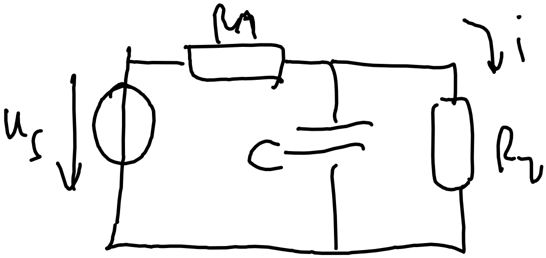
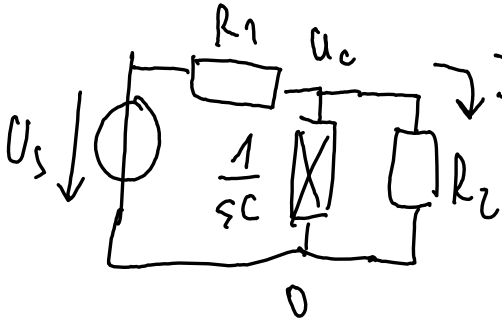


$H(j\omega) = ?$ 1

$u_s \rightarrow U_s$; $i \rightarrow I$; $u_c \rightarrow U_c$



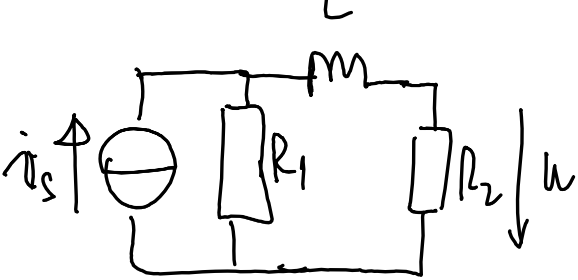
1 $sC \cdot U_c + \frac{U_c}{R_2} + \frac{U_c - U_s}{R_1} = 0$

2 $I = \frac{U_c}{R_2}$

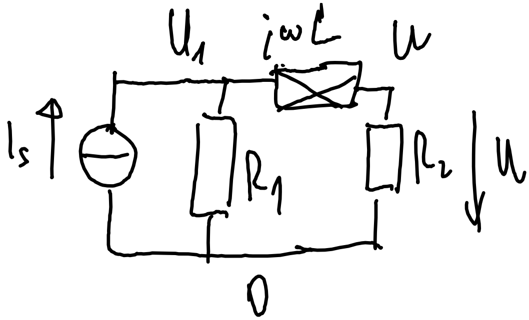
$$U_c\left(sC + \frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{U_s}{R_1}$$

$$U_c = \frac{U_s/R_1}{sC + \frac{R_1+R_2}{R_1R_2}} = \frac{U_s/R_1}{\frac{sCR_1R_2 + R_1+R_2}{R_1R_2}} = \frac{R_2}{sCR_1R_2 + R_1+R_2}\,U_s$$

$$\frac{U_c/R_2}{U_s} = \frac{1}{sCR_1R_2 + (R_1+R_2)} = \frac{1/R_1R_2}{1 + \frac{R_1+R_2}{R_1R_2\cdot C}} = \frac{1/R_1R_2}{1 + \frac{1}{(R_1\times R_2)\,C}}$$



$$H(j\omega) = ? \quad \frac{U(j\omega)}{I_s(j\omega)}$$



$$\left.\begin{aligned} -I_s + \frac{U_1}{R_1} + \frac{U_1 - U}{j\omega L} &= 0 \\ \frac{U}{R_2} + \frac{U - U_1}{j\omega L} &= 0 \end{aligned}\right\}$$

vagy $-I_s + \dfrac{U_1}{R_1} + \dfrac{U_1}{R_2 + j\omega L} = 0$ és $U = \dfrac{R_2}{R_2 + sL} \cdot U_1$

