802.3cu D1p0
TDECQ-SECQ considerations.

Marco Mazzini

Background

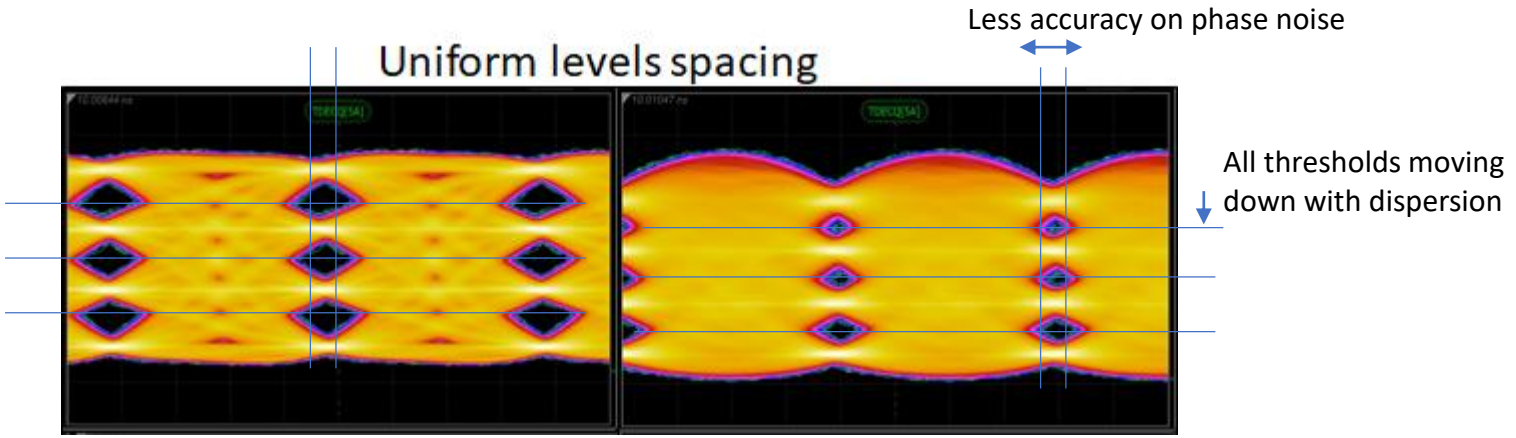
A new transmitter parameter, TDECQ-SECQ has been introduced into D1p0 Table 151–7 aplicable to 400GBASE-LR4 PMD only.

Quantification of TDECQ-SECQ requirement is going to require some effort and experimental contruibutions to be ensure that can effectively applied ‘at least’ to all existing PAM4 interfaces which can suffer the highest propagation penalties due to chromatic dispersion (like 400GBASE-ER8), thus potential interoperability problems.

This presentation try to address the problem proposing an alternative path rather than a new specification.

Description	400GBASE-FR4	400GBASE-LR4	Unit
Signaling rate, each lane (range)	53.125 ± 100 ppm		GBd
Modulation format	PAM4		—
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5		nm
Side-mode suppression ratio (SMSR), (min)	30		dB
Total average launch power (max)	9.5	11.6	dBm
Average launch power, each lane (max)	3.5	5.6	dBm
Average launch power, each lane[a] (min)	–3.3	–2.8	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min)[b]	–0.3	0.2	dBm
Difference in launch power between any two lanes (OMA_{outer}) (max)	4	4	dB
Launch power in OMA_{outer} minus TDECQ, each lane (min): for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	 –1.7 –1.6	 –1.2 –1.1	 dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max)	3.4	3.5	dB
TDECQ – $10\log_{10}(C_{eq})$[c] (max)	3.4	3.5	dB
TDECQ – SECQ	—	TBD	dB

Is TDECQ-SECQ an accurate metric ?



Source: [mazzini_3cu_adhoc_070319]

Because rely on the difference of two parameters taken under different propagation conditions.
Considering the TDECQ reference trasnmitter, TDECQ-SECQ penalty would more easily diverge from the real receiver under propagation condition.

- SECQ (TDECQ at km=0) would have a better fit with real receivers, and less results variation because the 1% threshold optimization will keep it almost stable.
- While TDECQ at maximum dispersion would probably need more than 1% threshold adjustment, result is expected to be less stable considering the current .

