TDECQ Measurements for 400GBASE-LR4

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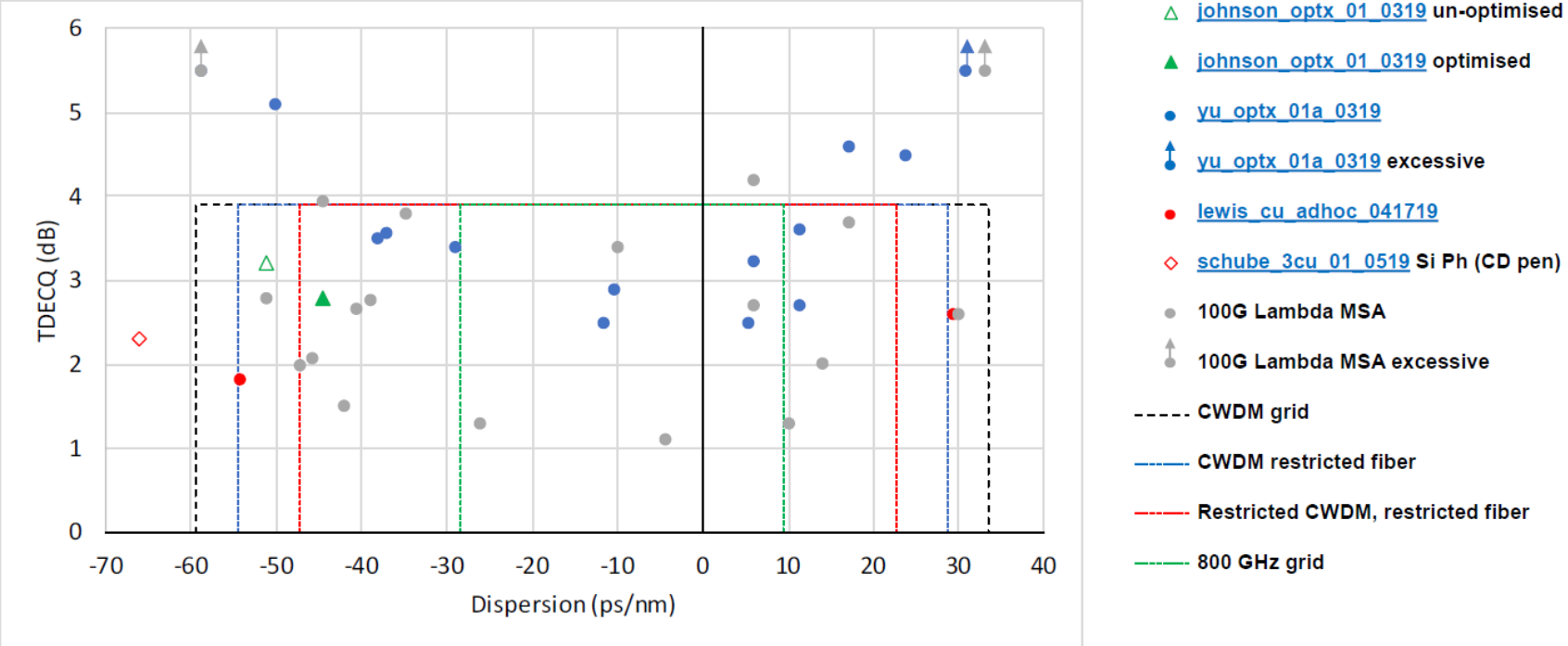
Background

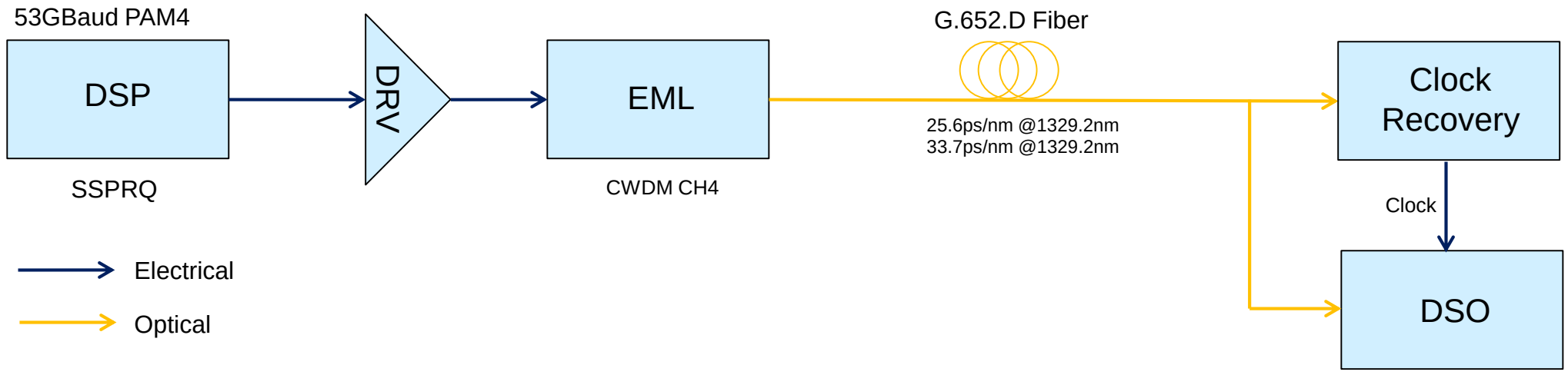
- A set of TDECQ values for 400GBASE-LR4 from multiple vendors were summarized in anslow_3cu_02a_0519.
- The presentation suggested that more data for devices optimized for 10km transmission was needed before making conclusion on Maximum TDECQ that impact the choice of wavelength grid.



