E85.2607 – Advanced Digital Signal Theory
Assignment 1: Filters
Due: 2010-02-11 by 5pm

Instructions

Send me an email containing your solutions by the due date listed above. Please attach a zip file containing your solutions, including the following:

1. A writeup including any requested plots as a **PDF** file. All Word documents will be ignored.
2. Any Matlab code you wrote as separate plain text files.
3. Any interesting sounds you generated.

Your submission should be your own work. If you're having trouble please send me an email or come to my office hours.

1 Making music with Matlab

This problem is meant to get you a little bit more comfortable with audio processing in Matlab.

1. Write a function to generate a pure tone at a given frequency for a given duration. The function should have the following signature:

   ```
   function x = puretone(frequency, duration, fs)
   % x = puretone(frequency, duration, fs)
   %
   % Generates a sinusoid at the given frequency (in Hz) that
   % lasts for the given duration (in seconds).
   ```

2. Write a Matlab script to play Mary Had a Little Lamb (or your favorite tune) using `puretone`.

   You'll probably find this to be a handy resource:
   `http://en.wikipedia.org/wiki/Piano_key_frequencies`

3. Play the same tune using a square wave oscillator instead of a sinusoid. Write the following function, analogous to `puretone`:

   ```
   function x = squarewave(frequency, duration, fs)
   ```

4. Plot spectrograms of the two signals you generated and comment on the differences in the way they sound/appear on the spectrogram. Play around with the `caxis`, `xlim`, and `ylim` commands to make it easier to see whats going on by changing the color axis and zooming in and out of the plots. Don't forget to add `colorbar`s!

   Please include wave files of the signals you generated with your submission.

2 Parametric equalizer

Lets build a real live effect using Matlab.

1. Write the following function:

```
function y = parametriceq(x, fs, gains, fc, fb)
% Filter x using the given EQ settings.
%
% Parameters:
%   gains:  list of gains (in dB) to be applied to each frequency band.
%   fc:     list of center/cutoff frequencies (in Hz) for each filter.
%   fb:     list of bandwidths (in Hz) for each filter.
%
% For each parameter P, P(1), P(2:end-1), and P(end) correspond
% to a low shelf filter, a list of peak filters, and a high shelf
% filter, respectively.
%
% Note that length(gains), length(fc), and  length(fb) should all
% be the same, but the values of fb(1) and fb(end) will be ignored.
%
% Example:
% The following command creates a 6 band equalizer with 4
% constant-Q peak filters between 800 and 6400 Hz:
%   y = parametriceq(x, fs, ...
%                    [  5,   3,  -2,    3,   -6,   10], ...
%                    [200, 400, 800, 1600, 3200, 6400], ...
%                    [  0, 100, 200,  400,  800,    0])
```

   You'll probably want to write some support functions to make it easy to reproduce multiple filters (e.g. `lowshelf, highshelf, peak`). Refer to the slides from lecture 2 for design equations for the EQ filters.

2. Plot the magnitude response (in dB) of your equalizer with the settings listed in the comments. (Hint: you probably don't want to use `freqz` for this.) Include the code you wrote to compute this in your submission.

3. Download `http://www.ee.columbia.edu/~ronw/adst/homeworks/hw1-badeq.wav`, read it into Matlab and try to make it sound better using your equalizer.

   Plot the magnitude response (in dB) of your equalizer with the settings you chose. List these settings, a brief explanation as to why you chose them (including plots if applicable), and the cleaned up sound file in your submission.

3 CSI: DSP

Download `http://www.ee.columbia.edu/~ronw/adst/homeworks/hw1-mysteryeffect.wav`, read it into Matlab and try to figure out whats going on, what effects are being used and what their parameters are (e.g. bandwidth, frequency range, etc.). Include any relevant plots you make with your writeup. There is no need to write a super detailed forensics report here. You should be able to make it clear that you understand whats going on in 3 or 4 sentences and one or two supporting plots.