RxS Specification Proposal

P802.3dj SMF Task Force Meeting

IEEE 802 March 2026 Plenary

March 9 - 13, 2026

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Outline

➢Incomplete RxS Conformance Test Signal Illustration

- RxS Specification Proposed Text
- RxS Conformance Test Signal Illustration
- Appendix 1: TFT Equations Illustrations
- Appendix 2: TFT Examples

Incomplete RxS Conformance Test Signal Spec in 180.9.15

The receiver sensitivity (OMA_{outer}) of each lane shall be within the limits given in Table 180–8 if measured using a test pattern for receiver sensitivity in Table 180–14. The conformance test signal at TP3 meets the requirements for a transmitter followed by an attenuator.

The TECQ of the conformance test signal is measured according to 180.9.6, except that the test fiber is not used. The measured value of TECQ is then used to calculate the limit for receiver sensitivity (OMA_{outer}) as specified in Table 180–8.

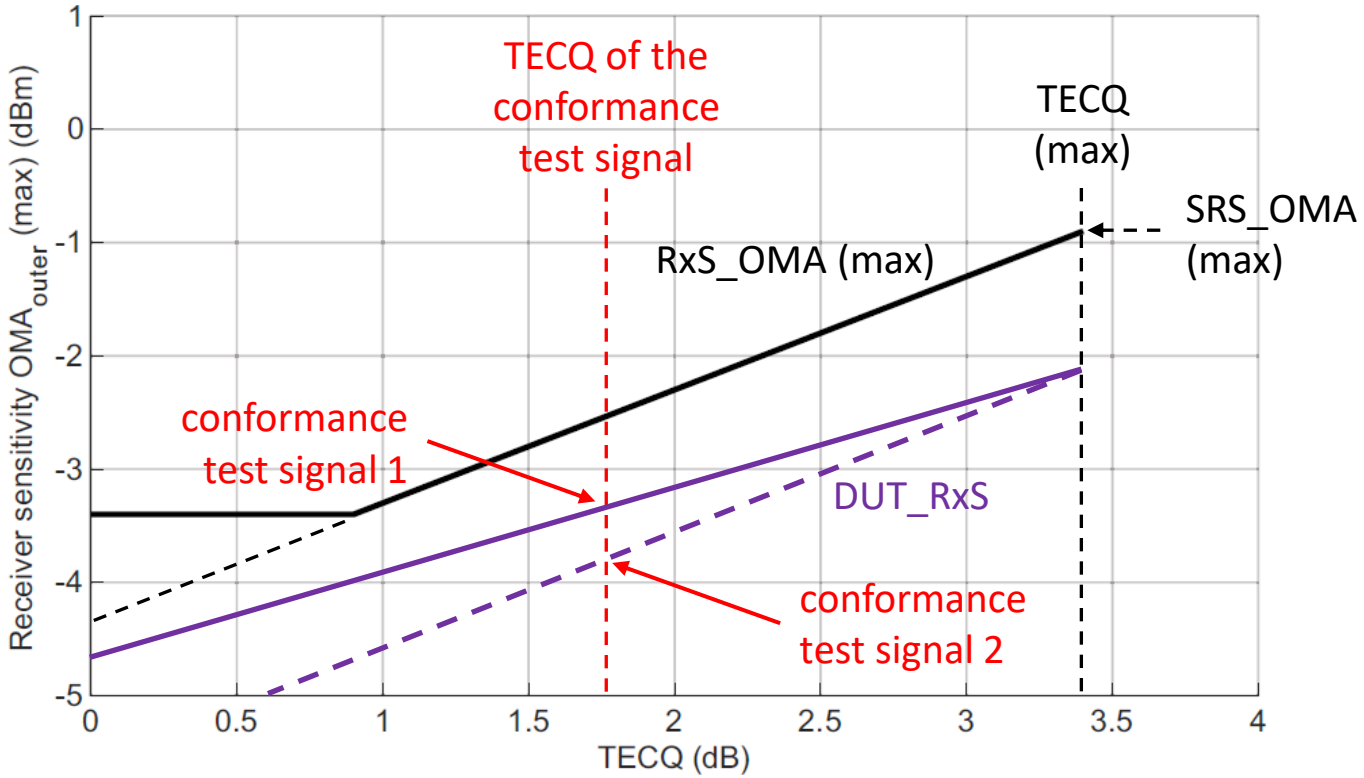

Figure 180–4—Receiver sensitivity (OMA_{outer}), each lane (max)

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180.9.15 Receiver Sensitivity

The receiver sensitivity (OMAouter) of each lane shall be within the limits given in Table 180–8 if measured at the signaling rate given in Table 180-7 using a test pattern for receiver sensitivity in Table 180–14.

