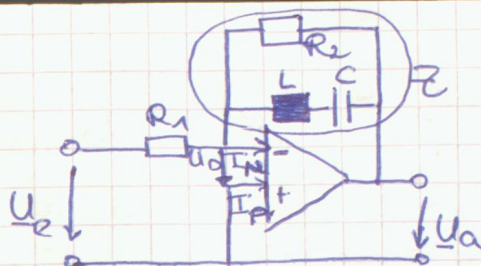


▷ Aufg. 1:

$$a) A(j\omega) = \frac{U_a(j\omega)}{U_e(j\omega)}$$



Op liegt in invertierender Grundschaltung vor, Op ist ideal

$$U_D = 0 \quad I_N = 0 \quad I_P = 0$$

$$A = -\frac{Z}{R_1}$$

Ersatzimpedanz im Rückführzweig:

$$Z = R_2 \parallel (Z_L + Z_C)$$

$$Z_L = j\omega L \quad Z_C = \frac{1}{j\omega C}$$

$$Z = \frac{R_2(j\omega L + \frac{1}{j\omega C})}{R_2 + j\omega L + \frac{1}{j\omega C}} = \frac{R_2(1 - \omega^2 LC)}{1 + j\omega CR_2 - \omega^2 LC}$$

$$A(j\omega) = -\frac{R_2}{R_1} \frac{(1 - \omega^2 LC)}{1 + j\omega CR_2 - \omega^2 LC} \quad \rightarrow 2. \text{ Ordnung} \quad \sim \omega^2$$

b) Amplitudengang $A(\omega) = |A(j\omega)| = \frac{|Z_{\text{Rückf}}|}{|Nennos|}$

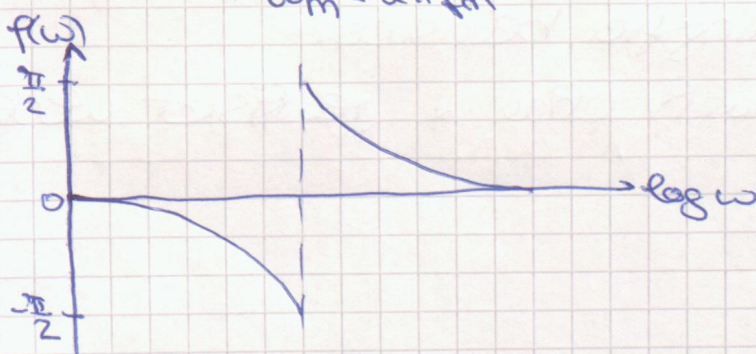
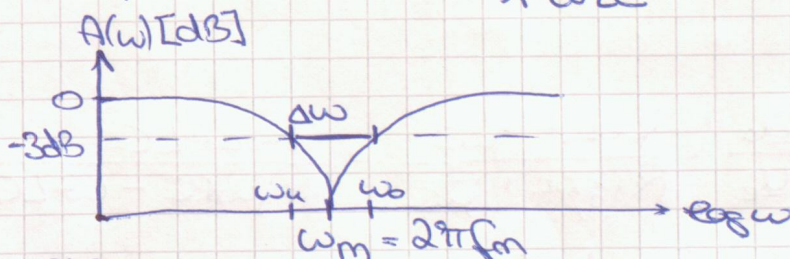
$$A(\omega) = \frac{\frac{R_2}{R_1} |1 - \omega^2 LC|}{\sqrt{(1 - \omega^2 LC)^2 + (\omega R_2 C)^2}}$$

Phasengang $\varphi(\omega) = \angle(A(j\omega)) = \angle(Z_{\text{Rückf}}) - \angle(Nennos)$

$\angle(Z_{\text{Rückf}}) = 0$ ($Z_{\text{Rückf}}$ ist reell)

$\angle(Nennos) = \arctan \frac{\omega R_2 C}{1 - \omega^2 LC}$

$\varphi(\omega) = -\arctan \frac{\omega R_2 C}{1 - \omega^2 LC} \quad \omega \neq \frac{1}{\sqrt{LC}}$



c) $G_{TP} \cdot (P_{TP}) = \frac{A_0}{1 + P_{TP}}$ $P_{TP} = \frac{P}{\omega_g} = \frac{j\omega}{\omega_g}$
 $\hookrightarrow$ Übertragungsfkt. G in Abh. eines normierten Frequenz
 Transformation: $P_{TP} \rightarrow \frac{\Delta\omega}{P_{BS} + \frac{1}{P_{BS}}}$
 $G_{BS} = \frac{A_0}{1 + \frac{\Delta\omega}{P + \frac{1}{P}}}$

$$= \frac{A_0(P + \frac{1}{P})}{P + \frac{1}{P} + \Delta\omega} = \frac{A_0(P^2 + 1)}{1 + \Delta\omega P + P^2}$$

