A low phase noise NLTL-based synthesis chain for a high performance Cs CPT atomic clock

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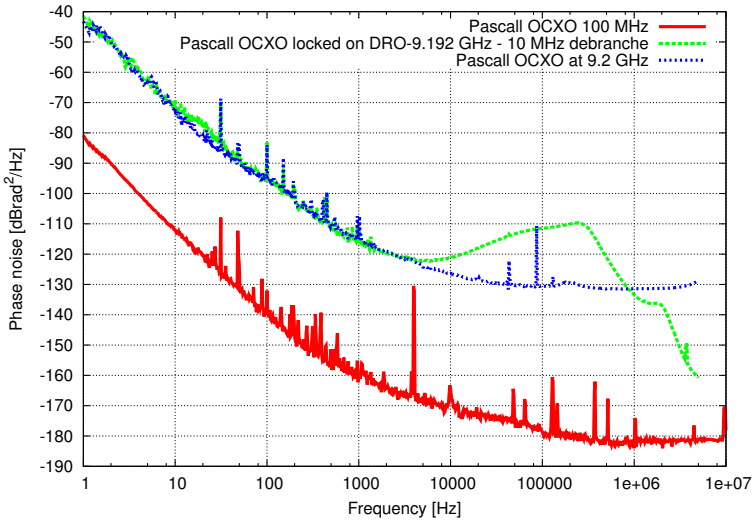
As investigated by Dick et al.[1], the frequency stability of atomic clocks can be limited by the phase noise of the local oscillator (LO) used to probe the hyperfine atomic transition. Indeed, harmonic frequencies of the local oscillator phase noise spectrum can be down-converted into the atomic resonator bandwith by an aliasing effect.

In the frame of the MClocks project funded by EURAMET, this paper aims to present a microwave 9.2 GHz frequency synthesis chain dedicated to interrogate a high performance Cs atomic clock based on coherent population trapping (CPT) with expected relative frequency stability at the level of 10^{-13} at 1 s integration time. The cycle time of this clock is about $T_c = 6$ ms. To reach the expected stability, the LO phase noise has to be lower than -105 dBrad^2/Hz at $f_c = \frac{2}{T_c} \simeq 330$ Hz.

The frequency synthesis architecture is inspired by [2] and is based on a NLTL (non-linear transmission line) component. The pilot of the synthesis is a state-of-the-art 100 MHz OCXO quartz oscillator (Pascall OCXOF-E) with an absolute phase noise of -140 dBrad^2/Hz and -184 dBrad^2/Hz at f = 100 Hz and 1 MHz respectively. The OCXO signal is frequency-doubled at 200 MHz with a low noise frequency doubler. The 200 MHz signal drives the NLTL. The signal at 9.2 GHz is selected by using a band pass filter and then amplified. A 9.192 GHz DRO is phased-locked to the frequency multiplied OCXO with a bandwidth of 120 kHz.

The 9.192 GHz output signal absolute phase noise is measured to be -96 dBrad^2/Hz at 100 Hz, -106 dBrad^2/Hz at $f_c \simeq 330$ Hz and -135 dBrad^2/Hz at 1 MHz respectively. At f = 100 Hz, the results with Pascall OCXO are compatible with the development of a CPT atomic clock with a frequency stability at 10^{-13} with a integration time of 1 s.



[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]R. Boudot et al. Simple-design low-noise NLTL-based frequency synthesizers for a CPT Cs clock. Instrumentation and Measurement, IEEE Transactions on, vol. 58, 2009, num. 10, pp. 3659-3665.