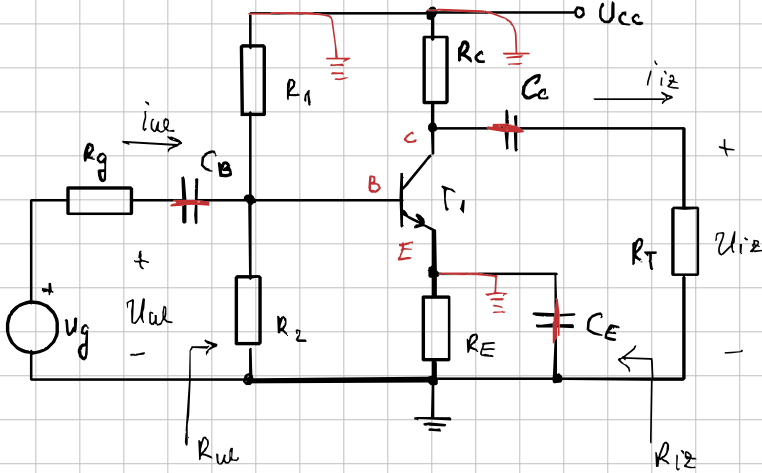


## 8.2. Pojačalo u spoju zajedničkog emitera

SZE

obnavljat pojačalo  
zajedničkog ulaza

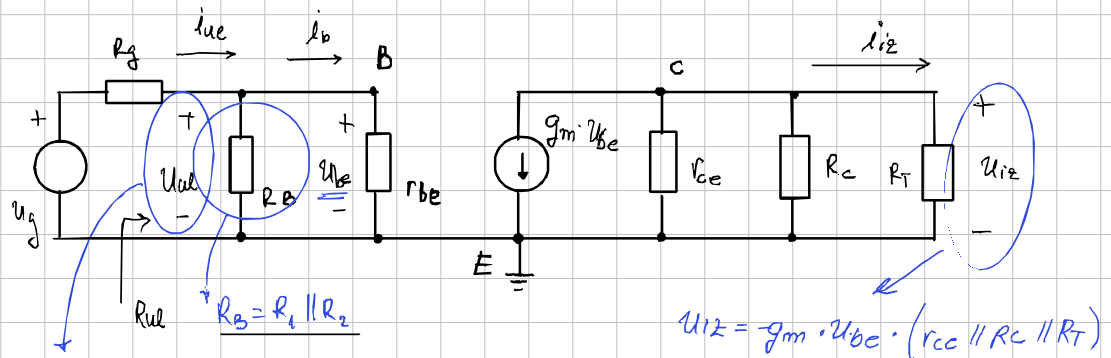


→ načelnijesma shema → dinamika

• E → masa

→ DC izvori :  $\text{---}$

→ k. a. kondenzatore



$$U_{ul} = U_{be}$$

$$U_{iz} = g_m \cdot U_{be} \cdot (r_{ce} \parallel R_c \parallel R_T)$$

$$A_v = \frac{U_{iz}}{U_{ul}} = -g_m \cdot (r_{ce} \parallel R_c \parallel R_T) \rightarrow A_v \approx -g_m \cdot (R_c \parallel R_T)$$

$$\text{uz ovih izvor } h_{fe} i_b \text{ i uz } g_m = \frac{h_{fe}}{r_{be}} \rightarrow A_v = \frac{U_{iz}}{U_{ul}} \approx -h_{fe} \frac{R_c \parallel R_T}{r_{be}}$$

Izvor strujnih pojačava:

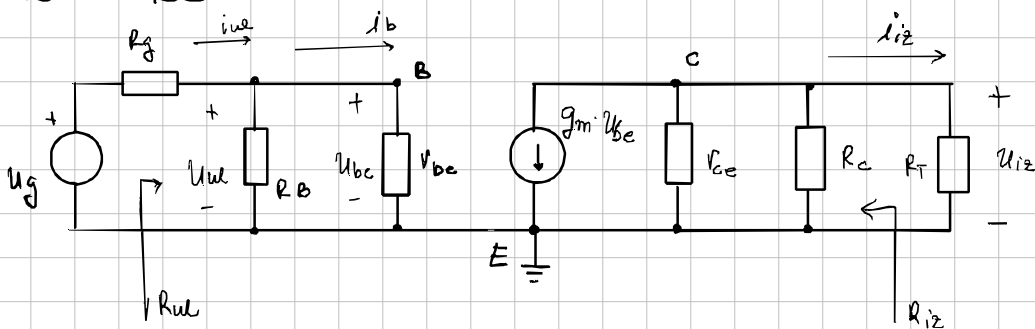
$$i_{iz} = -g_m \cdot U_{be} \cdot \frac{r_{ce} \parallel R_c}{r_{ce} \parallel R_c + R_T}$$

$$U_{be} = (R_B \parallel r_{be}) \cdot i_{ul}$$

$$\Rightarrow A_I = \frac{i_{iz}}{i_{ul}} = -g_m \cdot \frac{r_{ce} \parallel R_c}{r_{ce} \parallel R_c + R_T} (R_B \parallel r_{be}) \rightarrow A_I \approx -g_m \frac{R}{R_c + R_T} (R_B \parallel r_{be})$$

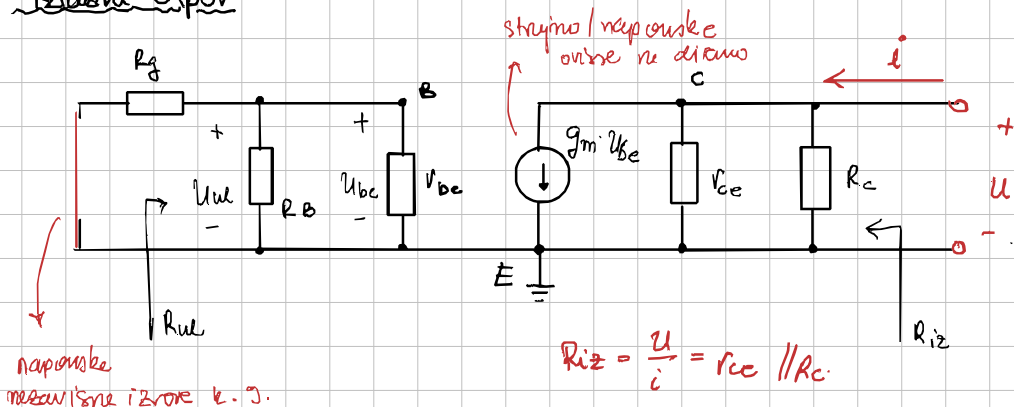
uz oznaci izvor  $h_{fe} \cdot i_b$  i uz  $g_m = \frac{h_{fe}}{r_{be}} \rightarrow A_I \approx -h_{fe} \cdot \frac{R_c}{R_c + R_T} \cdot \frac{R_B}{R_B + r_{be}}$

Ulazni otpor



$$R_{ul} = \frac{U_{ul}}{i_{ul}} = (R_B \parallel r_{be}) \rightarrow \text{strujno pojačanje: } A_I = \frac{i_{iz}}{i_{ul}} = -\frac{\frac{U_{iz}}{R_T}}{\frac{U_{ul}}{R_T}} = A_V \cdot \frac{R_{ul}}{R_T}$$

Izlazni otpor



$$R_{iz} = \frac{U}{i} = r_{ce} \parallel R_c$$

Primer 8.4.)

