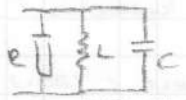
1.

RLC



$L = 200\,mH$
$C = 10\,\mu F$
$Q = 25$

$R = ?$

RL vagy RC: $\boxed{T = R \cdot C}$ $\boxed{T = \frac{L}{R}}$ $\Big\}\ T = \frac{1}{\omega_0}$

$\boxed{RLC \to T = \frac{2\pi}{\omega_0}}$

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

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

$\boxed{Z_0 = \sqrt{\frac{L}{C}}} = \sqrt{\frac{200m}{10\mu}} = 141,4$

$\boxed{Q_{párh} = \frac{R}{Z_0}} \to R = Q_p \cdot Z_0 = 25 \cdot 141,4 = 3535\,\Omega$

$\underline{\underline{R = 3535\,\Omega}}$

Rezonancia:

$X_L = X_C$

$Z_{eredő} = R$

2. RLC

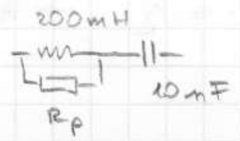
$L = 200\,mH$
$C = 10\,nF$
$Z_0 = 4472,13\,\Omega$

$Q = ?$

$\boxed{R_p \cdot R_S = Z_0^2} \to R_S = \frac{Z_0^2}{R_p}$

$\boxed{Q_{soros} = \frac{Z_0}{R_S}}$

3.



$Q = 25$
$R_p = ?$

$\boxed{Z_0 = \sqrt{\frac{L}{C}}} = \sqrt{\frac{200m}{10n}}$

$\boxed{Q_{soros} = \frac{Z_0}{R_s}} \to R_s$

$\boxed{R_s \cdot R_p = Z_0^2} \to R_p$

4.

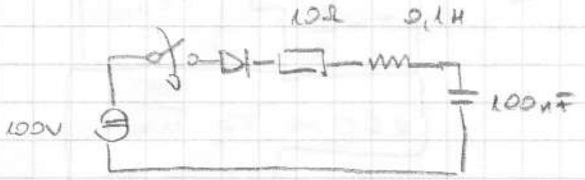
$L = 100\,mH$
$C = 10\,\mu F$
$Q = 10$

$R_S = ?$

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

$\boxed{Q_S = \frac{Z_0}{R_S}} \to R_S$

(5.)



$U_{C\,max} = ?$

fen kitnevező kapcsolás!

$100V < U_{C\,max} < 200V$

$Q > 0{,}5$ rezonancia
$Q \leq 0{,}5$ nincs rezgés, nincs túllövés

$\boxed{Q_S = \frac{Z_0}{R}} = 10 \rightarrow$ rezonancia

$\rightarrow$ max. az 1. csúcs $\rightarrow \frac{T}{2}$ -ben

$\boxed{U_{C\,max} = U_0 (1 + 1 \cdot e^{-\delta t}) =}$

$= U_0 (1 + 1 \cdot e^{-\delta \frac{T}{2}})$

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

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

$\delta T = \frac{\pi}{Q}$

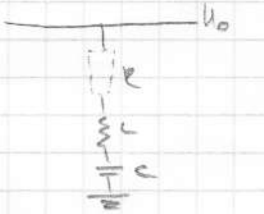
$\underline{\underline{U_{C\,max} = U_0 (1 + 1 \cdot e^{-\frac{1}{2}\frac{\pi}{Q}})}}$

1 periódus alatt U mennyit csillapodik? $\rightarrow e^{-\delta t} = e^{-\delta T} = e^{-\frac{\pi}{Q}}$

Hány periódus alatt csillapodik a felére? $\rightarrow e^{-\delta k T} = \frac{1}{2} \rightarrow k$

$e^{-\frac{k\pi}{Q}} = \frac{1}{2} \rightarrow k = 0{,}22\,Q$

(6.)



$k = 3$
$Q_{3f} = 3$ MVAR

$U_{C\,max} = ?$

rezonanciában $\rightarrow$ $\boxed{X_{L150} = X_{C150}}$

$\frac{1}{j\omega 3C} = j\omega 3L$

$\frac{1}{3} X_C = 3 X_L$

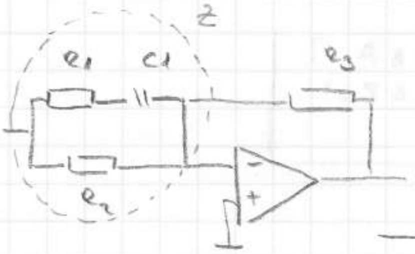
$X_C = 9 X_L$

$\boxed{\begin{array}{l} X_{C_k} = \frac{1}{k} X_C \\ X_{L_k} = k \cdot X_L \end{array}}$

$U_C = \underbrace{\frac{U_0 \sqrt{2}}{\sqrt{3}}}_{\text{csúcsérték + fázis}} \cdot \frac{X_C}{X_C + X_L} \rightarrow \hat{U}_0 \frac{9X_L}{9X_L + X_L} = \hat{U}_0 \frac{9}{10}$

csúcsérték + vonali

(7.)



$R_1 = 2k$
$R_2 = R_3 = 10k$
$C_1 = 10n$
$A = ?$
$\varphi_{max} = ?$

$$A = -\frac{R_2}{R_1} \to A = \frac{-R_3}{Z} = \frac{-R_3}{Z_1 \times R_2} = \frac{-R_3}{\left(\frac{1}{j\omega C} + R_1\right) \times R_2}$$

$$\left(\frac{1}{j\omega C} + R_1\right) \times R_2 = \frac{\left(\frac{1}{j\omega C} + R_1\right) R_2}{\frac{1}{j\omega C} + R_1 + R_2} \Big/ j\omega C$$

$$= \frac{R_2 + R_1 R_2 j\omega C}{1 + j\omega C R_1 + j\omega C R_2}$$

$$\to A = \frac{-R_3 (1 + j\omega C R_1 + j\omega C R_2)}{R_2 + R_1 R_2 j\omega C} = \frac{-R_3}{R_2} \cdot \frac{1 + sC(R_1 + R_2)}{1 + sC(R_1)} \begin{matrix} \to f_1 \\ \to f_2 \end{matrix}$$

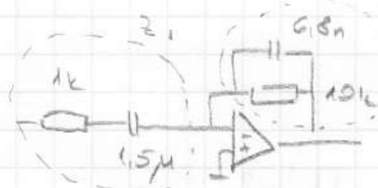
$$\boxed{f_1 = \frac{1}{2\pi C_1 (R_1 + R_2)}} \to \boxed{\varphi_1 = \arctan\left(\frac{f_0}{f_1}\right)}$$

$$\boxed{f_2 = \frac{1}{2\pi C_1 (R_1)}} \to \boxed{\varphi_2 = -\arctan\left(\frac{f_0}{f_2}\right)}$$

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

$$\boxed{\varphi_{max} = \varphi_1 + \varphi_2}$$

(8.)



$f = 1kHz$
$\varphi = ?$
$A = ?$

$$\boxed{A = \frac{-|Z_2|}{|Z_1|}}$$

$$Z_1 = R_1 + \frac{1}{j\omega C_1} = 1000 + \frac{1}{j\, 2\pi\, 1000 \cdot 1{,}5 \cdot 10^{-6}} = 1000 - j\,106 = 1005 \cdot e^{-j\,6{,}05^\circ}$$

$\varphi_1 = -6{,}05^\circ$

$$Z_2 = R_2 \times \frac{1}{j\omega C_2} = \frac{R_2 / j\omega C_2}{R_2 + \frac{1}{j\omega C_2}} = \frac{234 \cdot 10^{6} \cdot e^{-j90}}{25447 \cdot e^{-j66{,}86}} = 9{,}19 \cdot 10^{3} \cdot e^{-j\,23^\circ}$$

$\varphi_2 = -23{,}14^\circ$

$\to \underline{A = -9{,}14}$

$\to \underline{\varphi = +162{,}91^\circ}$

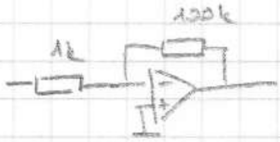
$$\boxed{f_1 = \frac{1}{2\pi R_1 C_1}} = 106\ Hz$$

$$\boxed{f_2 = \frac{1}{2\pi R_2 C_2}} = 2341\ Hz$$

$\varphi = 180 + \varphi_2 - \varphi_1$

nemí. nevero

9.



$f = 10\ kHz$ $\quad \Delta A = ?$

$f_T = 10\ MHz$ $\quad \Delta\varphi = ?$

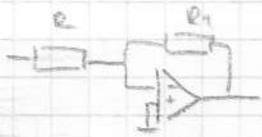
$A_0 = 100$ mert $\boxed{A_0 = \frac{R_2}{R_1}}$

$$\boxed{f = \frac{f_T}{A \cdot A_h}} \rightarrow A_h = \frac{f_T}{f \cdot A} = \frac{10M}{10k \cdot 100} = 10$$

$$\boxed{h = 1 - \frac{1}{1 + \frac{1}{-jA_h}}} = 1 - \frac{1}{1 + 0{,}1j} = 1 - 1{,}00499 \cdot e^{-j5{,}71}$$

$\Delta A = 0{,}5\ \%$ $\qquad \varphi = 5{,}71^\circ$

10.



