ECE 535 Digital Signal Processing

Problem Set 9

Spring 2003

Issued: Wednesday, April 16, 2003 **Due:** Tuesday, April 22, 2003

Reading in *Oppenheim and Schafer with Buck*

4/7/03	—	Sections 9.0-9.5
4/14/03	—	Section 9.6
4/21/03	—	Section 6.0-6.9

Problem 7.15 in *Oppenheim/Schafer/Buck*

Problem ECE535-9 In this problem you will use the window method to design an FIR linear-phase, causal discrete time filter that approximates the ideal response:

$$H_d(e^{j\omega}) = \begin{cases} 1 & |\omega| \leq \frac{\pi}{4} \\ 0 & \frac{\pi}{4} < |\omega| \leq \pi \end{cases}$$

(a) Obtain an expression for the infinite duration impulse response $h_d[n]$.

(b) Determine the coefficients of a 5-tap causal filter using a Hamming window.

(c) What is the group delay of this filter?

See additional problem on back of this page.

Problem ECE535-10 (Old exam question worth 25 points)
Let $s[n]$ be an N-point sequence, where N is even, such that $s[n] = 0$ for $n < 0$ and $n > N-1$. We would like to compute samples

$$T[k] = S(e^{j\omega})\Big|_{\omega = \frac{2\pi k}{(N/2)}}, \qquad k = 0, \ldots, \frac{N}{2} - 1$$

that is, $(N/2)$ samples in frequency, evenly-spaced between $\omega = 0$ and $\omega = 2\pi$. Five methods are proposed below for computing the desired samples, each yielding a different sequence $T_1[k], \ldots, T_5[k]$. For each method, state whether the computed samples $T_i[k]$ are guaranteed to be equal to the desired samples $T[k]$. Justify your answer.

Method 1: Define

$$t_1[n] = \begin{cases} s[n], & 0 \le n \le (N/2) - 1 \\ 0, & \text{otherwise} \end{cases}$$

Let $T_1[k]$ be the $(N/2)$-point DFT of $t_1[n]$.

Method 2: Define

$$t_2[n] = \begin{cases} s[n] + s[n + (N/2)], & 0 \le n \le (N/2) - 1 \\ 0, & \text{otherwise} \end{cases}$$

Let $T_2[k]$ be the $(N/2)$-point DFT of $t_2[n]$.

Method 3: Define

$$t_3[n] = \begin{cases} s[2n] + s[2n+1], & 0 \le n \le (N/2) - 1 \\ 0, & \text{otherwise} \end{cases}$$

Let $T_3[k]$ be the $(N/2)$-point DFT of $t_3[n]$.

Method 4: Define

$$q_1[n] = \begin{cases} s[n], & 0 \le n \le (N/2) - 1 \\ 0, & \text{otherwise} \end{cases}$$

$$q_2[n] = \begin{cases} s[n + (N/2)], & 0 \le n \le (N/2) - 1 \\ 0, & \text{otherwise} \end{cases}$$

Let $Q_1[k]$ and $Q_2[k]$ be the $(N/2)$-point DFT's of $q_1[n]$ and $q_2[n]$, respectively.
Let $T_4[k] = Q_1[k] + Q_2[k]$.

Method 5: Define

$$t_5[n] = \begin{cases} W_N^n \left(s[n] - s[n + (N/2)]\right), & 0 \le n \le (N/2) - 1 \\ 0, & \text{otherwise} \end{cases}$$

where $W_N = e^{-j(2\pi/N)}$. Let $T_5[k]$ be the $(N/2)$-point DFT of $t_5[n]$.