

# Advancements in OCXO Technologies

**rakon**  
Enabling the connected future



# Overview



**Profile**  
Miniaturization

**Thermal**  
Up to 105 °C

**Power**  
Lower

**Shock & Vibration**  
High resilience

**Reliability**  
Higher

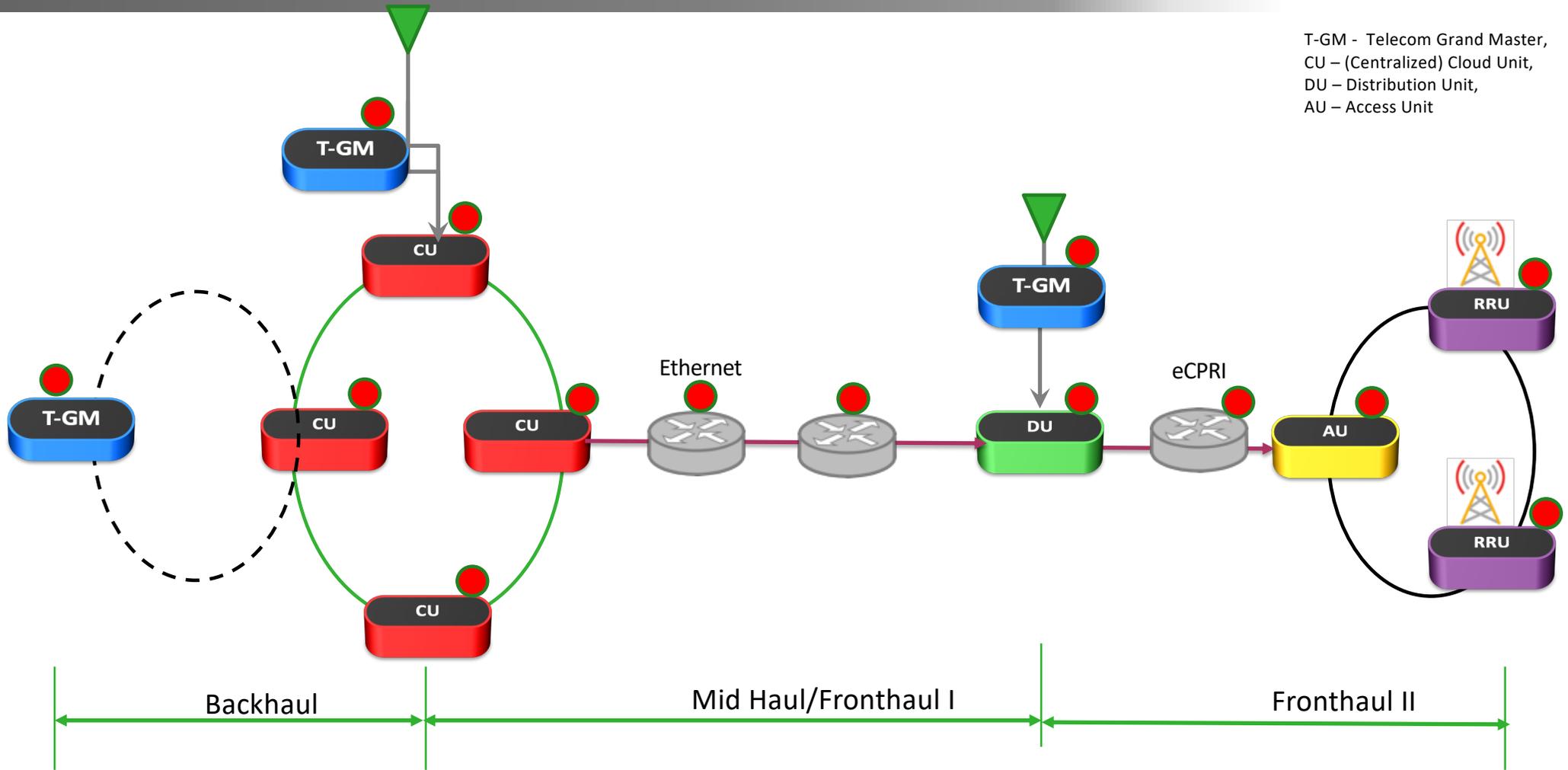
**Cost**  
Lower

## Next Generation Mobile and Transport Equipment

## 2 5G Architecture



T-GM - Telecom Grand Master,  
CU – (Centralized) Cloud Unit,  
DU – Distribution Unit,  
AU – Access Unit

