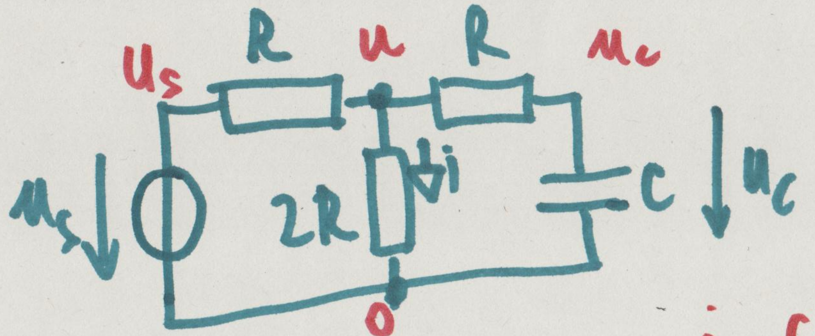


$i_C = C\cdot u_C'$

állapotváltozó: u_C

$i_C = C\cdot u_C'$

cél: meghatározni u_C', i

források: u_s, u_C

→ 2 csp-i egyenlet $\left(\begin{array}{l}\to u_C' \\ \to u\end{array}\right)$

→ kényszer egy. → i

① $\frac{u-u_s}{R}+\frac{u}{2R}+\frac{u-u_C}{R}=0$

② $Cu_C'+\frac{u_C-u}{R}=0$

③ $i=\frac{u}{2R}$

→ ① ⇒ $5u-2u_C-2u_s=0$

·2R

$u=\frac{2u_C+2u_s}{5}$

② → $RC\cdot u_C'+u_C-u=RCu_C'+\underbrace{u_C-\frac{2}{5}u_C}_{\frac{3}{5}u_C}-\frac{2}{5}u_s=0$

$$\boxed{u_C'=-\frac{3}{5RC}u_C+\frac{2}{5RC}u_s}$$

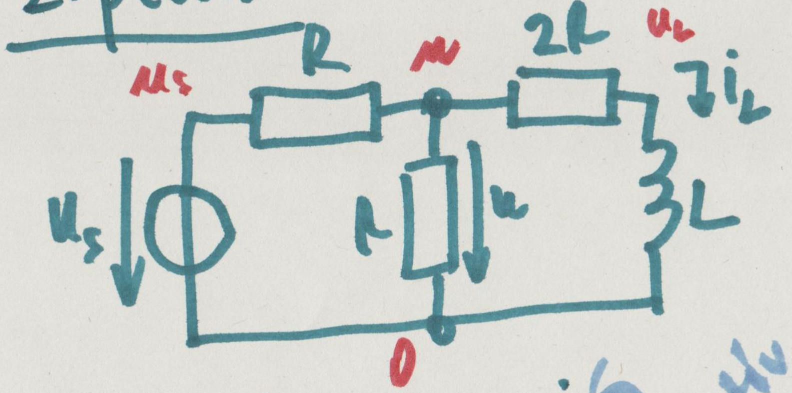
állapotváll. leírás normál alakja

$$u_C'=\underbrace{-\frac{3}{5RC}}_{\underline{\underline{A}}}\cdot u_C+\underbrace{\frac{2}{5RC}}_{\underline{\underline{B}}}u_s$$

$$i=\underbrace{\frac{1}{5R}}_{\underline{C^T}}u_C+\underbrace{\frac{1}{5R}}_{\underline{D}}\cdot u_s$$

$$i=\frac{1}{2R}\cdot\frac{2}{5}(u_C+u_s)=\frac{1}{5R}u_C+\frac{1}{5R}\cdot u_s$$

2. példa



áv: i_L forrás: u_s, i_L [illegible]

ism.: i_L', u

egyéb ism: u_L

① $\frac{u}{R} + \frac{u - u_s}{R} + i_L = 0$

② $i_L + \frac{u_L - u}{2R} = 0$

③ [illegible]
$u_L = L \cdot i_L'$

3 ism. (i_L', u_L, u) és 3 egyenlet

① → $2u - u_s + R i_L = 0$

$$\boxed{u = -\frac{R}{2} i_L + \frac{1}{2} u_s}$$

⇒ ③ → ② → $2R i_L + L i_L' - u = 0$

$$2R i_L + L i_L' + \frac{R}{2} i_L - \frac{1}{2} u_s = 0$$

$$\boxed{i_L' = -\frac{5R}{2L} i_L + \frac{1}{2L} u_s}$$

Mértékegységek!

