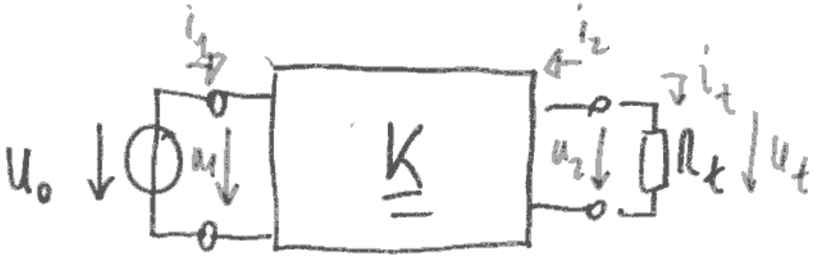
1)



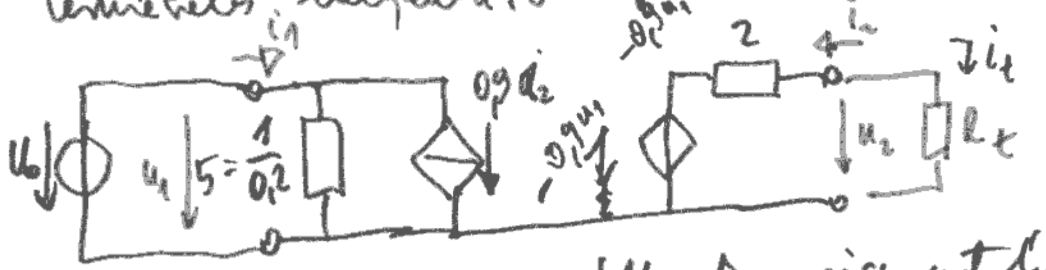
$R_t = ?$, maximális teljesítményhez $U_0 = 20V$

[kΩ, V, mA, mS, mW]

$$\underline{\underline{K}} = \begin{bmatrix} 0{,}2\,mS & 0{,}9 \\ -0{,}9 & 2\,k\Omega \end{bmatrix} \Rightarrow \begin{pmatrix} i_1 \\ u_2 \end{pmatrix} = \underline{\underline{K}} \cdot \begin{pmatrix} u_1 \\ i_2 \end{pmatrix}$$

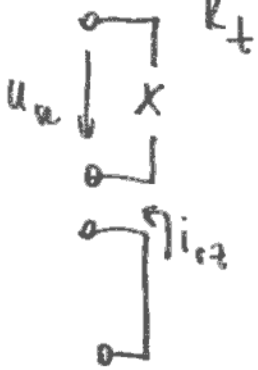
$\Downarrow$

természetes helyettesítő kép alkalmazásával



$u_1 = U_0 \Rightarrow u_1$ nem változik a visszahatás ellenére sem!

$$u_2 = \frac{R_t}{R_t + 2} \cdot (-0{,}9 \cdot u_1) = \frac{R_t}{R_t + 2} \cdot (-18)$$



$R_t \to \infty$

$$U_{sz} = -0{,}9 \cdot u_1 = -18\ V$$

$$i_{rz} = \frac{0 - (-0{,}9 \cdot u_1)}{2} = \frac{18}{2} = 9\ mA$$

$$R_B = \frac{U_{sz}}{-i_{rz}} = \frac{-18}{-(-9)} = 2\ k\Omega$$

$R_t = 2\ k\Omega \Rightarrow$ maximális ~~telj~~ teljesítmény a terhelésen

$$P_t = \frac{(U_{sz})^2}{4 R_B} = \frac{(-18)^2}{4 \cdot 2} = \cancel{9}\ 40{,}5\ mW$$

Csak egyenletekkel a legegyszerűbb:
(2 karakterisztika + 2 lezárás)

$$i_1 = 0{,}2\,u_1 + 0{,}9 \cdot i_2$$
$$u_2 = -0{,}9\,u_1 + 2 \cdot i_2$$
$$u_1 = U_0$$
$$u_2 = -i_2 \cdot R_t$$

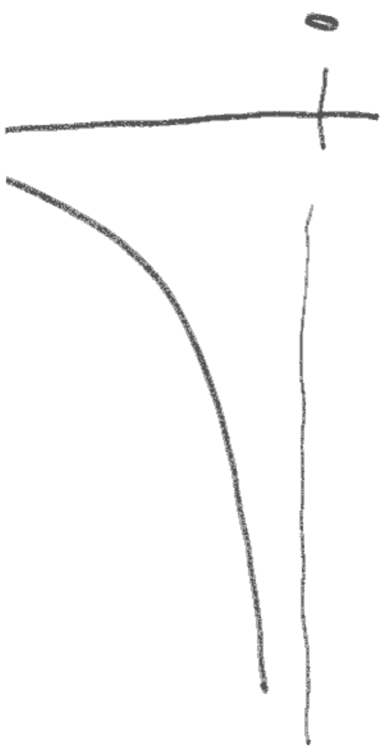
$R_t = 2\ k\Omega$ esetén ill. $R_t = 1\ k\Omega$, $R_t = 10\ k\Omega$

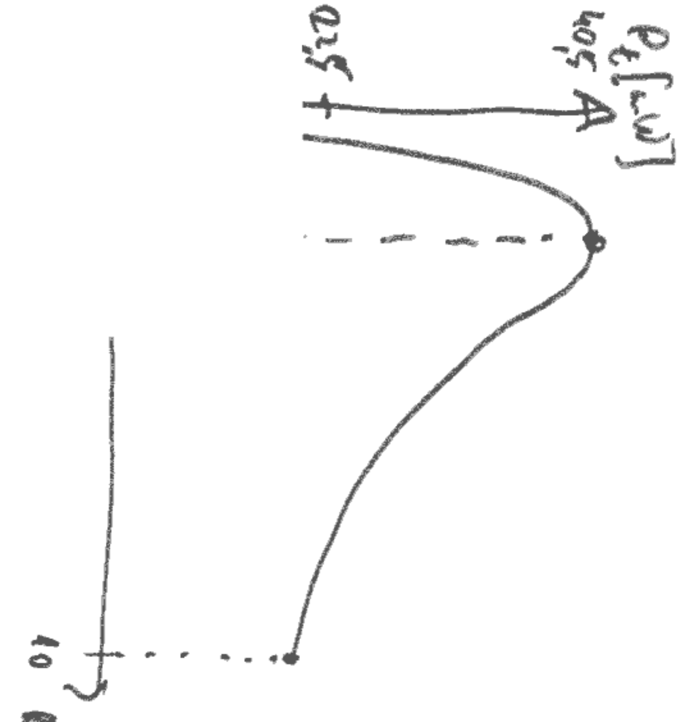
2019 tavasz /06/ ~~kétkap~~ lezartketkapuk.m

i_t	-4,5	-6	-15	[mA]
R_t	2	1	10	[kΩ]
P_t	40,5	36	22,5	[mW]

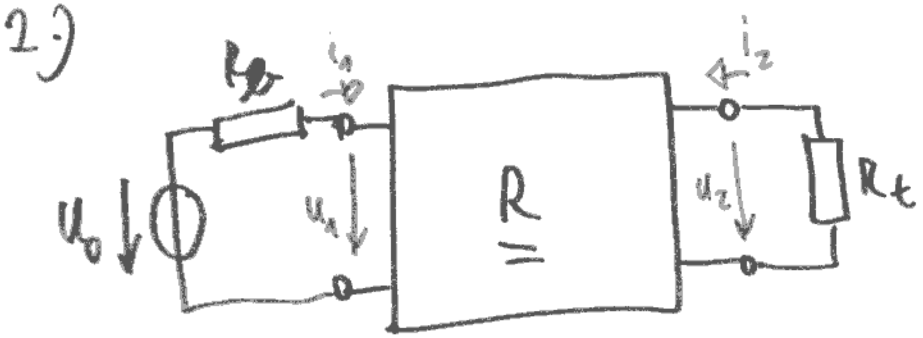
$$
\begin{array}{cccc} u_1 & i_1 & u_2 & i_2 \end{array}
$$

$$
\begin{pmatrix} 0{,}2 & -1 & 0 & 0{,}9 \\ -0{,}9 & 0 & -1 & 2 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & R_t \end{pmatrix}
\begin{pmatrix} u_1 \\ i_1 \\ u_2 \\ i_2 \end{pmatrix}
=
\begin{pmatrix} 0 \\ 0 \\ U_r \\ 0 \end{pmatrix}
$$



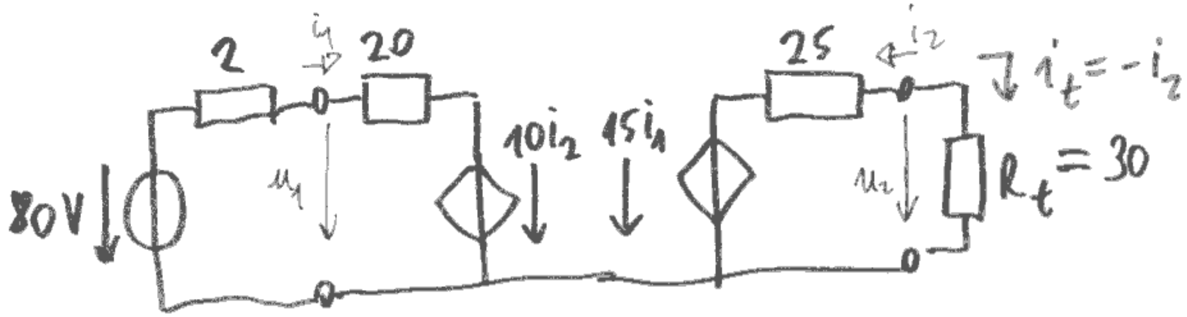


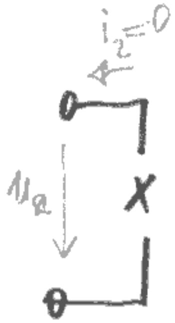
2.)



$$\underline{R} = \begin{pmatrix} 20 & 10 \\ 15 & 25 \end{pmatrix} k\Omega$$

V, kΩ, mA, mW





$$i_1 = \frac{80}{22} = 3{,}6364 \text{ mA}$$

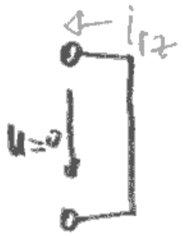
$$\boxed{U_{sz} = 15 \cdot i_1 = 54{,}545 \text{ V}}$$

$$i_1 = \frac{80 - 10 i_2}{2+20} \qquad 22 i_1 + 10 i_2 = 80$$

$$i_2 = -\frac{15 i_1}{25+30} \qquad 15 i_1 + 55 i_2 = 0$$

$$i_1 = 4{,}1509 \text{ mA}$$

$$i_2 = -1{,}1321 \text{ mA}$$



$$i_2 = i_{rz} = \frac{-15 i_1}{25}$$

$$\Rightarrow \boxed{i_2 = -3 \text{ mA} = i_{rz}}$$

$$\boxed{i_t = -i_2 = \underline{1{,}1321 \text{ mA}}}$$

$$R_B = \frac{U_{sz}}{-i_{rz}} = \frac{54{,}545}{-(-3)} = \underline{\underline{18{,}182 \text{ k}\Omega}}$$

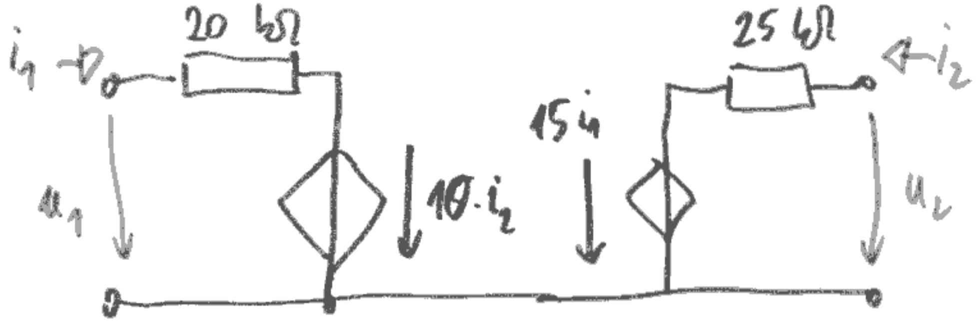
$$P_t = i_t^2 \cdot R_t = \underline{\underline{38{,}4495 \text{ mW}}}$$

$$P_{max} = \frac{U_{sz}^2}{4 \cdot R_B} = 40{,}908 \text{ mW}$$

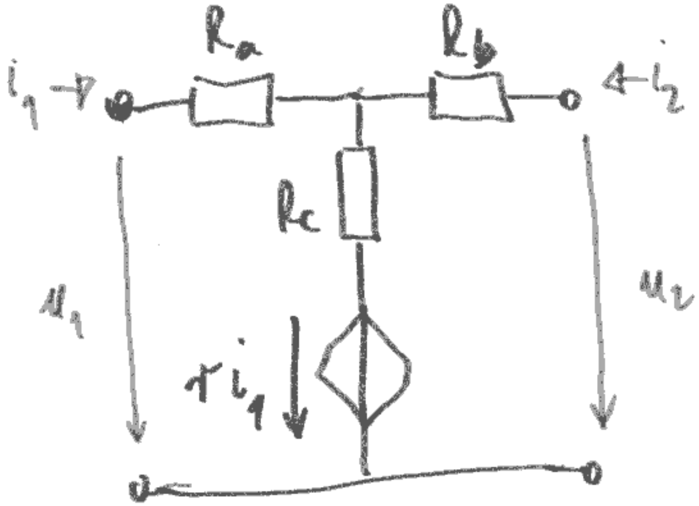
$$\Delta P = P_{max} - P_t = \underline{\underline{2{,}4585 \text{ mW}}}$$

