Bangladesh University of Engineering and Technology

Department of Electrical and Electronic Engineering (EEE)

Course No.: EEE 312   **Section:** A2

Experiment No. 3

Assignment – 3: Z-Transform and Its Application

Instructions: *Include your Matlab code snippets and all necessary command window output+plots in your report.*

1. Consider the systems on the left and answer the questions on the right:

a. $H_1(z) = \frac{4-3z^{-1}}{4-3z^{-1}-z^{-2}}$ b. $H_2(z) = \frac{4+3z^{-1}}{4-3z^{-1}+z^{-2}}$ c. $H_3(z) = \frac{1-z^{-1}}{1-\frac{13}{12}z^{-1}+\frac{3}{8}z^{-2}-\frac{1}{24}z^{-3}}$ d. $H_4(z) = \frac{1-z^{-1}}{1-\frac{13}{6}z^{-1}+\frac{7}{8}z^{-2}-\frac{1}{24}z^{-3}}$	(i) Write the time domain causal impulse responses of the given systems using `residuez()`. (ii) Use ***fvtool*** to show the magnitude and phase responses of the systems. (iii) Identify the unstable system/s and show a method to stabilize its/their response.

2. Determine and write the expression for each of the $H_{eq}(z)$ below,

(i) $Y(z) = H_{eq}(z).X(z) = [H_1(z).H_3(z)].X(z)$

(ii) $Y(z) = H_{eq}(z).X(z) = [H_2(z).H_4(z)].X(z)$

(iii) $Y(z) = H_{eq}(z).X(z) = [H_1(z) + H_2(z)].X(z)$

(iv) $Y(z) = H_{eq}(z).X(z) = [H_1(z) + z^{-2}H_2(z)].X(z)$

Here, the systems denoted by $H_k(z), k \in \{1,2,3,4\}$ are defined in the table of **Q-1**.

3. An input signal $x(n)$ is provided to a system and the obtained output is $y(n)$:

$$x(n) = \left(\frac{1}{2}\right)^n u(n) - \left(\frac{3}{4}\right)^{n-1} u(n-1)$$

$$y(n) = 3\left(\frac{1}{2}\right)^n u(n)$$

For which type of causality is the system stable? (i) Write the analytic expression of that stable system, (ii) plot the time domain response of it.

4. The system function of a 4-th order Butterworth low pass filter (LPF) is provided below:

$$H_{butter}(z) = \frac{0.0102 + 0.0408z^{-1} + 0.0613z^{-2} + 0.0408z^{-3} + 0.0102z^{-4}}{1 - 1.9684z^{-1} + 1.7359z^{-2} - 0.7245z^{-3} + 0.1204z^{-4}}$$

Using only `impz(b,a,n=50)`, find the outputs $Y(z)$ of the following inputs:

$\cos(0.2\pi n)u(n)$	$\cos(0.3\pi n)u(n)$	$\cos(0.4\pi n)u(n)$
$\cos(0.5\pi n)u(n)$	$\cos(0.6\pi n)u(n)$	$\cos(0.7\pi n)u(n)$

Comment on which inputs were not effectively passed by the LPF. (Also, in `zplane`, observe each pole-zero of $Y(z)$ as your input frequency increases. Only some poles change positions. Can you explain the reason behind it?)

5. Write a generalized function in MATLAB for testing Schür Cohn stability of any given system. Name the function `schur_cohn`. From the table provided in **Q-1**, test the stability of the given four systems through the Schür Cohn test. Are the testing results consistent with what you have observed in **Q-1(iii)**?