BIOL 708L/NACS 728B Lab #6
Fall 2011

Frequency Selective Filters, Applied to Broadband Signals, in MATLAB

The main goal of this lab is to apply a frequency selective filter (e.g. low-pass or high-pass) to a broadband signal and see the effect on that signal using Matlab.

Take your time on these and make sure you understand what's going on with the signals at each step.

For all problems here, use $N = 64$ points, starting from 0 (we need the points to be aligned properly with $n = 0$ when taking the Fourier Transform), and define n to be the ***column*** vector that runs up from zero, for N points. **In all graphs in the time domain, make sure you put *n* along the horizontal axis.** Make another column array of points corresponding to the Fourier frequency. Call it *fk*. *fk*, which takes values from 0 to (just less than) 1, should be N points long, starting at 0, in steps of $1/N$. **In all plots in the frequency domain, make sure you put *fk* along the horizontal axis.**

1) *Impulse*

   a) Create an N point version of the delta (impulse) function, called *del0*, as a column vector. You can do it simply by typing the correct numbers of ones and zeros in the right place, or more cleverly by making an array the same size as `n` using `zeros()` and then setting the appropriate values to one. The most elegant (i.e. the most useful for complicated signals) is to use the `find()` function to determine which points to change from zero, e.g. `find(0==n)`. Graph it in a new figure window using `stem()`. Make sure your horizontal axis is labeled by n.
   b) In a new figure window, graph the magnitude of the FFT against *fk*, using `stem()`. Is this a broadband signal, and why?
   c) In a new figure window, graph the phase of the FFT against *fk*, using `stem()`. Is this a linear phase signal (does the phase of the response change linearly with frequency)?

2) *Applying the two point moving average filter*

   a) Create the impulse response of the two-point moving average convolutive filter using: `h2pt = [1/2 1/2].'` , a low-pass filter, and apply it to the impulse from (1) using: `filtLPdel0 = filter(h2pt,1, del0).`
   b) In a new figure window, graph the magnitude of the FFT against *fk*. Compare this graph to the one from 1b. What effect, as a function of frequency, does the low-pass filter have? Specifically, what happens to the slowest frequency (0) and the fastest frequency (½)?
   c) In a new figure window, graph the phase of the FFT against *fk*. This is a linear phase signal (the phase of the response can be shown to change linearly with frequency). Is the phase obviously linear? Note: it's OK if there is a 2π phase jump. What is the slope of the linear phase (with respect to frequency)? What is the slope when divided by -2π (this is should be the effective delay of the filter)?
   d) In a new figure, graph the filter signal `filtLPdel0` as function of time (n), and compare it to the

figure in 1a. Having been low-pass filtered, its lowest frequency (the constant or DC component) should remain unaffected. Justify/Rationalize this statement.

3) Repeat question 2 for the *high* pass filter `hdiffhalf = [1/2 -1/2].'`, except replace the last section of part d with: Having been high-pass filtered, its lowest frequency (the constant or DC component) should no longer be present. Justify/Rationalize this statement.

4) (*OPTIONAL*) Repeat question 2 for the (somewhat faulty) *low* pass filter of the three point moving average: `h3pt = [1/3 1/3 1/3].'`, and observing its magnitude behavior for all frequencies between 0 and ½.
   a) How does the slope of the phase, and effective delay, compare to the results in questions 2 & 3?
   b) There should be a step discontinuity in the phase. What is the (approximate) value of the step? Is it (approximately) 2π? At what frequency does that discontinuity occur? What happens to the magnitude at that frequency? What might this step discontinuity mean?