



**AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF COMPUTER ENGINEERING**

**DATA COMMUNICATION LABORATORY**

**Fall 2023-2024, Section: I**

**Group: 4**

**EXPERIMENT ON: 02**

***Study of signal frequency, spectrum, bandwidth, and quantization using  
MATLAB***

**Submitted By:**

<b>Name</b>	<b>ID</b>	<b>Contribution</b>
1. MD. SHAHRIAR PARVEZ SHAMIM	21-44998-2	
2. MD. AL FAIAZ RAHMAN FAHIM	21-45080-2	
3. MD. OMAR FARUK SAKIB	21-45077-2	
4. MD. ABU HOJIFA	21-45081-2	
5. ASHFAT AHMAD MEDUL	21-44854-2	

**Date of Submission: September 27, 2023**

## **Abstract:**

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

## **Theory:**

**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  $\text{ms}^{-1}$ ), **f** is the frequency of the wave (in Hz), and  $\lambda$  (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.

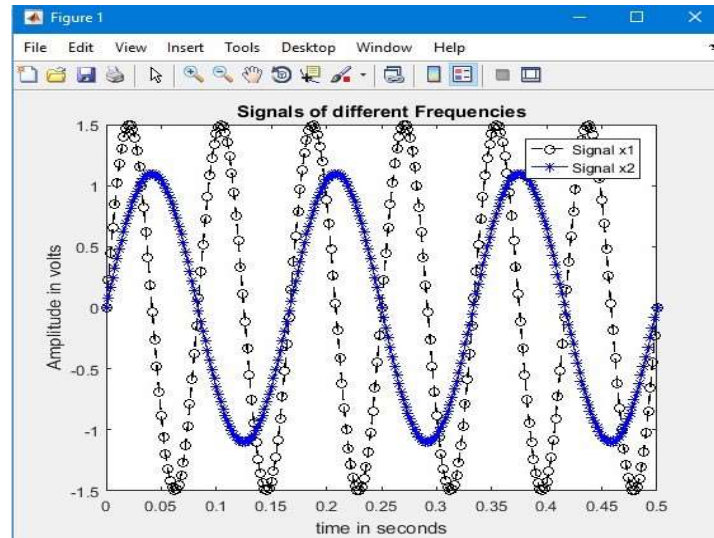
**II. Spectrum:** Usually we represent signals in time domain. But signals can be represented in frequency domain as well. When signals are represented in frequency domain, they are called spectrum.

**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.

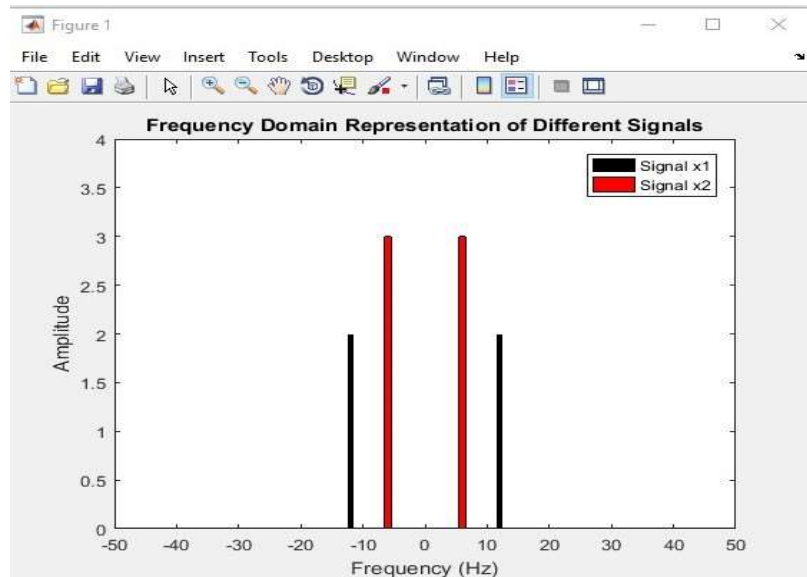
## Results:

```
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','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')
```



**Figure 1:** Signals of Different Frequencies.

```
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);
fx1 = fftshift(fx1)/(nx/2);
fx2 = fftshift(fx2)/(nx/2);
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')
```

