Baseline proposal for 800GBASE-LR4

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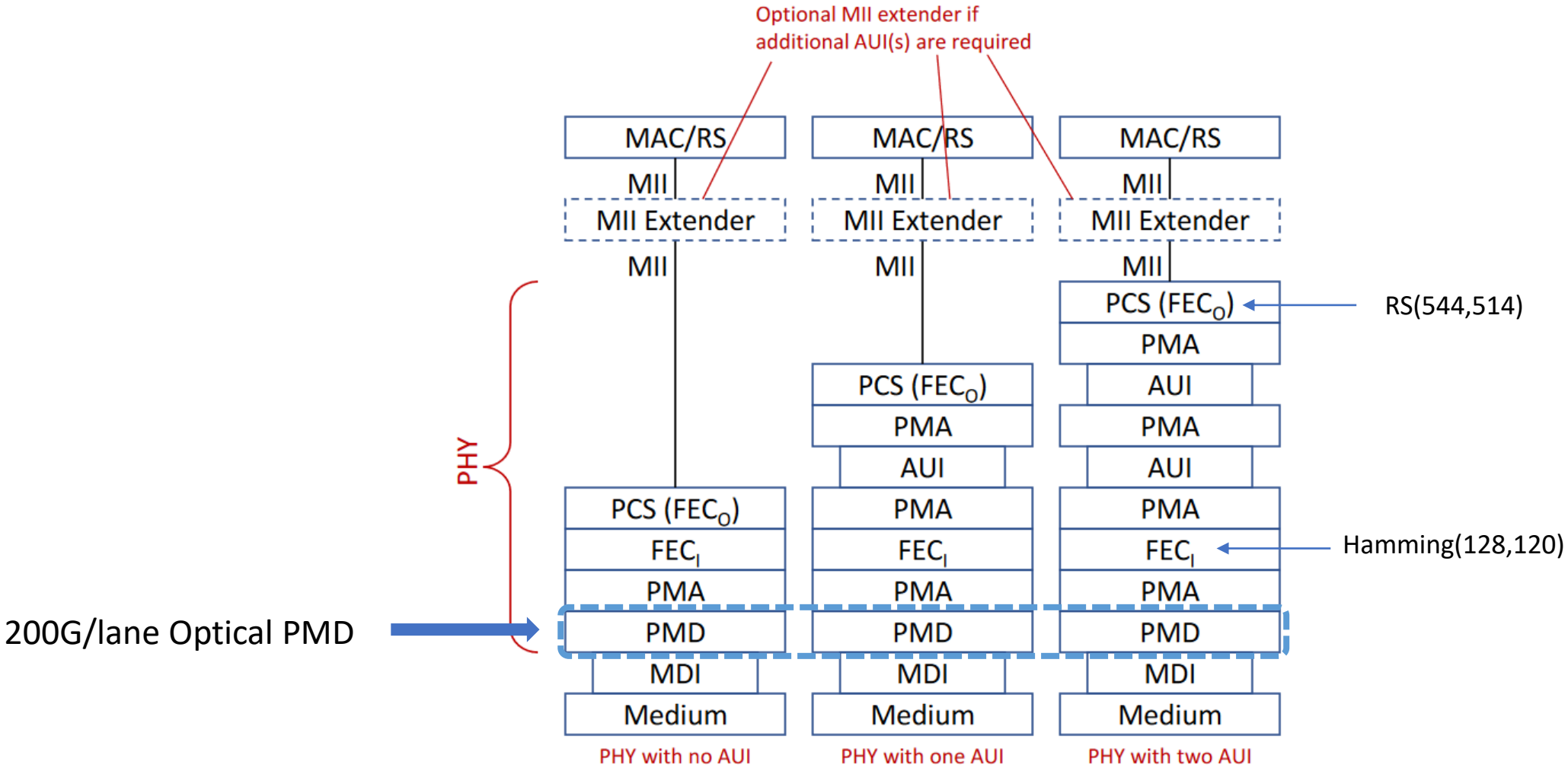
Content

