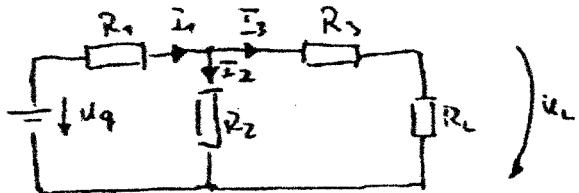


Lösungen zur Probeklausur Grundlagen der Elektronik WS 2007/2008

1



a) (1) $U_q = I_1 R_1 + U_L$ (4) $\sim (1) \quad U_q = (I_2 + I_3) R_1 + U_{R2}$

(2) $U_{R2} = I_3 (R_3 + R_L)$ mit (1) u. (3) $U_q = \frac{U_q R_2}{R_2} + \frac{U_{R2} R_1}{R_2 + R_L} + U_{R2}$

(3) $U_{R2} = I_2 R_2$

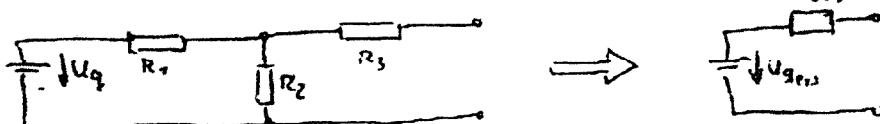
(4) $I_1 = I_2 + I_3$

$$U_q = \left(\frac{R_1}{R_2} + \frac{R_1}{R_3 + R_L} + 1 \right) U_{R2}$$

$$U_{R2} = \frac{U_q}{\frac{R_1}{R_2} + \frac{R_1}{R_3 + R_L} + 1}$$

$$U_{R2} = \frac{8V}{0,4762 + 0,44303 + 1} = 4,17V \quad U_L = \frac{R_L}{R_3 + R_L} \cdot U_{R2} = 2,37V$$

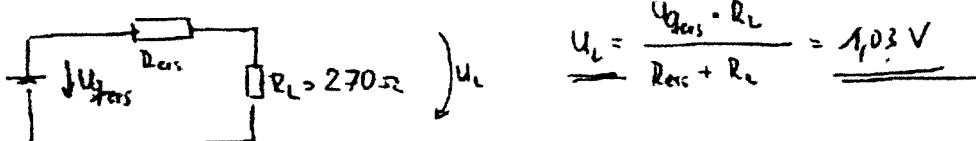
b)



$$\underline{\underline{U_{q_{2ers}}}} = \frac{U_q \cdot R_2}{R_1 + R_2} = 5,42V$$

$$\underline{\underline{R_{2ers}}} = R_3 + R_1 R_2 = R_3 + \frac{R_1 R_2}{R_1 + R_2} = 1,15k\Omega$$

c)



$$\underline{\underline{U_L}} = \frac{U_{q_{2ers}} \cdot R_L}{R_{2ers} + R_L} = 1,03V$$

② a) $R_1 = \frac{\sigma}{\rho} \cdot \frac{L}{A} \quad B_p = C \cdot \mu_p \cdot p = 1,6024^9 A_S \cdot 480 \frac{Vs}{V_S} \cdot 5 \cdot 10^{16} \text{ cm}^{-3} = 3,845 (\text{Oe cm})^{-1}$

$$\underline{\underline{R_1}} = \frac{\sigma \text{ cm}}{3,845} \cdot \frac{\pi \cdot 4}{2 \cdot \pi \cdot d^2} = \frac{8 \text{ cm}}{3,845} \cdot \frac{2 \cdot 2 \text{ cm}}{4 \cdot 0,6^2 \text{ cm}^2} = 0,92 \Omega$$

$$R_2 = \frac{\sigma}{\rho} \cdot \frac{L}{A} \quad B_u = e \cdot \mu_u \cdot u = 200,25 (\text{Oe cm})^{-1}$$

$$\underline{\underline{R_2}} = \frac{\sigma \text{ cm}}{200,25} \cdot \frac{2 \text{ cm}}{\pi d^2} = 0,0177 \Omega$$

b)

