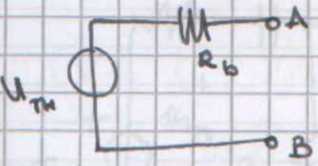
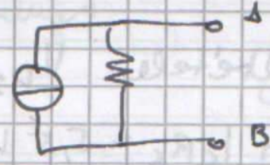
Januári hónap dec 29

DC Norton, Thévenin: "fekete doboz", egyenérték

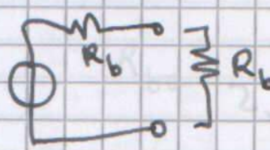
Thévenin Norton





Teljesítmény: $P = U \cdot I$

Üresjárás: nincs semmi az AB kapocspáron

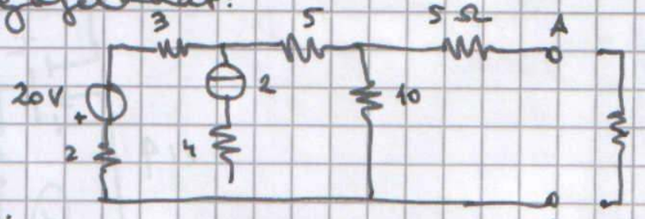


← max teljesítmény

Általánosítás:

$$R_b = \frac{U_{Th}}{I_N}$$

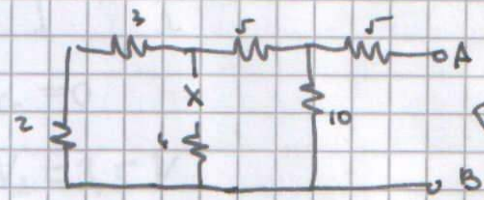
Ujjgyakorlat:



⇐ R_e

- Thévenin:

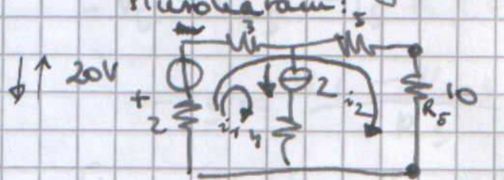
1.) Eredő ellenállás: dezaktiváljuk ~~...~~ ($\phi \to |$; $\ominus \to \times$)



⇐ $R_e = 5 + 10 \| (2+3+5) = \boxed{10\ \Omega = R_b}$

2.) Pot. különbség AB között: (U_{oc})

Hurokáram:



Egy áramforrásos egy hurok

$i_1 = 2A$

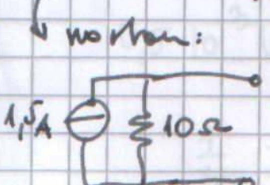
$20 + 3(i_1 + i_2) + 5 i_2 + 10 i_2 + 2(i_1 + i_2)$

$i_2 = 1{,}5A$

$U_{Th} = U_{R_5} = R \cdot I = 10 \cdot 1{,}5 = \underline{15\ V}$

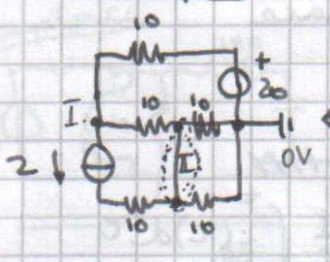
$$I_N = \frac{U_{Th}}{R_e} = 1{,}5A$$

Norton:



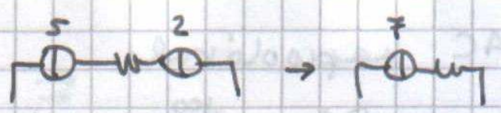
Teljesítmény disszipál: $P = U_{Th} I_N =$

Csomóponti:



← feszforrás mellett → jó

be ⊖
ki ⊕



önmagába, ha
nem áram
meg ha feszforrás
plusos fele van arra

I: $\frac{V_I - V_{II}}{10} + 2A + \frac{V_I - 20 - 0}{10} =$

II: $\frac{V_{II} - 0}{10} + \frac{V_{II} - 0}{10} - 2A + \frac{V_{II} - V_I}{10} = 0$

AC

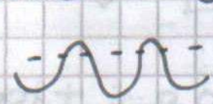
Másik tartomány (cél frekvencia)

$u(t) = U\sqrt{2}\cos(\omega t + \varphi)$

↓ Re ↓ frekv ↓ Im

$Re \underset{szög}{\angle} Im$ (polár)

