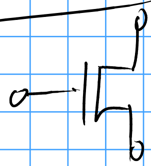
ST 1 - Tutorübung - Blatt 8 (22.12.09)

MOSFET-Schaltung

n-MOS



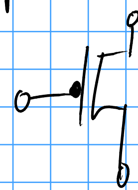
$U_{th} > 0V$ "normally off"

n-MOS-Enhancement-Typ

$U_{th} \leq 0V$ "normally on"

n-MOS-Depletion-Typ

p-MOS



$U_{th} < 0$ "normally off"

p-kanal-Enhancement

Festlegung von Drain/Source: $\underline{u_{ds} \geq 0V}$ — " — $\underline{u_{ds} \leq 0V}$

Schaltungstheoretische: Shichman-Hodges-Modell
(hier: ohne Berücksichtigung der Kanallängenmodulation)

n-MOS: $i_g = 0$

$$i_d = \begin{cases} 0 & u_{gs} - U_{th} \leq 0 \\ \beta\left((u_{gs}-U_{th})\,u_{ds} - \frac{1}{2}u_{ds}^2\right) & 0 \leq u_{gs} - U_{th} \geq u_{ds} \\ \frac{\beta}{2}\left(u_{gs}-U_{th}\right)^2 & 0 \leq u_{gs} - U_{th} \leq u_{ds} \end{cases}$$

$$\left.\frac{\partial i_d}{\partial u_{gs}}\right|_{AP} = \frac{\beta}{2} \cdot 2\left(u_{gs} - U_{th}\right)\Big|_{AP} \qquad \frac{A}{V^2} \cdot V = \frac{A}{V} = S$$

p-MOS: $\quad i_g = 0$

$$i_d = \begin{cases} 0 & u_{gs} - U_{th} \geq 0 \\ -\beta\left[(u_{gs}-U_{th})u_{ds} - \frac{1}{2}u_{ds}^2\right] & 0 \geq u_{gs} - U_{th} \leq u_{ds} \\ -\frac{\beta}{2}(u_{gs}-U_{th})^2 & 0 \geq u_{gs} - U_{th} \geq u_{ds} \end{cases}$$

Herleitung der KS-ESBs:

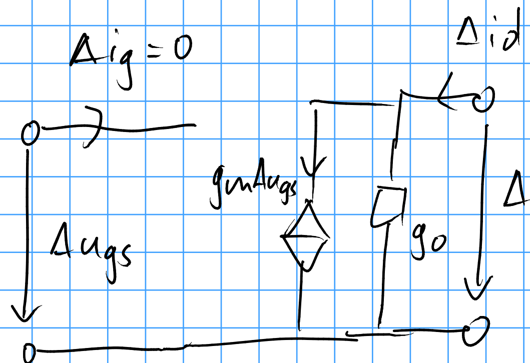
z.B. n-MOS-Schaltung, linearer Bereich

neu !

$$\left.\frac{\partial i_d}{\partial u_{ds}}\right|_{AP} = \beta\left[(u_{gs}-U_{th}) - u_{ds}\right]\Big|_{AP} = \beta\left[(U_{gs}-U_{th}) - U_{ds}\right]$$

$$\left.\frac{\partial i_d}{\partial u_{gs}}\right|_{AP} = \beta u_{ds}\Big|_{AP} = \beta U_{ds}$$

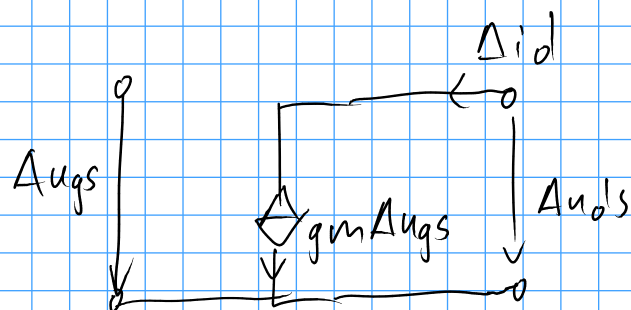
ausgehend von den Shichman-Hodges-Gleichungen



Kleinsignal-ESB für den linearen Bereich

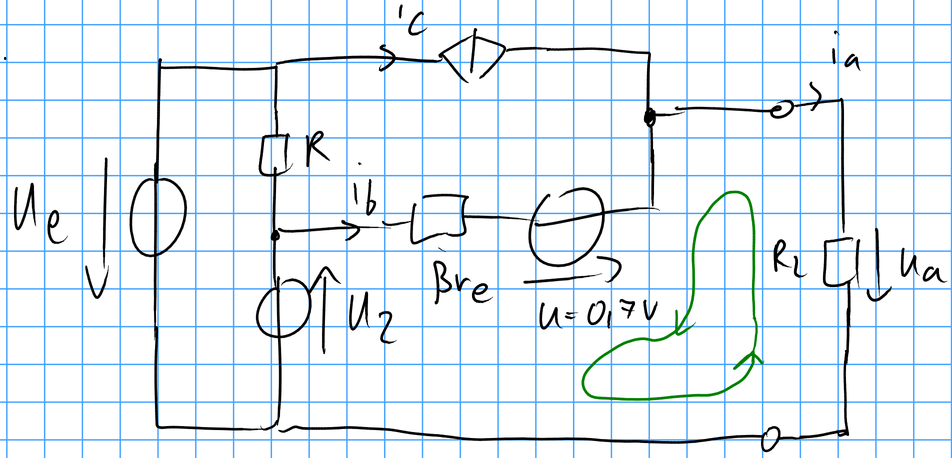
→ Analog: Sättigungsbereich

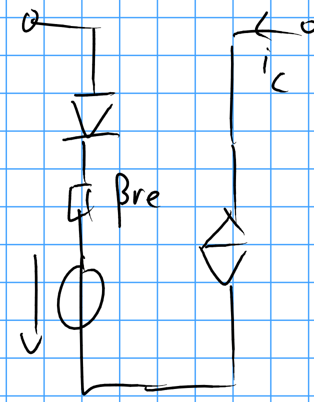
$$\frac{\partial i_d}{\partial u_{gs}} = g_m$$



Aufgabe 1:

1.





