Discrepancy in OMAouter and TDECQ penalty computation for link budget

Addressing comments #1, 4 of IEEE 802.3 dj draft 2.3

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Summary

- Addressing specifically comments #1, 4 against IEEE 802.3 dj draft 2.3, as well as #158, #50, #157, #52

- The presentation resolves the link budget inconsistency for transmitters presenting an OMA_{outer} measured per SC 180.9.5, which differs from the OMA_{TDECQ} measured "at the receiver equalizer output", and used as the reference amplitude for the computation of the transmitter penalty ($TDECQ$ and $TDECQ_{CER}$). It also clarifies the different OMA quantities considered at different points of the reference receiver, and suggests corresponding editorial changes to reconcile those quantities defined at their respective reference points.

- This presentation digs further into the discrepancy in OMA definitions existing in the link budget calculation and the one used in the TDECQ / TECQ penalty estimate, as reported originally in https://www.ieee802.org/3/dj/public/25_09/alloin_3dj_01b_2509.pdf

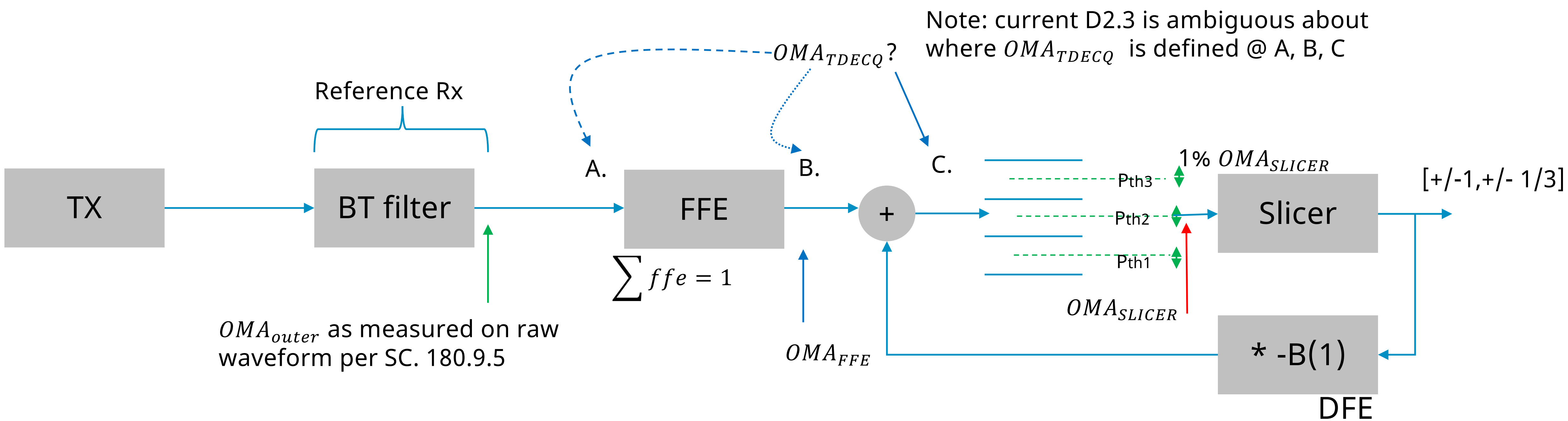
- The proposed solution is to use OMA_{outer} measured at the output of the reference receiver (as per SC 180.9.5) as the reference level for the computation of the transmitter penalty ($TDECQ$ and $TDECQ_{CER}$). Additional editorial changes are presented to address comments #46.

- It considers comments #62 & #94 as an alternative approach

Outline

- Various OMA quantities at different reference point in the receiver/equalizer
- IEEE definitions of OMA_{outer}
  for ER, RINxOMA, overshoot
  for TDECQ estimate
  Which OMA for OMA – TDECQ metric in link budget?
- TECQ interpretation
- OMA_{outer} measurement interpretation
- Results for 3 modules reported in https://www.ieee802.org/3/dj/public/25_09/alloin_3dj_01b_2509.pdf
- Proposed editorial changes
- Summary of proposal of comments #1, #4 and recommendation
- Alternative approach via comments #62, #94

Various OMA quantities @ reference receiver in D2.3



Notes:

1) With the use of a DFE, OMA_{TDECQ} @ B ≠ OMA_{TDECQ} @ C
With a DFE = 0, OMA_{TDECQ} @ B = OMA_{TDECQ} @ C

2) With $\sum ffe = 1$, OMA_{TDECQ} @ A = OMA_{TDECQ} @ B

3) But in some cases, measured OMA_{outer} per SC. 180.9.5 ≠ OMA_{TDECQ} @ A

B = unnormalized DFE coefficient

ER, OMA measurements

OMA_{outer} is measured **"before the reference equalizer"**

180.9.5 Outer optical modulation amplitude (OMA_{outer})

The OMA_{outer} of each lane shall be within the limit given in Table 180–7. The OMA_{outer} is measured using a test pattern specified for OMA_{outer} in Table 180–14 as the difference between the average optical launch power level P_3, measured over the central 2 UI of a run of 7 threes, and the average optical launch power level P_0, measured over the central 2 UI of a run of 6 zeros, as shown in Figure 180–8. OMA_{outer} is measured using the waveforms captured at the output of the reference receiver defined in 180.9.2.

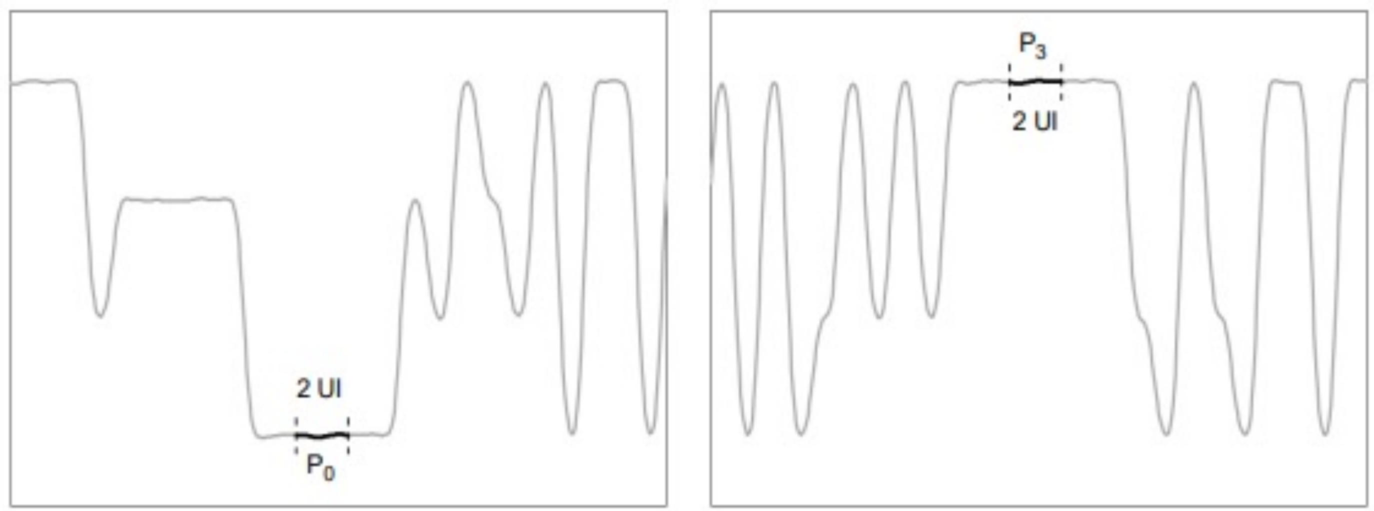


Figure 180–8—Example power levels P_0 and P_3 from PRBS13Q test pattern

TDECQ measurement

180.9.6 Transmitter and dispersion eye closure for PAM4 (TDECQ)

The TDECQ of each lane shall be within the limits given in Table 180–7.

