Digital Communication Systems

Laboratory Report

Spring 2024

Laboratory Number:	**4**
Laboratory Title:	**Baseband Transmission and Reception**
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Introduction:

The purpose of this lab is to investigate the effects of utilizing a noisy channel to transmit signals, filtering that received signal, and finally observing the effects on the probability of error due to the amount of noise. We are going to do this by generating a signal using a couple of parameters, emulate sending it through a noisy channel, and finally testing out Polar Non-Return to Zero and Unipolar Non-Return to Zero to see the effects of these different types of encodings on the signal and probability of error.

Procedure:

Before Starting:

1. Define an amplitude and bit rate to use based off of your TUID.

> tuid = [9,1,6,0,2,7,2,0,7];
> A = tuid(9) + 2; % amplitude in amps
> rb = 1000 * (tuid(8) + 3);   % Bit rate hz

Task 1:

1. Generate a binary signal where low is 0 and high is 1
2. Convert that binary signal to where low is -1 * A and high is 1 * A
3. Create a repeated vector of that binary signal the size of sampling rate / bit rate
4. Generate the appropriate times axis
5. Generate a list of signal-to-noise ratios from -20 dB to 50 dB with an interval of 2.
6. For each of these ratios, emulate the noise on the signal and calculate the probability of error
7. Plot these error rates as a function of the signal-to-noise ratio

Task 2:

