

Home Project №5

Due on July 24, 2009

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-scale¹. 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.

Note: Attach all your plots and Matlab codes to your answers.

¹To 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 signal². 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:

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

- 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.
- What is the delay of the filter?
- Determine the ideal impulse response $h_d[n]$ to which the Kaiser window should be applied.

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