

ECE 310: Problem Set 11

Due: 5pm, Friday November 16, 2018

1. Design a length-18 FIR low pass filter with cutoff frequency $\omega_c = \frac{\pi}{3}$ radians, using the window design method.
 - (a) Find an expression for the filter coefficients $\{h_n\}_{n=0}^{17}$ if the rectangular window is used for the design.
 - (b) Find an expression for the filter coefficients $\{h_n\}_{n=0}^{17}$ if the Hamming window is used for the design.
2. Find an expression for the filter coefficients $\{h_n\}_{n=0}^{29}$ of a FIR high-pass filter with cutoff frequency $\omega_c = \frac{2\pi}{3}$ radians, using the following methods:
 - (a) Directly using window design with a Hann window.
 - (b) First designing a low-pass filter and then converting it to a high-pass filter (and again using a Hann window).
3. Design a length-8, anti-symmetric (i.e., having odd symmetry) differentiating FIR filter ($D_d(\omega) = j\omega$ before shifting) using the window design method with a simple truncation (i.e., rectangular/boxcar) window. Give the filter coefficients as your answer.
4. The Hann window function can be written as

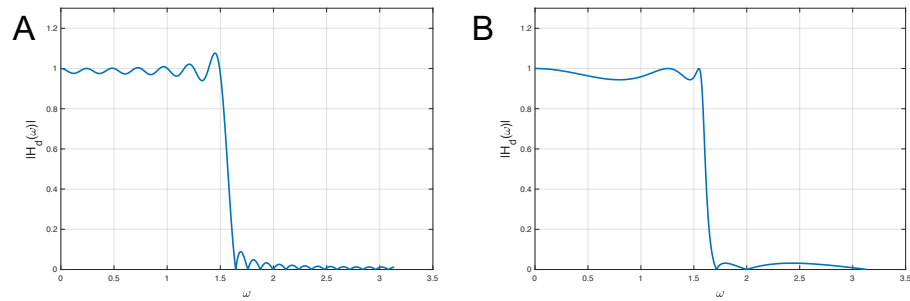
$$w[n] = [0.5 - 0.5 \cos(2\pi n/N)] w_R[n],$$

where $w_R[n]$ is the rectangular window of length $N + 1$.

- (a) Express the DTFT of $w[n]$ in terms of the DTFT of $w_R[n]$,
 - (b) Express the DTFT of $w[n]$ as $W_d(\omega) = A(\omega)e^{-j\omega N/2}$, where $A(\omega)$ is a real-valued function. By analyzing the shape of $A(\omega)$, explain why the Hann window has a wider mainlobe but lower sidelobes than the rectangular window of the same length.
5. Using the windowing method, you are supposed to design a GLP FIR bandpass filter to approximate a filter with the following specifications:
 - Stop band 1: $[0, 0.2\pi]$, attenuation of at least 30dB;
 - Stop band 2: $[\pi/2, \pi]$, attenuation of at least 45dB;
 - Pass band: $[0.3\pi, 0.45\pi]$; Passband ripple: at most 1dB.

Suppose you are only given four choices of windows: rectangular, Hann, Hamming, and Blackman. Which window choice would allow you to meet the design specifications with the shortest filter length? Determine the filter length and filter cutoffs to be used in your design. Explain your answers.

6. (a) Determine which of the following magnitude frequency responses corresponds to an FIR filter and which one corresponds to an IIR Elliptic filter. Explain your answer. Which considerations should you use if you had to decide between these two types of filter?



- (b) Both magnitude frequency responses below correspond to IIR filters. Determine the IIR filter types, explaining your reasoning. Which considerations should you use if you had to decide between these two types of filter?

