Exploring the Benefits of a Multi-Channel Analysis

Claudio E. Calosso[1], C. Fluhr[2], B. Dubois[2], V. Giordano[3], F. Vernotte[3], E. Rubiola[3]

[1] Istituto Nazionale di Ricerca Metrologica (INRIM), Torino, Italy
[2] FEMTO-Engineering, Besançon, France
[3] FEMTO-ST Institute, Besançon, France

Email: c.calosso@inrim.it

The possibility of measuring with high resolution and simultaneously the phase of many signals increases the possibilities of analysis beyond current practice. In the simplest case, with the comparison of two clocks, one can at most arrive at the difference of the measurements, and then calculate the variances (classical, Allan, modified…) of the measurements, or their spectrum. With three channels, in addition, one has access the three-cornered hat and the two-sample covariance, or the cross-spectrum, that allow for obtaining the noise of each individual clock, in case they are uncorrelated. With six channels, it is possible to reject also the noise contribution of the instrument[1]. By further increasing the number of channels, the possibilities increase even more, becoming practically infinite. For example, in the case of having many clocks of the same performance class, one can compare each single clock with the weighted average of the others. In this case, the measurement time is reduced compared to two sample covariance and cross-spectrum, because temporal averages are replaced by ensemble averages. When dealing with clocks of different classes, the weighted reference concept can be extended to include composite reference. In this approach, the measures of the individual clocks are combined to create virtual composite references that preserve the best performance of the different clock classes at various measurement times.

At the conference, we will present the benefits of a multi-channel approach, using the signals of the Oscillator IMP platform, which will be characterized at once as a whole using a 16-channel high-resolution phasemeter. The data obtained from the platform will be utilized for extensive monitoring and quick and simple detection of anomalies, as well as for demonstrating the virtues of composite references. For this purpose, we will present the analysis conducted to assess the frequency stability of a high-performance cryogenic sapphire oscillator for averaging times spanning from seconds to days[2].

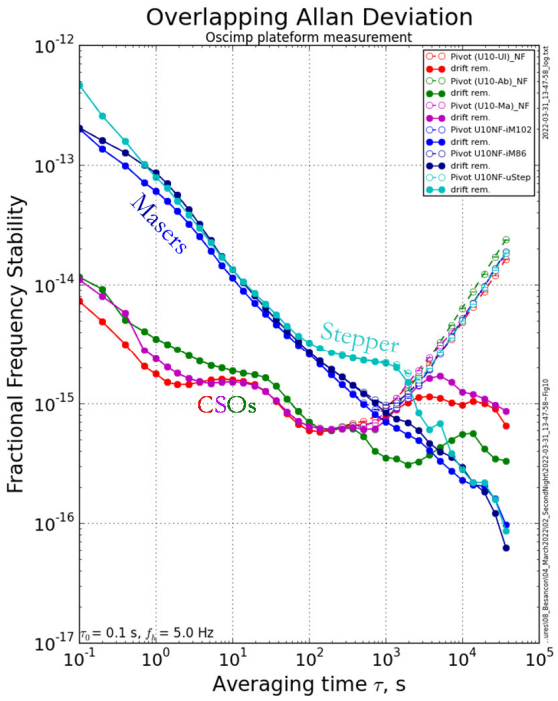

Fig. 1: For using composite references, it is required a simultaneous measure of the oscillator under test with respect to different classes of references. In this case: CSOs, masers, and UTC(OPB).

[1] C. E. Calosso et al., "Frequency Stability Measurement of Cryogenic Sapphire Oscillators…" in IEEE TUFFC (2019) doi: 10.1109/TUFFC.2018.2870593.

[2] C. Fluhr et al., "A cryogenic sapphire resonator oscillator with 10^{-16}…", Appl. Phys. Lett. 123, 044107 (2023) https://doi.org/10.1063/5.0153711