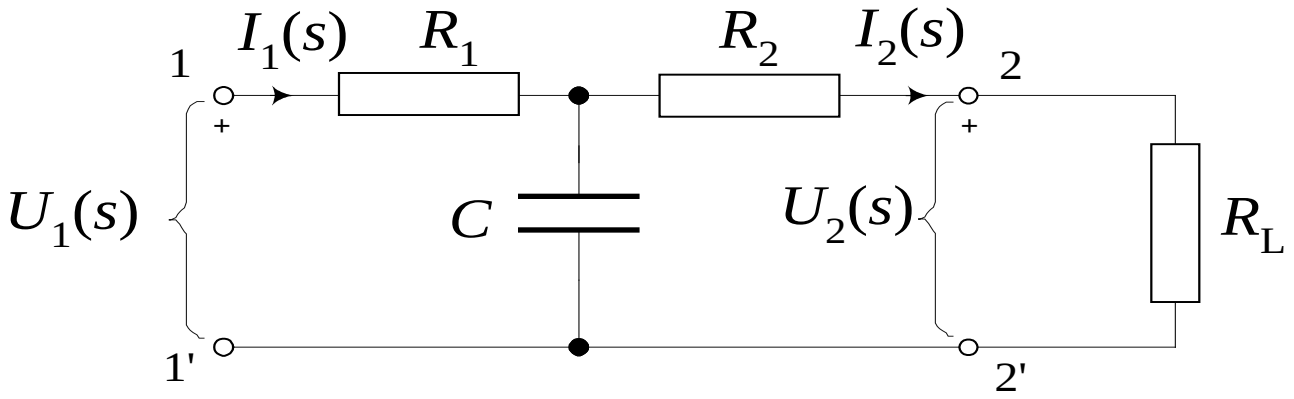
Električni krugovi

Prijenosne i ulazne funkcije četveropola-primjeri

- Primjer 1.: Odrediti prijenosne funkcije struje i napona



$$z_{11} = \left.\frac{U_1}{I_1}\right|_{I_2=0} = R_1 + \frac{1}{sC} \qquad z_{12} = -\left.\frac{U_1}{I_2}\right|_{I_1=0} = \frac{1}{sC}$$

$$z_{21} = \left.\frac{U_2}{I_1}\right|_{I_2=0} = \frac{1}{sC} \qquad z_{22} = -\left.\frac{U_2}{I_2}\right|_{I_1=0} = R_2 + \frac{1}{sC}$$