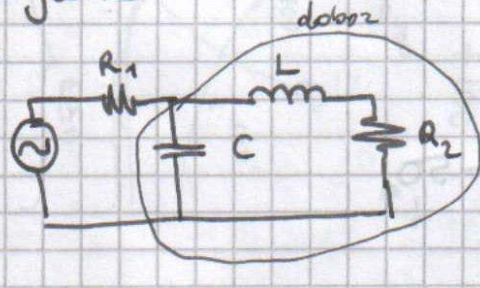
feszmérővel: effektív érték



• $\sqrt{2}$: amplitúdó
ωt: frekvencia
φ: eltolás 0-hoz képest

$Z_R = R$
$Z_C = 1/j\omega C$
$Z_L = j\omega L$

Állandósult:



$R_1 = 5\,\Omega$ $Z_{R1}: 5$
$R_2 = 10\,\Omega$ $Z_{R2}: 10$
$C = 10\,\mu F$ $Z_C: 1/(10^5 \cdot 10^{-5} j) = 1/j$
$L = 10\,mH$ $Z_L: 10^{-2} \cdot 10^5 j = 1000j$

$u(t) = 20\sqrt{2}\cos(10^5 t + 90°)$
↓
$20\angle 90$

$u_C = ?$

Feszosztó
$U_C = u(t) \cdot \frac{Z_{doboz}}{Z_{R_1} + Z_{doboz}}$

j -1

$Z_{doboz} = Z_C \| (Z_L + Z_{R2}) =$

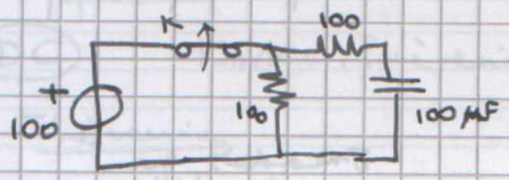
$= \frac{1/j\,(10^3 j + 10)}{-j + 10^3 j + 10} \cong \frac{10^3 - 10j}{10^3 j + 10} =$

↖ elhanyagoljuk

$\frac{(10^3 - 10j)(10^3 j - 10)}{10^2 + (10^3)^2} = \frac{10^6 j - 10^4 + 10^4 j + 100j}{100 + 100000}$

... stb

AC kapcsolóval: differenciál / Laplace

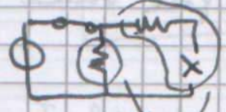


$U_L = L\cdot\frac{di}{dt}$

$i_C = C\cdot\frac{du}{dt}$

$u_C = V_C(0) + \frac{1}{C}\int_0^t i(\tau)\,d\tau$

K Bekapcsolva:



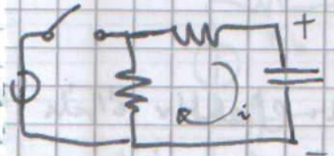
kondin fesz, de áram nem folyik

$i_C(0-) = 0\,A$

$V_C(0) = 100\,V$

ugyanaz a fesz

K kinyitva:



$i_C(t) = ?$

⊕, ment így vettük fel a körüljárást

$100\,\Omega\cdot i + 100\,\Omega\cdot i + V_C(0) + \frac{1}{C}\int_0^t i(\tau)\,d\tau = 0$ /deriválás

$200\frac{di}{dt} + \frac{1}{C}i = 0$

$i = Ae^{st}$

$\frac{di}{dt} = sAe^{st}$

$200\,sAe^{st} + \frac{1}{C}Ae^{st} = 0$

$Ae^{st}\left(200s + \frac{1}{C}\right) = 0$

0^{*}

$s = -\frac{1}{C\cdot 200} = -50$

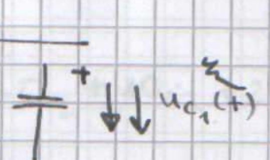
$i_C(0) = \frac{100\,V}{200\,\Omega} = 0{,}5\,A$

$i = A\,e^{-50t}$

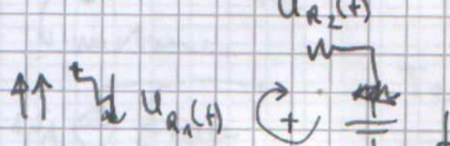
$i(0) = Ae^{-0} = A = 0{,}5$

$i = 0{,}5\,e^{-50t}$

$U_C(t) = U_{C0} + \underbrace{\frac{1}{C}\int_0^t i_C(\tau)\,d\tau}_{U_{C_1}(t)}$



