Prüfung ST SS21

A1

a) In das Gate fließen keine DC-Ströme da dieses eine ideale Kapazität darstellt.

b) Mosfet in Sättigung

$$f(U_{GS1}) = \frac{R_0 \cdot \beta}{2}(U_{GS1}-U_{th})^2(1+\lambda U_{GS1}) + U_{GS1} - U_0 \overset{!}{=} 0$$

$$f'(U_{GS1}) = R_0 \cdot \beta (U_{GS1}-U_{th})(1+\lambda U_{GS1}) + \frac{R_0\beta}{2}(U_{GS1}-U_{th})^2\lambda + 1$$

NRV $\rightarrow$ $U_{GS1}^{(4)} = 1{,}3257\,V$ $\quad I_0 = 674{,}9\,\mu A$

c) $I_{D2} = 8 \cdot I_0$

Voraussetzung: Sättigungsbereich d.h. $U_{DS2} = U_{DS1}$

↳ $\beta_2 = 8 \cdot \beta_1 \rightarrow W_2 = 8 \cdot W_1$

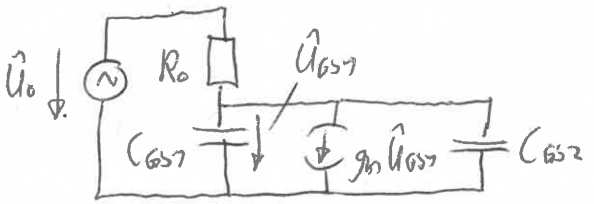
d) Strom teilt sich wegen R-2R-Struktur an den Knoten jeweils auf.

$$I_2 = -\frac{1}{4} I_{D2} = -1{,}35\,mA$$

e) $R_{ges} = 2R_0$ $\quad P = R_{ges} \cdot I_{D2}^2 = 0{,}0583\,W$

f) $P = -U_0 \cdot I_0 = -1{,}35\,mW$

g) $g_m = \frac{dI_{d1}}{dU_{GS1}} = \beta(U_{GS1}-U_{th})(1+\lambda U_{GS1}) + \frac{\beta}{2}(U_{GS1}-U_{th})^2 \cdot \lambda$



$$\hat{U}_{GS1} = \frac{|\hat{U}_0|}{\sqrt{(1+g_m R_0)^2 + (\omega(C_{GS1}+C_{GS2})R_0)^2}}$$

AL

a) $[\underline{A}_a] = \frac{1}{g_m}\begin{bmatrix} -\frac{1}{R_1} & -1 \\ -j\omega C_1 \frac{1}{R_1} & -j\omega C_1 \end{bmatrix}$

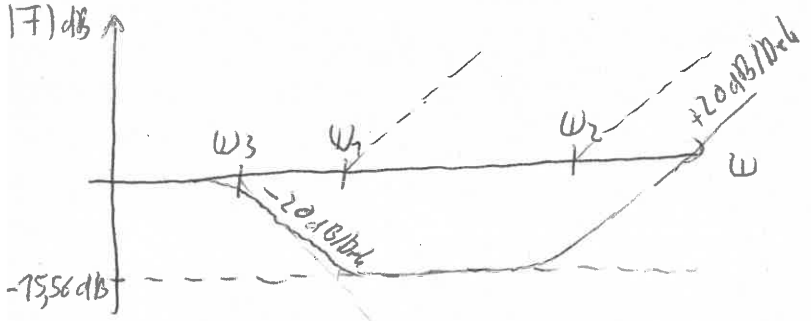
b) $[\underline{A}_b] = \begin{bmatrix} 1+(R_2+j\omega L_2)j\omega C_2 & R_2+j\omega L_2 \\ j\omega C_2 & 1 \end{bmatrix}$

c) $[\underline{A}_{ges}] = \begin{bmatrix} A_{a11}\cdot A_{b11} + A_{a12}\cdot A_{b21} & A_{a11}\cdot A_{b12} + A_{a12}\cdot A_{b22} \\ A_{a21}\cdot A_{b11} + A_{a22}\cdot A_{b21} & A_{a21}\cdot A_{b12} + A_{a22}\cdot A_{b22} \end{bmatrix}$

