LAB4	FILTER DESIGN AND ANALYSIS
	points: 17 hours: 4

Objectives

1. To understand the concepts of the *z*-domain.
2. To understand the concepts of digital filter design and analysis.

Exercise 4.1 [1 point]

Answer the following questions:

a. What is the transfer function of a filter?
b. How is the transfer function of a filter related to its difference equation?
c. What are the zeros and poles of a transfer function?
d. Describe FIR filter design process using windowing.
e. How to obtain the kernel of a high-pass filter from the kernel of a corresponding low-pass filter?

Exercise 4.2 [5 points]

Given five filters described by the following difference equations:

1) $y[n] = 0.36x[n] + 0.22x[n-1] – 0.85x[n-2]$
2) $y[n] = 0.76x[n] + 0.32x[n-1] + 0.15y[n-1]$
3) $y[n] = x[n] – x[n-5]$
4) $y[n] = 0.8x[n] – 0.2y[n-1] – 0.3y[n-2] + 0.8y[n-3]$
5) $y[n] = x[n] – x[n-2] + 0.9y[n-1] – 0.6y[n-2]$

Answer the following questions (for each filter):

a. Is it IIR or FIR filter?
b. Determine filter's transfer function.
c. Determine zeros and poles of filter's transfer function.
d. Draw a rough sketch of filter's frequency response.

Exercise 4.3 (CODE) [3 points]

Write your own code to design low-pass FIR-filter with custom order and cutoff frequency using Window method. Plot impulse response and step response of the designed filter.

Exercise 4.4 (CODE) [2 points]

Write code to plot:

a) frequency response
b) poles and zeros of transfer function

of each of the filters given in exercises 3.2 and 4.2. Compare figures with your analytic solutions of exercises 3.2 and 4.2.

Exercise 4.5 (CODE) [2 points]

Use filter kernel computed in exercise 3.4. Write code that computes new filter kernel to make filter high-pass with the same cutoff frequency. Implement your high-pass filter. Plot the spectrograms of each signal before and after filtering.

Exercise 4.6 (CODE) [4 points]

Create low-pass, band-pass and band-reject filters with the coefficients defined in Eq.4.13-Eq.4.29 and with the following parameters: f_c=1200 Hz; B_W=500 Hz. What does the transfer function of each filter look like? Write code to plot the filter frequency response and its zero-pole diagram. Apply each filter to the signals *s1*, *s2*, and *s3*. Plot the spectrograms of each signal before and after filtering.