nnp SZE

$$U_{CC} = 15V$$

$$R_E = 1k\Omega$$

$$R_g = 500\Omega$$

$$\beta \approx h_{FE} = 100$$

$$R_1 = 30k\Omega$$

$$R_2 = 11k\Omega$$

$$U_F = 0.7V$$

$$R_C = 2k\Omega$$

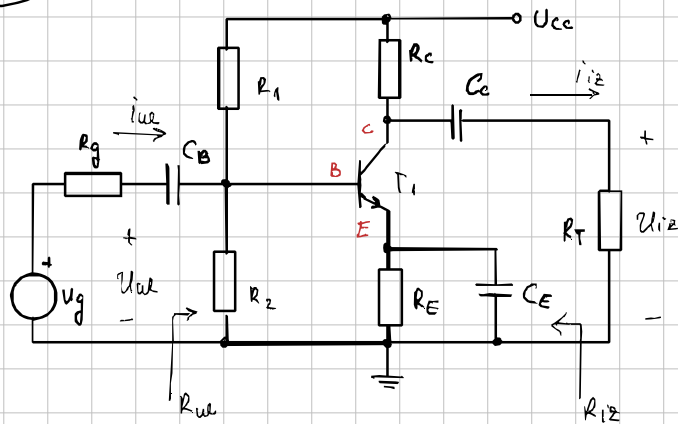
$$U_A = 200V$$

$$R_T = 1.2k\Omega$$

$$A_V = ? \quad A_I = ? \quad A_{Vg} = ?$$

$$U_i = 25mV$$

$$R_{in}, R_{iz} = ?$$



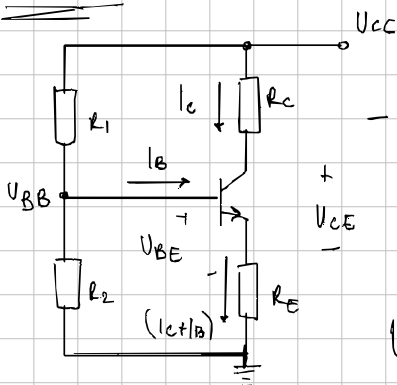
SZE  $\rightarrow$  E je spojen na masu!

$\rightarrow$  ulaz = B

$\rightarrow$  izlaz = C

+ spojka spojen kod na E i masu

Statika:



$$-U_{CC} + I_C R_C + U_{CEQ} + R_E (I_C + I_B)$$

$$-U_{BB} + (I_C + I_B) R_E + I_B R_B + U_{BEQ} = 0, \quad I_C = \beta I_B$$

$$\rightarrow U_{BB} = U_{BEQ} + R_B I_B + R_E I_B (1 + \beta)$$

$$U_{BB} = \frac{R_1}{R_1 + R_2} \cdot U_{CC}$$

$$U_{BEQ} = U_F$$

$$U_{BB} = 4.02V$$

$$U_{BEQ} = 0.7V$$

$$I_B = \frac{U_{BB} - U_{BEQ}}{R_B + R_E (1 + \beta)} = \frac{4.02 - 0.7}{R_1 \parallel R_2 + 10^3 \cdot 101} \Rightarrow I_B = 30.55 \mu A$$

$$\rightarrow I_C = 3.05mA$$

$$U_{CEQ} = U_{CC} - R_C I_C - R_E (I_C + I_B) \quad U_{CEQ} = 5.82V$$

Dinamika:

$$r_{be} = \frac{U_T}{I_B}$$

(vlastni dinamički otpor)

$$\rightarrow r_{be} = 822\Omega$$

$$r_{ce} = \frac{U_A}{I_C}$$

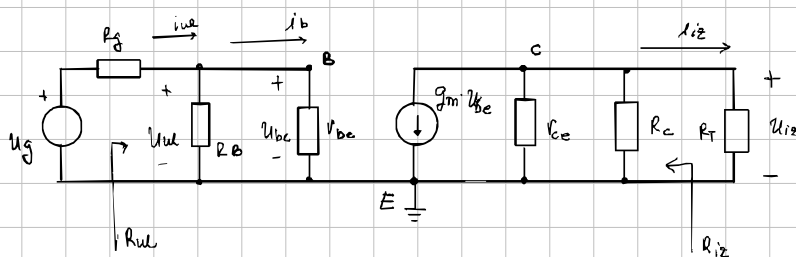
(izlazni dinamički otpor)

$$r_{ce} = 67.7k\Omega$$

$$g_m = \frac{h_{FE}}{r_{be}} = \frac{\beta I_B}{U_T} = \frac{I_C}{U_T} \quad (\text{strmina lip. T})$$