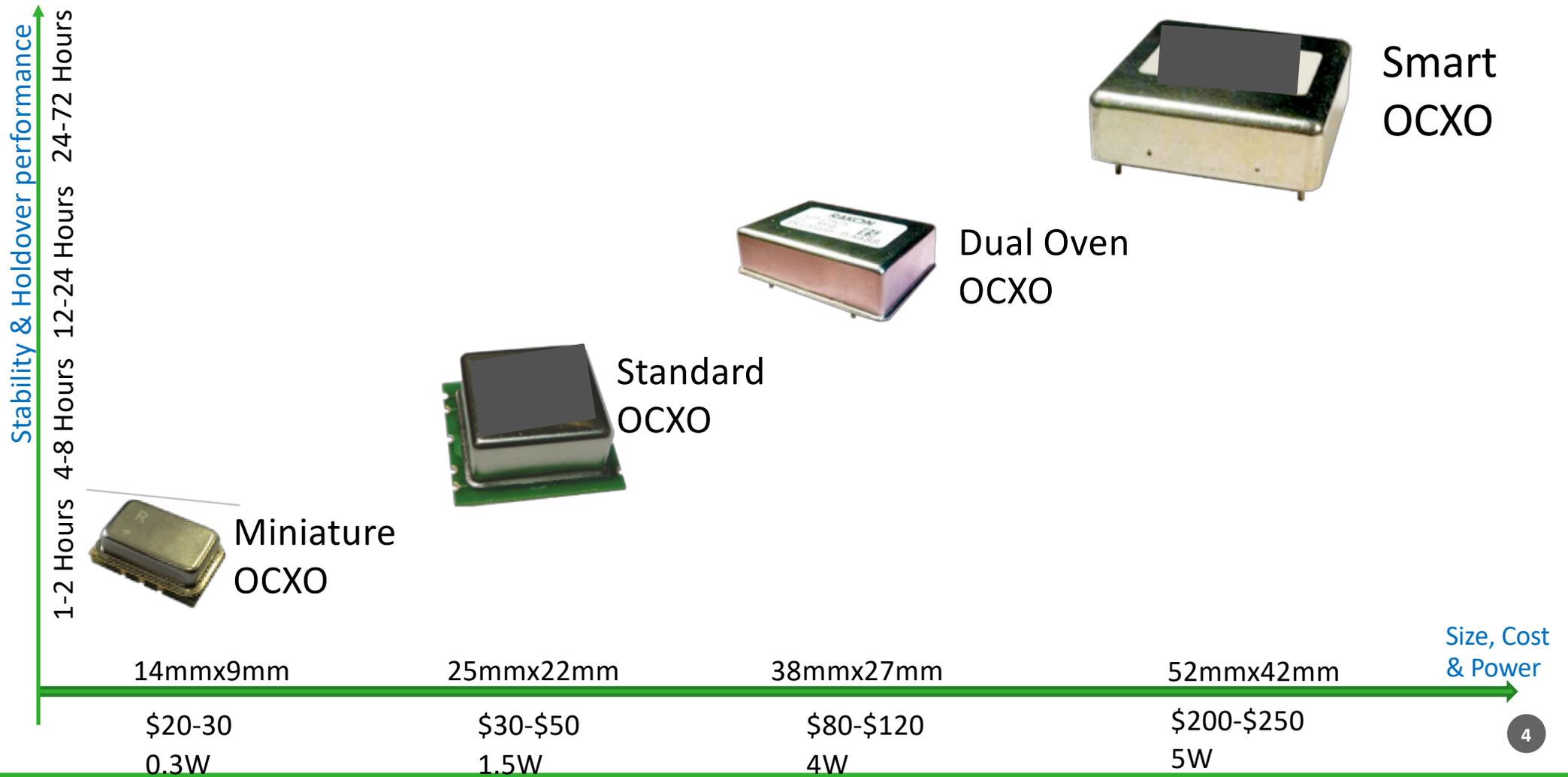


# Equipment and Reference Clocks

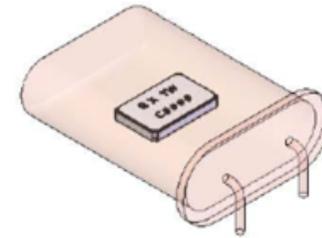


Equipment/	T-GM/CU	Backhaul Switch/Routers	DU/Edge GM	Front-Haul Switches	Access Unit / Remote Radio Unit
Sync features					
Reference Clocks					

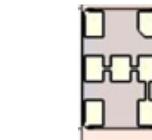
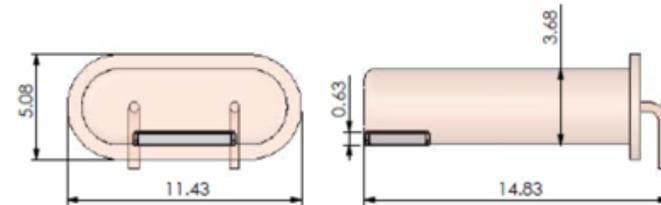
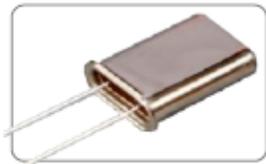
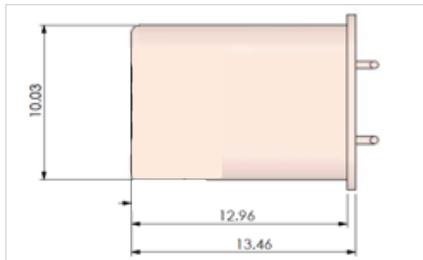
# OCXO range vs performance