TDECQ is a measure of each optical transmitter vertical eye closure when transmitted through a worst case optical channel specified in 180.9.6.2, as measured through a reference receiver specified in 180.9.2, and equalized with the reference equalizer as described in 180.9.6.3. The reference equalizer may be implemented in software or may be part of an oscilloscope.

For the TDECQ report, OMA_{TDECQ} is used and measured **"at the output of the reference equalizer"**

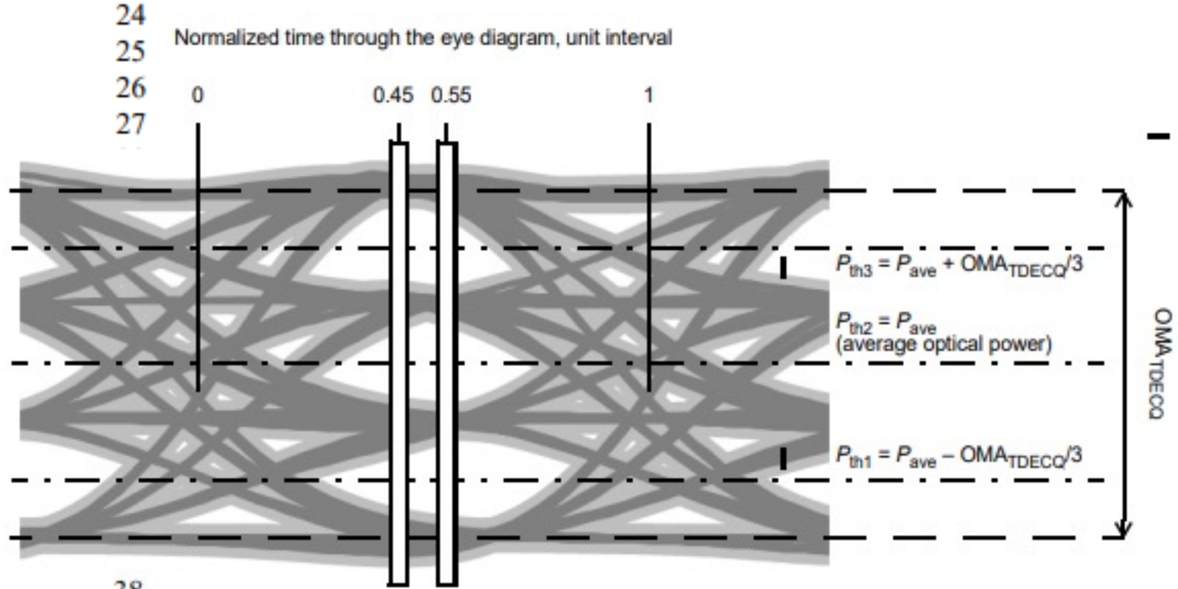


Figure 180–11—Illustration of the TDECQ measurement

TDECQ is given by Equation (180–12).

$$TDECQ = 10\log_{10}\left(\frac{OMA_{TDECQ}}{6} \times \frac{1}{Q_t R}\right) \quad (180\text{–}12)$$

where

OMA_{TDECQ}	is measured as defined in 180.9.5 except using waveforms captured at the output of the reference equalizer
Q_t	is 3.428, consistent with the target symbol error ratio for Gray mapped PAM4, and can be calculated according to Equation (180–27)

Link budget: OMA-TDECQ

The values of transmitter OMA_{outer} (max), transmitter OMA_{outer} (min) versus max (TECQ, TDECQ), and receiver sensitivity (OMA_{outer}) (max) versus TECQ are illustrated in Figure 180–5.

For Link budget calculation, it is ambiguous whether the OMA_{outer} considered is measured "before the reference equalizer" or "on the equalized signal"

Since OMA_{outer} -TDECQ is understood as the "usable" OMA of the TX as seen by the reference RX, both quantities need to be defined consistently.

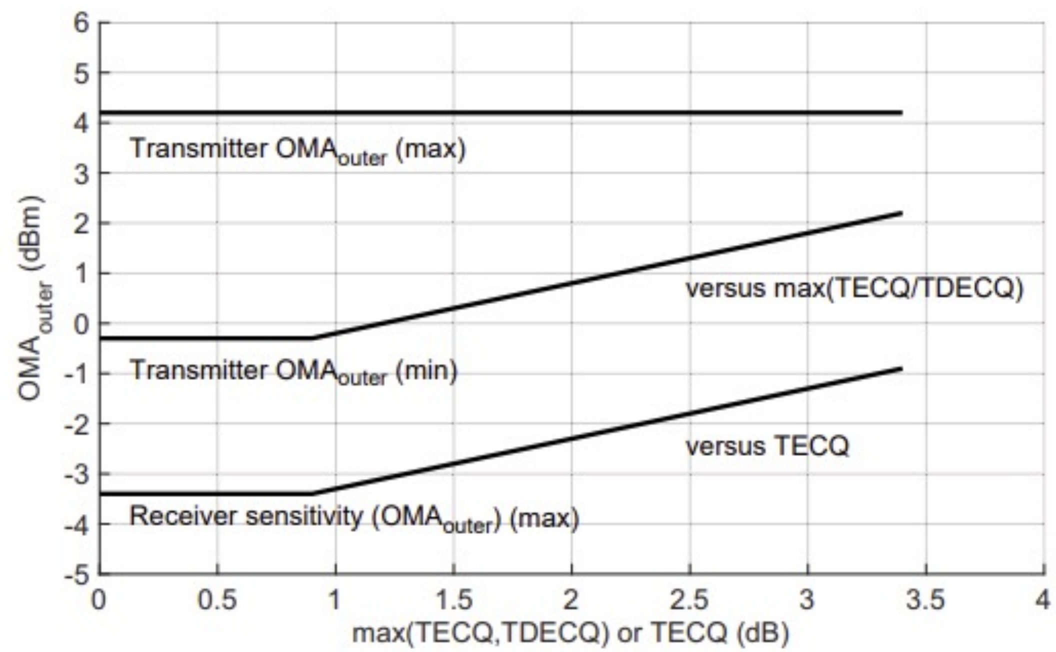
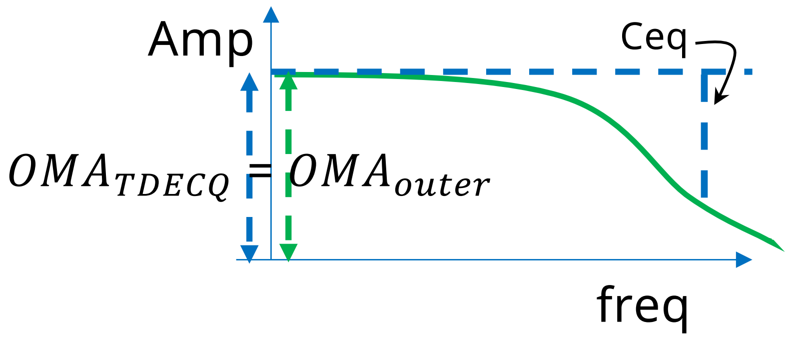


