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EE442: Lab 3—Design of FIR Filters

February 14th, 2018

**Task 1: Effect of the length of the filter**

1. Write a MATLAB function, ***lowPassRectangulat( )***, that computes the impulse response of the truncated and shifted lowpass filter of length M and cutoff frequency of ωc.

function [h] = lowPassRectangulat(M, wc)

h = fir1(M, wc, rectwin(M+1));

[H, W] = freqz(h, 1);

figure;

plot(W / pi, 20 \* log10(abs(H) / max(abs(H))));

title('Frequency Response of Rectangular Filter');

xlabel('Digital Frequency (0 to pi)');

grid;

end

1. Using the MATLAB function you wrote in procedure 1, design a lowpass filter with a cutoff frequency of ωc = 0.65π and i) length 21 and ii) length 101
2. Plot the magnitude response of the two filters (length 21 and 101).

|  |  |
| --- | --- |
| a. Length M = 21: | b. Length M = 101 |
|  |  |

1. Record the width of the transitional band and the attenuation in dB of the largest side lobe in both cases.

5. Discuss how the size of the filter affected the transition band and attenuation of the stopband of the filter.

* The larger the size of the filter, the attenuation remains constant and the sharper the transitional band
  + M = 21: Attenuation—22.64 dB Width of transition band—about 0.5π
  + M = 101: Attenuation—21.92 dB Width of transition band—about 0.2π

1. Comment on audio quality. Do the filters improve the audio quality? Is there any difference between the two filters in improving the audio quality?
   * The filter improved the audio quality significantly. The voice can be heard clearly and there is no excess noise audible.

**Task 2:**

1. Plot the blackman windows for M=21 in one figure using subplots. You may use the MATLAB blackman(M) functions.
2. Plot the magnitude frequency of response of the window function in dB.
3. From the magnitude response, measure the width of the main lobe, and also the difference, in dB, between the peak value of the main lobe and the peak value of the first side lobe. Compare your readings with the theoretical values.
   * The dB attenuation value is roughly the same as the theoretical value—about 58dB
   * The width of the main lobe is also about the same with the width being around 1.8
4. Design a lowpass filter with a cutoff frequency of ωc = 0.65π and length 61 using blackman window.
5. Plot the magnitude response of the filters in dB.
6. Record the width of the transitional band, and the attenuation in dB of the largest side lobe.
   * Transitional band width—0.1 \* pi
   * Attenuation—about -75.21 dB



1. Comment on audio quality. Does the filter improve the audio quality? Is there any difference of audio quality between the audio filtered using the rectangle window filters and the blackman window filter?
   * The filter improved the quality of the audio signal, and the Blackman filter greatly improved the attenuation on the background noise.

**Task 3: Kaiser filter Design**

1. Plot the Kaiser windows of length 21 for β= 5. To create the Kaiser windows, use the MATLAB function kaiser(M, beta).
2. Plot the magnitude response of the Kaiser window of procedure 1.
3. Design a Kaiser filter using the following specification: ωp = 0.57π, ωs =0.7π, and δ1 = 0.05 and δ2 =0.005, where ωp and ωs are the edge frequencies of the passband and stopband respectively.
4. Plot the coefficients of the impulse response of the filter.
5. Plot the magnitude response of the lowpass filter.
6. Play the sound of the filtered signal. Comment on the audio quality.
   * The sound quality did not change drastically, but the background noise did seem slightly more prominent with the use of the Kaiser filter over the Blackman filter.



**Task 4:**

1. Plot the magnitude response of the final filter designed, and record the ripple values achieved. (You only need to turn-in the plot of the magnitude response of the final filter)
   * Ripple: 0.048



1. Play the sound of the filtered signal, and comment on its audio quality.
   * The sound quality of the signal is similar to the Blackman filter. The background noise from the original audio signal is significantly attenuated and is barely audible.