American International University-Bangladesh

Experiment NO-3

Title: Sutdy of Nyquist bit rate ~~formula~~ and Shannon capacity using MATLAB.

Student ID: 23-51662-2

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Course title: Data Communication.

Section: L

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Experiment No: 3 Date: 03.11.2025

Student ID: 23-51662-2, Name: Porcoma Basak

Task: 1: Example of Nyquist bit rate calculation for a noiseless channel.

Solution

```
close all;
clc;
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);
L = 2;
BitRate = 2*bandwidth*log2(L)
```

Result: BitRate = 3.8019e+03

Task 3: Example of shannon capacity calculation for a noisy channel.

Solution:

```
clc
close all
fs = 8000;
f = 3;
t = 0:1/fs:1-1/fs;
A = 2;
s = 0.4;
x = A*sin(2*pi*f*t);
ns = s*randn(size(signal));
S_N_R = snr(x,ns);
bandwidth = obw(x,fs);
c = bandwidth * log2(1+SNR)
```

Result:

~~SNR~~ C =
6.6576e+04

Task 2: Calculation of SNR

```
close all;
clc;
fs = 8000;
f = 400;
t = 0:1/fs: 1-1/fs;
A = 3.0
powfound = A^2/2.
s = 0.1
varnoise = s^2
signal = A*sin(2*pi*f*t);
noise = s* randn(size(signal));
noisySignal = signal + noise
SNR = snr(noisySignal)
defSNR = 10* log10(powfund/varnoise)
```

Result:

SNR =
26.2571

defSNR =
26.5321

Name: Poroma Basak
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Title: Study of Nyquist bit rate and shannon capacity using MATLAB

Objective: The aim of this experiment is to learn how MATLAB helps to solve basic communication problems. here we calculate the Nyquist bit rate for noiseless channel and the shannon capacity for noisy channel. We also calculate the SNR value of the noisy signal and can know the quality of the signal that means which is more corrupted. We can also know the shannon capacity of noisy signal and helping us to know the bandwidth also.

Working priciple: In this experiment, we use the MATLAB to study how much data can be sent through the communication channel that means the bitrate. For noiseless channel, the Nyquist formula helps us to find the maximum bitrate using bandwidth and number of signal levels (L).

$$\text{Bitrate} = 2 \times \text{bandwidth} \times \log_2(L)$$

For noisy channel, the shannon capacity formula tells us the highest data rate of this channel. $\text{Capacity} = \text{bandwidth} \times \log_2(1+\text{SNR})$

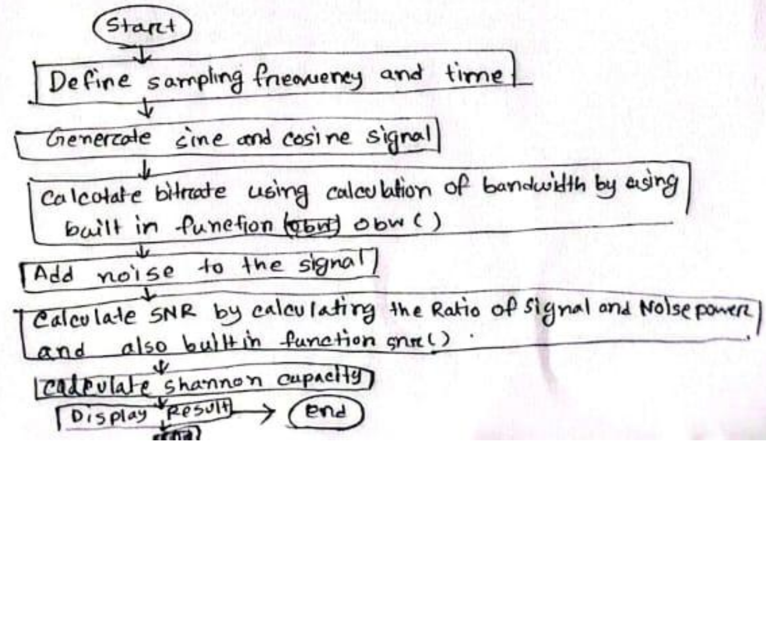
Here, SNR is the signal to Noise ~~Ratio~~. power Ratio.

$$\text{SNR} = \frac{\text{Average signal power}}{\text{Average Noise power}}$$

A higher SNR means the signal is less corrupted by noise, And low SNR means the signal is more corrupted by Noise.