Figure 180–5—Transmitter OMA_{outer} each lane versus max(TECQ, TDECQ) and receiver sensitivity (OMA_{outer}) each lane versus TECQ

TECQ interpretation



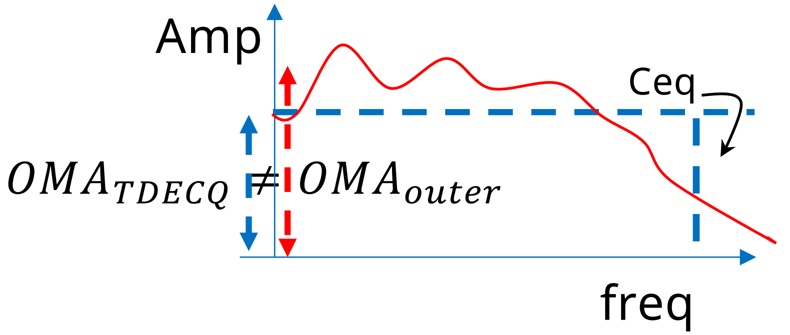
Example of a bandwidth limited transmitter:

Green: BW limited signal with Ceq $\neq 0$ and TECQ $\neq 0$

Blue: ideal reference PAM4 signal, against which the transmitter TECQ penalty is assessed

Here, without any reflections affecting the low frequency, with dfe =0:
OMA_{TDECQ} measured at the equalizer output = OMA_{outer} measured at the equalizer input, TECQ is correct!

What happens when reflections impact the low frequency (here destructively) , with dfe =0 ?



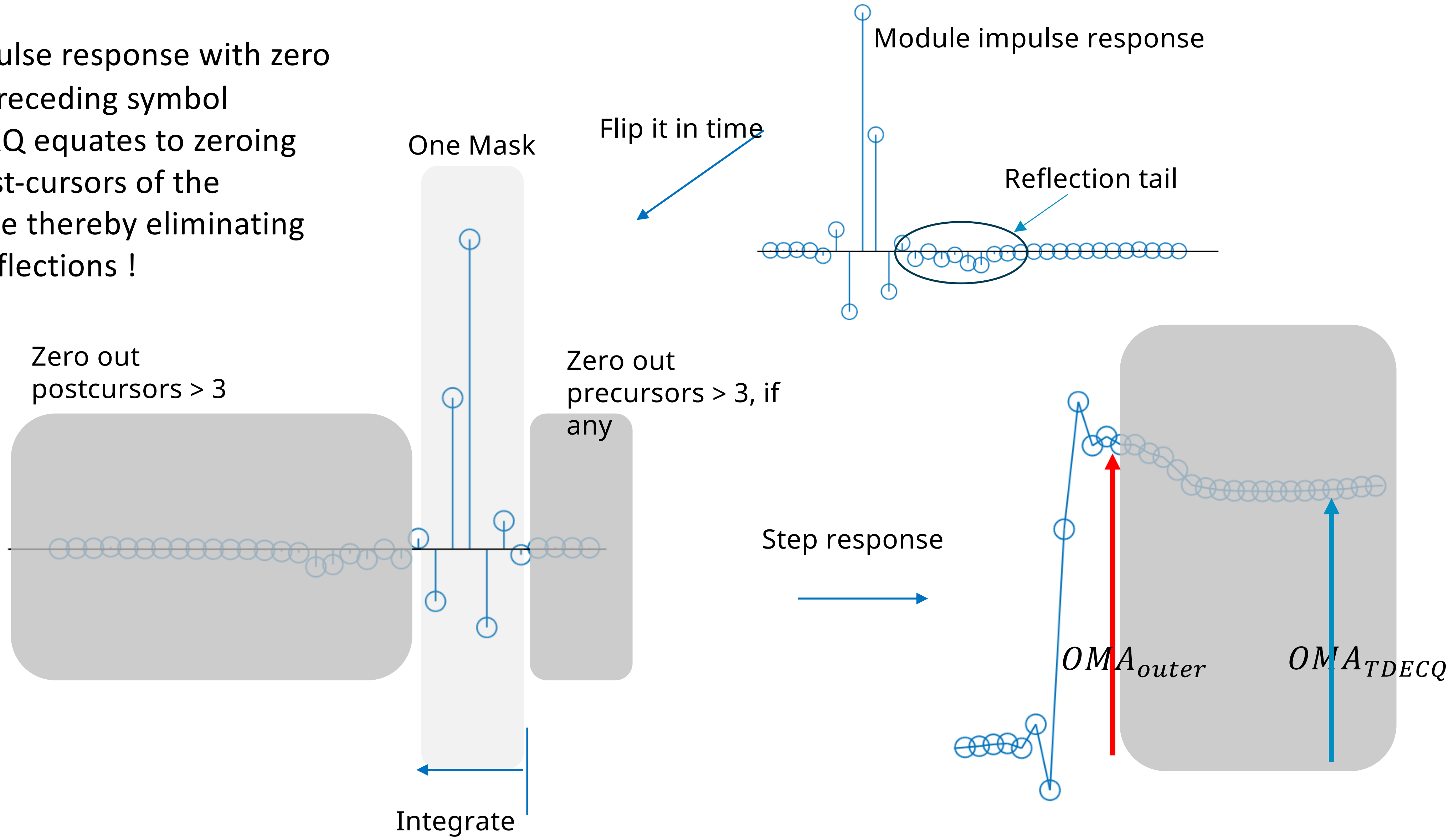
Red: BW limited signal with with Ceq $\neq 0$ and TECQ $\neq 0$, but also impacted by reflections

$OMA_{TDECQ} \neq OMA_{outer}$

TECQ is assessed against an ideal PAM4 signal of smaller amplitude, yielding low TECQ => TECQ, CEQ are incorrect!

