802.3dj D3.1 Comment Resolution Optical Topics

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Introduction

- This slide package was assembled by the 802.3dj editorial team to provide background and detailed resolutions to aid in comment resolution.
- Specifically, these slides are for the various optical-track comments.

TFT miscellaneous

Comments #77, 313,283,

Comment R1-77
TFT false fails

Cl **180** *SC* **180.9.1** *P* **488** *L* **37** # 77

Brown, Matthew Qualcomm

Comment Type **TR** *Comment Status* **X**

Comment I-25 against Draft 3.0 pointed out that the penalty attributed to a transmitter based on transmitter jitter may be optimistic if the functional receiver has a clock tracking bandwidth much higher than the assumed minimum of 4 MHz. However, the functional receiver calibration as defined in Draft 3.1 induces a penalty for receivers with better worst case tracking bandwidth. This ensures that a false pass does not occur. However, it does impose an unnecessary penalty upon a transmitter with negligible low-frequency jitter. The test as defined ensures no false passes but unfortunately might false fail a transmitter with very good low-frequency but otherwise near-marginal performance. An informative note in this regard would be helpful.

SuggestedRemedy

Add the following (or similar) informative note near the definition of ORx_TECQ_correction variable as follows:
"NOTE--The correction factor given by ORx_TECQ_correction might be moderately pessimistic depending upon the relative characteristics of the device used as the reference receiver and the transmitter under test. A failure of the TFT accurately identifies a transmitter that is not generally interoperable. However, the test might falsely fail a generally interoperable transmitter."

Proposed Response *Response Status* **O**

Updated wording of the informative note:

NOTE--The correction factor given by ORx_TECQ_correction might be *moderately* pessimistic depending upon the relative characteristics of the device used as the reference receiver and the transmitter under test. A failure of the TFT accurately identifies a transmitter that is not generally interoperable. However, the test might falsely fail a generally interoperable transmitter, which might be addressed by a moderate increase in transmitter OMA to pass TFT.

Comment R1-313
Test condition of TFT

Cl **180**	*SC* **180.9.8**	*P* **34**	*L* **34**	# 313

Dawe, Piers J G NVIDIA

Comment Type **T** *Comment Status* **X**

It is not clear to me how AUI errors are accounted for (see Table 174A-1). Normally in 802.3 "a transmitter" means the transmitted signal, impaired by everything behind it including host jitter, power supply noise, AUI errors and so on. Yet I wonder if this is intended as a module test. From Figure 180-12 it seems there are no receive side AUI errors.

SuggestedRemedy

If the TFT section is to be kept, clarify whether the mask is applicable with or without AUI errors in the transmitter. By reference to 174A, explain what to do in the other scenario.

Proposed Response *Response Status* **O**

Two decisions:

1. BER_added = ?
2. Is an Error ratio parameter table needed.

180.9.8.2 Test functional symbol error histogram (TFSEH)

The transmitter functional symbol error histogram (TFSEH) mask for each lane is given in Table 180–17. The limit $H_{max}(k)$ is calculated using the method in 174A.9.5 using ORx operating BER = 2.4×10^{-5} and $p = 1$. This operating BER is *ORx_RxS* BER decreased by amount corresponding to *Test_margin* increase of *ORx_RxS_OMA*. This improves the measurement SNR of the transmitter functional test. ORx and *Test_margin* are defined in 180.9.8.1.

The transmitter functional symbol error histogram is measured using a functional receiver as defined in 180.9.8.1 using the method defined in 180.9.8.2 and using the test pattern as given in Table 180–14. Minimum measurement time is 60 seconds.

A probable failure is indicated by either of the following:

— exceeding the TFSEH mask defined in Table 180–17

— a value greater than 0 in counter test_block_error_bin_*i*_*k* (see 174A.9.2), for *k* greater than 8

Table 180–17—Transmitter functional symbol error mask

Test symbol errors per test block, *k* (see 174A.9.5)	Probability $H_{max}(k)$
1	1.15×10^{-1}
2	7.47×10^{-3}
3	3.24×10^{-4}
4	1.05×10^{-5}
5	2.73×10^{-7}
6	5.88×10^{-9}
7	1.08×10^{-10}
8	1.75×10^{-12}

For each lane *i*, measure the error histogram $H_m^{(i)}(k)$ (see 174A.9.3).

The upper limit for $H_m^{(i)}(k)$ is defined by the histogram $H_{max}(k)$. $H_{max}(k)$ is the probability of *k* error test symbols in a test block with given random bit errors with a *BER* equal to BER_{max}. Compute the histogram $H_{max}(k)$ using Equation (174A–5), where $n = 544 / p$ and $BER_{max} = BER_{total} - BER_{added}$.

$$H_{max}(k) = \frac{n!}{k!(n-k)!} RSSER^k (1 - RSSER)^{n-k} \quad (174A–5)$$

$$RSSER = 1 - (1 - 2BER_{max})^5 \quad (174A–6)$$

The expected BLER is met if, for each lane *i*, $H_m^{(i)}(k)$ is less than $H_{max}(k)$ for all $k > 0$.