mérőirány megegyezik az áram irányával

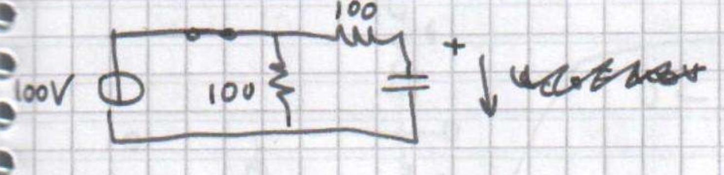


$u_{C_0} + \frac{1}{C}\int_0^t i_C(\tau)\,d\tau$

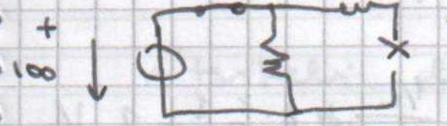
$U_{R_1}(t) + U_{R_2}(t) + U_C(0) + U_{C_1}(t) = 0$

Mále fémi hozni

Laplace

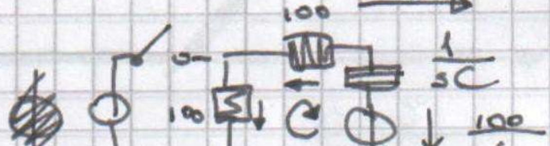


1) $t<0$: állandósult DC (AC)



$U_{C0} = 100V$

2) $t>0$: Laplace az áramkört



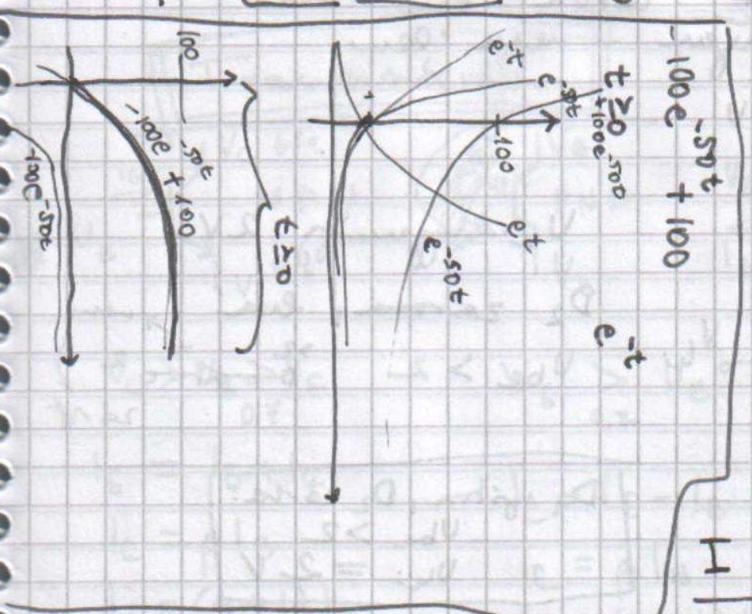
$$-\frac{100}{s} + \frac{1 I}{sC} + 200 I$$

$$\left(200+\frac{1}{sC}\right) I = \frac{100}{s}$$

$$I = \frac{100}{s}\cdot\frac{1}{200+1/sC} = \frac{100}{200s+\frac{1}{C}}$$

$$= \frac{100}{200s+\frac{1}{100\cdot10^{-6}}} = \frac{100}{200s+10^4}$$

$$\frac{100}{200}\cdot\frac{1}{s+\frac{10000}{200}}$$



$$I = \frac{1}{2}e^{-50t}\ A$$

$$U_C = I\cdot Z_C(s) = \frac{100}{200s+10^4}\cdot\frac{1}{sC} = \frac{100}{200s+10^4}\cdot\frac{1}{s\cdot10^{-4}} =$$

$$= \frac{10^6}{(200s+10^4)s} \rightarrow \text{parciális törtek}$$

$$\frac{A}{200s+10^4} + \frac{B}{s} = \frac{As+(200s+10^4)B}{(200s+10^4)s}$$

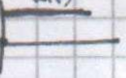
$$10^6 = As + 200sB + 10^4 B = (A+200B)s + 10^4 B = 10^6 + 0s$$