$$g_m = 122mA/V$$

Dinamika:



$$A_V = \frac{U_{iz}}{U_{ul}} = -g_m (r_{ce} \parallel R_C \parallel R_T) = -122 \cdot (67.7 \parallel 2 \parallel 1.2) = -90.5$$

$$A_I = \frac{i_{iz}}{i_{ul}} = -h_{FE} \frac{r_{ce} \parallel R}{r_{ce} \parallel R_C + R_T} \frac{R_B}{R_B + r_{be}} = -100 \cdot \frac{67.7 \parallel 2}{67.7 \parallel 2 + 1.2} \frac{8.05}{8.05 + 0.822}$$

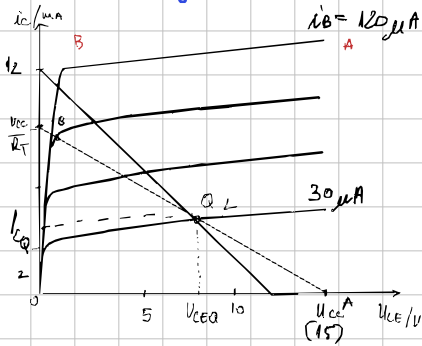
$$A_I = -56.1$$

$$R_{in} = R_B \parallel r_{be} = 8.05 \parallel 0.822 = 746\Omega$$

$$R_{iz} = r_{ce} \parallel R_C = 67.7 \parallel 2 = 1.94k\Omega$$

$$A_{Vg} = \frac{U_{iz}}{U_g} = \frac{U_{iz}}{U_{ul}} \cdot \frac{U_{ul}}{U_g} = A_V \cdot \frac{R_{in}}{R_g + R_{in}} = -90.5 \cdot \frac{746}{500 + 746} \rightarrow A_{Vg} = -54.2$$

## Primer 5.)



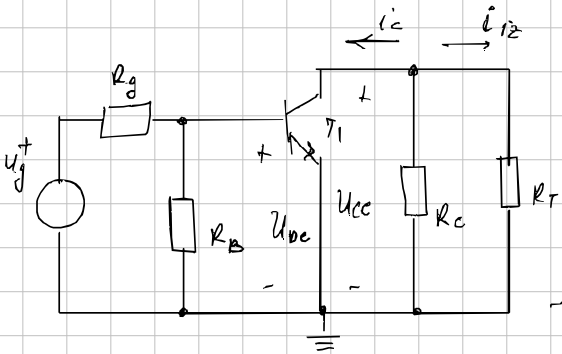
Koliki je maks hod izmjeničnih izlaznih napona i struji, a da pri tome R.T. ne izađe iz normalnog aktivnog područja?

$$U_{CE} = U_{CC} - (R_C + R_E)I_C \rightarrow U_{CE} = 0 \text{ točka spretanja}$$

