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Performance Analysis of Shift Keying Techniques using Eye-Pattern and Removal of Inter Symbol Interference using Raised Cosine Filters

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Abstract: Noise considerations are usually necessary in data transmission for assessment of imperfect channels. The eye pattern is examined to determine the impairment. An advanced method of analyzing eye patterns is proposed which plots the eye pattern as a function of the error rate. This method is applied to high-speed optical-transmission systems and its usefulness is confirmed. Several system performance measures can be derived by analyzing the display. If the signals are too long, too short, poorly synchronized with the system clock, too high, too low, too noisy, or too slow to change, or have too much undershoot or overshoot, this can be observed from the eye diagram. An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to inter symbol interference and noise appears as closure of the eye pattern. The performance of all shift keying techniques with eye pattern plots are observed as a function of the error rate with different alpha values as well as in the presence and absence of offset value.

Keywords: Eye pattern, Inter symbol interference, SINC function, raised cosine filter, excess bandwidth parameter.

1. INTRODUCTION

In telecommunications the eye-pattern , is an oscilloscope display in which a digital signal from the receiver is repetitively sampled at the vertical input, while data rate is used to trigger the horizontal sweep. The eye pattern [4, 9, 13] is used to measure so many parameters like eye amplitude, eye crossing amplitude, eye crossing percentage [1, 5, 7], eye height [11-12, 14], quality factor and signal to noise ratio etc.., to reduce the distortion this very useful.

Eye patterns plays a vital role in digital Communication. Since from the past few decades research, we witnessed the importance of eye-patterns.. The calibrate key parameters (eye amplitude, eye height and eye width) of eye pattern generation using an oscilloscope are explained. Some papers are published for systematic method of using voltage transfer functions for arbitrary sources and load terminations to improve the eye patterns of high speed [3,7-9] differential links with passive components that minimizes the distortions. Some other methods for simulating the eye pattern of high speed digital signal propagated [10, 21] on printed circuit boards using multi conductor transmission line modeling is also discussed. As technology is growing day-by-day there is more impact on the communication systems also. In order to overcome the problems in future communication we have to do new inventions. Communication plays a major key role in every system. Without communication is is impossible to imagine the world.

If the information that has to be carried is very weak then we will strengthen the signal by passing it through modulators. Here depending on input signal parameters (I.e., time, amplitude, frequency, phase) we are using different techniques to get the accurate output as input. For every system we are using input and output transducers they are nothing but modulation and demodulation. Modulation means the carrier signal is varied with respect to the message signal. To work the communication system accurately the signal to noise ratio should be very high. Automatic gain control systems are key components in optical transmission systems. Peaking techniques are especially essential to achieve a wide bandwidth. However peaking should be carefully controlled because excessive peaking degrades the flatness in the group delay response, resulting in waveform distortion.

2. EYE PATTERN

In telecommunication system, an eye pattern is [9, 13, 20, 21] also known as an eye diagram, is an oscilloscope display in which a digital signal from a receiver [19] is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is an experimental tool for the evaluation of the combined effects of channel noise and inter-symbol interference on the performance of a baseband pulse-transmission system [2].

An eye diagram is a useful tool for understanding signal impairments in the physical layer of high-speed digital data systems, verifying transmitter output compliance, and revealing the amplitude and time distortion elements that degrade the BER for diagnostic purposes. By taking high-bandwidth instantaneous samples of a high-speed digital signal, an eye diagram is the sum of samples from superimposing the 1's, 0's, and corresponding transition measurements. The resultant image that reveals the "eye" of the eye diagram [6], as shown in Figure 2. For easy viewing, the time axis in Figure 2 is normalized for 2 bits, with the 1 bit "eye opening" in the center of the display and 1/2 bit to the left and right of the center eye for capturing rise/fall-time transitions. Although the eye pattern in Figure 2 depicts some noise and jitter, other forthcoming examples will show data system waveforms with considerably more noise and a center eye that closes more significantly. Generally the more open the eye is (indicated by the arrows in the diagram), the lower the likelihood that the receiver in the transmission system will mistake a logical 1 bit for a logical 0 bit, or vice versa. These logic decisions require a certain margin of signal differential between the 0 and the 1 level. Noise, both amplitude and time jitter, reduces that margin and is logically depicted in Figure 2 as some closure of the eye opening. The ratio of bits that have errors, compared to the overall bits, is called BER. Eye pattern can be obtained like:

1. Extract one or more symbol periods
2. Superimpose all possible results
3. Can be easily obtained by oscilloscope

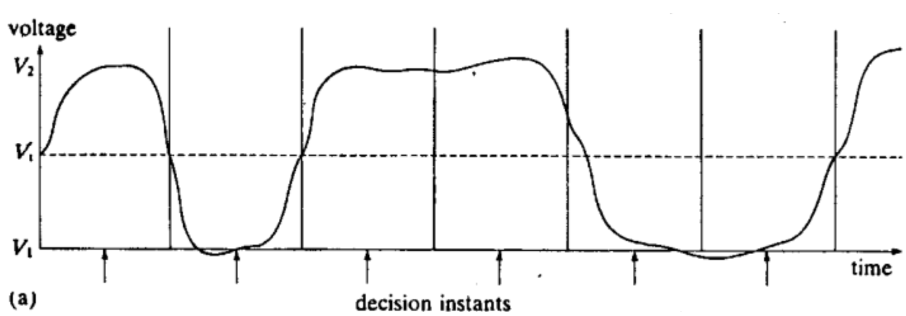


Figure 1: Decision instants of ISI

Results is an image that reveals the "eye" of the eye diagram, as shown in Figure 1. For easy viewing, the time axis in Figure 1 is normalized for 2 bits, with the 1 bit "eye opening" in the center of the display and 1/2 bit to the left and right of the center eye for capturing rise/fall-time transitions. Although the eye pattern in Figure .2 depicts some noise and jitter, other forthcoming examples will show data system waveforms with considerably more noise and a center eye that closes more significantly.

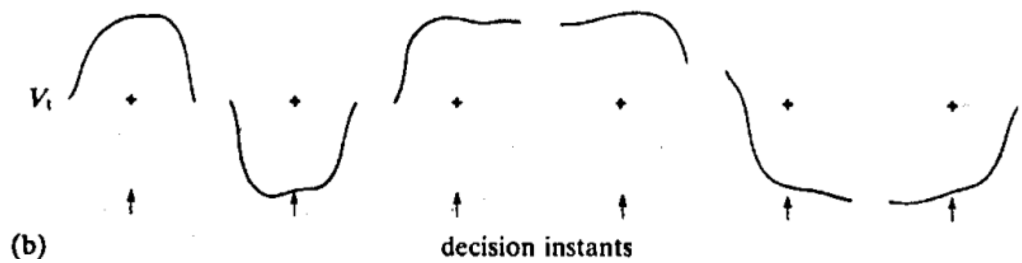


Figure 2: Individual decision instants of ISI

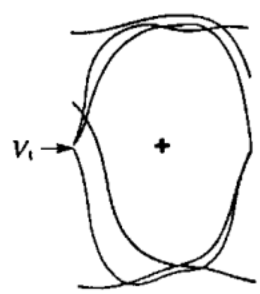


Figure 3: Obtaining eye pattern by superimposing individual instants

When the eye pattern is superimposed with the individual instants all the instants are added and form the eye pattern as shown in Figure 3. Here we can observe the noise is present.

The width of the waves of the eye diagram represents the time between the each sampled. The preferred time for the sampling transmission is the large opening of the chat. The more opening of the eye at the given sample represents the margin with respect to the noise as shown in above Figure 3.

