Universität Rostock Traditio et Innovatio

Institute of Communications Engineering

Prof. Dr.-Ing. Sascha Spors
Signal Theory and Digital Signal Processing
Institute of Communications Engineering (INT)
Faculty of Computer Science and Electrical Engineering (IEF)

Lab exercise I in Digital Signal Processing, winter semester 2018/19 (course #24505)

Lecturer: Vera Erbes, email: vera.erbes@uni-rostock.de, room: W: 8.211
Authors: Frank Schultz, Vera Erbes

All 4 lab exercises are due 10th Feb. 2019.

DFT and Windowing

Exercise: Windowing of a harmonic signal (10 points)

Solve the following tasks in Matlab or Python.

a) Generate two sine signals of $f_1 = 200$ Hz and $f_2 = 200.25$ Hz and amplitude $|x[k]|_{\max} = 1$ for the sampling rate $f_s = 800$ Hz in the range of $0 \leq k < N = 1600$. **(1 point)**

b) Generate a rectangular window, a Hanning window (in Matlab: `w = hann(N,'periodic')`) and a flat top window (in Matlab: `w = flattopwin(N,'periodic')`) with the same length as the sine signals. **(1 point)**

c) Window both sine signals with the three windows and calculate the DFT spectra. **(1 point)**

d) Plot the absolute value of the DFT spectra in dB as in fig. 1, 2 and 3. Pay attention to using the same normalisation: The DFT values apart from DC and $\frac{f_s}{2}$ have to be normalised with $\frac{2}{N}$ before calculating the logarithm to achieve physically interpretable spectra. **(1 point)**

e) Plot the magnitude spectra of the three windows in dB normalised to their maximum. Use zero-padding or the formulas for interpolation towards the DTFT to achieve a sufficiently high resolution of the spectra to show the characteristics of the windows. **(1 point)**

f) Interpret the results of d) with the help of e) regarding the best and worst case for the different windows. Why do the results for the signals with frequencies f_1 and f_2 differ? **(2 points)**

g) Determine the width of the main lobe (at the -3 dB corner frequencies) and the attenuation of the highest side lobe from the window spectra. **(1 point)**

h) Explain for which signal analysis task the rectangular window and the flat top window should be used. **(1 point)**

i) Do some research on your own: Which advantages exhibit the Kaiser-bessel (in Matlab: `kaiser`) and the Dolph-Chebyshev (in Matlab: `chebwin`) window? **(1 point)**