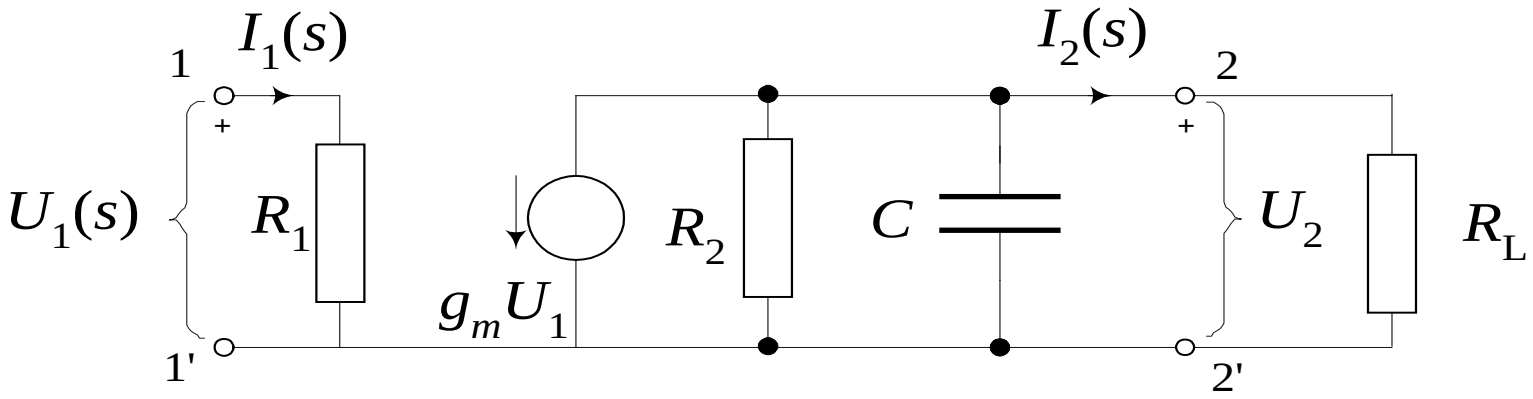
- Strujna prijenosna funkcija

$$H_i(s)=\frac{I_2}{I_1}=\frac{z_{21}}{Z_L+z_{22}}=\frac{1/sC}{R_L+R_2+1/sC}=\frac{1}{sC(R_L+R_2)+1}$$

- Naponska prijenosna funkcija

$$H_u(s)=\frac{U_2}{U_1}=\frac{Z_L z_{21}}{\Delta_z+z_{11}Z_L}=\frac{R_L}{s(R_1+R_L)R_2C+R_1+R_2+R_L}$$

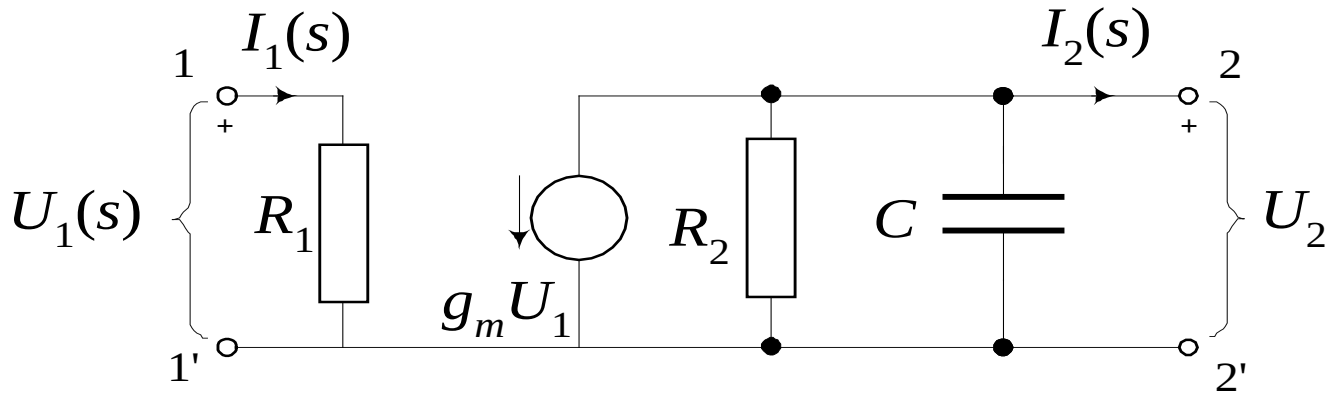
- Primjer 2.: Odrediti prijenosne parametre četveropola i prijenosne funkcije napona i struje



$$A = \left.\frac{U_1}{U_2}\right|_{I_2=0} = \frac{U_1}{-g_m U_1 \dfrac{R_2}{sR_2C+1}} = -\frac{sR_2C+1}{g_m R_2}$$

$$B = \left.\frac{U_1}{I_2}\right|_{U_2=0} = \frac{U_1}{-g_m U_1} = -\frac{1}{g_m}$$

