Department of Electrical Engineering

Faculty Member : **Sir Usman Ilyas** **Dated:** **31-3-2016**

Course/Section: **BEE-6B** **Semester:** **4th Semester**

Student Name: **Saad Iqbal** **Registration no :** **32903**

EE-232Signals and Systems

Lab Report #8 Fourier series

Objectives

The goal of this laboratory is to be able to calculate the Fourier series of approximately continuous time and discrete time signals and plot the real part of the spectrum / Fourier series coefficients.

- ✓ MATLAB Demos on Fourier series
- ✓ Fourier Series Calculation of Discrete Time Signals
- ✓ Inverse Fourier Series Calculation given Fourier Series Coefficients
- ✓ Determine Frequency Response of an LTI Causal System

Pre Lab Task 1:

Using Matlab *fseriesdemo package*:

Constructing saw tooth waveform from its Fourier series. In *figure 1*, red curve shows how the curve will look like using first 15 terms of its series and in *figure 2*, blue curve shows error in actual and developed curve from using first 15 terms of its series.

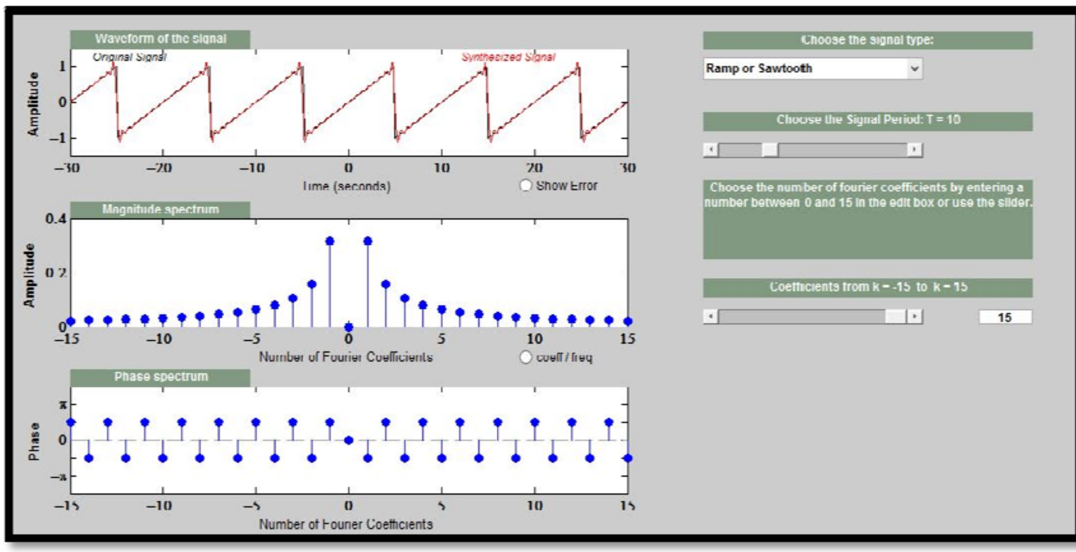


Figure 1

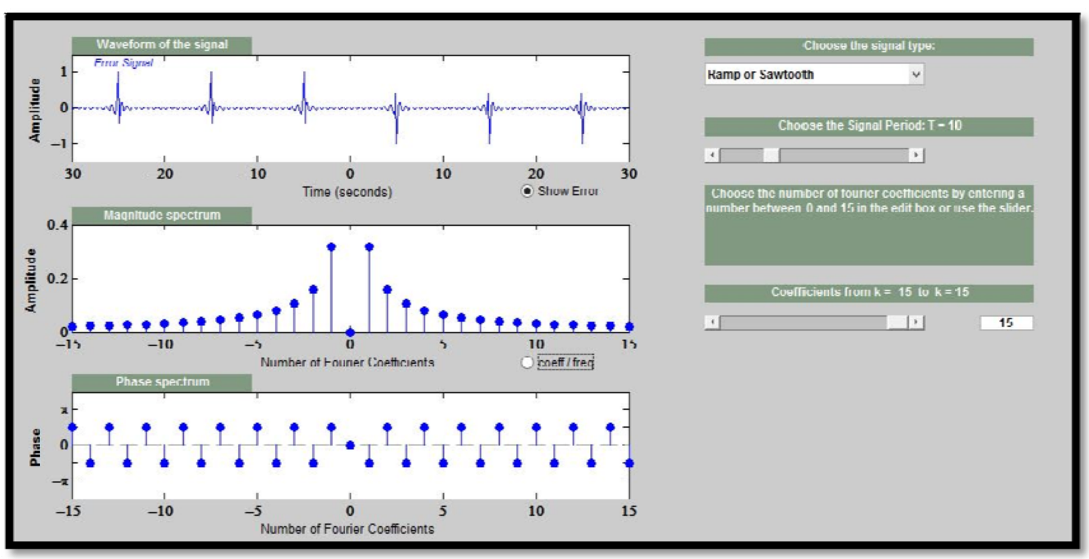


Figure 2

Pre Lab Task 2:

Using Matlab *Sinsum2 package*:

Construct Time domain signal using 5 harmonics frequencies with desired amplitudes and phase angle.

