CECS 463 System On Chip II
FALL 2020

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Assignment #04 – The Z-Transform

10/15/2020

```
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% CECS 463 Fall20
% Assignment #04 Due: 10/15/2020

clc; close all;
```

4.1a

x(n) = (0.8)^n * u(n - 2)

```
clc; close all;
A = [1, -0.8];
B = [0, 0, 0.64];
[D, N2] = impseq( 0, 0, 10 );
[U, N2] = stepseq( 2, 0, 10 );
X1 = filter( B, A, D );
X2 = ( (0.8) .^N2 ).* U;
Z = max ( abs ( X1 - X2 ));
fprintf('Problem 4.1a) Error is: %4.4d', Z);
```

Problem 4.1a) Error is: 1.1102e-16

4.1b

x(n) = (n + 1)(3)u(n)

```
clc; close all;
A = [1, -9, 27, -27];
B = [1, -3];
[D, N2] = impseq( 0, 0, 7 );
X1 = filter( B, A, D );
[U, N2] = stepseq( 0, 0, 7 );
X2 = ( ( N2 + 1 ) .*( 3.^ N2 ) ).* U;
Z = max ( abs ( X1 - X2 ));
fprintf('\nProblem 4.1b) Error is: %1d', Z);
```
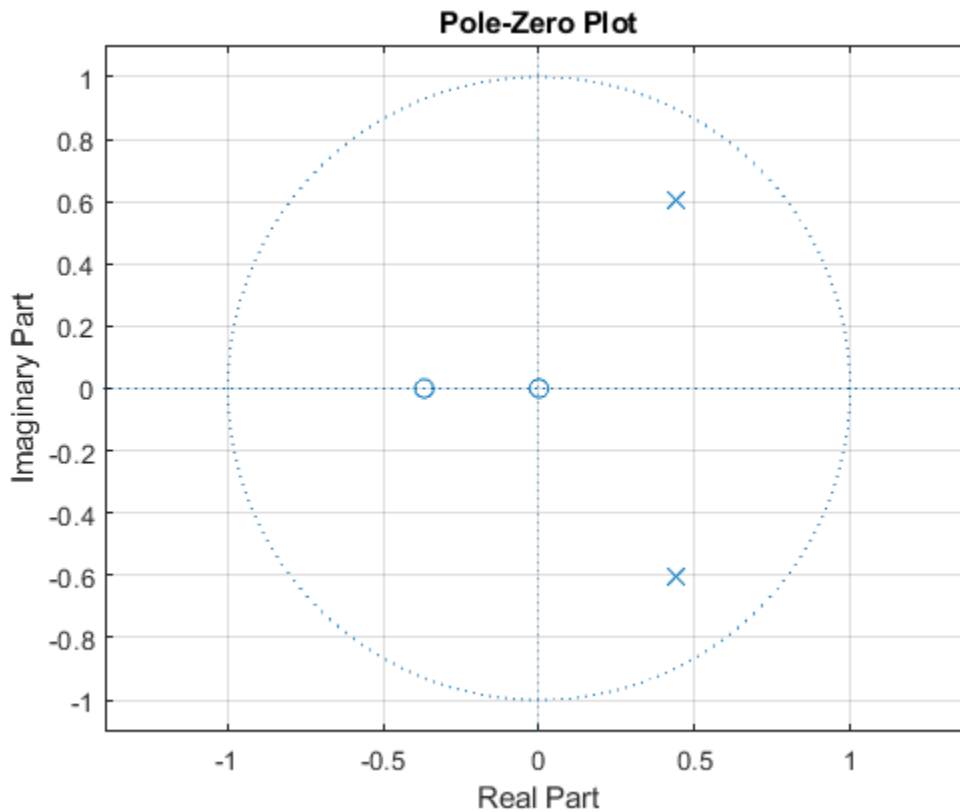
Problem 4.1b) Error is: 0

