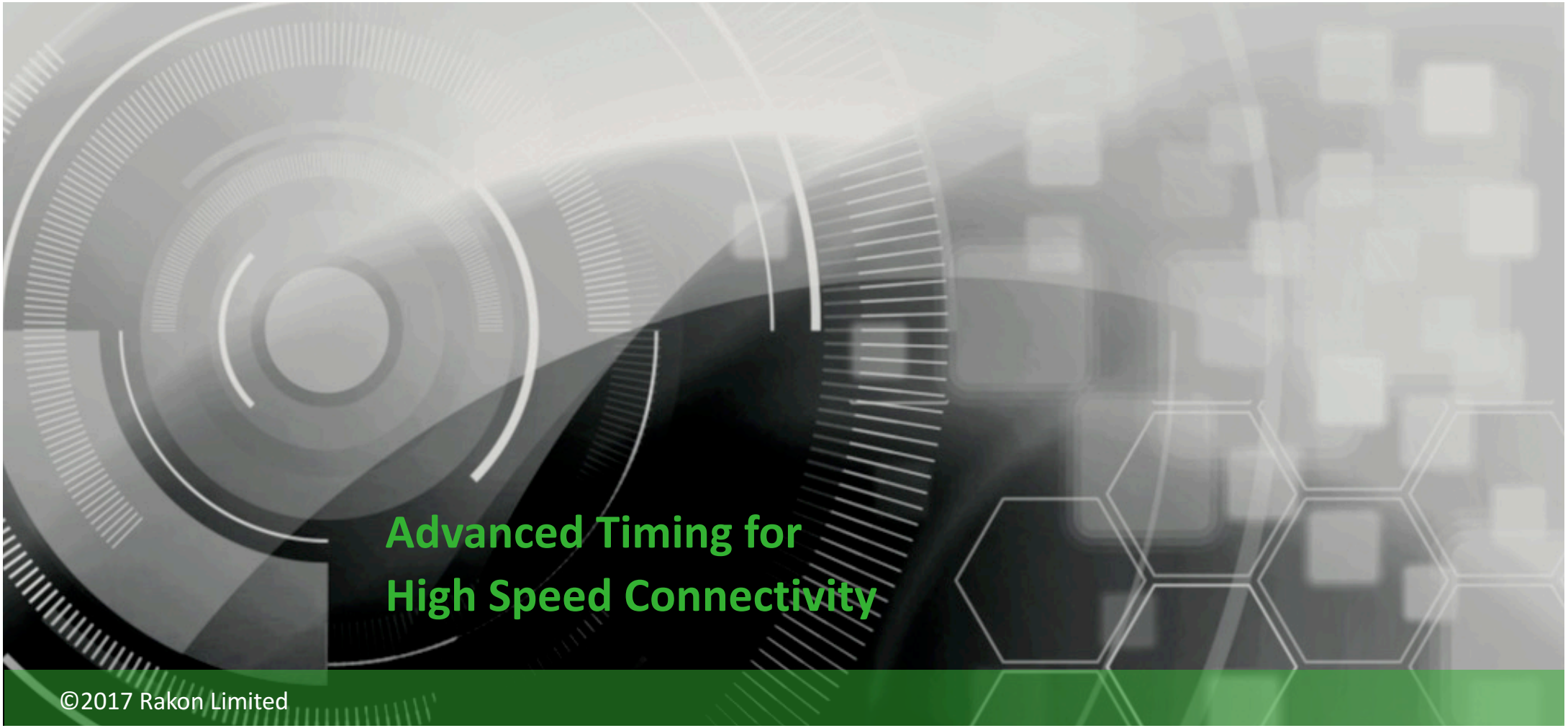
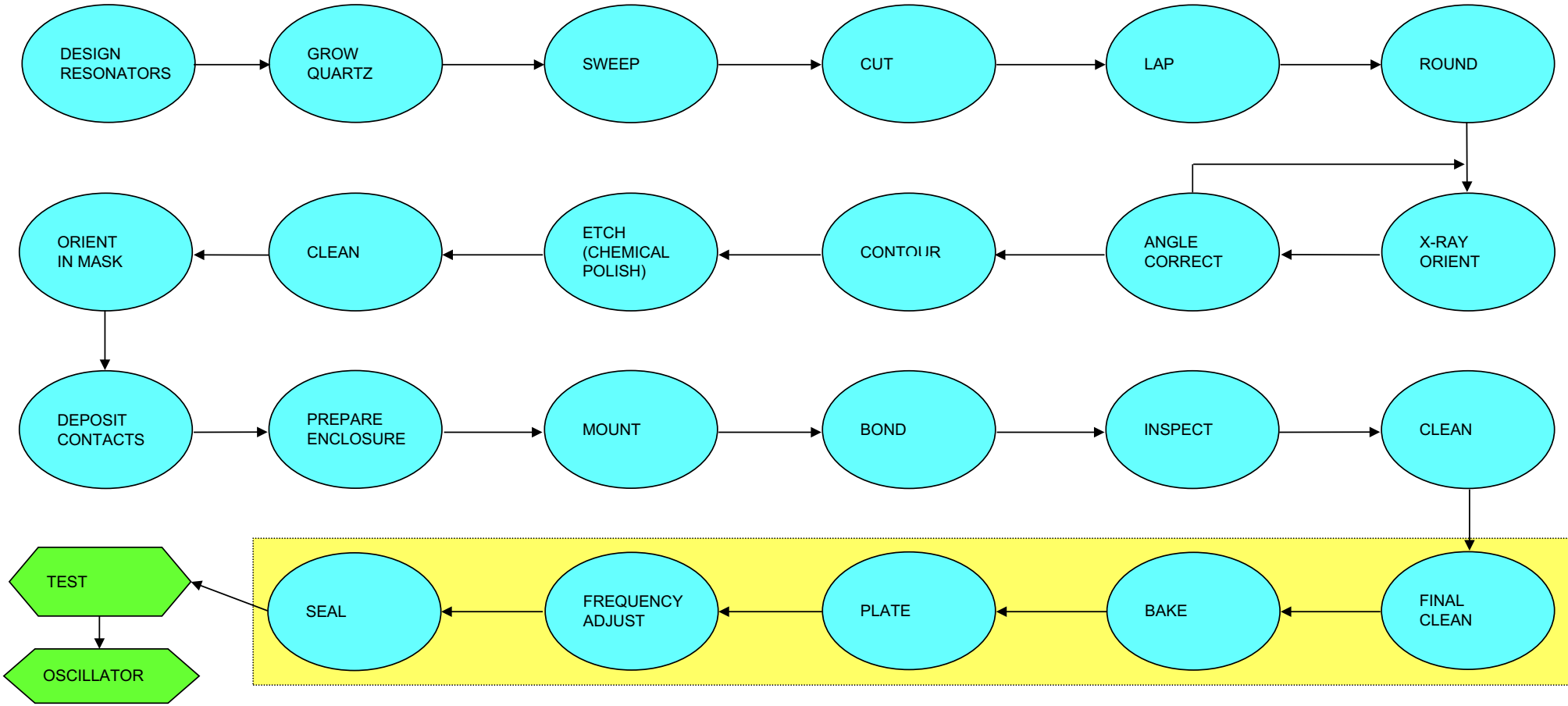
Advancements in Quartz Based Oscillator Technologies



