



# $\pm 5$ ppb DualMEMS™ Based TCXO for Stratum 3E Stability and Time Synchronization

Nov 2022



# Precision Oscillators are Critical to all Synchronization Applications

## Application drivers

- Synchronized ethernet
- GNSS timing
- IEEE1588 / PTP clock recovery

## Requirements beyond stability

- High reliability
- Small size
- Low power
- High temperature
- Resistance to environmental stressors



MICROWAVE BACKHAUL



4G+ / 5G RRH



SMALL CELL



SMART NIC

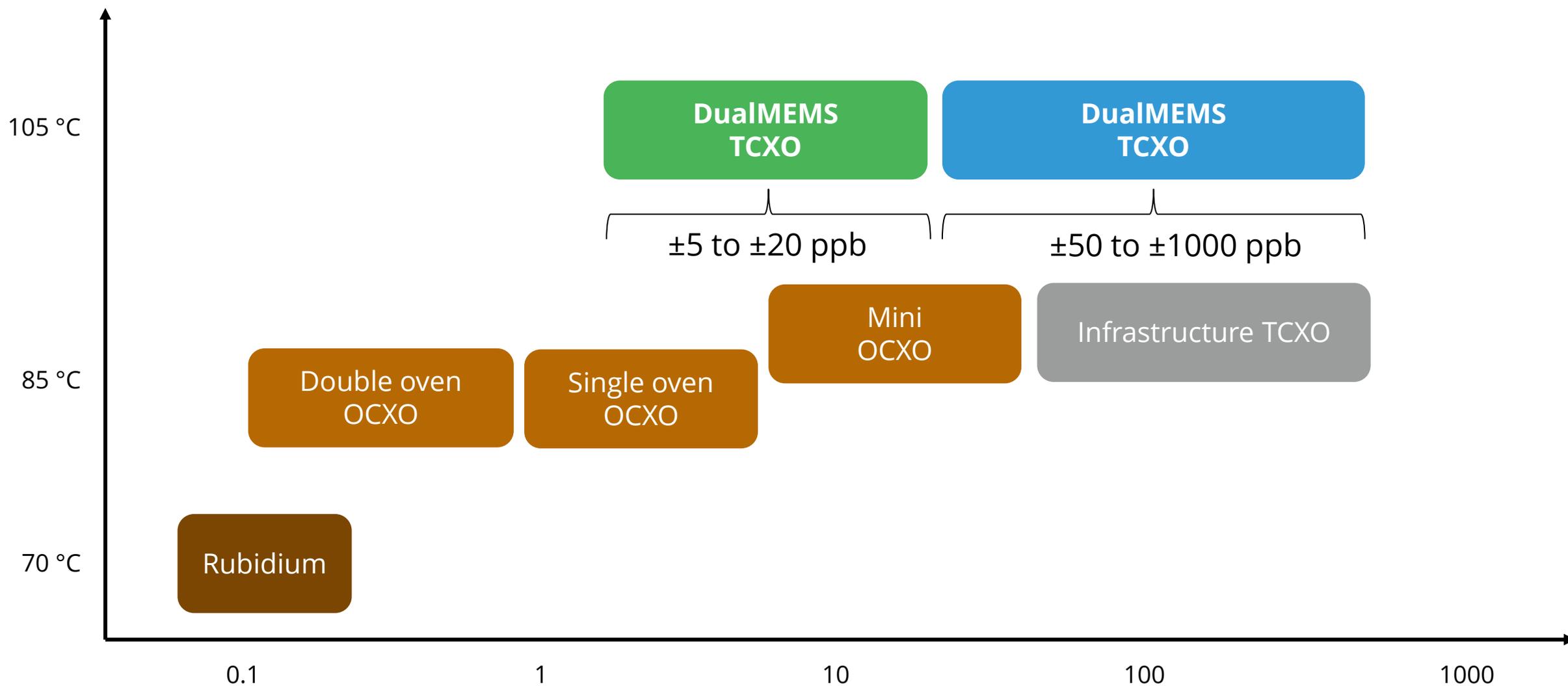


ROUTER, SWITCHES



SERVER

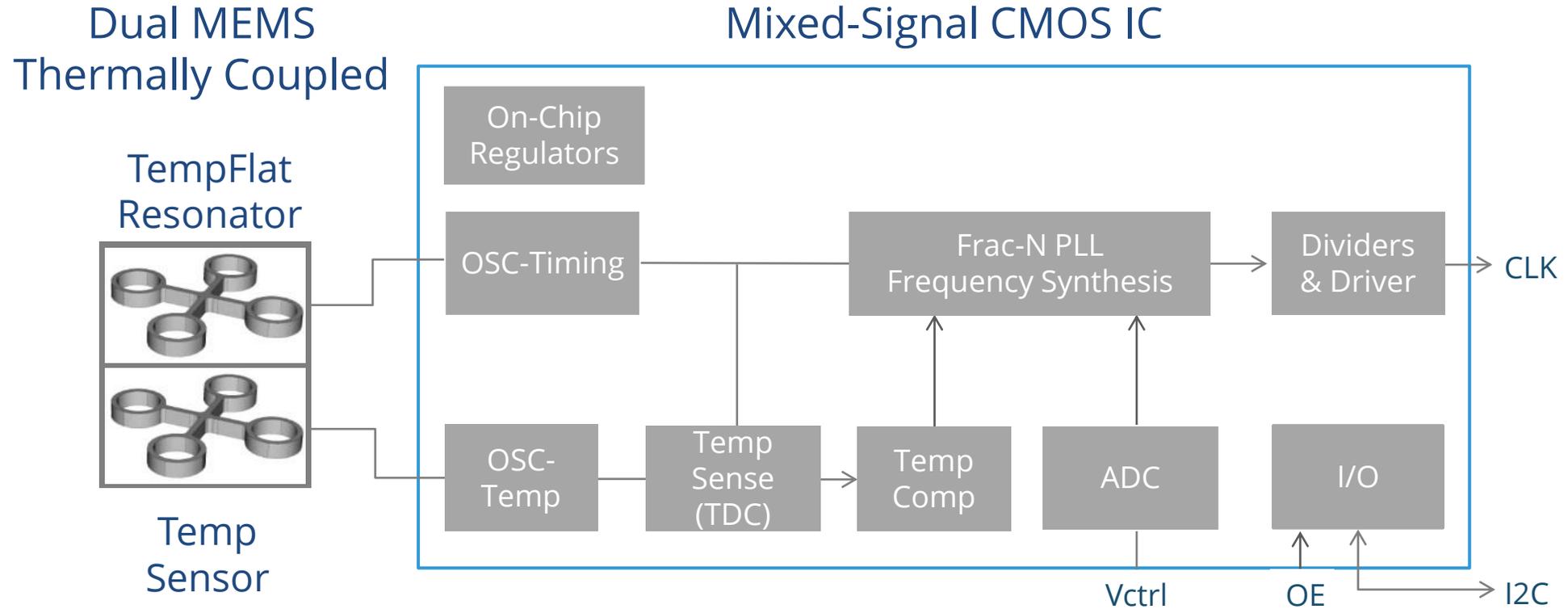
# DualMEMS™ TCXO Technology Delivers OCXO Grade Stability at 105 °C



# Technology Comparison

	DualMEMS Based TCXO	Mini-OCXO 1	Mini-OCXO 2
Technology	DualMEMS	Quartz	Quartz
Heater	No	Yes	Yes
Reliability / MTBF	2 billion hours	-	-
Frequency Range	1 to 220 MHz	10 to 50 MHz	10 to 40 MHz
Temperature Range	-40 to 105°C	-40 to 95°C	-40 to 95°C
Frequency Stability	±5	±10 ppb	±20 ppb
Stability over Temp Slope	±0.3 ppb/°C	±0.5 ppb/°C	±2 ppb/°C
Initial Tolerance	±100 ppb	±200 ppb	±200 ppb
Daily Aging	±0.3 ppb	±1 ppb	±5 ppb
Supply Voltage Sensitivity	±1 ppb (5% var)	±5 ppb (2% var)	±3 ppb (5% var)
Warm-Up Time	<1s	15s	>3 mins
Power Consumption	110 mW (2.5V)	400 mW (3.3V)	650 mW (3.3V)
Size	7 x 5 x 2.2 mm	9.7 x 7.5 x 3.9 mm	9.6 x 7.4 x 4.1 mm

