

A7

$$a) f(U_A) = R_1 \cdot I_{s,T_0} \left(e^{\frac{U_A}{2 U_{T,T_0}}} - 1 \right) + U_A - U_0 \stackrel{!}{=} 0V$$

$$f'(U_A) = \frac{R_1 I_{s,T_0}}{2 U_{T,T_0}} \left(e^{\frac{U_A}{2 U_{T,T_0}}} \right) + 1$$

nach 5 Iterationen $U_A = 1,684V$

$$I_D = 0,07376A$$

$$b) U_A = 2(U_D(T_0) + C \cdot (T_1 - T_0))$$

$$= 1,424V$$

$$I_{R_1} = \frac{U_0 - U_A(T_1)}{R_1} = 0,07576A$$

c) Taylorreihe am Entwicklungspunkt $T_1 = 400K$

$$a_0 = 1,1937 \cdot 10^{-11} A$$

$$a_1 = 1,05887 \cdot 10^{-12} \frac{A}{K} \quad \leftarrow \text{Produktregel beachten!}$$

$$\Rightarrow I_s(T, T_1) = 1,1937 \cdot 10^{-11} A + 1,05887 \cdot 10^{-12} \frac{A}{K} (T - T_1)$$

$$d) I_{R_1} = I_s(T, T_1) \left(e^{\frac{U_A}{2 U_{T,T_1}}} - 1 \right)$$

für $T = T_2$

$$T_2 = 404,94K$$

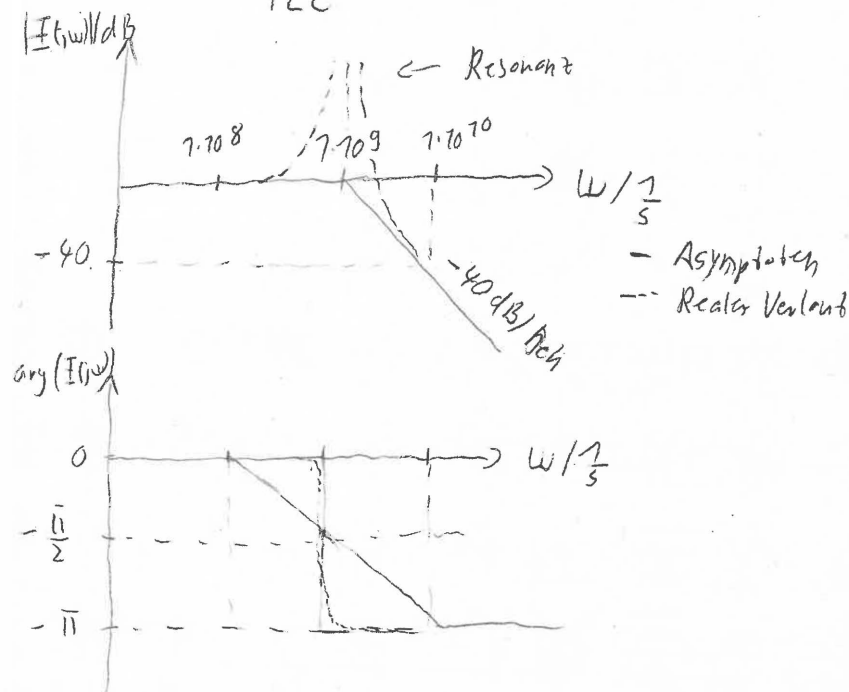
ST Prüfung WS 2027 Kurzlösung

A2

$$a) [A] = \begin{bmatrix} 1 + (j\omega)^2 LC & j\omega 2L + (j\omega)^3 L^2 C \\ j\omega C & 1 + (j\omega)^2 LC \end{bmatrix}$$

$$b) F(j\omega) = \frac{1}{A_{11}} = \frac{1}{1 + (j\omega)^2 LC} \quad d=0$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = 1 \cdot 10^9 \frac{1}{s}$$



$$c) [A_G] = [A] \cdot [A] = \begin{bmatrix} A_{11}^2 + A_{12} \cdot A_{21} & A_{11} \cdot A_{12} + A_{12} \cdot A_{22} \\ A_{21} \cdot A_{11} + A_{22} \cdot A_{21} & A_{21} \cdot A_{12} + A_{22}^2 \end{bmatrix}$$

$$d) \omega = 0 \frac{1}{s} \quad L \rightarrow KS, \quad C \rightarrow LL \quad A \rightarrow \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Leistungsanpassung $R_L = R_i = 50 \Omega$