n-Gebiet

Elektronen $n = 10^{18} \text{ cm}^{-3}$

Löcher $p = \frac{n^2}{n} = 225 \text{ cm}^{-3}$

Plasmarionen / Donatorionen $p_f : N_D = 10^{18} \text{ cm}^{-3}$

p-Gebiet

Löcher $p = 5 \cdot 10^{10} \text{ cm}^{-3}$

Elektronen $n = \frac{p^2}{p} = 4,5 \cdot 10^3 \text{ cm}^{-3}$

Borionen/Akzeptorionen $B^- : N_A = 5 \cdot 10^{16} \text{ cm}^{-3}$

c) (1) $\frac{U_{R_2}}{U_{R_1}} = \frac{R_2}{R_1}$ (2) $U_{R_1} + U_{R_2} = 0,6V$

[2]

$$U_{R_1} \cdot R_1 = (0,6V - U_{R_2}) R_1$$

$$\underline{\underline{U_{R_1} = \frac{0,6V \cdot R_1}{R_1 + R_2} = 0,5887V}}$$

$$\underline{\underline{U_{R_2} = \frac{0,6V \cdot R_2}{R_1 + R_2} = 0,0112V}}$$

$$v = \mu E$$

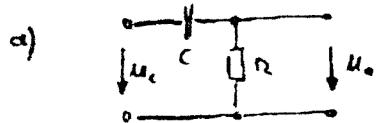
p-Gebiet

$$\underline{\underline{v = \mu_p \cdot \frac{U_{R_1}}{w/2} = 480 \frac{cm}{Vs} \cdot \frac{0,5887V}{1cm} = 282,6 \frac{cm}{s}}}$$

n-Gebiet

$$\underline{\underline{v = \mu_n \cdot \frac{U_{R_2}}{w/2} = 1250 \frac{cm^2}{Vs} \cdot \frac{0,0113V}{1cm} = 14,125 \frac{cm}{s}}}$$

(3) Hohopass



$$f_c = \frac{1}{2\pi R C}$$

$$R = \frac{1}{2\pi f_c C}$$

$$R = \frac{\pi \cdot f_c \cdot V}{2\pi \cdot 200 \cdot 10^3 \cdot R \cdot 10^{-12} A} = \underline{\underline{66,3 \Omega}}$$

$$2) \frac{U_o}{U_i} = \frac{R}{R + \frac{1}{j\omega C}} = \frac{R \cdot j\omega C}{1 + j\omega RC}$$

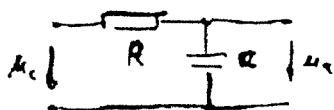
$$\underline{\underline{\frac{U_o}{U_i} = \frac{0,02C}{1 + (\omega RC)^2} (1 + j\omega RC)}}$$

$$\left| \frac{U_o}{U_i} \right| = \frac{\omega RC}{\sqrt{1 + \omega^2 R^2 C^2}}$$

$$100Hz: 5 \cdot 10^{-3}$$

$$1MHz: 0,981$$

Tiefpass



-II-

$$\underline{\underline{R = 66,3 \Omega}}$$

$$\frac{U_o}{U_i} = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{1}{1 + j\omega RC}$$

$$\underline{\underline{\frac{U_o}{U_i} = \frac{1}{1 + (\omega RC)^2} (1 - j\omega RC)}}$$

$$\left| \frac{U_o}{U_i} \right| = \frac{1}{\sqrt{1 + \omega^2 R^2 C^2}}$$

$$100Hz: 0,999...$$

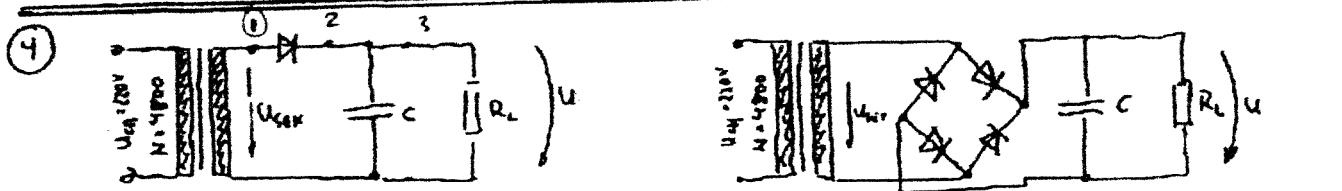
$$1MHz: 0,196$$

c) $C = \epsilon_0 \cdot \epsilon_r \cdot \frac{A}{d}$

$$A = \frac{C \cdot d}{\epsilon_0 \cdot \epsilon_r}$$

$$= \frac{12 \cdot 10^{-9} \text{ As} \cdot 2 \mu\text{m} \cdot \text{Nm}}{88 \cdot 10 \cdot 888 \cdot 10^{-12} \text{ As}}$$