$\omega_g \leadsto \omega_m$ Tülfungsfrequenz

d) Verstärkung des BS ^{Bandbreite} bei $\omega=0$
 (stat. Verstärkung)

$$G_{BS}(P=0) = A_0 = A_{BS}$$

Güte $Q = \frac{1}{\Delta\omega}$ $\Delta\omega =$ Bandbreite der Sperr
 (normiert)
 $= \frac{\Delta\omega}{\omega_m}$

$$G_{BS}(P) = \frac{A_{BS}(P^2 + 1)}{1 + \frac{P}{Q} + P^2}$$

e) $P = \frac{j\omega}{\omega_m} \rightarrow G_{BS}(j\omega) = \frac{A_{BS}(1 - \frac{\omega^2}{\omega_m^2})}{1 + j\frac{\omega}{\omega_m} \frac{1}{Q} - \frac{\omega^2}{\omega_m^2}}$

Reell vgl. mit $A(j\omega)$

$$A_{BS} = \frac{R_2}{R_1} \stackrel{!}{=} 1 \stackrel{!}{=} 0dB \leadsto R_1 = R_2$$

$$\frac{1}{\omega_m Q} = R_2 C \leadsto R_2 = 31,8 \Omega$$

$$\frac{1}{\omega_m^2} = LC \leadsto L = 101,3 mH$$

Teil 2:

f) Filter 3: $\frac{U_a}{U_e} = \frac{j\omega L + \frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}} = \frac{1 - \omega^2 LC}{1 + j\omega RC - \omega^2 LC}$

g) - richtungsfrei, belastbar

- könnte auch ohne L realisiert werden

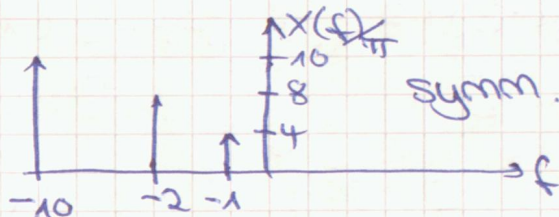
▷ Aufg. 2:

$$x(t) = 10 + 4 \cos(2\pi t) + 8 \cos(4\pi t) + 10 \cos(20\pi t)$$

KS KS

$$\omega = 2\pi f$$

a) $X(f) = 20\pi \delta(f) + 4\pi (\delta(f-1) + \delta(f+1))$
 $+ 8\pi (\delta(f-2) + \delta(f+2)) + 10\pi (\delta(f-10) + \delta(f+10))$

