

Towards an 800G-LR4 IMDD Specification Consensus - April 2023 update

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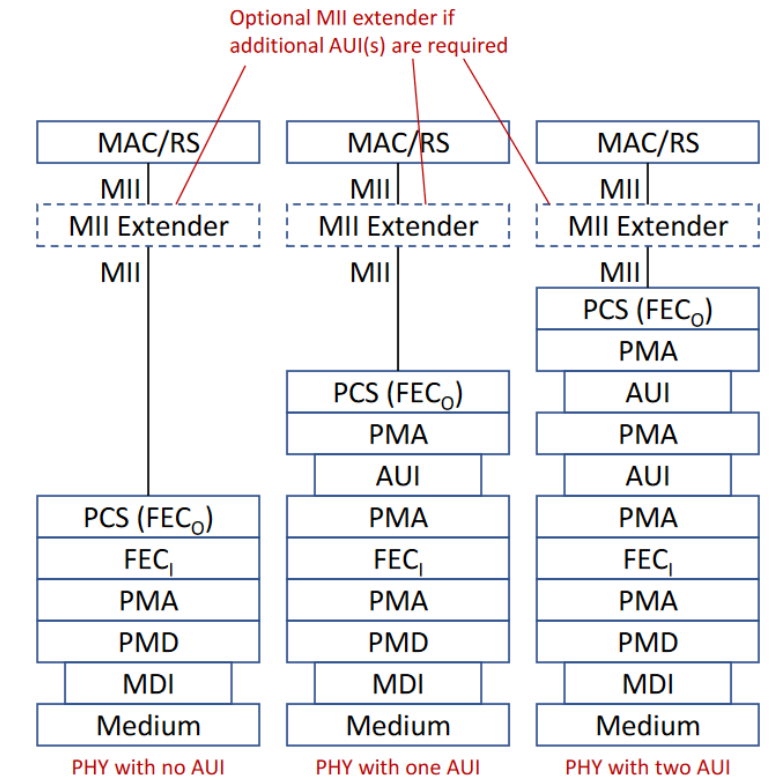
Introduction

- This presentation is an update to the 800GBASE-LR4 specs proposed in rodes_3df_01_2303
- Updated on this presentation:
 - Propose using same inner FEC adopted for other 200G/lane IMDD PMDs
 - Proposing TDECQ equalization to be left 'TBD' for future discussion
 - Updated FWM penalty allocation based on latest analysis
- We propose this specification as a baseline for 800GBASE-LR4 with further refinements based on contributions from the Task Force

FEC proposal

- 800G-LR4 small volume will not justify a dedicated IC design
- 800G-LR4 will necessarily reuse the same Type2 inner FEC as in Motion#5 in March 2023 Plenary
- Experimental and simulation data indicates FEC in [patra 3dj 01b 2303](#) is enough to accommodate:
 - CD up to -28ps/nm (assuming worst case dispersion window from ITU ZDW of 1300-1324nm). [kuschnerov 3df 02 221012](#)
 - LR power budget. [kuschnerov 3df 02 221012](#)
 - FWM. [liu 3dj 01 2303](#)
 - PMD. [kuschnerov 3df 01b 221012](#)
- Statistical link budget analysis could further increase margin on chromatic dispersion by slightly redefining the ZDW test points. [cole 3dj 01 230413](#)

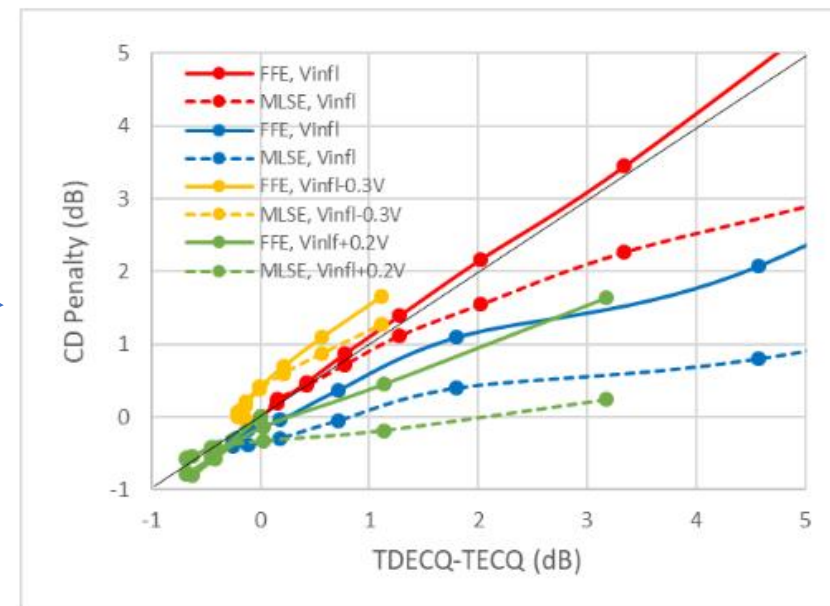
Type 2 PHY/FEC scheme



[brown 3dj optx adhoc 01a 230222](#)

TDECQ reference equalizer considerations

- 200G/lane requires stronger equalization compared to 100G/lane:
 - Higher ISI: components are not quite doubling the BW
 - Higher Noise: higher Xtalk and Rx IRN
 - Smaller CD tolerance: it reduces quadratically with Baudrate
 - Farther away reflections: round trip is two times the number of UIs for the same electrical length
- Real receivers have equalizers that are more powerful including FFE with more taps, DFE and MLSE
- Reference receiver needs to be updated accordingly otherwise:
 - TDECQ will not represent real link power penalty
 - Unnecessary yield hit and added cost in Tx
 - Distrust from users on SECQ to evaluate Rx Sensitivity
- A weaker TDECQ reference equalizer is inefficient to provide margin on Rx because it cannot distinguish Tx's with equalizable impairments from Tx's with unequalizable impairments
- We propose to leave TDECQ reference equalizer as 'TBD' in the first baseline. It requires careful evaluation with more data, and it is not strictly necessary to build link power budget.



