Concerning Comments r03-21, -22, -36, -39, -42, -43 On TDECQ

20180628

P802.3cd Ad Hoc

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In Support Of Comments r03-21, r03-43 Against 50GBASE-FR/LR In P802.3cd D3.3

Cl **139** *SC* **139.6** *P* **293** *L* **43** # r03-21

Tamura, Kohichi — Oclaro

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

In D3.2, 1% OMA threshold adjustment was introduced to the TDECQ algorithm in order to improve the yields of transmitters with slightly unequal eye levels and to improve correlation between changes in TDECQ and receiver sensitivity. Real receivers have threshold adjustment capability exceeding 1%, so the changes will mainly benefit transmitters with some nonlinearity, such as DML, but not adversely impact receivers. However, in D3.3, TDECQ (max) of 50GBASE-FR and 50GBASE-LR were reduced from 3.2 dB to 2.8 dB and from 3.4 dB to 3 dB, respectively, which negated the improvement gained with threshold adjustment. Furthermore, highly linear transmitters, for which TDECQ is the same with or without threshold adjustment, were penalized by a reduction in TDECQ (max) by 0.4 dB.

SuggestedRemedy

In Table 139-6, change TDECQ (max) of 50GBASE-FR from 2.8 dB to 3.2 dB.
In Table 139-6, change TDECQ (max) of 50GBASE-LR from 3 dB to 3.4 dB.

These changes will require additional changes as described below in other parts of the draft.
In Table 139-7, change "Stressed receiver sensitivity ... (max)" of 50GBASE-FR from -5.5 dB to -5.1 dB.
In Table 139-7, change "Stressed receiver sensitivity ... (max)" of 50GBASE-LR from -6.8 dB to -6.4 dB.
In Table 139-7, change foot note "c" from "... SECQ up to 2.8 dB for 50GBASE-FR and 3 dB for 50GBASE-LR." to "... SECQ up to 3.2 dB for 50GBASE-FR and 3.4 dB for 50GBASE-LR."
In Table 139-8, change "Power budget" of 50GBASE-FR from 7.2 dB to 7.6 dB.
In Table 139-8, change "Power budget" of 50GBASE-LR from 9.9 dB to 10.3 dB.
In Table 139-8, change "Allocation for penalties" of 50GBASE-FR from 3.2 dB to 3.6 dB.
In Table 139-8, change "Allocation for penalties" of 50GBASE-LR from 3.6 dB to 4 dB.
In 139.7.9, change "... SECQ up to 2.8 dB" to "... SECQ up to 3.2 dB" for 50GBASE-FR
In 139.7.9, change "... SECQ up to 3 dB" to "... SECQ up to 3.4 dB" for 50GBASE-LR.
In 139.7.9, change Figure 139-6 so that curves include SECQ of 3.2 dB and 3.4 dB for 50GBASE-FR and 50GBASE-LR, respectively.

Proposed Response *Response Status* **O**

Cl **139** *SC* **139.6** *P* **293** *L* **43** # r03-43

Liu, Hai-Feng — Intel Corporation

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

The primary benefit of introducing threshold adjustment in D3.2 was to improve the TDECQ and link BER penalty correlation. This change would also relax the TDECQ for those Tx with unequal sub-eyes. In D3.3, TDECQmax was reduced to keep the maximum sub-eye inequality no greater than before threshold adjustment was added. However, the proposed 0.4 dB reduction from 3.4 dB to 3 dB was based on the simulation/measurement for the worst symmetric eye compression case under 1% threshold adjustment. Applying the same 0.4 dB reduction in TDECQ max across the board will unnecessarily penalize a large portion of good Tx that would have nearly equal sub-eyes. These Tx will gain little in terms of TDECQ from the threshold adjustment, but the 0.4 dB reduction in TDECQmax will result in significant loss. In addition, the worst symmetric eye compression case is far from practical as it can be avoided at least for MZI and EML based Tx.

SuggestedRemedy

In Table 139-6, change TDECQ (max) of 50GBASE-FR from 2.8 dB to 3.2 dB.
In Table 139-6, change TDECQ (max) of 50GBASE-LR from 3 dB to 3.4 dB.
In Table 139-7, change "Stressed receiver sensitivity ... (max)" of 50GBASE-FR from -5.5 dB to -5.1 dB.
In Table 139-7, change "Stressed receiver sensitivity ... (max)" of 50GBASE-LR from -6.8 dB to -6.4 dB.
In Table 139-7, change "Stress eye closure for PAM4 (SECQ) of 50GBASE-FR from 2.8 dB to 3.2 dB
In Table 139-7, change "Stress eye closure for PAM4 (SECQ) of 50GBASE-LR from 3 dB to 3.4 dB
In Table 139-7, change foot note "c" from "... SECQ up to 2.8 dB for 50GBASE-FR and 3 dB for 50GBASE-LR." to "... SECQ up to 3.2 dB for 50GBASE-FR and 3.4 dB for 50GBASE-LR."
In Table 139-8, change "Power budget" of 50GBASE-FR from 7.2 dB to 7.6 dB.
In Table 139-8, change "Power budget" of 50GBASE-LR from 9.9 dB to 10.3 dB.
In Table 139-8, change "Allocation for penalties" of 50GBASE-FR from 3.2 dB to 3.6 dB.
In Table 139-8, change "Allocation for penalties" of 50GBASE-LR from 3.6 dB to 4 dB.
In 139.7.9, change "... SECQ up to 2.8 dB" to "... SECQ up to 3.2 dB" for 50GBASE-FR
In 139.7.9, change "... SECQ up to 3 dB" to "... SECQ up to 3.4 dB" for 50GBASE-LR.

