Digital Filters

In this assignment you will again be using the `frevalz` to look at the behavior of system functions in the z-plane. This time the system functions you will examine will be various digital filters that you use MATLAB to design. This will give you some insight into how digital filters are designed and what are the properties of different digital filter design algorithms. You will not be expected to understand the details of how these algorithms work; you only need to evaluate their behavior.

1. **FIR (Finite Impulse Response) Digital Filters**

   MATLAB has numerous built-in functions for generating discrete time filters. In this problem we are going to use a few to look at how higher order systems behave in the z-plane.

   (a) Use the MATLAB function FIR1 to create a low pass FIR filter of order 8 with cutoff frequency of $.4\pi$. The function FIR1 works with normalized frequencies between the range of $-1 \leq \omega \leq 1$, which corresponds to the unnormalized range $-\pi \leq \omega \leq \pi$. Use `frevalz` to study the system. Save your filter in a vector since you'll use it again in part 3.

   (b) Use the MATLAB function FIR1 to create a high pass FIR filter of order 8 with cutoff frequency of $.4\pi$. Comment on the placement of the zeros in this filter.

2. **IIR (Infinite Impulse Response) Digital Filters**

   (a) Use the MATLAB function BUTTER to create a low pass butterworth filter with cut-off frequency $.4\pi$ and filter order of 8. How does the performance of this filter compare to that of the FIR filter? In this context, performance refers to how close a filter matches an ideal low pass filter:

   $$H_{ideal}(e^{j\omega}) = \begin{cases} 1 & |\omega| \leq .4\pi \\ 0 & \text{otherwise.} \end{cases}$$

   Comment on any differences in the phase of the two filters. You do not need to hand in any plots. Save your filter in another vector since you'll use it again in part 3.

(b) Repeat part (a) of this problem for a high pass filter with cut-off frequency of $.4\pi$. Compare the performance of this IIR filter to that of the FIR. That is, how close is the performance of the two filters to that of an ideal high pass filter:

$$H_{ideal}(e^{j\omega}) = \begin{cases} 1 & |\omega| \geq .4\pi \\ 0 & \text{otherwise.} \end{cases}$$

Again, you do not need to hand in any plots.

3. **Filter Implementation**

Use the MATLAB function FILTER to implement the two low pass filters you produced in part (a) of problems 1 and 2. Let the input to the filters be a pulse of length ten:

$$x[n] = u[n] - u[n-10]$$

but let $x[n]$ be of length 60 (so append 50 zeros on the end).

Comment on the differences in the output of the two filters.

Hand in a plot of the output of both filters.