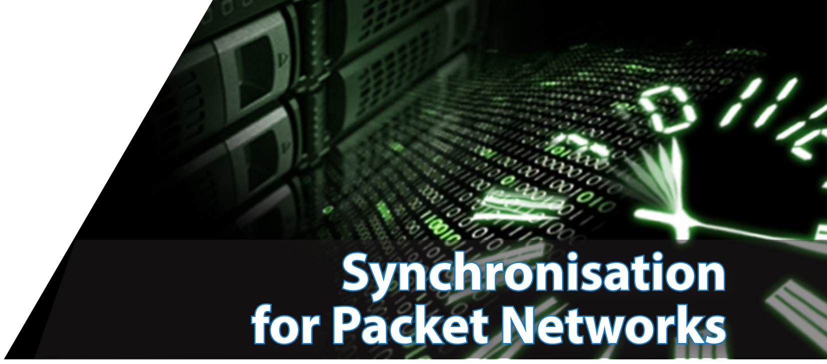
rakon



Synchronisation for Packet Networks

Introduction

Packet based synchronisation is finding its importance in many applications because of its abilities to provide frequency, phase and time to the end applications. Traditional physical layer synchronisation methods were limited to frequency synchronisation whereas protocol based synchronisation can achieve frequency, phase and time synchronisation. The application areas are including but not limited to Telecommunication Networks, Cellular Mobile Systems, Access Networks like Cable, DSL and Fibre, Power Grid systems, Enterprise Networks, Video Broadcast Systems.

One of the key areas where packet based synchronisation is being deployed is the cellular mobile networks, particularly with the evolution of 5G networks. 5G exploits the spectral efficiency to the full when the systems are supporting TDD mode, where phase alignment between base stations is a key requirement. Even in FDD mode, advanced features like CA, JT, eMBMS and CoMP are possible with phase alignment between stations. Location Based Service applications are only possible with this phase alignment. Traditionally, phase alignment has solely relied on GNSS based synchronisation, however, GNSS vulnerabilities and geographical limitations challenges this reliance. Overcoming these limitations, Packet-based synchronisation becomes an alternative or assistive technology for GNSS synchronisation.

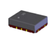
Choosing the Optimal Oscillator for Packet Based Application

Telecom synchronisation has moved onto packet transport based synchronisation technologies. There are a number of clock types defined by Standards bodies which depend on the type of networks (No on-path timing support, full on-path timing support and partial timing support) network elements (master, slave, and boundary) and clock types (filtered or transparent). Standards defined clock types also depend on whether they have for physical layer clocking support (with or without SyncE) and assistance (being a backup for a GNSS reference). These defined clock types can support either frequency only, or time, phase and frequency together. Often, one type of equipment is required to support many clocking options with software configuration.

All these clocks need a local reference time source to support the implementation of the servos that filters reference sources. The filter bandwidths range from <1 mHz (partial timing supported clocks with phase synchronisation) to all the way 10 Hz (EEC option 1). For a specific output wander generation performance under variable temperature, the lower the bandwidth of the servo system, the better oscillator with temperature stabilities and sensitivities are required.

Oscillator requirements are determined the following key criteria. Free-run accuracy, wander generation, holdover and short-term impairments and output jitter and wander requirements. Free-run accuracy is determined by the life time accuracy of the oscillator. Wander generation is a combined effect of the PLL and oscillator capabilities to be within the desired output error for a specific bandwidth. Furthermore, temperature stabilities and ageing contribute towards the target holdover of a given packet clock. A **Stratum 3E+**[1] OCXO handle a superset of standards requirements.

Packet Network Synchronisation Solutions

Oscillators		Stability over -40 / 85°C (ppb)	Ageing (ppm/year)	Phase Holdover (1.5 µs)	Supported Bandwidth (mHz)
Pluto+™ (5x3, 7x5)		±100 ppb	< ±1	–	100
Neptune™ (5x3, 7x5)		±50 ppb	< ±1	–	100
Mercury+™ (9x7)		±10 ppb	< ±1	15 min	3
Mercury+™ (14x9)		±5 ppb	< ±1	1 hour	1
ROX S4 (25x22, 25x25)		±5 ppb	≤ ±0.5	4 hours	1
ROX S3 (25x22)		±1 ppb	≤ ±0.3	8 hours	0.3

At the same time, applications are driving the node error to be lowest as possible (proposed node error values of 5ns) to support upcoming deployment scenarios such as the front-haul network of 5G cellular networks. Such applications demand still higher stability clock references.