$A = 50$ $\quad f = ?$

$f_T = 1\ MHz$

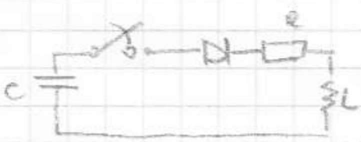
$H = 1\%$

$h = 0{,}01$

$$\boxed{A_h = \sqrt{\frac{1}{\frac{1}{(1-h)^2} - 1}}} = 7{,}018$$

$$\boxed{f = \frac{f_T}{A \cdot A_h}} = \frac{1M}{50 \cdot 7{,}018} = 2{,}85\ kH$$

11.



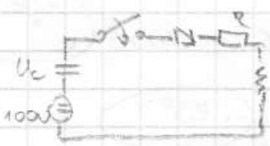
$U_c = 100V$ $\quad U_c' = ?$

$L = 100\ mH$

$C = 10\mu F$

$R = 100\ \Omega$

feltöltsük dt!



$U_c = 0V$

$U_0 = 100V$

$U_c = 100V - U_R - U_L$

· sem a fesz, sem az áram nem ugorhat

max $\rightarrow \frac{T}{2}$ -ben

$$\boxed{U_{Lmax} = U_0(1 + e^{-\delta t})} = U_0(1 + \underbrace{e^{-0{,}5m \cdot 500}}_{0{,}778}) = 177{,}8V$$

$\rightarrow 77{,}8V$

$$\left.\begin{array}{l}\boxed{\delta = \frac{R}{2L} = \frac{\omega_0}{2Q}} \\ \boxed{T = \frac{2\pi}{\omega_0}}\end{array}\right\} \delta t = -\frac{1}{2}\frac{\pi}{Q}$$

$\underline{\underline{U_c' = -77{,}8V}}$

12. II Bessel aluláteresztő

$f_1 = 350\ Hz \qquad A_1 = -40\ dB$

$f_2 = 50\ Hz \qquad A_2 = ?$

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

Butterworth

max lapos: $|A|^2 = \dfrac{A_0^2}{1+\Omega^{2n}}$

Aluláteresztő

$$A(P) = \frac{A_0}{(1+a_1P+b_1P^2)(1+a_2P+b_2P^2)}$$

Felüláteresztő

p helyett $\frac{1}{p}$

mindenáteresztő

$A(P) = \dfrac{1-p}{1+p}$ 1. rend

$A(p) = \dfrac{1-a_1p+b_1p^2}{1+a_1p+b_1p^2}$ 2. rend Bessel

Táblázatból:

$a = 1,3617$

$b = 0,6180$

$$A(P) = \frac{1}{1+1,3617P+0,6180P^2} \approx$$

$$\approx \frac{1}{0,6180p^2} = \frac{1}{0,6180\,\Omega_1^2}$$

$\rightarrow \Omega_1 = 12,72$

Visszaellenőrzés:

$$\frac{1}{|1+j1,3617\cdot 12,72 - 0,6180\cdot 12,72^2|} = \frac{1}{|-98,99+j17,32|} =$$

$= 0,00995 = -40,04\ dB$ ✓

$A_1 = \dfrac{1}{|j\Omega_1 + \dots j\Omega_1^2|} \rightarrow \Omega_1$

$A_2 = \dfrac{1}{|j\Omega_2 + \dots j\Omega_2^2|}$

$\Omega_1 = \dfrac{\omega_1}{\omega_0}$

$\Omega_2 = \dfrac{\omega_2}{\omega_0}$

$\Omega_2 = \Omega_1 \cdot \dfrac{\omega_2}{\omega_1} = \Omega_1 \cdot \dfrac{f_2}{f_1}$

$$\Omega_2 = \Omega_1 \cdot \frac{f_2}{f_1} = 12,72 \cdot \frac{50}{350} = 1,817$$

$$\boxed{A_2(\Omega_2) = \frac{1}{|1+1,3617\cdot j1,817 - 0,6180\cdot 1,82^2|}} = \frac{1}{\underbrace{|-0,12476+j2,4742|}_{2,4773}} =$$

$= 0,4036 = \underline{\underline{-7,88\ dB}}$

$$\boxed{X_{dB} = 20\cdot \log\left(\frac{X}{X_0}\right)}$$

Sávzáró

$$\boxed{A(P) = \frac{1+p^2}{1+\frac{1}{Q}P+p^2}}$$

13. III. Butterworth $\rightarrow n = 3$

Mekkora a kenyszh parti frekvencia?

$f_1 = 250\ Hz$ $A_1 = -30\ dB$

$f_2 = 50\ Hz$ $A_2 = ?$

max lapos feltétel: $\boxed{|A(\Omega)|^2 = \frac{A_0^2}{1+\Omega^{2n}}}$

$$\boxed{|A_1| = \frac{1}{\sqrt{1+\Omega_1^6}}} \rightarrow \Omega_1^6 = \left(\frac{1}{|A_1|}\right)^2 - 1 \Rightarrow \Omega_1 = 3{,}16$$

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

$$\boxed{\Omega_2 = \frac{f_2}{f_1}\Omega_1} = 0{,}6323$$

$$\boxed{f_0 = \frac{f_1}{\Omega_1}} = \frac{250}{3{,}16}$$

$$|A_2| = \frac{1}{\sqrt{1+\Omega_2^6}} = 0{,}9635 \rightarrow -0{,}27\ dB$$

$$f_0 = 79{,}11$$

14. II. Butterworth elulét.

$f_1 = 250\ Hz$ $A_1 = -30\ dB$

$f_2 = 50\ Hz$ $A_2 = ?$

$$\boxed{|A(\Omega)|^2 = \frac{A_0^2}{1+\Omega^{2n}}} \rightarrow |A_1| = \frac{1}{\sqrt{1+\Omega_1^{4}}}$$

$$\Omega_1^4 = \left(\frac{1}{|A_1|}\right)^2 - 1 \Rightarrow \Omega_1 = 5{,}62$$

$$-30\ dB = 10^{\left(-\frac{30}{20}\right)}$$

$$\boxed{\Omega_2 = \frac{f_2}{f_1}\Omega_1} = \frac{50}{250}\cdot 5{,}62 = 1{,}124$$

$$|A_2| = \frac{1}{\sqrt{1+\Omega_2^4}} = 0{,}6206 \rightarrow -4{,}14\ dB$$

(15.) III Bessel aluláteresztő

$f_1 = 350\,Hz \qquad A_1 = -30\,dB$
$f_2 = 50\,Hz \qquad A_2 = ?$

Táblázatból: $a_1 = 0{,}7560 \quad b_1 = 0$
$a_2 = 0{,}9996 \quad b_2 = 0{,}4772$

$$A(p) = \frac{1}{(1+0{,}7560p)(1+0{,}9996p+0{,}4772p^2)} \approx \frac{1}{0{,}7560\cdot 0{,}4772\,\underbrace{p^3}_{\Omega_1^3}}$$

$$\Omega_1 = \sqrt[3]{\frac{1}{A(p)\,0{,}7560\cdot 0{,}4772}} = \sqrt[3]{87{,}6552} = 4{,}4421$$

$$A(p) = \frac{1}{|(\Omega_j \ldots \Omega_j)|}$$

ellenőrzés

$$A(p) = \frac{1}{|\underbrace{(1+j3{,}358)}_{3{,}5037\cdot e^{j73{,}42}}\underbrace{(1-j4{,}4403-9{,}4162)}_{9{,}5157\cdot e^{-j152{,}18}}|} = 0{,}02999 \to -30{,}46\,dB$$

hiba elhanyagolható

$$\boxed{\Omega_2 = \frac{f_2}{f_1}\Omega_1} = 0{,}635$$

$$A_2 = \frac{1}{|\underbrace{(1+j0{,}48)}_{1{,}109\cdot e^{j25{,}6}}\underbrace{(1-j0{,}635-0{,}192)}_{1{,}0277\cdot e^{j38{,}2}}|} = 0{,}877 \to \underline{\underline{-1{,}14\,dB}}$$

(16.)