$$I_C = 0 \text{ točka spretanja}$$

$$I_B = I_{BQ} = 30 \mu A$$

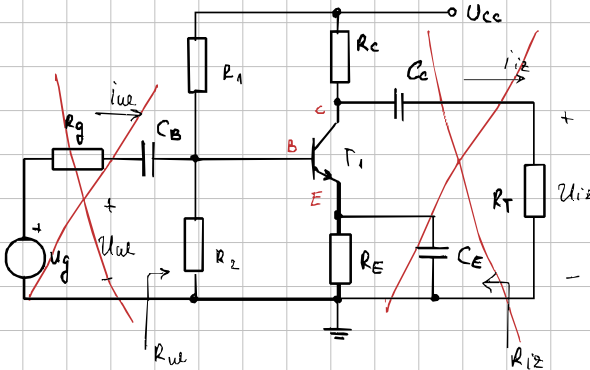
$$U_{CEQ} = 5.8 V$$



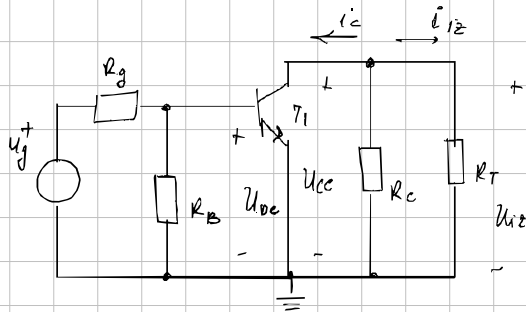
$$U_{CE} = -(R_C \parallel R_T) I_C$$

$$\frac{-1}{R_C \parallel R_T} = \frac{-1}{2 \parallel 1.2} = \frac{-1}{1.43} \approx -0.7$$

## Podrobniji SRT za max hod signala



$$U_{CEQ} = U_{CC} - (R_C + R_E)I_{CQ}$$



$$U_{CE} = -(R_C \parallel R_T) \cdot I_C$$

max hod  $\rightarrow$  Q je polovište  $\Rightarrow$  mjese u  $2 \cdot I_{CQ}$  i  $2 \cdot U_{CEQ}$

$$U_{CE} = -(R_C \parallel R_T) I_C$$

$$U_{CE} = U_{CE} + U_{CEQ}$$

"AC" "DC"

$$U_{CE} - U_{CEQ} = -(R_C \parallel R_T)(I_C - I_{CQ})$$

za  $U_{CE} = 0$ ,  $I_C = 2 I_{CQ} \rightarrow 0 - U_{CEQ} = -(R_C \parallel R_T)(2 I_{CQ} - I_{CQ})$

$$U_{CEQ} = (R_C \parallel R_T) I_{CQ}$$

$$I_{CQ} = \frac{U_{CC}}{R_C + R_E + R_C \parallel R_T}$$

$$U_{CEQ} = \frac{R_C \parallel R_T}{R_C + R_E + R_C \parallel R_T} U_{CC}$$

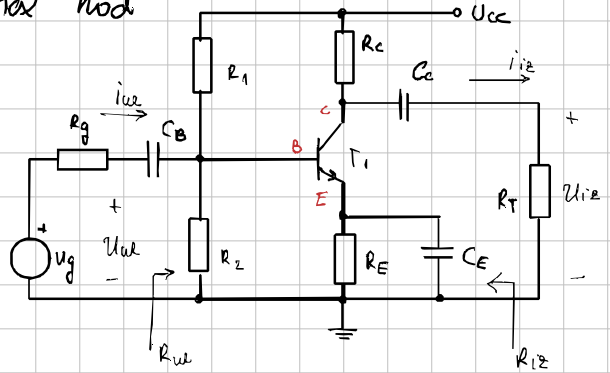
# Primer 8.6.) SRT za max hod

$$U_{iz} = ? \quad I_{iz} = ? \quad R_1, R_2 = ?$$

$$U_{CC} = 15V \quad R_E = 1k\Omega$$

$$R_C = 2k\Omega \quad \beta = 100$$

$$R_T = 1.2k\Omega \quad U_{BE} = 0.7V$$



$$I_{CQ} = \frac{U_{CC}}{R_C + R_E + R_C \parallel R_T} = \frac{15}{2 + 1 + 2 \parallel 1.2} = \underline{\underline{4mA}}$$

$$U_{CEQ} = \frac{R_C \parallel R_T}{R_C + R_E + R_C \parallel R_T} U_{CC} = \frac{2 \parallel 1.2}{2 + 1 + 2 \parallel 1.2} \cdot 15 = \underline{\underline{3V}}$$

