



Introduction

The Small Cell market is gearing up to support the need for greater coverage and ever increasing mobile broadband traffic. With respect to synchronisation requirements and depending on the timing architecture, the specifications for 3GPP air interface standards and relevant network interface standards must be met. High quality synchronisation is critical for the operation of the wireless access points over various operating conditions and over the life time of the equipment. While the technical requirements for Small Cells – the miniature mobile base station – remain identical to that of a macro base station, the cost structure of Small Cell equipment must be highly competitive.

Rakon – Best for Service Providers, Best for Consumers

Rakon’s OCXOs and Ultra Stable TCXOs meet the frequency and timing requirements of Small Cell designers. Rakon oscillators independently maintain time and frequency accuracy for extended periods, providing better service availability at the network edge. Many Small Cell designs leverage PoE (Power over Ethernet) technology for the system’s power supply – low power (20 mW) TCXOs contribute little to the overall power budget and are widely used.

Pluto+™ Ultra Stable TCXO: Rakon’s world class TCXOs are powered by in-house developed Pluto+™ technology, providing tight temperature stability ($\pm 50 - 100$ ppb) enabling excellent frequency holdover. The very low phase noise performance (20 MHz, -130 dBc/Hz @100 Hz) ensures higher modulation rates with very little contribution to the Error Vector Magnitude (EVM). Rakon’s advanced manufacturing facility uses high resolution temperature testing to screen crystals for activity dips. These test systems help produce TCXOs with excellent temperature sensitivity (as low as 10 ppb/°C) which is key in low loop bandwidth packet-based synchronisation applications like NTP and PTP.

A key differentiator of Rakon’s TCXOs is their patented tilt compensation technology. This keeps the TCXOs within frequency stability specification regardless of voltage control adjustments which are required for ageing compensation, and thus, long term operation of the equipment is guaranteed. The superior performance of Rakon’s Pluto+™ based products enables development of the best price/performance, timing and synchronisation solutions for Small Cells.

Mercury+™ IC OXCO: Rakon’s Mercury™ and Mercury+™ based 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 30) OCXOs in the industry, with temperature stabilities between ± 5 to ± 50 ppb. The LTE-A and LTE-TDD Small Cells technologies require tight phase accuracies (1.5 μ s) and applications like Location Based Services are driving the accuracy requirements to even more stringent values (~ 500 ns). Mercury+™ OCXOs enable Small Cell applications that require short phase holdover (15 minutes to 1 hour under limited ambient temperature excursions) but with much smaller size and lower power consumption than traditional OCXOs.

Frequency and Time Accuracy Requirement

Small Cell Class	Microcells (Rural)	Metrocells (Urban)	Picocells (Enterprise)	Femtocells (Home)
Air Interface	± 50 ppb	± 50 ppb	± 100 ppb	± 250 ppb
Time Accuracy (LTE-TDD)	≤ 1.5 μ s	≤ 1.5 μ s	≤ 1.5 μ s	≤ 1.5 μ s
Network Interface (suggested)	± 16 ppb	± 32 ppb	± 32 ppb	± 100 ppb
Rakon’s OXCO	[Progressive bar chart showing performance across cell classes]			
Rakon’s TCXO	[Progressive bar chart showing performance across cell classes]			

Why Rakon for Small Cells?

For the system designer, Rakon’s oscillators offer ease of integration and guaranteed consistency in performance, through:

- Tight control of electrical parameters through high resolution testing in manufacture
- A predictable, linear tuning range
- Guaranteed performance for the life of the equipment

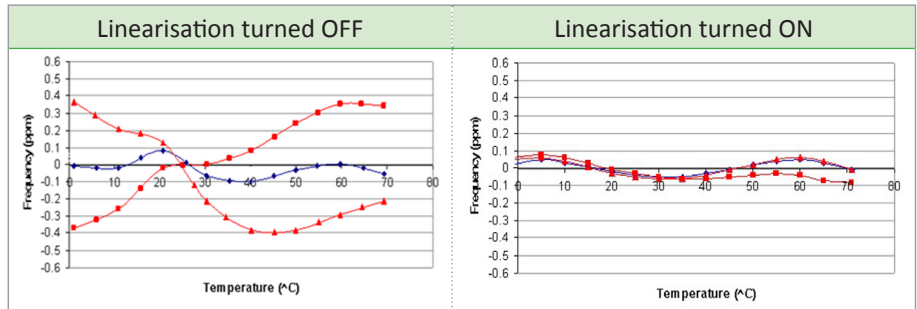


Small Cells



Impact of Linearisation on Small Cell Designs

Rakon's TCXOs are fitted with a patented 3rd order compensation polynomial which will pre-distort the control signal to maintain the linearity across all control voltages and temperatures. As shown in the figure on the right hand side, the oscillator performs within specifications at extremes of the voltage control across the temperature range. This is a key differentiator between Rakon TCXOs and general purpose TCXOs.



