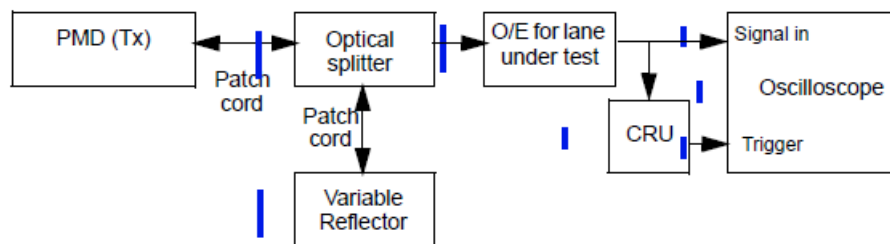


95.8.5 Transmitter vertical eye closure (TxVEC)

TxVEC of each lane shall be within the limits given in Table 95–6 if measured using the methods specified in 95.8.5.1 and 95.8.5.2. TxVEC is a measure of each optical transmitter’s vertical eye closure; it is based upon vertical histogram data from eye-diagrams measured through an optical to electrical converter (O/E) with a bandwidth equivalent to a combined reference receiver and worst case optical channel. Table 95–10 specifies the test patterns to be used for measurement of TxVEC.

95.8.5.1 TxVEC conformance test set-up

A block diagram for the TxVEC conformance test is shown in Figure 95–3. Other measurement implementations may be used with suitable calibration.



[Text from Figure 95–3 repeated for editing purposes below](#)

PMD (Tx) Patch cord Optical splitter Patch cord Variable Reflector O/E for lane under test Oscilloscope Signal in Trigger CRU

Figure 95–3—TxVEC conformance test block diagram

Each optical lane is tested individually with all other lanes in operation. The optical splitter and variable reflector are adjusted so that each transmitter is tested with an optical return loss of 12 dB.

The combination of the O/E and the oscilloscope used to measure the optical waveform has a fourth-order Bessel-Thomson filter response with a bandwidth of 12.6 GHz. Compensation may be made for any deviation from an ideal fourth-order Bessel-Thomson response.

The clock recovery unit (CRU) has a corner frequency of 10 MHz and a slope of 20 dB/decade.

95.8.5.2 TxVEC measurement method

The oscilloscope is set up to accumulate samples for the optical eye-diagram of the transmitter under test, as illustrated in Figure 95–4.

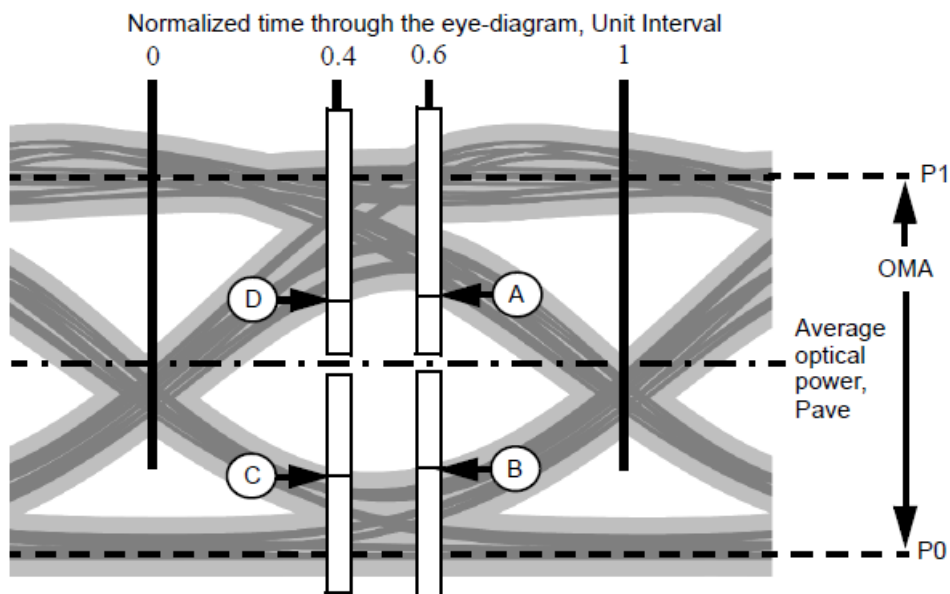
OMA is measured according to 95.8.4. ~~The power of the optical zeros (P0) and the power of the optical ones (P1) are recorded.~~ [Also the standard deviation of the noise of the oscilloscope, S, is found with no input optical signal and the same settings as used to capture the histograms described below.](#)

The average optical power and the crossing points of the eye-diagram, and the four vertical histograms used to calculate TxVEC, are measured using Pattern 3 or Pattern 5.