A. Inter Symbol Interference

The intersymbol interference [17] is a signal distortion in telecommunications. One or more symbols may be interfere with each other causing noise symbols or a signal less reliable. The main causes are inter-symbol interference or multipath propagation of nonlinear frequency in the channels [16, 18]. This has the blur effect or a mixture of symbols, which may reduce the clarity of the signal.

Inter Symbol Interference on Eye Diagrams

The oscilloscope representation of transmitted signals is known as an eye diagram. Pulse code modulation or data transmission systems can be used to apply sawtooth waves between an oscilloscope's deflection plates at a symbol rate R(R=1/T) at horizontal deflection plates. The resulting binary waves are comparable to the shape of the human eye. The patterns that are created with this tool can illustrate the transmission's performance within applicable constraints.

The width of the waves in eye diagrams represent the time between each sampling. The preferred time for sampling transmissions is when the eye is open widest on the diagram. The rate of eye closure intervals can determine the sensitivity of timing errors on the signal. The tallest opening of the eye diagram at any given sampling time illustrates the margin over noise. The noise margin is basically the limit of noise that causes errors at the receiver.

When intersymbol interference is applied to the transmissions, the resulting waves are distorted and delayed. The oscilloscope illustrates several pulse variations that have less definition, smaller noise margins, and sample windows. Transmissions with inter-symbol interference have worse performance within the system.

The rate of the interference between symbols is minimized by the use of raised cosine filter (RCF) techniques.

Shift keying techniques using RCF

1. Amplitude shift keying
2. Frequency shift keying
3. Phase shift keying

1. **ASK:** Amplitude shift [25-26] keying is also known as On-Off keying. The amplitude of the carrier is shifted in accordance with the message signal. It varies between 0 and 1, when binary '1' is present it represents the signal amplitude and binary '0' represents no signal.
2. **FSK:** In Frequency shift [25-26] keying digital information is transmitted through the discrete frequency changes of the carrier. The simplest form of FSK is Binary FSK which represents binary 0 and 1. Binary '1' is called the mark frequency and binary '0' is called the space frequency.
3. **PSK:** Phase shift keying [23, 25-27] conveys data by changing the phase reference of the carrier. Psk has finite number of phases each assigned a unique pattern of binary digits. Two common examples are binary phase shift keying which uses two phases and quadrature phase shift keying which uses four phases. To avoid the inter symbol interference in the shift keying techniques we introduce RCF at the filtering stage.

A. Raised Cosine Filter

In digital signal processing and information theory, the normalized sinc function is commonly defined for $x \neq 0$ by

$$\sin c(x) = \frac{\sin(\pi x)}{\pi x} \tag{1}$$

In either case, the value at $x = 0$ is defined to be the limiting value sinc(0) = 1 as shown in (2)

Standardization causes the definite integral of the function on the real numbers equal to 1 (as the same integral non normalized sinc function has a value of π). As another useful property all the zeros of the normalized sinc function are integer values of x. The normalized sinc function is the Fourier transform of the rectangular function without scaling. This function is critical in the design of the reconstruction of the web original signal limited from evenly spaced samples of this signal.

The only difference between the two definitions is the scaling of the independent variable (x-axis) by a π factor. In both cases, the value of the function to the removable singularity at zero means the limit value 1. The sinc function is analytic everywhere and therefore an entire function.

Filter commonly used for the formation of pulses in digital modulation [15, 23] because of its ability to minimize the inter symbol interference (ISI). Nonzero portion of the frequency spectrum of the simplest form is a cosine function, "raised" [28-29] to sit above the axis *f* (horizontal). No abrupt transitions.

In communication systems, data is transmitted by bits binary (ones and zeros). It is easier to implement a binary system using switches, which turn on a switch is "8" and turn it off is '0'. Such simple binary systems essentially represent ones and zeros as rectangular pulse of finite duration. In the frequency domain a rectangular pulse of duration τ finite manifests as a sinc pulse of infinite duration. In addition, most of the energy of the rectangular pulse is concentrated with $-1/\tau$ $1/\tau$ in the frequency domain. This implies a pulse duration τ requires twice the bandwidth for reliable transmission. This poses a limitation regarding the bandwidth limited system, if we want to increase the data transmission rate.