Comment R1-283

Cl **180** *SC* **180.9.8.1** *P* **488** *L* **50** # 283

Dawe, Piers J G NVIDIA

Comment Type **TR** *Comment Status* **X**

This says "the best estimate of the actual MPI and DGD penalties of the test fiber", yet the fibre alone doesn't make much MPI. The reflections between transmitter and connectors, and receiver and connectors, are more important. It is not clear which reflections are taken as baseline and which are attributed to the fibre, particularly as both transmitter and receiver reflectances are not necessarily at the spec limits. MPI varies with polarisation yet there is no polarisation control in Figure 180-12.

SuggestedRemedy

If the TFT section is kept;
if MPI penalty variations are important, explain how the MPI penalty is to be estimated and add polarisation control. If MPI penalty variations are not so important or not feasible to estimate with confidence, use a fixed allocation

Proposed Response *Response Status* **O**

Comment R1-283
TFT test fiber correction

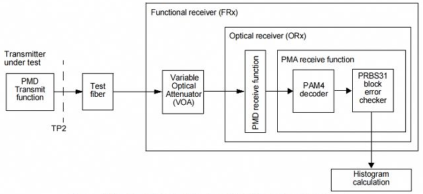


Figure 180–12—Transmitter functional test block diagram

180.9.6.2 Channel requirements

The transmitter is tested using an optical channel that meets the requirements listed in Table 180–15.

Table 180–15—Transmitter compliance channel specifications

Dispersion[a] (ps/nm)		Insertion loss[b]	Optical return loss[c] (dB)	Max mean DGD[d] (ps)
Minimum	Maximum			
0.0463×(λ – 1311) – 0.55	0.0443×(λ – 1311) + 0.37	Minimum	See Table 180–7	0.5

[a] Dispersion is measured for the wavelength of the transmitter lane under test (λ in nm). The coefficient assumes 500 m distance. The dispersion specifications are based on the statistical link design methodology documented in Appendix I of Recommendation ITU-T G.652 (08/2024).
[b] The value "Minimum" implies that the test channel insertion loss does not excessively degrade the signal to noise ratio of the measurement.
[c] The back-reflection is applied at TP2.
[d] The limit for maximum mean DGD is to ensure that the contribution to TDECQ from DGD is substantially less than the primary contribution from the channel due to chromatic dispersion.

VOA_level = Test_fiber_correction + ORx_TECQ_correction – Test_margin
Test_fiber_correction = Tx_DUT_power_budget – Test_fiber_power_budget
Test_fiber_power_budget = Test_fiber_loss + Test_fiber_MPI_and_DGD_penalties + Test_fiber_DUT_TDECQ

The transmitter under test is connected to the FRx by a test fiber which meets the requirements in 180.9.6.2. Full compliance with 180.9.6.2 requires the test fiber to provide back reflection with polarization state resulting in the greatest RIN. Other test fibers, including patch cords, may be used for additional tests.

Requirement of the channel listed in 180.9.6.2
- •Minimum IL
- •Maximum CD rang
- •Minimum DGD
- •No specific requirement on connector numbers and discrete reflectance (MPI)

Current specification:
"the power budget of the test fiber using the best estimates of the test fiber channel insertion loss, MPI and DGD penalties, and TDECQ of the DUT over the test fiber and is given by Equation (180–20)"

→ Allowing users to set MPI_DGD_Penalty to 0, or other value based on test setup conditions.

Receiver Sensitivity

Comments #294, 195, 129, 130

Comment R1-294
Per-lane or all-lane for Rx Sensitivity

Cl **180** *SC* **180.9.14** *P* **491** *L* **45** # 294

Dawe, Piers J G NVIDIA

Comment Type **TR** *Comment Status* **D** *Rx Sensitivity (O)*

D3.0 comment 493: as is explained at length in 174A.9 (referenced at line 53), receiver sensitivity is a property of the lanes together ("interface BER" concept, transferred to BLER), not each lane separately. We ensure that each transmit lane is good enough individually, and each channel lane individually. We test a receiver by applying the same optical power on each lane, but the receiver can share its error allocation across its lanes how it chooses, just as it can allocate errors to LSB and MSB, or I and Q, within a lane, as it chooses. This is what happens naturally if the errors are checked at the PCS, and it's fine: we put symbol distribution in the FEC to prepare for it. 174A.9.5 says "If this test passes for each lane, then the PHY or xMII Extender will meet the expected codeword error ratio. If this test fails, then the performance may be further verified using the method in 174A.9.6 or 174A.9.7." Those who wish to qualify a multilane receiver (e.g., 800GBASE-DR4) as multiple single-lane PMDs (e.g., 4 x 200GBASE-DR1) will continue to do so; those who don't like 174A.9.6 (evaluate the performance of all physical lanes in an AUI component or PMD) because they don't want to convolve the per-lane BLER histograms together, can continue to use 174A.9.5 or 174A.9.7 (evaluate the performance of each physical lane in an AUI component or PMD).

