

SGN-11006, Basic Course in Signal Processing

Exercise 8.

The first 3 problems should be solved and returned before the deadline: **14.11 at 4pm**. Submit your solutions either through Moodle or in the postbox #527 next to the room TC421. Matlab part is checked during the exercise sessions.

14.11 – 18.11.2016

Problem 1: A causal LTI system has a system function:

$$H(z) = \frac{-1 + z^{-1}}{1 - 0.25z^{-1}} \quad (1)$$

Find the z-transform of the input, $x[n]$, that will produce an output

$$y[n] = 2\left(\frac{3}{2}\right)^n \mu[-n - 1] - \frac{1}{2}\left(\frac{1}{4}\right)^n \mu[n + 1] \quad (2)$$

(3 points)

Problem 2: Calculate the convolution of the following three sequences using the Z-transform:

$$x_1[n] = 2\delta[n] \quad (3)$$

$$x_2[n] = \delta[-n] + \delta[n - 1] \quad (4)$$

$$x_3[n] = 3^n \mu[n+1] \quad (5)$$

(3 points)

Problem 3: Find the region of convergence of the Z-transform of the following sequences:

$$(a) \ x_a[n] = n(2)^n \mu[n+1]$$

$$(b) \ x_b[n] = \begin{cases} 1 & 1 \leq n \leq 3 \\ \delta[n] & \text{otherwise} \end{cases}$$

$$(c) \ x_c[n] = \mu[n] (\star) \mu[n - 1]$$

(4 points)

Problem 4: (Matlab) The following LPF specifications are known for the magnitude response: the maximum $A_{pass} = 0.4455$ dB and minimum

attenuations $A_{stop} = 40$ dB, the sampling rate $F_s = 8000$ Hz, the pass $F_{pass} = 1000$ Hz and stop $F_{stop} = 1500$ Hz frequencies.

Determine the filter order of Butterworth, Chebyshev I, Chebyshev II and Elliptic low-pass filters. Remember to determine the passband and stop-band edge frequencies ω_p and ω_s , respectively. Plot the magnitude responses for the mentioned above LPF (use subplot and `ylim([0 1])`) in the frequency range $f = 0 \dots F_s/2$.

(Check `butterord`, `cheb1ord`, `cheb2ord`, `ellipord`, `butter`, `cheby1`, `cheby2`, `ellip`, `freqz`) (4 points)

Problem 5: (Matlab) Open the GUI FDA Tool typing the command `fdatool` in the Command Window. Design the Elliptic IIR filter with the specifications mentioned in **Problem 4**. Use the Minimum order while setting the parameters. Check the magnitude response and compare it with that you plotted in **Problem 4**. Check the group delay, impulse response, step response and pole/zero plot. (3 points)

Problem 6: (Matlab) Design the Elliptic IIR Bandpass filter in GUI FDA Tool. Set your own specifications, but specify the following filter orders: 4, 12, 26. What happens? (3 points)