Abstract

Automatic endless polarization controllers are important components for polarization division multiplex receivers, PMD (polarization-mode dispersion) compensators, coherent optical receivers, optical fiber sensors and switches, as well as other optical interferometric solutions. High-speed polarization changes in the transmission fibers must be tracked, without any interruption, in order to realize a near-perfect polarization matching. Thus, fast polarization controllers typically use electro-optic polarization transformers which currently offer the fastest response time.

In this work, a method to characterize commercial multistage polarization transformers has been investigated. It has been developed based on a quaternion analysis of the optical retarders. The polarization transformation of the retarder can be inferred accurately using a quaternion-based optimization on series of polarimetric measurement data. Based on the calibration result, the electro-optic polarization transformers can be calibrated and operated as linear retarders or fractional waveplates with a high degree of accuracy, already taking into account any of retarder's non-ideal characteristics.

The electro-optic retarders have been used in a polarization control system. The hardware for the system has been developed using affordable commercial off-the-shelf components. The characteristics and the performance of two polarization control algorithms have been extensively studied. An ultra-fast implementation of the linear retarder algorithm, running on an FPGA (field programmable gate array), has been realized and tested in a polarization tracking experiment. The retarder calibration data are stored as look-up tables for very fast access. The implementation of the control algorithm has been optimized, reaching a control iteration cycle of just 2 µs. In the tracking experiments, it was found that the controller was able to track up to 15000 rad/s polarization changes caused by rotating waveplates with the maximum polarization mismatch of only 0.14 rad, corresponding to a negligible intensity fluctuation of 0.02 dB. Truly endless operation was confirmed in a long term experiment. This polarization controller is thus suitable for polarization demultiplexing and PMD compensation.