- Baseline proposal
- Technical feasibility demonstrations

For previous discussion and analysis see: rodes_3dj_01a_2309

Baseline Proposal for 800GBASE-LR4

Location in Ethernet Stack



brown_3dj_optx_adhoc_01a_230222

Transmitter Specifications

Description	800GBASE-LR4	Unit
Signaling rate, each lane (range)	113.4375 ± 50 ppm	GBd
Modulation format	PAM4	
Lane wavelengths (range)	1294.56 to 1296.59 1299.05 to 1301.09 1303.54 to 1305.63 1308.09 to 1310.19	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Total average launch power (max)	11.5	dBm
Average launch power, each lane (max)	5.5	dBm
Average launch power, each lane (min)	-0.9	dBm
Outer Optical Modulation Amplitude (OMAouter), each lane (max)	5.7	dBm
Outer Optical Modulation Amplitude (OMAouter), each lane (min) for TDECQ <1.4 dB for 1.4 dB ≤ TDECQ ≤ 3.9 dB	 1.9 0.5+TDECQ	 dBm dBm
Difference in launch power between any two lanes	3	dB
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max) *	3.9	dB
Transmitter eye closure for PAM4 (TECQ), each lane (max)	3.2	dB
|TDECQ-TECQ| (max)	2.5	dB
Over/under-shoot (max)	22	%
Transmitter power excursion (max)	3.1	
Extinction ratio, each lane (min)	3.5	dB
Transmitter transition time (max)	13	ps
Average launch power of OFF transmitter, each lane (max)	-16	dBm
$RIN_{15.6}OMA$ (max)	-139	dB/Hz
Optical return loss tolerance (max)	15.6	dB
Transmitter reflectance (max)	-26	dB

*Measured with 15-tap reference equalizer with SER = 9.6e-3 he_3dj_01a_2311

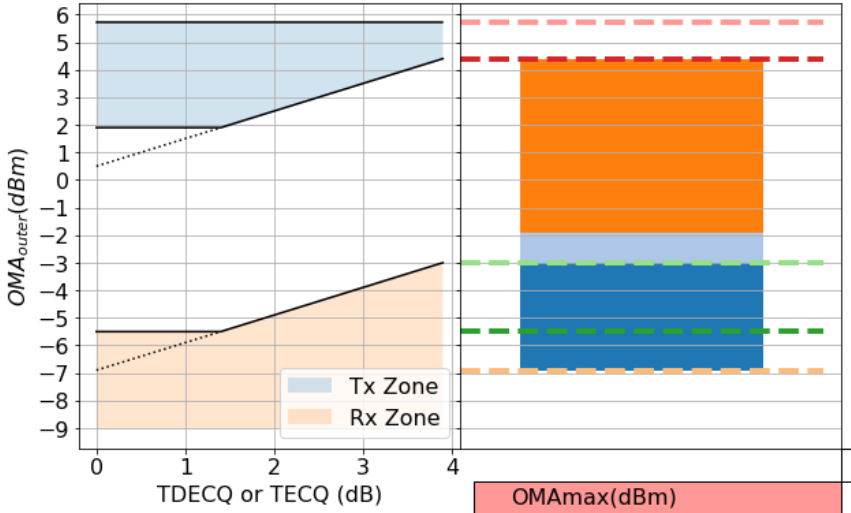
Receiver Specifications

Description	800GBASE-LR4	Unit
Signaling rate, each lane (range)	113.4375 ± 50 ppm	GBd
Modulation format	PAM4	
Lane wavelengths (range)	1294.56 to 1296.59 1299.05 to 1301.09 1303.54 to 1305.63 1308.09 to 1310.19	nm
Damage threshold, each lane	6.5	dBm
Average receive power, each lane (max)	5.5	dBm
Average receive power, each lane (min)	-8	dBm
Receive power (OMAouter), each lane (max)	5.7	dBm
Difference in receive power between any two lanes (OMAouter) (max)	3.3	dB
Receiver reflectance (max)	-26	dB
Receiver sensitivity (OMAouter), each lane (max) for TECQ <1.4 dB for 1.4 dB ≤ TECQ ≤ 3.9 dB	 -5.5 -6.9 + TECQ	 dBm dBm
Stressed receiver sensitivity (OMAouter), each lane (max)	-3	dBm
Conditions of stressed receiver sensitivity test:		
Stressed eye closure for PAM4 (SECQ), lane under test *	3.9	dB
OMAouter of each aggressor lane	0.3	dBm

