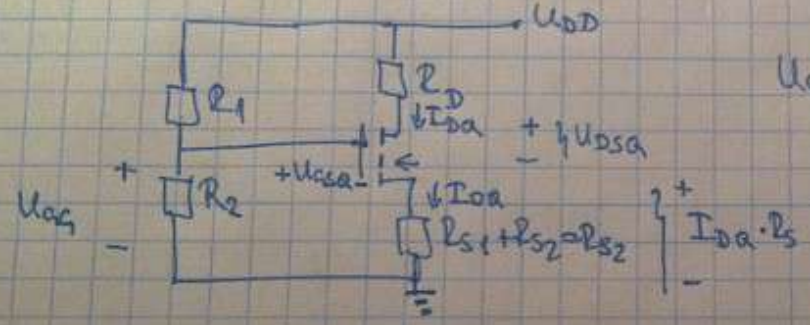
MASS 2 -> HOUSE

1. 2010/2011 2.MI. (8 bodova sklop s MOSFETOM)

$R_1 = 4\,k\Omega$
$R_2 = 1\,k\Omega$
$R_{S1} - R_{S2} = 95\,k\Omega$
$R_D = 5\,k\Omega$
$R_T = 10\,k\Omega$
$R_g = 500\,\Omega$
$U_{DD} = 12\,V$

$U_{GS\phi} = 1V$
$k = 5\,mA/V^2$
$\lambda = 9008\ V^{-1}$

3 boda a) SRT (I



$$U_{GG} = U_{DD} \cdot \frac{R_2}{R_1 + R_2} = 2{,}4\,V$$

$$U_{GSQ} = U_G - U_S = U_{GG} - I_{DQ} \cdot R_S \quad (1)$$

$$I_{DQ} = \frac{K}{2}\left(U_{GSQ} - U_{GS\phi}\right)^2 \quad (2)$$

(2) -> (1) ... $ax^2 + bx + c = \phi$ -> U_{GSQ} = 1,57 V > $U_{GS\phi} = 1V$ ✓ (nMO
0,025 V ✗

$$U_{GSQ}^2 + U_{GSQ}\left(\frac{2}{kR_S} - 2U_{GS\phi}\right) - \frac{2}{kR_S}U_{GG} + U_{GS\phi}^2 = \phi$$

$$I_{DQ} = \frac{U_{GG} - U_{GSQ}}{R_S} = \boxed{0{,}83\,mA}$$

$$U_{DSQ} = U_{DD} - I_{DQ}(R_D + R_S) = 7V$$

b) parametri tranzistora

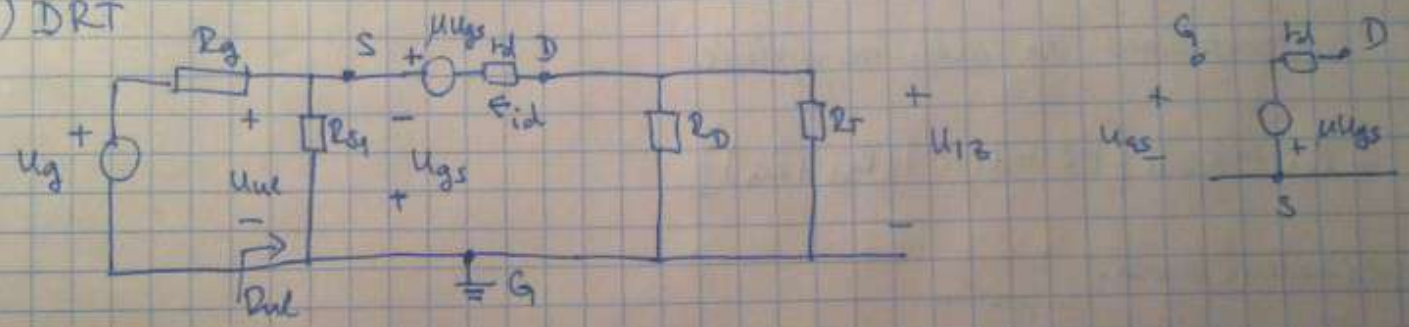
$$i_D = \frac{k}{2}(u_{GS} - u_{GSP})^2 (1 + \lambda u_{DS})$$