# Crystal Technologies



**rakon**



5mmx3.2mm



3.2mmx2.5mm

**HC-43**

**HC-45**

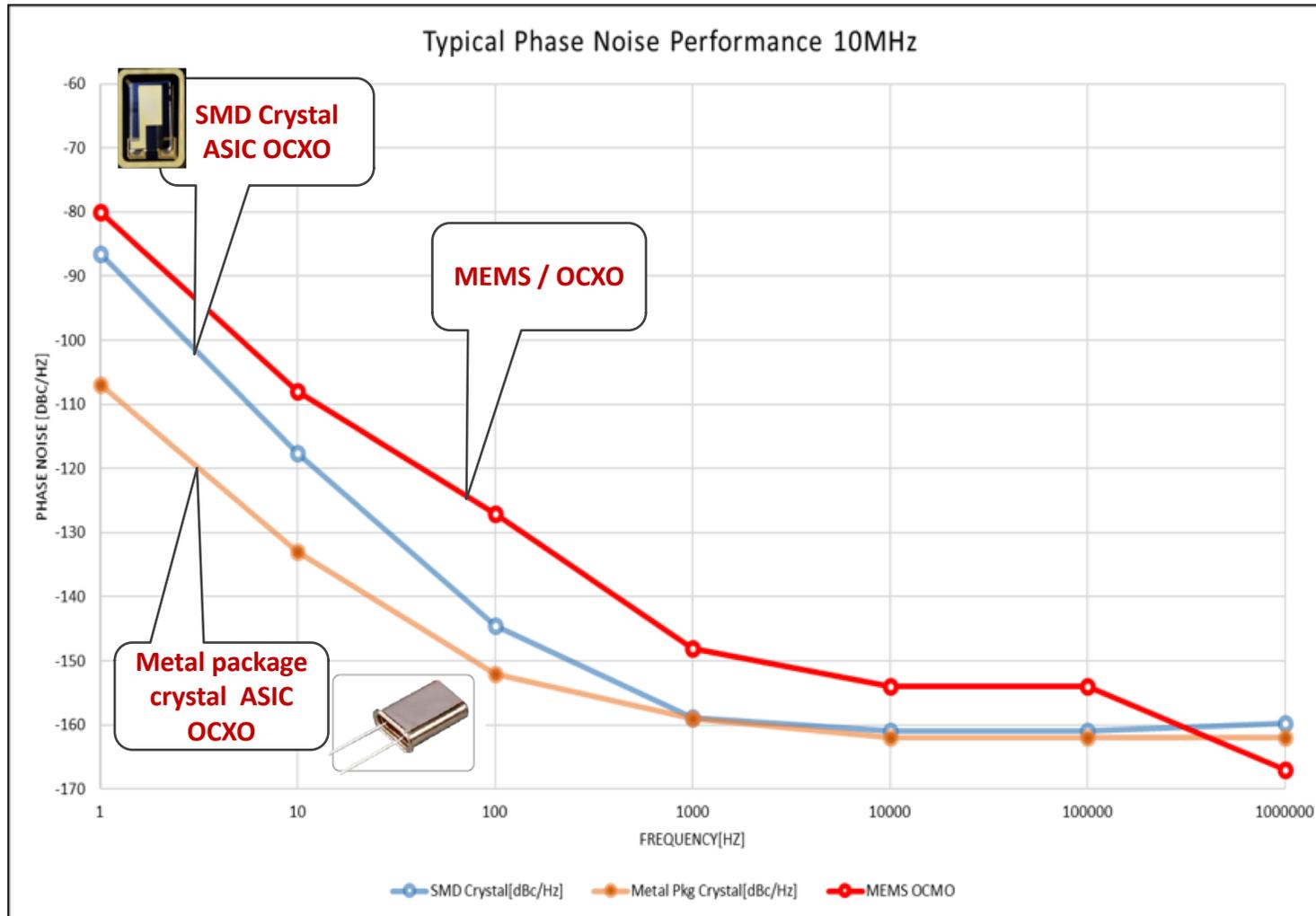
**HC-37**

**SC Strip**

Ageing Performance of Crystals			
	Day	1 yr	10yr
HC37	.05ppb	7.5ppb	37ppb
HC43	.1ppb	12ppb	60ppb
HC45	.4ppb	48ppb	240ppb
Strip SC	.5ppb	100ppb	400ppb

**Stratum 3E requirements : 1ppb/day ; 4.6ppm in 20 years**

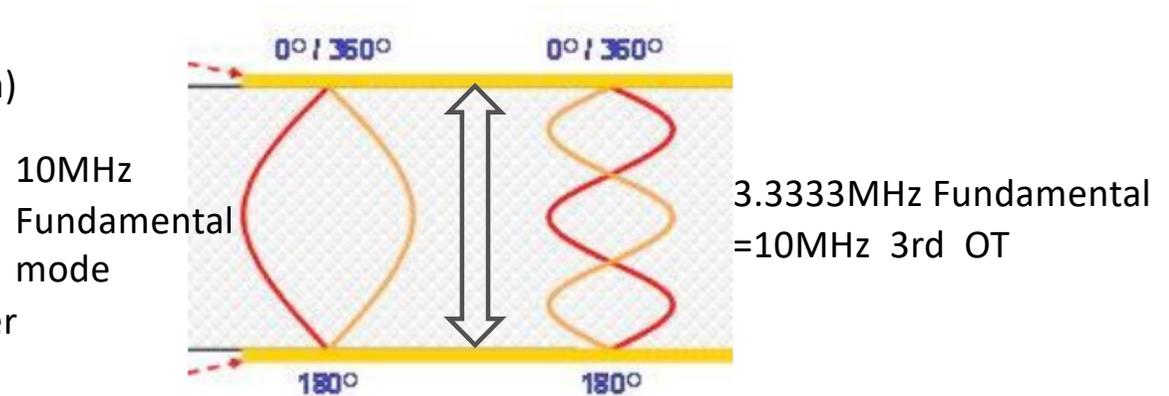
# Phase noise comparison



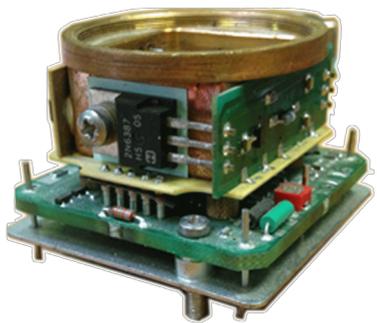
# 3<sup>rd</sup> overtone metal XTAL package



