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Section: CPE-401
Date Assigned: September 27, 2023
Date Submitted:

EXPERIMENT 6
DISCRETE FOURIER TRANSFORM (DFT)
Z-TRANSFORM

OBJECTIVES

1. To learn how to evaluate and plot the DFT.
2. To be able to write a MATLAB program that will compute and display the poles and zeros of a Z-transform.

MATERIALS AND EQUIPMENT

Computer with installed MATLAB 2013 or higher

INTRODUCTION

I. The discrete Fourier transform (DFT), *X*[*k*], of a finite-length sequence *x*[*n*] can be computed using MATLAB. The length of *X*[*k*] is the same as that of *x*[*n*]. The algorithm for N-point DFT of a finite-length sequence $x[n]$, defined for $0 \leq n \leq N - 1$, is given by

$$X(k) = \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N}nk} \qquad k = 0,1,2, \ldots N-1$$

II. The *z-transform* *X*(*z*) of a sequence x[*n*] is defined as

$$X(z) = \sum_{n=-\infty}^{\infty} x[n] z^{-n} \qquad where\ z\ is\ a\ complex\ variable$$

and expressed in the form of a ratio of polynomials in z^{-1} or in factored form. Some of the operations that are of interest in practice are as follows: (1) Evaluate the *z*-transform X(*z*) on the unit circle; (2) develop the pole-zero plot of X(*z*); and (3) determine the inverse *z*-transform x[*n*] of X(*z*).

PROCEDURES

DFT

STEP 1: Run the following program that obtains the DFT of a finite sequence x[n]. Use x[n]={1,1,2,3,3}.

NOTE: The MATLAB ***input*** command prompts for user input. Upon running the program, go to the command window to enter your data.

```
% Program Exp6_1
%Computing the DFT using the for loop
clf;
close all;
clear all;
N=input('How many point DFT  do you want?');   % 5 for x[n]=[1 1 2 3 3]
x2=input('Enter the sequence=');    % input using the format  [1 1 2 3 3]
 for k=1:N        %this is the outer loop
     for n=1:N    %this is the inner loop
         w=exp((-2*pi*i*(k-1)*(n-1))/N);
         x(n)=w;
     end
     c(k,:)=x;
 end
 r=[c]*[x2']
 %plotting magnitude and angle
subplot(2 1 1)
stem(abs(r),'filled','-r','LineWidth',2);   %plot of the magnitude
title('DFT-magnitude');
grid;
subplot(2 1 2)
stem(angle(r),'filled','-r','LineWidth',2);   %plot of the angle in radian
title('DFT-angle');
grid;
```

Write the DFT coefficients displayed on the command window (rectangular form).

r =

[10.0000 + 0.0000i

-1.8090 + 2.4899i

-0.6910 + 0.2245i

-0.6910 - 0.2245i

-1.8090 - 2.4899i]

On the space provided, write the magnitude and angle (in radian) for each of the DFTs obtained above. The result must agree with the values on the displayed Figure.

Magnitude:

10

3.07768353717525

0.726542528005361

0.726542528005361

3.07768353717525

Angle:

0

2.19911485751286

2.82743338823082

-2.82743338823081

-2.19911485751285

Answer the following. From the given program,

What is the name of the variable that holds the input [1 1 2 3 3]? **x2**

Which command computes the exponential part of the algorithm? Write the entire command.

w = exp((-2*pi*1i*(k-1)*(n-1)/N))

Which variable contains all the results done in the inner loop (values of the exponential part)? x[n]

Which variable contains the DFTs? r

What does the command **`r=[c]*[x2']`** do? The matrix c and the x2 will be multiplied.

Can we remove the symbol (**'**) on the command `r=[c]*[x2']` without causing any error? No cause it will cause an : error: operator *: nonconformant arguments (op1 is 5x5, op2 is 1x5)

What does the symbol do? Matrix Transpose

What is the purpose of the MATLAB command **abs**? For every element in the array represents the absolute value of the corresponding element in the input array X, it return an array Y.