[illegible] helyettesítő kapcsolás az $\underline{\underline{R}}$-rel adott kétkapuhoz!

pl. természetes helyettesítő kapcsolás



vagy hibrid T-helyettesítő



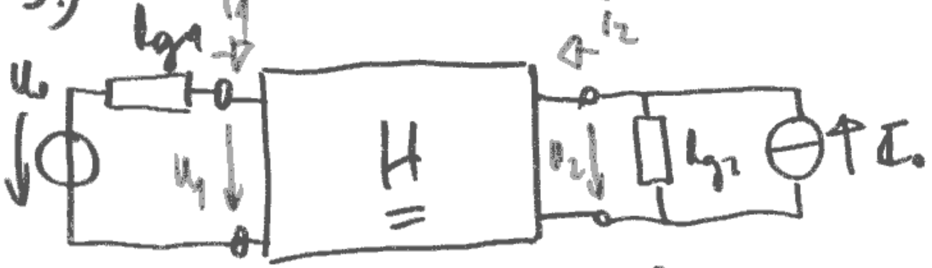
Ennek kiszámítása lehet pl. hurokáramokkal

$$\left.\begin{aligned} i_1 \cdot R_a + (i_1 + i_2) R_c + r i_1 - u_1 &= 0 \\ i_2 R_b + (i_1 + i_2) R_c + r i_1 - u_2 &= 0 \end{aligned}\right\}$$

$$\left.\begin{aligned} u_1 &= (R_a + R_c + r)\, i_1 + R_c i_2 \\ u_2 &= (r + R_c)\, i_1 + (R_b + R_c)\, i_2 \end{aligned}\right\}$$

$$\left.\begin{aligned} R_a + R_c + r &= R_{11} \\ R_c &= R_{12} \\ r + R_c &= R_{21} \\ R_b + R_c &= R_{22} \end{aligned}\right\} \Rightarrow \begin{aligned} R_a &= R_{11} - R_{21} = 5\ \text{k}\Omega \\ R_b &= R_{22} - R_{12} = 15\ \text{k}\Omega \\ R_c &= R_{12} = 10\ \text{k}\Omega \\ r &= R_{21} - R_{12} = 5\ \text{k}\Omega \end{aligned}$$

3.)



$$\underline{\underline{H}} = \begin{pmatrix} 2k\Omega & 0{,}9 \\ -0{,}7 & 0{,}4\,mS \end{pmatrix}$$

matematikai megközelítés
(karakterisztika + leírás)

(1) $u_1 = 2 \cdot i_1 + 0{,}9 \cdot u_2$

(2) $i_2 = -0{,}7\, i_1 + 0{,}4 \cdot u_2$

(3) $U_0 - i_1 \cdot R_{g1} = u_1$ →

$20 - i_1 \cdot 10 = u_1$

(4) $i_2 = I_0 + R_{g2}^{-1} \cdot (-u_2)$ →

$i_2 = 0{,}2 - \left(\frac{1}{8}\right) u_2$

rendezve

$$\left.\begin{aligned} u_1 - 2i_1 - 0{,}9\,u_2 &= 0 \\ 0{,}7\,i_1 - 0{,}4\,u_2 + i_2 &= 0 \\ u_1 + 10\,i_1 &= 20 \\ 8u_2 + i_2 &= 0{,}2 \end{aligned}\right\}$$

$$\begin{array}{cccc} u_1 & i_1 & u_2 & i_2 \end{array}$$

$$\begin{pmatrix} 1 & -2 & -0{,}9 & 0 \\ 0 & 0{,}7 & -0{,}4 & 1 \\ 1 & 10 & 0 & 0 \\ 0 & 0 & 1/8 & 1 \end{pmatrix} \begin{pmatrix} u_1 \\ i_1 \\ u_2 \\ i_2 \end{pmatrix} = \begin{pmatrix} 0 \\ [illegible] \\ 20 \\ 0{,}2 \end{pmatrix}$$

$$\begin{pmatrix} u_1 \\ i_1 \\ u_2 \\ i_2 \end{pmatrix} = \cancel{\begin{pmatrix} 3{,}4546\ V \\ 1{,}6545\ mA \\ 0{,}1617\ V \\ -1{,}0935\ mA \end{pmatrix}} \begin{pmatrix} 5{,}1082\ V \\ 1{,}4892\ mA \\ 2{,}3665\ V \\ -0{,}0958\ mA \end{pmatrix}$$

$\cancel{P_{u0} = U_0 \cdot (-i_1) = -33{,}09\ mW}$

$\cancel{P_{I0} = (-u_2) \cdot I_0 = -0{,}0323}$

~~Kétkapu teljesítménye~~:

$\cancel{u_1 i_1 + u_2 i_2 = 5{,}7158 + (-0{,}1768) = 5{,}5390\ mW}$

$\cancel{P_{Rg1} = i_1^2 \cdot R_{g1} = 27{,}375\ mW}$ $\quad P_{Rg2} = (-u_2)^2 / R_{g2} =$

$$\left.\begin{aligned} u_1 &= U_0 - i_1 R_g = 2 i_1 + \alpha u_2 \\ i_2 &= I_0 - \frac{u_2}{R_b} = \beta i_1 + 0{,}4\, u_2 \end{aligned}\right\}$$

$$\boxed{\left.\begin{aligned} (2+R_g)\, i_1 + \alpha\, u_2 &= U_0 \\ \beta\, i_1 + \left(0{,}4 + \frac{1}{R_b}\right) u_2 &= I_0 \end{aligned}\right\}}$$

$$i_1 = \frac{\begin{vmatrix} U_0 & \alpha \\ I_0 & 0{,}4 + 1/R_b \end{vmatrix}}{\begin{vmatrix} 2+R_g & \alpha \\ \beta & 0{,}4 + \frac{1}{R_b} \end{vmatrix}} = \frac{U_0\left(0{,}4 + \frac{1}{R_b}\right) - \alpha I_0}{\Delta \underline{\underline{A}}}$$

ahol $\Delta \underline{\underline{A}} = (2+R_g)(0{,}4 + G_b) - \alpha\beta = 6{,}3 - \alpha\beta$

I_0 $0{,}2$

[illegible] I_0, ha $I_0\left(\beta U_0 - I_0(2+R_g)\right) = 0$

$$\beta U_0 = I_0 (2+R_g)$$

$$\beta = \frac{I_0}{U_0}(2+R_g) = \frac{0{,}2}{20}(2+10) = 0{,}12$$

$$u_2 = \frac{\begin{vmatrix} 2+R_g & U_0 \\ \beta & I_0 \end{vmatrix}}{\Delta \underline{\underline{A}}} = \frac{(2+R_g)I_0 - \beta U_0}{\Delta \underline{\underline{A}}}$$

$$P_{U0} = U_0 \cdot (-I_1) = \frac{-U_0^2 \cdot \left(0{,}4 + \frac{1}{R_b}\right) + \alpha U_0 I_0}{\Delta \underline{\underline{A}}}$$

>0 fogyaszt
<0 termel

$$P_{I0} = I_0 \cdot (-U_2) = \frac{\beta U_0 I_0 - I_0^2 (2+R_g)}{\Delta \underline{\underline{A}}}$$

nonenergikus U_0, ha $U_0\left(\alpha I_0 - U_0\left(0{,}4 + G_b\right)\right) = 0$

$$\alpha I_0 = U_0(0{,}4 + G_b)$$

$$\alpha = \frac{U_0}{I_0}(0{,}4 + G_b) = \frac{20}{0{,}2}(0{,}4 + 0{,}125) = 52{,}5$$

nonenergikus I_0, ha $I_0\left(\beta U_0 - I_0(2+R_g)\right) = 0$

$$\beta U_0 = I_0(2+R_g)$$

$$\beta = \frac{I_0}{U_0}(2+R_g) = \frac{0{,}2}{20}(2+10) = 0{,}12$$

Tekintsük az alábbi $\underline{\underline{H}}$-t!

$$\underline{\underline{H}} = \begin{pmatrix} 2\,k\Omega & \alpha \\ \beta & 0{,}4\,mS \end{pmatrix}$$

Rajzoljuk fel az α-β síkon azt a tartományt (görbét) amelyen

- a kétkapu nonrecipkon
- mindkét forrás teret
- .. foggyont

$$P_{U0} = U_0 \cdot (-I_1) = -29{,}7835\ mW$$

$$P_{I0} = (-U_2)\, I_0 = -0{,}4733\ mW$$

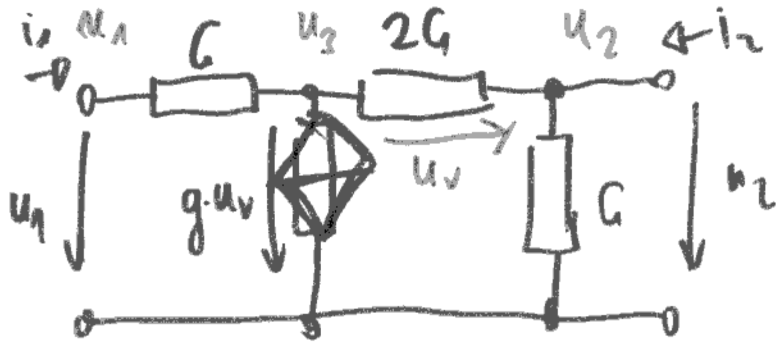
$$U_1 I_1 + U_2 I_2 = 7{,}6071 - 0{,}2267 = 7{,}3803\ mW$$

$$P_{Rg1} = i_1^2 R_{g1} = 22{,}1765\ mW$$

$$P_{Rg2} = \frac{(-U_2)^2}{R_{g2}} = 0{,}7\ mW$$

$u_1 = 2 i_1 + \alpha u_2$

4)



$$u_v = u_3 - u_2$$

$$\text{(2)}\quad G(u_3 - u_1) + g(u_3 - u_2) + 2G(u_3 - u_2) = 0$$

$$-i_1 + G \cdot (u_1 - u_3) = 0$$

$$-i_2 + G u_2 + 2G \cdot (u_2 - u_3) = 0$$

$$\text{(2)} \rightarrow u_3 (3G + g) = G u_1 + (2G + g) u_2$$

$$\boxed{u_3 = \frac{G}{3G+g} u_1 + \frac{2G+g}{3G+g} u_2}$$

$$i_1 = \left(G - \frac{G^2}{3G+g}\right) u_1 - G \cdot \frac{2G+g}{3G+g} u_2$$

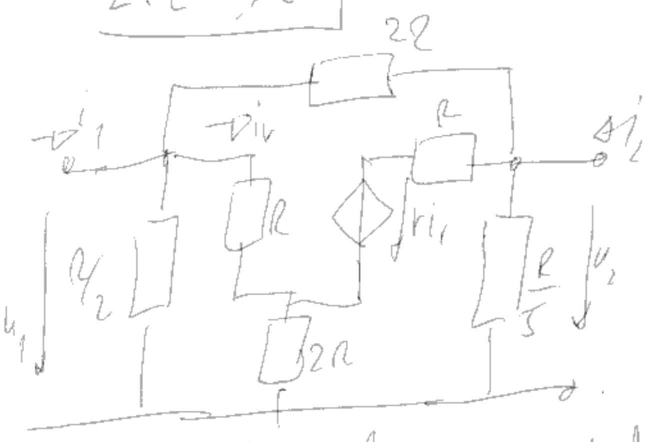
$$i_1 = \frac{2G^2 + gG}{3G+g} u_1 - \frac{2G^2 + gG}{3G+g} u_2$$

$$i_2 = -2G \cdot \frac{G}{3G+g} u_1 + \left(3G - 2G \cdot \frac{2G+g}{3G+g}\right) u_2$$

$$\boxed{i_2 = \frac{-2G^2}{3G+g} u_1 + \frac{5G^2 + gG}{3G+g} u_2}$$

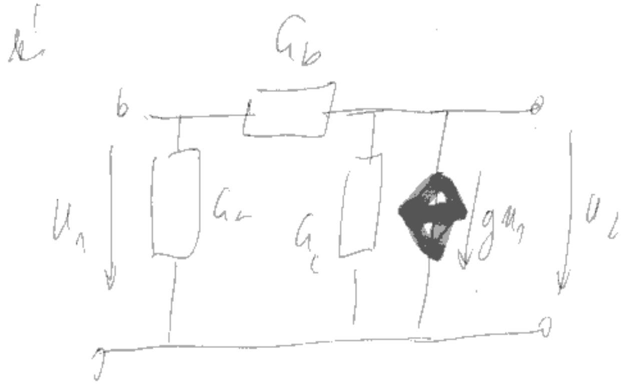
$$G_{11} = -G_{12} ;$$

2.2-28 $\quad r = 2R$



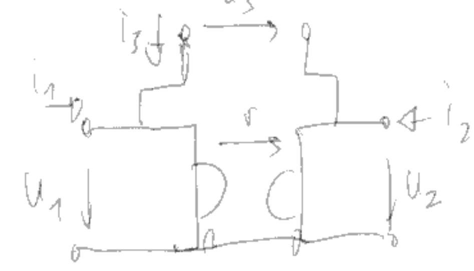
valamely karakterisztikáját

Ki!



a Π-típusú helyettesítés paramétereit!