Prijenosne i ulazne funkcije četveropola

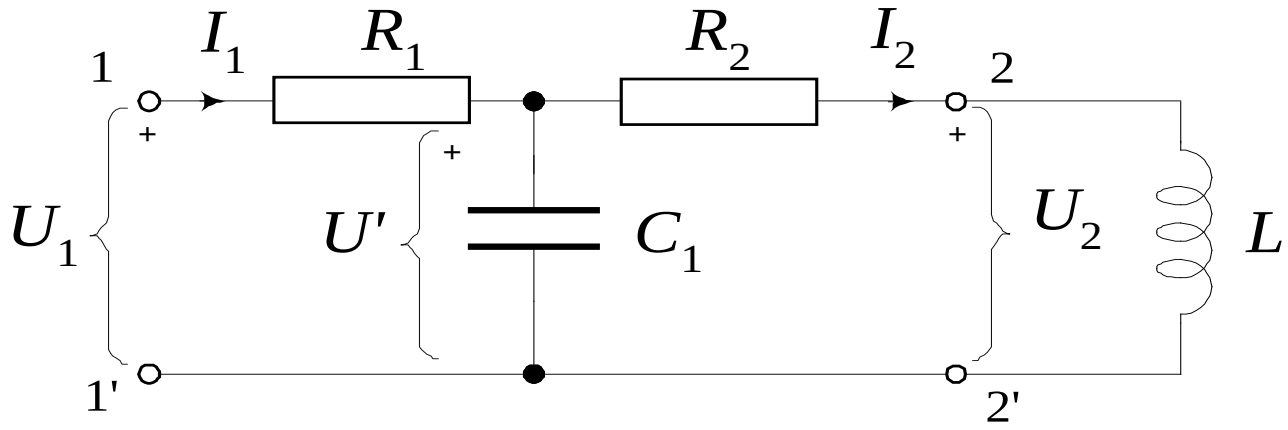


$$C = \left.\frac{I_1}{U_2}\right|_{I_2=0} = \frac{I_1}{-g_m U_1 \dfrac{R_2}{sRC+1}} = -\frac{sR_2C+1}{g_{m1}R_1R_2}$$

$$D = \left.\frac{I_1}{I_2}\right|_{U_2=0} = \frac{I_1}{-g_m U_1} = -\frac{1}{g_m R_1}$$

Primjer 3.:Odrediti A, B, C, D parametre i Z_{ul1}

uz $I_2=0$

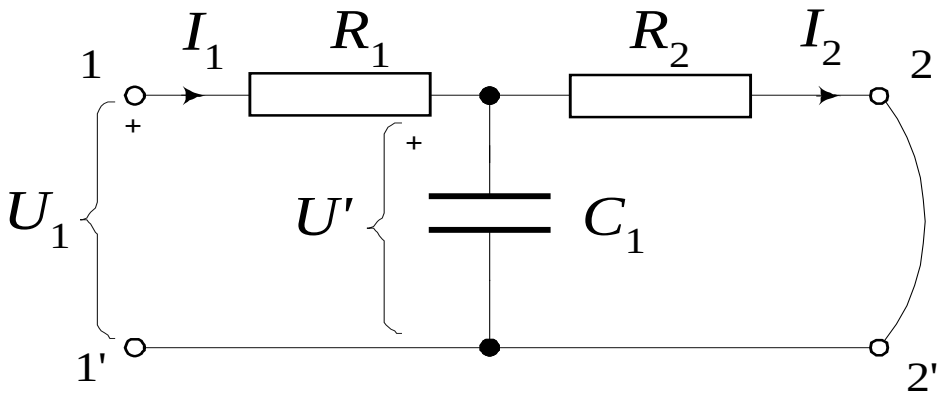


$$I_1 = \frac{U_1}{R_1 + 1/sC_1} \qquad U_2 = I_1 \frac{1}{sC_1} = U_1 \frac{1/sC_1}{R_1 + 1/sC_1} = U_1 \frac{1}{R_1 sC_1 + 1}$$

$$A = \left.\frac{U_1}{U_2}\right|_{I_2=0} \Rightarrow \boxed{A = R_1 sC_1 + 1} \qquad C = \left.\frac{I_1}{U_2}\right|_{I_2=0} \Rightarrow \boxed{C = sC_1}$$

