95.7 PMD to MDI optical specifications for 100GBASE-SR4

The operating range for the 100GBASE-SR4 PMD is defined in Table 95–5. A 100GBASE-SR4 compliant PMD operates on 50/125 µm multimode fibers, type A1a.2 (OM3) or type A1a.3 (OM4), according to the specifications defined in Table 95–12. A PMD that exceeds the operating range requirement while meeting all other optical specifications is considered compliant (e.g., a 100GBASE-SR4 PMD operating at 120 m meets the operating range requirement of 0.5 m to 100 m).

Table 95–5—100GBASE-SR4 operating range

PMD type	Required operating range[a]
100GBASE-SR4	0.5 m to 70 m for OM3
	0.5 m to 100 m for OM4

[a]The RS-FEC correction function may not be bypassed for any operating distance.

95.7.1 100GBASE-SR4 transmitter optical specifications

Each lane of a 100GBASE-SR4 transmitter shall meet the specifications in Table 95–6 per the definitions in 95.8.

Table 95–6—100GBASE-SR4 transmit characteristics

Description	Value	Unit
Signaling rate, each lane (range)	25.78125 ± 100 ppm	GBd
Center wavelength (range)	840 to 860	nm
RMS spectral width[a] (max)	0.6	nm
Average launch power, each lane (max)	2.4	dBm
Average launch power, each lane (min)	–9.1	dBm
Optical Modulation Amplitude (OMA), each lane (max)	3	dBm
Optical Modulation Amplitude (OMA), each lane (min)[b]	–7.1	dBm
Launch power in OMA minus ~~TDP~~ TxVEC (min)	–8	dBm
Transmitter ~~and dispersion penalty~~ vertical eye closure (~~TDP~~TxVEC), each lane (max)	5	dB
Average launch power of OFF transmitter, each lane (max)	–30	dBm
Extinction ratio (min)	2	dB
Optical return loss tolerance (max)	12	dB
Encircled flux[c]	≥ 86% at 19 µm ≤ 30% at 4.5 µm	
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3} Hit ratio 1.5×10^{-3} hits per sample	{0.3, 0.38, 0.45, 0.35, 0.41, 0.5}	

[a]RMS spectral width is the standard deviation of the spectrum.
[b]Even if the ~~TDP~~ TxVEC < 0.9 dB, the OMA (min) must exceed this value.

[c]If measured into type A1a.2 or type A1a.3 50 µm fiber in accordance with IEC 61280-1-4.

95.7.2 100GBASE-SR4 receive optical specifications

Each lane of a 100GBASE-SR4 receiver shall meet the specifications in Table 95–7 per the definitions in 95.8.

Table 95–7—100GBASE-SR4 receive characteristics

Description	Value	Unit
Signaling rate, each lane (range)	25.78125 ± 100 ppm	GBd
Center wavelength (range)	840 to 860	nm
Damage threshold[a] (min)	3.4	dBm
Average receive power, each lane (max)	2.4	dBm
Average receive power, each lane[b] (min)	–11	dBm
Receive power, each lane (OMA) (max)	3	dBm
Receiver reflectance (max)	–12	dB
Stressed receiver sensitivity (OMA), each lane[c] (max)	–5.6	dBm
Conditions of stressed receiver sensitivity test:		
Vertical eye closure penalty (VECP),[d] lane under test	4.2	dB
Stressed eye J2 Jitter,[d] lane under test	0.41	UI
Stressed eye J4 Jitter,[d] lane under test	0.55	UI
OMA of each aggressor lane	3	dBm
Stressed receiver eye mask definition {X1, X2, X3, Y1, Y2, Y3}	{0.28, 0.5, 0.5, 0.33, 0.33, 0.4}	
TxVEC of stressed eye conformance signal[d]	5	dB

[a]The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level on one lane. The receiver does not have to operate correctly at this input power.
[b]Average receive power, each lane (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.
[c]Measured with conformance test signal at TP3 (see 95.8.9) for the BER specified in 95.1.1.
[d]Vertical eye closure penalty and stressed eye jitter are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

95.7.3 100GBASE-SR4 illustrative link power budget

An illustrative power budget and penalties for 100GBASE-SR4 channels are shown in Table 95–8.

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.

95.8.6.1 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.

