New Mexico State University
Klipsch School of Electrical Engineering

EE395 - Introduction to Digital Signal Processing

Fall 2009
Final Exam

Name: _____

Prob. 1	/ 20 points
Prob. 2	/ 20 points
Prob. 3	/ 20 points
Prob. 4	/ 20 points
Prob. 5	/ 20 points
Total	/ 100 points

Prob. 1

(i) What is the purpose of the anti-aliasing filter in the continuous-to-discrete time conversion?

(ii) Given the N-point discrete Fourier transform (DFT), what frequency ω_k does the point $X[k]$ represent?

(iiii) Suppose we have an analog, low-pass filter with a cutoff frequency, $f_c = 500$ Hz. For a digital signal processing (DSP) system with a sampling frequency, $F_T = 2000$ samples/s what is the required cutoff frequency, ω_c in rads/sample of an equivalent digital filter?

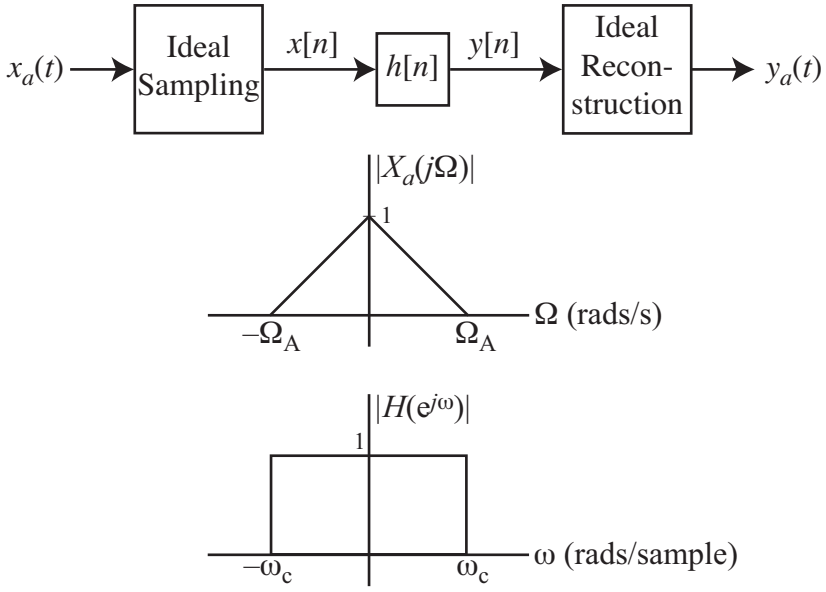
(iv) Consider the following MATLAB code:

```
fs = 16000;
n = [0:2*fs-1];
w0 = 2*pi/10;
x = cos(w0.*n);
sound(x,fs);
```

What is the frequency of tone emitted from the sound card and how many milliseconds will it last?

Prob. 2

Consider the digital filtering system below with ideal sampling and ideal reconstruction (interpolator); the band-limited spectrum of the continuous-time input $x_a(t)$ and the frequency response of the digital filter are also shown. Let $\Omega_A = 2\pi \times 1000$ rads/s and $\omega_c = \pi/2$ rads/sample.



For each of the following sample frequencies (sample rates), carefully graph $|X(e^{j\omega})|$ and $|Y(e^{j\omega})|$ for $-\pi \leq \omega \leq \pi$ and $|Y_a(j\Omega)|$ for $-2\Omega_A \leq \Omega \leq 2\Omega_A$. Be sure to include important frequency values in your graphs.

(a) $F_T = 2000$ samples/s.

Prob. 2 (cont.)

(b) $F_T = 4000$ samples/s.

(c) $F_T = 500$ samples/s.

Prob. 3

A digital filter has two poles at $p_1 = 1/3$ and $p_2 = 2/3$ and two zeros at $z_1 = z_2 = -1$.

(a) Graph the pole-zero pattern of the filter.

(b) Determine the system function, $H(z)$ and Region of Convergence (ROC) correponding to a *stable* filter.

(c) Determine the linear, constant-coefficient difference equation (LCCDE).

Prob. 3 (cont.)

(d) Draw a block-diagram of the canonical (Direct-Form II) realization of the filter.

(e) Determine the impulse response, $h[n]$ (closed-form expression).

(f) The filter is: causal (YES / NO), FIR (YES / NO), highpass (YES / NO).

Prob. 4

Consider the length-8 signal

$$x[n] = 1 + 2\sin\left(\frac{\pi n}{4}\right) - 2\sin\left(\frac{\pi n}{2}\right) + 2\sin\left(\frac{3\pi n}{4}\right) + 3\sin\left(\pi n\right), \quad 0 \leq n \leq 7.$$

Determine the 8-point Discrete Fourier Transform (DFT), $X[k],\ 0 \leq k \leq 7$, i.e. specify the values of $X[0],\ \ldots,\ X[7]$.

Hint: Express $x[n]$ in terms of complex exponentials.

Prob. 5

A causal, stable filter has the following system function

$$H(z) = \frac{5}{1 + 0.25z^{-2}} - \frac{4}{1 - 0.25z^{-2}} = \frac{1 - 2.25z^{-2}}{(1 + 0.25z^{-2})\,(1 - 0.25z^{-2})}.$$

(a) Draw the Direct Form I (DF I) realization for $H(z)$. How many words of memory and how many accumulators are needed for this realization?

(b) Draw the canonical realization [also known as Direct Form II or (DF II)] for $H(z)$. How many words of memory and how many accumulators are needed for this realization?

(c) Draw the cascade realization for $H(z)$. Follow convention and realize all second-order sections (SOSs) in canonical form.