A P P L I C A T I O N   N O T E

Oscillator Selection *Guide*

All EndRun products can be configured with optional disciplined oscillators. This application note will help you decide which of these oscillators is right for you. The standard disciplined oscillator in all products is a temperature-compensated quartz oscillator (TCXO). Since TCXOs are used in high-volume consumer products such as cellular telephones, prices have fallen precipitously over the years and they now offer a very high performance-to-cost ratio. They are generally adequate for most computer network synchronization applications and low-end time and frequency applications. For more demanding requirements, EndRun offers a range of oscillator upgrades that include the finest quality oven-controlled quartz oscillators (OCXO) available. These are manufactured by EndRun Technologies for exclusive use in our rackmount products.

An oscillator upgrade is indicated when your application requires either improved holdover accuracy while not locked to the synchronization signal, or improved short-term stability whether locked to the synchronization signal or not. We offer options ranging from a low-cost OCXO in a miniature, dual-inline package (DIP-OCXO) to the state-of-the-art in compact Rubidium vapor atomic frequency standards.

Holdover Accuracy and Short-Term Stability

Disciplined means that the oscillator's frequency is being controlled by the internal microprocessor based on measurements of its frequency relative to the received CDMA or GPS signal. Should reception of the CDMA or GPS signal be interrupted, the accuracy of the unit degrades gracefully over time because it *flywheels* on the disciplined oscillator.

Holdover accuracy refers to the time error that a transfer standard accumulates, when operating without its reference signal, relative to an absolute time reference standard. A typical observation interval for holdover accuracy is one day. For example, the Medium-Stability OCXO will accumulate 100 microseconds of error within the first 24 hours after the reference signal (GPS or CDMA) is lost.

Short-term stability refers to the movement of the zero crossings of a signal relative to those of a reference frequency standard, measured over observation intervals that are typically shorter than one second. When measured in units of time, in a broad bandwidth, it is commonly called jitter. When measured in units of phase, in a 1 Hz bandwidth centered at specific frequencies, it is called phase noise.

Computer Networks

In networked computer synchronization applications, the short-term stability of the oscillator in the NTP server is usually unimportant because the asymmetry of the delays in the network paths is the dominant contributor to jitter in the NTP timestamps. For these applications, the oscillator upgrade decision should be based on the desired holdover behavior during an expected period of signal loss. The holdover period is the length of time that the NTP Server will continue to serve Stratum 1 time after signal loss. In CDMA applications, signal loss could be due to marginal, sporadic CDMA reception or base station outages. For GPS applications, sub-optimal GPS antenna installations in windows, or on rooftops in urban canyons could create similar signal outages. Antenna damage from vandalism or lightning could also interrupt GPS reception.

Wired Telecommunications Networks

Both short-term stability and holdover accuracy are critical in T1/E1 wired telecommunications network synchronization applications. Stratum I clocks for digital switches require moderately low levels of jitter and wander because propagation of the timing signal through the network can have a phase error multiplication effect. If the stability of the timing signal at the source were not good enough, downstream network elements that depend upon a recovered version of this clock for their timing would experience "whip crack" phase transients large enough to cause sporadic buffer overflows. By starting with a stable source, a usable clock can be recovered even after multiple hops. Holdover accuracy is important because a persistent frequency mismatch at the two ends of a T1/E1 link ultimately causes persistent buffer overruns and data loss.

Wireless Telecommunications

An example of an application requiring high-performance short-term stability is carrier frequency control in phase shift keyed (PSK), spread spectrum wireless telecommunications. In these applications a microwave frequency carrier is synthesized via frequency multiplication of the 10 MHz reference oscillator. When the reference frequency is multiplied, its phase noise is also multiplied. If the short-term stability of the 10 MHz reference is too high, then excessive phase noise at the microwave carrier frequency will result. This will degrade the signal-to-noise ratio of the recovered PSK data modulation at the receiver.

