Assigned: 10/20/10 Due: 10/29/10

Z-transforms and Pole-Zero Response

This project will give you some exposure to z-transforms and the effects of pole and zero placement on the frequency response of a digital filter.

Exercises

1. Consider a two-pole/two-zero system function

$$H(z) = \frac{1 + 0.2z^{-1} - 0.8z^{-2}}{1 + 0.7z^{-1} + 0.64z^{-2}}$$

   (a) Find the pole and zero locations of this system. (Hint: the functions `roots` and `poly` may be useful in this exercise.)

   (b) Generate a pole-zero plot using `zplane`.

   (c) Sketch the frequency response you expect to see by looking at the pole-zero plot.

   (d) Display the frequency response with `freqz`. Note that your sketch will reflect magnitude response, while the MATLAB plot will show log-magnitude response.

2. Run `fdatool`. Go to File->Import Filter from Workspace. Select Direct-Form 1 filter structure, and specify [1 0.2 -0.8] for the numerator and [1 0.7 0.64] for the denominator. Then click "Import Filter." Go to the pole-zero editor by clicking the appropriate icon on the left side. Using trial-and-error, determine the pole and zero locations of a system so that it implements the best highpass filter possible with cutoff $\frac{\pi}{2}$ using two poles and two zeros. ("Best" may be in the eye of the beholder to a degree.) Be sure to choose the poles and zeros so that the difference equation has real coefficients (complex-conjugate pole and zero locations). If you want complex-conjugate zeros, unselect "Conjugate", drag a zero off of the real axis, reselect "Conjugate", and then delete the unwanted zero that remains on the real axis. Select File->Export... and export the resulting coefficients to variables in MATLAB.

   (a) Report the coefficients.

   (b) Provide pole-zero and magnitude response plots.

3. (a) Determine the difference equation defined by the filter you designed in the previous step.

   (b) Generate a signal $x[n] = \cos(0.25\pi n) + \cos(0.75\pi n)$ of length 100.

   (c) Using the `filter` function, filter this signal with the filter you designed, and examine the result.

   (d) Explain this result in terms of the frequency response of your filter.

4. (a) Generate a 50-point impulse response from the difference equation using `impz`.

   (b) Does this impulse response look like it would implement a highpass filter? (Think about a modulated lowpass filter impulse response. Or, does the impulse response appear to contain high frequencies and not low frequencies?) Explain.

5. Read in `fanfare.au` with `auread`. Filter this signal with the filter you designed and listen to the result with `sound`. Comment on the difference before and after filtering.

Write a **short** report describing your findings following my format instructions. The text should be no more than two pages of 12-point type with 1.5 line spacing, not including plots. The report should contain a concise description of your results. **Include all plots you were required to generate. Include the plots as small as possible *within* the text of the report, not at the end.** *Be sure to answer all questions.*

NOTE: All out-of-class work is to be done independently. Sharing of programming tips and discussing general concepts is ok. Collaborating on experiments or code-writing is not. Any such collaboration on these assignments will be considered an act of dishonesty and will be treated accordingly.
For further help:

- Matlab Primer
- Matlab Help Desk