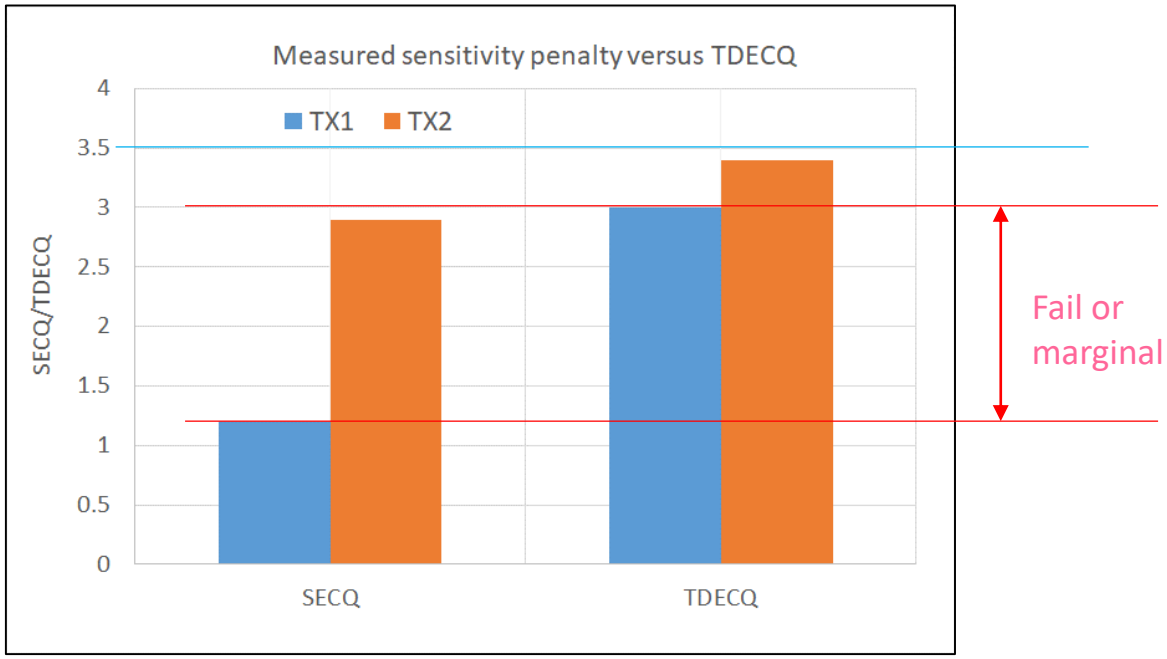
Thus TDECQ-SECQ can not an accurate metric.

TDECQ-SECQ need to be carefully specified.

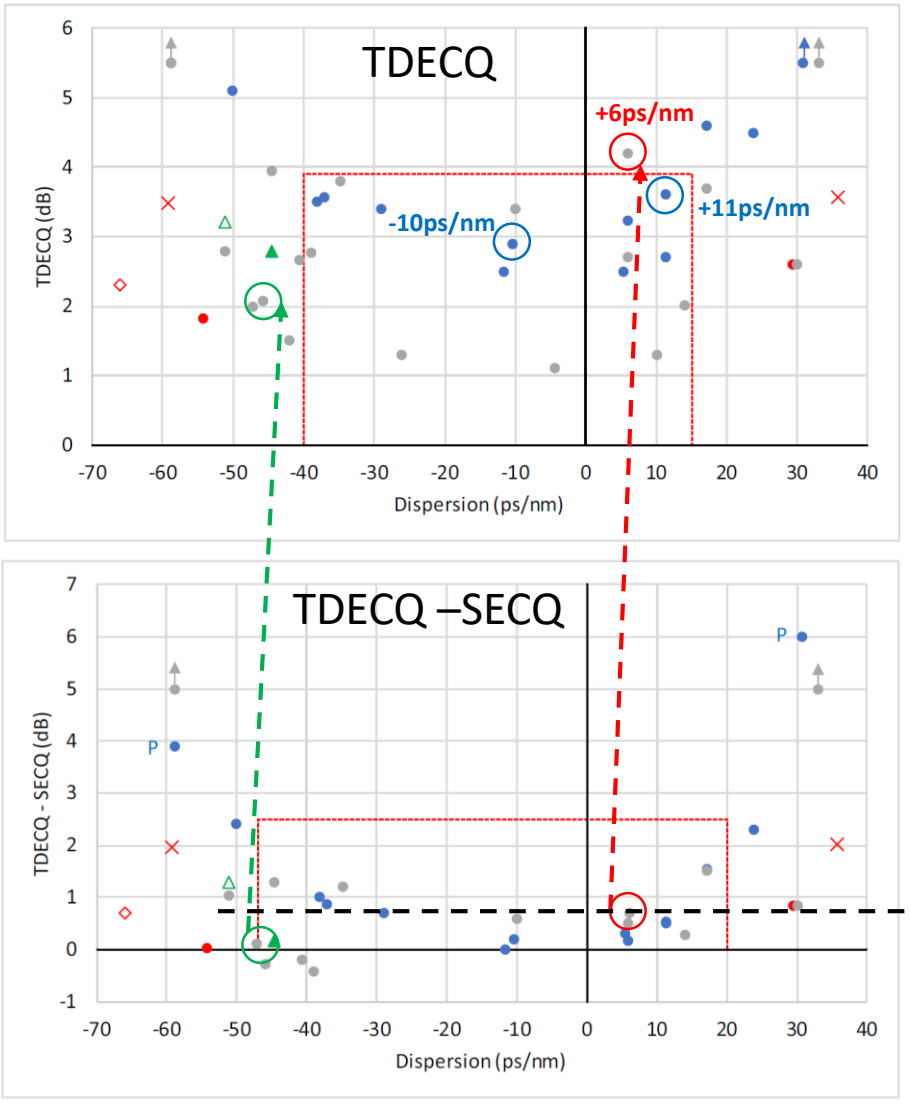
TDECQ-SECQ can actually potentially penalize ‘virtuous’ transmitters with low SECQ, which can still meet the absolute TDECQ at the worst case fiber propagation conditions, but fail this just this new parameter.