OMA_{outer} measurement interpretation

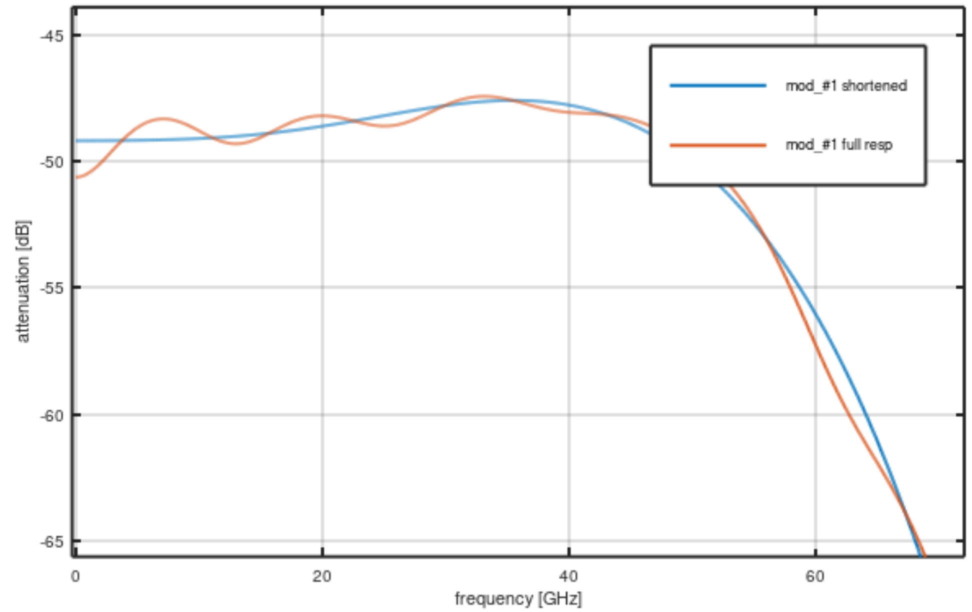
Convolving impulse response with zero mean random preceding symbol patterns of SSPRQ equates to zeroing out pre- and post-cursors of the impulse response thereby eliminating impact of the reflections !

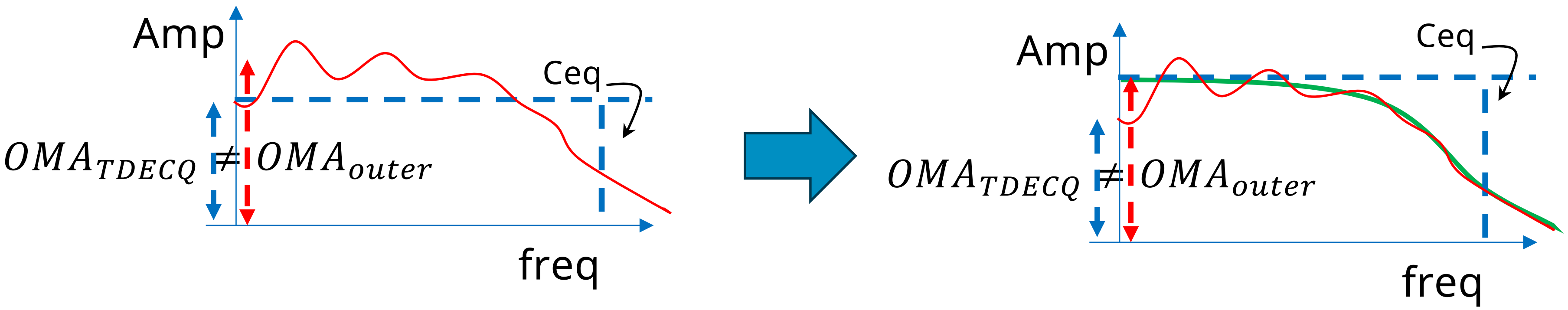


OMA_{outer} measurement interpretation (cont.)

The transfer function derived from the windowed impulse response properly reflects the module transfer function without the impact of the long tail reflections

The Low frequency quantity reflects the 'true' OMA_{outer} estimate representative of the actual waveform without the impact of the reflections. The windowed impulse response also preserves the BW limitation expected from the actual module





⇒ OMA_{outer} as per SC 180.9.5 is a better reference for TDECQ then OMA_{TDECQ}

OMA_{outer} estimate with SSPRQ / PRBS13Q

For 3 modules reported in https://www.ieee802.org/3/dj/public/25_09/alloin_3dj_01b_2509.pdf

OMA_{outer} estimate based on PRB13Q remains close to the SSPRQ estimate, despite its pattern being non-random. The OMA_{outer} estimate deviates significantly for module # 1 and #3 from the OMA_{TDECQ}

Module	**#1**	**#2**	**#3**	
Txpower	4.10	4.10	4.10	dBm
$\boldsymbol{OMA_{outer}}$ **(SSPRQ)**	3.13	3.28	3.37	dBm
$\boldsymbol{OMA_{outer}}$**(PRBS13Q)**	3.18	3.30	3.37	dBm
$\boldsymbol{OMA_{TDECQ}}$ **(SSPRQ)**	2.49	3.25	3.93	dBm
$\boldsymbol{OMA_{outer}}$ **(SSPRQ) -** $\boldsymbol{OMA_{TDECQ}}$ **(SSPRQ)**	0.64	0.02	-0.56	dBm

Note: OMA_{TDECQ} is measured here @ B with DFE B = 0

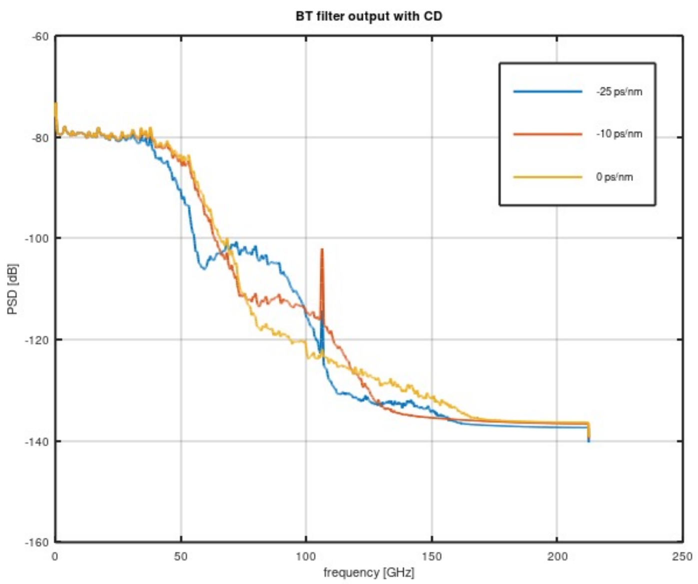
OMA_{outer} measurement interpretation (cont.)

Results with CD range for nominal module, 800GBASE- LR4:

Table 183–9—Optical channel characteristics

Description	800GBASE-FR4	800GBASE-LR4	Unit
Operating distance (max)	2	10	km
Channel insertion loss[a, b](max)	See Table 183–11	See Table 183–12	dB
Channel insertion loss (min)	0		dB
Positive dispersion[b] (max)	6.02	2.8	ps/nm
Negative dispersion[b] (min)	–11.26	–24.6	ps/nm
DGD_max[c]	2.3	4	ps
Optical return loss (min)	25	22	dB

CD	OMAouter [dBm]
	avg runs6+(3rd,4thUI only)
0 ps/nm	3.23
3 ps/nm	3.25
-25 ps/nm	3.19