$$g_m = \left.\frac{2i_D}{2u_{GS}}\right|_Q = k(u_{GSQ} - u_{GSP})(1 + \lambda u_{DSQ}) = \ldots = \boxed{3\,mA/V}$$

$$r_d = \frac{1}{g_d} = \frac{1}{\left.\frac{2i_d}{2u_{DS}}\right|_Q} = \frac{1}{\frac{k}{2}(u_{GSQ} - u_{GSP})^2 \cdot \lambda} = \ldots = \frac{1}{I_{DQ} \cdot \lambda} = \boxed{150\,k\Omega}$$

$$\mu = g_m r_d = 450$$

c) DRT



(ako su sić D na $\frac{1}{2}$ onda struji izvor + rd u ||)

$$i_d \cdot (R_D \| R_T) + i_d \cdot r_d - \mu \cdot u_{gs} - u_{gs} = 0$$

$$i_d (R_D \| R_T + r_d) = (1+\mu) u_{gs} = -(1+\mu) u_{ul}$$

$$u_{gs} = -u_{ul}$$

$$i_d = \frac{-(1+\mu) u_{ul}}{R_D \| R_T + r_d} \quad (1)$$

$$u_{iz} = -i_d (R_D \| R_T) = \frac{(1+\mu) u_{ul}}{R_D \| R_T + r_d} (R_D \| R_T) \quad | : u_{ul}$$

$$\frac{u_{iz}}{u_{ul}} = A_v = \frac{(1+\mu)(R_D \| R_T)}{r_d + R_D \| R_T} = \ldots = \boxed{9{,}8}$$

(uobičajeno > 0 u zaj. G)

↳ $\sim g_m (R_D \| R_T)$

$$R_{ul}' = \frac{u'}{i'_T}, \quad u' = u_{ul}$$
$$i' = -i_d$$

$$R_{ul}' = -\frac{u_{ul}}{i_d} \Rightarrow (1) \Rightarrow \frac{R_D \| R_T + r_d}{1+\mu}$$

$$R_{ul} = R_{s1} \| R_{ul}' = R_{s1} \| \frac{R_D \| R_T + r_d}{1+\mu}$$

R_{iz}: odspojiti R_T i u_{gs}, umjesto R_T strujni izvor

$$R_{iz} = \frac{u}{i}$$

pretpostavimo da μu_{gs} ne djeluje

$$R_{iz} = R_D \| \left[r_d + (1+\mu)(R_{s1} \| R_G) \right]$$

presikavanje otpora:

otpor iz (S) $\xrightarrow{u}$ (D) se pročita $(1+\mu)\times$ veći

(D) $\rightarrow$ (S) $(1+\mu)\times$ manji $\left(\frac{1}{1+\mu}\right)$

(2.) npn silicij (8b)