d) $\underline{T}_b = \frac{R_L + R_2 + j\omega(L_2 + R_2 R_L C_2) + (j\omega)^2 L_2 C_2 R_L}{j\omega C_2 R_2 + 1}$

e) $\underline{T} = \frac{1 + j\omega(L_2 + R_2 R_L C_2)\frac{1}{R_2+R_L} + (j\omega)^2 \frac{L_2 C_2 R_L}{R_2+R_L}}{j\omega C_2 R_2 + 1}$

$d = 13{,}44$, $\omega_1 = 72\cdot 10^6 \frac{1}{s}$, $\omega_2 = 70\cdot 10^9 \frac{1}{s}$, $\omega_3 = 2\cdot 10^6 \frac{1}{s}$



$\left|\underline{T}(j\omega_0)\right|_{dB} = \left|\frac{2d}{\frac{\omega_0}{\omega_3}}\right|_{dB} = -75{,}56\ dB$

f) $\underline{U}_B = \frac{1}{2}\left[\underline{A}_{ges,11}\cdot\sqrt{\frac{R_L}{R_0}} + \underline{A}_{ges,12}\cdot\frac{1}{\sqrt{R_L\cdot R_0}} + \underline{A}_{ges,21}\sqrt{R_L\cdot R_0} + \underline{A}_{ges}\sqrt{\frac{R_0}{R_L}}\right]$

g) ~~$U_0 = A_{ges}$~~

$P_{R_L} = \frac{|U_3|^2}{R_2} = \frac{U_{3,eff}^2}{2R_L} = \frac{U_{0,eff}^2}{\left|\left(\underline{A}_{ges,21}R_0 + \underline{A}_{ges,22}\cdot\frac{R_0}{R_L} + \underline{A}_{ges,11} + A_{ges,12}\cdot\frac{1}{R_L}\right)\right|^2}\cdot\frac{1}{2R_L}$

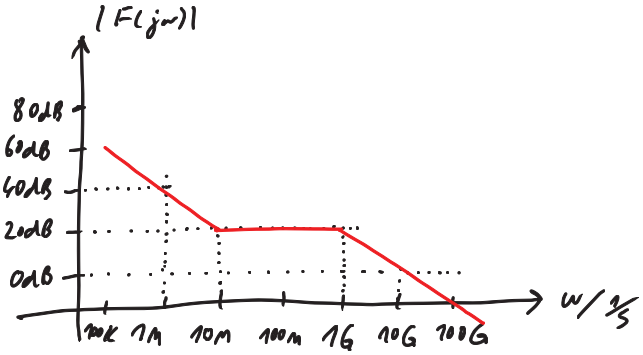
A 3 IKL

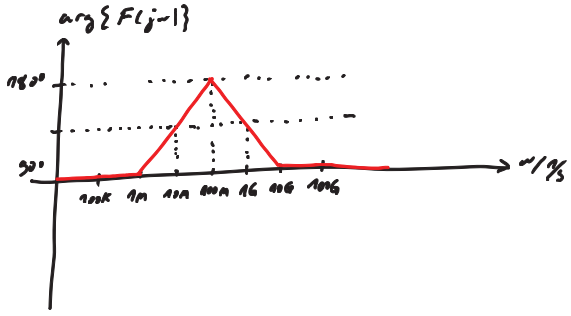
a) $\underline{Z}_1 = R_1 \qquad Z_2 = R_2 + \frac{1}{j\omega C} \qquad$ mit (5-237)

$$\underline{F}(j\omega) = -\frac{(j\omega C R_2 + 1) A_0 \omega_T}{(\omega_T + j\omega A_0)(1 + j\omega C R_2 + R_1 j\omega C) + A_0 \omega_T R_1 j\omega C}$$