NIC!



2.2-7a

Milyen kétkapu eredménye az 1:n áttételű IT és r girációs rezisztenciájú girátor láncolása, ha

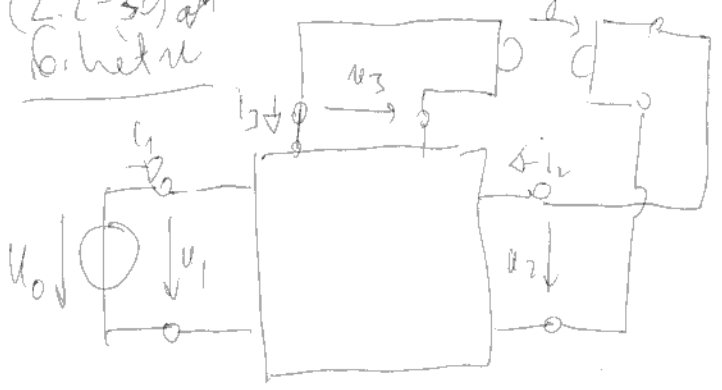
a) IT–girátor

b) girátor–IT

a sorrend?

(2.2-30)a

Kiinduló



U_0, g adott valamint a kétkapu hibrid karakterisztikája

$$i_1 = -G u_2 + i_3; \quad i_2 = G u_1 + i_3; \quad u_3 = u_1 + u_2;$$

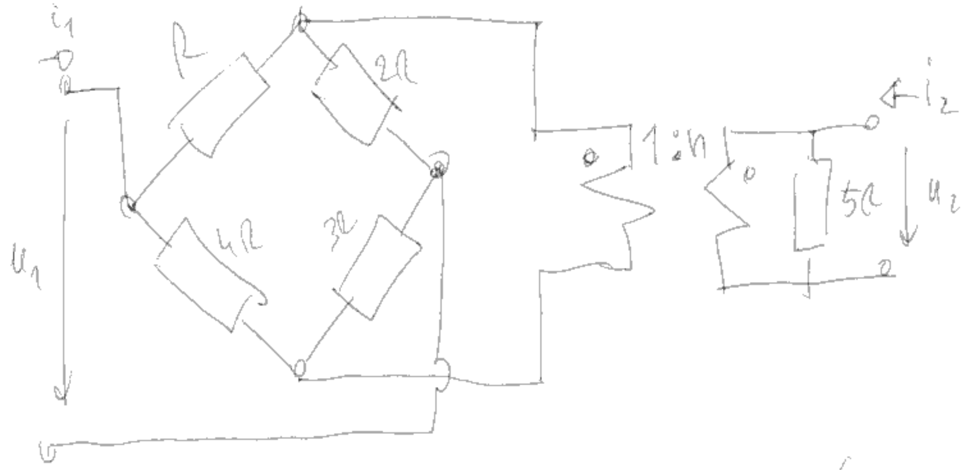
$$\begin{pmatrix} i_1 \\ i_2 \\ u_3 \end{pmatrix} = \begin{pmatrix} 0 & -G & 1 \\ G & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ i_3 \end{pmatrix}$$

$u_2 = ?$

$u_3 = ?$

a forráshoz kapcsolódó kétpólus eredő rezisztenciáját!

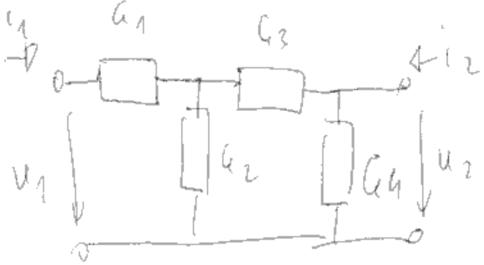
2.2-6.



· Helyettesítő T és Π-tag paraméterei

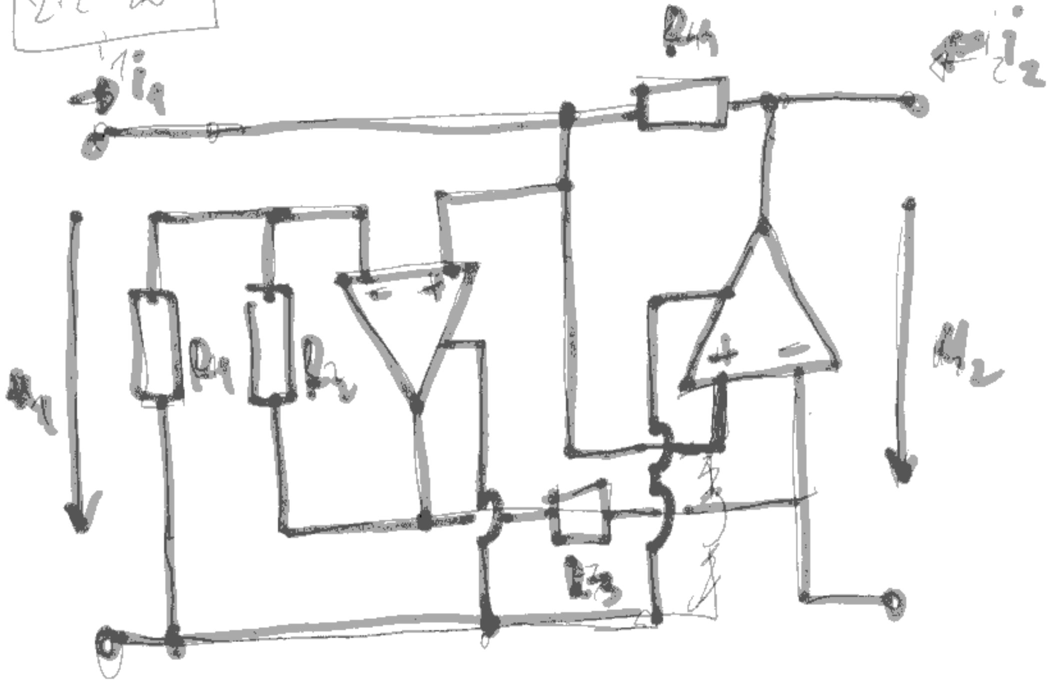
· Mikor szimmetrikus?

2.2-4*



Hogy válasszuk meg G_1, G_2, G_3, G_4 értékét hogy a kétkapu karakterisztikája megegyezzen egy 1:n áttételű ideális transzformátoréval?

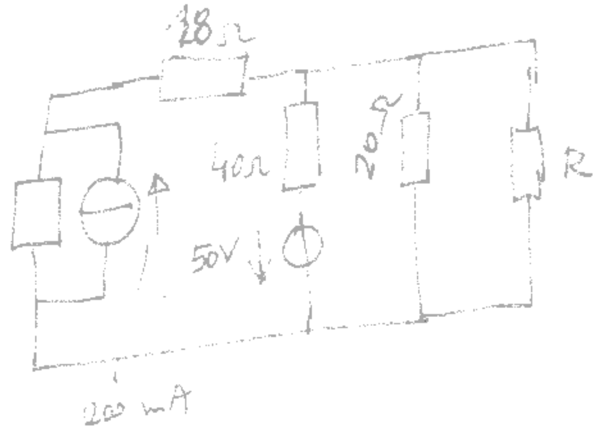
2.2-20



· impedancia karakterisztika

· $R_3R_1 = R_2R_4$ esetén mit realizál

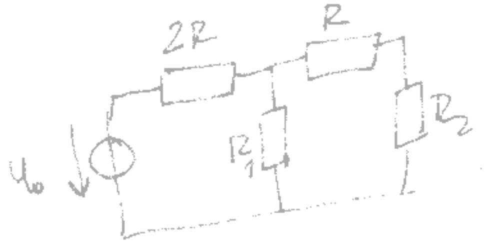
7.)



R = ? hogy $P = P_{max}$ = ? legyen

(teljesítményillesztés!)

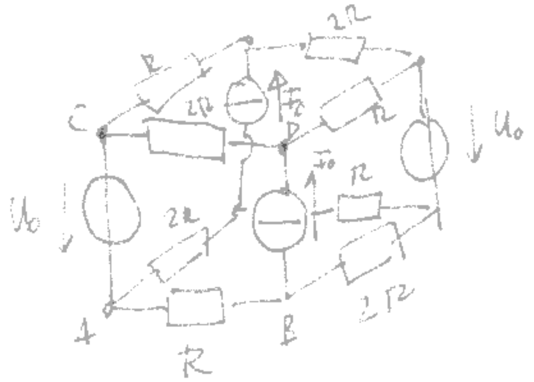
8.)



U_0, R adott értékek

Határozzuk meg hogy R_1 és R_2 értékét, hogy mindkettőn maximális teljesítmény legyen!

9.)*



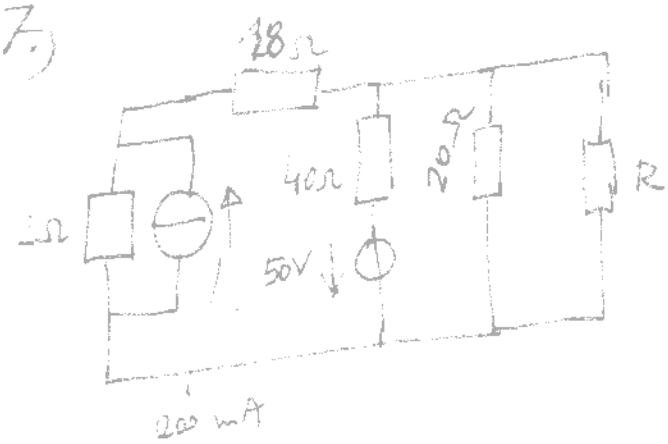
A kocka függőleges élei helyett felváltva U_0 feszültségforrást illetve I_0 áramforrást helyezünk.

A vízszintes éleket rendre R ill. 2R ellenállásokkal helyettesítjük.

Számítsuk ki a Thevenin helyettesítő képet az A–B illetve a C–D póluspárokra!

Határozzuk meg a Norton-hk. paramétereit az AD illetve BC kétpólusokra!

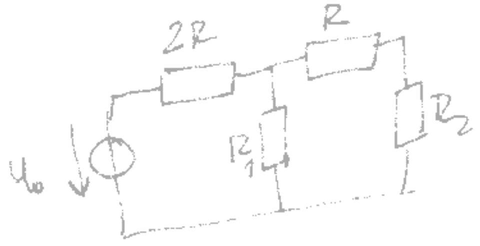
7.)



$R=?$ hogy $P=P_{max}=?$ legyen

(teljesítményillesztés!)

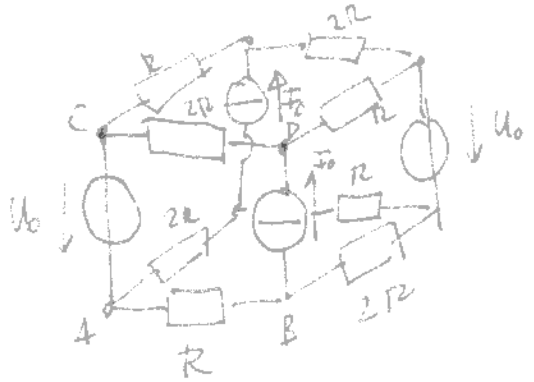
8.)



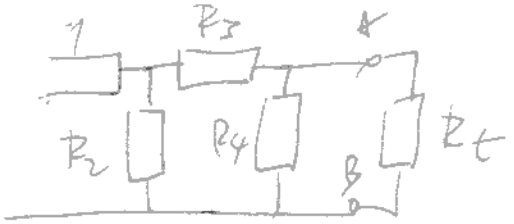
U_0, R adott értékek

Határozzuk meg hogy R_1 és R_2 értékét, hogy mindkettőn maximális teljesítmény legyen!

9.)*



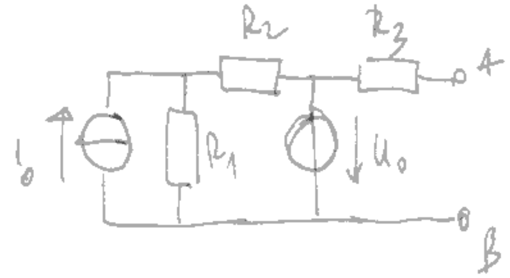
A kocka függőleges élei helyett felváltva U_0 feszültségforrást illetve I_0 áramforrást helyezünk. A vízszintes éleket rendre R ill. 2R ellenállásokkal helyettesítjük. Számítsuk ki a Thevenin helyettesítő képet az A-B illetve a C-D póluspárokra! Határozzuk meg a Norton-hk. paramétereit az AD illetve BC kétpólusokra!



