Experiment No. 4 : Study of the Eye-Pattern

What is an Eye-Pattern?

An Eye-Pattern is the Lissajus Figure obtained on the CRO screen, when a slightly distorted PRBS signal is connected to the Y-input of the CRO and a Saw-Tooth waveform (sweep) is connected to its X-input, and the CRO is set in the X-Y display mode.

Conditions for appearance of a stable eye-pattern:-

The following conditions should be satisfied for appearance of a stable eye-pattern on the CRO screen:-

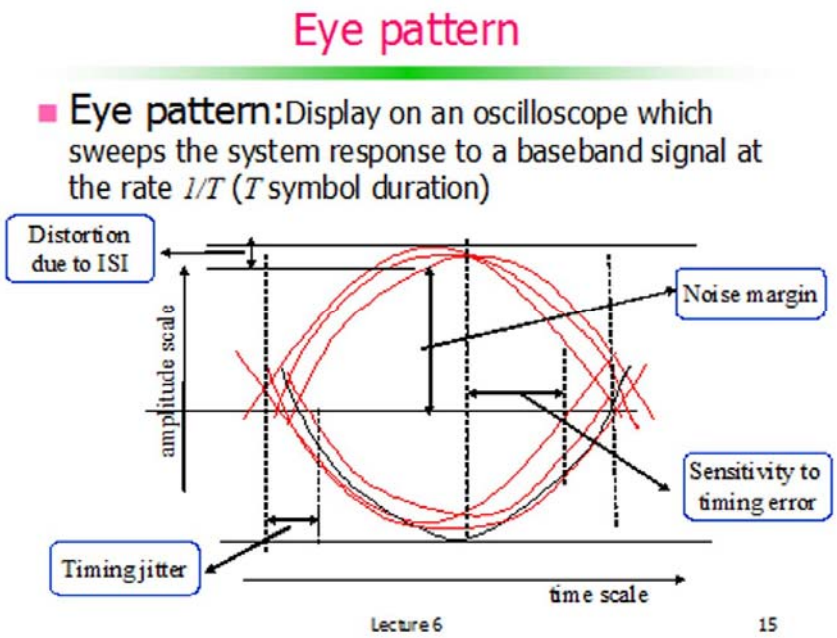
1 The clock generating the PRBS signal, should have the following relation with the sweep signal:-

Clock rate = Twice the sweep frequency	Sweep period = 2x(duration of one eye)

2 The sweep signal should be synchronized with the clock.

When the above conditions are satisfied, then the Lissajous figure obtained on the CRO screen looks like a human eye, and hence it is called an eye-pattern.

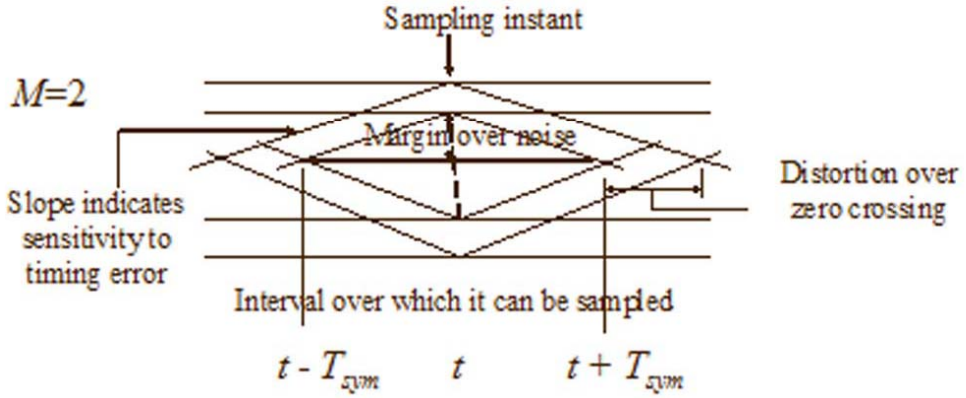
The following figure illustrates an eye-pattern of a semi-closed eye appearing on the CRO screen, when a binary data (PRBS) is transmitted through a channel realized by a R-C network and the channel introduces some distortion in the data due its characteristics; this distorted data is fed to the Y-input of the CRO through a buffer used to avoid a mismatch between the output impedance of the data source (PRBS generator) and the input impedance of the R-C channel:-