SuggestedRemedy

Here, remove "of each lane" from line 45 (because the sensitivity of a single lane in a multi-lane PMD is not a spec item) and add "on each lane" on page 492 line 1 after "OMAouter" because this really is the OMA to be applied to each victim lane. Similarly in 180.9.15 for SRS. Similarly in other IMDD clauses.

I hope that the electrical clauses and AIs don't have this defect to be corrected.

Proposed Response *Response Status* **W**

PROPOSED REJECT.

This is a substantial change of the intepretation of Rx. sensitivity. if we do as suggested, the out come reads:

"The measured receiver sensitivity is the lowest value of OMAouter of each lane where the PMD receiver meets the BLER
requirements in 180.2," meaning:

Receiver sensitivity of an 800GBASE-DR4 or 800GBASE-FR4 PMD is the lowest OMA value of the four tested per-lane receiver sensitivity.
-- This may not be what the industry is doing and inteprets the standard.

Pending CRG discussion. Resolve prior to comment R1-195.

Cl **180** *SC* **180.9.14** *P* **492** *L* **2** # R1-129

mi, guangcan — Huawei Technologies Co., Ltd

Comment Type **TR** *Comment Status* **D** *Rx Sensitivity (O)*

174A.9.6 is PMA method of all lanes in PMD. While to measure the receiver sensitivity, the lowest OMAouter value, of any one lane, using all lane method can not isolate the contribution to the error histogram of the lane under test from all other lanes. the all lanes PMA method can not be easily adopted to measure the receiver sensitivity.

SuggestedRemedy

delete 174A.9.6, also in stressed receiver sensitivity.

Proposed Response *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.

Resolved using the response to R1-195.

Cl **180** *SC* **180.9.14** *P* **492** *L* **6** # R1-130

mi, guangcan — Huawei Technologies Co., Ltd

Comment Type **TR** *Comment Status* **D** *Rx Sensitivity (O)*

this note says "When measuring receiver sensitivity of a complete PHY at the PCS", the receiver sensitivity is not a characteristic of a complete phy, it is defined as the characteristic of the PMD, and is defined as per lane characteristic. A complete phy using a pmd compliant to CL180 needs to satisfy the error ratio requirement as defined in 180.2. however, extending the phy requirement to receiver sensitiviy definition and method is wrong and un-necessary.

SuggestedRemedy

delete the note.

Proposed Response *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
Resolved using the response to comment R1-195

Cl **180** *SC* **180.9.14** *P* **491** *L* **45** # R1-195

Dudek, Michael — Marvell

Comment Type **T** *Comment Status* **D** *Rx Sensitivity (O)*

This comment is in support of comment i-493 against D3.0. For a multilane system what matters is the Frame Loss Ratio of the interface which is a function of the performance of all the lanes. It is not necessary for all the lanes to meet the specification here. Also it is not possible to test the performance of the individual lanes when using scrambled idle (pattern 5). Also the test method called out in 174A.9.6 (allowed by page 492 line 2) specifically allows is a multilane test.

SuggestedRemedy

Delete "of each lane" here and for stressed sensitivity on page 493 line 37. Make the equivalent changes in clauses 181, 182, and 183 (note that the change is not needed in 181.9.15 or 183.9.15 as they already do not say "of each lane". If the committee decision is that all lanes must meet the specification individually then pattern 5 needs to be removed as a test pattern option, 174A.9.6 needs to be deleted and exceptions need to be made to 174A.9.5 and 174A.9.7 which allow the use of 174A.9.6.

Proposed Response *Response Status* **W**

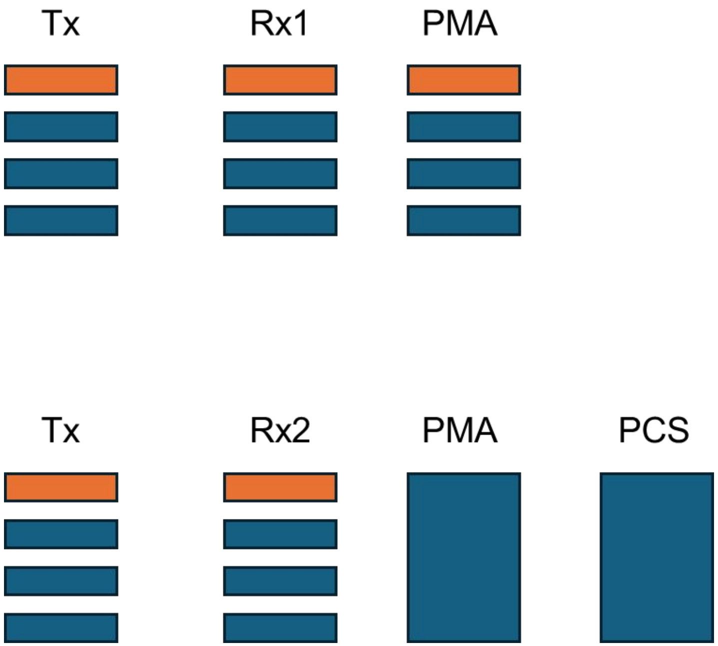
PROPOSED ACCEPT IN PRINCIPLE.