# DualMEM Optimized for Dynamic Performance / Synchronization



## TempFlat™ MEMS Resonator

- No aging
- No activity dips
- 30x better vibration immunity

## DualMEMS™ Temp Sensing 100% Thermal Coupling

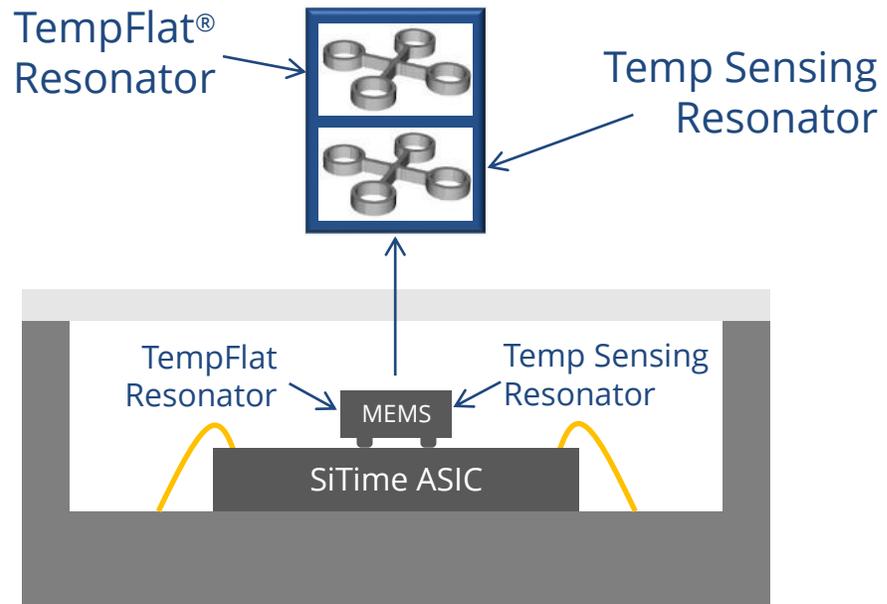
- 30  $\mu$ K, 10x more accurate
- 350 Hz tracking, 40x faster
- Airflow, temp ramp resistant

## Low Noise CMOS Enabling Frequency Agility

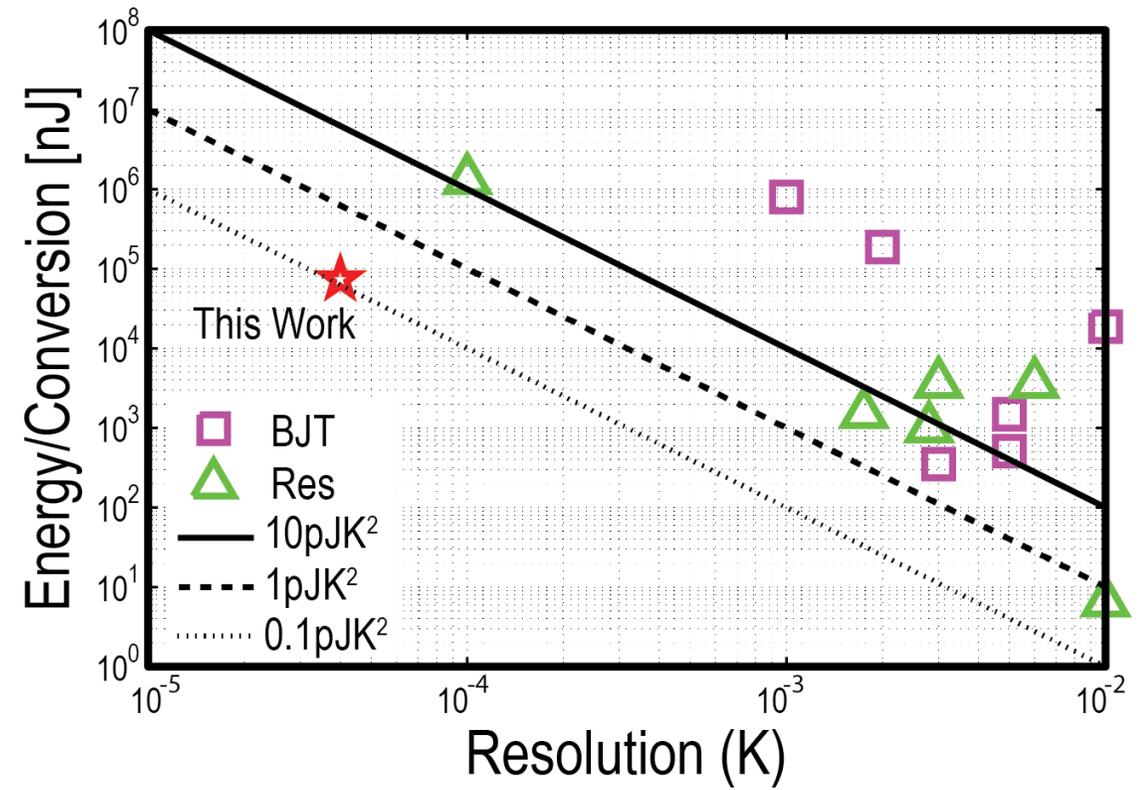
- 1 to 220 MHz, steps in mHz
- 0.2 ps/mv PSNR, 5x better
- In-system programmability

