Digital Signal Processing

25 January, 2024

LAB 1

GROUP MEMBERS

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AIM: To find frequency response of a given system in differential equation form

THEORY:

The Discrete Fourier Transform (DFT) is a mathematical tool used to analyze discrete signals in the frequency domain. It is a form of Fourier analysis that is applicable to a sequence of discrete values . The DFT is often used to analyze samples of a continuous function . The DFT of a discrete sequence x(n) represents the frequency content of the sequence x(n). The DFT is defined as:

$$Xe^{jw} = \sum_{n=-\infty}^{\infty} x(n)e^{-jwn}$$

where x(n) is the input sequence and is the frequency variable. The DFT has several properties such as linearity, symmetry, time scaling, and more. These properties are useful in solving problems involving Fourier transforms. I hope this helps!
Basic equation to find the DFT of a sequence is given below.

$$X(k) = \sum_{n=0}^{N-1} x(n)W_N^{nk}$$

$$where\, W_N^{nk} = e^{-j^{\frac{2\pi nk}{N}}}$$

Basic equation to find the IDFT of a sequence is given below.

$$x_n = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{\frac{2\pi i}{N}kn}$$

Algorithm:
Step I: Get the input sequence.
Step II: Find the DFT of the input sequence using direct equation of DFT.
Step III: Find the IDFT using the direct equation.
Step IV: Plot DFT and IDFT of the given sequence using matlab command stem.
Step V: Display the above outputs.

⋆ Code in GNU Octave:

```
clc;
close all;
clear all;
pkg load signal;

%Getting the signal
x = input('Enter Amplitude of Input sequence x(n) : ');
l = length(x);
t = 1:l;
subplot(3, 2, 1);
stem(t-1, x);
xlabel('n');
ylabel('x(n)');
title('Input Signal');
dt = zeros(1, l);
idft = zeros(1, l);

%Discrete Fourier Transform
for k = 0:l-1
for n = 0:l-1
dt(k+1) = dt(k+1) + exp(-1*i*2*k*n*pi/l)*x(n+1)
endfor
endfor
subplot(3, 2, 2);
stem(t-1, dt);
ylabel('x(n)');
xlabel('n');
```

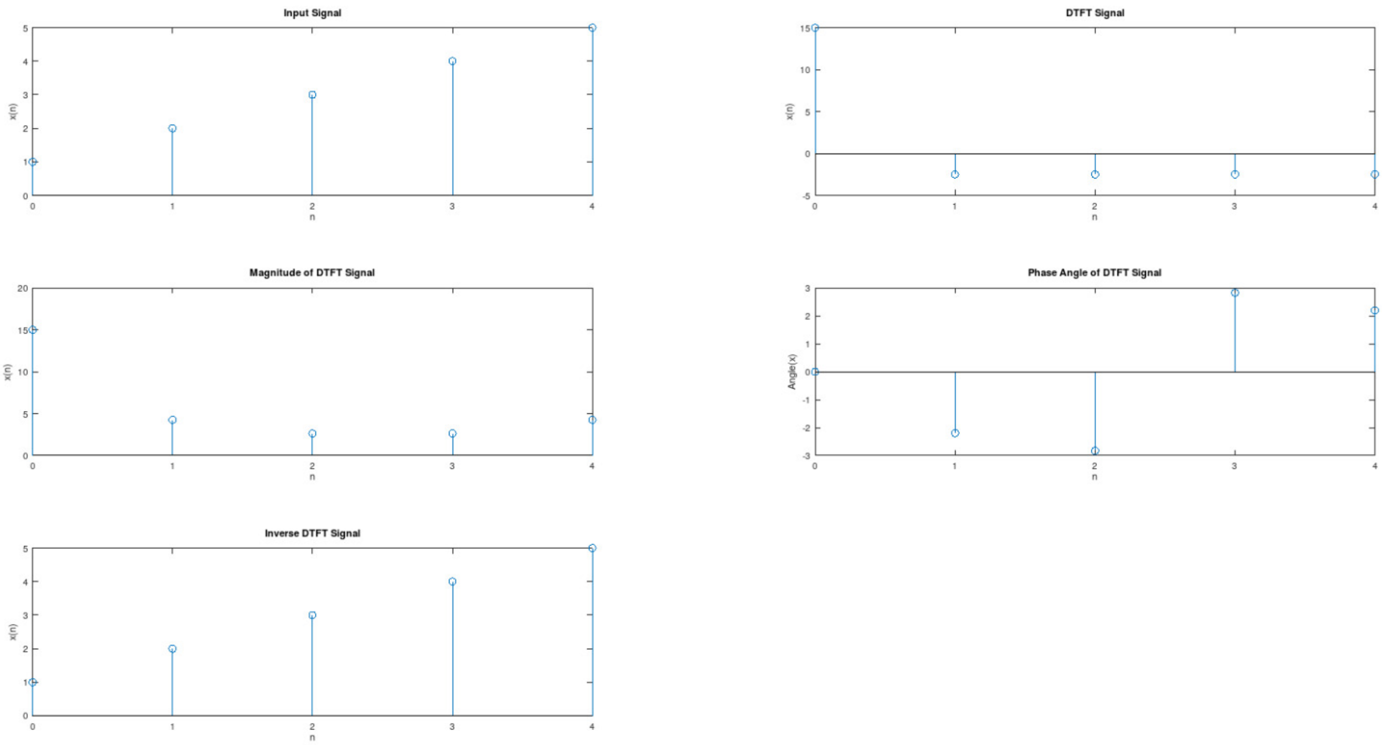
```
title('DFT Signal');

%Magnitude of DFT
m = abs(dt);
subplot(3, 2, 3);
stem(t-1, m);
ylabel('x(n)');
xlabel('n');
title('Magnitude of DFT Signal');

%Phase of DFT
ph = angle(dt);
subplot(3, 2, 4);
stem(t-1, ph);
ylabel('Angle(x)');
xlabel('n');
title('Phase Angle of DFT Signal');

%Inverse Discrete Transform
for k = 0:l-1
for n = 0: l-1
idft(k+1) = (idft(k+1) + exp(i*2*k*n*pi/l)*dt(n+1));
endfor
endfor
idft = idft./l;
subplot(3, 2, 5);
stem(t-1, idft);
ylabel('x(n)');
xlabel('n');
title('Inverse DFT Signal');
```

