Highly-stable metrological thermostat for active characterization of resonators with automatic turnover point settings

Vorobyev Nikolay[1], Imbaud Joel[1], Abbe Philippe[1] and Sthal Fabrice[1]

[1]FEMTO-ST Institute, UFC, CNRS, ENSMM, UTBM, Besançon, France

Email: nikolay.vorobyev@femto-st.fr

The passive measurement of the ultra-stable quartz crystal resonators was conducted at FEMTO-ST Institute, Besancon, France where we observed that the SC-cut resonator itself can reach a phase noise of about -140 dBc/Hz @ 1Hz carrier offset[1,2]. To confirm these results, it was decided to measure the quartz crystal resonators in the active mode (as oscillator). Everyone knows that quartz has very stable mechanical properties over time, but the temperature changes and gradients often cause frequency changes that are large compared to the slope of the static curve.

In this paper, we describe an original digitally controlled double thermostat system for the quartz crystal oscillator that allows setting the turnover point of crystal oscillator automatically and its characterization. The oscillator optimization was implemented with an EDA software. This simulation included the resonator noise and amplifier noise, which was measured previously for different transistors.

In developing the thermostat, focus was directed towards simplicity of the oscillator replacement and high performance of the system itself.

The main program searches for the turnover point of the crystal oscillator in two steps (approximate and exact) and calculates the approximation function to a third degree of the frequency-temperature curve of the crystal oscillator automatically as show Fig. 1. The setting of the thermostat for crystal turnover point takes about 8 hours though this process is completely automatic.

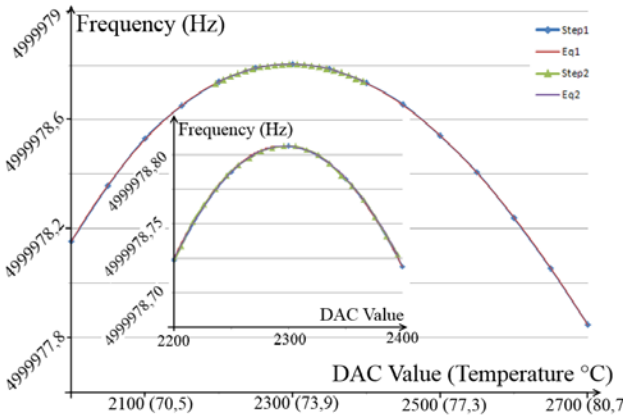

Fig. 1: Searching the turnover point of the quartz crystal oscillator in two steps.

Application of the simulation for optimizing the crystal oscillator allowed reduction in the phase noise, but despite this the oscillator's phase noise shows significant difference (up to 10dBc/Hz) in comparison with the resonator noise itself (passive measurement)

[1] F. Sthal, S. Galliou, J. Imbaud, X. Vacheret, P. Salzenstein, E. Rubiola, G. Cibiel, "About Quartz Crystal Resonator Noise: Recent Study", Proc. ICNF, Pisa, Italie, 15-19 June, pp. 607-610, (2009).

[2] S. Ghosh, F. Sthal, J. Imbaud, M. Davel, R. Bourquin, C. Vuillemin, A. Bakir, N. Cholley, P. Abbe, D. Vernier, G. Cibiel, "Theoretical and experimental investigations of 1/f noise in quartz crystal resonators", Proc. EFTF, Prague, 21-25 July, pp. 737-740, (2013).