$$= 2,7 \text{ cm}^2$$
(3)



a) $U = 5V$
 $U_{CEK} = 5V - 0,7V = 5,7V$

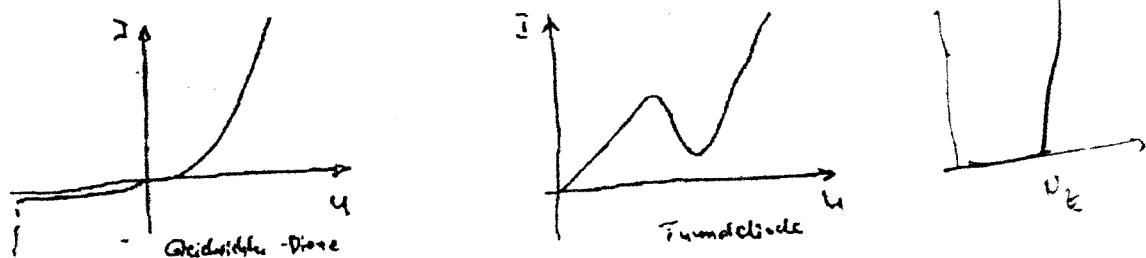
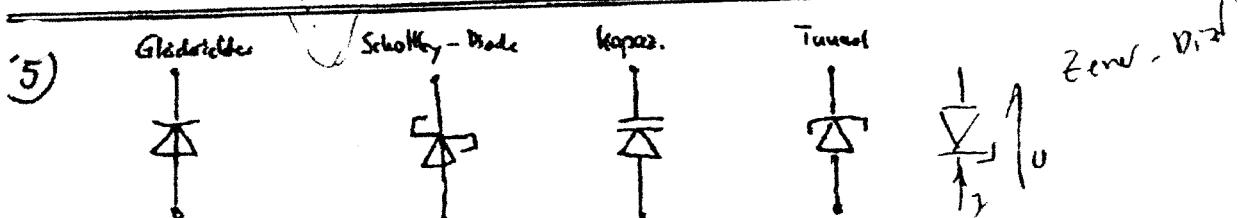
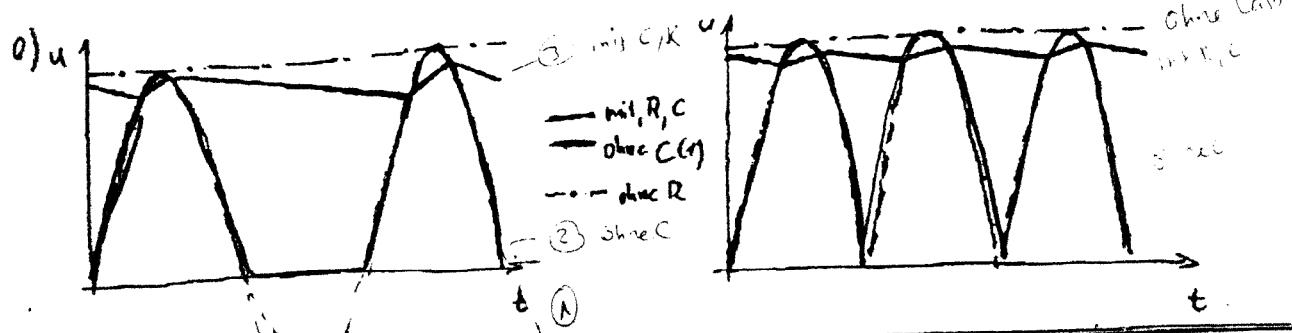
$$N_{SEK} = \frac{U_{SEK}}{\hat{U}_{PEIN}} \cdot 4800$$

$$\underline{N_{CEK}} = \frac{5,7V}{T^2 \cdot 220V} \cdot 4800 \approx \underline{88}$$