If TDECQ-SECQ will not be carefully quantified, what can then happen then is the absurde situation that after propagation tests a ‘good’ transmitter ends with lower TDECQ with respect a worse one, but just fails the new TDECQ-SECQ metric ...

This becasue the added Noise/Distorsion ‘equivalent’ sigma generated by chromatic dispersion will affect more transmitters having the merit to have a lower Noise/Distortion sigma (corresponding to lower SECQ), while having less impact on trasmitters starting with higher SECQ.



TDECQ – SECQ does not discriminate pre-distorted transmitters.



Into [stassar_3cu_01_0919](#) a TDECQ chart with scattered results was reported (slide 6), observing that the TDECQ-SECQ chart (slide 7) can be scattered was more consistent to quantify the CD penalty.

However, scattered TDECQ values can be considered normal if the transmitters were pre-distorted to deal with CD.

This is why transmitter TDECQ-10Log(Ceq) (see [mazzini_3cd_01d_0718](#)), has also to be tested together with TDECQ.

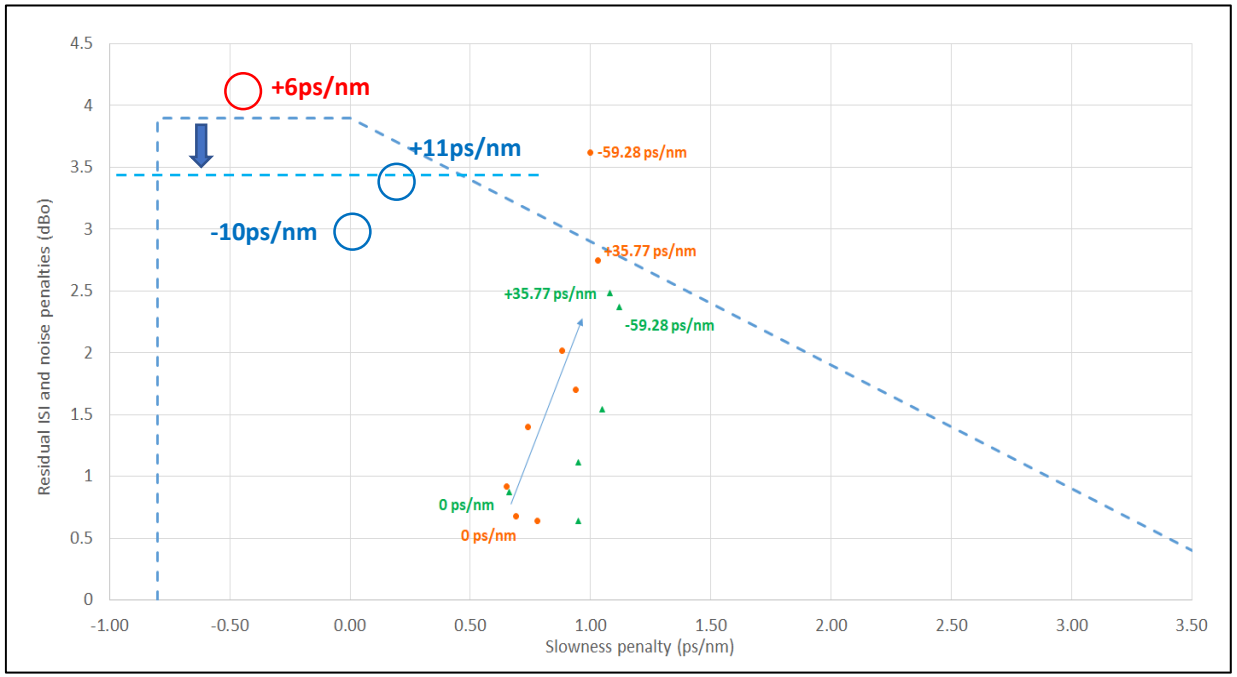
Based on same charts, the example is showing that two point at low TDECQ-SECQ have quite different TDECQ, which make clear that TDECQ-SECQ is not going to catch pre-distorted transmitter which distortion cannot be equalized.

