LAB2	SIGNAL PROCESSING IN FREQUENCY DOMAIN points: 15 hours: 4

Objectives

1. To understand the concepts of the DTFT and DFT.
2. To use FFT for spectral analysis and convolution of signals.
3. To demonstrate the Gibbs effect and windowing effects.

Exercise 2.1 [1 point]

Answer the following questions:

a. What is the matter of Fourier transform?
b. What are the Complex Discrete Fourier transform (DFT) and Inverse Complex Discrete Fourier transform (IDFT)?
c. What are magnitude spectrum and phase spectrum of a signal?
d. What does the Convolution theorem state?
e. How is FFT Convolution carried out?
f. What is circular convolution? How to avoid it?
g. What is deconvolution?
h. What is frequency response of a system?
i. How is sinc function related to a rectangular pulse?
j. What is the purpose of window functions? Give the equations of Hanning window, Blackman window, Hamming window, Kaiser window.

Exercise 2.2 [2 points]

Given a signal sampled at frequency 16000 Hz. The FFT is performed over N = 2048 samples.

a. Determine the length of analyzed block in milliseconds.
b. Determine the frequency resolution.

Exercise 2.3 (CODE) [3 points]

In this exercise you will perform simple spectral analysis of signals. Write code to do the following:

1. Open WAVE files containing signals *s1*, *s2*, *s3*, *s4*, *sn* from exercise 1.3. You will also be given speech file LAB2_SPEECH.wav containing signal *s5*. Compute and plot magnitude and phase spectrums of each signal (use FFT size $N = fs$ so that you'll analyze 1 sec of a signal). What can you say about the magnitude spectrum of signal *s4*? Is frequency *f3* present there? Explain your results.
2. Perform the Inverse FFT. Plot your results. Compare obtained signal with source signal.
3. Plot the spectrogram of each signal.

Exercise 2.4 (CODE) [3 points]

In this task you will investigate various window functions. Write code to do the following:

1. Compute and plot the rectangular, Hamming, Hanning, Blackman, and Kaiser window functions of length N = 93 on a single figure.
2. Compute and plot magnitude spectrum on a dB scale of each window. Use FFT size NF=512. What can you say about rectangular window?

Exercise 2.5 (CODE) [3 points]

In this task you will investigate the effect of windowing. Use 1024 samples for FFT. Write code to do the following:

1. Compute the DFT of the signal $x(n) = cos(\pi n/4)$. Use sampling frequency fs = 4096 Hz. Plot the magnitude and phase spectrum of $x(n)$.
2. Truncate $x(n)$ using Hamming window of size 93. Plot its magnitude and phase spectrum. Obtain the 512-point signal $z[n]$ by zero-padding $x[n]$. Plot its magnitude and phase spectrum.
3. Repeat steps 1-2 for signals *s1, s2, s3,* and *sn*.

Exercise 2.6 (CODE) [3 points]

Write code that carries out FFT convolution of two signals. Plot the result. Compare the result with your solution of exercise 1.4.