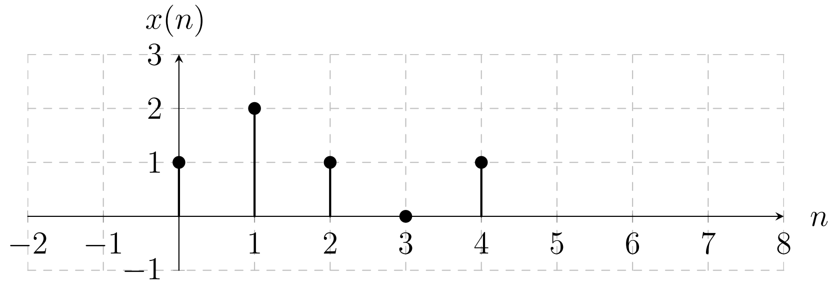
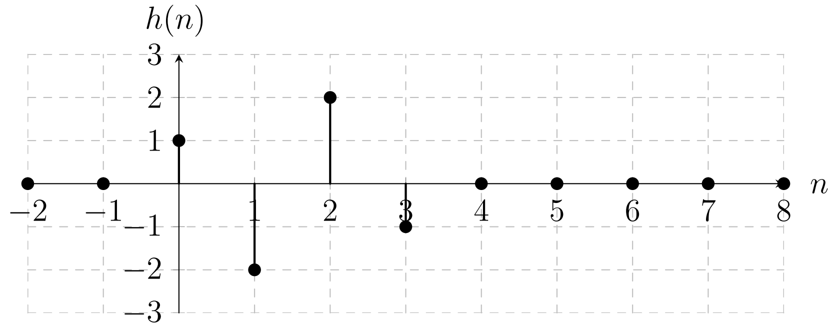
Musterlösung zur Klausur
"Digitale Signalverarbeitung"
11.03.2014

Aufgabe 1

a.) (1 Punkt)

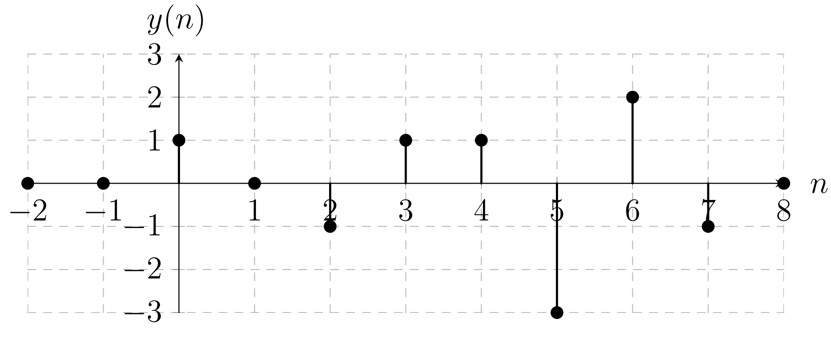


b.) (2 Punkte)



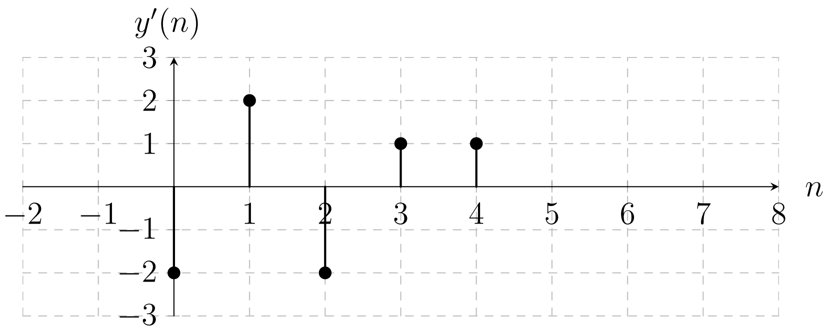
c.) (1 Punkte)
Ja, Typ IV. Punktsymmetrie und ungerade Filterordnung.

d.) (3 Punkte)



e.) (1 Punkt)
Tiefpass, da "zero at $\Omega = 0$" bzw. herausfiltern des Gleichanteils in $y(n)$ zu sehen.

f.) (2 Punkte)



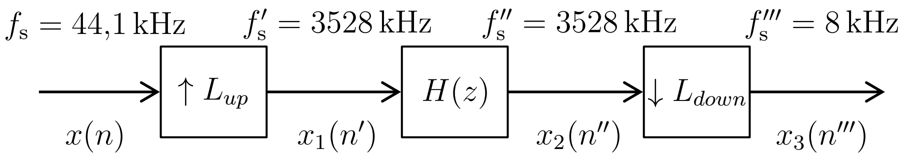
g.) (1 Punkte)
$K = 5 + 4 - 1 = 8$

Aufgabe 2

(10 Punkte gesamt)

