Extending the delay compensation range of the fiber optic time and frequency transfer system

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Fiber optic based distribution of time and frequency signals suffers from seasonal delay fluctuations, observed in fibers due to temperature variations. One of the methods proposed to overcome this problem is an active delay stabilization system, exploiting dedicated electronic delay lines to compensate the fiber delay fluctuations[1,2]. Some limitation of this solution is however the tuning range of the developed delay lines, being about 100 ns. As we measured, the annual delay fluctuations in long-haul links may be substantially higher (see Fig. 1), thus some means of extending the compensation range are desired. In this work we described and analyzed three different solutions for this problem: cascading of currently used electronic delay lines, redesign of the delay lines for higher tuning range, and a new idea of hybrid, electronic and optical delay compensation (see Fig. 2) exploiting a bank of switched optical delays.

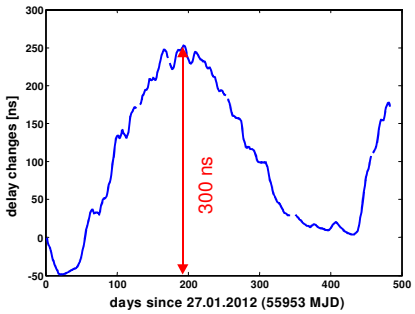

Fig. 1: Annual delay fluctuations in 420 km-long fiber link deployed in Poland. Cable buried in soil.

As we found, the first two solutions may be used when the needed compensation range is about 200-300 ns, but for distances exceeding about 300 km, requiring larger tuning range, they lead to severe performance degradation. In the hybrid, electronic and optical delay scheme we obtain the compensation range of 1150 ns, which is enough for about 1500 km-long link. We observed practically the same frequency stability as in the basic system, with only some small, temporary phase excursions (about 20 ps) in the instants of switching of the optical delay bank.

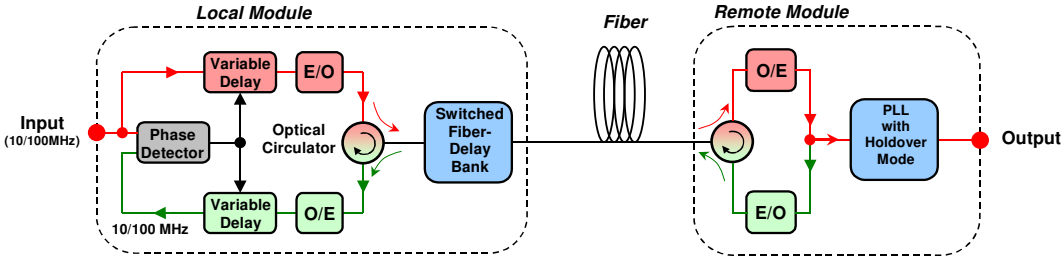

Fig. 2: System with hybrid, electronic and optical delay compensation.

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[2] Ł Śliwczyński, P. Krehlik, A. Czubla, Ł. Buczek and M. Lipiński, "Dissemination of time and RF frequency via a stabilized fibre optic link over a distance of 420 km", Metrologia vol. 50, 2013.