Proposed Response *Response Status* **O**

In Support Of Comments r03-22, r03-42 Against 100GBASE-DR In P802.3cd D3.3

Cl **140** *SC* **140.6** *P* **318** *L* **42** # r03-22

Tamura, Kohichi — Oclaro

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

In D3.2, 1% OMA threshold adjustment was introduced to the TDECQ algorithm in order to improve the yields of transmitters with slightly unequal eye levels and to improve correlation between changes in TDECQ and receiver sensitivity. Real receivers have threshold adjustment capability exceeding 1%, so the changes will mainly benefit transmitters with some nonlinearity, such as DML, but not adversely impact receivers. However, in D3.3, TDECQ (max) of 100GBASE-DR reduced from 3.4 dB to 3 dB, which negated the improvement gained with threshold adjustment. Furthermore, highly linear transmitters, for which TDECQ is the same with or without threshold adjustment, were penalized by a reduction in TDECQ (max) by 0.4 dB.

SuggestedRemedy

In Table 140-6, change "TDECQ (max)" of 100GBASE-DR from 3 dB to 3.4 dB.
In Table 140-7, change "stressed receiver sensitivity ... (max)" of 100GBASE-DR from -2.3 dB to -1.9 dB.
In Table 140-7, change foot note "c" from "... SECQ up to 3 dB." to "... SECQ up to 3.4 dB."
In Table 140-7, change the "Stressed eye closure for PAM4 (SECQ)" from 3 dB to 3.4 dB
In Table 140-8, change "Power budget" of 100GBASE-DR for extinction ratio >= 5 dB from 6.1 dB to 6.5 dB.
In Table 140-8, change "Power budget" of 100GBASE-DR for extinction ratio < 5 dB from 6.4 dB to 6.8 dB.
In Table 140-8, change "Allocation for penalties" of 100GBASE-DR for extinction ratio >= 5 dB from 6.1 dB to 6.5 dB.
In Table 140-8, change "Allocation for penalties" of 100GBASE-DR for extinction ratio < 5 dB from 6.4 dB to 6.8 dB.
In 140.7.9, change "...SECQ up to 3 dB" to "...SECQ up to 3.4 dB"
In 140.7.9, change Figure 140-5 so curve includes up to SECQ of 3.4 dB.

Proposed Response *Response Status* **O**

Cl **140** *SC* **140.6** *P* **318** *L* **42** # r03-42

Liu, Hai-Feng — Intel Corporation

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

The primary benefit of introducing threshold adjustment in D3.2 was to improve the TDECQ and link BER penalty correlation. This change would also relax the TDECQ for those Tx with unequal sub-eyes. In D3.3, TDECQmax was reduced to keep the maximum sub-eye inequality no greater than before threshold adjustment was added. However, the proposed 0.4 dB reduction from 3.4 dB to 3 dB was based on the simulation/measurement for the worst symmetric eye compression case under 1% threshold adjustment. Applying the same 0.4 dB reduction in TDECQ max across the board will unnecessarily penalize a large portion of good Tx that would have nearly equal sub-eyes. These Tx will gain little in terms of TDECQ from the threshold adjustment, but the 0.4 dB reduction in TDECQmax will result in significant loss. In addition, the worst symmetric eye compression case is far from practical as it can be avoided at least for MZI and EML based Tx.