$R_1 = R_3 = 10\Omega$

$R_2 = 20\Omega$ $U_0 = 10V$

$R_4 = 25\Omega$

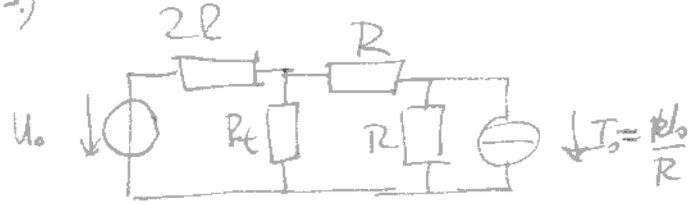


$R_1 = 10\ k\Omega$

$R_2 = 20k\Omega$; $R_3 = 5\ k\Omega$

$I_0 = 10\ mA$ $U_0 = 10V$

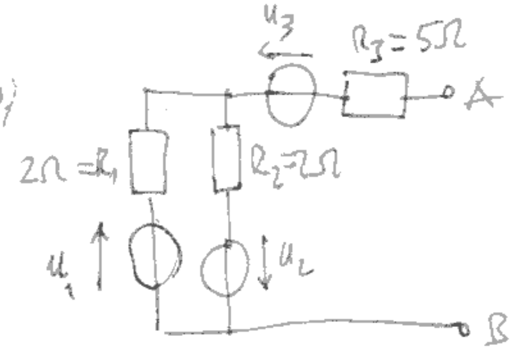
3.)



$R = 50\Omega$

$U_0 = 9V$

4.)

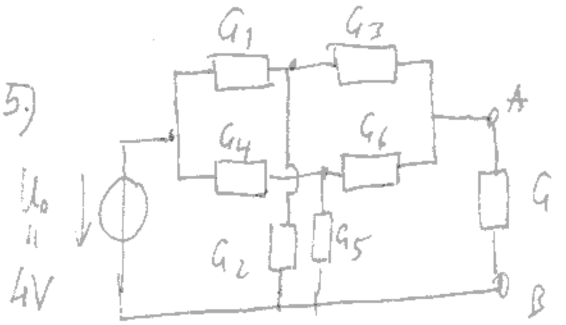


a) $U_1(t) = 5V$; $U_2(t) = 3V$; $U_3(t) = 3V$

b.) $U_1(t) = 5V$; $U_2(t) = 3\cdot\cos(\omega t)\ V$;

$U_3(t) = 3V$;

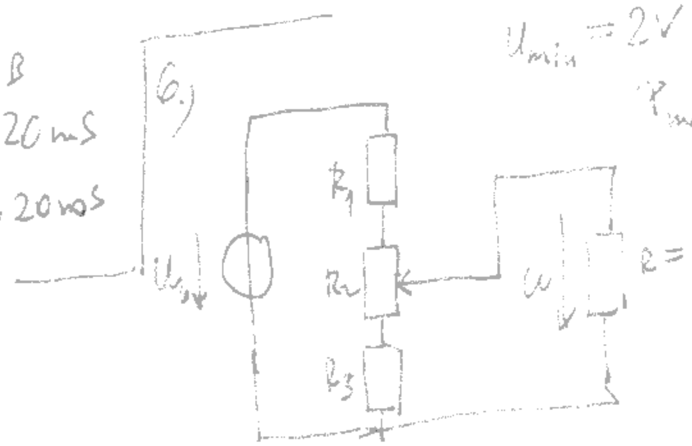
5.)



$G = ?$ $P_{max} = ?$

$G_1 = 50\ mS$; $G_2 = 30\ mS$; $G_3 = 120\ mS$

$G_4 = 50\ mS$; $G_5 = 30\ mS$; $G_6 = 20\ mS$



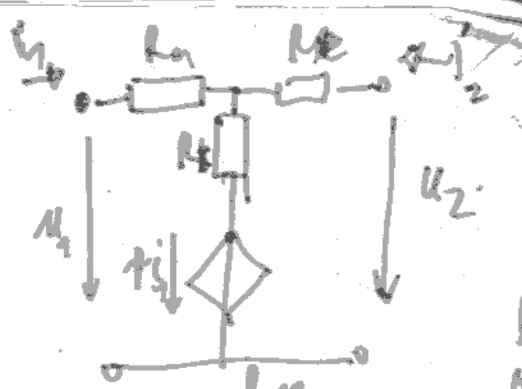
$U_{min} = 2V$; $U_{max} = 4V$

$P_{max} = 0{,}24W$

a forrásból!

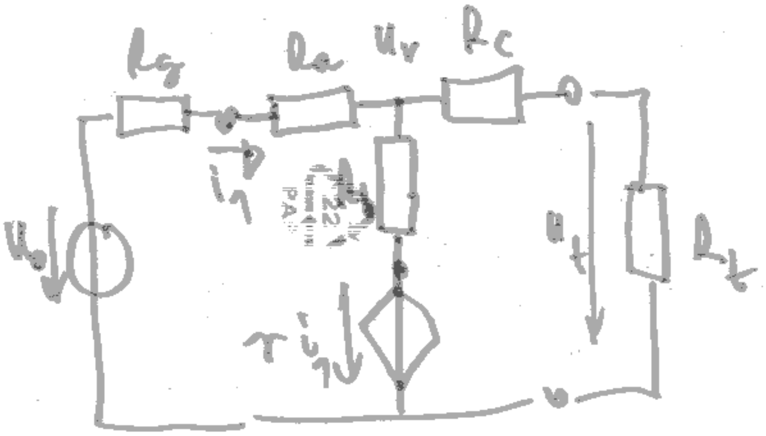
felvett teljesítmény

$R_1 = ?$ $R_2 = ?$ $R_3 = ?$

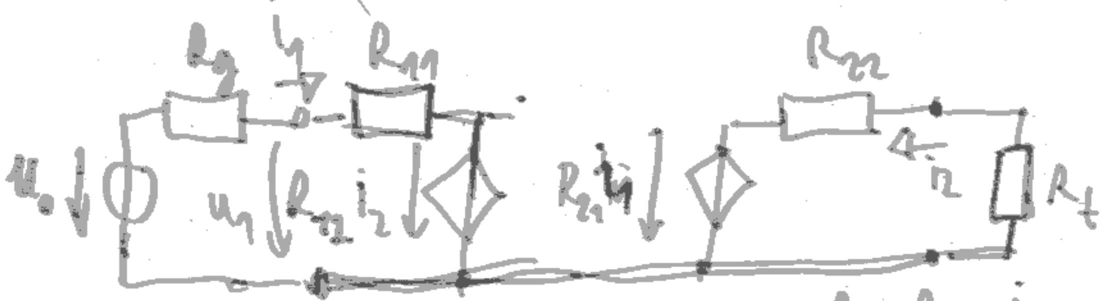


$$u_1 = i_1 \underbrace{(R_a + R_b + r)}_{R_{11}} + i_2 R_{\dots}$$

$$u_2 = \underbrace{(R_b + r)}_{=R_{21}} i_1 + i_2 \underbrace{(R_b + R_{\dots}}_{=R_{22}}$$



$$D \quad \left. \begin{aligned} &\frac{u_v - r \cdot i_1}{R_b} + \frac{u_v}{R_c + R_t} + \frac{u_v - u_0}{R_g + R_a} = 0 \\ &i_1 = \frac{u_0 - u_v}{R_g + R_a} \end{aligned} \right\}$$

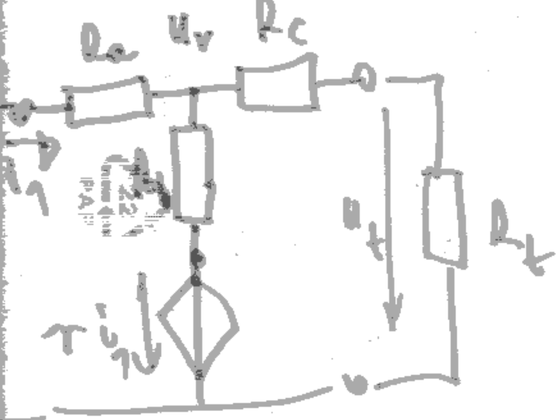


$$i_1 = \frac{U_0 - R_{12} \cdot i_2}{R_g + R_{11}} \qquad i_2 = \frac{0 - R_{21} \cdot i_1}{R_t + R_{22}}$$

$$i_1 (R_g + R_{11}) = U_0 - R_{12} \frac{-R_{21} i_1}{R_t + R_{22}}$$

$$U_0 = i_1 \left(R_g + R_{11} - \frac{R_{12} R_{21}}{R_t + R_{22}} \right) \rightarrow i_1 = \frac{U_0}{\dots}$$

$$u_t = (-i_2) R_t = \frac{R_t}{\dots} \dots$$



R_{12}

$$u_1 = i_1 \overbrace{(R_a + R_b + r)}^{R_{11}} + i_2 R_b$$

$$u_2 = \underbrace{(R_b + r)}_{=R_{21}} i_1 + i_2 \underbrace{(R_b + R_c)}_{=R_{22}}$$

$$D \quad \frac{u_v - r \cdot i_1}{R_b} + \frac{u_v}{R_c + R_t} + \frac{u_v - u_0}{R_g + R_a} = 0$$

$$i_1 = \frac{u_0 - u_v}{R_g + R_a}$$

$$i_2 = \frac{0 - R_{21} \cdot i_1}{R_t + R_{22}}$$

$$= \frac{U_0 - R_{12} \cdot i_2}{R_g + R_{11}}$$

$$i_1 (R_g + R_{11}) = U_0 - R_{12} \cdot \frac{-R_{21} i_1}{R_t + R_{22}}$$

$$= i_1 \left(R_g + R_{11} - \frac{R_{12} R_{21}}{R_t + R_{22}}\right) \longrightarrow i_1 = \frac{U_0}{\dots}$$

$$= (-i_2) R_t = \frac{R_t}{R_t + R_{22}} \cdot R_{21} \cdot i_1$$

terhelés esetén:

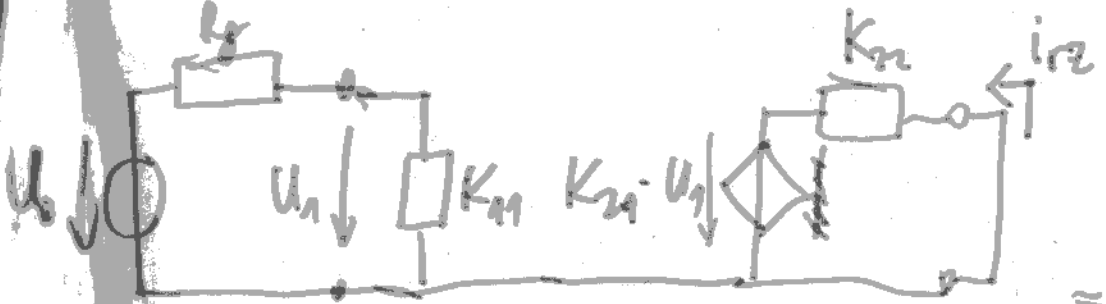
$$i_t = 0{,}7\,u_1 \cdot \frac{1}{R_{ki}+R_t} = \frac{0{,}7\,u_1}{2+3}$$

$$u_1 = \frac{1/0{,}9}{R_g + 1/0{,}9}\, u_0 = \frac{1/K_{11}}{R_g + 1/K_{11}}\, u_0 = \frac{10/9}{1/10 + 10/9}\, 10 = 10 \cdot \frac{10}{10 + 9/10} = \frac{100}{10{,}9}$$

szakadási feszültség

$$U_{sz} = K_{21} \cdot u_1 = K_{21} \cdot \frac{1/K_{11}}{1/K_{11} + R_g} \cdot u_0 = \frac{K_{21} \cdot u_0}{1 + R_g K_{11}}$$

rövidzárás

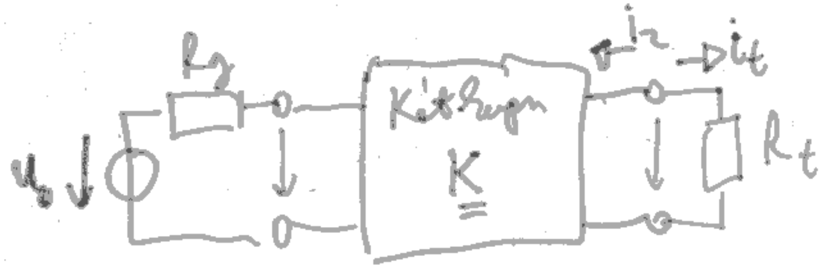


$$i_{rz} = -\frac{K_{21}\, u_1}{K_{22}} = -\frac{K_{21}}{K_{22}} \cdot \frac{1/K_{11}}{1/K_{11} + R_g}\, u_0 =$$