b) $$\lim_{A_0 \to \infty} F(j\omega) = -\frac{\omega_T (j\omega C R_2 + 1)}{\omega_T R_1 j\omega C + j\omega (1 + j\omega C (R_1 + R_2))}$$

c) $$\underline{F}(j\omega) = \frac{\left(\frac{j\omega}{\frac{1}{CR_2}} + 1\right)}{j\omega \left(\frac{j\omega}{\frac{1 + \omega_T R_1 C}{C(R_1 + R_2)}} + 1\right)} \cdot \frac{-\omega_T}{(1 + R_1 C \omega_T)}$$





d) $$V_e(f) = \frac{U_1}{3} \cdot \frac{1}{j2\pi f} \left\{1 + 2e^{-j2\pi f \frac{T_1}{4}} - 2e^{-j2\pi f \frac{3T_1}{4}} - e^{-j2\pi f T_1}\right\}$$

e) $$V_a(f) = \underline{F}(j\omega)\Big|_{j\omega = j2\pi f} \cdot V_e(f)$$

f) $$V_a(p) = -\frac{\omega_T \left(p + \frac{1}{R_2 C}\right) \cdot R_2 C}{p \cdot \left(p + \frac{1 + \omega_T R_1 C}{C(R_1 + R_2)}\right) C (R_1 + R_2)} \cdot \frac{U_1}{3} \cdot \frac{1}{p} \cdot \underbrace{\left\{1 + 2e^{-p\frac{T_1}{4}} - 2e^{-p\frac{3T}{4}} - e^{-pT_1}\right\}}_{ZV}$$

(p_1 = $\frac{1}{R_2 C}$, p_2 = $\frac{1 + \omega_T R_1 C}{C(R_1 + R_2)}$)

$$= \tilde{K} \cdot \{ZV\} \cdot \left(\frac{1}{p(p + p_2)} + \frac{p_1}{p^2 (p + p_2)}\right)$$

$$\tilde{K} = -\frac{\omega_T R_2 U_1}{(R_1 + R_2) \cdot 3}$$

$$\tilde{u}_a(t) = \frac{1}{p_2}(1 - e^{-p_2 t}) \cdot s(t) + p_1 \cdot s(t) \cdot \frac{1}{p_2^2}(p_2 t + e^{-p_2 t} - 1)$$

$$u_a(t) = \tilde{K} \cdot \left(\tilde{u}_a(t) + 2\tilde{u}_a\left(t - \frac{T_1}{4}\right) - 2\tilde{u}_a\left(t - \frac{3T_1}{4}\right) - \tilde{u}_a(t - T_1)\right)$$

ST I/II Aufgabe 4 Kurzlösung

a)

$$i_L(t=0) = 0 \qquad i_C(t=0) = 0 \qquad u_C(t=0) = 0$$

b)

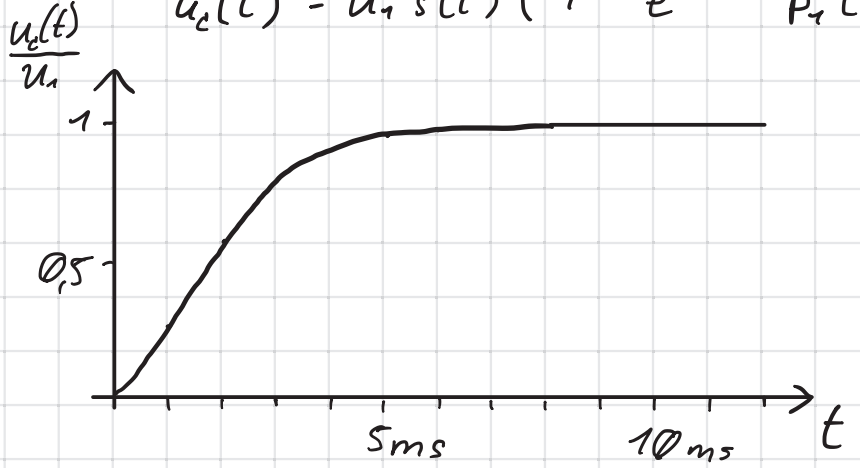
$$C \parallel R: \quad \underline{Z} = \frac{R}{1+pCR} \qquad \underline{V}_C(p) = \frac{U_1}{p} \frac{R}{p^2CLR + pL + R}$$