$f = 500\,Hz$
$A = ?$
$\varphi = ?$

$$\boxed{A = \frac{-|Z_2|}{|Z_1|}} = \frac{8{,}94}{1{,}022} = 8{,}75 \to \underline{\underline{18{,}8\,dB}}$$

$$Z_1 = 1k + \frac{1}{j\omega 1{,}5\mu} = 1k + \frac{1}{j\,2\cdot 500\cdot\pi\cdot 1{,}5\mu} = 1k - j\,212{,}3 = 1{,}022k\cdot e^{-j11{,}98^\circ}$$

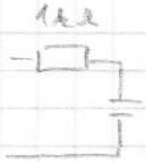
$$\varphi_1 = -11{,}98^\circ$$

$$Z_2 = 10k \times \frac{1}{j\omega 16nF} = \frac{10k/j\omega C}{10k + \frac{1}{j\omega C}} \Big/ \cdot j\omega C = \frac{10k}{j\omega C\,10k+1} =$$

$$= \frac{10k}{\underbrace{j\,3{,}14\cdot k\cdot 16\cdot 10^{-9}\cdot 10\cdot k + 1}_{1+j0{,}502 \;=\; 1{,}119\cdot e^{j26{,}66}}} = 8{,}94\,k\cdot e^{-j26{,}66} \to \varphi_2 = -26{,}66^\circ$$

$$\boxed{\varphi = \underset{-}{180} + \underset{\text{visszacs.}}{\varphi_2} - \underset{\text{osztó}}{\varphi_1}} = \underline{\underline{165{,}32^\circ}}$$

(17.)



$f = 50\,Hz$
$\varphi = 0{,}57°$

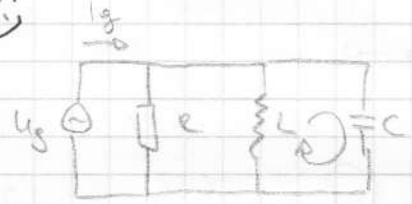
$C = ?$

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

$\tan\varphi = \frac{\frac{1}{\omega C}}{R} \rightarrow C = \frac{1}{\omega R \tan\varphi} =$

$= \frac{1}{100\pi \cdot k \cdot 0{,}00995} = \underline{\underline{0{,}32\ mF}}$

(18.)



$\omega = \omega_0$

$I_L = ?\quad I_C = ?$

rezonancia:
$Z_{soros} = 0 \quad + R$
$Z_{párh.} = \infty \quad + R$

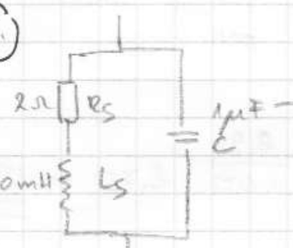
$Z \approx \infty$

$I_R = \frac{U_g}{R}$

$\boxed{I_L = I_C = Q \cdot I_R}$

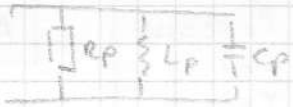
$\boxed{Z_0 = \sqrt{\frac{L}{C}}}$ $\boxed{Q = \frac{R}{Z_0}}$

(19.)



$Z(\omega_0) = ?$

$\rightarrow$



$Z(\omega_0) = R_P$

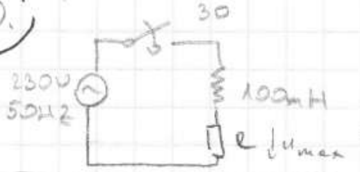
$C_P = C_S$
$L_P = L_S$
$R_P \cdot R_S = Z_0^2$

$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{10m}{1\mu}} = 100\,\Omega$

$R_P = \frac{Z_0^2}{R_S} \rightarrow \frac{10000}{2} = 5000 = 5\,k\Omega$

$\underline{\underline{Z(\omega_0) = 5\,k\Omega}}$

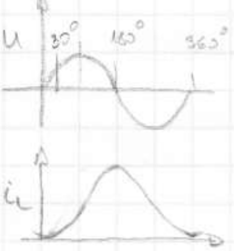
20.



$\hat{I}, \hat{I}_{eff} = ?$

$U_{max} = ?$

$U_{max} = \hat{I} \cdot R$



$$U_L = \frac{di}{dt} L$$

$\hat{I}_0 = \frac{\hat{U}}{|Z|}$ → állandósult

$\hat{I} = \hat{I}_0 (1 + \cos 30°)$

állandósult, tranziens

(mivel 50Hz alatt nem csengle) $\tau = \frac{L}{R} \gg \frac{1}{50Hz}$

$$I_{eff\,max} = \sqrt{I_{tran}^2 + \left(\hat{I}_0/\sqrt{2}\right)^2}$$

DC-nek vesznük, stacioner

21.

$k = 11$

$Q = 5$

$f = 50Hz$

$Q_{C3f} = 10 MVar$

R_S vagy R_p jobb?

rezonanciánál: $X_L = X_C$

$X_{C_k} = \frac{1}{j\omega C k}$ | $X_{L_k} = j\omega L k$

$$\boxed{Q_{C3f} = \frac{U^2}{X_C}} \rightarrow X_{C_{50}} = \frac{(20k)^2}{10 \cdot 10^6} = 40\,\Omega$$

$X_{C_{k11}} = \frac{40}{k} = 3{,}64\,\Omega$

$X_{L_{k11}} = X_{C_{k11}} = 3{,}64$

$$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{\omega L}{\omega C}} = \sqrt{X_L \cdot X_C} = \underline{\underline{3{,}64\,\Omega}}$$

Soros

$$\boxed{Q_S = \frac{Z_0}{R_S}} \rightarrow R_S = \frac{Z_0}{Q_S} = 0{,}728\,\Omega$$

Párhuzamos

$$\boxed{Q_p = \frac{R}{Z_0}} \Rightarrow R = Q_p \cdot Z_0 = 18{,}18\,\Omega$$

Melyik jobb?

$$Z_{eredő} = X_{C_{50}} + R_S + X_L = 40 + 0{,}728 + \frac{3{,}64}{11} = 41{,}06\,\Omega$$

$$I = \frac{U}{Z_{eredő}} = \frac{20/\sqrt{3}}{41{,}06} = 281\,A$$

$$P_S = I^2 \cdot R_S = 57{,}48\,kW$$

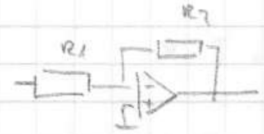
$$Z_{eredő} = \frac{R_p X_L}{R_p + X_L} + X_C = 40{,}32\,\Omega$$

$I \cong 281\,A$

$$P_p = \frac{(I \cdot X_L)^2}{R_p} = 476\,W$$

Ez a jobb!

(22)



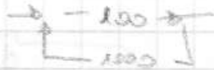
$\frac{R_2}{R_1} = 100$

$A_0 = ?$

0,1% pontosság

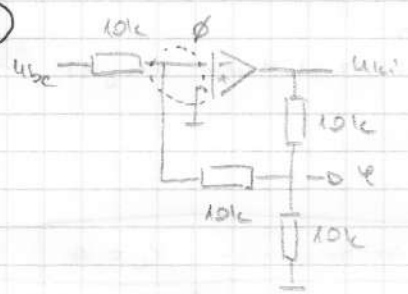
$h = 0{,}001$

$\boxed{H = \frac{1}{h} = 1000}$ → hurok erősítés



$\boxed{A_0 = A \cdot H = 10^5}$ → 100 dB

(23)

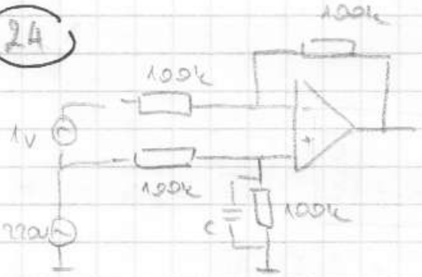


$A = ?$

$\varphi = u_{ki} \frac{10 \times 10}{10 \times 10 + 10} = \frac{1}{3} u_{ki}$

$\frac{u_{be}}{10k} = -\frac{1}{3} \frac{u_{ki}}{10k}$ → $A = -\frac{1}{3}$

(24)



$C_{max} = ?$
1% pontosság → 220 V → 0,01 V-ot hagy ki el

$\boxed{CMMR = \frac{u_{ki}}{u_0}} = \frac{0{,}01}{220} = 4{,}5 \cdot 10^{-5}$ → -87 dB

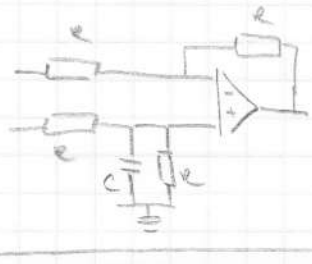
$\boxed{CMMR = \frac{|\Delta R|}{2R}}$ → $\Delta R = 9\,\Omega$

$100k - 9 = R \times C = \frac{R}{R j\omega C + 1} = \frac{100k}{100k\,\omega C + 1}$

$\omega C = \frac{\frac{100k}{100k - 9} - 1}{100k} = 9{,}0 \cdot 10^{-10}$

$C = 2{,}8\,pF$

(25.)



$\Delta\varphi_f = ?$

$CMRR_f = ?$

$R = 100k$

$C = 10pF$

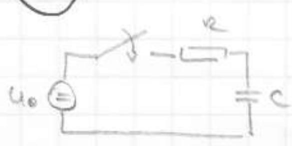
$f = 50Hz$

$$\boxed{\Delta R = R - R \times X_C} = R - \frac{R \cdot \frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = R + \frac{R}{j\omega CR + 1} = 31{,}4\Omega \cdot e^{j0{,}018}$$

$\Delta\varphi = 0{,}018°$

$$\boxed{CMRR = \frac{|\Delta R|}{2R}} = \frac{31{,}4}{200k} = 1{,}57 \cdot 10^{-4} = -76\ dB$$

(26)



$t = ?$ mikor éri be U_0-ra $h = 0{,}2\%$-os hibával?