1. Generate a binary signal where low is 0 and high Is 1
2. Convert that binary signal to where low is -1 * A and high is 1 * A
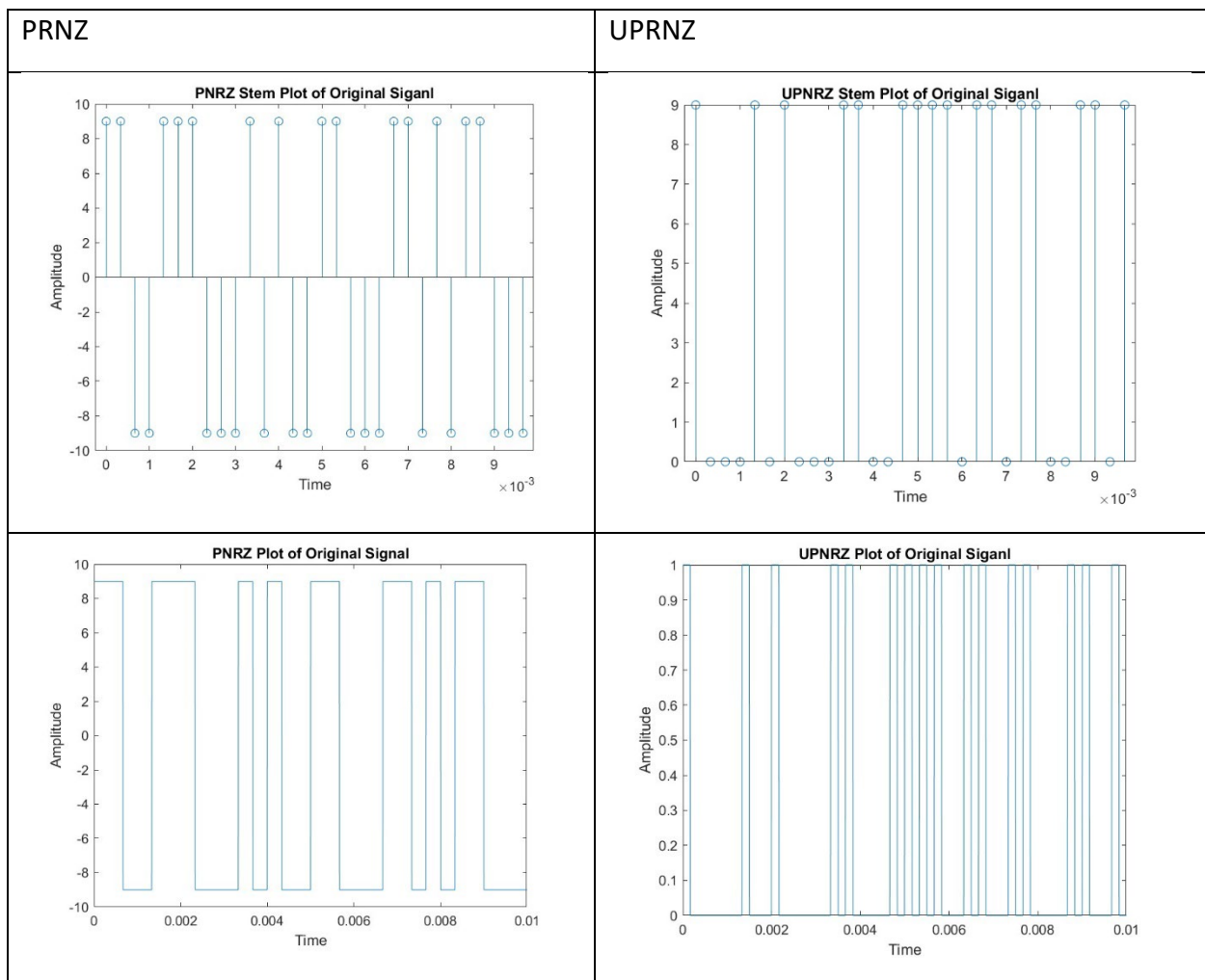
3. Alternate that binary data with zeros
4. Create a repeated vector of that binary signal the size of sampling rate / bit rate
5. Generate the appropriate time axis
6. Generate a list of signal-to-noise ratios from -20 dB to 50 dB with an interval of 2