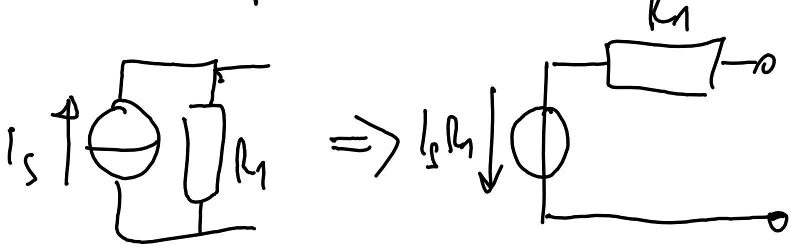
$$U_1 = \frac{I_s}{\frac{1}{R_1} + \frac{1}{R_2 + j\omega L}} = \frac{R_1 \cdot (R_2 + sL) \cdot I_s}{R_1 + R_2 + sL}$$

$$U = \frac{R_2}{\cancel{R_2 + j\omega L}} \cdot \frac{R_1 (\cancel{R_2 + j\omega L})}{(R_1 + R_2) + j\omega L} \cdot I_s = \frac{R_1 R_2}{(R_1 + R_2) + j\omega L} I_s =$$

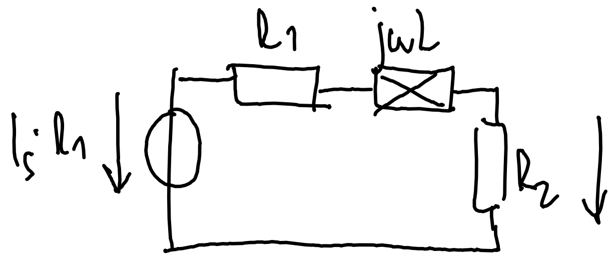
$$= \frac{R_1 R_2 / L}{j\omega + \frac{R_1 + R_2}{L}} I_s \qquad \boxed{H(j\omega) = \frac{R_1 R_2 / L}{j\omega + \frac{R_1 + R_2}{L}}}$$

dimenziók!

másképpen is lehet!



ezzel egyszerűbb lesz!

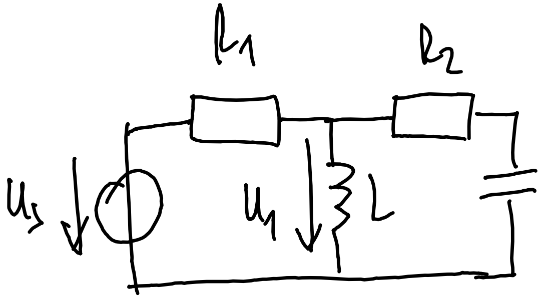


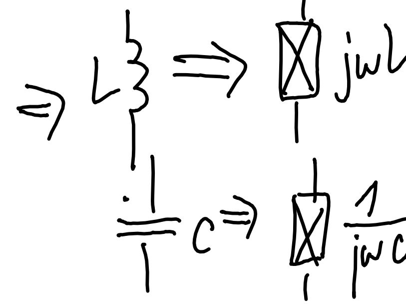
$$U = \frac{R_2}{R_1 + j\omega L + R_2} \cdot I_s R_1$$

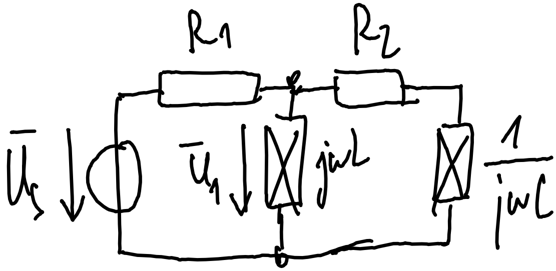
$$U = \frac{R_1 R_2}{j\omega L + (R_1 + R_2)} I_s$$

ami megegyezik a másik módszerrel!

