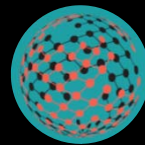




TDP vs TDEC for 25GbE SMF

20160523

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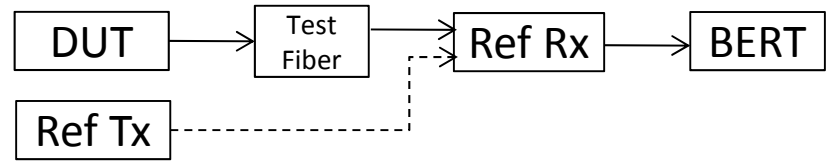
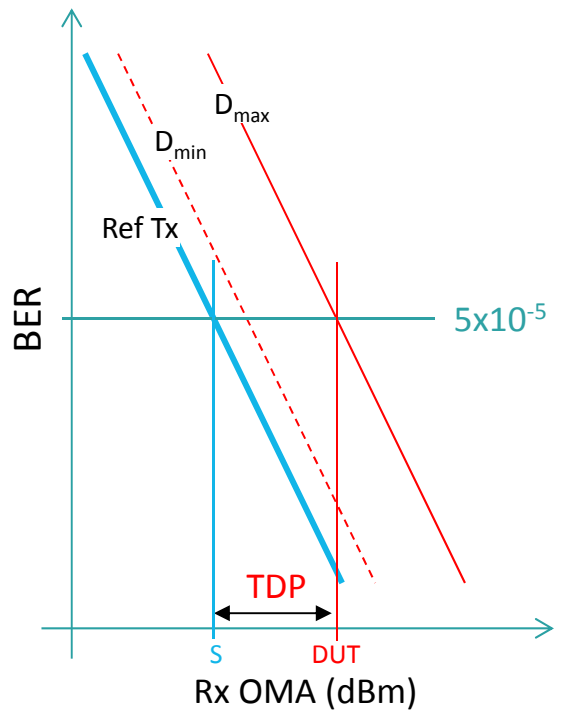


Background

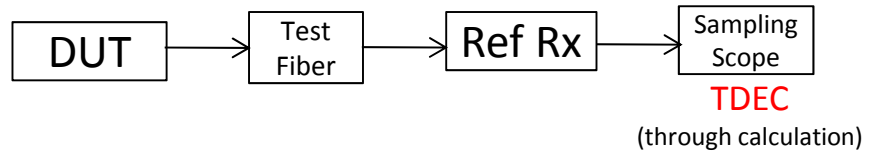
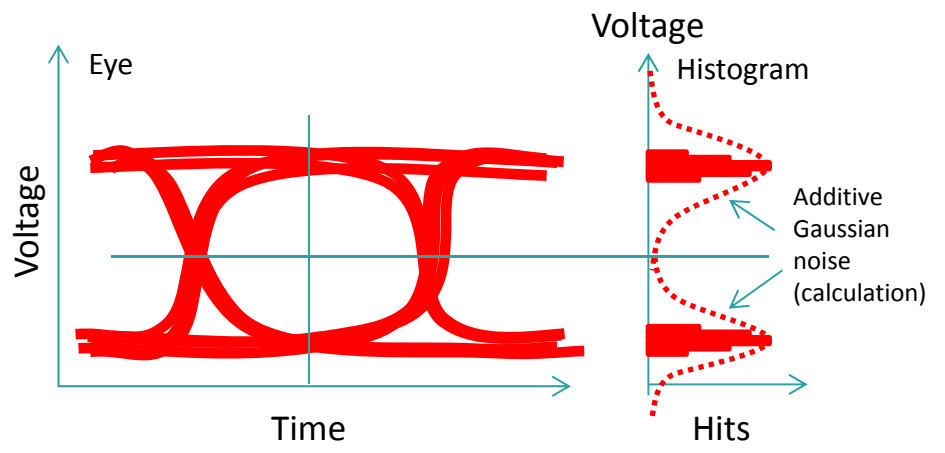
- 25GBASE-SR optical specification references one lane of 100GBASE-SR4:
 - Table 95-6: Transmitter specification
 - Table 95-7: Receiver specification
 - Table 95-8: Illustrative link power budget
 - Budget for penalties due to waveform distortion and modal noise uses TDEC (transmitter and dispersion eye closure) instead of TDP (transmitter and dispersion penalty)
- Purpose of presentation: To review TDP and TDEC and hear views on using TDEC for 25GbE SMF specifications

Basics Of TDP And TDEC

TDP: BER Measurement



TDEC: Eye Measurement



TDP vs TDEC (Assuming SMF)