OCXO Options

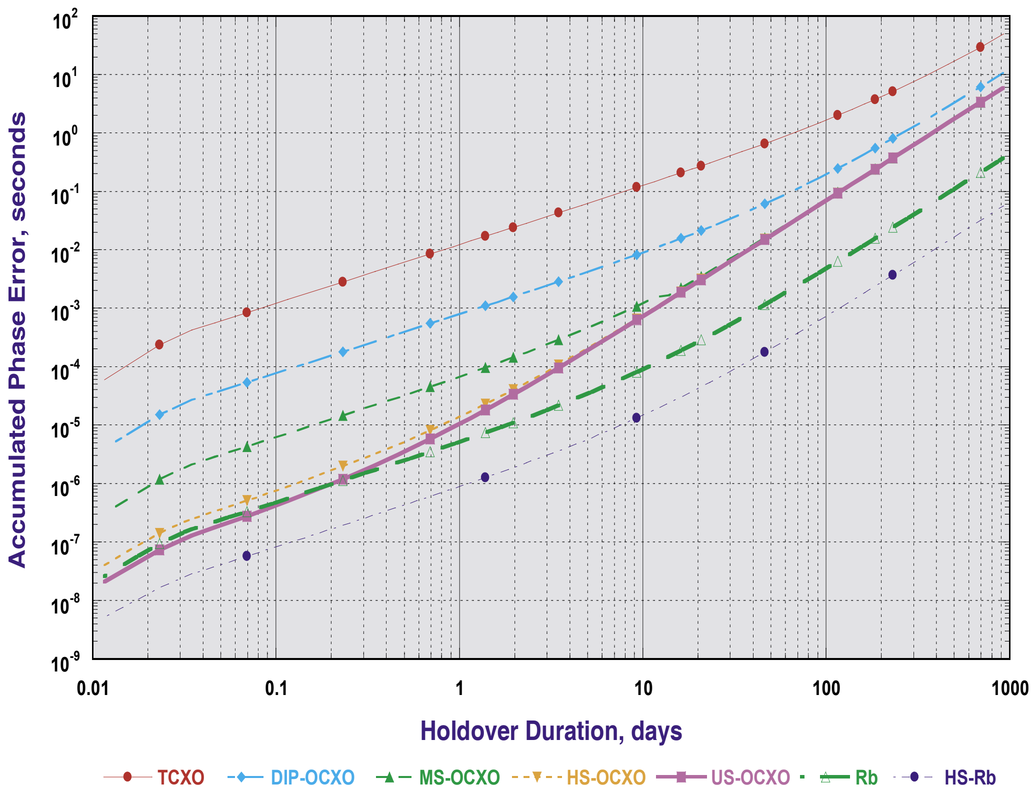
The ultra-miniature DIP-OCXO option offers more than an order-of-magnitude of improvement in temperature stability relative to the standard TCXO along with improved ageing. It is available as an option for the Præcis Ce OEM circuit board and for the Præcis Cf and Præcis Ct (desktop) products. The DIP-OCXO provides the simplest, lowest cost upgrade for holdover enhancement in computer synchronization applications.

Three OCXO options are available in the rackmount products: a medium-stability OCXO (MS-OCXO), a high-stability OCXO (HS-OCXO) and an ultra-stable OCXO (US-OCXO). All of these options are high-performance oscillators that use SC-cut crystals for fast warm-up, low ageing rate and reduced sensitivity to ambient temperature fluctuations. Long-term ageing performance is at the state-of-the-art. Their differences in performance are in temperature stability and close-in phase noise.

The MS-OCXO provides an order-of-magnitude improvement in temperature stability relative to the DIP-OCXO option and a further reduction in ageing. Since it has very good phase noise characteristics, it can support sinewave outputs with high spectral purity. The HS-OCXO offers a fourfold improvement in temperature stability and significantly better phase noise performance than the MS-OCXO at all offset frequencies.