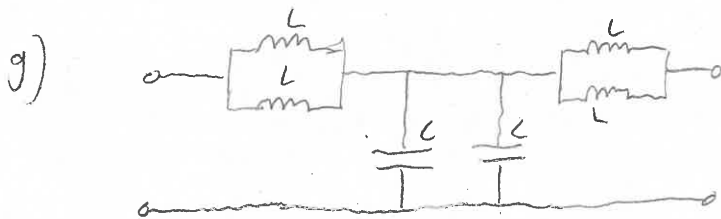
$$e) \underline{U}_2 = \frac{1}{A_{21} R_1 + A_{22} \cdot \frac{R_1}{R_L} + A_{11} + A_{12} \cdot \frac{1}{R_L}} \cdot \underline{U}_0 \quad (6-704)$$

$$U_{2,eff} = 3,743 \cdot 10^{-3} \cdot 7,07V = 0,022V$$

$$P_{RL} = 8,06 \mu W$$

$$f) f \rightarrow \infty \quad L \rightarrow LL, \quad C \rightarrow KS$$

$$P_{RL} = 0W$$



$$C_{neu} = 2C \quad L_{neu} = \frac{L}{2} \rightarrow \text{Vergleich mit Gleichung aus e)}$$

$R_e \{ \underline{U}_2 \}$ bleibt gleich

$\operatorname{Im} \{ \underline{U}_2 \}$ wird größer

$\Rightarrow U_{2,eff}$ wird kleiner $\rightarrow P_{RL}$ wird kleiner

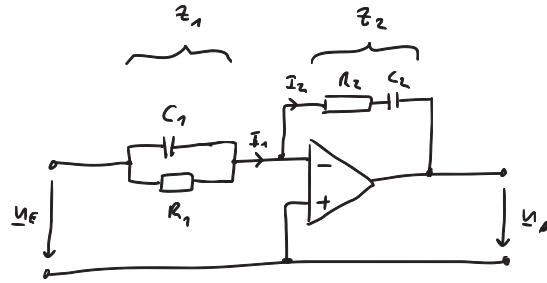
A3 KL

$$a) \quad \underline{Z}_1 = \frac{R_1}{j\omega C_1 R_1 + 1}$$

$$\underline{Z}_2 = \frac{1 + j\omega C_2 R_2}{j\omega C_2}$$

mit $I_1 = I_2$

$$\Rightarrow \underline{F}(j\omega) = \frac{u_a}{u_E} = - \frac{\underline{Z}_2}{\underline{Z}_1} = - \frac{(1 + j\omega C_2 R_2)(1 + j\omega C_1 R_1)}{j\omega C_2 R_1}$$

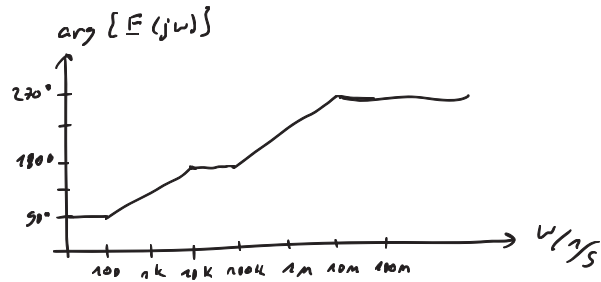
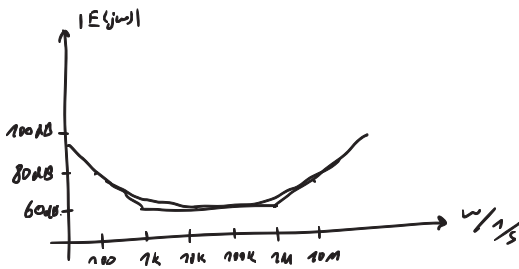


$$b) \quad \underline{F}(j\omega) = - \frac{\left(1 + \frac{j\omega}{\frac{1}{R_2 C_2}}\right) \left(1 + \frac{j\omega}{\frac{1}{R_1 C_1}}\right)}{j\omega \cdot R_1 C_2}$$

$$\omega_1 = \frac{1}{R_1 C_1} = 1 \cdot 10^6 \frac{1}{s}$$

$$\omega_2 = \frac{1}{R_2 C_2} = 10^3 \frac{1}{s}$$

$$\omega_3 = 1/(R_1 \cdot C_2)$$



$$c) \quad u_E(t) = \frac{u_1}{T_1} t \cdot s(t) - \frac{u_2}{T_1} (t - T_1) s(t - T_1) - \frac{u_1}{2T_1} \cdot (t - 3T_1) s(t - 3T_1) + \frac{u_2}{2T_1} (t - 5T_1) s(t - 5T_1)$$

$$v_E(t) = \frac{u_2}{T_1} \cdot \frac{1}{(j2\pi f)^2} \cdot \left(1 - e^{-j2\pi f T_1} - \frac{1}{2} e^{-j2\pi f 3T_1} + \frac{1}{2} e^{-j2\pi f 5T_1}\right)$$

$$d) \quad \underline{V}_a(f) = \underline{V}_E(f) \cdot \underline{F}(j\omega) \Big|_{j\omega = j2\pi f}$$

$$e) \quad \underline{V}_a(p) = \underbrace{\frac{-(1 + \frac{p}{\omega_2})(1 + \frac{p}{\omega_1})}{\frac{p}{\omega_0}}}_{\hat{V}_a(p)} \cdot \underbrace{\frac{u_2}{T_1} \cdot \frac{1}{p^2} \left(1 - 2e^{-pT_1} + e^{-p2T_1}\right)}_{ZV} \quad \text{mit } \omega_0 = \frac{1}{R_1 C_2}$$