SuggestedRemedy

In Table 140-6, change "TDECQ (max)" of 100GBASE-DR from 3 dB to 3.4 dB.
In Table 140-7, change "stressed receiver sensitivity ... (max)" of 100GBASE-DR from -2.3 dB to -1.9 dB.
In Table 140-7, change foot note "c" from "... SECQ up to 3 dB." to "... SECQ up to 3.4 dB."
In Table 140-8, change "Power budget" of 100GBASE-DR for extinction ratio >= 5 dB from 6.1 dB to 6.5 dB.
In Table 140-7, change the Stressed eye closure for PAM4 (SECQ) from 3 dB to 3.4 dB
In Table 140-8, change "Power budget" of 100GBASE-DR for extinction ratio < 5 dB from 6.4 dB to 6.8 dB.
In Table 140-8, change "Allocation for penalties" of 100GBASE-DR for extinction ratio >= 5 dB from 6.1 dB to 6.5 dB.
In Table 140-8, change "Allocation for penalties" of 100GBASE-DR for extinction ratio < 5 dB from 6.4 dB to 6.8 dB.
In page 323, 140.7.9, Change "...SECQ up to 3 dB" to "...SECQ up to 3.4 dB"

Proposed Response *Response Status* **O**

In Support Of Comment r03-39 Against 50GBASE-FR/LR And 100GBASE-DR In P802.3cd D3.3

Cl **138** *SC* **138.8.10** *P* **275** *L* **43** # r03-39

Dawe, Piers J G — Mellanox Technologie

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

The rule of "at least half of the dB value of the stressed eye closure" is not consistent with the transmitter specs (D3.2 comment 55) for any of the optical PMDs.

SuggestedRemedy

When we have decided where the corner between the "top limit" and the "diagonal limit" on the TDECQ map is (see other comments), align the SRS range to that:
Add another exception, saying that the requirement that the combination of the low-pass filter and the E/O converter should have a frequency response that results in at least half of the dB value of the stressed eye closure (SECQ) before the sinusoidal and Gaussian noise terms are added, does not apply.
Change "The signaling rate and the required stressed eye closure (SECQ) of the stressed receiver conformance test signal is specified in Table 138-9" to "The signaling rate, the required stressed eye closure (SECQ) and SECQ-10*log10(Ceq) of the stressed receiver conformance test signal are specified in Table 138-9. For a particular setup, one of SECQ and SECQ-10*log10(Ceq) matches the table and the other is lower. A pattern generator with emphasis may be used."
Do we want to give more advice about this, e.g. a 2-tap FIR, which one is the cursor? The FIR is to move the test condition to the left; to move it to the right the filter should be used.
Also in 138 and 140.

Proposed Response *Response Status* O

Not In Support Of Comment r03-36 Against 50GBASE-FR/LR And 100GBASE-DR In P802.3cd D3.3

Cl 139 *SC* 139.7.5.3 *P* 298 *L* 52 # r03-36

Dawe, Piers J G Mellanox Technologie

Comment Type TR *Comment Status* X

In this draft, it is still possible to make a bad SMF transmitter with emphasis (e.g. with a distorted signal) that even an equalizer better than the reference equalizer won't be able to improve. Note the receiver is tested for a slow signal only, not for such signals. But notice that in the survey (e.g. dawe_3cd_01b_0518 slide 8), the 50G SMF points are near neutral and below 1.8 dB, not near the upper left.
We need to exclude unnecessary regions, too high up the TDECQ map, that would waste equalizer power and complexity.
D3.0 comment 116, D3.1 comment 71, D3.2 comment 52.

SuggestedRemedy

Limit TDECQ -10*log10(Ceq) to the lower of 3 dB or the max. TDECQ.
E.g. for a SMF TDECQ limit of 2.8 dB (50GBASE-FR), limit TDECQ -10*log10(Ceq) to 2.8 dB; for 3 dB (50GBASE-LR), limit TDECQ -10*log10(Ceq) to 3 dB.
Add the limit to the transmitter and receiver (conditions of stressed receiver sensitivity test) tables if appropriate.
This limit protects the equalizer and decison circuit or A to D from worse than reasonable waveforms, while OMA-TDECQ protects the receiver front end from excessive sensitivity demands.

Proposed Response *Response Status* O

Background

- TDECQ may impact yield of SMF PMDs.
  - **P802.3bs**: way_3bs_01a_0517, way_3bs_01a_0717, tamura_3bs_01a_0917, tamura_01a_1017_smf (ad hoc)
  - **P802.3cd**: chang_3cd_01a_0917, baveja_3cd_01_1117, chang_3cd_01b_0318, chang_3cd_02_0318

- Link measurements show adequate margins for Rx Sensitivity, even when TDECQ (max) exceeded by wide margin.
  1. TDECQ too stringent.
  2. Rx Sensitivity has margin to spare.

- Threshold adjustment added to TDECQ algorithm (mazzini_120617_3cd_adhoc-v2, liu_3cd_01b_0118,).
  1. Improve correlation between TDECQ and Rx Sensitivity.
  2. Improve yield of transmitters with some nonlinearity (i.e. EML, DML).

- Minimal impact on Rx assured by limiting threshold adjustment range to up to 1% OMA (confirmed by several IC vendors).

Background (Cont.)