# Stability Breakthrough via DualMEMS Temperature Sensing

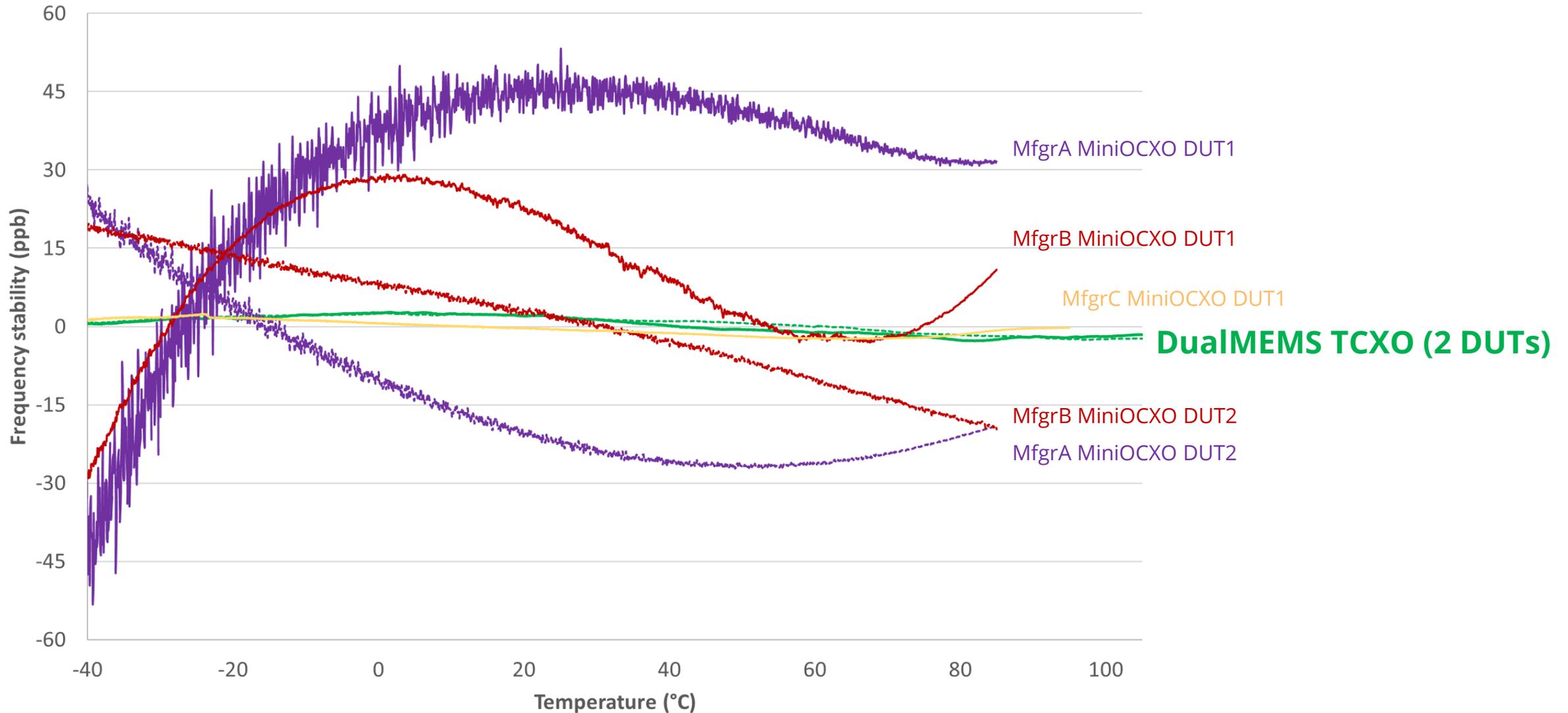
Best thermal coupling between two MEMS resonators on the same die