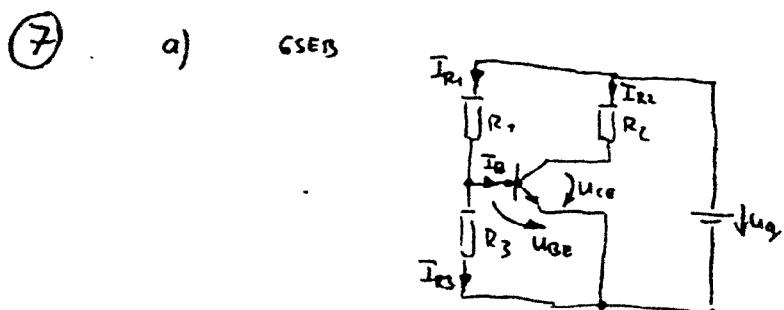
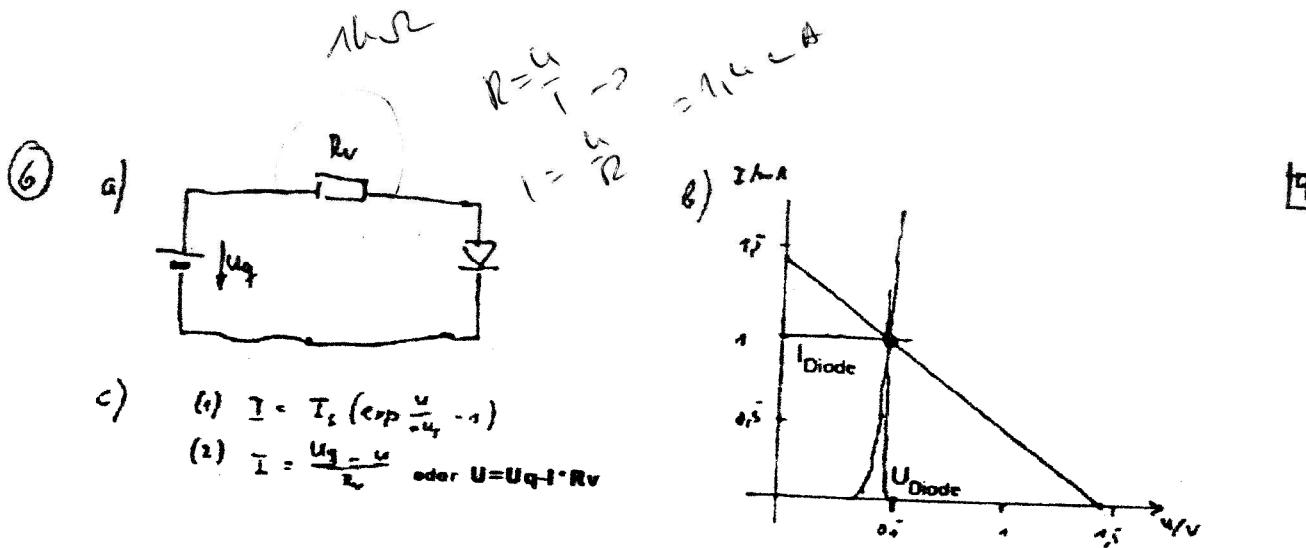
$U = 5V$
 $U_{CEK} = 5V + 2 \cdot 0,7V = 6,4V$

$$N_{SEK} = \frac{U_{SEK}}{\hat{U}_{PEIN}} \cdot 4800$$

$$\underline{N_{CEK}} = \frac{6,4V}{T^2 \cdot 220V} \cdot 4800 \approx \underline{99}$$



KL der Gleichrichterdiode: $I = I_s (e^{\frac{U}{nV_T}} - 1)$



$$\text{AP: } U_{ce} = \frac{U_q}{2} = 7,5 \text{ V}$$

$$U_q = I_c R_2 + U_{ce} \quad \underline{\underline{R_2 = \frac{U_q}{2 I_c} = 300 \Omega}}$$