Removing "each lane" as an option is addressed by the reponse to comment R1-294.

Implement the following changes:
delete pattern 5 from test pattern specified for receiver sensitivity and Stressed receiver sensitivity in Table 180-13.
delete reference of 174A.9.6 from the receiver sensitivity methodology.
Delete the note that begins with "When measuring receiver sensitivity of a complete PHY at the PCS...."
Add an exception in 180.9.14 and 180.9.15 that, when testing using 174A.9.5 or 174A.9.7, the compliance may not be further verified using 174A.9.6.
Similarly update clauses 181, 182, and 183.
Implement with editorial license.

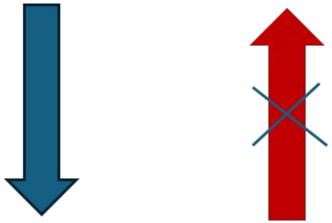
For CRG discussion. Resolve comment R1-294 first.

Comment R1-294, 195, 129, 130
Per-lane or all-lane for Rx Sensitivity



The safer approach
More stringent on Rx

Rx1 each lane passes the single lane test



No guarantee
interoperability

Rx2 passes the all-lane test (PMA/PCS)

Comment R1-294, 195, 129, 130
Per-lane or all-lane for Rx Sensitivity

Outer optical modulation amplitude (OMA_{outer}), each lane (max)	180.9.5	4.2	dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) < 0.9 dB for 0.9 dB ≤ max(TECQ, TDECQ) ≤ 3.4 dB	180.9.5	 −0.1 −1 + max(TECQ, TDECQ)	 dBm dBm

Outer optical modulation amplitude (OMA_{outer}), each lane (max)	181.9.5	4.8	dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) <0.9 dB for 0.9 dB ≤ max(TECQ, TDECQ) ≤ 3.4 dB		 0.9 max(TECQ, TDECQ)	 dBm dBm

Receiver sensitivity (OMA_{outer}), each lane[c] (max) for TECQ < 0.9 dB for 0.9 dB ≤ TECQ ≤ SECQ	180.9.14	 −3.4 −4.3 + TECQ	dBm
Stressed receiver sensitivity (OMA_{outer}), each lane[c] (max)	180.9.15	−0.9	dBm
Conditions of stressed receiver sensitivity test[d]:			
Stressed eye closure for PAM4 (SECQ), lane under test	—	3.4	dB
OMA_{outer} of each aggressor lane[e]	—	4.2	dBm

Receiver sensitivity (OMA_{outer}), each lane[c] (max) for TECQ < 0.9 dB for 0.9 dB ≤ TECQ ≤ SECQ	181.9.14	 −3.2 −4.1 + TECQ	 dBm dBm
Stressed receiver sensitivity (OMA_{outer}), each lane[c] (max)	181.9.15	−0.7	dBm
Conditions of stressed receiver sensitivity test:[d]			
Stressed eye closure for PAM4 (SECQ), lane under test	—	3.4	dB
OMA_{outer} of each aggressor lane	—	1.3	dBm

If receiver sensitivity is not defined as a *per lane* property, then for a multi-lane PMD:

•Each lane_i will have a distinct minimum OMA, $OMA_{outer,i}$

•$OMA_{outer,i}$ value may also be dependent on the conditions of the other lanes

•Receiver sensitivity is a single value, then max{$OMA_{outer,i}$} is considered the receiver sensitivity of the PMD, which will need to be clarified

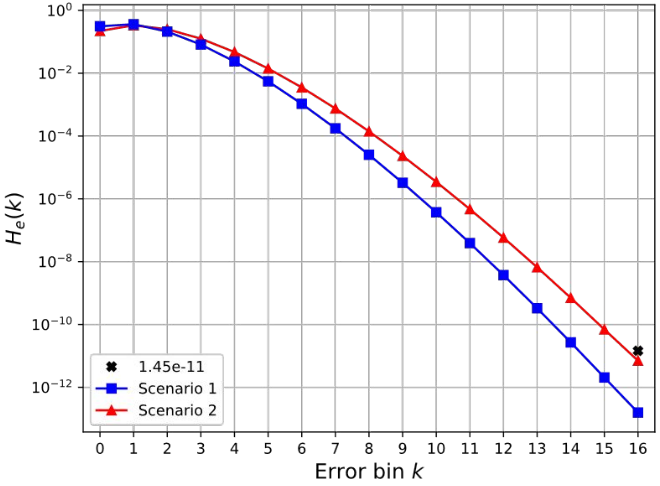
Comment R1-294, 195, 129, 130
Per-lane or all-lane for Rx Sensitivity

BLER test method for all lanes 174A.9.6

Assume four optical lanes 0,1,2,3, consider two scenarios:

1. BER over four lanes is [3e-4, 1e-4, 1e-4, 1e-4]
2. BER over four lanes is [2.5e-4, 2e-4, 2e-4, 2e-4]

Calculate $H_e(k)$ with BER_{added} = 6.4e-5, and compare $H_e(16)$ with 1.45e-11



Both scenarios pass the test method for all lanes, but with BER > 2.28e-4 for lane 0.