By using MATLAB, this experiment determine all of this above and gives us the clear knowledge.

Flowchart

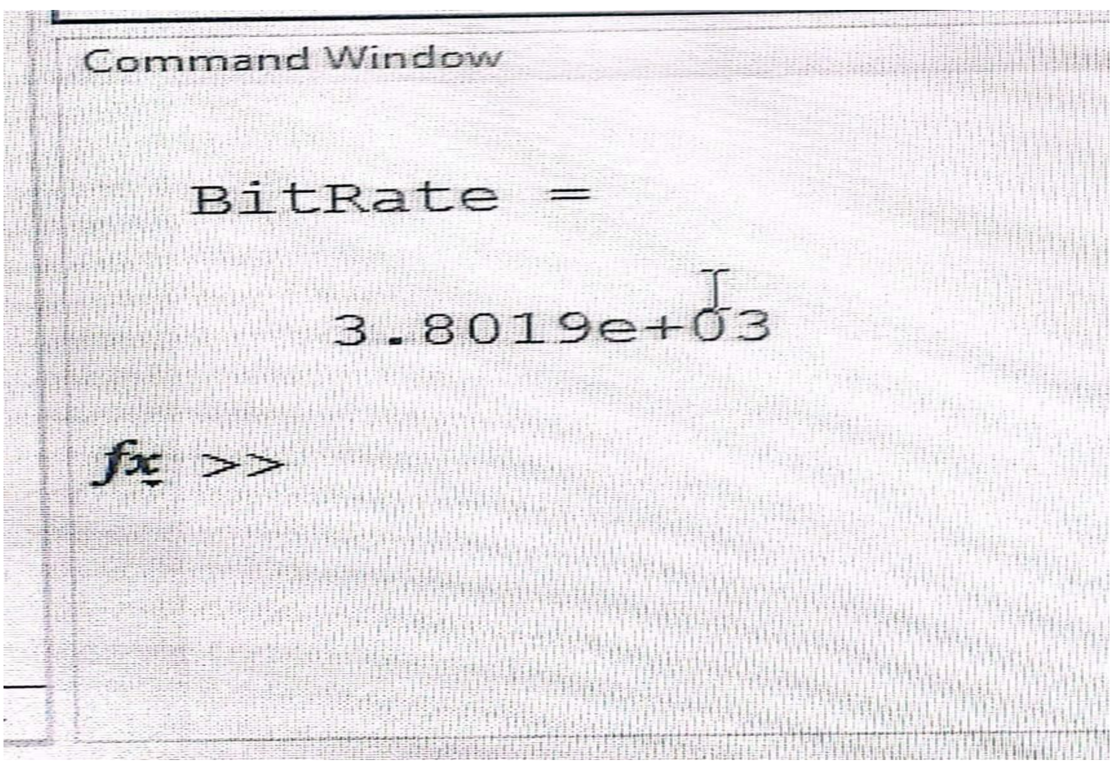


MATLAB CODE AND RESULT: Name: Poroma Basak, ID: 23-51662-2

Problem 1: Example of Nyquist bit rate calculation for a noiseless channel:

```
close all;
clc;
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); % Bandwidth of the signal
L=2; % Level of the signal
BitRate = 2*bandwidth*log2(L)
```