4.2a

x(n) = 3(0.75)^n * cos(0.3πn) * u(n) + 4(0.75)^n * sin(0.3πn)u(n)

```
clc; close all;
A = [1, -1.5*cos(0.3*pi), 0.5625];
B = [3, (3 * sin(0.3 * pi) - 2.25 * cos(0.3*pi))];
[D, N2] = impseq( 0, 0, 7 );
X1 = filter( B, A, D );
[U, N2] = stepseq( 0, 0, 7);
X2 = 3 * (((0.75).^N2) .* cos(0.3 * pi * N2)) .* U + 4 *(((0.75).^N2).*sin(0.3 * pi *
N2)) .*U;
Z = max( abs( X1 - X2 ));
fprintf('\nProblem 4.2a) Error is: %4.4d', Z);
figure('NumberTitle','off','Name','Problem 4.2a');
hold on; grid on;
title('Pole-Zero Plot');
[~, ~, ~] = zplane( B, A );
```
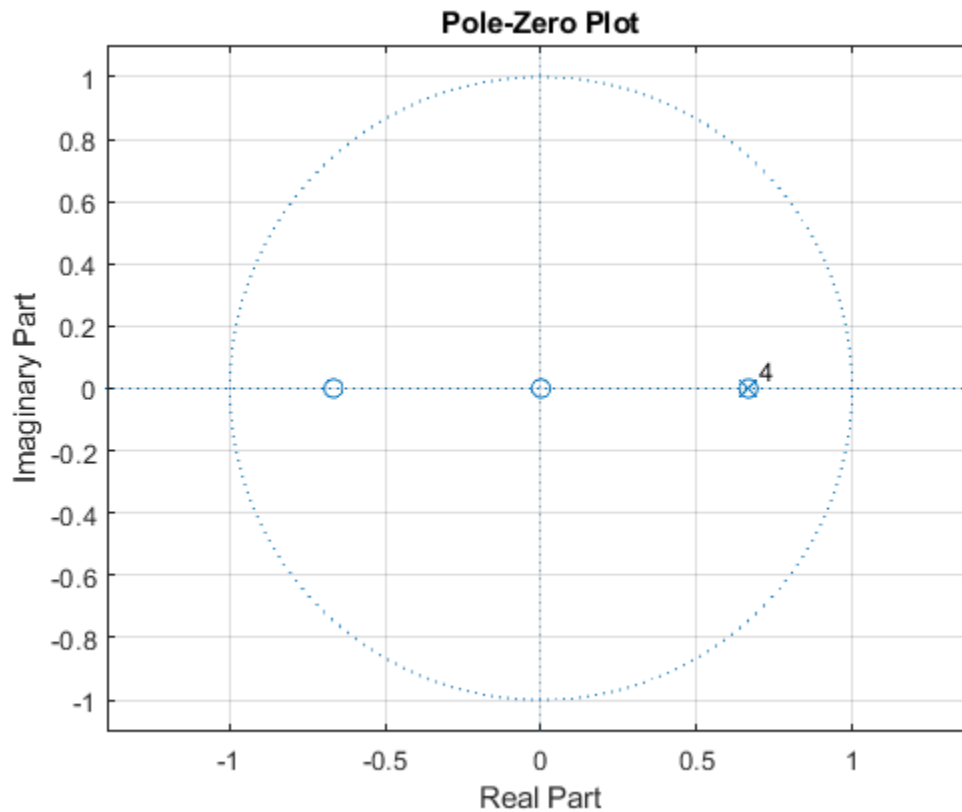
Problem 4.2a) Error is: 4.4409e-16

4.2b

x(n) = n^2 *(2/3)^(n-2) * u(n - 1)

```
clc; close all;
A = [1, -8/3, 8/3, -32/27, 16/81];
B = 3/2 * [0, 1, 0, -4/9];
[D,N2] = impseq(0, 0, 8);
X1 = filter(B, A, D);
[U, N2] = stepseq(1, 0, 8);
X2 = ( (N2.^2) .*((2/3).^( N2 - 2 ))) .*U;
Z = max( abs ( X1 - X2 ));
fprintf('\nProblem 4.2b) Error is: %4.4d\n', Z);
figure('NumberTitle','off','Name','Problem 4.2b');
hold on; grid on;
title('Pole-Zero Plot');
[~, ~, ~] = zplane( B, A );
```

Problem 4.2b) Error is: 9.7700e-15

4.3a

Z Transform of x(n) is X(z) == 1/(1+0.5z^-1) , z >= 0.5 x(n) = x(3 - n) + x(n - 3)

```
clc; close all;
fprintf('\nProblem 4.3a)');
fprintf('\nX(z) =   Z[x(n)]');
fprintf('\n     =   Z [ x(3 - n) + x(n - 3)]');
fprintf('\n     =   Z[x {-n(n - 3)}] + Z[ x(n - 3)]');
fprintf('\n     =   (z^-3 * X(1/z)) + (z^-3 * X(z))');
fprintf('\n     =   z^-3[( 1/1 + 0.5z ) + 1/( 1+ 0.5z^-1 )],  0.5 < |z| < 2');
fprintf('\n     =   ((0.5*z^-3) + (2*z^-4) + (0.5*z^-5)) / (0.5 + (1.25*z^-1) +
(0.5z^-2)), 0.5 < |z| < 2\n');
```

```
Problem 4.3a)


X(z) =   Z[x(n)]


     =   Z [ x(3 - n) + x(n - 3)]


     =   Z[x {-n(n - 3)}] + Z[ x(n - 3)]


     =   (z^-3 * X(1/z)) + (z^-3 * X(z))


     =   z^-3[( 1/1 + 0.5z ) + 1/( 1+ 0.5z^-1 )],  0.5 < |z| < 2


     =   ((0.5*z^-3) + (2*z^-4) + (0.5*z^-5)) / (0.5 + (1.25*z^-1) + (0.5z^-2)), 0.5 <
|z| < 2
```

