(1.) Feszmérés négyzetösszegző módszerrel:

$U_{1pr} = 20kV$

$U_{1sz} = 100V$

$U_{2pr} = 250V$

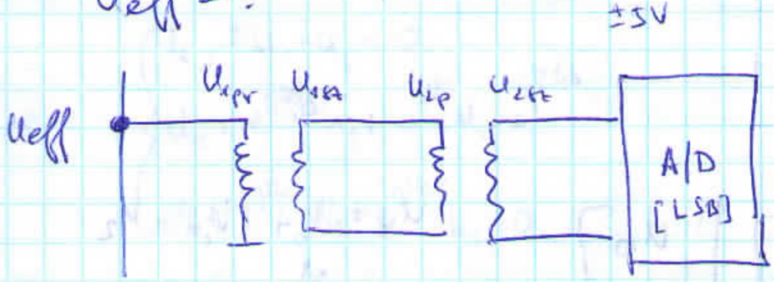
$U_{2sz} = 15V$

van egy A/D konverter: $AD_{in} = \pm 5V$

A konverter 12 bites és $N = 32 \frac{\text{minta}}{\text{periódus}}$

Az összegző tár: $382\,0000_H \rightarrow 3 \cdot 16^6 + 8 \cdot 16^5 + 2 \cdot 16^4 = 58851328$

$U_{eff} = ?$



van egy áttétel

$$\frac{U_{1pr}}{U_{1sz}} \cdot \frac{U_{2p}}{U_{2sz}} = \frac{20 \cdot 10^3}{100} \cdot \frac{250}{15} =$$

$$\text{Lépték} \left[\frac{V}{LSB}\right] = \frac{AD_{in}}{2^{AD_{bit}-1}} \cdot \frac{U_{1pr}}{U_{1sz}} \cdot \frac{U_{2p}}{U_{2sz}} =$$

$$= \frac{5}{2^{12-1}} \cdot \frac{20 \cdot 10^3}{100} \cdot \frac{250}{15} = \underline{8{,}138 \frac{V}{LSB}}$$

$$U_{eff}[V] = U_{eff}[LSB] \cdot U_{lépték}\left[\frac{V}{LSB}\right]$$

$$U_{eff}^{[LSB]} = \sqrt{\frac{1}{N} \cdot \sum_{n=0}^{N-1} U^2(n)} = \sqrt{\frac{58851328}{32}} = 1356{,}15\ (LSB)$$

négyzetösszegző módszer

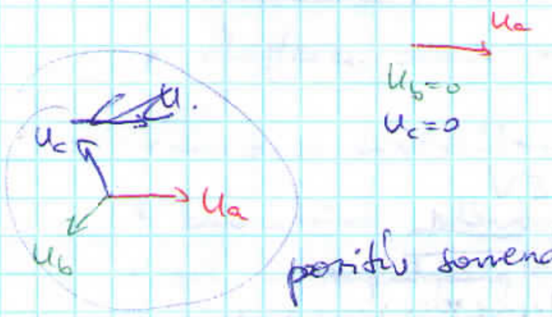
összegző tárban lévő érték

így $U_{eff}[V] = 1356{,}15 \cdot 8{,}138 = \underline{11{,}036k\ V}$

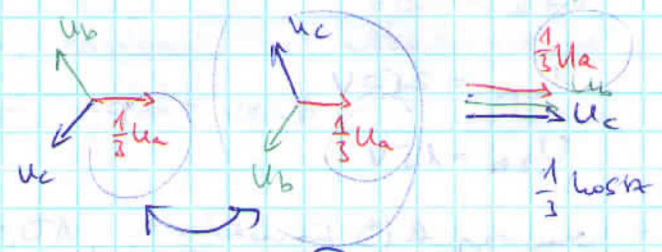
(2.) Sorrendi mennyiségekre felbontás:

a, $U_b = U_c = 0$

$U_1 + U_2 + U_0$



pozitív sorrend



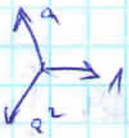
(+) sorrend

$$\begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}$$

$$\begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix}\begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix}$$

$U_b = U_0 + a^2 U_1 + a U_2$

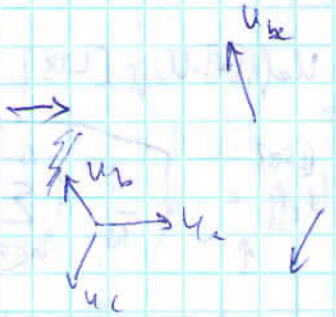
$\cdot\ e^{j120°}$



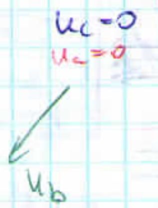
$a^2 U_1 = e^{j240} \cdot U_1$

$a^2 \cdot U_1$

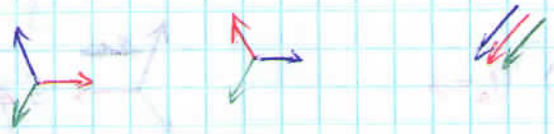
$a \cdot U_2$



b) $U_a = U_c = 0$



$U_1 \quad + \quad U_2 \quad + \quad U_0$



$$\boxed{\begin{aligned} U_a &= U_0 + U_1 + U_2 = 0 \\ U_b &= U_0 + a^2 U_1 + a U_2 = e^{j240} \\ U_c &= U_0 + a U_1 + a^2 U_2 = 0 \end{aligned}}$$

egyenletrendszerként megoldani

↓

papírra

$$\begin{cases} U_0 + U_1 + U_2 = 0 \\ U_0 + e^{j240} U_1 + e^{j120} U_2 = e^{j240} \\ U_0 + e^{j120} U_1 + e^{j240} U_2 = 0 \end{cases}$$

$$2U_0 + U_1 (\underbrace{e^{j240} + e^{j120}}_{-1}) + U_2 (\underbrace{e^{j120} + e^{j240}}_{-1}) = e^{j240}$$

$$2U_0 - U_1 - U_2 = e^{j240}$$

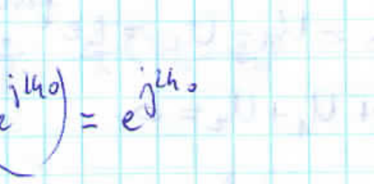
$$U_0 + U_1 + U_2 = 0$$

$$3U_0 = e^{j240}$$

$$U_0 = \frac{1}{3} \cdot e^{j240}$$

$$\begin{cases} \frac{1}{3} \cdot e^{j240} + U_1 + U_2 = 0 \\ \frac{2}{3} \cdot e^{j240} = e^{j240} + U_1 + U_2 \end{cases}$$

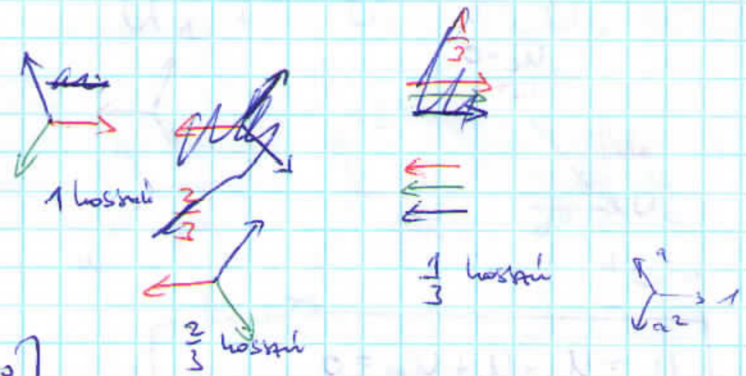
$$-\frac{1}{3} \cdot e^{j240} = U_1 + U_2$$



felvenném U_1-et és ahhoz képest 240°-kal elforgatom, majd x-tengelyre tükrözve kapom U_2-t.

c, $U_a = \phi$

$U_1 \quad + \quad U_2 \quad + \quad U_0$



$$\begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix}$$

$$U_a = U_0 + U_1 + U_2 = 0$$

$$U_b = U_0 + e^{j240} U_1 + e^{j120} U_2 = e^{j240}$$

$$U_c = U_0 + e^{j120} U_1 + e^{j240} U_2 = e^{j120}$$

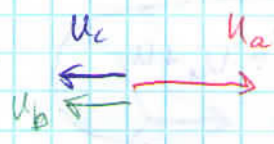
$$2U_0 - U_1 - U_2 = e^{j240} + e^{j120} = -1$$

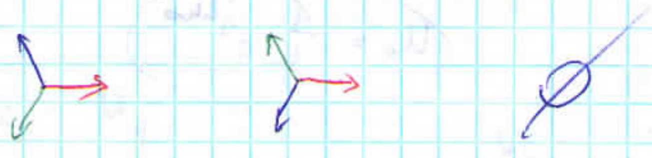
$$U_0 + U_1 + U_2 = 0$$

$$3U_0 = -1 \qquad U_1 + U_2 = -\frac{1}{3}$$

$$U_0 = -\frac{1}{3}$$

d, $U_b = U_c = -\frac{U_a}{2}$ $\qquad U_1 \quad + \quad U_2 \quad + \quad U_0$





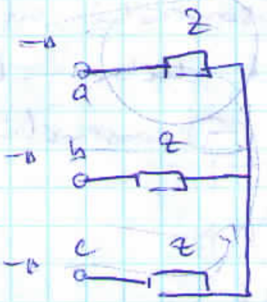
$$U_a = U_0 + U_1 + U_2 = 1$$

$$U_b = U_0 + e^{j240} U_1 + e^{j120} U_2 = -\frac{1}{2}$$

$$U_c = U_0 + e^{j120} U_1 + e^{j240} U_2 = -\frac{1}{2}$$

$$2U_0 - U_1 - U_2 = -1$$

$$U_0 + U_1 + U_2 = 1 \quad \rightarrow \quad U_0 = 0 \qquad U_1 + U_2 = 1$$



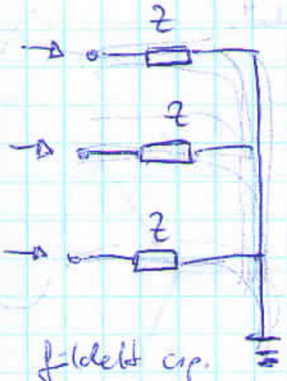
$Z_0 = \infty$

$Z_1 = Z$

$Z_2 = Z$

papírra felírni ábrát

szigetelt csp.

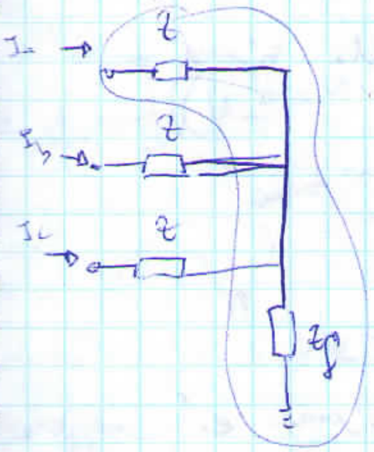


$Z_1 = Z$

$Z_2 = Z$

$Z_\phi = Z$

földelt csp.



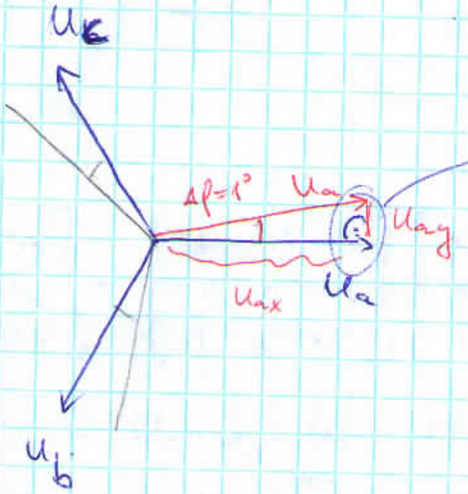
$Z_1 = \cancel{\frac{U_a}{I_a} + \frac{U_b}{I_b} \cdot \frac{1}{3}(Z_a + Z_b)}$

$Z_2 =$

$Z_\phi = \frac{1}{3}(Z_a + Z_b + Z_c) = \frac{1}{3}(Z + Z_g + Z + Z_g + Z + Z_g) =$

$= \cancel{\frac{1}{3}\left(\frac{U_a}{I_a} + \frac{U_b}{I_b} + \frac{U_c}{I_c}\right)}$

③ Van egy teljesen szimmetrikus, tisztán ⊕ sorrendű hálózatom, amiben mintavételezés miatt 1°-kal hibásan (később) vesszük mintát. Eredetileg nem volt ⊖ sorrendű mennyiség, de most lesz.



→ mivel 1° kicsi, ezért ~~lásd~~ derékszögnek vehető.

$U_{ax} \approx U_a$

~~$U_{ay}=$~~

$$\sin \Delta\varphi = \frac{U_{ay}}{U_a}$$

↓

$$U_{ay} = U_a \cdot \sin \Delta\varphi = U_a \cdot \sin 1° =$$

$\Delta U_2 =$ $\quad \Delta U_{ay} \quad \Delta U_{by} \quad \Delta U_{cy}$

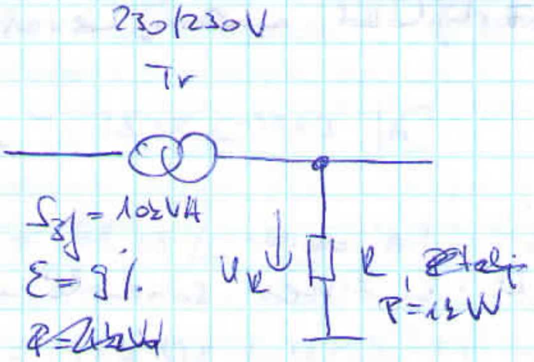
$$U_2 = \frac{1}{3}\left(U_a + a U_b + a^2 U_c\right)$$

$\Delta U_2 = \frac{1}{3} \cdot \Delta U_a$, a többi változatlan

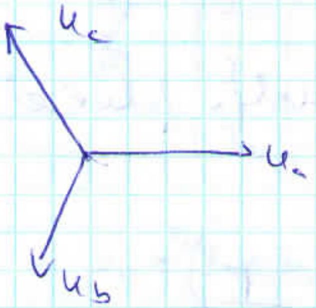
A többiek nem fordulnak el ugyanúgy? Nem lesz hiba ugyanúgy U_{by} és U_{cy} miatt (vagy ezeknél már nem is biztos, hogy csak az y komponens miatt)

és $\Delta U_a = U_{ay} \Rightarrow \Delta U_2 = 5{,}81 \cdot 10^{-3}$

4.



Tisztán (+) sorrendből indulunk ki. Az elrendezés hány % (−) sorrendű összetevőt fog generálni és milyen kapcsolású lehet a trafó?



$$P = \frac{U^2}{R}$$

$$R = \frac{U^2}{P} = \frac{230^2}{1000} = 52{,}9\ \Omega$$

$$X_{tr} = \frac{\varepsilon}{100} \cdot \frac{U^2}{S} = 0{,}09 \cdot \frac{230^2}{\frac{10 \cdot 10^3}{3}} = 1{,}428\ \Omega$$

$$U_2 = \frac{1}{3}(U_a + aU_b + a^2U_c)$$

↑ most csak erre felel az eset.

$$U_R = 230 \cdot \frac{R}{R + X_{tr}} = 230 \cdot \frac{52{,}9}{52{,}9 + 1{,}428} = 223{,}95\ \text{V}$$

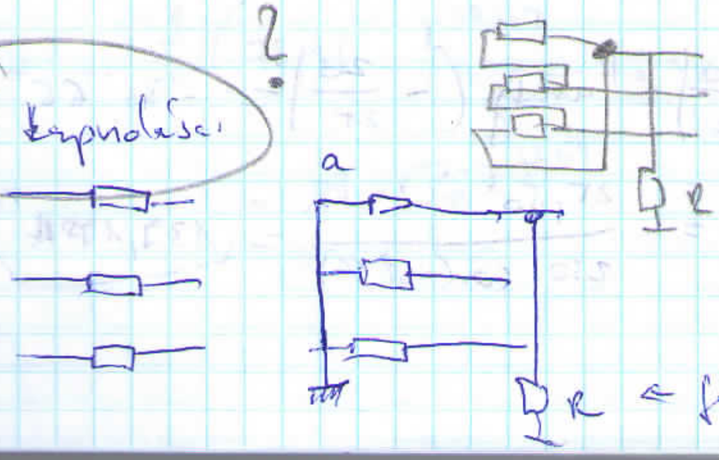
vagyis $\Delta U = 230 - 223{,}95 = 6{,}04$ V ekkora a transzformátoron bekövetkező feszültségesés.

$$\Delta U_2 = \frac{1}{3} \cdot \Delta U_{a} = 2{,}015\ \text{V}$$

, ami $\frac{2{,}015}{230} \cdot 100 = 0{,}876\%$ negatív sorrendű összetevő

?

trafó kapcsolása



emiatt Δ-be nem lehet a szekunder

7.

Van egy 230V-os szimm. 3F hálózat, amin a következőket mérjük:

$P_a = 15kW$

$Q_a = 10kvar$

$P_b = 15kW$

$Q_b = 10kvar$

$P_c = 25kW$

$Q_c = 20kvar$

Kell: az összes soros mennyiség.

$P = U \cdot I \cdot \cos\varphi$

$Q = U \cdot I \cdot \sin\varphi$, de mivel meddőtelj. felvétel van, ezért Q negatív.

