

ASSIGNMENT COVER SHEET

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Date of Submission	2/05/2020

Question	Max [%]	Mark [%]
Transmitter	/20	
a	5	
b	5	
c	5	
d	5	
Receiver	/40	
e	10	
f	10	
g	20	
Equaliser	/40	
h	20	
i	10	
j	10	
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1 Transmitter and pulse shaping

1.1 Real World Feasibility

1.1.1 Binary Polar Signalling

Binary polar signalling is a very robust signalling method as it has a much higher noise tolerance. However, it has a much lower throughput compared to other options such as 4-PAM and 8-PAM. The noise tolerance makes binary polar signalling suitable for wireless communications as this environment can have much more noise over a much further distance.

1.1.2 4-PAM

4-PAM is also a reasonably robust signalling method as there is still some noise tolerance as the different levels are reasonably well defined. This signaling method also allows double the data rate when compared to binary polar signalling. These properties make this method well suited to wired communication as noise is less noticeable in the signal as the medium can be controlled.

1.1.3 8-PAM

8-PAM however, has comparatively poor noise performance, which could require significant error correction with large overhead which could negate the improved throughput compared to other methods.

1.1.4 Recommendation

Overall, I would recommend using 4-PAM as it has a strong balance between data throughput and noise tolerance. As 8-PAM has only 50% more throughput but half the separation between signals of 4-PAM. Overall the double throughput of 4-PAM to binary signalling is worth the decreased noise resilience.

1.2 Power Spectral Density of 4-PAM (Rectangular Pulse Shaping)

With a rectangular pulse shaping the PSD of a 4-PAM signal is shown in (8) and the values for S_x and R_n can be found in (5) and (3, 1) respectively.

$$R_n = \lim_{N \rightarrow \infty} \frac{1}{N} \sum_k a_k a_{k-n} \quad (1)$$

Assuming that the data is random:

$$P_{a_k} = \begin{cases} \frac{1}{4} & a_k = 3 \\ \frac{1}{4} & a_k = 1 \\ \frac{1}{4} & a_k = -1 \\ \frac{1}{4} & a_k = -3 \end{cases} \quad \text{Therefore, } R_n = 0 \quad (2)$$

As in the previous equation the probabilities are equal for all a_k ,

$$R_0 = \lim_{N \rightarrow \infty} \frac{1}{N} \sum_k a_k^2 \quad \text{With, } P_{a_k^2} = \begin{cases} \frac{1}{2} & a_k^2 = 9 \\ \frac{1}{2} & a_k^2 = 1 \end{cases} \quad (3)$$

Therefore,

$$R_0 = 5 \quad (4)$$

$$S_x(f) = \frac{1}{T_s} [R_0 + 2 \sum_{n=1}^{\infty} R_n \cos 2\pi n f T_s] \quad (5)$$

As,

$$T_b = \frac{1}{R_b} \quad \text{Therefore with a bitrate of 1Mbps, } T_b = \frac{1}{1 \times 10^6} \quad (6)$$

As 4-PAM has two bits per pulse $T_s = 2T_b$ so $T_s = 2\mu s$ Therefore,

$$S_x(f) = \frac{1}{T_s} [5 + 0] \quad \text{For } T_s = 2\mu s \quad S_x = 2500000 \quad (7)$$

The equation for PSD is,

$$S_y(f) = \left| \frac{T_s}{2} \text{sinc}\left(\frac{f\pi T_s}{2}\right) \right|^2 S_x(f) \quad (8)$$

So,

$$S_y(f) = \left| \frac{T_s}{2} \text{sinc}\left(\frac{f\pi T_s}{2}\right) \right|^2 (2500000) \quad (9)$$

