Measurement of the Temperature Sensitivity of Phase Modal Birefringence of Polarization Maintaining Optical Fibers using a Sagnac Interferometer Based Temperature Sensor

Cezary Kaczmarek
Institute of Electronics and Information Technology
Lublin University of Technology
Lublin, Poland
E-mail: c.kaczmarek@pollub.pl

***Abstract*—The paper presents a significantly improved method for measuring the temperature sensitivity of phase modal birefringence of polarization-maintaining optical fibers (PMFs) based on the Sagnac interferometer. In this method, a measurement of the spectral temperature sensitivity of a PMF based Sagnac interferometer temperature sensor is performed. The measured spectral temperature sensitivity of the sensor is used to determine the polarimetric temperature sensitivity of the PMF, and with the additionally measured phase modal birefringence, to determine its temperature sensitivity of phase modal birefringence based on the derived equations relating these quantities to the spectral temperature sensitivity of the sensor. In addition, a new procedure for determining the sign of the group modal birefringence was given and a new procedure for determining the sign of the temperature sensitivity of phase modal birefringence of a PMF. Using this method, measurements of PMFs were performed: a PM-PCF and a PANDA PMF, in the temperature range 20-70 degrees Celsius for the 1550 nm wavelength. A comparison of the results of these measurements with results obtained by other methods for the same types of fibers is presented.**

Keywords—polarization maintaining fiber; birefringence; sensitivity to temperature

I. INTRODUCTION

The temperature sensitivity of phase modal birefringence $d\Delta n/dT$ of a polarization-maintaining (or highly birefringent) fiber (PMF) is usually determined on the basis of a measurement of the polarimetric temperature sensitivity of this fiber K_T, which represents the change of the phase shift between the polarization modes induced by a unit change of temperature, of a unit length segment of the fiber. This measurement is most often carried out in the time domain using for this purpose a fiber optic polarimetric interferometer. The measure of the change of the phase shift between the polarization modes in this measurement is the number of fringes of the interference image [1,2]. Less often, a polarimeter is used for this purpose and the phase shift is determined by observing the Poincaré sphere [3]. Both for practical and scientific reasons the magnitude and the sign of $d\Delta n/dT$ are determined. Thus the magnitude and the sign of the polarimetric sensitivity K_T are also determined. For determining the sign of K_T special procedures have been developed [1-3].

The inconveniences of measuring $d\Delta n/dT$ using a polarization interferometer are associated with the employment of bulk optical elements in its structure and the need of adjusting the setup for guiding the light into and out of the tested fiber segment. The use of a polarimeter for measuring $d\Delta n/dT$ is limited due to the high cost of this instrument. The absolute value of $d\Delta n/dT$ of a PMF was determined in [4,5] from the measurement of the temperature sensitivity of the Sagnac interferometer with the tested PMF. When determining $d\Delta n/dT$, the effect of linear thermal expansion of the tested fiber was not taken into account.

The paper presents a significantly improved method of measuring the temperature sensitivity of phase modal birefringence of polarization maintaining optical fibers based on the Sagnac interferometer. In this method, the measurement of the spectral temperature sensitivity of a PMF based Sagnac interferometer temperature sensor (SITS) K_{sT} is performed. The measured K_{sT} is used to determine the polarimetric temperature sensitivity K_T of the PMF, and with its additionally measured phase modal birefringence, to determine its $d\Delta n/dT$ from the derived equations relating these quantities to the sensitivity K_{sT}. In addition, a new procedure was given for determining the sign of the group modal birefringence and a new procedure for determining the sign of the $d\Delta n/dT$ of a PMF. Measurements of two types of PMFs were carried out at the 1550 nm wavelength in the temperature range 20-70ºC: a PM-PCF manufactured by Blaze Photonics Ltd. with the trade designation PM-1550-01 and a conventional Panda PMF manufactured by Fujikura with the designation SM13-PS-U25A. The results of these measurements are consistent with results of measurements obtained using other methods for the same types of fibers.

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