Prince of Songkla University
Department of Electrical Engineering

Midterm Examination
Date: Aug. 5, 2010
Subject: 210-431 Digital Signal Processing

Semester: 1/2010
Time: 9:00-12:00
Room: S104

สำหรับผู้เข้าสอบ

- ข้อสอบทั้งหมดมีจำนวนรวม 13 หน้า และมีโจทย์รวม 6 ข้อ ให้ทำโจทย์ทุกข้อ
- ให้เขียนคำตอบลงในพื้นที่ว่างที่เว้นไว้ให้ในกระดาษคำถามเท่านั้น
- ไม่อนุญาตให้นำตำรารวมทั้งเอกสารใด ๆ เข้าห้องสอบ
- อนุญาตให้ใช้เครื่องคิดเลขไม่จำกัดชนิดได้
- คะแนนเต็มของข้อสอบแต่ละข้อเป็นดังต่อไปนี้

ข้อที่	1	2	3	4	5	6	รวม
คะแนนเต็ม	20	20	20	20	20	20	120
คะแนนที่ได้							

พรชัย พฤกษ์ภัทรานนต์
Jul. 25, 2010

1. (a) Consider the sequence $x[n] = \delta[n]+2\delta[n-1]+\delta[n-3]$. Find the four-point DFT of $x[n]$.

   (b) Assume that a complex multiply takes 1 μs and that the amount of time to compute a DFT is determined by the amount of time it takes to perform all of the multiplications. How much time does it take to compute a 2048-point DFT directly? How much time is required if an FFT is used?

$$X[k] = \sum_{n=0}^{N-1} x[n]W_N^{nk}$$

$$W_N = e^{-j\frac{2\pi}{N}}$$

2. Let $x[n] = \{\underset{\uparrow}{1}, 0.5\}$ and $h[n] = \{\underset{\uparrow}{1}, 0, 2, 1\}$,

(a) Find the linear convolution $y_L[n] = x[n] * h[n]$.

(b) At what value of n will the linear convolution $y_L[n]$ attain its maximum value, and what is this maximum value?

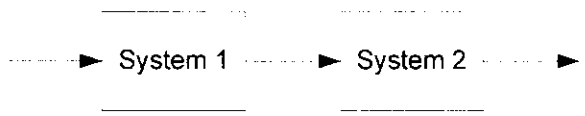
(c) Find the 4-point circular convolution.

(d) What condition that the linear convolution is equivalent to the N-point circular convolution?

(e) Find $h[\langle 2-n \rangle_4] + h[\langle n-1 \rangle_4]$.

3. A filter operating at a sampling frequency of 200 samples/s has poles at $z = \pm j2$ and zeros at $z = \pm 1$. Find
   (a) Transfer function
   (b) Difference equation
   (c) Gain at dc
   (d) Amplitude response at 50 Hz

4. Consider the parallel combination of two causal discrete-time LTI systems



You are told that System 1 is described by the difference equation

$$y[n]-0.5y[n-1]=x[n]$$

and System 2 is described by the difference equation

$$y[n]+0.5y[n-1]=x[n]$$

(a) Find the difference equation of the total system.
(b) Plot the magnitude response of the total system.

5. A major problem in the recording of electrocardiograms (ECGs) is the appearance of unwanted 50-Hz interference in the output. The causes of this power line interference include magnetic induction, displacement currents in the leads on the body of the patient, and equipment interconnections. Assume that the bandwidth of the signal of interest is 100 Hz, that is,

$$X_a(f) = 0 \qquad |f| > 100 \text{ Hz}$$

The analog signal is converted into a discrete-time signal with an ideal A/D converter operating using a sampling frequency f_s. The resulting signal $x[n] = x_a(nT_s)$ is then processed with a discrete-time system that is described by the difference equation

$$y[n] = x[n] + ax[n-1] + bx[n-2]$$

The filtered signal, $y[n]$, is then converted back into an analog signal using an ideal D/A converter. Design a system for removing the 50-Hz interference by specifying values for f_s, a, and b so that a 50-Hz signal of the form $w_a(t) = A\sin(100\pi t)$ will not appear in the output of the D/A converter.

6 Consider the discrete-time system characterized by the input-output relation

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

(a) Find the output of this system when $n = 6$ ($y[6]$) for an input $x[n] = 0.25u[n]$ with $y[-1] = 1$.

(b) Find the output of this system when $n = 12$ ($y[12]$) for an input $x[n] = 0.49u[n]$ with $y[-1] = 1$.

(c) What is the input-output relation resulting from this discrete-time system?