- TDP
 - Perform BER measurement after transmission over fiber with worst-case dispersion and compare against “ideal” transmitter to find penalty
- TDEC
 - Use sampling oscilloscope to measure eye after transmission over fiber with worst-case dispersion and perform calculations on histograms to estimate sensitivity and penalty
- Comparing TDP and TDEC
 - TDEC does not require reference transmitter
 - TDEC uses scope instead of BERT
 - TDEC faster test that lends itself to automation

TDP Measurement (Clause 52.9.10, Clause 88.8.5)

88.8.5.1 Reference transmitter requirements

The reference transmitter is a high-quality instrument-grade device, which can be implemented by a CW laser modulated by a high-performance modulator. The basic requirements are as follows:

- Rise/fall times of less than 12 ps at 20% to 80%.
- The output optical eye is symmetric and passes the transmitter optical waveform test of 88.8.8.
- In the center 20% region of the eye, the worst-case vertical eye closure penalty as defined in 87.8.11.2 is less than 0.5 dB.
- Total Jitter less than 0.2 UI peak-to-peak.
- RIN of less than -138 dB/Hz.

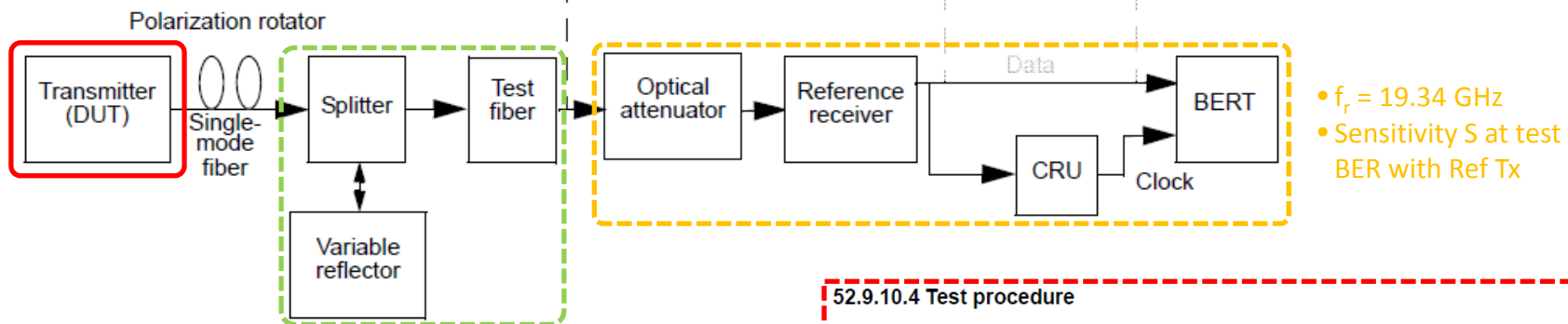


Figure 52-12—Test setup for measurement of transmitter and dispersion penalty (TDP)

Table 88-12—Transmitter compliance channel specifications

PMD type	Dispersion ^a (ps/nm)		Insertion loss ^b	Optical return loss ^c	Max mean DGD
	Minimum	Maximum			
100GBASE-LR4	$0.2325 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.2325 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	20 dB	0.8 ps
100GBASE-ER4	$0.93 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.93 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	20 dB	0.8 ps

^aThe dispersion is measured for the wavelength of the device under test (λ in nm). The coefficient assumes 10 km for 100GBASE-LR4 and 40 km for 100GBASE-ER4.

^bThere is no intent to stress the sensitivity of the BERT's optical receiver.

^cThe optical return loss is applied at TP2.

52.9.10.4 Test procedure

To measure the transmitter and dispersion penalty (TDP) the following procedure shall be used. The decision threshold amplitude is defined to occur at the average signal level. The sampling instant is displaced from the eye center by ± 0.05 UI. The following procedure is repeated for early and late decision and the larger TDP value is used:

- Configure the test equipment as described above and illustrated in Figure 52-12.
- Adjust the attenuation of the optical attenuator to obtain a BER of 1×10^{-12} .
- Record the optical power in OMA at the input to the reference receiver, P_{DUT} , in dBm.
- If P_{DUT} is larger than S , the transmitter and dispersion penalty (TDP) for the transmitter under test is the difference between P_{DUT} and S , $TDP = P_{DUT} - S$. Otherwise the transmitter and dispersion penalty is zero, $TDP = 0$.