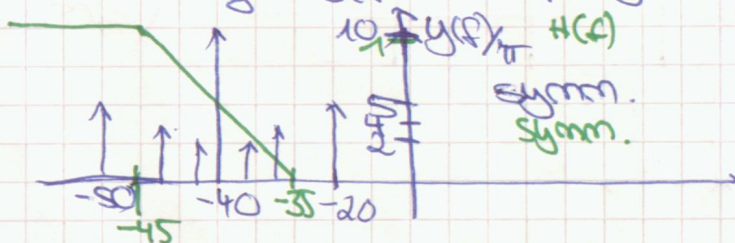


b) $\omega_c = 80\pi \rightarrow f_c = 40 \text{ [Hz]}$

$$y(t) = x(t) \cdot d(t) = x(t) \cos(\omega_c t)$$

$$Y(f) = \frac{1}{2} X(f) * (\delta(f-f_c) + \delta(f+f_c))$$

Filtrierung: $S(f) = H(f) \cdot Y(f)$



$$S(-50) = 5\pi$$

$$S(-42) = 2,8\pi \quad \left(\frac{7}{10} 4\pi\right)$$

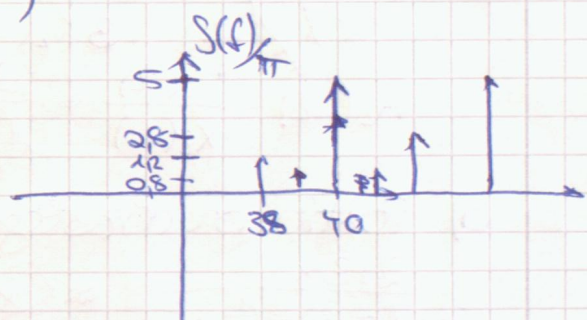
$$S(-40) = 1,2\pi$$

$$S(40) = 5\pi$$

$$S(-39) = 0,8\pi$$

$$S(-38) = 1,2\pi$$

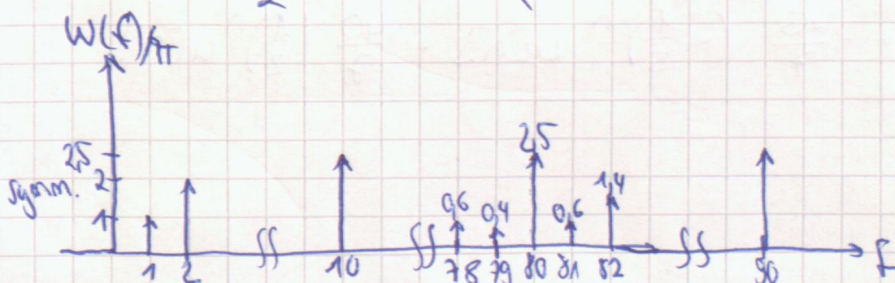
$$S(-30) = 0$$



c) $w(t) = S(t) \cos(\omega_c t)$

$$f_c = 40 \text{ KS}$$

$$W(f) = \frac{1}{2} S(f) * (\delta(f-40) + \delta(f+40))$$



$$d) 10 \leq \omega_0 \leq 78 \text{ [Hz]}$$

▷ Aufg. 3:

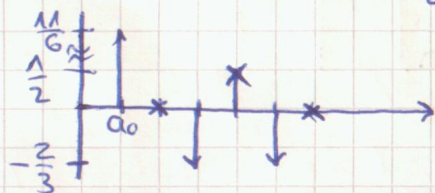
$$I a) x_1[n] = 3\delta[n-2] + 2\delta[n-1] + \delta[n] + 2\delta[n+1] + 3\delta[n+2]$$

$$N=6$$

$$\begin{aligned} a_k &= \frac{3}{6} e^{-jk \frac{2\pi}{6}} (-2) + \frac{2}{6} e^{-jk \frac{2\pi}{6}} (-1) + \frac{1}{6} \\ &\quad + \frac{2}{6} e^{-jk \frac{2\pi}{6}} \cdot 1 + \frac{3}{6} e^{-jk \frac{2\pi}{6}} \cdot 2 \\ &= \frac{1}{2} \left(e^{jk \frac{2\pi}{3}} + e^{-jk \frac{2\pi}{3}} \right) + \frac{1}{6} + \frac{1}{3} \cdot 2 \cdot \left(\frac{1}{2} \left(e^{jk \frac{\pi}{3}} + e^{-jk \frac{\pi}{3}} \right) \right) \\ &\quad \cos \frac{2\pi k}{3} \qquad \cos \frac{k\pi}{3} \end{aligned}$$

$$a_k = \frac{1}{6} + \cos\left(\frac{2\pi k}{3}\right) + \frac{2}{3} \cos\left(\frac{k\pi}{3}\right)$$

$$b) \begin{array}{c|c|c|c|c|c} a_0 & a_1 & a_2 & a_3 & a_4 & a_5 \end{array} \quad (k=0 \text{ bis } 5) \quad \text{einsetzen}$$



$$\begin{aligned} II c) y_2(z) &= \frac{3}{10} y_2(z) e^{-j\Omega} - \frac{1}{10} y_2(z) e^{-2j\Omega} \\ &= 2x_2(z) + 3x_2(z) e^{-j\Omega} \\ H_2(z) &= \frac{y_2(z)}{x_2(z)} = \frac{2 + 3e^{-j\Omega}}{1 + \frac{3}{10} e^{-j\Omega} - \frac{1}{10} e^{-2j\Omega}} \end{aligned}$$