3







elegendő $\bar U_1$!

$$\frac{\bar U_1}{j\omega L}+\frac{\bar U_1}{R_2+\frac{1}{j\omega C}}+\frac{\bar U_1-\bar U_s}{R_1}=0$$

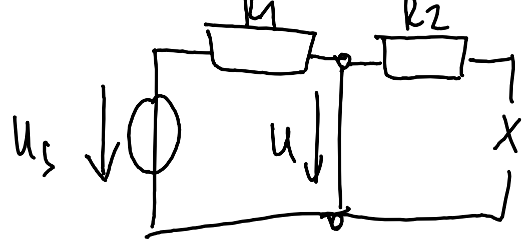
$$\bar U_1=\frac{U_s/R_1}{\frac{1}{j\omega L}+\frac{j\omega C}{1+j\omega R_2 C}+\frac{1}{R_1}}=\frac{\frac{1}{R_1}\cdot U_s\cdot R_1\, j\omega L\cdot(1+j\omega R_2 C)}{R_1(1+j\omega R_2 C)+j\omega C R_1\, j\omega L+j\omega L(1+j\omega R_2 C)}$$

$$\frac{\bar U_1}{U_s}=\frac{(j\omega)^2 R_2 LC+j\omega L}{(j\omega)^2 LC(R_1+R_2)+j\omega(L+R_1R_2C)+R_1}=$$

$$=\frac{R_2}{R_1+R_2}\cdot\frac{(j\omega)^2+\frac{1}{R_2C}\cdot j\omega}{(j\omega)^2+j\omega\left(\frac{L}{R_1+R_2}+\frac{R_1R_2C}{R_1+R_2}\right)+\frac{R_1}{R_1+R_2}}$$

"szélső" helyzetek":

$\omega \to 0$ hálózat alapján: ($\to |$ és $\to \times$)

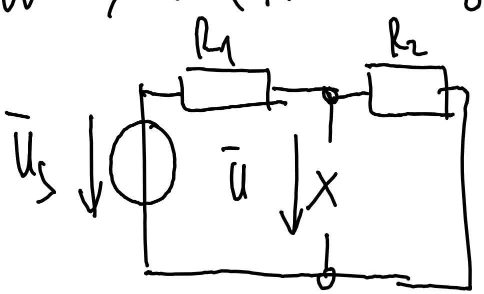


$U = 0$ $\quad H = 0$

$H(j\omega)$ alapján

$$\lim_{\omega \to 0} A_0 \cdot \frac{(j\omega)^2 + j\omega \cdot \ldots}{(j\omega)^2 + j\omega \cdot \ldots + \ldots} = \frac{0}{\ldots} = 0$$

$\omega \to \infty$ (HF – High Frequency) $\to \times$ és $\to |$

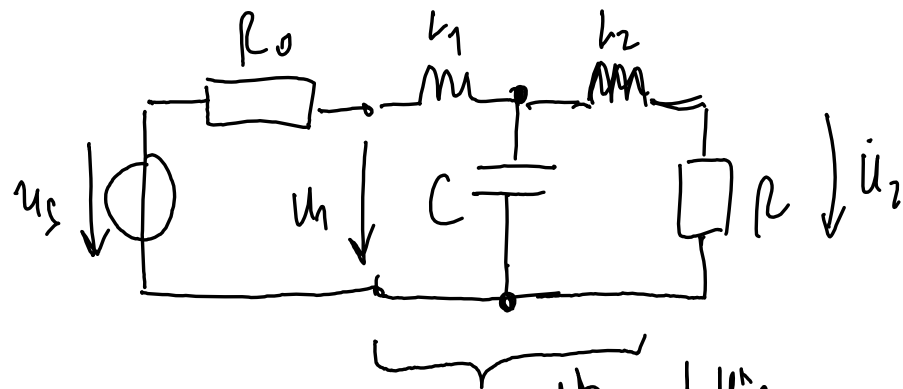


$$\overline{U} = \overline{U}_s \cdot \frac{R_2}{R_1 + R_2}$$

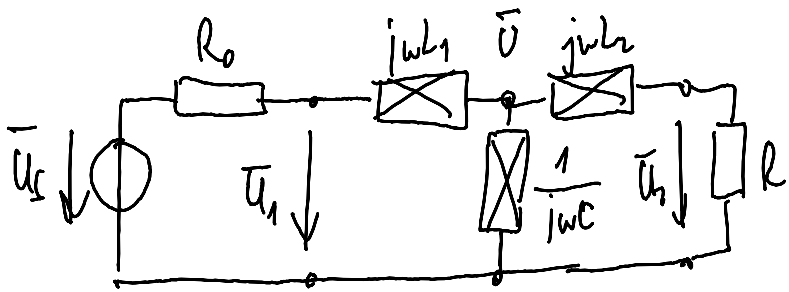
$$\lim_{\omega \to \infty} A_0 \cdot \frac{(j\omega)^2 + j\omega \cdot \ldots}{(j\omega)^2 + j\omega \cdot \ldots + \ldots} = \lim \frac{(j\omega)^2}{(j\omega)^2} A_0 \frac{1 + \frac{1}{j\omega}\ldots}{1 + \frac{1}{j\omega}\ldots + \ldots}$$

