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

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Introduction

- This presentation introduces into .3dj the same list of 800GBASE-LR4 specs proposed in rodes_3df_01a_2211 with minor updates

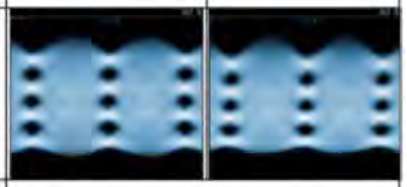
- We propose this specification as a baseline for 800GBASE-LR4 with further refinements based on contributions from the Task Force

Key discussions

- FWM exceeding allocated budget:
  - Is ‘static probability’ of ~4E-5 enough? johnson_3dj_01a_230206
    - This means operators, over 1 million links, would have 40 occasions that would experience SNR degradation beyond allocated margin.
  - If not, we could achieve lower probability by one or more of these approaches:
    - Considering realistic fiber segmentation (‘Static probability’ <1e-7) kuschnerov_3df_01a_2211, liu_3dj_01_2303
    - Adoption of statistical modelling of fibre properties based on modern fibre distributions with the sigma points chosen to reflect acceptable probability limits cole_3df_01a_2211
    - Account for ZDW longitudinal variation kikuchi_3dj_01b_230206
    - Polarization Interleaving and PMD distribution: liu_3df_01a_221012
    - Laser wavelength shift via temperature tuning kuschnerov_3dj_01a_230206
- Is Chromatic dispersion manageable and how to spec it?
  - OFC demonstration of 10km with transmission 200G EML showing 2.2dB TDECQ

    Kazuki Nishimura et al., M2D.4. OFC, 2023.
  - Obsolete fiber model might require FFE+MLSE: kuschnerov_3df_02_221012
  - Statistical model of CD could require simpler Rx DSP: parsons_3df_01a_2211
- Higher AOP spec achievable with 200G EML?

  OFC papers have shown >8dBm AOP supporting proposed spec:
  - *Kazuki Nishimura et al., ‘225-Gb/s PAM4 Operation Using Lumped-Electrode-Type EA-DFB Laser for 5- and 10-km Transmission With Low TDECQ’, OFC, 2023.*
  - *Prashanth Bhasker et al., ‘200G per Lane Uncooled CWDM Hybrid CMBH-Ridge Electroabsorption Modulated Lasers for 2-km Transmission’, OFC, 2023.*

	225-Gb/s PAM4, 50°C	
Transmission Distance	BTB	10-km
Waveform OuterER = 4.5 dB		
λ (nm)	1293.5	
Pave (dBm)	9.0	
TDECQ (dB)	2.3	2.2

Tx Spec proposal

Following spec approach on rodes_3df_01b_221012 combining FWM and CD penalties:

- TDECQmax = 3.9dB for full range
- TDECQmax for limited dispersion = 3.2dB

OMAouter increased to 5.7dBm to provide sufficient headroom for OMAmin@TDECQmax (1.3dB)

AOP is kept to 5.5dBm, 0.2dB lower than OMAouter max. Same than 400GBASE-DR4

ERmin is kept to 3.5dB to provide flexibility to module manufactures, as long as they pass related specs such as RINOMA, OMAmin, AOPmax and TDECQ

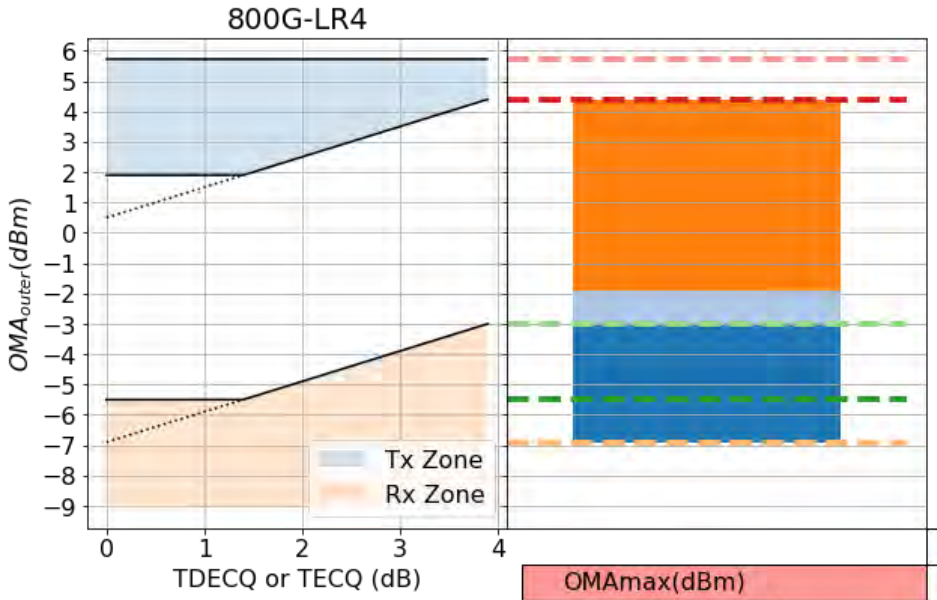
Description	800G-LR4	Unit
Signaling rate, each lane (range)	112.5 – 113.44	GBd
Modulation format	PAM4	
Lane wavelengths (range)	1294.6 to 1296.6 1299.1 to 1301.1 1303.6 to 1305.6 1308.1 to 1310.1	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Total average launch power (max)	11.5	dBm
Average launch power, each lane (max)	5.5	dBm
Average launch power, each lane (min)	-0.9	dBm
Outer Optical Modulation Amplitude (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) -7ps/nm ≤ Dispersion ≤ 7 ps/nm -28ps/nm ≤ Dispersion ≤ 9 ps/nm	 3.2 3.9	 dB 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

Description	800G-LR4 proposal	Unit
Signaling rate, each lane (range)	112.5 – 113.44	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
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

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 a complete set of specs for 800GBASE-LR4
  - This is the same set of specs reliably used on 400G-FR4/LR4
- Preliminary data shows that this proposal is a good starting point. We expect further refinement as the task force progresses and more data comes available
- These specifications do not assume a particular approach to resolve the FWM discussion, and leaves it to the ongoing discussion in other contributions