$P_a = U_a \cdot I_a \cdot \cos\varphi_a$

$Q_a = -U_a \cdot I_a \cdot \sin\varphi_a$ $\rightarrow$ $\frac{P_a}{Q_a} = -\frac{1}{tg\,\varphi_a}$

$\cancel{\frac{15}{40}}$ ~~t_1~~ $-\frac{10}{15} = tg\,\varphi_a$

$\varphi_a = -33{,}69°$

$I_a = \frac{P_a}{U_a \cdot \cos\varphi_a} = \frac{15 \cdot 10^3}{230 \cdot \cos(-33{,}69)} = 78{,}38A$

Ugy

$\frac{Q_b}{P_b} = -tg\,\varphi_b \rightarrow \varphi_b = arctg\left(-\frac{10}{15}\right) = -33{,}69°$

$I_b = \frac{P_b}{U_b \cdot \cos\varphi_b} = 78{,}38A$

$\varphi_c = arctg\left(-\frac{Q_c}{P_c}\right) = arctg\left(-\frac{20}{25}\right) = -38{,}66°$

$I_c = \frac{P_c}{U_c \cdot \cos\varphi_c} = \frac{25 \cdot 10^3}{230 \cdot \cos(-38{,}66)} = 139{,}198A$

Vagyis a fázisáramok fazorálisan:

$\bar{I}_a = 78{,}38 \angle -33{,}69° \; [A]$

$\bar{I}_b = 78{,}38 \angle -33{,}69° \pm 120 \; [A] = \cancel{78{,}38 \angle 86{,}31°} \; [A] = 78{,}38 \angle -153{,}69° \; [A]$

$\bar{I}_c = 139{,}198 \angle -38{,}66 \pm 120 \; [A] = 139{,}198 \angle 86{,}31° \; [A]$

A sorrendi mennyiségek ezzől:

$$\begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \cdot \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

$$I_0 = \cancel{\frac{1}{3}(I_a + I_b + I_c) = 78{,}38 \angle} \frac{1}{3}\left[\cancel{78{,}38 \cdot e^{-j\,33{,}69} + 78{,}38 \cdot e^{j\,153{,}69} + 139{,}198 \cdot e^{j\,86{,}31}}\right] = 1{,}34\,j$$

$$I_0 = \frac{1}{3}(I_a + I_b + I_c) = \frac{1}{3}\Big[78{,}38 \cdot (\cos(-33{,}69) + j\sin(-33{,}69)) + 78{,}38 \cdot (\cos(-153{,}69) + j \cdot \sin(-153{,}69)) + 139{,}198 \cdot (\cos 86{,}31 + j \cdot \sin 86{,}31)\Big] = +j\,20{,}23$$

$$I_1 = \frac{1}{3}\left[I_a + a I_b + a^2 I_c\right] = \frac{1}{3}\left[78{,}38 \cdot e^{-j\,33{,}69} + e^{j120} \cdot 78{,}38 \cdot e^{-j\,153{,}69} + e^{-j120} \cdot 139{,}198 \cdot e^{j\,86{,}31}\right] =$$

$$= \frac{1}{3}\left(78{,}38\, e^{-j\,33{,}69} + 78{,}38 \cdot e^{-j\,33{,}69} + 139{,}198 \cdot e^{-j\,33{,}69}\right)$$

$$= \cancel{78{,}38\, e^{j\,33{,}69}} = 82{,}08 + j \cdot 54{,}7$$

(8.) Másodrendű digitális Bessel LPF

$f_1 = 250\,Hz$

$A_1 = -30\,dB$

$f_m = 6400\,Hz$ mintavételi frekv

Határozzuk meg a szűrő paramétereit!

papíron egy ilyet!

másodrendű Bessel:

$$A(p) = \frac{1}{1 + 1{,}3617p + 0{,}618p^2}$$

Becslés:

$$\left|\frac{1}{0{,}618p^2}\right| = A_1$$

$$p = j\Omega_1 \qquad \Omega_1 = \frac{\omega_1}{\omega_0} = \frac{f_1}{f_0}$$

$20\lg x = -30$

$$\frac{1}{0{,}618\cdot\left(\frac{f_1}{f_0}\right)^2} = A_1 \to -30\,dB \to 0{,}0316$$

$$\frac{1}{0{,}618}\cdot\frac{1}{0{,}0316} = \frac{f_1^2}{f_0^2}$$

$$f_0 = f_1\cdot\sqrt{0{,}618\cdot 0{,}0316} = \boxed{34{,}95\,Hz}$$

A normált mintavételi frekvencia:

$$\Omega_m = \frac{f_m}{f_0} = \frac{6400}{34{,}95} = 183{,}1$$

$$l = \operatorname{ctg}\frac{\pi}{\Omega_m} = \operatorname{ctg}\frac{180}{183{,}1} = 58{,}27$$

A transzformációs egyenlet:

$$\Omega_a = \ell \cdot tg \frac{\pi \cdot \Omega_d}{\Omega_m},$$

analóg szűrő stb. egyenletek, tehát ez pl. sávszűrőre is igaz

akkor $\Omega_d = \frac{\Omega_m}{2}$.

A másodfokú digitális szűrő paraméterei:

$A(p) = \frac{d_0 + d_1 p + d_2 p^2}{c_0 + c_1 p + c_2 p^2}$ $\quad A(z) = \frac{D_0 + D_1 z + D_2 z^2}{C_0 + C_1 z + C_2 z^2}$

$\cancel{D_0 = \frac{d_0 - d_1 \ell + d_2 \ell^2}{c_0 + c_1 \ell + c_2 \ell^2} =}$

most $A(p) = \frac{1}{1 + 1{,}361 p + 0{,}618 p^2}$, így

$d_0 = 1 \qquad c_0 = 1$

$d_1 = 0 \qquad c_1 = 1{,}361$

$d_2 = 0 \qquad c_2 = 0{,}618$

Az egész a bilineáris transzformáción alapul:

$\boxed{p = \ell \cdot \frac{z-1}{z+1}}$ -et kell helyettesíteni

és az $A(z)$-hez szükséges paraméterek:

$$D_0 = \frac{d_0 - d_1 \ell + d_2 \ell^2}{c_0 + c_1 \ell + c_2 \ell^2} = \frac{1}{1 + 1{,}361 \cdot 58{,}27 + 0{,}618 \cdot 58{,}27^2}$$

$$= 0{,}000459$$

$$D_1 = \frac{2(d_0 - d_2 \ell^2)}{c_0 + c_1 \ell + c_2 \ell^2} = \frac{2 \cdot 1}{1 + 1{,}361 + \dots} = 0{,}000918$$

$$D_2 = \frac{d_0 + d_1 \ell + d_2 \ell^2}{c_0 + c_1 \ell + c_2 \ell^2}$$

$$C_0 = \frac{c_0 - c_1 \ell + c_2 \ell^2}{c_0 + c_1 \ell + c_2 \ell^2} \quad \dots$$

PAPÍRRA ezeket felírni!

mindegyiket egy számolni

+ előjelre is

7.

$U_a = 230\,V$

$U_b = 230\,V$

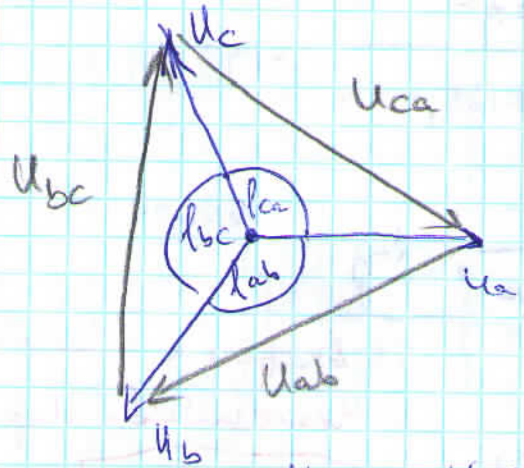
$U_c = 228\,V$

$U_{ab} = 400\,V$

$U_{ca} = 396\,V$

$U_2 = ?$

$$\begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix} = \frac{1}{3} \cdot \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \cdot \begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix}$$



Kosinustétellel:

$$U_{ca}^2 = U_a^2 + U_c^2 - 2U_c \cdot U_a \cdot \cos \varphi_{ca}$$

$$\varphi_{ca} = \arccos \frac{U_a^2 + U_c^2 - U_{ca}^2}{2 U_c U_a} = \arccos \frac{230^2 + 228^2 - 396^2}{2 \cdot 230 \cdot 228}$$

$$= 119{,}68^\circ$$

$$\varphi_{ab} = \arccos \frac{U_b^2 + U_a^2 - U_{ab}^2}{2 U_a U_b} = \arccos \frac{230^2 + 230^2 - 400^2}{2 \cdot 230 \cdot 230} =$$

$$= 120{,}81^\circ$$

így $\varphi_{bc} = 360 - (\varphi_{ca} + \varphi_{ab}) = 119{,}5^\circ$

Όπου $\overline{U_a} = U_a \angle 0^\circ$

$\overline{U_b} = U_b \angle -120{,}81^\circ$

$\overline{U_c} = U_c \angle 119{,}68^\circ$

$$U_2 = \frac{1}{3}\left(\overline{U_a} + a^2\overline{U_b} + a\overline{U_c}\right) =$$

$$= \frac{1}{3}\left(U_a + e^{j240} \cdot U_b \cdot e^{-j120{,}81} + e^{j120} \cdot U_c \cdot e^{j119{,}68}\right) =$$

$$= \frac{1}{3} \cdot \left(230 + 230 \cdot e^{+j\,119{,}19} + 228 \cdot e^{j \cdot 239{,}68}\right)$$

$$\cancel{U_{2x} = \frac{1}{3}\left(230 + 230 \cdot \cos(-0{,}81^\circ) + 228 \cdot \cos(359{,}68^\circ)\right) =}$$

$$\cancel{= \frac{1}{3}\left(230 + 229{,}97 + \right.}$$

$$U_{2x} = \frac{1}{3}\left(230 + 230 \cdot \cos 119{,}19^\circ + 228 \cdot \cos 239{,}68^\circ\right) = 0{,}908\,V$$

$$U_{2y} = \frac{1}{3}\left(0 + 230 \cdot \sin 119{,}19^\circ + 228 \cdot \sin 239{,}68^\circ\right) =$$

$$= 1{,}325\,V$$

άρα $U_2 = \sqrt{U_{2x}^2 + U_{2y}^2} = \underline{\underline{1{,}607\,V}}$

8.

AD bitszám = 12

AD input = ±10V

N = 64

$U_{primer1} = 20kV$

$U_{primer2} = 100V$

$U_{szekunder1} = 250V$

$U_{szekunder2} = 5V$

$I_{primer1} = 300A$

$I_{primer2} = 1A$

$I_{szekunder1} = 1A$

$I_{szekunder2} = 0{,}01A$

$R_i = 300\Omega$

Amit kaptunk:

$U_x = 6\,000\,000_H$

$U_y = 8\,000\,000_H$

$I_x = 6\,000\,000_H$

$I_y = 4\,000\,000_H$

$maxérték = 4000_H$

$U_{RMS} = ?$

$I_{RMS} = ?$

$P = ?$

$Q = ?$

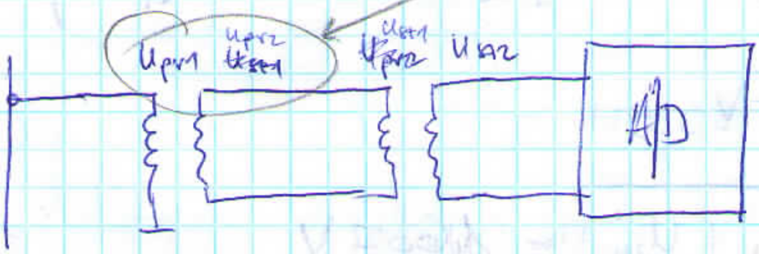
$\cos\varphi = ?$

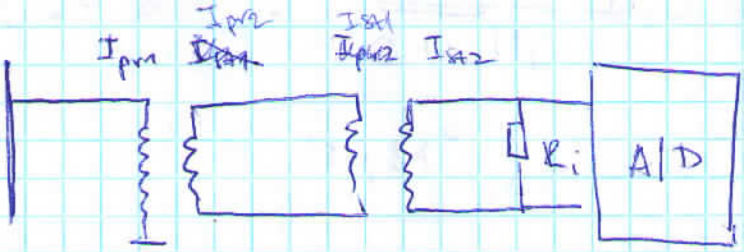
$U_x = 6 \cdot 16^6 = 100{,}66 \cdot 10^6$

$U_y = 8 \cdot 16^6 = 134{,}21 \cdot 10^6$

$maxérték = 4 \cdot 16^3 = 16384$

ezek hogy vannak egymáshoz?





$$U_{lép}\left[\frac{V}{LSB}\right] = \frac{AD_{in}}{2^{ADbit-1}} \cdot \frac{U_{pr1}}{U_{sz1}} \cdot \frac{U_{pr2}}{U_{sz2}} = 48{,}28\ \frac{V}{LSB}$$

$$I_{lép}\left[\frac{A}{LSB}\right] = \frac{AD_{in}}{2^{ADbit-1}} \cdot \frac{I_{pr1}}{I_{sz1}} \cdot \frac{I_{pr2}}{I_{sz2}} \cdot \frac{1}{R_i} = 0{,}4883\ \frac{A}{LSB}$$

$$U = \frac{1}{N}\left[\sum_{n=0}^{N-1} U(n)\cdot\cos\left(n\frac{2\pi}{N}\right) - j\sum_{n=0}^{N-1} U(n)\cdot\sin\left(n\frac{2\pi}{N}\right)\right]$$

$$N \cdot U = \sum_{n=0}^{N-1} U(n)\cdot\cos\left(n\frac{2\pi}{N}\right) - j\sum_{n=0}^{N-1} U(n)\cdot\sin\left(n\frac{2\pi}{N}\right)$$

$$U_{xtár} = N.U_x \cdot maxsin \cdot \frac{1}{2}$$ ez miért van itt?

$$U_x = \frac{2 \cdot U_{xtár}}{N \cdot maxsin} = \frac{2 \cdot 100{,}66 \cdot 10^6}{64 \cdot 16384} = 191{,}99\ [LSB]$$

így $U_x[V] = U_x\left[\frac{V}{LSB}\right] \cdot U_x[LSB] =$

$$= 48{,}28 \cdot 191{,}99 = 9269{,}45\ V$$

U_y hasonlóan:

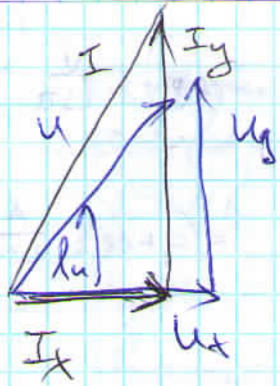
$$U_y = \frac{2 \cdot U_{ytár}}{N \cdot maxsin} = \frac{2 \cdot 134{,}21 \cdot 10^6}{64 \cdot 16384} = 255{,}98\ [LSB]$$

így $U_y[V] = 48{,}28 \cdot 255{,}98 = 12358{,}97\ V$

$$U = \frac{\sqrt{U_x^2 + U_y^2}}{\sqrt{2}} = \underline{\underline{10924\ V}}$$

RMS miatt

A teljesítmények számolásához a fázisszöget és az áram szögét is meg kell határozni:



$$\varphi_u = \operatorname{arctg} \frac{u_y}{u_x} = \operatorname{arctg} \frac{12800{,}4}{9375} =$$

$$= 53{,}13^\circ$$

$$\varphi_I = \operatorname{arctg} \frac{I_y}{I_x} = \operatorname{arctg} \frac{62{,}5}{93{,}75} = 33{,}69^\circ$$

papíron !

$$\varphi = \varphi_I - \varphi_u = 33{,}69 - 53{,}13 = -19{,}44^\circ$$

$$\cos\varphi = 0{,}943$$

így $P = u \cdot I \cdot \cos\varphi = \underbrace{11048{,}75}_{\frac{\sqrt{u_x^2+u_y^2}}{\sqrt{2}}} \cdot \underbrace{79{,}67}_{\frac{\sqrt{I_x^2+I_y^2}}{\sqrt{2}}} \cdot 0{,}943 =$

$= \underline{\underline{830{,}07 \text{ kW}}}$

$Q = u \cdot I \cdot \sin\varphi = -292{,}96 \text{ kVar}$

φ negatív, így induktív

(9.) Szigetelt csillagpontú hálózaton az alábbi mennyiségeket mérjük:

$U_{ab} = 100 V$

$U_{bc} = 80 V$

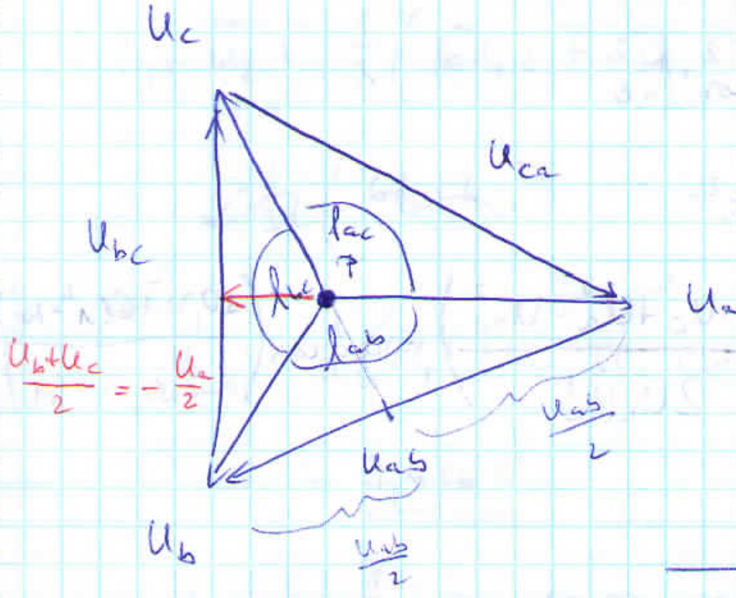
$U_{ac} = 100 V$

$U_a = ?$

$U_b = ?$

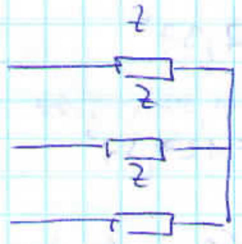
$U_c = ?$

$U_z = ?$ %



$\frac{3}{2} U_a$

Szigetelt csp.:



$Z_1 = Z$

$Z_2 = Z$

$Z_\phi = \infty$

zérus sorrendű kompo-
nens nincs

$$U_a + U_b + U_c = 0$$
$$\Downarrow$$
$$U_b + U_c = -U_a$$

A P pont tehát súlypont.

$$U_c^2 = \left(\frac{U_{bc}}{2}\right)^2 + \left(\frac{U_a}{2}\right)^2$$

$$\left(\frac{3}{2}U_a\right)^2 + \left(\frac{U_{bc}}{2}\right)^2 = U_{ca}^2$$

$$U_a = \frac{\sqrt{U_{ca}^2 - \left(\frac{U_{bc}}{2}\right)^2}}{\frac{3}{2}} = \frac{\sqrt{100^2 - \left(\frac{80}{2}\right)^2}}{\frac{3}{2}} = \underline{61{,}1\,V}$$

$$U_c = \sqrt{\left(\frac{U_{bc}}{2}\right)^2 + \left(\frac{U_a}{2}\right)^2} = \sqrt{\left(\frac{80}{2}\right)^2 + \left(\frac{61{,}1}{2}\right)^2} = \underline{50{,}33\,V}$$

$$|U_b| = |U_c| = \underline{50{,}33\,V}$$

$$U_{ac}^2 = U_c^2 + U_a^2 - 2U_a U_c \cdot \cos \varphi_{ac}$$

$$\cancel{U_{ac}^2 - U_c^2 - U_a^2}$$

$$\cancel{\varphi_{ac} \approx}$$

$$\varphi_{ac} = \arccos\left(\frac{U_c^2 + U_a^2 - U_{ac}^2}{2U_a U_c}\right) = \arccos\left(\frac{50{,}33^2 + 61{,}1^2 - 100^2}{2 \cdot 50{,}33 \cdot 61{,}1}\right)$$

$$= 127{,}37^\circ$$

$$\varphi_{ab} = \varphi_{ac} = 127{,}37^\circ$$

$$\varphi_{bc} = 360 - (\varphi_{ab} + \varphi_{ac}) = 105{,}24^\circ$$

$$\begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix}$$

$$\begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix}$$

$$\overline{U}_2 = \frac{1}{3}\left(\overline{U}_a + a^2 \overline{U}_b + a \overline{U}_c\right)$$

$$\overline{U}_a = U_a \angle 0^\circ$$

$$\overline{U}_b = U_b \angle -127{,}37^\circ$$

$$\overline{U}_c = U_c \angle 127{,}37^\circ$$

így $\bar{U}_2 = \frac{1}{3}\left(61{,}1 + 50{,}33 \cdot e^{-j\cdot 127{,}37} \cdot e^{j240} + 50{,}33 \cdot e^{j127{,}37} \cdot e^{j120}\right)$

~~$\frac{1}{3}\left(61{,}1+\right.$~~

$U_{2x} = \frac{1}{3}\left(61{,}1 + 50{,}33 \cdot \cos 112{,}63^\circ + 50{,}33 \cdot \cos 247{,}37^\circ\right) =$

$= \underline{\underline{7{,}456\,V}}$

$U_{2y} = \frac{1}{3}\left(0 + 50{,}33 \cdot \sin 112{,}63^\circ + 50{,}33 \cdot \sin 247{,}37^\circ\right) =$

$= 0\,V$ a szimmetriából is adódik.

