Baseline proposal for 800GBASE-LR4 chromatic dispersion specifications

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Introduction

- The optical channel model and transmitter compliance specifications for 800G-LR4 have been left incomplete pending conclusion of the statistical analysis of fiber CD data. D1.1 dispersion TBDs include:
  - Table 183–9—Optical channel characteristics
  - Table 183–14—Transmitter compliance channel specifications
- Statistical analysis of fiber CD data is being led by two groups:
  - ITU-T SG15 Q5 is drafting a new Appendix to G.652. See the Jan'24 liaison from ITU-T to P802.3. Recent discussions at the July'24 SG15 Plenary meeting have resolved outstanding questions about the analysis methodology.
  - Earl Parsons has analyzed a massive database of fiber from his affiliation, CommScope, and published the results within P802.3dj (parsons_3dj_01a_2405, parsons_optx_01_240627, and parsons_3dj_01_2407).
- To progress the P802.3dj draft standard, we need to make a decision on CD specs for 800G-LR4 in the D1.1 Task Force comment round.
- This presentation proposes to use values from ITU for 800GBASE-LR4 specification, while still acknowledges that ITU-T analysis uses extremely conservative dataset

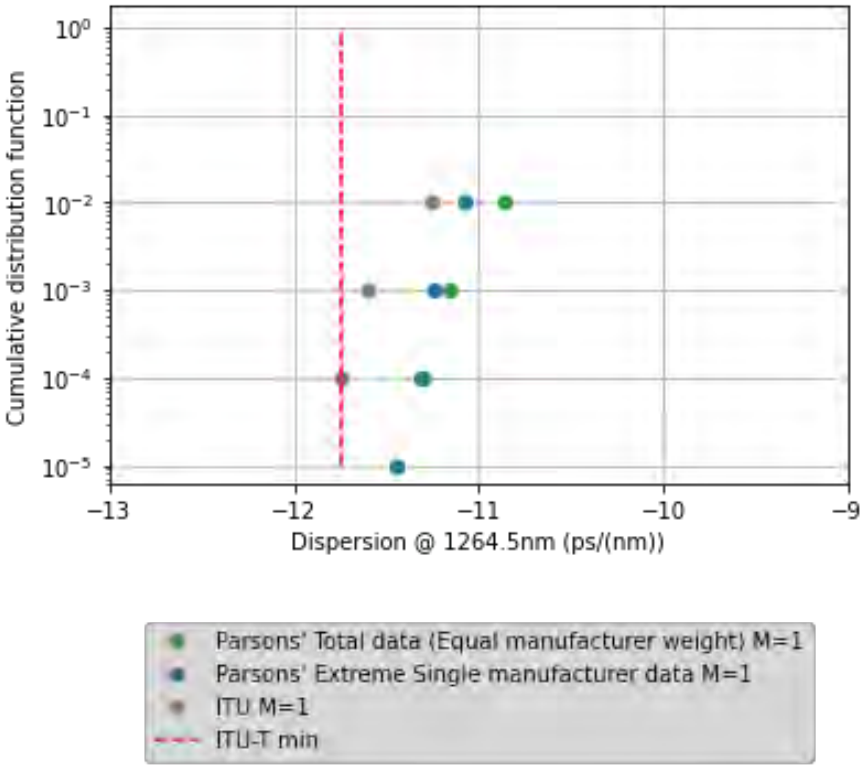
Comparison of statistical dispersion analyses