Precoding (see 176.7.1.2) is enabled if the receiver requests it using the ILT function.

The TECQ of the conformance test signal is measured according to 180.9.6, except that the test fiber is not used. The measured value of TECQ is then used to calculate the limit for receiver sensitivity (OMAouter) as specified in Table 180–8.

The measured receiver sensitivity is the lowest value of OMAouter where the PMD receiver meets the BLER requirements in 180.2, measured at the PMA using the test method in either 174A.9.5, 174A.9.6, or174A.9.7 with parameters provided in Table 180–19. The error mask Hmax(k) to be used in the method of 174A.9.5 is provided in Table 180–20.

The Low-stressed Receiver Sensitivity (LRS) conformance test signal at TP3 meets the transmit characteristics given in Table 180-7 except for characteristics in Table 180-18a.

180.9.15 Receiver Sensitivity; new Table

Table 180-18a-Conformance test signal LRS transmit characteristics exceptions to Table 180-7

Parameter	Reference	DRn	Unit
TECQ (max)	180.9.8	1.3	dB
TECQ (min)	180.9.8	0.9	dB
Overshoot and undershoot (max)	180.9.10	0	%
Extinction ratio (max)	180.9.12	7	dB
Extinction ratio (min)	180.9.12	5	dB
Transition time (max)	180.9.13	6	ps
Transition time (min)	180.9.13	4.5	ps
ORL tolerance (max)	-	15.5	dB

180.9.15 Receiver Sensitivity, cont.

NOTE—When measuring receiver sensitivity of a complete PHY at the PCS using the method of 174A.11 (see 180.2), a different value of BER_{added} is required.

NOTE—If the statistical projection is modeled accurately by a linear fit extrapolation, a means to provide statistical projection of the measured histograms (see174A.9.3) in order to reduce test time follows. Extrapolate the measured histogram to $H_m(i)(16)$ using a line determined by a linear fit of $\log10(H_m(i)(k))$, for k = 1 to n, where n is the largest value of k, where all bins from 0 to n have a count greater than 2.

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Proposed LRS Conformance Test Signal at TP3

LRS ≡ Low-stressed Receiver Sensitivity

RxS Conformance Test Signals Added Impairments			
Test Signal	**Gaussian noise generator**	**sinusoidal interferer**	**sinusoidal jitter**
SRS	yes	yes	yes
LRS	no	no	no

