

Medium term stability challenges for oscillators used in IEEE 1588v2

Introduction

The local synchronised oscillator is increasingly moving from a phase or frequency locked loop, based on the physical layer to effectively a time locked system via secondary layer protocols. The time lock loop bandwidth can mean that the medium term stability performance of an oscillator is important to the overall system performance. This implies high stability over longer time periods and this imposes particular challenges. Effectively the oscillator's stability performance is now dominated by environmental changes during these extended time periods.

Traditionally oscillators have been measured under idealised conditions of constant temperature. In addition, measurements of frequency variation such as Allan Variance are taken over seconds, and variations due to oscillator ageing are characterised over months and years. So the oscillator stability over the medium term (minutes to hours) is poorly characterised for these effects and they have either not been accounted for at all, or the stability under these conditions is covered indirectly by other oscillator/system specifications.

Historically there have been only two "oscillator / lock bandwidth" combinations, namely Stratum 3 and Stratum 3E. For Stratum 3 oscillators, the effect of variable temperature on TDEV and MTIE was likely to be minimal since the oscillator has a lock bandwidth in the 1 to 10 Hz range and so any slow changes in frequency due to, for example, temperature fluctuations were filtered out. Conversely, with the Stratum 3E oscillator, because of the very high stability required for the variable temperature holdover requirement (± 5 ppb), small changes in temperature would not affect the TDEV and MTIE even with a 1 millihertz (mHz) lock bandwidth.

However, we now have a new set of requirements for the local oscillator. It must operate with lock bandwidths in the 10 mHz to 0.1 mHz region to filter the inherent low frequency wander; traditionally this requirement would have been met with a Stratum 3E OCXO. But not all system nodes will require the Stratum 3E holdover requirements, so it is not necessary to have a full Stratum 3E oscillator. A lower specification, lower cost oscillator may still provide the wander filtering necessary to meet the TDEV / MTIE requirements. It is important to note there are no changes in the holdover behaviour requirements;

it is only the locked behaviour which has changed. The challenge for the system designer is to assess which oscillator will work at which lock bandwidth and still meet the implied TDEV/MTIE requirements. This is where Rakon can help.

Why Rakon for time lock loop applications?

At Rakon we have the expertise to help determine the best oscillator solution for our customers' systems requirements. Oscillator solutions require knowledge of the differential in frequency versus the differential in temperature. Full characterisation is determined by defining the temperature ramp and measurement rate and a detailed analysis over the characterisation time period. Rakon has characterised various types of oscillators under changing environmental conditions for the loop time periods relevant to IEEE 1588v2.

Rakon oscillators for time lock loop applications

Pluto SMD TCXOs

Rakon's flagship TCXO, based on our in-house designed Pluto ASIC, has many proprietary features which help with addressing medium term stability issues. Our patented pre-distort circuitry gives a class-leading linearity of better than 0.1% and the rate of change of frequency with control voltage is constant over the whole operating temperature range. The critical $\Delta f/\Delta T$ is minimised and kept constant and predictable through various techniques including: reducing high order error curves via the linear pulling, screening for minor crystal perturbations over the entire temperature range and protecting the oscillator from thermal gradients and airflow. These techniques lead to a TCXO with excellent slope and wander performance, over the entire operating temperature range.

