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

Abstract:
Different MATLAB operations and functions will be performed in this experiment. The purpose of this experiment is to develop understanding of Nyquist bit rate and Shannon capacity using MATLAB and develop an understanding of the MATLAB environment, commands and syntax as well as how to use it to solve communication engineering problems. The experiment was conducted using MATLAB software. All the objectives were successful. It helped us with a better understanding of the MATLAB environment and command and syntax usage.

Introduction:

MATLAB is a high-performance language for technical computing. It integrates computing, programming, and visualization in a welcoming environment where problems and answers are laid forth in plain English.

Two theoretical formulas were developed to calculate the data rate:

- Nyquist Bit Rate for a noiseless channel.
- Shannon Capacity for a noisy channel.

Nyquist Bit Rate: The theoretical maximum bit rate for a noiseless channel is determined by the Nyquist bit rate formula.

$$\text{BitRate} = 2 \times \text{bandwidth} \times \log2\text{L}$$

In this equation, the terms bandwidth and L—which describe the number of signal levels utilized to represent data—as well as BitRate—which denotes the bit rate in bits per second—are used.

Shannon capacity: In order to determine the theoretical maximum data rate for a noisy channel, the Shannon capacity formula was developed.

$$Capacity = bandwidth \times log2(1 + SNR)$$

In this equation, bandwidth denotes the channel's bandwidth, SNR denotes the signal-to-noise ratio, and capacity denotes the channel's capacity in bits per second.

Signal-to-noise ratio (SNR): We need to know the ratio of the signal power to the noise power in order to calculate the theoretical bit rate limit. As specified, the signal-to-noise ratio is-

$$\text{SNR} = \frac{\text{Average Signal Power}}{Average\ Noise\ Power}$$

A higher SNR indicates less noise-induced signal degradation, while a lower SNR indicates more noise-induced signal degradation.

Apparatus:

1. Computer
2. MATLAB2016a software

Performance Task:

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where, AB-CDEFG-H

Equation: $x = A1\ sin(2\pi(C * 100)t) + A2\ cos(2\pi(G * 100)t) + s * randn(size(t));$

So,

Amplitude, $A1 = AB = 2$ (Excluding B=0)

Amplitude, $A2 = AF = 2 * 7 = 14$

$s = AH = 2 * 1 = 2$

Signal Frequency, $fc1 = C = 4$

Signal Frequency, $fc2 = G = 6$

Sampling Frequency, $fs = 6 * 100 * 20 = 12000$

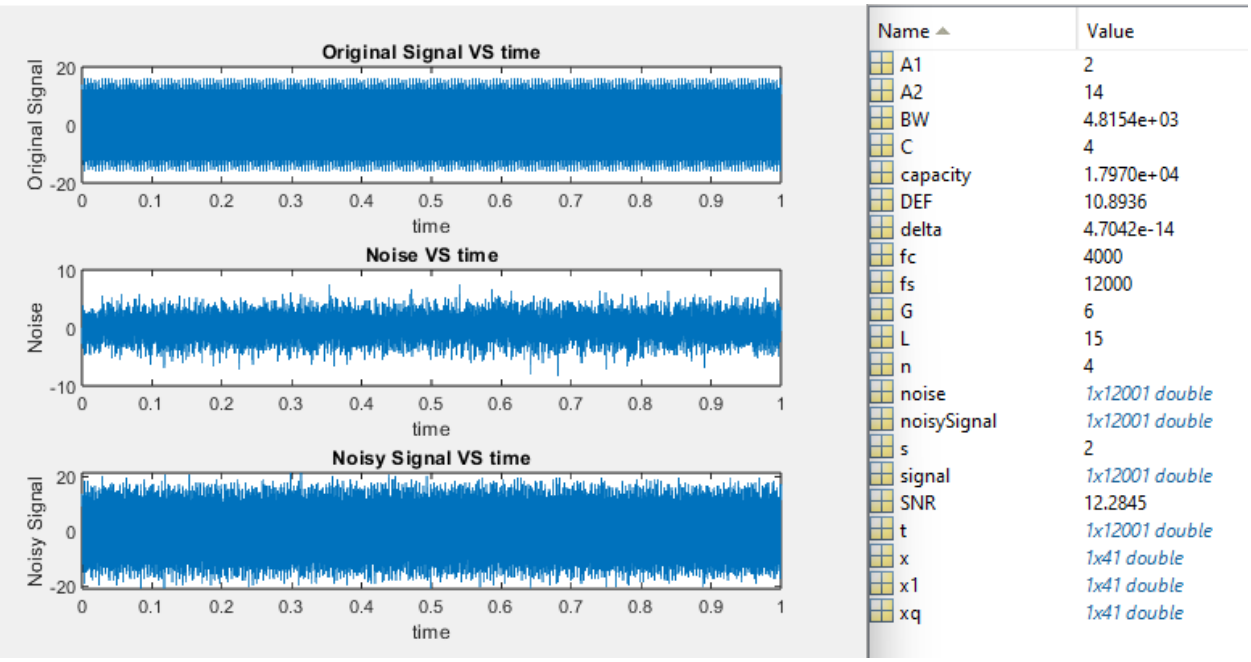
Time, $t = 0: 1/fs: 1;$

Code:

```
A1 = 2;
A2 = 14;
s = 2;
C = 4;
G = 6;
fs = 12000;
t = 0:1/fs:1;
signal = A1*sin(2*pi*(C*100)*t) + A2*cos(2*pi*(G*100)*t);

noise = s*randn(size(t));
```

```
noisySignal = signal + noise;

SNR = snr(noisySignal,fs);

DEF = 10*log10(SNR);

BW = obw(noisySignal,fs); % Bandwidth of the signal

capacity = BW*log2(1+SNR);% Capacity of the channel

subplot(3,1,1);
plot(t,signal);
xlabel('time');
ylabel('Original Signal');
title('Original Signal VS time')

subplot(3,1,2);
plot(t,noise);
xlabel('time');
ylabel('Noise');
title('Noise VS time')

subplot(3,1,3 );
plot(t,noisySignal);
xlabel('time');
ylabel('Noisy Signal');
title('Noisy Signal VS time')
```

Simulation:



Discussion:

We were able to better comprehend Nyquist bit rate and Shannon capacity using MATLAB and the MATLAB environment, instructions, and syntax, as well as its application to solve communication engineering challenges as a result of various MATLAB operations carried out in accordance with the purpose.

Conclusion:

The goal of this experiment was to use MATLAB, the MATLAB environment, commands, and syntax, as well as its implementation to solve communication engineering problems, to get a grasp of Nyquist bit rate and Shannon capacity. We were successful in achieving all of the goals. We had no issues utilizing the MATLAB software in the lab. We used some MATLAB functions, plots, and operations in this experiment. Perhaps the results of this experiment could be checked using different software, and then they could be compared. This experiment demonstrates the importance of MATLAB in the solution of challenging mathematics and data communication problems. It is very simple to use, saves a considerable amount of time, and produces extremely precise results.

REFERENCE:

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