$R = 1k\Omega \qquad C = 10\mu F$

nincs hiba: $\boxed{U_C = U_0 (1 - e^{-t/T})}$

hibával: $\boxed{U_C = U_0 (1 - h) = U_0 (1 - e^{-t/T})}$

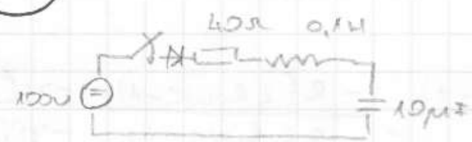
$$0{,}998 = 1 - e^{-t/T}$$

$$0{,}002 = e^{-t/T}$$

$$t = 6{,}215\,T \qquad \boxed{T = R \cdot C} = 1k \cdot 10\mu F =$$

$$\underline{\underline{t = 62{,}15\,mSec}} \qquad = 10\ mSec$$

(27.)



$U_{Cmax} = ?$

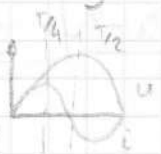
$i_{Cmax} = ?$

$\boxed{Z_0 = \sqrt{\frac{L}{C}}} = 100\Omega \qquad \boxed{Q_S = \frac{Z_0}{R_S}} = 2{,}5 \rightarrow > 0{,}5 \rightarrow$ leng (rezonencia)

$$\boxed{U_{C_{max}} = U_0 (1 + e^{-\delta t})} = U_0 (1 + e^{-\frac{1}{2}\frac{\pi}{Q}}) = \underline{153{,}4V}$$

U_{max}: $\boxed{t = T/2} = \frac{\pi}{\omega_0}$, $\boxed{\delta = \frac{\omega_0}{2Q}}$ $\Big\}$ $\boxed{\delta t = \frac{1\pi}{2Q}}$

$I_{C_{max}} = I_{max}$



$$\boxed{I_{max} = \frac{U}{Z} e^{-\frac{1}{4}\frac{\pi}{Q}}} = \frac{100}{40} \cdot e^{-\frac{1}{4}\frac{\pi}{Q}} = \underline{\underline{1{,}83A}}$$

$i_C = C \cdot \frac{du}{dt} \qquad \boxed{t = T/4} \qquad \boxed{Z_{rezonancia} = R}$

(28.) Szűrő méretezés

$A = 1$ $\quad R_3 = ?$

$R_2 = 2R_1$

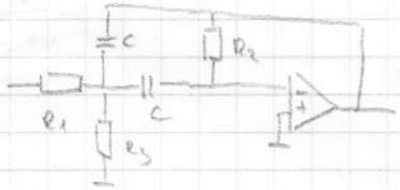
C

$R_1 = R_2/2$

$$\boxed{R_2 = \frac{Q}{\pi \cdot C \cdot f_0}}$$

$$\boxed{R_3 = \frac{1}{R_2 (2\pi (f_0)^2)}}$$

(29.) Szűrő méretezés



$f_0 = 50\,Hz$

$A = 1$

$C = 47\,nF$

$Q = 50$

Sávszűrő

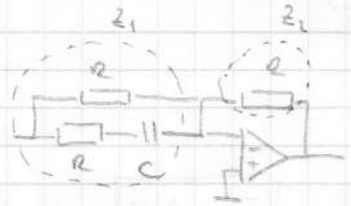
$$\boxed{f_0 = \frac{1}{2\pi C}\sqrt{\frac{R_1 + R_3}{R_1 \cdot R_2 \cdot R_3}}}$$

$$\boxed{A = -\frac{R_2}{2R_1}} \rightarrow R_1$$

$$\boxed{R_2 = \frac{Q}{\pi \cdot C \cdot f_0}} \rightarrow R_2$$

$$\boxed{R_3 = \frac{1}{R_2 (2\pi f_0^2)}} \rightarrow R_3 \quad (\text{ha } R_1 \gg R_3) \quad \text{ha nem: } \boxed{R_1 \times R_3 = \frac{R_2}{4Q^2}}$$

(30)



$R = 10\,k$

$C = 3{,}3\,nF$

$\varphi_{max} = ?$

$$Z_1 = R \times (R + X_C) = \frac{R\left(R + \frac{1}{jwC}\right)}{2R + \frac{1}{jwC}} = \frac{R^2 jwC + R}{2R\,jwC + 1}$$

$$Z_2 = R$$

$$A = \frac{-Z_2}{Z_1} = \frac{-R}{\frac{R^2 jwC + R}{2R\,jwC + 1}} = \frac{-R(2R\,jwC + 1)}{R^2 jwC + R} = \frac{-R(2R\,jwC + 1)}{R(R\,jwC + 1)} \begin{matrix} \rightarrow f_1 \\ \rightarrow f_2 \end{matrix}$$

$$\boxed{f_1 = \frac{1}{2\pi\, 2RC}} = 2411\,Hz$$

$$\boxed{f_2 = \frac{1}{2\pi RC}} = 4822\,Hz$$

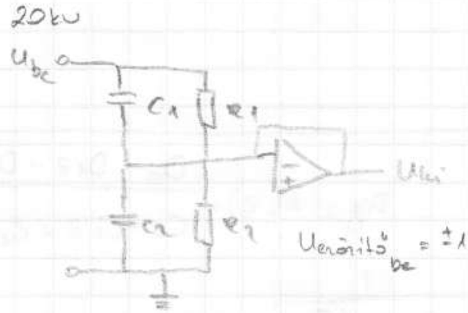
$$\boxed{f_0 = \sqrt{f_1 \cdot f_2}} = 3410\,Hz$$

$$\boxed{\varphi_1 = \text{arc tan}\left(\frac{f_0}{f_1}\right)} = 54{,}74^\circ$$

$$\boxed{\varphi_2 = -\text{arc tan}\left(\frac{f_0}{f_2}\right)} = -35{,}27^\circ$$

$$\boxed{\varphi_{max} = \varphi_1 + \varphi_2} = \underline{\underline{19{,}47^\circ}}$$

31 kapacitív osztó



$U_{erősítő\,be} = \pm 10V$

R?
C=? ha $U_{ki} = \pm 10V$

R_1 és C_1 adott

$R_2, C_2 = ?$

$$\boxed{R_1C_1 = R_2C_2}$$

$$\boxed{Q_1 = Q_2}$$

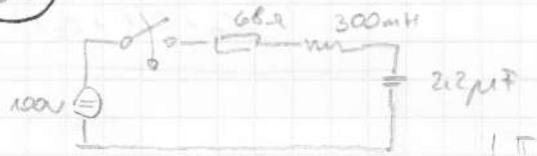
$$\boxed{C_1U_1 = C_2U_2}$$

$$U_2 = \frac{C_1}{C_2}U_1 \quad \Big| \quad U_2 = U_{ki}$$

$$U_{ki} = \frac{C_1}{C_2}U_1 = 20kV \cdot \frac{1}{\sqrt{3}} \cdot \sqrt{2} \cdot \frac{C_1}{C_2} \rightarrow \underline{\underline{C_2}}$$

$$R_1C_1 = R_2C_2 \rightarrow \underline{\underline{R_2}}$$

32



$U_{C\,max} = ?$

$$U_{C\,max} = U_C(1 + e^{-\sigma t}) \quad \underbrace{-\sigma t}_{-\frac{1}{2}\frac{\pi}{Q}}$$

de! mivel ~~nincs~~ dióda !! $\boxed{t = \frac{T}{4}}$, σ } $-\frac{1}{4}\frac{\pi}{Q}$

$$I_{C\,max} = \frac{U}{Z} \cdot e^{-\frac{\pi}{4Q}}$$

33. Sávszűrő

$f_1 = 7\times f_0 \rightarrow -40$ dB
$f_2 = 1{,}02\times f_0 \rightarrow$? dB

$Q = ?$

$$\boxed{B = \frac{1}{Q} \text{ sávszélesség}}$$

$$A(p) = \frac{\frac{1}{Q}p}{1 + \frac{1}{Q}p + p^2} \qquad \Omega_1 = 7$$

$$A = 0{,}01 = \left|\frac{j\frac{1}{Q}7}{1 + j\frac{1}{Q}7 - 49}\right| = \left|\frac{j\frac{7}{Q}}{\underbrace{j\frac{7}{Q}}_{\text{elhagyjuk}} - 48}\right| = \frac{7}{48 \cdot Q} \rightarrow \underline{\underline{Q = 14{,}6}}$$

Záró tart.

$$\frac{1}{A} = Q\Omega \quad \text{ha } \Omega \gg 1$$

$$\frac{1}{A} = Q\frac{1}{\Omega} \quad \text{ha } \Omega \ll 1$$

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

áteresztő tart. $\Delta\Omega \ll \frac{B}{2}$

$$A(\Omega) = \frac{1}{1 + j\frac{\Delta\Omega}{B/2}}$$

Ellenőrzés visszahelyettesítéssel...

