LAB1	SIGNAL PROCESSING IN TIME DOMAIN points: 15 hours: 4

Objectives

1. To understand the concepts of signal sampling.
2. To examine the properties of convolution.

Exercise 1.1 [1 point]

Answer the following questions:

a. What is signal? What is system?
b. Give the classification of signals.
c. What does the Nyquist-Shannon-Kotelnikov sampling theorem state? How is it used in practice?
d. Define LTI system. What are the main properties of LTI systems?
e. What is system's impulse response?
f. Describe the convolution operation.
g. What is cross-correlation of signals?

Exercise 1.2 [4 points]

Given an analog audio signal 100ms long with frequencies up to 7000Hz. Answer the following questions:

a. What is the minimum required sampling frequency that allows an exact reconstruction of the signal from its samples?
b. What will happen if the sampling frequency is 5000 Hz?
c. What will happen if the sampling frequency is 15000 Hz?
d. How many samples are needed to store the corresponding digital signal if the sampling frequency is 15000 Hz?

Exercise 1.3 (CODE) [5 points]

In this task you'll programmatically generate digital audio signals. Write code to do the following:

1. Generate signal *s1* consisting of three sinusoids with frequencies *f1*, *f2* and *f3*, respectively. The signal has to be 600 milliseconds long, and it should be sampled with sampling frequency *fs*. The values of the frequencies are given in table 1.1.
2. Generate noise signal *sn* 600 milliseconds long.
3. Superimpose signals *s1* and *sn* (get the "noisy" version of *s1*). The resulting signal will be *s2*.
4. Generate signal *s3* by shifting *s1* by 300 samples.
5. Generate signal *s4*. It must be identical to signal *s1* except that it has to be sampled at frequency fs_4=11025 Hz.
6. Plot the first 50 samples of each signal.

7. Save each signal to WAVE file (set number of channels equal to 1).
8. Load each signal from corresponding WAVE file. Listen to signal *s1* and *s4*. Explain the difference.

Exercise 1.4 (CODE) [3 points]

Write code that computes the convolution and cross-correlation of signals and plots the results. Use signals from Example 2.4 and signal pairs {*s1*, *s2*} and {*s1*, *s3*} as the input into your program. Explain the results. Compare your results with the results of MATLAB functions *conv()* and *xcorr()*.

Exercise 1.5 (CODE) [2 points]

Write code that processes a segment of an input signal and evaluates the following characteristics: 1) energy, 2) zero-cross rate, 3) mean, and 4) variance. The program should allow setting the positions of the first and the last samples of a signal segment to process.

TABLE 1.1. Table of frequencies

№	fs (Hz)	f1 (Hz)	f2 (Hz)	f3 (Hz)
1	44100	900	1400	7100
2	44100	2000	3000	7000
3	44100	1500	4500	8100
4	44100	1200	2500	6300
5	44100	1000	3500	7200
6	22050	900	1400	7100
7	22050	2000	3000	7000
8	22050	1500	4500	8100
9	22050	1200	2500	6300
10	22050	1000	3500	7200
11	16000	900	1400	6100
12	16000	2000	3000	6800
13	16000	1500	4500	6100
14	16000	1200	2500	6300
15	16000	1000	3500	6200