Source: http://www.ieee802.org/3/cu/public/May19/anslow_3cu_02a_0519.pdf

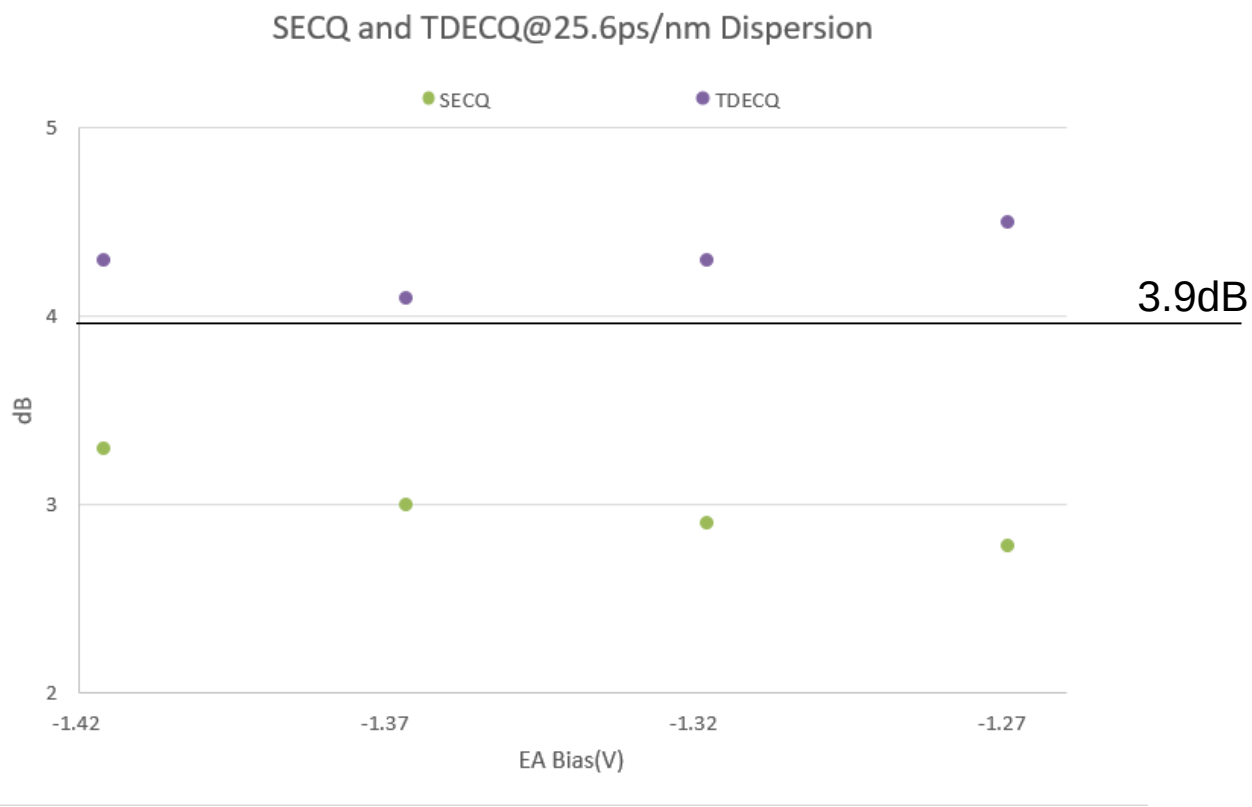
Introduction

- Given the suggestion of anslow_3cu_02a_0519, this presentation provides the measurement result of a typical device with optimization for best TDECQ with dispersion.
- Based on the that, high temperature environment had also been tested.
- The test setup is as below.



TDECQ at 25.6ps/nm dispersion vs. EA Bias

- Adjusting the EA bias is one way to optimize the performance. Based on the test result, TDECQ could be decreased by 0.4dB with the expense of 0.2dB SECQ.
- The best TDECQ at 25.6ps/nm dispersion measured in this experiment is 4.1dB, still higher than the proposed 3.9dB of maximum TDECQ.