c)

$$\underline{V}_C(p) = \left| \begin{array}{l} \frac{U_1}{LC} \frac{1}{p(p+p_1)^2} \\ \frac{1}{\sqrt{LC}} \overset{*}{=} p_1 = \frac{1}{2RC} \end{array} \right. \qquad \text{PBZ:} \quad \frac{1}{p(p+p_1)^2} = \frac{A}{p} + \frac{B}{p+p_1} + \frac{C}{(p+p_1)^2}$$

$$\Rightarrow \underline{V}_C(p) = \frac{U_1}{LC}\left(\frac{1}{p_1^2 p} - \frac{1}{p_1^2(p+p_1)} - \frac{1}{p_1(p+p_1)^2}\right)$$

$$u_C(t) = U_1 s(t)\left(1 - e^{-p_1 t} - p_1 t e^{-p_1 t}\right) \qquad p_1 = 1\,\text{kHz}$$



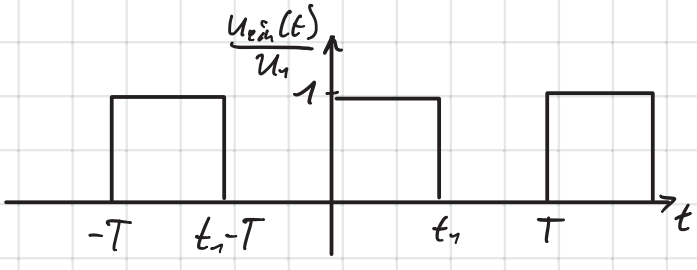
d)

$$\underline{\tilde{V}}_C(p) = \frac{U_1}{LC} \frac{1}{p\left(p+\frac{1}{\sqrt{LC}}\right)^2}\left(1 - e^{-pt_1}\right) \qquad \Big| \quad s(t) \rightarrow rect(t)$$

Alternativ über DGL + AB

$$\underline{\tilde{V}}_C(p) = \frac{u_C(t_1)\left(Cp + \frac{1}{R}\right) + C\left.\frac{du_C(t)}{dt}\right|_{t=t_1}}{Cp^2 + p\frac{1}{R} + \frac{1}{L}}$$

e)



f) $\underline{U}_{R,DC} = \underline{G}_{ein} \cdot \lim_{p \to 0} F(p) = U_1 \beta_t \qquad P_{DC} = \frac{U_{R,DC}^2}{R} = \frac{(U_1 \beta_t)^2}{R}$

g) $\underline{C}_{1,ein} = \frac{1}{2} U_1 si\left(\frac{\pi}{2}\right)(-i) \qquad \tilde{F} = \frac{1}{LC\left(j\frac{2\pi}{T} + \frac{1}{\sqrt{LC}}\right)^2} \qquad \underline{U}_{R,1} = \tilde{F} \cdot \underline{C}_{1,ein}$

$P_{R,1} = \frac{\left(2 \cdot \frac{1}{\sqrt{2}} |\underline{U}_{R,1}|\right)^2}{R} = P_{R,DC} \cdot 0{,}01$

Bonuspunkte g)

$|\underline{U}_{R,1}| = \frac{1}{2} U_1 si\left(\frac{\pi}{2}\right) \frac{1}{LC\left(\frac{4\pi^2}{T^2} + \frac{1}{LC}\right)} \qquad P_{R,1} \doteq 0{,}01 \cdot P_{R,DC}$

$\underline{T \simeq 2{,}22\ ms} \qquad \Leftrightarrow \underline{\underline{f \simeq 450\ Hz}}$