While TDECQ-10Log(Ceq) will catch this difference, having being defined for it.

Low
TDECQ-SECQ

- High TDECQ and low TDECQ-SECQ (so high SECQ) -> Distortion penalty -> high TDECQ-10Log(Ceq)
- Low TDECQ and low TDECQ-SECQ -> Distortion penalty -> Low TDECQ-10Log(Ceq)
- [yu_optx_01a_0319](#) measurements

TDECQ – SECQ does not discriminate pre-distorted transmitters (c'ed).



yu_optx_01a_0319 measurements

100G Lambda MSA

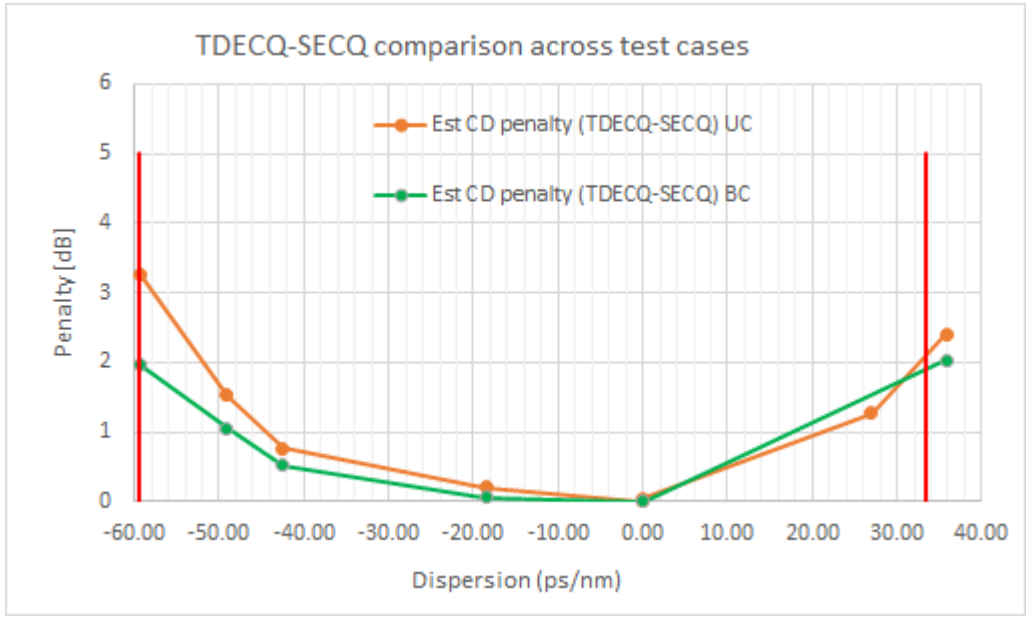
Following same 'Transmitter TDECQ criteria' used to drive TDECQ and TDECQ-10Log(Ceq) choices for 802.3cd (see mazzini_3cd_01d_0718).