$$= A_0 \cdot 1 = \frac{R_2}{R_1 + R_2}$$

$\frac{1}{(j\omega)^2}\ldots$



pl. egy vezeték modellje



$$\frac{\bar{U}-\bar{U}_s}{R_0+j\omega L_1}+j\omega C\cdot\bar{U}+\frac{\bar{U}}{R+j\omega L_2}=0 \Rightarrow$$

$$\bar{U}_2=\frac{R}{j\omega L_2+R}\bar{U}$$

$$\bar{U}_1=\bar{U}+\frac{j\omega L_1}{R_0+j\omega L_1}(\bar{U}_s-\bar{U})$$

$$\bar{U}\left(\frac{1}{R_0+j\omega L_1}+j\omega C+\frac{1}{R+j\omega L_2}\right)=\frac{\bar{U}_s}{R_0+j\omega L_1}$$

$$\frac{(R+j\omega L_2)+j\omega C(R_0+j\omega L_1)(R+j\omega L_2)+R_0+j\omega L_1}{\cancel{(R_0+j\omega L_1)}(R+j\omega L_2)}\bar{U}=\frac{\bar{U}_s}{\cancel{R_0+j\omega L_1}}$$

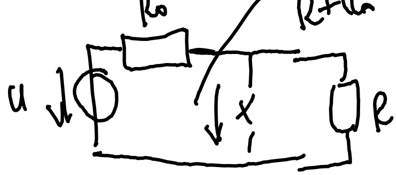
$$\frac{(R+j\omega L_2)+j\omega C(R_0+j\omega L_1)(R+j\omega L_2)+R_0+j\omega L_1}{\cancel{(R_0+j\omega L_1)}(R+j\omega L_2)}\,\bar{U} = \frac{\bar{U}_S}{\cancel{R_0+j\omega L_1}}$$

$$\frac{\bar{U}}{\bar{U}_S} = \frac{R+j\omega L_2}{(j\omega)^3(L_1L_2C)+(j\omega)^2C\cdot(L_1R+L_2R_0)+j\omega(L_1+L_2+CR_0R)+(R+R_0)}$$

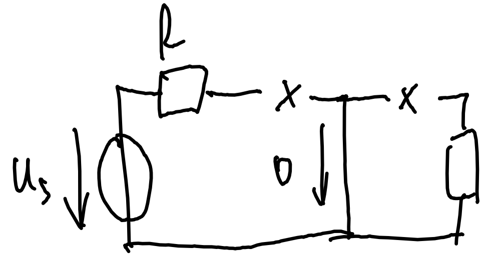
$$= \underbrace{\frac{L_2}{L_1L_2C}}_{\frac{1}{L_1C}}\cdot\frac{j\omega+R/L_2}{(j\omega)^3+(j\omega)^2\left(\frac{R}{L_2}+\frac{R_0}{L_1}\right)+(j\omega)\left(\frac{L_1+L_2}{L_1L_2C}+\frac{R_0R}{L_1L_2}\right)+\frac{R+R_0}{L_1L_2C}}$$

$$\omega\to 0 \qquad \frac{1}{L_1C}\cdot\frac{R/L_2}{\frac{R+R_0}{L_1L_2C}} = \frac{R}{R+R_0}$$