This contribution

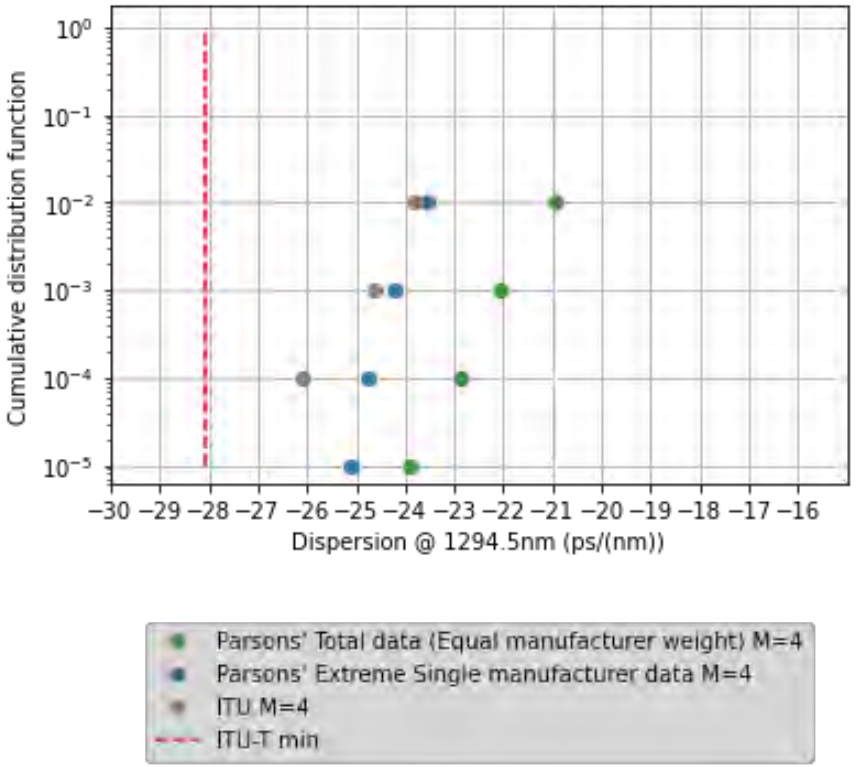
	800GBASE-FR4	800GBASE-LR4
Source data	CommScope, 6 fiber vendors	ITU-T Q5, 8 fiber vendors
Reference for channel model	802.3 Annex-TDB	ITU-T G.652, Appendix I
Distribution type	Single extreme vendor for each tail	Single extreme vendor for each tail
Distribution fitting	Direct from histograms	Direct from histograms
Number of cable segments	M = 1, no Monte Carlo	M = 4, Monte Carlo
Confidence level	Q = 99.99%	Q = 99.9%
TX Compliance formula	Linear fit per channel	Sellmeier fit given in G.652, Appendix I
Minimum dispersion	-11.32 ps/nm at 1264.5 nm	-24.6 ps/nm at 1294.53 nm
Maximum dispersion	+ 5.86 ps/nm at 1337.5 nm	+ 2.8 ps/nm at 1310.19 nm
Comments	• CommScope dataset is an excellent model for the CD distributions seen by high-volume fiber consumers. • Little difference between CommScope single extreme vendor and mixed vendor distributions. • M = 1 and Q = 99.99% are conservative assumptions.	• Each fiber vendor submitted their own analyses, and the worst-case results were selected by Q5. • 10% larger dispersion compared to total market • ITU-T Q = 99.9% aligns with CommScope Q = 99.99%.