így $\boxed{U_2 = 7{,}456\,V}$

(10.) Motoros fogyasztó teljesítményét mérjük

$U_{rms} = 218V$

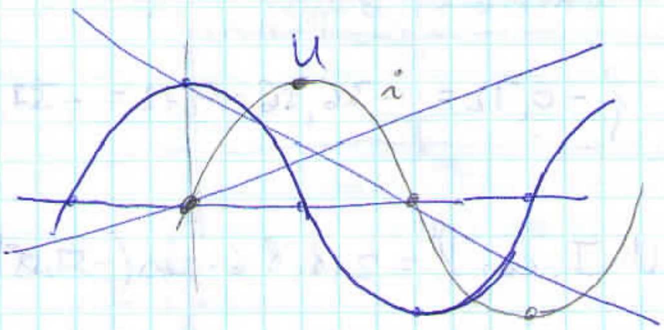
$I_{rms} = 8{,}6A$

$P_{mért} = 1500W$ (rms)

$T_{ad} = 40\,\mu s$ a két mintavétel között eltelt idő

A mintavétel sorrendje: előbb U, aztán I.

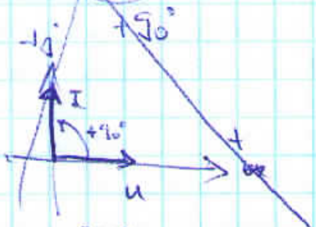
Mennyi a valós teljesítmény?



induktív fogyasztó

$j\omega L$

$U = I \cdot j\omega L =$



$P = U \cdot I \cdot \cos \varphi$

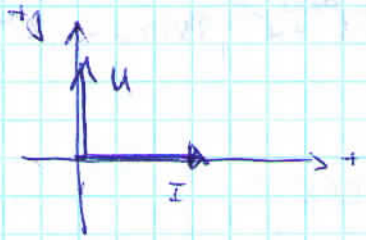
$\varphi = \arccos \frac{P}{U \cdot I} = \arccos \frac{1500}{218 \cdot 8{,}6} = 36{,}86^\circ$

$\cos\varphi = 0{,}8$

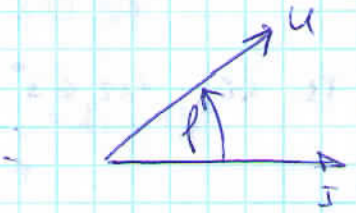
A 40μs-os elcsúszás miatt szöghiba lesz:

papírra! $\boxed{\Delta\varphi = 2\pi\cdot\frac{\Delta t}{T}} = 2\pi\cdot\frac{40\cdot10^{-6}}{20\cdot10^{-3}} = 0{,}72°$

Mivel induktív fogyasztónk van:



$U = I\cdot j\omega L = I\cdot X_L\cdot e^{j90°}$

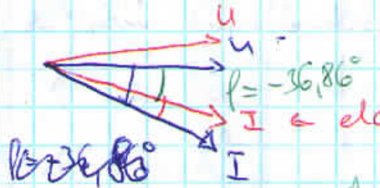


← Ha induktív jellegű, de nem tisztán induktív fogyasztó.

$\cos\varphi = 0{,}8$

$\varphi = 36{,}86°$

Ha előbb U-ból veszünk mintát és utána I-ből, akkor:



Azért, mert mi mérünk, s így ami rés a késett áramot mintázzuk meg, ~~A valóságban azonban~~ a nem késett feszültséggel együtt, s ezek között van egy szög. A valóságban azonban a U mintavételezésekor I még a 0,72°-kal hátrébb van, vagyis:

$$\varphi' = \varphi - 0{,}72 = -36{,}86 - 0{,}72 = -37{,}58°$$

És így

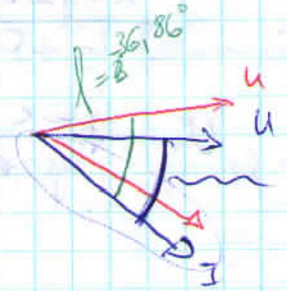
$$P' = U\cdot I\cdot\cos\varphi' = 218\cdot 8{,}6\cdot\cos(-37{,}58°) =$$

$$= 1485{,}78\ W$$

Így $|\Delta P| = |P - P'| = 14{,}21\ W$, ami

$h = \frac{14{,}21}{1500}\cdot 100 = \underline{0{,}947\%}$ hiba

Ha viszont előbb mintavételezzük I-t:



φ' : erre vagyok kíváncsi

$\cancel{\varphi' + 0{,}72 = \varphi}$

$\cancel{\varphi' = \varphi - 0{,}72}$

$|\varphi'| + 0{,}72 = |\varphi|$

$|\varphi'| = |\varphi| - 0{,}72$, de mivel φ negatív és φ' is negatív, ezért

$\varphi' = \varphi + 0{,}72 = -36{,}86 + 0{,}72 = -36{,}14°$

$P' = U \cdot I \cdot \cos\varphi' = 218 \cdot 8{,}6 \cdot \cos(-36{,}14) = 1514{,}047\,W$

$|\Delta P| = 14{,}048\,W$

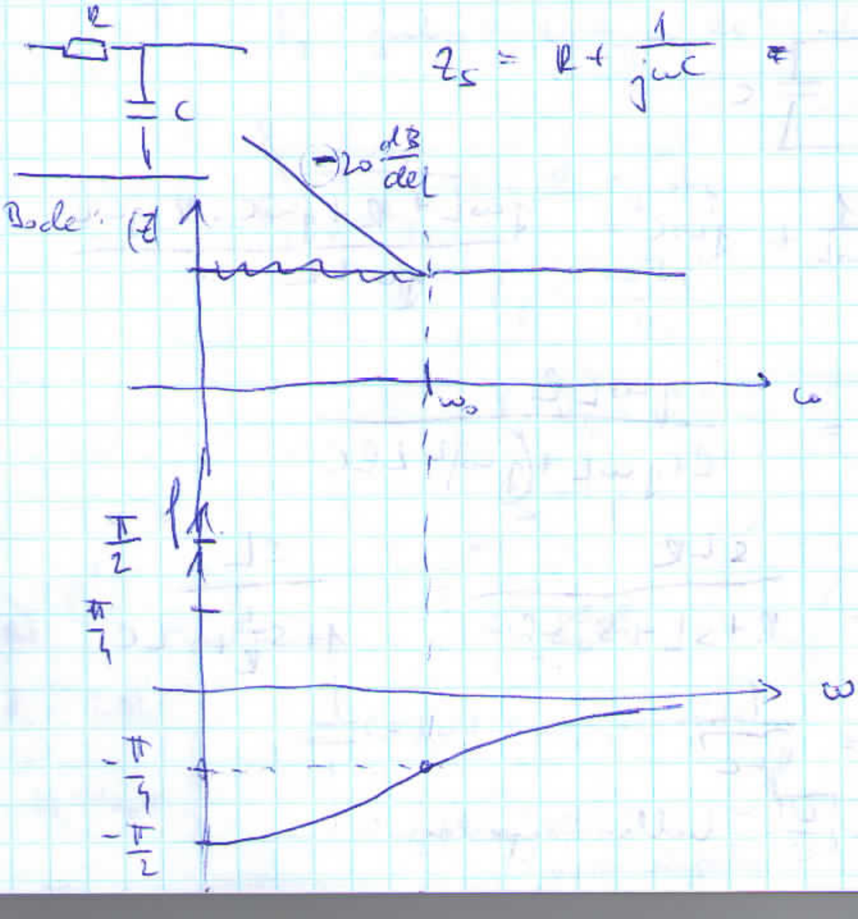
így $h = \underline{0{,}936\ \%}$ hiba

1.

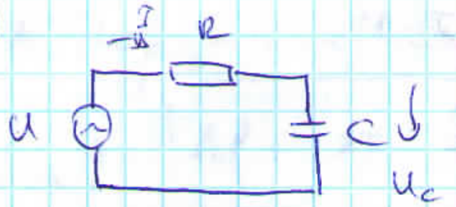
$Z_s = R + \frac{1}{j\omega C}$

$\omega = 0 : Z_s = \infty$

$\omega \to \infty : Z_s = R$



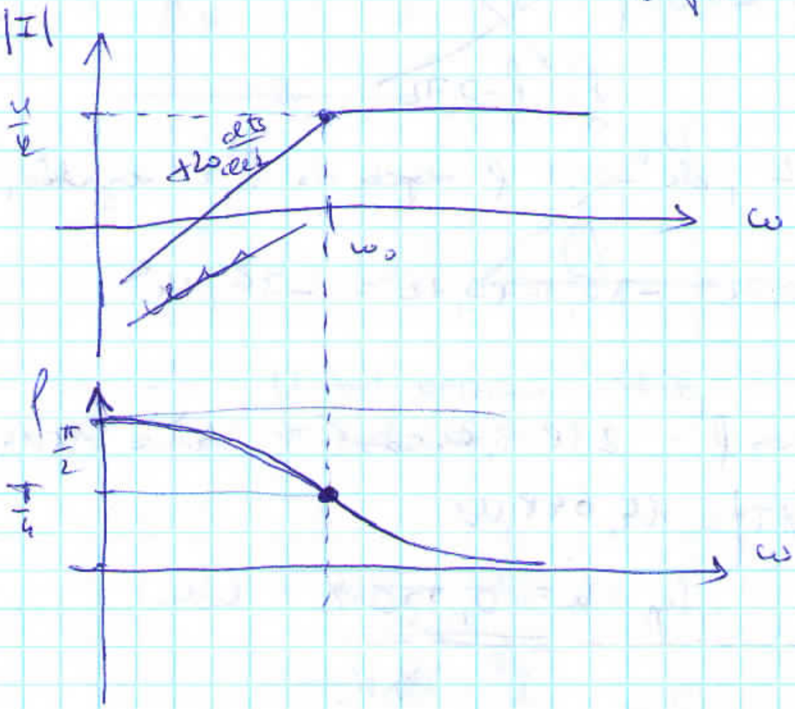
(2.)



$$Z = R + \frac{1}{j\omega C} = \frac{1 + j\omega RC}{j\omega C}$$

$$I = \frac{U}{Z} = U \cdot \frac{j\omega C}{1 + j\omega RC}$$

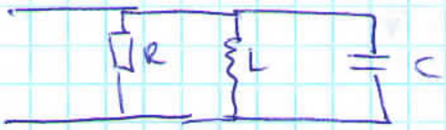
$$I = \frac{U}{R + \frac{1}{j\omega C}}$$



$$\omega = 0 \quad : I = \frac{U}{R + \frac{1}{0}} = \frac{U}{\infty} = $$
$$= 0$$

$$\omega \to \infty : \quad I = \frac{U}{R + \frac{1}{\infty}} = \frac{U}{R}$$

(3.)



$$Y = \frac{1}{R} + \frac{1}{j\omega L} + j\omega C = \frac{j\omega L + R + j\omega C \cdot R \cdot j\omega L}{j\omega LR}$$

$$Z = \frac{1}{Y} = \frac{j\omega LR}{R + j\omega L + (j\omega)^2 LRC}$$

$$Z(s) = \frac{sLR}{R + sL + s^2 LRC} = \frac{sL}{1 + s\frac{L}{R} + s^2 LC}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

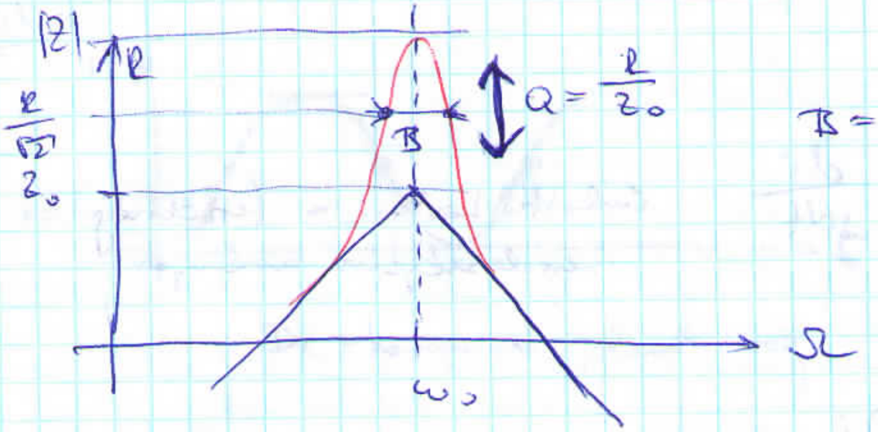
$$Z_0 = \sqrt{\frac{L}{C}}$$ hullámimpedancia

$\Omega = \frac{\omega}{\omega_0}$ $S = j\Omega$

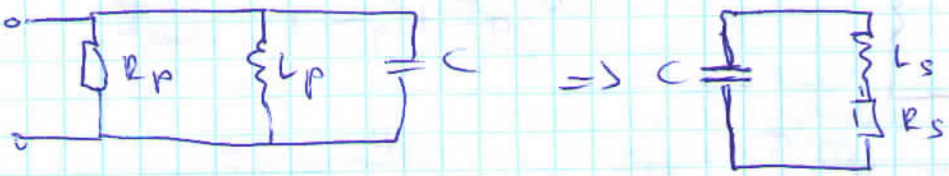
így $Z(S)$ felírható

jósági tényező: $Q = \frac{R}{Z_0}$ párhuzamosan

$Q = \frac{Z_0}{R}$ sorosra



$B = \frac{1}{Q}$ sávszélesség



$R_p + j\omega L_p = R_s + j\omega L_s$, mert C ugyanaz.

$$\frac{R_p \cdot j\omega L_p}{R_p + j\omega L_p} = R_s + j\omega L_s$$

$\Downarrow$

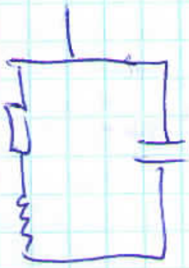
$$R_p = \frac{\omega^2 L_s^2}{R_s}$$

$$R_p \cdot R_s = Z_0^2$$

$$L_s = L_p$$

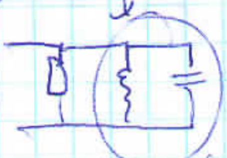
megfeleltetés

pl:



$R_s = 2\Omega$, $C = 1\mu F$, $L_s = 10mH$ => átalakítjuk

$Z(\omega_0) = ?$ rezonanciafrekvencián

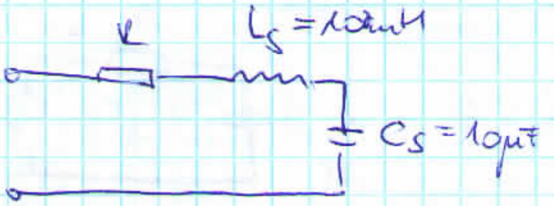


= a elleni -re

$L_s = L_p$

$$R_p = \frac{Z_0^2}{R_s} = \frac{\left(\sqrt{\frac{L_s}{C}}\right)^2}{R_s} = \frac{\left(\sqrt{\frac{10 \cdot 10^{-3}}{10^{-6}}}\right)^2}{2} = 5k\Omega$$

(2.)



$R = ?$

$Q = 10$

soros rezgőkör: $Q = \frac{Z_0}{R}$

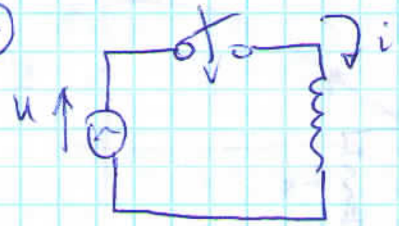
$\frac{10^{-1}}{10^{-5}} = 10^{4}$

$$R = \frac{Z_0}{Q} = \frac{\sqrt{\frac{L}{C}}}{Q} = \frac{\sqrt{\frac{10\cdot10^{-3}}{10\cdot10^{-6}}}}{10} = \frac{100}{10} = \underline{\underline{10\,\Omega}}$$

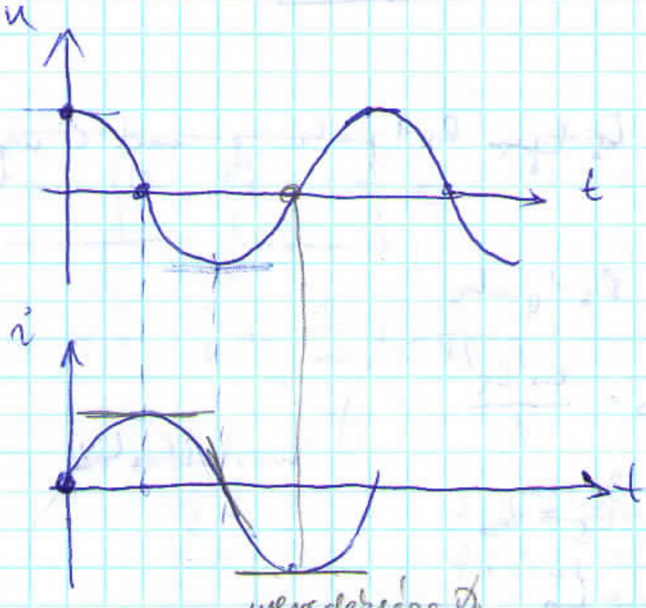
RLC – tranziensek

$U = L\cdot\frac{di}{dt}$ indukciós törvény: a feszültség az áram meredekségével arányos.

