Namal University, Mianwali

Department of Electrical Engineering

EE 345 (L) – Digital Signal Processing (Lab)

Lab – 6

Analysis of Z- Transform, Inverse Z-Transform and Pole Zero Map for Discrete Time systems

Student Name	Student ID

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Version 1.0 – Muhammad Usman – 15/04/2021
Version 1.1 – Zulaikha Kiran – 05/04/2022
Version 1.2 – Husnain, Saiqa Dilawaiz – 06/04/2023
Version 1.3 – Faizan Ahmad – 26/02/2024

Introduction

The purpose of this lab is to revise some MATLAB concepts and implementations including Z-Transform, Inverse Z-Transform and how poles and zeros are affected to the stability of the system.

Course Learning Outcomes

CLO1: Develop algorithms to perform signal processing techniques on digital signals using MATLAB and DSP Kit DSK6713

CLO3: Deliver a report/lab notes/presentation/viva, effectively communicating the design and analysis of the given problem

Equipment

- Software
    - MATLAB

Instructions

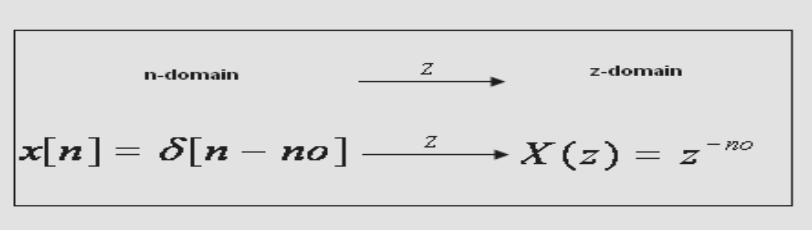
1. This is an individual lab. You will perform the tasks individually and submit a report.
2. Some of these tasks are for practice purposes only while others (marked as ‘Exercise’) have to be answered in the report.
3. When asked to display an image/ graph in the exercise either save it as jpeg or take a screenshot, in order to insert it in the report.
4. The report should be submitted on the given template, including:
    a. Code (copy and pasted, NOT a screenshot)
    b. Output values (from command window, can be a screenshot)
    c. Output figure/graph (as instructed in 3)
    d. Explanation where required
5. The report should be properly formatted, with easy to read code and easy to see figures.
6. Plagiarism or any hint thereof will be dealt with strictly. Any incident where plagiarism is caught, both (or all) students involved will be given zero marks, regardless of who copied whom. Multiple such incidents will result in disciplinary action being taken.

Z-Transform

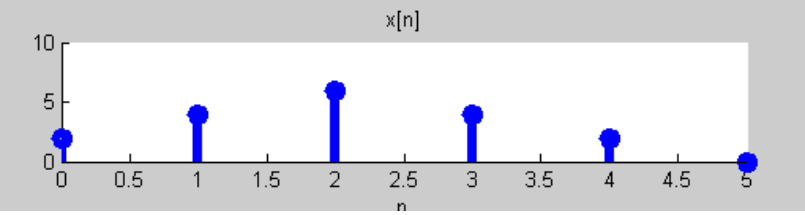
The z-transform of signal x[n] can be represented by the formula

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=-\infty}^{\infty} x[n]z^{-n}$$

Where we will assume that z represents any complex number i.e., z is the independent (complex) variable of the z-transform X(z).
We suppose that x[n] is unit impulse sequence