$\frac{R}{R+R_0}\cdot U_S$



$$\omega\to\infty \qquad \to 0$$

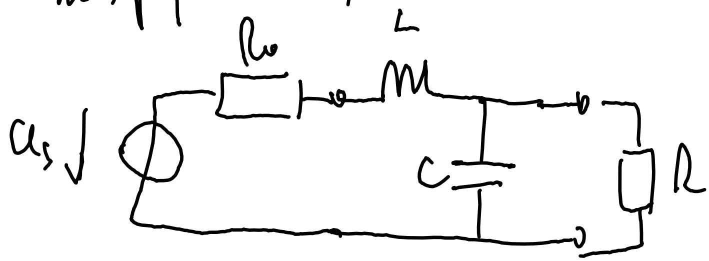


$$= \underbrace{\frac{L_2}{L_1L_2C}}_{\frac{1}{L_1C}} \cdot \frac{j\omega + R/L_2}{(j\omega)^3 + (j\omega)^2\left(\frac{R}{L_2}+\frac{R_0}{L_1}\right) + (j\omega)\left(\frac{L_1+L_2}{L_1L_2C} + \frac{R_0R}{L_1L_2}\right) + \frac{R+R_0}{L_1L_2C}}$$

$L_1 = L_2 = L$ szimmetrikus eset

$$\frac{1}{LC} \cdot \frac{j\omega + R/L}{(j\omega)^3 + (j\omega)^2\cdot\left(\frac{R+R_0}{L}\right) + j\omega\left(\frac{2}{LC} + \frac{R_0R}{L^2}\right) + \frac{R+R_0}{L^2C}}$$

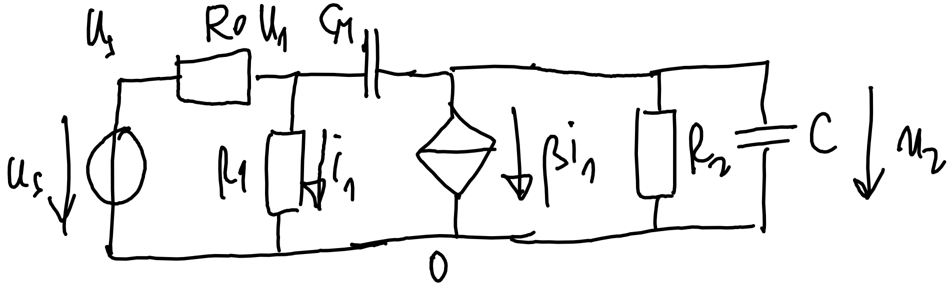
másfajta helyettesítés szokott lenni



ami persze egyszerűbb

de ha elegendően sok részre osztjuk a vezetéket akkor azonos lesz a ST eset

5



$$i_1 = \frac{u_1}{R_1}; \quad \frac{u_1 - u_s}{R_0} + \frac{u_1}{R_1} + j\omega C_M \cdot (u_1 - u_2) = 0$$

$$j\omega C_M (u_2 - u_1) + \beta \cdot \frac{u_1}{R_1} + \frac{u_2}{R_2} + j\omega C \cdot u_2 = 0$$

$$\begin{pmatrix} \frac{1}{R_0} + \frac{1}{R_1} + j\omega C_M & -j\omega C_M \\ -j\omega C_M + \frac{\beta}{R_1} & j\omega (C + C_M) + \frac{1}{R_2} \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} u_s / R_0 \\ 0 \end{pmatrix}$$

$$\frac{u_2}{u_s} = \frac{j\omega (C_M R_1 R_2) - \beta \cdot R_2}{(j\omega)^2 C \cdot C_M \cdot R_0 R_1 R_2 + j\omega \left(C (R_0 R_2 + R_1 R_2) + C_M (R_0 (R_1 + R_2 + \beta R_2) + R_1 R_2) \right) + (R_0 + R_1)}$$

