Exploring the potential of watch crystals

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Watch crystals are amazing devices. Typical 32KHz clock crystals are very stable in frequency if you can keep them close to their turnover temperature. If you can hold the crystal to within 1 degC of the turnover temperature, it is +/-.04 ppm from the frequency at turnover. That is 40ppb - very good. If you can hold .1 degC, it is .0004 ppm. That is .4 ppb. Very expensive. (It goes as the square of the difference in temperature from the turnover temperature - which varies from crystal to crystal.) The turnover temperature is around 25 degC. A typical stability vs temperature chart can be found in this Abracon data sheet [1]. A fuller explanation of what this all means can be found at IDQ Frequency Products [2].

I saw some 40mm on a side thermoelectric heaters/coolers units for $15 at Spark Fun [3]. I thought I might have some fun. Two heat transfer units and a power supply. Plus a honking current amp. Although with a milliwatt or much less for the oscillatorm it might not take a lot of heat pumping to keep the oscillator at a constant temperature near room temperature. And +/- 10°C to 20°C is probably enough range for experiments.

It would be interesting to see if this could be engineered to compete with OCXOs. A VariCap would be included in later experiments for tuning if the initial experiments show promise. There would be 6 wires out to start: 2 wires for power, 2 for a thermistor, and 2 for frequency out. Any suggestions for an oscillator? With the oscillator in the center of the coolers, the material arrangement would be: the oscillator potted with a high thermal conductivity material (any suggestions?). A void surrounding the oscillator. The outer insulation surrounding the void. With another thermistor or temperature sensor in the outer insulation. Possibly another temperature sensor in the vicinity on the outside. I'm open to suggestions. And also possible proof I'm barking up the wrong tree. The idea is to keep the whole package as thin as possible to minimize heat flow to or from the outside - except through the coolers/heaters plus the milliwatt or so of oscillator power. I'm hoping for 3 to 5 uW of oscillator power in practice.

There is a fly in this wondrous unguent. Watch crystals have an aging rate of 5 ppm

the first year (13ppb/day) and 3 ppm (8ppb/day) after the first year. That might be good enough if you are keeping the oscillator disciplined with GPS.

I currently have no method for testing such a rig for stability.

The above is in part a recap of my side of a discussion on a list which prefers you to find it on your own.

M. Simon's e-mail can be found on the sidebar at Space-Time Productions [4].

Engineering is the art of making what you want from what you can get at a profit.

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