Topics

- Background
- Resonator Improvements
- Profile, Power & Performance
- Atomic clock stabilities with Quartz

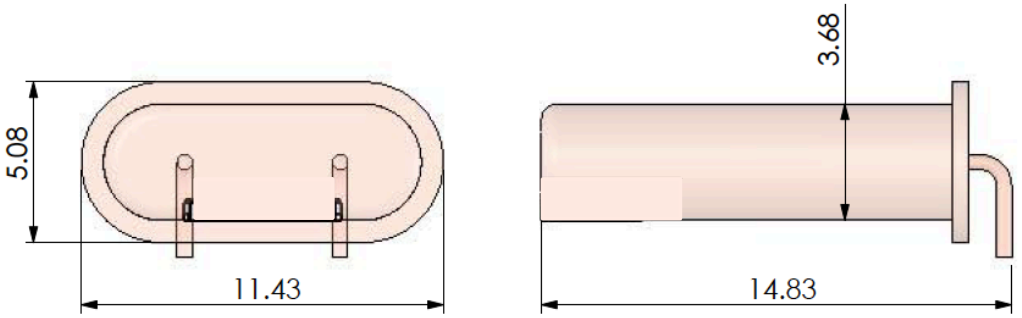
Resonator Fabrication



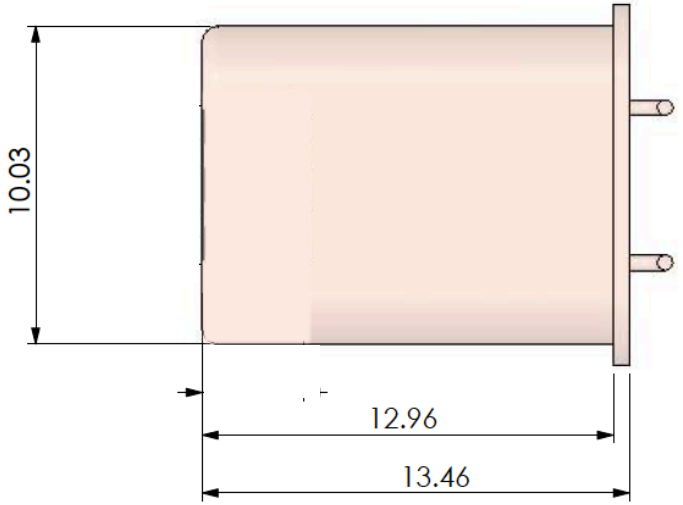
Low Profile Crystals

SC vs Stripped SC

- HC43 vs Strip



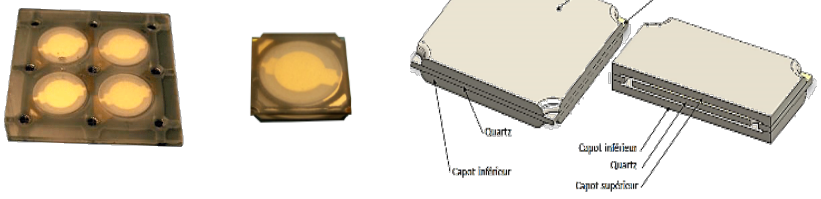
- Key Advantages in :
  - Size
  - Power
  - Performance
  - Higher reliability
  - Automated process
  - Low component OCXOs