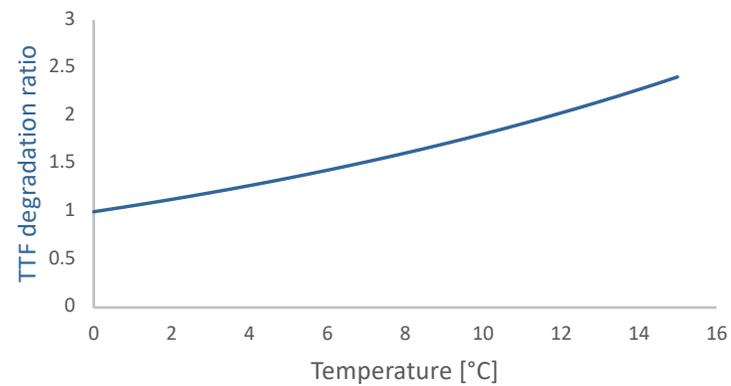
- Metal package Cold Welding CW can guarantee **2<sup>nd</sup> order vacuum** over lifetime
  - Very low mass loading long term ageing/frequency drift (the simple weight of any material onto Xtal will affect frequency drift)
  
- **3<sup>rd</sup> overtone** -> for same end frequency, XTAL blank will be 3 times thicker
  - Better quality factor Q
    - Phase Noise (close to carrier)
    - Short term stability (Allan Deviation)
  - Better ageing
    - Reduced mass loading effect
    - Less sensitivity to mechanical holder



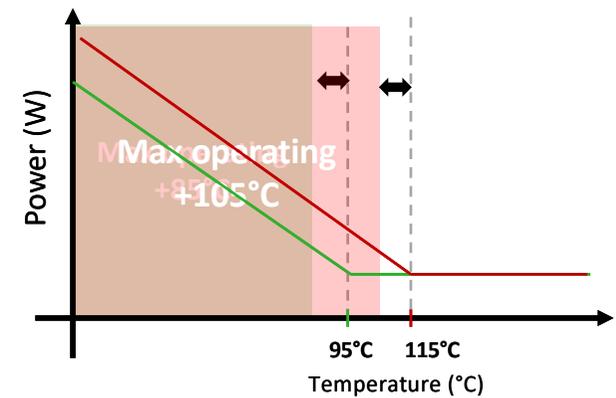
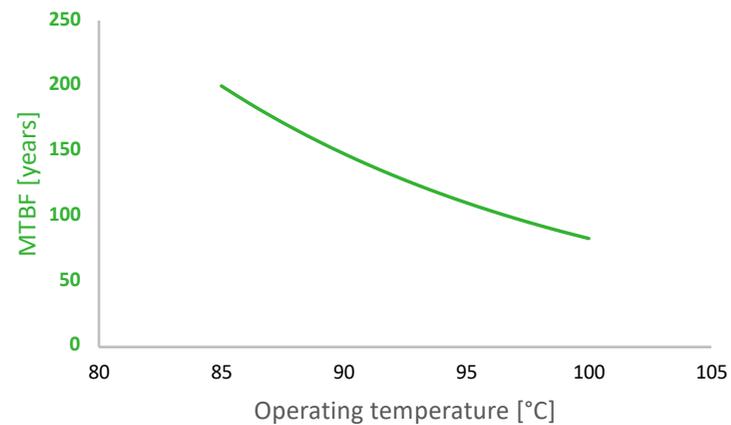
# Reliability & High Temp of Operation



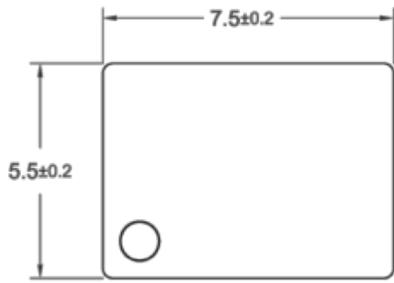
time to failure degradation vs. Temperature elevation



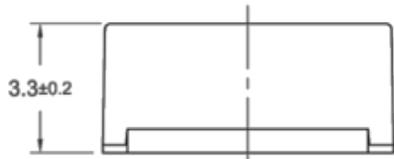
MTBF evolution vs. operating temperature



