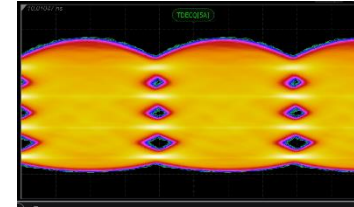
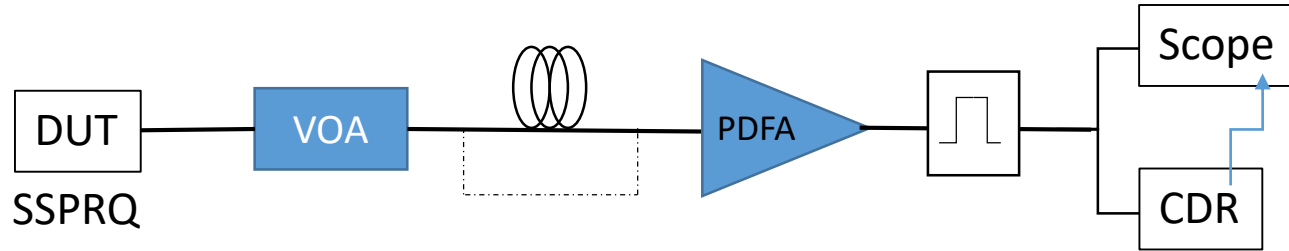


802.3cu: 400GBASE-LR4 fiber propagation penalty test completion - positive dispersion tests -

Marco Mazzini

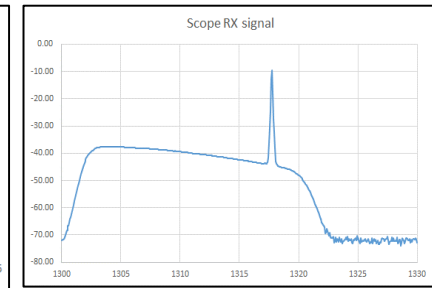
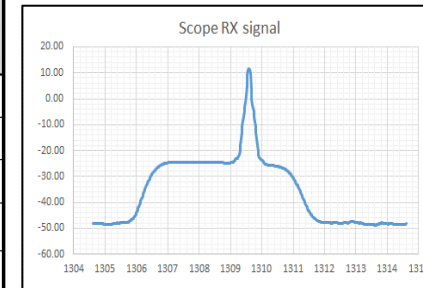
Background.

Closing investigation about 400GBASE-LR4 over CWDM grid ([mazzini 3cu adhoc 070319](#), [welch 3cu 01 0719](#)) to measure positive dispersion penalties and possible mitigations.



Measured TDECQ, TDECQ-10Log(Ceq) with current IEEE 802.3cd Reference Receiver.

Fiber code	CD22 +BZS	CD22 +Fiber4	CD22	BZS	Btb	Btb	TMGBA	TMGBA +Fiber2	Unit
Total dispersion	-59.28	-49.06	-42.49	-18.57	0.00	0.00	26.97	35.77	ps/nm
Wavelength	1309.56	1309.56	1309.56	1309.56	1309.56	1317.76	1317.76	1317.76	nm
Est PMD	0.36	0.31	0.27	0.24	0	0	0.28	0.33	ps
Est DGD (SF=3)	1.08	0.92	0.82	0.71	0	0	0.83	0.99	ps
Total length	19.539	12.211	1.5	18.039	0	0	24.666	34.822	km
OSNR	36	36	36	36	36	36	36	33	dB