2. $R_L = \frac{U_a}{I_a}$

3. $I_a = f(b, \beta)$

$$I_a = I_b + I_c = I_b + I_b\beta = I_b(\beta+1)$$

4. $I_b = \frac{I_a}{(\beta+1)} = \frac{U_a}{R_L(\beta+1)}$ (aus (2) u. (3))

5. $U_a = f(U_2, \beta, R_L, re)$

$$U_a = -U - \beta re I_b - U_2 = -U - \beta re \frac{U_a}{R_L(\beta+1)} - U_2$$

$$U_a\left(1 + \frac{\beta re}{R_L(\beta+1)}\right) = -U - U_2 = -0,7V - U_2 \quad \Big|:(\sim)$$

$$U_a = \frac{-0,7V - U_2}{1 + \frac{\beta re}{R_L(\beta+1)}}$$

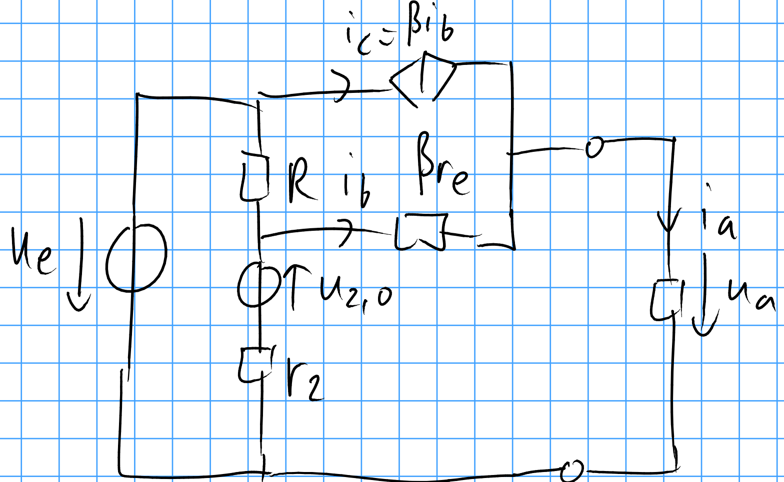
6. $\lim\limits_{r_e \to 0} U_a = -0{,}7V - U_2$

7. → spannungsgesteuert

→ passiv

→ quellenfrei

8.

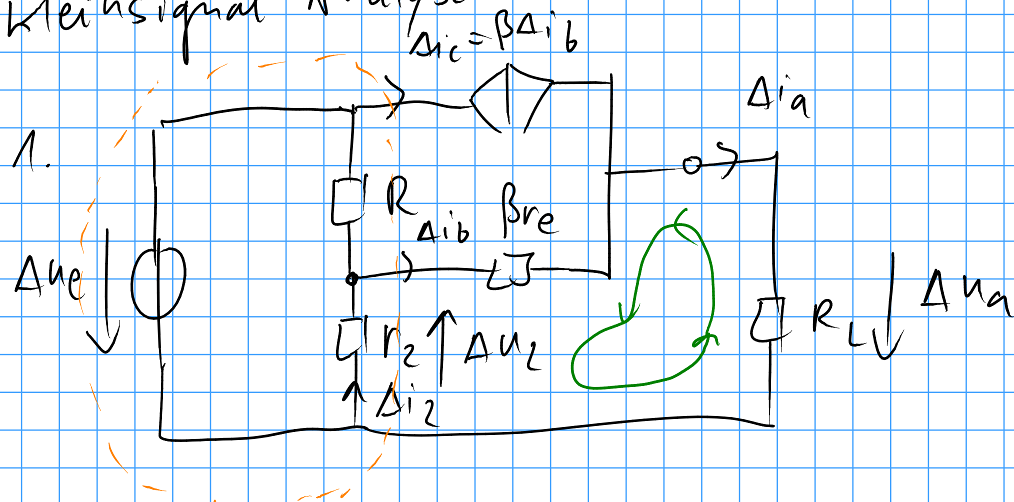


$r_2 = \frac{1}{7} k\Omega$

$U_{2,0} = -6{,}67V$

Kleinsignal-Analyse

1.



2. $\Delta u_a = f(\Delta u_2, \beta, R_L, r_e)$; $\Delta i_a = \Delta i_b(\beta+1)$ $R_L = \frac{\Delta u_a}{\Delta i_a}$

$$\Delta u_a = -\beta r_e \Delta i_b - \Delta u_2 = -\beta r_e \frac{\Delta u_a}{R_L(\beta+1)} - \Delta u_2$$

$$\Delta u_a \left(1 + \frac{\beta r_e}{R_2(\beta+1)} \right) = -\Delta u_2 \qquad | : (-)$$

$$\Rightarrow \Delta u_a = \frac{-\Delta u_2}{1 + \frac{\beta r_e}{R_L(\beta+1)}}$$

3. $\Delta i_b = 0 \Rightarrow \Delta u_2 = f(\Delta u_e, R, r_2)$

$$\Delta u_2 = - \Delta u_e \frac{r_2}{R+r_2}$$

$$\Delta u_a = + \frac{1}{1 + \frac{\beta r_e}{R_L(\beta+1)}} \Delta u_e \frac{r_2}{R+r_2}$$