$$A_2(p) = \left|\frac{j1{,}02 \cdot \frac{1}{14{,}6}}{1 + j\frac{1}{14{,}6}1{,}02 - 1{,}0404}\right| = \left|\frac{j\,0{,}0699}{\underbrace{-0{,}0404 + j\,0{,}0699}_{0{,}0807 \cdot e^{j120}}}\right| =$$

$$= \left|0{,}866 \cdot e^{-j30°}\right|$$

$$\rightarrow \underline{\underline{A = -1{,}25 \text{ dB}}}$$

(34) Digitális szűrő

II Bessel aluláteresztő

$f_0 = 50\,Hz,\ f_s = 1600\,Hz$

Analóg: $A(p) = \dfrac{d_0 + d_1 p + d_2 p^2}{c_0 + c_1 p + c_2 p^2} \rightarrow p = l\,\dfrac{z-1}{z+1}$ Dig.: $A(z) = \dfrac{D_0 + D_1 z + D_2 \cdot z^2}{C_0 + C_1 z + C_2 z^2}$

$$l = ctg\,\frac{\pi}{\Omega_m} = \frac{1}{\tan\left(\frac{\pi}{\Omega_m}\right)}$$

$$\Omega_m = \frac{f_m}{f_0}$$

DII

$$D_0 = \frac{d_0 - d_1 l + d_2 l^2}{c_0 + c_1 l + c_2 l^2} \quad D_1 = \frac{2(d_0 - d_2 l^2)}{c_0 + c_1 l + c_2 l^2} \quad D_2 = \frac{d_0 + d_1 l + d_2 l^2}{c_0 + c_1 l + c_2 l^2}$$

$$C_0 = \frac{c_0 - c_1 l + c_2 l^2}{c_0 + c_1 l + c_2 l^2} \quad C_1 = \frac{2(c_0 - c_2 l^2)}{c_0 + c_1 l + c_2 l^2} \quad C_2 = \frac{c_0 + c_1 l + c_2 l^2}{c_0 + c_1 l + c_2 l^2} = 1$$

DI D_0, C_0 $\quad D_1 = \dfrac{d_0 + d_1 l}{c_0 + c_1 l} \quad C_1 = \dfrac{c_0 + c_1 l}{c_0 + c_1 l} = 1$

táblázatból: $d_0 = 1 \quad d_1 = 0 \quad d_2 = 0$

$c_0 = 1 \quad c_1 = 1{,}361 \quad c_2 = 0{,}618$

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

$$\boxed{l = ctg\,\frac{\pi}{\Omega_m}} = ctg\,\frac{\pi}{32} = 10{,}15$$

$\rightarrow$ $C_0 = 0{,}64 \quad C_1 = -1{,}59 \quad C_2 = 1$

$\rightarrow$ $D_0 = 0{,}013 \quad D_1 = 0{,}02 \quad D_2 = 0{,}01$

$\boxed{\text{áll: } \in [-2;2]}$

így: $$A(z) = \frac{0{,}013 + 0{,}02\,z + 0{,}01\,z^2}{0{,}64 - 1{,}59\,z + z^2}$$

(35) Digit Sáváteresztő

$f_0 = 50\,Hz$
$f_m = 3200\,Hz$
$Q = 10$

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

$\rightarrow$ $d_0 = 0$ $d_1 = 0{,}1$ $d_2 = 0$
$c_0 = 1$ $c_1 = 0{,}1$ $c_2 = 1$

$\downarrow$ D II sáváteresztő

$$\boxed{\Omega_m = \frac{f_m}{f_0}} = \frac{3200}{50} = 64$$

$$\boxed{l = ctg\frac{\pi}{\Omega_m}} = \frac{1}{tan\left(\frac{\pi}{\Omega}\right)} = 20{,}35$$

RAD!

$C_0 = 0{,}99$ $C_1 = -1{,}98$ $C_2 = 1$

$D_0 = -0{,}005$ $D_1 = 0$ $D_2 = 0{,}005$

$$A(z) = \frac{-0{,}005 + 0{,}005z^2}{0{,}99 - 1{,}98z + z^2}$$

(36.) Digit II Bessel

$f_1 = 250\,Hz$ $A_1 = -30\,dB$
$f_m = 6400$

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

$$A_1 = 0{,}0316 = \frac{1}{\left|-0{,}618\Omega_1^2\right|}$$

$\downarrow$ $\Omega = 7{,}095$

$$\boxed{\Omega_1 = \frac{f_1}{f_0}} \rightarrow f_0 = 34{,}95\,Hz$$

$d_0 = 1$ $C_0 = 1$
$d_1 = 0$ $C_1 = 1{,}361$
$d_2 = 0$ $C_2 = 0{,}618$

$\rightarrow$ $$\boxed{\Omega_m = \frac{f_m}{f_0}} = \frac{6400}{35} = 182{,}86$$

$$\boxed{l = ctg\frac{\pi}{\Omega_m}} = 58{,}20$$ RAD!

$\rightarrow$ $C_0 = 0{,}927$ $D_0 = 0{,}0005$
$C_1 = -1{,}925$ $D_1 = 0{,}0009$
$C_2 = 1$ $D_2 = 0{,}0005$

37 Bessel $\underline{VIII}$.

$\frac{f}{f_0} = 0{,}05$

$\varphi = ?$

$\boxed{\Omega_1 = \frac{f_1}{f_0} = 0{,}05}$ $\boxed{p = j\Omega = j\,0{,}05}$

táblázatból:

$a_1 = 1{,}1112$ $a_2 = 0{,}9754$ $a_3 = 0{,}7202$ $a_4 = 0{,}3728$

$b_1 = 0{,}3162$ $b_2 = 0{,}2979$ $b_3 = 0{,}2621$ $b_4 = 0{,}2087$

$$A(p) = \frac{1}{(1+a_1p+b_1p^2)(1+a_2p+b_2p^2)(1+a_3p+b_3p^2)(1+a_4p+b_4p^2)} \approx$$

$$(1+j1{,}1112\cdot 0{,}05 - 0{,}3162\cdot 0{,}05^2) = 0{,}999 + j\,0{,}0556 = r_1 \cdot e^{j\,3{,}18^\circ}$$

$$(1+j0{,}9754\cdot 0{,}05 - 0{,}2979\cdot 0{,}05^2) = 0{,}9993 + j\,0{,}04877 = r_2 \cdot e^{j\,2{,}79^\circ}$$

$$\ldots = r_3 \cdot e^{j\,2{,}59^\circ}$$

$$\ldots = r_4 \cdot e^{j\,1{,}068^\circ}$$

$$\varphi = -9{,}628^\circ$$

38 Digit szűrő

$f_0 = 50\,Hz$

$f_m = 6{,}400\,Hz$

$f_1 = 150\,Hz \rightarrow A = 0{,}099$

$f_0 \rightarrow 1$

$f_1 \rightarrow 0{,}099 \rightarrow -20\,dB$

Záró tart.: $\boxed{\Omega_1 = \frac{f_1}{f_0}} = 3 > 1 \rightarrow \boxed{0{,}99 = \frac{\frac{1}{Q}p}{1+\frac{1}{Q}p+p^2}}\Bigg|_{p=j3} \rightarrow \underline{\underline{Q = 3{,}79}}$

$$\boxed{A(p) = \frac{\frac{1}{Q}p}{1+\frac{1}{Q}p+p^2}} = \frac{0{,}297}{1+0{,}297p+p^2}$$

$d_0 = 0$ $c_0 = 1$

$d_1 = 0{,}297$ $c_1 = 0{,}297$ $\rightarrow$ D_0 C_0

$d_2 = 0$ $c_2 = 1$ D_1 C_1

D_2 C_2

analóg digitális

$$\boxed{\ell = ctg\frac{\pi}{\Omega_m} = \frac{1}{\tan\left(\frac{\pi}{3}\right)}} = 0{,}5774$$

(39) Sorrendi mennyiségek

Szimmetrikus hálózat, poz. sorrend, nincs zérus sorrend

1° hibával mérünk → mit fogunk mérni?

Szimmetrikus összetevők

$I_1 = \frac{1}{3}(I_a + a I_b + a^2 I_c)$

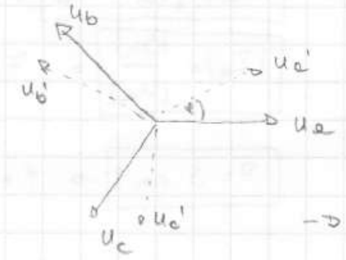
$I_2 = \frac{1}{3}(I_a + a^2 I_b + a I_c)$

$I_0 = \frac{1}{3}(I_a + I_b + I_c)$

$I_a = I_0 + I_1 + I_2$

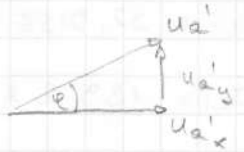
$I_b = I_0 + a^2 I_1 + a I_2$

$I_c = I_0 + a I_1 + a^2 I_2$



$\varphi = 1°$

→ zérussorrendű hibát okoz



$\varphi = 1° \rightarrow U_{a_x}' \approx U_a'$

$\boxed{U_{a_y}' = U_a' \cdot \sin\varphi}$

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

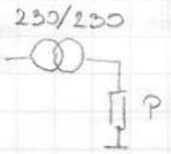
$= \frac{1}{3} U_{a_y}' = \frac{1}{3} U_a' \sin(1°) = 5{,}8 \cdot 10^{-3} U_a$

↓

0,6 % hibát okoz

Normál értelemben zérus sorrend 1-2% → 0,6% nagy hiba!