(4.)



feszültségmaximumba kapcsolva



meredeksége Ø, mert U = Ø

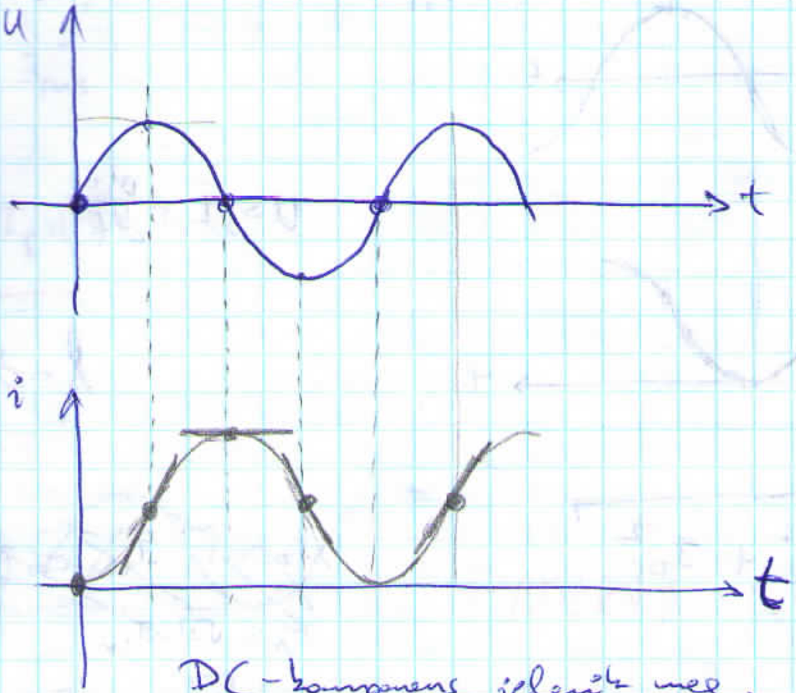
$U = L\cdot\frac{di}{dt}$

↓

ahol $U = max$, ott $\frac{di}{dt} = max$

ahol $U = 0$, ott $\frac{di}{dt} = \cancel{max}\ \emptyset$

A fesz. ø átmenetben bekapcsolás:



$u = L \cdot \frac{di}{dt}$

DC-komponens jelenik meg.

$I^{eff}_{eredő} = \sqrt{I_p^2 + I_{DC}^2}$

$I_{tr} = \frac{U_0}{Z_e}$

$I_{DC} = \sqrt{2} \cdot I_{tr} \cdot \cos\varphi$, ~~de ezt~~

$\varphi = 0°$ bekapcsolás höze

~~$\varphi = 90°$, ezt ténylegesen indukt. tér~~

$I_p = \sqrt{2} \cdot I_{tr}$

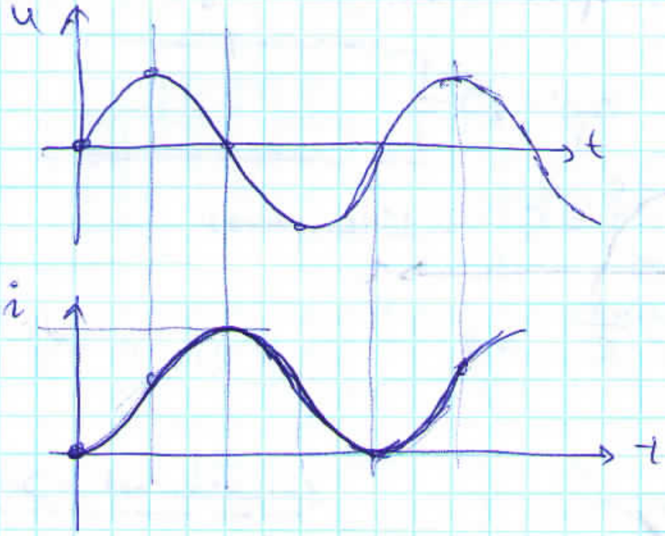
$I^{eff}_{eredő} = \cancel{\sqrt{\sqrt{2} \cdot I_{tr}(1+}} \sqrt{2 I_{tr}^2 (1 + \cos^2\varphi)} =$

ahol $\varphi = 0°$

$= \sqrt{2 I_{tr}^2 \cdot (1+1)} = 2 I_{tr} =$

$= 2 \cdot \frac{I_p}{\sqrt{2}}$

$I_e = \sqrt{2} \cdot I_{tr} + \sqrt{2} \cdot I_{tr} \cdot \cos\varphi = 2\sqrt{2}\, I_{tr}$



$$u = L \cdot \frac{di}{dt}$$

$$\varphi = 0^\circ$$

$$I_{eredő}^{eff} = \sqrt{I_p^2 + I_{pc}^2}$$

$$\cancel{I_{pc} = \sqrt{2} \cdot I_{tr} \cdot \cos\varphi}$$

$$\cancel{I_p = \sqrt{2}\, I_{tr}}$$

$$I_{tr} = \frac{U_0}{Z}$$

$$\cancel{I_p = I_{tr}}$$

$$\cancel{I_{pc} = \sqrt{2} \cdot I_{tr} \cdot \cos\varphi}$$

$$\cancel{I_{eredő}^{eff} = \sqrt{I_{tr}^2 + (1+\sqrt{2}}$$

$$\cancel{I_{tr}(1+\sqrt{2}\cos\varphi)}$$

$$\cancel{I_{eredő}^{eff} = \sqrt{I_{tr}^2 + 2 I_{tr}^2 \cdot \cos^2\varphi}}$$

mert $\varphi =$

$$I_{pc} = \frac{I_p}{\sqrt{2}} \cdot \cos\varphi$$

$$I_{eredő}^{eff} = \sqrt{I_p^2 + \frac{I_p^2}{2} \cdot \cos^2\varphi} = \sqrt{\frac{3}{2} I_p^2} = \frac{\sqrt{3}}{\sqrt{2}} \cdot I_p = \boxed{\frac{I_p}{\sqrt{2}} \cdot \sqrt{3}}$$

mert $\cos\varphi = 1$

$$\frac{2}{2 \cdot 4}$$

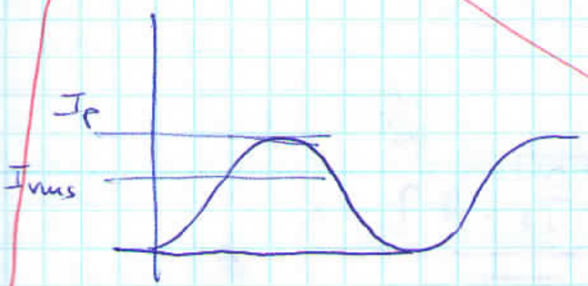
$\varphi = 45^\circ$:

$$I_{eredő}^{eff} = \sqrt{I_p^2 + \frac{I_p^2}{2} \cdot \left(\frac{\sqrt{2}}{2}\right)^2} = \sqrt{I_p^2\left(1 + \frac{1}{4}\right)} = I_p \cdot \sqrt{1{,}25}$$

$$= \frac{I_p}{\sqrt{2}} \cdot \sqrt{2 \cdot 1{,}25} = \frac{I_p \cdot \sqrt{2{,}5}}{\sqrt{2}}$$

I_{rms}

$$I_{DC} < I_p = \sqrt{2} \cdot I_{rms}$$



PAPÍRRA

$$I_p = I_{rms} \cdot \sqrt{2} \qquad \cancel{Eff} \quad I_{rms} = \frac{I_p}{\sqrt{2}}$$

$$I_{rms} = \frac{U_o}{Z}$$

$$I_{DC} = \sqrt{2} \cdot I_{rms} \cdot \cos\varphi$$

$$I_{eff} = \sqrt{I_{rms}^2 + I_{DC}^2} = \sqrt{I_{rms}^2 + (\sqrt{2} \cdot I_{rms} \cdot \cos\varphi)^2} =$$

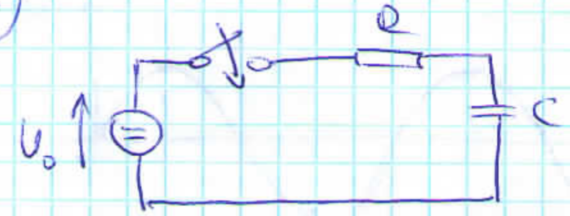
$$= I_{rms} \sqrt{1 + 2 \cdot \cos^2\varphi}$$

~~cos~~ $\varphi = 90°$-nál $\cos\varphi = 1$, így ilyenkor

$$I_{eff} = I_{rms} \cdot \sqrt{3} = \frac{I_p}{\sqrt{2}} \cdot \sqrt{3}$$

$$I_p = \sqrt{2} I_{rms} + I_{DC} = \sqrt{2} I_{rms} (1 + \cos\varphi)$$

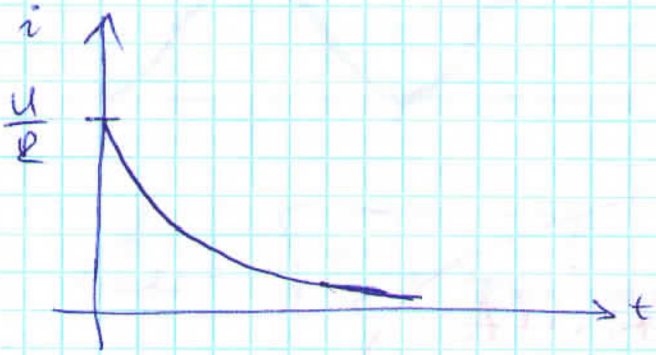
6.

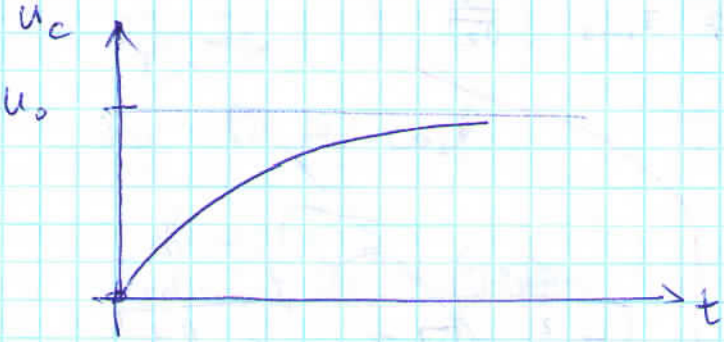


$\tau = RC$

bekapcsolás pillanatában a C rövidzár

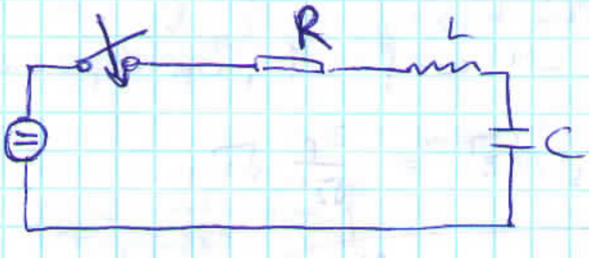
$i = \frac{U}{R} \cdot e^{-\frac{t}{\tau}}$





$u_C = U_0 \left(1 - e^{-\frac{t}{\tau}}\right)$

7. Soros RLC-kör.



$Z = R + sL + \frac{1}{sC} = \frac{1 + sRC + s^2LC}{sC}$

~~Langási ... [illegible]~~ ↓ kis s

$s = j\omega$

$S = j\Omega$, ahol $\Omega = \frac{\omega}{\omega_0}$

$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad \text{soros rezgőkörre:} \quad Q = \frac{Z_0}{R}$$

$$Z_0 = \sqrt{\frac{L}{C}}$$

$$Z = \frac{1 + j\omega RC + (j\omega)^2 LC}{j\omega C} = \cancel{1 + j\frac{\omega}{\omega_0} R \cdot C \frac{1}{\sqrt{LC}}}$$

$$= \frac{1 + j\frac{\omega}{\omega_0} R \cdot \frac{1}{\sqrt{LC}} \cdot C + \left(j\frac{\omega}{\omega_0}\right)^2 \cdot \frac{1}{LC} \cdot LC}{j\frac{\omega}{\omega_0} \cdot \frac{1}{\sqrt{LC}} \cdot C} =$$

$$\frac{1}{Z_0} \rightarrow$$

$$\Rightarrow \frac{1 + sR \cdot \sqrt{\frac{C}{L}} + s^2}{s\sqrt{\frac{C}{L}}} = R \cdot \frac{1 + s\frac{1}{Q} + s^2}{s\frac{1}{Q}}$$

Lengés akkor alakul ki, ha a számlálóból álló másodfokú egyenlet diszkriminánsa negatív:

$$1 + s\frac{1}{Q} + s^2 = 0$$

$$s_{1,2} = \frac{-\frac{1}{Q} \pm \sqrt{\frac{1}{Q^2} - 4}}{2} \rightarrow \frac{1}{Q^2} - 4 < 0$$

$$\frac{1}{Q^2} < 4$$

$$\frac{1}{4} < Q^2 \rightarrow \boxed{Q > \frac{1}{2}}$$

Rezgőkör csillapítási tényezője:

$$\delta = \frac{R}{2L} = \frac{Z_0}{2LQ} = \frac{\omega_0}{2Q}$$

$$\cancel{Z_0 = \sqrt{\frac{L}{C}}}$$

$$Q = \frac{Z_0}{R} \rightarrow R = \frac{Z_0}{Q}$$

$$Z_0 = \sqrt{\frac{L}{C}} \rightarrow \frac{Z_0}{L} = \frac{\sqrt{\frac{L}{C}}}{L} = \frac{1}{\sqrt{LC}} = \omega_0$$

$$\omega_0 = \frac{2\pi}{T}$$

$i = \frac{U}{R} \cdot e^{-\delta t}$, így 1 periódus alatt a kör csillapodása:

$$i = \frac{U}{R} \cdot e^{-\frac{\omega_0}{2Q} \cdot T} =$$

$$= \frac{U}{R} \cdot e^{-\frac{\pi}{Q}}$$

Hány periódus alatt csillapodik a felére?

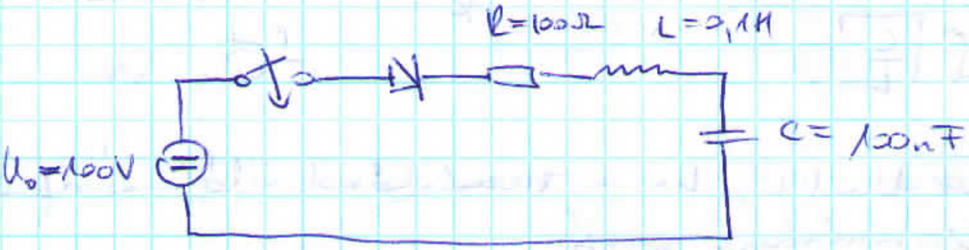
$$\frac{1}{2} = e^{-\delta t} \qquad t = k \cdot T \qquad \omega_0 = \frac{2\pi}{T}$$

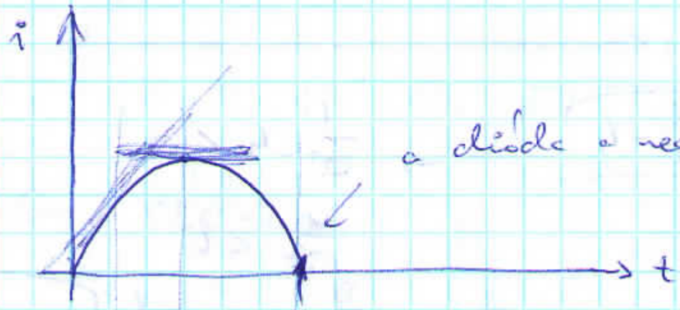
$$\frac{1}{2} = e^{-\frac{\omega_0}{2Q} \cdot k \cdot T} = e^{-\frac{2\pi}{2QT} \cdot kT} = e^{-\frac{\pi}{Q} k}$$

$$\ln \frac{1}{2} = -\frac{\pi}{Q} \cdot k$$

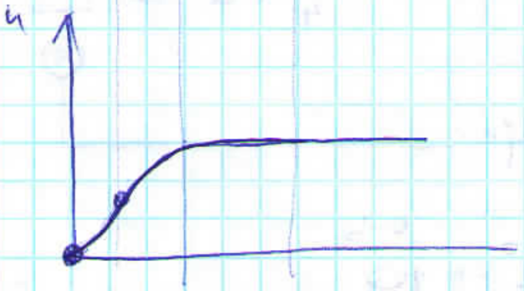
$$k = \frac{Q}{\pi} \cdot \ln 2 = Q \cdot 0{,}22$$

3.