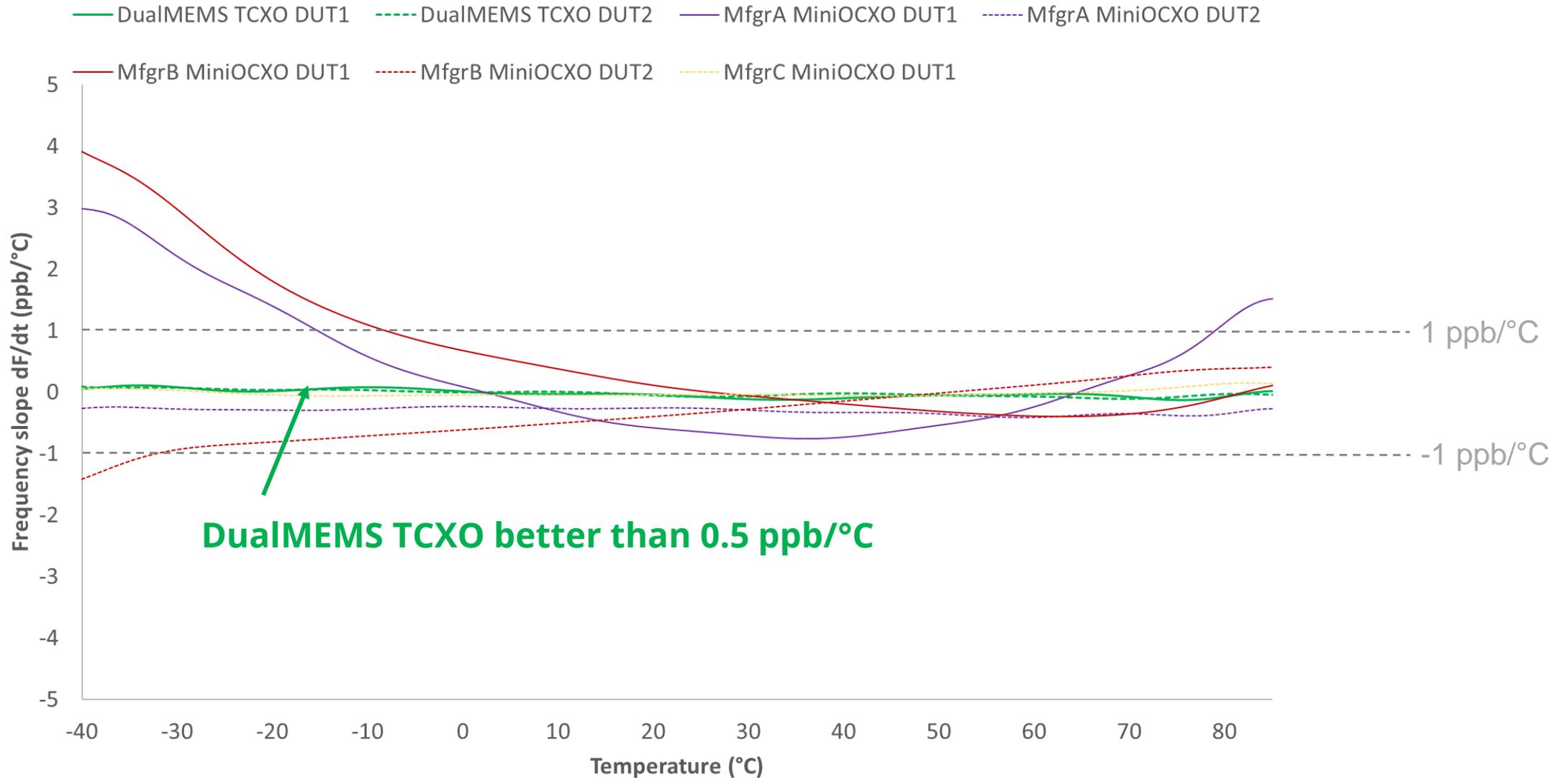
Highest Figure of Merits (FOM) in (Energy/Conversion) & Resolution<sub>2</sub>



