PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I
Date: 6 October 2009
Subject: 241-571 Digital Signal Processing

Academic Year: 2009
Time: 13:30-16:30
Room: A400

Instructions:

This exam has 6 problems, 10 pages and 60 points. Please show all your work for full credit. You may use the back of the pages for scratch work. This exam is closed book and closed note. You are allowed to bring in a calculator and one A4 sheet of notes.

Name:______________________________ Student code:__________

"ทุจริตในการสอบ โทษขั้นต่ำ คือ พักการเรียน 1 ภาคการศึกษา และปรับตกในรายวิชาที่ทุจริต"

1. Sketch the magnitude response of the following system: (10 points)

$$H(z)=\frac{1-z^{-1}}{1+1.4z^{-1}+0.53z^{-2}}$$

2. Sketch the phase response of the following system: (10 points)

$$H(z) = \frac{1 - 10z^{-1}}{(1 - (-0.8 + j0.3)z^{-1})(1 - (-0.8 - j0.3)z^{-1})}$$

3. Compute the inverse z-transform of the following transfer function: (10 points)

$$H(z) = \frac{0.7z^{-5}}{(1-0.5z^{-1})(1+0.4z^{-1})}$$

4. A discrete-time system described by the following difference equation

$$y[n] = x[n] + 0.9\,x[n\text{-}1]$$

where $x[n]$ is the input sequence and $y[n]$ is the output sequence. Is this system low-pass or high-pass filter? Justify your answer. (10 points)

5. For a single pole continuous-time filter, $H(s) = \frac{1}{s+p}$, determine the location of the pole if we convert this filter to a digital filter using the bilinear transform method, $s = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$ (10 points)

6. Consider an elliptic lowpass filter whose system function is

$$H(z) = \frac{0.2z^2 + 0.18z + 0.2}{z^2 + 0.77z - 0.42}$$

This second-order system was designed using the bilinear transformation to meet the following specifications:

Passband frequency	0.3π rad./sec.
Stopband frequency	0.6π rad./sec.
Max. passband attenuation	1 dB
Min. stopband attenuation	20 dB

Suppose we want a highpass filter with passband cutoff frequency $\omega_p = 0.5\pi$. Use the lowpass-highpass transformation to determine the system function of the desired highpass filter. (10 points)

Table 9.1: Spectral transformations of a lowpass filter with a cutoff frequency ω_c.

Filter type	Spectral transformation	Design parameters
Lowpass	$z^{-1} = \frac{\hat{z}^{-1} - \lambda}{1 - \lambda \hat{z}^{-1}}$	$\lambda = \frac{\sin\left(\frac{\omega_c - \hat{\omega}_c}{2}\right)}{\sin\left(\frac{\omega_c + \hat{\omega}_c}{2}\right)}$ $\hat{\omega}_c$ = desired cutoff frequency
Highpass	$z^{-1} = -\frac{\hat{z}^{-1} + \lambda}{1 + \lambda \hat{z}^{-1}}$	$\lambda = -\frac{\cos\left(\frac{\omega_c + \hat{\omega}_c}{2}\right)}{\cos\left(\frac{\omega_c - \hat{\omega}_c}{2}\right)}$ $\hat{\omega}_c$ = desired cutoff frequency
Bandpass	$z^{-1} = -\frac{\hat{z}^{-2} - \frac{2\lambda\rho}{\rho+1}\hat{z}^{-1} + \frac{\rho-1}{\rho+1}}{\frac{\rho-1}{\rho+1}\hat{z}^{-2} - \frac{2\lambda\rho}{\rho+1}\hat{z}^{-1} + 1}$	$\lambda = \frac{\cos\left(\frac{\hat{\omega}_{c2} + \hat{\omega}_{c1}}{2}\right)}{\cos\left(\frac{\hat{\omega}_{c2} - \hat{\omega}_{c1}}{2}\right)}$ $\rho = \cot\left(\frac{\hat{\omega}_{c2} - \hat{\omega}_{c1}}{2}\right)\tan\left(\frac{\omega_c}{2}\right)$ $\hat{\omega}_{c2}, \hat{\omega}_{c1}$ = desired upper and lower cutoff frequencies
Bandstop	$z^{-1} = \frac{\hat{z}^{-2} - \frac{2\lambda}{1+\rho}\hat{z}^{-1} + \frac{1-\rho}{1+\rho}}{\frac{1-\rho}{1+\rho}\hat{z}^{-2} - \frac{2\lambda}{1+\rho}\hat{z}^{-1} + 1}$	$\lambda = \frac{\cos\left(\frac{\hat{\omega}_{c2} + \hat{\omega}_{c1}}{2}\right)}{\cos\left(\frac{\hat{\omega}_{c2} - \hat{\omega}_{c1}}{2}\right)}$ $\rho = \tan\left(\frac{\hat{\omega}_{c2} - \hat{\omega}_{c1}}{2}\right)\tan\left(\frac{\omega_c}{2}\right)$ $\hat{\omega}_{c2}, \hat{\omega}_{c1}$ = desired upper and lower cutoff frequencies