Pluto

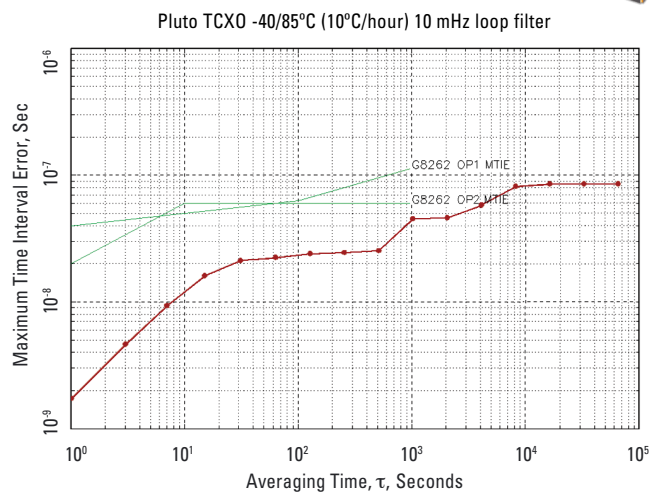


Figure 1. Pluto at 10 mHz lock bandwidth

Mercury



Rakon's Mercury TC-OCXO offers even higher levels of performance than TCXOs, but without the large size, high power consumption and cost penalty of traditional OCXOs. Mercury uses the most recent of Rakon's in-house designed ASICs, giving all the functionality and performance of an OCXO on a single piece of silicon. This allows the production of the smallest OCXO-type product available, with a footprint of only 9 mm x 7 mm and ensures cost minimisation with no compromise on performance. Mercury's on-chip features give a typical frequency versus temperature performance of better than ± 20 ppb over -40 to 85°C and a typical slope performance of ≤ 2 ppb/°C.

Mercury TC-OCXO -40/85°C (10°C/hour) 3 mHz loop filter

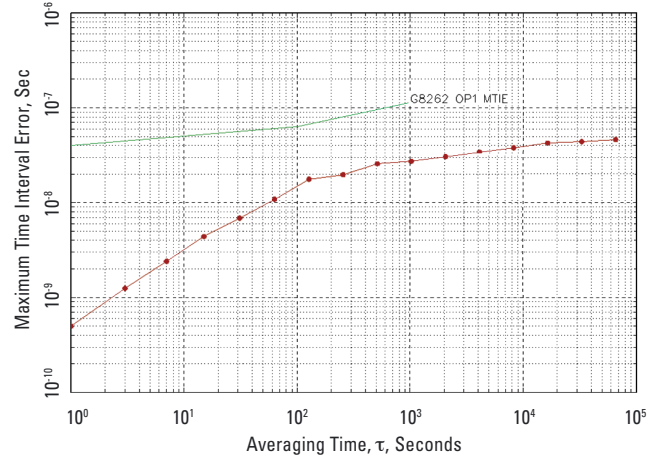


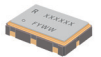
Figure 2. Mercury at 3 mHz lock bandwidth

OCXOs



For the very best stability performance, Rakon's traditional OCXOs using ultra-high stability 3rd overtone SC-cut crystals are available. Designed for bandwidths of 1mHz and below and for very tight holdover performance, these products are designed for the most stringent system requirements.

VCXOs



Rakon's VCXOs are available with single, dual or quad selectable outputs. The selectable output feature enables designers to support multiple frequency formats (from 10 MHz to 1.5 GHz) using a single component, while still enabling 0.5 ps - 1 ps RMS jitter performance. The reduced part count simplifies circuit design, reducing overall system size and cost. Available in 14 mm x 9 mm, 7 mm x 5 mm or 5 mm x 3.2 mm package sizes.

ROX2522S4 -40/85°C (10°C/hour) 1 mHz loop filter

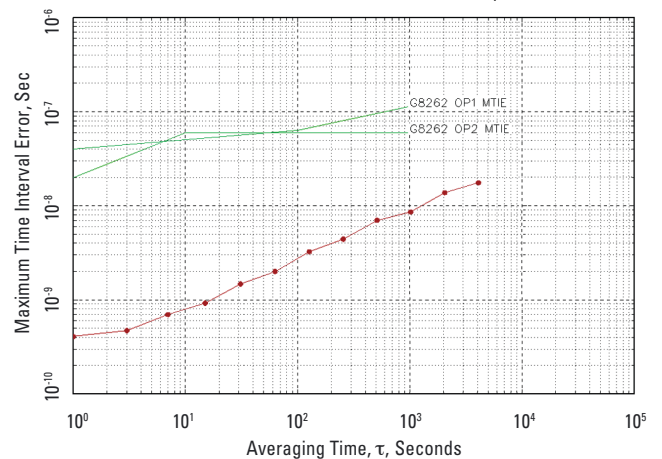


Figure 3. ROX2522S4 at 1 mHz bandwidth

Why Rakon?

Whatever your system requirements, Rakon has the products to address them. With detailed correlation between the oscillator and system test, together we can achieve the correct balance between oscillator cost and performance.

Product		Lock bandwidth
TCXO	Pluto	Down to 10 mHz
TC-OCXO	Mercury	Down to 3 mHz
OCXO	ROX2522S4	Down to 1 mHz
OCXO	ROX3627T3	Down to 0.3 mHz
OCXO	ROX5142T2	Down to 0.1 mHz

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