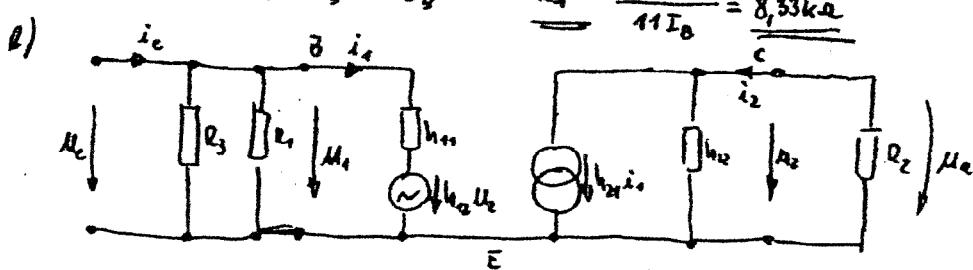
$$I_c = B_V \cdot I_B \quad (\text{since } I_{c0})$$

$$I_B = \frac{I_c}{B_V} = 156 \mu\text{A}$$

$$\underline{\underline{R_3 = \frac{U_{BE}}{10 I_B} = 449 \Omega}}$$

$$I_{R4} = 10 I_B + I_B < 11 I_B$$

$$\underline{\underline{R_4 = \frac{U_q - U_{ce}}{11 I_B} = 8,33 \text{ k}\Omega}}$$



$$c) Z_e = R_1 R_3 / (R_1 + R_3)$$

$$\underline{\underline{Z_{e,T2} = h_{11} - \frac{h_{21} h_{22}}{\frac{1}{R_2} + h_{22}} = 2,46 \Omega - \frac{0,0224}{0,00331} \Omega = 2,333 \Omega}}$$

$$\frac{1}{Z_e} = \frac{1}{833 \Omega} + \frac{1}{449 \Omega} + \frac{1}{2393 \Omega}$$

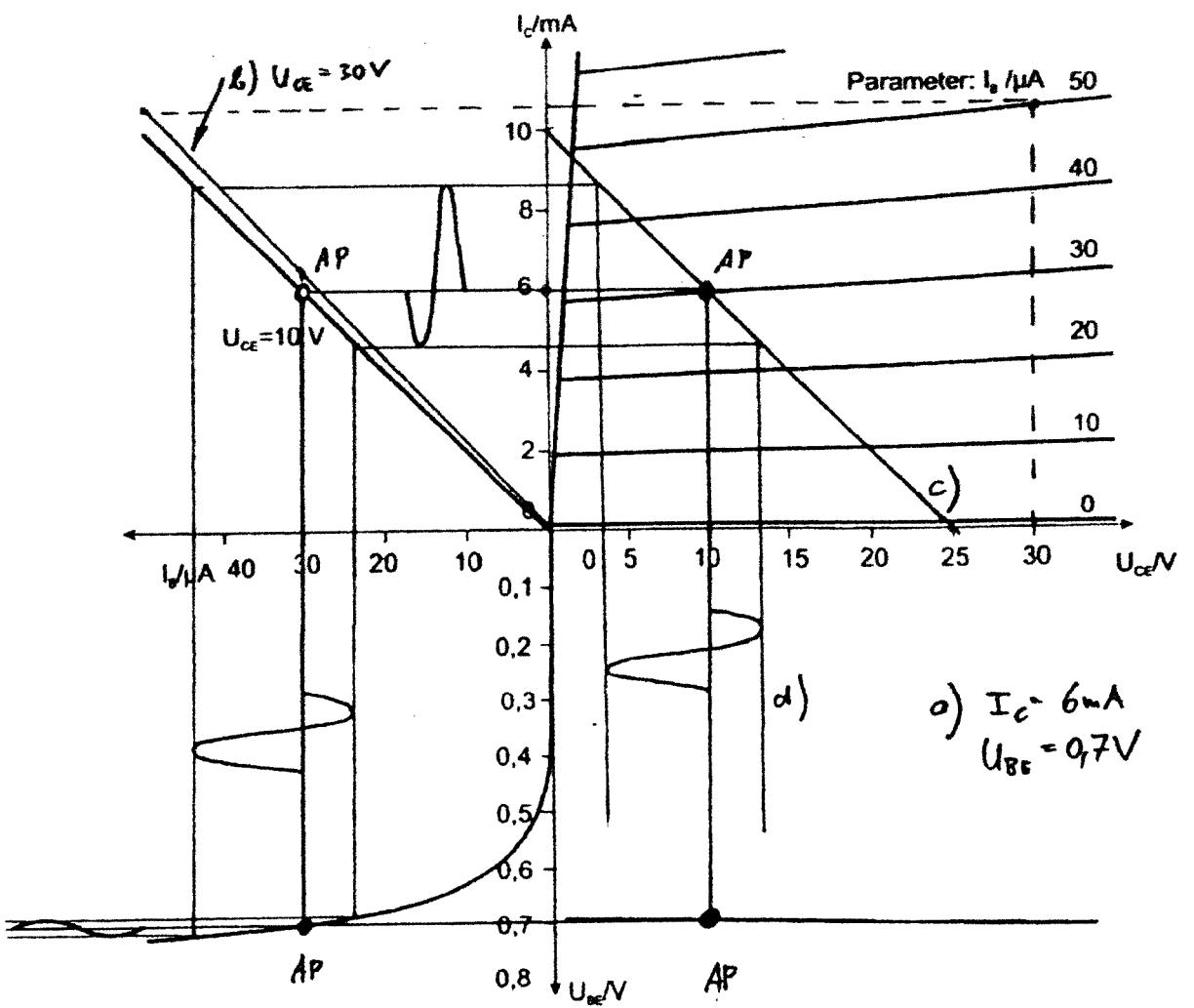
$$\underline{\underline{Z_e = 361,6 \Omega}}$$