Holdover Performance - Oscillator Options

Typical, 5° C Max Delta, 7.5° C/Hr Max SlewRate



The ultimate in OCXO performance is provided by our US-OCXO option. This unit halves the temperature coefficient relative to the HS-OCXO option to a very respectable 5 parts in 10^{10}. With outstanding close-in phase noise performance, it can also support sinewave outputs with very high spectral purity, and provides lab-standard class Allan deviation performance of 6 parts in 10^{13} for 1 second observation intervals. Performance at this level in a 1U chassis has previously been unobtainable, as oscillators having comparable stability are typically very large, power-hungry units that cannot operate to +70°C ambient. Examples of such oscillators are the Oscilloquartz BVA series, which operates to +60°C, or the Symmetricom 1000B, which operates to +55°C. Neither of these can be packaged into a 1U chassis or operate inside of a chassis at an external ambient temperature of +50°C. These EndRun OCXOs can easily operate to +70°C. This is the worst case interior chassis temperature of our 1U rackmount products operating at +50°C ambient temperature–with no fans.

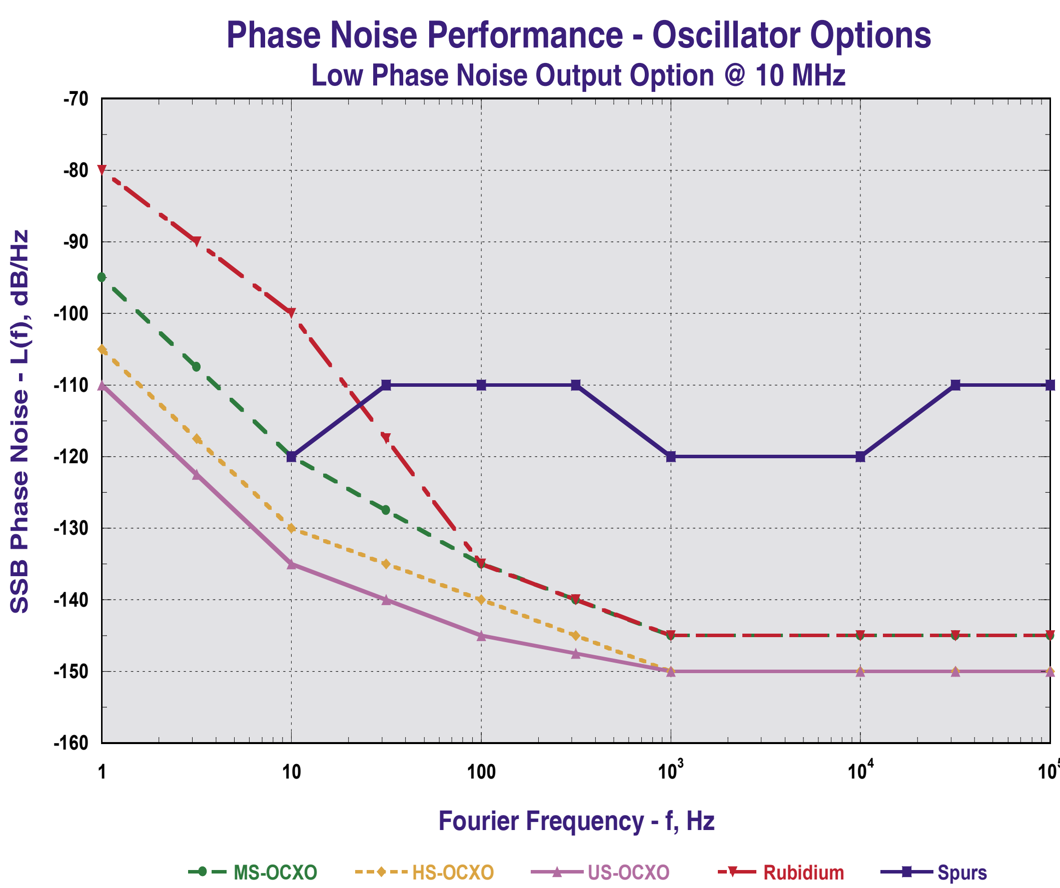
Compact Rubidium Options

Phase noise and short-term stability of Rubidium vapor atomic frequency standards are inferior to that of quality OCXOs, so in many situations the HS-OCXO or US-OCXO is a better choice, offering comparable holdover performance for periods of a few hours, superior short-term stability and much lower cost. But if you need the ultimate in long-term holdover performance and medium-term stability, a compact Rubidium option is the right choice. We offer two Rubidium options: standard and high-stability.

Relative to the HS-OCXO, the temperature stability of the standard Rubidium option is improved only slightly, but its long-term ageing is reduced by more than an order of magnitude. This unit is an excellent choice for mission critical computer network synchronization applications and general purpose precision time and frequency references.