$A+200B=0$ $\qquad B=10^2$

$10^4 B = 10^6$ $\qquad A+200\cdot10^2 = A+20000=0$

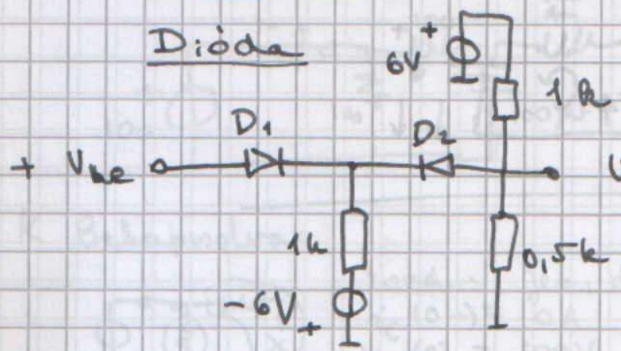
$A=-20000$

$$U_C(s) = \frac{2\cdot10^4}{200s+10^4} + \frac{10^2}{s} \xrightarrow{\mathcal{L}^{-1}} U_C(t) = -10^2 e^{-50t} + 100u(t)$$



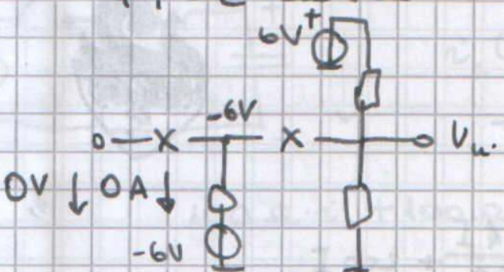
Nonlin

Dióda



$V_{be} \in [-3;3]$ Ideális diódák:

- D_1, D_2 zárva

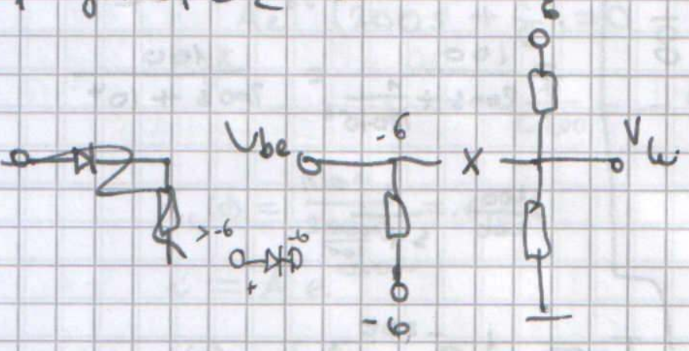


$$V_{ki} = 6 \cdot \frac{0,5}{1+0,5} = 6 \cdot \frac{1/2}{3/2} = 6 \cdot \frac{2}{3}\frac{1}{2} = 2\ V$$

$$V_{ki} = +2\ V$$

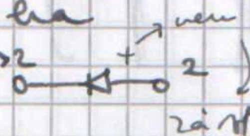
így D2 nem lehet zárva: ez nem feltételezés, ilyen nem lesz

- D_1 nyitva, D_2 zárva



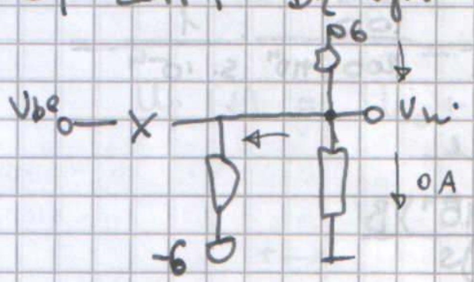
V_{ki}: ugyanúgy 2V

D_2 zárva, ha $V_{be} > 2$



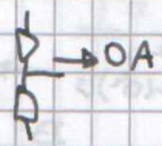
$$\boxed{\begin{array}{c} D_1 \text{ nyitva}, D_2 \text{ zárva:} \\ V_{be} > 2 \\ V_{ki} = 2\ V \end{array}}$$

- D_1 zárt, D_2 nyit

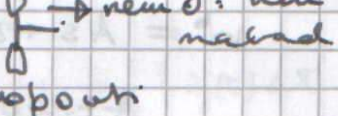


terhelt feszosztó

(-etlen:



terhelt:



itt: csomópont:

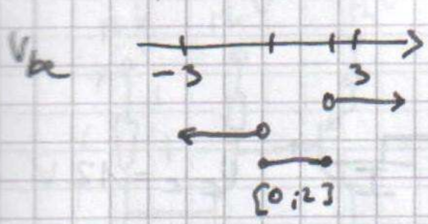
$$\frac{V_{ki}-6}{1000} + \frac{V_{ki}-0}{500} + \frac{V_{ki}-(-6)}{1000} = 0$$

$$V_{ki} - 6 + 2V_{ki} + V_{ki} + 6 = 0$$

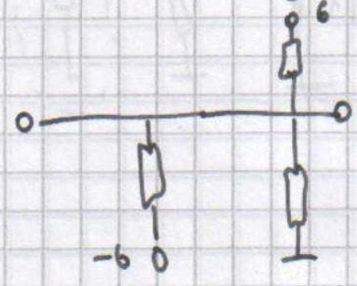
$$4V_{ki} = 0$$

$$V_{ki} = 0$$

$$\boxed{\begin{array}{c} V_{ki} = 0\ V \\ D_1 \text{ tényleg zárva}: V_{be} < 0 \end{array}}$$