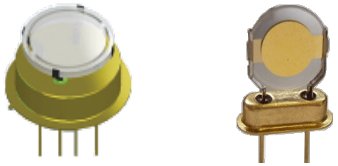
Low Profile Crystals – 2

Quartz Crystal ½ Package Size

WAFER LEVEL MANUFACTURING

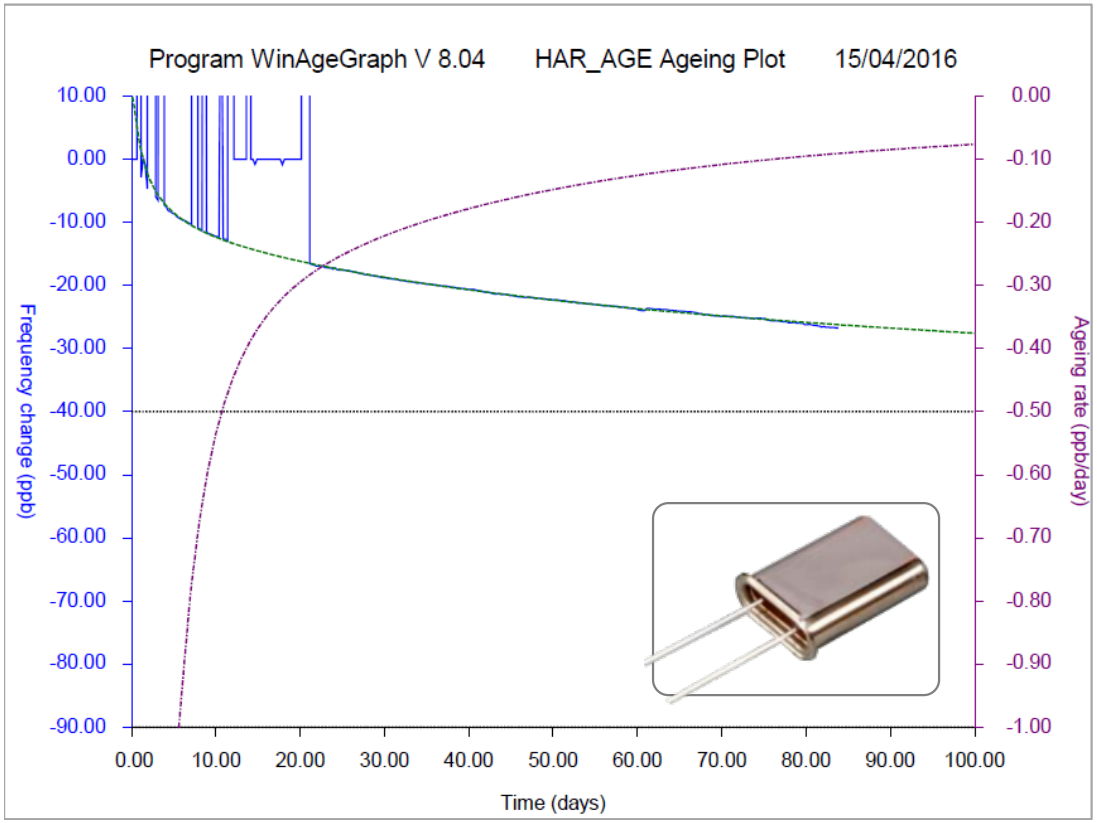


STRESS RELIEF FROM MOUNTING

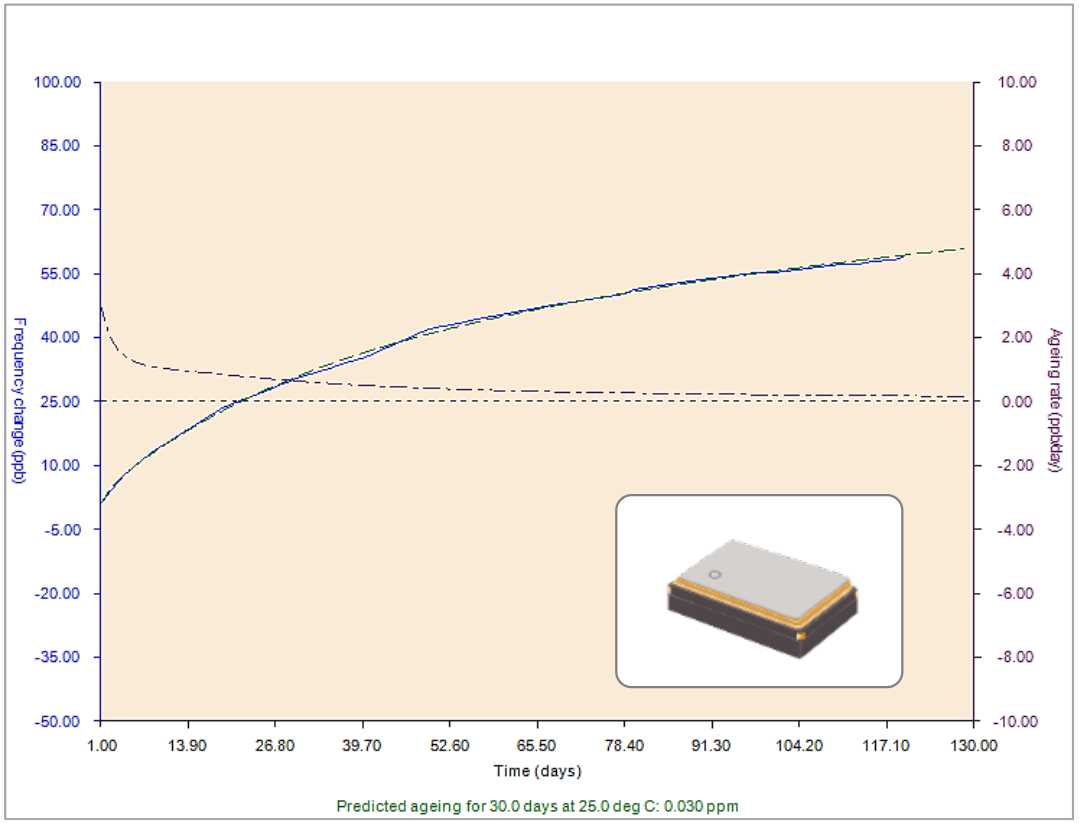


Low Ageing Crystals

HC-43 3OT SC-Cut: <0.5 ppb/day @ 10 days

