Experiment No:07 Date: 3-09-2024

PROPERTIES OF DFT

Aim

To perform the following properties of DFT:

1. Linearity
2. Convolution
3. Multiplication
4. Parsevals theorem

Theory

1. Linearity

The linearity property of DFT states that the DFT of a linear weighted combination of two or more signals is equal to similar linear weighted combination of the DFT of individual signals.

Let,

$$DFT\{x1(n)\}=X_1(K) \text{ \& } DFT\{x2(n)\}=X2(K)$$

then,

$$DFT[a_1x_1(n)+a_2x_2(n)\}=a_1X_1(K)+a_2X_2(K) \text{ where a, \& } a_2 \text{ are constants}$$

2. Convolution

The Circular Convolution of two N-Point Sequences $x_1(n)$ & $x2(n)$ is defined as,

$$x_1(1)\ \Theta\ x2(n) = \Sigma = x_1(n)\ x_2((n-m))_N$$

The Convolution Property of DFT says that, the DFT of circular convolution of two sequences is equivalent to product of their individual DFTS. Let,

$$DFT[x_1(n)\}=X_1(K) \text{ and } DFT(x2(n)\}=X2(K)$$

then, By Convolution property,

$$DFT(x_1(n)\ \Theta\ x2(n)\}=X_1(K)\ X_2(K)$$

3. Multiplication

The Multiplication Property of DFT says that the DFT of product of two discrete time sequences is equivalent to circular convolution of DFT's of the individual sequences scaled by the factor of 1/N.If,

$$DFT(x(n))=X(K)$$

then,

$$DFT(x,(n)\ x2(n)\}=1/N[X_1(K)\Theta X_2(K))$$

4. Parseval theorem

Let DFT(x_1(n)]=X_1(K) & DFT[x2(n))=X2(K) then by Parseval' theorem

$$\Sigma_{n=0}^{N-1} x_1(n)x_2^*(n)=1/N\ \Sigma_{k=0}^{N-1} X_1(K)\ X_2^*(K)$$

Program

1)Linearity property

```
clc;
clear all;
close all;
x1=[1 2 3 4];
x2=[2 1 2 1];
a1=2;
a2=3;
x1k=fft(x1);
x2k=fft(x2);
lhs=(a1*x1)+(a2*x2);
lhsk=fft(lhs);
disp('LHS=');
disp(lhsk);
rhsk=(a1*x1k)+(a2*x2k);
disp("RHS=");
disp(rhsk);
```

2)Convolution property

```
clc;
```

```
close all;
clear all;
x1=[1 2 3 4];
x2= [2 1 2 1];
N=max(length(x1), length(x2));
x1new=[x1 zeros(1, N-length(x1))];
x2new=[x2 zeros(1, N-length(x2))];
X1= fft(x1new);
X2 =fft(x2new);
circular_conv_time =cconv(x1new, x2new, N);
product_freq =ifft(X1 .*X2);
disp("x1(n) cconv x2(n):");
disp(circular_conv_time);
disp("IDFT(X1(k)*X2(k)):");
disp(product_freq);
```

3)Multiplication property

```
clc;
close all;
clear all;
x1 = [1 2 1 2];
x2 =[1 2 3 4];
N=max(length(x1), length(x2));
x1new=[x1 zeros(1, N-length(x1))];
x2new=[x2 zeros(1, N-length(x2))];
product_time=x1new.*x2new;
dft_product_time=fft(product_time);
X1=fft(x1new);
X2=fft(x2new);
```

```
Y=cconv (X1,X2, N);
disp("DFT(x1(n)*x2(n)}:");
disp(dft_product_time);
disp("X1(k)circonvX2(k)/N:");
disp(Y./N);
```

4)Parsevals theorem

```
clc;
clear all;
close all;
x1=[1 2 1 1];
x2=[1 2 3 4];
N =max(length(x1), length(x2));
x1new=[x1 zeros(1, N-length(x1))];
x2new=[x2 zeros(1, N-length(x2))];
time_domain_value=sum(x1new.*conj (x2new));
freq_domain_value = sum(fft(x1new).*conj (fft(x2new)))./ N;
disp("Sum{n:0->N-1; x1(n) *conj(x2(n))}:");
disp(time_domain_value);
disp("Sum{k:0->N-1;X1(k)*conj(X2(k))}/N:");
disp(freq_domain_value);
```

Result

Performed various properties of dft and verified the outputs.

Observation

1)Linearity property

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

2)Convolution property

x1(n) cconv x2(n):

14 16 14 16

IDFT(X1(k)*X2(k)):

14 16 14 16

3)Multiplication property

DFT(x1(n)*x2(n)}:

16.0000 + 0.0000i -2.0000 + 4.0000i -8.0000 + 0.0000i -2.0000 - 4.0000i

X1(k)circonvX2(k)/N:

16.0000 + 0.0000i -2.0000 + 4.0000i -8.0000 + 0.0000i -2.0000 - 4.0000i

4)Parsevals theorem

Sum{n:0->N-1; x1(n) *conj(x2(n))}:

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Sum{k:0->N-1;X1(k)*conj(X2(k))}/N:

12