$C_1 \to 0$ esetén

$$\frac{U_2}{U_S} = \frac{\beta R_2}{j\omega (R_0+R_1) R_2 C + (R_0+R_1)} =$$

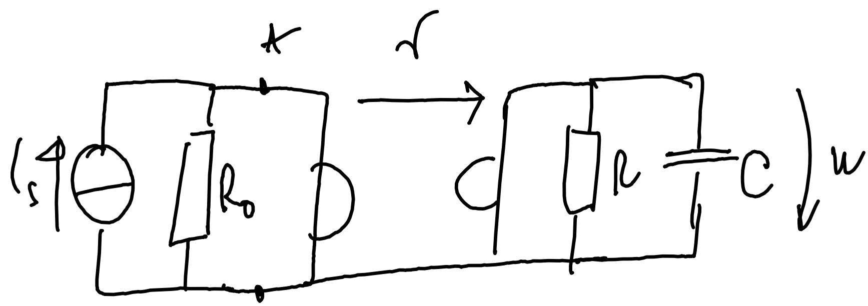
$$= \underbrace{\frac{\beta R_2}{(R_0+R_1) R_2 C}}_{\frac{\beta}{C(R_0+R_1)}} \cdot \frac{1}{j\omega + \underbrace{\frac{R_0+R_1}{(R_0+R_1) R_2 C}}_{1/R_2 C}}$$

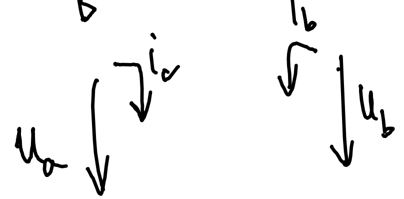
ami "egyszerű" elsőrendű rendszer (aluláteresztő)

$$A_0 = \frac{\beta}{C(R_0+R_1)}$$

$$\Omega_0 = \frac{1}{R_2 C}$$

6





$$u_a = -r\, i_b$$
$$u_b = r \cdot i_a$$

$$I_B + \frac{1}{R} U_B + j\omega C U_B = 0 \qquad I_B = -g \cdot U_A$$

$$-I_s + \frac{U_A}{R_0} + I_A = 0 \qquad I_A = g \cdot U_B$$

$$\left.\begin{aligned} -g U_A + \frac{1}{R} U_B + j\omega C U_B &= 0 \\ -I_s + \frac{1}{R_0} U_A + g U_B &= 0 \end{aligned}\right\} \qquad U_A = \frac{\frac{1}{R} + j\omega C}{g} U_B$$

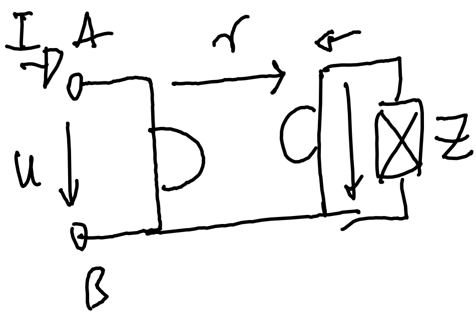
$$I_s = \left\{ g + \frac{1}{R_0 g} \underbrace{\left(\frac{1}{R} + j\omega C \right)}_{\frac{1+j\omega RC}{R}} \right\} U_B$$

$$U_B = \frac{R \cdot R_0 g}{(1+j\omega RC) + g^2 R R_0} =$$

$$U_B = \frac{R\cdot R_0 g\cdot I_S}{(1+j\omega RC)+g^2RR_0} \Rightarrow$$

$$\frac{U_B}{I_S} = \frac{gRR_0}{j\omega RC+(1+g^2RR_0)} = \frac{gR_0}{C}\cdot\frac{1}{j\omega+\frac{1+g^2RR_0}{RC}}$$

általánosítsuk a lineáris visszatranszformálást

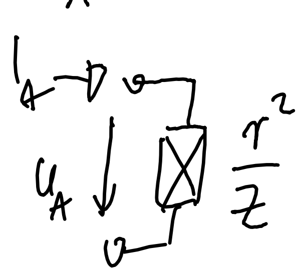


$$\left.\begin{aligned} U_B &= -I_B\cdot Z \\ U_A &= -r I_B \\ U_B &= r I_A \end{aligned}\right\}$$

nemváltó!

