Testing for worst-case Dispersion Effects (Transmitter characterization)

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Problem

- Zero dispersion fibers have wide range (1300-1322nm) of zero crossing.
- MPN dispersion penalty is highly sensitive to the spectral difference between the actual wavelength during measurement to the zero crossing wavelength.
- Modeling MPN (mode partition Noise) contribution to link budget loss, for a specific FP laser under-test is difficult. (e.g. $\Delta\lambda$ is current dependent, and current has very strong temperature dependency).

How to avoid the modeling inaccuracies and rely on actual measurements of dispersion penalties

- The total dispersion parameter

$$\beta(L,\lambda) := \pi \cdot B \cdot D(\lambda) \cdot \Delta\lambda \cdot L \cdot km$$

- Link budget loss due MPN (k introduction)

$$\sigma_{mpn}(L,\lambda,k) := \frac{k}{\sqrt{2}} \cdot \left(1 - e^{-\beta(L,\lambda)^2}\right)$$

$$\alpha(L,\lambda,k) := 5 \cdot \log\left(\frac{1}{1 - Q^2 \cdot \sigma_{mpn}(L,\lambda,k)^2}\right)$$

- Total link budget loss due to dispersion can be measured by comparison of sensitivity with known test fiber to attenuator based sensitivity test
- To enable testing in the lab the Dispersion*Length must be equivalent to worst case situation

How to avoid the modeling and rely on actual measurements of dispersion penalties

- To enable testing the Dispersion*Length must be equivalent to worst case situation
- Allowing fixed sensitivity loss MAX (e.g. 2dB) for total fiber effect (excluding the signal attenuation including both chromatic and MPN dispersion penalties) provides worst case vehicle for testing transmitter dispersion effects.
- Thus eliminating the need to measure $\Delta\lambda$ and to assume k factor for compliance testing!

Use same fiber type for lab measurements as for field deployments

- Under testing with known fiber

$$\mathrm{Dtest}(\lambda, \lambda o) := \frac{So}{4} \cdot \left[\lambda - \frac{(\lambda o)^4}{(\lambda)^3} \right] \cdot \mathrm{Ltest}$$

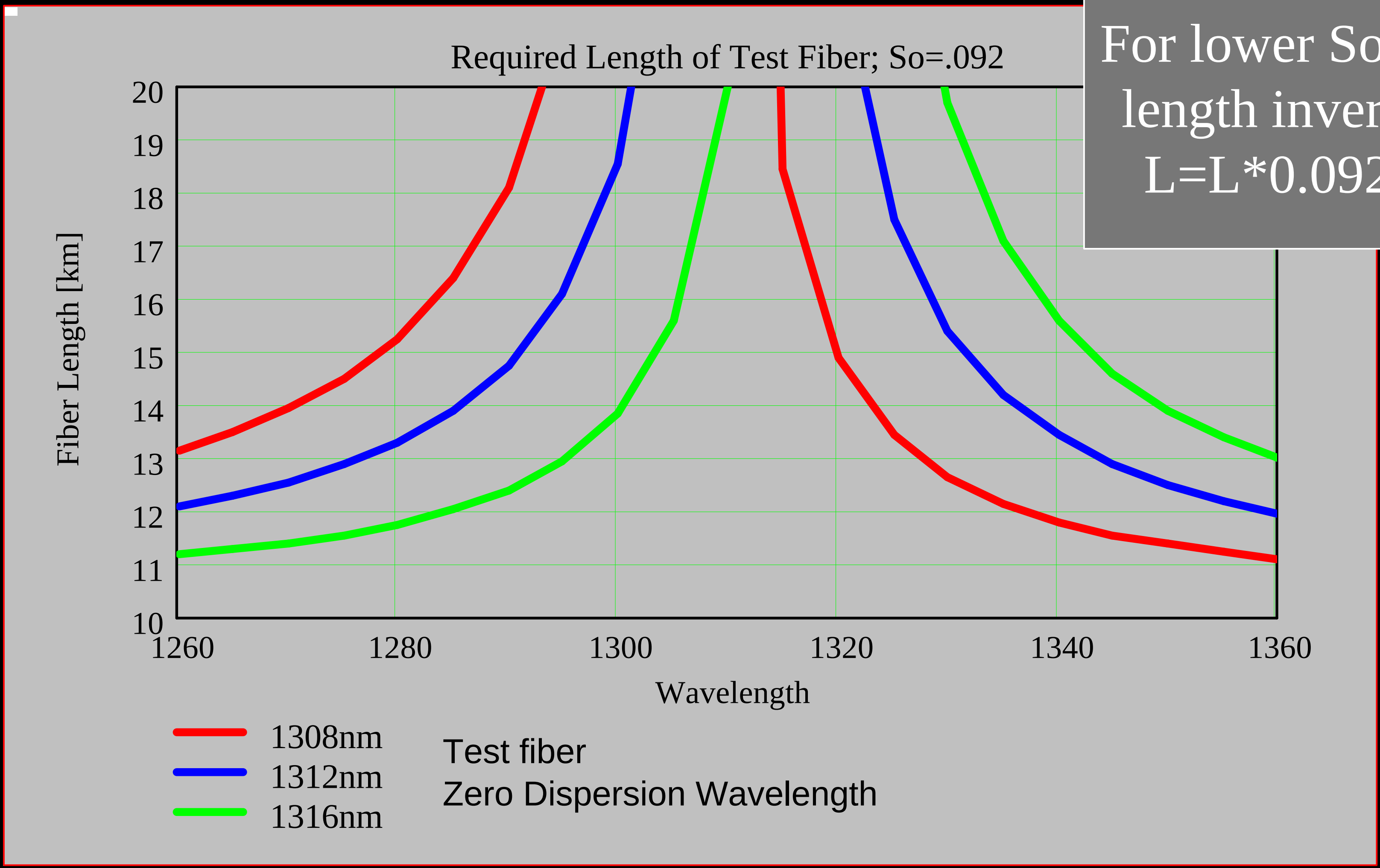
- Worst Case for “hot” laser (longer λ)

$$\mathrm{Dh}(\lambda) := \frac{So_{\,wc}}{4} \cdot \left[\lambda - \frac{(\lambda o_{\,min})^4}{(\lambda)^3} \right] \cdot 10 \cdot \mathrm{km}$$

- Worst Case for “cold” laser (shorter λ)

$$\mathrm{Dc}(\lambda) := \frac{So_{\,wc}}{4} \cdot \left[\lambda - \frac{(\lambda o_{\,max})^4}{(\lambda)^3} \right] \cdot 10 \cdot \mathrm{km}$$

Required Test Fiber length (for 10km links)



For lower So scale length inversely:
L=L*0.092/So

Examples

- 13 km fiber with lo = 1312nm enable testing of FP lasers with nominal wavelength of 1290 to 1325nm at Room Temperature at both extreme temperatures (-40 and 85°C)
- 12km fiber with lo = 1308nm enable testing of FP lasers with nominal wavelength of 1290 to 1325nm at Room Temperature at the hot extreme temperatures (85°C)
- 12km fiber with lo = 1316nm enable testing of FP lasers with nominal wavelength of 1290 to 1325nm at Room Temperature at the cold extreme temperatures (-40°C)

Conclusion

- With the help of fiber vendors (providing certified performance for test fibers) a worst-case test can be used to characterized the dispersion effects of FP laser source for upstream data at GbE rate.
- Concept can be extended to compliance for 20km links!