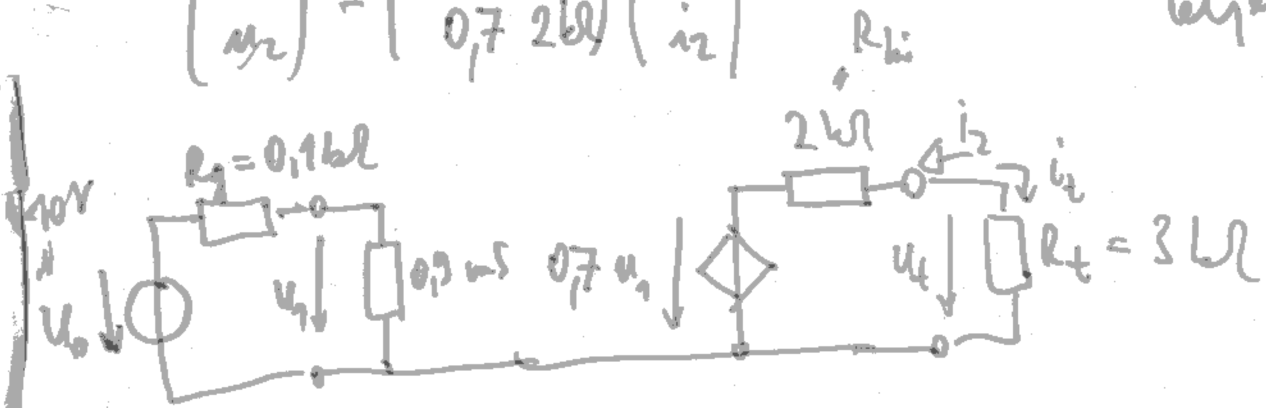
$$R_b = \frac{U_{sz}}{\ldots} = \frac{\frac{K_{21} u_0}{1+R_g K_{11}}}{\ldots} = -\frac{K_{21}\, u_0 / K_{22}}{\ldots}$$

Lezárt kétkapu

a) Határozzuk meg az R_t terhelő ellenállás áramát és maximális teljesítményét!



$$\begin{pmatrix} i_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} 0{,}9\,mS & 0 \\ 0{,}7 & 2\,k\Omega \end{pmatrix} \begin{pmatrix} u_1 \\ i_2 \end{pmatrix}$$

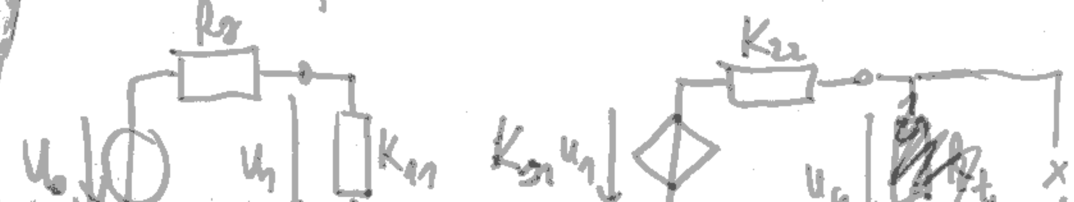


terhelés esetén:

$$i_t = 0{,}7\,u_1 \cdot \frac{1}{R_{ki}+R_t} = \frac{0{,}7\,u_1}{\cancel{R_{ki}}\,2+3}$$

$$u_1 = \frac{1/0{,}9}{R_g + 1/0{,}9} \cdot U_0 = \frac{1/K_{11}}{R_g + 1/K_{11}} U_0 = \frac{10/9}{1/10 + 10/9}\,10 = 10 \cdot \frac{10}{10 + 9/10} = \frac{100}{10{,}9}$$

szakadási feszültség



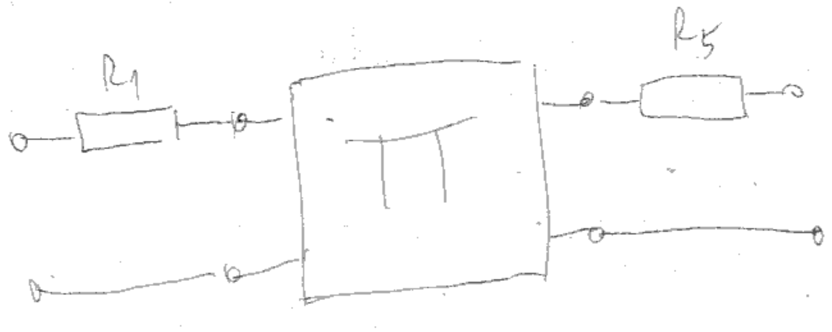
①

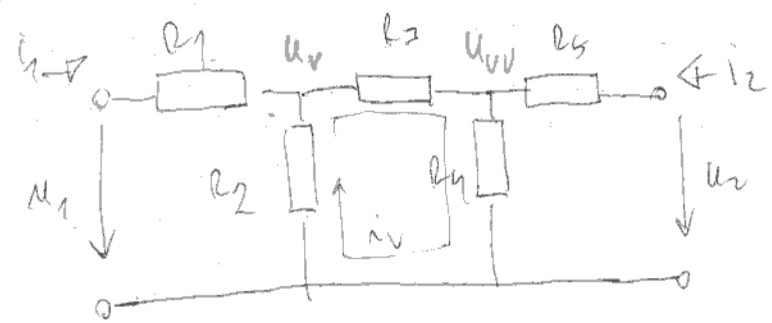
$$\left.\begin{aligned} & i_1 R_1 + R_2(i_1 - i_v) - u_1 = 0 \\ & i_2 R_5 + R_4(i_2 + i_v) - u_2 = 0 \\ & R_3 i_v + R_4(i_v + i_2) + R_2(i_v - i_1) = 0 \end{aligned}\right\}$$

$$(R_2 + R_3 + R_4)\, i_v = i_1 R_2 - i_2 R_4$$

$$\boxed{i_v = \frac{i_1 R_2 - i_2 R_4}{R_2 + R_3 + R_4}}$$

$$\underline{R} = \begin{pmatrix} R_1(R_2+R_3+R_4) + R_2(R_3+R_4) & R_2 R_4 \\ R_2 R_4 & R_5(R_2+R_3+R_4) + R_4(R_2+R_3) \end{pmatrix} \cdot \frac{1}{R_2+R_3+R_4}$$





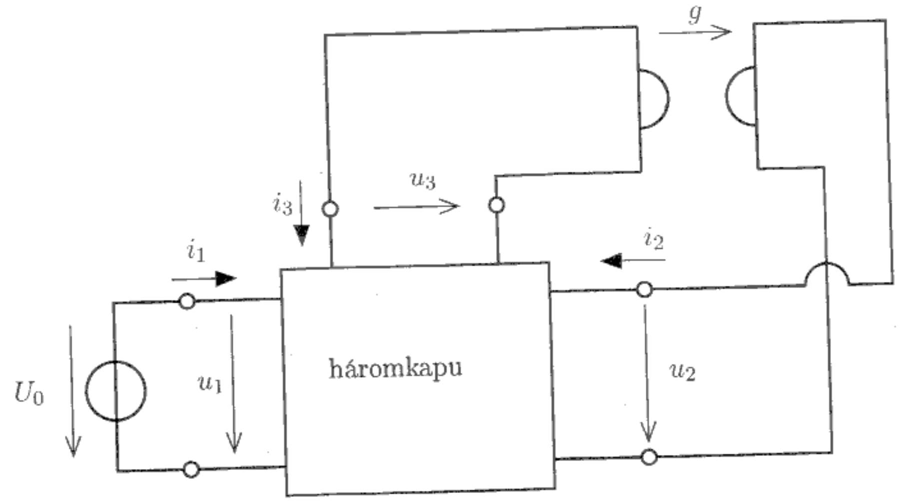
①

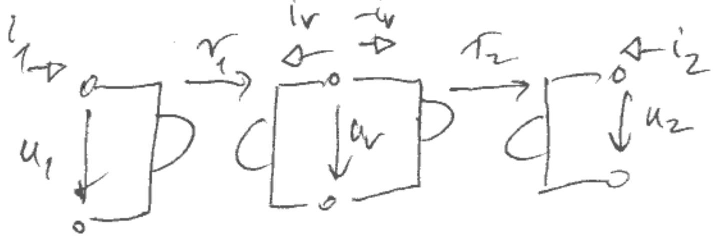
$$\left.\begin{aligned} &i_1 R_1 + R_2(i_1 - i_v) - u_1 = 0 \\ &i_2 R_5 + R_4(i_2 + i_v) - u_2 = 0 \\ &R_3 i_v + R_4(i_v + i_2) + R_2(i_v - i_1) = 0 \end{aligned}\right\}$$

$$(R_2 + R_3 + R_4)\, i_v = i_1 R_2 - i_2 R_4$$

$$\boxed{i_v = \frac{i_1 R_2 - i_2 R_4}{R_2 + R_3 + R_4}}$$

$$\underline{R} = \begin{pmatrix} R_1(R_2+R_3+R_4) + R_2(R_3+R_4) & R_2 R_4 \\ R_2 R_4 & R_5(R_2+R_3+R_4) + R_4(R_2+R_3) \end{pmatrix} \frac{1}{R_2+R_3+R_4}$$