$$\underline{\underline{\frac{V_i}{V_o} = \frac{Z_e}{Z_e + R_1}}}$$

$$V_i = \frac{Z_e}{Z_{e,T2}} = V_{i,T2}$$

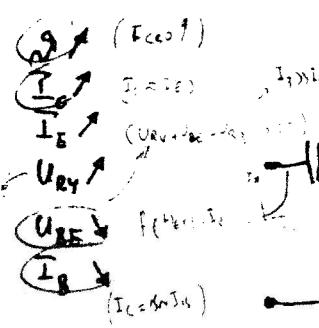
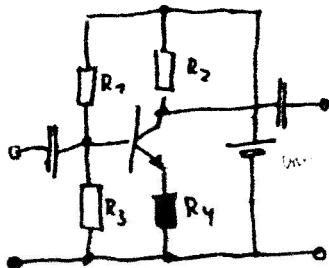
$$\underline{\underline{V_{i,T2} = \frac{h_{21}}{1 + R_2 h_{22}} = \frac{160}{1 + 300 \cdot 12 \cdot 10^{-6}} = 157,4}}$$

$$\underline{\underline{V_i = \frac{361,6}{2393} \cdot 157,4 = 24,1}}$$

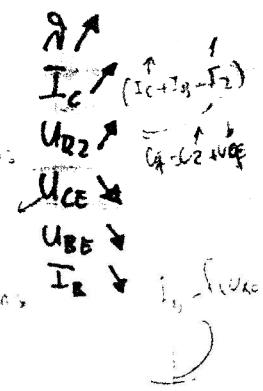
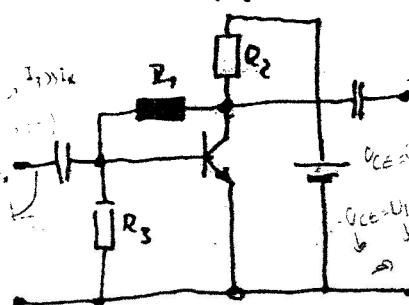


- e) differentieller Eingangswiderstand $r_{BE} = \frac{dU_{BE}}{dI_B}$ im Arbeitspunkt, III. Quadrant
 Spannungsrückwirkung $V_p = \frac{dU_{BE}}{dU_{CE}}$ im Arbeitspunkt, IV. Quadrant
 Ausgangswiderstand $r_{CE} = \frac{dU_{CE}}{dI_C}$ im Arbeitspunkt, I. Quadrant
 Wechselstromverstärkung $\beta = \frac{dI_C}{dI_B}$ im AP, II. Quadrant

