Theoretical and experimental investigation of phase noise processes on optical fiber links for frequency comparison and dissemination

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The employment of optical fiber links in frequency / time dissemination is developing fast for the last 5 years in frequency / time metrology enabling optical frequency transfer below 10^{-13} at one second over typically 1000 km, opening applications in fundamental and particle physics, astrophysics and geodesy.

The most demanding application in terms of stability is the direct comparison of distant optical clocks. Their resolution well below 10^{-16} is out of reach of regular satellite techniques. To ensure the possibility to compare these sources with a resolution as good as possible, and to allow further improvements of the links in order to ensure the comparison of clocks of next generation, a fine understanding of the phase noise contributions of a fiber link is needed.

This contribution will first address the different sources of noise that are affecting different zones on the phase PSD and Allan variance stability plots, following the general approach of Newbury[1]; then we will show an autocorrelation-based method for the theoretical calculation of the so-called delay-unsuppressed phase noise for various configurations of dissemination / comparison optical fiber links: a classical compensated frequency dissemination link[2], an extraction link[3], a two way / Sagnac link[4], and a mixed two-way / compensated link[5].

The second part of our contribution will be dedicated to the study of the interferometer-related noise, which typically affects the long-term stability of a fiber link. We will show a model of the interferometer behavior capable of taking into account his temperature / time error characteristic with a very good uncertainty. Applying a compensation technique based on this model, the temperature stability of the interferometers employed on a compensated link was improved by an order of magnitude, scaling down from 8 fs/K to a fraction of fs/K.

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