7. For each of these ratios, emulate the noise on the signal and calculate the probability of error
8. Plot these error rates as function of the signal to noise ratio
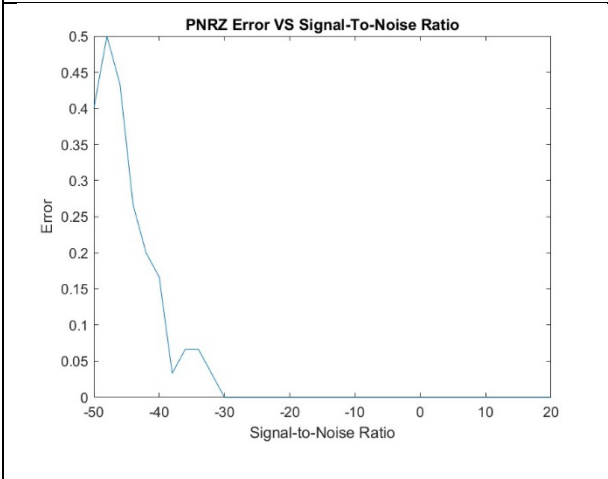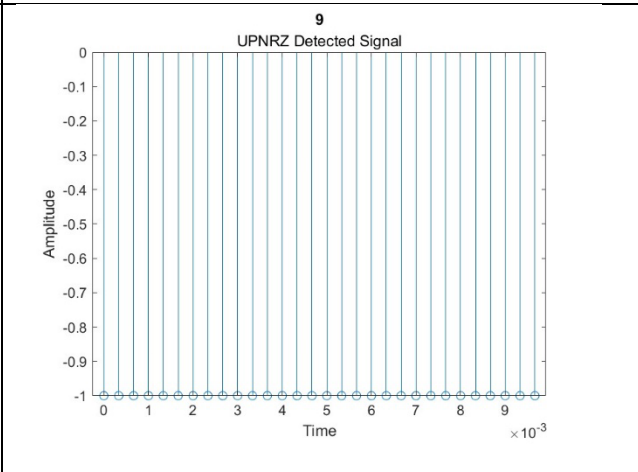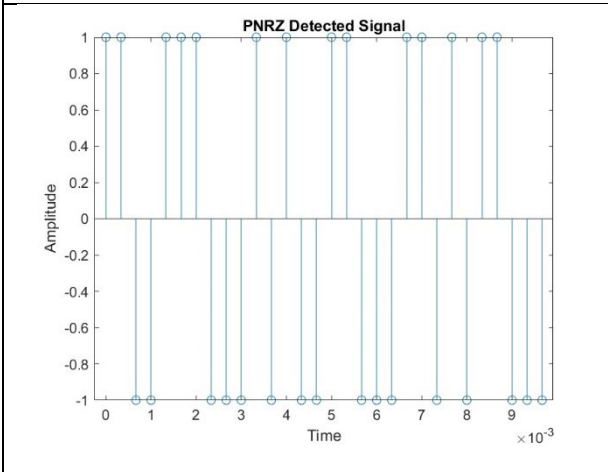9. For the 0 dB signal-to-noise ratio plot the transmitted signal, received signal, and filtered signal
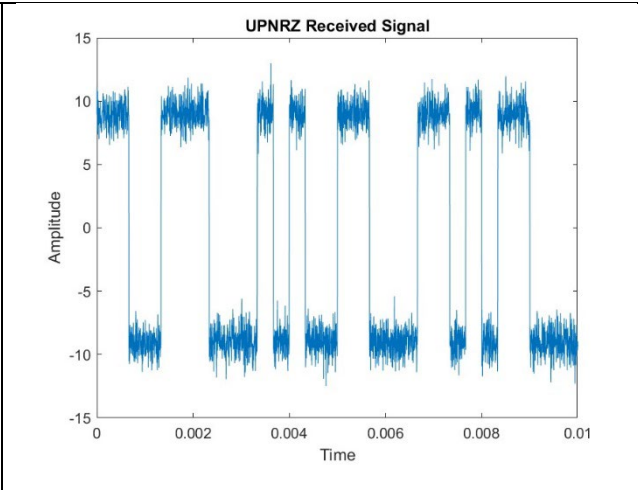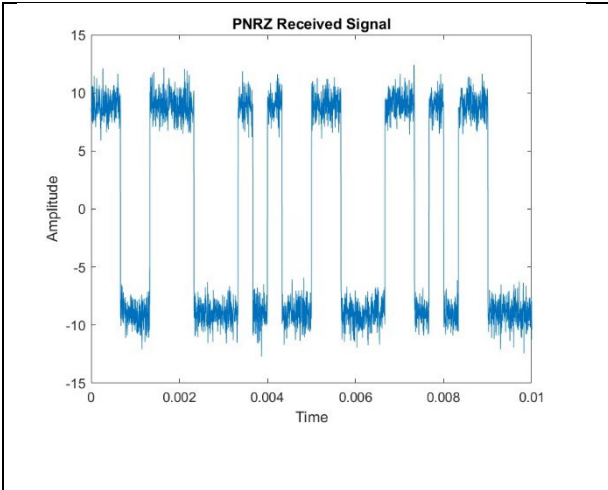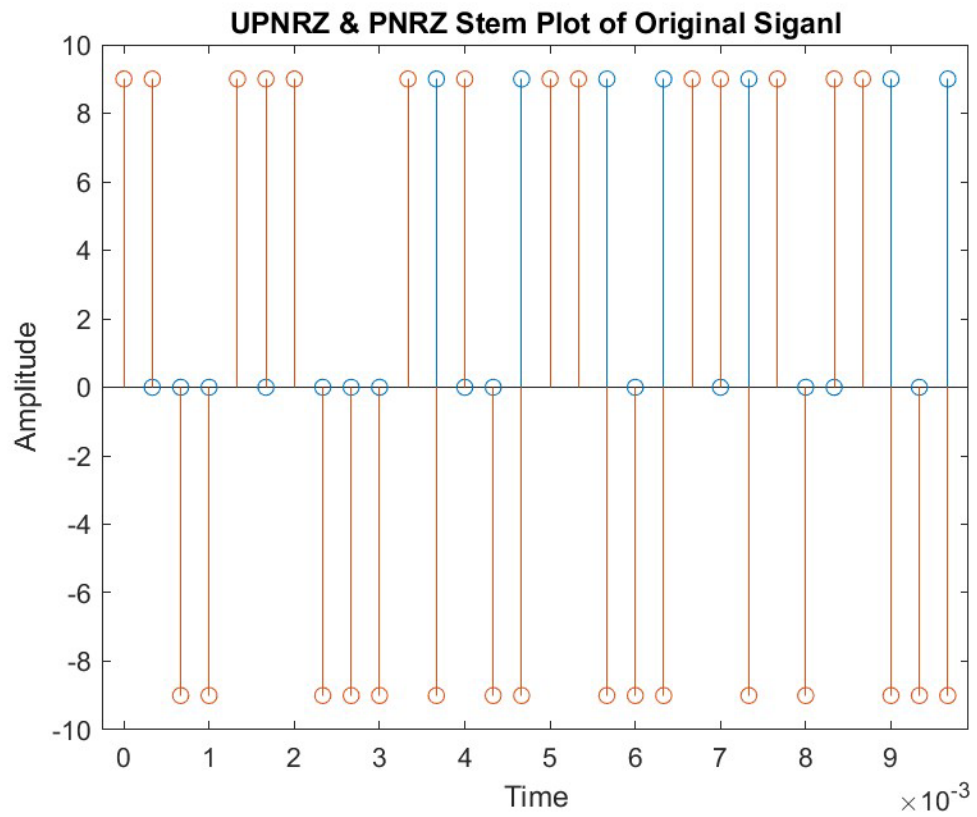
Task 3:

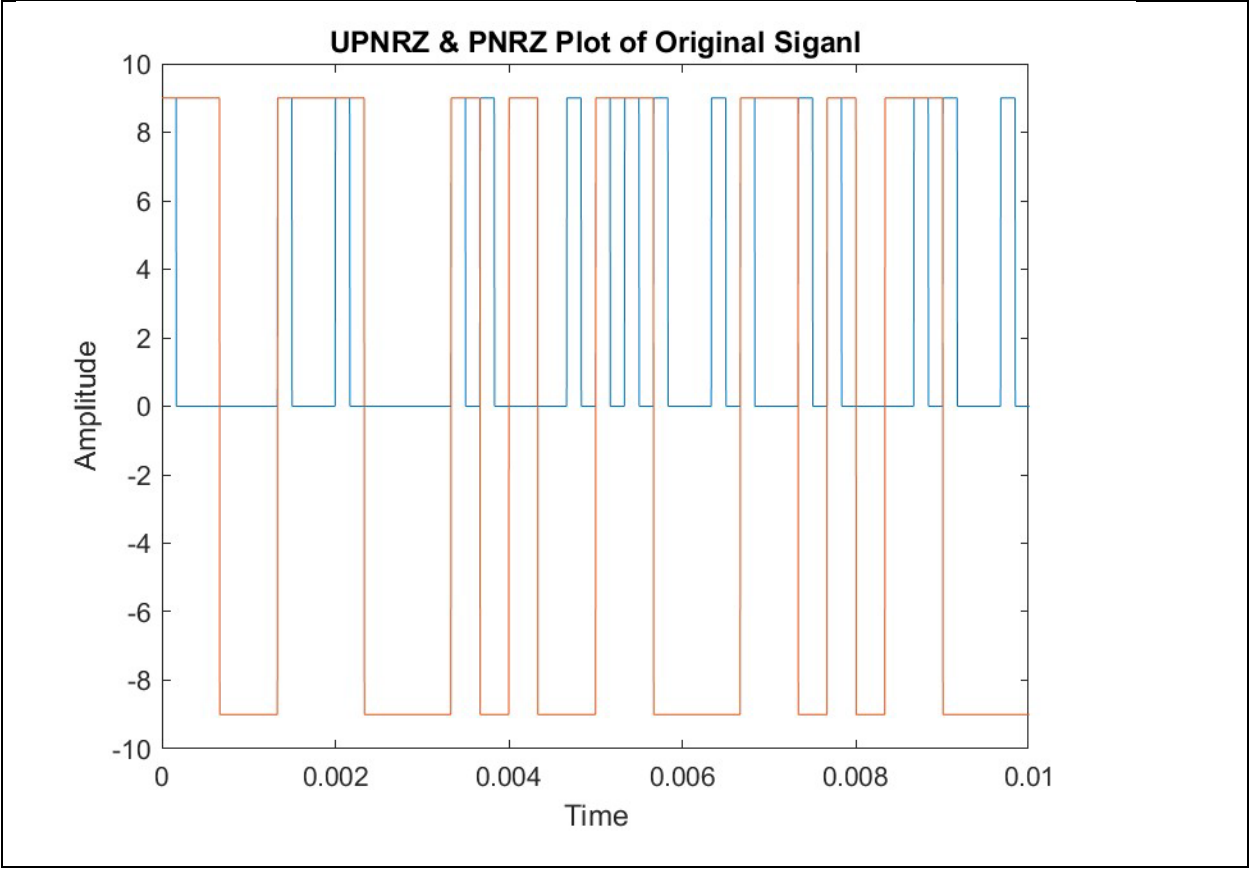1. Take the error rate plots from task 1 and task 2 and plot them on the same graph.