[1] The **Stratum 3E+**'s performance is better than Strum 3E.

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Medium Term Stability Challenges for Oscillators used in IEEE 1588

In packet-based synchronisation implementations, the local synchronised oscillator is moving from a physical layer-based phase or frequency locked loop, to a time locked system via secondary layer protocols.

Oscillators present themselves as high pass filters in the control loop, thus smaller loop bandwidths can mean that the medium- term stability performance of an oscillator is important to the overall system performance. Effectively the oscillator's stability performance is now dominated by environmental changes during these 'medium-term' time periods.

The oscillator stability over the medium-term (minutes to hours) is either poorly characterised or has not been accounted for at all, since 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.

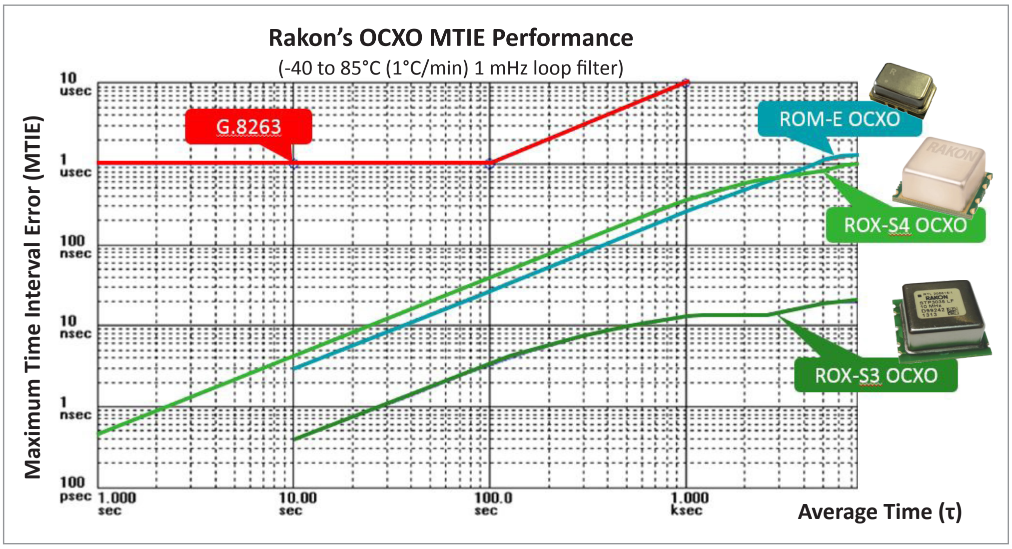
However, packet based implementations introduce other loop bandwidths depending on the network scenario and thus stability at each loop bandwidth becomes important.

The non-stationary nature of Packet Delay Variation (PDV) imposes new requirements for the local oscillator. Loops operate with lock bandwidths in the 10 to 0.1 mHz region (time constant 10000 s) to filter the wander introduced by PDV. System specifications for frequency stability, holdover requirements for frequency and if required, phase error, will determine the requirements for oscillators.

With better than Stratum 3E oscillators (1 ppb temperature stability and 0.2 ppb/day ageing) very low bandwidths in the range of 0.1 mHz could be supported for very low wander generation requirements. Such devices also offer good medium term holdover (8 - 12 hours with 20°C temperture variation) offering cost-effective performance.

IEEE 1588

MTIE Performance for Rakon's OCXOs



Rakon's ASIC based and conventional OCXOs are designed for bandwidths of 1 mHz down to 0.1 mHz and below and for very tight holdover performance. These products are designed for the most stringent system requirements. The Mercury+™ ASICs have made possible the smallest (14 x 9 mm and 9 x 7 mm), lowest power consuming (350 mW) and most reliable (FIT of <50) OCXOs in the industry, with temperature stabilities between ±5 to ±20 ppb. LTE-A and LTE-TDD Small Cell technologies require tight phase accuracies (±1.5 µs) and applications like Location Based Services (LBS) are driving accuracy requirements to even more stringent values (~500 ns). ROX2522S4 devices provides the performance of traditional Stratum 3E discrete OCXO performances. Footprint compatible ROX2522S3 products improve the performance one magnitude, introducing 1 ppb temperature stability and 0.2 ppb/day ageing performance.

For systems that do not require holdover, oscillators that are compliant to G.8263 specifications may still provide the wander filtering necessary to meet the TDEV/MTIE requirements. 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 in locked conditions. System designers must also assess which oscillators are needed to provide adequate holdover for the specified duration of time required by the application. This is where Rakon can help!