Experiment No: 7 Date:29/08/2024

PROPERTIES OF DFT

Aim

To perform the following properties of dft :

a) Convolution
b) Linearity
c) Multiplication
d) Parseval

Theory

a)Convolution

Convolution is a mathematical operation that combines two signals to produce a third signal, representing how the shape of one signal modifies the other. In discrete-time systems, the convolution of two sequences x[n] and h[n] (where h[n] is typically the impulse response of a system) is given by:

$$y[n] = \sum_{k=-\infty}^{\infty} x[k] \cdot h[n-k]$$

Convolution is used in signal processing to determine the output of a linear time-invariant (LTI) system when the input and the system's impulse response are known.

b) Linearity

The DFT is a linear transformation, meaning that the DFT of the sum of two signals is equal to the sum of their individual DFTs, and multiplying a signal by a constant in the time domain results in the DFT being multiplied by the same constant.If x1(n) and x2(n) are two sequences and a and b are constants then:

DFT(ax1(n)+bx2(n))= a.DFT(x1(n))+b.DFT(x2(n))

c) Multiplication

Multiplication in the frequency domain refers to the process of multiplying two signals. In signal processing, convolution in the time domain corresponds to multiplication in the frequency domain, and vice versa. Mathematically, if the DFT of two signals x[n] and h[n] are X[k] and H[k] then their product in the frequency domain is:

$$Y[k]=X[k]\cdot H[k]$$

This principle is used in filters, where a signal is multiplied with a frequency response to remove or enhance specific frequency components.

d)Parseval

Parseval's theorem relates the total energy of a signal in the time domain to its energy in the frequency domain. For a discrete-time signal x[n] with DFT X[k], Parseval's theorem states:

$$\sum_{n=0}^{N-1} |x[n]|^2 = \frac{1}{N} \sum_{k=0}^{N-1} |X[k]|^2$$

This theorem ensures that the energy is preserved across both domains, which is useful in energy analysis of signals. It is often applied in applications like audio processing, where energy conservation is essential.

PROGRAM

a)Convolution

```
clc;
clear all;
close all;
x3=[1,2,3,4];
x4=[2,1,2,1];
N = max(length(x3),length(x4));
convolution = cconv(x3,x4,N);
lhsk = fft(convolution);
disp(lhsk);
x3k = fft(x3);
x4k = fft(x4);
Rhsk = x3k.*x4k;
disp(Rhsk);
```

OBSERVATION

OUTPUT

a)Convolution

60 0 -4 0

60 0 -4 0

b) Linearity

LHS=

38.0000 + 0.0000i -4.0000 + 4.0000i 2.0000 + 0.0000i -4.0000 - 4.0000i

RHS=

38.0000 + 0.0000i -4.0000 + 4.0000i 2.0000 + 0.0000i -4.0000 - 4.0000i

c) Multiplication

3.0000 + 0.0000i 1.0000 - 2.0000i -1.0000 + 0.0000i 1.0000 + 2.0000i

3.0000 + 0.0000i 1.0000 - 2.0000i -1.0000 + 0.0000i 1.0000 + 2.0000i

d)Parseval

Energy in time domain:

30

Energy in frequency domain:

30

b) Linearity

```
clc;
clear all;
close all;
x1=[1 2 3 4];
 x2=[2 1 2 1];
 x1=x1(:,end:-1:1);
 for i =1:length(x1)
 x1=[x1(end) x1(1:end-1)];
 y1k(i)=sum(x1.*x2);
 end
 lhs=fft(y1k);
 disp('LHS=')
 disp(lhs);
  x1k=fft(x1);
 x2k=fft(x2);
 rhs=x1k.*x2k;
 disp('RHS=');
disp(rhs);
```

c) Multiplication

```
clc;
clear all;
close all;
x1 = [1,2,3,4];
x2 =[ 1,1,0,0];
x1k = fft(x1);
x2k = fft(x2);
```

```
N = max(length(x1),length(x2));
lhs =fft(x1.*x2);
disp(lhs);
rhs = cconv(x1k,x2k,N);
rhsk = rhs/N;
disp(rhsk);
```

d)Parseval

```
clc;
clear all;
close all;
% Define a discrete signal
x = [1, 2, 3, 4]; % Example signal
% Length of the signal
N = length(x);
% Compute the DFT of the signal
X = fft(x);
% Calculate the energy in the time domain
energy_time = sum(abs(x).^2);
disp('Energy in time domain:');
disp(energy_time);
% Calculate the energy in the frequency domain
energy_freq = (1/N) * sum(abs(X).^2);
disp('Energy in frequency domain:');
disp(energy_freq);
```

RESULT

Verified Convolution, linearity, multiplication, and parseval's properties of DFT