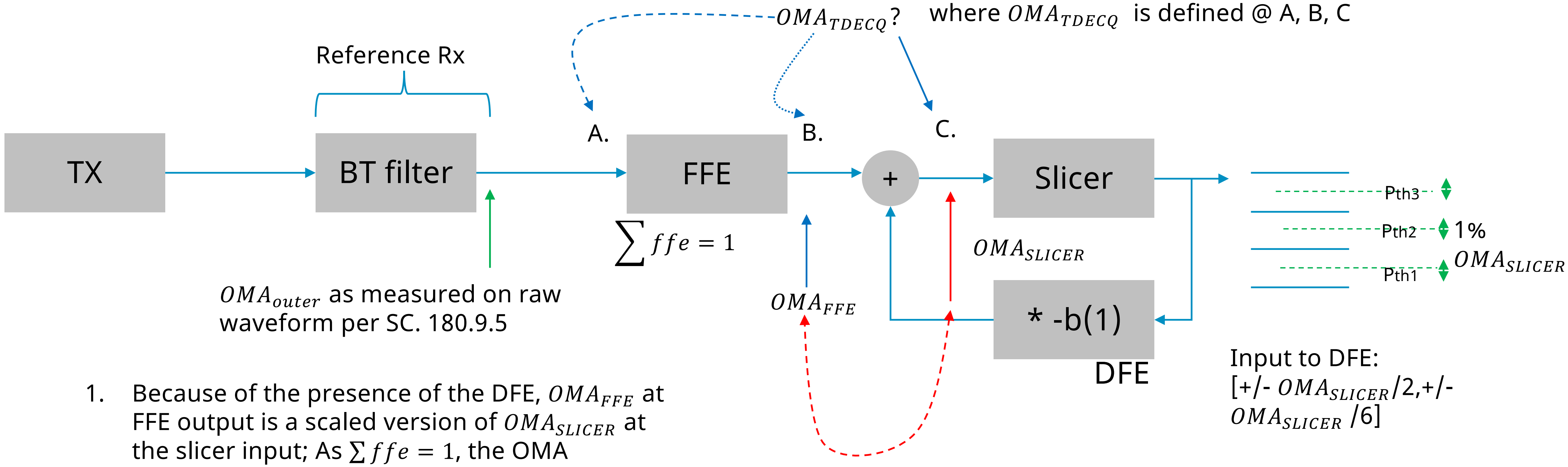


CD effect translates into the presence of a notch that gradually chips away the IM-DD signal bandwidth, but the low frequency signal content is preserved

=> OMA_{outer} estimate unaffected !

Various OMA quantities @ reference receiver in D2.3

Note: current D2.3 is ambiguous about where OMA_{TDECQ} is defined @ A, B, C



If DFE = b (b≥0 per Table 180-16)
=> OMA_{FFE} = OMA_{SLICER} * (1+b) in linear terms

1. Because of the presence of the DFE, OMA_{FFE} at FFE output is a scaled version of OMA_{SLICER} at the slicer input; As $\sum ffe = 1$, the OMA referenced at the input to the FFE is identical to its output: OMA_{SLICER} * (1+b)

2. However, the OMA referenced at the input to the FFE and derived from the equalizer output may still be different from the OMA_{outer} as measured per SC 180.9.5

Important note:
Relationship holds for b referenced to $OMA_{SLICER}/2$
If referencing b to $OMA_{outer}/2$ as in sub-note of Table 180-16, the relationship is OMA_{FFE} = OMA_{SLICER} / (1-b)

Proposed edits to D2.3

1. Keep OMA_{TDECQ} as defined at the equalizer output (FFE+DFE), as suggested by its definition line 46 p485, and in agreement with the definition of the reference equalizer in 180.9.6.3. (i.e. point C from prior slide)

where

$\text{OMA}_{\text{TDECQ}}$	is measured as defined in 180.9.5 except using waveforms captured at the output of the reference equalizer

If specified accordingly, then OMA_{TDECQ} is correctly used to determine threshold levels Pth1, Pth2, Pth3 (as currently in equations 180-1, 180-3, and depicted in Figure 180-11)

$$P_{th1} = P_{ave} - \frac{\text{OMA}_{\text{TDECQ}}}{3} \quad (180\text{–}1)$$

$$P_{th2} = P_{ave} \quad (180\text{–}2)$$

$$P_{th3} = P_{ave} + \frac{\text{OMA}_{\text{TDECQ}}}{3} \quad (180\text{–}3)$$

=> No changes !

Draft Amendment to IEEE Std 802.3-2022
IEEE P802.3dj 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Ethernet Task Force

IEEE *Draft* P802.3dj/D2.3
28 November 2025

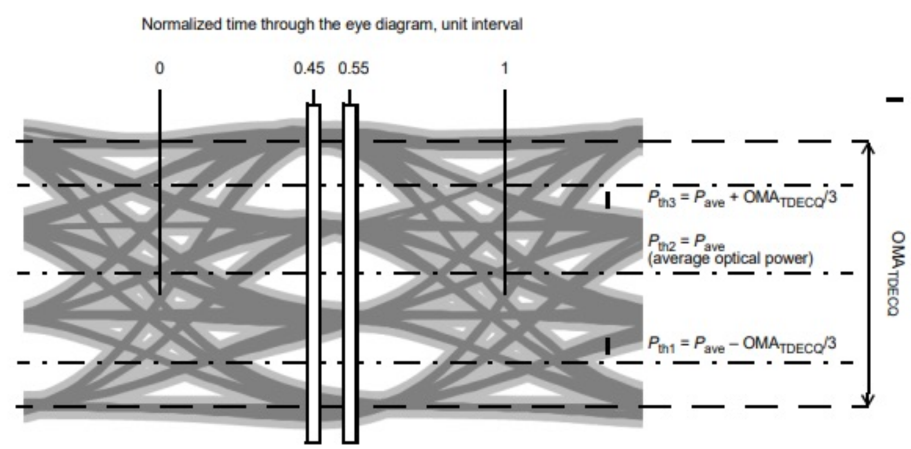


Figure 180–11—Illustration of the TDECQ measurement

Proposed edits to D2.3 (cont.)

2. Do not attempt "to reference the OMA_{TDECQ} to the input to the FFE", as the quantity to use to report the TDECQ penalty in eq. 180-12 should be OMA_{outer} as measured in SC 180.9.5

2a: Delete L 53 p 482 as per comment #46.

=> Changes !

The TDECQ reference point where $\mathrm{OMA_{TDECQ}}$ is referenced to and noise is added is at the input of the reference equalizer.

482

2b. Replace quantity OMA_{TDECQ} in the report of the TDECQ penalty (Eq. 180-12), by OMA_{outer} as measured at the input to the reference equalizer (SC 180.9.5).

TDECQ is given by Equation (180–12).

=> Changes !

$$\mathrm{TDECQ} = 10\log_{10}\left(\frac{\mathrm{OMA_{TDECQ}}}{6} \times \frac{1}{Q_t R}\right) \qquad (180\text{–}12)$$

Proposed edits to D2.3 (cont.)

3. Replace quantity OMA_{TDECQ} in the report of the $TDECQ_{CER}$ penalty (Eq. 180-25, Eq. 180-26), by OMA_{outer} as measured at the input to the reference equalizer (SC 180.9.5).

$$\mathrm{TDECQ_{CER}} = 10\log_{10}\left(\frac{\sigma_{\mathrm{ref}}}{R}\right) \qquad (180\text{–}25)$$

where σ_{ref} is defined in Equation (180–26).

=> Changes !

$$\sigma_{\mathrm{ref}} = \frac{\mathrm{OMA_{TDECQ}}}{6Q_t} \qquad (180\text{–}26)$$

where:

$\mathrm{OMA_{TDECQ}}$	is measured as defined in 180.9.5 except using waveforms captured at the output of the reference equalizer,

488

Proposed edits to D2.3 (cont.)