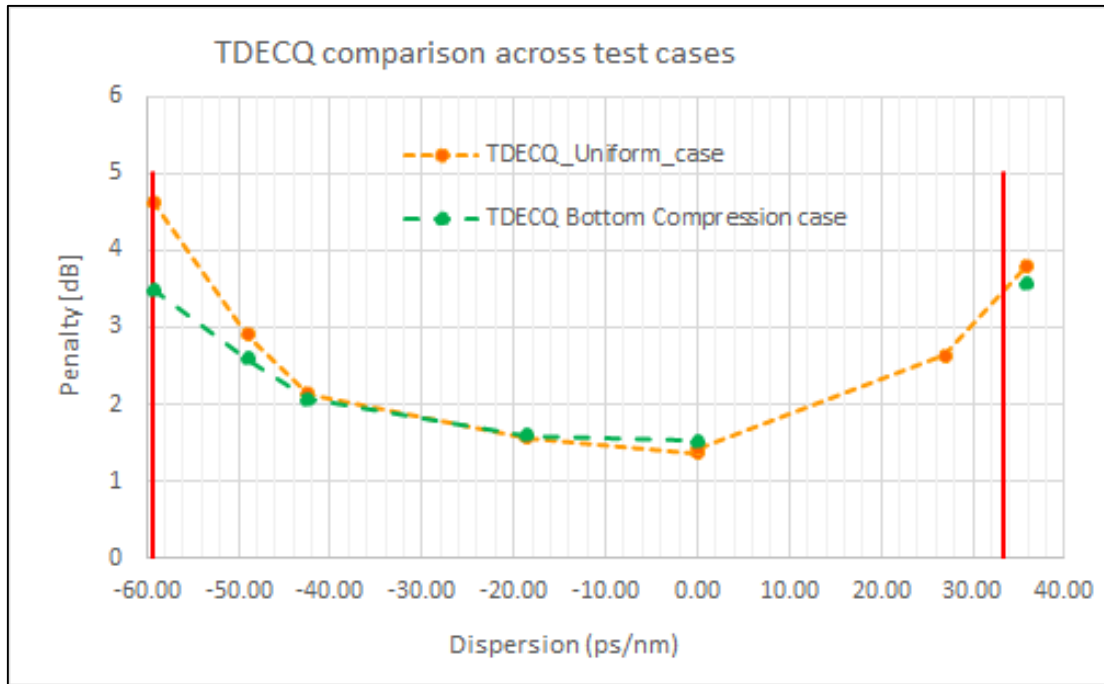


Built two fiber link combinations, emulating different positive CD values.

To keep linear region into the fiber a PDFA and avoid non-system related penalties on scope, a pre-amplifier has to be inserted - this limits the system OSNR to ≈ 36 dB for all negative cases, but to ≈ 33 dB for worst case positive one.

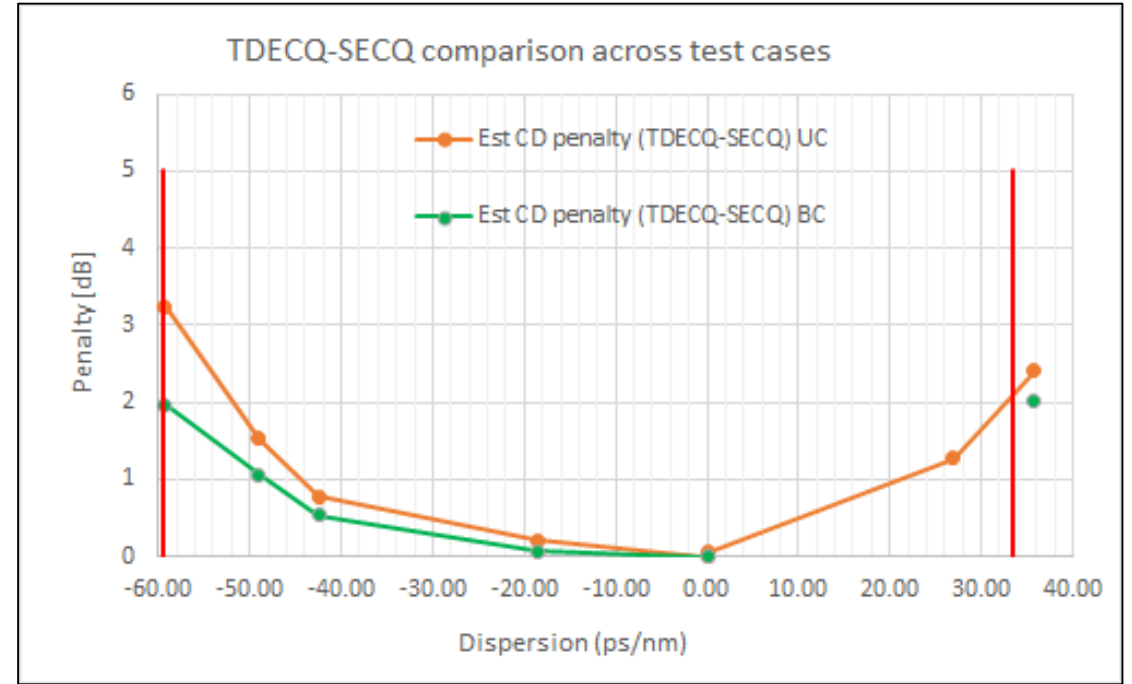
Note: for positive CD measurements, laser wavelength was tuned at 1317.76nm by heating DUT >70C, while for negative CD it has been cooled.