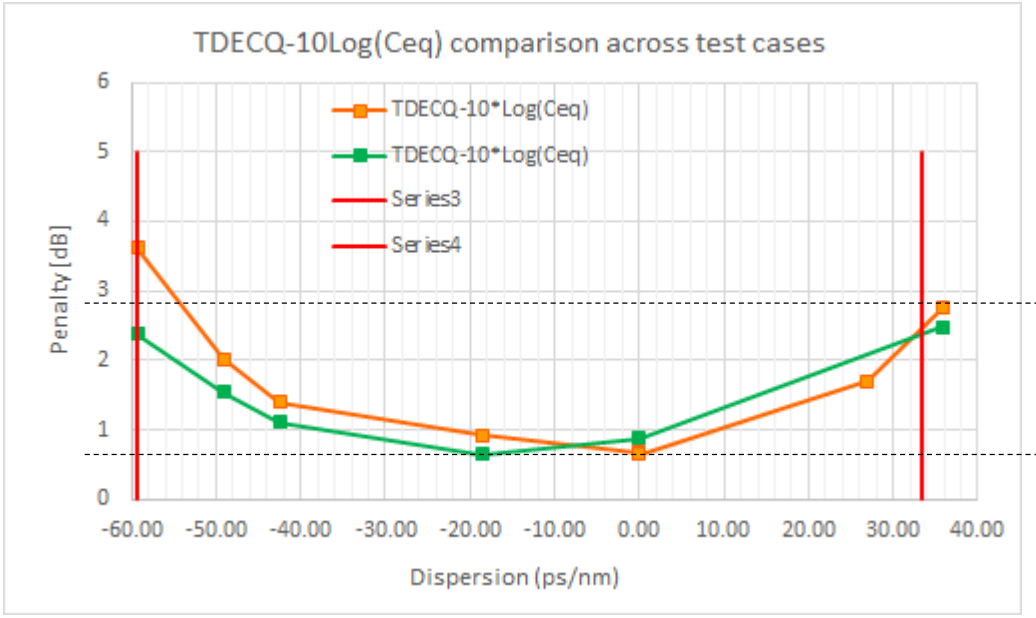
Plot of dispersion penalty results from mazzini_3cu_adhoc_082119 for uniform level spacing and bottom compression.
Orange and green showing CD penalty trend being partially equalized and improvement due to bottom compression.

Red and Blue circles are estimations of worst cases 100G Lambda MSA and yu_optx_01a_0319 TDECQ and TDECQ-SECQ measurements from previous slides.
Because referring to very small dispersion, both cases seems heavily pre-distorted.

To avoid these cases, one option would to furtherly tight the TDECQ-10Log(Ceq) limit, by not aligning it anymore with TDECQ.

TDECQ-SECQ seems a redundant parameter.





2.9dB

Residual ISI and distortion

Comparing data shared into mazzini_3cd_01d_0718.
TDECQ-SECQ and TDECQ-10*Log(Ceq) trends are quite similar behavior.
A previous slide, we can consider that the existing distortion will give the baseline penalty at 0ps/nm, while CD will provide additional penalty, which is just partially compensated by the reference equalizer.
A thumb rule would be that TDECQ-10*Log(Ceq) has to be reduce as much as CD penalty is present.

TDECQ-10Log(Ceq) can be also used to estimate chromatic dispersion penalty as TDECQ-SECQ, while TDECQ-SECQ cannot discriminate transmitter distortion.

TDECQ-SECQ is a time consuming (expensive) test.

TDECQ-SECQ rely on a parameter that is been NOT defined in the transmitter, but is a receiver input requirement, used to calibrate stressed receiver sensitivity.
So, to verify this requirement, there'll be the need to verify BOTH the fiber propagation at CD limits AND the 0 ps/nm condition.

