Performance Evaluation of Digital Transmission with Matlab on Eye Pattern Parameter

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Abstract. The effect of digital transmission impairments is seen from a diagram called an eye pattern. Measurements of the device can be represented in a simulation. Our motivation in conducting this simulation aims to dig deeper into the variation of parameter changes that exist in improving the eye pattern opening angle. The raised cosine pulse with roll-off (α) of 0.3 was used as the basis for this study, using the Matlab simulation. Important parameter values have been explored to show the best data. Finally, we suggest that we continue to explore optimization techniques for the best results for this eye pattern visualization.

1. Introduction
Distortion during transmission of telecommunication is a fact of life. One source of distortion to a pulse train is random noise, and we will take up this in the next section. A host of non-noise distortions, or "impairments" as they are called, can affect signals. Channel filters are a necessity because they make a signal bandwidth-efficient and reduce interference to neighboring transmissions, but filters also distort signals. So also do nonlinearities in signal amplifiers. Another kind of distortion occurs when the timing of the sampler is faulty so that the signal there is sampled too early or too late. Some of these impairments are supported with the aid of a convenient tool called the eye pattern. [1]

Eye patterns are important in the operation of digital transmission devices because they can help monitor device performance or as a parameter checkpoint when troubleshooting digital transmission devices. In addition to eye patterns, the constellation pattern modulation process includes this checkpoint parameter. [2] The aim of this research is to simulate and visualize eye patterns as an important parameter of digital transmission equipment. The simulation is carried out by comparing the results of various changes in device system parameters so that an analysis of the opportunities for optimizing device performance can be carried out on existing parameters. With the help of Matlab on this eye pattern and related parameters, it is possible to deepen monitoring of the performance of digital transmission equipment in the future.
2. Related Works

2.1 Raised Cosine Pulse

Much of what happens to pulse trains can be characterized as inter-symbol interference [ISI]. Loosely defined, ISI is the effect of a pulse on the detection in other symbol intervals. Figure 1 shows the standard 30% excess-band width raised cosine (RC) pulse together with a delayed version of the same pulse and a low-pass filtered version. The original pulse is Nyquist. Consequently, in a sampling receiver with accurate sampling times nT, the pulse is zero at all sample times other than its own and does not affect the other sampler outputs. In the linear receiver, with root RC pulses, the response at the receiver filter output to each root RC pulse is the RC pulse, and here, again, with accurate sample timing, each transmitted pulse affects only one sampler output. The second pulse in Figure 1 is delayed by 0.2T so that the sampling occurs 0.2T too early. Now the pulse contributes at other sampling times, in the amounts shown in the figure. This is ISI stemming from sampling time error. The third pulse is the RC pulse, filtered at a cut-off frequency of 0.5 / T Hz by a six-pole Butterworth filter. The filter has a delay of around 1.4 T seconds; but even with this taken off, at the other sampling times, substantial contributions exist. This ISI stems from the time dispersion of the filter.[1]

![Figure 1. Inter-symbol interference](image)

2.2 Eye Pattern

A classical technique for visualizing the effect of Inter Symbol Interference (ISI) is the eye pattern. The eye pattern gives a qualitative measure of system performance. A well-defined and open eye usually indicates good performance, while a poorly defined eye usually indicates poor performance. In addition, the size of the eye relates to the accuracy required of the symbol synchronizer. While the eye diagram does not provide a quantitative measure of system performance, it is difficult to conceive of a high-performance system having a poorly defined eye diagram. Three segments of a waveform, with each segment corresponding to a symbol period, are shown in figure 2. The waveform corresponding to three data symbols is illustrated in figure 2(a). Assume that this waveform is displayed on an oscilloscope and that the oscilloscope is triggered at the points denoted by the dotted vertical lines. The result will be the three-segment eye diagram illustrated in figure 2(b). [3]
ISI is constructed by overlapping multiple segments of the received waveform over a fixed window, which tells us how different combinations of symbols could potentially create ISI. For an ideal channel and square root Nyquist pulses at either end, the eye is open. However, for the dispersive channel, the eye is closed. An open eye implies that, by an appropriate choice of sampling times, we can make reliable single-sample symbol decisions, while a closed eye means that more sophisticated equalization techniques are needed for symbol recovery.