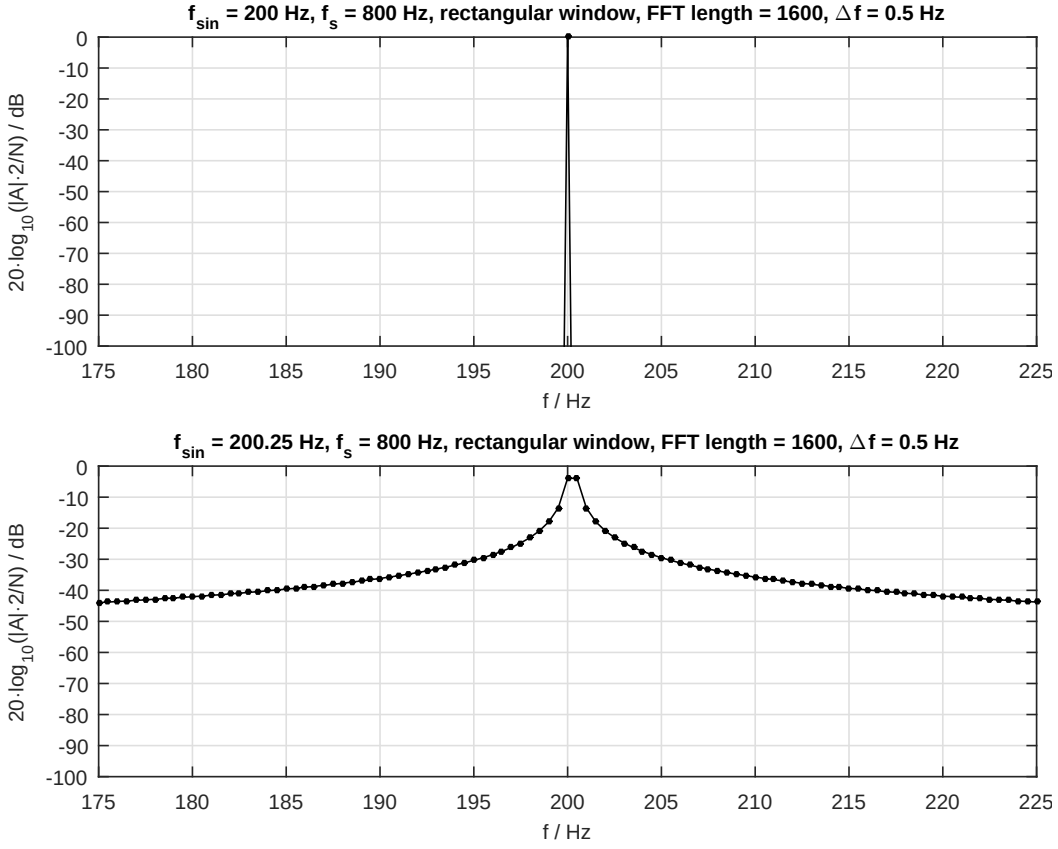

Figure 1: Rectangular windowing of sine signals

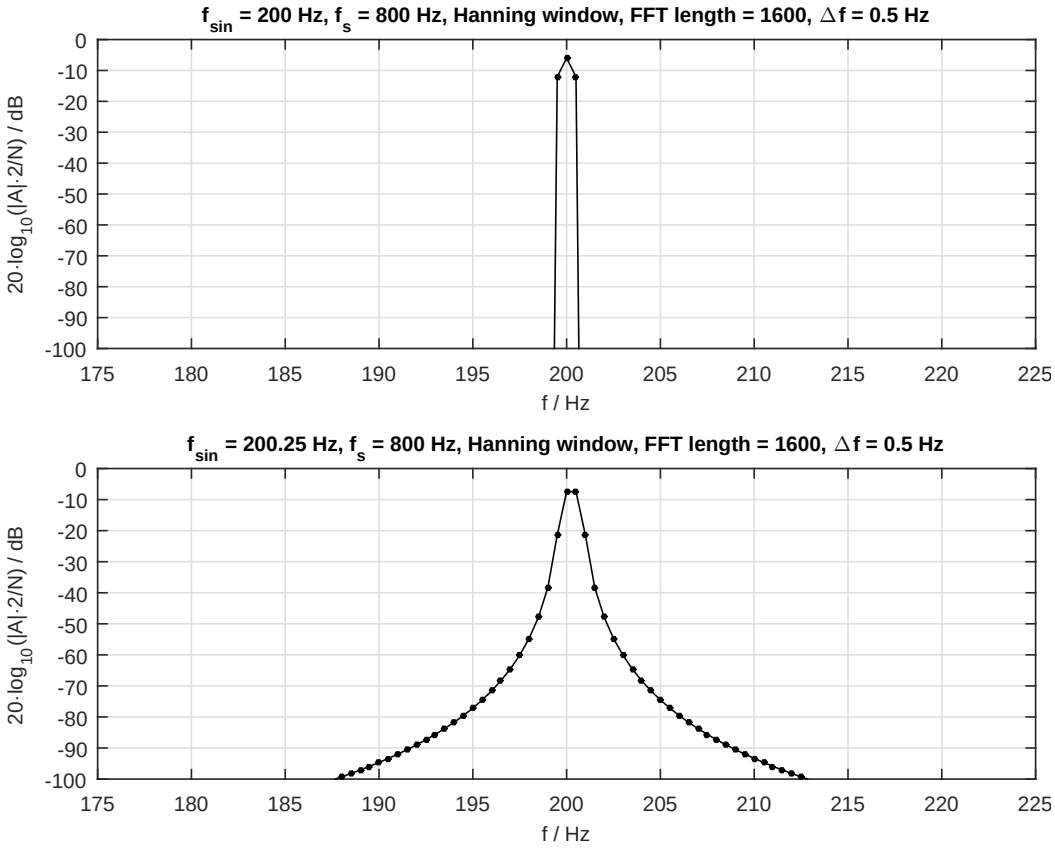

Figure 2: Hanning windowing of sine signals

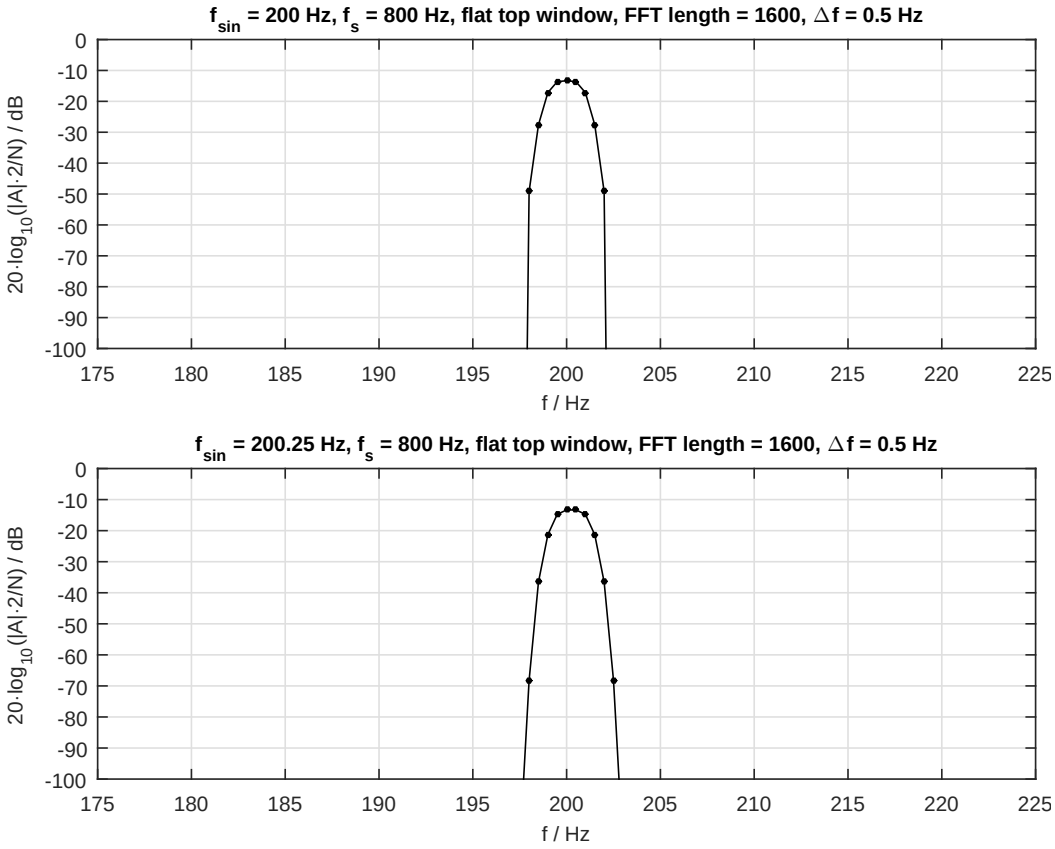

Figure 3: Flat top windowing of sine signals