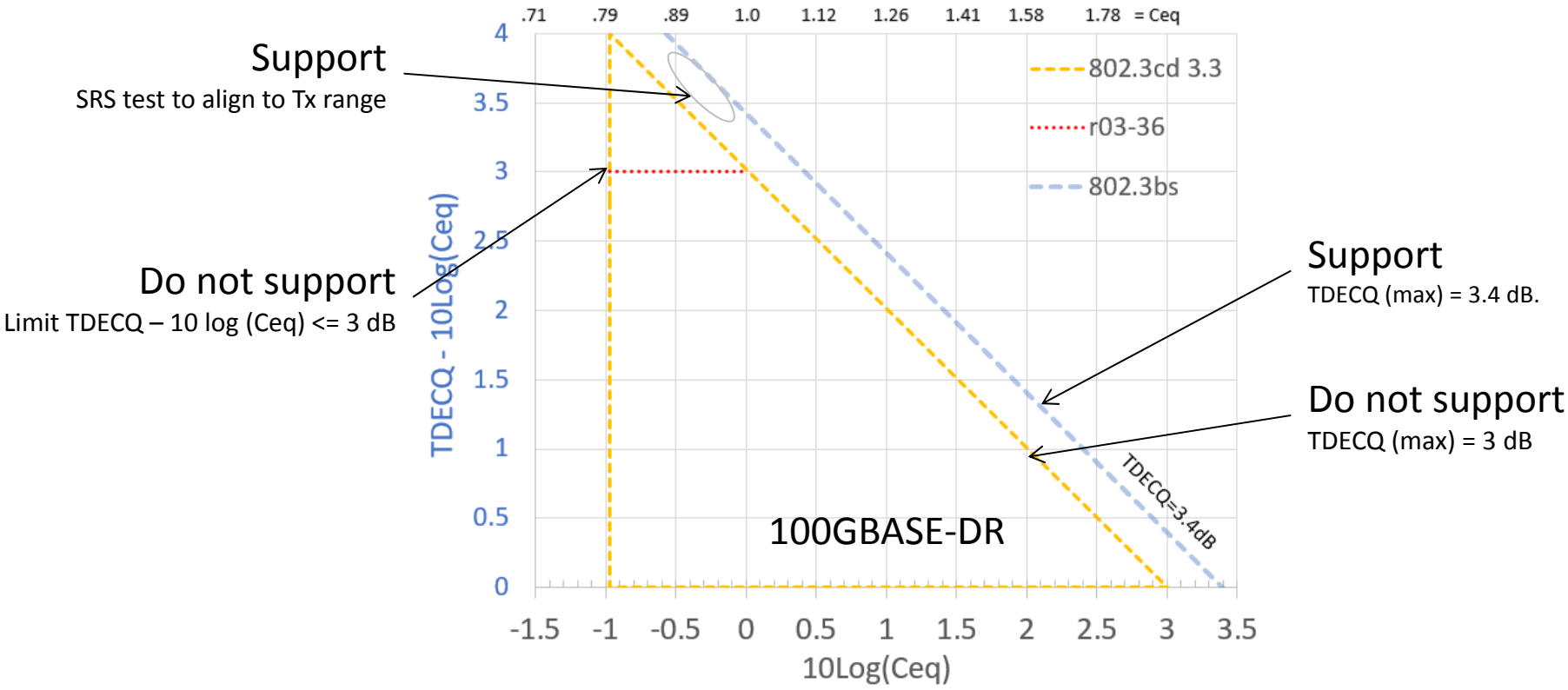
- In D3.3, TDECQ (max) was reduced by 0.4 dB for all optical PMDs in P802.3cd (50GBASE-SR/FR/LR, 100GBASE-DR).

- Issues with reducing TDECQ (max) for SMF PMDs:
  1. Penalizes high linearity Tx, which do not benefit from threshold adjustment.
  2. Makes already tight Tx specs even tighter. 50GBASE-FR, 50GBASE-LR, or 100GBASE-DR already had low values for TDECQ (max) of 3.2 dB, 3.4 dB, and 3.4 dB, respectively.

- This presentation:
  - New measurements on 50G-PAM4 DML and 100G-PAM4 EML to support TDECQ (max) values of P802.3cd D3.2 with 1% OMA threshold adjustment for SMF PMDs.
  - Recommendation to change SRS spec to align to Tx TDECQ range.
  - Recommendation to reject constraining TDECQ – 10 log(Ceq) to <= 3 dB.

Background (Cont.)