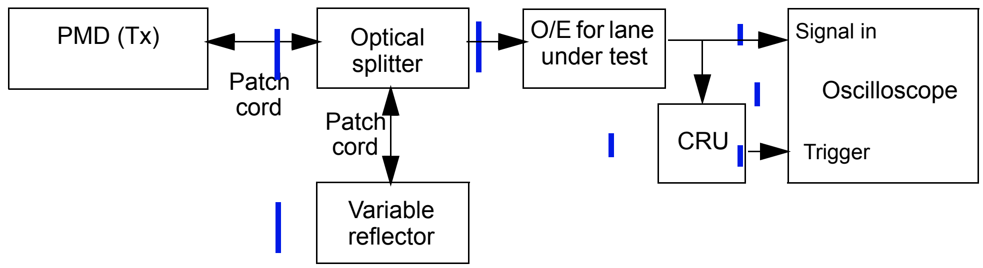

Figure 95–3—TxVEC conformance test block diagram

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.

95.8.6.2 TxVEC measurement method

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

OMA is measured according to 95.8.4.

The standard deviation of the noise of the O/E and oscilloscope combination, S, is determined with no optical input signal and the same settings as used to capture the histograms described below.

The average optical power (P_{ave}) 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 diagram crossing points, as measured at P_{ave}, as illustrated in Figure 95–4.

Four vertical histograms are measured through the eye diagram, centered at 0.4 UI and 0.6 UI, and above and below P_{ave}, as illustrated in Figure 95–4.

Each histogram window has a width of 0.04 UI. Each histogram window has an inner height boundary which is set close to P_{ave} (so that no further samples would be captured by moving it closer to P_{ave}), and an outer height boundary which is set beyond the outer-most samples of the eye diagram, so that no further samples would be captured by increasing the outer boundary of the histogram.

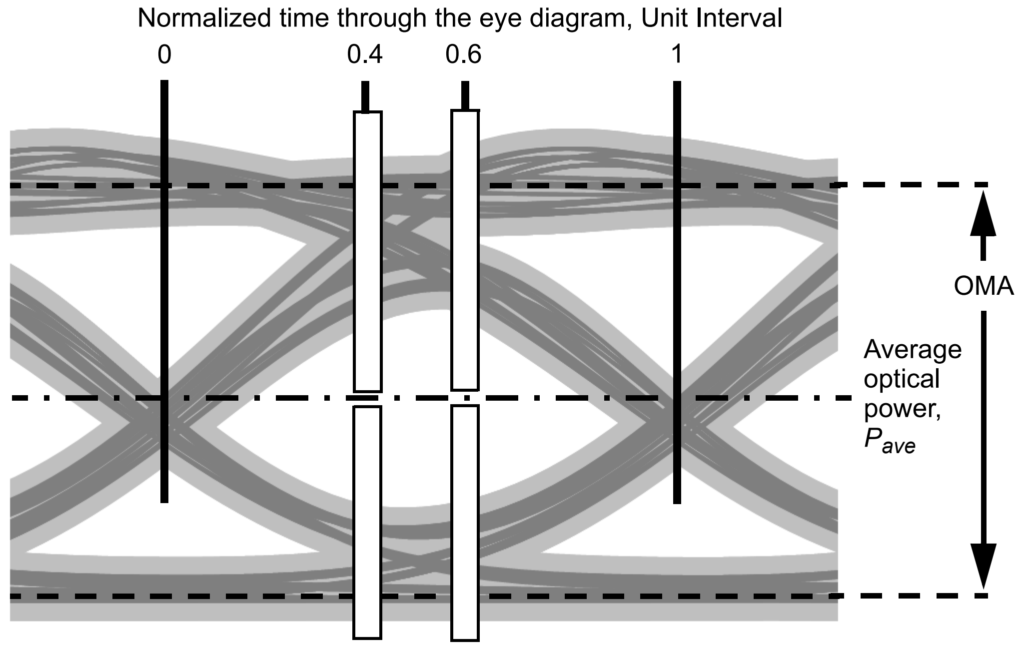

Figure 95–4—Illustration of the TxVEC measurement

The distributions of the two histograms on the left are each multiplied by Q functions which represent an estimate of the probability of errors caused by each part of the distribution for the greatest tolerable noise that could be added by an optical channel and a receiver. The resulting distributions are integrated and each integral is divided by the integral of the distribution it was derived from, giving two bit error probabilities. The Q function uses a standard deviation, σ_L, chosen so that the average of these two bit error probabilities is 5×10^{-5}. Similarly, for the two histograms on the right, a standard deviation, σ_R, is found.