$u_1 = -r_1 \cdot (i_v)$

$u_v = r_1 \cdot i_1$

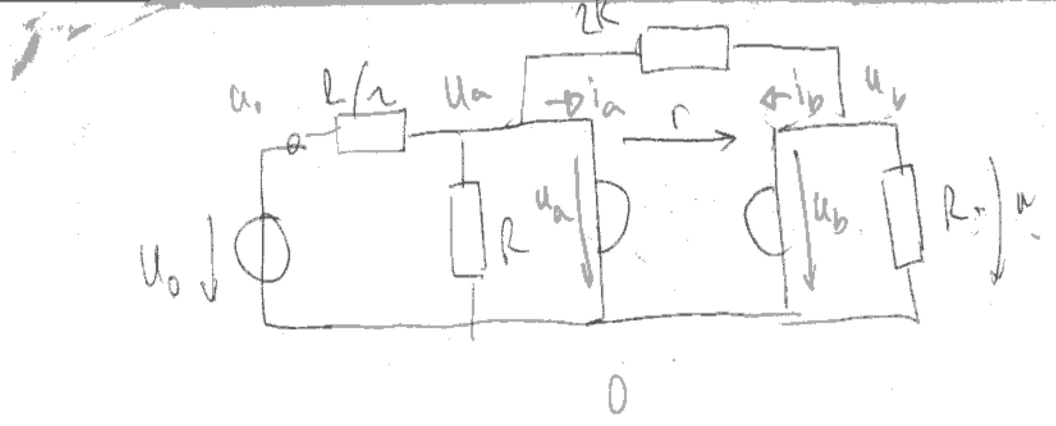
$u_v = -r_2 \cdot i_2$

$u_2 = r_2 \cdot (-i_v)$

$r_1 i_1 = -r_2 i_2$

$u_1 = r_1 \cdot \frac{u_2}{r_2} = \frac{\overbrace{r_1}^{n}}{r_2} u_2$

$i_2 = -\frac{r_1}{\underbrace{r_2}_{n}} i_1$



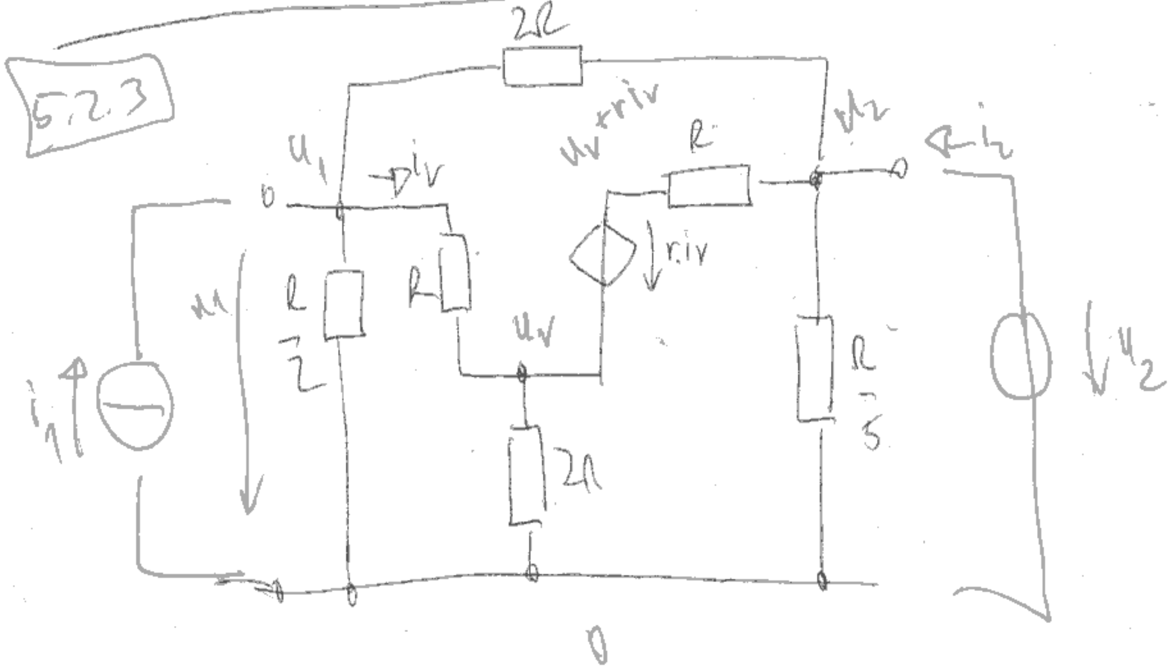
$U_0 = 1{,}5V$; $R = \ldots$

$r = R/3$; a) $u = ?$ $p = ?$

b) $P_{max} = ?$

$$\frac{U_a - U_0}{R/2} + \frac{U_a}{R} + I_a = 0$$

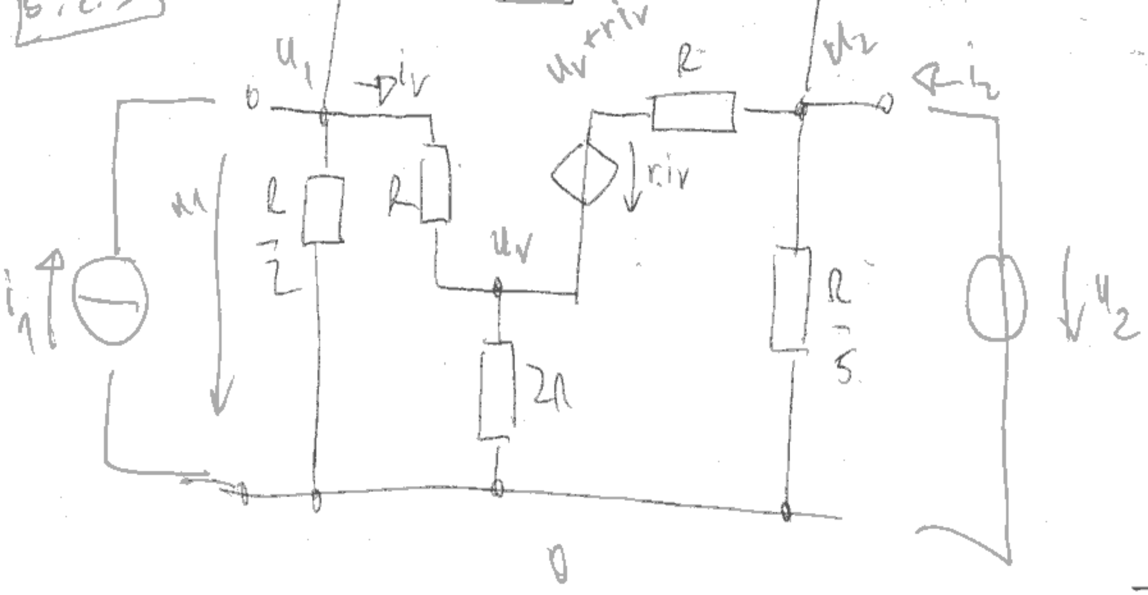
5.2.3



→ isnepoznate:

u_1, i_2, u_v, i_v

$$-i_1 + \frac{u_1}{R/2} + \frac{u_1 - u_v}{R} + \frac{u_1 - u_2}{2R} = 0 \quad (1)$$



→ ismeretlenek:
u_1, i_2, u_v, i_v

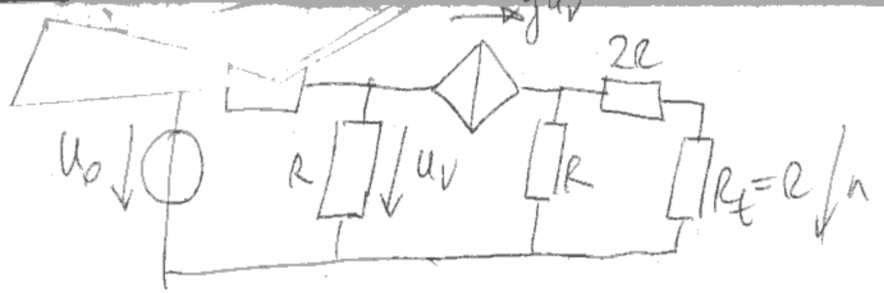
$$-i_1 + \frac{u_1}{R/2} + \frac{u_1 - u_v}{R} + \frac{u_1 - u_2}{2\Omega} = 0 \quad (1)$$

$$-i_2 + \frac{u_2}{R/5} + \frac{u_2 - (u_v + r i_v)}{R} + \frac{u_2 - u_1}{2\Omega} = 0 \quad (2)$$

$$\frac{u_v + r i_v - u_2}{R} + \frac{u_v}{2\Omega} + \frac{u_v - u_1}{R} = 0$$

$$i_v = \frac{u_1 - u_v}{R};$$

$u_1 \quad i_2 \quad u_v \quad i_v$



$gR = \frac{2}{R} \cdot R = 2$

$$① \quad \frac{U_V - U_0}{R} + \frac{U_V}{R} + gU_V = 0$$

$$② \quad -g \cdot U_V + \frac{U_1}{R} + \frac{U_1}{3R} = 0$$

$$(2U_V + gRU_V) = U_0$$

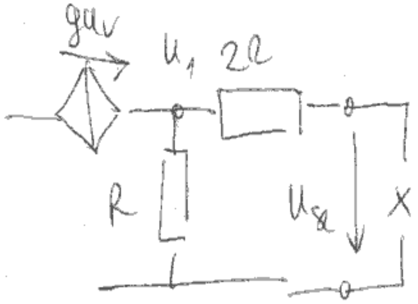
$$\boxed{U_V = \frac{U_0}{2+gR} = \frac{U_0}{4}}$$

$$U_1 \cdot 4 = 3gR\, U_V$$

$$\boxed{U_1 = \frac{3gR}{4} U_V = \frac{3 \cdot 2\, U_0}{4 \cdot 4} = \frac{3U_0}{8}}$$

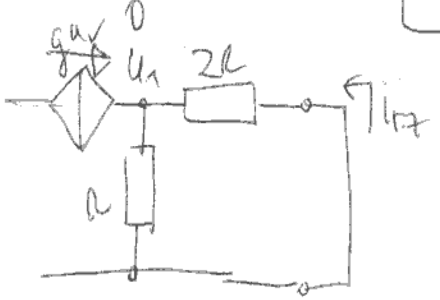
$$\boxed{U = \frac{U_1}{3} = \frac{U_0}{8}} = 1{,}125\ V$$

$$p = \frac{U^2}{R} = \boxed{0{,}6328\ mW}$$



$$② \to ②' \quad \frac{U_1}{R} - gU_V = 0$$

$$\boxed{U_T = U_1 = gR \cdot U_V = 2 \cdot \frac{U_0}{4} = \frac{U_0}{2}} = 4{,}5\ V$$

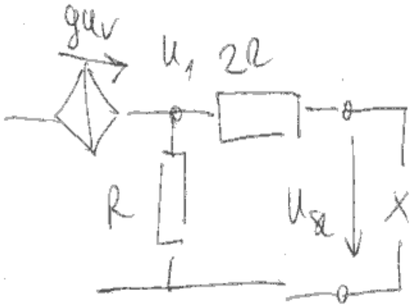


$$I_{KZ} \quad ② \to ②'' \quad \frac{U_1}{R} + \frac{U_1}{2R} - gU_V = 0$$

$$U_1 = \frac{gU_V}{3/2R} = \frac{2Rg\, U_V}{3} = \frac{2 \cdot 2 \cdot U_0/4}{3} = \frac{U_0}{3}$$

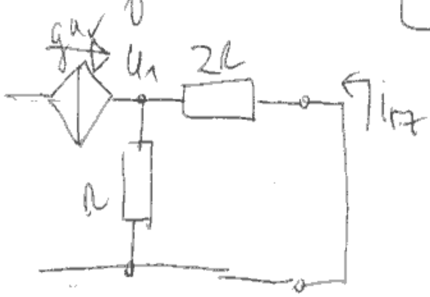
3 8

$P = \frac{U^2}{R} = \boxed{0{,}6328\,\mathrm{mW}}$



(2) → (2') $\quad \frac{U_1}{R} - gU_v = 0$

$\boxed{U_T = U_1 = gR\cdot U_v = 2\cdot\frac{U_0}{4} = \frac{U_0}{2}} = 4{,}5\,V$



i_{rz} (2) → (2') $\quad \frac{U_1}{R} + \frac{U_1}{2R} + -gU_v = 0$

$U_1 = \frac{gU_v}{3/2R} = \frac{2Rg\,U_v}{3} = \frac{2\cdot 2\cdot U_0/4}{3} = \frac{U_0}{3}$

$i_{rz} = -\frac{U_1}{2R} = -\frac{U_0}{6R} \simeq -0{,}75\,mA$

$\boxed{R_B = \frac{U_{sz}}{-i_{rz}} = \frac{4{,}5V}{-(-0{,}75)} = 6\,k\Omega} = 3R$ ✓

innen némi számolással

$$u_1 = \frac{R^2 10 - 4rR}{31R - 10r} i_1 + \frac{9R - 2r}{31R - 10r} u_2$$

$$i_2 = \frac{-9R}{31R - 10r} i_1 + \frac{181R - 55r}{R(31R - 10r)} u_2$$ 27,5

ha ebből admittancia karakterisztika

$$i_1 = \frac{31R - 10r}{2R(5R - 2r)} u_1 + \left(- \frac{9R - 2r}{2R(5R - 2r)} \right) u_2$$ 2,5

$$i_2 = - \frac{9}{(5R - 2r)2} u_1 + \frac{61R - 22r}{2R(5R - 2r)} u_2$$

$R = 2{,}5\ k\Omega \quad r = 2\Omega$

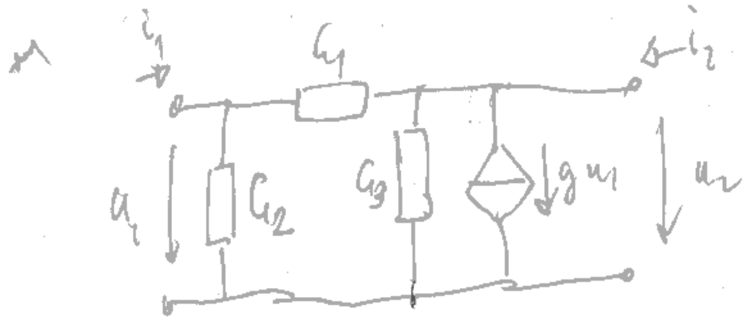
$$i_2 = - \frac{\dots}{(5R-2r)\,2}\, u_1 + \frac{\dots}{2R(5R-2r)}\, u_2$$

$R = 2{,}5\ \mathrm{k\Omega} \qquad r = 2R$

$$\underline{\underline{H}} = \begin{pmatrix} 0{,}4545\ \mathrm{k\Omega} & 0{,}4545\ \cancel{\mathrm{k\Omega}} \\ -0{,}8181 & \cancel{0{,}4545}\ 2{,}5818\ \mathrm{mS} \end{pmatrix}$$

$$\underline{\underline{G}} = \begin{pmatrix} 2{,}2\ \mathrm{mS} & -1\ \mathrm{mS} \\ -\cancel{0{,}72}\ 1{,}8\ \mathrm{mS} & 3{,}4\ \mathrm{mS} \end{pmatrix}$$

$$\underline{\underline{M}}^{-1} \cdot \underline{\underline{N}} = \begin{pmatrix} \boxed{\begin{matrix} 0{,}4545 & 0{,}4548 \\ -0{,}8182 & 2{,}5818 \end{matrix}} \\ \begin{matrix} -0{,}9091 & 1{,}0909 \\ 0{,}5455 & -0{,}2545 \end{matrix} \end{pmatrix} \qquad \underline{\underline{H}}$$



$$\left.\begin{aligned} -i_1 + G_2 u_1 + G_1(u_1 - u_2) &= 0 \\ G_1(u_2 - u_1) + G_3 \cdot u_2 + g\,u_1 &\overset{i_2}{=} 0 \end{aligned}\right\}$$

$$i_1 = (G_1 + G_2)\,u_1 - G_1 u_2$$

$$i_2 = (g - G_1)\,u_1 + (G_1 + G_3)\,u_2$$

$$\underline{\underline{G}} = \begin{pmatrix} 2{,}2 & -1 \\ -1{,}8 & 3{,}4 \end{pmatrix} \text{mS}$$

$$\left.\begin{aligned} G_1 + G_2 &= 2{,}2 \\ -G_1 &= -1 \\ g - G_1 &= -1{,}8 \\ G_1 + G_3 &= 3{,}4 \end{aligned}\right\}$$

$$\boxed{G_1 = 1 \text{ mS}}$$

$$\boxed{g = -1{,}8 + G_1 = -0{,}8 \text{ mS}}$$

$$\boxed{G_2 = 2{,}2 - G_1 = 1{,}2 \text{ mS}}$$

$$\boxed{G_3 = 3{,}4 - G_1 = 2{,}4 \text{ mS}}$$

Megoldás numerikus oldalról!