TDECQ and TDECQ-SECQ: uniform and bottom compression cases.



TDECQ:

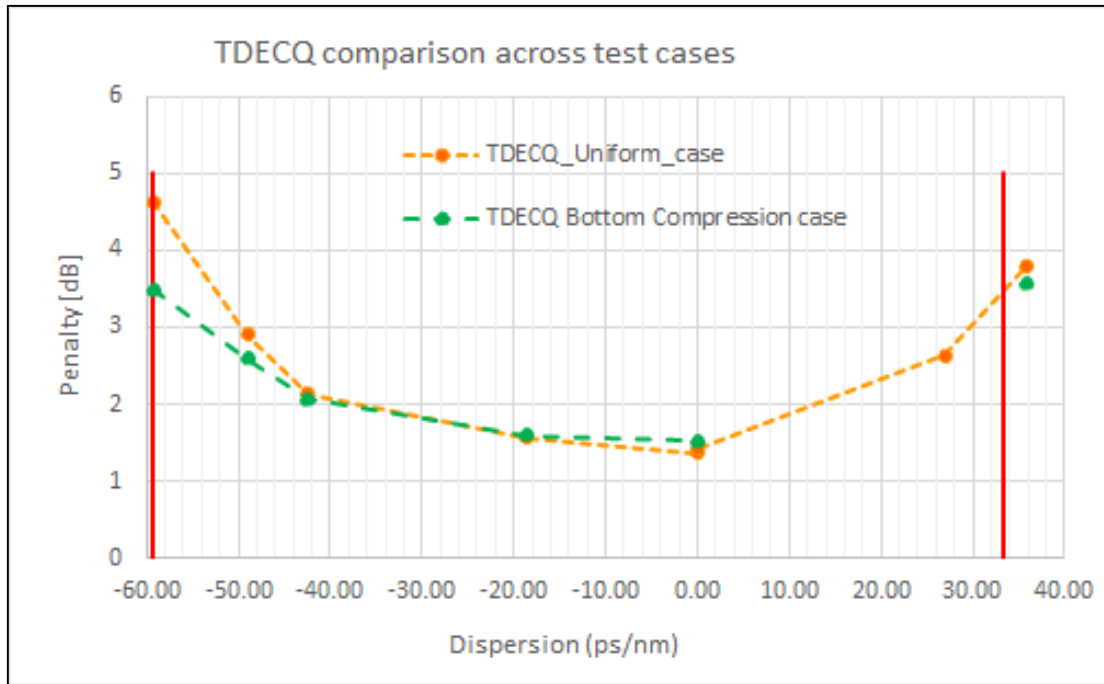
- Bottom compression case:
 - 3.49dB at negative CD limit.
 - ≈3.3dB at positive CD limit (3.56dB at +35.77ps/nm dispersion).
- Uniform case:
 - 4.62dB at negative CD limit.
 - ≈3.5dB at positive CD limit (3.78dB at +35.77ps/nm dispersion).



