Habib University

EE/CE 453/352: Digital Signal Processing - Spring 2025
Saad Baig

Time = 30 minutes **Quiz 02 SOLUTION** Max Points: 30

Instructions:

i. **Smart watches, laptops, and similar electronics are strictly NOT allowed.**
ii. **Answer sheets should contain all steps, working, explanations, and assumptions.**
iii. Attempt the quiz with black/blue ink.
iv. Print your name and HU ID on all sheets.
v. This is a closed-book examination but you are allowed a single-sided A4 sized cheat sheet.
vi. You are not allowed to ask/share your method or answer with your peers. The work submitted by you is solely your own work. Any violation of this will be the violation of HU Honor code and proper action will be taken as per university policy if found to be involved in such an activity.

CLO Assessment:

This quiz will assess students for the following course learning outcomes.

Course Learning Outcome		Learning Domain Level
CLO 2	Analyze discrete-time signals and systems in transform domain using z-Transform, DTFT, and DFT.	Cog-4

Undertaking:

I hereby affirm that I have read the instructions. I am fully aware of the HU honor code and the repercussions of its violation, and hereby pledge that the work I am going to submit is clearly my own.

Signature: _____

Name: **INSTRUCTOR SOLUTION** **HU ID:** _____

Question 01 [10 pts]: Consider a digital filter shown that has the following impulse response:

$$h[n] = \delta[n] - 2\cos\omega_0\,\delta[n-1] + \delta[n-2]$$

a) Determine $H(e^{j\omega})$.
b) Determine $H(z)$.

Solution:

a) $H(\omega) = 1 - 2\cos\omega_0\, e^{-j\omega} + e^{-j2\omega}$
b) $H(z) = 1 - 2\cos\omega_0\, z^{-1} + z^{-2}$, RoC = all except $z = \infty$

Question 02 [20 pts]: For the system below:

$$H(z) = \frac{1 - 2z^{-1} + 2z^{-2}}{[1 \pm jz^{-1}](1 - 0.5z^{-1})(1 + 0.2z^{-1})}, \qquad |z| > 1$$

a) Sketch the pole-zero pattern and highlight the RoC.
b) Comment on its stability.

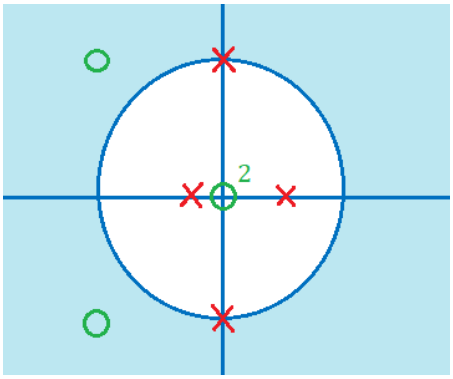
Solution:

$$H(z) = \frac{1 - 2z^{-1} + 2z^{-2}}{[1 \pm jz^{-1}](1 - 0.5z^{-1})(1 + 0.2z^{-1})} \times \frac{z^4}{z^4}$$

$$H(z) = \frac{z^2(z^2 - 2z + 2)}{(z \pm j)(z - 0.5)(z + 0.2)}$$

$$H(z) = \frac{(z - 0)(z - 0)(z - 1 + j)(z - 1 - j)}{(z + j)(z - j)(z - 0.5)(z + 0.2)}$$

System is unstable as some poles lie on the unit circle.



Question 03 [10 pts]: By means of DFT and N of your choice, determine the response of an FIR filter with impulse response $h(n) = \{1, 2, 3\}$ to the input sequence $x(n) = \{1, 2, 2, 1\}$.

Solution:

N can't be less than 4. So, we need to zero pad $h[n]$.

$$X(k) = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 6 \\ -1 - j \\ 0 \\ -1 + j \end{bmatrix} \qquad H(k) = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 0 \end{bmatrix} = \begin{bmatrix} 6 \\ -2 - j2 \\ 2 \\ -2 + j2 \end{bmatrix}$$

$$Y(k) = X(k)H(k) = \begin{bmatrix} 36 \\ j4 \\ 0 \\ -j4 \end{bmatrix}$$

$$y[n] = \frac{1}{4}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix} \begin{bmatrix} 36 \\ j4 \\ 0 \\ -j4 \end{bmatrix} = \begin{bmatrix} 9 \\ 7 \\ 9 \\ 11 \end{bmatrix}, \qquad y[n] = \{9,7,9,11\}$$