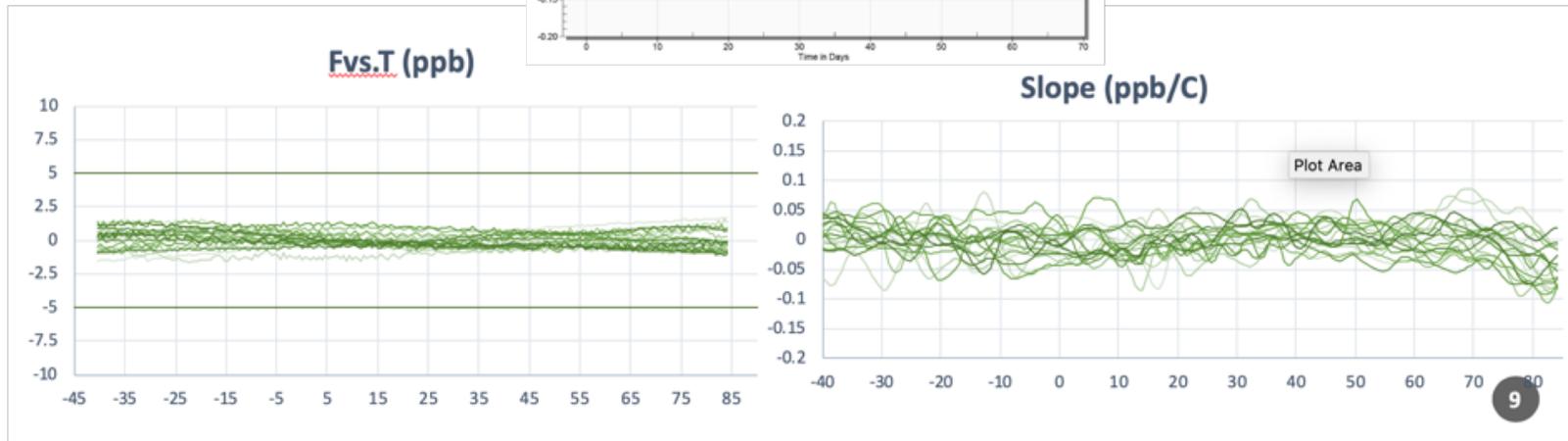
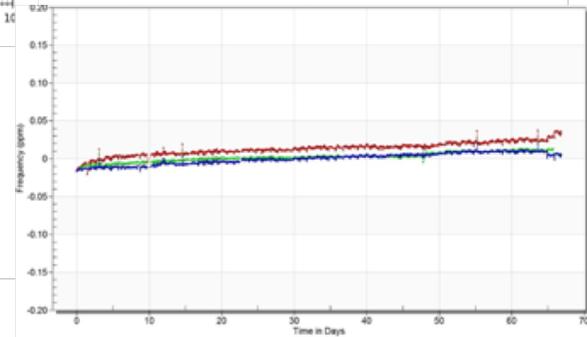
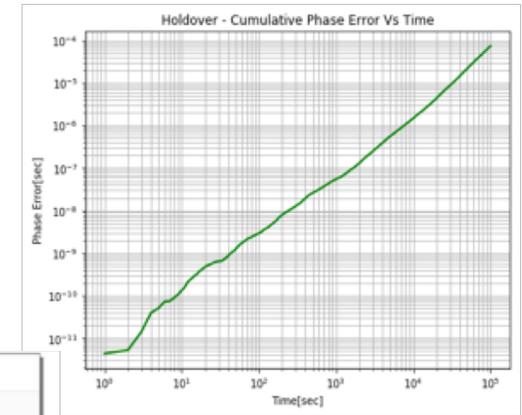
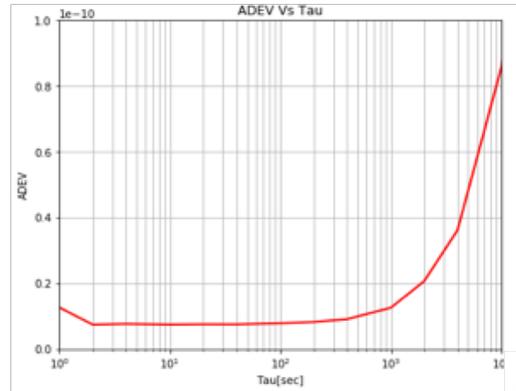
# Miniature OCXOs – 7mm x 5mm



1  
TOP VIEW



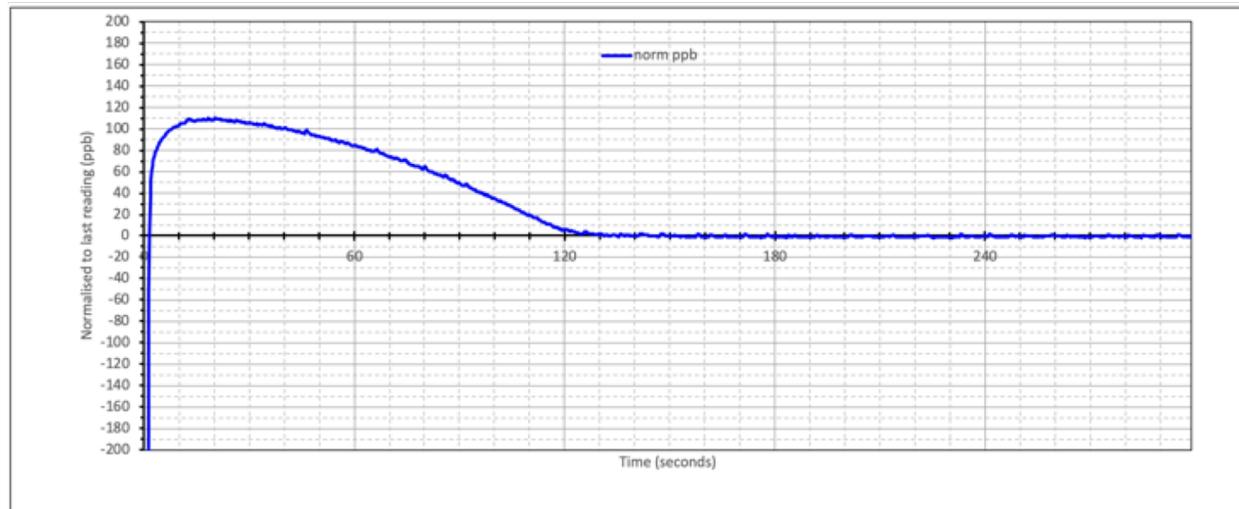
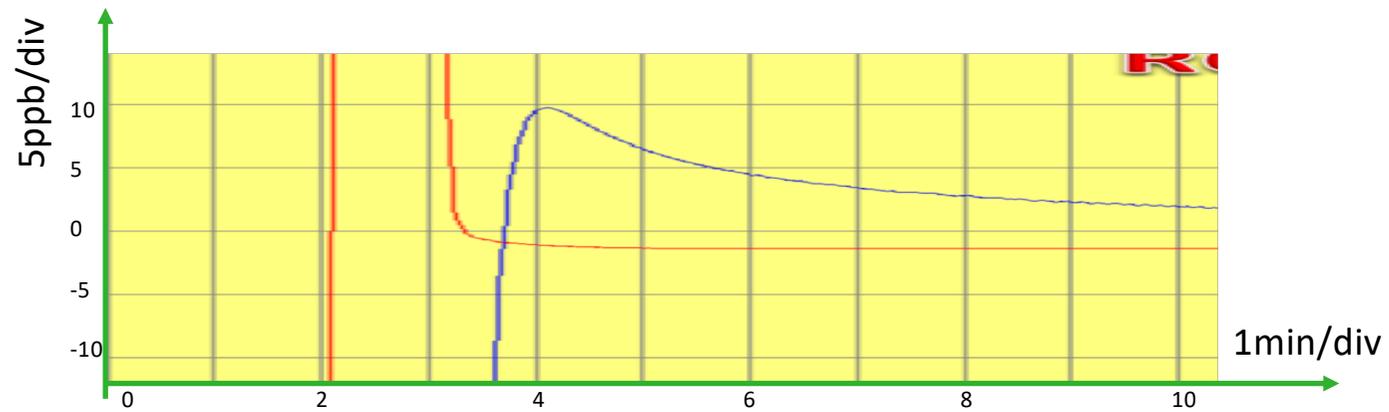
FRONT VIEW