p-anoda
n-katoda

$N_{DE} = 2 \cdot 10^{18}\ cm^{-3}$

$N_{AB} = 3 \cdot 10^{16}\ cm^{-3}$

$\mu_{pE} = 270\ cm^2/Vs$

$\mu_{nB} = 540\ cm^2/Vs$

$I_E = 10\ \mu A$

$w_B = 1{,}1\ \mu m = 1{,}1 \cdot 10^{-4}\ cm$

$w_E = 1{,}7\ \mu m = 1{,}7 \cdot 10^{-4}\ cm$

$S = 1\ mm^2 = 10^{-2}\ cm^2$

$U_{BE} = 0{,}55\ V$

$U_{CB} = 5\ V$

$U_T = 25\ mV$

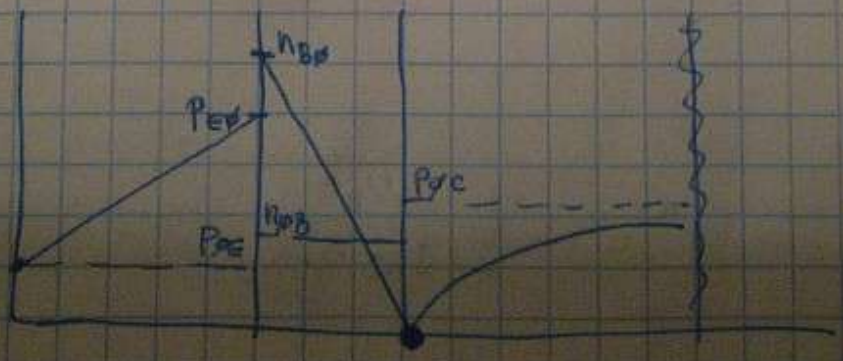
$I_{CB\phi} \approx \phi A$

$N_{DE} = n_{\phi E} \Rightarrow p_{oE} = \frac{n_i^2}{n_{\phi E}} = 1{,}05 \cdot 10^2\ cm^{-3}$

$N_{AB} = p_{\phi B} \Rightarrow n_{\phi B} = \frac{n_i^2}{p_{\phi B}} = 7{,}1 \cdot 10^3\ cm^{-3}$

$N_{DE} > N_{AB} > N_{DC}$

$p_{oE} < n_{oB} < p_{oC}$



$$p_{E0} = p_{0E} \exp\left(\frac{U_{BE}}{U_T}\right) = 3{,}76 \cdot 10^{11}\ cm^{-3}$$

$$n_{B0} = n_{0B} \exp\left(\frac{U_{BE}}{U_T}\right) = 2{,}51 \cdot 10^{13}\ cm^{-3}$$

$$I_{pE} = q \cdot S \cdot D_{pE} \cdot \frac{dp(x)}{dx} = q \cdot S \cdot \Delta p \cdot U_T \frac{p_{E0}}{w_E} = 23{,}9\,\mu A$$

$$I_{nE} = q \cdot S \cdot D_{nE} \cdot \frac{n_{B0}}{w_B} = 4{,}929\,mA$$

$$I_E = I_{nC} - I_{nC} \Rightarrow I_{nC} = I_{nE} - I_E = \boxed{4{,}919\,mA}$$

$$I_E = -(I_{nE} + I_{pE}) = \boxed{-4{,}953\,mA}$$

$$I_C = I_{nE} = \boxed{4{,}919\,mA}$$

$$I_B + I_E + I_C = 0$$

$$I_B = -I_C - I_C = \boxed{34\,\mu A}$$

$$\alpha = \frac{I_C}{-I_E} = \frac{4{,}919\,mA}{4{,}953\,mA} = 0{,}9931$$

$$\beta = \frac{I_C}{I_B} = 145$$

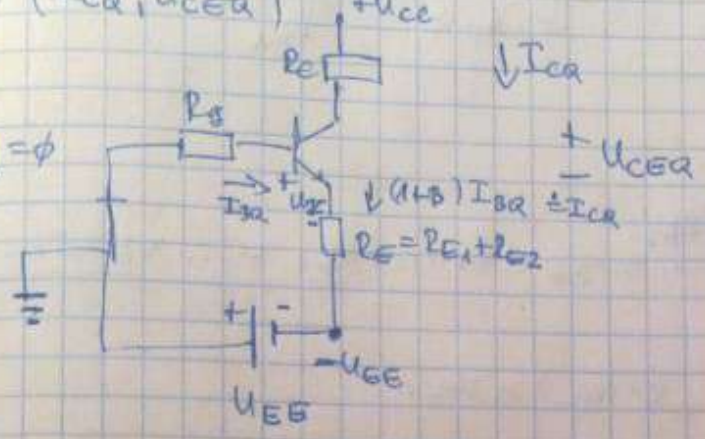
$$\beta^* = \frac{I_{nC}}{I_{nE}} = 0{,}9980$$

$$\beta^* = 1 - \frac{1}{2}\left(\frac{w_B}{L_{nB}}\right)^2$$

$$\hookrightarrow D_{nB} \cdot \tau_{nB} \qquad \Rightarrow \beta^* = 1 - \frac{1}{2}\frac{w_B^2}{D_{nB} \cdot \tau_{nB}}$$