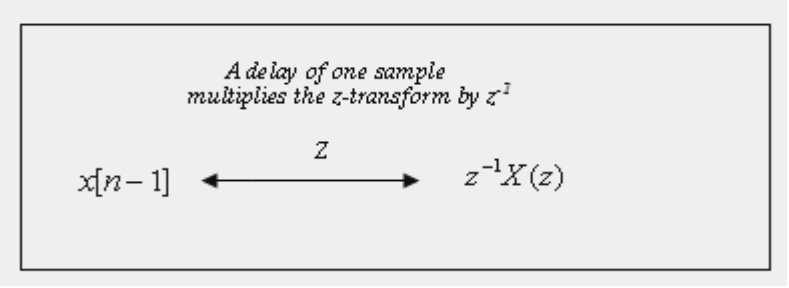
Example



n	0	1	2	3	4	5
x[n]	2	4	6	4	2	0

$$X(z) = 2 + 4z^{-1} + 6z^{-2} + 4z^{-3} + 2z^{-4}$$

Important Properties of Z_Transform



Time delay of one sample
multiplies the z-transform by z^{-no}

$$x[n-no] \overset{Z}{\longleftrightarrow} z^{-no}X(z)$$

Convolution and the Z-Transform

Convolution in the n-domain corresponds to multiplication in the z-domain

$$y[n] = h[n] * x[n] \overset{Z}{\longleftrightarrow} Y(z) = H(z)X(z)$$

Pole/Zero Diagram

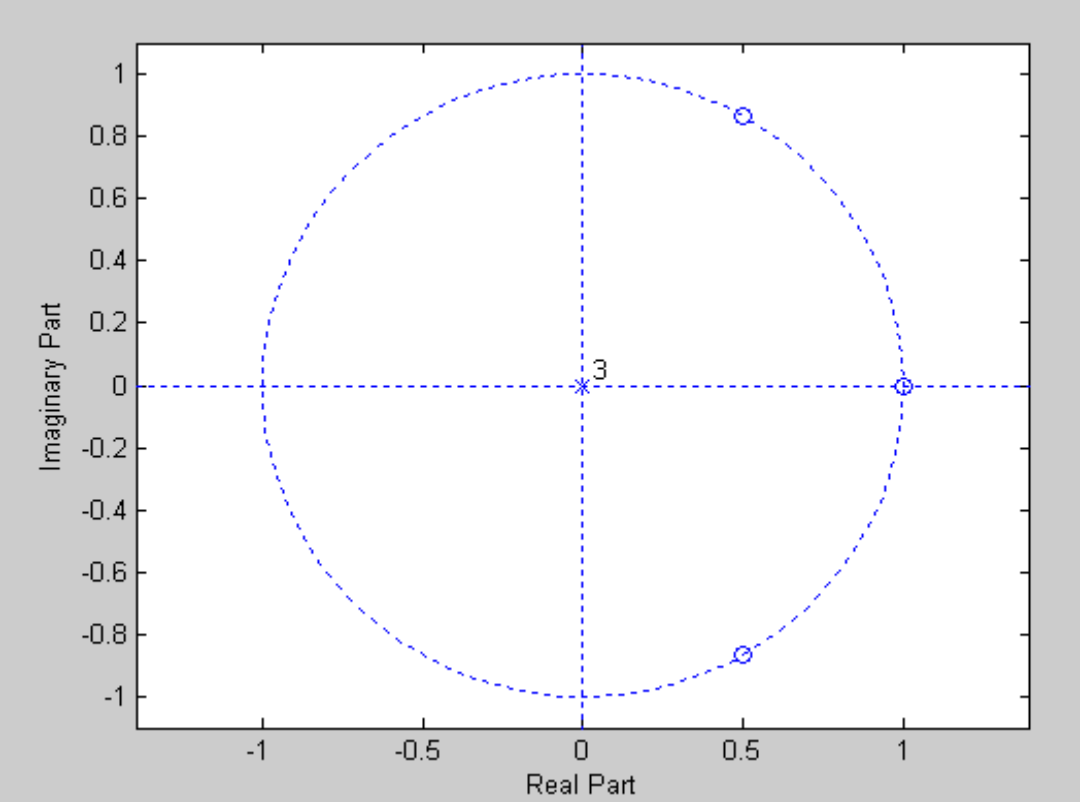
Consider the system function

$$H(z) = 1 - 2z^{-1} + 2z^{-2} - z^{-3}$$

$$H(z) = \frac{z^3 - 2z^2 + 2z - 1}{z^3}$$

Matlab Code for Pole/Zero Diagram

```
close all
clear all
b=[1 -2 2 -1];
a=[1 0 0 0];
[z,p]=tf2zp(b,a);
zplane(z,p);
```



Z-Transform

Ztrans:

ztrans(f) computes the Z transform of the expression f = f(n) with respect to the index n.