Prijenosne i ulazne funkcije četveropola

uz $U_2=0$



$$U_1 = I_1\left(R_1 + \frac{R_2}{R_2 sC_1 + 1}\right)$$

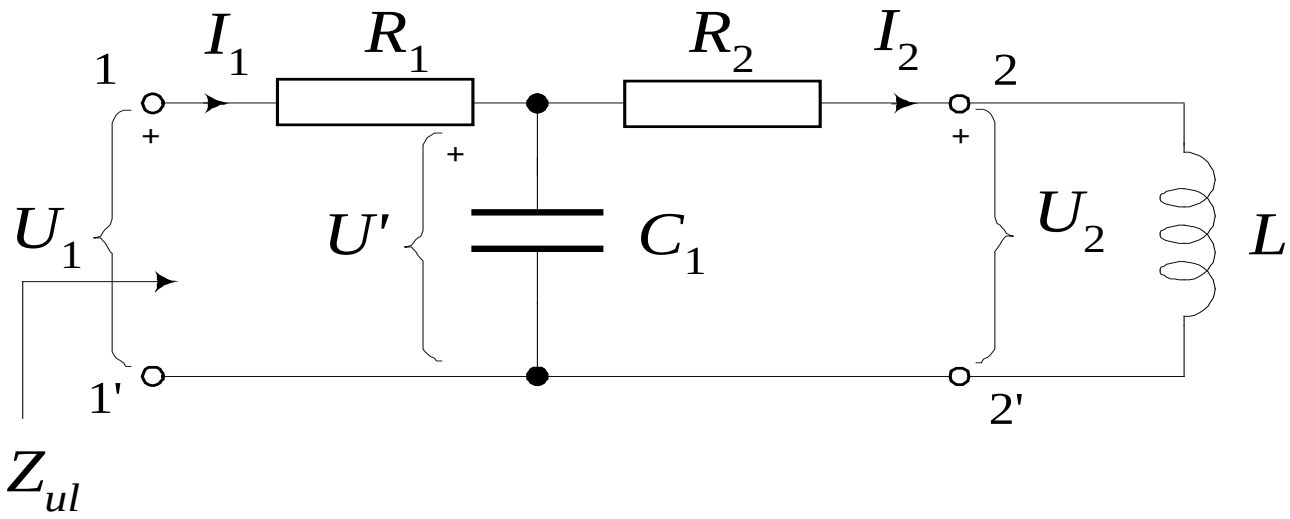
$$U' = I_1 \frac{R_2}{R_2 sC_1 + 1}$$

$$B = \left.\frac{U_1}{I_2}\right|_{U_2=0} \Rightarrow \boxed{B = R_1\left(R_2 sC_1 + 1\right) + R_2}$$

$$I_2 = U'\frac{1}{R_2} = \frac{I_1}{R_2 sC_1 + 1}$$

$$D = \left.\frac{I_1}{I_2}\right|_{U_2=0} \Rightarrow \boxed{D = R_2 sC_1 + 1}$$

