An ultra low noise frequency synthesis chain for a high performance Cs compact vapor cell atomic clock

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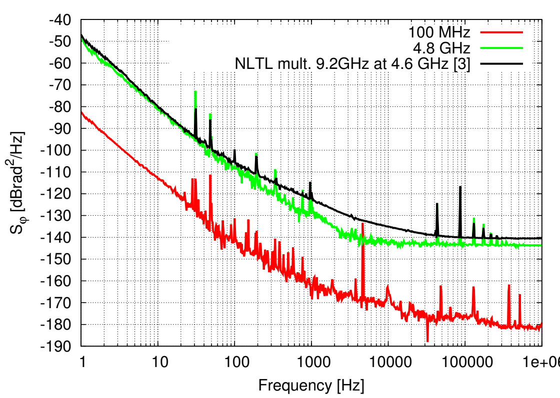
In order to prevent short term frequency stability degradation by the so-called Dick effect [1], compact vapor cell atomic clocks, based on coherent population trapping (CPT) or double resonance techniques, need microwave local oscillators exhibiting high spectral purity for Fourier frequencies typically in the $100-1$ kHz range.

This paper aims to present a novel simple-architecture 4.596 GHz frequency synthesizer dedicated to the interrogation of a high performance Cs atomic clock based on CPT with an expected short term frequency stability of a few 10^{-13}. In order to reach such performances at 4.6 GHz, the LO phase noise has to be lower than -111 dBrad^2/Hz at f = $\frac{2}{T_c}$ = 330 Hz where T_c (6 ms) is the cycle time of the clock. In the present CPT clock, optical sideband generation is performed through modulation at 4.5963 GHz of a Mach-Zender electro-optic modulator [2].

We reported recently a microwave frequency synthesizer based on a non-linear transmission line (NLTL) [3]. In the latter, the absolute phase noise of the output signal was clearly limited by the residual noise of the NLTL component in the f = $100-1000$ Hz range. Moreover, this key component is expensive and requires high input power. The new frequency synthesis chain is mainly based on a XM16 Pascall multiplication module (XM16-E-1600-E-12). This module integrates a state-of-the-art 100 MHz OCXO quartz oscillator (Pascall OCXOF-E) with an absolute phase noise of -140 dBrad^2/Hz at f = 100 Hz respectively, late frequency multiplied by 16 to 1.6 GHz without any phase noise degradation. The 1.6 GHz output signal is multiplied by 3 to 4.8 GHz and mixed with a with a 200 MHz from the synthesis chain and a 3.7 MHz from a direct digital synthesizer (DDS). The output is band-pass filtered to select the 4.5963 GHz signal.

The figure on the right shows preliminary absolute phase noise results of the synthesis. These measurements were performed with the signal source analyzer (Agilent E5052B) used in [3]. The 4.8 GHz output signal absolute phase noise is measured to be -108 dBrad^2/Hz at 100 Hz, -120 dBrad^2/Hz at f $\simeq$ 330 Hz and -143 dBrad^2/Hz at 1 MHz respectively. At f = 330 Hz, an improvement of about $3-4$ dB is noticed in comparison with [3]. Nevertheless, a wide uncertainty mainly due the cross-spectral function in phasemeters [4] is present in our measurements. The work is still in progress also for reducing this source of uncertainty. Latest results will be shown at the conference.



[1]G.J. Dick. Local oscillator induced instabilities in trapped ion frequency standards. Proc. Precise Time and Time Interval, 1987, Redondo Beach, CA, pp. 133-147.

[2]X. Liu et al. Ramsey spectroscopy of high-contrast CPT resonances with push-pull optical pumping in Cs vapor, Optics Express, vol. 21, 2013, num. 10, pp. 12451-12459

[3]B. François et al. A low phase noise microwave frequency synthesis for a high-performance cesium vapor cell atomic clock. Review of Scientific Instruments, vol. 85, 2014, num. 9, pp. 094709

[4]C. W. Nelson, A collapse of the cross-spectral function in phase noise metrology, Review of Scientific Instruments, vo.l 85, pp. 024705-1 - 024705-7