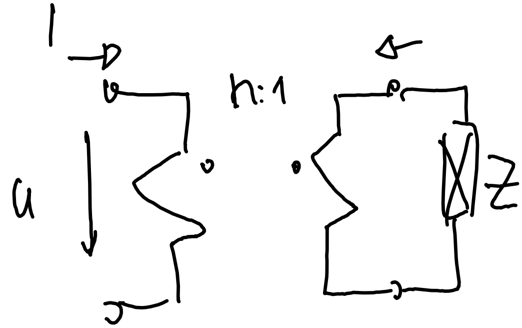
$$-I_B\cdot Z = r\cdot I_A$$

$$U_A = -r\cdot\left(-\frac{r}{Z}I_A\right) = \frac{r^2}{Z}\cdot I_A$$



tfh. $Z = R+jX \Rightarrow \frac{1}{Z} = \frac{1}{R+jX} =$

$$= \frac{R-jX}{R^2+X^2}$$ azaz jelleget vált



$$U_A = n \cdot U_B$$

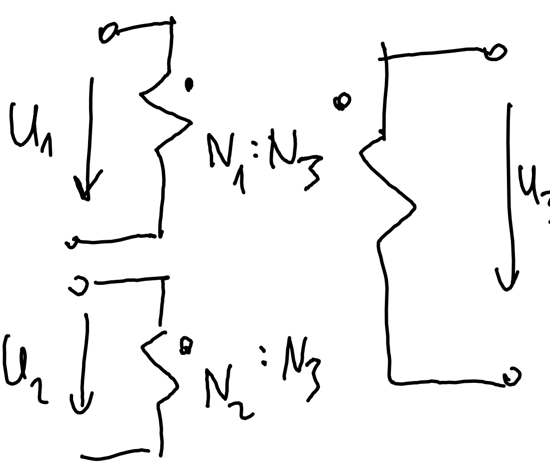
$$I_B = -n I_A$$

$$U_B = -I_B \cdot Z \qquad U_A = n \cdot U_B = n \cdot \left(-Z \cdot (-n I_A)\right) =$$

$$= n^2 Z I_A$$

$$Z_{BE} = \frac{U_A}{I_A} = n^2 \cdot Z$$

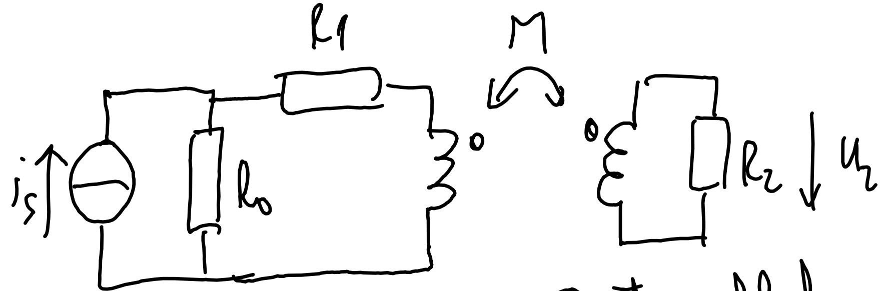
megtartja a jelleget



$$\frac{U_1}{N_1} = \frac{U_2}{N_2} = \frac{U_3}{N_3}$$

$$N_1 I_1 + N_2 I_2 + N_3 I_3 = 0$$

7

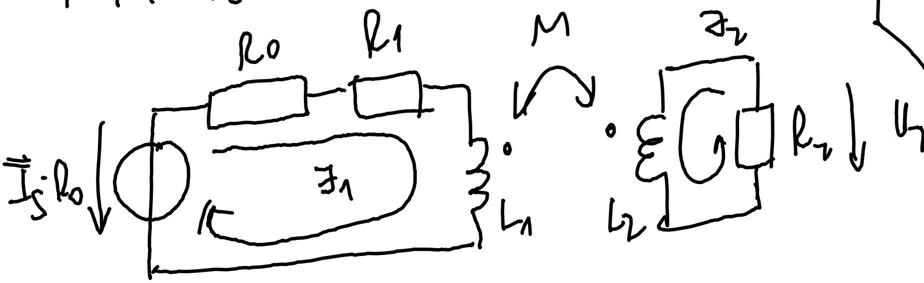


→ célszerű hurokáramokat alkalmazni!

