American International University-Bangladesh

Experiment No- 2

Title of the Experiment

study of signal frequency, spectrum, bandwidth, and quantization using MATLAB.

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Course Title: Data communication.

Section: L

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01, November, 2025

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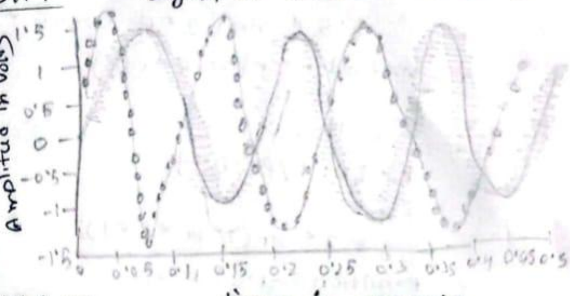
Experimen No 2

Student ID - 23-51662-2, Name: Poroma Basak.

task 1: Generating Sinusidal signals with different frequencies.

Solution:
```
clc
clear all
close all
fs = 500;
t = 0:1/fs:0.5;
f1 = 12;
f2 = 6;
A1 = 1.5
A2 = 1.1;
x1 = A1 * sin(2*pi * f1 * t);
x2 = A2 * sin (2 * pi * f2 * t);
Plot (t, x1, 'k--o', Lindwidth', 1)
hold on
Plot (t, x2, 'b-*'; Linewidth', 1)
hold off
xlabel ('time in seconds')
y label ('Amplitude in volts')
title ( ' signals of different Frequencies').
legen ('signal x1','signal x2)
```

result: signal of different frequencies

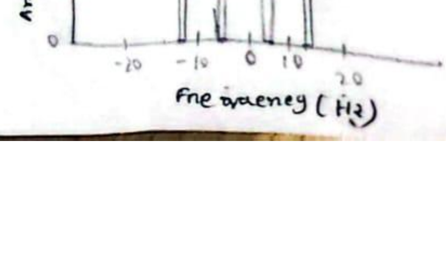


task 2: Signals can be represent in frequency domain as well

Solution.
```
clc
Clean all
close all
fs = 5000;
t = 0:1/fs:2;
f1 = 12;
f2 = 6;
A1 = 2;
A2 = 3;
x1 = A1 * sin(2* pi * f1 * t);
x2 = A2 * sin (2 * pi * f2 * t);
nx = length (t);
fx1 = fft (x1);
fx2 = fft(x2)
f = linspace (-fs/2, fs/2, nx);
bar (f, abs (fx1), 2, 'k')
hold on
bar (f, abs (fx2), 2, 'r')
hold off
axis ([-50 50 0 4])
xlabel ( "Frequency (Hz)');
ylabel ('Amplitude');
title ('Frequency Domain Representation of Different signals');
legend ('signal x1','signal x2')
```

Result:

Frequency domain Representation of Different signals.



task 3: Example of Bandwidth calculation.

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Name: Paroma Basak

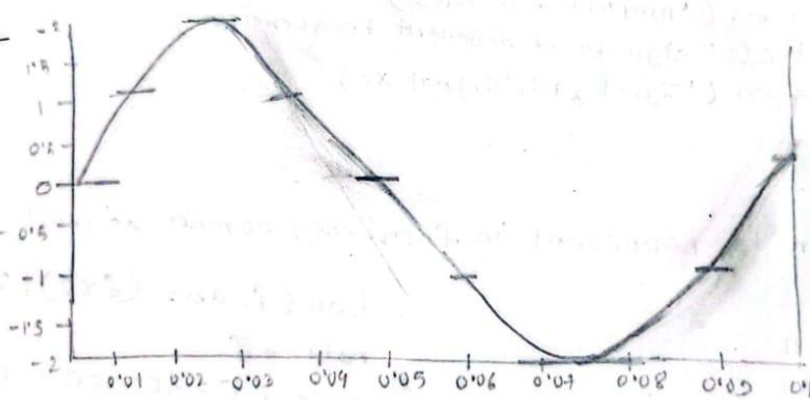
```
fs = 8000;
t = 0:1/fs : 1 - 1/fs;
cx = 1.1 * sin(2*pi* 100* t) + 1.3*cos(2* pi *300* t)+
     1.5 * sin(2*pi * 2000 * t);
bandwidth = obw(cx, fs)
```

Result: bandwidt = 1.9010e+03.

task 5:

```
fs = 10000;
t = [0: 1/fs: 0.1];
f = 10;
sig = 2* sin(2* pi *f *t);
partition = -1.5 : 1.5;
codebook = -2: 2;
[index, quants= [quantize(sig, partition, codebook);
figure
plot(t, sig, 'x', t, quants, '.')
legend('original signl', 'quantized signal');
```

result:



Name: Porora Basak
ID: 23-51662-2

Title: Study of signal frequency, spectrum, bandwith and quantization Using MATLAB.