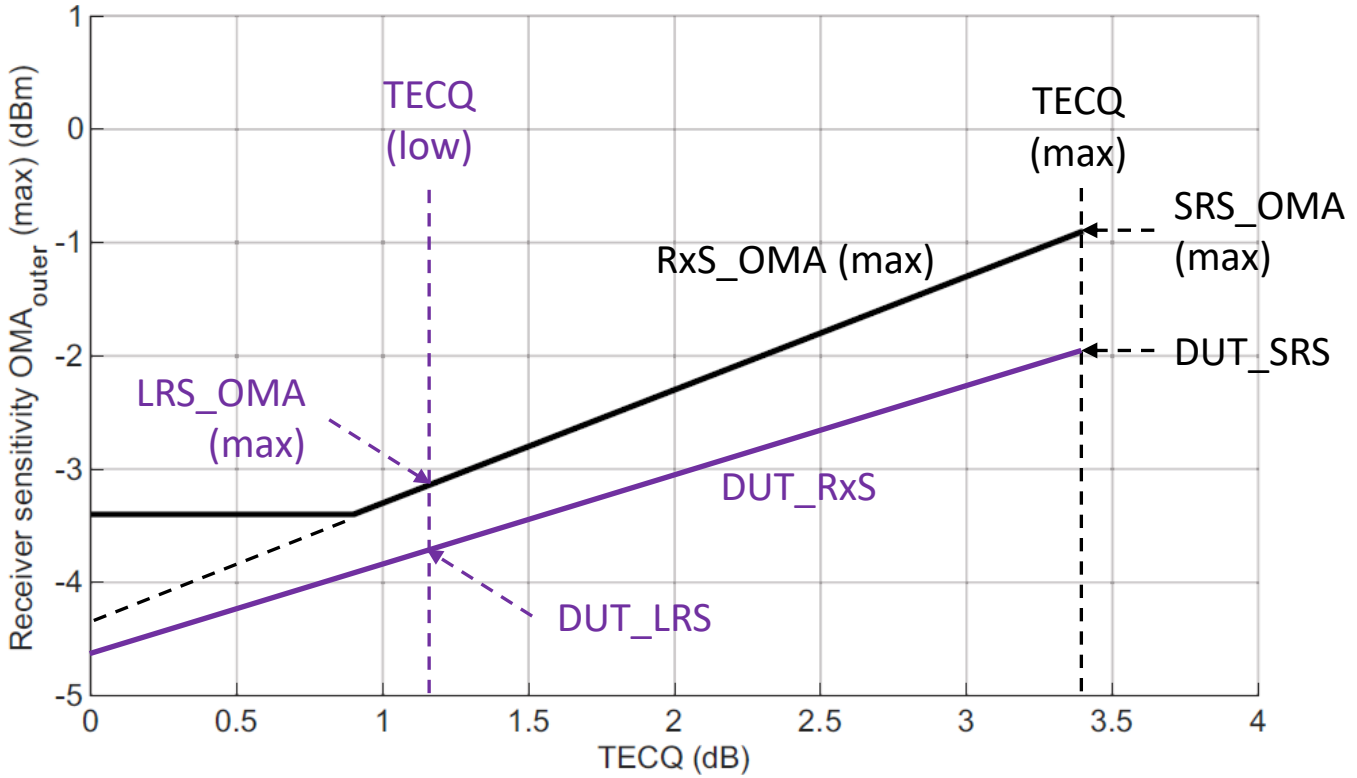

Figure 180–4—Receiver sensitivity (OMA$_{outer}$), each lane (max)

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VOA_level Equation (180-28)

VOA_level = Test_fiber_correction + ORx_TECQ_correction - Test_margin

Test_fiber_correction normalizes differences in test fibers so that symbol error counts are repeatable across different conditions, and is determined by the same algebraic expressions as determine normative transmitter characteristics.

ORx_TECQ_correction normalizes differences in optical receivers so that symbol error counts are repeatable across different conditions, and is determined by the same algebraic expressions as determine normative receiver characteristics.

Test_margin is additional ORx_OMA, to improve SNR of transmitter under test measurement. It equals 1.5dB, which decreases the required ORx operating BER to 2.4×10^{-5}.

Test_fiber_correction using referenced Table 180-9

Test_fiber_correction = Tx_DUT_power_budget - Test_fiber_power_budget (180-29)

—Tx_DUT_power_budget, given by Equation (180–30), uses measured instead of max TDECQ value in link power budget below, same as used in determining transmitter OMA (min)

—Test_fiber_power_budget, given by Equation (180–31), uses best estimates of the test fiber channel insertion loss, MPI, DGD and TDECQ penalties instead of max values in link power budget below

Table 180–9—Illustrative link power budget

Parameter	Value	Unit
Power budget (for max TDECQ)	6.7	dB
Operating distance	500	m
Channel insertion loss[a, b]	3	dB
Maximum discrete reflectance	–35	dB
Allocation for penalties[c] (for max TDECQ)	3.7	dB
Additional insertion loss allowed	0	dB

Test_fiber_correction over range of conditions

Test_fiber_correction = Tx_DUT_power_budget - Test_fiber_power_budget (180-29)

CIL ≡ Channel Insertion Loss

- Tx_DUT_power_budget = CIL + MPI+DGD_penalty (max) + DUT_TDECQ

Ex1. Zero CIL & zero penalties test fiber (patch cord TECQ test condition)

- Test_fiber_power_budget = DUT_TECQ
- Test_fiber_correction = Tx_DUT_power_budget - DUT_TECQ

Ex2. Max CIL & max penalty values test fiber

- Test_fiber_power_budget = Tx_DUT_power_budget
- Test_fiber_correction = 0

  (positive Test_margin requires negative VOA_level, i.e. gain)

