

Ethernet PMDs and Chromatic Dispersion

David Lewis, Lumentum

Jan 2020 Workshop, Geneva, CH

Background – Ethernet Rates

- All recent 802.3 SMF PMDs are in the O-band wavelength region for cost reasons.
- Uncooled operation over at least NEBs temperature range [-5 to 75°C] is preferred.
- Ethernet SMF PMD data rates have increased to the point [53 GBd PAM4] that chromatic dispersion penalties are now a significant issue for reaches of 10 km.

Background – SMF Dispersion

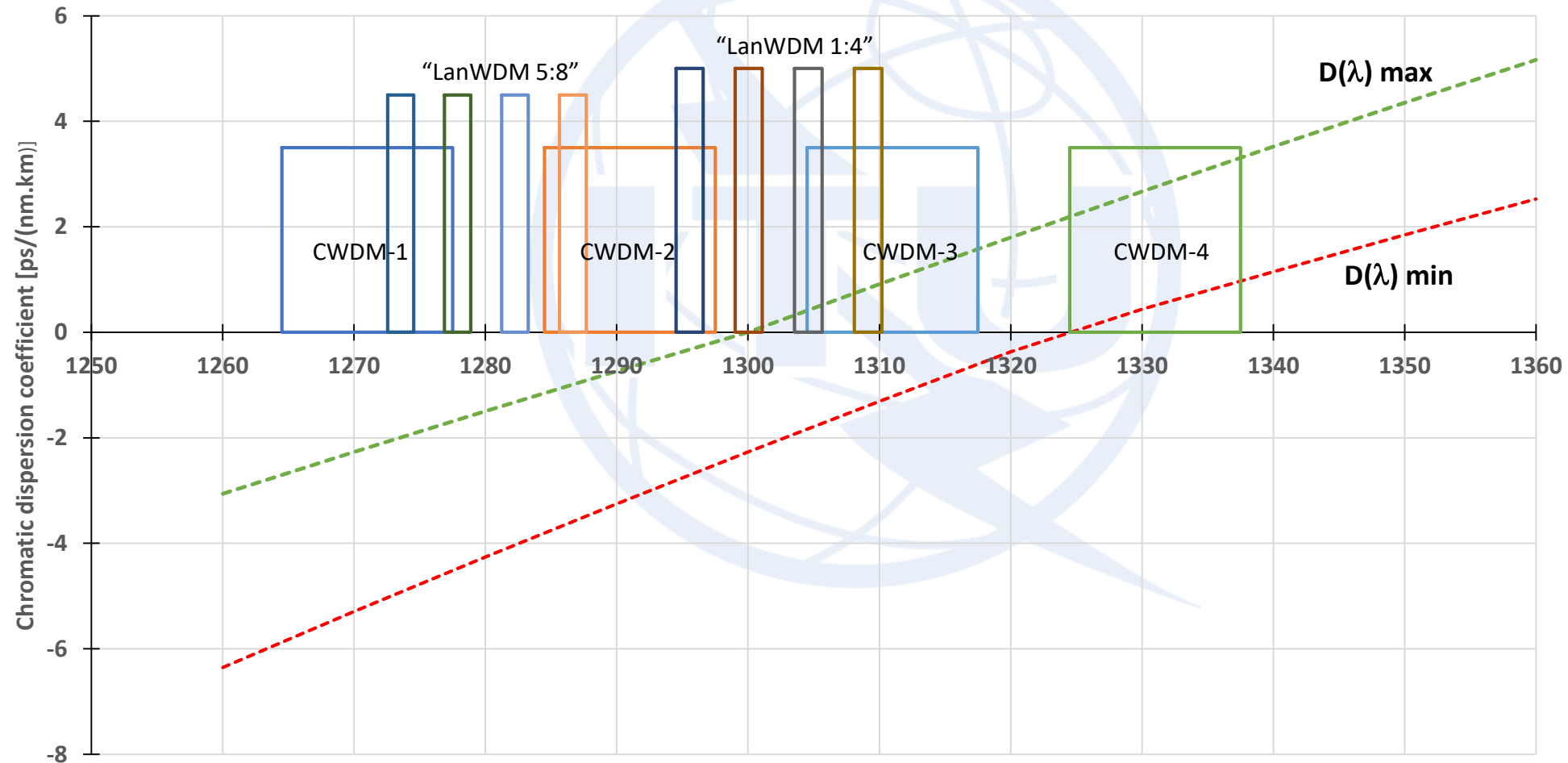
- 802.3 has referenced ITU-T G.652 for SMF characteristics. The zero dispersion wavelength (λ_0) range from 1300 to 1324 nm is limiting the reach for new PMDs.
 - E.g., 400GBASE-LR4 reduced the reach from the goal of 10 km to 6 km in order to have a reference-able worst case dispersion value that limits the dispersion penalty to < 0.5 dB.
- High volume Ethernet users have informed the 802.3cu task force that real, deployed fiber has a much tighter distribution of λ_0 than 1300-1324 specified in G.652.

