Multi-Purpose Constant-Delay Optical Link

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A stable signal-propagation delay is an important factor in many different synchronization and clock-distribution systems[1]. Over short distances of a few tens of meters a signal may still be transferred via coaxial cables[2], while on longer distances the use of fiber-optic links is more appropriate. This is due to a low attenuation, a large bandwidth and various possibilities of a signal transfer and a signal-delay compensation[3].

The proposed constant-delay optical transfer system stabilizes an optical-path length between a master (MU) and a slave unit (SU) connected via a standard single-mode optical fiber (Fig. 1). Multi-purpose user signals (e. g. pulses, RF, data) are transferred over independent bidirectional xWDM channels. The detection of propagation-delay changes is done in the compensation module inside the MU. The thermally stabilized compensation module consists of a microwave reference oscillator, a DFB laser, an optical circulator, a PIN photodiode and a phase detector. An intensity modulated optical signal is propagated to the SU using one of the xWDM channels where it is reflected back to the MU, demodulated and compared to the reference signal. A resulting phase difference is then used for a stabilization of an optical link with a compensation chamber, consisted of a heated/cooled fiber spool and/or a piezo-controlled fiber stretcher.

The first delay-stability measurements of an external 3 GHz radio-over-fiber user signal show a delay stability better than 1 ps peak-peak in a 24 hour period. The optical link was 948 m long placed in a non-temperature stabilized environment. Due to an availability, a reliability and costs, telecom-grade components are intentionly implemented in the proposed system.

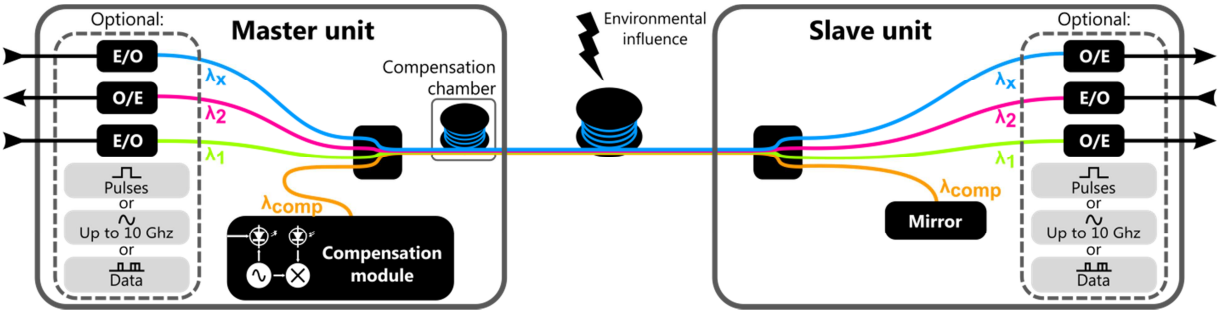

Fig. 1: Constant-delay optical link with an internal MW phase comparison used for link compensation.

[1]B. Batagelj, et al., "Use of femtosecond synchronization system with long-term stability over optical infrastructure", ICTON 2011, Stockholm, p. 1-4, 2011.

[2] S. Hunziker, et al., "Towards an Ultra-Stable Reference Distribution for the New PSI 250 MeV Injector", DIPAC09, TUPB43, p. 266-268, 2009.

[3] R. B. Wilcox, et al., "System Design Concepts for Optical Synchronization in Accelerators", PAC07, FROA05, p. 3807-3809, 2007.