*Measured with 15-tap reference equalizer with SER = 9.6e-3

Link Budget

Parameter	800GBASE-LR4	Unit
Power budget (for maximum TDECQ)	11.3	dB
Operating Distance	10	km
Channel insertion loss	6.3	dB
Maximum discrete reflectance	-35	dB
Allocation for penalties (for maximum TDECQ) *	5	dB



	800G-LR4
OMAmax(dBm)	5.7
OMA-TDECQ(dBm)	0.5
OMAmin@TDECQmax(dBm)	4.4
SRS(dBm)	-3.0
Rx Sens (TECQ <= 1.4dB)	-5.5
RSnominal(dBm)	-6.9
OpticalLossBudget	6.3
AdditionalPenalties	1.1
TDECQmax	3.9
PowerBudget	11.3

Overview of Statistical Methodology for CD

Methodology to evaluate more realistic chromatic dispersion was presented here:
ferretti_3dj_optx_01b_230615

MonteCarlo computation is set up using M = 4 concatenations and cable length of LCab = 2.5 km for a 10 km link, and a Q value of 10^{-4} which corresponds to a 99.99% confidence

$$CD_M(\lambda) = \sum_{i=1}^{M} L_{Cab} D_i(\lambda),$$

Dispersion of each segment for a given λ is calculated using 3rd order Sellmeier equation

$$D(\lambda) = \frac{\lambda S_0}{4}\left[1 - \left(\frac{\lambda_0}{\lambda}\right)^4\right]$$

Specific values to be determined once ITU-T statistical data gets available

Fiber optic cabling (channel) characteristics

Description	800GBASE-LR4	Unit
Operating distance (max)	10	Km
Channel insertion loss (max)	6.3	dB
Positive dispersion (max)	TBD	ps/nm
Negative dispersion (min)	TBD	ps/nm
DGDmax*	4	ps

* kuschnerov_3dj_optx_01_230829

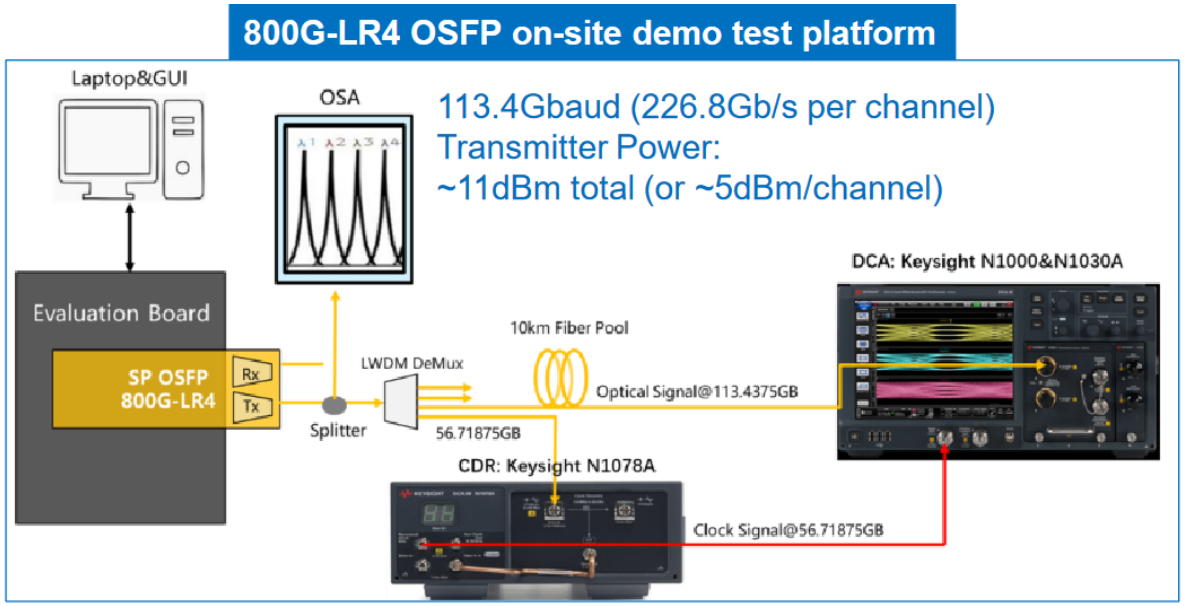
Transmitter compliance channel specifications

