{2}(s) \\ \vdots & \vdots & \vdots \\ I_{1}(s) & C & \vdots \\ \vdots & \vdots & \vdots \\ I_{2}(s) & \vdots \\ U_{2}(s) & \vdots \\$$

$$I_2=0 \rightarrow$$
 otvorene priključnice 2-2'

$$z_{11} = \frac{U_1}{I_1}\Big|_{I_2=0} = R_1 + \frac{1}{sC}$$

$$z_{21} = \frac{U_2}{I_1}\Big|_{I_2=0} = \frac{1}{sC}$$

$$I_1=0 \rightarrow$$
 otvorene priključnice 1-1'

$$z_{12} = -\frac{U_1}{I_2}\bigg|_{I_1=0} = \frac{1}{sC} \qquad \qquad z_{22} = -\frac{U_2}{I_2}\bigg|_{I_1=0} = R_2 + \frac{1}{sC}$$

Određivanje z-parametara direktno postavljanjem jednadžbi petlji

$$U_{1}(s) = I_{1}(s) + I_{1}(s) + I_{2}(s) + I_{2}(s) + I_{3}(s) + I_{4}(s) + I_{5}(s) + I_{5}(s)$$

$$U_1 = \left(R_1 + \frac{1}{sC}\right)I_1 - \frac{1}{sC}I_2 = z_{11}I_1 - z_{12}I_2$$

$$U_2 = \frac{1}{sC}I_1 - \left(R_2 + \frac{1}{sC}\right)I_2 = z_{21}I_1 - z_{22}I_2$$

Primjer4.: z-parametri

$$U_{1}(s) = \begin{bmatrix} I_{1}(s) & R_{1} & I_{2}(s) \\ \vdots & \vdots & \vdots \\ I_{1}(s) & R_{2} & \vdots \\ I_{2}(s) & \vdots \\ R_{2} & \vdots \\ I_{2}(s) & \vdots \\ I_{2$$

 $I_2=0 \rightarrow \text{otvorene priključnice } 2-2$ 

$$z_{11} = \frac{U_1}{I_1}\Big|_{I_2=0} = R_1 + R_2$$
  $z_{21} = \frac{U_2}{I_1}\Big|_{I_2=0} = R_2(1-k)$ 

 $I_1=0 \rightarrow$  otvorene priključnice 1-1'

$$z_{12} = -\frac{U_1}{I_2} \bigg|_{I_1 = 0} = R_2 \qquad z_{22} = -\frac{U_2}{I_2} \bigg|_{I_1 = 0} = R_2 (1 - k)$$

Define ion F and F are the second of F

Primjer 5.: 
$$a$$
-parametri  $U_1 = AU_2 + BI_2$   $I_1 = CU_2 + DI_2$ 

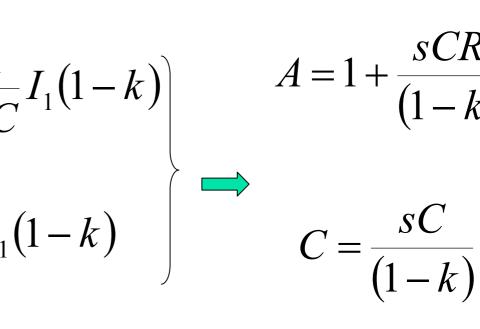
$$C \xrightarrow{I_{2}(S)} U_{2}(S)$$

$$K_{1} \xrightarrow{I_{2}(S)} U_{2}(S)$$

$$KI_{1} \xrightarrow{I_{2}(S)} U_{2}(S)$$

 $I_2=0 \rightarrow$  otvorene priključnice 2-2'

$$A = \frac{U_1}{U_2} \Big|_{I_2 = 0} \qquad \begin{cases} U_1 = I_1 R + \frac{1}{sC} I_1 (1 - k) \\ U_2 = \frac{1}{sC} I_1 (1 - k) \end{cases}$$

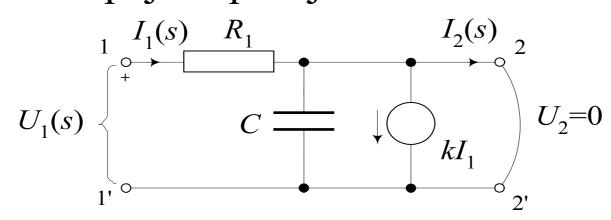


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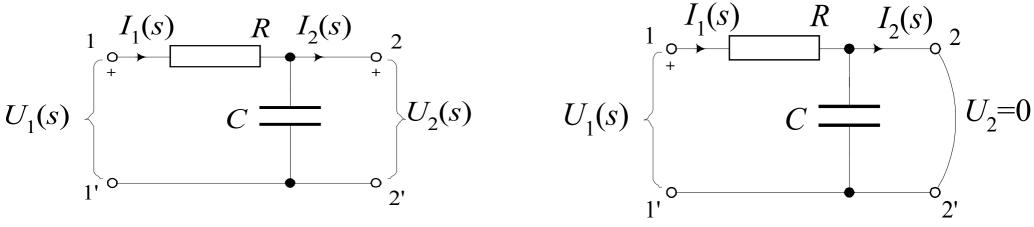
# $U_2=0 \rightarrow$ kratko spojene priključnice 2-2'



