Nima Naimi

EE442: Digital Signal Processing

Lab 2: Design of Digital Filters I

**Task 1:**

1. Using MATLAB, plot the magnitude frequency response of the filter for the following values of *θ* in the range of frequency *–π < ω < π*. Put together the figures in a subplots.



1. Explain how the value of *θ* affects the filter characteristics:
   * As theta is increased, the low frequencies in the signal are attenuated less:
2. Play the file the sound function of MATLAB.

***>> sound(specch1, 8000);***

Do you hear the beep tone embedded in a speech?

* + Yes, there is a loud beep tone that drowns out a speech signal

1. Plot 100 samples of speech1 from the indices 1001: 1100
2. Plot magnitude of ***X*** versus the frequency axis ***w***. Note that the range of the frequency plot is *|ω|< π*. (Do you see two peaks at positive and negative side of the w axis? That corresponds to the frequency of the tone)



1. What is the actual (analog) frequency of the tone?
   * The analog frequency of the tone is 0.42 \* 8000 / 2 = 1680Hz
2. Write an ***FIRfilter ( )*** MATLAB code to filter the ***speech1*** signal. Note that FIR filter are easily implemented using convolution.

function [x] = FIRfilter(X, tone\_freq)

b = [1 -2 \* cos(tone\_freq) 1];

x = filter(b, 1, X);

end

1. Play the sound of the filtered signal. Is the tone removed? Comment about the sound you heard.
   * The tone was not fully removed, but its amplitude was significantly reduced. It no longer masked the speech signal
2. Plot the magnitude of the dtft of the signal versus the frequency axis ***w***. Do you see the peaks you observed for the ***speech1*** signal?
   * The peaks are still there, but as observed in part m, the amplitude relative to the speech signal is significantly reduced



**Task 2:**

1. Plot the magnitude of the frequency response of the filter given by eqn (4) for *θ=π/3* and for the following values of *r=0.7*, *r=0.9* and *r = 0.99*. Plot the three plots in one figure with three subplots. Use freqz function to plot the magnitude response.

****

1. Explain how the magnitude of r affects the magnitude response of the filter.
   * As the magnitude of r is increased, the filter’s response becomes narrower at the corresponding digital frequency index. The peak is less distributed over neighboring frequencies.
2. Play the signal using the sound function of MATLAB. Describe what your heard. Did you hear a background noise?
   * Yes, there is a lot of noise masking a repetitive beeping tone
3. Plot 100 sample of the signal from 1001:1100.
4. Compute the DTFT of the signal taking 1000 samples from 101:1100 of the signal. Plot the magnitude of the DTFT for |ω| < π. The two peaks in the magnitude plot correspond to the center frequency of the modulated signal and the low amplitude wideband signal is the background noise.



1. The modulated signal has a frequency of *3146 HZ* and the sampling rate is 8000. Using this information, calculate the value of θ for the filter H(z) given in eqn(4).
   * theta = 3146 \* 2 \* pi / 8000 = 2.47086
2. Taking *r = 0.995* and the calculated value of θ, write a MATLAB function, ***y= IIRfilter( )***, that implements the filter given by eqn(4).

function [y] = IIRfilter(x, theta)

r = 0.995;

y = zeros(1, length(x));

for n = 3 : length(x)

y(n) = x(n) + (2 \* r \* cos(theta)) \* y(n - 1) - r^2 \* y(n - 2);

end

end

1. Plot 100 samples (1001:1100) of the filtered signal
2. Compute the DTFT of the filtered signal taking 1000 samples, (101:1100).
3. Plot the magnitude of the dtft of the filtered signal for *|ω| < π*. Comment of what you observed



The noise has been significantly reduced, leaving the beeping tones more audible / clear than before

1. In order to see the DTFT around *ω = θ* more clearly, plot also the portion of this DTFT for the values of ω in the range [θ - 0.02, θ + 0.02]