$$\frac{[R]}{[L]} = \frac{1}{[t]} \quad \text{és} \quad [R] \cdot [C] = [t]$$

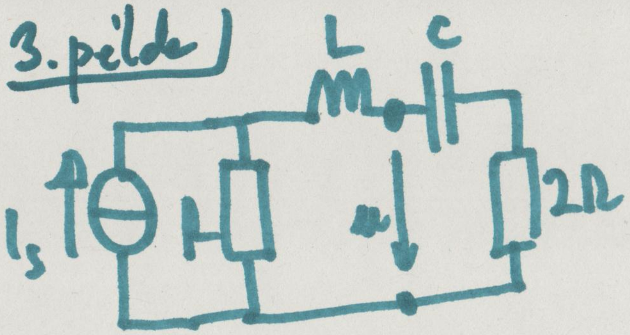
$$\frac{[R]}{[L]} \cdot [I] = \frac{[I]}{[t]} = \left[\frac{di}{dt}\right] \quad \text{és} \quad \frac{[U]}{[L]} = \frac{[I] \cdot [R]}{[L]} = \frac{[I]}{[t]}$$

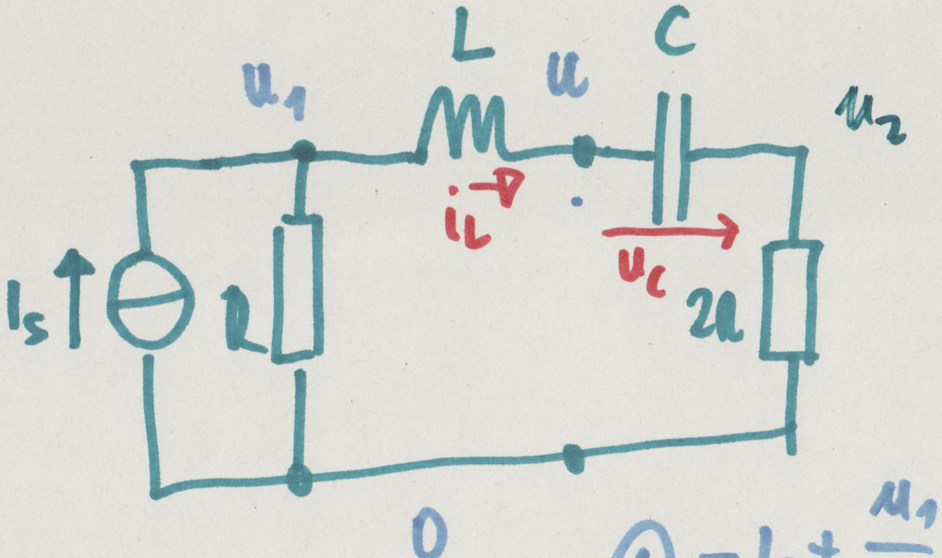
ÁVLNA:

$$i_L' = \underbrace{-\frac{5R}{2L}}_{\substack{A \\ =}} i_L + \underbrace{\frac{1}{2L}}_{\substack{B \\ =}} u_s$$

$$u = \underbrace{-\frac{R}{2}}_{\substack{C^T \\ =}} i_L + \underbrace{\frac{1}{2}}_{\substack{D \\ =}} u_s$$

3. példa)





3 csp egyenlet

2 ágegyenlet egy.

ár: i_L és u_C

$$\underline{x} = \begin{pmatrix} u_C \\ i_L \end{pmatrix}$$

① $-I_s + \frac{u_1}{R} + i_L = 0$

② $-i_L + Cu_C' = 0$

③ $-Cu_C' + \frac{u_2}{2R} = 0$

} 3 csp egyenlet

④ $u_1 - u = Li_L'$

⑤ $u - u_2 = u_C$

① $\rightarrow$ $u_1 = -Ri_L + Ri_s$

② ~~④~~ $\rightarrow$ $\boxed{u_C' = \frac{1}{C} i_L}$

③ $\rightarrow$ $u_2 = 2RCu_c'$

④ $u = (-Ri_L + Ri_S) - Li_L'$

⑤ $\rightarrow$ $-Ri_L + Ri_S - 2R(\cdot\frac{1}{C}i_L) = u_c$ 3R

$-Li_L'$

$Li_L' = -u_c - 3Ri_L + Ri_s$

$\Uparrow$

$$\boxed{i_L' = -\frac{1}{L}u_c - \frac{3R}{L}i_L + \frac{R}{L}i_s}$$

u_C', i_L', u_1, u_2, u

✓ ✓ ✓

$$\rightarrow u = -Ri_L + Ri_s - L\left(-\frac{1}{L}u_C - \frac{3R}{L}i_L + \frac{R}{L}i_s\right) = u_C + 2Ri_L$$