Ex3. Fraction α CIL (α < 1) & max penalty values test fiber (TDECQ test condition)

- Test_fiber_power_budget = α CIL + MPI+DGD_penalty (max) + DUT_TDECQ
- Test_fiber_correction = (1 - α) CIL

Test_fiber_correction using referenced Figure 180-5

Test_fiber_correction = Tx_DUT_power_budget - Test_fiber_power_budget (180-29)

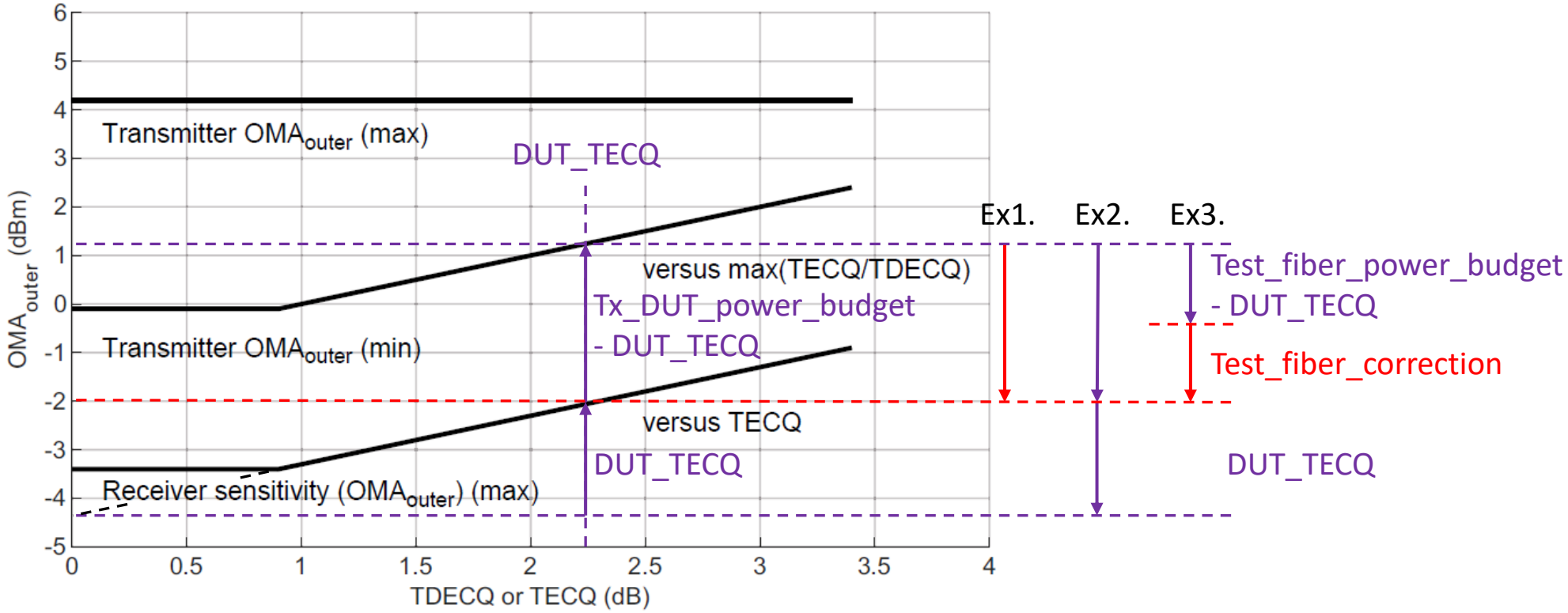

Figure 180–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ

ORx_TECQ_correction using referenced Figure 180-4

ORx_TECQ_correction = RxS_OMA@DUT_TECQ - ORx_RxS@DUT_TECQ (180–32)

—RxS_OMA@DUT_TECQ is the receiver sensitivity OMA (max) spec for TECQ >= 0.9 dB, extrapolated to TECQ = 0 dB (-4.3 dBm), at the TECQ measured for the transmitter under test

—ORx_RxS@DUT_TECQ is the actual ORx receiver sensitivity OMA at the TECQ measured for the transmitter under test