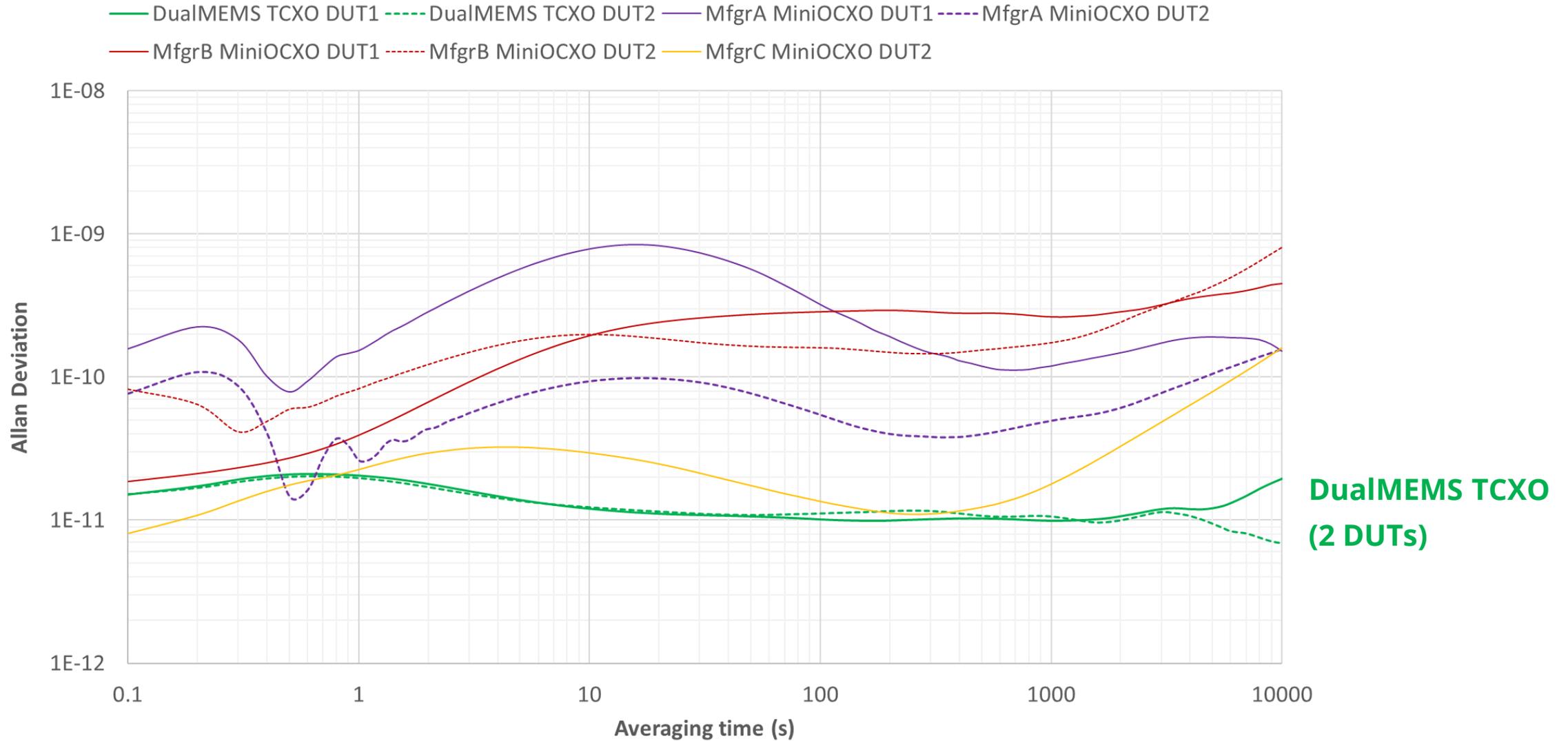
# DualMEMS Delivers Consistent Frequency Stability over Temp