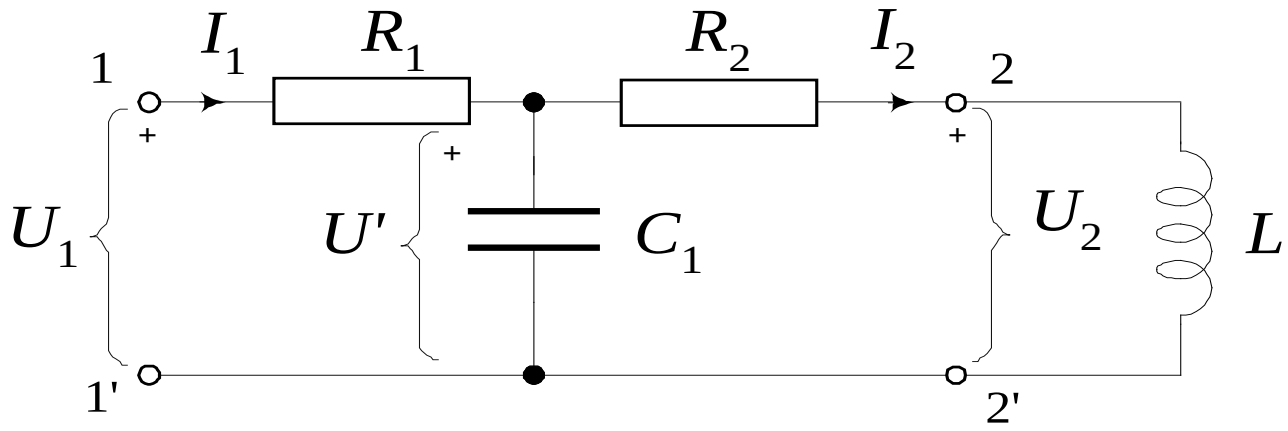
Prijenosne i ulazne funkcije četveropola



$$Z_2 = sL$$

$$Z_{ul} = \frac{AZ_2 + B}{CZ_2 + D} \Rightarrow \boxed{Z_{ul} = R_1 + \frac{R_2 + sL}{(R_2 + sL)sC + 1}}$$

Prijenosna funkcija napona U_2/U_1

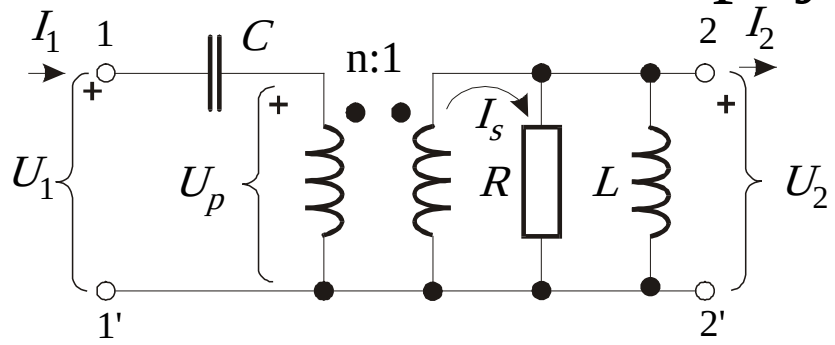


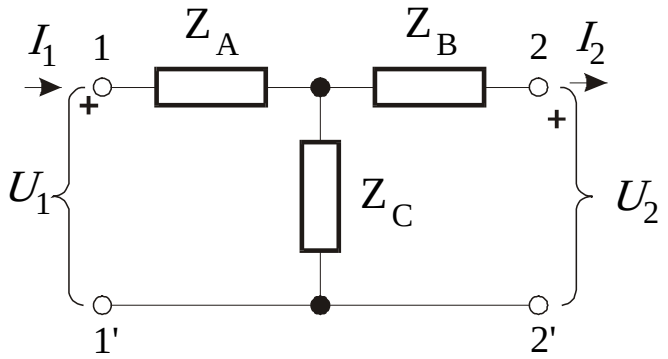
$$A = R_1 s C_1 + 1 \qquad B = R_1\left(R_2 s C_1 + 1\right) + R_2$$

$$C = s C_1 \qquad D = R_2 s C_1 + 1$$

$$H_u(s) = \frac{U_2}{U_1} = \frac{Z_L}{A Z_L + B} = \frac{sL}{s^2 R_1 C_1 L + s R_1 R_2 C_1 + R_1 + R_2}$$