TDECQ-SECQ:

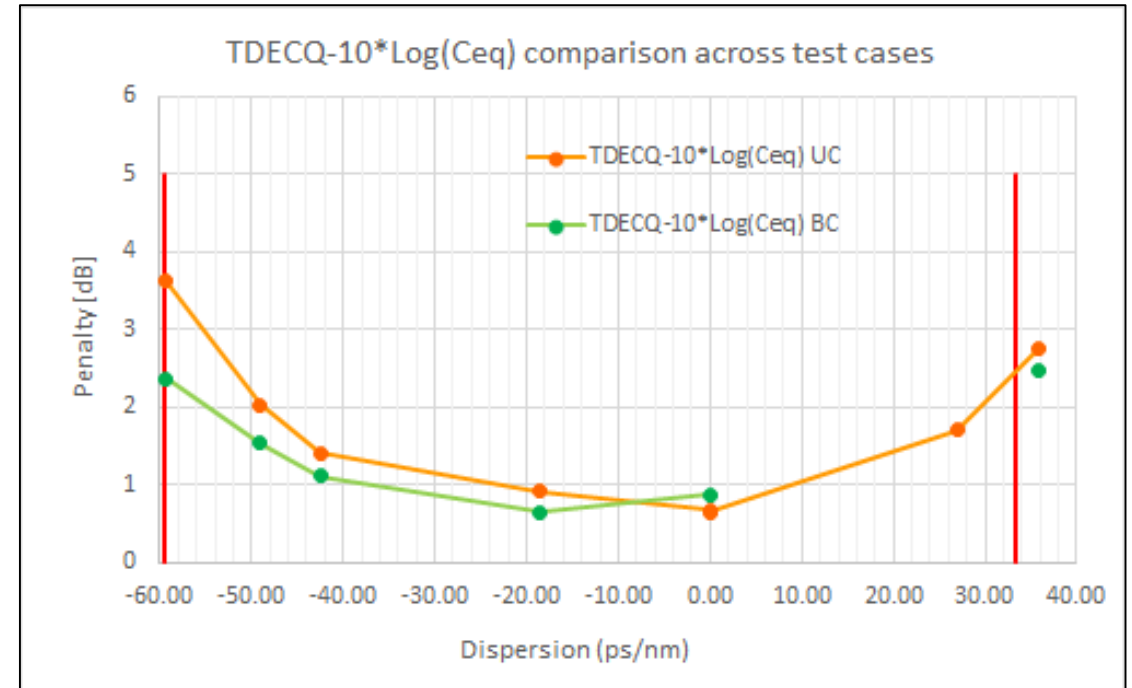
- Bottom compression case:
 - 2dB at negative CD limit.
 - < 2dB at positive CD limit (estimated, mid point not measured).
- Uniform case:
 - 3.25dB at negative CD limit.
 - ≈2.1dB at positive CD limit (2.41dB at +35.77ps/nm dispersion).

TDECQ and TDECQ-SECQ: uniform and bottom compression cases.



TDECQ:

- Bottom compression case:
 - 3.49dB at negative CD limit.
 - ≈3.3dB at positive CD limit (3.56dB at +35.77ps/nm dispersion).
- Uniform case:
 - 4.62dB at negative CD limit.
 - ≈3.5dB at positive CD limit (3.78dB at +35.77ps/nm dispersion).



TDECQ-10Log(Ceq):

- Bottom compression case:
 - 2.4dB at negative CD limit.
 - ≈2.2 at positive CD limit (estimated, mid point not measured).
- Uniform case:
 - 3.6dB at negative CD limit.
 - ≈2.5dB at positive CD limit (2.41dB at +35.77ps/nm dispersion).

Summary of experiments.

