Chromatic Dispersion Analysis
Regarding comment #208

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IEEE 802.3dj Interim
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Supporters

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• Mark Kamber, Semtech
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• Roberto Rodes, Coherent
• Nobuhiko Kikuchi, Hitachi
• Eric Maniloff, Ciena
• Angie Lambert, Corning
• Vince Ferretti, Corning
Overview

• This contribution provides an overview of the latest data set
• Chromatic dispersion accumulated over 1 km is evaluated at four extreme wavelengths
  • 800G-FR4: 1264.5 and 1337.5 nm
  • 800G-LR4: 1294.53 and 1310.19 nm
• Results from total data set as well as subsets are included
  • G.657.A1 fiber vs. G.657.A2 fiber
  • 200 and 250 micron coating diameter
  • Each year from 2014-2024
  • Different manufacturers
• Future contributions will use this data set for modeling and to propose dispersion values for channel model for FR4 and LR4
Information about the data set

• This data set includes >2.5 million fibers
• Fibers compliant to ITU-T standards
  • G.652.D/G.657.A1
  • G.657.A2
• Fibers were shipped from 2013-2024
• Six manufacturers are included with factories in North America, Europe, and Asia (including China)
• Of top 10 global fiber manufacturers (weighted by market share)
  • This data set covers 64% of top 10 market
  • ITU-T data set covers 68% of top 10 market
Extreme dispersion values allowed by ITU-T standards

- **Slope:** 0.092 ps/(nm^2*km)

- **Lambda0:** 1300 or 1324 nm

**Note:** Dispersion over 1 km
Most extreme dispersion values from the entire data set

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<thead>
<tr>
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<th>Min</th>
<th>Max</th>
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<tbody>
<tr>
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<td>Slope0</td>
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• A small number of fibers in data set have values outside ITU-T values at 800G-FR4 wavelengths

• Occurs with extreme zero dispersion wavelengths and smaller slopes
Histograms for 800G-FR4 wavelengths at 1 km with entire data set

- Fit to normal distribution
- Most values well within extreme cases (red lines)
Histograms for 800G-LR4 wavelengths at 1 km with entire data set

- Fit to normal distribution
- Most values well within extreme cases (red lines)
## Statistics of entire data set

<table>
<thead>
<tr>
<th></th>
<th>CWDM</th>
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<tbody>
<tr>
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<td>ITU-T Max</td>
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### Statistical Dispersion Values

- **ITU-T Max**: $3.41, 3.31, 0.51, 0.93$
- **Data Max**: $3.1, 3.07, 0.6, 0.73$
- **99.99%**: $3.58, 2.84, 0.88, 0.51$
- **99.99%**: $3.75, 2.8, 0.93, 0.47$
- **99%**: $3.88, 2.66, 1.05, 0.35$
- **99%**: $4.05, 2.48, 1.26, 0.13$

### Wavelength (nm)

- **1260**
- **1280**
- **1300**
- **1320**
- **1340**
- **1360**

### Dispersion (ps/(nm*km))

- **ITU-T Max**: $3.41, 3.31, 0.51, 0.93$
- **Data Max**: $3.1, 3.07, 0.6, 0.73$
- **99.99%**: $3.58, 2.84, 0.88, 0.51$
- **99.99%**: $3.75, 2.8, 0.93, 0.47$
- **99%**: $3.88, 2.66, 1.05, 0.35$
- **99%**: $4.05, 2.48, 1.26, 0.13$

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Statistics of entire data set (continued)

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**Data Min**

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**Dispersion values**

- ITU-T Max
- ITU-T Min
- Data Max
- Data Min
- 99.99%
- 99.99%
- 99.999%
- 99.999%

**Wavelength (nm)**

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Compare dispersion values for different subsets

- Look at 99% values for subsets of entire data set
  - Since different subsets have different numbers of fibers, doesn’t make sense to look at 99.99%
  - Want to avoid “chasing noise”

- Subsets considered
  - A1 and A2 fiber
  - 200 and 250 micron coating diameter
  - Different manufacturing years
  - Different manufacturers

- Focus on dispersion values at 800G-FR4 wavelengths since they provide largest variation
  - 1264.5 nm (most negative)
  - 1337.5 nm (most positive)
Compare G.657.A1 to G.657.A2 fiber

- Both A1 and A2 are bend-insensitive
- A2 has smaller bend radius
- Top graph has G.652.D/G.657.A1
- A2 fiber is newer and lower volume in this data set
- Similar standard deviation, A2 has mean that is more negative
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G.657.A1 vs .A2 fibers

• Distributions for .A2 fiber shifted more negative than .A1 fiber
• Fewer .A2 than .A1 fibers
250 vs. 200 micron coating diameter

• 200 micron coating is a new option for reduced cable size
• Dispersion slightly better for 200 micron
Dispersion values over time

• Little change over the years
Dispersion values over time

- Small variations over time
- Recent years have higher percentage of A2
- No obvious trend preventing models developed around current fibers being used over fibers manufactured in last 10 years
Dispersion parameters by different manufacturers

- Include values when weighing sources equally or by market share
- Max and min of manufacturers
- A1/A2 mix varies by manufacturer
Entire data set histogram weighted by market share

Histogram of Dispersion (ps/nm*km) @ 1264.5

Normal

Mean: -4.715
StdDev: 0.2878
N: 7499999

Histogram of Dispersion (ps/nm*km) @ 1337.5

Normal

Mean: 1.955
StdDev: 0.2318
N: 97199818
An easy process to compare other fiber data to this data set

• We are a “contribution driven organization”. If you feel that this data set is missing key data, please present the missing data at a future meeting.

• Collect zero dispersion wavelength ($\lambda_0$) and slope ($S_0$) pairs
  • Treating wavelength and slope as independent variable is too conservative

• Calculate dispersion over 1 km at 1264.5 nm and 1337.5 nm for each fiber
  • $D = 1264.5 * \frac{S_0}{4} \left( 1 - \left( \frac{\lambda_0}{1264.5} \right)^4 \right)$
  • $D = 1337.5 * \frac{S_0}{4} \left( 1 - \left( \frac{\lambda_0}{1337.5} \right)^4 \right)$

• Find mean, standard deviation, and 99% value of dispersion values and compare to values in this contribution

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Conclusions

• Latest fiber data set was reviewed
• Presented statistics for entire data set and subsets
• This data set represents a significant portion of the fiber market
• This data set can be used to develop models and determine dispersion parameters for 800G-FR4 and 800G-LR4