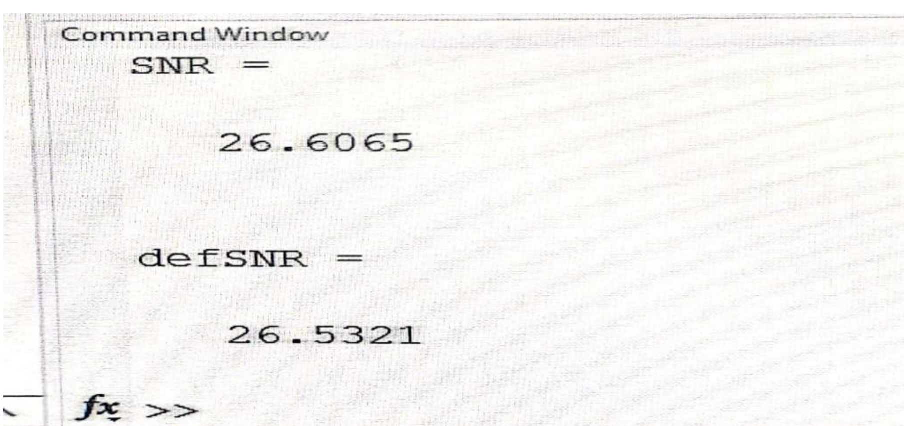
Result:



Problem 1: Example: Calculation of SNR Name: Poroma Basak, ID: 23-51662-2

```
close all;
clc;
%Define number of samples to take
fs = 8000; % Sampling frequency
f = 400; %Hz
%Define signal
t = 0:1/fs:1-1/fs;
A = 3.0;
powfund = A^2/2
s = 0.1;
varnoise = s^2;
signal = A*sin(2*pi*f*t);
%noise
noise = s*randn(size(signal));
%noisy signal
noisySignal = signal + noise;
SNR = snr(noisySignal) %Calculation of SNR using snr function
defSNR = 10*log10(powfund/varnoise) %Calculation of SNR following the definition
```

Result:



Task 1: Name: Poroma Basak, ID: 23-51662-2

Similar task can be done considering a noisy composite signal. Suppose our composite signal is,

signal = 1.5*sin(2*pi*2*t)+0.9*cos(2*pi*10*t)+1.1*sin(2*pi*20*t) + 0.13*randn(size(t));

*****Calculate the SNR value of the signal.

Solution:

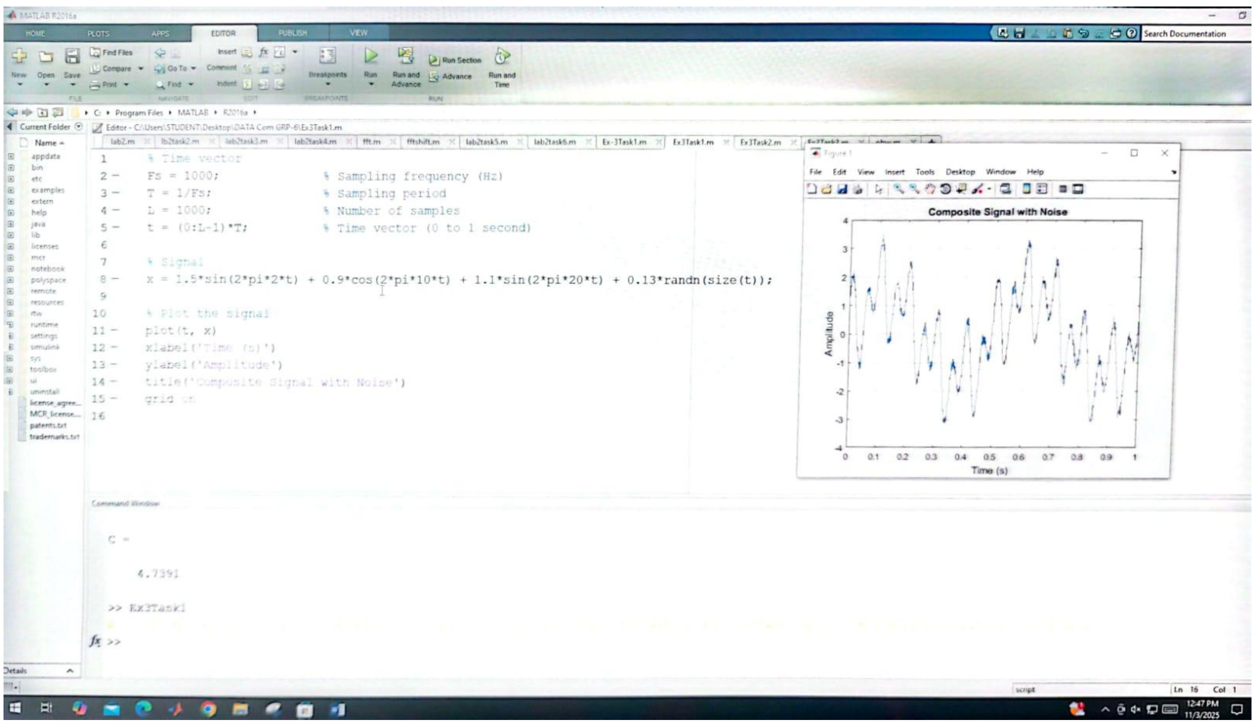
```
close all;
clc;
% Sampling frequency
fs = 8000;
% Time vector
t = 0:1/fs:1-1/fs;
% Signal parameters
A1 = 1.5; f1 = 2;
A2 = 0.9; f2 = 10;
A3 = 1.1; f3 = 20;
% Noise parameters
s = 0.13;            % standard deviation of noise
varnoise = s^2;      % noise variance
% Composite clean signal
signal = A1*sin(2*pi*f1*t) + A2*cos(2*pi*f2*t) + A3*sin(2*pi*f3*t);
% Add noise
noise = s * randn(size(signal));
noisySignal = signal + noise;
% Signal power (theoretical)
powfund = (A1^2 + A2^2 + A3^2) / 2;
% SNR using built-in function
SNR = snr(signal, noise);
```

```
% SNR using definition
defSNR = 10*log10(powfund / varnoise);
% Display output in your desired format
disp(['SNR = ', num2str(SNR)]);
disp(['defSNR = ', num2str(defSNR)]);
```