Fiber code	CD22 +BZS	CD22 +Fiber4	CD22	BZS	Btb	Btb	TMGBA	TMGBA +Fiber2	Unit
Total dispersion	-59.28	-49.06	-42.49	-18.57	0.00	0.00	26.97	35.77	ps/nm
Wavelength	1309.56	1309.56	1309.56	1309.56	1309.56	1317.76	1317.76	1317.76	nm
Est PMD	0.36	0.31	0.27	0.24	0	0	0.28	0.33	ps
Est DGD (SF=3)	1.08	0.92	0.82	0.71	0	0	0.83	0.99	ps
Total lenght	19.539	12.211	1.5	18.039	0	0	24.666	34.822	km
TDECQ/SECQ	4.62	2.9	2.14	1.57	1.37	1.42	2.64	3.78	dB
Est CD penalty (TDECQ-SECQ)	3.25	1.53	0.77	0.2	0	0.05	1.27	2.41	dB
Ceq	1	0.88	0.74	0.65	0.69	0.78	0.94	1.03	dB
TDECQ-10*Log(Ceq)	3.62	2.02	1.4	0.92	0.68	0.64	1.7	2.75	dB

Uniform level case

- Assuming 3.9dB as maximum TDECQ value (proposed in [lewis 3cu adhoc 061919 v2](#)).
- ON NEGATIVE DISPERSION, bottom compression allows to achieve this limit with no changes in current IEEE TDECQ reference receiver and methodology, neither limiting foreseen link characteristics.
- ON POSITIVE DISPERSION, uniform level spacing is enough to meet this proposal (bottom compression improving by 0.2dB TDECQ).

Fiber code	CD22 +BZS	CD22 +Fiber4	CD22	BZS	Btb	TMGBA +Fiber2	Unit
Total dispersion	-59.28	-49.06	-42.49	-18.57	0.00	35.77	ps/nm
Wavelength	1309.56	1309.56	1309.56	1309.56	1309.56	1317.76	nm
Est PMD	0.36	0.31	0.27	0.24	0	0.33	ps
Est DGD (SF=3)	1.08	0.92	0.82	0.71	0	0.99	ps
Total lenght	19.539	12.211	1.5	18.039	0	34.822	km
TDECQ/SECQ	3.49	2.59	2.06	1.59	1.53	3.56	dB
Est CD penalty (TDECQ-SECQ)	1.96	1.06	0.53	0.06	0	2.03	dB
Ceq	1.12	1.05	0.95	0.95	0.66	1.08	dB
TDECQ-10*Log(Ceq)	2.37	1.54	1.11	0.64	0.87	2.48	dB

Bottom compression case

Comments.

- Completed SiP transmitter chromatic dispersion penalty results against 10kms standard SMF chromatic dispersion limits for 400GBASE-LR4 in CWDM grid.
- The proposed 3.9dB TDECQ value proposed in [lewis 3cu adhoc 061919 v2](#) appears adequate considering SiP transmitters technology.
 - Also TDECQ-10*Log(Ceq) requirement is met for both testing conditions.
- Bottom compression (BC) significantly helps only at the extreme of negative chromatic dispersion.
 - Bottom compression does not violate any of current standards requirements.
 - Bottom compression is just one knob available on SiP transmitter (besides chirp management, transmitter BW control or any combination of these).
 - Should be a viable tuning method for different transmitter technologies (ie, EML and SiP).
- From this experimental cases, bottom compression to be applied only when:
 - Link length = 10km, $\lambda_0 = 1324\text{nm}$, $S_0 = 0.093\text{ps/nm}^2\text{km}$ AND
 - Lower wavelength of the CWDM grid it's at the edge of the CWDM grid (low T laser case).