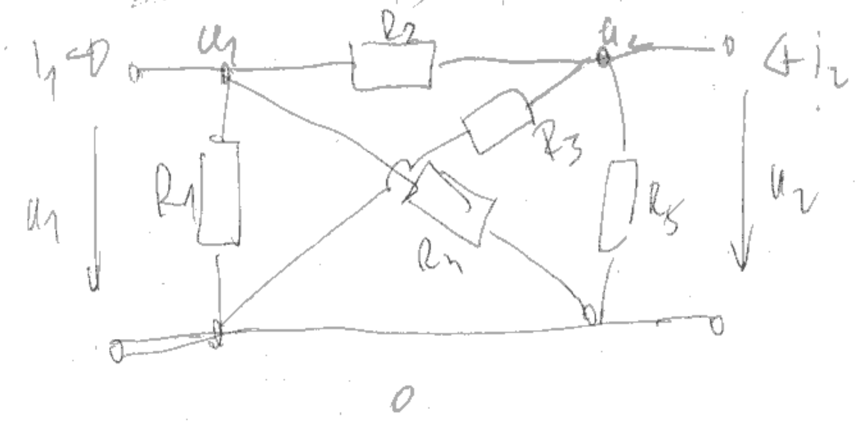
egyenleteket numerikus értékekkel írjuk fel

$$\underline{\underline{M}} \cdot \begin{pmatrix} u_1 \\ i_2 \\ u_v \\ i_v \end{pmatrix} = \underline{\underline{N}} \cdot \begin{pmatrix} i_1 \\ u_2 \end{pmatrix} \Rightarrow$$

$$\begin{array}{cccc} u_1 & i_2 & u_v & i_v \\ \end{array} \qquad\qquad\qquad\qquad \begin{array}{cc} i_1 & u_2 \end{array}$$

$$\begin{pmatrix} \frac{2}{R}+\frac{1}{R}+\frac{1}{2R} & 0 & -\frac{1}{R} & 0 \\ +\frac{1}{2R} & +1 & \frac{1}{R} & \frac{r}{R} \\ -\frac{1}{R} & 0 & \frac{1}{R}+\frac{1}{R}+\frac{1}{2R} & \frac{r}{R} \\ 1 & 0 & -1 & -R \end{pmatrix} \begin{pmatrix} u_1 \\ i_2 \\ u_v \\ i_v \end{pmatrix} = \begin{pmatrix} 1 & \frac{1}{2R} \\ 0 & \frac{1}{R}+\frac{1}{2R}+\frac{5}{R} \\ 0 & \frac{1}{R} \\ 0 & 0 \end{pmatrix} \begin{pmatrix} i_1 \\ u_2 \end{pmatrix}$$

$$\underline{\underline{M}}^{-1} \cdot \underline{\underline{N}} = \begin{pmatrix} \boxed{\begin{matrix} 0,4545 & 0,4545 \\ -0,8182 & 2,5818 \end{matrix}} \\ \begin{matrix} -0,9091 & 1,0909 \\ 0,5455 & -0,2545 \end{matrix} \end{pmatrix} \qquad \underline{\underline{H}}$$

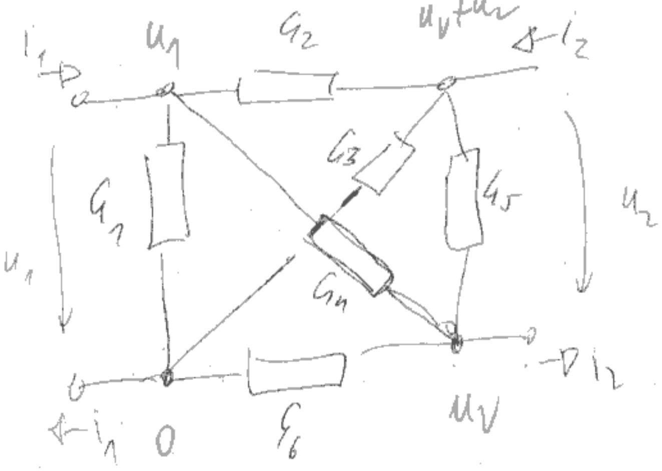


$$-i_1 + \frac{u_1}{R_1} + \frac{u_1-u_2}{R_2} + \frac{u_1}{R_4} = 0$$

$$-i_2 + \frac{u_2}{R_5} + \frac{u_2}{R_3} + \frac{u_2-u_1}{R_2} = 0$$

$$i_1 = \overbrace{(G_1+G_2+G_4)}^{G_a+G_b} u_1 \overbrace{-G_2}^{-G_b} u_2$$

$$i_2 = \underbrace{-G_2}_{-G_b} u_1 + \underbrace{(G_2+G_3+G_5)}_{G_c+G_b} u_2$$



$$-i_1 + G_1 u_1 + G_2(u_1-(u_V+u_2)) + G_4(u_1-u_V) = 0$$

$$-i_2 + G_2(u_V+u_2-u_1) + G_5 u_2 + G_3(u_V+u_2) = 0$$

$$i_2 + G_6 u_V + G_4(u_V-u_1) + G_5(-u_2) = 0$$

$i_1 = \frac{3u_1}{2} - \frac{u_2}{2}$; $i_2 = -\frac{u_1}{2} + \frac{3u_2}{2}$

$G_1 = G_5 = G_V = 1$

$G_* = G_6 = G_x = 0{,}5$

$$-i_2 + G_2(u_V + u_2 - u_1) + G_5 \cdot u_2 + G_3(u_V + u_2) = 0$$

$$i_2 + G_6 u_V + G_4(u_V - u_1) + G_5(-u_2) = 0$$

$G_1 = G_5 = G_V = 1$ $\quad G_3 = G_4 = G_x = 0{,}5$

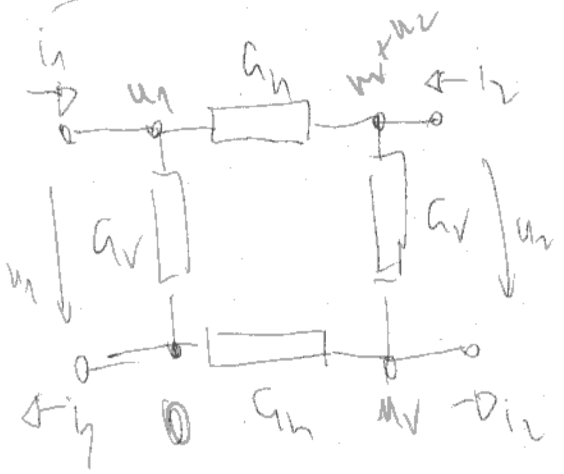
$G_2 = G_6 = G_h = 1$

$\cancel{i_1 = 2u_1}$

$i_1 = \frac{3u_1}{2} - \frac{u_2}{2}$; $i_2 = -\frac{u_1}{2} + \frac{3u_2}{2}$

$$\boxed{i_1 = \frac{7u_1}{4} - \frac{u_2}{4} \qquad i_2 = -\frac{u_1}{4} + \frac{7u_2}{4}}$$

ani reciproční je simetrick



① $-i_1 + u_1 \cdot G_V + G_h \cdot (u_1 - (u_V + u_2)) = 0$

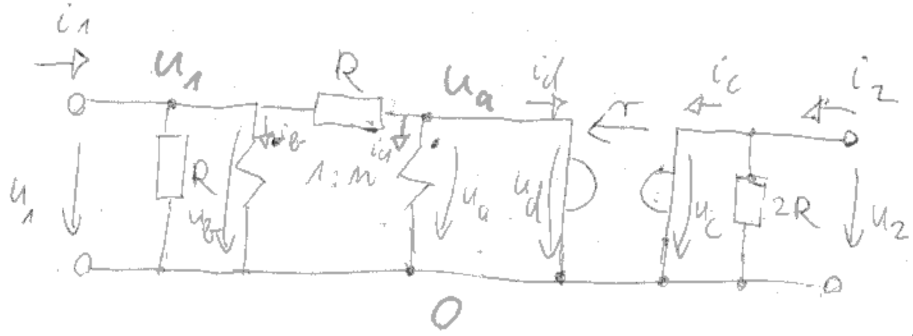
② $-i_2 + (u_V + u_2 - u_1) G_h + G_V(u_2) = 0$

③ $i_2 + G_h \cdot u_V + G_V \cdot (-u_2) = 0$

④ $i_1 + G_h \cdot (-u_V) + G_V \cdot (-u_1) = 0$

$$\left(\frac{G_n}{2} + G_v\right) u_1 - \frac{G_n}{2} \cdot u_2 = i_1$$

$$-\frac{G_n}{2} u_1 + \left(\frac{G_n}{2} + G_v\right) u_2 = i_2$$



$R = ?$

$u_1, u_2,$ u_a, u_b, u_c, u_d

i_a, i_b, i_c, i_d

$u_a = n \cdot u_1$

$i_b = -n \cdot i_a$

$u_a = r \cdot i_c$

$u_c = -r \cdot i_d$

$$-i_1 + \frac{u_1}{R} + i_b + \frac{u_1 - u_a}{R} = 0$$

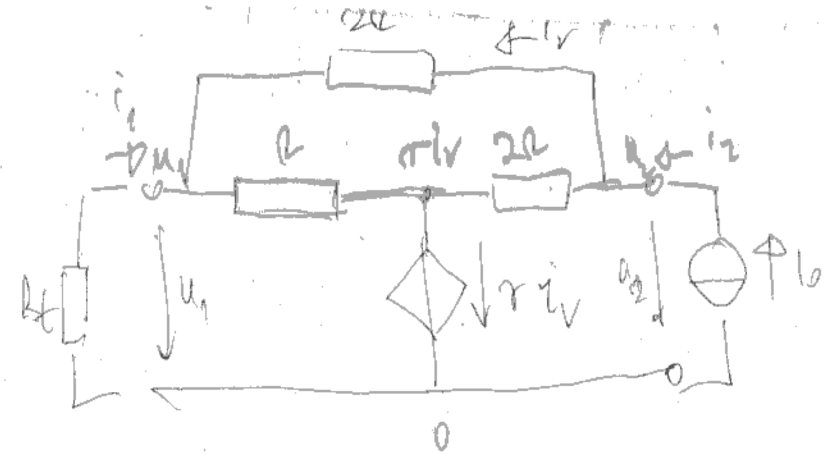
$$i_a \cancel{+} i_d + \frac{u_a - u_1}{R} = 0$$

$$-i_2 + i_c + \frac{u_2}{2R} = 0$$

$u_a = u_d$

$u_b = u_1$

$u_c = u_2$



$$2R \cdot i_2 = 2u_2 - u_1 - \frac{r}{2R} \cdot (u_2 - u_1)$$

$$2R \cdot i_2 = -\left(1 + \frac{r}{2R}\right) u_1 + \left(2 - \frac{r}{2R}\right) u_2$$

$$\boxed{i_2 = \frac{r - 2R}{4R^2} u_1 + \frac{4R - r}{4R^2} u_2}$$

$$2R\, i_1 = 3u_1 - u_2 - 2r \cdot \left(\frac{u_2 - u_1}{2R}\right) =$$

$$= \left(3 + \frac{r}{R}\right) u_1 - \left(1 + \frac{r}{R}\right) u_2$$

$$\boxed{i_1 = \frac{3R + r}{2R^2} u_1 - \frac{R + r}{2R^2} u_2}$$

① $i_v = \dfrac{u_2 - u_1}{2R}$

② $-i_2 + \dfrac{u_2 - r i_v}{2R} + \dfrac{u_2 - u_1}{2R} = 0$

③ $-i_1 + \dfrac{u_1 - r i_v}{R} + \dfrac{u_1 - u_2}{2R} = 0$

$$G_0 = \frac{1}{R}$$

$$\boxed{i_1 = \frac{G_0}{2}\left(3 + G_0 r\right) u_1 - \frac{G_0}{2}\left(1 + G_0 r\right) u_2}$$

$$\boxed{i_2 = -\frac{G_0}{4}\left(2 - G_0 r\right) u_1 + \frac{G_0}{4}\left(4 - G_0 r\right) u_2}$$

$$\left(\frac{\quad}{2R}\right) \qquad -\frac{G_0}{2}(1+G_0 r)u_2$$

$$=\left(3+\frac{r}{R}\right)u_1-\left(1+\frac{r}{R}\right)u_2$$

$$\boxed{i_1=\frac{3R+r}{2R^2}u_1-\frac{R+r}{2R^2}u_2}$$

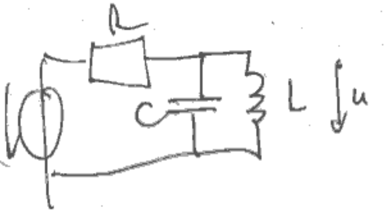
$$\boxed{i_2=-\frac{G_0}{4}(2-G_0 r)u_1+\frac{G_0}{4}(4-G_0 r)u_2}$$