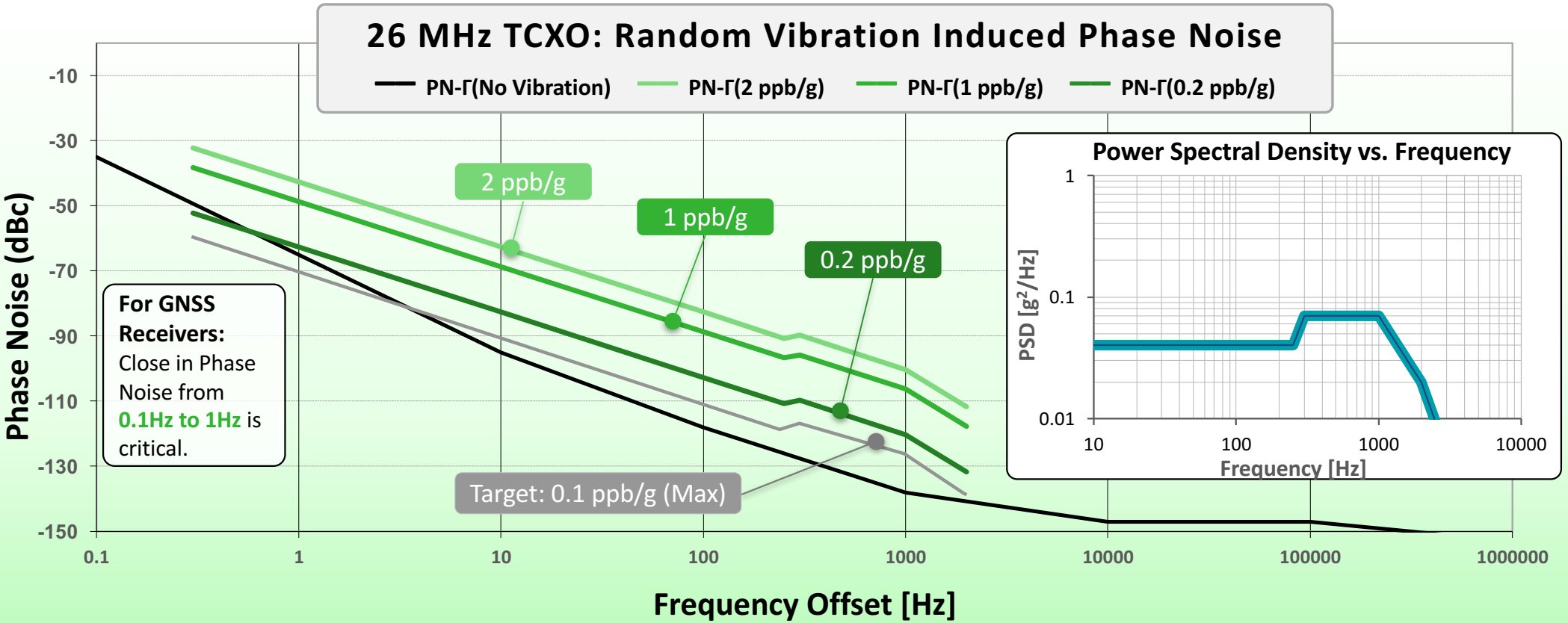


Strip Crystal: <0.5 ppb/day @ ~30 days



Phase Noise vs. *g*-Sensitivity

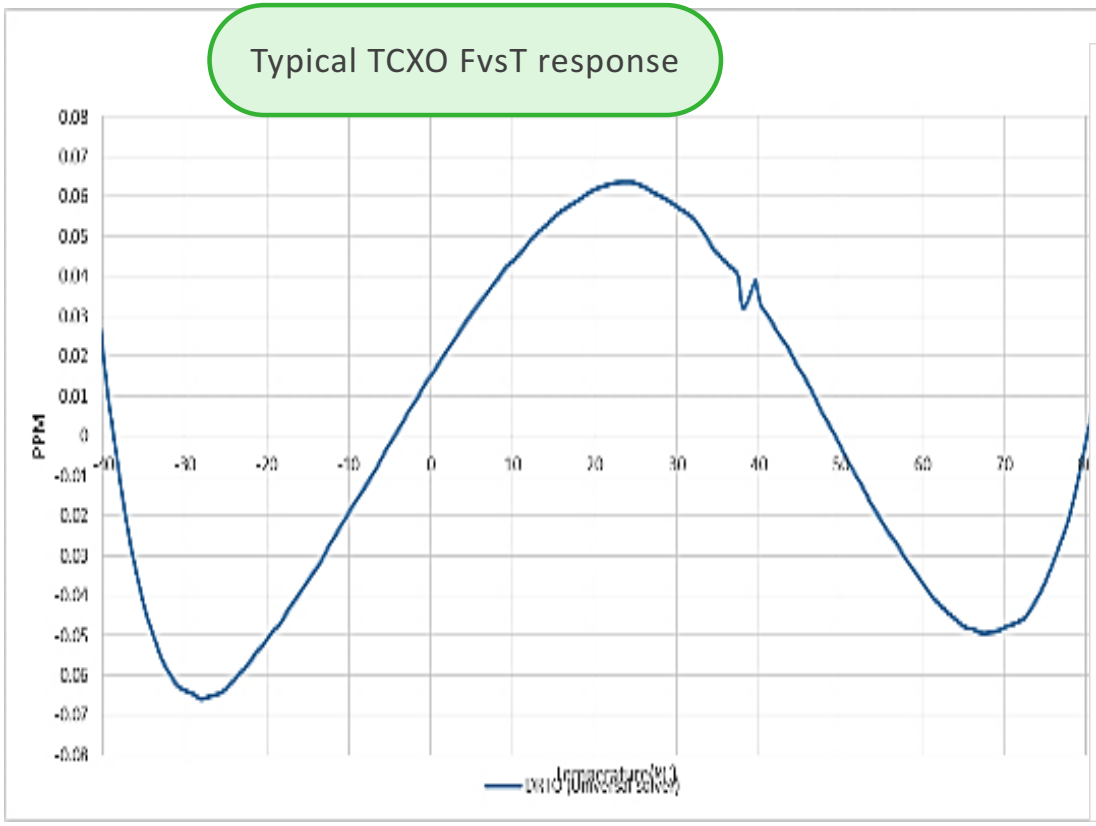
In the presence of Vibration, oscillator Phase Noise is degraded. Oscillators with low *g*-sensitivity will reduce the impact of Vibration.