We offer the high-stability HS-Rubidium option for the ultimate in temperature stability and long-term ageing performance . This unit is ideal in portable applications where intermittent connection to the antenna is the normal mode of operation and temperature variations are expected. Precision metrology and calibration applications can benefit as well from the excellent stability it provides over a wide range of observation intervals.

Until recently Rubidium has been a very expensive option, typically reserved for military and highest stratum commercial applications. The continuing expansion of mobile telecommunications infrastructure, which requires at least one of these units at each of tens of thousands of base stations, has created the large market needed to attract multiple vendors and stimulate price and performance competition. These modern units are much smaller and require less power than previous ones, making it possible for us to offer these options in an economical 1U high chassis.



Disciplined Oscillator Options

The following table summarizes the performance of the oscillator options. For detailed application information or special requirements, please contact sales@endruntechnologies.com or call our toll-free number: 1-877-749-3878.

Oscillator Options – Summary Performance Data

	TCXO	DIP-OCXO	MS-OCXO	HS-OCXO	US-OCXO	Rubidium	HS-Rubidium
Product Type	All	Ce, Cf, Ct	Rackmount	Rackmount	Rackmount	Rackmount	Rackmount
Temp Stability	$+/-2.5 \times 10^{-6}$	$+/-7.5 \times 10^{-8}$	4×10^{-9}	1×10^{-9}	5×10^{-10}	1×10^{-9}	1×10^{-10}
Temp. Range ˚C	-20 to +70	-20 to +70	0 to +70	0 to +70	0 to +70	-20 to +70	-20 to +70
Ageing Rate/Year	1×10^{-6}	1×10^{-7}	3×10^{-8}	3×10^{-8}	3×10^{-8}	1×10^{-9}	5×10^{-10}
Allan Deviation @ 1 sec	1×10^{-9}	5×10^{-10}	3×10^{-12}	1×10^{-12}	6×10^{-13}	2×10^{-11}	2×10^{-11}
10 MHz Phase Noise dBc/Hz:							
1 Hz	-70	N/A	-95	-105	-110	-80	-80
10 Hz	-100	N/A	-120	-130	-135	-100	-100
100 Hz	-125	N/A	-135	-140	-145	-135	-135
1 KHz	-135	N/A	-145	-150	-150	-145	-145
10 KHz	-140	N/A	-145	-150	-150	-145	-145
100 KHz	-145	N/A	-145	-150	-150	-145	-145
5 MHz Phase Noise dBc/Hz:							
1 Hz	N/A	N/A	-100	-110	-115	-80	-80
10 Hz	N/A	N/A	-125	-135	-140	-100	-100
100 Hz	N/A	N/A	-140	-145	-150	-135	-135
1 KHz	N/A	N/A	-150	-155	-155	-145	-145
10 KHz	N/A	N/A	-150	-155	-155	-145	-145
100 KHz	N/A	N/A	-150	-155	-155	-145	-145

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