Results:

Task 1:

PRNZ	UPRNZ

PNRZ Received Signal

UPNRZ Received Signal

PNRZ Detected Signal

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UPNRZ Detected Signal

PNRZ Error VS Signal-To-Noise Ratio

UPNRZ Error VS Signal-To-Noise Ratio

UPNRZ & PNRZ Stem Plot of Original Siganl

UPNRZ & PNRZ Plot of Original Siganl

UPNRZ & PNRZ Received Signal
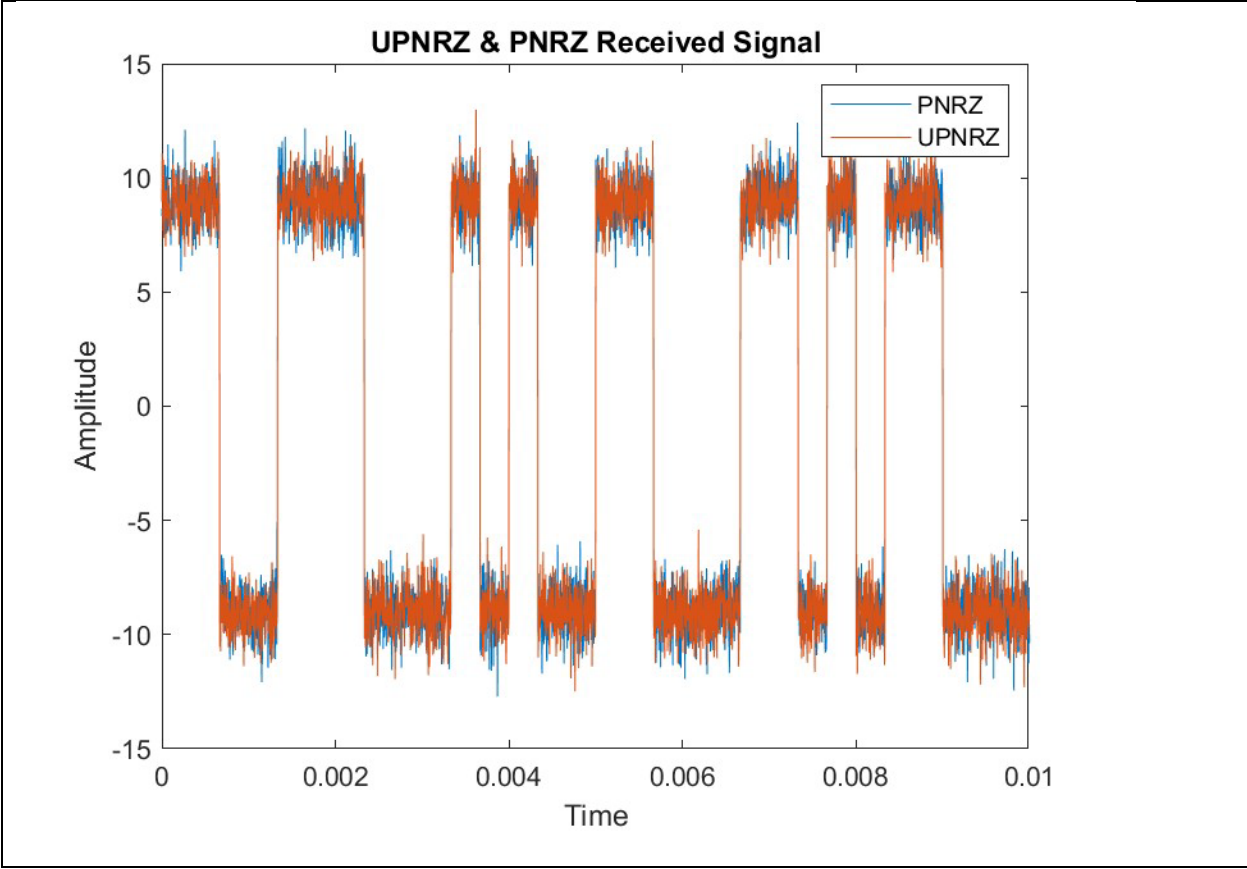
UPNRZ & PNRZ Detected Signal
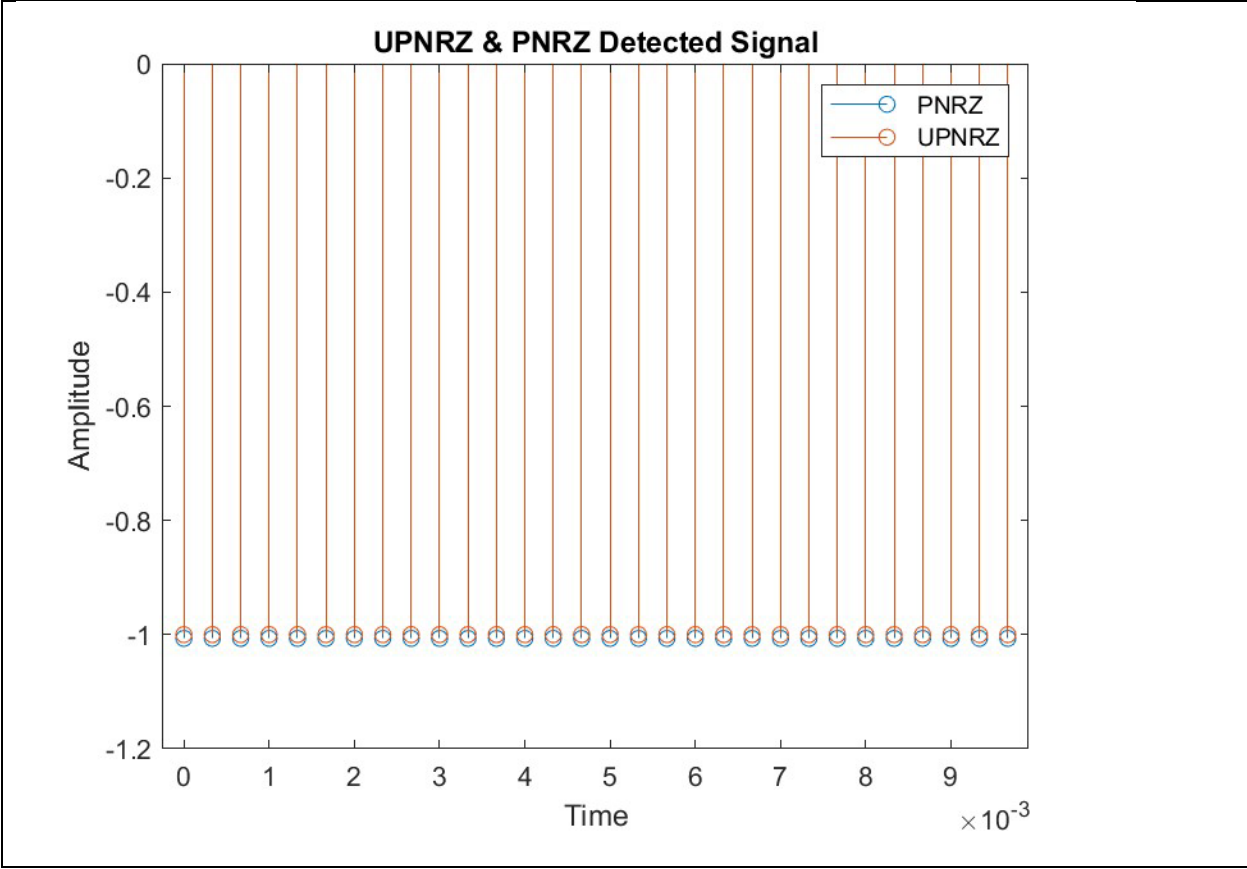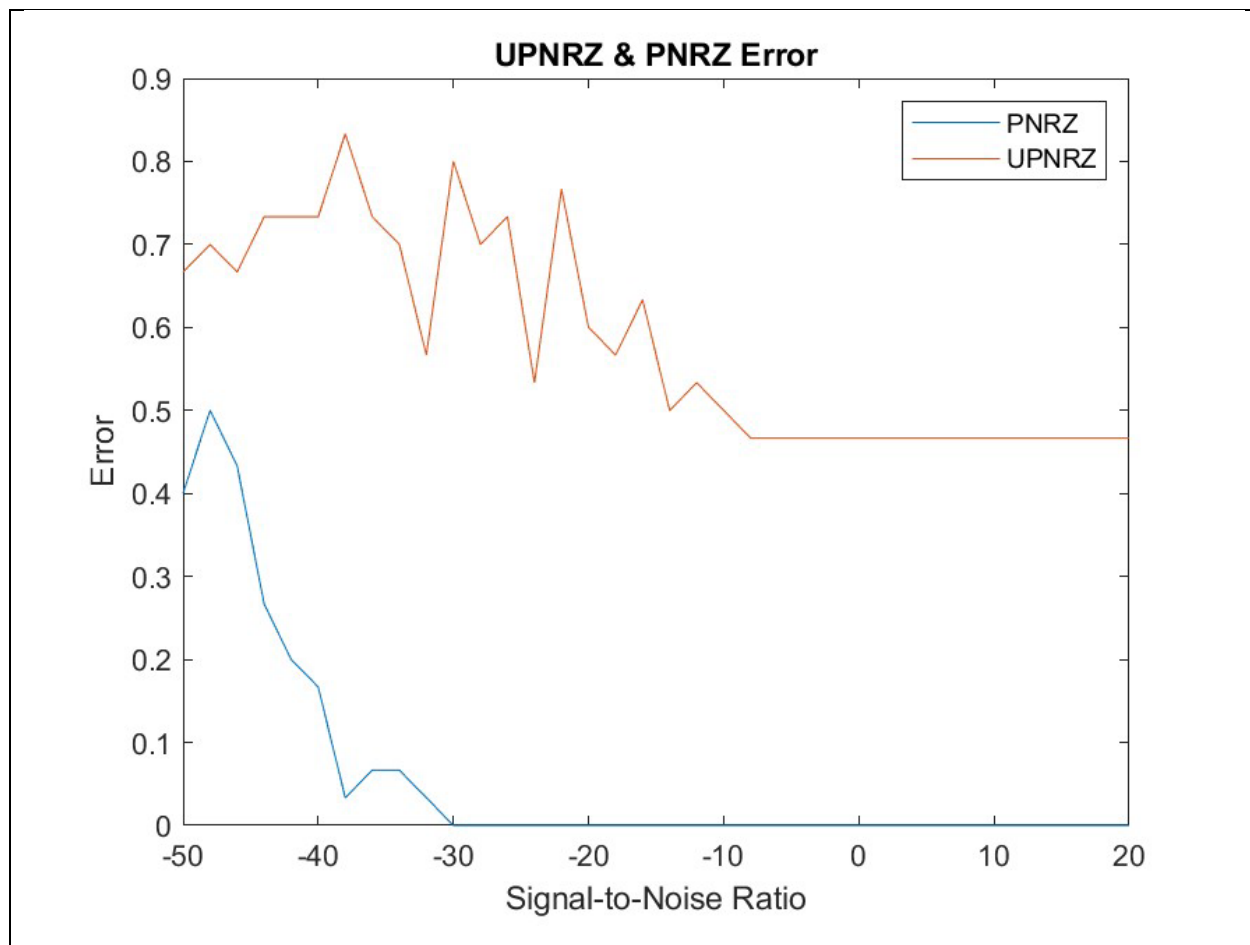
UPNRZ & PNRZ Error
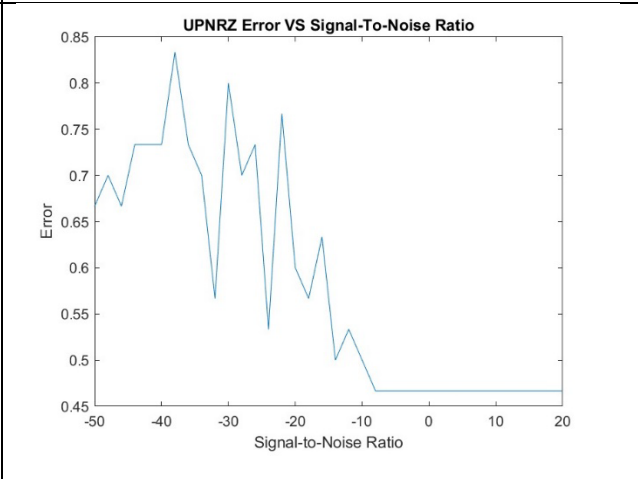
Descriptive Answers to Tasks:

As the Signal-to-Noise Ratio (SNR) increases, we can see that the error decreases. This is due to the increased amplitude of the signal compared to the amplitude of the noise. This means that as our SNR increases, our perceived signal becomes much cleaner.

When we compare our error rates, we can see that when the signal gets relatively clean, the Polar Non-Return to Zero (PNRZ) has an error rate of zero Unipolar Non-Return to Zero (UPNRZ) had an error-rate of .5. This is because every other bit of UPNRZ is dedicated to keeping track of clock timing for time-sensitive signals. In other words, we are sacrificing some of the information in order to keep the timing.

Conclusion:

By comparing these two encoding techniques, we can see that PRNZ is much better for the application of keeping raw data over a noisy channel. This is due to the inherent nature of these two different types of encodings being meant for different applications. While PRNZ is better for

this task UNPRZ would be better for timing related tasks where the clocking rate needs to be accounted for.