FALL 24 EC516 Problem Set 08

Due: Sunday November 3 (Before 11:59pm)

You must submit your homework attempt on Blackboard Learn. For this purpose, you must convert your homework attempt to a pdf file and upload it at the corresponding homework assignment on Blackboard Learn.

Problem 8.1

In this problem, we consider the design linear phase FIR filters using the Kaiser Windowing Method. Please refer to *slide set 2* for FIR filter Design on the Content section of the Blackboard Learn site for EC516.

a) Suppose we want to design a lowpass filter for which $\delta_p = \delta_s = 0.15$, $\omega_p = 0.5\pi$ and $\omega_s = 0.75\pi$. Determine the length and the value of the shape parameter (β) of the Kaiser window.
b) Suppose we want to design a lowpass filter for which $\delta_p = \delta_s = 0.15$, $\omega_p = 0.5\pi$ and $\omega_s = 0.75\pi$. Determine the length and the value of the shape parameter (β) of the Kaiser window.
c) Suppose we want to design a lowpass filter for which $\delta_p = \delta_s = 0.09$, $\omega_p = 0.5\pi$ and $\omega_s = 0.75\pi$. Determine the length and the value of the shape parameter (β) of the Kaiser window.
d) Suppose we want to design a lowpass filter for which $\delta_p = \delta_s = 0.09$, $\omega_p = 0.5\pi$ and $\omega_s = 0.65\pi$. Determine the length and the value of the shape parameter (β) of the Kaiser window.

Problem 8.2

In this problem, we consider the design of linear phase FIR filters using the Optimal FIR Filter Design Method. Please refer to *slide set 3* for FIR filter Design in the Content section of the Blackboard Learn site for EC516. Suppose we want to design a lowpass filter for which $\delta_p = 0.10, \delta_s = 0.05$, $\omega_p = 0.5\pi$ and $\omega_s = 0.75\pi$.

a) Explain why you would prefer Optimal FIR Filter Design over the Windowing Design for these specifications.
b) The length $(2L + 1)$ of the impulse response of a Type I FIR filter can be selected by picking the smallest odd integer that is greater than the following quantity:
$$\frac{-10log_{10}(\delta_p\delta_s) - 13}{14.6(\omega_s - \omega_p)/(2\pi)}$$
Determine the length of the impulse response of the Optimal FIR filter for the given design specifications in this problem.
c) What would have been the length of the Kaiser window had the Kaiser windowing method been used to design a filter for the same design specifications as given in the beginning of this problem?
d) For the impulse-response length you determined in part (b) of this problem, what is the highest integer power of $\cos(\omega)$ that could be present in the function $R(\omega)$ when Optimal FIR Filter Design is used to produce a filter with frequency response $H(e^{j\omega}) = R(\omega)e^{-jL\omega}$. Explain your answer.

Problem 8.3

Let $g[n] = x[n]w[n]$ be the observation signal obtained by windowing the signal $x[n]$ by the window $w[n]$. Suppose $x[n] = \cos(0.25\pi n) + \cos(0.5\pi n) + \cos(0.6\pi n)$ and suppose the $w[n]$ is a rectangular (box) window of length *N*.

a) If $N = 4$, explain why the observation signal $g[n]$ cannot provide sufficient frequency resolution to separate the frequency components of $x[n]$. Use a hand plot of $|G(e^{j\omega})|$ to supplement your explanation.
b) What is the smallest value of *N* for which the observation signal $g[n]$ can be said to provide sufficient frequency resolution to separate the frequency components of $x[n]$? Explain your answer with the aid of a hand plot of $|G(e^{j\omega})|$.
c) Explain what happens to the frequency resolution of a spectral analyzer as $N \to \infty$.

Problem 8.4

Fill in the blanks:

a) F_________ R_________ of a spectral analyzer is produced as a result of the *D*________ Process for a spectral analyzer
b) The L_______ and the S_______ of the observation window are produced as a result of a D________ Process for a spectral analyzer.