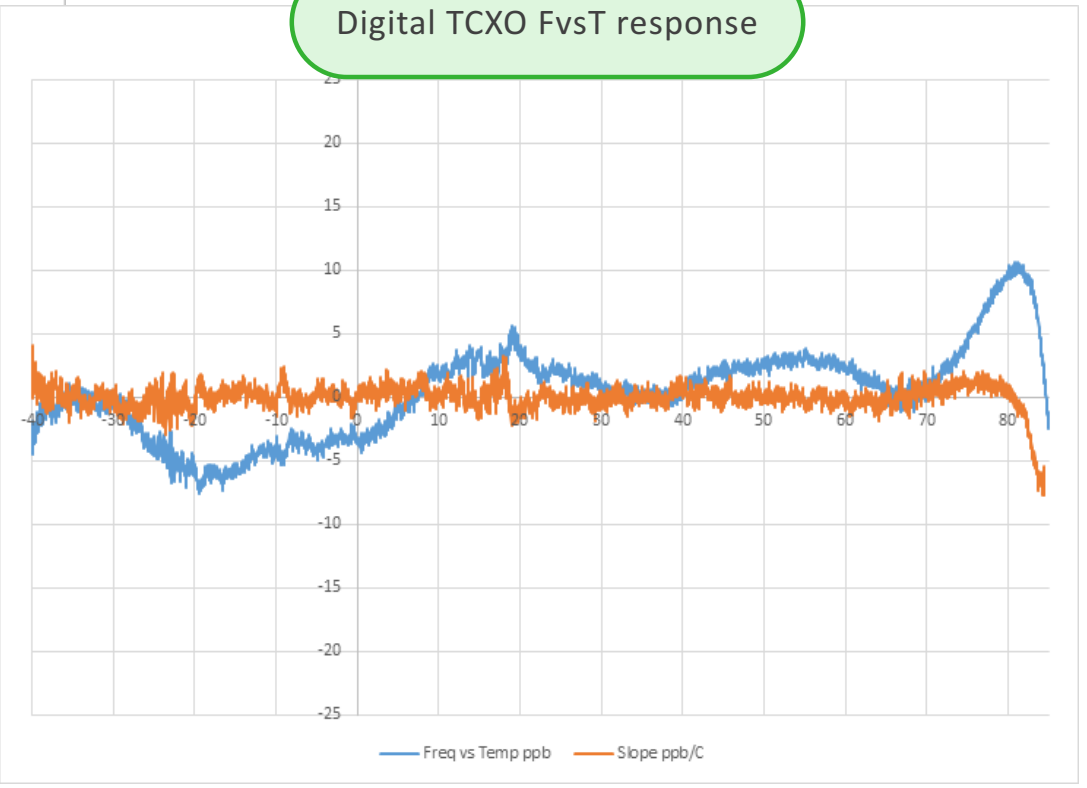
TCXOs with low F vs T & slope

FREQUENCY STABILITY FROM -40°C TO 85°C

Typical TCXO FvsT response



Digital TCXO FvsT response



Low Spurious Levels

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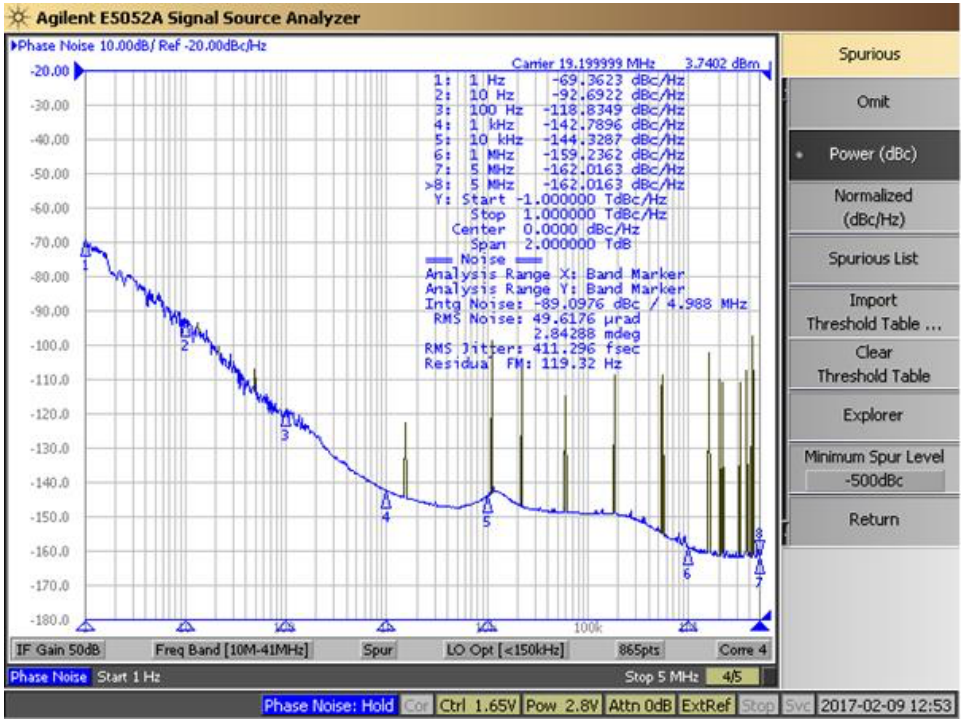
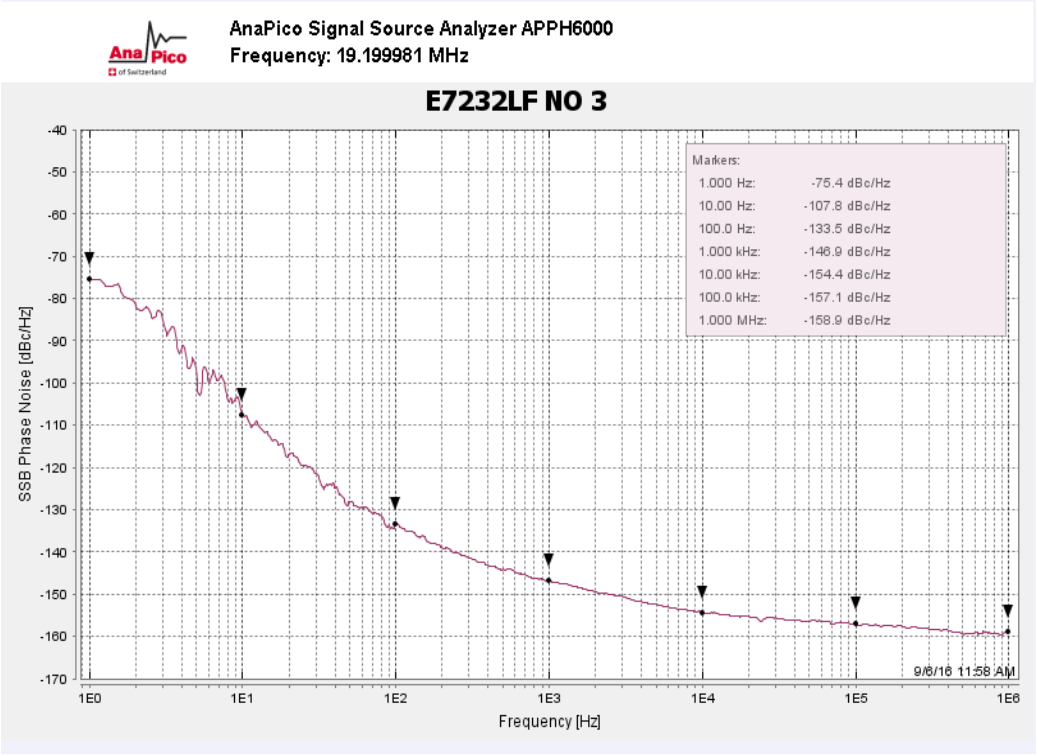
Other Technologies

