Experiment No: 6 Date: 26/09/24

DFT AND IDFT

Aim:

1. DFT using inbuilt function, without using inbuilt function and twiddle factor. Also plot magnitude and phase plot of DFT

2. IDFT using inbuilt function, without using inbuilt function, and twiddle factor.

Theory:

Discrete Fourier Transform (DFT)

The **Discrete Fourier Transform (DFT)** is a mathematical transformation used to analyze the frequency content of discrete signals. For a sequence x[n] of length N, the DFT is defined as:

$$X[k] = \sum_{n=0}^{N} x[n] \cdot e^{-j\frac{2\pi}{N}nk}, \; k = 0, 1, 2, ..., N-1$$

- X[k] is the DFT of the sequence x[n].
- The exponential factor represents $e^{-j\frac{2\pi}{N}nk}$ the complex sinusoidal basis functions.
- The DFT maps the time-domain signal into the frequency domain.

Inverse Discrete Fourier Transform (IDFT)Method:

The **Inverse Discrete Fourier Transform (IDFT)** is used to convert a frequency-domain sequence X[k] back into its time-domain sequence x[n]. The IDFT is defined as:

$$x[n] = \frac{1}{N}\sum_{k=0}^{N} X[k] \cdot e^{j\frac{2\pi}{N}nk}, \; n = 0, 1, 2, ..., N-1$$

- The IDFT takes the frequency components X[k] and reconstructs the original sequence x[n].
- The exponential factor $e^{j\frac{2\pi}{N}nk}$ is the inverse of the DFT's complex sinusoidal basis functions.

The twiddle factor is a complex number that is used in the Cooley-Tukey algorithm, a fast Fourier transform (FFT) algorithm. It is defined as:

W_N^k = exp(-j * 2 * pi * k / N)

- The twiddle factor represents a rotation in the complex plane by an angle of 2*pi*k/N radians. It is used to combine the results of the smaller FFTs that are computed in the Cooley-Tukey algorithm to obtain the final FFT result.

Application

- Spectrum (Analysis)
- Filtering
- Compression
- Modulation
- Convolution
- Demodulation
- Estimation

Program:

1. Discrete Fourier Transform (DFT)

```
clc;
clear all;
close all;
x=input("enter sequence:");
N=input("enter the N point:");
l=length(x);
x=[x zeros(1,N-l)];
X1=zeros(1,N);
for k=0:N-1
    for n=0:N-1
        X1(k+1)=X1(k+1)+x(n+1)*exp(-1j*2*pi*n*k/N);
    end
end
X2 = zeros(N,1);
T = zeros(N, N);
for k = 0:N-1
    for n = 0:N-1
        T(k+1, n+1) = exp(-1i * 2 * pi * k * n / N);
    end
end
X2=T*x';
```

```
disp('Using built-in function');
disp(fft(x));
disp('Without using built-in function');
disp(X1);
disp('Using twiddle factor');
disp(X2);
%plotting
k=0:N-1;
magX=abs(X1);
phaseX=angle(X1);
subplot(2,1,1);
stem(k,magX);
title("Magnitude Plot");
hold on;
plot(k,magX);
subplot(2,1,2);
stem(k,phaseX);
hold on;
title("Phase Plot");
plot(k,phaseX);
```

2. IDFT

```
clc;
clear all;
close all;
X=input("enter sequence:");
N=input("enter the n point:");
l=length(X);
X=[X zeros(1,N-l)];
x1=zeros(N,1);
```

```
for k=0:N-1
    for n=0:N-1
        x1(n+1)=x1(n+1)+X(k+1)*exp(1j*2*pi*n*k/N);
    end
end
x1=1/N.*x1;
x2 = zeros(N,1);
T = zeros(N, N);
for k = 0:N-1
    for n = 0:N-1
        T(k+1, n+1) = exp(1i * 2 * pi * k * n / N);
    end
end
x2=T*X';
x2=(1/N).*x2;
disp('Without Using built in function');
disp(x1);
%verification
disp('Using built in function');
disp(ifft(X));
disp('Using Twiddle factor');
disp(x2);
```

Result:

Performed

1)DFT using inbuilt function, without using inbuilt function and twiddle factor. Also plotted magnitude and phase plot of DFT.

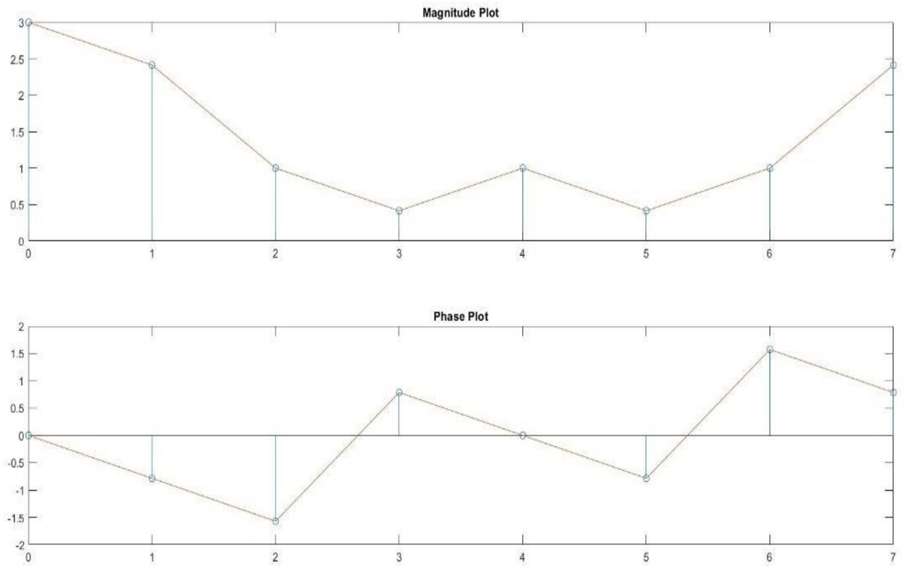
2)IDFT using inbuilt function, without using inbuilt function and twiddle factor.

and verified the result.

Observations

1. DFT

```
enter sequence:[1 1 1 0]

enter sequence:[1 1 1 0]

enter the N point:8

Using built-in function

Columns 1 through 3

   3.0000 + 0.0000i   1.7071 - 1.7071i   0.0000 - 1.0000i

  Columns 4 through 6

   0.2929 + 0.2929i   1.0000 + 0.0000i   0.2929 - 0.2929i

  Columns 7 through 8

   0.0000 + 1.0000i   1.7071 + 1.7071i

Without using built-in function

  Columns 1 through 3

   3.0000 + 0.0000i   1.7071 - 1.7071i   0.0000 - 1.0000i

  Columns 4 through 6

   0.2929 + 0.2929i   1.0000 + 0.0000i   0.2929 - 0.2929i

  Columns 7 through 8

  -0.0000 + 1.0000i   1.7071 + 1.7071i

Using twiddle factor

   3.0000 + 0.0000i

   1.7071 - 1.7071i

   0.0000 - 1.0000i

   0.2929 + 0.2929i

   1.0000 + 0.0000i

   0.2929 - 0.2929i

  -0.0000 + 1.0000i

   1.7071 + 1.7071i
```



>

2. IDFT

enter sequence:[3 -i 1 i]

enter the n point:4

Without Using built in function

1.0000 + 0.0000i

1.0000 - 0.0000i

1.0000 - 0.0000i

0.0000 + 0.0000i

Using built in function

1 1 1 0

Using Twiddle factor

1.0000 + 0.0000i

0.0000 + 0.0000i

1.0000 - 0.0000i

1.0000 - 0.0000i