Multi-branch Laser Stations for dense ultra-stable frequency distribution networks

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Ultra-stable optical frequency transfer via telecom fiber is the only viable technology to compare today's optical clocks without degrading their performance. Similarly, high precision fundamental science experiments have been enabled thanks to the high-performance frequency links to a primary standard. All these very successful use cases call for an increased number of frequency links and thereby network densification.

We report on Exail's Multi-branch Laser Stations (MLS), a robust and reliable equipment for ultra-stable frequency transfer through optical fiber. Conceptually similar to a Repetear Laser Station (RLS)[1], MLS includes the repeater function and disseminates the ultra-stable signal to up to 6 links simultaneously[2]. In addition, one MLS assesses the end-to-end frequency transfer A MLS is thereby an essential tool if densification of an existing or new optical frequency network requests a distribution hub.

Fig. 1: Example of the possible configurations available for MLS.

The MLS working principle is based on an ultra-low noise free space optical interferometer with one input and more than twenty outputs. The noise floor of the interferometer measured by a short link between two outputs shows an average thermal sensitivity of 0.05fs/K, with a measured stability at 2×10^{-21}@10^{3}s (80 better than previously[1]). The MLS is completed by low-noise phase compensation electronics that has proven performant, reliable, and field compatible in the RLS deployed within Refimeve for > 10 years now. Since they share the same electronics, the optical frequency transfer by MLS and RLS is not limited by the local oscillator fluctuations[3].

The MLS modular design allows different configurations and adaptations to user needs. Thereby, additional fiber links are feasible even under tight constraints of space and power. Following technology transfer from SYRTE and LPL, we will present the first units produced by Exail and detail their metrological evaluation.

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[1] F. Guillou-Camargo et al., « First industrial-grade coherent fiber link for optical frequency standard dissemination », Applied Optics, vol. 57, nº 25, p. 7203, sept. 2018, doi: 10.1364/AO.57.007203.

[2] E. Cantin, et al., « An accurate and robust metrological network for coherent optical frequency dissemination », New J. Phys., vol. 23, nº 5, p. 053027, mai 2021, doi: 10.1088/1367-2630/abe79e.

[3] O. Lopez, et al., « Ultra-stable long distance optical frequency distribution using the Internet fiber network », Optics Express, vol. 20, nº 21, p. 23518, oct. 2012.