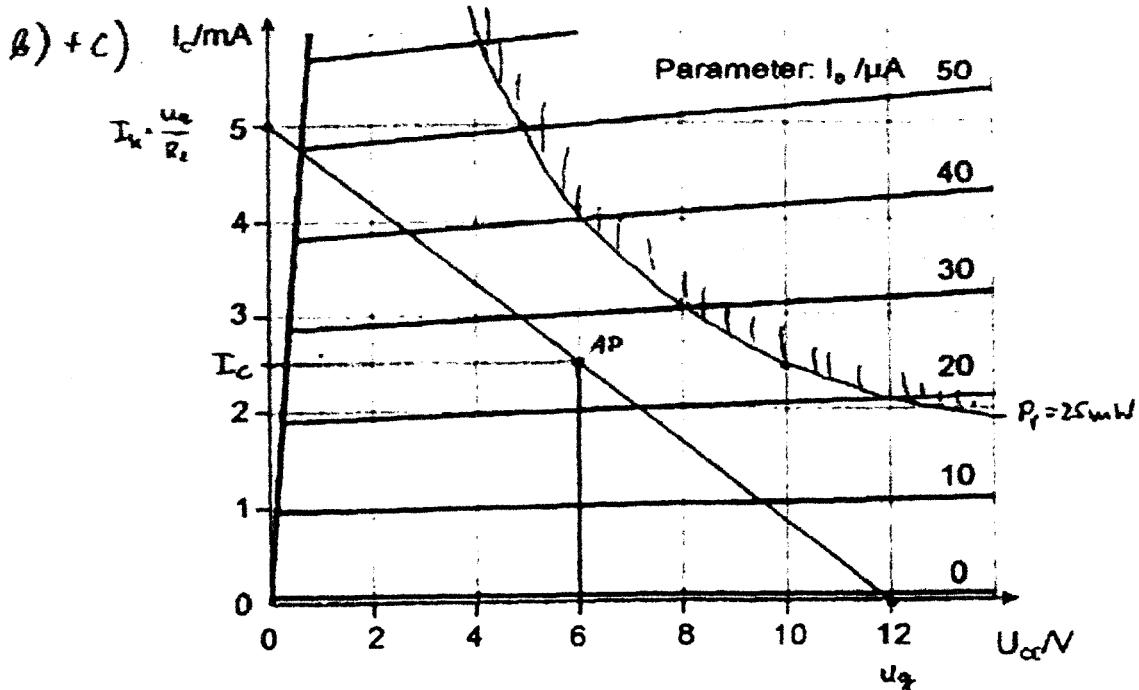
g) Stromgegenkopplung



Spannungsgegenkopplung



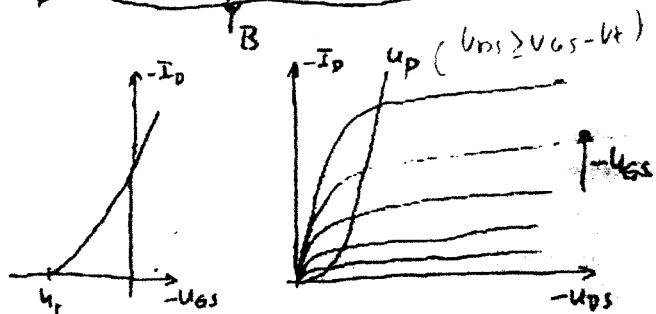
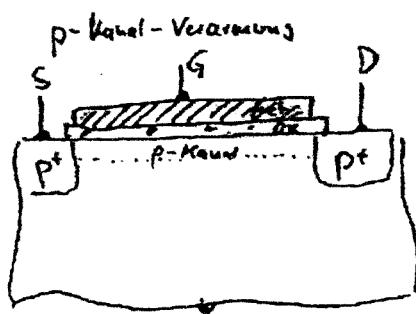
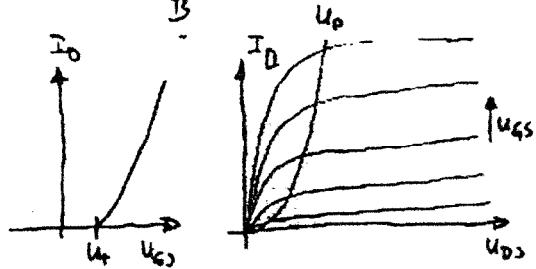
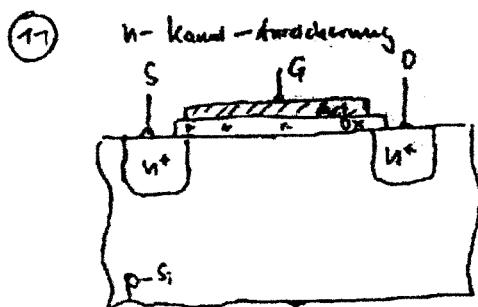
$$a) \quad B_V = \frac{I_C}{I_B} = \frac{3mA}{30\mu A} = 100$$



