Clarification of proposal for value of TDECQ – SECQ
Related to comment #7.

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IEEE P802.3cu Task Force , Waikoloha, 11 - 12 November 2019

Introduction

- During the IEEE 802.3 interim meeting in Indianapolis, 9 – 12 September 2019, a baseline specification for 400GBASE-LR4 was agreed, including the insertion of a new parameter “TDECQ – SECQ”, with the value “TBD”.

- The relevant motion, noted in the minutes, passed with Y: 44, N: 1, A: 12.

- The insertion of new the parameter “TDECQ – SECQ” in the baseline specification was based on the information contained in stassar_3cu_01_0919.

- This presentation provides further background to justify the new parameter and also includes a proposal to replace “TBD” with 2.5 dB.

Optical path (dispersion) penalty versus TDP

- In IEEE 802.3 specifications for NRZ modulated systems the parameter TDP (transmitter and dispersion penalty) has been used to distinguish good from bad transmitters.
  - By combining transmitter (distortion) and (chromatic) dispersion penalties in a single parameter, vendors of optical transceivers could trade-off one versus the other and optimize manufacturing yields.
  - The procedure for measuring TDP is provided in Clause 52.9.10
  - Key element is measuring BER on a worst case (dispersion) link
  - If transmitters suffer a high TDP then the specification allows to increase the transmitter power to a higher level, while meeting a minimum value for TX-OMA minus TDP.
  - If a transmitter has very low TDP, then the TX-OMA can be reduced until a certain limit, being 1 dB higher than the TX-OMA minus TDP limit.

Optical path (dispersion) penalty versus TDP, continued

- In ITU-T optical interface recommendations the parameter optical path penalty has been used to distinguish good from bad transmitter.
  - The major contributor to optical path penalty is chromatic dispersion.
  - Also in this case generally a BER test is done to determine the penalty.
  - In the first optical interface Recommendation G.957 a maximum optical path penalty of 1 dB was defined except for 1550 nm 2.5 Gbit/s applications, where 2 dB was defined.
  - In later Recommendations up to 2 dB was specified for single channel applications and up to 2.5 dB for multi-channel applications (including 0.5 dB Xtalk penalty).
  - The general philosophy for these maximum levels was the experience that above those values, the penalty could increase exponentially versus chromatic dispersion values.
  - It was considered good engineering practice to avoid the exponential area and to define the limits at levels of 2 – 2.5 dB.

TDECQ versus TDP

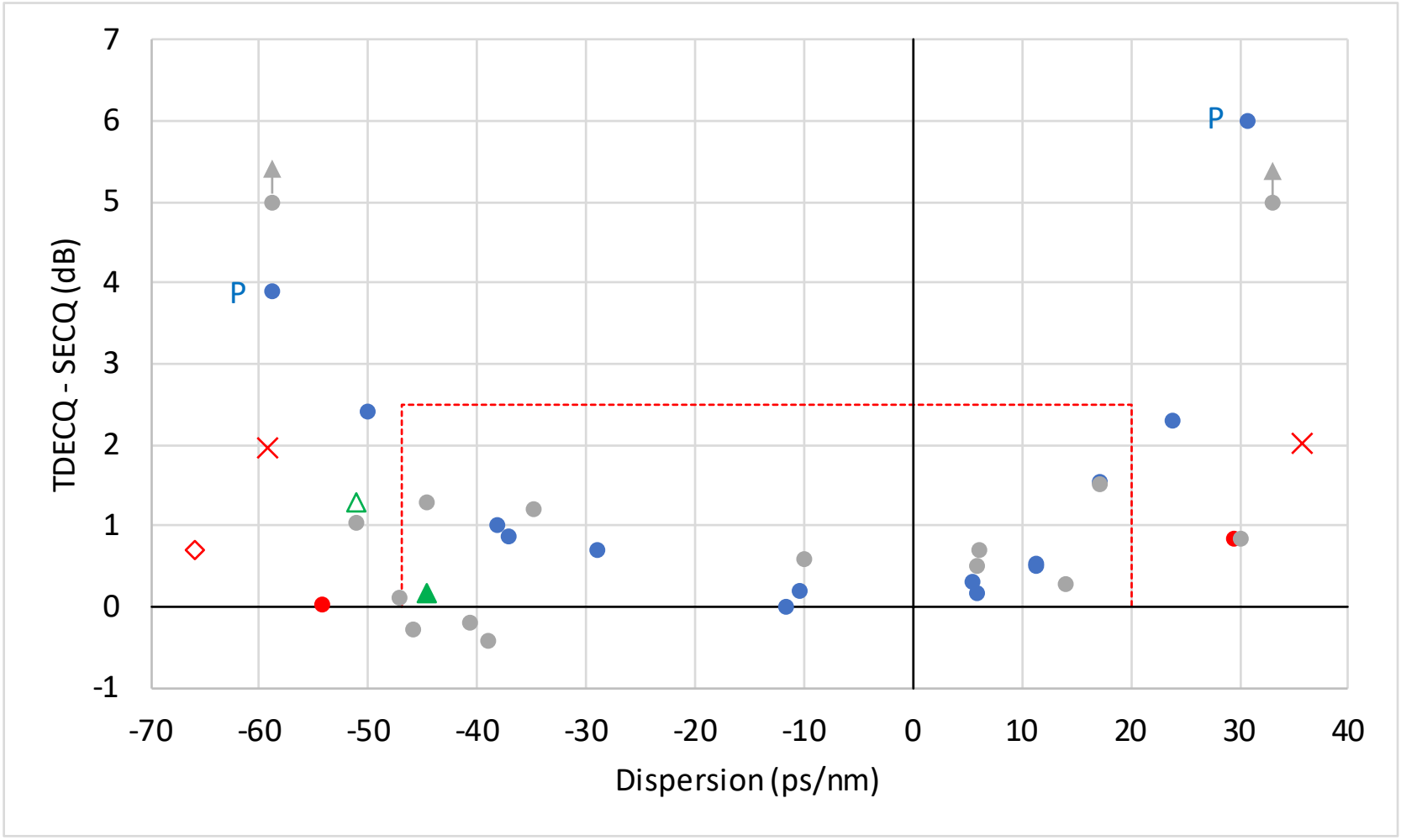
- Since IEEE 802.3 introduced PAM4 modulated systems, the parameter TDP could no longer be used in the same way as for NRZ modulated systems.
- TDECQ was introduced as the parameter to distinguish good from bad PAM4 transmitters.
  - In PAM4 systems generally equalizers are used inside receivers to achieve desired receiver performance.
  - To decouple the transmitter TDECQ testing from system receivers a reference equalizer with minimum number of taps was introduced and it is no longer based on a BER test, but based on capturing the waveform and processing it.
  - Unfortunately TDECQ was very new and limited experimental verification was available.
  - During the course of the P802.3bs and P802.3cd projects several modifications were agreed.

