EE/CE 453/352: Digital Signal Processing

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Homework 2
Assigned: February 23, 2024
Due by: March 4, 2024
Total marks: 50

Important Notes

There are problems for which pen and paper solutions have to be submitted for grading. Preceding the solutions, you must include the following information:

- Your name
- Student ID
- Course ID
- Homework number
- Date and time submitted

Solution should be elaborative, sketch neat circuits wherever required, show clearly all steps of calculation & mention reference (for example formula, law, rule) to strengthen your understanding to solve the electric circuit problems.

Also, please comply with Academic Integrity Policies of Habib University related to plagiarism while submitting this assignment for grading.

Late Submission Policy

You need to submit your solution by the due date. Every day the assignment is late, 10% will be reduced from the total score. Assignment will not be graded after fifth day of submission deadline.

Course Learning Outcomes targeted using this assessment		
CLO	**Description**	**Learning-Domain Level**
CLO 1	Analyze discrete-time signals and systems in transform domain using z-Transform, DTFT, and DFT	Cog - 4

Question 1 [4 pts]: Determine the DTFT for each of the following sequences:

a) $x_1[n] = \alpha^n u[n-1]$
b) $x_2[n] = \alpha^n u[-n-1]$

Question 2 [4 pts]: Determine the inverse DTFT for each of the following DTFTs:

a) $H_2(e^{j\omega}) = 1 + 2\cos(\omega) + 3\cos(2\omega)$
b) $H_3(e^{j\omega}) = j[3 + 4\cos(\omega) + 2\cos(2\omega)]\sin(\omega)$

Question 03 [14 pts]: Consider the following sequences:

1. $x_1[n] = (0.3)^n \mu[n+1]$
2. $x_2[n] = (0.7)^n \mu[n-1]$
3. $x_3[n] = (0.4)^n \mu[n-5]$
4. $x_4[n] = (-0.4)^n \mu[-n-2]$

a) Determine the ROCs of the z-transform of each of the above sequences.
b) From the ROCs indicated in part (a), determine the ROCs of the following sequences:
   i. $y_1[n] = x_1[n] + x_2[n]$
   ii. $y_2[n] = x_2[n] + x_3[n]$
   iii. $y_3[n] = x_3[n] + x_4[n]$

Question 04 [8 pts]: The transfer function of a causal LTI discrete-time system is given by:

$$H(z) = \frac{1 - 3.3z^{-1} + 0.36z^{-2}}{1 + 0.3z^{-1} - 0.18z^{-2}}$$

Determine the output $y[n]$ of the above system for all values of n, for the following input:

$$x[n] = 2.1(0.4)^n \mu[n] + 0.3(-0.3)^n \mu[n]$$

Question 05 [4 pts]: Determine the frequency response $H(e^{j\omega})$ of the following transfer function, and show that the magnitude response $|H(e^{j\omega})|$ assumes its maximum value of $2/(1-\alpha)$ at $\omega = \omega_C$:

$$H(z) = \frac{1 - z^{-2}}{1 - (1+\alpha)\cos(\omega_C)\, z^{-1} + \alpha z^{-2}}$$

Question 6 [8 pts]: Consider the two finite-length sequences $g[n] = \{2, -1, 3\}, 0 \leq n \leq 2$ and $h[n] = \{-2, 4, 2, -1\}, 0 \leq n \leq 3$.

a) Determine the linear convolution: $y_L[n] = g[n] * h[n]$.
b) Determine the circular convolution (after zero padding): $y_C[n] = g[n] ④ h[n]$.
c) Determine $y_C[n]$ using DFT-based approach (non-matrix).
d) Determine circular convolution (after zero padding): $y_C[n] = g[n] ⑥ h[n]$ and compare your result with part (a).

Question 7 [4 pts]: Compute the 4-point DFT of the following sequence:

$$x[n] = \sin\left(\frac{n\pi}{2}\right), \qquad n = 0, 1, 2, 3 \ldots$$

Question 8 [4 pts]: Find the IDFT of the following function with $N = 4$: $X(k) = \{1, 0, 1, 0\}$.