$$U_{CE \max} = U_{CEQ} = \underline{\underline{3V}}$$

$$I_{C \max} = I_{CQ} = \underline{\underline{4mA}}$$

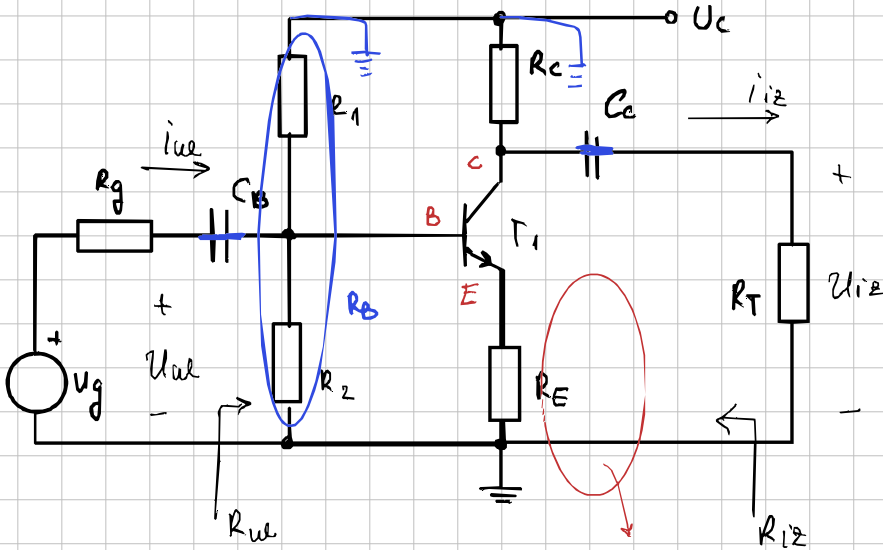
\* Za dinamičku E → Masa ⇒  $U_{iz \max} = U_{CE \max}$

$$U_{iz \max} = 3V$$

$I_C$  se grama na  $I_{iz}$  i  $I_E$

$$\rightarrow I_{iz \max} = I_{C \max} \cdot \frac{R_C}{R_C + R_T} = \Rightarrow I_{iz \max} = \underline{\underline{2.5mA}}$$

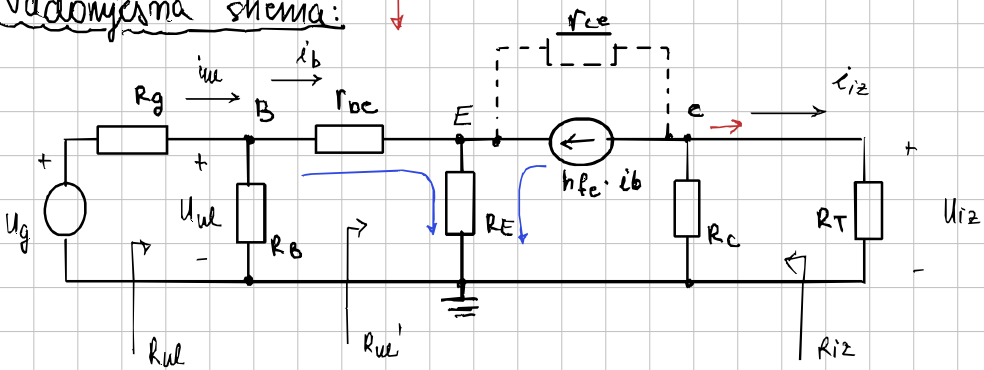
# Pojacalo u SZE s emiterkom degeneracijom



više nije  
na malom

nedostaje  $\parallel C$  (razlika sa i bez  
degeneracije  
• koji je utjecaj?

## Nadomjesna shema:



$$U_{ul} = i_b \cdot r_{be} + i_b \cdot R_E + R_E \cdot h_{fe} \cdot i_b$$

$$U_{ul} = i_b \cdot r_{be} + i_b \cdot R_E (1 + h_{fe})$$

$$U_{iz} = -h_{fe} \cdot i_b (R_C \parallel R_T)$$

## Naponsko pojačanje

$$\Rightarrow A_v = \frac{U_{iz}}{U_{ul}} = -h_{fe} \frac{R_C \parallel R_T}{r_{be} + (1 + h_{fe}) \cdot R_E}$$

$$\rightarrow A_v \approx \frac{g_m (R_C \parallel R_T)}{1 + g_m R_E}$$

$$\text{uz } g_m R_E \gg 1 \rightarrow A_v \approx -\frac{R_C \parallel R_T}{R_E}$$

