

Further analysis of G.652 & G.657 chromatic dispersion coefficients

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Introduction

During P802.3dj meeting in 22 – 25 January 2024 [stassar_3dj_01a_2401](#) was presented, containing an analysis of the response Liaison Statement (LS) from ITU-T SG15 on the examination of the statistical chromatic dispersion properties of G.652 / G.657 fiber

This LS can be found at: <https://www.ieee802.org/3/minutes/jan24/index.html>

This presentation continues a further analysis of G.652 & G.657 chromatic dispersion coefficients to establish an insight on the relationship between the zero dispersion wavelength & dispersion slope and the resulting chromatic dispersion coefficients for the adopted wavelength plans for 800GBASE-FR4 (CWDM) and 800GBASE-LR4 (LAN-WDM)

No suggestions are made to define more restrictive fiber specifications, which is left for further debate

Calculations

The following slides show chromatic dispersion coefficients for G.652 and G.657 fibers calculated using the Sellmeier formula for chromatic dispersion $D(\lambda)$ in terms of dispersion slope (S_0) and zero dispersion wavelength (ZDW or λ_0): $D(\lambda) = 0.25 * \lambda * S_0 (1 - (\lambda_0 / \lambda)^4)$

The following cases have been investigated:

- A 10 km link on a LAN-WDM grid (4 wavelengths on 800 GHz grid) appropriate for the adopted 800GBASE-LR4 baseline specification:
 - Lowest (most negative) dispersion coefficient at 1294.53 nm
 - Highest (most positive) dispersion coefficient at 1310.19 nm
- A 2 km link on a CWDM grid (nominal wavelengths 1271 nm, 1291 nm, 1311 nm, and 1331 nm):
 - Lowest (most negative) dispersion coefficient at 1264.5 nm
 - Highest (most positive) dispersion coefficient at 1337.5 nm

Information on calculations

- Calculations have been done for both G.652 and G.657 fibers
- Both fiber types have the same specifications for chromatic dispersion:
 - ZDW range 1300 – 1324 nm
 - Slope S_0 minimum 0.073 ps/nm²km and maximum 0.092 ps/nm²km
- For negative dispersion the upper limit of ZDW is relevant and therefore the tables show cd values for ZDW 1324 nm and lower.
- For positive dispersion the lower limit of ZDW is relevant and therefore the tables show cd values for ZDW 1300 nm and higher
- The slope is shown for its maximum value downward

Impact of changing ZDW and Slope on 800GBASE-LR4 negative dispersion

The following table shows chromatic dispersion coefficients in ps/nm for a 10 km link at 1294.53 nm (lowest LAN-WDM wavelength) for G.652 & G.657 fibers versus zero dispersion wavelength (ZDW) and dispersion slope S_0

ZDW [nm]	S_0 : 0.084 ps/nm ² km	S_0 : 0.086 ps/nm ² km	S_0 : 0.088 ps/nm ² km	S_0 : 0.090 ps/nm ² km	S_0 : 0.092 ps/nm ² km
1324	-25.61	-26.22	-26.83	-27.04	-28.05
1323	-24.72	-25.30	-25.89	-26.48	-27.07
1322	-23.82	-24.93	-24.95	-25.52	-26.09
1321	-22.93	-23.47	-24.02	-24.56	-25.11
1320	-22.03	-22.56	-23.08	-23.61	-24.11
1319	-21.14	-21.56	-22.15	-22.66	-23.16
1318	-20.26	-20.74	-21.22	-21.70	-22.19
1317	-19.37	-19.83	-20.29	-20.76	-21.22
1316	-18.49	-18.93	-19.37	-19.81	-20.25

- The upper right point in **RED** font shows the worst case specification point, same for G.652 & G.657.
- **Yellow marked** cd values worst case ~-10%
- **Green marked** cd values worst case ~-20%
- **Orange marked** cd values worst case ~-30%

Observations for 10 km negative dispersion

- Conventional worst case approach: -28.05 ps/nm
- Calculated from ITU-T LS: -26.3 ps/nm, assuming 4 segments of 2.5 km
- The reduction is “only” 6.2%:
 - Distance of ~30 nm between 1294.35 nm and effective maximum ZDW of 1324 nm
 - High average ZDW of 1314.6 nm
- Conditions for further reduction of minimum negative dispersion:
 - 10% if effective upper ZDW ~1322 nm
 - 20% if effective upper ZDW ~1319 nm
 - 30% if effective upper ZDW ~1316 nm
 - Effect of slope reduction is of secondary relevance

Impact of changing ZDW and Slope on 800GBASE-LR4 positive dispersion

The following table shows chromatic dispersion coefficients in ps/nm for a 10 km link at 1310.19 nm (highest LAN-WDM wavelength) for G.652 & G.657 fibers versus ZDW and dispersion slope S_0

ZDW [nm]	S_0 : 0.084 ps/nm ² km	S_0 : 0.086 ps/nm ² km	S_0 : 0.088 ps/nm ² km	S_0 : 0.090 ps/nm ² km	S_0 : 0.092 ps/nm ² km
1310	0.16	0.16	0.17	0.17	0.17
1309	1.00	1.02	1.05	1.07	1.09
1308	1.83	1.88	1.92	1.97	2.01
1307	2.67	2.73	2.80	2.86	2.92
1306	3.50	3.59	3.67	3.75	3.84
1305	4.33	4.44	4.54	4.64	4.75
1304	5.16	5.29	5.41	5.53	5.65
1302	6.82	6.98	7.14	7.30	7.46
1300	8.46	8.66	8.86	9.06	9.27