$$\tilde{u}_a(t) = - \frac{u_1 \omega_0}{T_1} \left(s(t) \cdot \frac{t^2}{2} + s(t) \cdot t \left(\frac{1}{\omega_1} + \frac{1}{\omega_2} \right) + s(t) \cdot \frac{1}{\omega_1 \omega_2} \right) \quad (\text{keine PBZ notwendig})$$

$$u_a(t) = \tilde{u}_a(t) - 2\tilde{u}_a(t - T_1) + \tilde{u}_a(t - 2T_1)$$

Aufgabe 4 KL

a) $t > 0$:

$$\begin{aligned}
 Z &= \frac{\frac{1}{pC} R_L}{\frac{1}{pC} + R_L} = \frac{R_L}{1 + pCR_L} \\
 \Rightarrow \frac{U_H(p)}{U_0(p)} &= \frac{\frac{R_L}{1 + pCR_L}}{R_i + \frac{R_L}{1 + pCR_L}} = \frac{R_L}{R_L + R_i(1 + pCR_L)} \\
 U_0(p) &= U_0 \frac{1}{p} \\
 \Rightarrow U_H(p) &= \frac{U_0 R_L}{R_L + R_i(1 + pCR_L)} \frac{1}{p} = \frac{1}{p} U_0 \frac{R_L}{R_i R_L C} \frac{1}{p + \frac{R_i + R_L}{R_i R_L C}} \\
 \Rightarrow u_H(t) &= \frac{U_0}{R_i C} \frac{1}{\frac{R_i + R_L}{R_i R_L C}} \left(e^{-\frac{R_i + R_L}{R_i R_L C} t} - 1 \right) s(t) = \frac{U_0 R_L}{R_i + R_L} \left(1 - e^{-\frac{R_i + R_L}{R_i R_L C} t} \right) s(t)
 \end{aligned}$$

b) $e^{-\frac{R_i + R_L}{R_i R_L C} t_0} \stackrel{!}{=} \frac{1}{1000}$

$$-\frac{R_i + R_L}{R_i R_L C} t_0 = \ln\left(\frac{1}{1000}\right) \Rightarrow t_0 = -\frac{\ln\left(\frac{1}{1000}\right)}{\frac{R_i + R_L}{R_i R_L C}} \approx 57,57 \text{ ps}$$

c) $\tilde{t} = t - t_1$

$$\begin{aligned}
 U_{\text{HC0}} &= u_H(t_1) \\
 u_H(\tilde{t}) &= u_C(\tilde{t}) = -R_L \cdot i_C(\tilde{t}) = -R_L \cdot C \cdot \frac{du_C(\tilde{t})}{d\tilde{t}} = -R_L C \frac{du_H(\tilde{t})}{d\tilde{t}} \\
 \circ & \quad \bullet \\
 U_H(p) &= -R_L C (pU_H(p) - U_{\text{HC0}}) \\
 U_H(p) &= \frac{U_{\text{HC0}}}{p + \frac{1}{R_L C}} \quad \bullet \text{---} \circ \quad u_H(\tilde{t}) = U_{\text{HC0}} e^{-\frac{\tilde{t}}{R_L C}} s(\tilde{t}) \\
 u_H(t) &= u_H(t_1) e^{-\frac{t-t_1}{R_L C}} s(t - t_1) \\
 e^{-\frac{1}{R_L C} \tau_2} &\stackrel{!}{=} 1 - \frac{1}{1000} \\
 \tau_2 &= -R_L C \ln\left(1 - \frac{1}{1000}\right) \approx 50,03 \text{ fs}
 \end{aligned}$$

d) $U_{\text{HC2}} = u_H(t_2)$

$$\begin{aligned}
 R_{\text{ges}} &= \frac{R_L R_S}{R_L + R_S} \\
 \text{wie c): } u_H(t - t_2) &= u_H(t_2) e^{-\frac{R_L + R_S}{R_L R_S C} (t - t_2)} s(t - t_2) \\
 u_H(t_2) &= u_H(t_1) e^{-\frac{1}{R_L C} \cdot 100 \text{ ps}} \\
 u_H(t_1) &= \frac{U_0 R_L}{R_i + R_L} \left(1 - e^{-\frac{R_i + R_L}{R_i R_L C} 50 \text{ ps}} \right) \approx 0,83 U_0 = 0,83 \text{ V} \\
 u_H(t_2) &\approx 0,112 U_0 = 0,112 \text{ V} \\
 u_H(\tau_3) &= u_H(t_2) e^{-\frac{R_L + R_S}{R_L R_S C} \tau_3} \stackrel{!}{=} \frac{U_0}{1000}
 \end{aligned}$$

$$\tau_3 = -\frac{R_L R_S C}{R_L + R_S} \ln\left(\frac{1}{0,112 \cdot 1000}\right) \approx 471 \text{ fs}$$

e)