Objective: The objective of this experiment is to learn the concepts of signal frequency, spectrum, bandwith and quantization by using MATLAB. We learn how we convert time domain signal to frequency domain. by the process fourier transformation. We also learn about all 3 steps of fourier transformation which are the ①Sampling, ② quantization, ③ Encoding. We learn how to measure bandwidth of periodic and, non-periodic signal. We learn all that thing by using MATLAB command and code. Through this experiment we can analyze and visualize different signal properties both time and frequency domain which enhance our knowledge.

Working principle: In this experiment, using MATLAB, we study about the signals in both time and frequency domain. First of all ~~a time domain~~ signals of different frequencie are taken in time domain and convert them in frequency domain to visualize the spectrum. This process is called fourier transformation. Which have 3 steps. smapling, qunatization and Encoding. This experimet shows the signal processing (noise reduction) is convenient in frequency domain. This shows the Time and frequency domain representation of the noise and also the noise signal of a signal which is also represented in both time and frequency domain. This experiment also shows the Bandwidth calculation using MATLAB command. and quantiz a signal ~~using~~ both in using built in MATLAB function quantiz and without using this function.

Over all this experiment is working on changes of freocueney. amplitude, Perform fourier transform which helps us to learn ~~tho~~ all those process By using MATLAB.

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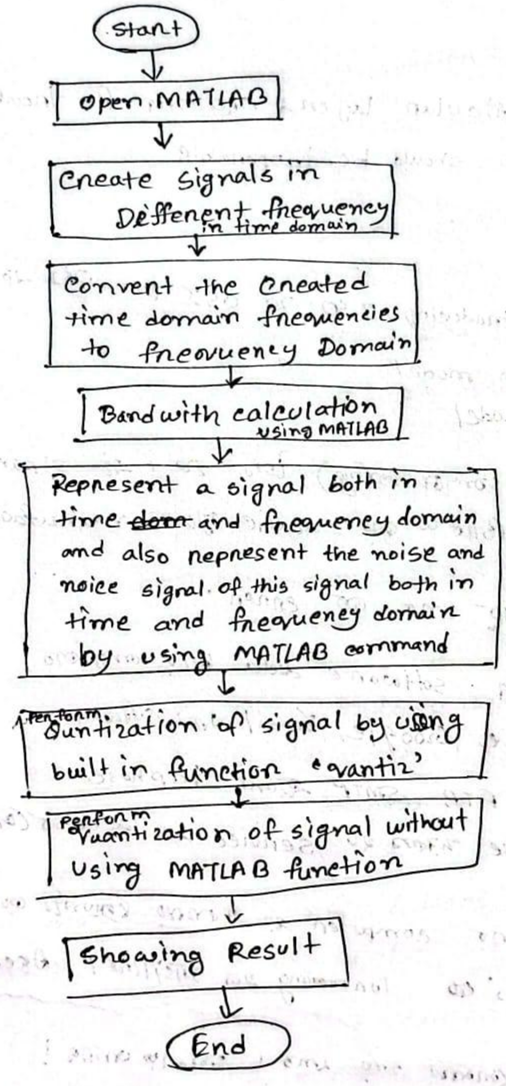
ID: 23-51662-2

Flow chart:



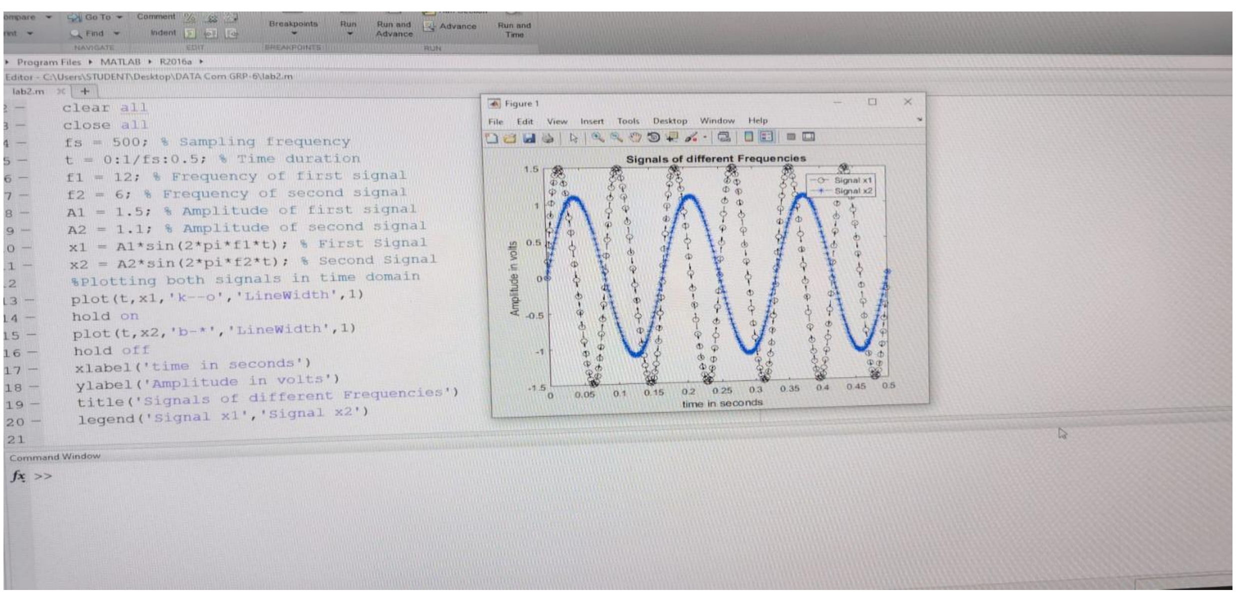
MATLAB CODE:

[Name: Poroma Basak, ID: 23-51662-2]

1. Generating sinusoidal signals with different frequencies:

```
clc
clear all
close all
fs = 500; % Sampling frequency
t = 0:1/fs:0.5; % Time duration
f1 = 12; % Frequency of first signal
f2 = 6; % Frequency of second signal
A1 = 1.5; % Amplitude of first signal
A2 = 1.1; % Amplitude of second signal
x1 = A1*sin(2*pi*f1*t); % First Signal
x2 = A2*sin(2*pi*f2*t); % Second Signal
%Plotting both signals in time domain
plot(t,x1,'k--o','LineWidth',1)
hold on
plot(t,x2,'b-*','LineWidth',1)
hold off
xlabel('time in seconds')
ylabel('Amplitude in volts')
title('Signals of different Frequencies')
legend('Signal x1','Signal x2')
```

Result:

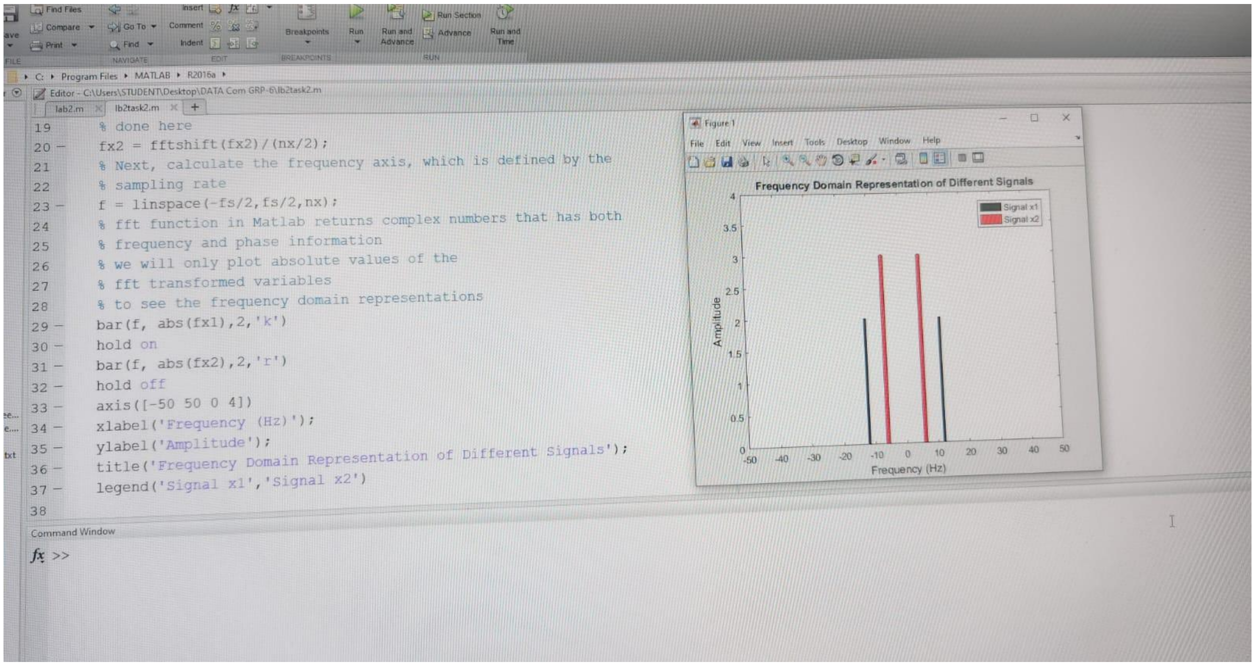


[Name: Poroma Basak, ID: 23-51662-2]

2. Signals can be represented in frequency domain as well:

```
clc
clear all
close all
fs = 5000; % Sampling frequency
t = 0:1/fs:2; % Time duration
f1 = 12; % Frequency of first signal
f2 = 6; % Frequency of second signal
A1 = 2; % Amplitude of first signal
A2 = 3; % Amplitude of second signal
x1 = A1*sin(2*pi*f1*t); % First Signal
x2 = A2*sin(2*pi*f2*t); % Second Signal
nx = length(t); % Total number of samples
%Take fourier transform
fx1 = fft(x1); % Frequency analysis is done here
fx2 = fft(x2);
% Apply fftshift to put it in the form we are used to (see
% documentation)
fx1 = fftshift(fx1)/(nx/2); % Axis correction and scaling are
% done here
fx2 = fftshift(fx2)/(nx/2);
% Next, calculate the frequency axis, which is defined by the
% sampling rate
f = linspace(-fs/2,fs/2,nx);
% fft function in Matlab returns complex numbers that has both
% frequency and phase information
% we will only plot absolute values of the
% fft transformed variables
% to see the frequency domain representations
bar(f, abs(fx1),2,'k')
hold on
bar(f, abs(fx2),2,'r')
hold off
axis([-50 50 0 4])
xlabel('Frequency (Hz)');
ylabel('Amplitude');
title('Frequency Domain Representation of Different Signals');
legend('Signal x1','Signal x2')
```

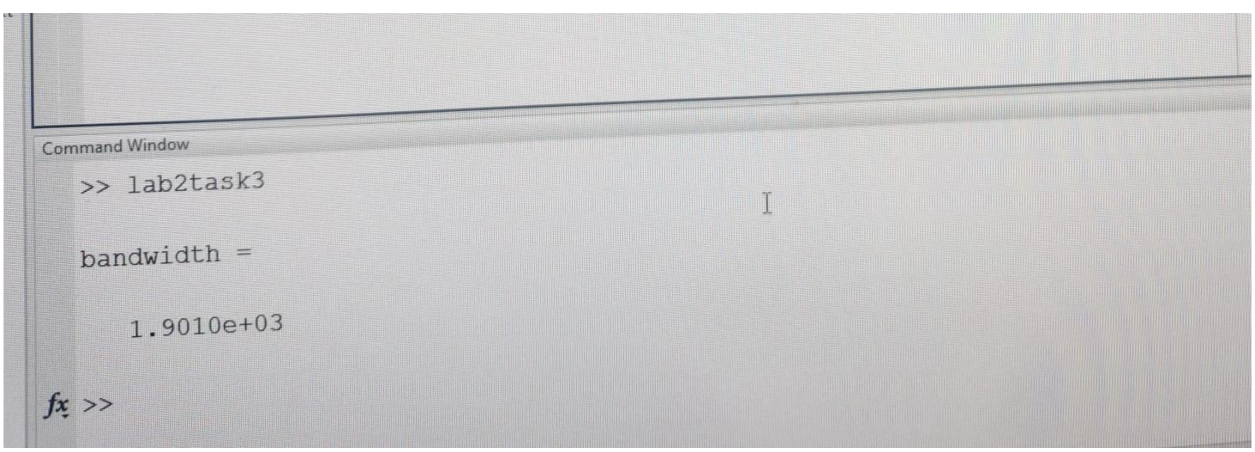
Result: [Name: Poroma Basak, ID: 23-51662-2]