IEEE vs ITU comparison

Lowest dispersion FR4



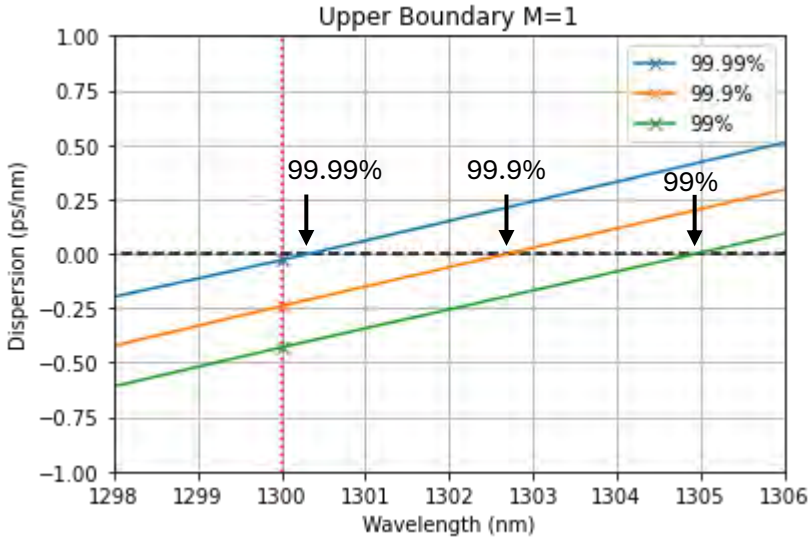
Lowest dispersion LR4

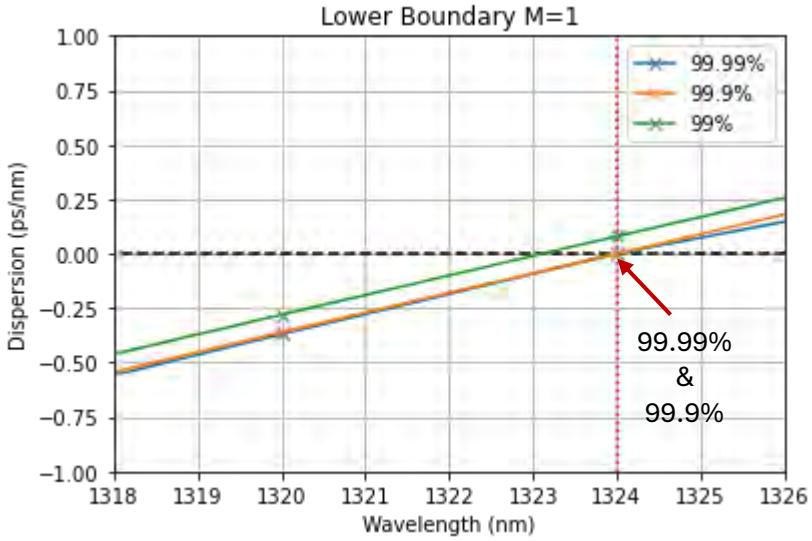


- ITU values show very little to no reduction at 99.99% and 99.9% confidence levels
  - It requires at the same time maximum ZDW and maximum slope (even though they have negative correlation)
- Parson's data does not show such case

- Specifying for **single extreme manufacturer** requires transmitter to target **~10% larger dispersion on LR4**
- Using 99.9% value from ITU would correspond to:
  - ~99.99% extreme single manufacturer in Earl's
  - < 99.999% on considering total market

ITU values analysis





Expected behavior of upper bound data:
Zero-crossing at 99.99% confidence is a bit higher than 1300nm and continues to get higher as we look at 99.9% and 99% of the fibers.

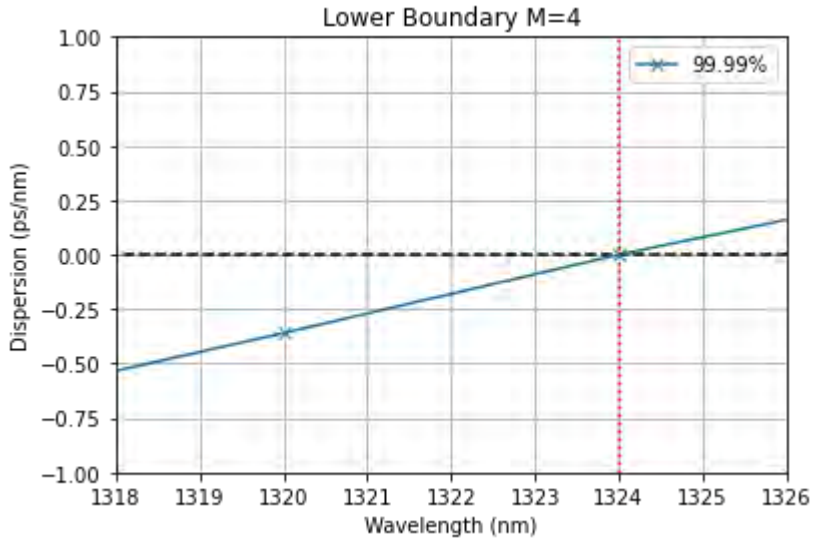
However, for the lower boundary, the 99.99% and 99.9% data is exactly ZDW=1324nm on both cases.
This is caused by the extreme vendor having a truncated distribution at ZDW = 1324 nm

ITU values analysis

Four randomly chosen fiber segments in ITU MonteCarlo analysis have a combined ZDW of 1324nm.

