ECE 464/564 - Final Exam

March 16, 2006

(2 hours - open textbook and open notes)

Problem 1 (35 points) – Design a second-order IIR digital notch filter $H'(z)$ according to the following specifications:

– sampling rate: $F_s = 12\,kHz$;
– notch frequency: $F_o' = 2\,kHz$;
– 3-dB bandwidth: $B_w = 1\,kHz$.

After designing $H'(z)$, by using an appropriate spectral transformation, design another second-order IIR digital notch filter $H''(z)$ working at the same sampling rate, with the same 3-dB bandwidth as $H'(z)$, and a notch frequency $F_o'' = 4\,kHz$.

Problem 2 (35 points) – Design a causal FIR digital bandstop filter $H_{BS}(z)$, by using the fixed-window approach, according to the following specifications:

– sampling rate: $F_T = 10\,MHz$;
– cutoff frequencies: $F_{p1} = 1.25\,MHz$, $F_{s1} = 1.875\,MHz$, $F_{s2} = 3.125\,MHz$, $F_{p2} = 3.75\,MHz$;
– minimum stopband attenuation: $\alpha_s = 60\,dB$.

a) Provide the details of all the steps necessary for the filter design, starting from the analytical expression of the impulse response $h_{BS}[n]$ of this filter given in Eq. (10.18) of the textbook.
b) Does $H_{BS}(z)$ have a linear phase? What's its group delay?
c) What's the peak ripple α_p of $H_{BS}(z)$ in the two passbands?

Problem 3 (30 points) – Let us consider a digital communication channel having input $x[n]$ and output $y[n]$. Its behavior in the time domain is described by the difference equation

$$y[n] + 4y[n-2] = x[n] - 2x[n-1] + 4x[n-2].$$

Design a digital equalizer $E(z)$ to correct for the magnitude distortion introduced by the channel. Such an equalizer has to be causal, BIBO-stable, and must have minimum phase.