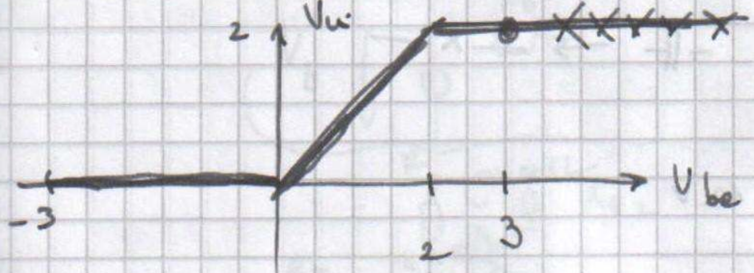
D_1, D_2 nyitva $(U_{be} \in [0;2]$



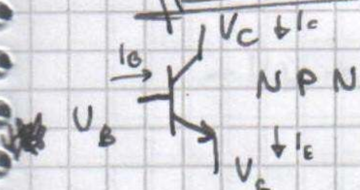
$0 < V_{be} < 2$

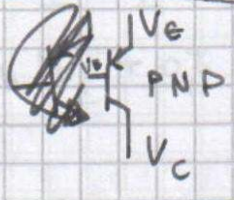
$U_{ki} = U_{be}$

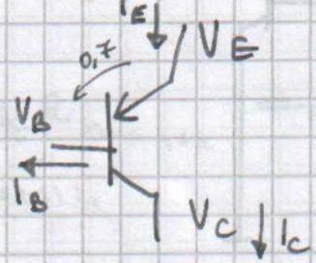
Átviteli karakterisztika



Tranzisztorok







$V_C > V_B \underset{0,7}{>} V_E$

$I_E = I_B + I_C$

$I_C = \beta I_B$

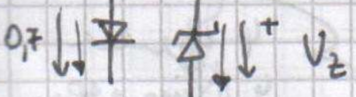
$I_E = (\beta + 1) I_B$

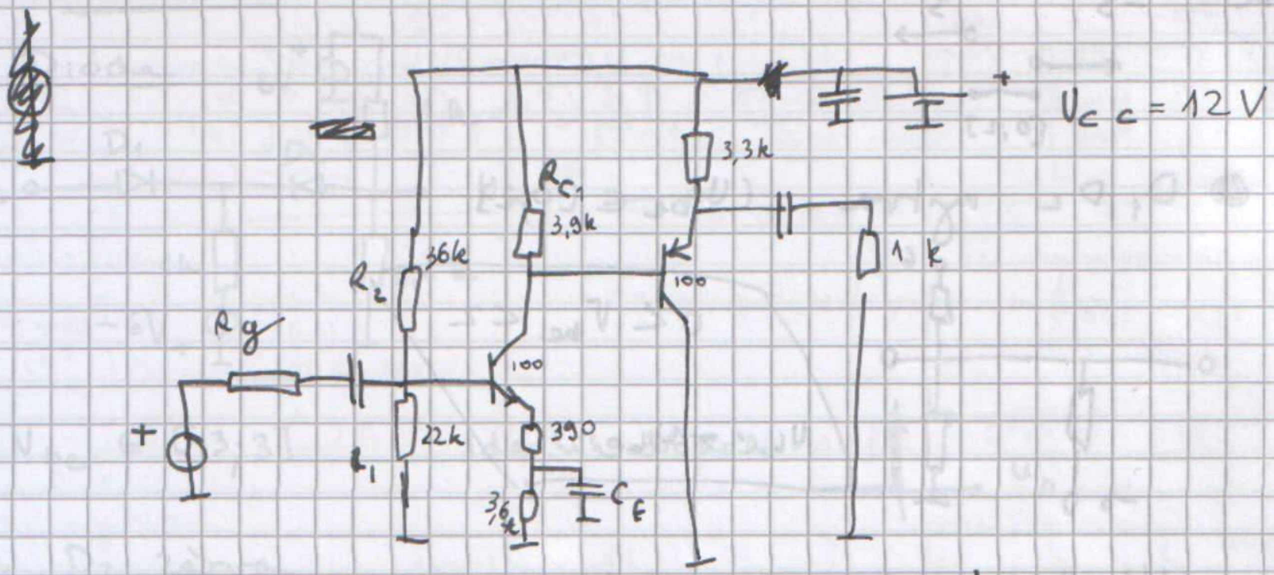
$V_E \underset{0,7}{>} V_B$

$I_C = I_E - I_B$

$I_C = \beta I_B$

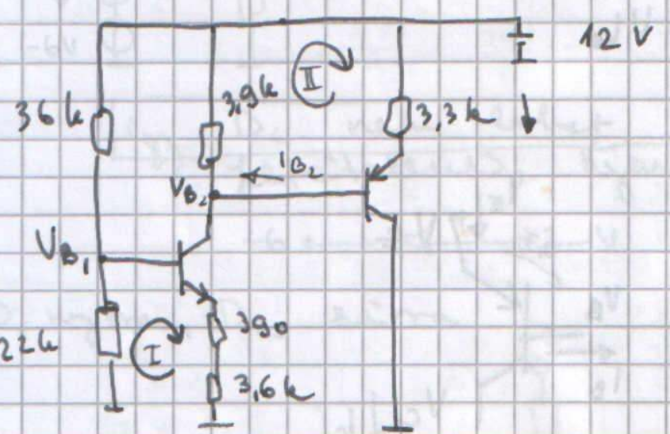
$I_E = (\beta + 1) I_B$





Munkapont számítás - mi lesz változó

állandósult DC —||— → —x—