In a band-limited system, when we try to increase the data rate, it can lead to Inter Symbol Interference (ISI). There are two criteria for non-interference systems where the pulse shaping is used. The pulse shape has a zero crossing point of all the pulse intervals, with the exception of its own sampling, The shape of the pulses is such that the amplitude decreases rapidly outside of the pulse interval.

A raised cosine [29] pulse is designed to satisfy these two criterions and thus provides an ISI free system. Alpha, is the excess bandwidth parameter.

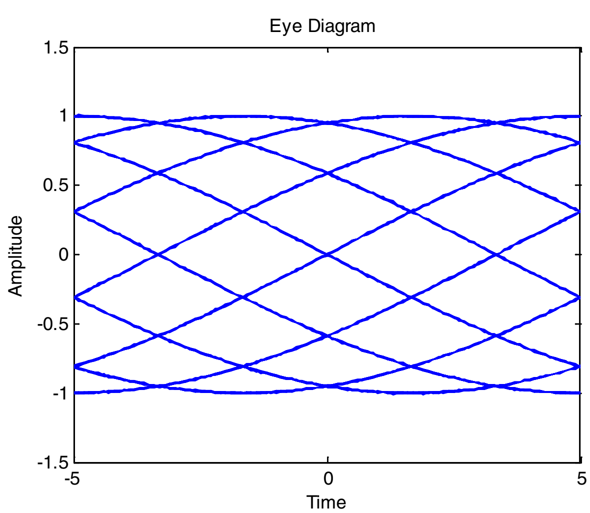
$$\frac{\cos(\alpha\pi t/\mathrm{T})}{1-(2\alpha t/\mathrm{T})^2} = \frac{\pi}{4} \text{ for } \left|\frac{\alpha t}{\mathrm{T}}\right| = \frac{1}{2} \tag{2}$$

3. RESULTS AND DISCUSSION

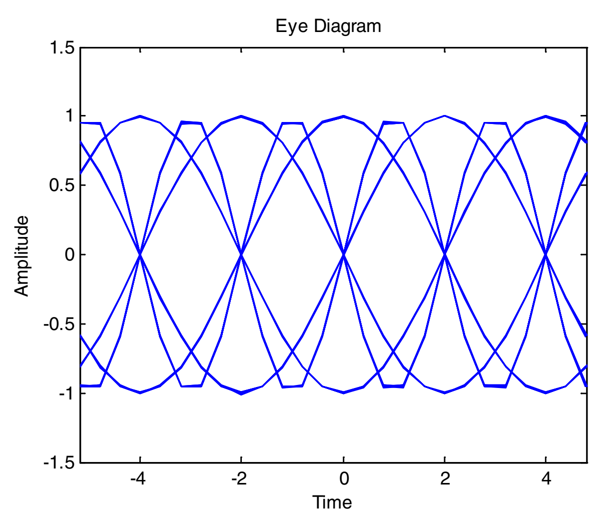
The general diagram of eye pattern of ASK shown in Figure 4(a). It shows the eye pattern of ASK .Here the eye is opened it is very clear and has less noise.

In the FSK the amplitude of the signal is constant but the frequency of the signal is varied. The variations in the eye pattern of frequency are shown in Figure 4(b) in detailed.