# Warm – up Time



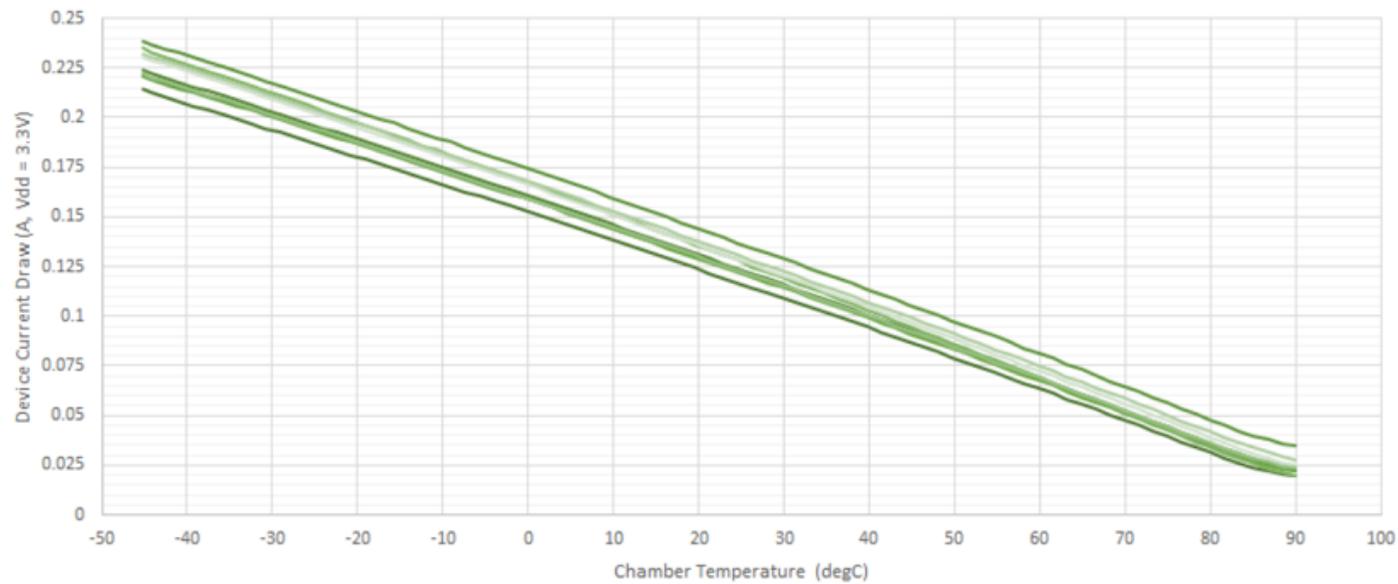
## ◀ Discrete Vs ASIC OCXOs



# Power – Always Lower



## ◀ ASIC based OCXOs

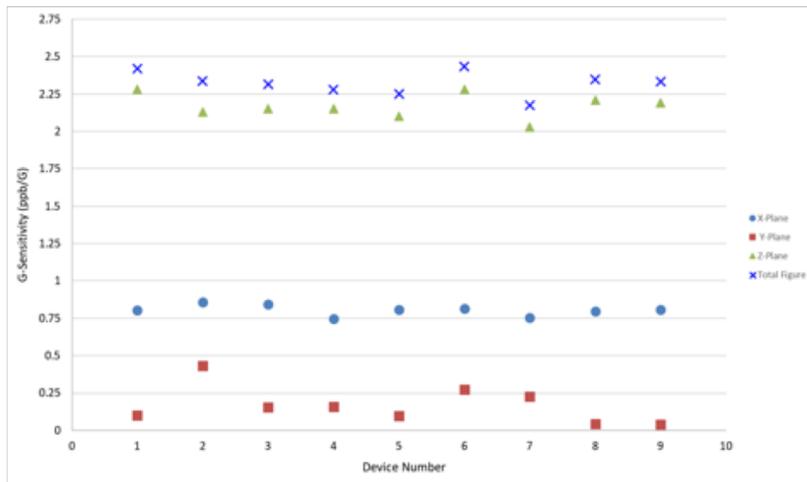


# Acceleration Sensitivity

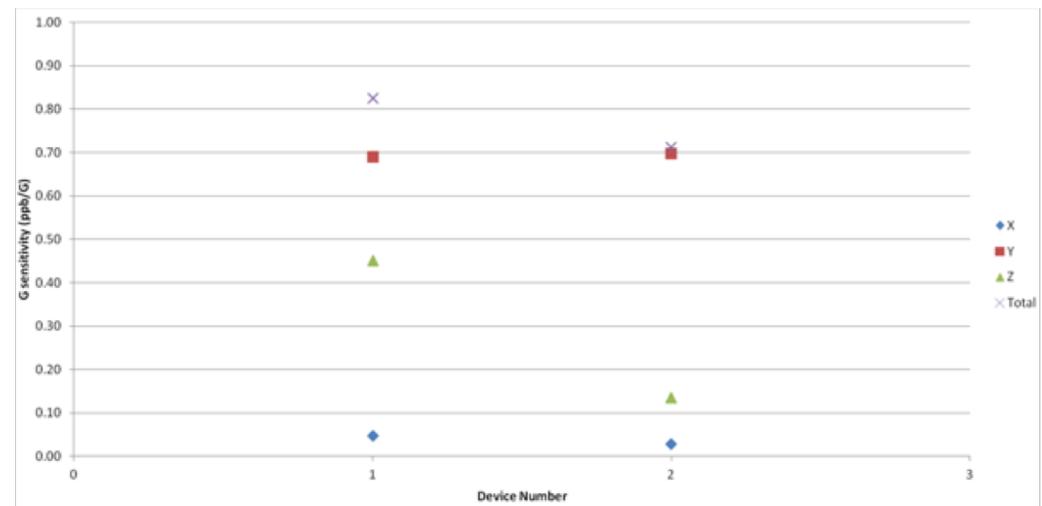


- ◀ G – Sensitivity is critical for 5G outdoor equipment