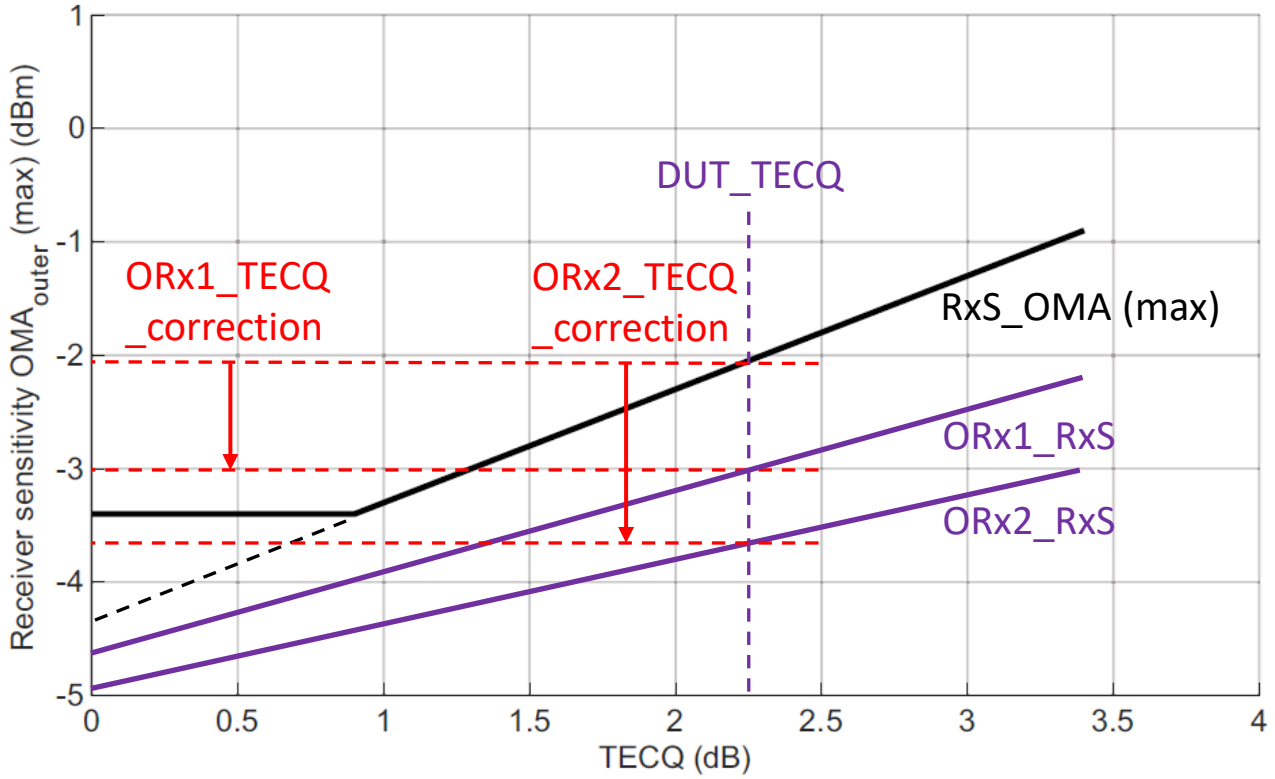

Figure 180–4—Receiver sensitivity (OMA$_{outer}$), each lane (max)

Test_margin of Transmitter Under Test

Test_margin is additional ORx_OMA, to improve SNR of transmitter under test measurement. It equals 1.5dB, which decreases the required ORx operating BER to 2.4×10^{-5}.

- Model: Tx_DUT → Channel → Rx
  - SNR_M ≡ SNR of transmitter under test measurement
  - ch_loss < 1 ≡ Channel loss (linear)
- SNR_M = Tx_DUT_Signal * ch_loss / (Tx_DUT_Noise * ch_loss + Rx_Noise)
  - SNR_M objective: SNR_M ≈ Tx_DUT_Signal / Tx_DUT_Noise → Tx_DUT_Noise * ch_loss > Rx_Noise
  - At receiver sensitivity: Tx_DUT_Noise * ch_loss < Rx_Noise
  - test_margin > 1 ≡ offset gain to reduce effect of ch_loss (linear)
- SNR_M = Tx_DUT_Signal * ch_loss * test_margin / (Tx_DUT_Noise * ch_loss * test_margin + Rx_Noise)
- Transmitter only test operating BER must be decreased from full link (PMD to PMD) BER = 2.28×10^{-4}
- Experimental validation
- Example of common SNR_M improvement: after fiber eye measurement
  - Tx_DUT → Fiber → Gain → DCA

