Milwaukee School of Engineering

Electrical Engineering and Computer Science Department

EE-3220 – Final Exam – Dr. Durant

Monday 22 February 2010

May use calculator, one-sided note sheet, provided note sheet, and nothing else.

Good luck!

Name: _____

Page 3:	(11 points)	_____
Page 4:	(12 points)	_____
Page 5:	(12 points)	_____
Page 6:	(12 points)	_____
Page 7:	(20 points)	_____
Page 8:	(15 points)	_____
Page 9:	(18 points)	_____
Total:	(100 points)	_____

Signal $x[n]$	z Transform $X(z)$	Region of Convergence
$\delta[n]$	1	all z
$u[n]$	$\dfrac{z}{z-1}$	$\lvert z\rvert > 1$
$\beta^n u[n]$	$\dfrac{z}{z-\beta}$	$\lvert z\rvert > \lvert\beta\rvert$
$nu[n]$	$\dfrac{z}{(z-1)^2}$	$\lvert z\rvert > 1$
$\cos(n\Omega)u[n]$	$\dfrac{z^2 - z\cos\Omega}{z^2 - 2z\cos\Omega + 1}$	$\lvert z\rvert > 1$
$\sin(n\Omega)u[n]$	$\dfrac{z\sin\Omega}{z^2 - 2z\cos\Omega + 1}$	$\lvert z\rvert > 1$
$\beta^n\cos(n\Omega)u[n]$	$\dfrac{z^2 - \beta z\cos\Omega}{z^2 - 2\beta z\cos\Omega + \beta^2}$	$\lvert z\rvert > \lvert\beta\rvert$
$\beta^n\sin(n\Omega)u[n]$	$\dfrac{\beta z\sin\Omega}{z^2 - 2\beta z\cos\Omega + \beta^2}$	$\lvert z\rvert > \lvert\beta\rvert$

1. (4 pts) Sketch the overall “pipeline” of a DSP system starting with an analog signal on the left and ending with the processed analog signal on the right. Label all components of the pipeline properly for full credit.
2. (3 pts) What is the effect of quantization on a digitally processed signal, for example, an audio signal?
3. (4 pts) Why does aliasing occur? Be specific. Include a sketch.

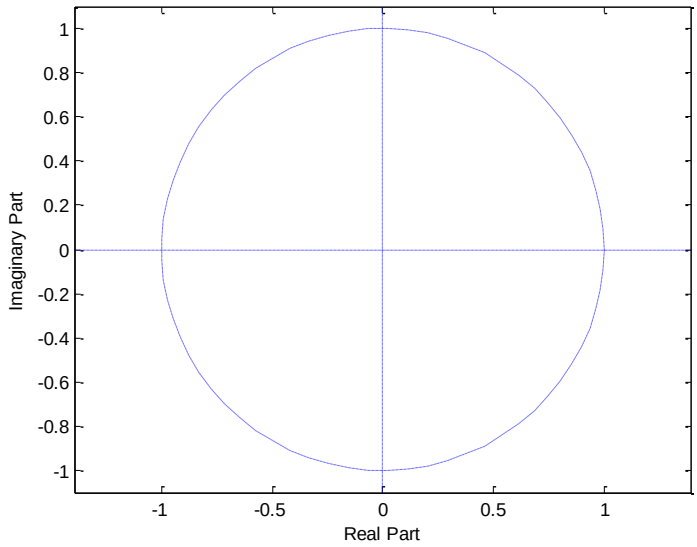
4. (4 pts) Explain what it means to say that the phase shift of the optimal reconstruction filter is linear. Why is this a good thing?
5. (4 pts) Why is zero-insertion (resulting in an increased sampling frequency) followed by interpolation often beneficial before zero-order hold?
6. (4 pts) Compare and contrast non-recursive and recursive filters. Why might one be desirable over the other and vice versa?

7. (4 pts) What is the purpose of the bilinear transformation? Be specific for full credit.
8. (5 pts) A signal with 3 and 12 kHz components is sampled at 8 kHz. Sketch the sampled signal's frequency spectrum from -20 to 20 kHz.
9. (3 pts) What is the digital frequency, Ω, of $x[n] = \sin(n5\pi/4)$? Explain why aliasing does or does not occur.

10. (4 pts) Calculate the first four samples of the step response of a system with the impulse response $h[n] = 3\delta[n] + 2\delta[n-1] - \delta[n-2]$.
11. (8 pts) Convolve $x = [7\ -6\ 4\ -1\ 0\ 2]$ with $h = [5\ 3\ 2]$. Show your work. Indicate which outputs are part of the transient and which are part of the steady state response.

12. A 3.5 kHz analog sinusoid is sampled at 48 kHz.
    a. (6 pts) ***Determine*** where the ***peak(s)*** in its DFT magnitude spectrum will occur for a 128-point DFT.
    b. (3 pts) ***Why*** is it impossible to select a DFT length that makes the sinusoid appear at the fundamental?
    c. (3 pts) What is the ***shortest DFT*** length that will cause the signal to appear in a single DFT frequency bin?
13. (8 pts) ***Explain*** the effects of zero-padding a sequence on its DTFT, $X(\omega)$, and on its DFT, $X[k]$. Provide an ***illustration*** showing these effects.

14. A DSP system implements the following difference equation: **y[n] = 0.8y[n-1] - 0.32y[n-2] + x[n] – 2x[n-1] + x[n-2]**.
    a. (6 pts) ***What is the transfer function***, H(z), for this system? Be sure to state in standard form (no negative exponents).
    b. (6 pts) ***Create*** a pole-zero plot for this system. Label the pole(s) and zero(s).



    c. (3 pts) Is the system ***stable***? ***Explain*** your answer.

d. (6 pts) Set up the expression, with all variables substituted, for the exact ***magnitude*** and ***phase*** response for a 2.4 kHz sinusoidal input sampled at 8 kHz. Hint: Use the DTFT and evaluate at Ω.
e. (3 pts) Is this a ***recursive or non-recursive*** system? ***Why***?
f. (3 pts) Is this an ***IIR or FIR*** system? ***Why***?
g. (6 pts) Find and simplify, if possible, an ***expression for the step response*** in the z-domain. You do not need to perform the inverse transform.