+ Th-Nt

$$k^2 = \frac{M^2}{L_1 L_2}$$

csatolás



$$\left.\begin{aligned} &(R_0+R_1)J_1 + j\omega L_1 \cdot J_1 + j\omega M \cdot J_2 - I_s \cdot R_0 = 0 \\ &j\omega L_2 \cdot J_2 + j\omega M \cdot J_1 + J_2 \cdot R_2 = 0 \end{aligned}\right\}$$

$$J_1 = \frac{R_2 + j\omega L_2}{j\omega M} \cdot J_2$$

$$I_s \cdot R_0 = \left(j\omega M + (R_0 + R_1 + j\omega L_1) \cdot \frac{R_2 + j\omega L_2}{j\omega M}\right) J_2$$

$$\frac{J_2}{I_s} = \frac{j\omega M \cdot R_0}{(j\omega)^2 (M^2 + L_1 L_2) + j\omega\left(L_1 R_2 + L_2 (R_0 + R_1)\right) + R_2 (R_0 + R_1)}$$

$$\frac{\mathcal{I}_2}{I_s} = \frac{j\omega M \cdot R_0}{(j\omega)^2(M^2+L_1L_2) + j\omega\left(L_1R_2 + L_2(R_0+R_1)\right) + R_2(R_0+R_1)}$$

$$\frac{M \cdot R_0}{M^2+L_1L_2} \cdot \frac{j\omega}{(j\omega)^2 + j\omega\left(\frac{R_2}{(M^2+L_1L_2)/L_1} + \frac{R_0+R_1}{(M^2+L_1L_2)/L_2}\right) + \frac{R_2(R_0+R_1)}{M^2+L_1L_2}}$$

- $0 \leq k \leq 1 \rightarrow M = k\sqrt{L_1L_2}$

$R_0 = 0{,}5$; $R_1 = 10$ $R_2 = 15$

$L_1 = 10$; $L_2 = 20$; a) $k \cong 0{,}95$ $M \cong 13{,}5$

b.) $k \cong 0{,}1$ $M = 1{,}4$

$(j\omega)^2 + 1{,}7825\, j\omega + 0{,}7799$

$-1{,}0117$

$-0{,}7709$

$(j\omega)^2 + 0{,}9418\, j\omega + 0{,}4120$

$-0{,}4709 \pm j\,0{,}4362$

$\boxed{8.}$

$\omega_0 - n \qquad 2\omega_0 L_3 = \frac{1}{2\omega_0 C_3} = 20\ k\Omega \qquad 4\,mA,\ k\Omega_1$

$\omega_0 L_1 = 10 \qquad \frac{1}{\omega_0 C_2} = 30 \qquad R_2 = 10\ k\Omega$

$R_1 = 10$

$u_s(t) = [10 + 5 \cdot \cos(\omega_0 t) + 8 \cdot \cos(\omega_0 t + 45^\circ)]\,V$

$$Z_1 = j\omega L_1 \times R_1 = \frac{R_1 j\omega L_1}{j\omega L_1 + R_1} = R_1 \cdot \frac{j\omega}{j\omega + R_1/L_1}$$

$$Z_2 = R_2 \times \frac{1}{j\omega C_2} = \frac{R_2/j\omega C_2}{R_2 + \frac{1}{j\omega C_2}} = \frac{R_2}{1 + j\omega R_2 C_2} =$$

$$= \frac{1}{C_2} \cdot \frac{1}{j\omega + \frac{1}{R_2 C_2}}$$

$$Z_3 = j\omega L_3 \times \frac{1}{j\omega C_3} = \frac{j\omega L_3 / j\omega C_3}{j\omega L_3 + \frac{1}{j\omega C_3}} = \frac{j\omega L_3}{(j\omega)^2 L_3 C_3 + 1}$$

$$= \frac{1}{C_3} \frac{j\omega}{(j\omega)^2 + \frac{1}{L_3 C_3}}$$

$L_3 = \frac{20}{2\omega_0} \qquad C_3 = \frac{1}{2\omega_0 \cdot 20}$

$L_3 C_3 = \frac{1}{4\omega_0^2} \rightarrow \Omega = \frac{1}{\sqrt{L_3 C_3}} = 2\omega_0$