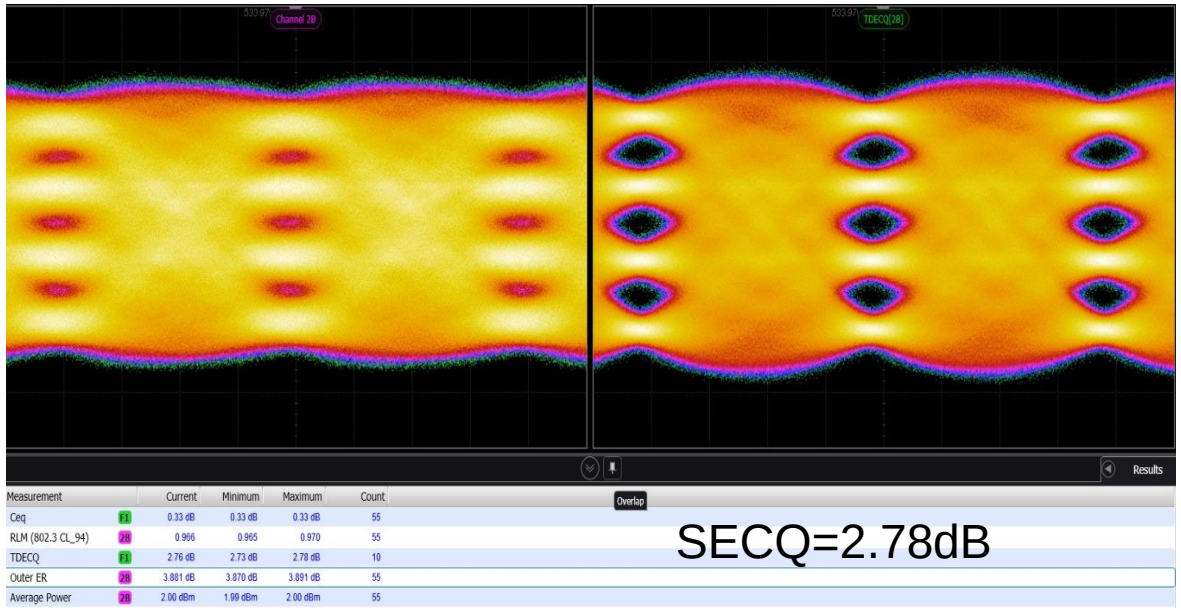


BTB vs. 25.6ps/nm Dispersion Eye Diagram

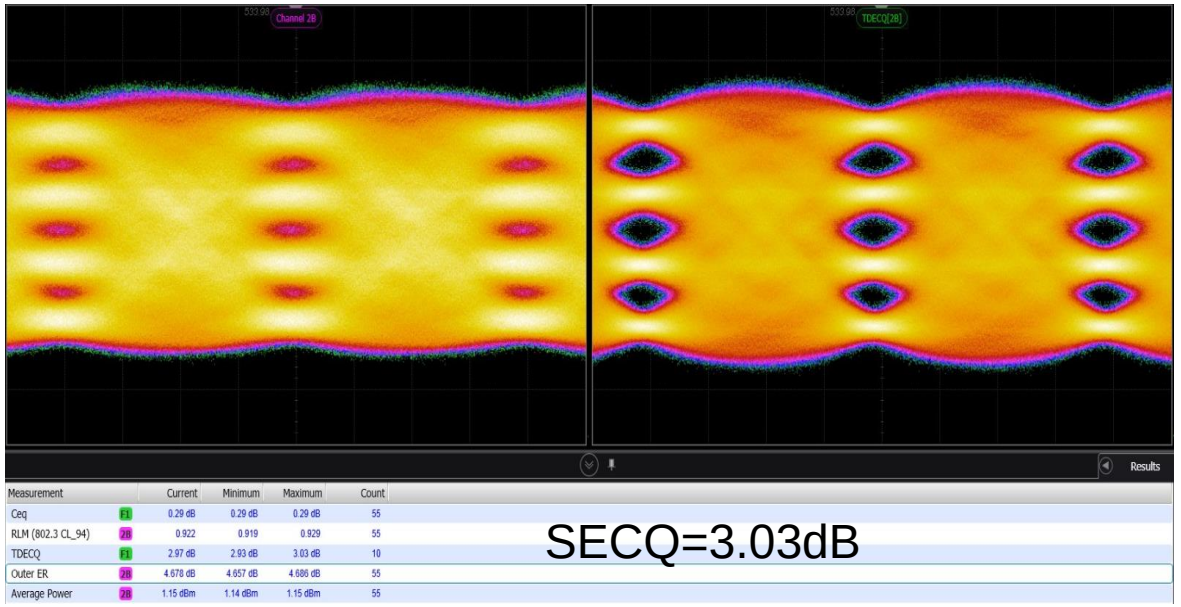
EA Bias set for best SECQ at BTB

EA Bias set for best TDECQ at 25.6ps/nm Dispersion

BTB

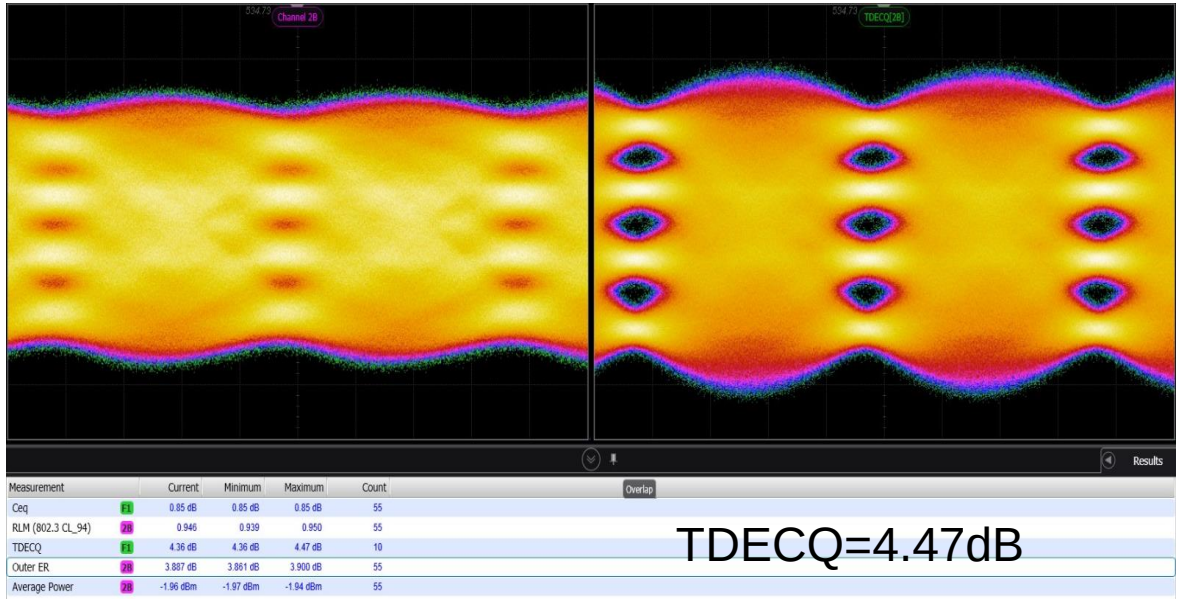


