Assignment 4 - The Inverse z-Transform and Applications

Due January 30, 1996

Please show your work. For those questions that ask you to use Matlab show the exact commands you used to compute the results. You don't have to use the Unix script command if you have find a better alternative (e.g screen cut & paste).

Question 1

A system has a transfer function

$$H(z) = \frac{1}{(z-1)(z+1)^2}$$

(a) Find the first 6 terms of this system's impulse response by using polynomial division.

(b) Find the first 20 terms of the system's impulse response using Matlab's `filter()` function (not `deconv()`).

Hints:

1. *The* `filter()` *function will compute the response of an FIR or IIR filter to an input sequence.*
2. *The Matlab statement* `x=[1 zeros(1,19)]` *will generate a vector that has a sample with value '1' followed by 19 samples with value zero.*
3. *By definition the impulse response of a system is the response of that system to an impulse.*

Note that the meanings of the a's and b's in the on-line documentation of the `filter()` *function are the reverse of the usage in the lecture notes.*

(c) Use Matlab's `filter()` function to find the first 20 terms of the impulse response of the following system:

$$H(z) = \frac{z}{(z-0.5+0.5j)^4(z-0.5-0.5j)^4}$$

Hint: The Matlab command `conv([1 -1],[1 -1])` *will compute the coefficients of the polynomial $(z-1)^2$. The command* `conv(ans,ans)` *will then compute the coefficients of $(z-1)^4$, etc.*

Question 2

A system has a transfer function

$$H(z) = \frac{z}{(z-2)(z-3)}$$

(a) expand $H(z)$ into a sum of first- and second-order terms using partial fraction expansion.

(b) check your results using Matlab's `residue()` function.

(c) Use the Matlab residue() function to find the partial fraction expansion of the following transfer function:

$$H(z) = \frac{z}{z^3-7z^2+16z-12}$$

Question 3

Problem 3.17 in the text. *Hint: you may want to use Matlab's* `roots()` *function.*

Question 4

In this question you will design a simple bandpass filter by adjusting the positions of poles until the filter's amplitude response matches the desired shape.

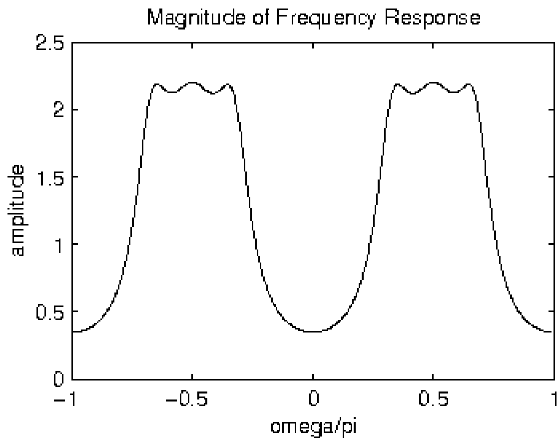
To do this you will use a simple interactive Matlab program, `pez`, that allows you to see the effect of changing pole and zero positions. Detailed documentation on `pez` is available on the course Web page.

To allow Matlab to find the `pez` code you should add the following command to the `.login.local` file in your home directory:

```
setenv MATLABPATH \
   /usr/home/frick/courses/elec466/matlab
```

Then use the command `source .login.local` to set the `MATLABPATH` environment variable. Run matlab and type `pez` to run the pole/zero editor.

Use your understanding of the effect of pole placement to design a three-pole bandpass filter with an amplitude frequency response *similar* to the one shown below:



In particular, try to get a design that has the following features:

- the passband should be centered around $F_s/4$ (where F_s is the sampling frequency)
- the bandwidth of the filter should be about $F_s/4$.
- the passband should be approximately flat but should have "ripples" in it with three peaks.

Print the page containing the pole-zero plot and the frequency response. Record the 3 pole locations (both the real and imaginary parts) to 3 decimal places. Then use these pole positions to obtain a transfer function, the filter coefficients and a signal flow graph (in direct form similar to that shown in figure 3.14) for a 3rd-order IIR filter that implements your bandpass filter.

This method demonstrates the basic principles of filter design, but it is time-consuming and you will probably not be able to get a very good approximation to the desired shape. We will study better filter design techniques in the second part of the course.

Question 5

Refer to figure 3.18 on page 154 for textbook problem 3.13. Solve for $w(n)$ as a function of $x(n)$ and then for $y(n)$ as a function of $w(n)$. Find the two corresponding transfer functions. Solve for the overall transfer function.