(40)



1 ph terhelés

Hány % neg. sorrendű hiba?

Tr. kapcsolása?

$S_{3f} = 10$ kVA

$\varepsilon = 9\%$

$P = 1$ kW

$\boxed{X_{tr} = \frac{U_v^2}{S_{3f}} \cdot \varepsilon = \frac{3 \cdot U_f^2}{S_{3f}} \cdot \varepsilon} = \frac{3 \cdot 230^2}{10k} \cdot 0{,}09 = 1{,}43\ \Omega$

$\boxed{R_{terhelés} = \frac{U_f^2}{P}} = \frac{230^2}{1k} = 52{,}9\ \Omega$

$\boxed{U_{a_p} = U_a \cdot \frac{R}{R + X_{tr}}} = 223{,}9$ V $\rightarrow \boxed{\Delta U_a} = 6{,}21$ V → trafón eső fesz

$\boxed{U_2 = \frac{1}{3}(\dots)} = \frac{1}{3}(\Delta U_a) = 2{,}09$ V $= 0{,}908\%$ (230V)

kapcsolás: szekunder $\curlywedge$ → mert 1ph terhelés csak ilyen lehet

primer $\curlywedge$ vagy Δ

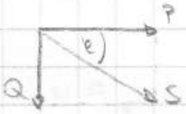
(41) 230 V-os szimmetrikus hálózat, nincs neg. sz rendszer a fsz-ben.

$P_a = 15\ kW$ $\quad P_b = 15\ kW$ $\quad P_c = 25\ kW$

$Q_a = 10\ kVar$ $\quad Q_b = 10\ kVar$ $\quad Q_b = 20\ kW$ $\quad$ áramban lehet

Sorrendi mennyiségek?

$$\boxed{\begin{aligned} S &= \sqrt{P^2 + Q^2} \\ P &= S \cdot \cos\varphi \\ Q &= S \cdot \sin\varphi \\ P &= U \cdot I_R \\ Q &= U \cdot I_Q \end{aligned}}$$



φ negatív mert Q pozitív, meddő felvétel

$$\boxed{|S_a| = \sqrt{P_a^2 + Q_a^2}} = 18{,}0278\ kVA$$

$$\boxed{|I_a| = \frac{|S_a|}{|U_a|}} = 78{,}38\ A$$

$$\boxed{P = S \cdot \cos\varphi} \rightarrow \varphi = \arccos\left(\frac{P}{S}\right) = 33{,}7^\circ$$

$$I_a = 78{,}38 \cdot e^{-j33{,}7^\circ}$$

$$I_b = 78{,}38 \cdot e^{-j33{,}7^\circ} \cdot e^{-j120^\circ}$$

$$|S_c| = 32{,}0156\ kVA$$

$$|I_c| = 139{,}2\ A$$

$$\varphi = -38{,}6^\circ$$

$$I_c = 139{,}2 \cdot e^{-j38{,}6^\circ} \cdot e^{j120^\circ}$$

komplexen kell végigszámolni!

$$\boxed{I_0 = \frac{1}{3}(I_a + I_b + I_c)} = \frac{1}{3}(\underbrace{65{,}2 - j43{,}5}_{I_a} \underbrace{- 70{,}3 - j34{,}7}_{I_b} \underbrace{+ 20{,}8 + j137{,}6}_{I_c}) =$$

$$= \frac{1}{3}(15{,}7 + j59{,}4) = 5{,}2 + j19{,}8 = 20{,}48 \cdot e^{j75{,}2^\circ}$$

$\rightarrow \underline{I_0 = 20{,}48\ A}$ $\rightarrow$ ide már csak az ABS érték kell.

... $\rightarrow \underline{I_1 = 98{,}6\ A}$ ... $\rightarrow \underline{I_2 = 20{,}5\ A}$

(42) Effektív érték mérés (Négyzetösszeg módszer)

$U_{1p} = 20\ kV$ $\quad U_{1s} = 100\ V$

$U_{2p} = 250\ V$ $\quad U_{2s} = 15\ V$

$AD_{in} = \pm 5\ V$, 12 bit

$N = 32$

Össz tár: 382.0000 h

$U = ?$

$$\boxed{U \text{ lépték} \left[\frac{V}{LSB}\right] = \frac{AD_{in}}{2^{n-1}} \cdot \frac{U_{1p}}{U_{1s}} \cdot \frac{U_{2p}}{U_{2s}}} =$$

$$= \frac{5}{2^{11}} \cdot \frac{20k}{100} \cdot \frac{250}{15} = 8{,}138\ \frac{V}{LSB}$$

$\rightarrow$ 1 LSB ennyi V

$$\boxed{U_{eff} = \sqrt{\frac{1}{N}\sum_{n=1}^{N} U(n)^2}} = \boxed{\sqrt{\frac{\text{Össz tár}}{N}}} =$$

$$= \sqrt{\frac{2 \cdot 16^4 + 8 \cdot 16^5 + 3 \cdot 16^6}{32}} = 1356{,}136\ [LSB]$$

$$\boxed{U_1 = \frac{1}{3}\sqrt{\frac{1}{N}\sum_{n=1}^{N}\left[U_a(n) + U_{b_{120}}(n) + U_{c_{-120}}(n)\right]^2}}$$

poz. sorrend mérése

$$\boxed{U_{eff_V} = U_{eff_{LSB}} \cdot U \text{ lépték}} = \underline{11{,}036\ kV}$$

43. P, Q mérés

Motoros fagyasztó $\rightarrow$ P, Q mérés

Mérjük U-t, majd I-t $T_{ad} = 40\,\mu s$ különbséggel

$U_{rms} = 218\,V$ $\quad P_{mért} = 1500\,W$ $\quad$ P, Q hiba = ? $\quad$ mi a valós érték?

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

$\boxed{P = 3\,U \cdot I \cdot \cos\varphi} \rightarrow \cos\varphi = \frac{P}{U \cdot I} \rightarrow \varphi = (-)36,86^\circ$

attól függően h. 1 v. 3 ph. $\rightarrow$ itt most 1ph

$\rightarrow$ mert induktív!

hiba: T_{ad} miatt $40\,\mu s \rightarrow \boxed{\frac{40\mu}{20m} \cdot 360^\circ = 0,72^\circ = \Delta\varphi}$

$\boxed{P_{korrigált} = \underbrace{U_{rms} \cdot I_{rms}}_{1ph} \cdot \cos(\varphi - \Delta\varphi)} =$

$= 218 \cdot 8,6 \cdot \cos(-36,86^\circ - 0,72^\circ) =$

$= 1485,78\,W$

$\rightarrow \Delta P = 14,216\,W = 0,95\,\%_{(P_{korrigált})}$

$\boxed{Q_{korrigált} = \underbrace{U_{rms} \cdot I_{rms}}_{1ph} \cdot \sin(\varphi - \Delta\varphi)} = 1143,38\,Var$

$\boxed{\Delta Q = U_{rms} \cdot I_{rms} \cdot \sin(\Delta\varphi)} = 23,56\,Var = 2,06\,\%_{(Q_{korrigált})}$

44. Sorrendi mennyiségek

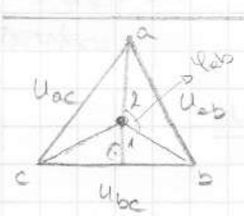
Δ kapcsolás, $U_{ac} = 100\,V$ $\quad U_2 = ?$

$U_{ab} = 100\,V$ $\quad U_1 = ?$

$U_{bc} = 80\,V$

$\boxed{c^2 = a^2 + b^2 - 2ab\cos(\alpha)}$

$\rightarrow \Delta$ miatt $U_0 = \emptyset$



$$\left(\frac{U_{bc}}{2}\right)^2 + \left(\frac{3}{2}U_a\right)^2 = U_{ab}^2 \rightarrow U_a = 61,1010 \cdot e^{j0^\circ}\,[V]$$

$$\left(\frac{U_{bc}}{2}\right)^2 + \left(\frac{1}{2}U_a\right)^2 = U_b^2 \rightarrow U_b = 50,3322 \cdot e^{-j127,37}\,[V]$$

$$U_c = 50,3322 \cdot e^{j127,37}\,[V]$$

mert a súlypont a súlyvonalakat 2:1 arányban osztja

$\boxed{U_{ab}^2 = U_a^2 + U_b^2 - 2U_aU_b\cos(\varphi_{ab})}$

$\rightarrow \varphi_{ab} = \arccos\left(\frac{U_{ab}^2 - U_a^2 - U_b^2}{2U_aU_b}\right) = 127,37^\circ$

„a"-val „a^2"-el itt is kell szorozni!