Consider other pictures of eye-pattern on the next page:-

Eye Diagram for 2-PAM

- **Useful for PAM transmitter and receiver analysis and troubleshooting**



- **The more open the eye, the better the reception**

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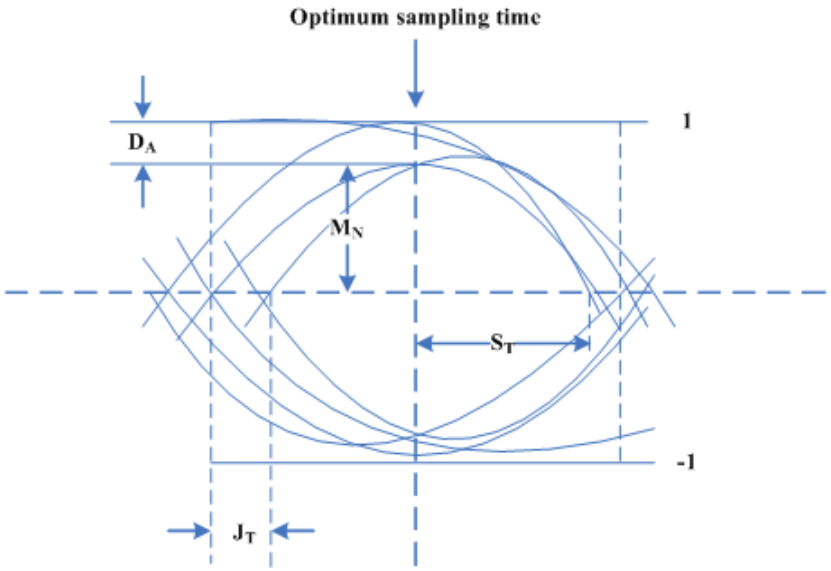
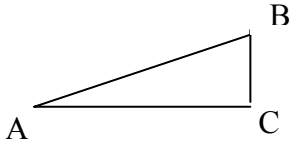


The Eye-patterns shown in the above figures, illustrate the following:-
he duration (width) of each eye = bit duration = duration of zero crossing jitter plus the duration of sampling interval.
The total duration of the two eyes = duration of two bits = sweep period.
The total distortion, D = Maximum Noise margin (M_S) + D_A
The % distortion = (D_A / D) X100 %
The sensitivity to timing error is the **slope** of the outer boundary of the eye, intersected by the perpendicular drawn at the center of the eye.



Slope = (BC/AC)

All the measurements along X-axis of the eye-pattern are taken in Cms and their actual values are calculated by multiplying their measured values by the X-calibration factor.
The X-calibration factor is evaluated as follows:-
Let l =Duration of one eye in Cms, so l = half of the sweep period in time-units (in ms)
= T/2, ms
Therefore One Cm = (T/2l) ms = X-Calibration factor.

