Low-g sensitivity of HBAR Oscillator

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One of the challenges of frequency sources dedicated to space and airborne systems is controlling the oscillator sensitivity to acceleration generated by chocks and vibrations. Until now, acoustic resonators such as Bulk or Surface Acoustic Wave (BAW or SAW) resonators present a g-sensitivity around 5.10^{-10}/g for SAW operating in the 300-600 MHz range and around few 1.10^{-10}/g for BAW in the range 10-100 MHz. New resonator principles have been investigated recently to increase frequency. New two-port High-overtone Bulk Acoustic Resonators (HBAR) combining GHz-range operation capabilities with high quality factor *Q* have been proposed. HBAR oscillator has been built in package around 3×4 cm². Their phase noise floor performance challenging best multiplied quartz OCXO. Measuring their g-sensitivity was one of the milestone for validating their compliance to on-board applications. No particular effort was made to damp the vibration, e.g. using an appropriate package design, to produce the presented results.

This work presents first acceleration sensitivity measurements of oscillators stabilized by very high *Q-f* product HBARs (*Q-f* in excess of 3.10^{13}). Two kinds of HBAR have been considered respectively built combining sapphire and AlN, and Quartz and LiNbO3. First HBARs are obtained by sputtering µm to sub-µm thick piezoelectric layer (AlN) yielding resonance frequencies of 2.4 GHz and 4 GHz respectively. Second HBARs were built using gold bonding and lapping of the $LiNbO_3$ wafer. The overall sizes of HBAR are 1×1.5 mm² for the AlN/Sapphire structures and 2×2 mm² for the LiNbO3/Quartz stacks. The resonators have been conditioned either into CMS packages or onto a dedicated PCB. The measurements of g-sensitivity have been achieved in all space directions on a test bench applying random vibrations in the 10-2000 Hz frequency range with 5 and 7 g rms intensity levels respectively. The impact of acceleration on the phase noise of the HBAR-stabilized oscillators is illustrated in Fig.1. $LiNbO_3$/Quartz HBAR oscillators operating at 690 MHz experience a g-sensitivity of 1.10^{-9}/g whereas AlN/Sapphire HBAR oscillators exhibit a g-sensitivity better than 2.10^{-10}/g. The best result of this experiment campaign corresponds to a g-sensitivity smaller than 7.10^{-11}/g for an AlN/Sapphire-HBAR-stabilized oscillator operating at 2.36 GHz. The first analysis of these results yields the conclusion that the size of HBAR may directly impact the g-sensitivity of the oscillators. Whatever, these results indicate that two-port-HBAR resonators actually are an attractive solution for RF oscillator stabilization.

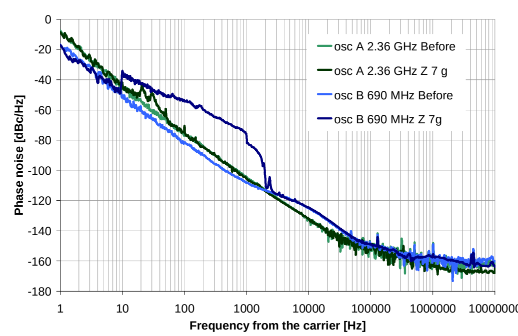

Fig.1: Phase noise evolution of two HBAR submitted to 7 g random vibration.