ECE113: DSP

Homework 8

Due 06/04/2021, 11:59pm

Problem 1: Problem 3.45 in R1

Problem 2: Problem 4.22 in R1 ((c) and (e) only)

Problem 3: Problem 5.27 in R1

Problem 4: Problem 5.68 in R1 ($r_{xy}(l)$ only)

Problem 5: Problem 5.84 in R1

MATLAB:

Design a linear-phase bandpass filter using the Hann window design technique. The specifications are

$$\begin{array}{ll} \text{lower stopband edge: } 0.2\pi & A_s = 40 \text{ dB} \\ \text{upper stopband edge: } 0.75\pi & \\ \text{lower passband edge: } 0.35\pi & R_p = 0.25 \text{ dB} \\ \text{upper passband edge: } 0.55\pi & \end{array}$$

Plot the impulse response and the magnitude response (in dB) of the designed filter.

Hints:

1) Use "fir1" function with proper arguments.
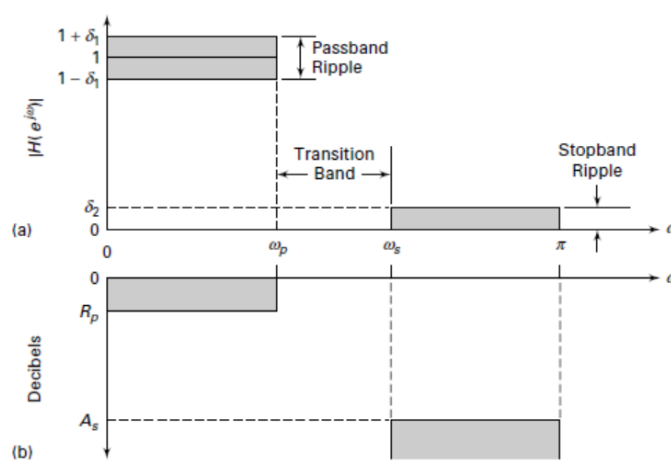2) Note that the stopband attenuation A_s and the passband ripple R_p are defined as follows:

$$R_p = -20 \log_{10} \frac{1 - \delta_1}{1 + \delta_1} > 0 \ (\approx 0)$$

$$A_s = -20 \log_{10} \frac{\delta_2}{1 + \delta_1} > 0 \ (\gg 1)$$

FIGURE 7.1   *FIR filter specifications: (a) absolute (b) relative*

3) But, remember that in most window-based designs, our only design parameters are the window type and the number of taps in the filter (or the filter order). We already know that the Hann window will meet ~44dB stopband attenuation, and as such, will meet our A_s spec above. Therefore, for this problem, you will NOT use the A_s and R_p specs above in your design explicitly. You will just need to find the minimum number of taps for your filter, as described below, and then once you have the filter, just confirm that it does meet your specs for both passband ripple and stopband attenuation.
4) Also remember that in window-based FIR design, we always get $\delta_1 = \delta_2$. So from A_s and R_p specs, you would have to find δ_1 and δ_2, and then once you have the filter, just confirm that it will indeed meet the minimum of the two.

5) The exact value of the main-lobe width, and therefore the filter transition bandwidth, associated with Hann window is $6.2\pi/M$ where M is the length of the window, or equivalently the number of taps in your FIR filter. So, given the specs, you can find the narrowest transition bandwidth you need to achieve, and based on that, find the minimum number of taps for your filter. Use an odd number so you end up with a Type I linear-phase FIR filter.

6) Use the center points of the transition bands as the edges of your passband, as passed to "fir1" function (i.e., $[w_1 \ w_2]$).