Effect of the channel parameters on the Eye-pattern and its compensation:-

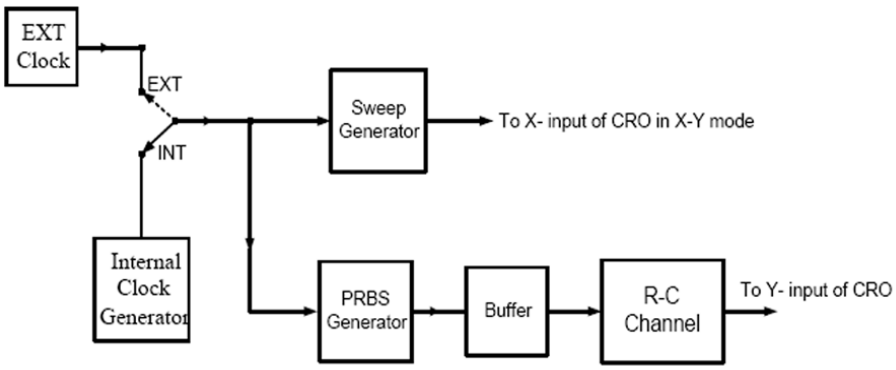
By varying the channel parameter R, the distortion in the data varies and consequently the eye opening varies. When R makes the distortion maximum, the eye is fully closed.
When R makes the distortion minimum or zero, the maximum opening of the eye occurs.
Now consider the case when maximum distortion is introduced in the data by the channel resulting in the closure of the eye, then, **how the data will be recovered?**
In the above condition, equalizers are used to compensate for the effect of maximum distortion. Two types of equalizers may be used :- (a) Resistive, such as a preset pot of10 KΩ and (b) Inductive, such as a coil of around 25 mH (winding of a transformer).
The Resistive equalizer is used in parallel of the channel capacitance while an inductive equalizer is used in series with the channel resistance. By using either of the equalizers, the closed eye will open, showing the reduction in the distortion and consequently making the recovery of the data easy.

Experimental Set-up for Eye-pattern

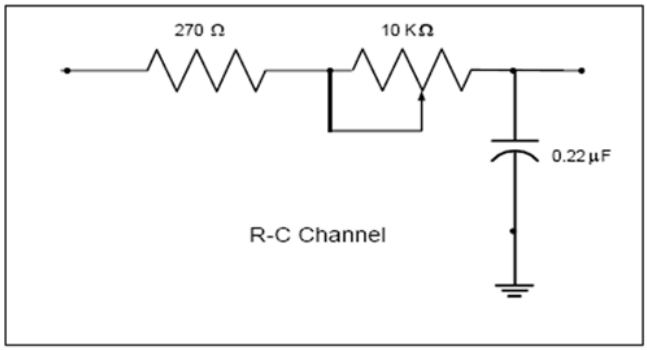
The experimental set-up for the eye-pattern comprises of the following apparatus:-

1. The Eye-pattern Kit
2. An R-C Channel box,
3. Equalizers, 10K preset pot
4. DC Power supplies:- 5-Volts (fixed) and a symmetrical dual supply: +/- 15-Volts; for biasing the electronics circuits of the Eye-pattern kit.
5. A dual trace CRO with X-Y display facility (20 MHz)

The following figure shows the connection of the above apparatus for conducting an experiment on the eye-pattern in the laboratory:-



The Channel used in the experiment has been realized by the R-C network connected as shown in the following figure:-



The Eye-Pattern Kit:-

The Eye-Pattern Kit consists of :- (i) A Sweep generator, (ii) A Data (PRBS) generator and (iii) A clock generator, for synchronizing the sweep with the PRBS, and (iv) A buffer.
The internal clock is selected by a selector switch provided in the kit.

Procedure:-

1 Connect the DC biasing supplies with proper polarities to the eye-pattern kit
2 Make the experimental set-up as explained above.
3 Observe the wave-shapes of the clock, the data (PRBS) and the sweep signals on the CRO and measure their time periods.
4 Observe the Eye-pattern for different channel parameters and tabulate the sampling interval and the noise-margin for different values of R, as under:-

S. No.	R	Sampling Interval (ms)	Noise Margin (V)
1			
2			
3			
4			
5			
6			

5 Find the value of R at the point where eye closes.
6 Find the value of R when the eye opening is maximum.
7 Using an equalizer 10 KΩ preset pot with the channel, find the noise margin and the sampling interval.
8 Using the channel with R = 2 KΩ (adjusted) and C = 0.22 μF (fixed), trace the boundaries of the eye pattern and find:-

(a) Space for sampling,
(b) Noise margin at the best sampling instant,
(c) Zero-crossing jitter
(d) Distortion at the sampling time,
(e) Sensitivity to timing error in the center of the sampling space.

Report:-

1 Comment on the results obtained.
2 Give the circuit details of the PRBS generator.
3 What will be the eye pattern of the M- array signal? What is its significance?

Reference:- Haykins, S.: "Digital Communication". John Wiley & Sons, (1988)

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