$\boxed{U_1 = \frac{1}{3}(U_a + a U_b + a^2 U_c)} = \frac{1}{3}(61,1010 + 50,3322 \cdot e^{-j7,37} + 50,3322 \cdot e^{-j7,37}) =$

komplexen számoljuk!

$= 53,64 - j12,9 = 55,17 \cdot e^{-j13,5^\circ} \rightarrow U_1 = 55,17\,V$

$U_2 = \ldots = 7,46\,V = 13,9\,\%_{[U_1]}$

(45) Alapharmonikus mérés

AD bitszám = 12
AD_{in} = +/- 10V
mintaszám = N = 64

U_{pr1} = 20 kV
U_{pr2} = 100 V
U_{sz1} = 250 V
U_{sz2} = 5 V

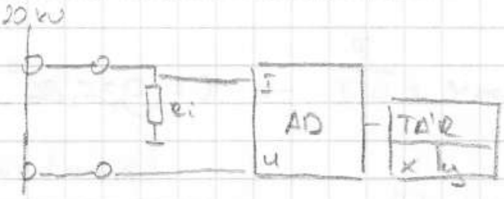
I_{pr1} = 300 A
I_{pr2} = 1 A
I_{sz1} = 1 A
I_{sz2} = 0,01 A

U_{rms} = ?
I_{rms} = ?
P = ?
Q = ?
$\cos\varphi$ = ?

$R_i = 300\,\Omega$ (AD ezen méri az áramot)

U_x = 6.000.000 h
U_y = 8.000.000 h
I_x = 6.000.000 h
I_y = 4.000.000 h

max sin = 4.000 h
(szinusz a tárban ennel van felszorozva)



-> valós és képzetes rész

$$\boxed{\text{Lépték}_I = \frac{AD_{in}}{2^{n-1}} \cdot \frac{I_{pr1}}{I_{pr2}} \cdot \frac{I_{s1}}{I_{s2}} \cdot \frac{1}{R_i}} =$$

-> AD-tól a tényleges érték felé haladva

$$= \frac{10}{2^{11}} \cdot \frac{300}{1} \cdot \frac{1}{0{,}01} \cdot \frac{1}{300} = 0{,}4883 \left[\frac{A}{LSB}\right]$$

$$\text{Lépték}_U = \frac{10}{2^{11}} \cdot \frac{200}{1} \cdot \frac{50}{1} = 48{,}8281 \left[\frac{V}{LSB}\right]$$

$$\left.\boxed{\begin{array}{l} U = \frac{1}{N}\sum_0^{N-1} U(n)\cos\left(n\frac{2\pi}{N}\right) - j\frac{1}{N}\sum_0^{N-1} U(n)\sin\left(n\frac{2\pi}{N}\right) \\ U = U_x + jU_y \end{array}}\right\} \quad \boxed{\begin{array}{l} U_{x\,tár} = N \cdot U_x \cdot \text{maxsin} \cdot \frac{1}{2} \\ U_{y\,tár} = N \cdot U_y \cdot \text{maxsin} \cdot \frac{1}{2} \end{array}}$$

$$\rightarrow U_x = \frac{2 \cdot U_{x\,tár}}{N \cdot \text{maxsin}} \cdot \text{Lépték} = \frac{2 \cdot 6 \cdot 10^6}{64 \cdot 4 \cdot 10^3} \cdot 48{,}8281 = 9.374{,}9952 \text{ V}$$

$U_y = \ldots = 12.500$ V

$\left.\begin{array}{l} I_x = 93{,}75 \text{ A} \\ I_y = 62{,}5 \text{ A} \end{array}\right\} 112{,}67 \cdot e^{j33{,}69°}$

φ_i -> 0°-hoz képest!

$15{,}624 \text{ kV} \cdot e^{j53{,}13°}$ (φ_u)

ezek csúcsértékek!

$$\boxed{U_{rms} = |\hat{U}| \cdot \frac{1}{\sqrt{2}}} = \sqrt{U_x^2 + U_y^2} \cdot \frac{1}{\sqrt{2}} = 15{,}624 \text{ kV} \cdot \frac{1}{\sqrt{2}} = \underline{11{,}045 \text{ kV}}$$

$I_{rms} = \ldots = \underline{79{,}67 \text{ A}}$

$$\boxed{S = U \cdot I \cdot e^{j(\varphi_u - \varphi_i)}} = 879{,}95 \cdot e^{-j19{,}44°} \text{ kVA}$$

-> negatív mert induktív (áram késik fesz.-hez képest)

$\varphi \rightarrow \cos\varphi = \underline{0{,}9429}$

$$\boxed{P = S \cdot \cos\varphi} = 879{,}95 \cdot \cos(-19{,}44°) = \underline{830{,}1 \text{ kW}}$$

$$\boxed{Q = S \cdot \sin\varphi} = 879{,}95 \cdot \sin(-19{,}44°) = 293 \text{ kVar}$$

46. Digit Butterworth II.

$f_1 = 350\,Hz \quad A_1 = -30\,dB$
$f_m = 1600\,Hz$

max. lapos: $\boxed{|A(\Omega)|^2 = \frac{A_0^2}{1+\ell^{2n}}}$

$A_1 = -30\,dB = 0{,}0316$

$$\Omega_1 = \sqrt[1]{\left|\frac{1}{A_1^2}\right| - 1} = 5{,}6240$$

$$\boxed{\Omega_1 = \frac{f_1}{f_0}} \to f_0 = 62{,}2329\,Hz$$

$$\boxed{\Omega_m = \frac{f_m}{f_0}} = 25{,}7099 \qquad \boxed{\ell = ctg\frac{\pi}{\Omega_m}} = 8{,}1429$$

$$\boxed{A(p) = \frac{1}{1+a_1 p + b_1 p^2}}$$

$a_1 = 1{,}4142$
$b_1 = 1$
táblázatból

$\to$ $d_0 = 1$, $d_1 = 0$, $d_2 = 0$; $c_0 = 1$, $c_1 = 1{,}4142$, $c_2 = 1$ $\to$ $D_0 = 0{,}0127$, $D_1 = 0{,}0254$, $D_2 = 0{,}0127$

$C_0 = 0{,}7041$
$C_1 = -1{,}7041$
$C_2 = 1$

47. Digit szűrő I. Minden Áteresztő

$50\,Hz \to \varphi = 60°$
$f_m = 1600\,Hz$

$$\boxed{A(p) = \frac{1-p}{1+p}}$$

$$\frac{1-j\Omega_1}{1+j\Omega_1} = 1\cdot e^{j60} = 0{,}5 + j\,0{,}8660$$

$$1 - j\Omega_1 = 0{,}5 + j0{,}5\Omega_1 - j\,0{,}8660 - 0{,}8660\Omega_1$$

$$\Omega_1(-j1{,}5 + 0{,}8660) = -0{,}5 + j\,0{,}8660$$

$$\Omega_1 = \frac{-0{,}5 + j\,0{,}8660}{0{,}8660 - j1{,}5} = \frac{0{,}99998\cdot e^{j120}}{1{,}7320\cdot e^{-j60}} = 0{,}5774\cdot e^{j180°}$$

$$\boxed{\Omega_1 = \frac{f_1}{f_0}} \to f_0 = 86{,}5951\,Hz$$

$$\boxed{\Omega_m = \frac{f_m}{f_0}} = 18{,}4768$$

$$\boxed{\ell = ctg\frac{\pi}{\Omega_m}} = 5{,}8246$$

$d_0 = 1$, $d_1 = -1$; $c_0 = 1$, $c_1 = 1$ $\to$ D_0, D_1; C_0, C_1

(48) Digit sávzáró

$f_0 = 50\,Hz$
$f_1 = 150\,Hz \qquad A = 0,99$
$f_m = 6400\,Hz$

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

$\boxed{\Omega_1 = \frac{f_1}{f_0}} = 3 \rightarrow 0,99 = \frac{1-9}{\left|1+j\frac{1}{Q}3-9\right|} = \frac{-8}{\sqrt{8^2+\frac{9}{Q^2}}}$

$$\frac{9}{\left(\frac{-8}{0,99}\right)^2-8^2} = Q^2$$

$$Q = 2,6317$$

↓

$$A(p) = \frac{1+p^2}{1+0,3799p+p^2}$$

↓

$d_0 = 1 \qquad c_0 = 1$
$d_1 = 0 \qquad c_1 = 0,3799$
$d_2 = 1 \qquad c_2 = 1$

↓

$D_0 \quad C_0$
$D_1 \quad C_1$
$D_2 \quad C_2$

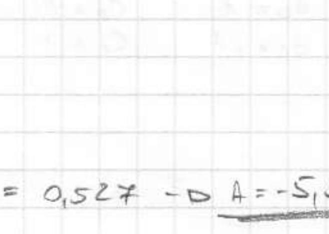
(49) Sávszűrő

$8 \cdot f_0 \rightarrow -50\,dB$
$0,98 f_0 \rightarrow ?$

$\Omega_1 = 8$
$\Omega_2 = 0,98$
$-50\,dB =$

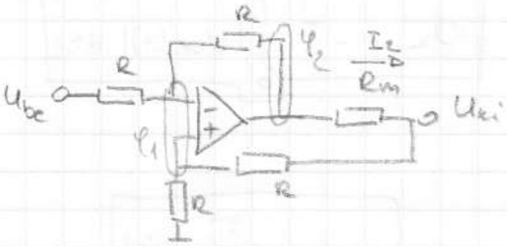
$\boxed{0,003 = \frac{j\frac{1}{Q}8}{\underbrace{1+j\frac{1}{Q}8-64}_{}}} \rightarrow Q = 40,18$

$$\frac{j\frac{8}{Q}}{-63}$$



$$\left|\frac{j\,0,025\cdot 0,98}{1+j\,0,025\cdot 0,98-0,98^2}\right| = \left|\frac{j\,0,0245}{-0,0396+j\,0,0245}\right| = \frac{0,0245}{\left|0,0465\cdot e^{j148°}\right|} = 0,527 \rightarrow \underline{A = -5,56\,dB}$$

