Communication Systems
Lab – 4 Report

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Correction

```
m = randi(4,1,N);
for i = 1:N
    if(m(i) == 0)
        m(i) = -3;
    elseif (m(i) == 1)
        m(i) = -1;
    elseif (m(i) == 2)
        m(i) = 1;
    else
        m(i) = 3;
    end
end
```

```
m = randi(4,1,N);
for i = 1:N
    if(m(i) == 1)
        m(i) = -3;
    elseif (m(i) == 2)
        m(i) = -1;
    elseif (m(i) == 3)
        m(i) = 1;
    else
        m(i) = 3;
    end
end
```

To get correct results, I changed my PAM code to this way because I was seeing 2 eyes instead of three at the eye diagram. That is why, in this way the program is modulating correctly and resulting in 3 eyes as expected.

Figure 1 & Question 2

In these figures, we directly see the effects of rolloff factors on both frequency and time domain. At time domain, it is seen that higher rolloff factor (closer to 1) decreases the fluctuations around the main peak. This results in less ISI because the amplitudes, which will be overlap, are smaller. At frequency domain, rolloff factor affects the slope of the pulse shape. The smaller rolloff is, the steeper the slopes are. So, at 0, it is in the best pulse shape. Also, at higher rolloff values our bandwidth is greater because of the formula of $BT = \mathrm{W}(1 + \mathrm{rolloff})$.

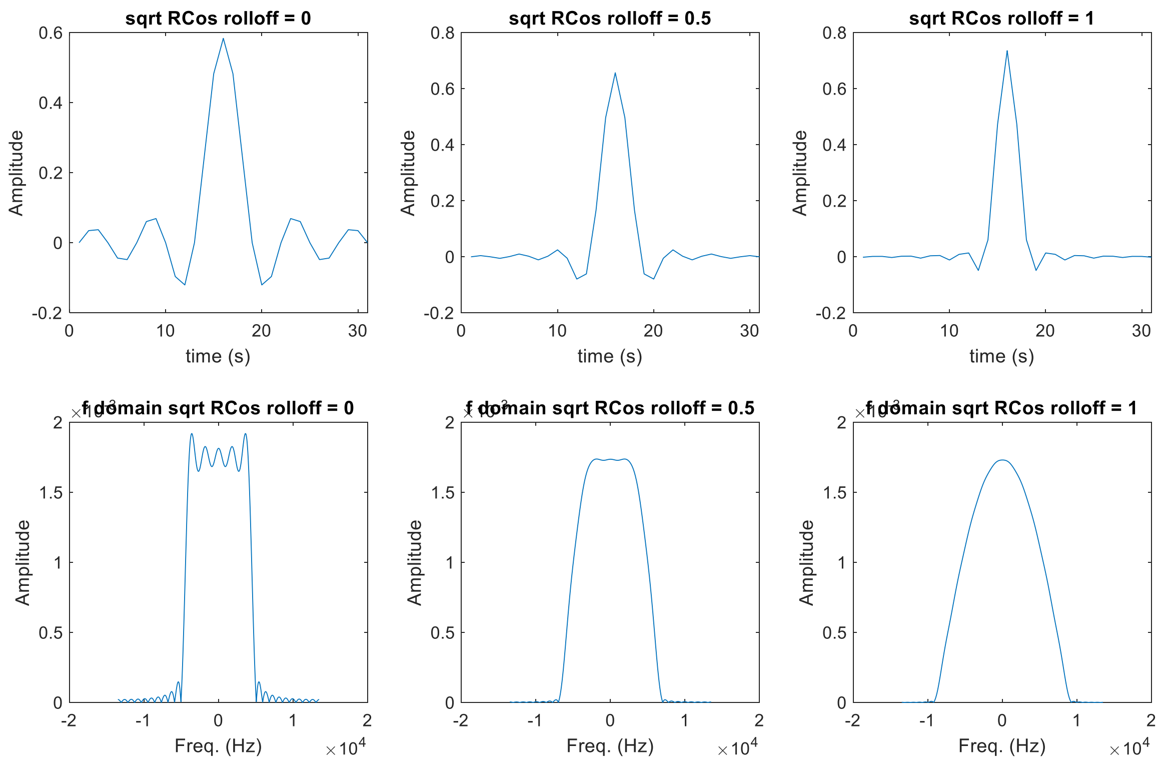
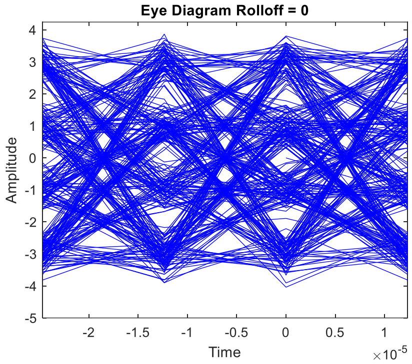
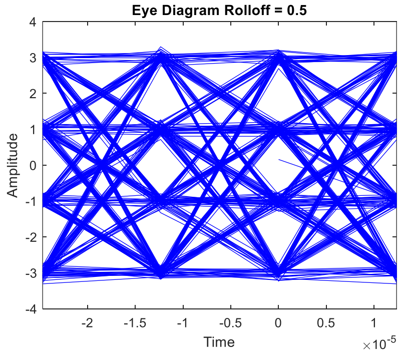
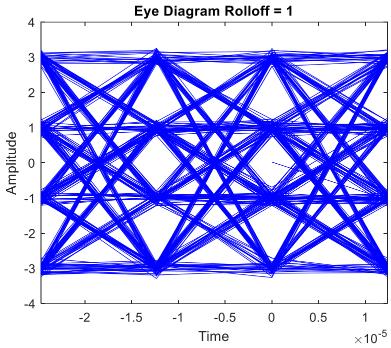


Figure 2, 3 & 4

As we expected, we see 3(M-1) eye openings in the figures because we have 4-ary PAM signal. It is seen that upper portion of the eye pattern is getting higher when rolloff is closer to 1 which means that there is less intersymbol interference. Furthermore, because of noise we see that eye openings and their heights are smaller which indicates noise. If there were no noise, we would observe bigger eye openings.







Questions

Q1.

To deal with ISI, we consider satisfying Nyquist's Criterion and try to implement Nyquist's Channel approach by using raised cosine with PAM systems to make it applicable. Additionally, to compensate ISI, we can use equalizer and we can design our transmitter and receiver filters for this purpose.

Q2. Answered at Figure 1

Q3.

Excess bandwidth is the product of rolloff factor (*rolloff/2T*). Therefore, when the rolloff is bigger, excess bandwidth is greater and ISI is smaller. If we see less ISI, this means higher eye openings. Thus, we can interpret higher eye openings as higher excess bandwidth or in the opposite way.

Q4.

If we consider Ideal Nyquist's Channel, W = Rb/2. Rb is equal to 2Rs, therefore W is directly Rs. However, this is not realizable for real life, so if we add rolloff factor and raised cosine to our method, our new bandwidth will be equal to Rs(1 + rolloff).