SECQ=2.78dB

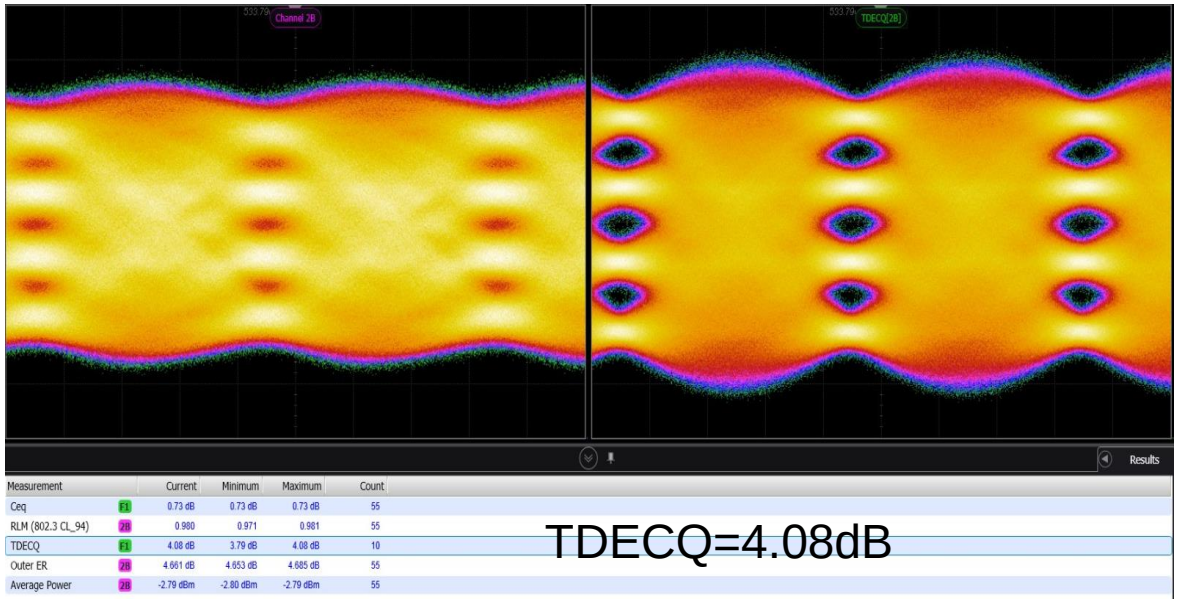


SECQ=3.03dB

25.6ps/nm Dispersion



TDECQ=4.47dB

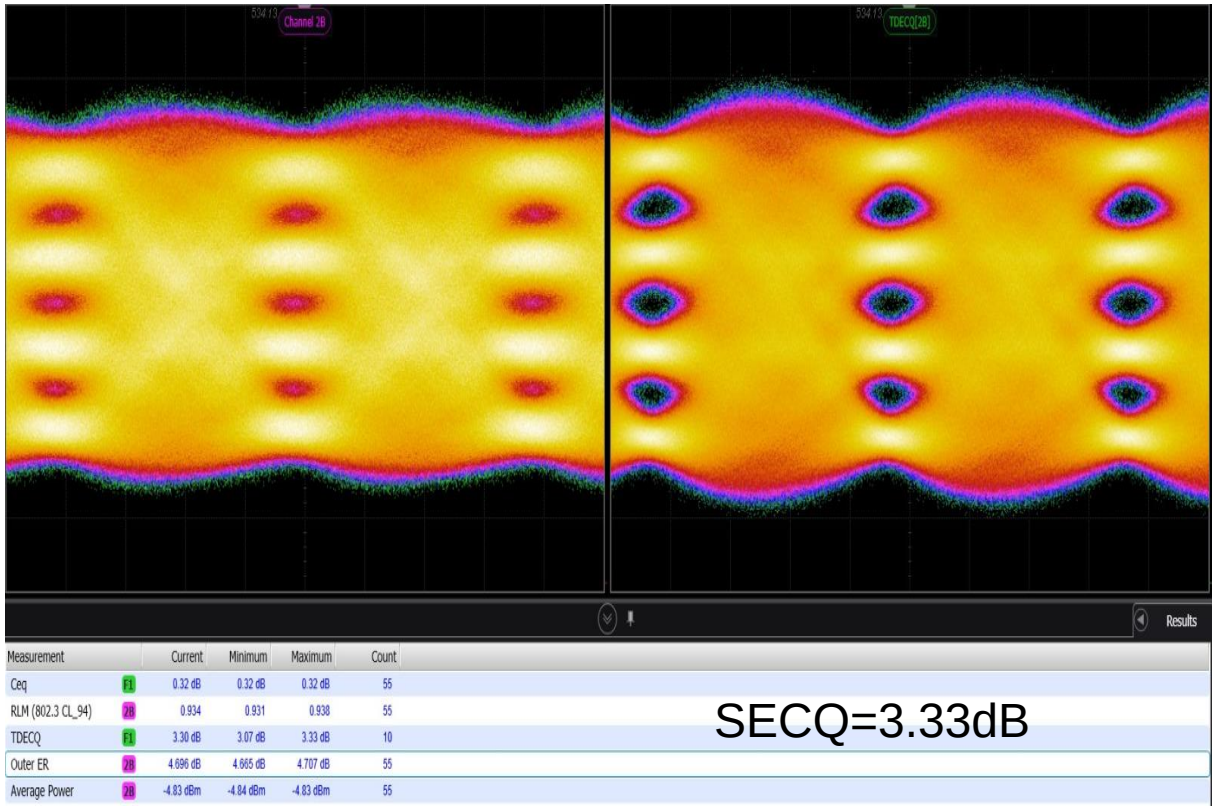


TDECQ=4.08dB

TDECQ at 33.7ps/nm dispersion vs. EA Bias

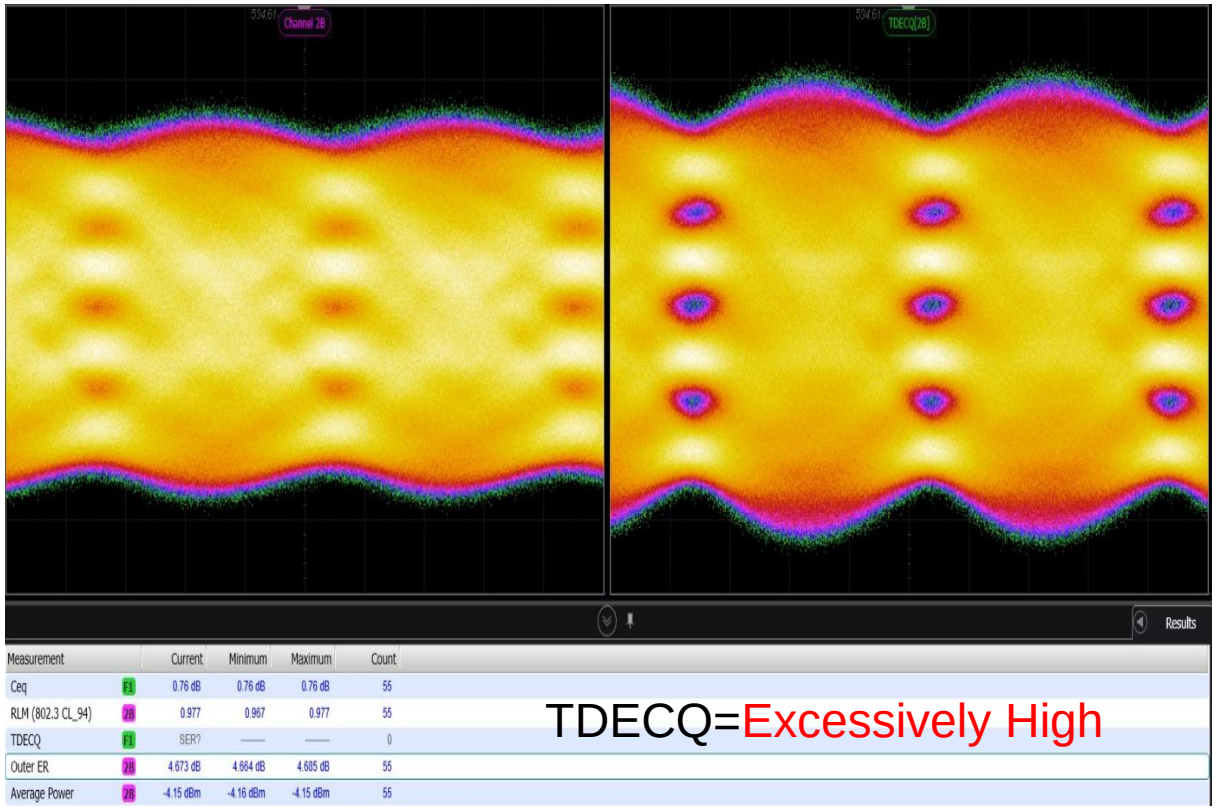
- No matter what the EA Bias, the TDECQ values at 10km worst case dispersion are always excessively high.
- The SECQ with extra attenuation has been tested to confirm that TDECQ can be measured at such lower level of average optical power by the scope.