The 0 UI and 1 UI crossing points are determined by the time average of the eye crossing points, as measured at the average optical power level, as illustrated in Figure 95–4.

Four vertical histograms are measured through the eye, centered at 0.4 UI and 0.6 UI, and above and below the average optical power of the eye-diagram, as illustrated in Figure 95-4.

Each histogram window has a width of 0.04 UI. Each histogram window has one height boundary set close to the average power level P_{ave} of the eye-diagram, and the other height boundary is set beyond the outer-most samples of the eye, so that no further eye samples would be captured by increasing the outer boundary of the histogram. ~~Starting from the boundary of the histogram closest to the average optical power level, the optical power at which the cumulative distribution of each histogram equals the 0.005th percentile of the total number of samples for each histogram is recorded (these are the powers A, B, C, and D illustrated in Figure 95-4).~~



In Figure 95-4, delete the round labels and arrows A, B, C, D. The values of P1 and P2 are not used in the calculation; they could be deleted if desired

Text from Figure 95-4 repeated for editing purposes below

Normalized time through the eye-diagram, Unit Interval

0 0.4 0.6 1

Average optical power, P_{ave}

$P1$ $P0$ _[PD1] OMA ~~C-D-A-B~~

Figure 95-4—Illustration of the TxVEC measurement

The two histograms on the left are each convolved with a Gaussian function with a standard deviation A so that the sum of the portion of the resulting upper distribution below P_{ave} plus the portion of the resulting lower distribution above P_{ave} is 5×10^{-5} of the total of both distributions. Similarly, the two histograms on the right are each convolved with a Gaussian function with a standard deviation B so that the sum of the portion of the resulting upper distribution below P_{ave} plus the portion of the resulting lower distribution above P_{ave} is 5×10^{-5} of the total of both distributions. Both Gaussian functions have a mean of zero.

Convolution is defined by

$$f(y) * G(y) = \int_{-\infty}^{\infty} f(z)G(y-z)dz \quad (95-1)$$

where f is one of the histograms. The Gaussian function G can be written as

$$G(y) = \exp(-y^2 / (2\sigma_G^2)) / \text{sqrt}(2\pi\sigma_G^2) \quad (95-2)$$

where σ_G is the standard deviation, A or B .

The lesser of A and B is N , an estimate of the noise that could be added by the optical channel and receiver.

The noise that could be added by the receiver is R , given by

$$R^2 + M^2 = N^2 + S^2 \quad (95-1)$$

~~TxVEC is defined as the largest of the four quantities given by Equation (95-1) to Equation (95-4):~~

~~$$\text{TxVEC}(A) = 10\log_{10}((P1 - Pave) / (A - Pave)) \quad (95-1)$$~~

~~$$\text{TxVEC}(B) = 10\log_{10}((Pave - P0) / (Pave - B)) \quad (95-2)$$~~

~~$$\text{TxVEC}(C) = 10\log_{10}((Pave - P0) / (Pave - C)) \quad (95-3)$$~~

~~$$\text{TxVEC}(D) = 10\log_{10}((P1 - Pave) / (D - Pave)) \quad (95-4)$$~~

where M is the noise that could be added by the optical channel.

$$M^2 = (0.0257OMA)^2 + (0.01Pave)^2 \quad (95-2)$$

where

$Pave$ is the average optical power of the eye-diagram
 ~~$P0, P1, OMA$ are~~ $P0, P1, OMA$ are the optical modulation amplitude ~~one and optical zero levels~~ of the eye-diagram, and
 ~~A, B, C, D are the 0.005th percentile optical power levels of the four vertical histograms described in 95.8.5.2.~~

S is the standard deviation of the noise of the oscilloscope.

TxVEC is given by:

$$\text{TxVEC} = 10\log_{10}(OMA / (2Qmin R)) \quad (95-3)$$

where

$Qmin$ is 3.8906.

The method described in 95.8.5.2 is the reference measurement method. Other (equivalent) measurement methods may be used with suitable calibration.