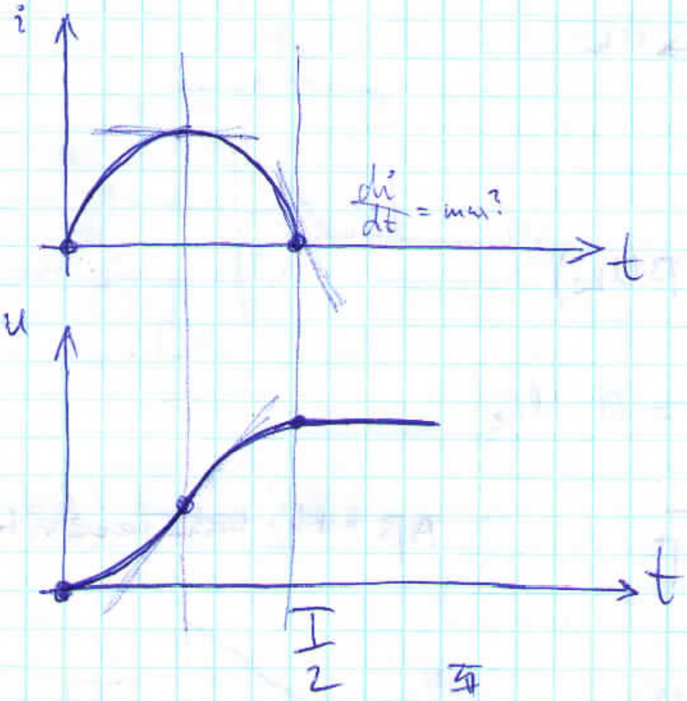




a dióda a negatív ~~félhullámnál lezár~~ áramnál lezár



$$u = L \cdot \frac{di}{dt}$$



$$U = L \cdot \frac{di}{dt}$$

$$\delta = \frac{R}{2L} = \frac{\omega_0}{2Q} = \frac{2\pi}{2QT}$$

$t = \frac{T}{2}$ -ig feszültség

$$u_{Cmax} = U_0 \cdot \left(1 + e^{-\delta t}\right) =$$

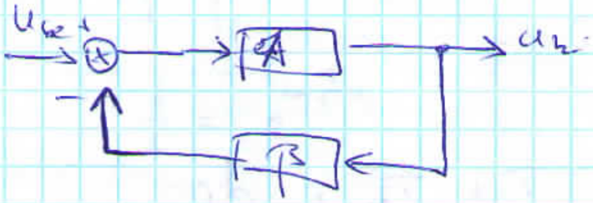
$$= U_0 \left(1 + e^{-\frac{R}{2L} \cdot \frac{T}{2}}\right) = U_0 \cdot \left(1 + e^{-\frac{2\pi}{2QT} \cdot \frac{T}{2}}\right) =$$

$$= U_0 \cdot \left(1 + e^{-\frac{\pi}{2Q}}\right) = U_0 \cdot \left(1 + e^{-\frac{\pi}{20}}\right) = \underline{\underline{185{,}47\,V}}$$

fontos

$$Q = \frac{Z_0}{R} = \frac{\sqrt{\frac{L}{C}}}{R} =$$

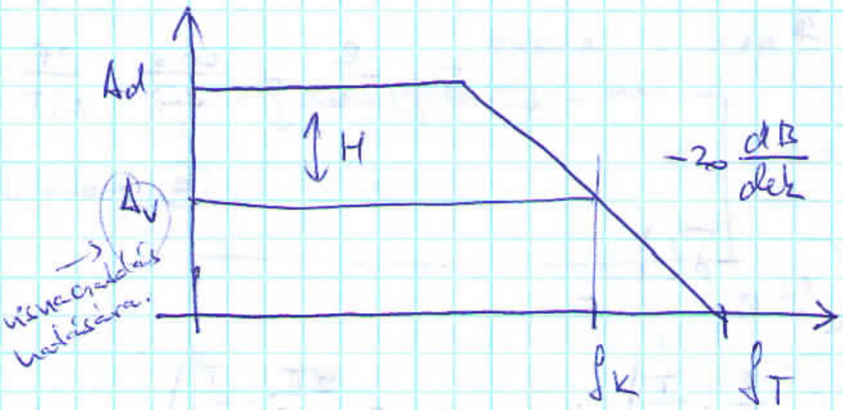
$$= \frac{\sqrt{\frac{0{,}1}{100 \cdot 10^{-9}}}}{100} = 10$$



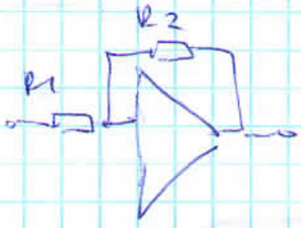
$$U_{ki} = A(U_{be} - \beta U_{ki})$$

$$U_{ki}(1+A\beta) = A \cdot U_{be}$$

$$\frac{U_{ki}}{U_{be}} = \frac{A}{1+A\beta} \qquad A\beta = H \text{ : hurokerősítés}$$



$$h = \frac{1}{1+\frac{1}{jH}} \qquad h = \frac{1}{1+\frac{1}{jH}}$$

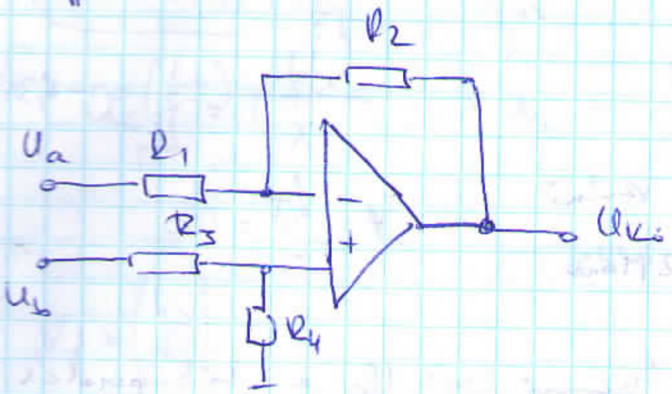


$$\beta = \frac{R_1}{R_1+R_2}$$

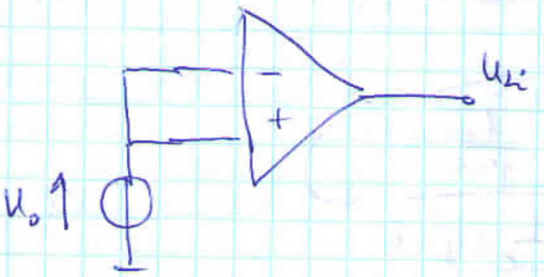
$$H = A \cdot \beta = 100 \cdot \frac{1}{11} = \frac{100}{11}$$

$$h = \frac{1}{1+\frac{1}{j\frac{100}{11}}}$$

Differenciaerősítő:

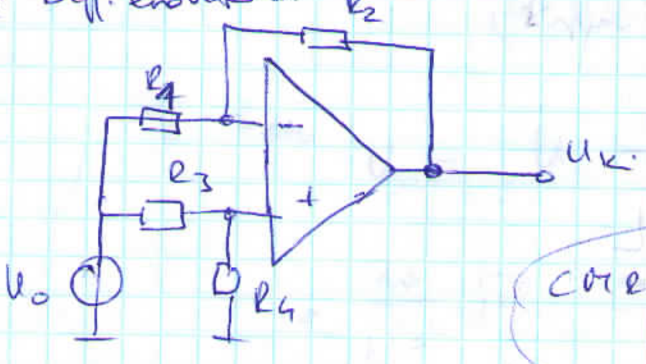


CMRR: közös jelelnyomás:



$$CMRR = \frac{U_{ki}}{U_0} \quad [dB]$$

Diff. erősítőnél:

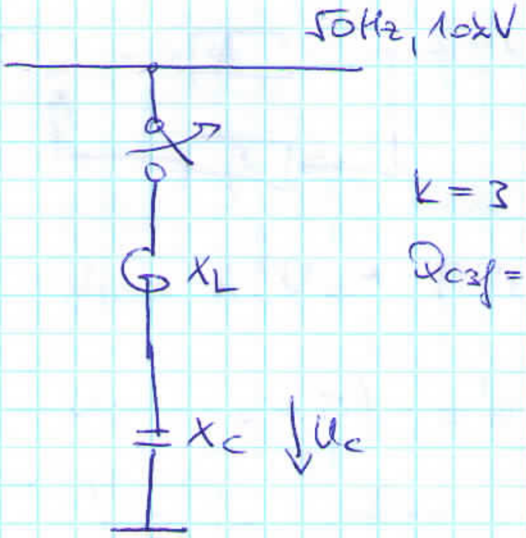


$R_1 = R_2 = R_4 = R$

$R_3 = R + \Delta R$

$$CMRR \approx -\frac{\Delta R}{2R+\Delta R} \approx -\frac{1}{2}\frac{\Delta R}{R}$$

(9.)



$k = 3$ között

$Q_{C3f} = 2$ Mvar

$$\frac{1}{1+\frac{1}{j9}} = \frac{1}{1-j\frac{1}{9}} \to \boxed{\varphi = +6,34°}$$

$\operatorname{arctg}\left(-\frac{1}{9}\right) = -6,34°$

vagy

$A = \frac{f_I}{f} = 100$

Mennyi lesz U_c a bekapcsolás után?

$$\left|\frac{1}{1-j\frac{1}{9,09}}\right| = \frac{1}{\sqrt{1^2+\left(\frac{1}{9,09}\right)^2}} =$$

$$U_c = U \cdot \frac{-X_c}{-X_c+X_L}$$

mert

$$U_c = U \cdot \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C}+j\omega L}$$

$k=3$ -ra van hangolva, vagyis

$$X_{C150} = X_{L150}$$

$$\frac{1}{3\omega_0 \cdot C} = 3\omega_0 \cdot L$$

$$\frac{1}{3} \cdot X_C = 3 \cdot X_L \to X_L = \frac{1}{9} X_c$$

így $U_c = U \cdot \frac{-X_c}{-X_c+\frac{1}{9}X_c} = U \cdot \frac{X_c}{\frac{8}{9}X_c} = \frac{9}{8} U$

$U = \frac{10}{\sqrt{3}} \cdot \sqrt{2}$ kV, így

$$U_c = \frac{10}{\sqrt{3}} \cdot \sqrt{2} \cdot 10^3 \cdot \frac{9}{8} [V]$$

$$\uparrow \quad \frac{k^2}{k^2-1}$$

Másképp megoldva:

$$Q_{C3f} = \frac{U_v^2}{X_C} \rightarrow X_C = \frac{U_v^2}{Q_{C3f}} = \frac{10^3}{2} = 500 = \frac{1}{\omega C}$$

ebből

$$\frac{1}{\omega X_C} = C$$

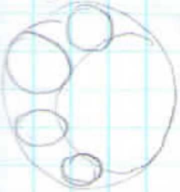
$$U_f = \left(\frac{U_v}{\sqrt{3}}\right) \qquad C = \frac{500}{2\pi f} =$$

$$U_v^2 = 3U_f^2 \qquad C = \frac{1}{2\pi \cdot 50 \cdot 500} = 6{,}37 \cdot 10^{-6}\,F$$

amiből mivel $X_{C150} = X_{L150}$, ezért L meghatározható:

$$X_{C150} = \frac{1}{2\pi 150 \cdot 6{,}37 \cdot 10^{-6}} = \omega_{150} L$$

$$L = \frac{1}{(2\pi \cdot 150)^2 \cdot 6{,}37 \cdot 10^{-6}} = 0{,}177\,H$$



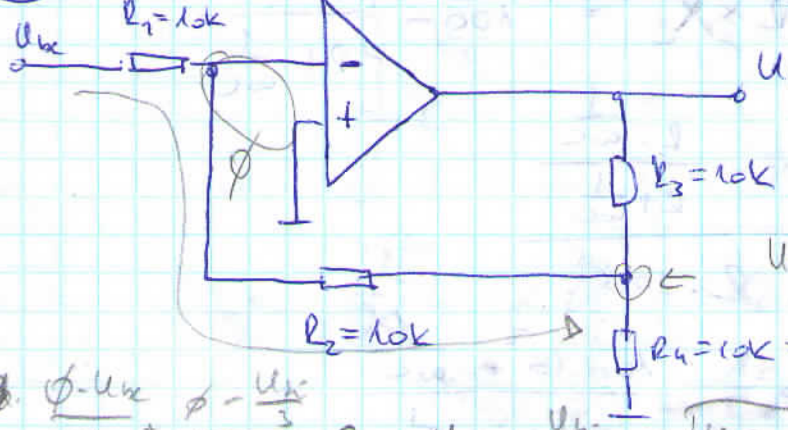
Így X_{250}

$$U_C = U \cdot \frac{-X_{C50}}{-X_{C50} + X_{L50}} = \text{tk.}$$

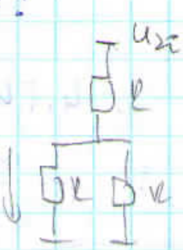
$$= \frac{10}{\sqrt{3}} \cdot \sqrt{2} \cdot \frac{-\frac{1}{2\pi \cdot 50 \cdot 6{,}37 \cdot 10^{-6}}}{-\frac{1}{2\pi \cdot 50 \cdot 6{,}37 \cdot 10^{-6}} + 2\pi \cdot 50 \cdot 0{,}177} =$$

$$= 56{,}25 \cdot \frac{10}{\sqrt{3}} \cdot \sqrt{2}$$

10.



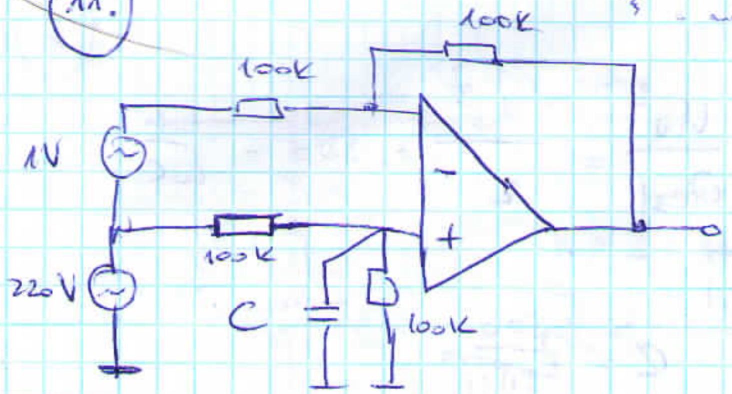
$A = ?$



$$U_{ki} \cdot \frac{R \times R}{R + (R \times R)} = U_{ki} \cdot \frac{\frac{1}{2}R}{(1+\frac{1}{2})R} = \frac{U_{ki}}{3}$$

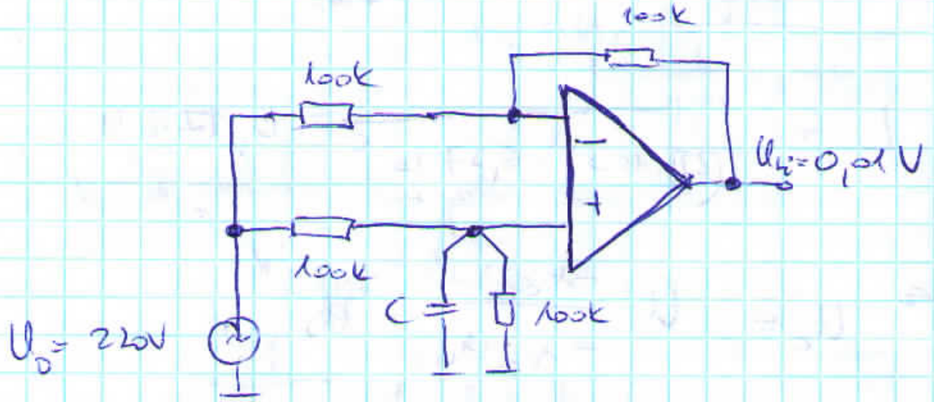
$$\frac{\emptyset - U_{be}}{R} + \frac{\emptyset - \frac{U_{ki}}{3}}{R} = 0 \rightarrow U_{be} = -\frac{U_{ki}}{3} \rightarrow \boxed{\frac{U_{ki}}{U_{be}} = -3}$$

(11.)



$C_{max} = ?$, hogy 1% pontossággal mérjünk?

CMRR meghatározása: Ha a 220V a zavarjel, mi az 1V-os söntött szeretnénk 1% pontossággal mérni, vagyis a 220V zavarjel hatására ennyi: 0,01 V lehet a kimeneten.



$$CMRR = \frac{U_{ki}}{U_0} = \underbrace{\frac{0{,}01}{220}}_{= 4{,}54 \cdot 10^{-5}} \Rightarrow -86{,}85 \text{ dB}$$

$$CMRR = -\frac{\Delta R}{2R + \Delta R} \approx -\frac{1}{2}\frac{\Delta R}{R}$$

$$\Delta R = R - R \times X_C = 100 - \frac{R \cdot \frac{1}{\omega C}}{R + \frac{1}{\omega C}}$$

$$4{,}54 \cdot 10^{-5} = \frac{100 - \frac{R \cdot \frac{1}{\omega C}}{R + \frac{1}{\omega C}}}{2 \cdot 100}$$

$$9{,}09 = 100 \cdot 10^3 - \frac{100 \cdot 10^3 \cdot \frac{1}{\omega C}}{100 \cdot 10^3 + \frac{1}{\omega C}}$$

$\cancel{(100\cdot10^3-9{,}09)}$

$$\left(100\cdot10^3+\frac{1}{\omega C}\right)\left(100\cdot10^3-9{,}09\right)=100\cdot10^3\cdot\frac{1}{\omega C}$$

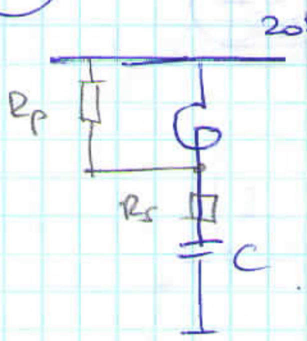
$$100\cdot10^3\left(100\cdot10^3-9{,}09\right)=\frac{1}{\omega C}\cdot\left[100\cdot10^3-\left(100\cdot10^3-9{,}09\right)\right]$$

$$100\cdot10^3\left(100\cdot10^3-9{,}09\right)=\frac{1}{\omega C}\cdot 9{,}09$$

$$\frac{100\cdot10^3\left(100\cdot10^3-9{,}09\right)}{9{,}09}\cdot 2\pi\cdot 50=\frac{1}{C}$$

$$\boxed{C=2{,}89\cdot10^{-12}\,F}$$

12.



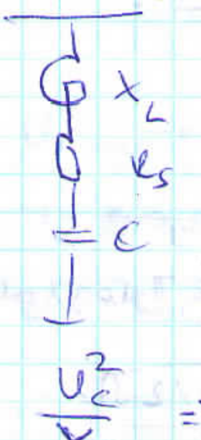
$k=11$

$Q=5$ jósági tényező

$Q_{C3f}=10\,Mvar$

Egy ellenállást tervezünk be (sorosan és párhuzamosan is lehet), ami a jósági tényezőt rontja. Hova tegyük és miért?