$$AP: \quad U_{CE} = \frac{U_G}{2} = 6V$$

$$I_C = 2,5 \mu A \quad I_B = \frac{I_C}{B_V} = 25 \mu A$$

$P_r = 25 \text{ mW} \rightarrow \text{Hyperbel}$



$|U_{GS}| < |U_G| \rightarrow$ kein Kanal \rightarrow kein Stromfluss vom S zum Drain

$|U_{GS}| > |U_G| \rightarrow$ Inversion \rightarrow leitfähiger Kanal verbindet S und D

$|U_{GS}| \rightarrow$ Gatespannung bestimmt die Leitfähigkeit im Kanal und damit I_D

$$\textcircled{12} \quad a) \quad f_0 = \frac{1}{2\pi \sqrt{LC}}$$

7

$$C = \frac{1}{4\pi^2 f_0^2 L} = \frac{1 \text{ s}^2 \text{ A}}{\pi^2 600^2 \cdot 0,4 \text{ Vs}}$$

$$\underline{C = 175 \text{ nF}}$$

- b) Die Permeabilität geht über $L = N^2 \mu_0 \mu_r \frac{A}{l}$ linear in die Induktivität ein. Folglich ändert sich die Induktivität auf $\frac{1}{1000}$ zu $L = 0,4 \text{ mH}$

$$f_0 = \frac{1}{2\pi \sqrt{LC}} = \frac{1}{2\pi \sqrt{0,4 \cdot 10^{-3} \frac{\text{Vs}}{\text{A}} \cdot 175 \cdot 10^{-9} \frac{\text{A}}{\text{V}}}}$$

$$f_0 = -19 \text{ kHz}$$

- c) Ich rechne mit den Werten nach Aufgabe b) ^{*1)}
also $L = 0,4 \text{ mH}$ $C = 175 \text{ nF}$

$$R = 0,75 \Omega$$

$$Q = \frac{1}{R} \sqrt{\frac{L}{C}} = \frac{1 \text{ A}}{0,75 \text{ V}} \cdot \sqrt{\frac{0,4 \cdot 10^{-3} \text{ Vs}}{175 \cdot 10^{-9} \text{ As}}} = 63,75$$

$$B = \frac{f_0}{Q} = \frac{19 \cdot 10^3}{63,75} \text{ Hz} = 298 \text{ Hz}$$

$$\text{Gleichungssystem} \quad f_0 = \sqrt{f_1 \cdot f_2} \quad (1) \quad f_2 = \frac{f_0^2}{f_1} \quad \text{in (2)}$$

$$B = f_2 - f_1 \quad (2)$$

↓

$$0 = f_1^2 + Bf_1 - f_0^2$$

$$f_{1,2} = -\frac{B}{2} \pm \sqrt{\frac{B^2}{4} + f_0^2} = -149 \text{ Hz} \pm \sqrt{22201 + 19000} \text{ Hz}$$

$$f_{1,2} = -149 \text{ Hz} \pm 203 \text{ Hz} \quad 19 \text{ kHz}$$

$$\underline{f_2 = 19,149 \text{ kHz}}$$

$$\underline{f_1 = 18,851 \text{ kHz}}$$

$$\cancel{f_2 = -19,149 \text{ kHz}}$$

*1) man könnte auch mit den Werten aus a) rechnen, die Formulierung ist nicht exakt, allerdings sind die Werte dazu wohl gut zum Rechnen!