List of 802.3 WDM PMDs and dispersion at maximum reach

PMD Type	Imin	Imax	Grid	#lambda	# fiber	BaudRate	Mod	Reach	Ch.IL max	CD max	CD min	DGD max	UI	Cdmax/UI	Cdmin/UI
40GBASE-LR4	1264.5	1337.5	CWDM	4	1	10.3125	NRZ	10	6.7	33.5	-59.5	10	96.97	0.35	-0.61
40GBASE-ER4	1264.5	1337.5	CWDM	4	1	10.3125	NRZ	40	18.5	134	-238	12	96.97	1.38	-2.45
100G-CWDM4	1264.5	1337.5	CWDM	4	1	25.78	NRZ	2	5	6.7	-11.9	3	38.79	0.17	-0.31
100GBASE-LR4	1294.53	1310.19	LanWDM	4	1	25.78	NRZ	10	6.3	9.5	-28.5	8	38.79	0.24	-0.73
100GBASE-ER4	1294.53	1310.19	LanWDM	4	1	25.78	NRZ	40	18	36	-114	10.3	38.79	0.93	-2.94
200GBASE-FR4	1264.5	1337.5	CWDM	4	1	26.5625	PAM4	2	4	6.7	-11.9	3	37.65	0.18	-0.32
200GBASE-LR4	1294.53	1310.19	LanWDM	4	1	26.5625	PAM4	10	6.3	9.5	-28.4	8	37.65	0.25	-0.75
200GBASE-ER4	1294.53	1310.19	LanWDM	4	1	26.5625	PAM4	40	18	37	-114	10.3	37.65	0.98	-3.03
400GBASE-FR8	1272.55	1310.19	LanWDM	8	1	26.5625	PAM4	2	4	1.9	-10.2	3	37.65	0.05	-0.27
400GBASE-LR8	1272.55	1310.19	LanWDM	8	1	26.5625	PAM4	10	6.3	9.5	-50.8	8	37.65	0.25	-1.35
400GBASE-ER8	1272.55	1310.19	LanWDM	8	1	26.5625	PAM4	40	18	37	-201	10.3	37.65	0.98	-5.34
400GBASE-FR4	1264.5	1337.5	CWDM	4	1	53.125	PAM4	2	4	6.6	-11.7	2.3	18.82	0.35	-0.62
400GBASE-LR4-6	1264.5	1337.5	CWDM	4	1	53.125	PAM4	6	6.3	19.9	-35.2	4	18.82	1.06	-1.87

- 400GBASE-LR4-6 has a maximum reach of 6 km instead of the 10 km of all prior “LR” PMDs.
- At 10 km reach, the 53 Gbd PAM4 dispersion penalty can be too large with worst-case G.652.D fiber properties. [Depends on transmitter chirp properties].
- CWDM grid is preferred by users, even if the maximum reach is less than 10 km.

G.652.D Min/Max Chromatic Dispersion Coefficient & Commonly Used 802.3 Wavelength Grids



List of 802.3 single wavelength PMDs and dispersion at maximum reach

PMD Type	Imin	Imax	Grid	#lambda	# fiber	BaudRate	Mod	Reach	Ch.IL max	CD max	CD min	DGD max	UI	Cdmax/UI	Cdmin/UI
10GBASE-LR	1260	1355		1	1	10.3125	NRZ	10	6	N/A	N/A	10	96.97	N/A	N/A
10GBASE-ER	1530	1565		1	1	10.3125	NRZ	40	11	728	N/A	19	96.97	7.51	N/A
25GBASE-LR	1295	1325		1	1	25.78	NRZ	10	6.3	22.6	-27.9	8	38.79	0.58	-0.72
25GBASE-ER	1295	1310		1	1	25.78	NRZ	40	18	36.8	-111.6	10.3	38.79	0.95	-2.88
100G-PSM4	1295	1325		1	4	25.78	NRZ	0.5	3.26	1.2	-1.4	2.24	38.79	0.03	-0.04
50GBASE-FR	1304.5	1317.5		1	1	26.5625	PAM4	2	4	3.2	-3.7	3	37.65	0.09	-0.10
50GBASE-LR	1304.5	1317.5		1	1	26.5625	PAM4	10	6.3	16	-18.6	8	37.65	0.43	-0.49
50GBASE-ER	1304.5	1317.5		1	1	26.5625	PAM4	40	18	64	-74	10.3	37.65	1.70	-1.97
200GBASE-DR4	1304.5	1317.5		1	4	26.5625	PAM4	0.5	3	0.8	-0.93	2.24	37.65	0.02	-0.02
100GBASE-DR	1304.5	1317.5		1	1	53.125	PAM4	0.5	3	0.8	-0.93	2.24	18.82	0.04	-0.05
100GBASE-FR1	1304.5	1317.5		1	1	53.125	PAM4	2	4	3.2	-3.7	2.3	18.82	0.17	-0.20
100GBASE-LR1	1304.5	1317.5		1	1	53.125	PAM4	10	6.3	16	-18.6	5	18.82	0.85	-0.99
400GBASE-DR4	1304.5	1317.5		1	4	53.125	PAM4	0.5	3	0.8	-0.93	2.24	18.82	0.04	-0.05

How to enable higher speeds & longer reaches

- Beyond 400 Gb/s, maximum reaches in the standard will continue to drop if we rely on worst-case G.652 specifications.
- Many of the potential tools add significant cost:
 - Tighter wavelength grids (requires tighter temperature controls & high-power dissipation)
 - Controlled chirp at each wavelength
 - Dispersion compensation

How to enable higher speeds & longer reaches (cont'd)

- Improved fiber parameters in the 1260 to 1360 nm range
 - Tighter range for λ_0 min to λ_0 max
 - Suggest a range of 4 to 6 nm instead of current 24 nm range
- New specifications for new installations
 - For hyperscale applications, it's not necessary to require operation with legacy fiber

What can SG15 do to help?

- Develop a recommendation with SMF parameters much tighter than current version of G.652.
 - Based on currently shipping fibers (CY2020).
 - Could be labelled as a subset of G.652.D for use in the O-Band.

THANKS!