R_s eset:



$Q=\frac{Z_0}{R_s}$ soros

$Z_0=\sqrt{\frac{L}{C}}$

$$Q_{C3f}=\frac{U_C^2}{X_C}\Rightarrow\frac{20^2}{X_C}\qquad X_C=\frac{U_C^2}{Q_{C3f}}=\frac{20^2}{10}=40\,\Omega$$

$$X_C=\frac{1}{2\pi f C}\rightarrow\frac{1}{C}=2\pi f\cdot X_C\rightarrow\boxed{C=79{,}61\,\mu F}$$

VLE $X_{L1650} = X_{C1650}$

$$11\cdot 2\pi 50\cdot L = \frac{1}{11\cdot 2\pi\cdot 50\cdot C}$$

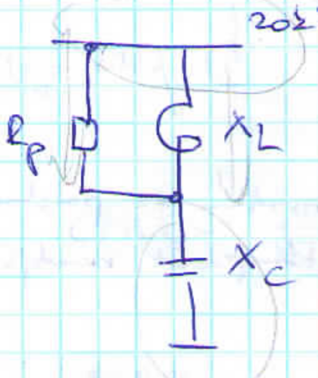
$$L = \frac{1}{(11\cdot 2\pi\cdot 50)^2\cdot C} = \frac{1}{(11\cdot 2\pi\cdot 50)^2\cdot 79{,}61\cdot 10^{-6}} =$$

$$= \boxed{1{,}053\ mH}$$

!n $$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{1{,}053\cdot 10^{-3}}{79{,}61\cdot 10^{-6}}} = 3{,}63\ \Omega$$

!n $$R_S = \frac{Z_0}{Q} = \frac{3{,}63}{5} = \boxed{0{,}727\ \Omega}$$

A párhuzamos ellenállásra:



$$Q = \frac{R_p}{Z_0}$$

$\downarrow$

$$R_p = Q\cdot Z_0 = 5\cdot 3{,}63 = \boxed{18{,}15\ \Omega}$$

A teljesítményeket kell meghatározni:

$$P_S = I^2\cdot R_S$$

$$Z_S = \sqrt{R_S^2 + X_L^2 + X_C^2} = \sqrt{0{,}727^2 + (2\cdot\pi\cdot 50\cdot 1{,}053\cdot 10^{-3})^2 + \left(\frac{1}{2\cdot\pi\cdot 50\cdot 79{,}61\cdot 10^{-6}}\right)^2} = 40{,}012\ \Omega$$

Azaz $$I = \frac{U}{Z_S} = \frac{\frac{20\cdot 10^3}{\sqrt{3}}}{40{,}012} = 288{,}59\ A$$

így $P_s = 288{,}59^2 \cdot 0{,}727 = \underline{\underline{60{,}54\ kW}}$

A párhuzamos ellenállásra:

$$P_p = \frac{U_p^2}{R_p} = \frac{(U-U_c)^2}{R_p} =$$

~~$Z_p = R_p \times j\omega X_L$~~

$$U_c = U \cdot \frac{-X_c}{-X_c+X_L} = \boxed{U} \frac{k^2}{k^2-1} = \frac{20}{\cancel{\ }} \cdot \cancel{\ } \cdot \frac{11^2}{11^2-1} =$$

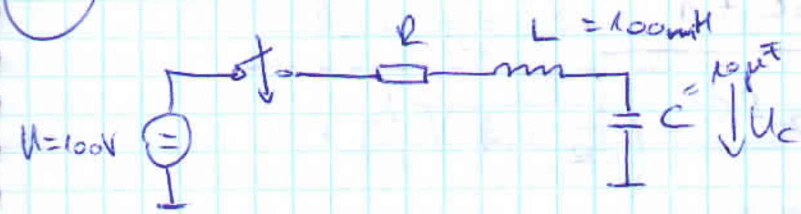
$$= \cancel{28{,}52\ kV}$$

$$\cancel{P_p = \frac{(20-28{,}52)^2 \cdot 10^6}{18{,}15}}$$

$$\frac{\left[20 \cdot \left(1 - \frac{11^2}{120}\right)\right]^2}{3 \cdot 18{,}15} = \underline{\underline{510{,}15\ W}}$$

$\sqrt{2}$-es szorzó U_c számolásakor miért nem kell bele?

(13.)



$R = ?$, hogy $U_{c_{max}} \le 100V$

Ha $U_{c_{max}} \le 100V$, akkor nincs túllendülés, vagyis

$$Q \le 0{,}5$$

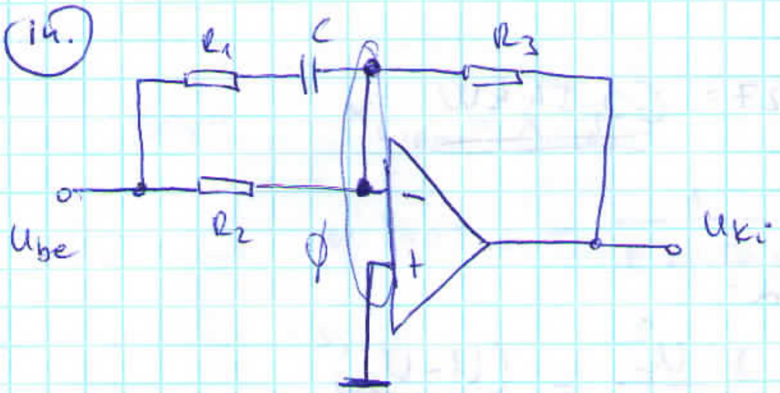
soros RLC-kör, tehát $Q = \frac{Z_0}{R} = \frac{\sqrt{\frac{L}{C}}}{R} =$

$$\sqrt{\frac{10^{-1}}{10^{-5}}} = 100$$

$$= \frac{\sqrt{\frac{100 \cdot 10^{-3}}{10 \cdot 10^{-6}}}}{R} \le 0{,}5 \rightarrow \frac{100}{0{,}5} \le R$$

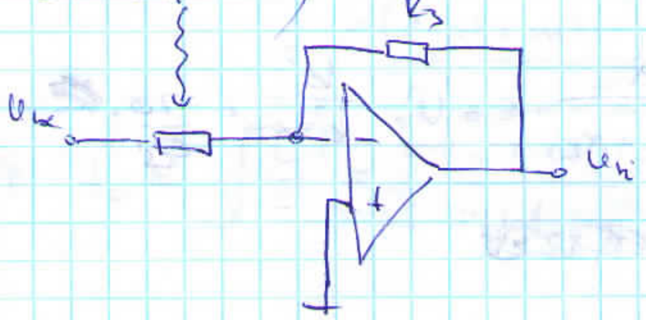
$$\boxed{200\,\Omega \le R}$$

(14.)



$A = ?$

$R_2 \times (R_1 + \frac{1}{sC})$



$$\frac{U_{ki}}{U_{be}} = -\frac{R_3}{R_2 \times (R_1 + \frac{1}{sC})} = -\frac{R_3}{\frac{R_2 \cdot (R_1 + \frac{1}{sC})}{R_2 + R_1 + \frac{1}{sC}}} =$$

$$= -\frac{(R_2 + R_1 + \frac{1}{sC}) \cdot R_3}{R_2 (R_1 + \frac{1}{sC})} = \cancel{-R_3}$$

$$= -\frac{R_3}{R_2} \cdot \frac{(R_1 + R_2) \cdot sC + 1}{1 + R_1 \cancel{R_2} sC}$$

$$-\frac{R_3}{R_2} \cdot \frac{\cancel{R} \cdot 1 + (R_1 + R_2) \cdot sC}{1 + sR_1 C}$$

A számlálóból: $f_1 = \frac{1}{2\pi} \cdot \frac{1}{(R_1 + R_2) C}$

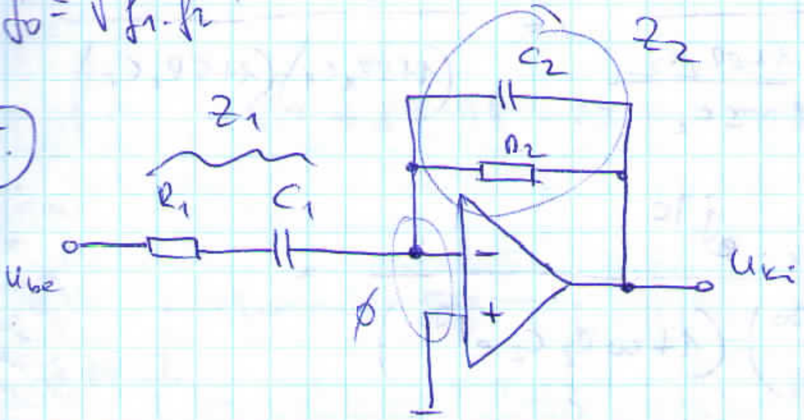
A nevezőből: $f_2 = \frac{1}{2\pi} \cdot \frac{1}{R_1 C}$

$$\frac{1+sT_1}{(1+sT_2)(1+sT_3)} \rightarrow \cancel{f = \frac{1}{T}}$$

$$f = \frac{1}{2\pi}\cdot$$

$$f_0 = \sqrt{f_1 \cdot f_2}$$

(I.)



$R_1 = 1k\Omega$
$C_1 = 1,5\,\mu F$
$R_2 = 10k\Omega$
$C_2 = 0,0068\,\mu F$
$f = 1000\,Hz$

$A(f) = ?$
$\varphi(f) = ?$

$$A = \frac{u_{ki}}{u_{be}} = -\frac{Z_2}{Z_1} = -\frac{R_2 \times \frac{1}{j\omega C_2}}{R_1 + \frac{1}{j\omega C_1}} =$$

$$= -\frac{\frac{R_2 \cdot \frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}}}{R_1 + \frac{1}{j\omega C_1}} \Rightarrow$$

$$-\frac{R_2 \cdot \frac{1}{sC_2}}{\left(R_2 + \frac{1}{sC_2}\right)\left(R_1 + \frac{1}{sC_1}\right)} = -\frac{R_2 \cdot \frac{1}{\cancel{sC_2}}}{\frac{(1+sR_2C_2)(1+sR_1C_1)}{sC_1\,\cancel{sC_2}}} =$$

$$= -\frac{R_2\,sC_1}{(1+sR_2C_2)(1+sR_1C_1)}$$

$$A = \frac{-R_2 \times \frac{1}{sC_2}}{R_1 + \frac{1}{sC_1}} = \frac{-R_2 \cdot \frac{1}{sC_2}}{\left(R_1 + \frac{1}{sC_1}\right)\left(R_2 + \frac{1}{sC_2}\right)} =$$

$$= \frac{-R_2 \cdot \frac{1}{sC_2}}{\frac{1+sR_1C_1}{sC_1} \cdot \frac{1+sR_2C_2}{sC_2}} = \frac{-R_2 \cdot sC_1}{\left(1+sR_1C_1\right)\left(1+sR_2C_2\right)}$$

$$= \frac{-R_2 \cdot \omega \cdot C_1 \cdot e^{j90}}{\left(1+\omega R_1 C_1 \cdot e^{j90}\right)\left(1+\omega R_2 C_2 e^{j90}\right)} =$$

$$\Rightarrow |A| = \frac{R_2 \omega C_1}{\sqrt{1^2+(\omega R_1 C_1)^2} \cdot \sqrt{1+(\omega R_2 C_2)^2}} =$$

$$= \frac{10 \cdot 10^3 \cdot 2\pi \cdot 1000 \cdot 1{,}5 \cdot 10^{-6}}{\sqrt{1^2+(2\pi \cdot 1000 \cdot 1000 \cdot 1{,}5 \cdot 10^{-6})^2} \cdot \sqrt{1^2+(2\pi \cdot 1000 \cdot 10^4 \cdot 0{,}008 \cdot 10^{-6})^2}}$$

$$= \frac{94{,}2}{\sqrt{89{,}7} \sqrt{1{,}18}} = \underline{\underline{9{,}15}}$$

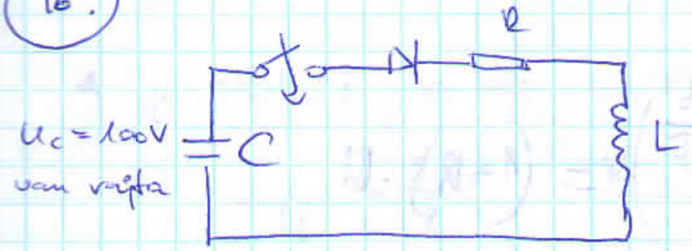
$$\varphi = 180° + 90° - 30{,}89 - 1{,}4 = 57{,}71°$$

$\varphi_2 = \text{arctg}\left(\underbrace{2\pi \cdot 10^3 \cdot 10^3 \cdot 1{,}5 \cdot 10^{-6}}_{\omega R_1 C_1}\right) = \cancel{0{,}539\,\text{rad} = 30{,}89°}$ $83{,}94°$

$\varphi_3 = \text{arctg}\left(2\pi \cdot 10^3 \cdot 10 \cdot 10^3 \cdot 0{,}0068 \cdot 10^{-6}\right) = \cancel{0{,}024\,\text{rad} = 1{,}4°}$ $23{,}12°$

$\varphi = -90 - 83{,}94 - 23{,}12 = -197{,}06° = \underline{\underline{162{,}93°}}$

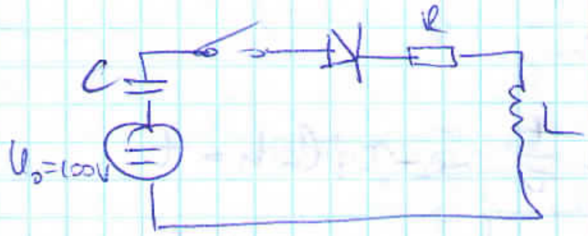
16.



$C = 10\,\mu F$
$L = 100\,mH$
$R = 40\,\Omega$

$U_C' = ?$

$\Downarrow$



$t = \frac{T}{2}$ $\quad \omega = \frac{2\pi}{T}$

$U_{C_{max}} = U_0\left(1 + e^{-\delta t}\right) =$ $\quad \delta = \frac{R}{2L} = \frac{\omega_0}{2\pi}$

$= U_0 \cdot \left(1 + e^{-\frac{\omega_0}{2Q} \cdot \frac{T}{2}}\right) = 100 \cdot \left(1 + e^{-\frac{2\pi}{2QT} \cdot \frac{T}{2}}\right) =$

$= 100\left(1 + e^{-\frac{\pi}{2Q}}\right) = 100\left(1 + e^{-\frac{\pi}{5}}\right) = 153{,}36V$

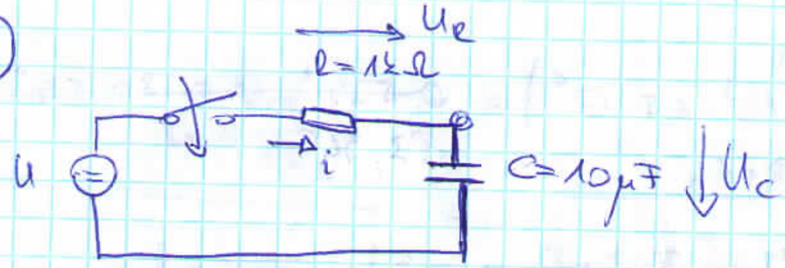
$Q = \frac{Z_0}{R} = \frac{\sqrt{\frac{L}{C}}}{R} = \frac{\sqrt{\frac{100 \cdot 10^{-3}}{10 \cdot 10^{-6}}}}{40} = \frac{100}{40} = 2{,}5$

mert soros

$U_C' = U_C - U_{C_{max}} = \underline{-53{,}36V}$

$\frac{10^{-1}}{10^{-5}}$

17.



$t = ?$ idő múlva éri el a kondenzátor feszültsége $h = 0{,}2\,\%$ hibával a generátor feszültségét?

$$U_C = U - U_R$$

$$U_R = R \cdot \underbrace{\frac{U}{R}}_{i} \cdot e^{-\frac{t}{\tau}} \qquad \tau = RC$$

$$U_C = U\left(1 - e^{-\frac{t}{\tau}}\right) = (1-h) \cdot U$$

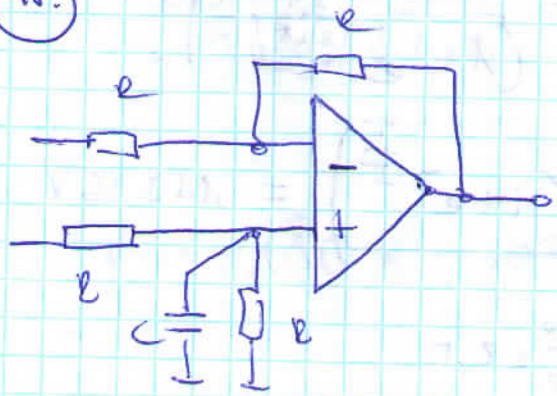
$$1 - e^{-\frac{t}{\tau}} = 1 - h$$

$$h = e^{-\frac{t}{\tau}}$$

$$\ln h = -\frac{t}{\tau} \rightarrow -\tau \cdot \ln h = t$$

$$t = -1000 \cdot 10 \cdot 10^{-6} \cdot \ln\left(0{,}2 \cdot 10^{-2}\right) = \underline{\underline{62{,}14\,ms}}$$

18.



$R = 100k\Omega$

$C = 10pF$

$f = 50Hz$

$\Delta f = ?$

$CMRR = ?$

$$CMRR \cong -\frac{\Delta R}{2R + \Delta R} \approx -\frac{\Delta R}{2R}$$

$$\Delta R = R - R \times X_C = \cancel{R} \; 100 \cdot 10^3 - \frac{100 \cdot 10^3 \cdot \frac{1}{2\pi \cdot 50 \cdot 10 \cdot 10^{-12}}}{100 \cdot 10^3 + \frac{1}{2\pi 50 \cdot 10 \cdot 10^{-12}}}$$

$$= 100 \cdot 10^3 - \cancel{99968,86} =$$
$$99968,6 \quad = \underline{31,39\,\Omega}$$

$$\text{hy}\quad CMRR = -\frac{\Delta R}{2R + \Delta R} = -\frac{31,39}{2 \cdot 10^5} \Rightarrow \boxed{-76,08\,dB}$$

$$CMRR = -\frac{\Delta R}{2R + \Delta R}$$

A fáziskiba:

ez vajon ⊖ itt?

$$\Delta \varphi_f = -\frac{\Delta R}{R} = -\frac{R - R \times X_C}{R} =$$

$$= -\left(1 - \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}}\right) - \left(1 - \frac{1}{1 + j\omega RC}\right) =$$

$$= \cancel{1-1} - \frac{j\omega RC}{1 + j\omega RC} \to \Delta\varphi = -90^\circ - 0,01799^\circ = \underline{\underline{89,982^\circ}}$$

$$90 - \qquad\qquad \underline{\underline{-90,018^\circ}}$$

$$e^{j90} = j$$

$$\arctg(\omega RC) = \arctg\left(2\pi \cdot 50 \cdot 100 \cdot 10^3 \cdot 10 \cdot 10^{-12}\right) =$$

$$= 0,01799^\circ$$

$$e^{j90,018^\circ}$$

(19.) Másodrendű Bessel LPF

$f_1 = 350 Hz$

$A_1 = -40 dB \rightarrow$

$f_2 = 50 Hz$

$A_2 = ?$

$$A(P) = \frac{1}{1 + 1,3617 P + 0,618 P^2}$$

$P = j\Omega_1$

$$A_1 = \frac{1}{1 + 1,3617 \cdot j\Omega + 0,618 (j\Omega)^2}$$

$$|A_1| \cong \frac{1}{0,618 \Omega_1^2}$$ közelítés

$$\Omega_1 = \frac{\omega_1}{\omega_0} = \frac{f_1}{f_0}$$

$$0,01 = \frac{1}{0,618 \cdot \left(\frac{f_1}{f_0}\right)^2}$$

$$\frac{f_1}{f_0} \cdot 0,618 \cdot 0,01 = 1$$

$$f_0 = f_1 \cdot 0,618 \cdot 0,01 = 350 \cdot 0,618 \cdot 0,01 = 2,163$$

így $\Omega_1 = \frac{f_1}{f_0} = \frac{350}{2,163}$

$$0,01 \cdot 0,618 \cdot \Omega_1^2 = 1$$

$$\Omega_1 = \sqrt{\frac{1}{0,01 \cdot 0,618}} = 12,72$$

$\Omega_2 = \frac{f_2}{f_0}$

$\Omega_1 = \frac{f_1}{f_0}$

$$\rightarrow \frac{\Omega_2}{\Omega_1} = \frac{\frac{f_2}{f_0}}{\frac{f_1}{f_0}} = \frac{f_2}{f_0} \cdot \frac{f_0}{f_1} = \frac{f_2}{f_1}$$