Primjer 5.: Ekvivalentni T-spoj





$$U_1 = I_1 z_{11} - I_2 z_{12} \qquad U_p = nU_2$$

$$U_2 = I_1 z_{21} - I_2 z_{22} \qquad I_1 = I_s / n$$

$I_2 = 0$

$$U_p = nU_2 = nI_s \frac{RsL}{R+sL} = n^2 I_1 \frac{RsL}{R+sL}$$

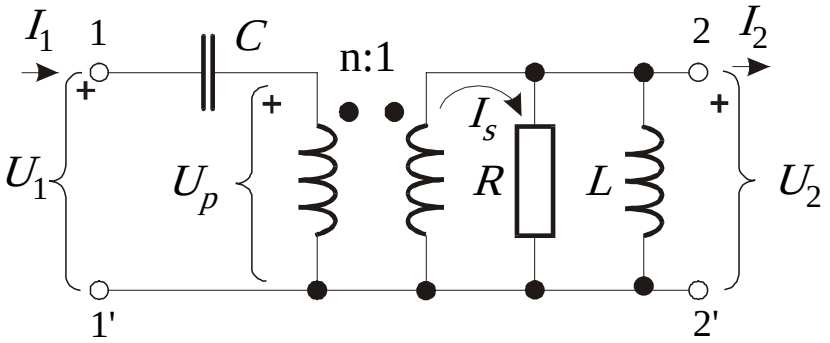
$$z_{11} = \left.\frac{U_1}{I_1}\right|_{I_2=0} = \frac{1}{sC} + \frac{U_p}{I_1}$$

$$\boxed{z_{11} = \left.\frac{U_1}{I_1}\right|_{I_2=0} = \frac{1}{sC} + n^2 \frac{RsL}{R+sL}}$$

Prijenosne i ulazne funkcije četveropola

$$z_{21} = \left.\frac{U_2}{I_1}\right|_{I_2=0} = \frac{I_s \dfrac{RsL}{R+sL}}{I_1} = n \cdot \frac{RsL}{R+sL}$$

