

A1

a) $D_1: U_a > U_{DD} = 5V$

$D_2: U_a < 0V$

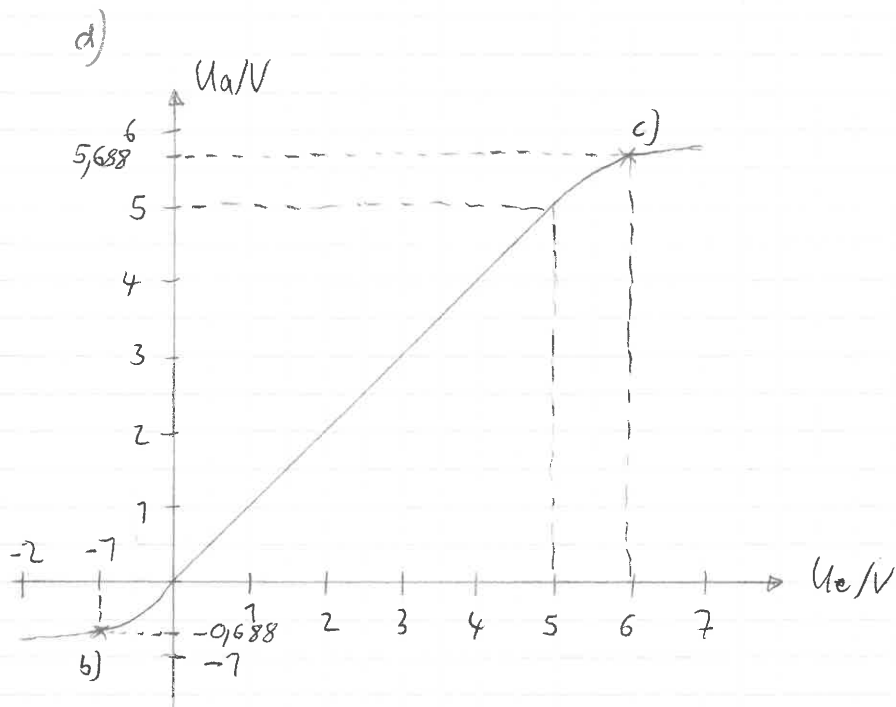
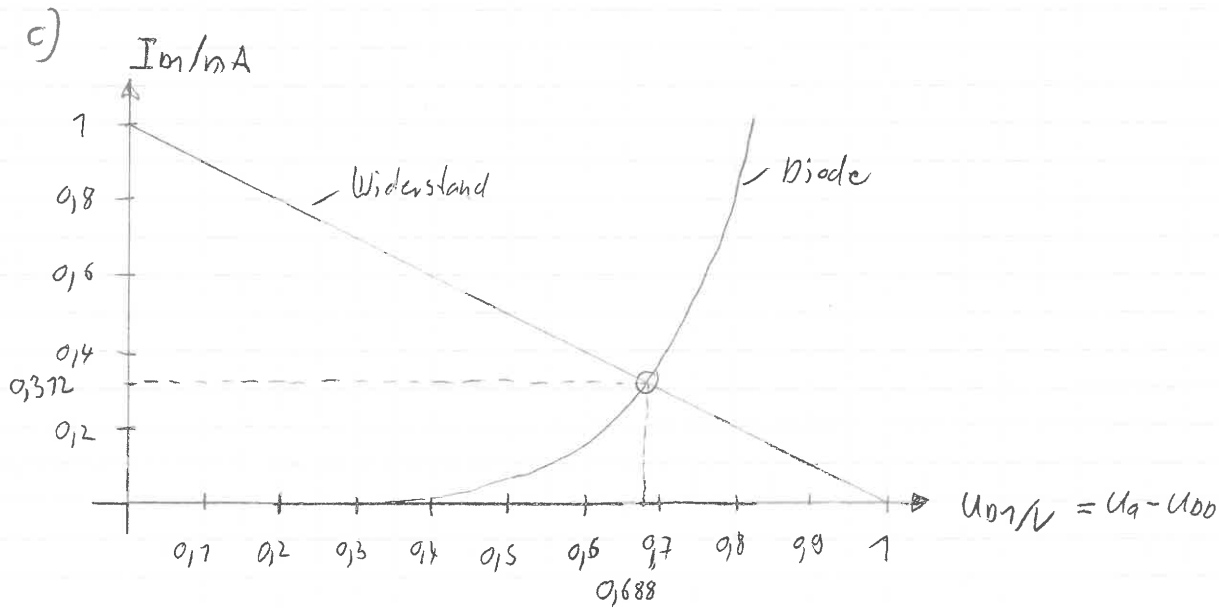
b) $f(U_a) = -R_1 \cdot I_S (e^{-U_a/U_T} - 1) + U_a - U_e = 0$

