EE502 Spring 2005 Homework #3

Assigned: Wednesday 23 March 2005
Due: Friday 1 April 2005

In this homework assignment you will use Matlab to investigate some numerical issues with digital filter implementations.

Task: design a set of 5 band pass filters according to the following specifications.

> Sample rate: 48 kHz
> Center frequencies: 12.5 Hz, 16.0 Hz, 20.0 Hz, 25.0 Hz, and 31.5 Hz
> Use 6th-order Butterworth design (see Matlab's `butter()` function, with N=3)
> Use *one-third octave* filters:
>
> $$F_{low} = F_c \cdot 2^{-\frac{1}{6}} \qquad F_{hi} = F_c \cdot 2^{+\frac{1}{6}}$$

(1) Obtain direct-form coefficients (b, a) for each of the five filters and then locate the poles and zeros (use `roots()` to find them). Do the resulting filters appear to be stable based on the pole positions? Explain.

(2) Now use `butter()` again, but this time have it generate the poles, zeros and gain scaling factor instead of the direct form polynomial coefficients. Do the resulting pole locations indicate stable filters? Explain.

(3) Using the explicit pole/zero/scale calculations from (2), create a three-stage cascaded 2nd-order section implementation for each filter. Show a verification of the five filters using a plot of gain in dB vs. frequency on a log axis. Overlap the response plots of the five band pass filters in a single graph.

(4) Finally, write Matlab code that will implement the 2nd-order sections and calculate the unit sample response of each of the filters.

How long is each unit sample response, based on the number of samples before the response envelope is 60 dB below the peak value?

Plot the five unit sample responses as subplots, using the same time and amplitude scales for each plot.