TDEC Measurement (Clause 95.8.5)

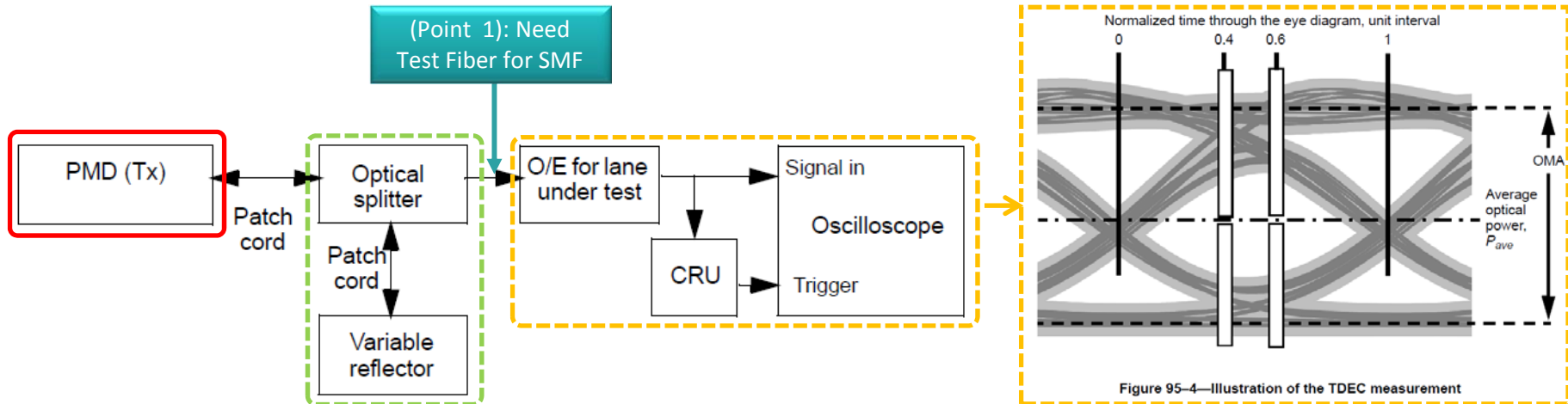


Figure 95-3—TDEC conformance test block diagram

TDEC measurement method (Clause 95.8.5.2):

1. Measure scope noise S with zero input
2. Measure P_{avg} and 4 vertical histograms $f_u(y)$ on eye at points shown
3. Multiply histograms on left (right) by $Q(y - P_{avg})$ where σ is chosen so average error probability equals specification BER of 5×10^{-5} (Eq. 95-2, see right). Use worst-case σ for noise R in TDEC calculation per Eq. 95-6 (see below).

$$\frac{1}{2} \left(\frac{\int f_u(y) Q\left(\frac{y - P_{ave}}{\sigma_G}\right) dy}{\int f_u(y) dy} \right) + \frac{1}{2} \left(\frac{\int f_l(y) Q\left(\frac{P_{ave} - y}{\sigma_G}\right) dy}{\int f_l(y) dy} \right) = 5 \times 10^{-5}$$

where

$f_u(y), f_l(y)$ are the upper and lower distributions
 σ_G is the left or right standard deviation, σ_L or σ_R

$$TDEC = 10 \log_{10} \left(\frac{OMA}{2} \times \frac{1}{3.8906R} \right)$$

TDEC Measurement (Clause 95.8.5) (cont.)

(Point 2): Clause 95.8.5 written for MMF. Received noise R needs to be appropriate for SMF

The noise, R , that could be added by a receiver is given by Equation (95–3).

$$R = (1 - M_1) \sqrt{N^2 + S^2 - M_2^2} \quad (95-3)$$

where

M_1, M_2

defined in Equation (95–4) and Equation (95–5), account for mode partition noise and modal noise that could be added by the optical channel

S

is the standard deviation of the noise of the O/E and oscilloscope combination

$$M_1 = 0.04 \quad (95-4)$$

$$M_2 = 0.0175 P_{ave} \quad (95-5)$$

Summary

- Reviewed TDP and TDEC
- Considered where TDEC measurement procedure needs revision to apply to 25GbE SMF
 - Test fiber
 - Definition of receiver noise R
- Where specification tables would change

Spec table	Spec name (w/ TDP)	Spec name (w/ TDEC)
Transmit characteristics	Transmitter and dispersion penalty (max)	Transmitter and dispersion eye closure (max)
Transmit characteristics	Launch power in OMA minus TDP (min)	Launch power in OMA minus TDEC (min)
Receive characteristics	SRS Test Condition: - Vertical eye closure penalty	SRS Test Condition: - Stressed eye closure
Illustrative link power budget	Power budget (for max TDP)	Power budget (for max TDEC)
Illustrative link power budget	Allocation for penalties (for max TDP)	Allocation for penalties (for max TDEC)

- Data would be needed to support TDEC-based specifications