Dispersion								Max mean DGD
Lane0		Lane1		Lane2		Lane3		
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	0.8 ps

CD values to be specified once ITU-T statistical data gets available

Module demonstration of Technical Feasibility at ECOC 2023

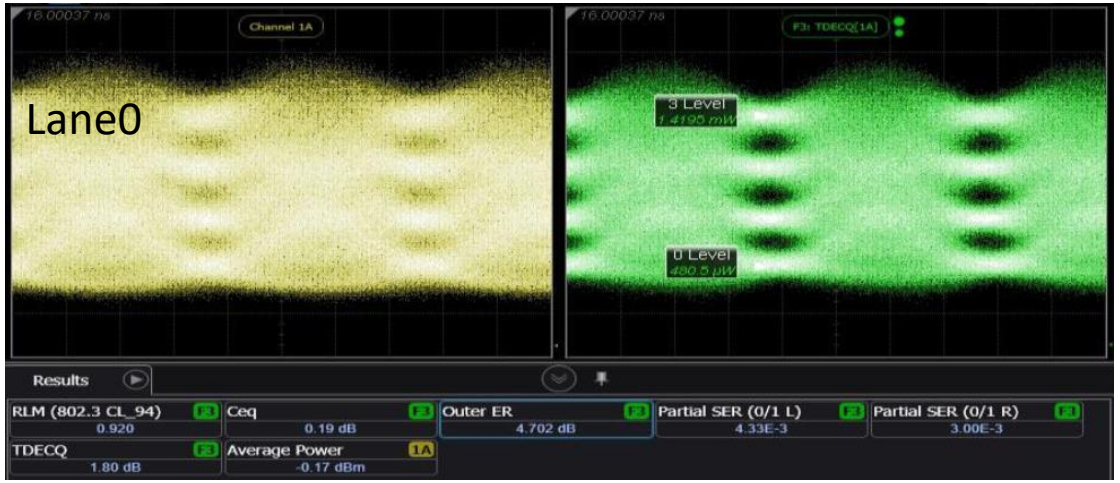
Transmitter demonstrations

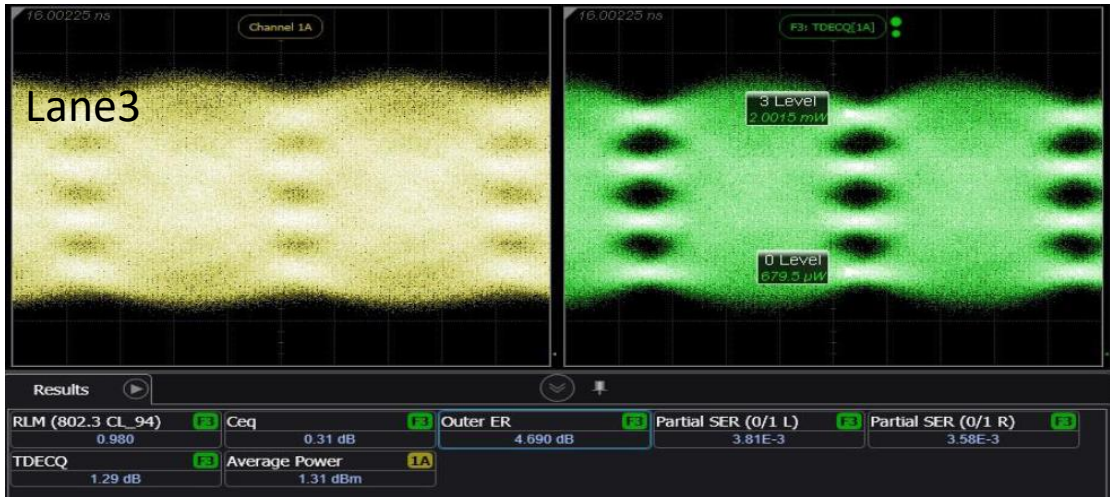


[liu_3dj_optx_01a_231019]