(3.) zajednički emiter ⇒ negativno pojačanje (8b)

a) SRT (I_{CQ}, U_{CEQ})



BE-krug

$$I_{BQ} \cdot R_g + U_\gamma + (1+\beta) I_{BQ} \cdot R_E - U_{EE} = 0$$

$$I_{BQ} = \frac{U_{EE} - U_\gamma}{R_g + (1+\beta) R_E} = \frac{10 - 0{,}7}{0{,}5 + 101 \cdot 8{,}5} = 0{,}01083\ mA = \boxed{10{,}83\ \mu A}$$

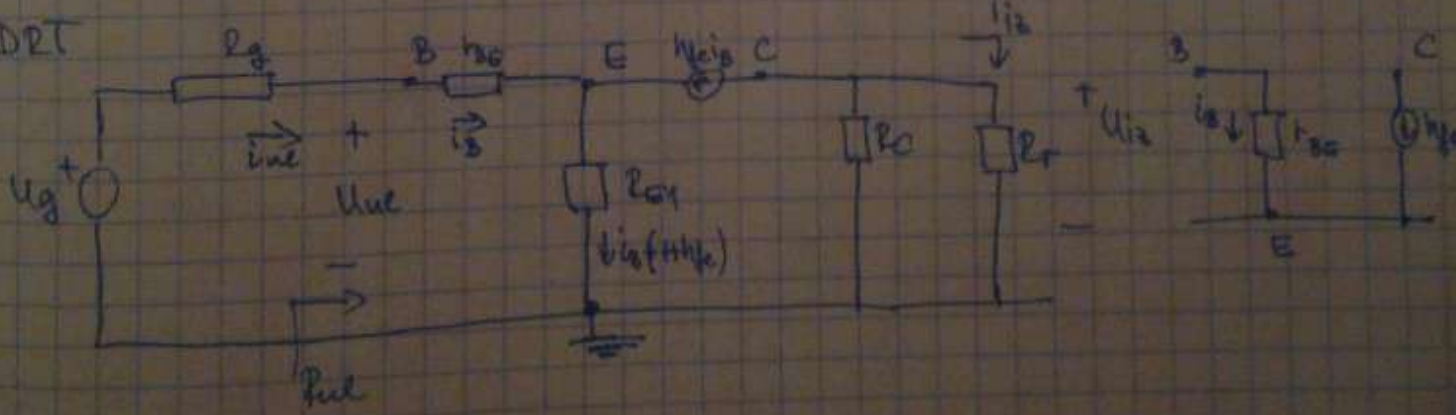
$$I_{CQ} = \beta \cdot I_{BQ} = 1{,}083\ mA$$

$$U_{CEQ} = U_{cc} - (-U_{EE}) - I_{CQ}(R_C + R_E) = 10 + 10 - 1{,}083\,(6 + 8{,}5) = \boxed{4{,}3\ V}$$