Comment R1-294, 195, 129, 130
Per-lane or all-lane for Rx Sensitivity

Propose to use only the per-lane test method for receiver sensitivity, and define receiver sensitivity as per-lane property

Table 180–13—Test patterns

Pattern	Pattern description	Defined in
3[a]	PRBS31Q	176.7.4.2
4	PRBS13Q	176.7.4.3
5[a]	Scrambled idle	119.2.4.9, 172.2.4.11, 175.2.4.11
6	SSPRQ	176.7.4.5
7	Valid 200GBASE-R, 400GBASE-R, 800GBASE-R, or 1.6TBASE-R signal	119.2.4, 172.2.4, 175.2.4

[a] Precoding (see 176.7.1.2) is added to this pattern as necessary (see 180.9.14 and 180.9.15).

Applies to all lanes in multi-lane PMD

Table 180–14—Mapping of parameters to test patterns and related subclauses

Parameter	Pattern	Related subclause
Transmitter transition time	6	180.9.12
RIN_xOMA	4 or 6	180.9.13
Receiver sensitivity	3 ~~or 5~~	180.9.14
Stressed receiver conformance test signal calibration	6	180.9.15
Stressed receiver sensitivity	3 ~~or 5~~	180.9.15

Comment R1-294, 195, 129, 130
Per-lane or all-lane for Rx Sensitivity

The receiver sensitivity (OMA_{outer}) of each lane shall be within the limits given in Table 180–8 if measured using one of the test patterns specified 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.

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

The measured receiver sensitivity is the lowest value of OMA_{outer} 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~~, or 174A.9.7 with parameters provided in Table 180–19. The error mask $H_{max}(k)$ to be used in the method of 174A.9.5 is provided in Table 180–20.

~~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*~~$\cancel{_{added}}$ ~~is required.~~

NOTE—In order to predict whether a receiver meets the BLER requirement in a short test time, extrapolation of the measured histogram (see 174A.9.3) to $H_m(16)$ can be performed. One way of doing this is using a linear fit of $\log_{10}(H_m(k))$ for $k = (n - 2)$ to n, where these values of k are the three highest bins having a count of 10 or more. If the slope of the histogram over the measured bins is increasing, it might be an indication of not meeting the BLER requirement. To verify that the slope is not increasing, the values of $(\log_{10}(H_m(k)) - \log_{10}(H_m(4)) / (k - 4)$ should be less than $(\log_{10}(H_m(4)) - \log_{10}(H_m(2)) / 2$ for each k greater than 4.

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 180–18.

Delete test method that uses all lanes

174A.9.6 BLER method for all lanes using PMA measurements

174A.11 Error ratio tests for a PHY using PCS measurements

Add exception: when testing using 174A.9.5 or 174A.9.7, the compliance may not be further verified using 174A.9.6.

Comment R1-294, 195, 129, 130
Per-lane or all-lane for Rx Sensitivity

The measured stressed receiver sensitivity is the lowest value of OMA_{outer} where the receiver meets the requirements in 180.2 using the test method in either 174A.9.5, ~~174A.9.6,~~ or 174A.9.7 with parameters

provided in Table 180–19. The error mask $H_{max}(k)$ to be used in the method of 174A.9.5 is provided in Table 180–20.

NOTE—In order to predict whether a receiver meets the BLER requirement in a short test time, extrapolation of the measured histogram (see 174A.9.3) to $H_m(16)$ can be performed. One way of doing this is using a linear fit of $\log_{10}(H_m(k))$ for $k = (n - 2)$ to n, where these values of k are the three highest bins having a count of 10 or more. If the slope of the histogram over the measured bins is increasing, it might be an indication of not meeting the BLER requirement. To verify that the slope is not increasing, the values of $(\log_{10}(H_m(k)) - \log_{10}(H_m(4)) / (k - 4)$ should be less than $(\log_{10}(H_m(4)) - \log_{10}(H_m(2)) / 2$ for each k greater than 4.

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

Delete 174A.9.6

The PCS test method was not included in D3.1, so no updates needed here.

TFT BER test margin and BER

Comment R1-118, 125, 305, 308
TFT BER test margin and BER

Cl **180** *SC* **180.9.8.1** *P* **488** *L* **40** # R1-118

mi, guangcan Huawei Technologies Co., Ltd

Comment Type **T** *Comment Status* **R** *TFT wording (O) (B)*

"It equals 1.5 dB, which decreases the required ORx operating BER to 2.4 Î 10û5 " This sentence seems to say, test margin 1.5dB = operating BER of Orx is 2.4e-5. while the intention I believe is the BER target assuming random error can be tightened to 2.4e-5.

SuggestedRemedy

change to "It equals to 1.5dB. The BER target assuming random error is changed to 2.4e-5. The transmitter functional symbol error mask is calcualted using this BER target."

Response *Response Status* **Z**

REJECT.

This comment was WITHDRAWN by the commenter.

