Fiber chromatic dispersion measurements based on programmable spectrum shaping and wavelength-to-time mapping

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Introduction

➢ In this work, a flexible way for dispersion measurement based on wavelength-to-time mapping is demonstrated. A broadband spectrum is obtained by spreading the output of a home-made ML fiber laser, and it is shaped with a space light modulator (SLM) based pulse shaper which is controlled by a computer. So programmable spectrum shaping is achieved. The shaped signal is then employed for wavelength-to-time mapping. The dispersion of a 4-km single mode fiber (SMF) is measured and compared with the values provided by manufacturer.

Principle

➢ Fig. 1 shows the schematic diagram of fiber dispersion measurement using programmable spectrum shaping and wavelength-to-time mapping.

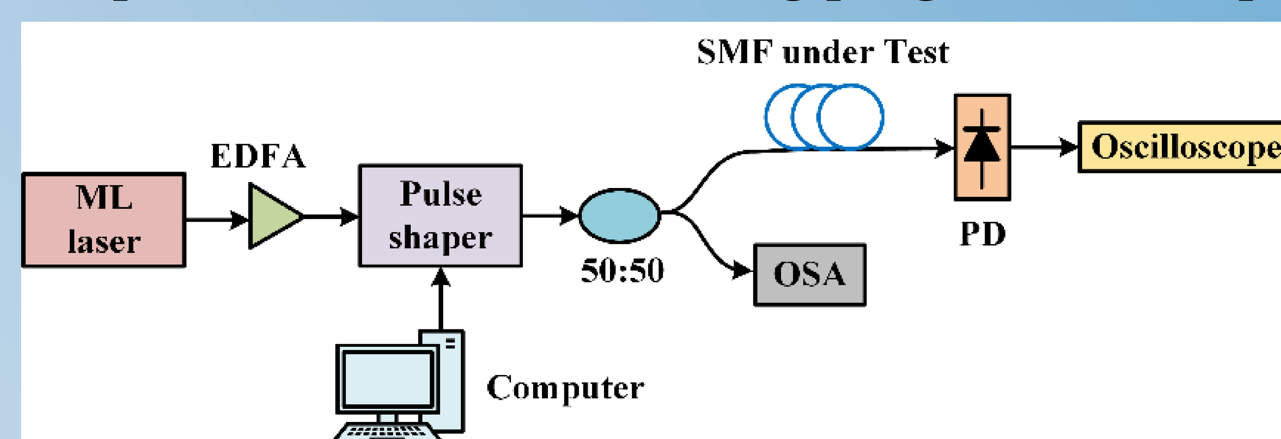

Fig. 1. Schematic diagram of fiber dispersion measurement based on programmable spectrum shaping and wavelength-to-time mapping

● After the shaped laser propagating in a section of SMF under test and owing to the dispersion in the fiber, wavelength-to-time mapping is achieved if the input pulse is sufficiently short. Consequently, the temporal waveform detected by the photo-detector (PD) will trace out the spectrum input to the test fiber. So, a point in the waveform at a time delay of $\Delta\tau$ measured from an arbitrary reference point (t_0) is mapped from a point with a wavelength spacing of $\Delta\lambda$ from the corresponding reference point (λ_0) in the spectrum.

● A feasible shaping function can be described as:

$$H(\omega) = \cos(a\omega + 0.5b\omega^2) \quad (1)$$

● The measured time interval of $\Delta\tau$ is the differential group delay and described as:

$$\Delta\tau(\omega) \approx \beta_2 L(\omega-\omega_0) + \frac{\beta_3 L}{2}(\omega-\omega_0)^2 \quad (2)$$

● The dispersion coefficient (D) and dispersion slope (S) of the test fiber at the wavelength of λ_0 can be obtained according to the following relationships:

$$D = -\frac{2\pi c}{\lambda_0^2}\beta_2 \qquad S = \beta_3\left(\frac{2\pi c}{\lambda_0^2}\right)^2 - \frac{2D}{\lambda_0} \quad (3)$$

Experiment results and discussion

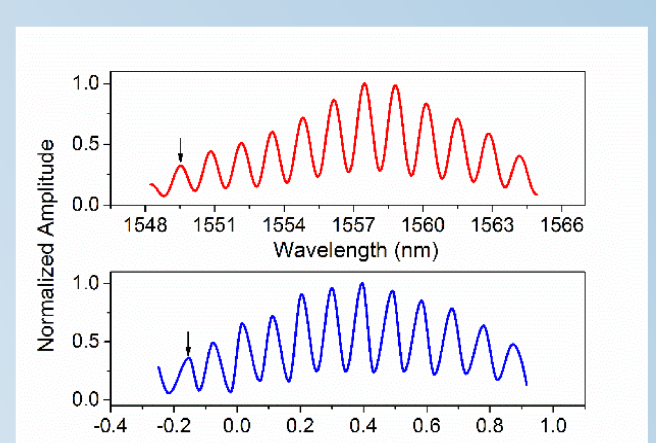

Fig. 2. Experiment results of the shaped spectrum (upper figure) and the mapped temporal waveform (lower figure).