$$B = \frac{U_1}{I_2}\Big|_{U_2 = 0}$$
  $U_1 = I_1 R = \frac{I_2}{1 - k} R$   $\implies$   $B = \frac{R}{1 - k}$ 

$$D = \frac{I_1}{I_2} \Big|_{U_2 = 0} \qquad I_1 = \frac{I_2}{1 - k} \qquad D = \frac{1}{1 - k}$$

# Primjer 6.: h-parametri RC četveropola



•
$$\underline{U}_2$$
=0 → kratki spoj na 2-2'

$$\frac{\underline{U}_{2}\underline{U}_{1}}{U_{1}}$$

$$U_1$$

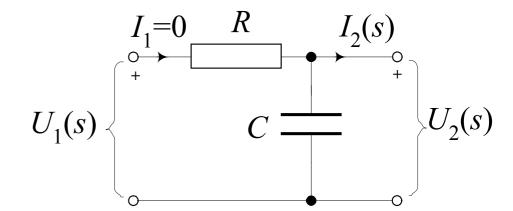
$$H_1 \Rightarrow h_{11} = R$$

$$h_{21} = \frac{I_2}{I_1}$$

$$I_1$$

$$u_{21} = 1$$

$$\underline{I_1}$$
 =0 →otvorene 1-1'



$$h_{12} = \frac{U_1}{U_2} \bigg|_{I_1 = 0}$$

$$U_2 = U$$

$$\Rightarrow h_{12} = 1$$

$$h_{22} = rac{I_2}{U_2}\Big|_{I_1=0}$$

$$I_2 = U_2 s C$$

$$\Rightarrow h_{22} = -sC$$

# Primjer 7.: g-parametri RC četveropola

$$U_{1}(s) = \begin{bmatrix} I_{1}(s) & R & I_{2}(s) \\ \vdots & \vdots & \vdots \\ I_{1}(s) & R & I_{2}(s) \end{bmatrix}$$

$$U_{1}(s) = \begin{bmatrix} I_{1}(s) & R & I_{2}=0 \\ \vdots & \vdots & \vdots \\ I_{1}(s) & C & \vdots \\ \vdots & \vdots & \vdots \\ I_{2}(s) & \vdots \\ U_{2}(s) & \vdots \\ U_{2}(s) & \vdots \\ \vdots & \vdots & \vdots \\ I_{1}(s) & C & \vdots \\ U_{2}(s) & \vdots \\ U_{2}(s$$

$$\bullet \underline{I}_2 = 0$$
 → otvorene 2-2'

$$g_{11} = \frac{I_1}{U_1}\Big|_{I_2=0}$$
  $U_1 = \left(R + \frac{1}{sC}\right) \cdot I_1 \implies g_{11} = \frac{sC}{sRC+1}$ 

$$g_{21} = \frac{U_2}{U_1}\Big|_{L_2=0}$$
  $U_1 \frac{sC}{sRC+1} = U_2 sC$   $\Rightarrow$   $g_{21} = \frac{1}{sRC+1}$ 

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<u>U₁=0</u> → kratko spojene 1-1'

$$U_{1}=0$$

$$C = \begin{bmatrix} I_{1}(s) & R & I_{2}(s) \\ \vdots & \vdots & \vdots \\ I_{2}(s) & \vdots \\ U_{2}(s) & \vdots \\ U_{2}(s) & \vdots \\ \vdots & \vdots & \vdots \\ U_{2}(s) & \vdots$$

$$g_{12} = \frac{I_1}{I_2} \bigg|_{U_1 = 0}$$

$$g_{12} = \frac{I_1}{I_2}\Big|_{U_1=0}$$
  $I_2\left(\frac{R}{sRC+1}\right) = I_1R \implies g_{12} = \frac{1}{sRC+1}$ 

$$g_{22} = \frac{U_2}{I_2}\Big|_{U_1=0}$$

$$g_{22} = \frac{U_2}{I_2}\Big|_{U_1=0}$$
  $I_2 = U_2\Big(\frac{1}{R} + sC\Big)$   $\Rightarrow$   $g_{22} = -\frac{R}{sRC + 1}$