Hops and Pops in Timing aren't a Child's Game

Quartz resonators have many desirable properties, but they also show something called “hops and pops”. Unlike the fun subjects of Dr. Seuss' children's book, hops and pops in timing set a limit on how precise a frequency one can get from a quartz TCXO. The reasons crystals do this are not completely understood, but they include surface imperfections, contamination, material interfaces, anchor stress, and spurious resonances. With careful design and fabrication, hops and pops can be reduced but not removed.

The size of these sets a limit on how stable a frequency one can derive from a TCXO. There are other limiting factors in crystals, like compensation error, hysteresis, and retrace – but hops and pops cause abrupt frequency shifts, are unpredictable, and are particularly insidious. This means that a quartz oscillator can switch from one to another frequency suddenly. In high precision TCXOs these steps can be tens to hundreds of parts per billion. That may sound small, but many precision applications like GPS and timing references can fail when this happens.

Getting these hops and pops down to even to a few tens of parts per billion requires highly developed processes that only a handful of quartz companies have. High precision TCXOs with minimum hops and pops are rare and expensive, but still often not good enough. I know of one company that has been buying the world’s best quartz TCXOs and then testing and discarding half of them because of hops and pops.

MEMS oscillators don’t show hops and pops. Why is this? First of all, MEMS timing devices use a completely different material system. The resonators are built in silicon, not quartz, and billions of dollars have been invested in silicon to make it the purest and most defect free material in the world. In addition, manufacturers in the space such as SiTime have very clean resonators with contamination-free surfaces , again because of the investment in silicon process and fabrication. Also, in SiTime's case, we have far less external interaction with our resonators as there is no metal on the resonators or material interfaces, and nothing touches them. lastly, In SiTime's case we build complex three dimensional resonators rather than the simple

plates that quartz uses, and therefore have the design freedom to avoid the spurious edge reflections that plague quartz.

In short, when new technologies replace old technologies, they don’t always just reduce the problems with the old technologies – sometimes they eliminate the problems entirely. With MEMS resonators we may be finally done with hops and pops.

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