TDECQ in 400GBASE-LR4

- Within the context of the discussions surrounding the creation of a baseline specification for 400GBASE-LR4 in the P802.3cu project (and the preceding SG effort) a lot of experimental data from a variety of vendors was made available.
- Results were reported in stassar_3cu_01_0919, showing:
  - TDECQ versus chromatic dispersion shows a “bathtub” shape with significant scattering.
  - TDECQ minus SECQ versus chromatic dispersion curves show a “bathtub” shape with significantly less scattering and much more consistency.
  - In a private email (8 May 2019) Jonathan King remarked:

    I was impressed by Pete’s graph, and yes I think a proposal to include it would be good. The plots certainly show which transmitters are on the edge of runaway dispersion penalty, much more so than the TDECQ plot.

TDECQ minus SECQ in stassar_3cu_01_0919



johnson_optx_01_0319 un-optimised

johnson_optx_01_0319 optimised

yu_optx_01a_0319

P yu_optx_01a_0319 predicted

lewis_cu_adhoc_041719

schube_3cu_01_0519 Si Ph (CD pen)

X mazzini_3cu_adhoc_082119 Si Ph

100G Lambda MSA

100G Lambda MSA excessive

–47 to 20 ps/nm with 2.5 dB penalty

TDECQ minus SECQ in stassar_3cu_01_0919, continued

- From the results shown on slide 7 it can be concluded that the known phenomena for NRZ modulated systems, that above 2 – 2.5 dB the penalty versus chromatic starts to increase exponentially.
- This is a situation that needs to be avoided, because for small variations of dispersion there can be significant variations of penalty, resulting in unstable/run-away system performance.
- In 400GBASE-LR4, where currently (D1.0) a maximum TDECQ of 3.5 dB is specified, it would be possible that a transmitter would have an SECQ of less than 1 – 1.5 dB, resulting in a TDECQ minus SECQ higher than 2 – 2.5 dB.
- For reasons outlined, it would be wise to avoid this condition.
- It was agreed to include the parameter “TDECQ – SECQ”, with the value “TBD”.
- While 2 dB would be a conservative limit consistent with traditional limits used in ITU-T Recommendations, it is proposed to use the less conservative limit of 2.5 dB.

Proposal

In line with the strawman proposal in stassar_3cu_01_0919 it is proposed to set a limit of 2.5 dB maximum for "TDECQ – SECQ"

Notes:

- It may not be necessary to actually test "TDECQ – SECQ". SECQ may be a design parameter.
- The IEEE 802.3 specifications do NOT require to measure any of the parameters.

Thanks!