AMERICAN INTERNATIONAL UNIVERSITY BANGLADESH

Faculty of Engineering

Laboratory Report Cover Sheet

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Please submit all reports to your subject supervisor or the office of the concerned faculty.

Laboratory Title: Study of signal frequency, spectrum, bandwidth and quantization using MATLAB

Experiment Number: 02 Submission Date: 08/02/2023 Semester: Spring 2022 – 2023

Subject Code: COE 3201 Subject Name: Data Communication Section: K

Course Instructor: DR. SHUVRA MONDAL Degree Program: BSc CSE

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Group Number (if applicable): **01** ☐ Individual Submission ☒ Group Submission

No.	Student Name	Student ID	Contribution
1	SHEAKH, MOHAMMAD BIN AB. JALIL SHEAKH	20-42132-1	Class Task (50%), Performance Task (a)
2	AURTHY, MOST. LILUN NAHAR	20-43997-2	Class Task (50%), Performance Task (a)
3	NISHAT, TARIKUL ISLAM	21-44632-1	Discussion, Conclusion, Performance Task (c)
4	MULLICK, IFTEKHAR UDDIN	21-44649-1	Class Task (50%), Performance Task (b)
5	ULLAH, MD ISMAIL JOBI	21-44747-1	Abstract, Introduction, Performance Task (c)
6	ALANSAR, SADIAH	21-45612-3	Class Task (50%), Performance Task (b)

For faculty use only:

Total Marks:_______ Marks Obtained: ________

Faculty comments____

Title:
Study of signal frequency, spectrum, bandwidth and quantization using MATLAB

Abstract:
This experiment was designed to help understand the use of MATLAB for solving communication engineering problems. This experiment also helps us develop the understanding of MATLAB environment, commands and syntax.

Introduction:

I. **Frequency:** The frequency of a wave describes how many waves go past a certain point in one second. Frequency is measured in Hertz (usually abbreviated Hz), and can be calculated using the formula:

$V = f\lambda$

where V is the velocity of the wave (in ms^{-1}), f is the frequency of the wave (in Hz), and λ (the Greek letter lambda) is the wavelength of the wave (distance from one peak / trough to the next, in m). Frequency is the rate of change with respect to time. Change in a short span of time means high frequency. Change over a long span of time means low frequency.

II. **Spectrum:** Usually we represent signals in time domain. But signals can be represented in frequency domain as well. When signals are represented in frequency domain they are called spectrum.

III. **Bandwidth:** Bandwidth is the range of frequency a signal contains in it. If a composite signal is made up of multiple sinusoids of 100, 250, 300, and 400 Hz. Then its bandwidth is the difference of the highest and lowest frequency components. So here the bandwidth of the signal is (400-100) = 300 Hz.

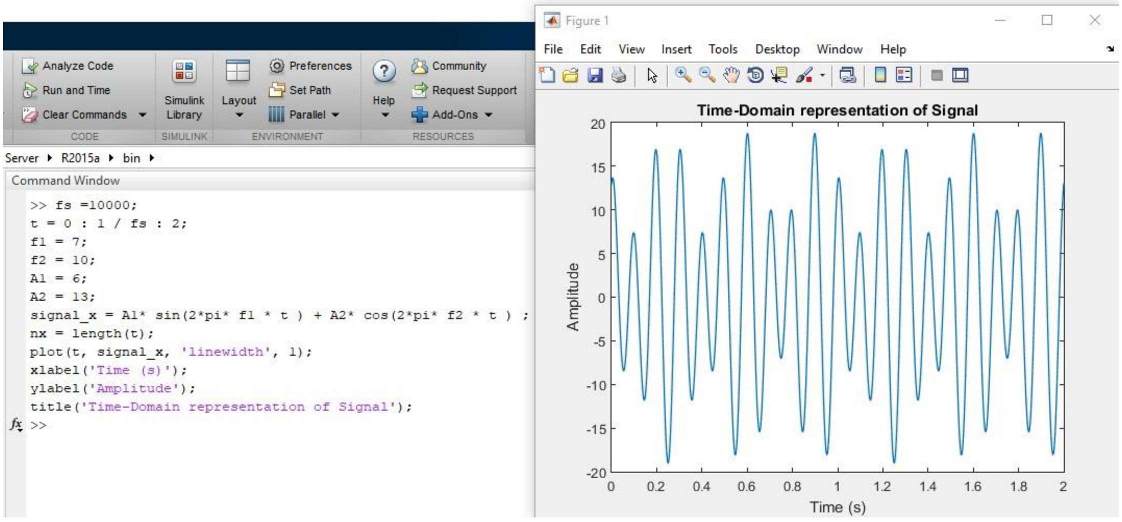
IV. **Quantization:** The digitization of analog signals involves the rounding off of the values which are approximately equal to the analog values. The method of sampling chooses a few points on the analog signal and then these points are joined to round off the value to a near stabilized value. Such a process is called as Quantization.