Cl **180** *SC* **180.9.8.1** *P* **488** *L* **40** # R1-305

Dawe, Piers J G NVIDIA

Comment Type **TR** *Comment Status* **D** *TFT wording (O) (B)*

This says that Test_margin equals 1.5 dB, which decreases the required ORx operating BER to
2.4e5. But, 1.5 dB and 2.4e5 are not related, and there is no *required* ORx operating BER, although an ORx operating BER for calculating the bin mask is chosen in 180.9.8.2. It doesn't "equal" 1.5 dB as the output of some formula or measurement; it was chosen.

SuggestedRemedy

If the TFT section is kept, change to just "It is set to 1.5 dB."

Proposed Response *Response Status* **W**

PROPOSED ACCEPT IN PRINCIPLE.
Resolved using the response to comment R1-118.

Cl **180** *SC* **180.9.8.2** *P* **489** *L* **37** # R1-308

Dawe, Piers J G NVIDIA

Comment Type **TR** *Comment Status* **D** *TFT operating BER (O)*

This says "This operating BER is ORx_RxS BER decreased by ...". Yet there is no sensitivity BER. Sensitivity is defined by BLER.

SuggestedRemedy

If the TFT section is kept, clear up the logic.

Proposed Response *Response Status* **W**

PROPOSED REJECT.
The suggested remedy does not propose an actionable (within the draft) remedy. A question or call to action is not valid.

Cl **180** *SC* **180.9.8.2** *P* **489** *L* **38** # R1-125

mi, guangcan Huawei Technologies Co., Ltd

Comment Type **TR** *Comment Status* **D** *TFT operating BER (O)*

"This operating BER is ORx_RxS BER decreased by amount corresponding to Test_margin increase of
ORx_RxS_OMA." again, seems to claim that the ORx with input OMA = ORX_RxS_OMA + test margin, will operate at 2.4e-5. this would be a requirement on the ORx. What if an ORx shows lower BER than 2.4e-5 at this input OMA?

SuggestedRemedy

need clarify. Will discuss with the TFSEH team before July meeting to come in with clarification, or withdraw.

Proposed Response *Response Status* **W**

PROPOSED REJECT.
The suggested remedy does not propose an actionable (within the draft) remedy. A question or call to action is not valid.

Comment R1-118, 125, 305, 308

TFT BER test margin and BER

$$VOA\_level = Test\_fiber\_correction + ORx\_TECQ\_correction - Test\_margin \quad (180–17)$$

where:

Test_fiber_correction	is given by Equation (180–18), and is the difference between the power budget used to determine the transmitter under test OMAouter (min) and the best estimate of the test fiber power budget
ORx_TECQ_correction	is the difference between receiver sensitivity (max) as given in Table 180–8 and ORx receiver sensitivity, both at transmitter under test TECQ, and is given by Equation (180–21)
Test_margin	is the additional *ORx_OMA*, to improve SNR of the transmitter functional test. It equals 1.5 dB, which decreases the required ORx operating BER to 2.4×10^{-5}

180.9.8.2 Test functional symbol error histogram (TFSEH)

The transmitter functional symbol error histogram (TFSEH) mask for each lane is given in Table 180–17. The limit $H_{max}(k)$ is calculated using the method in 174A.9.5 using ORx operating BER = 2.4×10^{-5} and $p = 1$. This operating BER is *ORx_RxS* BER decreased by amount corresponding to *Test_margin* increase of *ORx_RxS_OMA*. This improves the measurement SNR of the transmitter functional test. ORx and *Test_margin* are defined in 180.9.8.1.

The transmitter functional symbol error histogram is measured using a functional receiver as defined in 180.9.8.1 using the method defined in 180.9.8.2 and using the test pattern as given in Table 180–14. Minimum measurement time is 60 seconds.

Proposed change:
It equals to 1.5dB. The *ORx operating* BER target assuming random error is changed to 2.4×10^{-5}. The transmitter functional symbol error mask (see Table 180-17) is calculated using this BER target.

Proposed change:
Using *ORx operating BER target* of 2.4×10^{-5}
This operating BER target corresponds to Test_margin increase *from* OMA value of receiver sensitivity of ORx.

Note: ORx_RxS_OMA was not previously defined in the draft.

Comment R1-226

Repeating description of polarization.

The optical splitter and variable reflector are adjusted so that each transmitter is tested with the optical return loss specified in Table 180–7. The state of polarization of the back reflection is adjusted to create the greatest RIN. Each optical lane is tested with the optical channel described in 180.9.6.2.

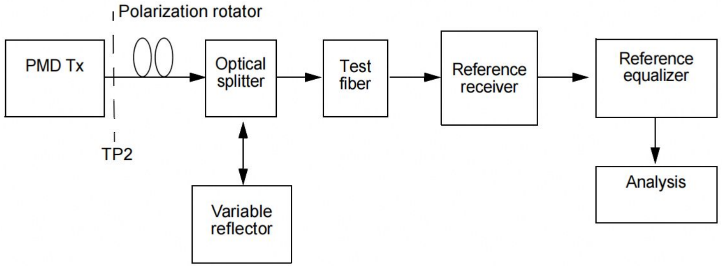


Figure 180–9—TDECQ conformance test block diagram

180.9.6.2 Channel requirements

The transmitter is tested using an optical channel that meets the requirements listed in Table 180–15.