d) Partialbruchzerlegung

$$\frac{2+3x}{1-\frac{3}{10}x-\frac{1}{10}x^2} \quad x = e^{-j\Omega}$$

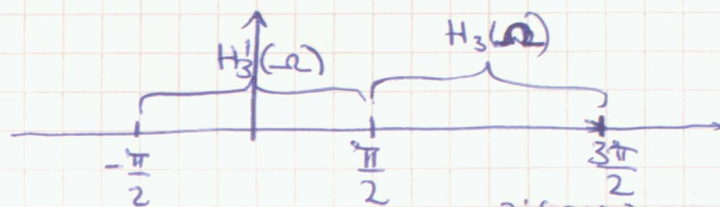
$$= \frac{A}{x+5} + \frac{B}{x-2}$$

$$A = -\frac{80}{7} \quad B = -\frac{130}{7}$$

$$H_2(z) = \frac{-\frac{80}{7}}{e^{-j\Omega} + 5} + \frac{-\frac{130}{7}}{e^{-j\Omega} - 2}$$

$$h_2[n] = -\frac{26}{7} \left(-\frac{1}{5}\right)^n u[n] + \frac{40}{7} \left(\frac{1}{2}\right)^n u[n]$$

III e)



$\leftarrow H_3$ verschoben zu H_3'

$$H_3'(\Omega) = H_3(\Omega + \pi) = \begin{cases} e^{-3j(\Omega + \pi)} \\ 0 \end{cases}$$

$$|\Omega| \leq \frac{\pi}{2}$$

$$\frac{\pi}{2} < |\Omega| \leq \pi$$

$$R_3'[n] = -\frac{\sin(\frac{\pi}{2}(n-3))}{\pi(n-3)}$$

mit Frequenzverschiebung:

$$R_3[n] = -e^{j\pi n} \cdot \frac{\sin(\frac{\pi}{2}(n-3))}{\pi(n-3)}$$

f) Faltung:

$$y_3[n] = R_3[n] * \cos(\frac{\pi}{4}n) + R_3[n] * \cos(\frac{2\pi}{3}n + \frac{\pi}{2}) + R_3[n] * 3\delta[n-5] + 2R_3[n]$$

$$y_3[n] = \underbrace{|H_3(\frac{\pi}{4})|}_0 \cdot \cos(\frac{\pi}{4}n) + \underbrace{|H_3(\frac{2\pi}{3})|}_1 \cdot \cos(\frac{2\pi}{3}n + \frac{\pi}{2} + \angle H_3(\frac{2\pi}{3}))$$

$$+ 3 \cdot R_3[n-5]$$

$$= \cos(\frac{2\pi}{3}n - \frac{3}{2}\pi) - 3e^{j\pi(n-5)} \cdot \frac{\sin(\frac{\pi}{2}(n-8))}{\pi(n-8)}$$

▷ Aufg. 4:

$$\omega_A = \frac{2\pi}{T} = 40\pi \text{ kHz}$$

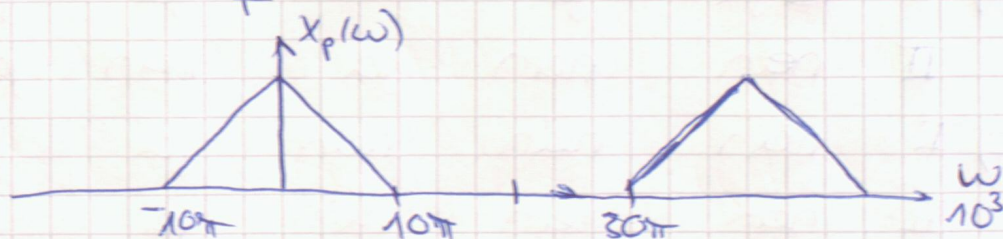
$$a) x_p(t) = F\{x(t) \cdot p(t)\} = \frac{1}{2\pi} X_c(\omega) * P(\omega)$$

Thema 3
Folie 5.1

$$p(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT)$$

$$P(\omega) = \frac{2\pi}{T} \sum_{k=-\infty}^{\infty} \delta(\omega - k\omega_A)$$

