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Quartz as a reference material for radio frequency waves: the best performances ever obtained on quartz oscillators with stressed compensated cut

Patrice Salzenstein ^{1*}, Alexander Kuna ², Frédéric Lefebvre ^{3*}

¹ Centre National de la Recherche Scientifique (CNRS), UMR6174 FEMTO-ST, Université de Franche Comté, 15b avenue des Montboucons, F25030 Besançon Cedex, FRANCE

² Institute of Photonics and Electronics (UFE) of the Academy of Sciences, Prague, CZECH REPUBLIC

³ Oscilloquartz SA, Avenue des Paquiers 1, CH2072 Saint-Blaise, canton de Neuchâtel, SWITZERLAND

Abstract

Best performances ever obtained in terms of frequency stability for radio frequency quartz oscillators using stressed compensated cut quartz resonators are a flicker frequency modulation floor of 2.5×10^{-14} at 5 MHz for an integration time around 10 s.

State-of-the-art ultrastable 5 MHz Quartz

The general characteristics are given in reference [1]. These oscillators are of the OSA 8607 series. Oscillator structure is given on Fig. 1. Boitier à Vieillessement Amélioré (BVA) type 8607-C oscillator with stressed compensated (SC) cut. Turnover temperature of the resonator is 88.6°C . Unloaded Q factor is 2.63×10^6 . The phase noise of quartz resonators is measured on a resonator phase noise bench [2]. Regarding experimental phase noise measurements, Q_L can be given by the 1.6 Hz intercept point between $1/f$ slope (phase flicker noise) and $1/f^3$ slope (frequency flicker noise). $Q_L = 1.57 \times 10^6$.

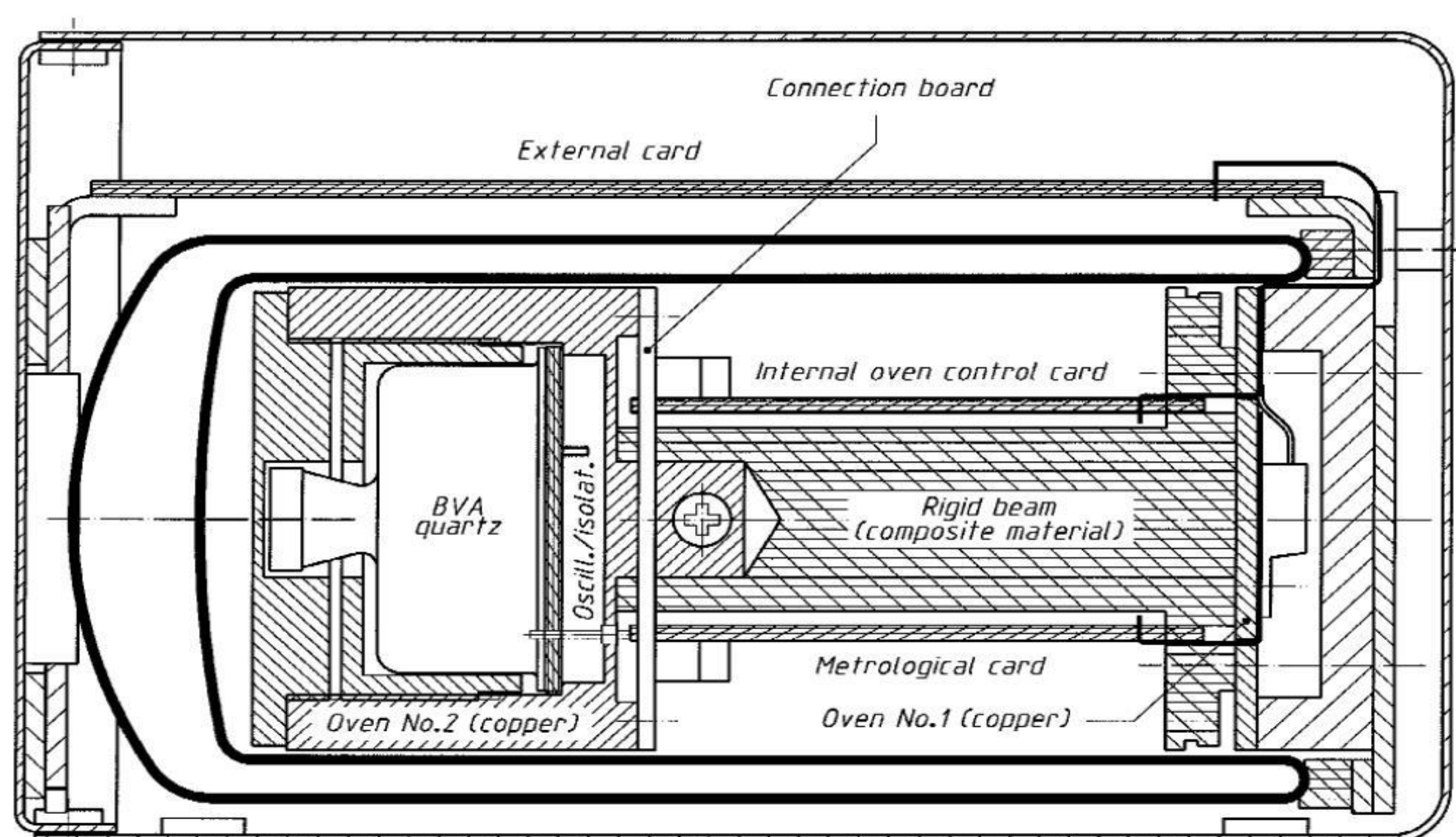


Fig. 1: Oscilloquartz BVA 5 MHz crystal oscillator.