SECQ at BTB with extra attenuation



SECQ=3.33dB

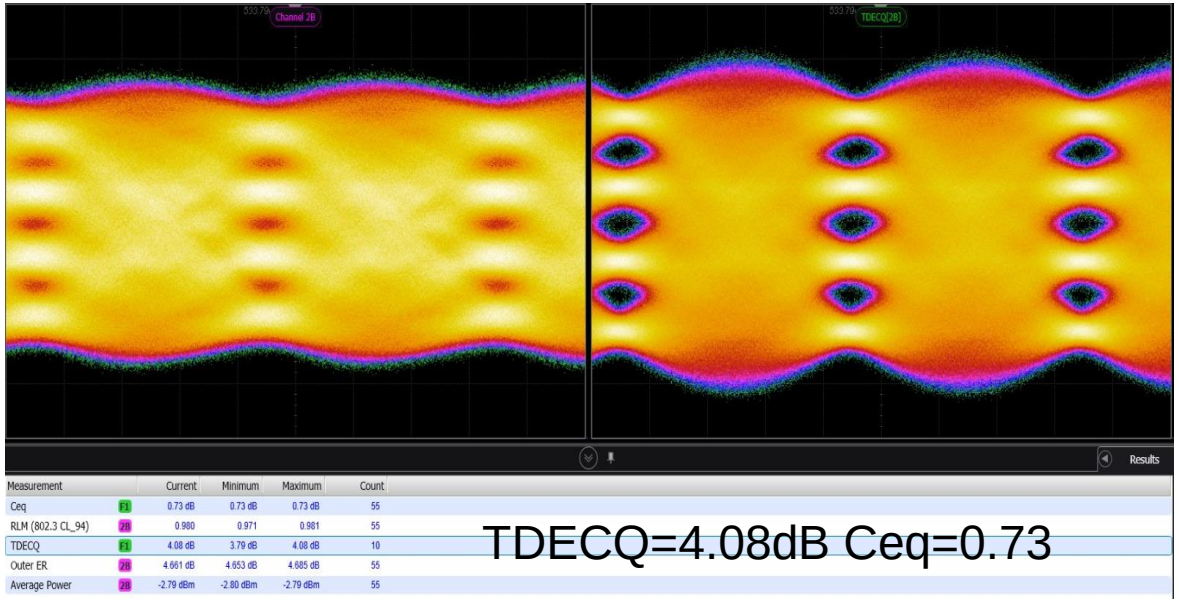
TDECQ at 33.7ps/nm dispersion



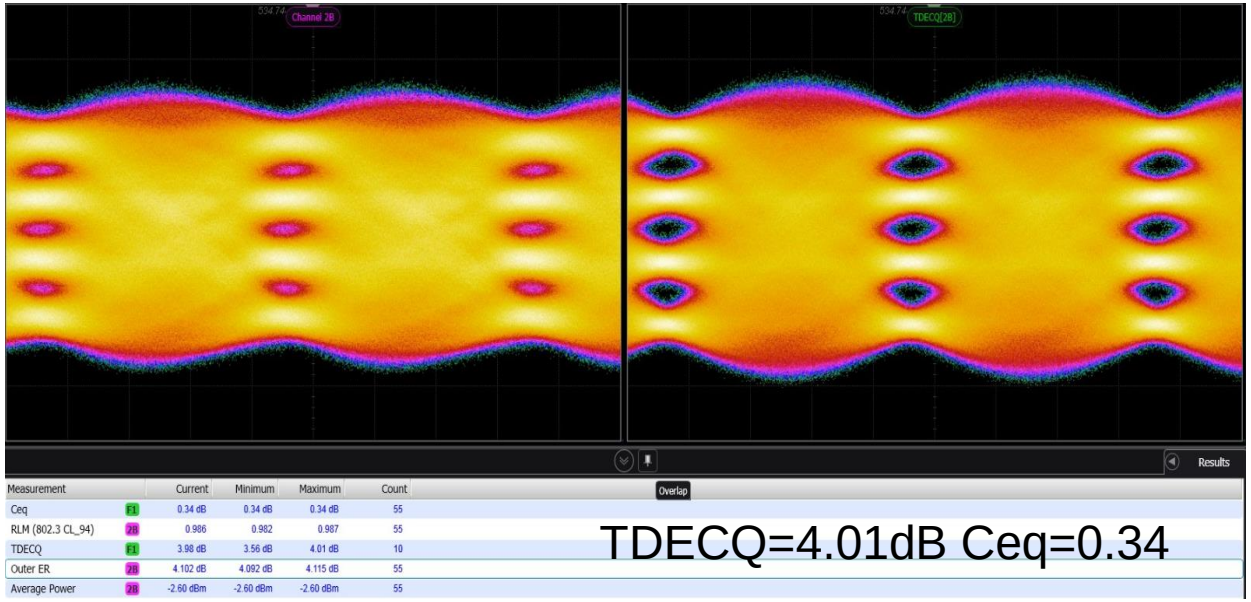
TDECQ=Excessively High

TDECQ at 25.6ps/nm dispersion vs. Pre-EQ

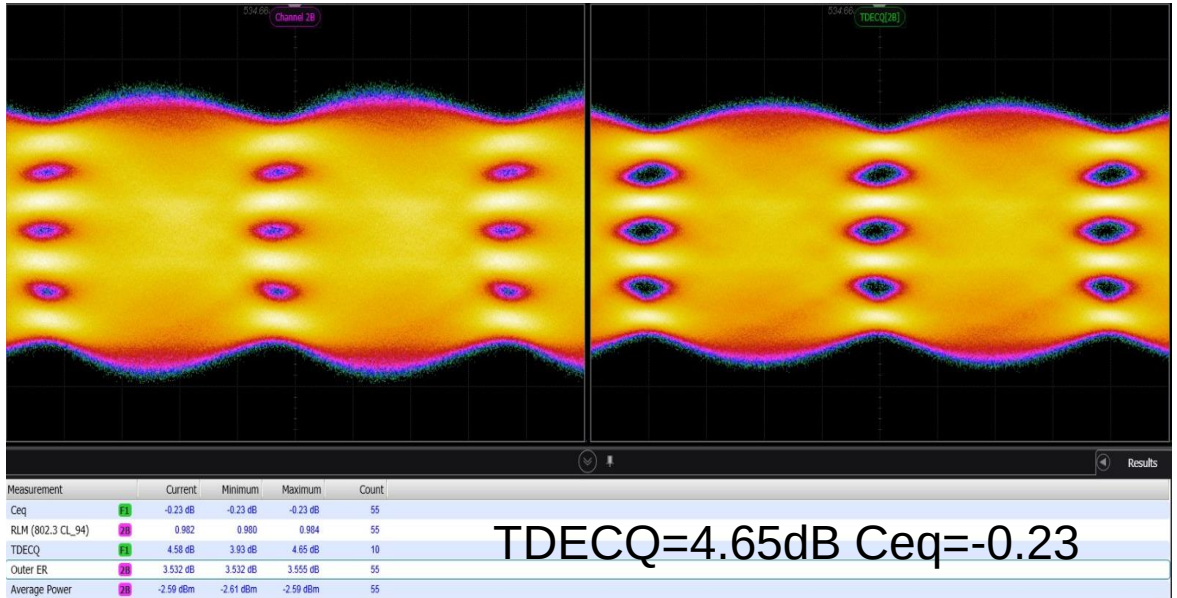
- No significant benefit (<0.1dB) can be found by tuning Pre-EQ Taps.