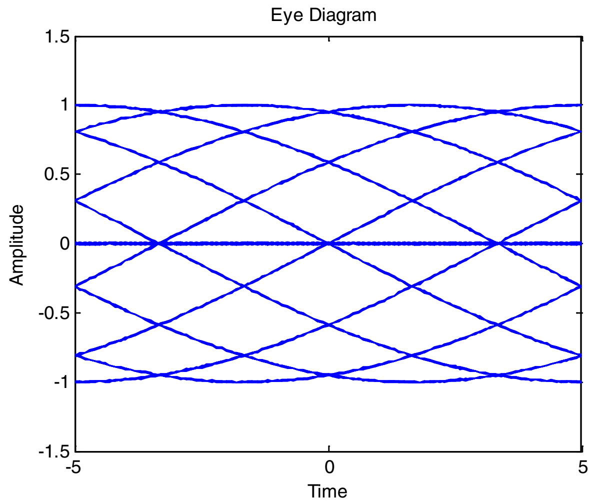
The basic diagram of PSK Eye pattern shown in Figure 4(c) we can see the normal pattern of PSK. Here in normal PSK the eye is opened clearly



(a)

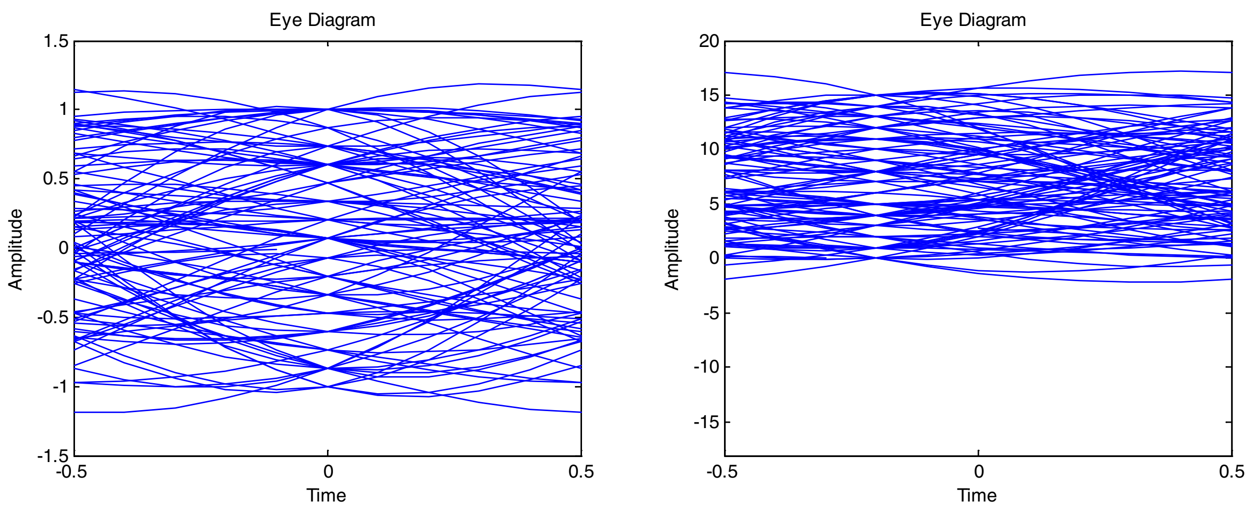


(b)



(c)