- Csomópont a bázisokra

$$\cancel{\frac{12-V_B}{36000}}$$

$$\frac{U_{B1}-12}{36000}+\frac{U_{B1}-0}{22000}+I_B=0$$

$$\frac{U_{B_2}-12}{3900}+\underbrace{I_{C_1}}_{\beta_1 I_{B_1}}-I_{B_2}=0$$

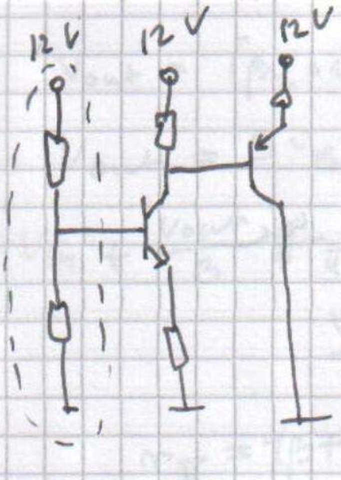
- Hurkok
BE átmenet

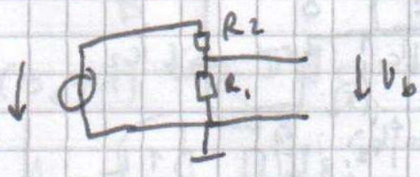
I $\quad -U_{B_1}+0{,}7+\overbrace{I_{E_1}}^{(\beta_1+1)I_{B_1}}\cdot(390+3600)=0$

II $\quad V_{B_2}-12+I_{E_2}\cdot 3{,}3\cdot 10^3+0{,}7=0$

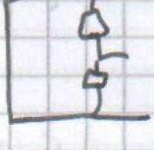
4 egyenlet
4 ismeretlen

Thévenin
terhelt feszosztó



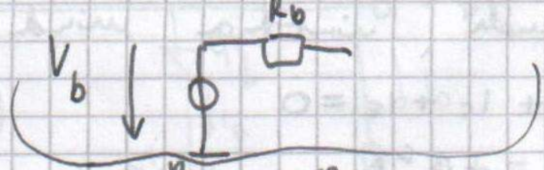


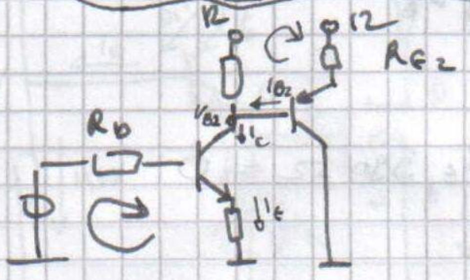
$$V_b = 12 \cdot \frac{R_1}{R_1 + R_2}$$