$f'(U_a) = \frac{R_1 \cdot I_S}{U_T} e^{-U_a/U_T} + 1$

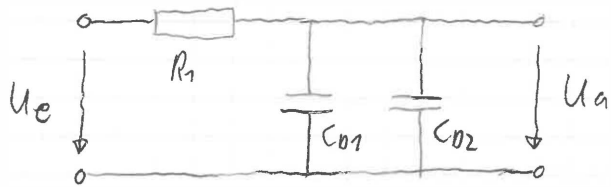
$U_a^{(j+1)} = U_a^{(j)} - \frac{f(U_a^{(j)})}{f'(U_a^{(j)})}$

⋮

$U_a^{(4)} = -0,6881 V$



e) ESB:



$$\Rightarrow \text{Tiefpass mit } f_0 = \frac{1}{2\pi R_1 (C_{01} + C_{02})} = 795,8 \text{ MHz}$$

$$|F(f_0)| = \frac{1}{\sqrt{2}} \quad \arg(F(f_0)) = -45^\circ$$

A2

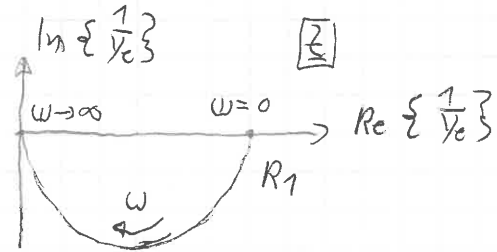
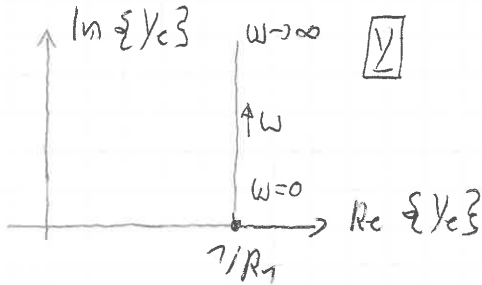
a) $\underline{Y}_{11} = \frac{1}{R_1} + j\omega C_1$

$\underline{Y}_{12} = 0$

$\underline{Y}_{21} = g_m$

$\underline{Y}_{22} = \frac{1}{R_2}$

b) $\underline{Y}_c = \frac{1}{R_1} + j\omega C_1$



c) $Z_{L,a} = \frac{1}{2} R_L$

d) $\underline{U}_1 = \frac{R_1}{R_1 + 2R_0 + j\omega Z C_1 R_1 R_0} \underline{U}_0$

e) $V_n = -\bar{u} \cdot g_m \cdot \frac{R_2 \cdot R_L}{2R_2 + R_L} \cdot \frac{R_1}{R_1 + 2R_0 + j\omega Z C_1 R_1 R_0}$

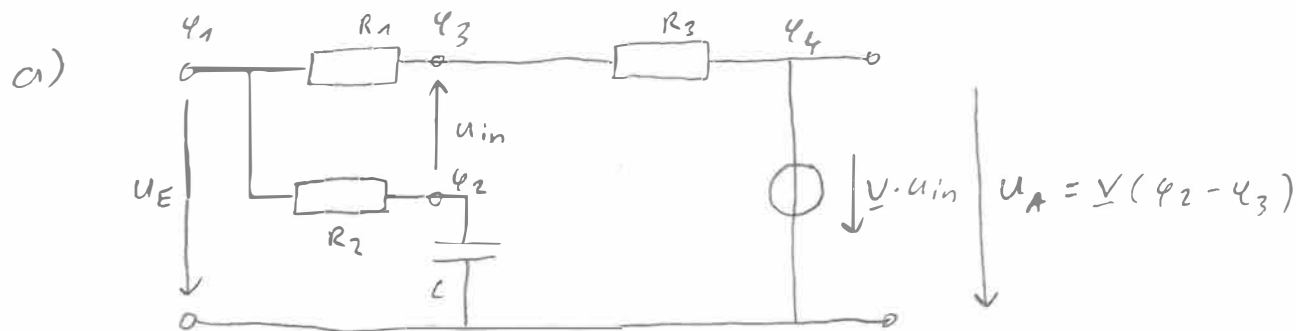
f) $P_w = \frac{|\underline{U}_L|^2}{R_L} = 0,0128 \text{ W}$