This means ITU values are driven by a vendor with truncated distribution having **10% of single segment fibers at the spec limit** (or between 1324.0 – 1324.4 nm assuming rounding rule)

(10%)^4 = 1e-4 (or 99.99% confidence)



Justification of choosing Q=99.9% on ITU-T (instead of 99.99%):

- Already a conservative analysis:
  - Each fiber vendor submitted their own analyses, and the worst-case results were selected by Q5
  - Values comes from one vendor truncated distribution with 10% of fibers at the spec limit
  - Corresponds to ~99.99% on Parson's massive dataset of single extreme vendor
  - Corresponds to higher than 99.999% on Parson's massive dataset of total market data
  - Total link confidence level is several orders of magnitude higher due to transceiver distributions on OMA, and Rx Sensitivity, as well as link length distribution
- There are transceiver design tradeoffs to optimize for small percentage of extreme fibers. Worse link budget and/or higher power overall to optimize for extreme dispersion. fan_3dj_01a_2407
- There is an alternative, a coherent-based PMD covering the same fiber length and loss budget for those applications/links requiring extreme dispersion

Table 183–9—Optical channel characteristics

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Description	800GBASE-FR4	800GBASE-LR4	Unit
Operating distance (max)	2	10	km
Channel insertion loss[a, b] (max)	4	6.3	dB
Channel insertion loss (min)	0		dB
Positive dispersion[b] (max)	TBD	-24.6	ps/nm
Negative dispersion[b] (min)	TBD	+2.8	ps/nm
DGD_max[c]	TBD	4	ps
Optical return loss (min)	TBD	TBD	dB

[a] These channel insertion loss values include cable, connectors, and splices.
[b] Over the wavelength range 1264.5 nm to 1337.5 nm for 800GBASE-FR4, and 1294.53 nm to 1310.19 nm for 800GBASE-LR4.
[c] Differential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system is required to tolerate.

Table 183–14—Transmitter compliance channel specifications

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PMD type	Dispersion[a] (ps/nm)		Insertion loss[b]	Optical return loss[c]	Max mean DGD
	Minimum	Maximum			
800GBASE-FR4	TBD	TBD	Minimum	17.1 dB	0.8 ps
800GBASE-LR4	$0.225\times\lambda\times[1-(1321.1/\lambda)^4]$	$0.2175\times\lambda\times[1-(1307.0/\lambda)^4]$	Minimum	15.6 dB	0.8 ps

[a] The dispersion is measured for the wavelength of the transmitter lane under test (λ in nm). The coefficient assumes 2 km for 800GBASE-FR4 and 10 km for 800GBASE-LR4.
[b] There is no intent to stress the sensitivity of the O/E converter associated with the oscilloscope.
[c] The optical return loss is applied at TP2.

Conclusions

- Chromatic dispersion specifications for the 800GBASE-LR4 optical channel characteristics and transmitter compliance specifications are proposed based on reference to G.652 Appendix with M=4 and Q=99.9%

- ITU has clarified its methodology. Vendors provided values based on actual ZDW and slope data pairs on its analysis and ITU selected the value from the most extreme (similar to Parson's single vendor data)

- The proposed dispersion value represent a small relaxation compared to historical worst-case values while still very conservative because:
  - Consider single extreme manufacturer
  - Driven by one fiber supplier with a truncated distribution of 10% of fibers at the spec limit
  - Include worst-case pairs of maximum ZDW and maximum slope. Not present in Parson's dataset.

Alternative solutions not proposed here but currently discussed:

- Using Parson's distribution with extreme single supplier. Proposed for FR4. johnson_3dj_01_2407
- Mixed-mode distribution with extreme corners left to 800G-LR1. yu_3dj_01_2407