VOA_level no Tx_margin using referenced Figure 180-5

VOA_level = Test_fiber_correction + ORx_TECQ_correction – Test_margin (180–28)

Tx_margin
= Tx_DUT OMA
- max(TECQ, TDECQ)
- (Tx_OMA(min)
@TECQ=0)

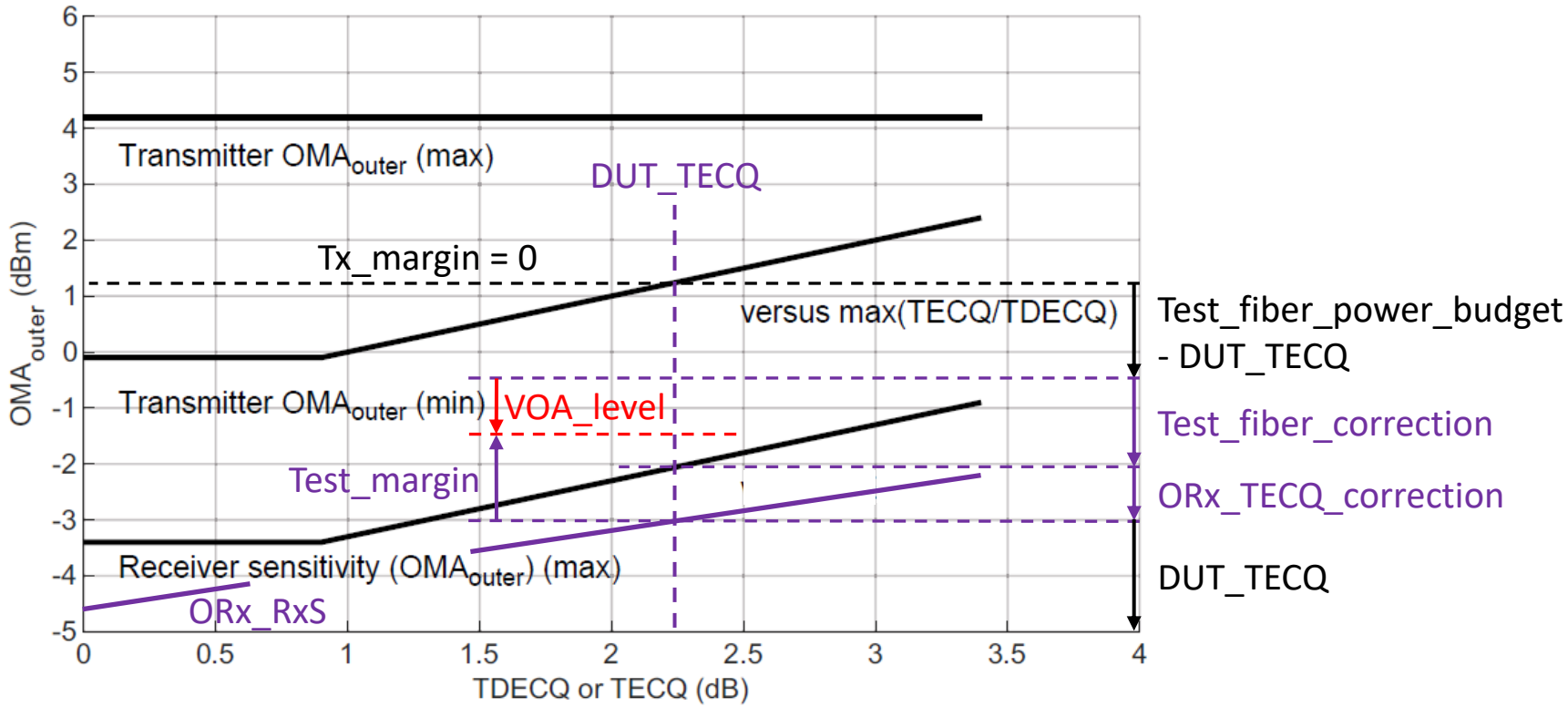

Figure 180–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ

VOA_level w/ Tx_margin using referenced Figure 180-5

VOA_level = Test_fiber_correction + ORx_TECQ_correction - Test_margin (180–28)