What is the purpose of the MATLAB command **angle**? Used to compute the phase angle in radians of the DFT coefficients.

STEP 2: The DFT coefficients may also be computed using the MATLAB command **fft**. At this point, x2 contains [1 1 2 3 3]. On the command window type fft(x2) . Did you get the same DFT coefficients? **Yes**

II. Analysis of Z-Transform

The function ***tf2zpk*** can be used to determine the zeros and poles of a rational *z*-transform $G(z)$. The program statement to use is **[z, p, k] = tf2zpk(num,den)** where num and den are row vectors containing the coefficients of the numerator and denominator polynomials of $G(z)$. The output file contains the gain constant k and the computed zeros, z, and poles, p. The pole zero plot is generated by the command **zplane(z,p)**.

The reverse process of converting a *z*-transform given in the form of zeros, poles, and the gain constant to a rational form can be implemented using the function zp2tf. The program statement to use is
[num,den] = zp2tf(z,p,k).

STEP 3: Write a MATLAB code that will compute and plot the values of the poles and zeros of G(z), H(z), and Q(z). Be sure not to terminate the tf2zpk command line with a semicolon so that you can view the result on the command window.

1) $G(z) = \dfrac{z^3 + z^2 + z + 1}{z^3 - 0.5z^2 - 4z + 2}$ 2) $H(z) = \dfrac{0.5z^2 + 0.5z}{z^2 - z + 0.5}$ 3) $Q(z) = \dfrac{1 + z^{-1}}{1 - z^{-1} + 0.5z^{-2}}$

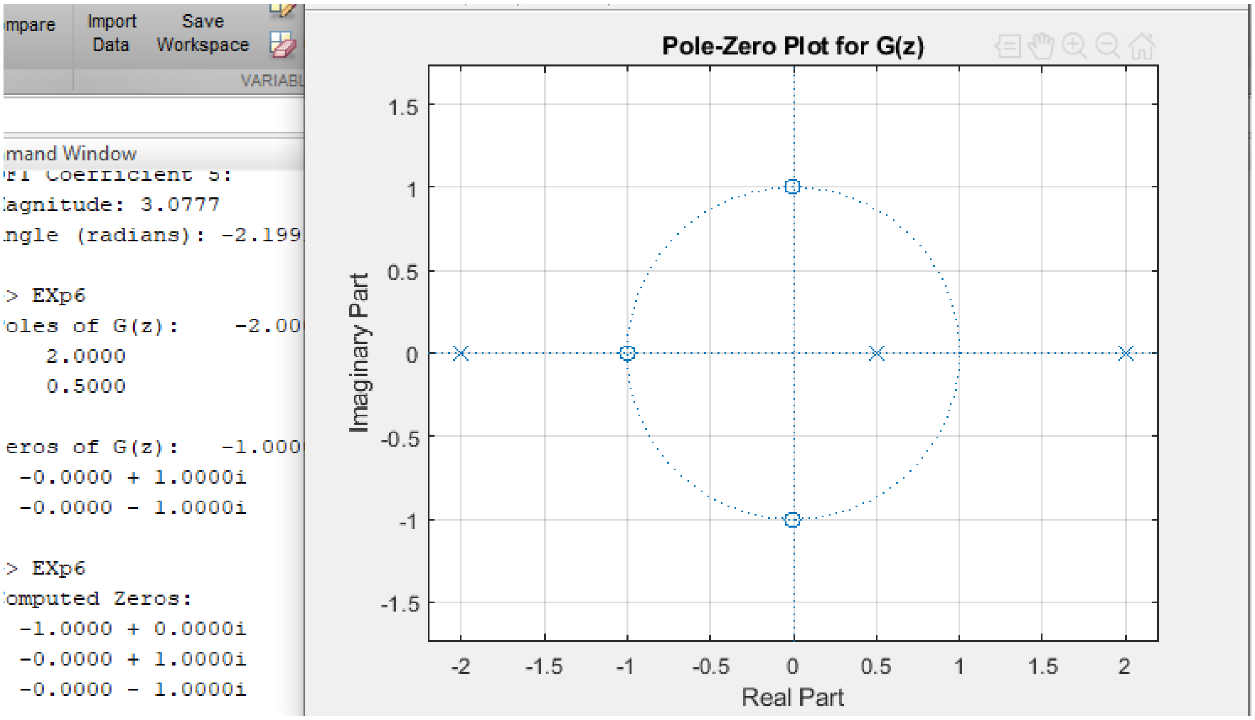
What are the poles and zeros of the given G(z), H(z), and Q(z)?

