Fiber Links for Sub-Femtosecond Timing over Kilometer Distances

White Paper

A Polarization-Maintaining Dispersion Managed Link (PM-DML) composed of standard PM fiber (e.g. TruePhase® 1550) and PM Dispersion Compensating Fiber (PM-DCF) provides ultimate transmission media for sub picosecond pulses without any pulse broadening. A PM-DML eliminates the impairment from chromatic dispersion and polarization mode dispersion (PMD). OFS' PM-DCF provides compensation of not only dispersion, but also dispersion slope, leveraging the advances over many years in the design of standard telecommunication DCFs.

Demonstration: Sub-fs Timing Distribution

These benefits of PM-DML are illustrated by a demonstration of precise timing distribution recently published [*M. Peng et al., Sub-Femtosecond Timing Distribution via a 1.2 km Polarization-Maintaining Fiber Link, Optics Express, Vol. 21, No. 17, pp. 19982-19989; 2013*]. Such a distribution system provides the synchronization between instruments that is essential for the performance of large science facilities, such as a synchrotron particle accelerator. Such a system must distribute a "clock" of pulses to various components in the km-scale accelerator path. It is also an example of a system where timing precision must be much better than conventional telecommunication systems and where simple upgrading of the passive fiber link can greatly improve the overall performance of a complex, sophisticated, and expensive system. Peng's system uses active feedback to cancel most sources of timing noise so that ~100 fs PMD eventually limits the timing precision possible using non-PM fiber. Once polarization is controlled using PM-DML, the system achieves 0.6 fs RMS drift over 16 days in a 1.2 km link. This is more than an order-of-magnitude improvement over previous results, which were limited, at best, to sub-10 fs precision over a few days of operation depending on environmental conditions, and were susceptible to large 100 fs delay jumps due to polarization mode dispersion when the fiber was significantly perturbed.

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