$$R_b = R_1 \parallel R_2$$

deaktiválás

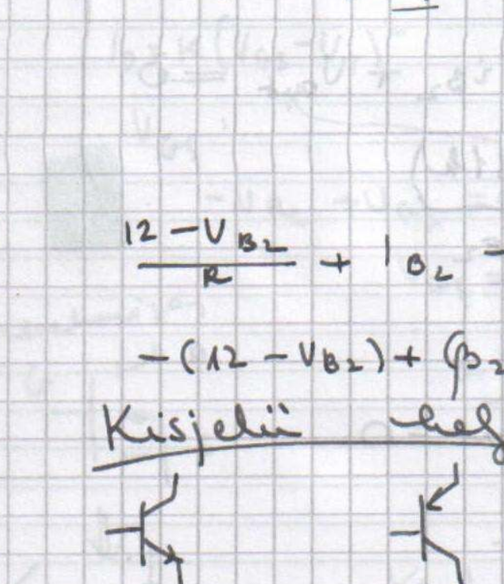


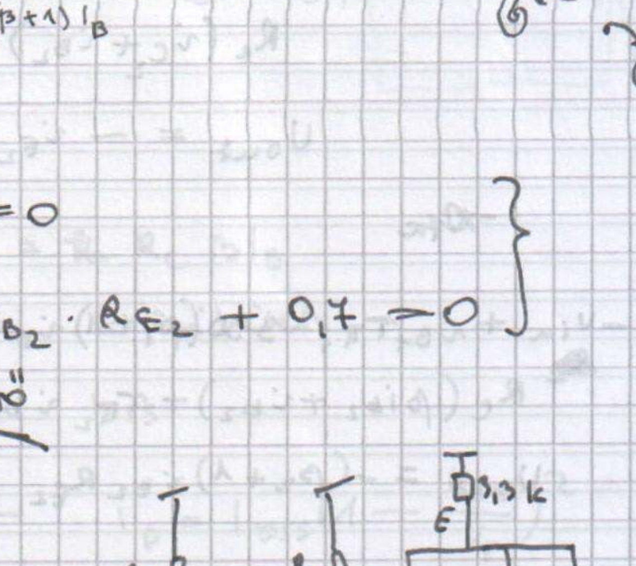


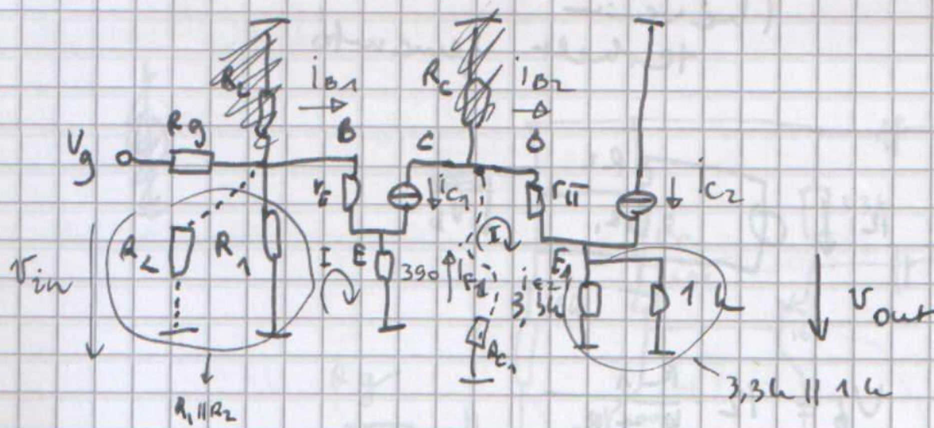
$$-V_b + R_b \underline{I_{b_1}} + 0{,}7 + \underbrace{I_E}_{(\beta+1) I_B} R_{330+3{,}6k} = 0$$

$$\left.\begin{aligned} &\frac{12 - V_{B2}}{R} + I_{B2} - I_c = 0 \\ &-(12 - V_{B2}) + (\beta_2 + 1) I_{B2} \cdot R_{E2} + 0{,}7 = 0 \end{aligned}\right\}$$

