Single-Mode Dispersion
Measurement Method

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Optical Fiber

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Scope

This information describes the reference method for measuring the chromatic dispersion of Corning® single-mode optical fibers.

General

Dispersion is the measure of the time-based broadening which occurs in pulses of light as they propagate along the length of the fiber. This pulse broadening imposes a limitation on the data transmission rate for a system and is therefore an important parameter to the system designer.

Terminology

λ = the operating wavelength of interest
λ_0 = the zero dispersion wavelenth
s_0 = the dispersion slope at λ_0
$D(\lambda)$ = the dispersion at λ
A, B, C, D, & E = fit parameters
ln = the logarithm to base e

Measurement Method

Single-mode dispersion data is obtained from measurements of the relative time-of-flight of light signals at various wavelengths. Light from an amplitude-modulated light-emitting diode (LED) is selected by a monochromator and launched into the fiber under test. The relative time of flight is calculated from the phase delay of the detected signal after passing through the fiber under test, referenced to the system phase response. Dispersion is measured on a full length of fiber (length ≥ 1 km).

The delay (τ) versus wavelength (λ) response is fit to a curve as specified below. Dispersion (D_λ) is the first derivative ($d\tau/d\lambda$) of the delay versus wavelength response (see Figure 1). Dispersion Slope (S_λ) is the first derivative ($dD/d\lambda$) of the Dispersion vs wavelength response or the second derivative of the delay versus wavelength response. This is typically specified at λ_0 and noted as s_0.

For *non-dispersion-shifted* single-mode products such as Corning® SMF-28™ and SMF-28e™ optical fiber, the time delay data are fit to the Sellmeier expression given in equation [1] and then differentiated to obtain dispersion [2]:

[1] Time Delay $= \tau(\lambda) = A + B\lambda^2 + C\lambda^{-2}$ for 1230-1360 nm

[2] Dispersion $= D(\lambda) = 2(B\lambda - C\lambda^{-3}) = \frac{s_0}{4}\left[\lambda - \frac{\lambda_0^{\,4}}{\lambda^3}\right]$ for 1230-1360 nm

$$\lambda_0 \equiv \left[\frac{C}{B}\right]^{1/4}$$

$$s_0 \equiv S(\lambda_0) = 8B$$

Dispersion in the 1200-1600 nm region can be approximated using equation 2.

For *dispersion-shifted* single-mode products such as SMF/DS™, SMF-LS™ and Submarine SMF-LS™ fiber, the time delay data are fit to a quadratic expression given in equation [1] and then differentiated to obtain dispersion [2]:

[1] Time Delay $= \tau(\lambda) = A + B\lambda^2 - C\lambda$ for 1500-1600 nm

[2] Dispersion $= D(\lambda) = 2B\lambda - C$ for 1500-1600 nm

$$\lambda_0 \equiv \left[\frac{C}{2B}\right]$$

$$s_0 \equiv S(\lambda_0) \equiv 2B$$

Dispersion in the 1200-1600 nm region can be approximated by

[3] $D(\lambda) \approx \lambda_0 \bullet s_0 \bullet \ln\left[\frac{\lambda}{\lambda_0}\right]$

The wavelength range for Submarine SMF-LS™ is 1550-1610 nm.

For other *dispersion-shifted* single-mode products such as Corning® LEAF® and MetroCor™ optical fiber, the time delay data are fit to a 5-term Sellmeir expression given in equation [1] and then differentiated to obtain dispersion [2]:

[1] Time Delay $= \tau(\lambda) = A\lambda^2 + B\lambda^{-2} + C + D\lambda^{-4} + E\lambda^4$

[2] Dispersion $= D(\lambda) = 2(A\lambda - B\lambda^{-3} - 2D\lambda^{-5} + 2E\lambda^3)$

λ_0 is found by an iterative technique
$s_0 \equiv S(\lambda_0) \equiv 2B$

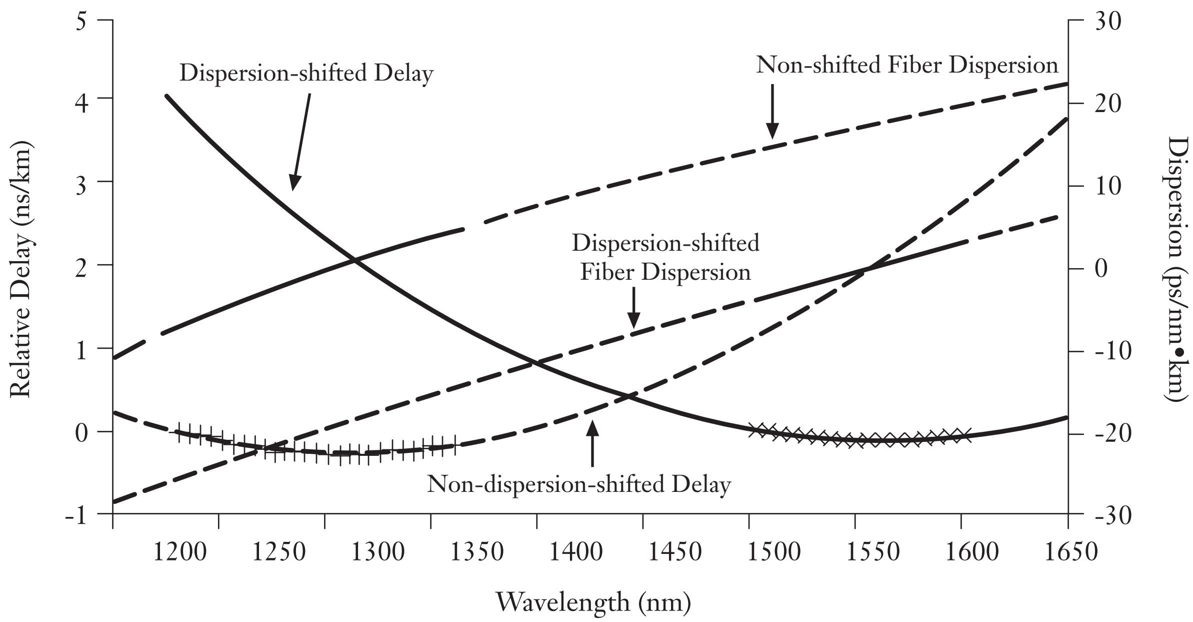
Dispersion in the 1200-1600 nm region can be approximated by

[3] $D(\lambda) \approx \lambda_0 \bullet s_0 \bullet \ln\left[\frac{\lambda}{\lambda_0}\right]$

The wavelength range for LEAF® optical fiber is 1460-1570 nm.

Typical Time-Delay and Dispersion Curves
Figure 1

Typical time-delay and dispersion curves for 1310 nm optimized non-dispersion-shifted and 1550 nm optimized dispersion-shifted single-mode fibers are shown in Figure 1.



- Test Fiber Length ≥ 1 km
- Measurement Wavelengths

non-dispersion-shifted fibers	Spaced across 1230 nm to 1360 nm
dispersion-shifted fibers (DS & LS)	Spaced across 1500 nm to 1600 nm
Submarine SMF-LS™	Spaced across 1550 nm to 1610 nm
LEAF®, MetroCor™	Spaced across 1460 nm to 1570 nm
Submarine LEAF®	Spaced across 1500 nm to 1625 nm

The measurement wavelengths are established to include analysis on both sides of λ_0.

References

EIA/TIA-455-169A (FOTP-169), Chromatic Dispersion Measurement of Single-Mode Optical Fibers by the Phase-Shift Method

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