## Strujno pojačanje:

$$i_b = i_{ul} \cdot \frac{R_B}{R_B + R_{ul}'}$$

$$R_{ul}' = \frac{U_{ul}}{i_b} = \frac{i_b \cdot r_{be} + i_b \cdot R_E (1 + h_{fe})}{i_b}$$

$$\rightarrow R_{ul}' = r_{be} + R_E (1 + h_{fe})$$

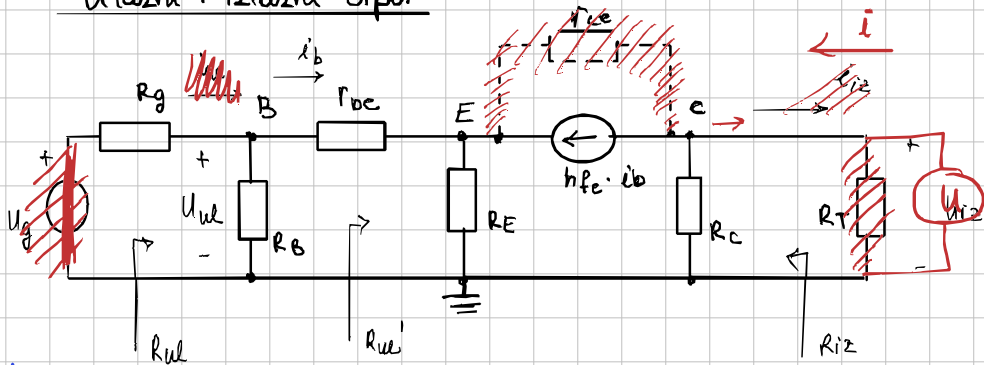
$$i_{iz} = -h_{fe} \cdot i_b \frac{R_C}{R_C + R_T} \quad (\text{gdalib})$$

$$A_T = -h_{fe} \cdot \frac{R_C}{R_C + R_T} \cdot \frac{R_B}{R_B + r_{be} + R_E (1 + h_{fe})}$$

$$i_b = i_{ul} \frac{R_B}{R_B + r_{be} + R_E (1 + h_{fe})}$$

$\rightarrow i_{ul}$  je recipročno

## Ulazni i izlazni otpor:



ulazni

$$R_{ul} = R_B \parallel R_{ul}' \rightarrow R_{ul} = R_B \parallel [r_{be} + (1+h_{fe})R_E]$$

izlazni

$$R_{i2} = \frac{U}{i}$$

$$i = \frac{i_c}{R_C} + h_{fe} \cdot i_b$$

točka E  $\rightarrow U_E = (1+h_{fe})i_b R_E$

$$U_E = -i_b (R_g \parallel R_B + r_{be})$$

$$R_{i2} = R_C$$

$$\Rightarrow i_b = 0$$

Primer 8.7.)

$$U_{CC} = 15V$$

$$R_C = 3k\Omega$$

$$A_V = \frac{U_{i2}}{U_{ul}} = -h_{fe} \frac{R_C \parallel R_T}{r_{be} + (1+h_{fe})R_E} = -5.64$$

$$R_g = 500\Omega$$

$$R_T = 2k\Omega$$

$$R_{ul}' = r_{be} + (1+h_{fe})R_E = 21.3k\Omega$$

$$R_1 = 25k\Omega$$

$$R_E = 200\Omega$$

$$R_2 = 2.2k\Omega$$

$$\beta \approx h_{fe} = 100$$

$$A_I = -h_{fe} \frac{R_C}{R_C + R_T} \cdot \frac{R_B}{R_B + R_{ul}} = -5.2$$

$$U_T = 25mV$$

$$U_g = 0.7V$$

$$R_{ul} = R_B \parallel R_{ul}' \rightarrow R_{ul} = 1.84k\Omega$$

$$A_V = ? \quad A_I = ? \quad A_g = ?$$

$$A_{gV} = A_V \cdot \frac{R_{ul}}{R_g + R_{ul}} = -4.43$$

$$R_{i2} = R_C = 3k\Omega$$