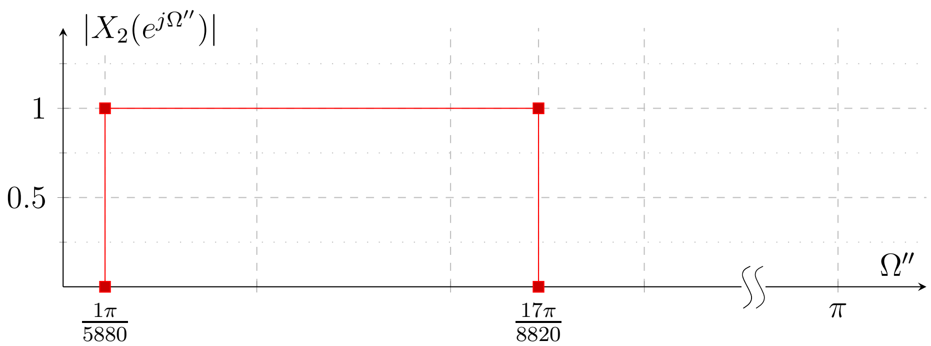
a.) (1 Punkt)
$R = \frac{8\,\text{kHz}}{44{,}1\,\text{kHz}} = \frac{80}{441}$

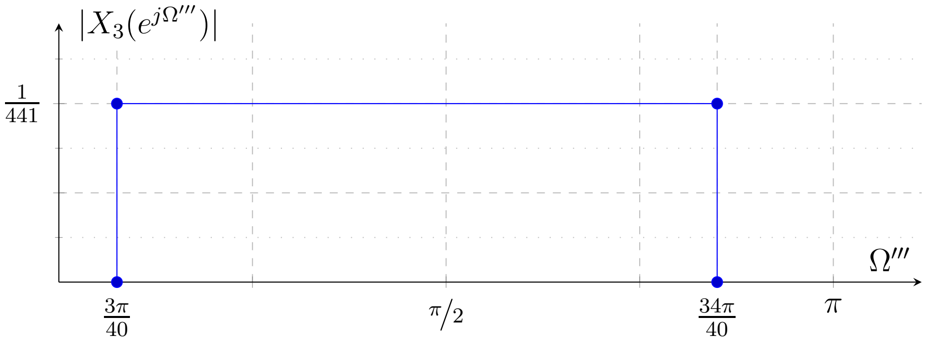
b.) (2,5 Punkte)



$L_{\text{up}} = 80, \quad L_{\text{down}} = 441, \quad \Omega_c = \frac{\pi}{441}$

c.) (4 Punkte)





d.) (1 Punkt)
$f_{c,\ell} = 300\,\text{Hz}$
$f_{c,u} = 3400\,\text{Hz}$

e.) (1,5 Punkte)
$\tilde{d}(\Omega = \pi) = \frac{4/3{,}4}{34/3{,}4} \cdot -1000\,\text{dB} - 3\,\text{dB} = -121\,\text{dB}$

Aufgabe 3

(15 Punkte gesamt)

a.) (1 Punkt)
$\beta = 9$ (siehe Skript S. 160)

b.) (1 Punkt)
Blackman (vgl. Skript S. 156 & 158)

c.) (3 Punkte)
$N_b = 229$ (siehe Skript S. 160)
Nein, Verzögerung λ ist zu groß! $\lambda = N_b/2 = 114{,}5 > 100$ (Abtastwerte)
Laut Skript S. 157 (Blackman): $12\pi/N_b = 0{,}05\pi$.

d.) (2 Punkte)
$d'_{st} = 100 \cdot 2 \cdot 2{,}29 \cdot 0.05\pi + 7{,}95 = 79{,}89$ [dB]

e.) (1 Punkt)
$\beta \geq 0{,}1102 \cdot (79{,}89 - 8{,}7) = 7{,}85,\ \beta = 8$

f.) (4 Punkte)

$$|H_a(j0{,}425\omega_s)|^2 = \frac{1}{1 + (\frac{0{,}425\omega_s}{\omega_c})^{2N}} = (1 - \delta_p)^2 = (0.89125)^2 = 0{,}79433$$
$$|H_a(j0{,}45\omega_s)|^2 = \frac{1}{1 + (\frac{0{,}45\omega_s}{\omega_c})^{2N}} = \delta_{st}^2 = (3.16228 \cdot 10^{-5})^2 = 10^{-9}$$

$$\begin{aligned}
\Rightarrow (\frac{0{,}425\omega_s}{\omega_c})^N &= 0{,}50885 \\
(\frac{0{,}45\omega_s}{\omega_c})^N &= 31622{,}78 \\
\Rightarrow (\frac{0{,}425}{0{,}45})^N &= \frac{0{,}50885}{31622{,}78} \\
\Rightarrow N \cdot \log({}^{17}/_{18}) &= \log(1{,}60912 \cdot 10^{-5}) \\
\Rightarrow N &\geq 193{,}10 \qquad \Rightarrow N = 194
\end{aligned}$$

$$\begin{aligned}
\Omega_c &= ? \\
(\frac{0{,}425\omega_s}{\omega_c})^N &= 0{,}50885 \\
N \cdot \log(\frac{0{,}425\omega_s}{\omega_c}) &= \log(0{,}50885) \\
\log(\frac{0{,}425\omega_s}{\omega_c}) &= -1{,}3711 \cdot 10^{-3} \\
\omega_c &= 0{,}43\omega_s \quad (\widehat{=} 3{,}41\,\mathrm{kHz})
\end{aligned}$$

g.) (1 Punkt)
$|H_a(j\omega_c)|^2 = \frac{1}{1+1}$
$20\log(|H_a(j\omega_c)|) = 20\log(\sqrt{\frac{1}{2}}) = -3\,\mathrm{dB}$