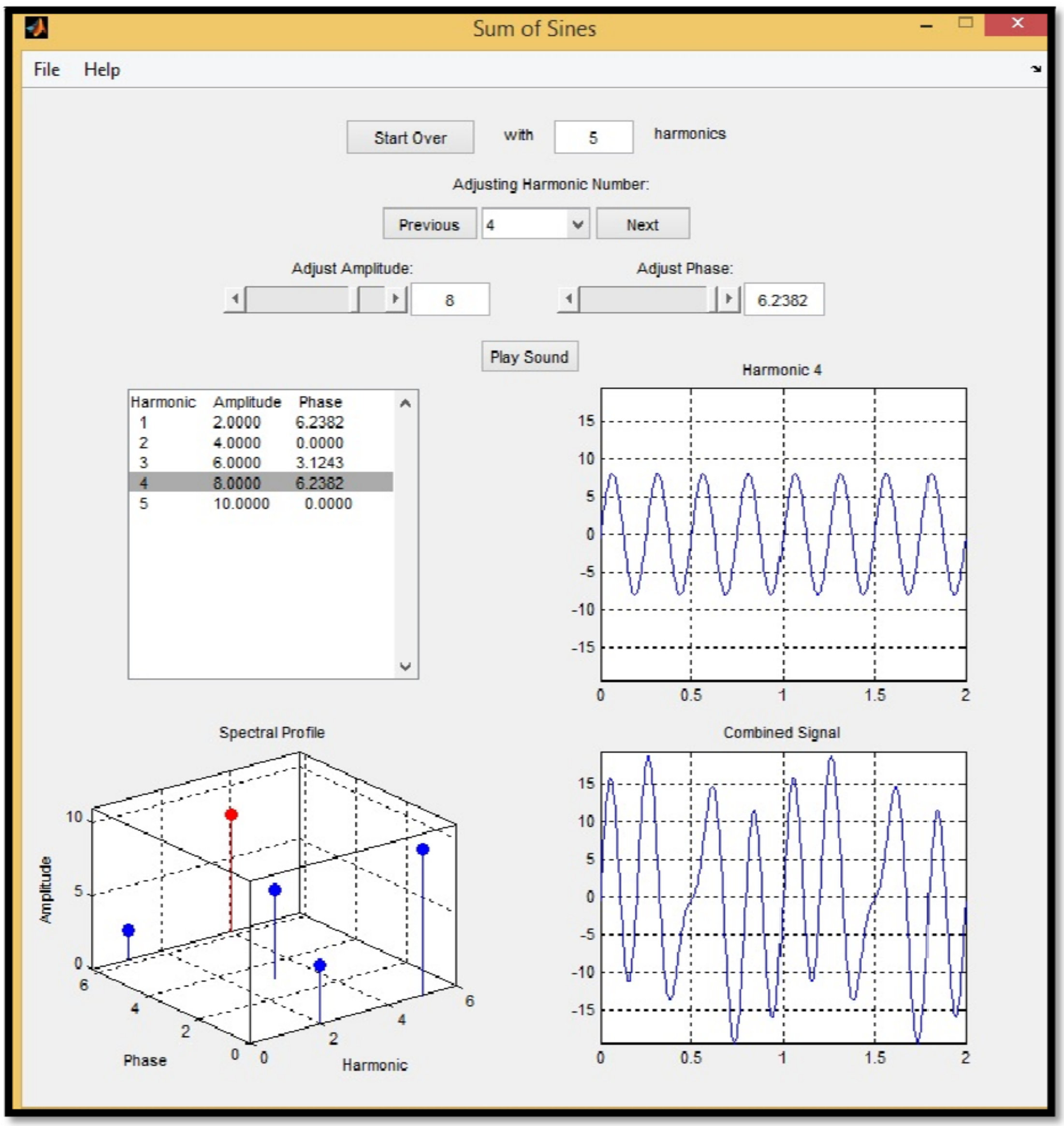


Figure 3

Lab Task 1:

Part A:

Write a function that will generate a single sinusoid, x[n] = A cos (kωn). Determine the Fourier series coefficients and plot only the real part of Fourier series coefficients when A=1 and **kω** = 2*pi*k/T and k=10 and T =10.

Matlab Code:

```
function [X] = cosmaker(A,k,N) %Y are coefficients
Xn=[0:0.05:N]; %Index
x=A*cos((k*2*pi*(Xn(1:length(Xn)))/(N))); %discrete cos function
L=length(x); %signal length
X=real(fft(x,L))/L; %cofficients


stem(X) %Frequency domain graph
hold on
xlabel('Frequencies(f)')
ylabel('Real Amplitudes')
title('Frequency analysis of signal')
hold off


plot(Xn,x) %Time domain graph
hold on
xlabel('Time (sec)')
ylabel('Amplitudes')
title('Time domain of signal')
hold off
```

Matlab Command Window:

```
>> cosmaker(1,10,10)
```

Matlab Graph:

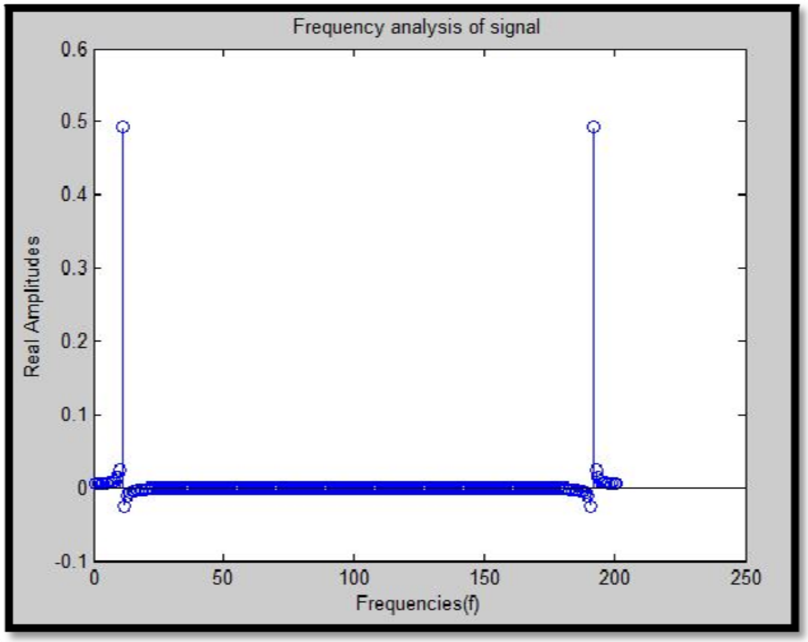


Figure 4

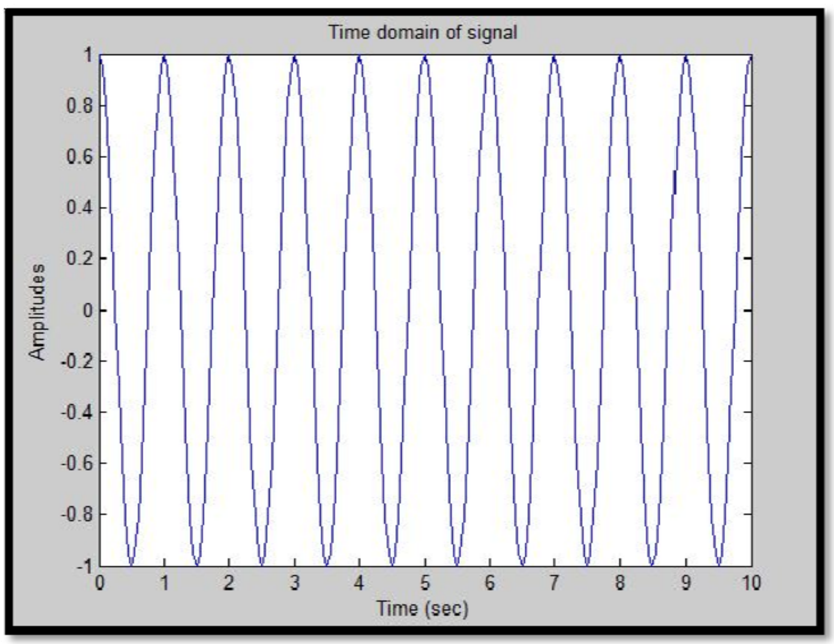


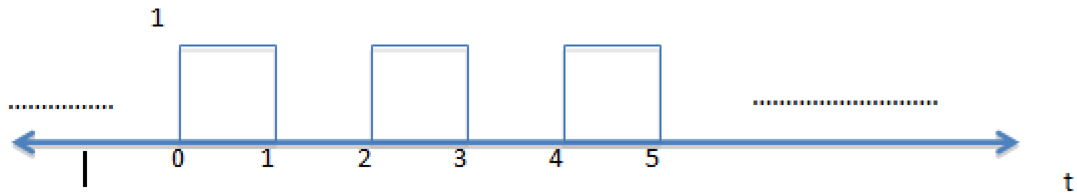
Figure 5

Explanation:

I adjust sampling frequency to be 20Hz and taking FFT of 10 sec sample and see its coefficients plot and got a peeks at value of k, which is 10. *Figure 4, 5* showing frequency and time domain graph respectively.

Part B:

Assume a rectangular wave as shown below. Assume that there are a finite number of values between 0 and 1 and when seen from a distance the function appears to be continuous (We know that this is not, especially for discrete systems such as computers). Using the FFT function determines the Fourier series of the rectangular waveform. Plot the Fourier series coefficients.



Matlab Code:

```
clc
clear all
x=[];
Xn=[0:0.01:5+0.01]
j=2;
x(1)=0
for i=0:0.01:5
    if rem(floor(i),2)==0
    x(j)=1
    else
        x(j)=0;
    end
    j=j+1;
end
L=length(x)
X=real(fft(x,L))/L


plot(Xn,x) %Time domain graph
hold on
title('Square wave')
axis([-1 6 -1 2])
hold off


stem(X) %Frequency domain graph
hold on
title('Square wave in frequency domain')
xlabel('Frequencies(f)')
ylabel('magnitude')
hold off
```

Matlab Graph:

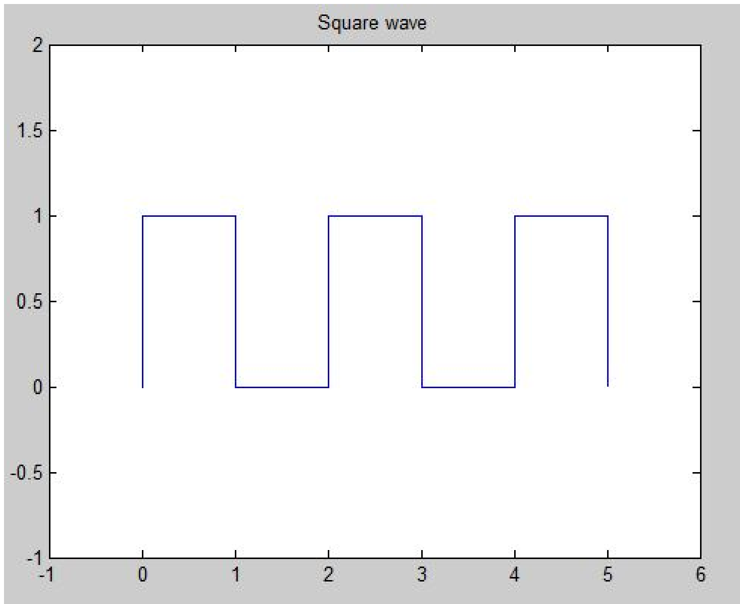


Figure 6

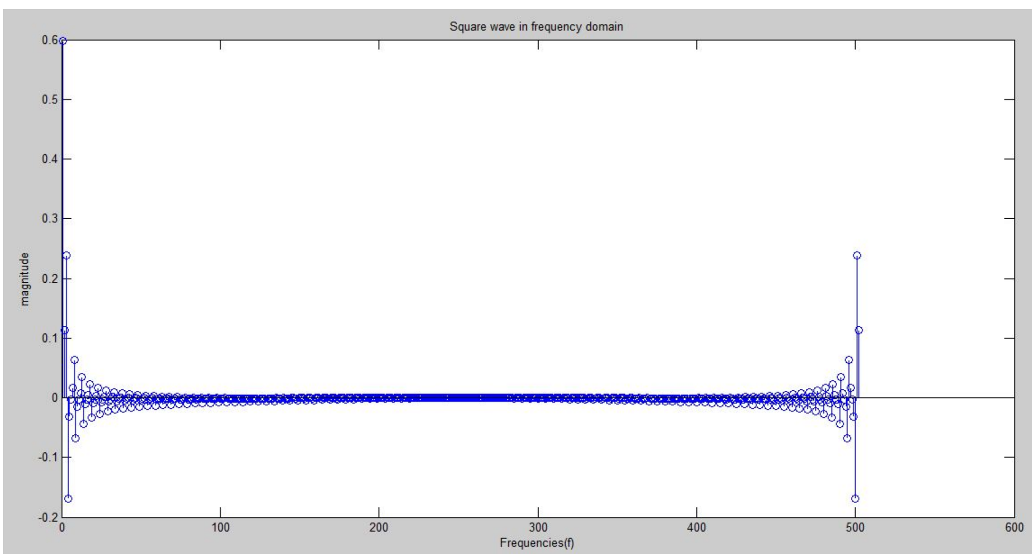


Figure 7

Explanation:

We construct square wave as given and calculate its frequency domain eignvalues and plot its graph. *Figure 6, 7* showing frequency and time domain graph respectively.

Lab Task 2:

Using the function 'IFFT' and knowledge of FS coefficients of a Cosine waveform determine the signal x[n]. For the lab report plot both the Fourier coefficients and time domain signal.

Now assuming that the DTFT was N Point DTFT or FFT. Then the fourier Series Coefficients of x[n] = cos (pi/4) n will have impulses at locations k and N-k.
ω_k = 2 pi k /N If ω_k = pi/4 Then k = N/8 Where N is the N point DTFT or FFT. Assuming that N =1024 locations k and N-k can be calculated. So the coeff_array will be an array of size N with Fourier series coefficients of a cosine waveform at locations k and N-k.

Matlab Code:

```
clc;
clear all;
cof_array=zeros(1,1024);
cof_array(129)=10;  %wave number is 128(N/8),so kth=129
cof_array(1024-127)=10  %(N-k)th=1024-127
Y=ifft(cof_array,1024)

stem(cof_array) %Frequency domain graph
title('Frequency domain analysis')

stem(real(Y)) %Time domain graph
title('Time domain analysis')
```

Matlab Graph:

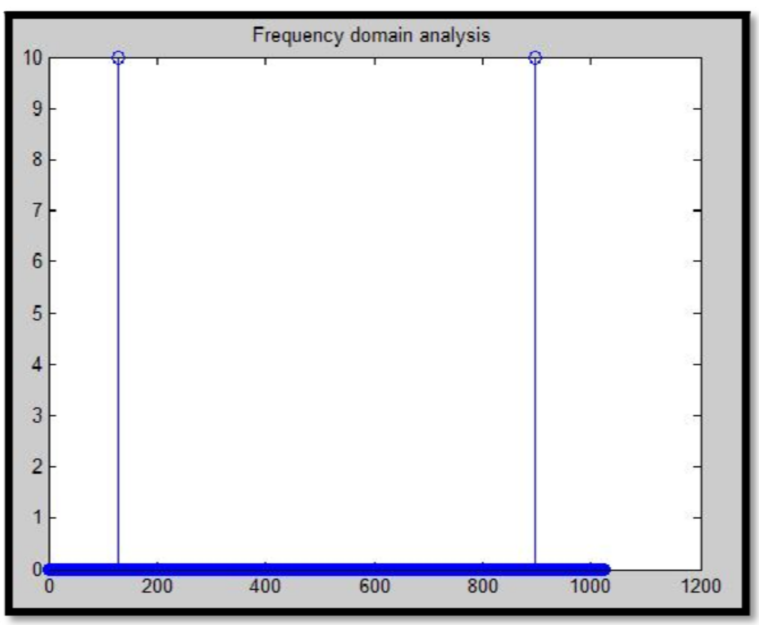


Figure 8

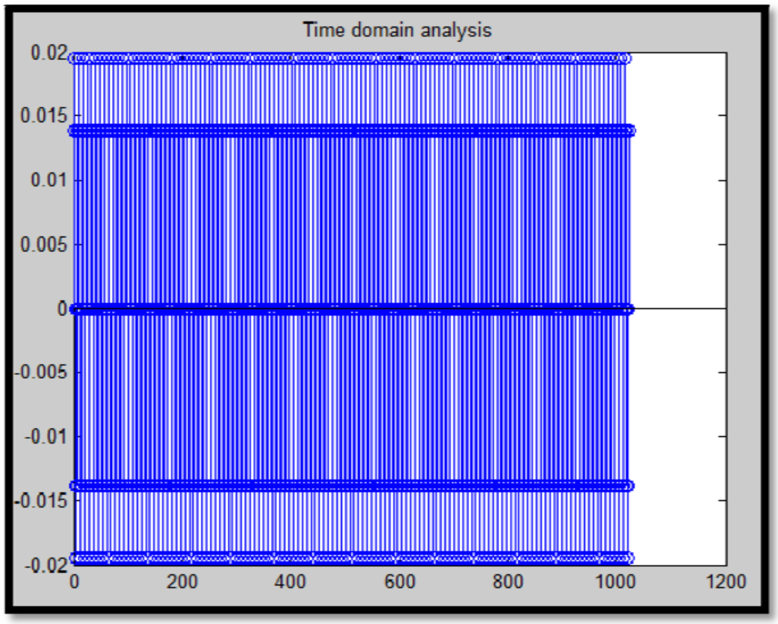


Figure 8

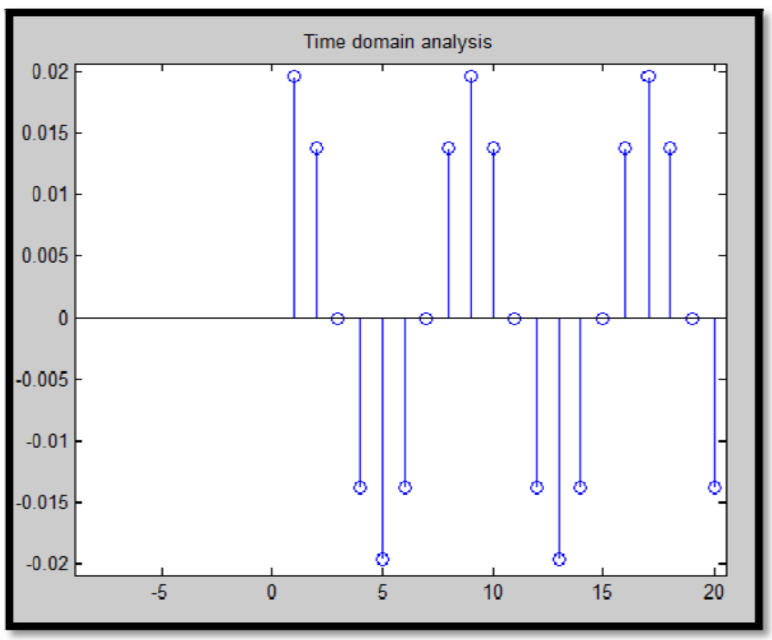


Figure 9

Explanation:

We create the frequency domain as required and find its time domain representation using IFFT command of Matlab. *Figure 7, 8* showing frequency and time domain graph respectively. *Figure 9* showing zoom analysis of time domain.

Lab Task 3:

(a) Assume a causal system h[n] = [1 1]. Such a system can be written in terms of a difference equation relating input x[n] to output y[n]. Write the system in terms of x[n] and y[n] and then using the matrix notation shown below determine the frequency response of the causal LTI system.

(b) Repeat the procedure for the system h[n] = [-1 1]

Matlab Code:

```
hn=[1 1] % for part (a)

hn=[-1 1] % for part (b)

b=[1]
a=conv(b,hn)
ob=[0 1]
[Magnitude_ans,Phase_ans]=freqz(b,a,1024)

plot(real(Magnitude_ans))

plot(Phase_ans)
```

Matlab Graph:

Part A:

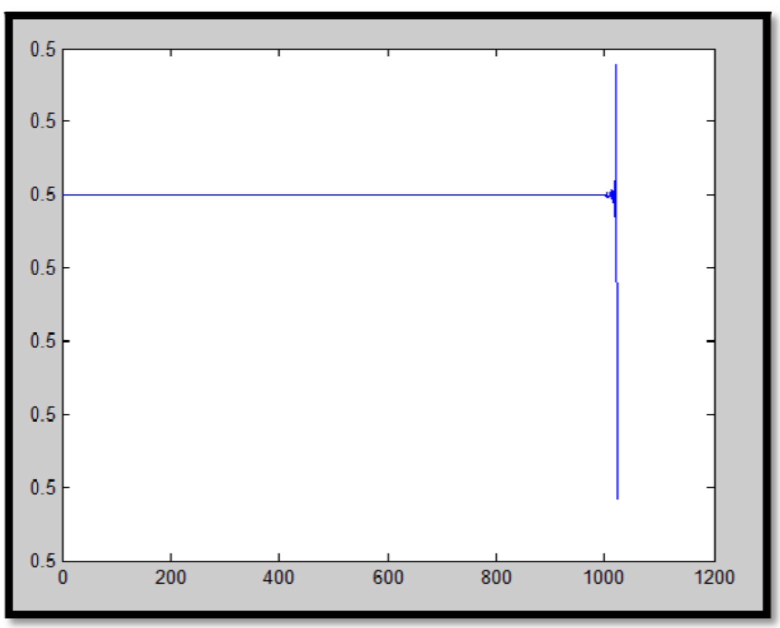


Figure 10

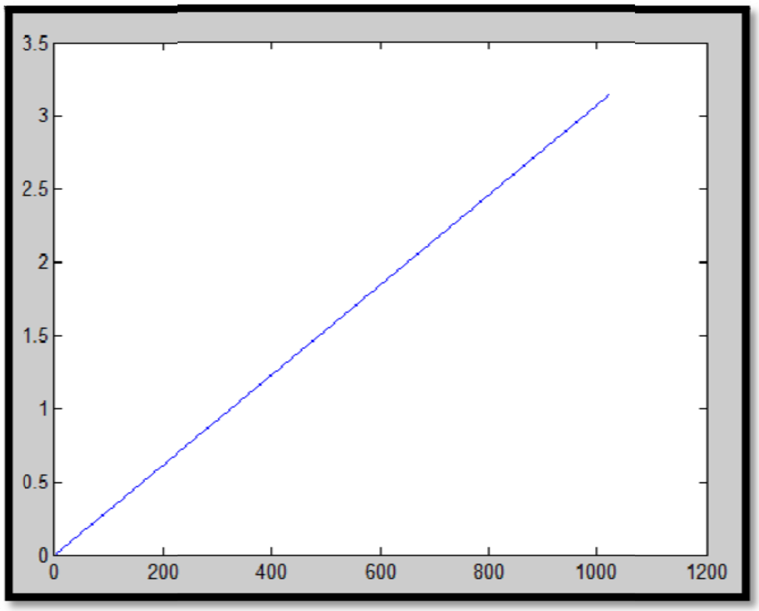


Figure 11

Part B:

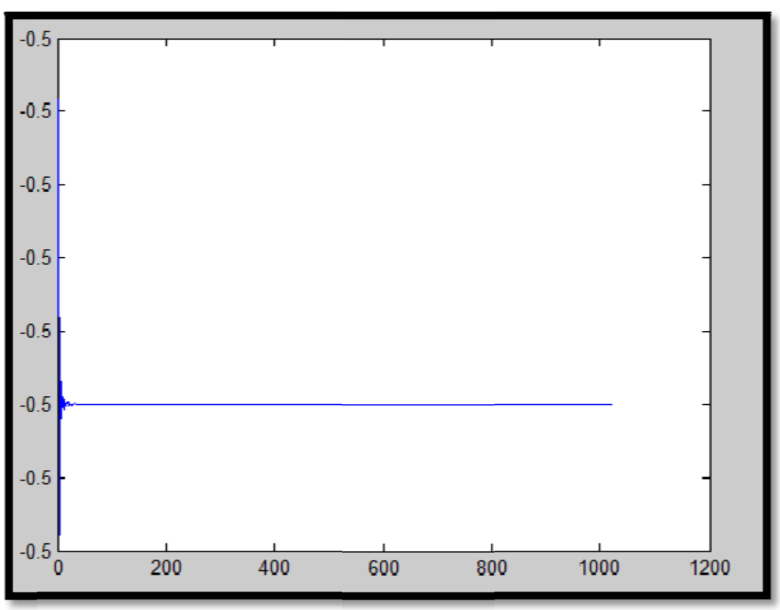


Figure 12

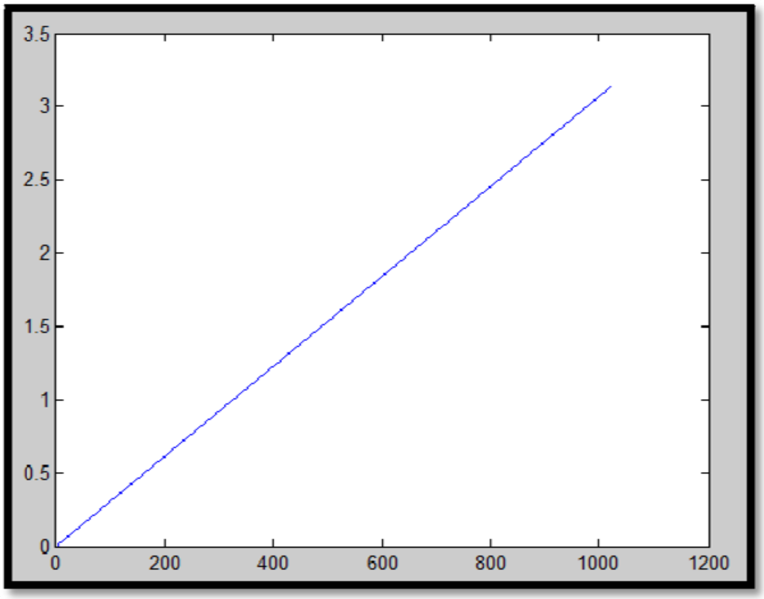


Figure 13

Explanation:

Constructing difference equation and then use freqz function for finding LTI system output for certain frequency.

Figure 10, 11 show magnitude and phase of **part A** activity respectively and *Figure 12, 13* show magnitude and phase of **part B** activity respectively.

Conclusion:

We get familiar with Fourier series manipulation and understand FFT, IFFT, freqz operations.