- In support of comments to return TDECQ back to 3.4dB for 100GBASE-DR.
  - Can include upper and lower limits on Ceq.
  - Include change to SRS test range
- Not in support of r03-36 to limit of TDECQ - 10 log(Ceq) <= 3 dB for 100GBASE-DR.
  - Or could support a limit of 4dB instead of 3dB



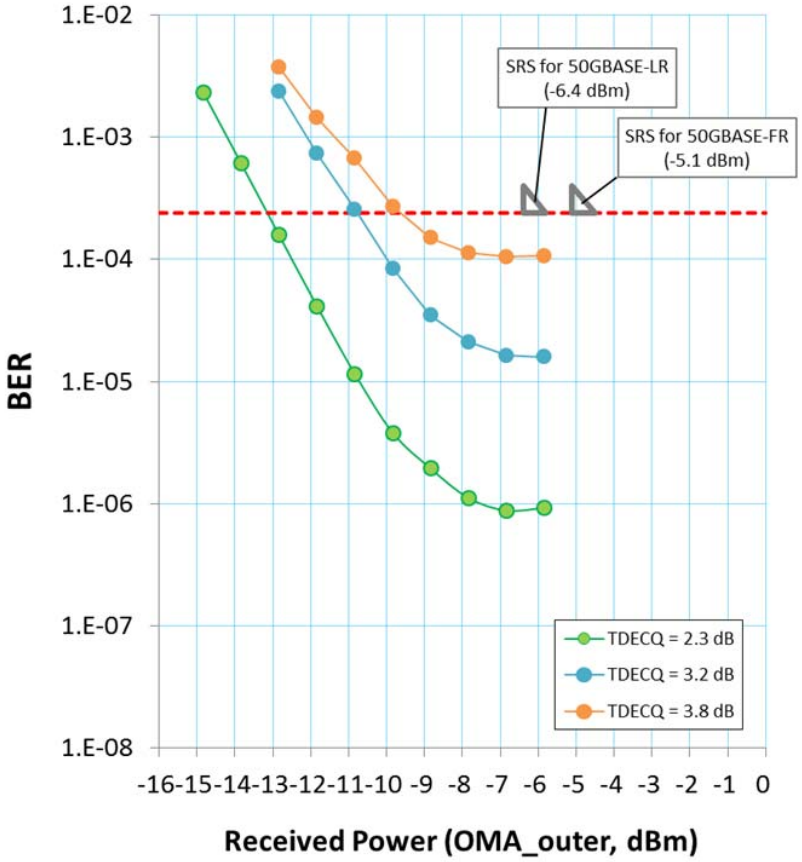
(1) 50G-PAM4 DML Measurements

Description:

- DML measured at high temperature with CoC + GSG probe.
- Bias current changed to vary TDECQ.

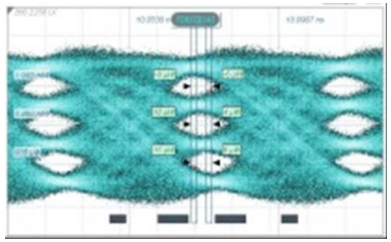
Setup details:

- Source: Keysight AWG (pre-emphasis)
- Modulation: PAM4
- Baud rate: 26.5625 Gbaud
- Temperature: >75 degC
- SECQ (TDECQ): SSPRQ; 1% Thresh; No SMF.
- Rx: PIN ROSA + DSP w/ 6-Tap FFE



Observations / Conclusion:

1. Rx Sensitivity << SRS even for SECQ (TDECQ) as high as 3.8 dB.
2. BER floor more than 1 decade below 2.4E-4 for SECQ (TDECQ) as high as 3.2 dB.
3. TDECQ (max) of 3.2/3.4 dB for 50GBASE-FR/LR, respectively, are reasonable.



Eye for ● case.

Data	TDECQ (dB)	Rx Sens (dBm)
●	2.3	-13.1
●	3.2	-10.8
●	3.8	-9.6

(2) 50G-PAM4 DML Measurements

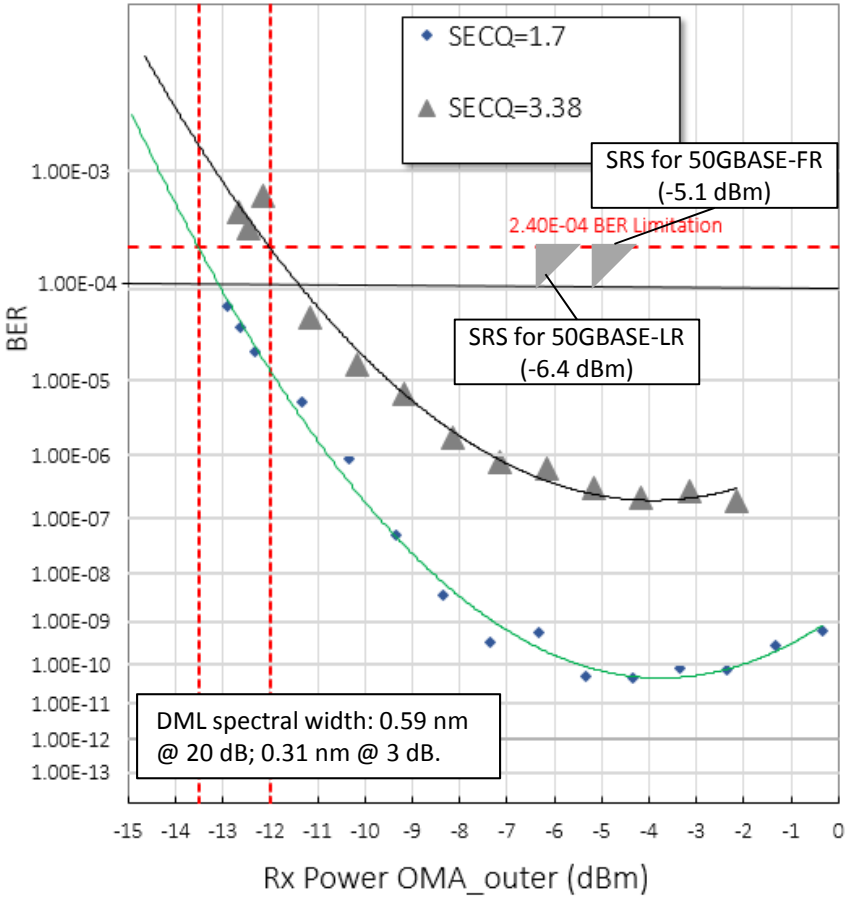
Description:

- DML sample measured at low and high temperature in Transceiver
- Higher Temperatures results in TDECQ degrade

Setup details:

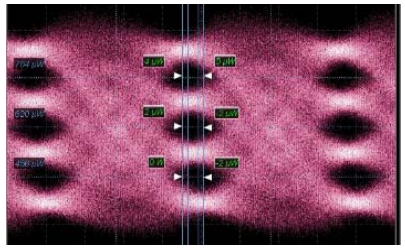
- Source: DSP
- Pattern (BER): PRBS31
- Baud rate: 26.5625 Gbaud PAM4
- SECQ (TDECQ): Keysight N1092A
  with 802.3cd Draft 3.2 (not 3.3)
  No Fiber and with PRBS15 (not SSPRQ)
  TDECQ will be > SECQ
- BER Rx: DSP w/ 6 TAP FFE + Pin ROSA

Data	TDECQ (dB)	Rx Sens (dBm)	BER floor
◆	>1.7	-13.5	1E-11
▲	*>3.4*	-12	3E-7



Observations / Conclusion:

1. Rx Sensitivity << SRS requirement even for TDECQ > 3.4 dB.
2. BER floor << 2.4E-4 even for TDECQ > 3.4 dB.
3. In addition TDECQ-10Log(Ceq) > 3.45 dB (Ceq=0.98)
4. Skew-degraded TDECQ allows BER floor and Rx Sens to remain good.
5. TDECQ (max) of ≥ 3.2/3.4 dB for 50GBASE-FR/LR needed for DML.



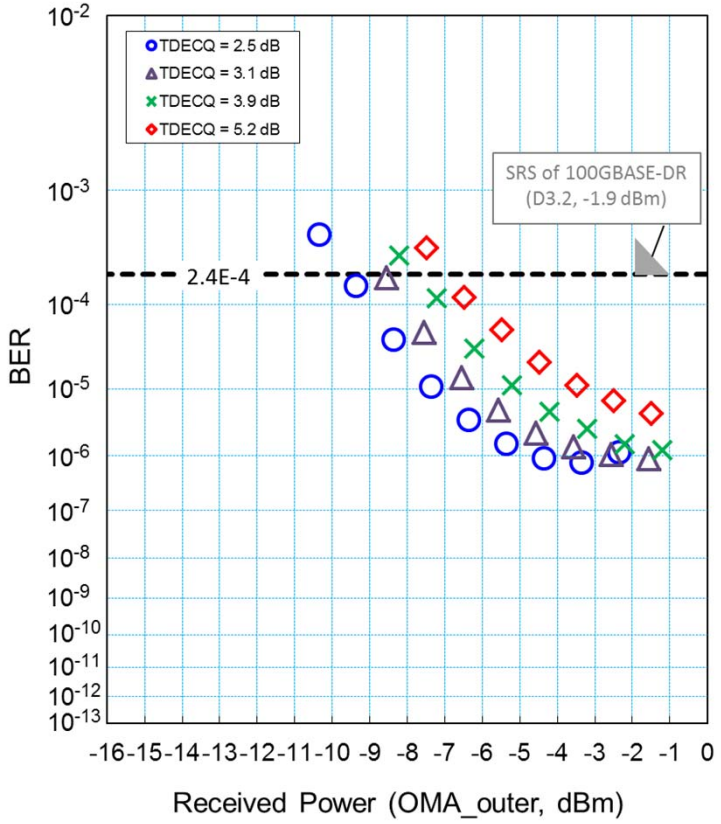
(1) 100G-PAM4 EML Measurements

Description:

- EML in GPPO test fixture.
- TDECQ changed by adjusting pre-emphasis

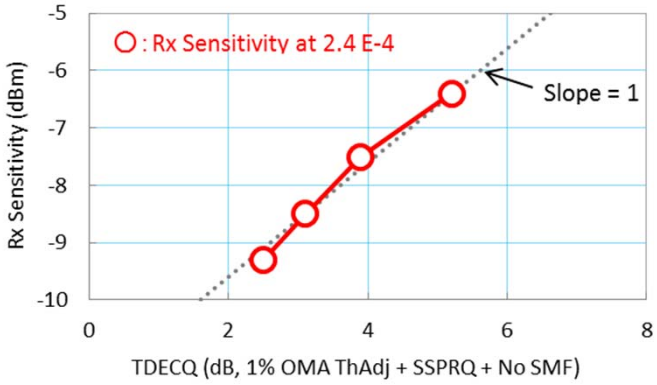
Setup details:

- Source: Keysight PPG
- Modulation: PAM4
- Baud rate: 53.125 Gbaud
- Temperature: Room
- SECQ (TDECQ): SSPRQ, 1% Threshold, No SMF.
- Rx: PIN ROSA + DSP w/ FFE (7-9 effective taps)



Observations / Conclusion:

1. Rx Sensitivity << SRS and BER floor << 2.4E-4 even for SECQ (TDECQ) as high as 5.2 dB.
2. Rx Sensitivity vs TDECQ has slope ~1.
3. TDECQ (max) of 3.4 dB for 100GBASE-DR is reasonable.



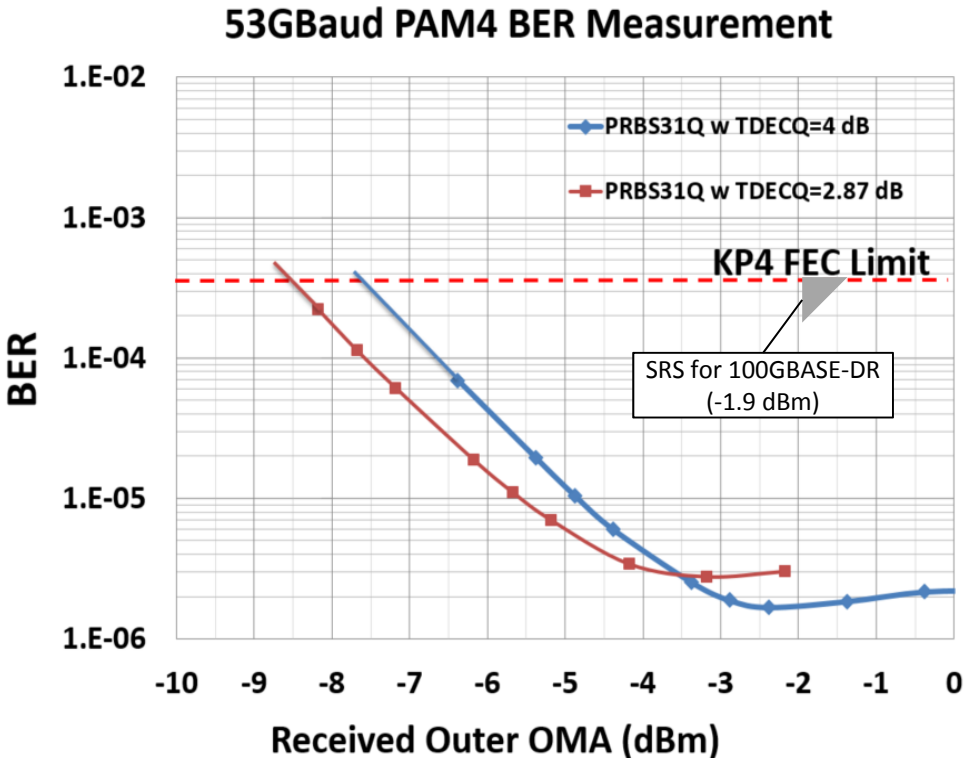
(2) 100G-PAM4 EML Measurements

Description:

- EML TOSA

Setup details:

- Source: DSP
- Pattern: PRBS31 or SSPRQ
- Baud rate: 53.125 Gbaud
- Temperature: Room
- SECQ (TDECQ): Keysight 1092A
  802.3cd Draft 3.2
  SSPRQ, No SMF.
- Rx: PIN ROSA +
  DSP w/ FFE (>5-Taps)