Figure 4: (a) ASK Eye pattern (b) FSK Eye pattern (c) PSK Eye pattern



(a) **(b)**

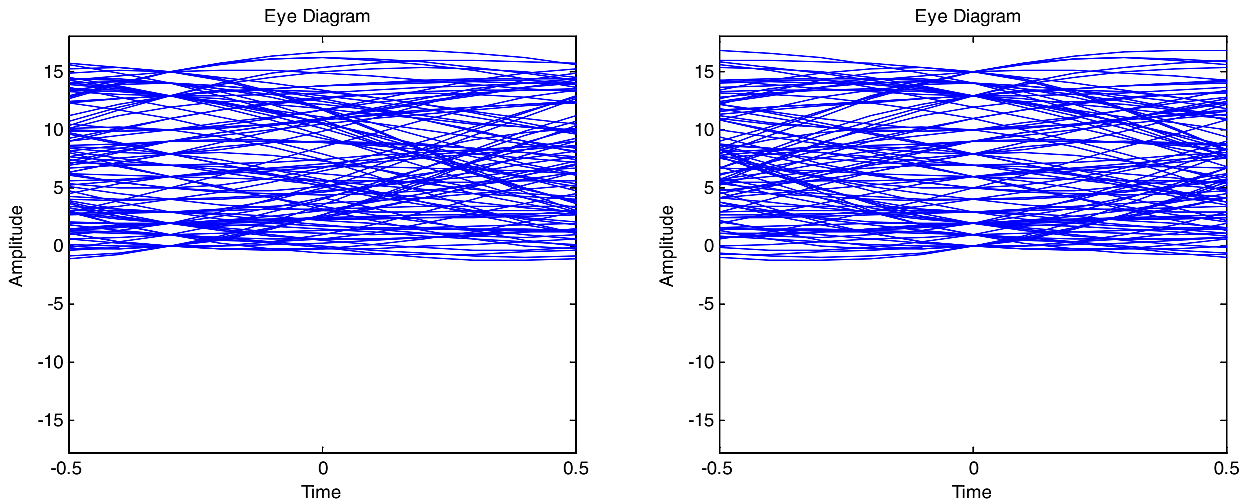
Figure 5: (a) ASK Eye pattern with Offset, (b) ASK Eye pattern with no Offset

In ASK the best sample is occured very quickly as shown in Figure 5(a) The eye pattern is clumsy which is not clear thereby it is not preferred.

When we observe the Figure 5(b) we are getting the best sample lately when compared to ASK with offset the signal noise will be less.

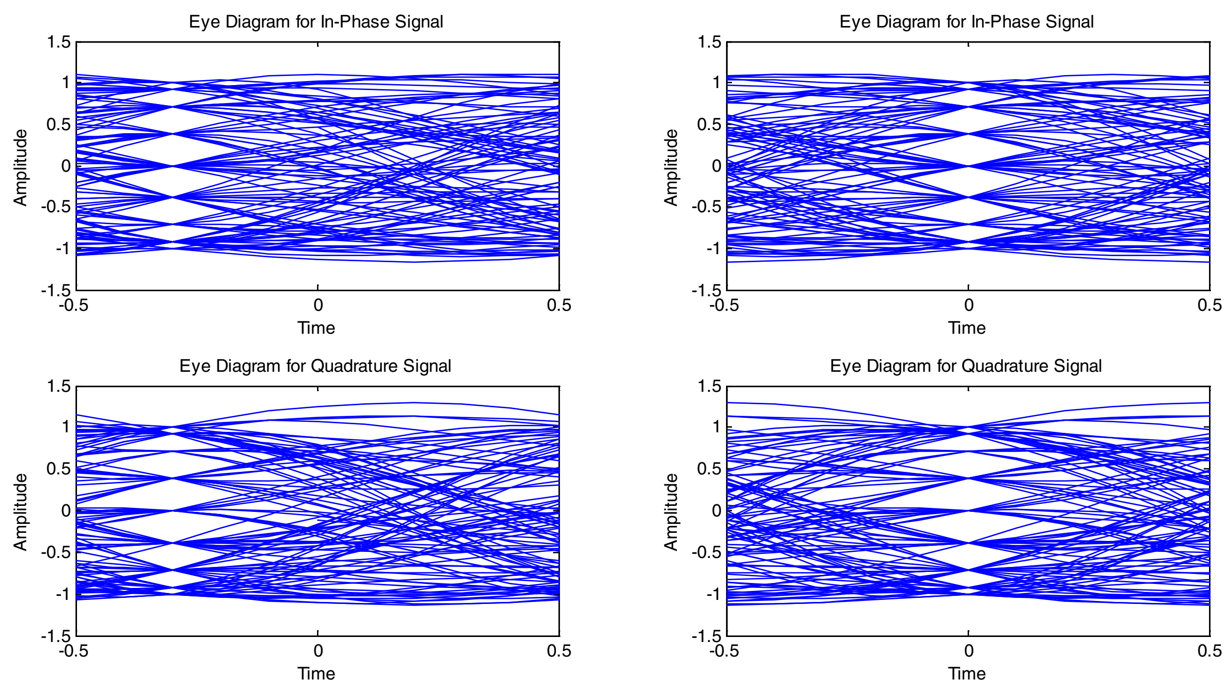
Figure 6(a)present the eye pattern of frequency shift keying applied with raised cosine filter. Here the offset is present .It is observed that there is some more noise in it the signal degradation takes place quickly.