~~4. In Table 180-16, line 24, p482 : the DFE coefficient b(1) should be referenced to OMA_{TDECQ} /2 measured at the output of the equalizer (FFE+DFE), not OMA_{outer} /2.~~

~~b(1) Maximum may need to be updated from 0.3 to 0.43~~

We do not recommend change to the current DFE normalization, as the current normalization is sufficient for its use in the tap limit equations !

Table 180–16—Reference equalizer tap coefficients

Parameter	Symbol	Value	
		Minimum	Maximum
Normalized equalizer coefficient limits:	$w(i)/w(0)$		
$i = -3$		–0.15	0.1
$i = -2$		–0.1	0.25
$i = -1$		–0.5	0.1
$i = 1$		–0.6	0.2
$i = 2$		–0.2	0.3
$i = 3$		–0.15	0.15
$i = 4$		–0.15	0.15
$i = 5$		–0.15	0.15
$i = 6$		–0.15	0.15
$i \geq 7$		–0.1	0.1
Pre-post equalizer coefficient difference limit: $\lvert w(1)/w(0) - b(1) - w(-1)/w(0) \rvert$	—	—	0.25
Equalizer DC gain[a]	—	1	
Decision feedback equalizer (DFE) length	N_b	1	
DFE coefficient limit[b]	$b(1)$	0	0.3

=> No Changes !

[a] The sum of all 15 equalizer coefficients, $w(i)$.
[b] The DFE coefficient $b(1)$ is referenced to $OMA_{outer}/2$ measured at the input of the FFE equalizer.

=> NO Changes !

Summary / proposal

- Currently, the TDECQ metric is associated with OMA_{TDECQ} measured on the equalized signal, while OMA_{outer} used in the link budget via the OMA_{outer} -TDECQ performance metric is measured on the un-equalized signal.

- With the extension to 15 tap reference equalizer (min 12 post-cursors), the two OMA quantities may differ significantly for modules impacted by certain reflections. Hence, the OMA_{outer} -TDECQ is no longer consistent across different modules.

- We showed that the OMA_{outer} estimate measured as per CL 180.9.5 is not impacted by the presence of those reflections. It therefore constitutes the desired OMA reference level of the ideal PAM4 signal against which the TECQ penalty of the module should be assessed.

- The solution is therefore to use OMA_{outer}, as measured per SC 180.9.5, for the report of TDECQ/TECQ in eq. 180-12 , and eq.180-26 for the report of $TDECQ_{CER}$

Recommendation

We recommend implementing the sole changes that are captured in edits proposed as 2a/2b in slide 16 for TDECQ and as 3 in slide 17 for TDECQ-CER.

It corrects ambiguities in the current spec, addresses the issue for modules where $OMA_{outer} \neq OMA_{TDECQ}$ and the usage of the quantity OMAouter- TDECQ in the link budget without consequences for nominal modules. It requires minimum editorial changes and does not alter the TDECQ and TDECQ_CER optimization procedure itself.

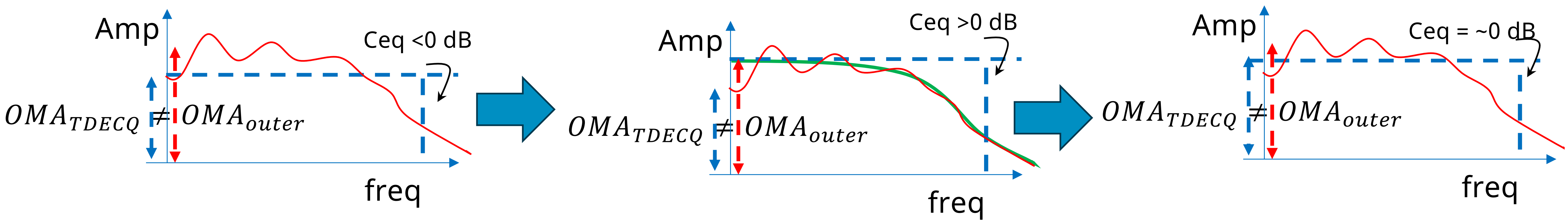
Alternative approach

- Comments #62 & #94 proposed to change OMA_{outer} measurement at the output of equalizer with equalizer main tap fixed to unity.

- Together, comments #62 & #94 address the ambiguity when the two OMA quantities OMA_{outer} and OMA_{TDECQ} may differ significantly for modules impacted by certain reflections. It eliminates one of the 2 quantities.

- TDECQ metric reported with OMA_{TDECQ} now determined by the constraint that main ffe Tap = 1, yields effectively Ceq ~ 0dB. The BW penalty (Eq. noise enhancement) captured in the Ceq metric, is taken out of TDECQ penalty and transferred to OMA_{TDECQ}

- For a nominal module, expect OMA and TDECQ to reduce by Ceq => change OMAmin and TDECQ/TECQ limits



Alternative approach (cont.)

- Comments #62 & #94 proposed to change OMA_{outer} measurement at output of equalizer with equalizer main tap fixed to unity.

	Ref eq	Normalization	Mod# 1	Mod# 2	Mod# 3	OMAouter
#1 & #4	NA		3.14	3.25	3.32	@ BT out
D2.3	15 taps-3pre	Sum(ffe) = 1	2.53	3.24	3.91	@ ffe out
#62 & #94		ffe(4) = 1	2.70	2.67	2.71	@ ffe out
Other possible normalization schemes		Sum(ffe(1:7)) = 1	3.07	3.24	3.37	@ ffe out
	7 taps-3pre	Sum(ffe) = 1	3.09	3.26	3.38	@ ffe out
	5 taps-2pre	Sum(ffe) = 1	3.11	3.25	3.32	@ ffe out

- For a nominal module (Mod#2), expect OMA and TDECQ to reduce by Ceq (i.e. 0.3 to 0.5dB in above table)

- Moreover, the OMA measured at the output of the equalizer would be dependent on the fiber (thru. CD among other): i.e. it would respond to bandwidth changes in the *modulated* channel too, which is inconvenient

Additional edits to D2.3 (cont.) for comments #62 & #94

It is understood that Heq(f) of the reference equalizer is the FFE portion of the FFE + DFE in Eq 180-9.

The value of C_{eq} can be calculated from the product of the normalized noise power density spectrum $N(f)$ at the input of the reference equalizer and the normalized frequency response $H_{eq}(f)$ of the reference equalizer, as shown in Equation (180–9).

$$C_{eq} = \sqrt{\int_f N(f) \times |H_{eq}(f)|^2 df} \qquad (180\text{–}9)$$

The normalization of the sum of the FFE taps to unity should be taken out. Eq.180-10

=> Changes !

$$\int_f N(f) df = H_{eq}(f = 0) = 1 \qquad (180\text{–}10)$$

Threshold definitions in Eq 180-1/3 need to change, as $H_{eq}(f = 0) \neq 1$,

=> Changes !

$$P_{th1} = P_{ave} - \frac{OMA_{TDECQ}}{3} \qquad (180\text{–}1)$$

$$P_{th2} = P_{ave} \qquad (180\text{–}2)$$

$$P_{th3} = P_{ave} + \frac{OMA_{TDECQ}}{3} \qquad (180\text{–}3)$$

Additional edits to D2.3 (cont.) for comments #62 & #94

figure 180-11 with the threshold definitions in Eq 180-1/3 will have to change

=> Changes !

