Time transfer over delay-stabilized fibre links using an optical pulse train

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In earlier work, we have demonstrated that microwave and optical frequencies can be transferred over many-km optical fibre links by propagation of a 30 nm-wide optical frequency comb at a level better than 10^{-17} [1]. Here we investigate using a frequency comb (a pulse train in the time domain), with 100 MHz repetition rate, for simultaneous time and frequency transfer. In order for the technique to be compatible with internet-carrying fibre networks, we restrict the bandwidth to one ITU channel (100 GHz). Using a similar set-up as in our previous work[1], we successfully suppressed the environmentally-induced phase noise of a 50 km optical fibre spool. In order to superimpose timing information onto the pulse train we use a 10 GHz Mach-Zehnder intensity modulator which is driven by a commercial pulse generator locked to the local frequency reference. A pulse with different amplitude acts as a time marker used to measure the absolute one-way and round-trip delays of the fibre, whilst the delay is kept constant by the fibre noise cancellation feedback loop. Measurements of the round trip delay using the modulated optical pulses show a counter-limited stability of approximately 10 ps at 1 s. The full implementation of the delay-stabilized, calibrated time transfer over km-scale fibre spools will be presented at the conference.

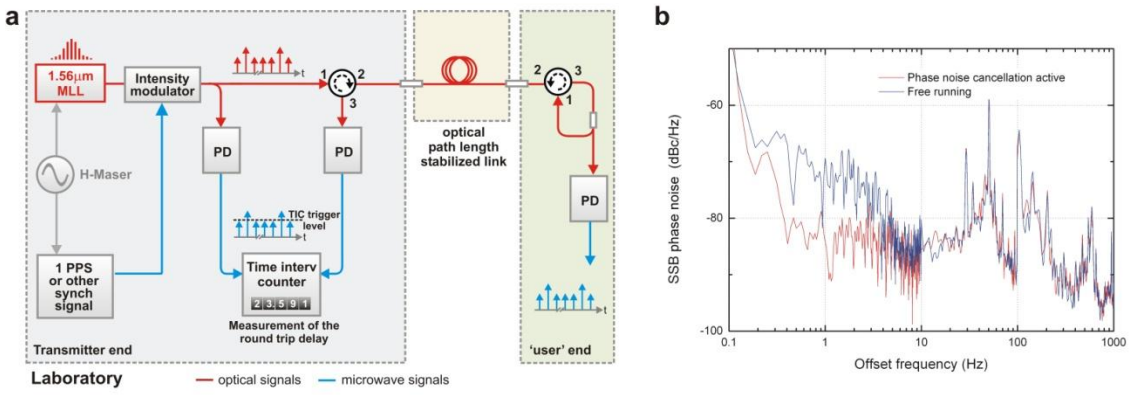

Fig. 1: (a) Working principle figure of the time transfer set-up (PD: photodiode, TIC: time interval counter). (b) Single sideband phase noise of the 80th harmonic of the frequency comb measured at the remote end after a 50 km fibre spool.

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[1] G. Marra *et al.*, "Dissemination of an optical frequency comb over fiber with 3 x 10^{-18} fractional accuracy", Opt. Express 20, 1775–1782, 2012.