Kisjelű helyettesítő







fesz erősítés

$$A_u = \frac{V_{out}}{V_{in}}$$

tranzisztor áramok, mintha mind be

$$i_B + i_C + i_E = 0$$
$$i_C = +\beta i_B$$

I Hurok

$$-V_{in} + i_{B_1} r_{\pi_1} - i_{E_1} 390\,\Omega = 0$$

II

$$\cancel{390 i_{E_2} \quad V_{EC_1}}$$

$$R_c(i_{C_2} + i_{B_2}) + r_{\pi_2} i_{B_2} + V_{out} = 0$$

$$V_{out} = -i_{E_2} \cdot \underbrace{(3{,}3k \| 1k)}_{R_{E_2}}$$

① $-v_{in} + i_{B_1} r_{\pi_1} - 390(\beta_1 + 1) i_B = 0$

② $R_C(\beta i_{b_2} + i_{b_2}) + r_{\pi_2} i_{b_2} + V_{out} = 0$

③ $V_{out} = -(\beta_2 + 1) i_{B_2} R_{E_2}$

$$\left(-V_{in} + i_{B_1} r_\pi - 390(\beta_1 + 1) i_{B_1} - R_C(\beta i_B + i_{B_2}) - r_{\pi_2} i_{b_2} - V_{out} = 0\right)$$

$$R_C(\beta i_B + i_{B_2}) + r_{\pi_2} i_{B_2} - (\beta_2 + 1) i_{B_2} R_{E_2} = 0$$

$$R_C \beta i_B + R_C i_{B_2} + r_\pi i_{B_2} - (\beta_2 + 1) \cdot i_{b_2} R_{E_2} = 0$$

$$R_C \beta i_B = [(\beta_2 + 1) R_{E_2} - r_{\pi_2} - R_C]\, i_{B_2}$$

$$i_B = A\, i_{B_2} \Longrightarrow i_{B_2} = \frac{i_B}{A}$$

$$V_{out} = (\beta_2+1)\frac{i_B}{A}\cdot R_{e2}$$

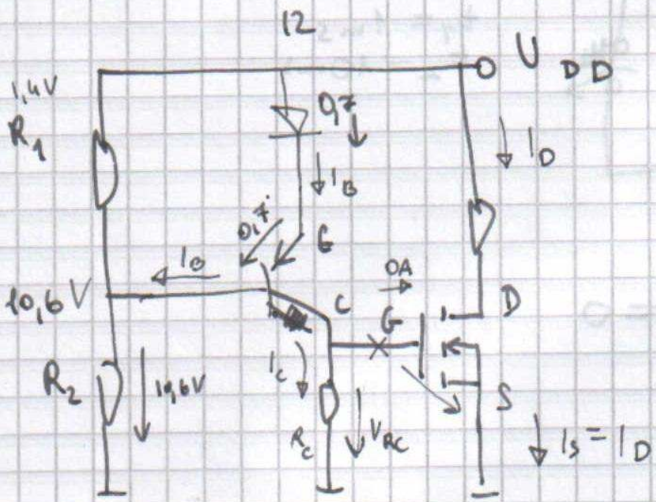
$$V_{out} = B\,i_B \to i_B = \frac{V_{out}}{B}$$

$$-V_{in} + \frac{V_{out}}{B}\,r_\pi - 390\,(\beta_1+1)\,\frac{V_{out}}{B} = 0$$

$$\frac{V_{out}}{V_{in}} = A_u$$

$$r_\pi = (\beta+1)\frac{V_T}{I_E} \qquad V_T = 25\,mV$$

munkapontból
emitter áram



$$I_{R_1} = \frac{1,4}{R_1}$$

$$I_{R_2} = \frac{10,6}{R_2}$$

$$I_{R_2} - I_{R_1} = I_B$$

$$I_E = (\beta+1)\,I_B$$

$$V_{RC} = R_C\,\beta I_B$$

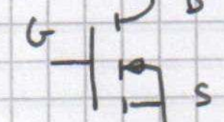
$$I_D = K(V_{GS}-V_T)^2$$

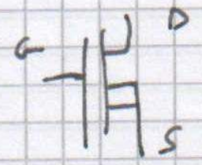
V_{GS} :

$$-V_{Rc} + U_{GS} = 0$$

$$U_{GS} = V_{RC} = R_C\,\beta I_B$$

növekményes

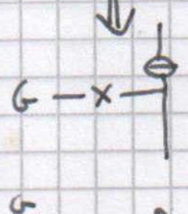


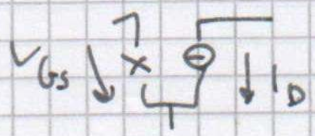


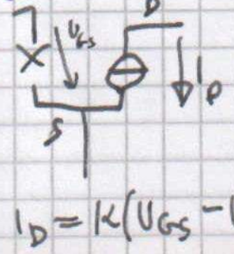
kiürítéses

I_{DSS}

$$I_D = I_{DSS}\left(1-\frac{U_{GS}}{U_P}\right)^2$$







$$I_D = K(U_{GS}-U_T)^2$$