Determination of the short term frequency stability of the new oscillator is performed thanks to a Dual Mixer Time Difference Multiplication (DMTDM) [2,3].

Experience

The contribution of each oscillator is deduced for every measure performed on each pair by 3 cornered hat analysis. 8607-C prototype is the best oscillator and is compared to two other BVA quartz (type 8607, serial number 543 and 567). The two oscillators referenced 543 and 567 are much stable in terms of aging, 8607-C has the best flicker frequency modulation (FFM) floor.

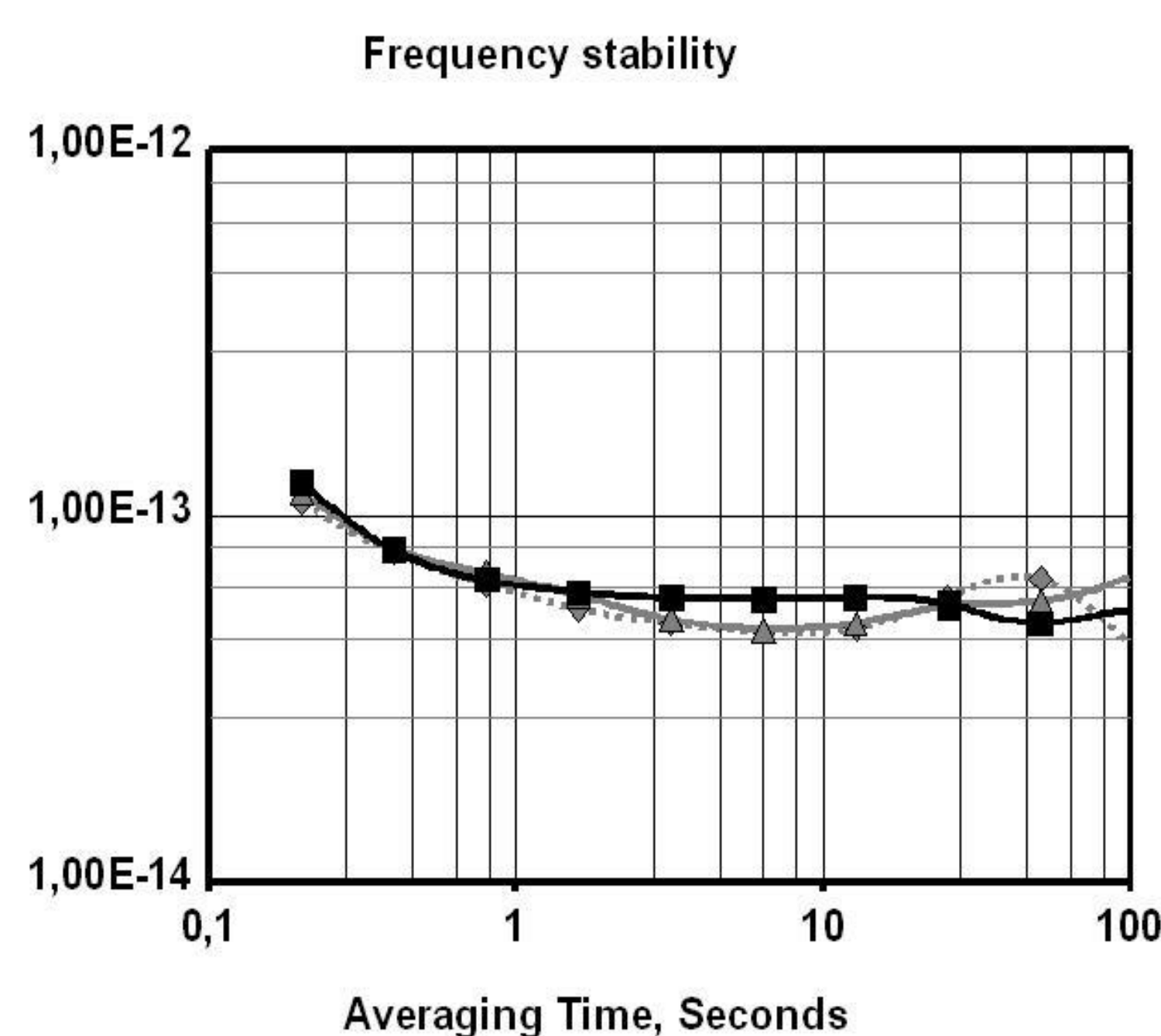


Fig. 2: Allan deviation. Frequency stability for each pair of oscillators: 543-567 (square), 567-8607C (rhombus), 543-8607C (triangle).