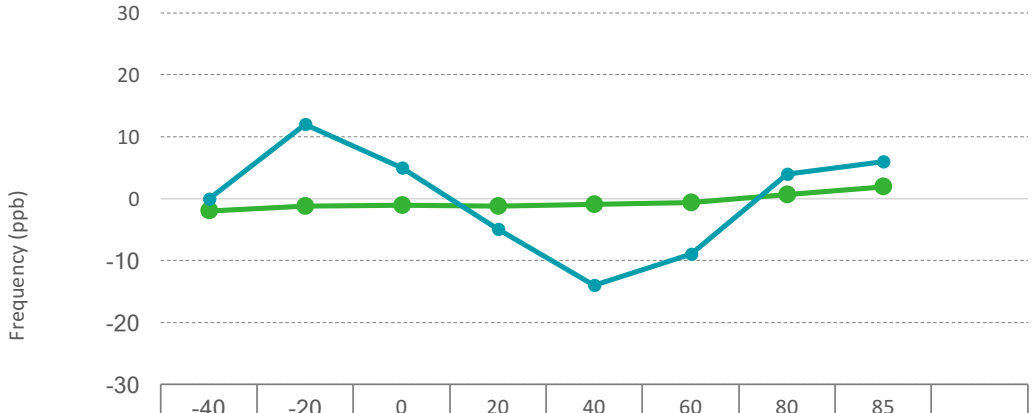


Quartz

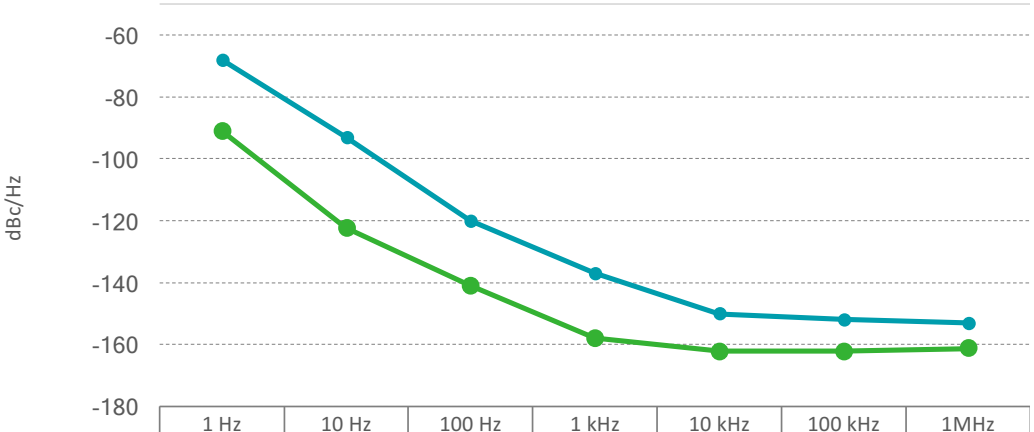


Improvements in IC based OCXOs

Feature	Previous Generation	Current generation
Temperature Stability	+/-20ppb	+/-5ppb
Ageing	1ppb	0.2ppb
Crystal Type	AT	AT, SC, SC-Strips
Frequency	<50M	100M+
Support for 3OT	No	Yes
Phase Noise (dBc/Hz@Hz, for 10M)		

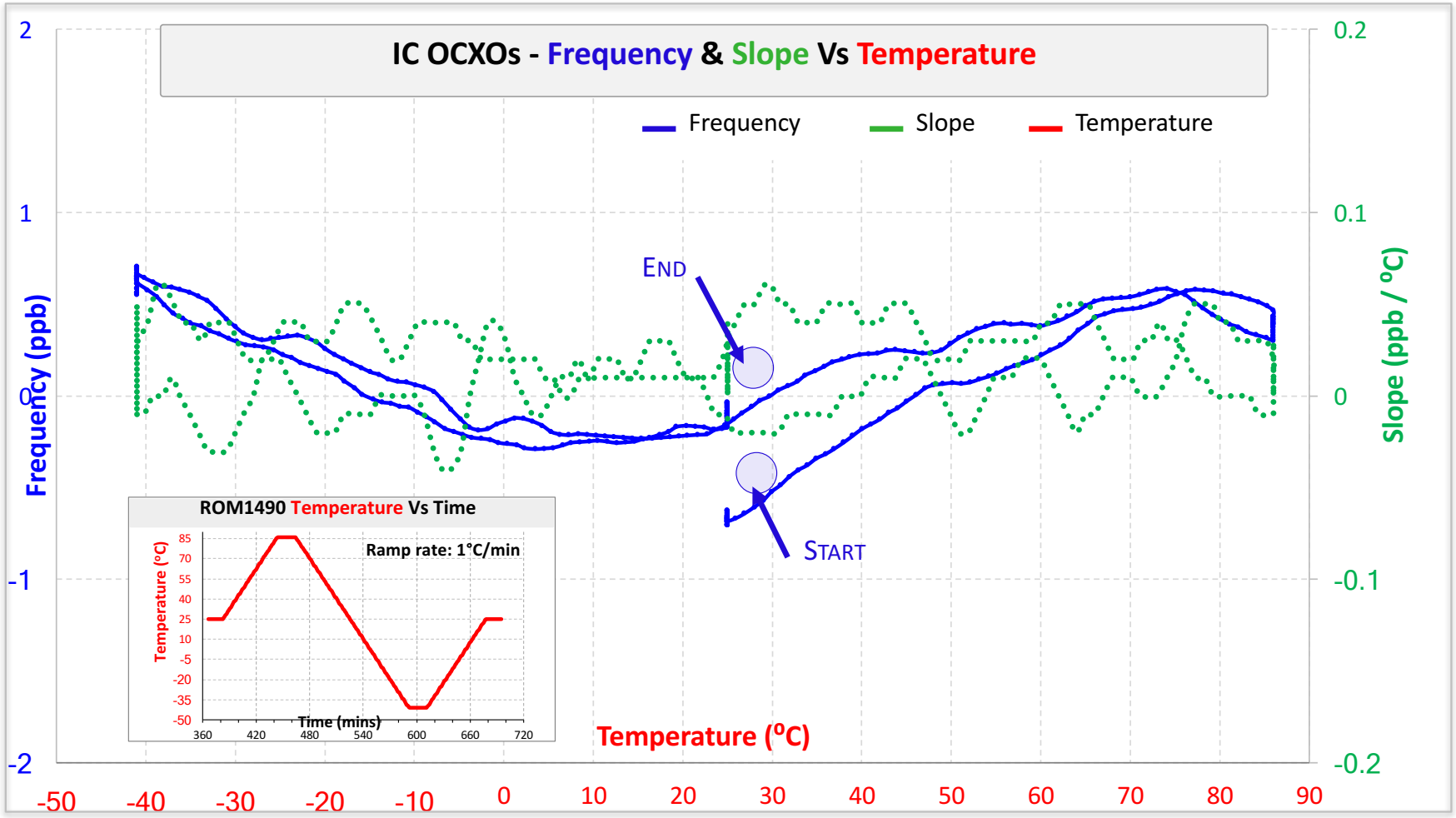


	-40	-20	0	20	40	60	80	85
Current Gen	-2	-1.2	-1.1	-1.2	-0.9	-0.7	0.7	1.9
Prev Gen	0	12	5	-5	-14	-9	4	6



	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1MHz
Current Gen	-91	-122.4	-140.9	-157.8	-162.1	-162.1	-161.2
Prev Gen	-68	-93	-120	-137	-150	-152	-153