Examples:

Code:

```
syms n
f = sin(n)
ztrans(f)
ans =
(z*sin(1))/(z^2 - 2*cos(1)*z + 1)
```

Inverse Z-Transform

Iztrans:

Iztrans(f) computes the inverse Z transform of the expression F = F(z) with respect to the variable z.

Example:

Code:

```
syms z
F = 2*z/(z-2)^2;
iztrans(F)
ans =
2^n + 2^n*(n - 1)
```

EXERCISE

TASK-01:

Compute the z-transform of following functions

Table of Z – Transforms

	f_n	F(z)
1.	$(1)^n$	$\frac{z}{z-1}$
2.	$(-1)^n$	$\frac{z}{z+1}$
3.	a^n	$\frac{z}{z-a}$
4.	n	$\frac{z}{(z-1)^2}$
5.	n^2	$\frac{z^2+z}{(z-1)^3}$

TASK-02:

Find Inverse z-transform of:

$$H(z) = \frac{(20z^2 - 30z + 11.2)}{z^3 - 0.3z^2 - 0.58z + 0.24}$$

Code	Command Window Output

$$H(z) = \frac{z^2}{(z-\frac{1}{2})(z-\frac{1}{4})}$$

Code	Command Window Output

$$H(z) = \frac{20(z-0.8)(z-0.7)}{(z-0.6)(z+0.8)(z-0.5)}$$

Code	Command Window Output

TASK-03:

Consider the following difference equation

$$y[n] = 1/3\ x[n] - 1/3\ x[n-1] + 1/3\ x[n-2]$$

- Determine H(z)
- Determine the impulse response h[n] using MATLAB
  *By using **impz (b, a)***
  Where b is numerator
  a is denominator
- The pole-zero diagram using [**z**, p] =tf2zp(b,a) and zplane(**z**,p). Note, to get complete pole-zero plots, you have to match the lengths of a and b by zero-padding the shorter vector.
- Comment about the stability of the above system

TASK-04:

Determine the z-transform from its zero and pole locations.
The zeros are at
z1=0.21, z2=3.14, z3=-0.3+j0.5, z4=-0.3-j0.5;
the poles are at
p1=-0.45, p2=0.67, p3=0.81+j0.72, p4=0.81-j0.72;
and the gain constant k is2.2.
Using command zp2tf

Evaluation Rubric

- **Method of Evaluation**: In-lab marking by instructors, Report submitted by students
- **Measured Learning Outcomes**:

CLO1: Develop algorithms to perform signal processing techniques on digital signals using MATLAB and DSP Kit DSK6713
CLO3: Deliver a report/lab notes/presentation/viva, effectively communicating the design and analysis of the given problem

	Excellent 10	Good 9-7	Satisfactory 6-4	Unsatisfactory 3-1	Poor 0	Marks Obtained
Tasks (CLO1)	All tasks completed correctly. Correct code with proper comments.	Most tasks completed correctly.	Some tasks completed correctly.	Most tasks incomplete or incorrect.	All tasks incomplete or incorrect.	
Output (CLO1)	Output correctly shown with all Figures/Plots displayed as required and properly labelled	Most Output/Figures/Plots displayed with proper labels	Some Output/Figures/Plots displayed with proper labels OR Most Output/Figures/Plots displayed but without proper labels	Most of the required Output/Figures/Plots not displayed	Output/Figures/Plots not displayed	
Answers (CLO1)	Meaningful answers to all questions. Answers show the understanding of the student.	Meaningful answers to most questions.	Some correct/ meaningful answers with some irrelevant ones	Answers not understandable/ not relevant to questions	Not Written any Answer	
Report (CLO3)	Report submitted with proper grammar and punctuation with proper conclusions drawn and good formatting	Report submitted with proper conclusions drawn with good formatting but some grammar mistakes OR proper grammar but not very good formatting	Some correct/ meaningful conclusions. Some parts of the document not properly formatted or some grammar mistakes	Conclusions not based on results. Bad formatting with no proper grammar/punctuation	Report not submitted	
Total						