Experiment No:06 Date: 3-09-2024

DFT AND IDFT

Aim

To perform DFT and IDFT with and without twiddle factor and to plot the magnitude and phase plot of DFT sequence.

Theory

Discrete Fourier Transform is the transformation used to represent the finite duration frequencies. DFT of a discrete sequence x(n) is obtained by performing sampling operations in both time domain and frequency domain. It is the frequency domain representation of a discrete digital signal.

The DFT of a sequence x (n) of length N is given by the following equation,

$$X(k) = \{\sum_{n=0}^{N-1} x(n)\, e^{\frac{-j2\Pi kn}{N}}; 0 \leq k \leq N-1 \}$$

IDFT performs the reverse operation of DFT, to obtain the time domain sequence x(n) from frequency domain sequence X(k). IDFT of the sequence is given as,

$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X(K).\, e^{\frac{j2\Pi kn}{N}}; n = 0,1,2,..,N-1$$

The IDFT takes the frequency components X[k] and reconstructs the original sequence x[n].

The exponential factor $e^{\frac{j2\Pi kn}{N}}$ is the inverse of the DFT's complex sinusoidal basis functions.

Program

a)

i)DFT

```
clc;
clear all;
close all;
x=[1 1 0 0];
N=length(x);
```

```
X=zeros(4,1);
for k=0:N-1
    for n =0:N-1
        X(k+1)=X(k+1)+x(n+1)*exp(-i*2*pi*n*k/N);
    end
end
disp(round(X));
%using built in function
disp("Using built in function:");
disp(fft(x));
```

ii)IDFT

```
clc;
clear all;
close all;
X=[2 1-i 0 1+i];
N=length(X);
x=zeros(4,1);
for n=0:N-1
    for k =0:N-1
        x(n+1)=(x(n+1)+X(k+1)*exp(i*2*pi*n*k/N));
    end
end
x=x/N;
disp(round(x));
%using built in function
disp("Using built in function:");
disp(ifft(X));
```

b)

i) DFT using twiddle factor

```
clc;
clear all;
close all;
x = [1 2 3 4];
N = length(x);
X = zeros(N, 1);
twiddle_factors = zeros(N, N);
for k = 0:N-1
    for n = 0:N-1
        twiddle = exp(-2*pi*1i*k*n/N);
        twiddle_factors(k+1, n+1) = twiddle;
        X(k+1) = X(k+1) + x(n+1) * twiddle;
    end
end
disp("Twiddle factors :");
disp(twiddle_factors);
%display dft result
disp("Dft of x: ");
disp(X);
```

ii)IDFT using twiddle factor

```
clc;
clear all;
close all;
X=[2,1-i,0,1+i];
N=length(X);
x=zeros(N,1);
twiddle_factors=zeros(N,N);
```

```
for n=0:N-1
    for k=0:N-1
        twiddle =exp(2*i*pi*k*n/N);
        twiddle_factors(n+1,k+1)=twiddle;
        x(n+1)=x(n+1)+X(k+1)*twiddle
    end
end
x=x/N;
disp(twiddle_factors);
disp("IDFT:");
disp(x);
```

c) Magnitude and phase plot of dft

```
clc;
clear all;
close all;
xn=[1 1 1];
N=input("enter the no: ");
 L=length(xn);
 if(N<L)
    error('N must be greater than or equal to L')
 end
 x=[xn,zeros(1,N-L)];
 N=length(x);
 Xk=zeros(N,1);
 for k=0:N-1
    for n =0:N-1
        Xk(k+1)=Xk(k+1)+x(n+1)*exp(-i*2*pi*n*k/N);
    end
 end
 mgXk=abs(Xk);
```

```
phaseXk=angle(Xk);
k=0:N-1;
subplot(2,1,1);
stem(k,mgXk);
hold on
plot(k,mgXk);
title('DFT sequence');
xlabel('Frequency');
ylabel('Magnitude');
subplot(2,1,2);
stem(k,phaseXk);
hold on
plot(k,phaseXk);
title('Phase of the DFT sequence');
xlabel('Frequency');
ylabel('Phase');
```

Result

Performed the DFT and IDFT operations using MATLAB and also plotting the phase and magnitude spectrum of DFT for better understanding. In addition performed the dft and and idft using twiddle factor .

Observation

a)

i)DFT

2.0000 + 0.0000i

1.0000 - 1.0000i

0.0000 + 0.0000i

1.0000 + 1.0000i

Using built in function:

2.0000 + 0.0000i

1.0000 - 1.0000i

0.0000 + 0.0000i

1.0000 + 1.0000i

ii)IDFT

1

1

0

0

Using built in function:

1

1

0

0

b)

i)DFT using twiddle factor

```
Twiddle factors for DFT:

 1.0000 + 0.0000i    1.0000 + 0.0000i   1.0000 + 0.0000i    1.0000 +
 0.0000i

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

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

 1.0000 + 0.0000i   -0.0000 + 1.0000i   -1.0000 - 0.0000i    0.0000 -
 1.0000i
```

DFT of x:

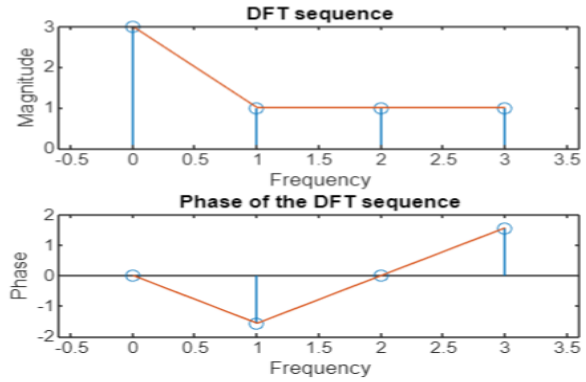
```
  10.0000 + 0.0000i

  -2.0000 + 2.0000i

  -2.0000 - 0.0000i

  -2.0000 - 2.0000i
```

ii)IDFT using twiddle factor

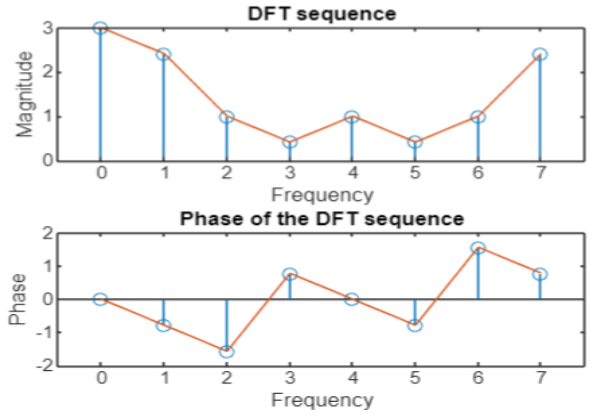
```
Twiddle factors for IDFT:
   1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 +
   0.0000i

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

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

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

IDFT result:
   1.0000 + 0.0000i

   1.0000 - 0.0000i

  -0.0000 + 0.0000i

   0.0000 + 0.0000i
```

c) Magnitude and phase plot of dft

N=4



N=8



N=16