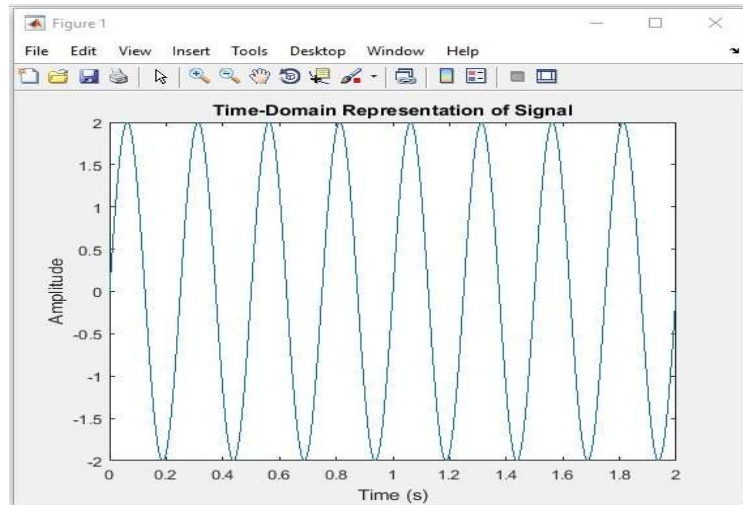


**Figure 2:** Frequency Domain Representation of Different Signals.

```

fs = 8000;
f = 4; %Hz
t = 0:1/fs:2;
signal = 2*sin(2*pi*f*t);
nx = length(t);
plot(t, signal,'linewidth',1);
title('Time-Domain
Representation of Signal');
xlabel('Time (s)');
ylabel('Amplitude');
fftSignal = fft(signal);
fftSignal =
fftshift(fftSignal)/(nx/2);
f = linspace(-fs/2,fs/2,nx);
figure;

```

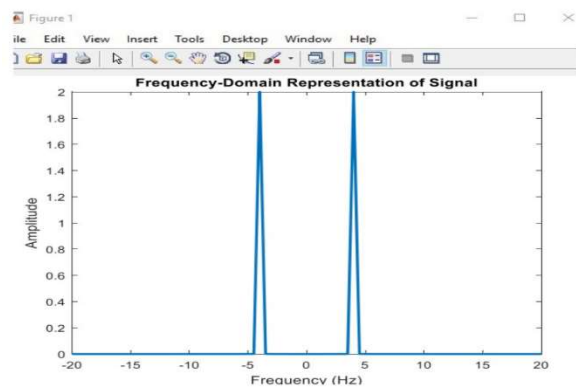


**Figure 3:** Time-Domain Representation of Signal.

```

plot(f, abs(fftSignal),'linewidth',2);
title('Frequency-Domain
Representation of Signal');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20])
sd = 2;
noise = sd*randn(size(signal));
figure

```

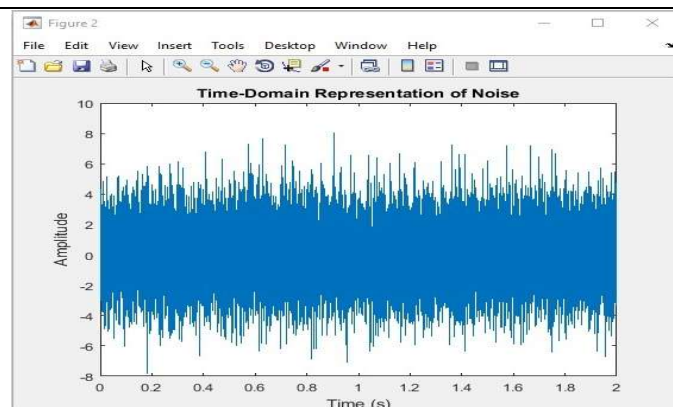


**Figure 4:** Frequency-Domain Representation of Signal.

```

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

```

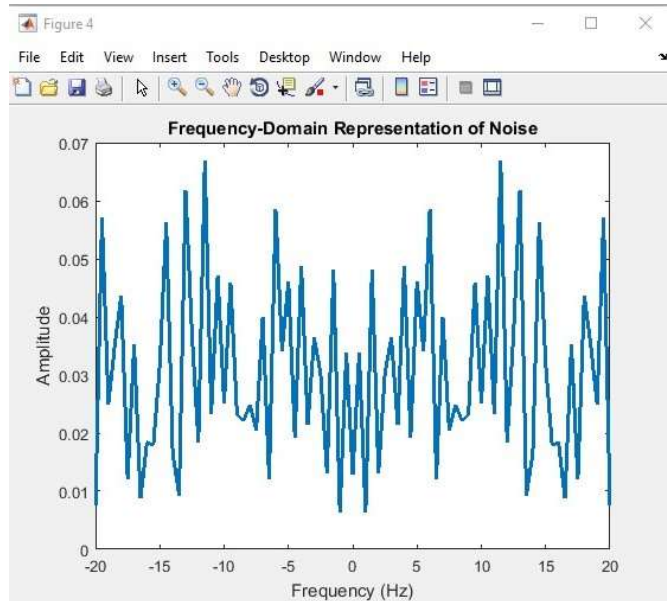


**Figure 5:** Time-Domain Representation of Noise.

```

plot(f,abs(fftNoise), 'linewidth', 2)
title('Frequency-Domain
Representation of Noise');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20])
noisySignal = signal + noise;
figure