így $\Omega_2 = \Omega_1 \cdot \frac{f_2}{f_1} = 12,72 \cdot \frac{50}{350} =$

$= 1,817$

Amiből $\cancel{A_2 = \frac{1}{0,618\,\Omega_2^2} = 0,42}$

$$A_2 = \frac{1}{1 + 1,2617 \cdot j \cdot 1,817 + 0,618 \cdot (j \cdot 1,817)^2} =$$

$$\Rightarrow |A_2| = \frac{1}{\sqrt{(1 - 0,618 \cdot 1,817^2)^2 + (1,3617 \cdot 1,817)^2}} =$$

$$= \frac{1}{\sqrt{1,082 + 6,1217}} = \underline{0,372}$$

(20.) Másodrendű Butterworth LPF

$$|A|^2 = \frac{1}{1 + \Omega^{2n}}$$

másodrendű: $n = 2$

$f_1 = 250\,Hz$
$A_1 = -30\,dB \rightarrow 0,0316$
$f_2 = 50\,Hz$
$A_2 = ?$

$$\cancel{A_1 = \frac{1}{1 + \left(\frac{f_1}{f_0}\right)^4}}$$

$$\Omega_1 = \frac{f_1}{f_0}$$

$$\cancel{0,0316 \cdot \left(1 + \left(\frac{250}{f_0}\right)^4\right) = 1}$$

$$\cancel{0,0316 \cdot \left(\frac{250}{f_0}\right)^4 = 1 - 0,0316}$$

$$\cancel{\frac{250^4}{f_0^4} = \frac{1 - 0,0316}{0,0316}} \rightarrow f_0 = \sqrt[4]{\frac{250 \cdot 0,0316}{1 - 0,0316}}$$

$$\Omega_1^4 = \frac{1 - 0,0316}{0,0316} \rightarrow \Omega_1 = \qquad = 1,69$$

$$|A_1|^2 = \frac{1}{1+\Omega_1^4}$$

$$0{,}0316^2 = \frac{1}{1+\Omega_1^4}$$

$$(1+\Omega_1^4)\cdot 0{,}0316^2 = 1$$

$$\Omega_1^4 \cdot 0{,}0316^2 = 1-0{,}0316^2$$

$$\Omega_1 = \sqrt[4]{\frac{1-0{,}0316^2}{0{,}0316^2}} = 5{,}622$$

$$\Omega_2 = \Omega_1 \cdot \frac{f_2}{f_1} = 5{,}622 \cdot \frac{50}{250} = 1{,}124$$

$$\text{így} \quad A_2 = \frac{1}{\sqrt{1+\Omega_2^4}} = 0{,}62 \rightarrow -4{,}147 \text{ dB}$$

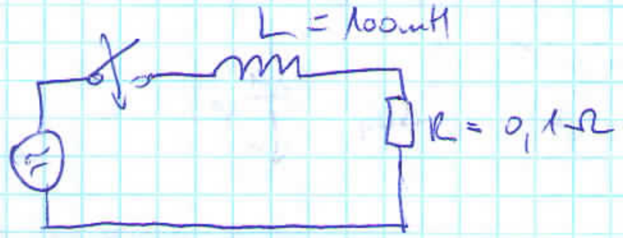
ZH sor

$\varphi = 45°$ bekapcsolás

$X_L = 2\pi \cdot 50 \cdot 0{,}1 = 31{,}4$

1.

$U = 230V$



$$Z = \sqrt{R^2 + X_L^2} = \sqrt{31{,}4^2 + 0{,}1^2} = 31{,}4\ \Omega$$

$I_{eff} = ?$

$U_L^{max} = ?$

$$\cancel{I_{eff}}\ I_{rms} = \frac{U_0}{Z} = \frac{230}{31{,}4} = 7{,}32A$$

$$\cancel{I_{eff}}\ I_{\infty} = \sqrt{2}\cdot I_{rms}\cdot \cos\varphi = \sqrt{2}\cdot 7{,}32 \cdot \frac{\sqrt{2}}{2} = 7{,}32A$$

$$I_p = \sqrt{2}\cdot I_{rms} = 10{,}35A$$

$$I_{eff} = \sqrt{I_{DC}^2 + I_{rms}^2} = \sqrt{7{,}32^2 + 10{,}31^2} = \underline{\underline{12{,}68\ A}}$$

$$U_p = U_R^{max} = I_p \cdot R = \cancel{\sqrt{2}\cdot I_{rms}\cdot R = \sqrt{2}\cdot 7{,}32\cdot 0{,}1 =}$$

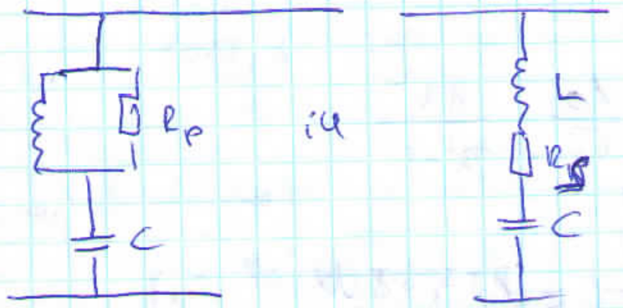
$$I_p = I_{DC} + I_{\cancel{rms}} = \sqrt{2}\cdot I_{rms}\cdot \cos\varphi + \sqrt{2}\, I_{rms} =$$

$$\cancel{= I_{rms}(} = \sqrt{2}\cdot I_{rms}\cdot(\cos\varphi + 1) =$$

$$= \sqrt{2}\cdot 7{,}32\left(\frac{\sqrt{2}}{2} + 1\right) = \underline{\underline{17{,}67\ V}}$$

2.

$U_v = 10\ kV$



$Q_{C3f} = 5\ MVar$

$\nu = 13$

$Q = 5$

fonos ert:

$Q = \frac{Z_0}{R_s}$ $\qquad Z_0 = \sqrt{\frac{L}{C}}$ $\qquad X_{C650} = X_{L650}$

$$\frac{1}{2\pi\cdot 13\cdot 50\cdot C} = 2\pi\cdot 13\cdot 50\cdot L$$

$$Q_{C3f} = \frac{U_v^2}{X_C} \to X_C = \frac{U_v^2}{Q_{C3f}} = \frac{10^2}{5} = 20\ \Omega = \frac{1}{2\pi\cdot 50\cdot C} \to \frac{1}{C} = 20\cdot 2\pi\cdot 50$$

$$\frac{1}{C} = (2\pi\cdot 13\cdot 50)^2\cdot L$$

$$20\cdot 2\pi\cdot 50 = (2\pi\cdot 13\cdot 50)^2 L \to L = 3{,}77\cdot 10^{-4}\ H$$

$$C = 1{,}59\cdot 10^{-4}\ F \qquad Z_0 = \sqrt{\frac{L}{C}} = 1{,}538\ \Omega$$

in R_s $\qquad R_s = \frac{Z_0}{Q} = \frac{1{,}538}{5} = 0{,}308\ \Omega$

$$Q = \frac{R_r}{Z_0}$$

$R_p = Q \cdot Z_0 =$

$= 5 \cdot 1{,}538 = 7{,}69\,\Omega$

$P_s = I^2 \cdot R_s$

$$I = \frac{U}{\sqrt{R_s^2 + X_C^2 + X_L^2}} = \frac{\frac{10 \cdot 10^3}{\sqrt{3}}}{\sqrt{0{,}308^2 + Z_0^2 + \left(2\pi \cdot 50 \cdot 3{,}77 \cdot 10^{-4}\right)^2}} =$$

$= 288{,}63\,A$

tj. $P_s = 288{,}63^2 \cdot 0{,}308 = \underline{\underline{25{,}66\,kW}}$

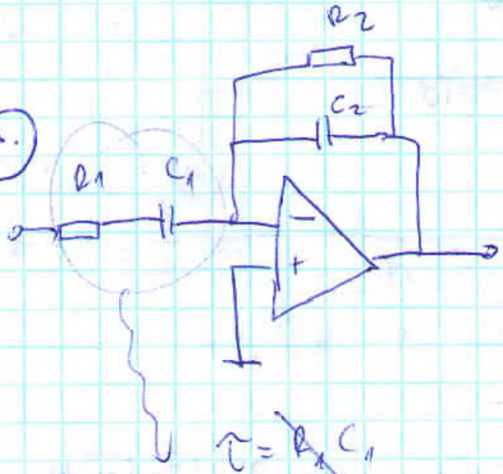
$$P_p = \frac{U_p^2}{R_p} = \frac{(U - U_c)^2}{R_p}$$

$$U_c = U \cdot \frac{k^2}{k^2 - 1} = \frac{10}{\sqrt{3}} \cdot \frac{13^2}{13^2 - 1}$$

$$P_p = \frac{\left(\frac{10^4}{\sqrt{3}}\right)^2 \cdot \left(1 - \frac{13^2}{13^2 - 1}\right)^2}{7{,}69} = \underline{\underline{153{,}58\,W}}$$

tj. - pokračovanie ...

3.



$$A = -\frac{Z_2}{Z_1} = -\frac{\frac{R_2 \times \frac{1}{j\omega C_2}}{}}{R_1 + \frac{1}{j\omega C_1}} =$$

$$= -\frac{R_2 \cdot \frac{1}{j\omega C_2}}{\left(R_1 + \frac{1}{j\omega C_1}\right)\left(R_2 + \frac{1}{j\omega C_2}\right)} =$$

$\cancel{\tau = R_1 C_1}$

$\cancel{f_1 = \frac{1}{2\pi} \cdot \frac{1}{R_1 C_1}}$

$$f_1 = \frac{1}{2\pi} \cdot \frac{1}{R_1 C_1}$$

$$C_1 = \frac{1}{2\pi} \cdot \frac{1}{R_1 f_1} = \frac{1}{2\pi} \cdot \frac{1}{1000 \cdot 100} = \boxed{1{,}5\,\mu F}$$

$$-\frac{R_2\cdot\frac{1}{j\omega C_2}}{\left(R_1+\frac{1}{j\omega C_1}\right)\left(R_2+\frac{1}{j\omega C_2}\right)}$$

$$|A| = \left.\frac{\frac{R_2}{\omega C_2}}{\sqrt{R_1^2+\left(\frac{1}{\omega C_1}\right)^2}\cdot\sqrt{R_2^2+\left(\frac{1}{\omega C_2}\right)^2}}\right|_{f=500\,Hz} =$$

$$= \frac{\frac{10^4}{2\pi\cdot 500\cdot 10\cdot 10^{-9}}}{\sqrt{10^6+\left(\frac{1}{2\pi\cdot 500\cdot 15\cdot 10^{-6}}\right)^2}\cdot\sqrt{10^8+\left(\frac{1}{2\pi\cdot 500\cdot 10\cdot 10^{-9}}\right)^2}} =$$

$$= \frac{318{,}471\cdot 10^6}{1022{,}3\cdot 33380} = \underline{\underline{9{,}33}} \rightarrow 19{,}39\,dB$$

φ meghatározásához:

$$\varphi_1 = 90° \text{ siettető}$$

$$\varphi_2 = \arctg\left(-\frac{1}{\omega C_1 R_1}\right) = \arctg\left(-\frac{1}{2\pi\cdot 500\cdot 15\cdot 10^{-6}\cdot 1000}\right) =$$

$$= -11{,}98° + 180 = 168°$$

$$\varphi_3 = \arctg\left(-\frac{1}{\omega C_2 R_2}\right) = \arctg\left(-\frac{1}{2\pi 500\cdot 10\cdot 10^{-9}\cdot 10^4}\right) =$$

$$= -72{,}56+180 = 107{,}43°$$

így $\varphi = \varphi_1-\varphi_2-\varphi_3 = 90-168-107{,}43 = -185{,}43° = \underline{\underline{174{,}56°}}$

(4.) 3. rendű Butterworth LPF

$f_1 = 50 Hz$

$A_1 = 0,96$

$f_0 = ?$

$f_2 = 350 Hz$

$A_2 = ?$

$20 \cdot lg x =$

Butterworth: $|A|^2 = \frac{1}{1+\Omega^{2n}}$ $n=3$

$$A_1 = \frac{1}{\sqrt{1+\Omega_1^6}} \rightarrow 0,96^2 = \frac{1}{1+\Omega_1^6}$$

$$0,96^2 (1+\Omega_1^6) = 1$$

$$\Omega_1 = \sqrt[6]{\frac{1-0,96^2}{0,96^2}} = 0,663$$

$\Omega_2 = \frac{f_2}{f_0}$

$\Omega_1 = \frac{f_1}{f_0} \rightarrow \frac{\Omega_2}{\Omega_1} = \frac{\frac{f_2}{f_0}}{\frac{f_1}{f_0}} = \frac{f_2}{f_1}$

$$\Omega_1 = \frac{f_1}{f_0} \rightarrow f_0 = \frac{f_1}{\Omega_1} = \frac{50}{0,663} = \underline{\underline{75,4}}$$

$$\Omega_2 = \Omega_1 \cdot \frac{f_2}{f_1} = \cancel{75,4} \, 0,663 \cdot \frac{350}{50} = \cancel{527,78} \, 4,64$$

$$A_2 = \sqrt{\frac{1}{1+\cancel{527,76}^6 \; 4,64^6}} = 0,01 \rightarrow \underline{\underline{-40 dB}}$$

(5.) Sávszűrő jósági tényezője

$f_1 = 7 \cdot f_0$

$A_1 = -40 dB \rightarrow 0,01$

sávszűrő: $A(p) = \frac{\frac{1}{Q} p}{1+\frac{1}{Q}p+p^2}$

$$0,01 = |A_1| = \left| \frac{\frac{1}{Q} \cdot j\Omega_1}{1+\frac{1}{Q} j\Omega_1 + (j\Omega_1)^2} \right|$$

$$\Omega_1 = \frac{f_1}{f_0} = 7$$

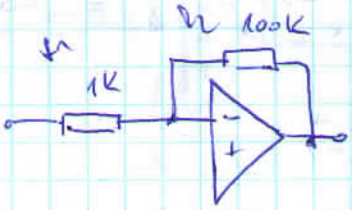
$$|A| \approx 0{,}01 = \frac{\frac{1}{Q}\cdot 7}{\left|1-7^2+j\frac{1}{Q}7\right|} = \frac{\frac{1}{Q}\cdot 7}{\sqrt{48^2+\frac{7^2}{Q^2}}}$$

$$0{,}01^2\cdot\left(48^2+\frac{7^2}{Q^2}\right)=\frac{7^2}{Q^2}$$

$$0{,}01^2\cdot 48^2=\frac{7^2}{Q^2}\left(1-0{,}01^2\right)$$

$$Q^2 \approx \frac{7^2}{0{,}01^2\cdot 48^2} \Rightarrow Q=\frac{7}{0{,}01\cdot 48}=\underline{14{,}58}$$

9.

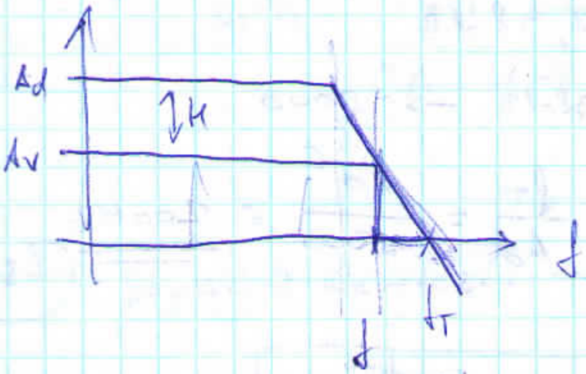


$f = 10\,kHz$

$f_T = 10\,MHz$

$\Delta A = ?$

$\Delta \varphi = ?$



$$A=\frac{f_T}{f}=\frac{10\cdot10^6}{10\cdot10^3}=1000$$

$$\beta=\frac{R_1}{R_1+R_2}=\frac{1}{1+100}=\frac{1}{101}$$

$$\frac{1}{H\cdot e^{j\,\mathrm{arctg}(}}$$

$$H=\beta\cdot A=\frac{1000}{101}$$

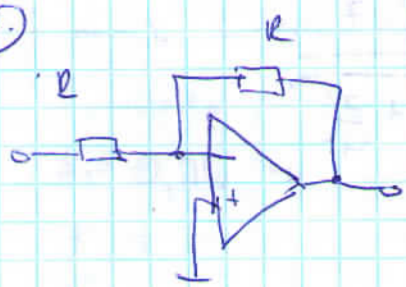
$$h=\frac{1}{1+\frac{1}{jH}}=\frac{1}{1+\frac{1}{j\cdot\frac{1000}{101}}}=\frac{1}{1-j\frac{101}{1000}}=$$

$$\Delta A = 1-\frac{1}{\sqrt{1^2+\left(\frac{101}{1000}\right)^2}}=5{,}061\cdot10^{-3}=\underline{0{,}506\,\%}$$

$$\boxed{\Delta\varphi = -\mathrm{arctg}\left(-\frac{101}{1000}\right)=-174{,}23^\circ = 5{,}77^\circ}$$

zamotaša!

(10.)

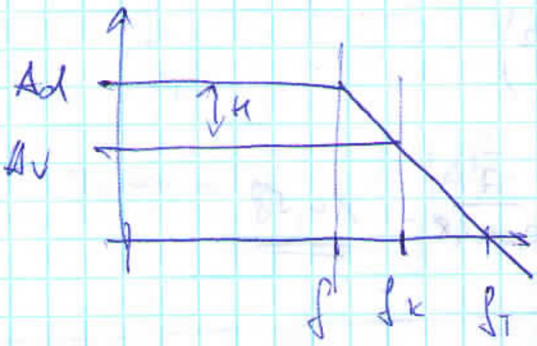


$A = 50$

$f_T = 1\,MHz$

$h = 1\%$? Ori – feladat ?

$f = ?$



$h \approx \frac{1}{H} = \frac{1}{\beta A}$

$\beta =$

$A = \frac{f_T}{f_k} \rightarrow f_k = \frac{f_T}{A} = 20\,kHz$

$A_d\,[dB] = A_v\,[dB] + H\,[dB]$

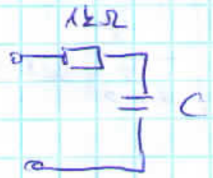
$h = 1\% \rightarrow h = \frac{1}{H} \rightarrow H = \frac{1}{h} = \frac{1}{0{,}01} = 100 = 40\,dB$

$A_v = 50 = 33{,}98\,dB$

így $A_d = 73{,}98\,dB \rightarrow \sim 5000$

így $f = \frac{f_T}{A_d} = \frac{10^6}{5000} \approx \underline{\underline{200\,Hz}}$

(17.)