The eye pattern is obtained by superimposing a large number of trajectories, with duration $2T$, of the matched filter's output signal. It can be displayed on an oscilloscope by synchronizing with the symbol rate $1/T$. The afterglow of the screen makes it possible for the superposition to persist. In the presence of noise, as we are going to see, the wider the eye is vertical, the lower the error probability. Therefore, we have to choose the decision time where the eye is vertically “widest”. The low level of interference is clearly shown by the eye pattern without noise represented in figure 3. The trajectories almost converge to the same point at multiplies of $T$. Therefore, if the sampling is done at these times, the values located around 1 are likely to correspond to the transmission of a bit 1. Eye pattern data is a representation of a high-speed digital signal that enables quick visualization and determination of key parameters of the electrical quality of a signal.

A method uses least-median-of-squares (LMS) location estimator for analyzing eye patterns always provides a unique solution stated in [8]. The LMS protocol is indifferent to outliers and data distributions, as opposed to widely used histogram approaches. The reason for designing this
algorithm is to create an autonomous, benchmark approach that is both suitable for detailed study of ambiguity and can act as a comparative tool as there are currently no standardized industry algorithms. Using this method, the basic parameters of an eye diagram are determined by the authors, namely the levels of one and zero, and the time and amplitude crossings. With these parameters determined, various efficiency measures, such as extinction ratio and root-mean-square jitter, can be obtained and the eye-mask synchronization performed.

3. Method
In this study, the changes in sequence length of the source and binary velocity were observed to the values of other parameters physically by observing the existing eye patterns. The tool used is Matlab. Although Matlab has its own eye diagram routine, a code snippet is provided here to convey the concept of this research clearly. The output from the resulting receiver filter is the input to these fragments, but in general, it can be plotted an eye diagram based on the baseband waveform at each stage in the system. Here the two roll-off prices $\alpha$ are taken as 0.3 and compared with 0.6 and 1.0 at several SNR values. The modulation scheme used is QPSK. Previously, in the baseband section, observations were made on level four PAM signal data. The complete parameters that the authors take in this study are listed in table 1.

| No. | Item                          | Symbol | Unit   | Value |
|-----|-------------------------------|--------|--------|-------|
| 1   | The sequence length of the source | N      | bits   | 10000 |
| 2   | Binary rate                   | BR     | bit/s  | 2000  |
| 3   | Band of the channel           | B      | Hz     | 500-1000 |
| 4   | Signal to Noise Ratio         | SNR    | dB     | 10    |
| 5   | Raised cosine pulse (roll-off) | $\alpha$ | -     | 0.3   |
| 6   | Constellation size            | M      | -      | 4     |
| 7   | Number of bit per symbol      | n      | -      | 2     |
| 8   | Number of point per symbol    | NpS    | -      | 10    |
| 9   | Number of sample per symbol   | NT     | -      | 4     |
| 10  | Response length               | Nblobes| -      | 30    |
| 11  | Number of trajectories        | NbTraj | -      | 200   |

4. Result and Discussions
In this research, a PAM signal with two bits per symbol was used. Therefore obtained the alphabet symbol set is (-3 -1 1 3) as figure 7. The overall impulse ensures that the ISI is low enough for the symbol-by-symbol decision to yield good results. The increase in SNR taken in the simulation from the 2 dB value which continues to be enlarged, will cause the eye pattern opening to improve, even towards a null noise eye pattern. The constellation of the QAM signal that is formed is shown in Figure 8.

At a price of $\alpha = 0.3$ with a band of the channel of 650 Hz, the eye pattern opening angle still looks small at the SNR price of 15 dB. This is shown in Figure 4, where the qualitative value is similar for the eye pattern price for the price $n = 2$; $B = 800$ Hz; $\alpha = 0.6$; and SNR = 10 dB. In the view of the opening towards the ideal, it can be seen in Figure 5. This can happen at other prices such as at $B = 900$; $\alpha = 0.8$; SNR = 30 dB. The other side of the increase in eye pattern openings occurs with an increase in the price of B which also results in an increase in $\alpha$. For the simulation, the increase in $\alpha$ corresponds to the increase in the band of the channel. Meanwhile, the increase in the angle of the eye pattern is getting bigger as the SNR is taken. Conversely, when the binary rate is reduced to
1000 bits / s, $\alpha = 0.3$ only occurs on the 325 Hz channel band, even though the number of bits $N$ (sequence length of the source) is halved.

**Figure 4.** Eye pattern ($n=2$; $B=650$; $\alpha=0.3$; SNR=15 dB)

**Figure 5.** Eye Pattern ($n=2$; $B=1000$; $\alpha=1.0$; SNR=20 dB)

**Figure 6.** Raised cosine pulse
5. Conclusion

The effect of the eye pattern opening depends on the amount of SNR in the system, the bigger the
SNR, the cleaner the eye pattern. In line with that, an enlarged α value at a fixed SNR will also
produce a better eye pattern opening.

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