This results in the following PSD,

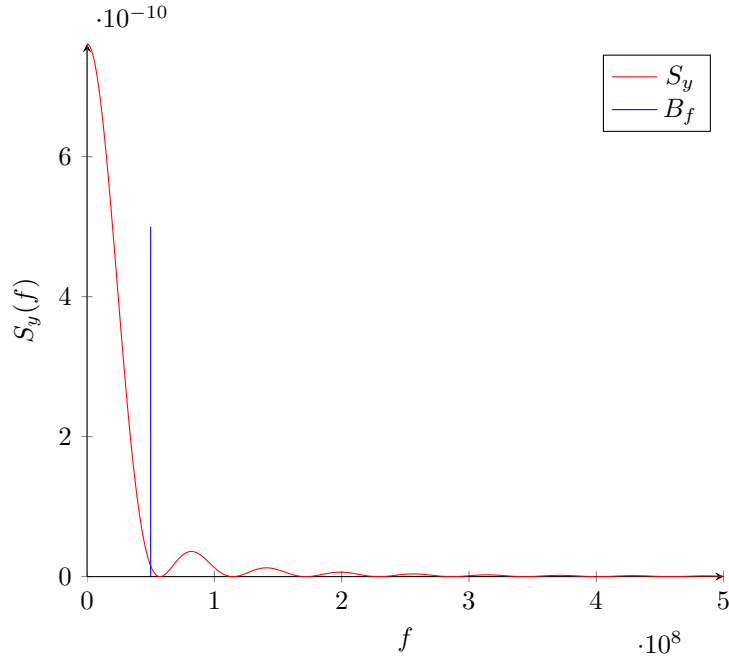


Figure 1: PSD of a 4-PAM Signal with rectangular pulse shaping

1.3 Power Spectral Density of 4-PAM (Nyquist Pulse Shaping)

The for the design of a Niquist pulse a roll off factor of $\alpha = 1$ was used as there is adequate bandwidth for the signal and the high roll off causes the tail oscillations of the pulse to fade more quickly, reducing the chance of intersymbol interference (ISI)

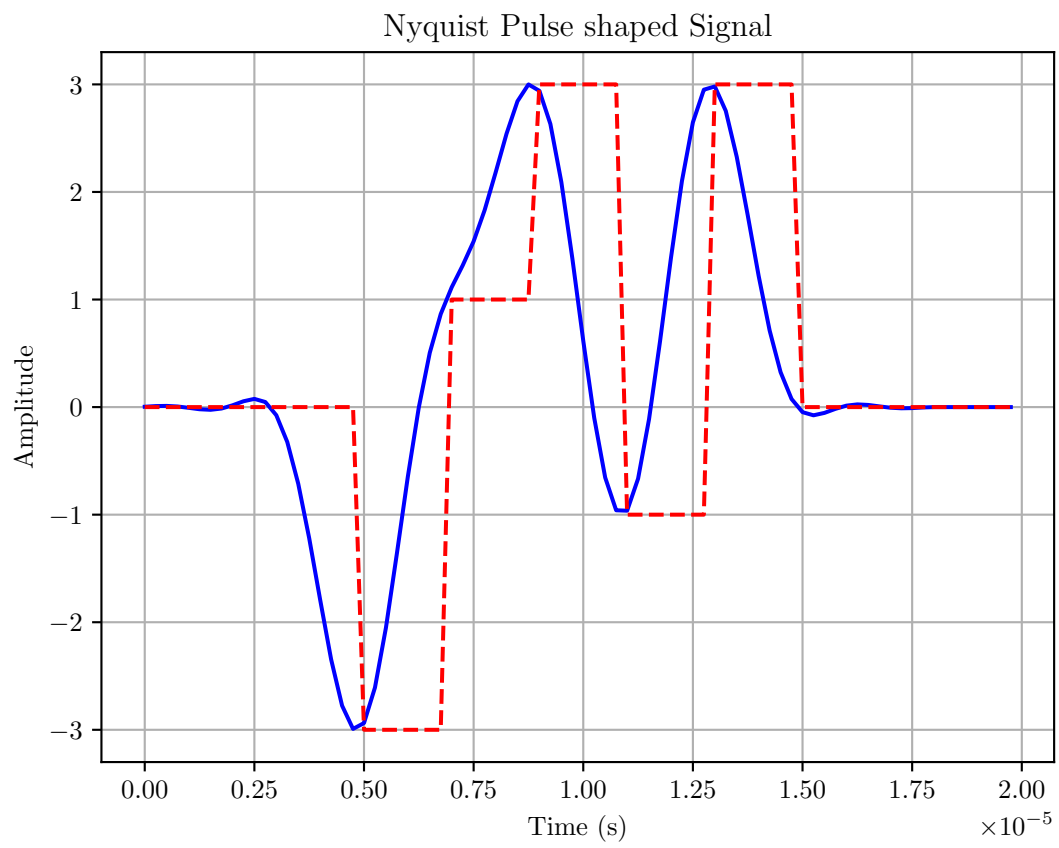


Figure 2: A Nyquist Pulse Shaped Signal carrying the data '0010110111'