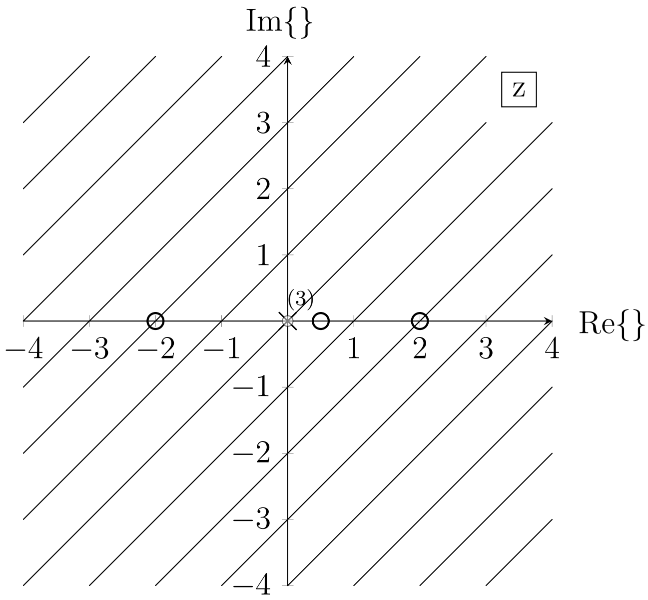
h.) (2 Punkte)
<Argumentation: Linearphasigkeit, Sperrdämpfung, Delay, algorithmische Komplexität, etc.>

Aufgabe 4

a.) (1 Punkt)
$y(n) = x(n) - 0.5x(n-1) - 4x(n-2) + 2x(n-3)$

b.) (1 Punkte)
$h(n) = \delta(n) - 0.5\delta(n-1) - 4\delta(n-2) + 2\delta(n-3)$

c.) (3 Punkte)
$z_{0,1} = 0.5$
$z_{0,2} = 2$
$z_{0,3} = -2$
$z_{\infty,1} = z_{\infty,2} = z_{\infty,3} = 0$
ROC: $|z| > 0$



d.) (3 Punkte)

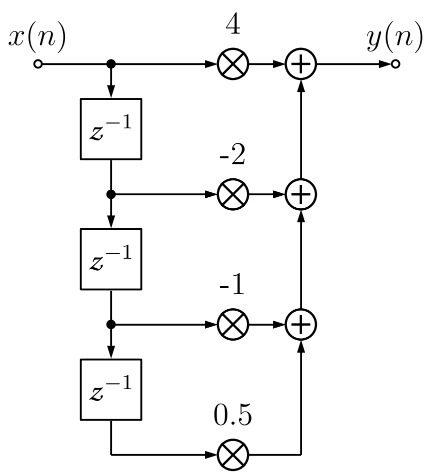
$$H_{\min}(z) = (1 - 0.5z^{-1})(1 - 0.5z^{-1})(1 + 0.5z^{-1})b_0$$

$$H_{\mathrm{AP}}(z) = \frac{(1 - 2z^{-1})(1 + 2z^{-1})}{(1 - 0.5z^{-1})(1 + 0.5z^{-1})}\frac{1}{b_0}$$

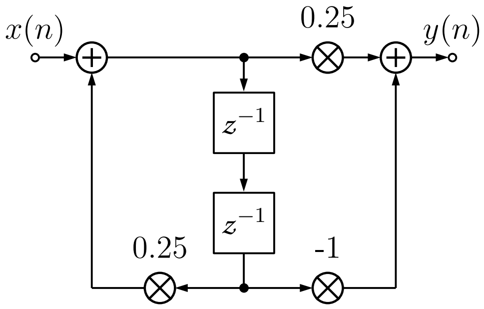
$$b_0 = 4$$

e.) (4 Punkte)

$$H_{\min}(z) = 4 - 2z^{-1} - z^{-2} + 0.5z^{-3}$$



$$H_{\mathrm{AP}}(z) = \frac{0.25 - z^{-2}}{1 - 0.25z^{-2}}$$



f.) (2 Punkte)
$h_{\min}(n) = 4\delta(n) - 2\delta(n-1) - \delta(n-2) + 0.5\delta(n-3)$
minimum energy delay property