$f = 50\,Hz$

$\varphi = 0{,}57°$

$Z = R + \frac{1}{j\omega C}$

$\longrightarrow$ $R = Z \cdot \cos\varphi$

ZRt $R = \left(R + \frac{1}{j\omega C}\right) \cdot \cos\varphi$

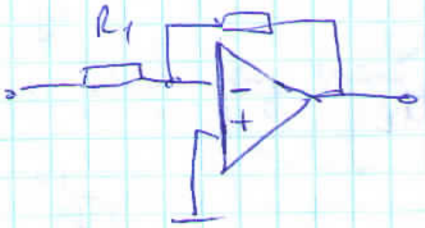
$1000 = \left(1000 - j\frac{1}{2\pi \cdot 50\,C}\right) \cdot \cos 0{,}57$

$$\sqrt{1000^2 + \left(\frac{1}{2\pi 50 C}\right)^2} \cdot \cos 0{,}17 = 1000$$

$$\left(\frac{1}{2\pi 50 C}\right)^2 = 98{,}976$$

$$\frac{1}{2\pi 50 C} = 9{,}948 \rightarrow \underline{\underline{C = 3{,}2 \cdot 10^{-4}\, F}}$$

22.



$$\frac{R_2}{R_1} = 100 \qquad \frac{1000}{10} \qquad \frac{10}{1010} \qquad \frac{1}{101}$$

h = 0,1% pontossággal $\Rightarrow h = 0{,}001$

$A_0 = ?$ $\qquad H = \frac{1}{h} = 1000$

$$\beta = \frac{R_1}{R_1 + R_2} = \frac{1}{101}$$

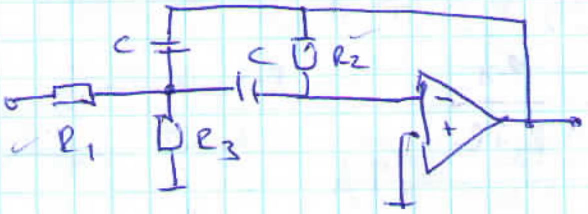
$$\beta A = H \rightarrow A = \frac{H}{\beta} = \frac{1000}{\frac{1}{101}} = 1000 \cdot 101 =$$

$$= 101000$$

$$\Downarrow$$

$$\underline{\approx 100{,}086\ dB}$$

23. Szűrő méretezés.



$f_0 = 50Hz$

$A = 1$

$C = 47nF$

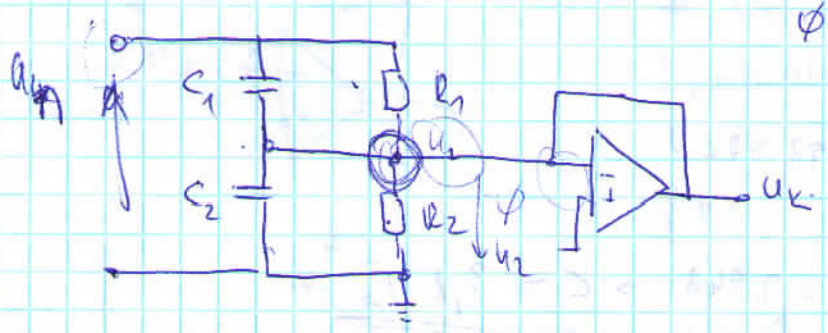
$Q = 50$

$$R_2 = \frac{Q}{\pi C f_0} = \frac{50}{\pi \cdot 47 \cdot 10^{-9} \cdot 50} = 6{,}776\ M\Omega$$

$$R_1 = \frac{R_2}{2} = 3{,}388\ M\Omega$$

$$R_3 = \frac{1}{R_2 (2\pi C f_0)^2} = \frac{1}{6{,}776 \cdot 10^6 (2\pi \cdot 47 \cdot 10^{-9} \cdot 50)^2} = 677{,}6\ \Omega$$

(31.) Kapacitív osztó:



$\phi - U_2 + 0 - U_K = 0$

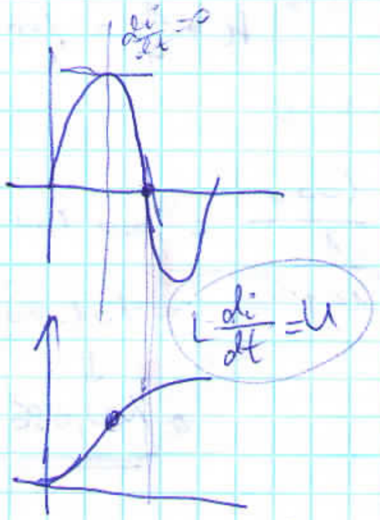
$U_2 = -U_K$

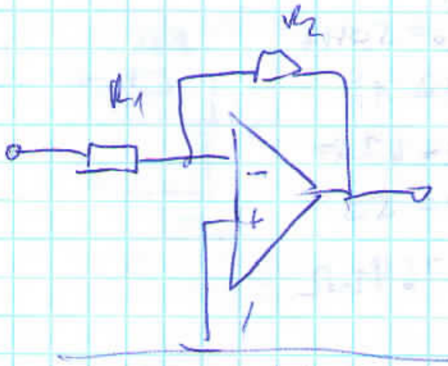
$R_1 C_1 = R_2 C_2$

$C_1 \cdot U_1 = C_2 \cdot U_2 \rightarrow U_2 = U_1 \cdot \frac{C_1}{C_2}$

$U_2 = 10V$

$U_n \cdot \frac{R_2}{R_1+R_2} = U_2$





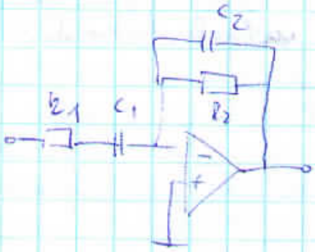
$\beta = \frac{R_1}{R_1+R_2}$

$H = A \cdot \beta = A(s) \cdot \frac{R_1}{R_1+R_2} \approx A(s) \cdot \frac{R_1}{R_2}$

$$\frac{1}{1 + \frac{R_1}{R_2} \cdot \frac{f_T}{jf} \cdot \frac{R_1}{R_2}} = \frac{1}{1 + \frac{R_2^2}{R_1^2} \cdot \frac{jf}{f_T}}$$

2008/12.07 (5)

+ túlfeszültségvédelmi eszközök felsorolás és paraméterei



2009/01.07

(3)

+ aluláteresztő szűrők típusainak felsorolása és bemutatása

2009/01.14 (5)

+ Sorolja fel negatív sorrendű összetevő mérési módszereket

2009/01/21

+ antialiasing szűrő jelentősége, méretezésének alapelvei

2010/01.07

(2)

(4)

+ negatív sorrendű összetevő mérésére szolgáló módszerek

2010/01/14

+ antialiasing szűrő jelentősége és méretezése

2009/01.07

(3.) Elsőrendű digitális szűrő együtthatói, ami 50Hz-nél 60°-os fázisforgatást ad? A szűrő ∀ frekvencián azonosan viszi át. $f_a = f_m = 1600\,Hz$

előző Tétel:

$$\cancel{A(P) = \frac{A_0}{1+P} \Rightarrow \frac{A_0}{1+j\omega}}$$

$$\cancel{A(P) = \frac{1+}{1+}}$$

$$\cancel{\varphi\big|_{f=50Hz} = 60}$$

$$A(P) = \frac{d_0 + d_1 P}{c_0 + c_1 P} \qquad \varphi =$$

$$\Rightarrow \frac{d_0 + j d_1 \omega}{c_0 + j c_1 \omega} \rightarrow \frac{\operatorname{arctg}\left(\frac{d_1 \omega}{d_0}\right)}{\operatorname{arctg}\left(\frac{c_1 \omega}{c_0}\right)}$$

mindentáteresztő: $$A(p) = \frac{1-a_1 p}{1+a_1 p}$$

$$\downarrow$$

$$\frac{1-ja_1\omega}{1+ja_1\omega} \Rightarrow \varphi = \operatorname{arctg}\left(-\frac{a_1\omega}{1}\right) - \operatorname{arctg}(a_1\omega) = 60^\circ$$

$$\Omega_m = \frac{f_m}{f_0} = \frac{1600}{50} = 32$$

$$l = \operatorname{ctg}\frac{\pi}{\Omega_m} = 10{,}15$$

$$-2\cdot\operatorname{arctg}(a_1\omega) = 60^\circ$$

$$\operatorname{arctg}(a_1\cdot 2\pi\cdot 50) = -30^\circ$$

$$a_1\cdot 2\pi\cdot 50 = -0{,}577$$

$$a_1 = -1{,}838\cdot 10^{-3}$$

$$A(p) = \frac{\overset{d_0}{1} - \overset{d_1}{(1{,}838\cdot 10^{-3})}p}{\underset{c_0}{1} + \underset{c_1}{(1{,}838\cdot 10^{-3})}p}$$

$$D_0 = \frac{d_0 - d_1 l}{c_0 + c_1 l} = \frac{1+1{,}838\cdot 10^{-3}\cdot 10{,}15}{1+1{,}838\cdot 10^{-3}\cdot 10{,}15} = 1$$

$$D_1 = \frac{d_0 + d_1 l}{c_0 + c_1 l} = \frac{1-1{,}838\cdot 10^{-3}\cdot 10{,}15}{1+1{,}838\cdot 10^{-3}\cdot 10{,}15} = 0{,}963$$

$$C_0 = \frac{c_0 - c_1 l}{c_0 + c_1 l} = 0{,}963$$

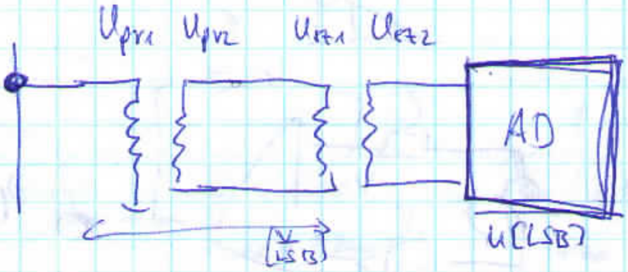
$$A(z) = \frac{1+0{,}963z}{\cancel{1+0{,}963}\ 0{,}963+z}$$

2009/01_14

5.

U_{eff}

$U[V]$



$\frac{U_{pr1}}{U_{pr2}}$ és $\frac{U_{ét1}}{U_{ét2}}$ ismert

$$\boxed{U_{lépték}\left[\frac{V}{LSB}\right] = \frac{AD_{in}}{2^{AD_{bit}}-1}} \cdot \frac{U_{pr1}}{U_{pr2}} \cdot \frac{U_{ét1}}{U_{ét2}}$$

$\cancel{U_{x\,tér} = N \cdot U_x}$ $U_x = U_x\left[\frac{V}{LSB}\right] \cdot U_x\,[LSB]$

$$U_x = \frac{U_{x\,tér}}{N} \qquad U \cdot I \cdot \cos\varphi = P$$

$$P_x = U_x \cdot I_x \cdot \cos\varphi$$

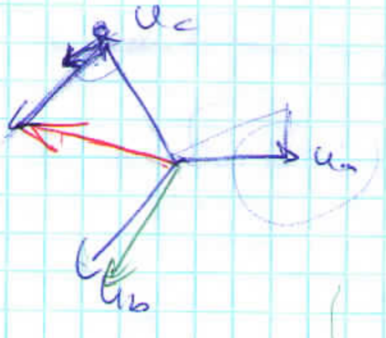
$$\frac{5}{2^{12-1}}$$

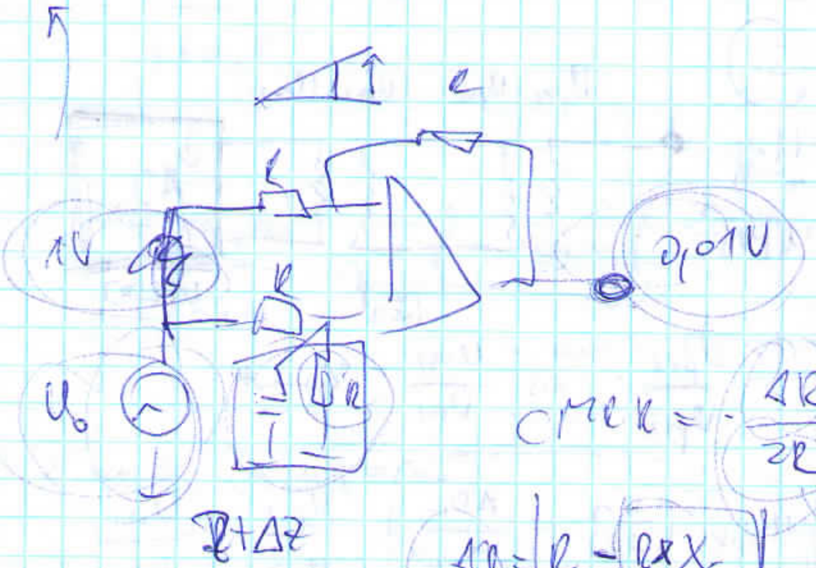
$P_{lépték}\left[\frac{W}{LSB}\right] =$

$$A(P) = \frac{1}{(1+0{,}776P)(1+0{,}9996P+0{,}4772P^2)} =$$

$$A(P) = \left|\frac{1}{0{,}36P^3}\right|$$

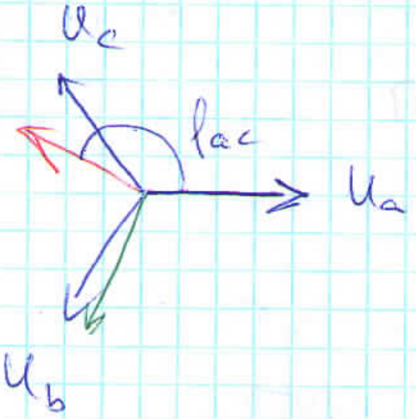
$A \cdot e^{j\varphi}$





$$CMRR = \frac{\Delta R}{2R} = \frac{U_{in}}{U_0}$$

$$\Delta R = \left| R - \boxed{R \ast X_c} \right|$$

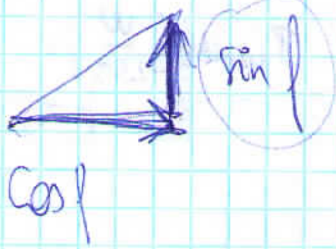


$$\Delta\varphi = 2\pi \cdot \frac{\Delta t}{T}$$

$$\Delta\varphi_b = 360 \cdot \frac{10 \cdot 10^{-6}}{20 \cdot 10^{-3}} = 0{,}18^\circ$$

$$\Delta\varphi_c = 360 \cdot \frac{20 \cdot 10^{-6}}{20 \cdot 10^{-3}} = 0{,}36^\circ$$

$$U_2 = \frac{1}{3}\left(U_a + a^2 U_b + a U_c\right)$$



$$\cancel{\Delta U_b = U_b \cdot \sin \Delta\varphi_b}$$

$$\cancel{\varphi_{ac} = 120 + \Delta\varphi_c = 120{,}36^\circ}$$

$$\cancel{\bar{U}_c = U_c \angle 120{,}36^\circ}$$

$$\frac{1}{3} \cdot \left(e^{j240} \cdot \sin 0{,}18 + e^{j120} \cdot \sin 0{,}36\right)$$

$$+ j \sin 240$$

$$= \frac{1}{3} \cdot \left(\underbrace{\cos 240 \cdot \sin 0{,}18 + \cos 120 \cdot \sin 0{,}36}_{-4{,}71 \cdot 10^{-3} \; + j \cdot 2{,}72 \cdot 10^{-3}}\right)$$

$5{,}44 \cdot 10^{-3}$

$0{,}181$

$\frac{(1+j)\,|\,(1+j)}{1\smile}$

2010/01_05

(4.) Telj. mérés

$P_{tour} = ?$

$AD = 10\,bit$

$AD_{in} = \pm 10V$

$N = 64$

$U_{pr1} = 20kV$

$U_{pr2} = 100V$

$U_{sec1} = 200V$

$U_{sec2} = 10V$

$I_{pr1} = 300A$

$I_{pr2} = 1A$

$I_{sec1} = 1A$

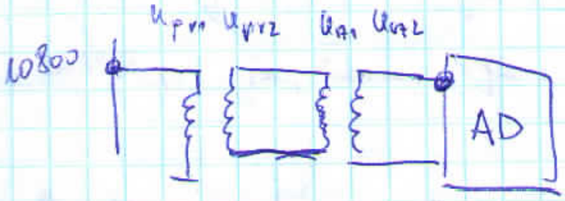
$I_{sec2} = 10mA$

$R_i = 300\Omega$

$U_{be} = 10800V$

$I_{be} = 215A$

$\cos\varphi = 0{,}96$



$U_{lépték}\left[\frac{V}{LSB}\right] = \frac{AD_{in}}{2^{AD_{bit}-1}} \cdot \frac{U_{1pr}}{U_{2pr}} \cdot \frac{U_{1tr}}{U_{2tr}} = \frac{10}{2^{10-1}} \cdot \frac{20\cdot10^3}{100} \cdot \frac{200}{10} =$

$= 78{,}125\left[\frac{V}{LSB}\right]$

$I_{lépték} = \frac{10}{2^{10-1}} \cdot \frac{300}{1} \cdot \frac{1}{0{,}01} \cdot \frac{1}{300} = 1{,}953\left[\frac{A}{LSB}\right]$

$U_{eff}[V] = U_{eff}[LSB] \cdot U_{lépték}\left[\frac{V}{LSB}\right]$

ismert

így $U_{eff}[LSB] = \frac{U_{eff}[V]}{U_{lépték}\left[\frac{V}{LSB}\right]} = \frac{10800}{78{,}125} = 138{,}24[LSB]$

$I_{eff}[LSB] = \frac{I_{eff}[A]}{I_{lépték}\left[\frac{A}{LSB}\right]} = \frac{215}{1{,}953} = 110{,}08\,[LSB]$

N. $\boxed{U \cdot I}$

$\cancel{P = U \cdot I \cdot \cos\varphi = 14609{,}7\,[LSB]}$

$\boxed{U_{tár} = N \cdot U_x \cdot \cancel{\frac{1}{2}}} = \frac{\cancel{64}\cdot 138{,}24}{\cancel{2}} = 4423{,}68$

$\frac{U_{be}}{U_{lépték}} = U_x = \frac{10800}{78{,}125}$

$I_{tár} = N \cdot I \cdot \frac{1}{2} = \frac{64 \cdot 1{,}953}{2} = 62{,}496$

$P_{tár} = 265403{,}8$

$$\frac{a_0 + a_1 s + a_2 s^2}{b_0 + b_1 s} \rightarrow \frac{(x_1 + s x_2)(x_3 + s x_4)}{b_0 + b_1 s}$$

$$= \frac{x_1 + s x_2}{b_0 + b_1 s} \cdot \frac{x_3 + s x_4}{b_0 + b_1 s}$$

$$i = \frac{U_0}{R} \cdot e^{-\delta t}$$