- The lower right point in **RED** font shows the worst case specification point, same for G.652 & G.657.
- **Yellow marked** cd values worst case ~-40%
- **Green marked** cd values worst case ~-60%
- **Orange marked** cd values worst case ~-80%

Observations for 10 km positive dispersion

- Conventional worst case approach: +9.27 ps/nm
- Calculated from ITU-T LS: +4.57 ps/nm, assuming 4 segments of 2.5 km
- The reduction is 51%:
 - Distance of ~5 nm between 1310.19 nm and effective minimum ZDW of 1305 nm
- Conditions for further reduction of maximum positive dispersion:
 - Increasing lower effective WZD from 1305 nm towards 1310 nm
 - Effect of slope reduction is not of any relevance

Impact of changing ZDW and Slope on 800GBASE-FR4 negative dispersion

The following table shows chromatic dispersion coefficients in ps/nm for a 2 km link at 1264.5 nm (lowest CWDM4 wavelength) for G.652 & G.657 fibers versus ZDW and dispersion slope S_0

ZDW [nm]	S_0 : 0.084 ps/nm ² km	S_0 : 0.086 ps/nm ² km	S_0 : 0.088 ps/nm ² km	S_0 : 0.090 ps/nm ² km	S_0 : 0.092 ps/nm ² km
1324	-10.72	-10.98	-11.23	-11.5	-11.75
1323	-10.53	-10.78	-11.03	-11.28	-11.53
1322	-10.34	-10.59	-10.83	-11.08	-11.32
1321	-10.15	-10.39	-10.63	-10.87	-11.11
1320	-9.96	-10.19	-10.43	-10.67	-10.90
1319	-9.77	-10.00	-10.23	-10.46	-10.70
1318	-9.57	-9.80	-10.03	-10.26	-10.49
1317	-9.38	-9.61	-9.83	-10.06	-10.28
1316	-9.20	-9.41	-9.63	-9.85	-10.08

- The upper right point in **RED** font shows the worst case specification point, same for G.652 & G.657.
- **Yellow marked** cd values worst case ~-10%
- **Green marked** cd values worst case ~-20%

Observations for 2 km negative dispersion

- Conventional worst case approach: -11.75 ps/nm
- About same value calculated from ITU-T LS, assuming 1 segment of 2 km
- Conditions for further reduction of minimum negative dispersion:
 - 10% if upper ZDW ~1321 nm
 - 20% if upper ZDW ~1315 nm
- Reducing from worst case requires drastic narrowing of ZDW range because the distance of ~60 nm between 1264.5 nm and maximum ZDW of 1324 nm

Impact of changing ZDW and Slope on 800GBASE-FR4 positive dispersion

The following table shows chromatic dispersion coefficients in ps/nm for a 2 km link at 1337.5 nm (highest CWDM4 wavelength) for G.652 & G.657 fibers versus ZDW and dispersion slope S_0

WZD [nm]	S_0 : 0.084 ps/nm ² km	S_0 : 0.086 ps/nm ² km	S_0 : 0.088 ps/nm ² km	S_0 : 0.090 ps/nm ² km	S_0 : 0.092 ps/nm ² km
1310	4.48	4.59	4.69	4.80	4.91
1309	4.64	4.75	4.86	4.97	5.08
1308	4.79	4.91	5.02	5.14	5.25
1307	4.95	5.07	5.19	5.31	5.42
1306	5.11	5.23	5.35	5.47	5.59
1305	5.26	5.39	5.51	5.64	5.77
1304	5.42	5.55	5.68	5.81	5.94
1302	5.73	5.87	6.00	6.14	6.28
1300	6.04	6.18	6.33	6.47	6.62

- The lower right point in **RED** font shows the worst case specification point, same for G.652 & G.657.
- **Yellow marked** cd values worst case ~-10%
- **Green marked** cd values worst case ~-20%
- **Orange marked** cd values worst case ~-30%

Observations for 2 km positive dispersion

- Conventional worst case approach: +6.62 ps/nm
- About same value calculated from ITU-T LS, assuming 1 segment of 2 km
- Conditions for further reduction of maximum positive dispersion :
 - 10% if lower ZDW ~1302 nm
 - 20% if lower ZDW ~1306 nm
 - 30% if lower ZDW ~1310 nm
- Reducing from worst case requires narrowing of ZDW range because the distance of ~37 nm between 1337.5 nm and minimum ZDW of 1300 nm

General observations

- For 800GBASE-LR4 employing a LAN-WDM plan (nominally 1295.56 nm, 1300.05 nm, 1304.58 nm, and 1309.14 nm), due to its inherent choice from 1310 nm downwards, increasing the minimum ZDW from 1300 nm upwards is most effective for reducing positive dispersion
- For 800GBASE-FR4 employing a CWDM plan (nominally 1271 nm, 1291 nm, 1311 nm, and 1331 nm), due to its broad spectrum, quite drastic narrowing of the ZDW range is required to reduce the maximum dispersion coefficient, especially for negative dispersion

Thanks!