3. Example of Bandwidth calculation:

```
fs = 8000; % Sampling frequency
t = 0:1/fs:1-1/fs; % Time duration
cx = 1.1*sin(2*pi*100*t) + 1.3*cos(2*pi*300*t) +
1.5*sin(2*pi*2000*t);
bandwidth = obw(cx,fs)
```

Result:



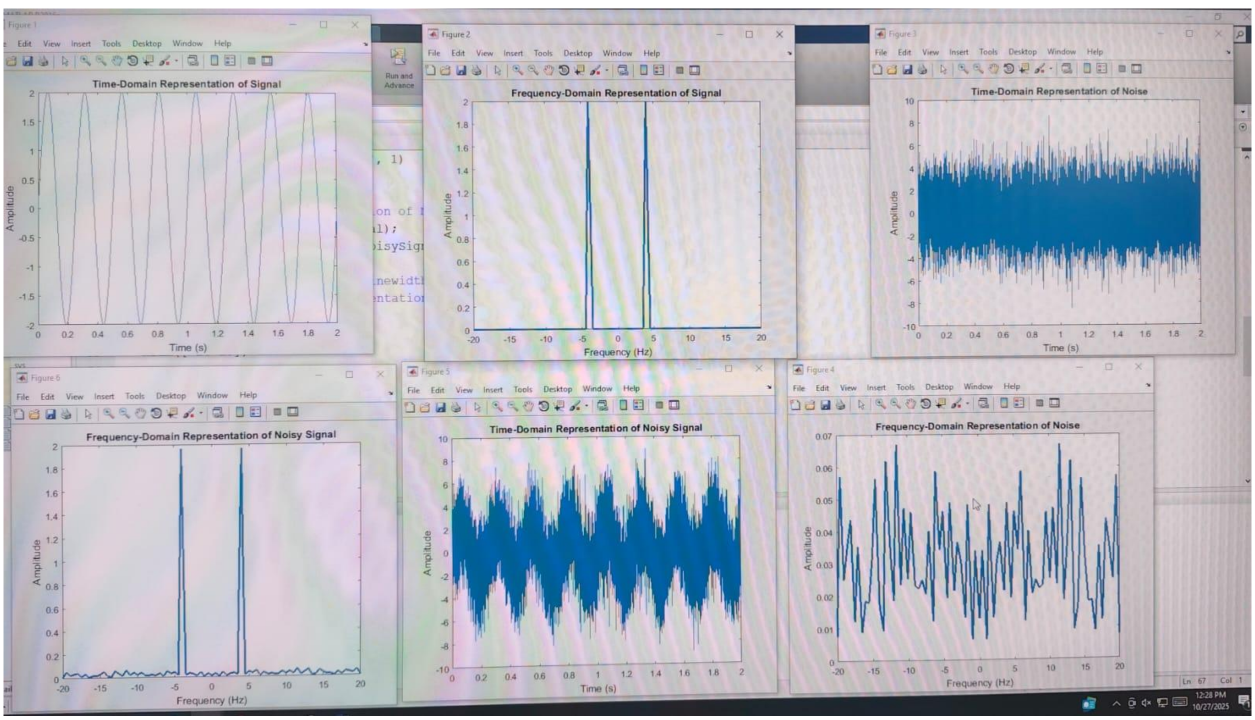
[Name: Poroma Basak, ID: 23-51662-2]

