American International University- Bangladesh

Course Name: Communication Laboratory

Experiment No: 03

Experiment title: Study of Nyquist bit rate and Shannon capacity using MATLAB

Course instructor: SADMAN SHAHRIAR ALAM

Section: D

Semester: Summer 23-24

Name: Tutul Majumder

ID:23-51364-1

Title: Study of Nyquist bit rate and Shannon capacity using MATLAB

Abstract:

This experiment is designed to-

1.Understand the use of MATLAB for solving communication engineering problems.
2.Develop an understanding of Nyquist bit rate and Shannon capacity using MATLAB.

Introduction:

I.Nyquist Bit Rate: The Nyquist bit rate formula defines the theoretical maximum bit rate for a noiseless channel.

$BitRate$=2 × $bandwidth$ × $log2L$

In this formula, bandwidth is the bandwidth of the channel, L is the number of signal levels used to represent data, and BitRate is the bit rate in bits per second.

II.Shannon capacity: Shannon capacity formula was introduced to determine the theoretical highest data rate for a noisy channel:

$Capacity$= $bandwidth$ × $log2$(1+ SNR)

In this formula, bandwidth is the bandwidth of the channel, SNR is the signal-to-noise ratio, and capacity is the capacity of the channel in bits per second.

Signal-to-noise ratio (SNR): To find the theoretical bit rate limit, we need to know the ratio of the signal power to the noise power. The signal-to-noise ratio is defined as

SNR=$Average\ Signal\ Power Average\ Noise\ Power$

We need to consider the average signal power and the average noise power because these may change with time.

A high SNR means the signal is less corrupted by noise; a low SNR means the signal is more corrupted by noise.

Performance Task for Lab Report: (my ID = 23-51364-1)

**Generate a composite signal using two simple signals as,

x = A1 sin(2π((C+D+H) *10)t) + A2 cos(2π((D+E+H)*10)t) + s*randn(size(t));

(a) Select the value of the amplitudes as follows: let A1 = (A+B+H), A2 = (B+C+H) and s = (C+D+H)/30

(b) Calculate the SNR value of the composite signal.

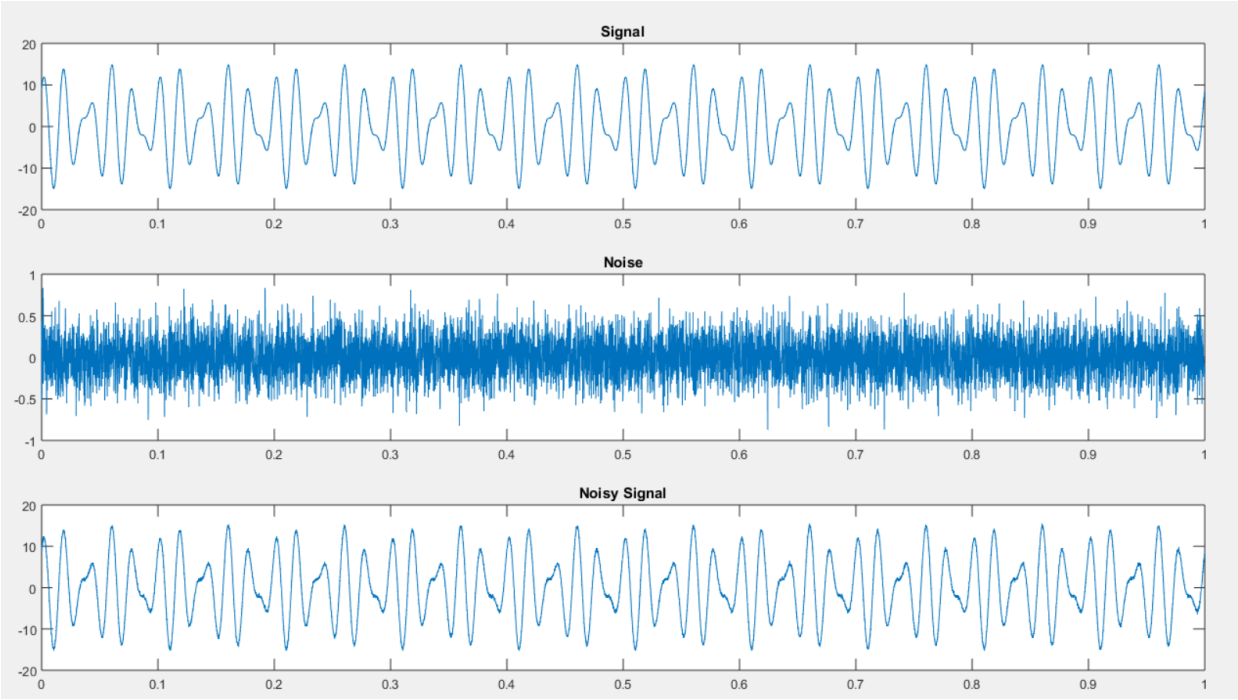
(c) Find the bandwidth of the signal and calculate the maximum capacity of the channel.

(d) What will be the signal level to achieve the data rate?

Code:

```
A=2;
B=3;
C=5;
D=1;
E=3;
F=6;
G=4;
H=1;

fs = 8000;
f = 400;
t = 0:1/fs:1-1/fs;
A1=(A+B+H);
A2=(B+C+H);
s=(C+D+H)/30;

signal=A1*sin(2*pi*((C+D+H)*10)*t ) + A2*cos(2*pi*((D+E+H)*10)*t);
noise=s*randn(size(t));
noisy_signal=signal+noise;
SNR=snr(noisy_signal)

subplot(3,1,1)
plot(t,signal)
title('Signal')
subplot(3,1,2)
plot(t,noise)
title('Noise')
subplot(3,1,3)
plot(t,noisy_signal)
title('Noisy Signal')


bandwidth = obw(noisy_signal,fs)
C = bandwidth*log2(1+SNR)

L=round(2^(C/(bandwidth*2)))
```

Output:




```
>> task
SNR =
    3.5067

bandwidth =
   20.9795

C =
   45.5691

L =
     2
```

References:

1. MATLAB user guide.
2. Prof. Dr.-Ing. Andreas Czylwik, “MATLAB for Communications”