1.4 Pulse shaping a signal with a Nyquist pulse

2 Receiver

2.1 Matched Receiver Eye Diagram

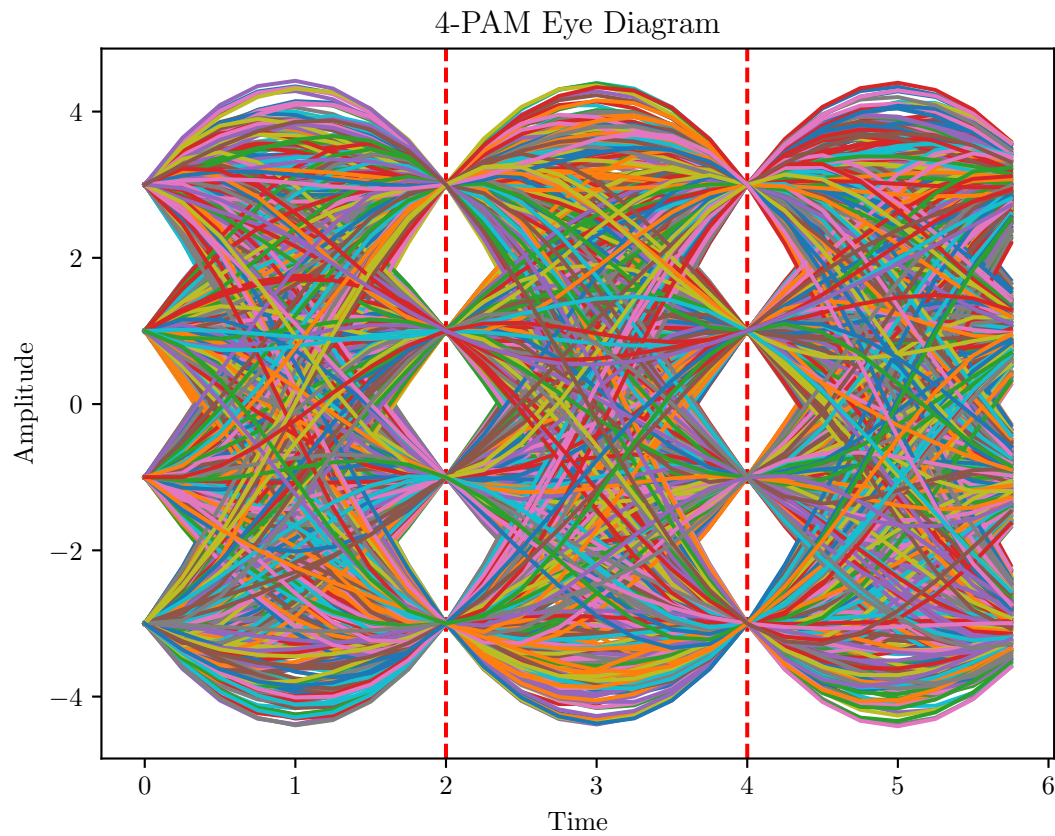


Figure 3: Eye Diagram of a signal passed through a matched filter with a $\text{SNR}=\infty$

