SATRE Modem Performance Characterization for 20 Mcps TWSTFT Optical Clock Comparisons

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Optical clock uncertainties are approaching the level of less than 10^{-17}, and there are several optical transitions selected as secondary representations of the SI second. In order to explore the capabilities to steer timescales with such low uncertainty, we prepare simultaneous high chip rate two-way satellite time and frequency transfer (TWSTFT) comparisons between optical clocks located at four European NMIs[1].

The usually employed chip rate of 1 Mcps limits TWSTFT to roughly 10^{-15}. Besides different approaches for remote optical clock comparisons such as transportable clocks, fiber links (not yet readily available), or satellite carrier-phase techniques, the lower limit of TWSTFT can be improved if higher chip rates are used with standard SATRE modems, because the 1pps jitter scales with the inverse of the chip rate[2,3], see Fig. 1 and the equation in its inset.

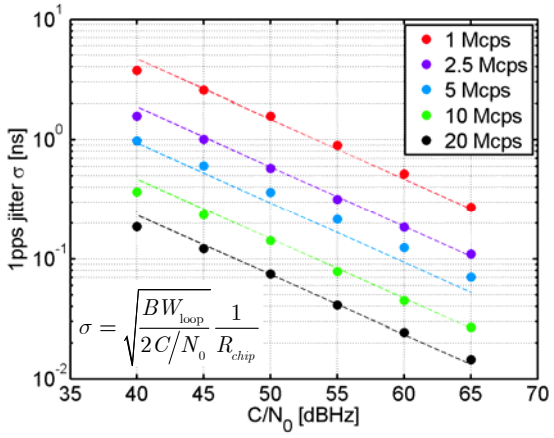

Fig. 1: 1pps jitter as a function of carrier to noise-density ratio. Filled circles: Measured values, dashed lines and equation: model (loop bandwidth BW_{loop} = 0.5 Hz). The lock-acquisition of the modem fails at $C/N_0 \lesssim 35$ dBHz.

Here, we present investigations of the SATRE modem performance at different chip rates up to 20 Mcps rate in preparation of the actual clock comparisons via satellite links.

In order to mimic the transmission via a satellite in the lab, we applied according attenuation of the 70 MHz Tx output signal of the modem and added a white noise signal with variable level, such that the carrier to noise-density ratio C/N_0 could be varied. This signal was looped back to the Rx channel of the modem. Fig. 1 shows the results of the C/N_0-dependent measurements at different chip rates between 1 and 20 Mcps. The data was fitted using the model shown as equation in the inset and with the loop bandwidth as the only parameter. The fit yielded good accordance with its nominal value of 0.6 Hz. Other potentially disturbing effects like interference between simultaneously operating links with different SATRE codes will be discussed.

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[1] H. Margolis et al., "International Timescales with optical clocks," Proc. 2013 Joint UFFC, EFTF and PFM Symposium, 21-25 July 2013, Prague, 908-911.

[2] P. Hartl et al., "Global Time Transfer Via Satellites," Z. Flugwiss. Weltraumforsch. 7, 335 (1983).

[3] "Understanding GPS: principles and applications," Ed. E. Kaplan, C. Hegarty, 2nd ed., pp. 173-200 (2006).