THANK YOU

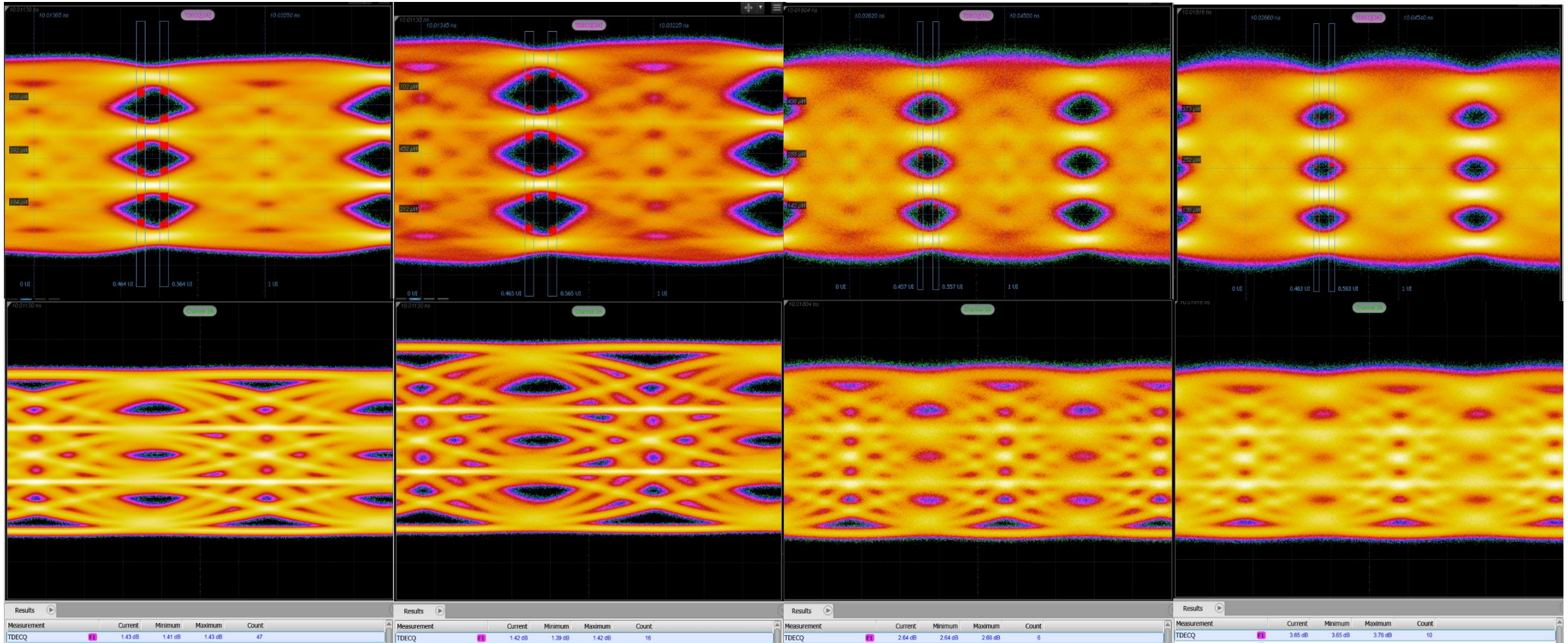
BTB and dispersion results – uniform case.