2.2 Eye Diagram with a $\text{SNR}=10\text{dB}$

2.3 Bit error rate performance

3 Equaliser

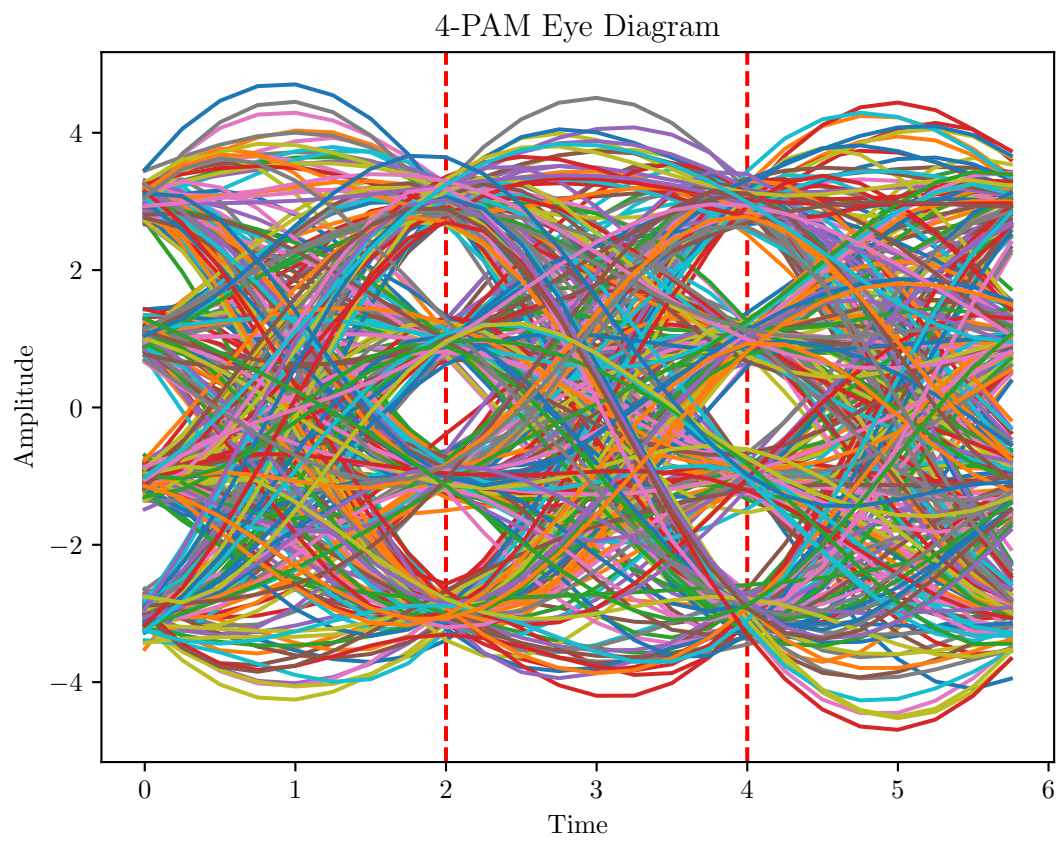


Figure 4: Eye Diagram of a signal passed through a matched filter with a SNR=10dB

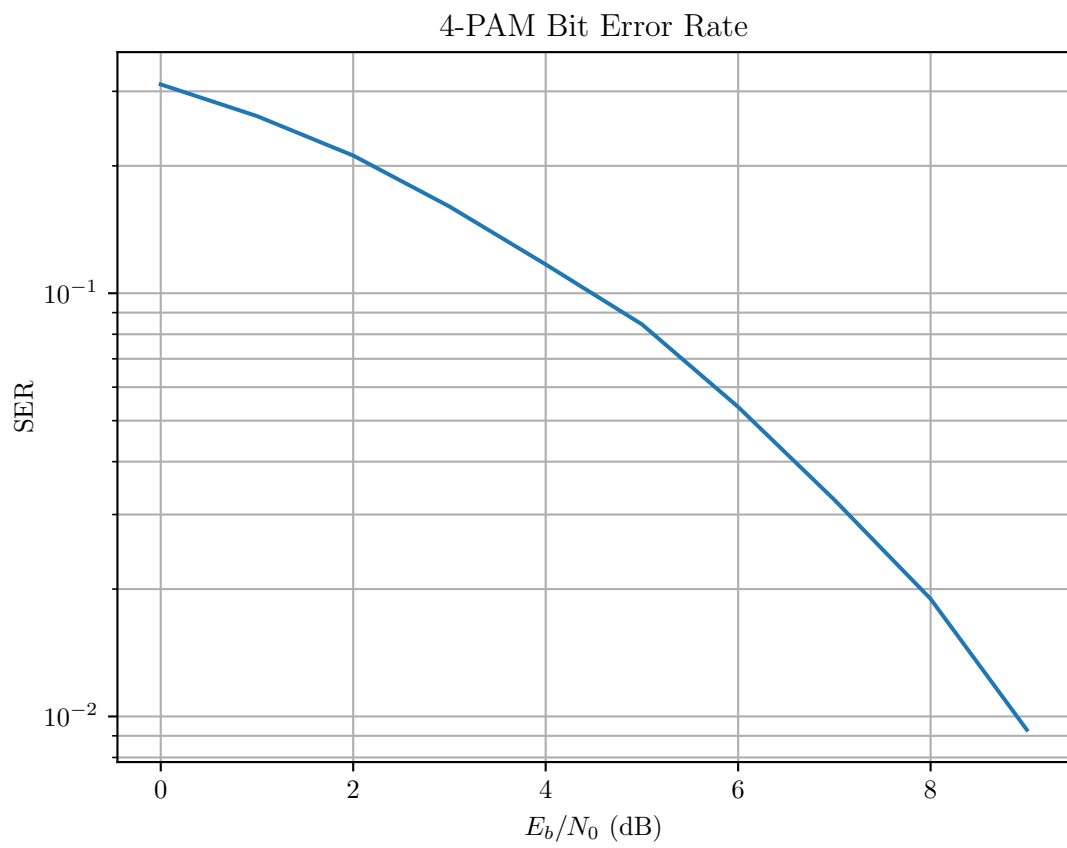


Figure 5: BER performance of 10,000 bits with an SNR from 0 to 10dB with a step of 0.01