Exploration of 1/f noise origin using time measurements

Ghosh Santunu[1], Sthal Fabrice[1], Devel Michel[1], Imbaud Joel[1], Bourquin Roger[1], P. Abbe[1], D. Vernier[1], A. Bakir[1], G. Cibiel[2]

[1]FEMTO-ST Institute, UFC, CNRS, ENSMM, UTBM, Besançon, France
[2]Microwave and Time-Frequency, CNES, Toulouse, France

Email: fsthal@ens2m.fr

The Centre National d'Etudes Spatiales (CNES), Toulouse, France and the FEMTO-ST Institute, Besancon, France, are investigating the origins of noise in bulk acoustic wave resonators together with several European manufacturers. During this study, numerous quartz crystal resonators with the same design have been cut from a quartz crystal block supplied specifically. Resonators are SC-cut with a 5 MHz resonant frequency. The noise measurements of these quartz crystal resonators have been done by using a passive phase noise measurement technique[1]. The short-term stabilities of a large portion of these resonators have been measured to be lower than $8 \cdot 10^{-14}$. However, some of the others give much worse results around few 10^{-12}, though they have been fabricated with exactly the same process as the best ones. We are consequently carrying investigations on the origin of these differences.

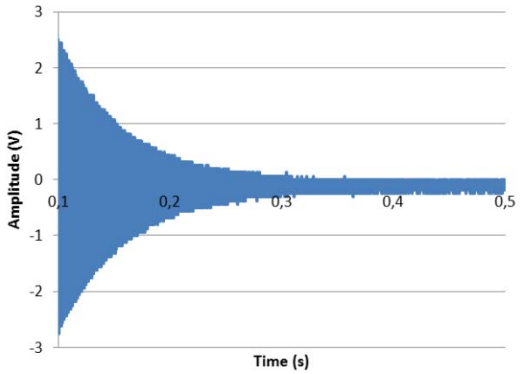

Fig. 1: Acoustic attenuation of a 5 MHz SC-cut Quartz crystal resonator.

In this paper, high speed measurements of the acoustic wave attenuation have been achieved on the best and worse resonators (cf. Fig. 1). Acoustic damping due to nonlinear effects such as interaction of the acoustic wave with crystal defects is a well-known phenomenon[2]. Hence, we explore the possibility to extract a damping contribution with the same physical origin as $1/f$ noise, by studying what is left after subtraction of the classical viscoelastic exponential damping. It is hoped that by carefully inspecting the residuals of the nonlinear fit by an exponentially damped sinusoid, a clear difference will be seen between good and bad resonators and that parameters of an internal friction model may be extracted. This would then allow us to compare our experimental results in the forced oscillator regime with the prediction of a physical model.

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

[2] H.J. Maris, "Ultrasonic attenuation in dirty dielectric crystals", Phys. Rev., vol 175, n° 3, Nov., (1968).