g) $\underline{Y}_{11} = \frac{1}{R_1} + j\omega(C_1 + C_2)$

$\underline{Y}_{12} = -j\omega C_2$

$\underline{Y}_{21} = g_m - j\omega C_2$

$\underline{Y}_{22} = \frac{1}{R_2} + j\omega C_2$



φ_1	φ_2	φ_3	φ_4	
1	0	0	0	U_E
$-\frac{1}{R_2}$	$\frac{1}{R_2} + j\omega C$	0	0	0
$-\frac{1}{R_1}$	0	$\frac{1}{R_1} + \frac{1}{R_3}$	$-\frac{1}{R_3}$	0
0	V	-V	-1	0

mit $\varphi_1 = U_E$ und $\varphi_3 = \varphi_2 - \frac{1}{V} \varphi_4$

φ_2	φ_4	
$\frac{1}{R_2} + j\omega C$	0	$\frac{U_E}{R_2}$
$\frac{1}{R_1} + \frac{1}{R_3}$	$-\frac{1}{R_3} - \frac{1}{V} \left(\frac{1}{R_1} + \frac{1}{R_3} \right)$	$\frac{U_E}{R_1}$

$$\frac{U_A}{U_E} = \frac{1}{U_E} \cdot \frac{\det \varphi_4}{\det \Delta} = \frac{\frac{1}{R_1} \left(\frac{1}{R_2} + j\omega C \right) - \frac{1}{R_2} \left(\frac{1}{R_1} + \frac{1}{R_3} \right)}{\left(\frac{1}{R_2} + j\omega C \right) \left(-\frac{1}{R_3} - \frac{1}{V} \left(\frac{1}{R_1} + \frac{1}{R_3} \right) \right)}$$

$$F(j\omega) = \frac{\frac{1}{R_1} \left(\frac{1}{R_2} + j\omega C \right) - \frac{1}{R_2} \left(\frac{1}{R_1} + \frac{1}{R_3} \right)}{\left(\frac{1}{R_2} + j\omega C \right) \left(-\frac{1}{R_3} - \frac{1 + j\omega \frac{V_0}{\omega_T}}{V_0} \left(\frac{1}{R_1} + \frac{1}{R_3} \right) \right)}$$

Alternativ:

- Maschen + Knoten direkt lösen
- Spannungsteiler

b)

$$F(j\omega) = \frac{\left(1 - j\omega \frac{C R_2 V_0 R_3}{V_0 R_1}\right) \cdot \frac{1}{V_0 R_1}}{\left(1 + j\omega R_2 C\right) \left(1 + j\omega \frac{\left(\frac{V_0}{\omega_T}\right) (R_1 + R_3)}{V_0 R_1 + R_1 + R_3}\right) (V_0 R_1 + R_1 + R_3)}$$

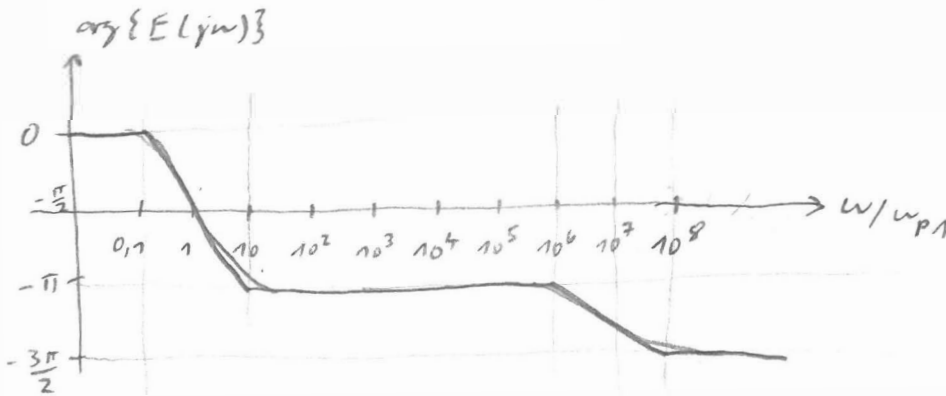
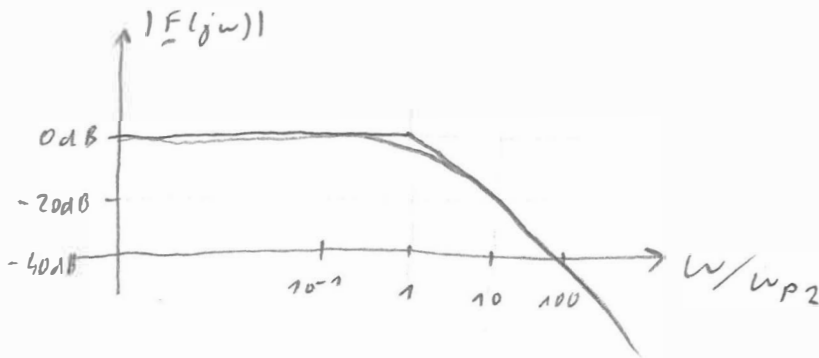
$\frac{1}{\omega_{p1}} \qquad \qquad \qquad \frac{1}{\omega_{p2}}$