High Resolution Frequency Stability Over Temperature Testing to Avoid Activity Dips

Rakon employs fine resolution temperature testing to identify and screen out any oscillators that display activity dips. Activity dips are unwanted sharp variations in crystal resonator behaviour. These could be as a result of non-optimised crystal or blank design and manufacturing processes. Rakon designs, manufactures and maintains its own in-house designed test chambers for its oscillators. With a long history of testing millions of consumer grade TCXO devices per week, Rakon has the experience and expertise needed to mass produce higher end, ultra stable devices for Small Cell market.

For example:

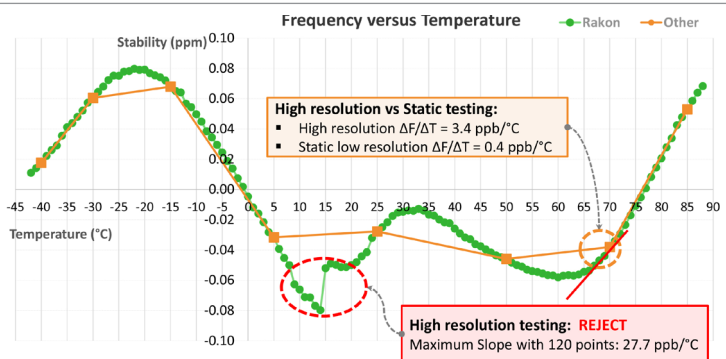
A TCXO with Frequency slope $(\Delta F/\Delta T)^* = \pm 20$ ppb/°C.
 $\Delta F/\Delta T^*$: ΔF – Frequency drift(pps/s) , ΔT – Temperature change (°C/s).

> Low resolution testing: FALSE PASS

8 point testing passes the unit, as it is only able to detect the maximum slope of 6 ppb/°C.

> High resolution testing: TRUE REJECT

Rakon's 120 point high resolution testing finds any sudden frequency jumps, and detects the worst slope of 27.7 ppb/°C.



Rakon Oscillators for Small Cells

Rakon offers the broadest range of oscillators optimised for the Small Cell market. As an early member of the Small Cell Forum, Rakon has been an integral part of the Small Cell ecosystem, helping enable the synchronisation technology for Small Cells. With a full range of TCXOs and OCXOs, Rakon is able to provide synchronisation solutions for a wide range of customer requirements. The following table summarises the solutions offered by Rakon:

Parameter	Ultra Stable TCXO (Pluto+™)	IC OCXO (Mercury™)	IC OCXO (Mercury+™)	Discrete OCXO (Conventional)	Discrete OCXO (Conventional)
Model (Package size)	RPT5032NR (5.0 x 3.2 mm) RPT7050/5032P (5.0 x 3.2 mm) (7.0 x 5.0 mm)	RFPO40 (9.7 x 7.5 mm) RFPO50 (14.6 x 9.7 mm)	ROM1490P (14.6 x 9.7 mm)	ROX1409S (14.3 x 9.3 mm)	ROX2522S (25.4 x 22.0 mm)
Stability	±50 ppb (0 to 70°C) ±100 ppb (-40 to 85°C)	±25 ppb (0 to 70°C) ±50 ppb (-40 to 85°C)	±5 ppb (0 to 70°C) ±25 ppb (-40 to 85°C)	±10 ppb (-40 to 85°C)	±5 ppb (-40 to 85°C)
Frequency Holdover (100 ppb)	1 week	>1 month	>1 month	>3 months	>6 months
Time Holdover (±1.5 μs @ 20°C window, 1 °C/hour variation)	–	0.5 hour	0.5 hour	3 hours	4 hours
Power	20 mW	400 mW	440 mW	550 mW	1.5 W