Typical IC based OCXO F vs T performance



Improvements in Stratum 3E stability levels

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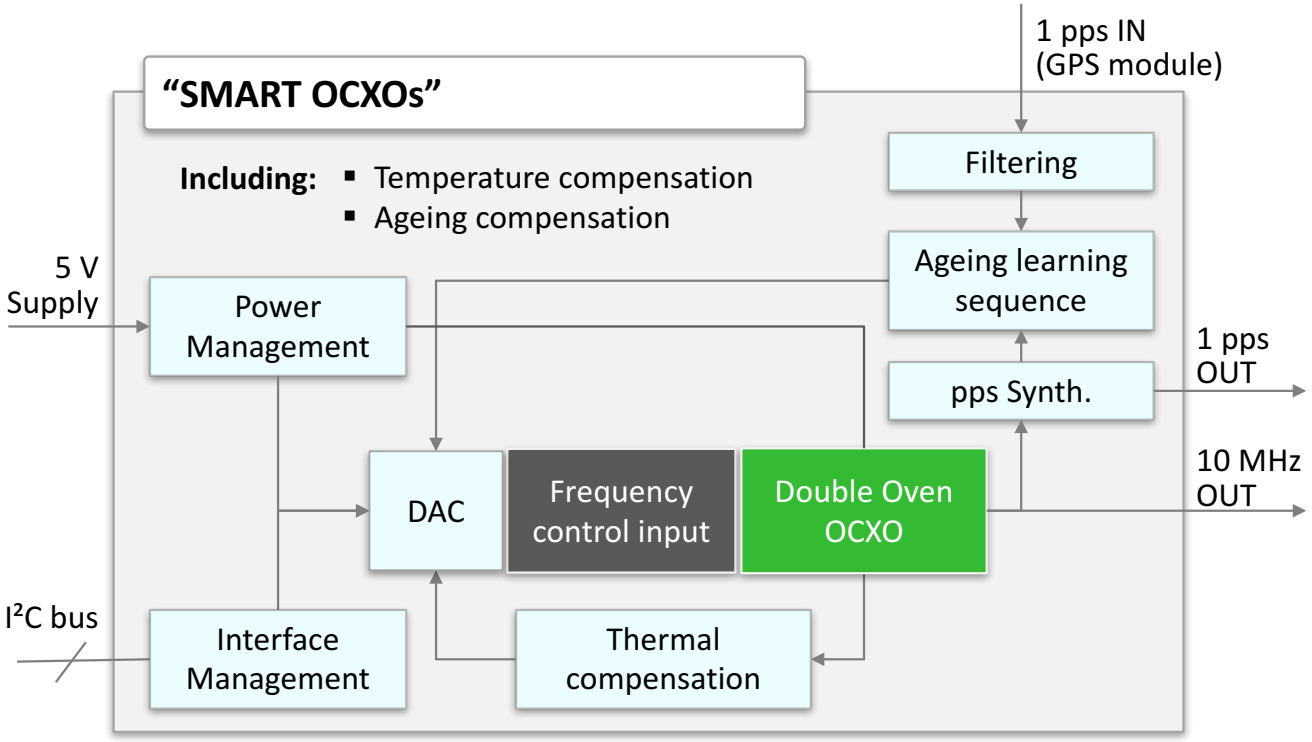
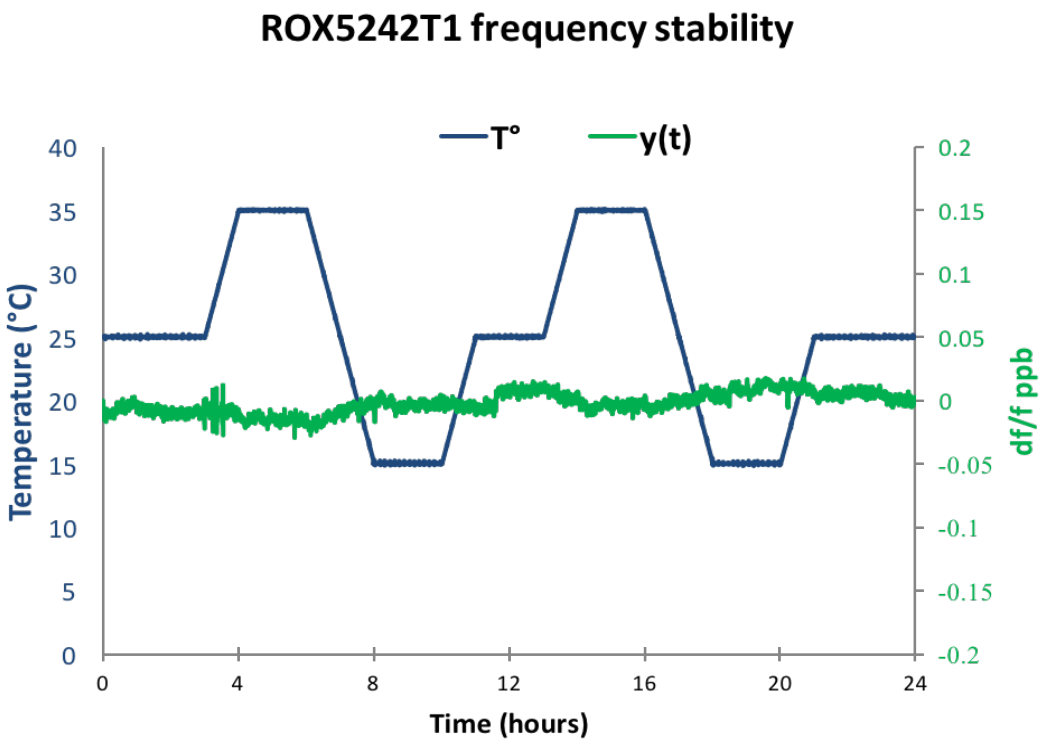
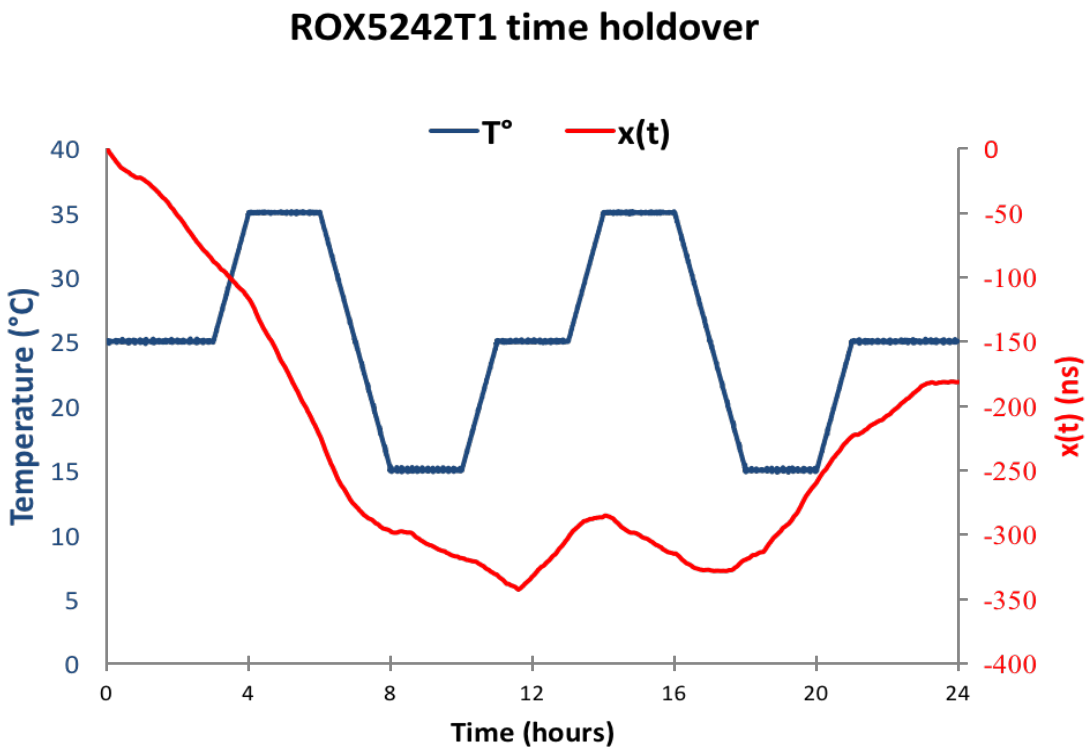
	Discrete
Package Size	25 x 22 mm
Temperature Stability	10 ppb pk-pk
Ageing	1ppb/day
Life Time Accuracy	±2 ppm
Temperature range	-40 to 85 °C
Sensitivity	0.2 ppb/°C
Hermetic sealing	Yes
Power	0.75 W