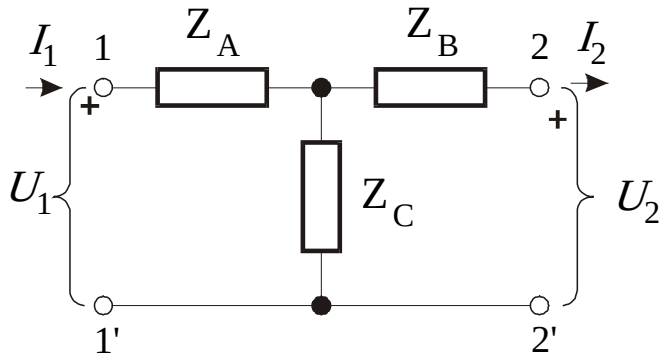
$\underline{I_1=0}$



$$z_{21} = z_{12}$$

$$z_{22} = -\left.\frac{U_2}{I_2}\right|_{I_1=0} = \frac{RsL}{R+sL}$$

Ekvivalentni T-spoj

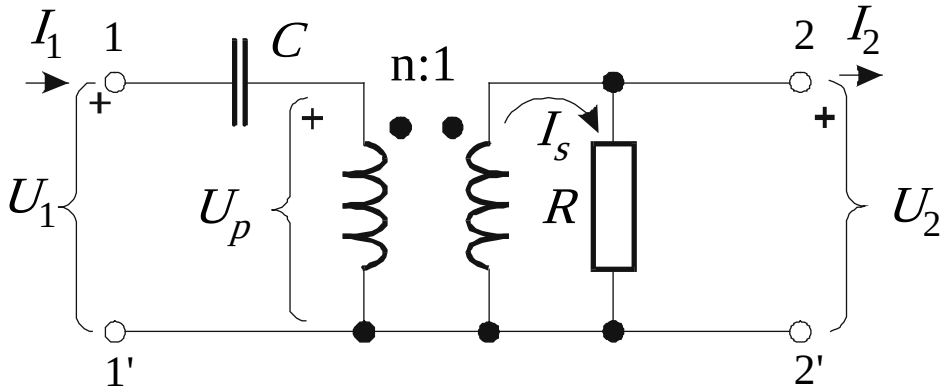


$$Z_A = z_{11} - z_{12} = \frac{1}{sC} + (n^2 - n)\frac{RsL}{R + sL}$$

$$Z_B = \frac{RsL}{R + sL}(1 - n)$$

$$Z_C = n\frac{RsL}{R + sL}$$

Primjer 6.: Ekvivalentni Π-spoj



$$I_1 = U_1 y_{11} - U_2 y_{12}$$

$$I_2 = U_1 y_{21} - U_2 y_{22}$$

$$U_p = nU_2$$

$$I_1 = I_s / n$$

$U_2=0$

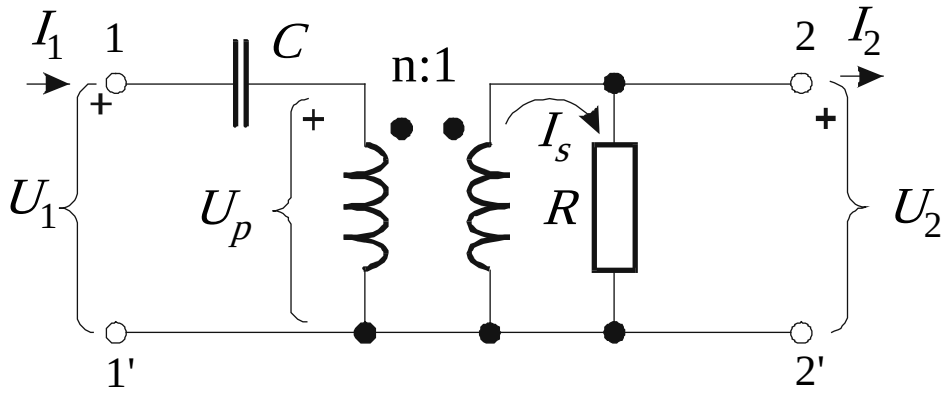
$$U_2 = 0 \Rightarrow U_p = 0$$

$$y_{11} = \left.\frac{I_1}{U_1}\right|_{U_2=0} = sC$$

$$y_{21} = \left.\frac{I_2}{U_1}\right|_{U_2=0} = \frac{I_s}{U_1} = \frac{nI_1}{U_1} = nsC$$

Prijenosne i ulazne funkcije četveropola

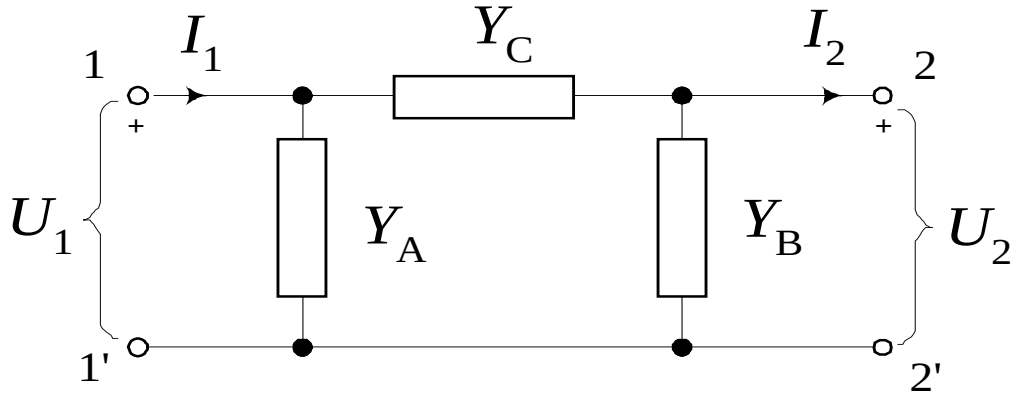
$\underline{U_1=0}$



$$y_{12} = -\left.\frac{I_1}{U_2}\right|_{U_1=0} = -\frac{I_1}{U_p/n} = nsC$$

$$y_{22} = -\left.\frac{I_2}{U_2}\right|_{U_1=0} = \frac{1}{R} - \frac{I_s}{U_2} = \frac{1}{R} - \frac{nI_1}{U_p/n} = \frac{1}{R} + n^2 sC$$

