

# Z-Transform of Causal, Noncausal, and Anticausal Systems

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## 1 Introduction

The Z-transform is a powerful tool used in signal processing to analyze discrete-time signals and systems. In this report, we will explore the Z-transform of causal, noncausal, and anticausal signals. MATLAB will be used to demonstrate the calculations and visualize the results.

## 2 Causal Signal

A causal signal is one that starts at a finite time and remains zero for all negative time indices. Let's consider a causal signal defined as:

$$x[n] = \{1, 2, 3, 4\} \quad \text{for } n \geq 0$$

### 2.1 MATLAB Code for Causal Signal

```
clc;
clear all;
% Define the causal signal
x=input('array: ');b=0;
y=sym('z');
n=length(x);
% Compute and plot the Z-transform
for i=1:n
    b=b+x(i)*y^(1-i);
end
z=[];
p=[0]
zplane(z,p)
grid
title('Z-plane for Causal Signal');
```

### 2.2 Results and Analysis

By applying the Z-transform to the causal signal, we obtain its corresponding representation in the Z-domain. The resulting Z-plane plot shows the location of the poles and zeros of the signal. Analyzing the plot can provide insights into the stability and frequency response of the signal.

## 3 Noncausal Signal

A noncausal signal is one that extends to infinity in both the positive and negative time directions. Let's consider a noncausal signal defined as:

$$x[n] = \{0, 1, 2, 3, 4\} \quad \text{for } -\infty < n < \infty$$

### 3.1 MATLAB Code for Noncausal Signal

```
% Define the noncausal signal
clc;
clear all;
x=input('array: ');b=0;
```

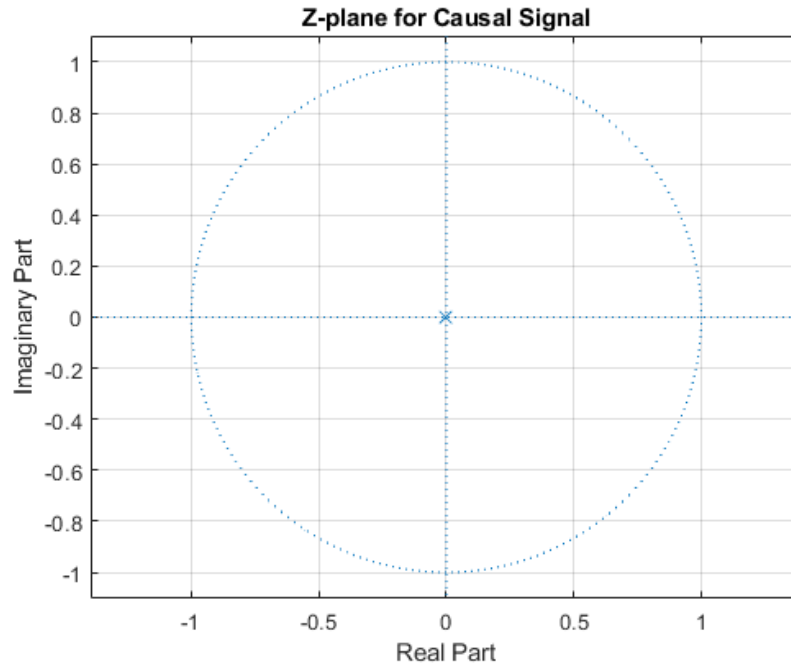


Figure 1: Z-transform of Causal System

```

y=sym('z');
n=length(x);
m=input('index:');
% Compute and plot the Z-transform
for i=1:n
    b=b+x(i)*y^(m-i);
end
z=[];
p=[0]
zplane(z,p)
grid
title('Z-plane for Noncausal Signal');

```

### 3.2 Results and Analysis

When applying the Z-transform to a noncausal signal, we observe its representation in the Z-domain. The Z-plane plot displays the distribution of poles and zeros, which can provide insights into the system's behavior.

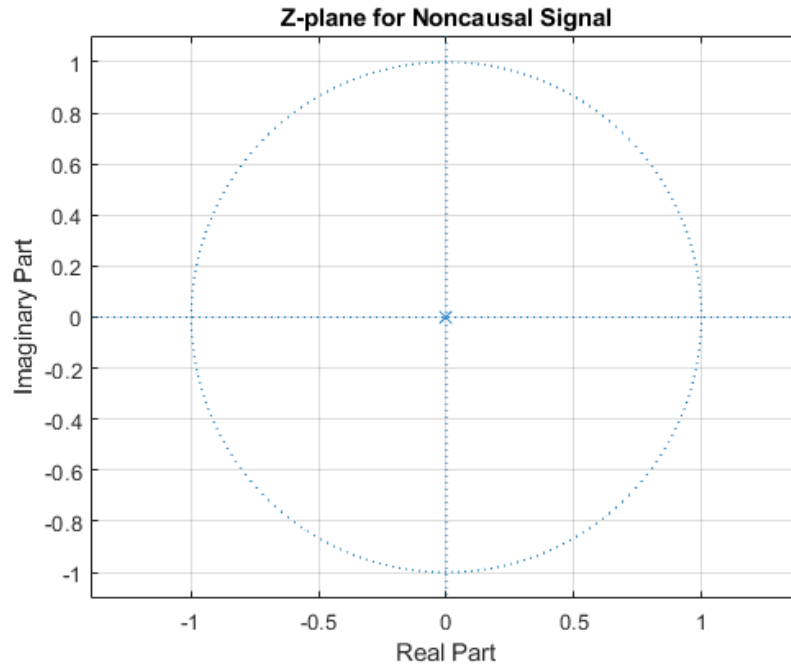


Figure 2: Z-transform of Noncausal System

## 4 Anticausal Signal

An anticausal signal is one that starts at negative infinity and remains zero for all nonnegative time indices. Let's consider an anticausal signal defined as:

$$x[n] = \{4, 3, 2, 1\} \quad \text{for } n \leq 0$$

### 4.1 MATLAB Code for Anticausal Signal

```
% Define the anticausal signal
clc;
clear all;
x=input('array: ');b=0;
y=sym('z');
n=length(x);
% Compute and plot the Z-transform
for i=1:n
    b=b+x(i)*y^(-(i-n));
end
z=[];
p=[]
```

```
zplane(z,p)
grid
```