● With $a = 5\times10^{-5}$s and $b = 2.5\times10^{-27}$s^2 in Eq. (1), the spread spectrum is shaped, as shown in Fig. 2. It is clear that there exists a pedestal in the spectrum, which is due to the non-ideal response of the pulse shaper. The temporal waveform recorded by the oscilloscope is also presented in Fig. 2. From the two figures, the similarity between the shaped spectrum and the temporal waveform is clearly observed.

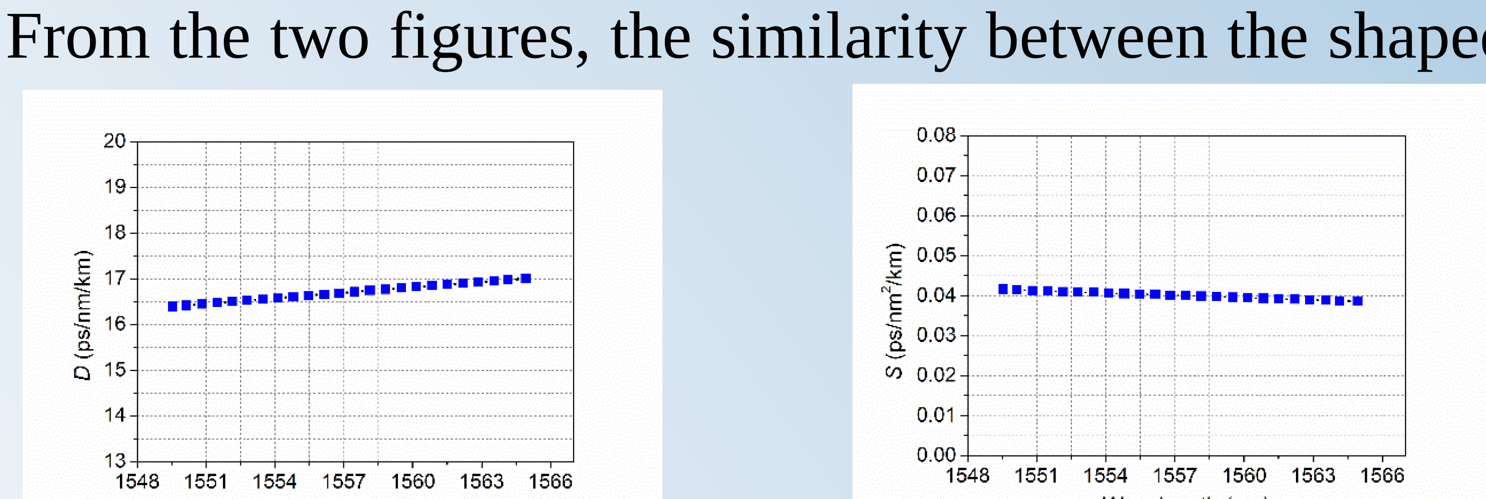

Fig. 3. Measured results of (a) the dispersion coefficient and (b) dispersion slope of the 4-km test fiber

● From Fig. 3, D and S @1550.148nm can be obtained for the test fiber. A comparison of the measured results and the nominal values provided by manufacturer is listed in Table 1.

TABLE 1. COMPARISON OF THE MEASURED DISPERSION PARAMETERS AND NOMINAL VALUES PROVIDED BY THE MANUFACTURER

	D (ps/nm/km)	S (ps/nm^2/km)
This method @1550.148nm	16.38	0.0415
Nominal values @1550nm	≤18.6	≤0.058

Conclusions

➢ A fiber dispersion measurement method based on programmable spectrum shaping and wavelength-to-time mapping has been experimentally demonstrated. The corresponding dispersion coefficient and the dispersion slope are calculated, and the results agree with the nominal values provided by manufacturer.

Acknowledgement

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