Ekvivalentni Π-spoj

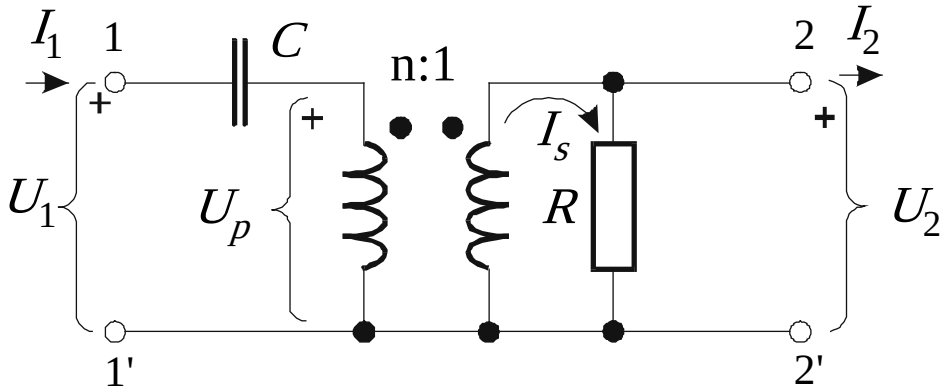


$$Y_A = y_{11} - y_{12} = sC(1-n)$$

$$Y_B = y_{22} - y_{12} = \frac{1}{R} + sC(n^2 - n)$$

$$Y_C = y_{12} = nsC$$

Primjer 7.: Prijenosni parametri



$$U_1 = AU_2 + BI_2$$

$$I_1 = CU_2 + DI_2$$

$$U_p = nU_2$$

$$I_1 = I_s / n$$

$I_2=0$

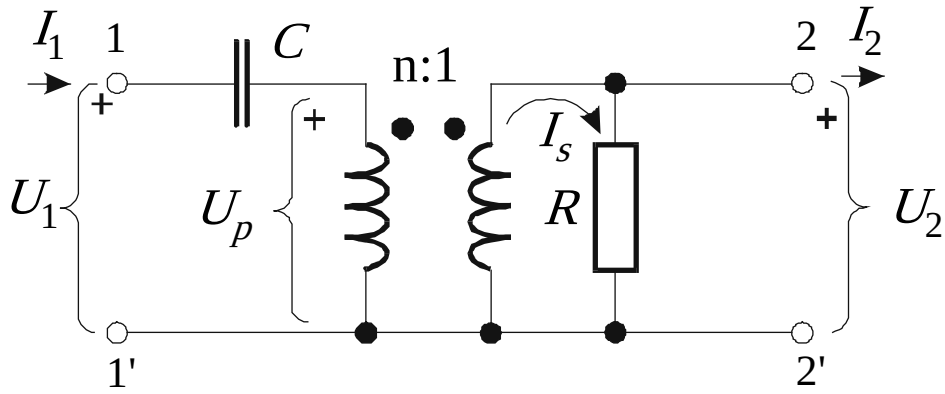
$$A = \left.\frac{U_1}{U_2}\right|_{I_2=0} = \frac{U_1}{I_s R} = \frac{U_1}{nI_1 R} = \frac{1}{nsRC} + n$$

$$C = \left.\frac{I_1}{U_2}\right|_{I_2=0} = \frac{I_s}{nU_2} = \frac{1}{nR}$$

Prijenosne i ulazne funkcije četveropola

$\underline{U_2=0}$

$$U_2 = 0 \Rightarrow U_p = 0$$



$$B = \left.\frac{U_1}{I_2}\right|_{U_2=0} = \frac{U_1}{nI_p} = \frac{1}{nsC}$$

$$D = \left.\frac{I_1}{I_2}\right|_{U_2=0} = \frac{1}{n}$$