Experiment No: 7 Date: 26/09/24

Properties of DFT

Aim:

Verify following properties of DFT using Matlab/Scilab.

1.Linearity Property

2.Parsevals Theorem

3.Convolution Property

4.Multiplication Property

Theory:

1. Linearity Property

The linearity property of the DFT states that if you have two sequences x1[n] and x2[n], and their corresponding DFTs are X1[k] and X2[k], then for any scalar a and b:

$$\text{DFT}\{a\cdot x1[n]+b\cdot x2[n]\} = a\cdot \text{DFT}\{x1[n]\}+b\cdot \text{DFT}\{x2[n]\}$$

2. Parseval's Theorem

Parseval's theorem states that the total energy of a signal in the time domain is equal to the total energy in the frequency domain. For a sequence x[n] and its DFT X[k]:

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

3. Convolution Property

The convolution property of the DFT states that the circular convolution of two sequences in the time domain is equivalent to the element-wise multiplication of their DFTs in the frequency domain:

$$\text{DFT}\{x1[n] \circledast x2[n]\}=\text{DFT}\{x1[n]\}\cdot \text{DFT}\{x2[n]\}$$

4. Multiplication Property

The multiplication property of DFT states that pointwise multiplication in the time domain corresponds to circular convolution in the frequency domain:

$$\text{DFT}\{x1[n]\cdot x2[n]\} = \frac{1}{N}\text{DFT}\{x1[n]\} \circledast \text{DFT}\{x2[n]\}$$

Program:

a) Linearity Property

```
clc;

clear;

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);
```

b) Parseval's Theorem

```
clc;
clear;
close all;
x=[1 2 3 4];
N=length(x);
e=sum(abs(x).^2);
X=fft(x);
ek=sum(abs(X).^2)/N;
disp('LHS=');
disp(e);
disp('RHS=');
disp(ek);
```

c) Convolution Property

```
clc;
clear;
close all;
x1=[1 2 3 4];
x2=[2 1 2 1];
```

```
y1=cconv(x1,x2,4);
lhsk=fft(y1);
x1k=fft(x1);
x2k=fft(x2);
y2=x1k.*x2k;
rhsk=y2;
disp('LHS=');
disp(lhsk);
disp('RHS=');
disp(rhsk);
```

d) Multiplication Property

```
clc;
clear;
close all;
x1=[1 2 3 4];
x2=[2 1 2 1];
l=length(x1);
m=length(x2);
N=max(l,m);
y1=x1.*x2;
x1k=fft(x1);
x2k=fft(x2);
rhsk=cconv(x1k,x2k,N)/N;
disp('LHS=');
disp(y1);
disp('RHS=');
disp(ifft(rhsk));
```

Result:

Performed and verified the following properties of DFT:

1)Linearity Property; 2)parseval's Theorem; 3)Convolution Property; 4)Multiplication Property

Observation:

a) 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

b) Parseval's Theorem

LHS=

30

RHS=

30

c) Convolution Property

LHS=

60 0 -4 0

RHS=

60 0 -4 0

d) Multiplication Property

LHS=

2 2 6 4

RHS=

2 2 6 4