$\boxed{3pilh/2}$

Összefoglalás

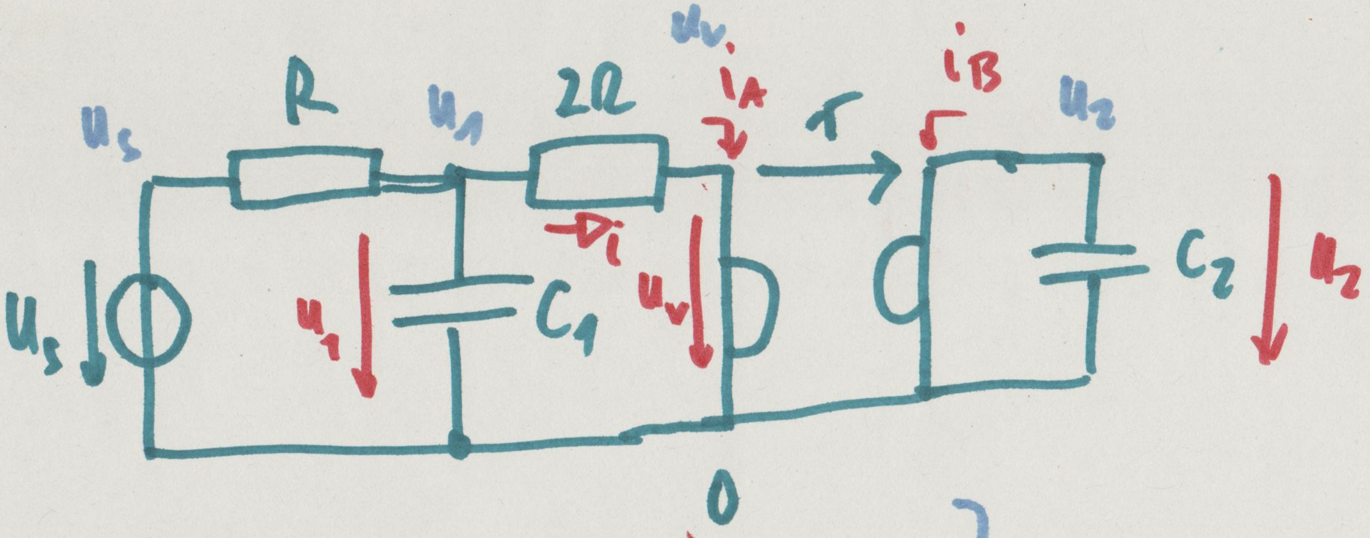
$$u_C' = \frac{1}{C}i_L$$

$$i_L' = -\frac{1}{L}u_C - \frac{3R}{L}i_L + \frac{R}{L}\cdot i_s$$

$$u = u_C + 2R\cdot i_L$$

$$\Rightarrow \underline{\underline{A}} = \begin{pmatrix} 0 & -\frac{1}{C} \\ -\frac{1}{L} & -\frac{3R}{L} \end{pmatrix} ; \underline{B} = \begin{pmatrix} 0 \\ R/L \end{pmatrix}$$

$$\underline{C}^T = \begin{pmatrix} 1 & 2R \end{pmatrix} ; D = 0$$



ism: u_1', u_2', i, i_A, i_B

u_V

3 csp egyenlet

1 hurok (i)