Figure 6(b) present the eye pattern of frequency shift keying applied with raised cosine filter .Here the offset is absent. It can be observed that there is noise so that the signal will get degrade compared to ask the noise level will be less thereby the frequency varies.



(a) **(b)**

Figure 6: (a) FSK Eye pattern with Offset (b) FSK Eye pattern with no Offset



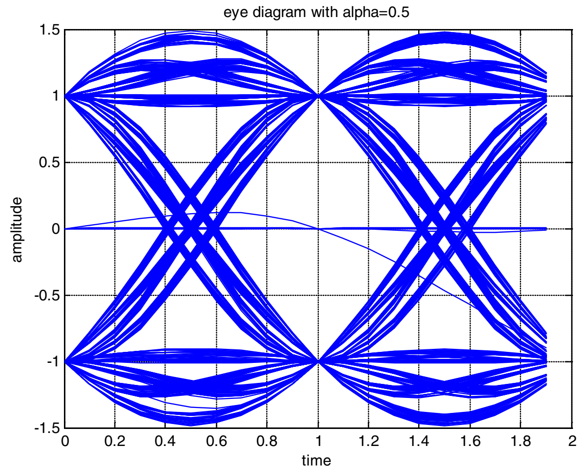
(a) **(b)**

Figure 7: (a) PSK RCF Eye pattern with Offset
(b) PSK RCF Eye pattern without Offset configurations

Figure 7(a) presents the eye pattern of phase shift keying applied with raised cosine filter. Here the offset is assumed to be present. It can be observed that in both the inphase signal and quadrature phase signal the eye opening is small thereby the signal is not accurate.

Figure 7(b) presents the eye pattern of phase shift keying applied with raised cosine filter. Here the offset is assumed to be absent. It can be observed that in both the in-phase signal and quadrature phase signal the eye opening is improved when compared to the case where offset is absent the eye pattern will be accurate thereby the signal will not degrade very quickly.

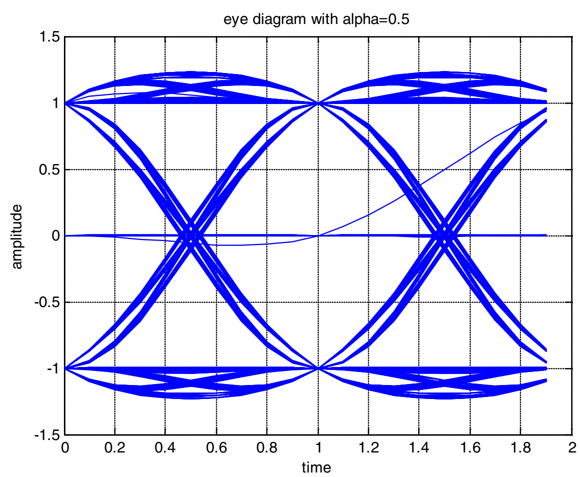
After applying raised cosine filter:



(a) **(b)**

Figure 8: (a) ASK RCF Eye pattern with alpha 0.5. (b) Ask RCF Eye pattern with alpha =1

Figure 8(a) and Figure 8(b) are plotted with excess bandwidth parameter alpha as 0.5 and 1 respectively for ASK. After applying raised cosine filter, the eye opening is wide showing better performance in ASK but the signal will degrade the bandwidth is less therefore it is not preferred for long distance transmission.