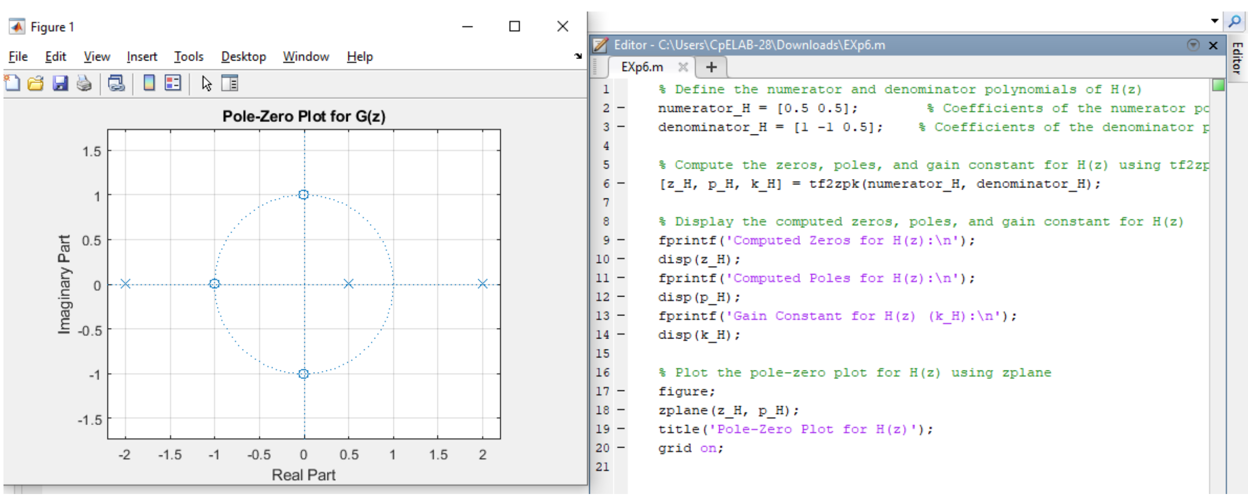
1.) P= -2.0
2.0000
0.5000
Z = -1.0000 + 0.0000i
-0.0000 + 1.0000i
-0.0000 - 1.0000i
K=1