Result:

SNR = 21.0835

defSNR = 21.0219



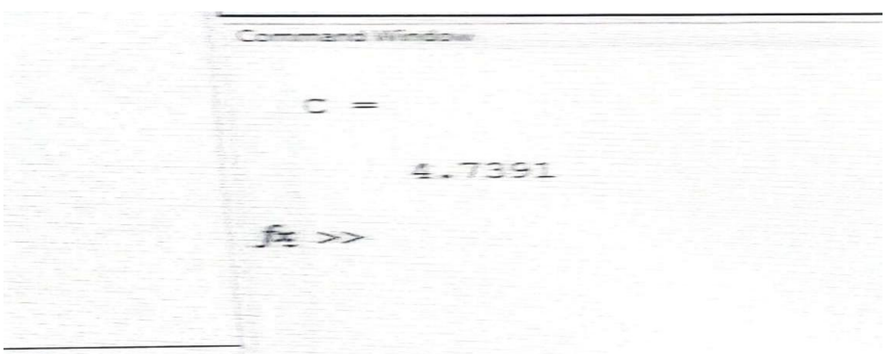
Problem 3:

Example of Shannon capacity calculation for a noisy channel:

```
clc
close all
fs = 8000; % Sampling frequency
f = 3; %Hz
%Define signal
t = 0:1/fs:1-1/fs;
```

```
A = 2;
s = 0.4;
%signal
x = A*sin(2*pi*f*t);
%noise
ns = s*randn(size(signal));
S_N_R = snr(x,ns);
bandwidth = obw(x,fs); % Bandwidth of the signal
%capacity
C = bandwidth*log2(1+SNR) % Capacity of the channel
```

Result:



Name: Poroma Basak
ID: 23-51662-2

Discussion: In this experiment, we used MATLAB to study how noice affects the data transmmisson. We calculate the Nyquist bit rate for a noiseless channel and Shannon capacity for a noisy channel. The results show that higher SNR gives a clear signal and higher channel The results show that higher SNR gives a clear signal and less corrupted signal. It also shows that bandwidth and signal levels are used to calculate Bitrate.

Conclussion: This experiment helped us understand the limits of data transfer in channels. We learned how Nyquist bit rate and Shannon capacity are affected by noise, bandwidth and signal Levels. Higher SNR improves signal quality and low SNR make the signal more corrupted or noisy.