Tribhuvan University

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DIGITAL SIGNAL ANALYSIS AND PROCESSING

Lab 5

z Transformations

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Title
z-Transformation

Background Theory
In Laplace transform, a function of time is converted into a function of frequency. The z-transform can be thought of as a discrete-time version of the Laplace transform. Using the complex variable z and by applying the z-transform to a sequence of data points, an expression is created that allows us to perform frequency-domain analysis of discrete-time signals.

With the z-transform, we can create transfer functions for digital filters, and we can plot poles and zeros on a complex plane for stability analysis. The inverse z-transform allows us to convert a z-domain transfer function into a difference equation that can be implemented in code written for a microcontroller or digital signal processor.

The relationship between a discrete-time signal x[n] and its one-sided z-transform X(z) is expressed as follows:

$$X(z) = \sum_{n=0}^{\text{inf}} x(n) z^{-n} \tag{1}$$

MATLAB implementation
In MATLAB, we use **signal** package for z- transformation. Some functions involved in z-transform are:

- **zplane** : Plot the poles and zeros on a complex plane.
- **sos2zp** : Convert series second-order sections to zeros, poles, and gains (pole residues).
- **ss2zp** : Converts a state space representation to a set of poles and zeros; K is a gain associated with the zeros.
- **tf2zp** : Convert transfer functions to poles-and-zero representations.
- **zp2sos** : Convert filter poles and zeros to second-order sections.
- **zp2ss** : Conversion from zero / pole to state space.
- **zp2tf** : Converts zeros / poles to a transfer function.
- **czt** : Chirp z-transform

Activity

Locate the position of zeroes and poles in the z plane.

Example:

$$H(z) = \frac{1 + 0.23z^{-1} + 0.65z^{-2} + 1.57z^{-3} + z^{-4}}{1 - z^{-2} + 0.77z^{-3} + 1.65z^{-4}}$$

```
pkg load signal
num = [1 0.23 0.65 1.57 1]
dem =  [1 0 -1 0.77 1.65 ]
[z,p,k] = tf2zp(num,dem)
zplane(z,p)
title('075BCT028')
```

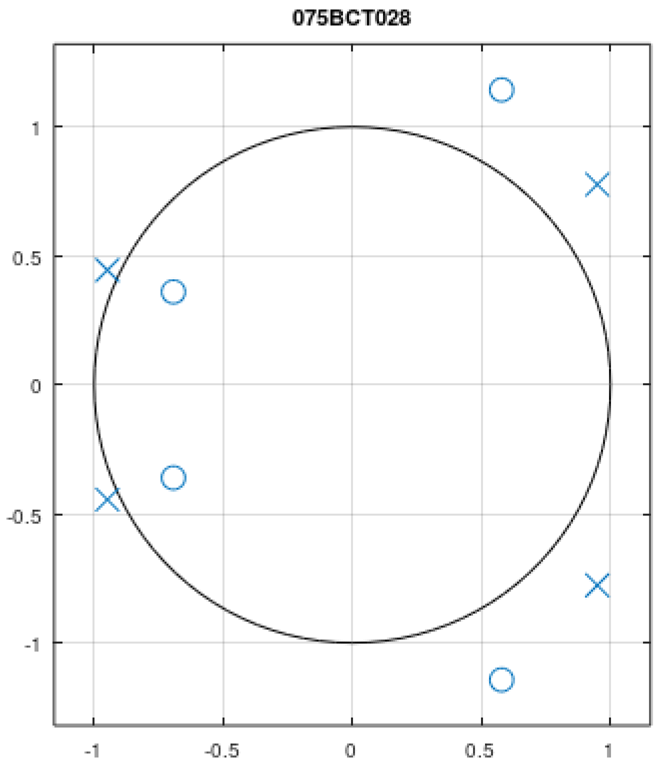

Figure 1: Poles and zeroes for example

1. `h[n] = [1, 2, 3.4, 6.3, 0.7, 2]`

```
pkg load signal
f=[1,2,3.4,6.3,0.7,2]
F = czt(f)
zplane(F)
title('075BCT028')
```