$$K \approx 1$$

$$\omega_{n1} = 500 \frac{1}{s}$$

$$\omega_{p1} = 500 \frac{1}{s}$$

$$\omega_{p2} = 5 \cdot 10^3 \frac{1}{s}$$



c)

$$u_E(t) = \frac{u_0}{T_0} (t + T_0) s(t + T_0) - 2u_0 s(t) - \frac{u_0}{T_0} (t - T_0) s(t - T_0)$$



$$V_E(p) = \frac{u_0}{T_0} \frac{1}{p^2} (e^{pT_0} - e^{-pT_0}) - \frac{2u_0}{p}$$

Da $u_E(t)$ beschränkt: KB $\in \mathbb{R}$

$$\Rightarrow V_E(f) = \frac{u_0}{T_0} \cdot \frac{1}{(j2\pi f)^2} (e^{j2\pi f T_0} - e^{-j2\pi f T_0}) - \frac{2u_0}{j2\pi f}$$

$$d) \quad \underline{F}(f) \Big|_{V_0 \rightarrow \infty} = \frac{-j 2\pi f C R_2 R_3 + 1}{(j 2\pi f R_2 C + 1) \left(j 2\pi f \left(\frac{R_1 + R_3}{\omega_T} \right) + R_1 \right)}$$

$$\underline{V}_A(f) = \underline{F}(f) \Big|_{V_0 \rightarrow \infty} \cdot \underline{V}_E(f)$$

e)

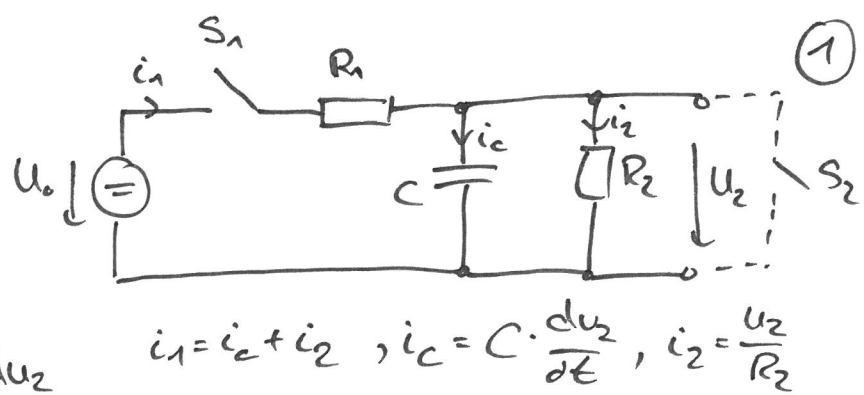
$$V_A(p) = \tilde{K} \frac{(p_1 - p)}{(p + p_2)(p + p_3)} \left(\frac{u_0}{T_0 p^2} (e^{p T_0} - e^{-p T_0}) - \frac{2u_0}{p} \right)$$

$$\tilde{U}_a(t) = A \cdot e^{-p_2 t} s(t) + B e^{-p_3 t} s(t) + C \cdot t \cdot s(t) + D \cdot s(t)$$

$$\tilde{\tilde{U}}_a(t) = E \cdot e^{-p_2 t} s(t) + F \cdot e^{-p_3 t} + G s(t)$$

$$U_a(t) = \tilde{U}_a(t + T_0) - \tilde{U}_a(t - T_0) - \tilde{\tilde{U}}_a(t)$$

Kurzlösung Aufgabe 4



a) $U_0(t) = i_1(t) \cdot R_1 + U_2(t)$

$$U_0(t) = \left[\frac{R_1}{R_2} + 1 \right] U_2(t) + R_1 \cdot C \frac{du_2}{dt}$$

$$\frac{U_0}{p} = \left[\frac{R_1}{R_2} + 1 \right] V_2(p) + R_1 \cdot C \cdot [p \cdot V_2(p) - U_{co}]$$

$$\Rightarrow V_2(p) = \frac{U_0/p + R_1 \cdot C \cdot U_{co}}{1 + \frac{R_1}{R_2} + p \cdot R_1 \cdot C}$$