Table 180–15—Transmitter compliance channel specifications

Dispersion[a] (ps/nm)		Insertion loss[b]	Optical return loss[c] (dB)	Max mean DGD[d] (ps)
Minimum	Maximum			
0.0463×(λ – 1311) – 0.55	0.0443×(λ – 1311) + 0.37	Minimum	See Table 180–7	0.5

[a] Dispersion is measured for the wavelength of the transmitter lane under test (λ in nm). The coefficient assumes 500 m distance. The dispersion specifications are based on the statistical link design methodology documented in Appendix I of Recommendation ITU-T G.652 (08/2024).
[b] The value "Minimum" implies that the test channel insertion loss does not excessively degrade the signal to noise ratio of the measurement.
[c] The back-reflection is applied at TP2.
[d] The limit for maximum mean DGD is to ensure that the contribution to TDECQ from DGD is substantially less than the primary contribution from the channel due to chromatic dispersion.

The channel provides back reflection with return loss specified in Table 180–15. ~~The state of polarization of the back reflection is adjusted to create the greatest RIN.~~

The mean DGD of the channel is to be less than the value specified in Table 180–15.

180.9.8 Transmitter functional test (TFT)

The transmitter functional test uses a functional receiver (FRx) defined in 180.9.8.1 to measure a transmitter functional symbol error histogram (TFSEH) defined in 180.9.8.2. A block diagram showing the FRx is shown in Figure 180–12. The transmitter under test is connected to the FRx by a test fiber which meets the requirements in 180.9.6.2. ~~Full compliance with 180.9.6.2 requires the test fiber to provide back reflection with polarization state resulting in the greatest RIN.~~ Other test fibers, including patch cords, may be used for additional tests.

Comments:

TDECQ calculation	180	[103, 229, 230]+, [228, 13]+,
TDECQ editorial	180	[98, 99, 100, 101, 96, [93, 309, 12]]+,
TDECQ histogram	180	[198,],
TDECQ optimization	180	265+, [205, 95, 227,]+, [102, 117, 239]+
TDECQ eye diagram	180	[97, 263,]+

Page 484 line 4

For a given sampling phase ϕ_0 and assumed RMS value σ_G for Gaussian noise $\eta(t)$, determine the equalizer coefficients w and $b(1)$, subject to the limits in Table 180–16, that result in the minimum mean squared error (MMSE) between y_n and $x(n)$. Alternative optimization methods may be used to determine equalizer tap weights if they report ~~equal or lower mean~~ values of TDECQ.

comparable

Page 484 Line 6

An eye diagram to help illustrate TDECQ is shown in Figure 180-11. The eye diagram corresponds to a particular equalizer setting optimized at ϕ_0.

~~An eye diagram is formed from the equalized captured waveform, y_n, as follows. With the coefficients fixed at the determined values, sweep the sampling phase ϕ from $\phi_0 - T/2$ to $\phi_0 + T/2$. For each phase ϕ, plot the scatter plot of y_n. An example eye diagram is shown in Figure 180–11.~~ The feedback symbol $x(n)$ changes at phase $\phi = \phi_0 - T/2$.

NOTE—The colored Gaussian noise $\eta(t)$ added to $r(t)$ in Figure 180–10 is not reflected in the eye diagram. It is accounted for separately when estimating the SER in the analysis block.

<<Replace eye diagram with an eye diagram where phi_0 has been optimized>>

Replace in Page 484

Two vertical histograms are measured through the eye diagram, nominally centered 0.05 UI before and after sampling phase ϕ_0. Each of the histogram windows spans all of the modulation levels of the eye diagram, as illustrated in Figure 180–11. The precise time position of the pair of histogram windows is adjusted to minimize TDECQ while keeping the histogram windows spaced 0.1 UI apart.

Each histogram window has a width of 0.04 UI. Each histogram window has outer height boundaries which are set beyond the extremes of the eye diagram (so that no further samples would be captured by increasing the vertical separation of the height boundaries).

For a given phase offset, ϕ_0, two regions of a UI are measured, each centered 0.05UI before and after the sampling phase ϕ_0 and have a width of 0.04UI. For the left side, all samples such that ϕ_0–0.07/T $\le t \le$ ϕ_0 –0.03/T will be included. For the right side, all samples such that ϕ_0+0.03/T $\le t \le$ ϕ_0 +0.07/T will be included. Let $y_{n,L}$ be the equalized samples in the left region, and let $y_{n,R}$ be the equalized samples in the right region

Also, insert the following sentence after the second sentence above:
The precise time position of the pair of regions is adjusted to minimize TDECQ while keeping the regions spaced 0.1 UI apart.

