Homework 4

Due: October 11, 20067, 12:15am (end of class)

Reading: Textbook sections 10.1-10.3 (without 10.3.1)

Problems from textbook:

1. Problem 10.5
2. Problem 10.22

Problem 1:

Consider a type III linear-phase FIR £lter with an amplitude response given by

$$H_{03}(\omega) = 2\sum_{n=0}^{S-1} h(n)\,\sin((S-n)\,\omega).$$

with $S = (L-1)/2$, where L denotes the £lter length. This equation can be rewritten as

$$H_{03}(\omega) = \sum_{n=1}^{S} c(n)\,\sin(\omega n).$$

Show that if the amplitude response is symmetric, i.e., $H_{03}(\omega) = H_{03}(\pi - \omega)$, then the even-indexed impulse response samples $h(n)$ are zero, if S is even.

Problem 2:

Digital £lter speci£cations are often given in terms of the loss function $H_l(\omega) = -20\,\log_{10}(|H(e^{j\omega})|)$ in dB. In this problem the peak passband ripple α_1 and the minimum stopband attenuation α_2 are given in dB, i.e., the loss speci£cations of the digital £lter are given by

$$\begin{aligned}\alpha_1 &= -20\,\log_{10}(1-\delta_1)\,\text{dB},\\ \alpha_2 &= -20\,\log_{10}(\delta_2)\,\text{dB}.\end{aligned}$$

(a) Estimate the order of an optimal equiripple linear-phase lowpass FIR £lter with the following speci£cations: passband edge $F_p = 1.8$ kHz, stopband edge $F_s = 2$ kHz, $\alpha_1 = 0.1$ dB, $\alpha_2 = 35$ dB, and sampling frequency $F_T = 12$ kHz.

The estimation formula can also be used to estimate the length of highpass, bandpass, and bandstop optimal equiripple FIR £lters. Then the width of the smallest transition band is used to estimate the £lter order.

(b) Estimate the order of an optimal equiripple linear-phase bandpass FIR £lter with the following speci£cations: passband edges $F_{p1} = 0.35$ kHz and $F_{p2} = 1$ kHz, stopband edges $F_{s1} = 0.3$ kHz and $F_{s2} = 1.1$ kHz, passband ripple $\delta_1 = 0.002$, stopband ripple $\delta_2 = 0.001$, and sampling frequency $F_T = 10$ kHz.