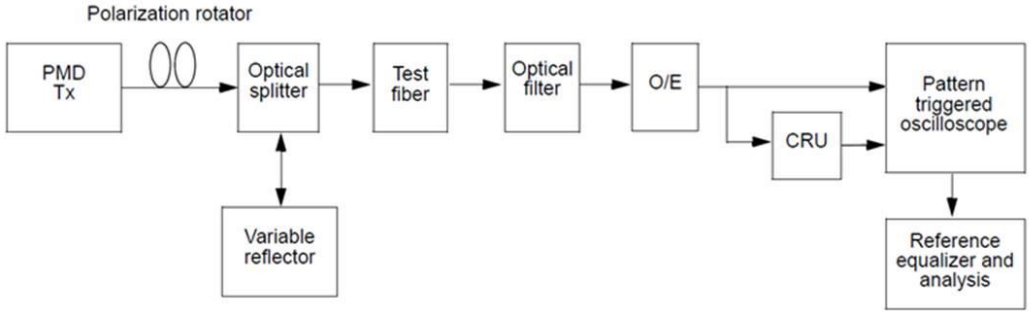
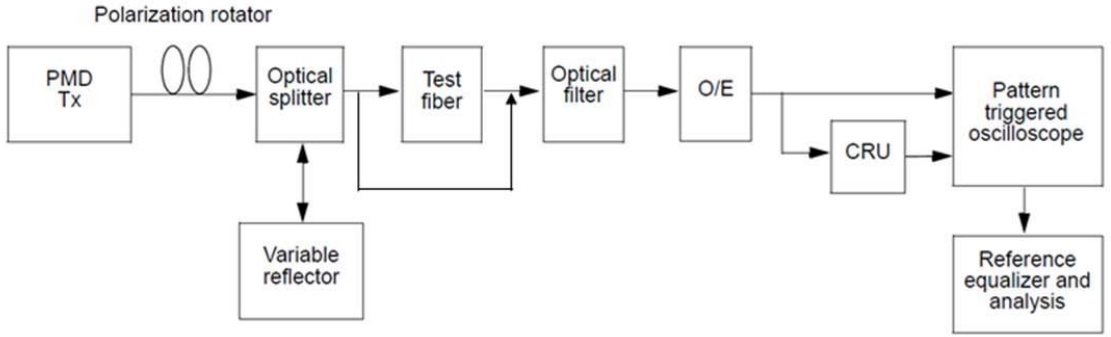


Figure 151–4—TDECQ conformance test block diagram



Potential TDECQ-SECQ conformance test block diagram

In manufacturing it will require a controlled environment in which, not only the TDECQ at the worst chromatic dispersion will have to be tested (and one can choose it own corner case test, once defined it in case), but ALSO the transmitter transmitter SECQ, run two tests: one for SECQ with 0 ps/nm dispersion and then one for TDECQ with worst case dispersion – doubling the testing time and then costs.
For multi-wavelength PMD (like 400GBASE-LR4) this will have of course more impact.

Comments

TDECQ-SECQ is not addressing the interoperability problem for PMD under long link/high chromatic dispersion and raise below concerns:

1. TDECQ-SECQ can be not an accurate metric.
   - Because rely on the difference of two parameters taken under different propagation conditions.
2. TDECQ-SECQ need to be carefully specified.
   - It can actually potentially penalize ‘virtuous’ transmitters with low SECQ with no evident reasons.
3. TDECQ – SECQ does not discriminate pre-distorted transmitters.
   - Which are instead the ones that affect interoperability.
   - These are identified by TDECQ-10*Log(Ceq), also on middle wavelengths.
4. TDECQ-SECQ seems a redundant parameter.
   - TDECQ-10Log(Ceq) can be also used to estimate chromatic dispersion penalty as TDECQ-SECQ, while **TDECQ-SECQ cannot discriminate transmitter’s distortion.**
5. TDECQ-SECQ is a time consuming (expensive) test.

TDECQ is used to build the overall budget: together with TDECQ-10*Log(Ceq) is enough to protect about interoperability over short and long reaches.

Proposed changes

The proposal change into Table 151–7 is to remove TDECQ-SECQ parameter.

Also is proposed to reduce the TDECQ-10*Log(Ceq) value to 3.3dB for 400GBASE-LR4 so to avoid too heavy pre-distorted transmitters and interoperability problems under chromatic dispersion conditions.

Description	400GBASE-FR4	400GBASE-LR4	Unit
Signaling rate, each lane (range)	53.125 ± 100 ppm		GBd
Modulation format	PAM4		—
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5		nm
Side-mode suppression ratio (SMSR), (min)	30		dB
Total average launch power (max)	9.5	11.6	dBm
Average launch power, each lane (max)	3.5	5.6	dBm
Average launch power, each lane[a] (min)	–3.3	–2.8	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	3.7	4.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min)[b]	–0.3	0.2	dBm
Difference in launch power between any two lanes (OMA_{outer}) (max)	4	4	dB
Launch power in OMA_{outer} minus TDECQ, each lane (min): for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	 –1.7 –1.6	 –1.2 –1.1	 dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max)	3.4	3.5	dB
TDECQ – $10\log_{10}(C_{eq})$[c] (max)	3.4	3.5 **3.3**	dB
~~TDECQ – SECQ~~		~~TBD~~	~~dB~~

THANK YOU