- ◀ <1ppb/g is generally required for reference clocks

Crystal Type A

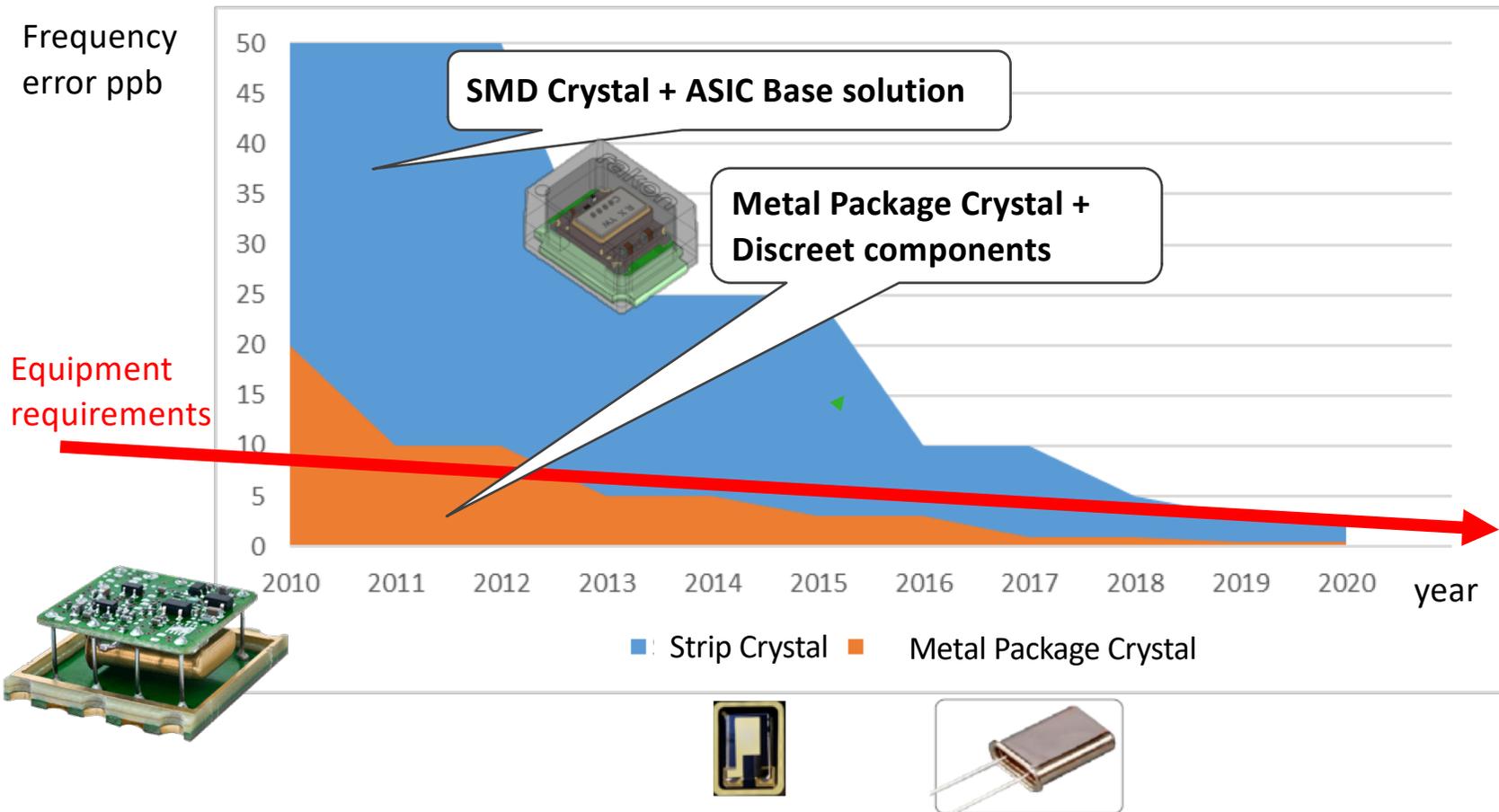


Crystal Type B



# ASIC OCXO Vs Standard OCXOs

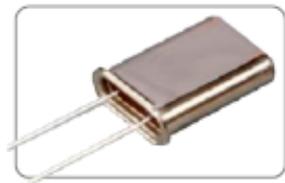
Frequency Stability evolution  
ASIC based OCXO vs 25x22 Discreet OCXO (H43)