Improvements on long holdover



Holdover

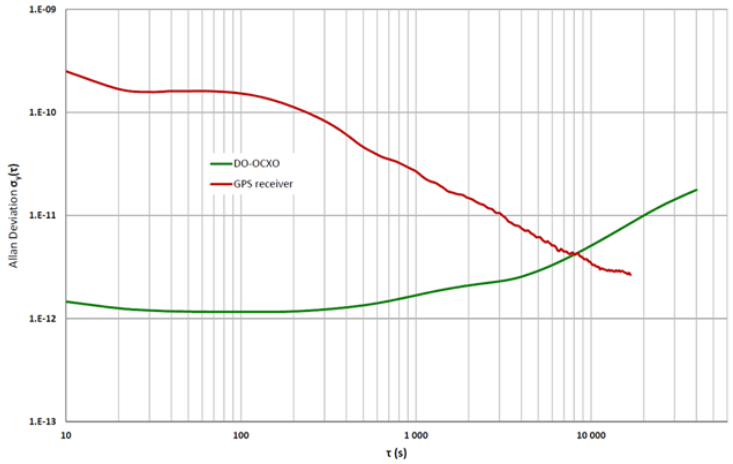

ROX5242T1 frequency stability
T°
y(t)
Temperature (°C)
df/f ppb
Time (hours)
0
4
8
12
16
20
24
40
35
30
25
20
15
10
5
0
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2


ROX5242T1 time holdover
T°
x(t)
Temperature (°C)
x(t) (ns)
Time (hours)
0
4
8
12
16
20
24
40
35
30
25
20
15
10
5
0
0
-50
-100
-150
-200
-250
-300
-350
-400

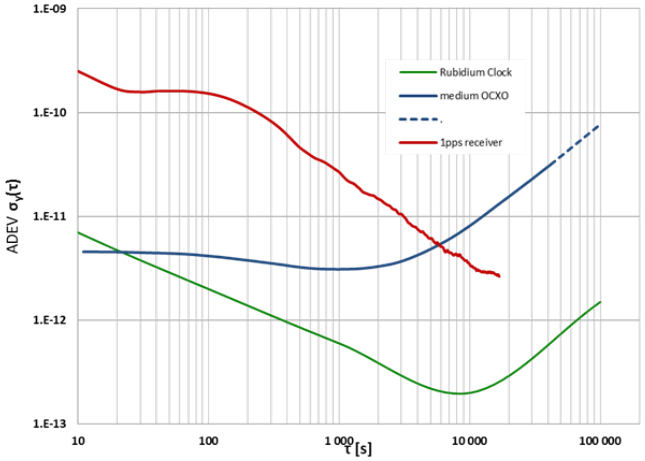
Performance updates

Characteristics	Current D-OCXO	Commercial Rb Clock
Dimension (L x W x H in mm)	38 x 27 x 12	51 x 51 x 18
Power Consumption		
at start	3.5W	14W
steady state @ +25°C	1.5W	5W
Operating Temperature	from -40°C to +85°C	from -10°C to +75°C
Holdover Performance	**with 1pps & learning**	
Stable conditons	1.5µs for 24h	
including ± 20°C variation	8µs for 24h	7µs for 24h
Frequency Stability	**with 1pps & learning**	
Vs. Time / Long Term Ageing		
per Day	< 2E-10	< 2.5E-11
Vs. Temperature (peak to peak)	< 1.0E-9	< 0.1E-9
Short term (Allan std. Dev. 1s)	< 3E-12	< 3E-11
COST COMPARISON	**x**	**10x**

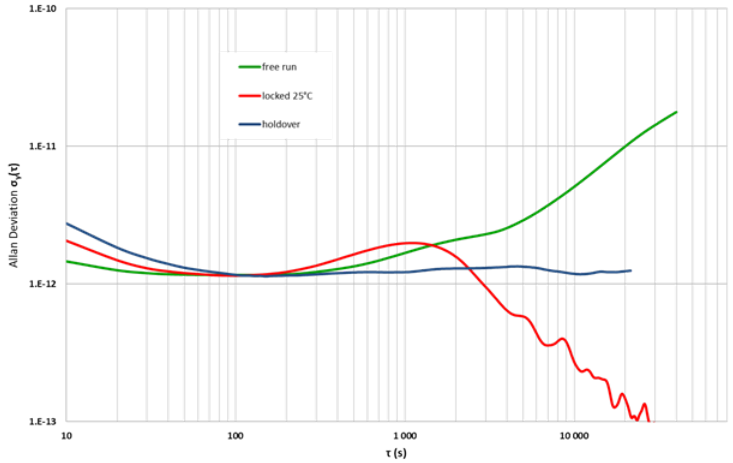
Performances



clock performance **-overlapping ADEV**



SMART Module -ADEV performance



Summary

- Quartz based crystal oscillators provide low phase noise, stable clock references
- Improved technologies move the performance of TCXOs to OCXO levels
- Strip SC crystal technology improves performance, power & cost in Stratum 3E stability levels
- IC-based oscillators reduce power and footprint profile at given stability levels
- SMART OCXOs performances move closer to Rubidium

References & Acknowledgements

- W.L. Bond, Crystal Technology, John Wiley & Sons, New York, 1976.
- J. A. Kusters, “Resonator and Device Technology," in E. A. Gerber and A. Ballato, Precision Frequency Control, Vol. 1, pp.161-183, Academic Press, 1985.

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Thank you

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