4. Example showing signal processing (noise reduction) is convenient in frequency domain

```
close all;
clc;
%Define number of samples to take
fs = 8000;
f = 4; %Hz
%Define signal
t = 0:1/fs:2;
signal = 2*sin(2*pi*f*t);
nx = length(t); % Total number of samples
%Plot to illustrate that it is a sine wave
plot(t, signal,'linewidth',1);
title('Time-Domain Representation of Signal');
xlabel('Time (s)');
ylabel('Amplitude');
% Take fourier transform
fftSignal = fft(signal);
% Apply fftshift to put it in the form
% we are used to (see documentation)
fftSignal = fftshift(fftSignal)/(nx/2);
% Scaling done by dividing with (fs/2)
% Next, calculate the frequency axis,
% which is defined by the sampling rate
f = linspace(-fs/2,fs/2,nx);
% Since the signal is complex, we need to
% plot the magnitude to get it to
% look right, so we use abs (absolute value)
figure;
plot(f, abs(fftSignal),'linewidth',2);
title('Frequency-Domain Representation of Signal');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20])
%noise
sd = 2;
noise = sd*randn(size(signal)); % noise power = sd^2
figure
plot(t,noise, 'linewidth', 1)
xlabel('Time (s)');
ylabel('Amplitude');
title('Time-Domain Representation of Noise');
fftNoise = fft(noise);
fftNoise = fftshift(fftNoise)/(nx/2);
```

```
figure
plot(f,abs(fftNoise), 'linewidth', 2)
title('Frequency-Domain Representation of Noise');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20])
%noisy signal
noisySignal = signal + noise;
figure
plot(t,noisySignal, 'linewidth', 1)
xlabel('Time (s)');
ylabel('Amplitude');
title('Time-Domain Representation of Noisy Signal');
fftNoisySignal = fft(noisySignal);
fftNoisySignal = fftshift(fftNoisySignal)/(nx/2);
figure
plot(f,abs(fftNoisySignal), 'linewidth', 2)
title('Frequency-Domain Representation of Noisy Signal');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20])
```

Result:



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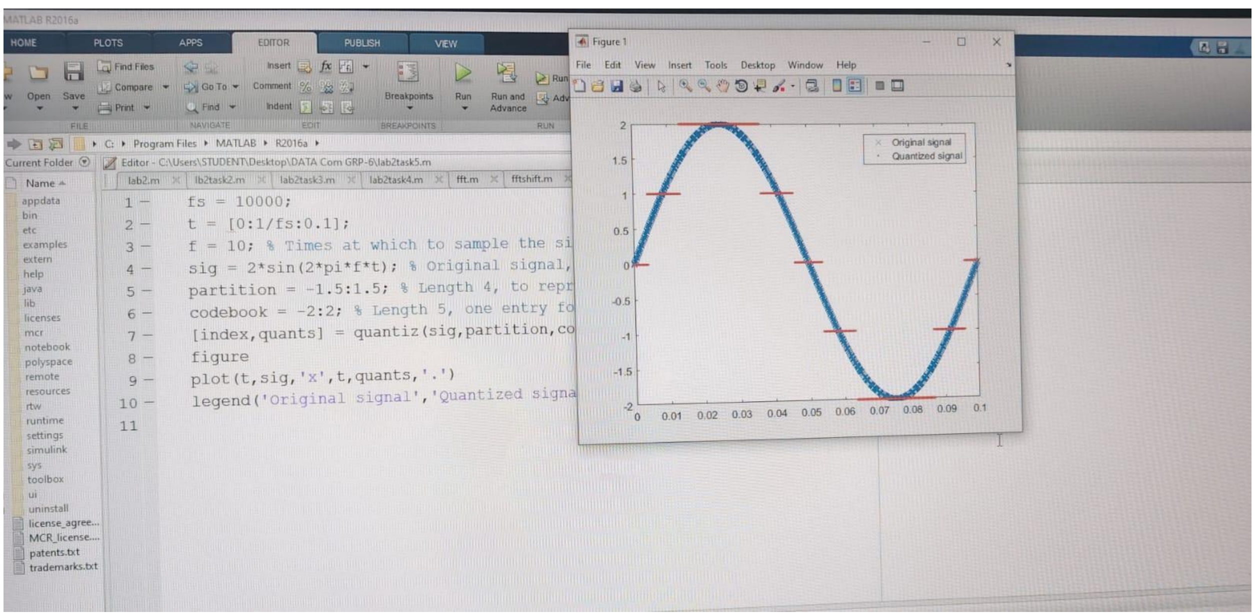
[Name: Poroma Basak, ID: 23-51662-2]