[johnson_3df_01a_221011](#)

Tx Spec proposal

Static FWM probability is low enough to not have significant economic consequences, based on

[liu 3dj 01 2303](#) and [johnson 3dj 01a 230206](#).

Therefore, lower TDECQ spec over the range of lower CD where FWM could possibly occur is not necessary anymore

OMA_{outer} is 5.7dBm to provide sufficient headroom for OMA_{min}@TDECQ_{max} (1.3dB)

AOP is 5.5dBm, 0.2dB lower than OMA_{outer} max. Same than, for example, 400GBASE-DR4

TDECQ reference receiver:

- BW: 4th order Bessel Thompson filter with -3dB cutoff at Nyquist
- Reference Equalizer: TBD

Description	800G-LR4	Unit
Signaling rate, each lane (range)	113.4375	GBd
Modulation format	PAM4	
Lane wavelengths (range)	1294.6 to 1296.6 1299.1 to 1301.1 1303.6 to 1305.6 1308.1 to 1310.1	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 (OMA _{outer}), each lane (max)	5.7	dBm
Outer Optical Modulation Amplitude (OMA _{outer}), 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

Rx Spec proposal

Rx sensitivity of -5.5dBm @ TDECQ = 1.4dB is achievable based simulation analysis:

[rodes 3df 01b 221012](#)

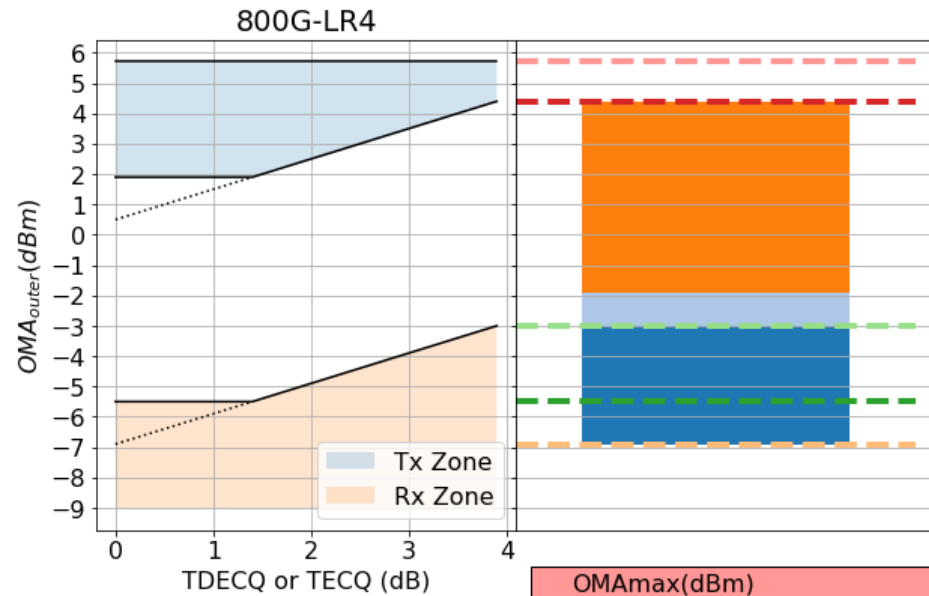
,and experimental data:

[kuschnerov 3df 02a 221012](#)

Rx sensitivity measured for BER= 4.85e-3 per [patra 3dj 01b 2303](#). Slight modification might be required based on final AUI BER requirement.

Description	800G-LR4 proposal	Unit
Signaling rate, each lane (range)	113.4375	GBd
Modulation format	PAM4	
Lane wavelengths (range)	1294.6 to 1296.6 1299.1 to 1301.1 1303.6 to 1305.6 1308.1 to 1310.1	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	1.3	dBm

Link Power Budget



	800G-LR4
OMAm _{ax} (dBm)	5.7
OMA-TDECQ(dBm)	0.5
OMAm _{in} @TDECQ _{max} (dBm)	4.4
SRS(dBm)	-3.0
Rx Sens (TECQ ≤ 1.4dB)	-5.5
RS _{nominal} (dBm)	-6.9
OpticalLossBudget	6.3
AdditionalPenalties	1.1
TDECQ _{max}	3.9
PowerBudget	11.3

Parameter	800G-LR4 proposal	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

*DGD=0.7dB and MPI= 0.4dB , [kuschnerov 3df 01b 221012](#), [kuschnerov 3df 02a 221012](#)

Conclusion

- We have presented an update on the set of specs for 800GBASE-LR4
- We propose to use the same FEC in [patra 3dj 01b 2303](#) that was adopted for all other 200G/lane PMDs as in Motion#5 in March 2023 Plenary
- TDECQ reference equalizer is proposed to be left as 'TBD' for future discussion
- Lower TDECQ spec over the range of lower CD where FWM could possibly occur is not necessary and has been removed
- We expect further refinement as the task force progresses and more data comes available