Department of Electrical & Computer Engineering

Course No: ECE 4124

Course Title: Digital Signal Processing Sessional

Experiment No. 05

Experiment name: Determining the Z-transform of a causal, anti-causal, and non-causal signal in MATLAB

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Experiment No. 05

Experiment name: Determining the Z-transform of a causal, anti-causal, and non-causal signal in MATLAB

Theory: A causal signal is one that exists and is nonzero only for time indices that are nonnegative. In a more suitable domain for study, the Z-transform can provide insights into the frequency characteristics, stability, and reactivity of the causal signal.

The following is the generic formula for the Z-transform of a causal discrete-time signal x[n]:

X(z) = ∑(n = 0 to ∞) [x[n] * z^(-n)]

A signal that occurs and is nonzero exclusively for negative time indices is referred to as an anti-causal signal. The Z-transform can provide information about the anti-causal signal's frequency characteristics, stability, and response in the Z-domain.

The following is the generic formula for the Z-transform of an anti-causal discrete-time signal x[n]:

X(z) = ∑(n = -∞ to -1) [x[n] * z^(-n)]

When dealing with a non-causal discrete-time signal, which occurs for both positive and negative time indices, the Z-transform is frequently divided into two parts: one for the positive time indices (causal portion) and one for the negative time indices (anti-causal part). This separation aids in dealing with the Z-transform of a signal that is nonzero in both directions.

The generic formula for a non-causal discrete-time signal x[n]'s Z-transform can be stated as a combination of the causal and anti-causal parts:

X(z) = X_causal(z) + X_anti_causal(z)

The Z-transform is a useful tool for evaluating discrete-time signals and systems in the frequency domain in all instances. It provides insights into system behavior, stability, frequency response, and other qualities, making it an important concept in many domains, including signal processing, control systems, and communication systems.

Required Software: MATLAB

Code:

1. Causal Signal:

```
clc;
clear all;

x=[2 5 7 7 5 2];
b=0;
n=length(x);
y=sym('z');
for i=1:n
 b=b+x(i)*y^(1-i);
end

disp('Z-Transform:  ');
disp(b);
```

Output:

```
Z-Transform:

5/z + 7/z^2 + 7/z^3 + 5/z^4 + 2/z^5 + 2
```

2. Anti-causal Signal:

```
clc;
clear all;

x=[1 3 5 7 3 1];
b=0;
n=length(x);
y=sym('z');
for i=1:n
 b=b+x(i)*y^(i-1);
end

disp('Z-Transform: ');
disp(b);
```

Output:

```
Z-Transform:

z^5 + 3*z^4 + 7*z^3 + 5*z^2 + 3*z + 1
```

3. Non-causal Signal:

```
Clc;
clear all;

x=[1 3 5 7 9];
pos=input('input zero index: ');
n=length(x);
y=sym('z');
b=0;
a=0;
for i=1:n
 if i>=pos
 b=b+x(i)*y^(pos-i);
 else
 b=b+x(i)*y^((-1)*(i-pos));
 end
end
disp('Z-Transform: ');
disp( b);
```

Output:

```
input zero index: 4

Z-Transform:

5*z + 9/z + 3*z^2 + z^3 + 7
```

Discussion and Conclusion:

We learned about the z transformation of causal, anticausal, and non-causal signals in this experiment. In the z domain, the power of z for a causal signal is negative. For anticausal signal, the power of z is positive in the z domain. A non-causal signal has two sides. We take the zero position of a signal from the user and calculate the z transformation based on that value for non-causal signals. We obtained the exact value as theory for the MATLAB code.