P. 484 Line 45

Nominal

~~The nominal sub-eye~~ threshold levels $P_{0,\text{th}1}$, $P_{0,\text{th}2}$, and $P_{0,\text{th}3}$, are determined from the $\text{OMA}_{\text{TDECQ}}$ and the average optical power ~~of the eye diagram~~ (P_{ave}) as defined in Equation (180–4), Equation (180–5), and Equation (180–6), and illustrated in Figure 180–11.

$$P_{0,\,th1} = P_{ave} - \frac{\text{OMA}_{\text{TDECQ}}}{3} \tag{180–4}$$

$$P_{0,\,\text{th}2} = P_{\text{ave}} \tag{180–5}$$

$$P_{0,\,\text{th}3} = P_{\text{ave}} + \frac{\text{OMA}_{\text{TDECQ}}}{3} \tag{180–6}$$

where $\text{OMA}_{\text{TDECQ}}$ is measured on the equalized captured waveform y_n using the method defined in 180.9.5.

P. 485, Line 6

The samples captured in each region are

~~Each captured histogram is~~ processed to, in effect, combine the PAM4 waveform with noise, in order to produce an estimate of the ~~partial~~ PAM4 symbol error ratio (SER) ~~for each sub-eye~~. One way of doing this is described below.

region

region

σ_G quantifies the amount of noise that can be added at the receiver while still achieving the target SER. For a given value of σ_G, the symbol error ratio for the left ~~histogram~~, SER_L, and that for the right ~~histogram~~, SER_R, are estimated as described below using the tap coefficients optimized to minimize the mean squared error between y_n and $x(n)$ at ϕ_0.

Replacement for P. 485 Line 14 to P. 486 Line 31

The probability that a sample value in the left region, $y_{n,L}$, will become a symbol error given the addition of noise *η(t)* with standard deviation σ_G can be calculated as:

$$P(y_{n,L},\sigma_G)=\frac{1}{2}\begin{cases}\operatorname{erfc}\left(\dfrac{P_{\mathrm{th1}}-y_{n,L}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=0\\ \operatorname{erfc}\left(\dfrac{y_{n,L}-P_{\mathrm{th1}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)-\operatorname{erfc}\left(\dfrac{P_{\mathrm{th2}}-y_{n,L}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=1\\ \operatorname{erfc}\left(\dfrac{y_{n,L}-P_{\mathrm{th2}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)-\operatorname{erfc}\left(\dfrac{P_{\mathrm{th3}}-y_{n,L}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=2\\ \operatorname{erfc}\left(\dfrac{y_{n,L}-P_{\mathrm{th3}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=3\end{cases}$$

Equation in issenhuth_01a was incorrect.

$$P(y_{n,L},\sigma_G)=\frac{1}{2}\begin{cases}\operatorname{erfc}\left(\dfrac{P_{\mathrm{th1}}-y_{n,L}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=0\\ \operatorname{erfc}\left(\dfrac{y_{n,L}-P_{\mathrm{th1}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)+\operatorname{erfc}\left(\dfrac{P_{\mathrm{th2}}-y_{n,L}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=1\\ \operatorname{erfc}\left(\dfrac{y_{n,L}-P_{\mathrm{th2}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)+\operatorname{erfc}\left(\dfrac{P_{\mathrm{th3}}-y_{n,L}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=2\\ \operatorname{erfc}\left(\dfrac{y_{n,L}-P_{\mathrm{th3}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right) & x_n=3\end{cases}$$

Use this instead.

Insert in P. 486 Line 51

The symbol error rate for the left scatter plot is calculated as

$$\mathrm{SER}_L(\sigma_G) = \frac{1}{N}\sum_n P(y_{n,L}, \sigma_G)$$

Where the sum is over all samples in the left region and *N* is the number of such sample. $SER_R(sigma_G)$ is calculated similarly using $P(y_{n,R},sigma_G)$

Replace Page 486, Line 52

$\max(\mathrm{SER}_L(\sigma_G), \mathrm{SER}_R(\sigma_G))$ $\max(\mathrm{SER}_L(\sigma_G), \mathrm{SER}_R(\sigma_G))$ is not equal to

When the SER is estimated, the actual thresholds, P_{th1}, P_{th2}, and P_{th3}, are adjusted by up to ±1% of OMA_{TDECQ} to minimize ~~max(SER_L, SER_R)~~. If ~~max(SER_L, SER_R) is not within 1% of~~ the target PAM4

SER of 4.56×10^{-4}, the process is iterated by changing σ_G and reoptimizing the equalizer tap coefficients. TDECQ is calculated using the optimized σ_G that results in ~~max(SER_L, SER_R) falling within 1% of~~ the target PAM4 SER.

$\max(\mathrm{SER}_L(\sigma_G), \mathrm{SER}_R(\sigma_G))$ as close as practical to

Comment R1-261

For those cases where there is an xAUI-n chip-to-chip (C2C) or chip-to-module (C2M) interface (see Table 180–1 through Table 180–4), the clock source for the transmitted SSPRQ test pattern is derived from the clock recovered from the xAUI-n input signal. The pattern of the xAUI-n input signal may be PRBS31Q, scrambled idle, or a valid xBASE-R signal. The lane under test transmits the SSPRQ test pattern instead of the test pattern from the xAUI-n input signal.