WM2 Modulation frequency-shift technique for dispersion measurements in optical fibers

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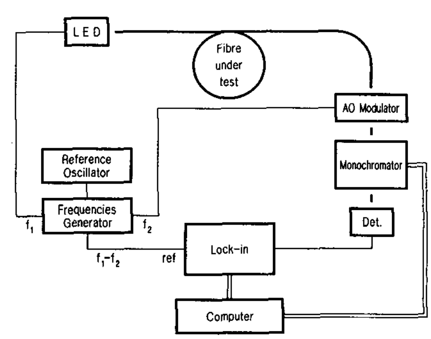
An improved technique for chromatic dispersion measurements in single-mode fibers using phase-shift measurements is presented. The conventional experimental setup using a modulated light emitting diode (LED) filtered by a monochromator as a light source, a fast receiver, and a vector voltmeter for the phase measurements[1] suffers from inherent drawbacks such as strong phase fluctuations due to poor SNR and rf interference providing biased measurements. Our method eliminates these drawbacks with optical signal processing by shifting the modulation frequency down to the kilohertz range and maintaining the phase resolution due to high-frequency modulation.

Our experimental setup (Fig. 1) also uses a wide spectrum light source modulated to a high frequency such as a LED. The modulation frequency shift is actually performed by remodulating the optical signal with an acoustooptic modulator at the fiber output before detection. If the second modulation frequency f_2 is different from the source modulation frequency f_1, sum- and difference-frequency signals are generated, each conserving the phase information of the primary signal. The difference frequency component can lie in the kilohertz range provided that f_2 is close enough to f_1, enabling low-frequency ultrasensitive detection to be made. Electrical signal processing is then performed by a lock-in amplifier providing reliable, accurate, and amplitude-free phase measurements.

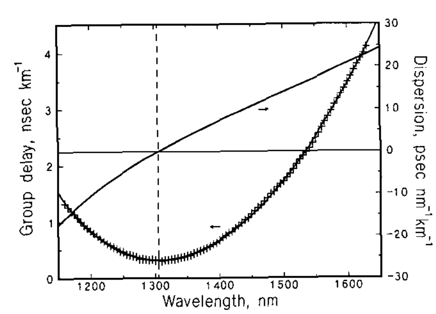
The spectral coverage is limited by fiber attenuation owing to the rapidly decreasing intensity in the tails of the spectrum of the LED. With a single LED the typical spectral coverage is 300 nm for 2-dB fiber attenuation decreasing to 100 nm for 30-dB attenuation. For measurements in both communication transmission windows, a wide spectral coverage setup was achieved using a single-mode coupler merging the light outputs of two LEDs having nominal center wavelengths of 1280 and 1500 nm, respectively. With our setup in this configuration, group delay was measured in a 3.7-km single-mode fiber from 1160 to 1630 nm with a 5-nm spectral width (Fig. 2).

The advantages inherent in low-frequency detection and signal processing, such as stability, low noise, and strong filtering capability, and the resolution achieved by using a high modulation frequency result in reliable and accurate group delay measurements, giving a measured standard deviation of <0.5 nm for the zero chromatic dispersion wavelength. **(12 min)**

1. B. Costa, M. Puleo, and E. Vezzoni, "Phase-Shift Technique for the Measurement of Chromatic Dispersion in Single-Mode Optical Fibres using LEDs," Electron. Lett. 19, 1074 (1983).



WM2 Fig. 1. Schematic diagram of the experimental setup.



WM2 Fig. 2. Measured group delays of a 3.7-km single-mode fiber using coupled outputs of two light emitting diodes and a fitted Sellmeier polynomial with a resulting chromatic dispersion curve.