```

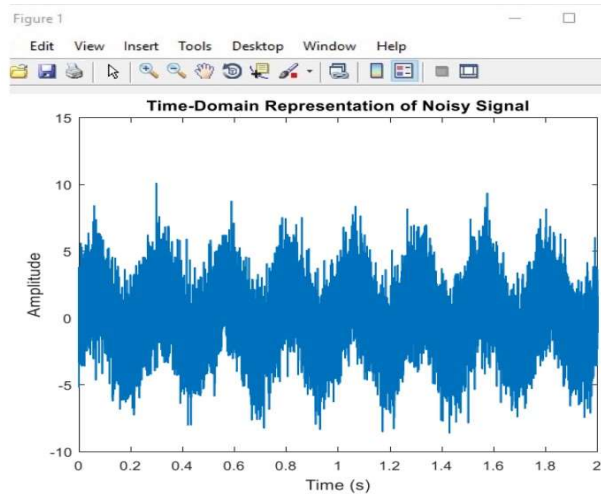


**Figure 6:** Frequency-Domain Representation of Noise.

```

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

```

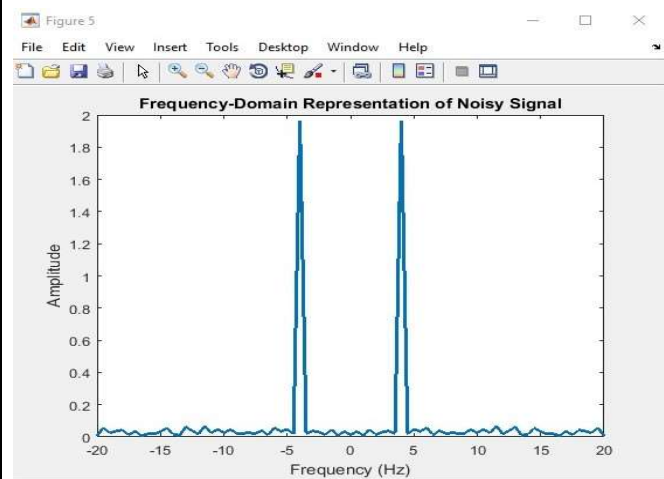


**Figure 7:** 'Time-Domain Representation of Noisy Signal.

```

plot(f,abs(fftNoisySignal), 'linewidth', 2)
title('Frequency-Domain Representation of
Noisy Signal');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
xlim([-20 20])
figure

```

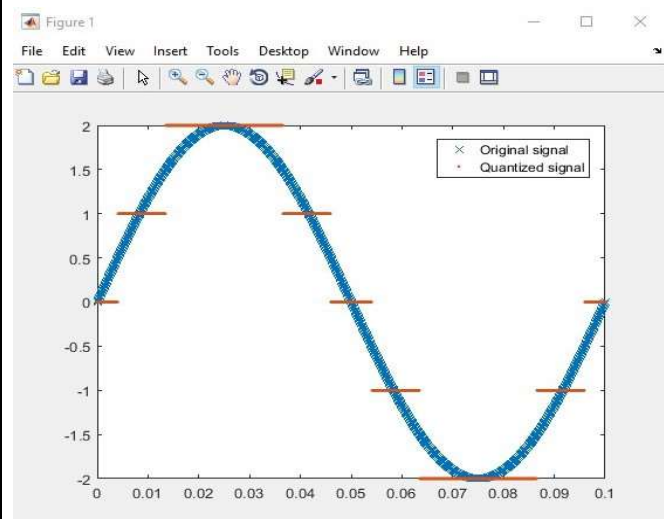


**Figure 8:** Frequency-Domain Representation of Noisy Signal.

```

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] =
quantiz(sig,partition,codebook);
plot(t,sig,'x',t,quants,')
figure
legend('Original signal','Quantized signal');

