ECE-486 Homework 9, Spring 2009

1. A discrete-time system utilizing a sample rate of 100 ksps is to implement a bandpass filter which meets the following specifications:

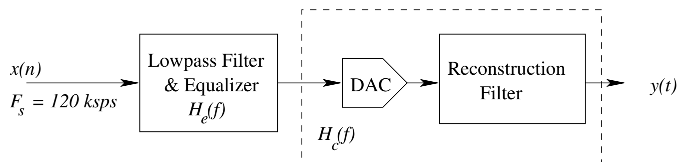
Passband:	7 kHz $\leq F \leq$ 12 kHz
Passband Gain:	6 ± 0.2 dB
Stopbands:	$F \leq 5$ kHz, and
	$F \geq 15$ kHz
Stopband Gain:	≤ -90 dB

   (a) Use the window method to design a linear phase filter which meets the above specification. (Make the filter order as low as you can.) Make a plot showing the magnitude response of the resulting filter. List the filter order and the number of filter coefficients, and indicate the window function that you used for your design.

   (b) Repeat problem 1a using the Parks-McClellan equiripple design.

   (c) Repeat problem 1a using an IIR design.

2. A 17 kHz bandwidth analog signal is to be reconstructed from a discrete-time signal $x(n)$ (sample rate $F_s = 120$ ksps) using the system shown below.



   The signal $x(n)$ contains the desired signal as well as undesired signal components at frequencies above 23 kHz. Because of hardware constraints, the DAC and reconstruction filter may be shown to have magnitude response

$$|H_c(F)| = \left|\frac{\sin(\pi F T_s)}{\pi F T_s}\right| \left(\frac{1}{1 + (F/50000)^2}\right)^{1/2} \qquad T_s = 1/F_s = 8.33\ \mu\text{s}$$

   The lowpass filter passband response is to be modified to "equalize" the linear distortion which the hardware will introduce. Design a linear phase filter $H_e(f)$ such that the composite system ($H_e(f)$ and $H_c(F)$) is flat (± 0.1 dB) in the passband ($0 \leq F \leq 17$ kHz), and so that all signals at frequencies above 23 kHz will be attenuated by at least 70 dB.

   Describe how you designed your filter, show a plot of the magnitude response of the filter.

3. Let $h(n)$ be the impulse response of a linear phase causal FIR filter. Show that if $H(z)$ has a zero at $z = z_0$, then it must also have a zero at $z = 1/z_0$.