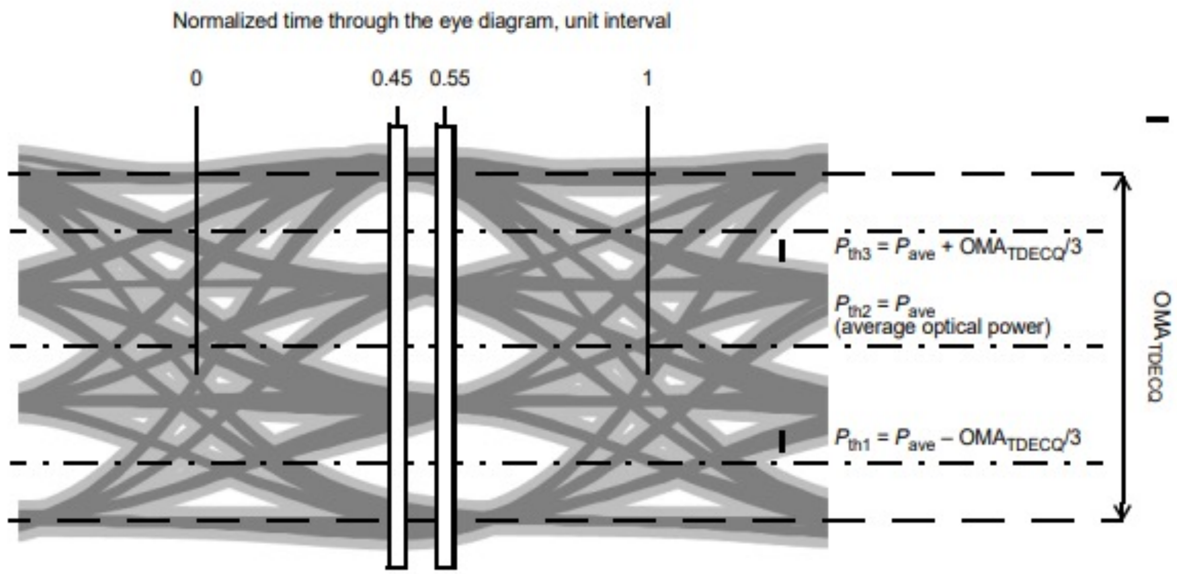


Figure 180–11—Illustration of the TDECQ measurement

And equations 180-4 thru. 180-8 needs to checked to account for the equalizer gain $H_{eq}(f = 0) \neq 1$, and threshold changes

=> Changes ?

$$CF_{L1}(y_i) = \begin{cases} \sum_{y = P_{th1}}^{y_i} F(y) \text{ for } y_i \geq P_{th1} \\ \sum_{y = y_i}^{P_{th1}} F(y) \text{ for } y_i < P_{th1} \end{cases} \qquad (180\text{–}4)$$

Additional edits to D2.3 (cont.) for comments #62 & #94

And equations 180-4 thru. 180-8 needs to be checked to account for for the equalizer gain $H_{eq}(f = 0) \neq 1$, and threshold changes

$$G_{\mathrm{th1}}(y_i) = \int_{y_i - \frac{\Delta y}{2}}^{y_i + \frac{\Delta y}{2}} \frac{1}{C_{\mathrm{eq}}\sigma_G\sqrt{2\pi}} \times e^{-\left(\frac{y - P_{\mathrm{th1}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)^2} dy \qquad (180\text{–}5)$$

=> Changes ?

$$G_{\mathrm{th1}}(y_i) = \frac{1}{C_{\mathrm{eq}}\sigma_G\sqrt{2\pi}} \times e^{-\left(\frac{y_i - P_{\mathrm{th1}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)^2} \times \Delta y \qquad (180\text{–}6)$$

$G_{\mathrm{th2}}(y_i)$ and $G_{\mathrm{th3}}(y_i)$ are similar Gaussian probability density functions with the same RMS value of σ_G, centered around the sub-eye thresholds P_{th2} and P_{th3} respectively. $G_{\mathrm{th2}}(y_i)$ and $G_{\mathrm{th3}}(y_i)$ are given by Equation (180–7) and Equation (180–8) respectively.

$$G_{\mathrm{th2}}(y_i) = \int_{y_i - \frac{\Delta y}{2}}^{y_i + \frac{\Delta y}{2}} \frac{1}{C_{\mathrm{eq}}\sigma_G\sqrt{2\pi}} \times e^{-\left(\frac{y - P_{\mathrm{th2}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)^2} dy \qquad (180\text{–}7)$$

=> Changes ?

$$G_{\mathrm{th3}}(y_i) = \int_{y_i - \frac{\Delta y}{2}}^{y_i + \frac{\Delta y}{2}} \frac{1}{C_{\mathrm{eq}}\sigma_G\sqrt{2\pi}} \times e^{-\left(\frac{y - P_{\mathrm{th3}}}{C_{\mathrm{eq}}\sigma_G\sqrt{2}}\right)^2} dy \qquad (180\text{–}8)$$

Alternative approaches – NOT recommended

1) Address comments #46 only
- Corrects ambiguities in the spec., but requires yet a new definition of OMA at the FFE input alongside OMA_{TDECQ} , if the later is kept at the equalizer output
- It does not address issue for modules where $OMA_{outer} \neq OMA_{TDECQ}$
- Does not change interpretation of OMA_{outer} nor TDECQ penalty for nominal modules

2) Implement changes per comments #62 , #94
- Corrects ambiguities in the spec.
- Addresses issue for modules where $OMA_{outer} \neq OMA_{TDECQ}$
- It changes interpretation of OMA_{outer} and TDECQ penalty for nominal modules => requires likely $OMA_{outer}\ (min)$, $OMA_{outer}\ (max)$ and TDECQmax limit changes
- The new OMA reference is dependent on the fiber length. This issue needs to be addressed.

3) Do nothing until SA ballot (we know the issue; we know how to correct it properly with the recommended solution)

Backup

Comments # 1 and #4

Cl **180** *SC* **180.9.6.4** *P* **485** *L* **41** # 4

Maniloff, Eric Ciena

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

Discrepancy in optical modulation amplitude used for OMAouter – T(D)ECQ penalty computation in link budget:
To compute the link budget the transmitter penalty (TECQ,TDECQ) per equation 180-12 is to be subtracted from the OMAouter measured per SC 180.9.5. However, in SC 180.9.6.4, equation 180-12 suggests using OMATDECQ as the reference level of the ideal PAM4 signal for computation of the transmitter penalty (TECQ,TDECQ). In case, OMAouter measured per SC 180.9.5 and OMATDECQ computed per SC 180.9.6.4 differ, the quantity OMAouter-TECQ or OMAouter-TDECQ used in the link budget will be incorrect.

SuggestedRemedy

In equation 180-12, substitute OMATDECQ with OMAouter (measured per SC 180.9.5) in the report of the TDECQ penalty.