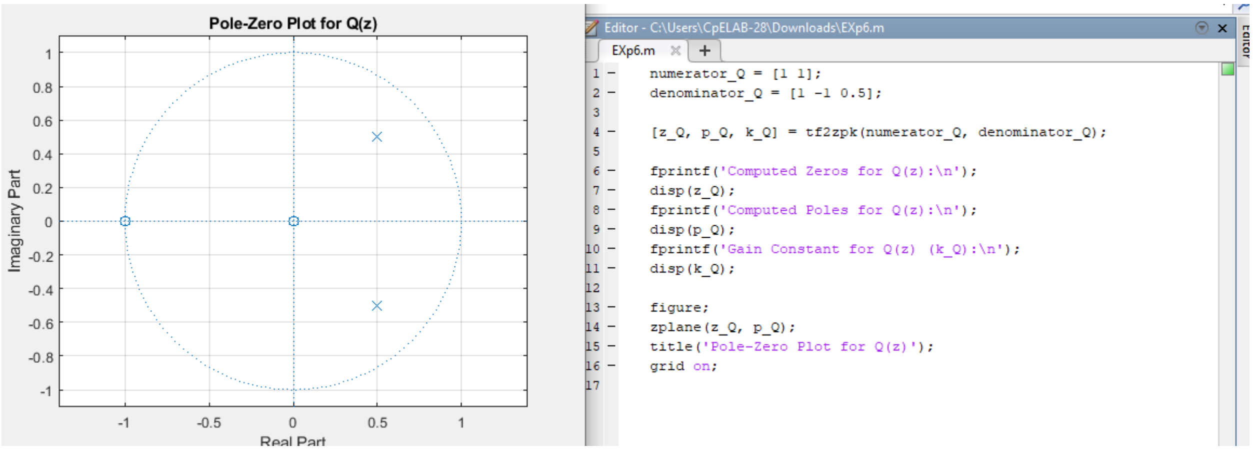
2.) p = 0.5000 + 0.5000i
0.5000 - 0.5000i
z = 0
-1
k = 1

3.) p = 0.5000 + 0.5000i
0.5000 - 0.5000i
z = 0
-1
k = 1

Attach the screenshot of the code and plot showing the poles and zeros for each transfer function:







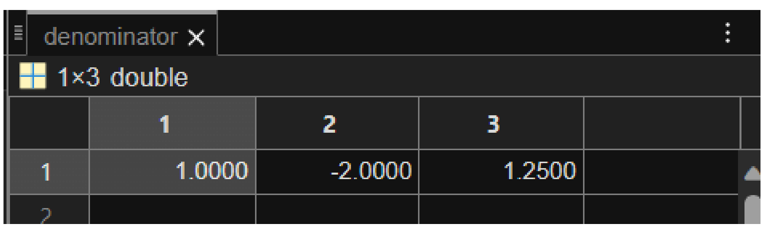
STEP 4: Write a MATLAB code that will compute the transfer function given the poles,zeros, and gain.

Poles: z=1+0.5j , z=1-0.5j

Zeros: z=0, z=-1

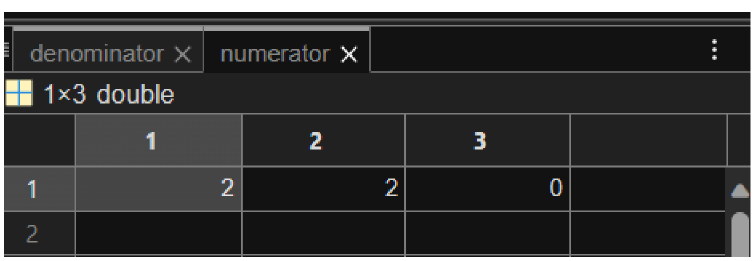
Gain=2

Attach the code with the result below:



denominator
1×3 double

	1	2	3
1	1.0000	-2.0000	1.2500
2			



denominator numerator
1×3 double

	1	2	3
1	2	2	0
2			

Write the equivalent transfer function below $H(z) = \frac{2z^2+2z}{z^2+2z+1.25}$

untitled.m
/MATLAB Drive/untitled.m

```
clc;
poles = [1 + 0.5j; 1 - 0.5j];
zeros = [0; -1];
gain = 2;


[num, den] = zp2tf(zeros, poles, gain);

% Display the transfer function
sys = tf(num, den);
disp(sys);
```

REMARKS AND CONCLUSION:

In this experiment, I learned about matrix multiplication and how important the (‘) when doing matrix multiplication. This experiment helps me to visualize the angle and magnitude of the DFT. By the end of this activity, I learned how to evaluate and plot the DFT. And be able to write a MATLAB program that will compute and display the poles and zeros of a Z-transform.