Tx_margin
= Tx_DUT OMA
- max(TECQ, TDECQ)
- (Tx_OMA(min)
@TECQ=0)

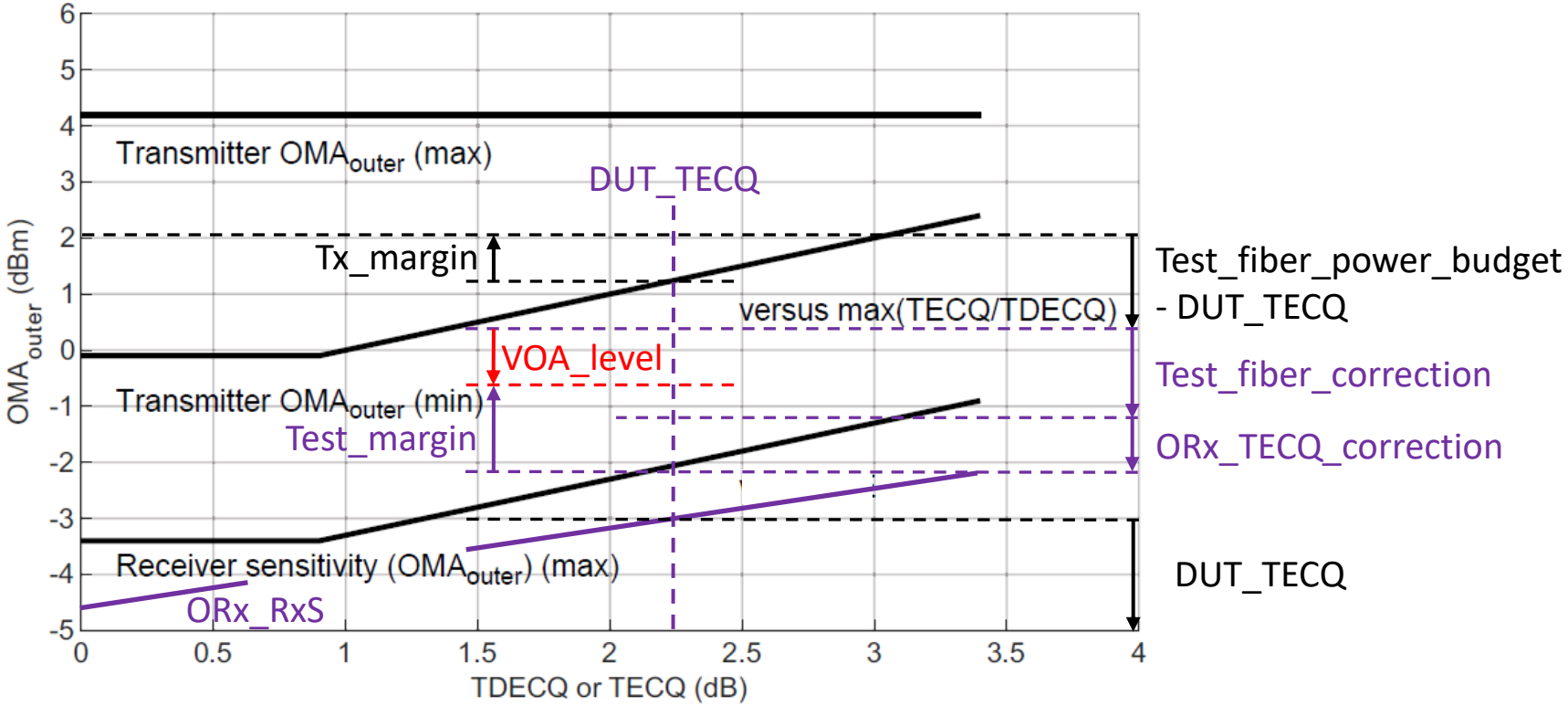

Figure 180–5—Transmitter OMA$_{outer}$ each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA$_{outer}$) each lane versus TECQ

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Lab Setup & VOA Equation Terms Pre-calculation