weiterer Ansatz: Überlagerungssatz

b)
$$V_2(p) = \frac{U_{co} \left(p + \frac{U_0}{U_{co} R_1 C} \right)}{p \left(p + \frac{R_1 + R_2}{R_1 R_2 C} \right)}$$

$$\Rightarrow n_1 = \frac{U_0}{U_{co} R_1 C}, \quad p_1 = 0, \quad p_2 = \frac{R_1 + R_2}{R_1 R_2 C}$$

$$V_2(p) = U_{co} \frac{p + n_1}{p(p + p_2)} \stackrel{!}{=} U_{co} \left(\frac{A}{p} + \frac{B}{p + p_2} \right)$$

$$\Rightarrow A = \frac{n_1}{p_2} = \frac{U_0 R_2}{U_{co} (R_1 + R_2)}$$

$$\Rightarrow B = \frac{n_1 - p_2}{-p_2} = \frac{U_{co} (R_1 + R_2) - U_0 R_2}{U_{co} (R_1 + R_2)}$$

$$\Rightarrow u_2(t) = \left(A \cdot s(t) + B \cdot e^{-p_2 t} s(t) \right) \cdot U_{co}$$

$$u_2(t) = \frac{U_0 R_2}{R_1 + R_2} \left[s(t) + e^{-\frac{R_1 + R_2}{R_1 R_2 C} t} s(t) \right] + U_{co} e^{-\frac{R_1 + R_2}{R_1 R_2 C} t} s(t)$$

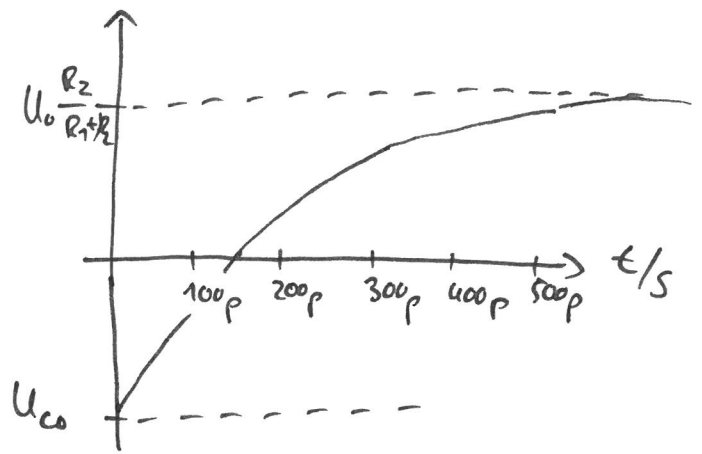
Kurzlösung Aufgabe 4

②

c) $t=0 \Rightarrow u_2(0) = u_{c0}$

$t \rightarrow \infty \Rightarrow u_2(t \rightarrow \infty) = u_0 \frac{R_2}{R_1 + R_2}$

$u_2(t)$



d)

$$i_1(t) = \frac{u_1(t)}{R_1} = \frac{u_0(t) - u_2(t)}{R_1}$$

für $i_{1,max} \rightarrow u_0(t) - u_2(t)$ maximal

$$i_{1,max}|_{t=0} = \frac{5V - (-5V)}{10\Omega} = 1A$$

e)

$$u_f = u_0 - u_2(T_s/2) = 72 \text{ mV}$$

$$u_{c0} = 0V \Rightarrow u_{f0} = u_0 \left(1 - \frac{R_2}{R_1 + R_2} \left(1 - e^{-\frac{R_1 + R_2}{R_1 R_2 C} \frac{T_s}{2}} \right) \right)$$

$$u_{f0} = 38,48 \text{ mV}$$

f)

$$T = R_2 \cdot C = 100 \text{ ns}$$

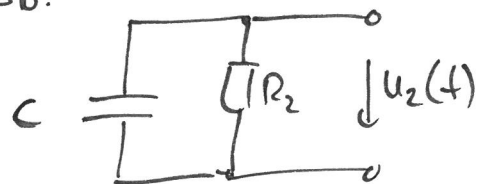
$$AW = u_2(T_s/2)$$

$$EW = 0$$

$$u_2(t) = EW + (AW - EW) e^{-\frac{1}{T}(t - T_s/2)}$$

$$\Rightarrow u_{f,h} = u_2(T_s/2) \left(1 - e^{-\frac{1}{R_2 C} (T_s - T_s/2)} \right) = u_2(T_s/2) \left(1 - e^{-\frac{T_s}{2R_2 C}} \right)$$

ESB:



g) kürzere Haltephase / niedrigere Abtastfrequenz

Hohe Ströme

komplexere Schaltung mit mehr Platzverbrauch