Q(x) is the area under a Normal curve for values larger than *x* (the tail probability, related to the "complementary error function"), as shown in Equation (95–1):

$$Q(x) = \int_x^{\infty} \frac{e^{(-z^2/2)}}{\sqrt{2\pi}} dz \tag{95–1}$$

where

x is $(y - P_{ave})/\sigma_G$ or $(P_{ave} - y)/\sigma_G$, as in Equation (95–2).

This procedure finds a value of σ_G such that Equation (95–2) is satisfied:

95.8.8 Transmitter optical waveform (transmit eye)

The required optical transmitter pulse shape characteristics are specified in the form of a mask of the transmitter eye diagram as shown in Figure 86-4 with the Transmitter eye mask coordinates and hit ratio in Table 95–6. The transmitter optical waveform of a port transmitting the test pattern specified in Table 95–10 shall meet specifications according to the methods specified in 86.8.4.6.1 with the ~~exception that the clock recovery unit's high-frequency corner bandwidth is 10 MHz. The filter nominal reference frequency f_r is 19.34 GHz and the filter tolerances are as specified for STM-64 in ITU-T G.691.~~ exceptions that:

— The clock recovery unit's high-frequency corner bandwidth is 10 MHz.

— The filter nominal reference frequency f_r is 19.34 GHz and the filter tolerances are as specified for STM-64 in ITU-T G.691.

Compensation may be made for variation of the reference receiver filter response from an ideal fourth-order Bessel-Thomson response, and for any excess reference receiver noise.

95.8.9 Stressed receiver sensitivity

Stressed receiver sensitivity shall be within the limits given in Table 95–7 if measured using the method defined by 95.8.9.1 and 95.8.9.5, with the conformance test signal at TP3 as described in 95.8.9.2.

Stressed receiver sensitivity is defined with all transmit and receive lanes in operation. Pattern 3 or Pattern 5, or a valid 100GBASE-SR4 signal, is sent from the transmit section of the PMD under test. The signal being transmitted is asynchronous to the received signal. The interface BER of the PMD receiver is the average of the BER of all receive lanes while stressed and at the specified receive OMA.

95.8.9.1 Stressed receiver conformance test block diagram

A block diagram for the receiver conformance test is shown in Figure 95–5. The patterns used for the received compliance signal are specified in Table 95–10. The optical test signal is conditioned (stressed) using the stressed receiver methodology defined in 95.8.9.2, and has sinusoidal jitter applied as specified in 95.8.9.5. A suitable test set is needed to characterize and verify that the signal used to test the receiver has the appropriate characteristics. The low-pass filter is used to create ISI-induced vertical eye closure penalty (VECP). The low-pass filter, when combined with the E/O converter, should have a frequency response that results in the appropriate level of initial vertical eye closure before the sinusoidal terms are added.

The sinusoidal amplitude interferer 1 causes jitter that is intended to emulate instantaneous bit shrinkage that can occur with DDJ. This type of jitter cannot be created by simple phase modulation. The sinusoidal amplitude interferer 2 causes additional eye closure, but in conjunction with the finite edge rates from the limiter, also causes some jitter. The sinusoidally jittered clock represents other forms of jitter and also verifies that the receiver under test can track low-frequency jitter. The sinusoidal amplitude interferers may be set at any frequency between 100 MHz and 2 GHz, although care should be taken to avoid harmonic relationships between the sinusoidal interferers, the sinusoidal jitter, the signaling rate, and the pattern repetition rate. The Gaussian noise generator, the amplitude of the sinusoidal interferers, and the low-pass filter are adjusted so that the VECP, stressed eye J2 Jitter, and stressed eye J4 Jitter specifications given in Table 95–7 are met simultaneously while also passing the stressed receiver eye mask in Table 95–7 according to the methods specified in 95.8.8 (the random noise effects such as RIN, or random clock jitter, do not need to be minimized).

For improved visibility for calibration, all elements in the signal path (cables, DC blocks, E/O converter, etc.) should have wide and smooth frequency response, and linear phase response, throughout the spectrum of interest. Baseline wander and overshoot and undershoot should be minimized.