(a) **(b)**

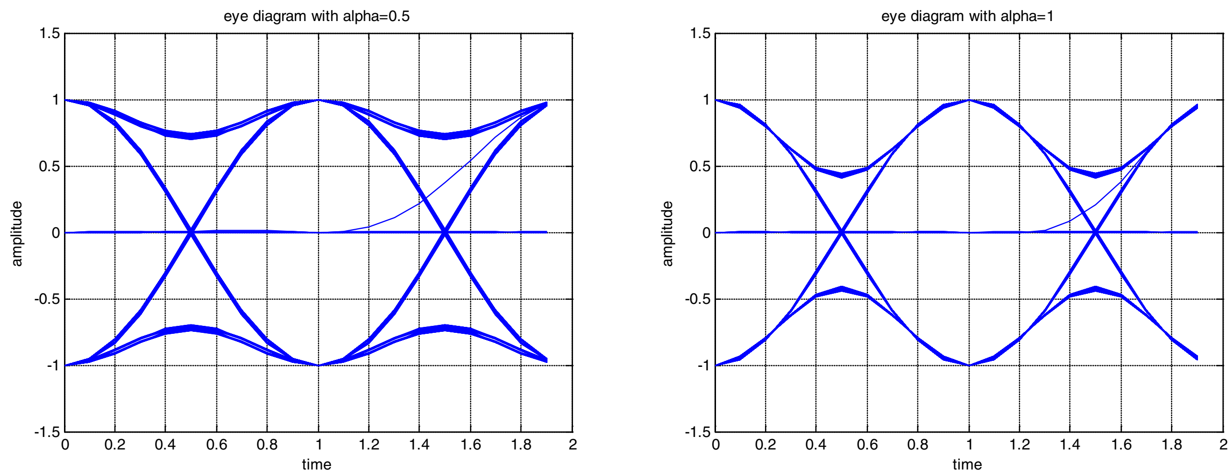
Figure 9: (a) FSK RCF Eye pattern with alpha 0.5. (b) FSK RCF Eye pattern with alpha =1

Figure 9(a) and Figure 9(b) are plotted with excess bandwidth parameter alpha as 0.5 and 1 respectively for FSK.

Figure 10(a) and Figure 10(b) are plotted with excess bandwidth parameter alpha as 0.5 and 1 respectively for PSK.

From the Figs it can be observed that the plots with alpha as 1gives the best results with maximum eye opening the bandwidth required for transmission.

In this paper we proposed that for different values of alpha for different shift keying techniques the eye pattern should be clearer. For α ='1' the eye pattern will be small compared to α ='0.5' which is large. One more factor is when α ='1' the tails of raised cosine filter dies away faster than the case α ='0.5' using α ='1' the bandwidth required for transmission should be increased.



(a) **(b)**

Figure 10: (a) PSK RCF Eye pattern with alpha 0.5. (b) PSK RCF Eye pattern with alpha = 1

The tails of the raised cosine filter with α=1 dies away faster than the case where α =0.5. Hence error in timing cause a bigger performance degradation for α =0.5 than for α =1 scenario. α However, the flip side of using α =1 is the increased bandwidth required for transmission. From the above Figs it can be concluded that the eye patterns without offset are showing better results than the eye patterns with offset. By comparing the results of all shift keying techniques PSK has good resolution in eye diagrams.

4. CONCLUSION

The performance analysis of all shift keying techniques which plots the eye pattern as a function of the error rate are observed with different cases of alpha values as well as in the presence and absence of offset value . The method is applied to high-speed optical-transmission systems and its usefulness is confirmed. An automatic gain-control system is evaluated from a viewpoint of eye margin, and a gain control having an improved eye margin performance is proposed. Low-probability abnormal phenomena, such as turn-on fluctuations and mode partitioning in directly modulated distributed feedback (DFB) lasers, are observed From the above Figs we observe that when the noise is present some of signal is degrading.And also we observe that when alpha is 1 we are getting more bandwidth that gives best results with maximum eye opening.Our future scope is to use some more advanced techniques and get the best eye patterns.

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