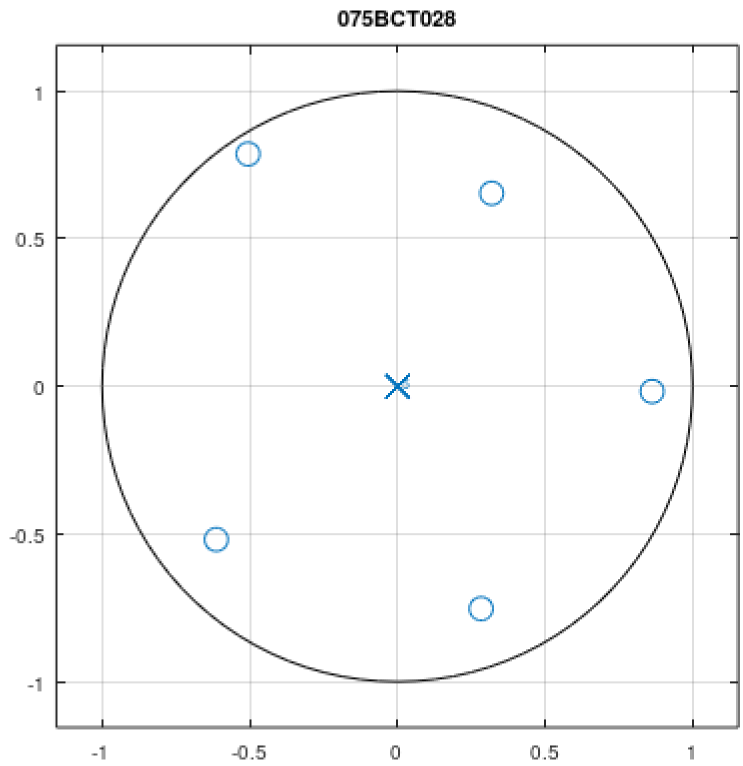

Figure 2: Poles and zeroes of h[n] = [1, 2, 3.4, 6.3, 0.7, 2]

2.

$$H(z) = \frac{1 - 0.4z^{-1} + 0.2z^{-3} + 0.77z^{-5}}{0.78 + 1.5z^{-1} + z^{-4} + 8.2z^{-5}}$$

```
pkg load signal
num = [1 -0.4 0 0.2 0 0.77]
dem =  [0.78 1.5 0 0 1 8.2]
zplane(num,dem)
title('075BCT028')
```

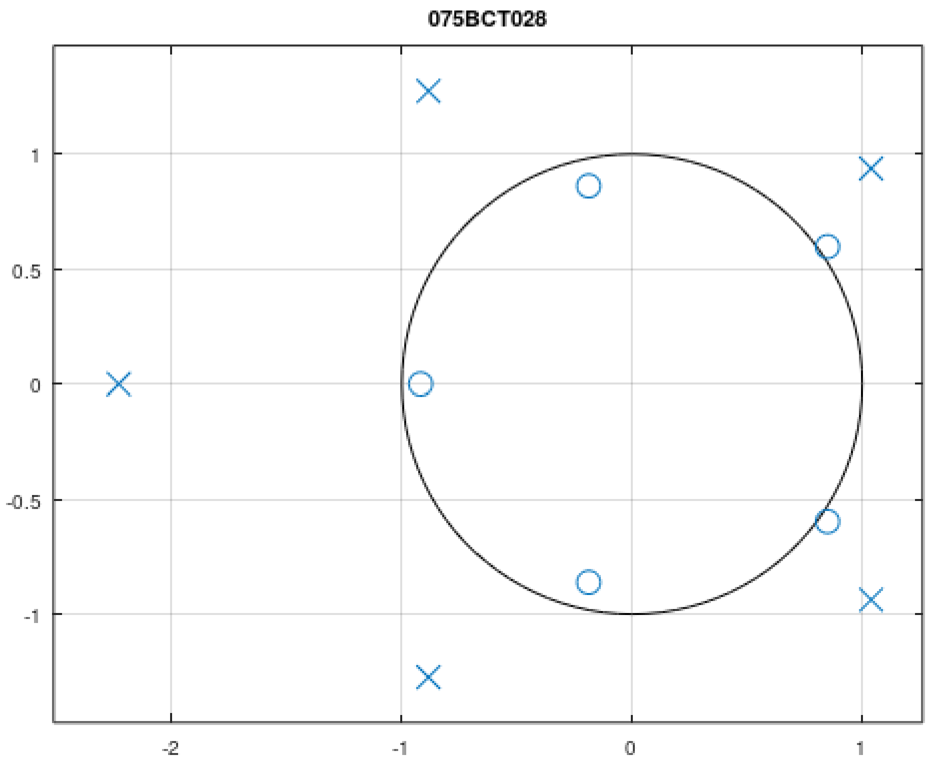

Figure 3: Poles and zeroes for activity 2

Conclusion
In this way "Lab 5 : z-Transformations" was completed with the help of signal package in MATLAB. For this we plotted a pole-zero plot for a discrete sequence signal and a pole-zero plot for a transfer function.