- Equipment
  - DCA, Power Meter, other
  - FRx = VOA + ORx (including RxS_OMA (max) & ORx_RxS OMA vs. TECQ data)
  - Test Fiber (including estimates of loss and MPI + DGD + Dispersion penalties)
- Tx DUT OMA setup during normal optical module programming
  - Measure TECQ & TDECQ
  - Tx_DUT OMA = (Tx_OMA(min)@TECQ=0) + max(TECQ, TDECQ) + Tx_margin
- FRx VOA equation terms pre-calculation
  - Test_fiber_correction1 = Tx_DUT_power_budget - Test_fiber_power_budget
  - Test_fiber_correction2 = Tx_DUT_power_budget - DUT_TECQ (Optional patch cord)
  - ORx_TECQ_correction = RxS_OMA@DUT_TECQ - ORx_RxS@DUT_TECQ

Transmitter Functional Test (TFT)

Summary: Connect DUT to FRx w/ Test Fiber, auto-set VOA, measure TFSEH

- Tx DUT functional test & optional TDECQ check
  - Tx DUT → Test Fiber → (FRx = VOA → ORx)
  - VOA_level = Test_fiber_correction1 + ORx_TECQ_correction - Test_margin
  - Measure Transmitter functional symbol error histogram (TFSEH)
  - Optionally adjust TDECQ estimate as shown in CL 183 LR4 Tests, p.23, ll. 4, 5
- Optional TECQ check
  - Tx DUT → Patch cord → (FRx = VOA → ORx)
  - VOA_level = Test_fiber_correction2 + ORx_TECQ_correction - Test_margin
  - Measure Transmitter functional symbol error histogram (TFSEH)
  - Optionally adjust TECQ as shown in CL 183 LR4 Tests, p.23, ll. 9, 10

CL 183 LR4 Over-fiber & BtB TFTs

CL 183		RxS_OMA(max)@TECQ=0 -6.9					Channel_insertion_loss 6.3			MPI+DGD_penalty_allocation 1.1			Tx_OMA(min)@TECQ=0 0.5				
Case		Tx_DUT (per Table 183-5)					Test_SMF						FRx (per 183.9.9)				
No.	Test_SMF actual DUT_CD	TECQ	TDECQ	max(TECQ, TDECQ)	margin	OMA dBm	actual			estimated			ORx_RxS @DUT _TECQ	Test _margin	VOA _level	ORx _OMA dBm	Test _margin _error
							loss	MPI+DGD	TDECQ	loss	MPI+DGD	TDECQ					
1	max pos penalty	2.0	3.5	3.5	0.0	4.0	6.3	1.1	3.5	6.3	1.1	3.5	-4.9	1.5	-1.5	-0.8	0.0
2		2.0	3.5	3.5	1.0	5.0	6.3	1.1	3.5	6.3	1.1	3.5	-4.9	1.5	-1.5	0.2	0.0
3		2.0	3.5	3.5	1.0	5.0	5.3	0.5	3.5	5.3	0.5	3.5	-4.9	1.5	0.1	-0.4	0.0
4		2.0	**5.5**	5.5	1.0	7.0	5.3	0.5	3.5	5.3	0.5	**5.5**	-4.9	1.5	0.1	1.6	**2.0**
5		2.0	**3.5**	3.5	1.0	5.0	5.3	0.5	3.5	5.3	0.5	**3.5**	-4.9	1.5	0.1	-0.4	**0.0**
6	typ. pos	2.0	3.5	3.5	1.0	5.0	5.3	0.5	3.0	5.3	0.5	3.0	-4.9	0.5	1.6	-1.9	0.0
7	0 penalty	2.0	3.5	3.5	0.0	4.0	0.0	0.0	2.0	0.0	0.0	2.0	-4.9	1.5	7.4	-3.4	0.0
8		2.0	3.5	3.5	1.0	5.0	0.0	0.0	2.0	0.0	0.0	2.0	-4.9	1.5	7.4	-2.4	0.0
9		**4.0**	**5.5**	5.5	1.0	7.0	0.0	0.0	2.0	0.0	0.0	**4.0**	-2.9	1.5	7.4	-0.4	**2.0**
10		**2.0**	**5.5**	5.5	1.0	7.0	0.0	0.0	2.0	0.0	0.0	**2.0**	-4.9	1.5	9.4	-2.4	**0.0**

Test_margin_error = (ORx_OMA = Tx_DUT_OMA - Test_SMF_actual_loss - VOA_level) - (ORx_RxS@TECQ=0 + Test_SMF_actual_MPI+DGD+TDECQ_penalties + Tx_margin + Test_margin)

RxS Specification Proposal

Thank you