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Techniques on Crystal Oscillator Vibration Compensation

An Oven Controlled Crystal Oscillator (OCXO) is a precision timing circuit based on a high Q quartz resonator enclosed in an oven to provide the best phase noise performance and high short-term stability.
OCXOs provide good short-term stability and clean frequency references for frequency standards, whether Rb [1], Cs, or Hydrogen Maser atomic clocks [2]. By locking the OCXO reference to atomic resonance, the short-term stability of reference is combined with the long-term stability of atomic resonance to enable novel tests of fundamental laws of physics which require extreme levels of precision and accuracy.
In addition, OCXOs are employed for precision timing and synchronization applications, such as telecommunication, instrumentation, and test equipment in today's Commercial, Defense, Military, Space, and LEO markets. Since 1978 Wenzel Associates (now Quantic Wenzel) has been researching and developing high-performance oscillators to provide the lowest phase noise and highest short-term stability in these markets.
Wenzel uses two Wenzel 5MHz BTULN oscillators for measuring ADEV of its high-performance products using Micro- semi 53100A phase noise analyzer with a stability of <3E-13 at τ of 1 sec and phase noise of <-125dBc/Hz at 1Hz frequency offset.
OCXO temperature stabilization and vibration isolation are two critical factors for femtosecond level stability. The OCXO phase noise performance is one of the key parameters considered when used as a reference in highly stable environments. Specifically, dynamic phase noise performance is critical where minute vibrations could affect short-term stability such as from a ground-based rotating platform, an aircraft cruising altitude, or a satellite in orbit.
Reducing OCXO sensitivity begins with crystal selection; low phase noise and low-g sensitive crystals (as low as 0.1 ppb/g) are critical to success. In addition, a further reduction in OCXO g-sensitivity is possible by sensing the vibration affecting the crystal and compensating for the effect. This technical note covers various vibration compensation techniques developed at Wenzel to reduce vibration-induced phase noise errors in crystal-based oscillators. An example of a compact microcontroller-based vibration-compensated OCXO developed at Wenzel will be presented. Such digitally controlled OCXO can also be employed to correct for thermal drift or errors in GPS location when GPS signals are not available in telecom and navigation systems.

References

[1] Zilong Chen et al, "A low phase noise microwave source for atomic spin squeezing experiments in Rb", arXiv:1204.4215, [physics.atom-ph]

[2] Mushtaq Ahmed et al, "The Brazilian time and frequency atomic standards program", Annals of the Brazilian Acad- emy of Sciences), p. 217-252, 2008, https://doi.org/10.1590/S0001-37652008000200002.

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Track Classification: Precision and Low Noise Signal Generation and Techniques