4.3b

Z Transform of x(n) is X(z) == 1/(1+0.5z^-1) , z >= 0.5 x(n) = (1/2)^n * x(n - 2)

```
clc; close all;
fprintf('\nProblem 4.3b)');
fprintf('\nX(z) =  Z[(1/2)^n * x(n - 2)]');
fprintf('\n     =  Z[x(n - 2)] * |(1/2)^-1z');
fprintf('\n     =  Z [ x(n - 2)]| * 2z');
fprintf('\n     =  [z^-2 * X(z)] * |2z');
fprintf('\n     =  [((z^-2) / (1 + 0.5z^-1)), |z| > 0.5]|2z');
fprintf('\n     =  ((0.25z^-2) / (1 + 0.25z^-1)), |z| > 0.25\n');
```

```
Problem 4.3b)


X(z) =  Z[(1/2)^n * x(n - 2)]


     =  Z[x(n - 2)] * |(1/2)^-1z


     =  Z [ x(n - 2)]| * 2z


     =  [z^-2 * X(z)] * |2z


     =  [((z^-2) / (1 + 0.5z^-1)), |z| > 0.5]|2z


     =  ((0.25z^-2) / (1 + 0.25z^-1)), |z| > 0.25
```

4.4a

Z Transform of X(z) is x(n) = (1/2)^n * u(n) X(z) = ((z - 1) / z) * X(z)

```
clc; close all;
fprintf('\nProblem 4.4a)');
fprintf('\nx(n) = Z^-1[ X(z) ]');
fprintf('\n     = Z^-1[ (1 - (1/2)) * X(z)]');
fprintf('\n     = Z^-1[ X(z) - z^-1 * X(z)]');
fprintf('\n     = x(n) - x(n - 1)');
fprintf('\n     = 0.5^n * u(n) - 0.5^(n - 1) * u(n - 1)');
fprintf('\n     = 1 - 0.5^n * u(n-1)\n');
```

```
Problem 4.4a)

x(n) = Z^-1[ X(z) ]

     = Z^-1[ (1 - (1/2)) * X(z)]

     = Z^-1[ X(z) - z^-1 * X(z)]

     = x(n) - x(n - 1)

     = 0.5^n * u(n) - 0.5^(n - 1) * u(n - 1)

     = 1 - 0.5^n * u(n-1)
```

4.4b

Z Transform of X(z) is x(n) = (1/2)^n * u(n) X(z) = X(z) * X(z^-1)

```
clc; close all;
fprintf('\nProblem 4.4b)');
fprintf('\nx(n) = Z^-1 [X(z)]');
fprintf('\n     = Z^-1 [X(z) * X(z^-1)]');
fprintf('\n     = x(n) * x(-n)');
fprintf('\n     = [0.5^n * u(n)] * [2^n * u(-n)]');
fprintf('\n     = (0.5)^k u(k) * 2^(n - k) * u(-n + k)');
fprintf('\n     = (4/3) * 2^|n|\n');
```

```
Problem 4.4b)

x(n) = Z^-1 [X(z)]

     = Z^-1 [X(z) * X(z^-1)]

     = x(n) * x(-n)

     = [0.5^n * u(n)] * [2^n * u(-n)]

     = (0.5)^k u(k) * 2^(n - k) * u(-n + k)

     = (4/3) * 2^|n|
```

4.5a

X(z) = ((1 - 2z^-1)+(3z^-2)-(4z^-3)) * ((4 + 3z^-1)-(2z^-2)-(z^-3))

```
clc; close all;
fprintf('\nProblem 4.5a)\n');
N1 = [0:3];
N2 = [0:3];
Y1 = [1, -2, 3, -4];
Y2 = [4, 3, -2, 1];
[X, N] = conv_m(Y1, N1, Y2, N2)
disp('X(z) = (4 - (5z^-1) + (4z^-2) - (2z^-3) - (20z^-4) + 11 + (z^-5) - (4z^-6))');
```

```
Problem 4.5a)

X =

     4    -5     4    -2   -20    11    -4

N =

     0     1     2     3     4     5     6

X(z) = (4 - (5z^-1) + (4z^-2) - (2z^-3) - (20z^-4) + 11 + (z^-5) - (4z^-6))
```

4.5b

X(z) = (((z^-1)(-3z^-3))+(2z^-5)+((5z^-7)(-z^-9)*(z+3z^2+2z^3+4z^4))

```
clc; close all;
fprintf('\nProblem 4.5b)\n');
N1 = [0:9];
N2 = [-4:0];
Y1 = [0, 1, 0, -3, 0, 2, 00, 5, 0, -1];
Y2 = [4, 2, 3, 1, 0];
[X, N] = conv_m(Y1, N1, Y2, N2)
disp('X(z) = 4z^3 + 2z^2 -9z^1 - 5 - z^-1 + z^-2 + 26z-3 + 12z^-4 + 11z^-5 + 3z^-6 -
3z^-7 - z^-8');
```

Problem 4.5b)

X =

  Columns 1 through 13

     0   4   2   -9   -5   -1   1   26   12   11   3   -3   -1

  Column 14

     0

N =

  Columns 1 through 13

    -4   -3   -2   -1   0   1   2   3   4   5   6   7   8

  Column 14

     9

X(z) = 4z^3 + 2z^2 -9z^1 - 5 - z^-1 + z^-2 + 26z-3 + 12z^-4 + 11z^-5 + 3z^-6 - 3z^-7 -
z^-8