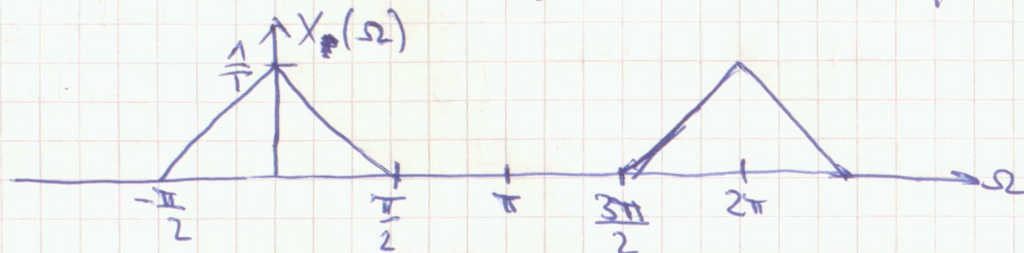
$$X_p(\omega) = \frac{1}{2\pi} \underbrace{\frac{2\pi}{T}}_1 \sum_{k=-\infty}^{\infty} X_c(\omega - k\omega_A)$$



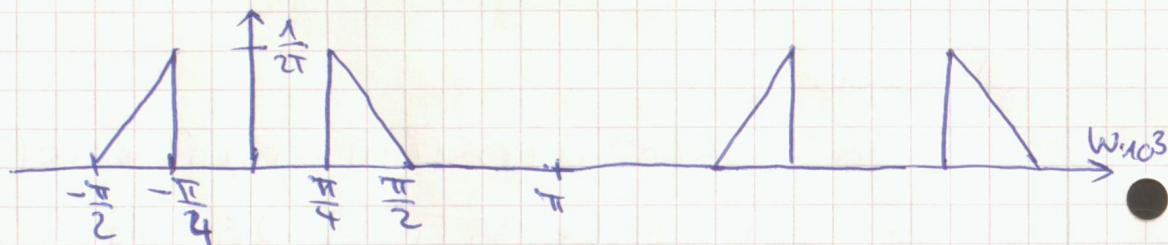
b) $X(\Omega)$

$$x[n] = x_c(nT)$$

$$X(\Omega) = F\{x[n]\} = F\{x_c(nT)\} = X_p\left(\frac{\Omega}{T}\right)$$

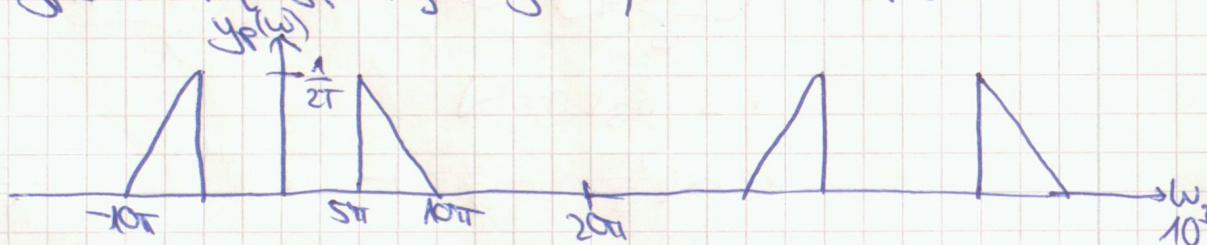


c) $y(\Omega) = X(\Omega) \cdot H_1(\Omega)$

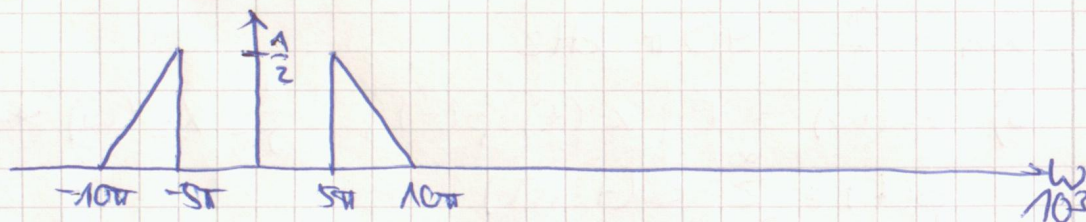


d) $y_p(\omega) = F\{y_p(t)\} = y(\omega T)$

Umrechnung
siehe b



e) $y_c(\omega) = y_p(\omega) \cdot H_2(\omega)$



▷ Aufg. 25:

a) I: ② II: ①

b) I: ~~ja~~ ja nein ja ja

II: nein nein ja nein ja

c) I: nein nein nein ja

II: nein nein nein ja

III: ja ja ja nein