Calibrated fiber-optic time distribution using dispersion-insensitive configuration

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Time dissemination requires accurate knowledge of the propagation delay introduced by the dissemination link. This delay must be kept constant during the link operation and its value is determined through the process of the link calibration.

One of the delay corrections that need to be determined in a fiber-optic time dissemination link is related to the chromatic dispersion of the fiber. This is related to the difference of the laser wavelengths ($\lambda_F - \lambda_B$) used to propagate the forward and backward signals, which are necessary to stabilize the propagation delay of the link (see Fig. 1a). Determining this chromatic dispersion correction requires an extra calibration step where the wavelength of one of the lasers (usually the forward one) is varied when the stabilization loop is temporarily opened[1]. This step must be repeated if, due to any reasons, the length of the fiber changes substantially. Calibration of such link may pose a level of difficulty, especially for users unfamiliar with metrological applications.

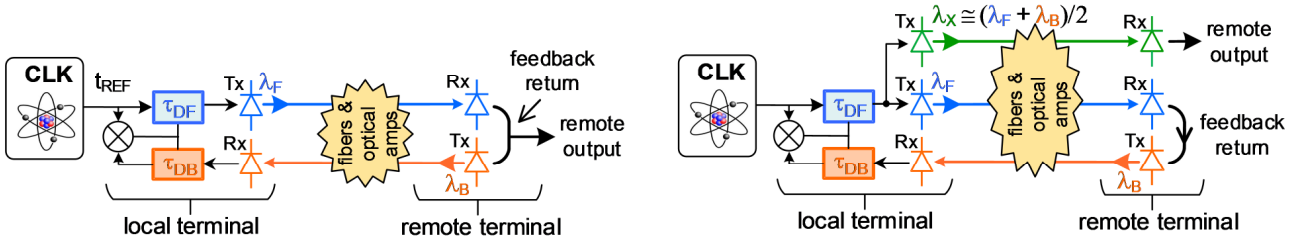

Fig. 1: Fiber optic time transfer link with stabilized propagation delay: basic configuration (a) and dispersion-insensitive configuration with additional forward laser (b).

In this paper we investigate the modified link configuration (Fig. 1b) containing additional forward laser (λ_X), which allows zeroing the chromatic dispersion correction. To get such a result it is necessary to place λ_X close to the middle between λ_F and λ_B, while the exact value depends on the spectral characteristics of the lasers used (mostly their residual frequency chirping) and the second order dispersion of the fiber installed in the link. An important feature of the solution discussed is that it is possible to set the correct wavelength of the λ_X during initial calibration of the link terminals, which does not any further user adjustment after the link installation.

Measurements carried out with a few prototypes of the system build accordingly to the described idea show that the time transfer accuracy and stability are in general comparable to the basic set-up, while the link calibration process is simplified.

[1]. Ł. Śliwczyński *et al.*, "Calibrated optical time transfer of UTC(k) for supervision of telecom networks," Metrologia, vol. 56, 015006, 2019, 10.1088/1681-7575/AAEF57