TDECQ=4.08dB Ceq=0.73



TDECQ=4.01dB Ceq=0.34

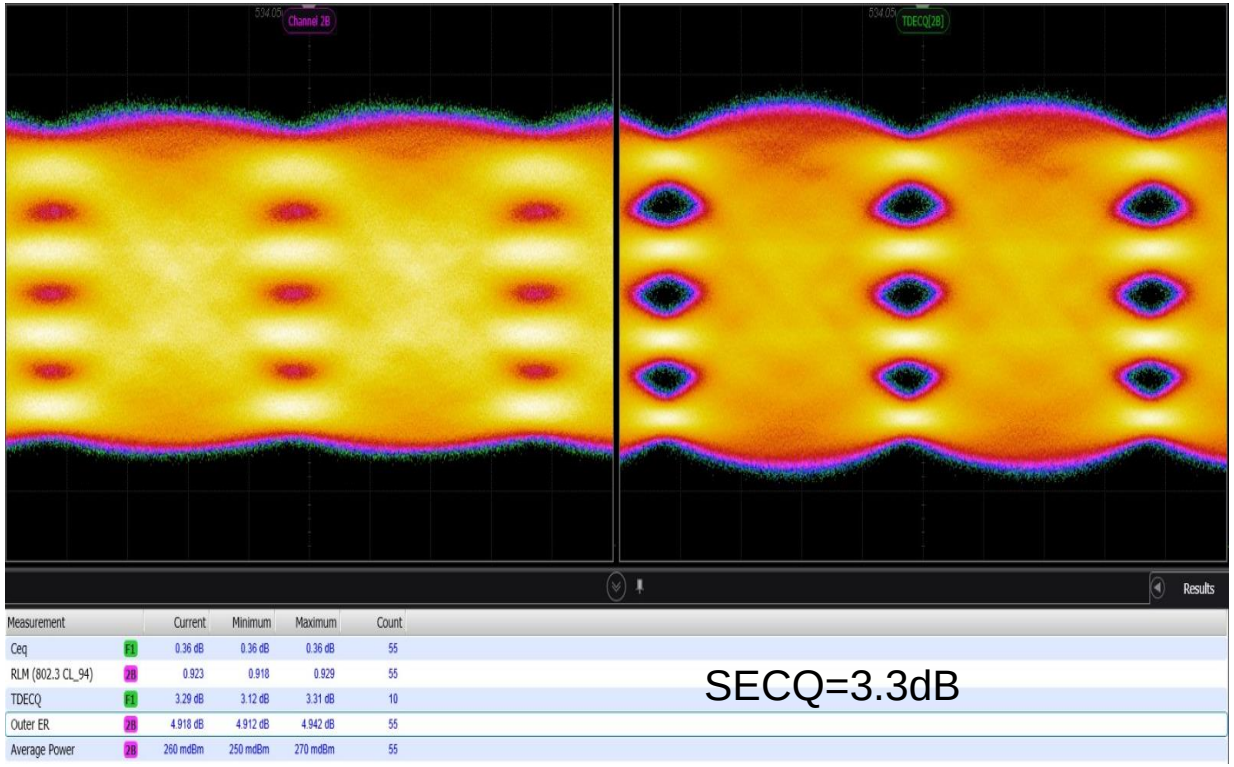


TDECQ=4.65dB Ceq=-0.23

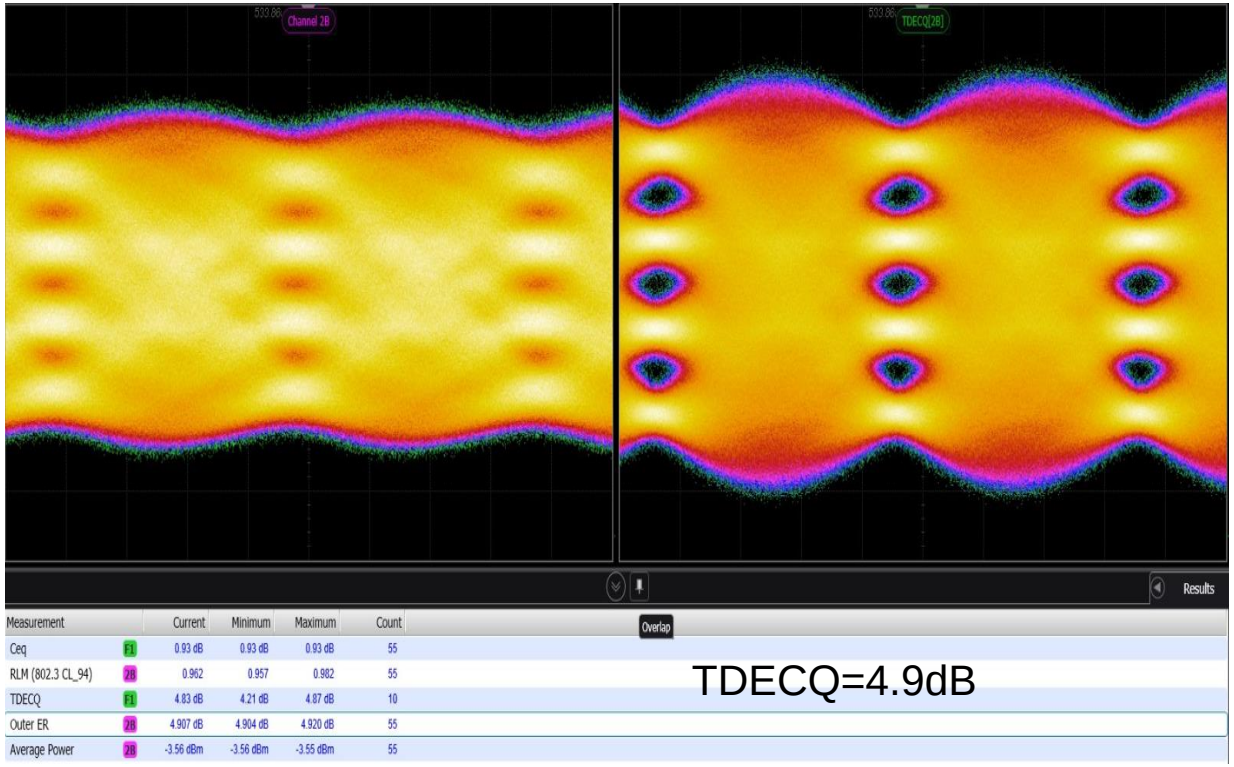
TDECQ at 25.6ps/nm dispersion in High Temp.

- With the optimized EA Bias, the maximum TDECQ at 25.6ps/nm dispersion is 4.9dB in high temperature.
- Comparing to the room temperature, the penalty introduced by high temperature is 0.8dB.

EA Bias set for best TDECQ at 25.6ps/nm Dispersion



SECQ=3.3dB



TDECQ=4.9dB

Summary

- Through the EA Bias optimization for best TDECQ over fiber transmission, TDECQ at 25.6ps/nm dispersion is decreased by 0.4dB at the expense of 0.2dB SECQ.
- The benefit brought by tuning Pre-EQ is lower than 0.1dB.
- With 25.6ps/nm dispersion, the optimized maximum TDECQ is 4.1dB, which is increased to 4.9dB in high temperature. The optimized maximum TDECQ-SECQ is 1.5dB at high temperature.
- Regardless of transmitter settings , maximum TDECQ at 33.7ps/nm dispersion is always excessively high due to significant dispersion penalty .

Temp.	Setting of Transmitter	SECQ	TDECQ	TDECQ-SECQ	TDECQ	TDECQ-SECQ
		dB	dB	dB	dB	dB
			25.6ps/nm		33.7ps/nm	
Room	EA Bias for Best SECQ	2.8	4.5	1.7	Excessively High	Excessively High
	EA Bias for Best TDECQ	3.0	4.08	1.08		
	EA Bias & Pre-EQ for Best TDECQ	2.8	4.01	1.21		
High	EA Bias for Best TDECQ	3.3	4.9	1.5		

Thoughts

- The measured maximum TDECQ values at 8km worst case dispersion exceeds the 3.9dB limit proposed in lewis_3cu_adhoc_061919_v2 even in room temperature. Consequently, it is very challenging for EML transmitters to meet the proposed spec for 10km transmission on a CWDM grid.
- Possible approach:
  - Adopting LWDM as a baseline for 10km reach.
- Further thoughts
  - Modify accepted 400GBASE-FR4 baseline to accommodate a higher loss than 4 dB
  - or Agree on a new additional objective for a higher loss ~7 km on the basis of demonstrated market need for such an application.