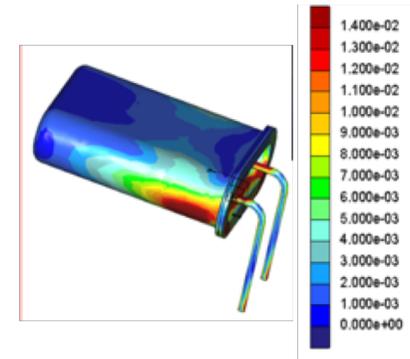
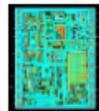
# Hybrid OCXOs



## ◀ Combining High Q Crystal to OCXO ASIC



HC43



### High Q Crystal

- Low Phase Noise
- Ageing performance
- Frequency recovery/retrace
- Overall thermal and mechanical sensitivity

### OCXO ASIC

- High integration
- High reliability
- Power saving
- Low profile

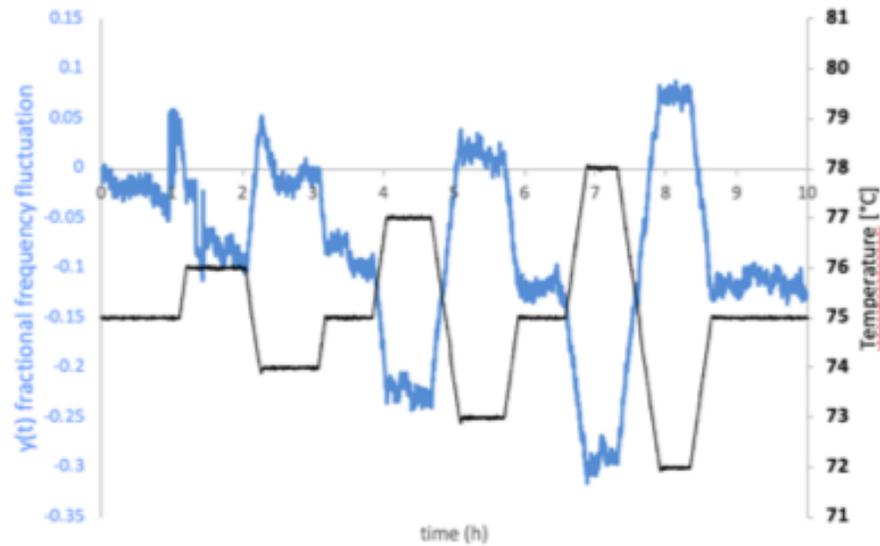
### Mechanical design

- Reducing Thermal Variation
- Reducing Thermal Gradient
- Reducing Mechanical Stress
- Thermal coupling effects

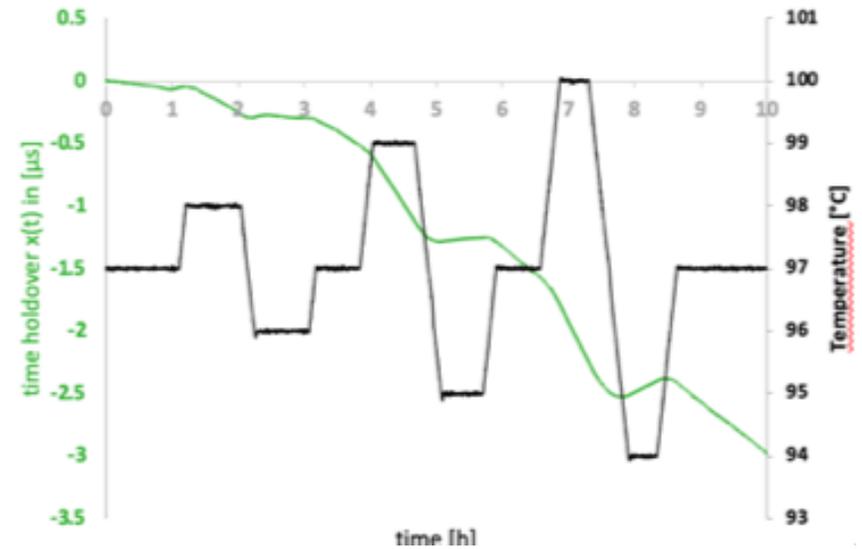
# Hybrid OCXO performances



High temperature HYBRID OCXO  
frequency stability over temperature



High temperature HYBRID OCXO  
phase stability over temperature



# Post Compensation techniques



## < Characterized Temperature Outputs

- ❑ Digital Temperature outputs
- ❑ Characterized Temp profile
- ❑ 10ppb FvT over temperature performance (25mmx22mm)

## < Self Compensating

- ❑ Characterized and compensated temperature
- ❑ No Ageing compensation
- ❑ 1ppb FvT over temperature performance (25mmx22mm)
- ❑

## < Disciplined self compensating

- ❑ Characterized and compensated temperature
- ❑ Ageing compensation with ref clock
- ❑ 0.05 ppb FvT over temperature performance (52mmx42mm)

## < Free Running self compensating

- ❑ Characterized and compensated temperature
- ❑ Ageing compensation with ref clock
- ❑ 0.05 ppb FvT over temperature performance (52mmx42mm)

## Conclusion



- ◀ 5G Network is demanding high performance lower cost synchronisation references
- ◀ OCXO technology is advancing – Crystal, ASICs and Design
- ◀ For given performance, the profile, power & price has improved significantly in recent years
- ◀ OCXOs in 7mm x 5mm size, close to the Stratum 3E performance grade specifications are achieved

# THANK YOU!



## ◀ Acknowledgements

Michael McLroy, Advanced Technology Manager – Global Engineering

Vincent Candelier, Advanced R&D manager/Senior Design Engineer