Proposed Response *Response Status* **O**

Cl **180** *SC* **180.9.7.1** *P* **488** *L* **47** # 1

Maniloff, Eric Ciena

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

Discrepancy in optical modulation amplitude used for OMAouter – TDECQCER penalty computation in link budget:
To compute the link budget the transmitter penalty (TDECQCER) per equation 180-25 is to be subtracted from the OMAouter measured per SC 180.9.5. However, in SC 180.9.7.1, equation 180-26 suggests using OMATDECQ as the reference level of the ideal PAM4 signal for computation of the transmitter penalty (TDECQCER). In case, OMAouter measured per SC 180.9.5 and OMATDECQ computed per SC 180.9.7.1 differ, the quantity OMAouter- TDECQCER used in the link budget will be incorrect.

SuggestedRemedy

In equation 180-26, substitute OMATDECQ with OMAouter (measured per SC 180.9.5) in the report of the TDECQCER penalty.

Proposed Response *Response Status* **O**

Comments # 50 and #52

Cl **180** *SC* **180.9.6.4** *P* **485** *L* **41** # 50

Rodes, Roberto Coherent

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

TDECQ in 180-12 is a penalty on the OMA to calculate the Link power budget. Therefore, OMA in equation 180-12 should be equivalent to OMAouter as defined in 180.9.5.

SuggestedRemedy

Replace OMAtdecq with OMAouter in equation 180-12,and use editorial license to align the rest of the text in the subclause to this change

Proposed Response *Response Status* **O**

Cl **180** *SC* **180.9.8** *P* **488** *L* **46** # 52

Rodes, Roberto Coherent

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

TDECQCER in 180-25 is meant to be a penalty on the OMA to calculate the Link power budget. Therefore, OMA in equation 180-26 should be equivalent to OMAouter as defined in 180.9.5.

SuggestedRemedy

Replace OMAtdecq with OMAouter in equation 180-26,and use editorial license to align the rest of the text in the subclause to this change

Proposed Response *Response Status* **O**

Comments # 157 and #158

Cl **180** *SC* **180.9.6.4** *P* **485** *L* **42** # 157

Mi, Guangcan Huawei Technologies Co., Ltd.

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

TDECQ is comparing the maximum additive noise to the optical power in OMA as measurement of the eye opening. Therefore the OMA used in equation 180-12 and noise R should be measured at the same point, which is OMA_outer

SuggestedRemedy

change the OMA_TDECQ in equation 180-12 to OMA_outer, and update its definition text accordingly.

Proposed Response *Response Status* **O**

Cl **180** *SC* **180.9.6.4** *P* **482** *L* **53** # 158

Mi, Guangcan Huawei Technologies Co., Ltd.

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

OMA_TDECQ is used to calculate the threshold power, Pth_1 and Pth_2, which is set accroding to the equalized eye diagram as shown in Figure 180-11. OMA_TDECQ should not be measured at the input of the equalizer.

SuggestedRemedy

add the definition of OMA_TDECQ, "is measured as defined in 180.9.5 except using waveforms captured at the output of the reference equalizer". Noise is added at the input of the reference equalizer.

Proposed Response *Response Status* **O**

Comments #46

Cl **180** *SC* **180.9.6.4** *P* **482** *L* **53** # 46

Brown, Matt Alphawave Semi

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

In the sentence "The TDECQ reference point where OMATDECQ is referenced to and noise is added is at the input of the reference equalizer." it is not clear what these reference points are. Further, the measurement point for OMA_TDEQ contradicts the text on page 485 line 46 and 488 line 52. If these are intended to be the same point then one or the other locations needs to be corrected. If they are intended to be different, then a different parameter name should be used. Finally, the definition of OMA_TDECQ should be colocated where it is used, e.g., along with equation 180-1 through 180-3.

SuggestedRemedy

Reconcile the measurement points for OMA_TDECQ or use different parameter names.
Define OMA_TDECQ where it is referenced in equations, e.g., page 483 line 45.
Delete the sentence at page 482 line 53. Note that another comment deals with the mention of noise in this sentence.

Proposed Response *Response Status* **O**

Comments #62

Cl **180** *SC* **180.9.6.3** *P* **482** *L* **23** # 62

Ran, Adee Cisco Systems

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

Footnote a (attached to the "Equalizer DC gain" row) says "The sum of all 15 equalizer coefficients, w(i)."

The DC gain is the response to an infinite run of identical symbols (with a certain nominal level) at the input, divided by that level. When the equalizer consists of only an FFE, it is indeed the sum of the coefficients. But with the DFE (which subtracts the nominal symbol level from the output) the sum of the FFE taps is no longer the DC gain. If the sum of w(i) is set to 1 then the DC gain will be 1-b(1).

However, "unity DC gain" is an arbitrary choice and perhaps not the best requirement.

Since the reference equalizer is long, it is likely to address not just limited bandwidth but also frequency ripple (e.g. reflections). In this case it is preferable to normalize the equalizer in a different way, to maintain the nominal levels equal before and after the equalizer; This requires that the normalization is to have w(0)=1 instead.
(rationale: in convolution of the equalizer and the pulse response, w(0) is multiplied by the nominal level of the symbol x(n)*h(0), creating the four levels of the eye diagram; other coefficients are multiplied by previous or subsequent symbols x(n+k)h(n-k+i); these terms have zero mean because the symbols are uncorrelated and equiprobable).

This would enable measuring OMA at the equalizer output and having only one definition of OMA.

A related change in the calculation of OMA_outer is suggested in another comment.

Note that this change does not affect TDECQ because the noise amplification is calculated from the equalizer's response, which is scaled by the same factor.

SuggestedRemedy

Add limits for i=0: min=1, max=1.
Change the "symbol" for limits to w(i) (no need to divide by w(0) since it is 1).
Delete the row for "Equalizer DC gain" and the footnote.
In equation 180-10, delete the middle term "H_eq(f=0)=" (the DC gain), because it is not equal to 1 anymore.

Delete the definition of OMA_TDECQ and change all instances of "OMA_TDECQ" to "OMA_outer".

Apply corresponding changes in clauses 181, 182, and 183.
A detailed proposal is planned.

Proposed Response *Response Status* **O**

Comments #94

Cl **180** *SC* **180.9.5** *P* **478** *L* **43** # 94

Ran, Adee Cisco Systems

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

"OMAouter is measured using the waveforms captured at the output of the reference receiver defined in 180.9.2"
As noted in previous comments, the illustration of the signal in Figure 180-8 does not match this statement; the signal in the figure is fully equalized. Indeed, in a non-equalized signal, there will likely be no flat region in a 6-UI run (noting that the reference equalizer is longer).

In another comment I am suggesting that the reference equalizer should be normalized to have c(0)=1. With this modification, the nominal 0 and 3 levels will be the same before and after the equalizer, but the eye diagram will be open, and thus OMA_outer will be measurable at the equalizer output on flat regions. This will also match the illustration in Figure 180-8.

The benefit of these two changes is that OMA_outer matches the original meaning of the distance between nominal levels measured without equalization (e.g. with an NRZ modulated pattern). Also, there is no need for two different definitions of OMA.

SuggestedRemedy

Change "at the output of the reference receiver defined in 180.9.2" to "at the output of the reference equalizer defined in 180.9.6.3".
Apply corresponding changes in clauses 181, 182, and 183.
A detailed proposal is planned.

Proposed Response *Response Status* **O**

Thank you