```

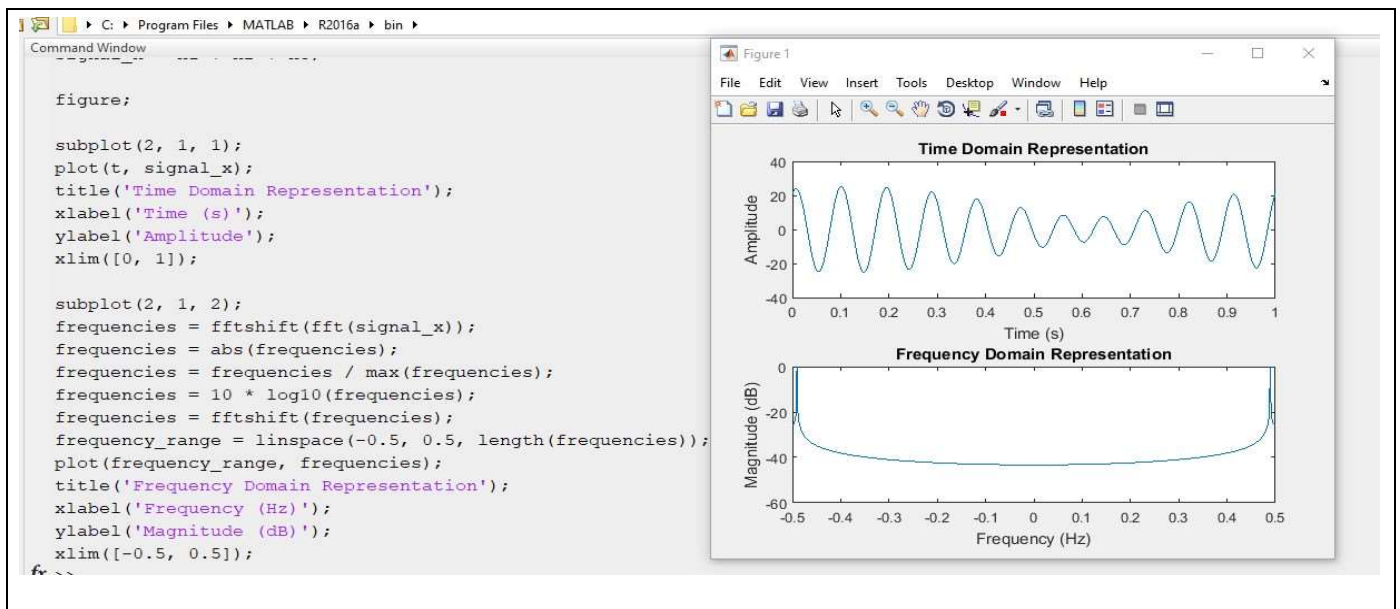


**Figure 9:** Example of Quantization.

**ID = AB-CDEFG-H**

Here,

A = 2		
B = 1	$a1 = G + 1 = 9$	
C = 4	$a2 = F + 2 = 11$	$x1 = a1 * \cos(2 * \pi * f1 * t) = 9 * \cos(2 * \pi * 10 * t)$
D = 4	$a3 = E + 3 = 12$	$x2 = a2 * \sin(2 * \pi * f2 * t) = 11 * \sin(2 * \pi * 11 * t)$
E = 9	$f1 = E + 1 = 10$	$x3 = a3 * \cos(2 * \pi * f3 * t) = 12 * \sin(2 * \pi * 11 * t)$
F = 9	$f2 = F + 2 = 11$	
G = 8	$f3 = G + 3 = 11$	
H = 2		



**Figure 10:** Example of Quantization.

## **Discussion & Conclusion:**

In the Experiment, 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.

## **References:**

- [1] P. C. Gupta, DATA COMMUNICATIONS AND COMPUTER NETWORKS. PHI Learning Pvt. Ltd., 2006. Accessed: Sept.26, 2023. [Online]. Available:[https://books.google.ie/books?id=kNn\\_p6WA38C&pg=PR27&dq=Prakash+C.+Gupta,+%22Data+communications%22,+Prentice+Hall+India+Pvt.&hl=&cd=2&source=gbs\\_api#v=onepage&q=Prakash%20C.%20Gupta%20C%20%22Data%20communications%22%2C%20Prentice%20Hall%20India%20Pvt.&f=false](https://books.google.ie/books?id=kNn_p6WA38C&pg=PR27&dq=Prakash+C.+Gupta,+%22Data+communications%22,+Prentice+Hall+India+Pvt.&hl=&cd=2&source=gbs_api#v=onepage&q=Prakash%20C.%20Gupta%20C%20%22Data%20communications%22%2C%20Prentice%20Hall%20India%20Pvt.&f=false)  
[Online Copy]
- [2] W. Stallings, Data and computer communications. 2000., Accessed: Sept. 26, 2023. [Online]. Available:[https://www.portcity.edu.bd/files/636444710465881602\\_Dataandcomputercommunications.pdf](https://www.portcity.edu.bd/files/636444710465881602_Dataandcomputercommunications.pdf) [Online Copy]
- [3] B. A. Forouzan, C. A. Coombs, and S. C. Fegan, Introduction to data communications and networking. McGraw-Hill Science, Engineering & Mathematics, 1998., Accessed: Sept. 26, 2023. [Online]. Available: [https://archive.mu.ac.in/myweb\\_test/syllFybscit/dcn.pdf](https://archive.mu.ac.in/myweb_test/syllFybscit/dcn.pdf) [Online Copy]