reciprocal, ha $G_{12}=G_{21}$

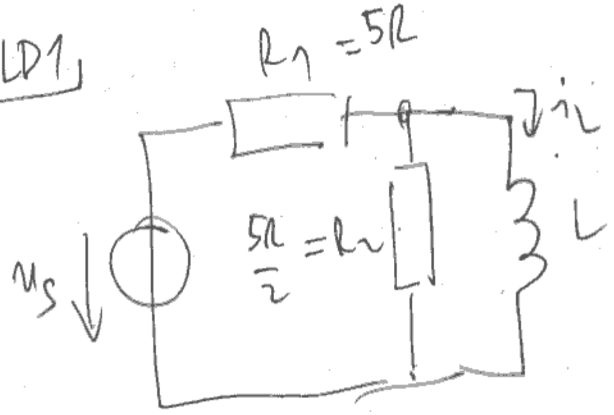
$$-\frac{G_0}{2}(1+G_0 r)=-\frac{G_0}{4}(2-G_0 r)$$

$$2+2G_0 r=2-G_0 r$$

$$\boxed{G_0 r=0}\Rightarrow\boxed{r=0}$$



PLD1



$$i_L + \frac{L i_L'}{R_2} + \frac{L i_L' - u_s}{R_1} = 0$$

$$R_1 R_2 i_L + (R_1+R_2) L i_L' = u_s R_2$$

$$i_L' = -\frac{R_1 R_2}{(R_1+R_2)L} i_L + \frac{R_2}{(R_1+R_2)L} u_s$$

$$\left.\begin{aligned} \frac{R_1R_2}{R_1+R_2} &= \frac{5R}{3} \\ \frac{R_2}{R_1+R_2} &= \frac{1}{3} \end{aligned}\right\}$$

$$\boxed{R_1 = \frac{5R}{3} : \frac{1}{3} = 5R}$$

$$3R_2 = R_1 + R_2$$

$$2R_2 = R_1 = 5R$$

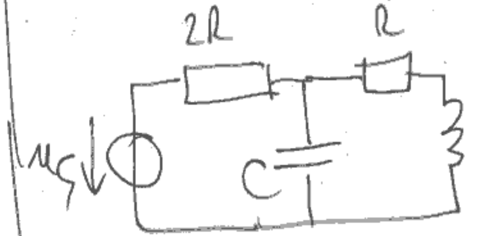
$$\boxed{R_2 = \frac{5R}{2}}$$

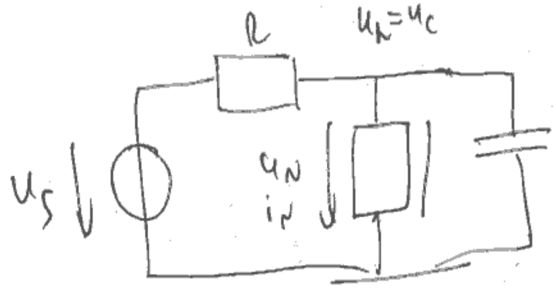
<M>/.../pld2.m

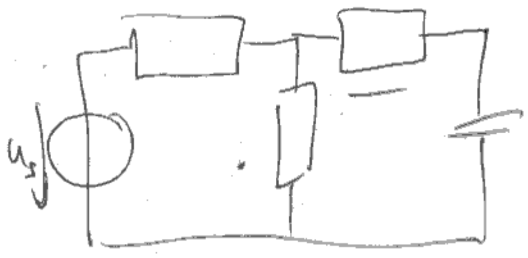
PLD2

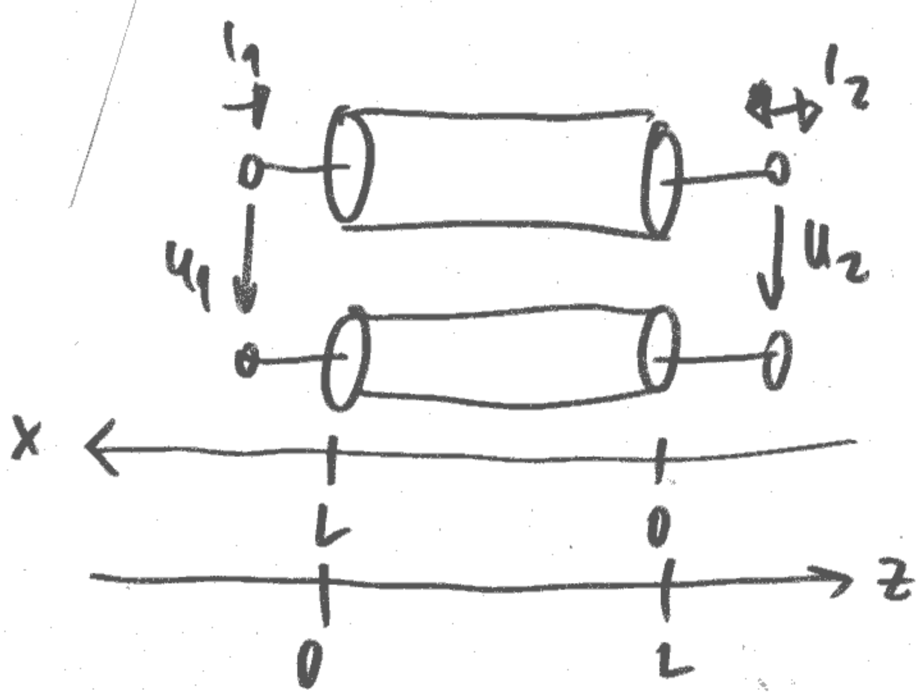
$$Cu' + \frac{u-u_s}{2R} + i$$

$$Li' = -Ri + u$$

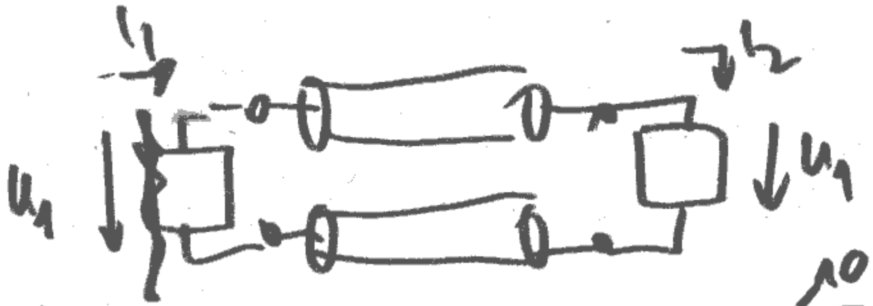




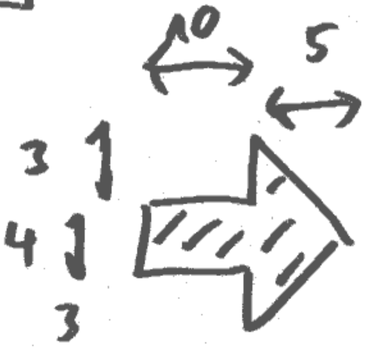




i_1
i_2
u_1
u_2
x
L
0
z
0
L

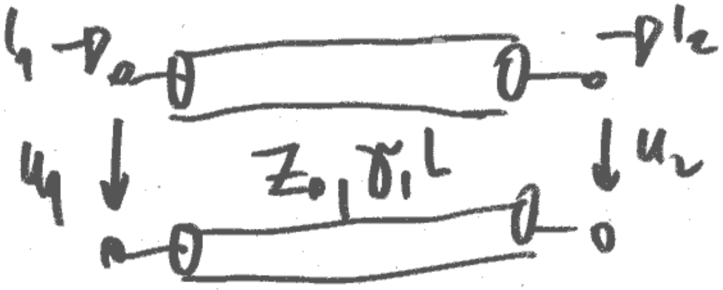


i_1
i_2
u_1
u_1

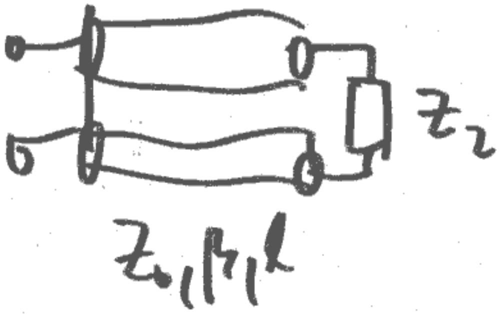


10
5
3
4
3

i_1
i_2
u_1
u_2
$\underline{\underline{A}}$



i_1
i_2
u_1
u_2
Z_0, γ, L



Z_2
Z_0, β, l

1.-2.

$$\boxed{i_L' = -\underbrace{\frac{2nR}{(3n^2+2n)L}}_{\frac{2R}{(3n+2)L}} i_L + \underbrace{\frac{2n^2}{(3n^2+2n)L}}_{\frac{2n}{(3n+2)L}} u_s}$$

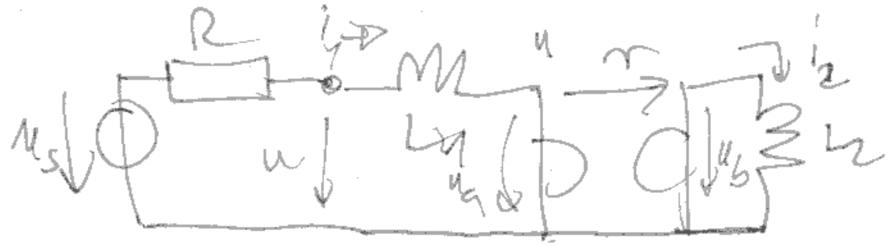
$$\boxed{u = -\frac{2nR}{3n+2} i_L + \frac{2n^2}{3n+2} u_s}$$

$$u = nL\cdot i_L'$$

$$i_1 = -\left(\frac{3u}{2R} - \frac{u_s}{R}\right) \quad + nLi_L'$$

$$-n^2R\left(-\frac{3}{2R} nLi_L' + \frac{u_s}{R}\right) + nRi_L = 0$$

$$\underbrace{\left(\frac{3n^2}{2}+n\right)}_{\frac{3n^2+2n}{2}} Li_L' = -nRi_L + n^2 u_s$$



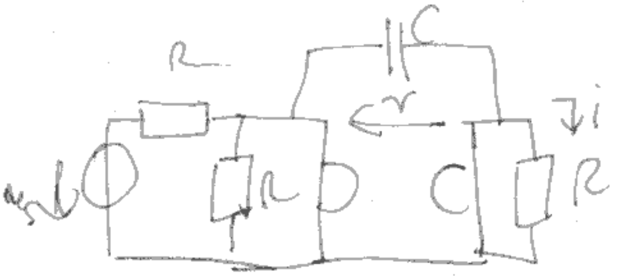
$$L_2 i_2' - r i_1 = 0 \rightarrow \boxed{i_2' = \frac{r}{L_2} i_1}$$

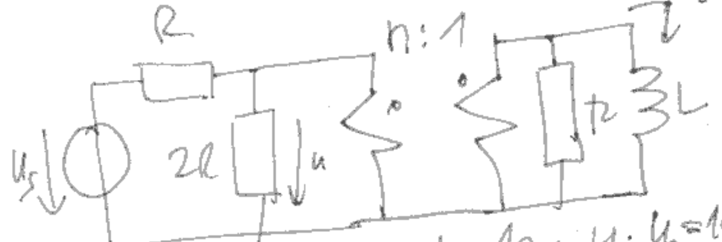
$$L_1 i_1' = u_s - Ri_1 - ri_2$$

$$\boxed{i_1' = -\frac{R}{L_1} i_1 - \frac{r}{L_1} i_2 + \frac{1}{L_1} u_s}$$

$$\lambda^2 + \frac{R}{L_1}\lambda + \frac{r^2}{L_1L_2} = 0$$

$$\frac{-\frac{R}{L_1} \mp \sqrt{\left(\frac{R}{L_1}\right)^2 - 4\frac{r^2}{L_1L_2}}}{2} = -\frac{R}{2L_1} \mp \sqrt{\frac{\frac{1}{4}R^2L_1 - r^2L_2}{L_1^2L_2}}$$





$n=3$; $R=2\,k\Omega$; $L=10\,mH$; $u_s=10\,V$

$$i_1 + \frac{u}{2R} + \frac{u-u_s}{R} = 0 \quad (1)$$

$$Li_L' - \frac{u}{n} = 0 \quad (3)$$

$$-ni_1 + \frac{u/n}{R} + i_L = 0 \quad (2)$$

$$u_a = -r(-i_2)$$

$$u_b = r\cdot i_1$$

$$u_s - Ri_1 - L_1i_1' - u_a = 0$$

$$L_2i_2' - u_b = 0$$

$$u = u_s - i_1\cdot R$$

$$\underline{A} = \begin{pmatrix} -\frac{R}{L_1} & -\frac{r}{L_1} \\ r/L_2 & 0 \end{pmatrix}$$

$$\left(\lambda + \frac{R}{L_1}\right)\cdot\lambda + \frac{r^2}{L_1L_2} = 0$$