Simulation:

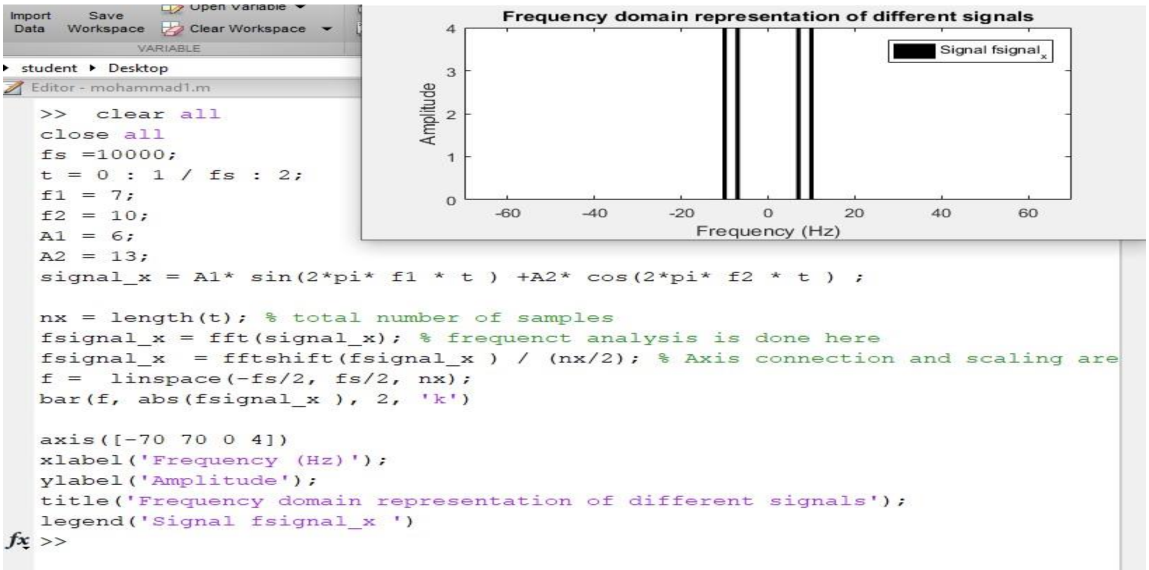
Class Task:

The selected ID is the following:

2	1	-	4	5	6	1	2	-	3
A	**B**		**C**	**D**	**E**	**F**	**G**		**H**



Task A: Generating sinusoidal signals with different frequencies



Task B : Signals can be represented in frequency domain as well

<u>Performance Task:</u>

The selected ID is the following:

2	0	-	4	2	1	3	2	-	1
A	**B**		**C**	**D**	**E**	**F**	**G**		**H**

Therefore,

a1 = G + 1 => 2 + 1 => 3
a2 = F + 2 => 3 + 2 => 5
a3 = E + 3 => 1 + 3 => 4

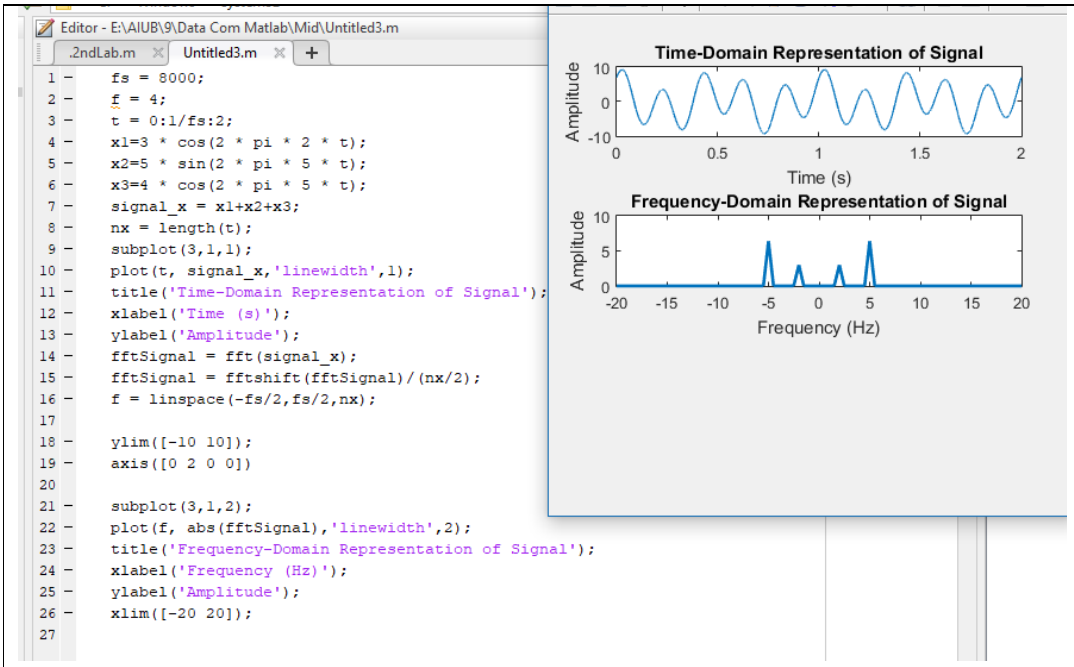
f1 = E + 1 => 1 + 1 => 2
f2 = F + 2 => 3 + 2 => 5
f3 = G + 3 => 2 + 3 => 5

x1 = a1 * cos(2 * pi * f1 * t) => 3 * cos(2 * pi * 2 * t)
x2 = a2 * sin(2 * pi * f2 * t) => 5 * sin(2 * pi * 5 * t)
x3 = a3 * cos(2 * pi * f3 * t) => 4 * cos(2 * pi * 5 * t)

Performance Task A : time domain and frequency domain representations of signal_x in a single figure window using subplot.

Code:

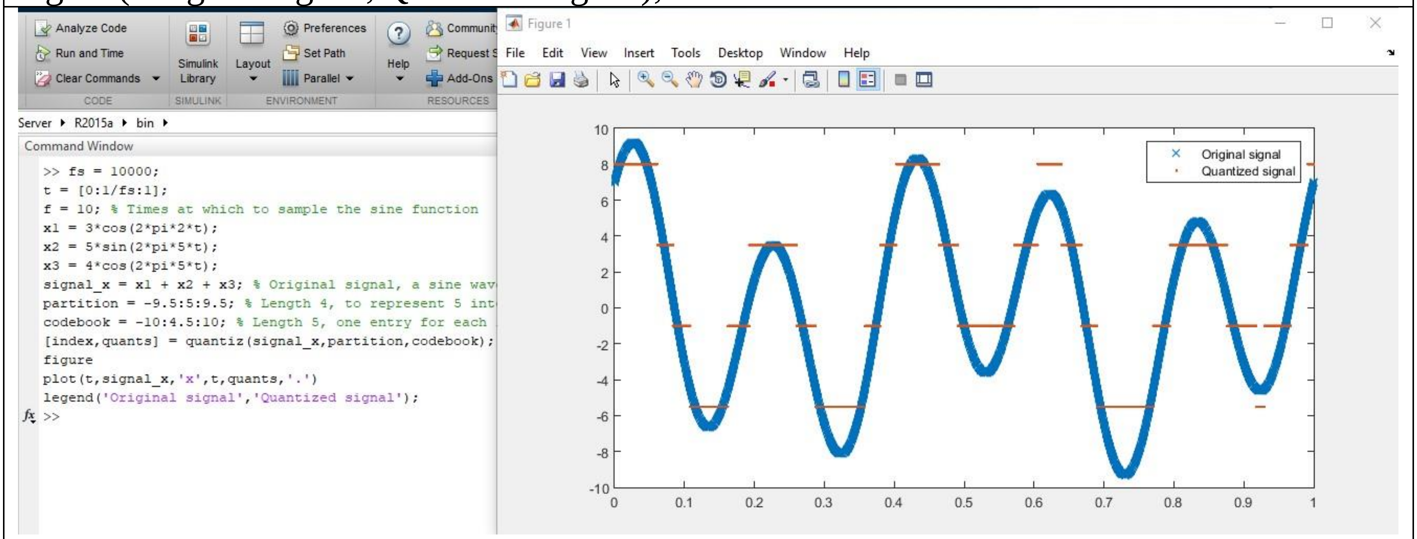
```
fs = 8000;
f = 4;
t = 0:1/fs:2;
x1=3 * cos(2 * pi * 2 * t);
x2=5 * sin(2 * pi * 5 * t);
x3=4 * cos(2 * pi * 5 * t);
signal_x = x1+x2+x3;
nx = length(t);
subplot(3,1,1);
plot(t, signal_x,'linewidth',1);
title('Time-Domain Representation of Signal');
xlabel('Time (s)');
ylabel('Amplitude');
fftSignal = fft(signal_x);
fftSignal = fftshift(fftSignal)/(nx/2);
f = linspace(-fs/2,fs/2,nx);

ylim([-10 10]);
axis([0 2 0 0])

subplot(3,1,2);
plot(f, abs(fftSignal),'linewidth',2);
title('Frequency-Domain Representation of Signal');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20]);
```



Performance Task B : Quantize signal_x in 4 equally distributed levels and provide image for one cycle of the original signal and quantized signal.

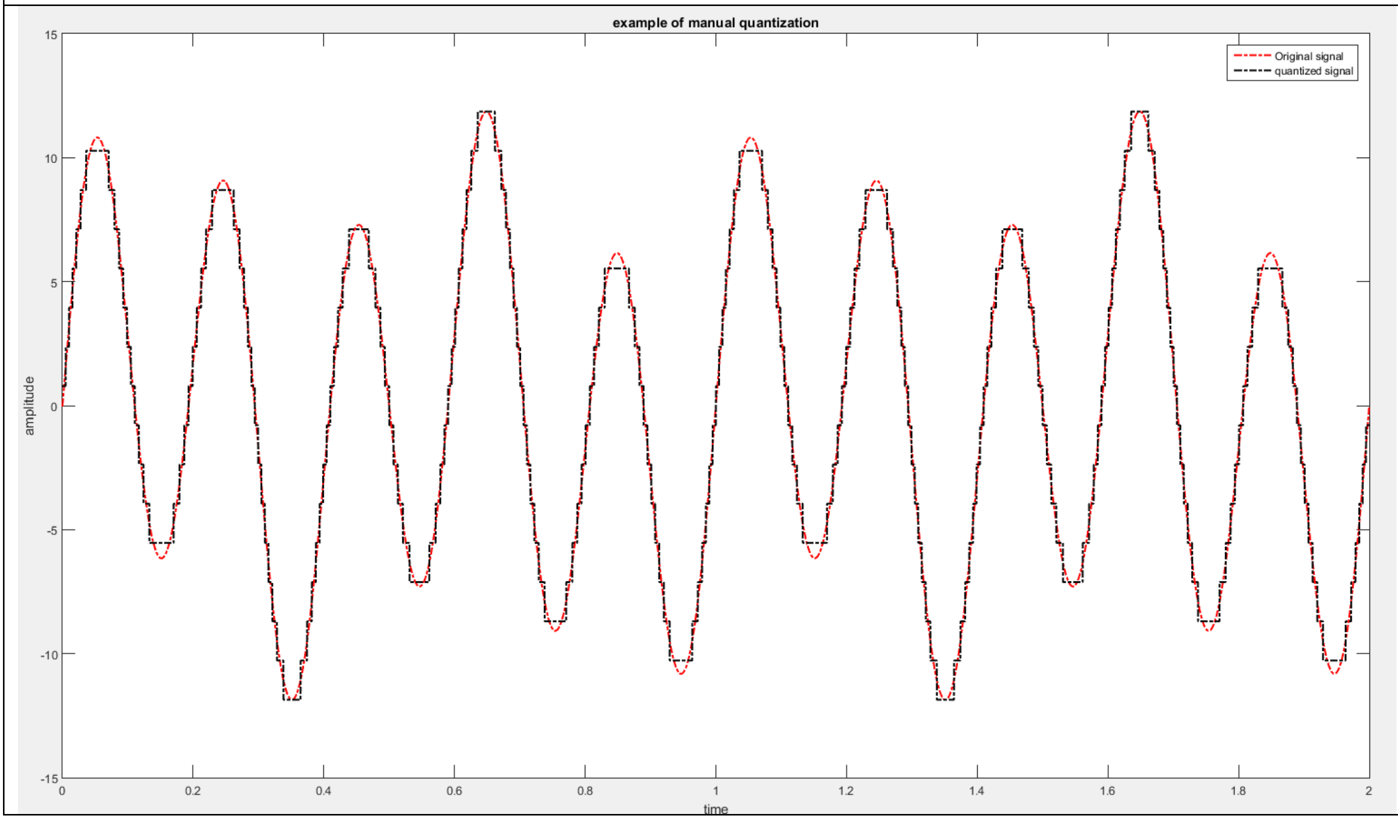
Code:

fs = 10000;
t = [0:1/fs:1];
f = 10; % Times at which to sample the sine function
x1 = 3*cos(2*pi*2*t);
x2 = 5*sin(2*pi*5*t);
x3 = 4*cos(2*pi*5*t);
signal_x = x1 + x2 + x3; % Original signal, a sine wave
partition = -9.5:5:9.5; % Length 4, to represent 5 intervals
codebook = -10:4.5:10; % Length 5, one entry for each interval
[index,quants] = quantiz(signal_x,partition,codebook); % Quantize.
figure
plot(t,signal_x,'x',t,quants,'.')
legend('Original signal','Quantized signal');



Performance Task C: Quantize signal_x in 8 equally distributed levels and provide image for one cycle of the original signal and quantized signal.

```
fs = 10000;
t = 0: 1/fs: 1;
a1 = 3;
a2 = 5;
a3 = 4;
f1 = 2;
f2 = 5;
f3 = 5;
x1 = a1* sin (2*pi*f1*t);
x2 = a2*sin (2*pi*f2*t);
x3 = a3* sin (2*pi*f3*t);
signal_x = x1 +x2 + x3;
n=8;
L=2*n;
delta = (max(signal_x)-min(signal_x))/ (L-1);
xq = min(signal_x)+(round((signal_x-min(signal_x))/delta)).*delta;
plot (t,signal_x,'r-.', 'linewidth',1.5);
hold on;
plot(t,xq,'k-.', 'linewidth',1.5);
xlabel('time')
ylabel('amplitude')
title('example of manual quantization')
legend('Original signal','quantized signal')
```



Discussion and Conclusion:

From the above simulations, various functionalities of MATLAB were observed in hand. Various functions that were available on MATLAB were learned and observed. Using this knowledge, MATLAB software plotted Frequency, Spectrum, Bandwidth, and Quantization. The quantizing of an analog signal is done by discretizing the signal with a number of Quantization levels. Various formatting on the graph was learned from this experiment as well. Hence, it can be said that all the objectives of this experiment were obtained properly.

References:

- Prakash C. Gupta, “Data communications”, Prentice Hall India Pvt.
- William Stallings, "Data and Computer Communications”, Pearson
- Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).
- AIUB Data Communication Engineering Lab Manual, Report 02