Statistical approach to chromatic dispersion

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CommScope
Introduction

• Chromatic dispersion penalty increases with square of baud rate
• For 200G lanes we need to consider chromatic dispersion parameters
  • Zero dispersion wavelength ($\lambda_0$)
  • Zero dispersion slope ($S_0$)
• This contribution does not propose a new fiber definition or change to existing fiber parameters
• Ethernet standard references ITU-T fiber types, parameters in ITU-T and IEEE should be consistent
• A new fiber type needs to be standardized in ITU-T before reference here
• Any deviation from ITU-T specifications in our standard will create confusion in the market
• A statistical approach to chromatic dispersion reveals that extreme dispersion cases are unlikely
Example: Clause 151 (802.3cu)

- Dispersion usually calculated using worst case
- Instead, we can take a statistical approach
- For 10 km with LAN WDM grid (1294.6 to 1310.1 nm)
  - -28.0 to +9.2 ps/nm dispersion worst case

\[
D \left( \frac{ps}{nm} \right) = \frac{S_0}{4} \left[ \lambda - \frac{\lambda_0^4}{\lambda^3} \right] L
\]
Monte Carlo simulations, 100,000 scenarios

**Basic assumptions**
- Length: 10 km, single fiber
- Short wavelength:
  - Truncated normal distribution
  - 1295.6 nm +/- 1 nm, 3 sigma
- Long wavelength:
  - Truncated normal distribution
  - 1309.1 nm +/- 1 nm, 3 sigma
- Lambda0:
  - Truncated normal distribution
  - 1312 nm +/- 12 nm, 3 sigma
- S0:
  - Truncated normal distribution
  - 0.09 ps/(nm^2*km) +/- .002, 3 sigma

**Realistic fiber parameters**
- Length: 10 km, single fiber
- Short wavelength:
  - Truncated normal distribution
  - 1295.6 nm +/- 1 nm, 3 sigma
- Long wavelength:
  - Truncated normal distribution
  - 1309.1 nm +/- 1 nm, 3 sigma
- Lambda0:
  - Truncated normal distribution
  - 1313.4 nm +/- 2.6 nm, 3 sigma
- S0:
  - Truncated normal distribution
  - 0.086 ps/(nm^2*km) +/- .000879, 3 sigma

Lambda0 and S0 from 250,000 fibers from 2020
Unlikely to see -28 or +9.2 ps/nm

Realistic Short Wavelength
Max -6.92889
Min -24.224
Mean -15.7721
Std Dev 2.358467
Mean+3 Sigma -8.7 ps/nm
Mean-3 Sigma -22.8 ps/nm

Basic Short Wavelength
Max -3.4576
Min -27.1133
Mean -15.107
Std Dev 3.699438
Mean+3 Sigma -4.0 ps/nm
Mean-3 Sigma -26.2 ps/nm

Realistic Long Wavelength
Max 4.514683
Min -11.8742
Mean -3.72254
Std Dev 2.282292
Mean+3 Sigma 3.1 ps/nm
Mean-3 Sigma -10.6 ps/nm

Basic Long Wavelength
Max 8.686157
Min -14.2747
Mean -2.61142
Std Dev 3.584352
Mean+3 Sigma 8.1 ps/nm
Mean-3 Sigma -13.4 ps/nm
Conclusions

• A new fiber standard is not needed for 200G lanes
• Fiber specifications should match existing ITU-T standards
• Extreme dispersion (e.g., +9.2 or -28 ps/nm) values unlikely to be seen
• A statistical approach can be taken for channel simulation and power budgets

• Further refinements can be made including:
  • Realistic Tx wavelength distributions
  • Multiple fibers in link
  • Multiple fiber manufacturers