Latest data in: [chang_3dj_01a_2311]

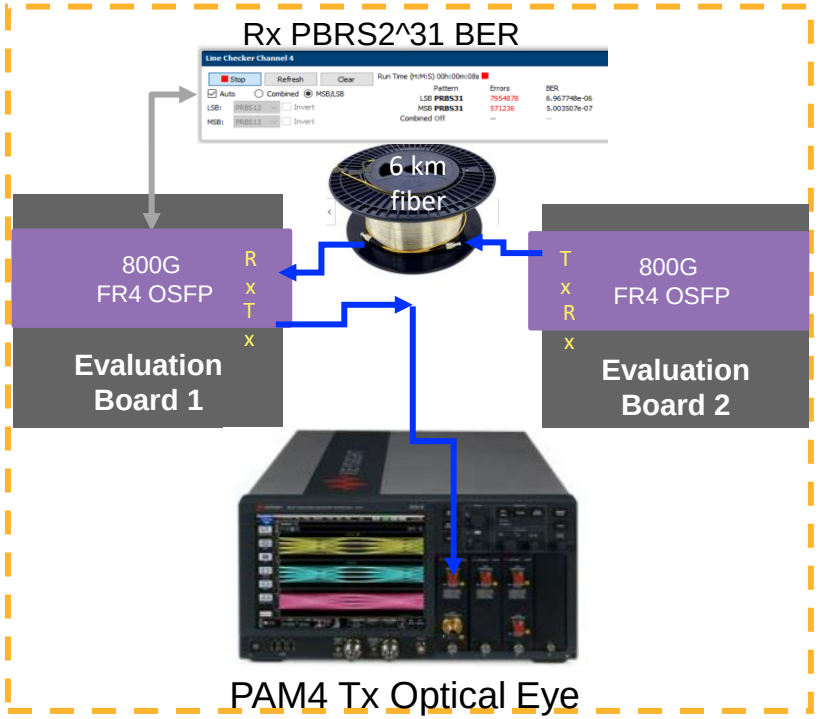
Tx after 10km SSMF

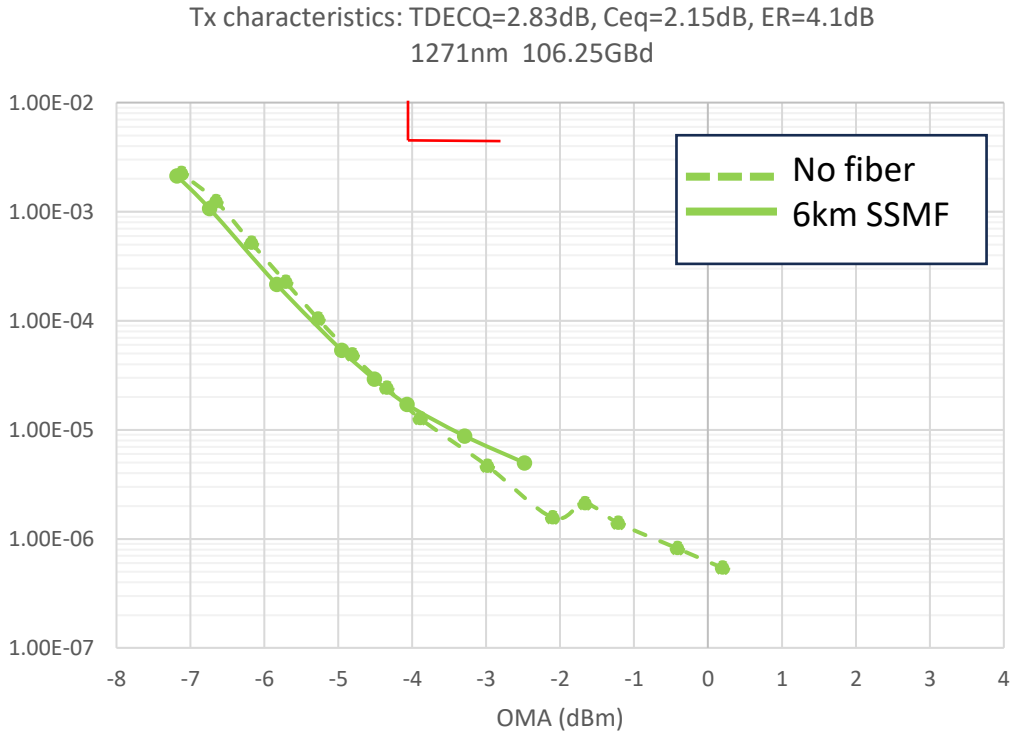




Receiver demonstrations

CWDM4 module over 6km SSMF



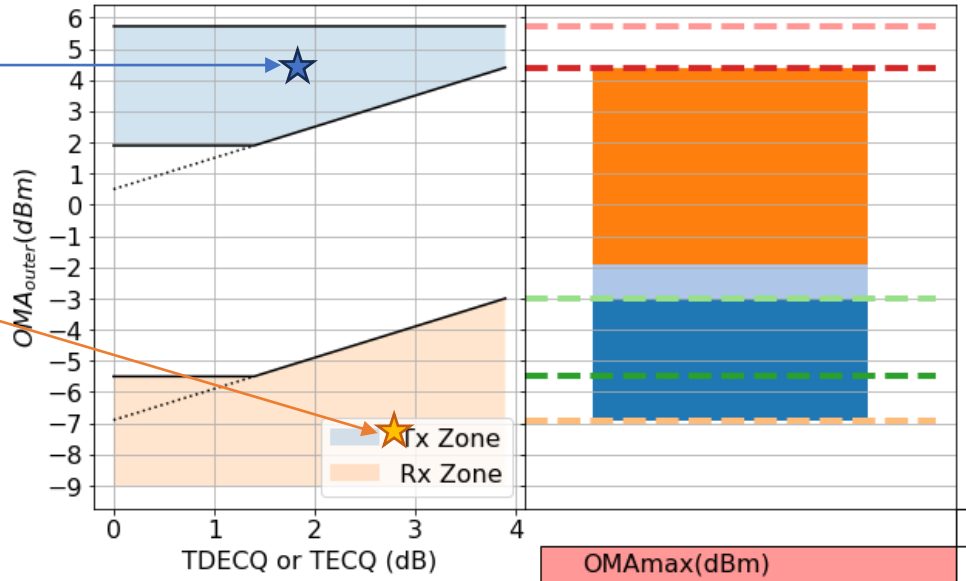


- CWDM4 Lane0 (1271nm) measured after ~-20ps/nm similar to worst-case dispersion on 800G-LR4 LWDM
- Slightly lower baudrate than 113.4375GBd, expected to add some penalty on sensitivity

Link budget of demonstration

Tx demonstration liu_3dj_optx_01a_231019

Rx demonstration



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Rx Sens (TECQ <= 1.4dB)	-5.5
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OpticalLossBudget	6.3
AdditionalPenalties	1.1
TDECQmax	3.9
PowerBudget	11.3

Caveats on demonstrations:

- Tx TDECQ with 10km SSMF (not worst-case CD)
- Rx waterfall at 106.25GBd

Even though there hasn't been a full 800G-LR4 module demonstration yet, latest demos presented during last ECOC from multiple companies show technical feasibility of meeting proposed Tx and Rx specs

Summary

- Baseline proposal for 800GBASE-LR4 has been presented
- Initial module results give confidence on technical feasibility of the proposed specs