(50) ME



$R_m \gg R$

$$\varphi_1 = \frac{U_{ki}}{2}$$

$$\varphi_1 = \frac{U_{be}}{2} + \frac{\varphi_2}{2}$$

$$\varphi_2 = U_{ki} + I_2 \cdot R_m$$

$$\frac{U_{ki}}{2} = \frac{U_{be}}{2} + \frac{\varphi_2}{2}$$

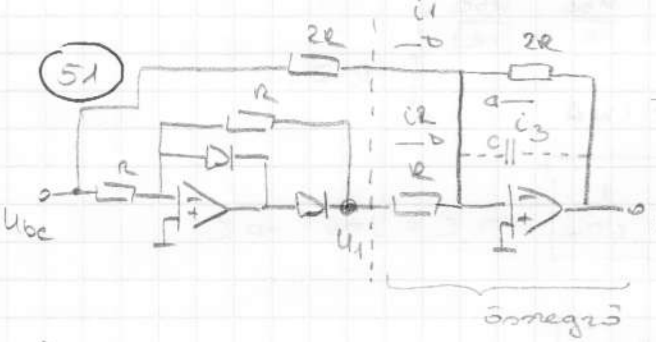
$$\underbrace{\cancel{\frac{U_{ki}}{2}} = \frac{U_{be}}{2} + \cancel{\frac{U_{ki}}{2}} + \frac{I_2 \cdot R_m}{2}}$$

$$U_{be} = -I_2 \cdot R_m$$

$$I_2 = -\frac{U_{be}}{R_m}$$

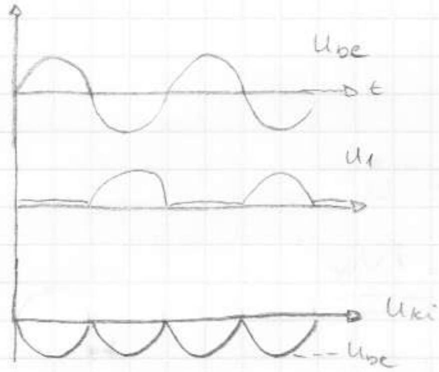
Fesz. vezérelt áramgenerátor

(51) Abszolút érték képző áramkör



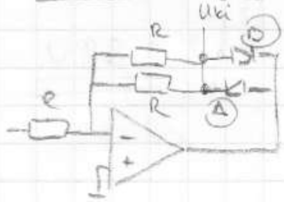
$$\boxed{U_{ki} = \underbrace{-U_{be}}_{\text{ha } U_1=0} + \underbrace{(-)2U_1}_{\text{ha } U_{be}=0} = -U_{be} - 2U_1}$$

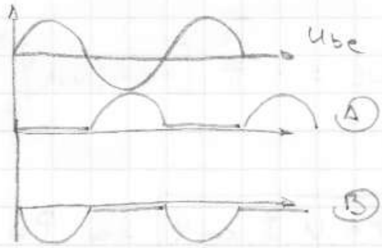
$$U_{ki} = \underbrace{-(U_{be} + 2U_1)}_{-|U_{be}|}$$



→ ideális egyenirányító

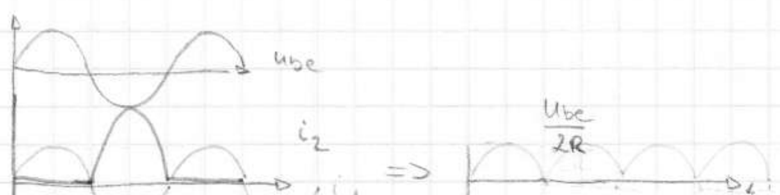
Dióda iránya





Összegző: szigorúan összegzi i_1, i_2, i_3-at.

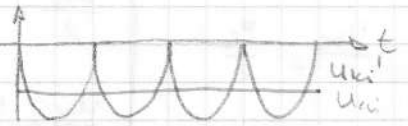
$$\boxed{i_1 = \frac{U_{be}}{2R} \qquad i_2 = \begin{cases} \dfrac{-U_{be}}{R} & \text{ha } U_{be} < 0 \\ 0 & \text{ha } U_{be} > 0 \end{cases}}$$



Kondi beiktatásával:

→ U_{ki} időben átlagolódik

$$\boxed{U_{ki}' = -\frac{1}{T}\int_0^T |U_{be}(t)|\, dt}$$



szinuszos jelre: $\boxed{U_{eff} = \frac{\pi}{2\cdot\sqrt{2}}|\bar{U}|}$

háromszög jelre: $\boxed{U_{eff} = \frac{2}{\sqrt{3}}|\bar{U}|}$

Méretezzük a kapcsolást!

$f_T = 10\ Hz \quad |U_{be}| < 10V$

$|I_{be}| < 1mA$

$$\left.\begin{aligned} I_{be} &= \frac{U_{be}}{R} + \frac{U_{be}}{(2R)} \\ I_{be} &< 1mA \end{aligned}\right\} R \geq \ldots$$

$$\boxed{(2R)\cdot C = \frac{1}{2\pi f_T}} \rightarrow C = \frac{1}{4\pi R} \rightarrow C$$

Mi lesz U_{ki}, ha → U_{be} jel 1 Vrms?

→ U_{be} 1 Vrms?

→ $U_{ki} = -\frac{1}{T}\int_0^T |U_{be}(t)|\,dt$ → $U_{eff} = \hat{U}$

$\underline{\underline{U_{ki} = 1\ V_{DC}}}$

$\hat{U} = \sqrt{2}\ U_{eff}$

$$U_{ki} = -\frac{1}{\pi}\int_0^\pi \sqrt{2}\sin(\omega t)\, d\omega t = -\frac{\sqrt{2}}{\pi}\left[-\cos(\omega t)\right]_0^\pi = -\frac{\sqrt{2}}{\pi}\cdot 2 \approx \underline{\underline{0{,}9\ V}}$$

(52) $P_{mérés}$

$U = 10.000\ V$ → Léptékú

$I = 230\ A$ → Léptéki

L_u

L_i

$\cos\varphi = 0{,}9$

$AD_{in} = 10V$

$n = 10$

$N = 64$

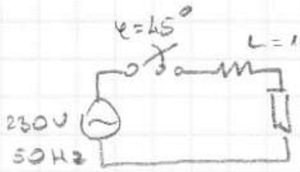
$P_{tén} = ?$

$\boxed{P = U\cdot I\cdot \cos\varphi} \rightarrow P_W$

$$\boxed{P = \frac{1}{N}\sum_1^N \underbrace{U(n)\,I(n)}} \rightarrow \boxed{P_{tén} = N\cdot P_W\cdot L_u\cdot L_i}$$

$P_{tén}$

(53)



$I_{eff} = ?$

$U_{R_{max}} = ?$

$\boxed{Z = R + j\omega L} = 0{,}1 + j10\pi\ \Omega$

$\boxed{\hat{I}_\infty = \frac{\hat{U}}{|Z|}} = 10{,}353\ A$

$\boxed{\hat{I}_{tranz} = \hat{I}_\infty (1 + \cos 45°)} = 10{,}35 + 7{,}32 = 17{,}67\ A$ csúcs $\rightarrow$ mert tranziens lecsengése >> 50 Hz 1 periódusa

$\boxed{U_{R_{max}} = \hat{I}_{tranz} \cdot R} = 1{,}767\ V$ csúcs

$U_{R_{max}} = 1{,}767 V$

$\tau = \frac{L}{R} = 1 sec$

$\boxed{I_{eff} = \sqrt{\underbrace{I_{\infty_{eff}}^2}_{AC} + \underbrace{I_{tranz_{eff}}^2}_{DC}}} = \sqrt{\left(10{,}353 \cdot \frac{1}{\sqrt{2}}\right)^2 + 7{,}32^2} = 10{,}35\ A_{eff}$