5. Example of Quantization using Matlab bulit-in function ‘**quantiz**’

```
fs = 10000;
t = [0:1/fs:0.1];
f = 10; % Times at which to sample the sine function
sig = 2*sin(2*pi*f*t); % Original signal, a sine wave
partition = -1.5:1.5; % Length 4, to represent 5 intervals
codebook = -2:2; % Length 5, one entry for each interval
[index,quants] = quantiz(sig,partition,codebook); % Quantize.
figure
plot(t,sig,'x',t,quants,'.')
legend('Original signal','Quantized signal');
```

Result:

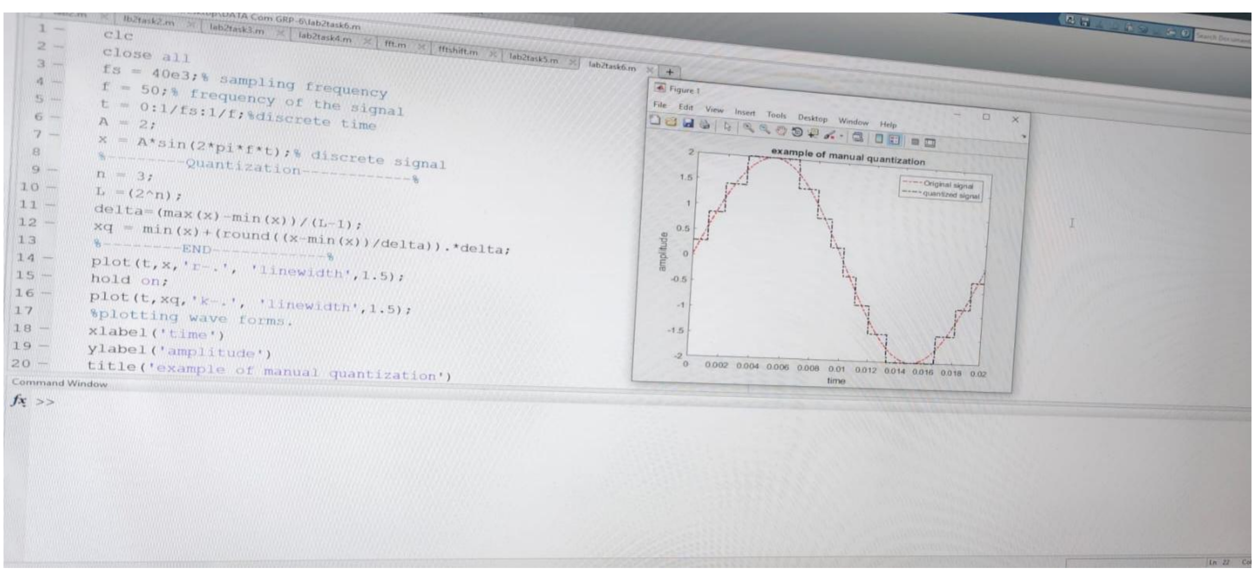


[Name: Poroma Basak, ID: 23-51662-2]

6. Example of Quantization **NOT** using Matlab bulit-in function

```
clc
close all
fs = 40e3;% sampling frequency
f = 50;% frequency of the signal
t = 0:1/fs:1/f;%discrete time
A = 2;
x = A*sin(2*pi*f*t);% discrete signal
%--------Quantization------------%
n = 3;
L =(2^n);
delta=(max(x)-min(x))/(L-1);
xq = min(x)+(round((x-min(x))/delta)).*delta;
%--------END------------%
plot(t,x,'r-.', 'linewidth',1.5);
hold on;
plot(t,xq,'k-.', 'linewidth',1.5);
%plotting wave forms.
xlabel('time')
ylabel('amplitude')
title('example of manual quantization')
legend('Original signal','quantized signal')
```

Result:



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Discussion: In this experiment, we learned about the basic properties of the signals such as frequency, spectrum, bandwidth and quantization, By using MATLAB. We learned that how a signal converted into frequency domain ~~to~~ from time domain using fourier transform. We can analysis the spectrum and bandwidth of a signal. We also learned how to convert ~~analg~~ analog signal to digital signal by quantization. Overall, we ~~gain~~ achived a knowledge about the ~~[illegible]~~ characteristics of a signal by this experiment.

Conclusion: By Doing this experiment, we can say that MATLAB is an effective tools for analyzing and understanding signal and it's characteristics. This tool makes easier the representation of signals both in time and frequency domain, quantization, measuring the bandwidth of a signal. Overall, This experiment helps us to know ~~how~~ signal's characteristics in communication system.