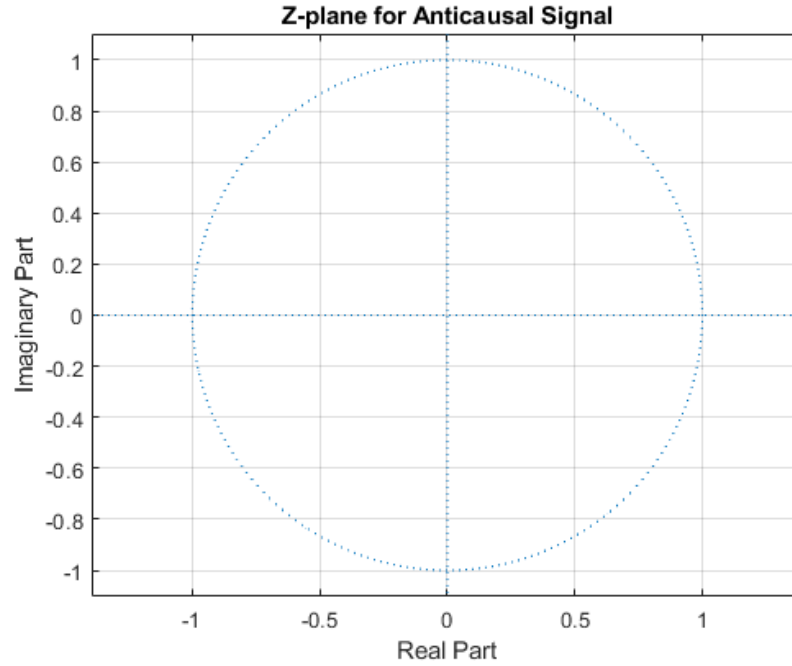


Figure 3: Z-transform of Anticausal System

## 4.2 Results and Analysis

By applying the Z-transform to an anticausal signal, we can observe its representation in the Z-domain. The Z-plane plot provides information about the poles and zeros, aiding in the analysis of system properties.

## 5 Inverse Z-Transform

The inverse Z-transform of a function  $F(z)$  is denoted as  $f[n]$  and represents the corresponding time-domain sequence. It can be computed using techniques such as partial fraction expansion, power series expansion, or contour integration.

### 5.1 MATLAB Code

```
clc;
clear all;
```

```

y=sym('z');syms n;
%f=exp(-2*n);
f=2^-n;
F=ztrans(f)
t=iztrans(F);
t=simplify(t);
disp(t);z=[0];
b = [1];
a = [1 -1/2];
[b,a] = eqtflength(b,a);
[z,p,k] = tf2zp(b,a)
zplane(b,a)
text(real(z)+0.1,imag(z),"Zero")
text(real(p)+0.1,imag(p),"Pole")

```

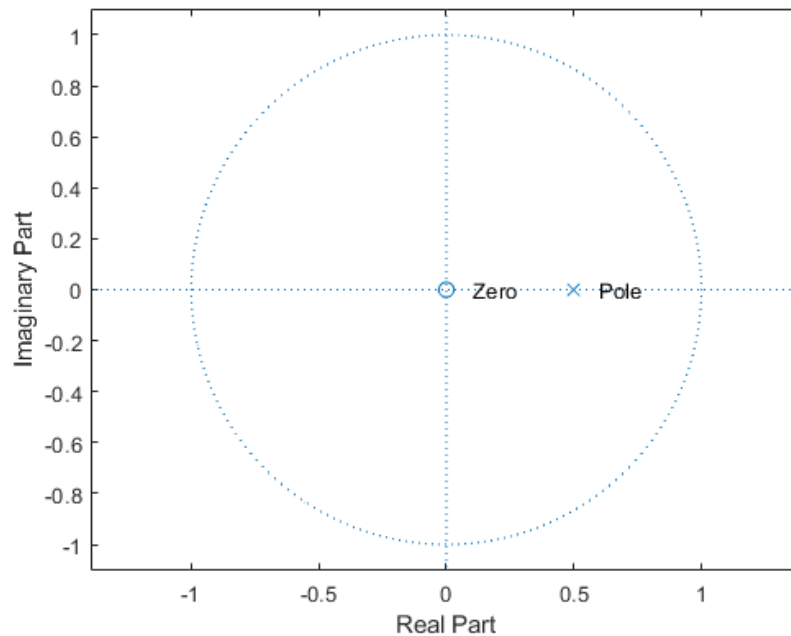


Figure 4: Inverse Z-transform of a System

## 5.2 Results and Analysis

The MATLAB code above demonstrates the computation of the inverse Z-transform for a rational function  $F(z)$ . The `residue` function is used to com-

pute the residues and poles of the function, which are then used to obtain the time-domain sequence  $f[n]$  up to  $n = 10$ .

The results of the inverse Z-transform are displayed in a table, showing the values of  $n$  and  $f[n]$ . The specific values will depend on the function and the desired range of  $n$ .

## 6 Conclusion

In this report, we explored the Z-transform of causal, noncausal, and anticausal signals using MATLAB. By analyzing the resulting Z-plane plots, we gained insights into the characteristics and behavior of the signals in the Z-domain. The Z-transform is a valuable tool for understanding discrete-time signals and systems and is widely used.