2 kar. egyenlet

① $C_1 u_1' + \frac{u_1 - U_S}{R} + \frac{u_1 - u_V}{2R} = 0$

② $i_A + \frac{u_V - u_1}{2R} = 0$

③ ~~[illegible] = 0~~

$i_B + C_2 u_2' = 0$

④ $i = \frac{1}{2R}(u_1 - u_V)$

⑤ $u_V = -r \cdot i_B$ ⑥ $u_2 = r i_A'$

→ megoldás

1) kézzel rendezve

2) adott (nem paraméteres) esetben az egyenletrendszer megoldásával

Kézzel rendezve:

$$\underline{x} = \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$$

$$⑥ \longrightarrow i_A = \frac{1}{r} u_2$$

$$⑤ \longrightarrow i_B = -\frac{1}{r} u_r$$

$$② \longrightarrow u_r = u_1 - 2R\left(\frac{1}{r} u_2\right)$$

$$③ \rightarrow u_2' = -\frac{1}{C_2} \cdot \left(-\frac{1}{r}\left(u_1 - 2R\frac{1}{r}u_2\right)\right) = \overbrace{\frac{1}{rC_2}}^{A_{21}} u_1 \overbrace{-\frac{2R}{r^2C_2}}^{A_{22}} u_2$$

$$① \rightarrow 2RC_1u_1' + 3u_1 - 2u_s - \left(u_1 - \frac{2R}{r}u_2\right) = 2u_1 + \frac{2R}{r}u_2 - 2u_s + 2RC_1u_1' = 0$$

$$u_1' = \underbrace{-\frac{1}{RC_1}}_{A_{11}} u_1 \underbrace{-\frac{1}{rC_1}}_{A_{12}} u_2 + \underbrace{\frac{1}{RC_1}}_{B_1} u_s$$

$$\underline{\underline{A}} = \begin{pmatrix} -\frac{1}{RC_1} & -\frac{1}{rC_1} \\ \frac{1}{rC_2} & -\frac{2R}{r^2C_2} \end{pmatrix}; \quad \underline{B} = \begin{pmatrix} 0 \\ \frac{1}{RC_1} \end{pmatrix}$$

$$④ \longrightarrow i = \frac{1}{2R}u_1 - \frac{1}{2R}\left(u_1 - \frac{2R}{r}u_2\right) = \overbrace{\frac{1}{r}}^{(C^T)_2} u_2$$

$$\underline{C}^T = \begin{pmatrix} 0 & 1/r \end{pmatrix} \qquad \underline{D} = 0$$

Egyenletrendszer alakjában

$$
\begin{array}{c|cccccc|}
 & u_1' & u_2' & i & i_A & i_B & u_V \\
\hline
① \to & C_1 & \cdot & \cdot & \cdot & \cdot & -1/2R \\
③ \to & \cdot & C_2 & \cdot & \cdot & 1 & \cdot \\
④ \to & \cdot & \cdot & 2R & \cdot & \cdot & 1 \\
② \to & \cdot & \cdot & \cdot & 2R & \cdot & 1 \\
⑤ \to & \cdot & \cdot & \cdot & \cdot & 1 & 1 \\
⑥ \to & \cdot & \cdot & \cdot & 1 & \cdot & \cancel{0} \\
\end{array}
\cdot
\begin{pmatrix} u_1' \\ u_2' \\ i \\ i_A \\ i_B \\ u_V \end{pmatrix}
=
\begin{array}{|ccc|}
u_1 & u_2 & u_s \\
\hline
-\frac{3}{2R} & \cdot & +\frac{1}{R} \\
\cdot & \cdot & \cdot \\
1 & \cdot & \cdot \\
1 & \cdot & \cdot \\
\cdot & \cdot & \cdot \\
\cdot & 1 & \cdot \\
\end{array}
\begin{pmatrix} u_1 \\ u_2 \\ u_s \end{pmatrix}
$$

$$\underline{\underline{P}} \cdot \underline{W'} = \underline{\underline{Q}}\,\underline{s}$$

$$(6\times6)(6\times1) = (6\times3)(3\times1)$$

$$(6\times1) = (6\times6)(6\times3)\underset{(3\times1)}{}$$

$$\underline{W} = \underline{\underline{P}}^{-1} \cdot \underline{\underline{Q}} \cdot$$

⇒ megoldás alakja :

$$
\begin{pmatrix} u_1' \\ u_2' \\ i \\ i_A \\ i_B \\ u_V \end{pmatrix}
=
\left(\begin{array}{cc|c}
\cdot & \cdot & \cdot \\
\multicolumn{2}{c|}{\underline{\underline{A}}} & \underline{\underline{B}} \\
\cdot & \cdot & \cdot \\
\hline
\cdot & C^T \ \cdot & \cdot \ D \\
\hline
\cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot \\
\end{array}\right)
\cdot
\begin{pmatrix} u_1 \\ u_2 \\ u_s \end{pmatrix}
\xleftarrow{\quad} \underline{\underline{P}}^{-1}\underline{\underline{Q}}
$$