thank you
danke
рахмат
謝謝
ngiyabonga
teşekkür ederim
Баярлалаа
спасибо
mersi
barka
welalin
tack
dank je
faafetai lava
vinaka
blagodaram
misaotra
matondo
paldies
gracias
tapadh leat
mahalo
хвала
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manana
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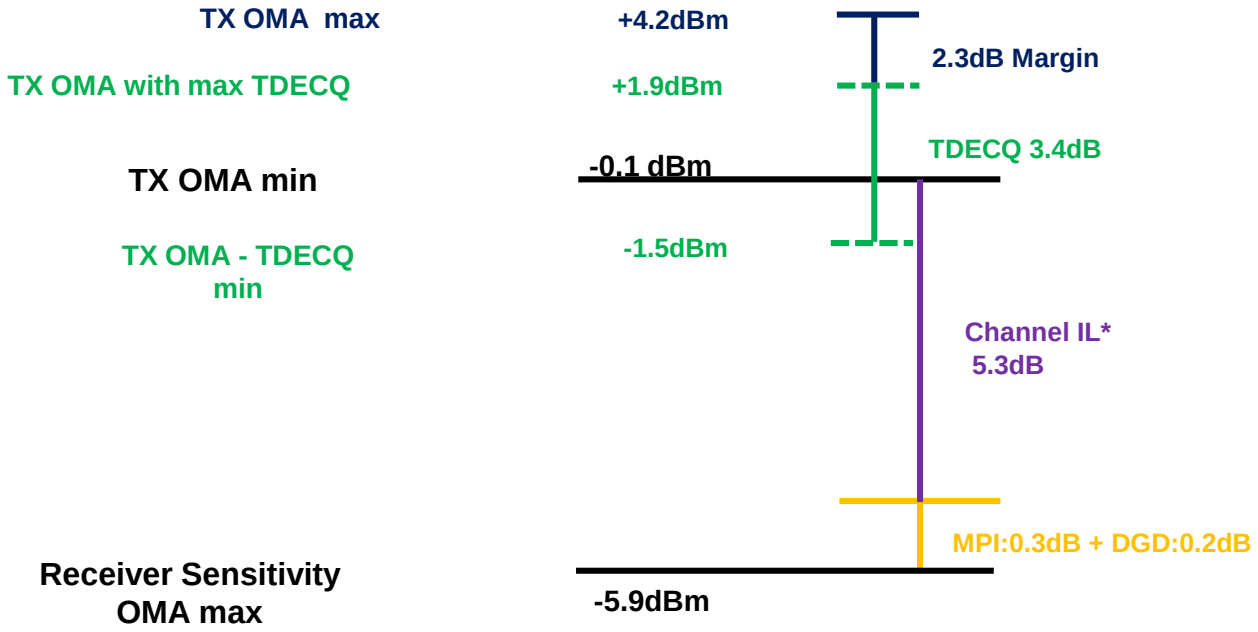
CWDM Baseline Suggestion

- The following is for starting a discussion.
- A low cost solution could be one of the direction of our discussion, which could satisfy the technical requirement for a reasonable market.



*The exact distance needs to be investigated.

Transmitter Suggestion

Description	Value	Unit
PAM4 Signaling rate, each lane (range)	53.125 ± 100 ppm	GBd
Lane wavelengths (range)	1264.5 to 1277.5	nm
	1284.5 to 1297.5	
	1304.5 to 1317.5	
	1324.5 to 1337.5	
Side-mode suppression ratio (SMSR), (min)	30	dB
Total average launch power (max)	10	dBm
Average launch power, each lane (max)	4	dBm
Average launch power, each lane[a] (min)	-3.1	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	4.2	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane[b] (min)	-0.1	dBm
Difference in launch power between any two lanes (OMA_{outer}) max	4	dB
Launch power in OMA_{outer} minus TDECQ, each lane (min): for extinction ratio ≥ 4.5 dB for extinction ratio ≥ 4.5 dB	 -1.5 -1.4	dBm
Transmitter and dispersion penalty eye closure for PAM4 (TDECQ), each lane (max)	3.4	dB
TDECQ – 10*$\log_{10}(C_{eq})$, each lane (max)[d]	3.4	dB
Average launch power of OFF transmitter, each lane (max)	-20	dBm
Extinction ratio (min)	3.5	dB
Transmitter transition time (max)	17	ps
$RIN_{15.6}$ OMA (max)	-136	dB/Hz
Optical return loss tolerance (max)	15.6	dB
Transmitter reflectance[c] (max)	-26	dB

Receiver Suggestion

Description	Value	Unit
PAM4 Signaling rate, each lane (range)	53.125 ± 100 ppm	GBd
Lane wavelengths (range)	1264.5 to 1277.5	nm
	1284.5 to 1297.5	
	1304.5 to 1317.5	
	1324.5 to 1337.5	
Damage threshold, each lane (min)[a]	5.0	dBm
Average receive power, each lane (max)	4.0	dBm
Average receive power, each lane [b] (min)	-8.4	dBm
Receive power, each lane (OMA_{outer}) (max)	4.2	dBm
Difference in receive power between any two lanes (OMA_{outer}) (max)	4.1	dB
Receiver reflectance (max)	-26	dB
Receiver sensitivity (OMA_{outer}), each lane [c] (max)	RS =MAX(-5.9,SECQ-7.3)	
Stressed receiver sensitivity (OMA_{outer}), each lane [d] (max)	-3.9	dBm
Conditions of stressed receiver sensitivity test:		
Stressed eye closure for PAM4 (SECQ), lane under test	3.4	dB
SECQ – $10*\log_{10}(C_{eq})$, lane under test (max) [e]	3.4	dB
OMA_{outer} of each aggressor lane	0.2	dBm

Power Budget Suggestion

Description	Value	Unit
Power budget (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	 9.2 9.3	dB
Operating distance	--*	km
Channel insertion loss[a]	5.3	dB
Maximum discrete reflectance	See Table Below	dB
Allocation for penalties[b] (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	 3.9 4.0	dB
Additional insertion loss allowed	0	dB

[a] The channel insertion loss is calculated using the maximum distance specified in Table 2-2 and cabled optical fiber attenuation of 0.47 dB/km plus an allocation for connection and splice loss given in 5.2.1.
[b] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

Number of discrete reflectance above -55dB	Maximum value for each discrete reflectance	Unit
1	-22	dB
2	-29	dB
4	-33	dB
6	-35	dB
8	-37	dB
10	-39	dB

*The exact distance needs to be investigated