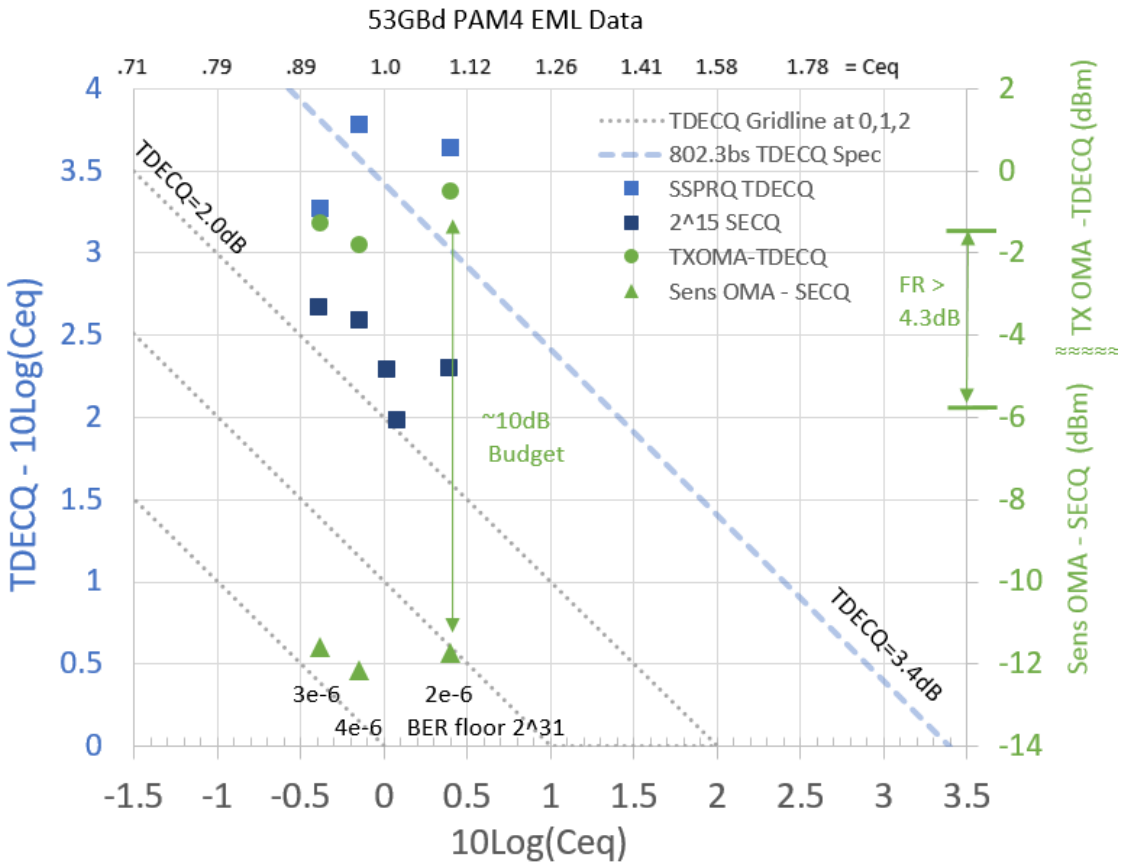


Observations / Conclusions:

- Sensitivity correlates with TDECQ
- BER floor < 5E-6 didn't correlate well with TDECQ
- Rx Sensitivity OMA - TDECQ < -11 dBm stays good for TDECQ >3.4 dB.

(2) 100G-PAM4 EML Measurements (Cont.)

- ~10dB link budget is obtainable with TDECQ - 10Log(Ceq) > 3.5dB.
- As MPI is added beyond the spec, Rx Sensitivity degrades only < 1.4dB as TDECQ degrades >>4dB.
- High TDECQ does not demonstrate a “cliff” in Rx Sensitivity as long as the SNR maintains a BER floor < 1E-4
- Requiring distributions at +-0.05 UI to support threshold offset inaccuracies is similar to creating a square, instead of a diamond, mask margin.
- Conclusion: TDECQ - 10Log(Ceq) should not be used to limit higher noise transmitters.



MPI (dB)	TDECQ w/ SSPRQ (dB)	10log(Ceq) (dB)	SECQ PRBS15 (dB)	Rx Sens OMA (dBm)	Rx Sens OMA - TDECQ (dBm)	BER Floor
NA	2.89	-0.39	2.28	-8.70	-11.59	3.6E-06
	4.04	0.40	2.70	-7.70	-11.74	1.7E-06
	5.50	0.00	3.15	-6.83	-12.33	3.0E-05
-29	6.68	0.00	3.50	-6.80	-13.48	5.0E-05
-23	13.00	0.00	7.60	-6.35	-19.35	7.2E-05

Contributed by Source Photonics.

Summary

- Accept comments r03-21, 22, 39, 42, 43, and restore TDECQ (max) values of P802.3cd D3.2 for 50GBASE-FR, 50GBASE-LR, and 100G-BASE-DR and have SRS test range align with the Tx TDECQ map.
- Reject comment r03-36 or change limit to TDECQ - 10Log(Ceq) <= 4dB.