BTB – with PDFA

BTB – without PDFA

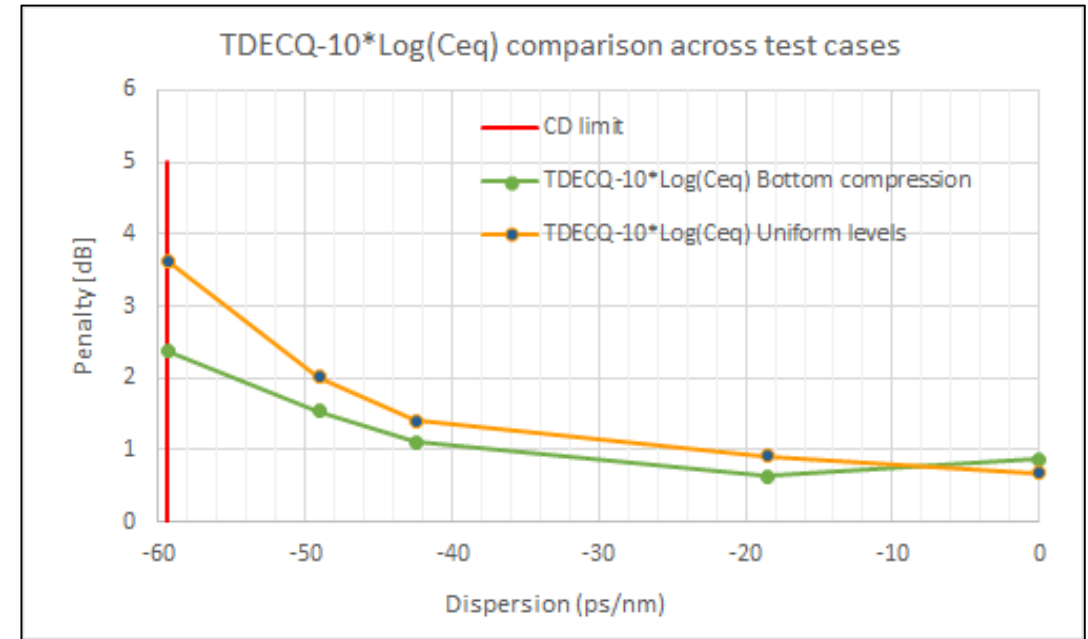
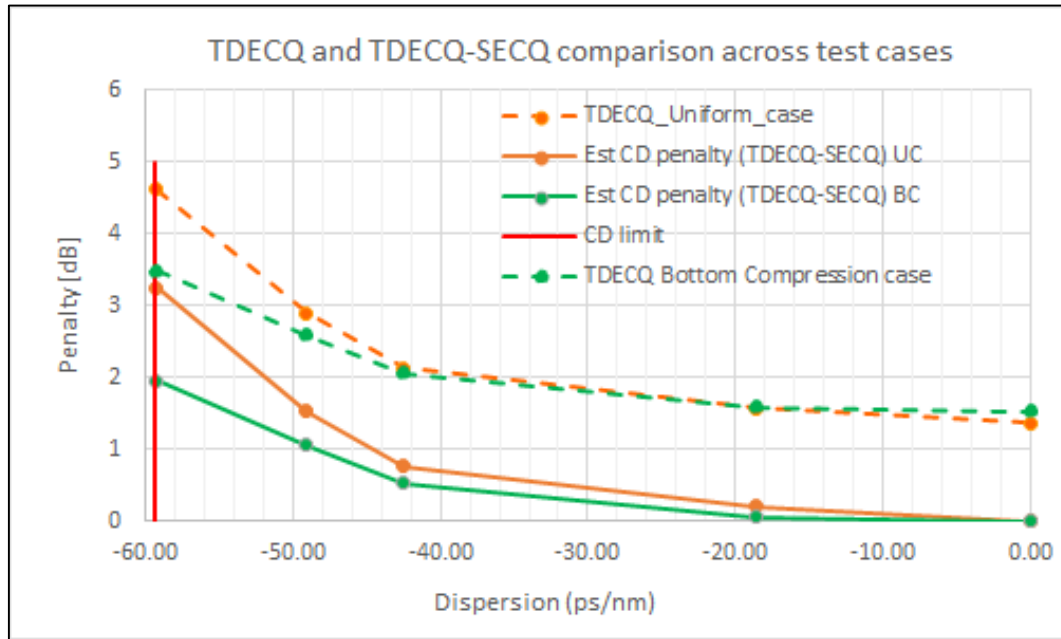
26.97ps/nm CD

35.77ps/nm CD



- For positive dispersion, there's no need of compression to compensate CD penalty.
- Still bottom compression provides ≈ 0.2 dB improvement on TDECQ under maximum positive CD.

Uniform/bottom levels spacing TDECQ/TDECQ-SECQ and TDECQ-10Log(Ceq) comparison.



- Both TDECQ and TDECQ-10*Log(Ceq) < 3.5dB for bottom compression case.
- Around 0.2dB TDECQ and TDECQ-10*Log(Ceq) at zero dispersion for bottom compression case versus uniform spaced levels.
- *Bottom compression does NOT violate any of current IEEE transmitter requirements.*