$U_{CEQ} > U_{BEQ} - U_\gamma \Rightarrow$ tranz. je u NAP-u

$$r_{be} = \frac{U_T}{I_{BQ}} = \boxed{2{,}3\ k\Omega}$$

b) DRT



$$A_V = \frac{u_{iz}}{u_{ul}} = \frac{-h_{fe} \cdot i_B \cdot R_C \| R_T}{i_B r_{BE} + (1+h_{fe}) i_B \cdot R_{E1}} = \ldots = \boxed{-4{,}55}$$

$$\hookrightarrow A_V \approx -\frac{R_C \| R_T}{R_{E1}}$$

~~$R_{ul} = u_{ul}$~~

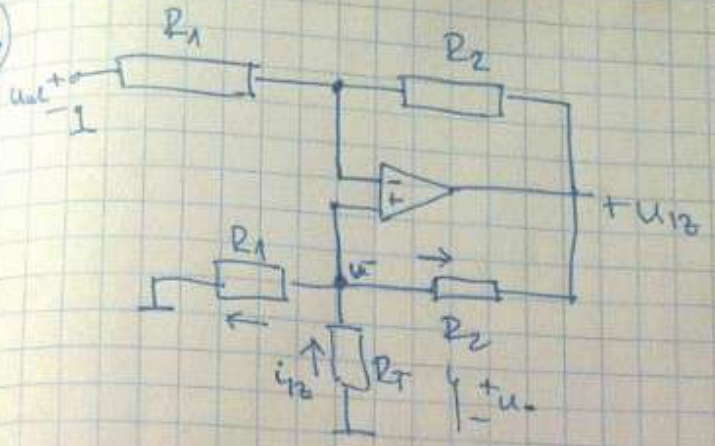
$$R_{ul} = \frac{u_{ul}}{i_{ul}} = \frac{i_B \cdot r_{BE} + (1+h_{fe}) i_B \cdot R_{E1}}{i_B} = r_{BE} + (1+h_{fe}) R_{E1} = \ldots = \boxed{52{,}8\,k\Omega}$$

otpor iz (E) u (B) se preslika $(1+h_{fe})$ x veći

(B) u (E) $(1+h_{fe})$ x manji

$$A_I = \frac{i_{iz}}{i_{ul}} = \frac{\frac{u_{iz}}{R_T}}{\frac{u_{ul}}{R_{ul}}} = \frac{u_{iz}}{u_{ul}} \cdot \frac{R_{ul}}{R_T} = A_V \cdot \frac{R_{ul}}{R_T} = -4{,}55 \cdot \frac{52{,}8}{4} = \boxed{-60}$$

(4.0)



$u_{ul} = 0{,}5 \sin \omega t \; V$

$R_1 = 1\,k\Omega$

$R_2 = 2\,k\Omega$

$R_T = 3\,k\Omega$

$i_{iz} = ?\quad f(u_{ul})$ *

(1) $\dfrac{u_{ul} - u^-}{R_1} = \dfrac{u^- - u_{iz}}{R_2}$

(2) $u^- = -i_{iz} \cdot R_T$

(3) $i_{iz} = \dfrac{u^-}{R_1} + \dfrac{u^- - u_{iz}}{R_2}$

(2) → (3) $i_{iz} = -i_{iz} \cdot \dfrac{R_T}{R_1} - i_{iz} \dfrac{R_T}{R_2} - \dfrac{u_{iz}}{R_2}$

$i_{iz}\left(1 + \dfrac{R_T}{R_2} + \dfrac{R_T}{R_1}\right) = \dfrac{u_{iz}}{R_2}$ (4)

(2) → (1) $\dfrac{u_{ul}}{R_1} + i_{iz} \cdot \dfrac{R_T}{R_1} = -i_{iz} \cdot \dfrac{R_T}{R_2} - \dfrac{u_{iz}}{R_2}$ (5)

(4) → (5) $= \dfrac{u_{ul}}{R_1} + i_{iz}\left(\dfrac{R_T}{R_1} + \dfrac{R_T}{R_2}\right) = i_{iz}\left(1 + \dfrac{R_T}{R_1} + \dfrac{R_T}{R_2}\right)$

$i_{iz} = \dfrac{u_{ul}}{R_1} = \dfrac{0{,}5}{1k} = \boxed{0{,}5\ mA}$