Short term frequency stability

The best performances are obtained on a modified OSA 8607 prototype [4], and confirmed by a determination using another bench on another principle [5]. An estimation on the confidence in measures is carried out in reference [6]. The best performances ever obtained remain in the 2.5×10^{-14} to 3.2×10^{-14} range for a 10 – 20 seconds integration time for such oscillators at a 5 MHz nominal frequency as shown on Fig. 3.

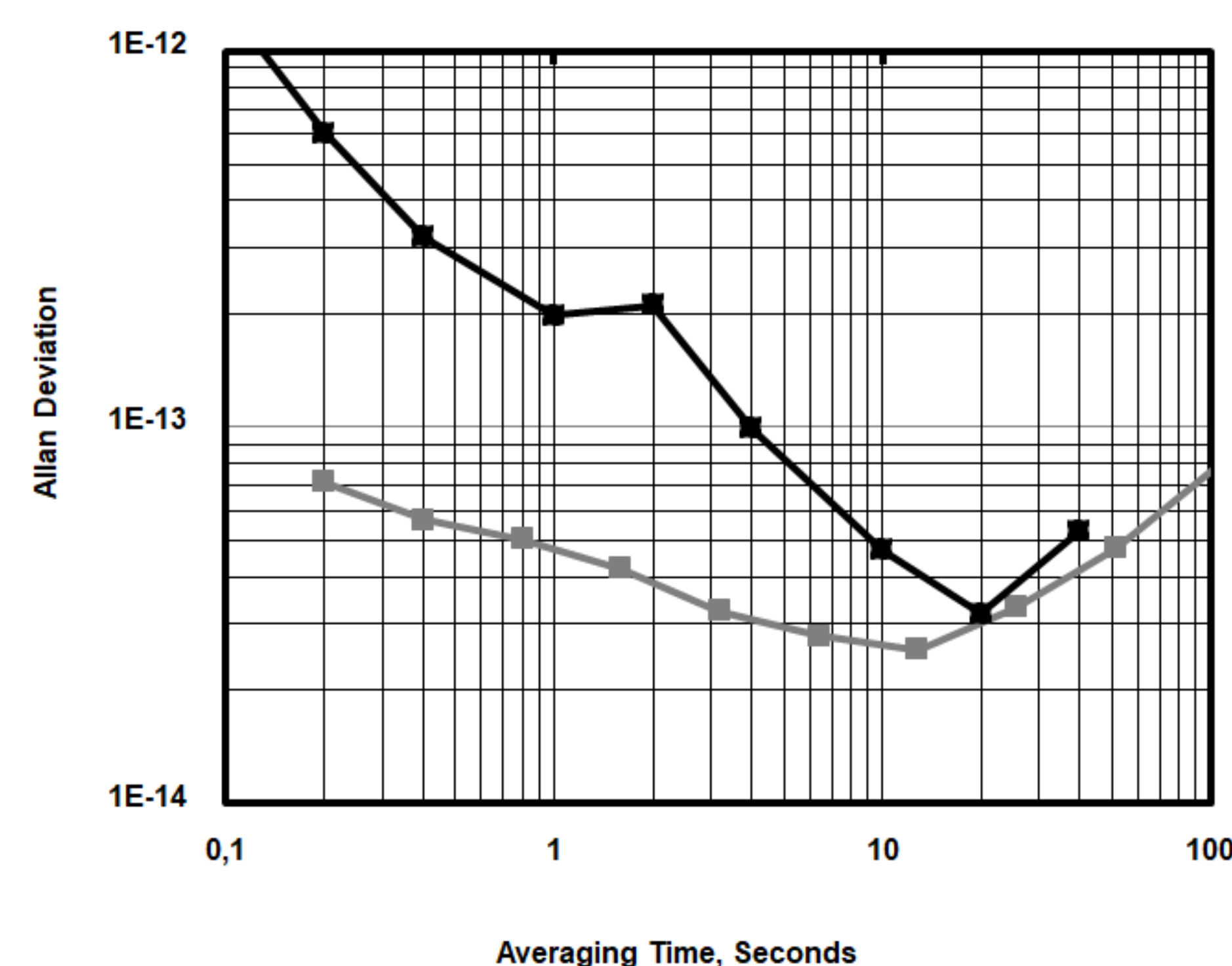


Fig. 3: Best performances obtained on a OSA 8607 quartz oscillator at 5 MHz. The FFM floor is in the range of 2.5×10^{-14} to 3.2×10^{-14} for 10 – 20 s integration time. In grey the best result measured by Dual Mixer Time Difference Multiplication, in black the confirmation of this state-of-the-art performance measured with a time interval analyzer (TIA). For the black curve, results are limited by the TIA for lower averaging time and by aging for upper averaging times.

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* Corresponding authors

patrice.salzenstein@cnrs.fr
lefebvre@oscilloquartz.com

Besançon, Belfort, Montbéliard, Sévenans
www.femto-st.fr