OUTPUT:



VIVA QUESTIONS:

Ques 1 : Define signal. Give Examples for 1-D, 2-D, 3-D signals.

A *signal* is a function that conveys information about a phenomenon. Any quantity that can vary over space or time can be used as a signal to share messages between observers.

1. *one-dimensional signal* is a signal that depends on only one variable. For example, a signal that varies with time is a one-dimensional signal. A common example of a one-dimensional signal is an audio signal.

2. *two-dimensional signal* is a signal that depends on two variables. For example, an image is a two-dimensional signal. The two variables are usually the x and y coordinates of the image.

3. *three-dimensional signal* is a signal that depends on three variables. For example, a video is a three-dimensional signal. The three variables are usually the x and y coordinates of the image and time.

Ques 2 : Define transform. What is the need for transform?

A *transform* is a mathematical operation that converts a signal from one domain to another. The need for a transform arises when we want to analyze a signal in a different domain than the one it is originally defined in. For example, we may want to analyze a signal in the frequency domain instead of the time domain.

Ques 3 : Differentiate Fourier transform and discrete Fourier transform.

The *Fourier transform* and the *discrete Fourier transform (DFT)* are both mathematical operations that convert a signal from the time domain to the frequency domain. The Fourier transform is a continuous transform, while the DFT is a discrete transform. The Fourier transform is used to analyze continuous signals, while the DFT is used to analyze discrete signals.

Ques 4 : Differentiate DFT and DTFT.

The *DFT (Discrete Fourier Transform)* and the *DTFT (Discrete Time Fourier Transform)* are both mathematical operations that convert a signal from the time domain to the frequency domain. The DFT is used to analyze finite-length discrete-time signals, while the DTFT is used to analyze infinite-length discrete-time signals.

Ques 5 : Explain mathematical formula for calculation of DFT.

The mathematical formula for calculating the *DFT (Discrete Fourier Transform)* of a signal x[n] of length N is given by:

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j2\pi kn/N}$$

where k is the frequency index, and j is the imaginary unit.

Ques 6 : Explain mathematical formula for calculation of IDFT.

The mathematical formula for calculating the *IDFT (Inverse Discrete Fourier Transform)* of a signal X[k] of length N is given by:

$$x[n] = \frac{1}{N} \sum_{k=0}^{N-1} X[k] e^{j2\pi kn/N}$$

where n is the time index, and j is the imaginary unit.

Ques 7 : How to calculate FT for 1-D signal?

To calculate the *Fourier Transform (FT)* of a one-dimensional signal, we can use the following mathematical formula:

$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-j2\pi ft} dt$$

where f is the frequency variable, and t is the time variable.

Ques 8 : What is meant by magnitude plot, phase plot?

A *magnitude plot* is a plot that shows the magnitude of each frequency component present in a signal. A *phase plot* is a plot that shows the phase shift of each frequency component. Together, these plots are called a *frequency-domain plot*.

Ques 9 : What is meant by magnitude plot, phase plot?

The *DFT (Discrete Fourier Transform)* has many applications in signal processing, including:

- *Spectral analysis*: The DFT can be used to analyze the frequency content of a signal.
- *Filtering*: The DFT can be used to design and implement digital filters.
- *Compression*: The DFT can be used to compress signals by removing redundant information.
- *Convolution*: The DFT can be used to perform fast convolution of signals.

EXERCISE:

Find 8-point DFT of the sequence $x(n) = [\mathbf{1\ 2\ 3\ 4\ 4\ 3\ 2\ 1}]$