Home Project №5

Due on July 28, 2009 - until 6:00pm

Exercise 1

Consider $N = 128$ samples of a continuous-time signal $x_c(t)$ using a sampling period of $T_s = \frac{1}{128}$ sec.

- What is the minimal distance (in Hz) between two (distinct) frequency components of the signal?
- Load the signal `x.mat` to your Matlab workspace.
- Plot the absolute value of the DFT of $x[n]$ in log-scale[1]. What are the frequency components (in Hz) of the original signal $x_c(t)$ according to this analysis?
- To identify more frequency components, one can consider windowing $x[n]$ by either a Hann or a Hamming window. Which window can be expected to perform better in terms of its main-lobe width and peak-to-side lobe ratio parameters? Explain.
- Apply the Hann window to $x[n]$ (using `hann.m`) and plot the absolute value of the DFT of the resulting signal in log-scale. What are the frequency components (in Hz) of the original signal according to this analysis?
- Repeat the previous step using the Hamming window (`hamming.m`)
- Which of the two windows reveals more of the frequency content of $x[n]$ which could not be observed using the rectangular window analysis? Does this meet your expectations? Explain.

<u>Note:</u> Attach all your plots and Matlab codes to your answers.

[1] To this end, you may want to use `semilogy.m`.

Exercise 2

A continuous-time signal $s_c(t) = \sum_{k=1}^{N} \sin(\omega_k t + \frac{\lambda_k}{2} t^2)$ has been sampled with a sampling frequency of $f_s = 1$ kHz with no aliasing distortion.

- Load the sampled signal `s.mat` to your Matlab workspace.
- Determine N, $\{\omega_k\}_{k=1}^{N}$ and $\{\lambda_k\}_{k=1}^{N}$ using the spectrogram of the sampled signal[2]. Note that the spectrogram can be computed by means of the Matlab function `spectrogram.m`.

Attach the spectrogram plot and your Matlab code to your answer.

Exercise 3

We wish to use the Kaiser window method to design a discrete-time filter with generalized linear phase that meets specifications of the following form:

$$\begin{aligned} |H(e^{j\omega})| &\le 0.01, & 0 &\le |\omega| \le 0.25\pi, \\ 0.95 \le |H(e^{j\omega})| &\le 1.05, & 0.35\pi &\le |\omega| \le 0.6\pi, \\ |H(e^{j\omega})| &\le 0.01, & 0.65\pi &\le |\omega| \le \pi. \end{aligned}$$

(a) Determine the minimum length $(M+1)$ of the impulse response and the value of the Kaiser window parameter β for a filter that meets the preceding specifications.

(b) What is the delay of the filter?

(c) Determine the ideal impulse response $h_d[n]$ to which the Kaiser window should be applied.

[2]The spectrogram of $s[n]$ is nothing else but the absolute value of the STFT of $s[n]$