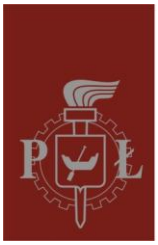

Politechnika Łódzka
Instytut Elektroniki

SIGNAL PROCESSING

Laboratory #5:

Fourier transform of signals in Python

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PURPOSE:

Computing and plotting the Fourier transform of signals in Python environment.

TASKS:

Task 1:

Define a harmonic signal $x(t)=A\sin(2\pi ft)$ of frequency f=50 Hz and amplitude A=10 consisting of N=2000 samples and sampled at a rate of fs=1000 Hz.

a. plot the defined signal in a correct time scale, compute its amplitude Fourier spectrum (using the *fft* command form *scipy.fftpack* package) and plot it in a physical frequency scale in Hertz units; comment the result; (hint: frequency scale of the DFT can be computed from the formula: $kf_0 = k\frac{f_s}{N}$, where f_0 is the frequency resolution);.
b. compute the inverse transform of the Fourier spectrum of the harmonic signal $x(t)$ and plot the result (hint: due to limited computing precision you will need to select and plot the real part of the obtained complex signal)
c. repeat a) by changing just the frequency of the harmonic function to f=50.25 Hz . What difference do you notice in the spectrum plot for the new frequency of the sinusoid? To see better the difference use the *stem* command from the *pylab* package for plotting the spectrum and select the zoom icon  in the figure window and zoom in onto appropriate plot fragment.
d. build a signal being a sum of the three sinusoids: $x1(t)=5\sin(50\pi t)$, $x2(t)=10\sin(100\pi t)$, $x3(t)=20\sin(150\pi t)$. Compute the Fourier amplitude spectrum of the defined signal. Can you determine frequencies and amplitudes of these harmonic functions from the Fourier spectrum?

Task 2:

a. to the signal defined in 1d add a Gaussian noise of zero mean and standard deviation $\sigma = 20$ (hint: use *random.normal* function from the *numpy* package).
b. Plot the obtained noisy signal. Can you determine from the time plot of this signal what are the hidden frequencies in it?
c. Computer and plot the amplitude spectrum of the signal defined in 2a. Can you determine now the harmonic components in the noisy signal?

Task 3:

Load the *ecg_mit. mat* ECG signal given in the Matlab binary file from the signal Processing lecture signal bank.

a. plot the loaded ECG signal in a correct time (in seconds) and amplitude (in mV) scales given a sampling rate of *fs*=360Hz and an 11-bit coding of signal amplitude range: -5mV ÷ +5mV
b. compute and plot the Fourier amplitude spectrum of the first N=1800 samples of the ECG signal; What is the frequency resolution used for plotting this spectrum? How can you comment the obtained poor result showing that the spectra amplitudes are almost zero except for the 0Hz value?
c. now, before computing the Fourier spectrum, remove the mean value (i.e. the DC component) of the ECG signal. Why do we need to do it?
d. can you spot in the plotted spectrum the frequency of the power line contaminating the recorded ECG signal? What is the frequency of the power line in the USA?
e. for the volunteer: propose a method for removing the powerline contamination and verify your method by plotting the enhanced ECG signal in the time domain.

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