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Measurement of nonlinear and chromatic dispersion parameters of optical fibers using modulation instability

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Abstract

We present a simple method for the measurement of Kerr, second- and third-order dispersion coefficients in optical fibers using power and dispersion dependences of modulation instability near the zero-dispersion wavelength. We also complete the analysis by the accurate determination of the zero-dispersion wavelength of the fiber using the phase-matched four wave mixing process which occurs near this specific wavelength.

Keywords: Optical fiber; Nonlinearity; Modulation instability; Four wave mixing; Chromatic dispersion

1. Introduction

In ultrafast telecommunication systems using optical time division multiplexing and dispersion management techniques, picosecond and even subpicosecond pulses will be transmitted through optical fibers [1,2]. Consequently, the impact of effects such as nonlinearity, second- and third-order chromatic dispersion on transmitted pulses will be increasingly dramatic. Thus, the ability to measure the parameters responsible for these different

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effects with a reasonable accuracy has become of great interest for the transmission-line designers and the prediction of system performance. Several methods have been proposed for measuring fiber nonlinear coefficient; most of those are based on the detection of the phase shift caused by self phase modulation (SPM), or on cross phase modulation (XPM) [3,4]. But in general, these techniques need short pulses and small chromatic dispersion; in addition, they only give access to the Kerr coefficient value. More recently, in Ref. [5], four wave mixing (FWM) was proved to be a possible way to simultaneously measure the Kerr and dispersion coefficients. This method is based on the measurements of the zero-dispersion wavelength and dispersion slope coefficient from which the chromatic dispersion is then numerically determined. Consequently, this method is dramatically dependent on zero-dispersion wavelength variations along the fiber length and very sensitive to the measurement error on dispersion slope. In Refs. [6,7], modulation instability was also proposed to measure the Kerr and dispersion coefficients but did not strictly take into account for fiber losses. We report here an extension of this method by the simultaneous measurement of Kerr, second- and third-order chromatic dispersion parameters and by using a modulation instability model taking strictly into account for fiber losses [8]. To check the accuracy of the method, we have also completed our study by a direct measurement of the zero-dispersion wavelength using FWM. We have applied our technique to the measurement of the parameters of a 12.5 km long non-zero dispersion shifted fiber (NZ-DSF). We believe that such a simple and relatively cheap technique, which allows the measurement of four different fiber parameters, could be of a great interest for future telecommunication design.

2. Experimental setup

The experimental setup is shown in Fig. 1, a continuous wave (CW) at 1550 nm was emitted by a tunable-wavelength external-cavity laser-diode (ECL). The CW was then amplified to the desired average power level by means of an erbium-doped fiber amplifier (EDFA). Stimulated Brillouin scattering (SBS) was suppressed by externally modulating the ECL with a 130-MHz sinusoidal signal applied to a $LiNbO_3$ phase modulator. This frequency was experimentally optimized to give negligible SBS back reflected power. A 95:5 coupler was placed at the amplifier output to allow for real-time monitoring of the SBS signal. The CW was finally injected in the fiber under test (standard 12.5 km long NZ-DSF)

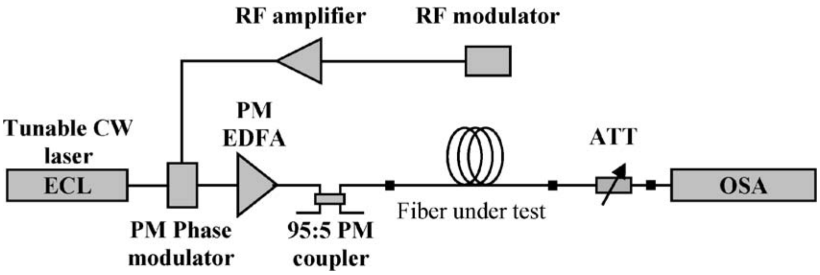

Fig. 1. Experimental setup. ATT: variable optical attenuator, PM: polarization maintained.