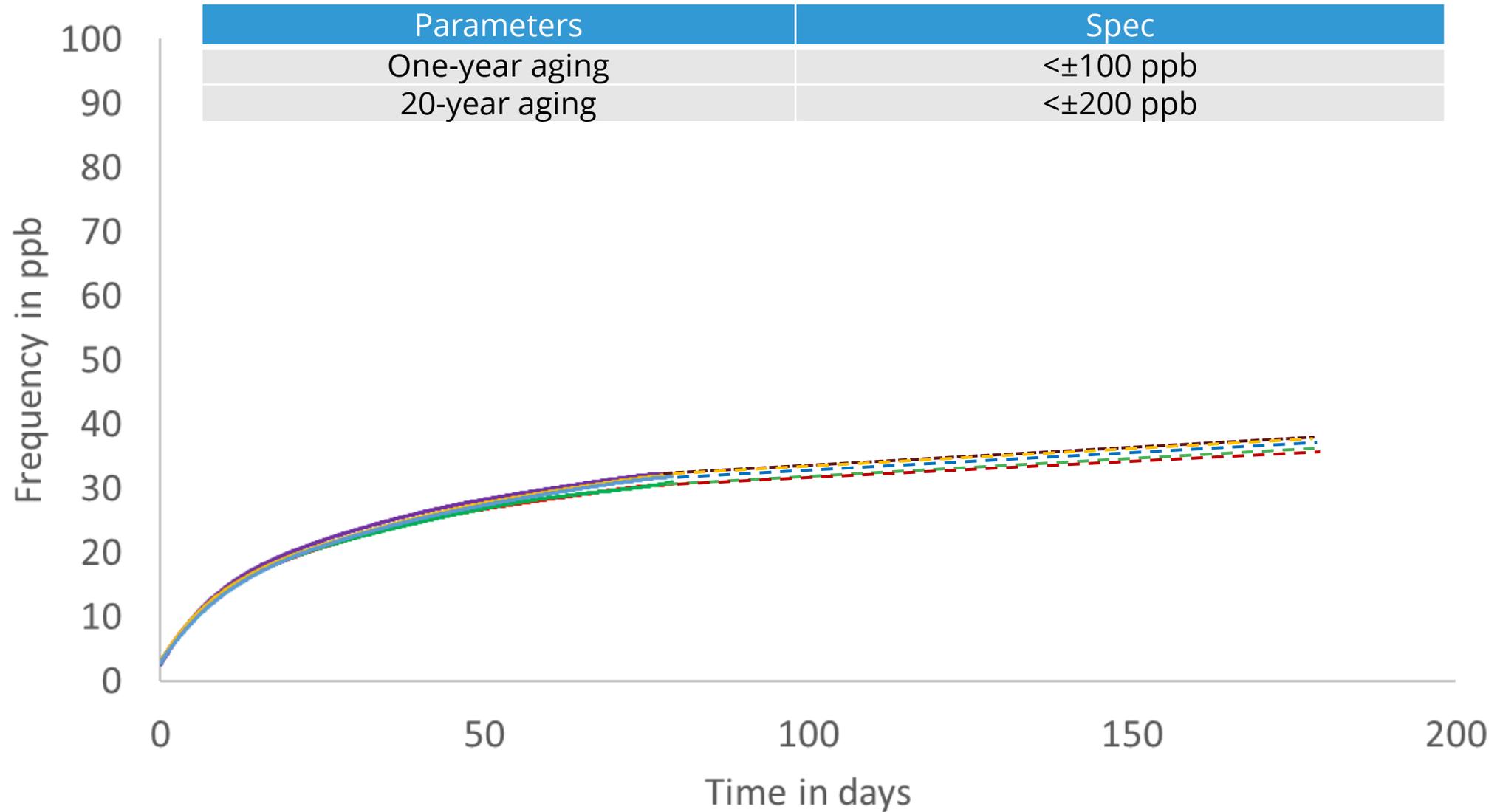
# DualMEMS has Consistent Frequency Slope Over Temp (dF/dT)



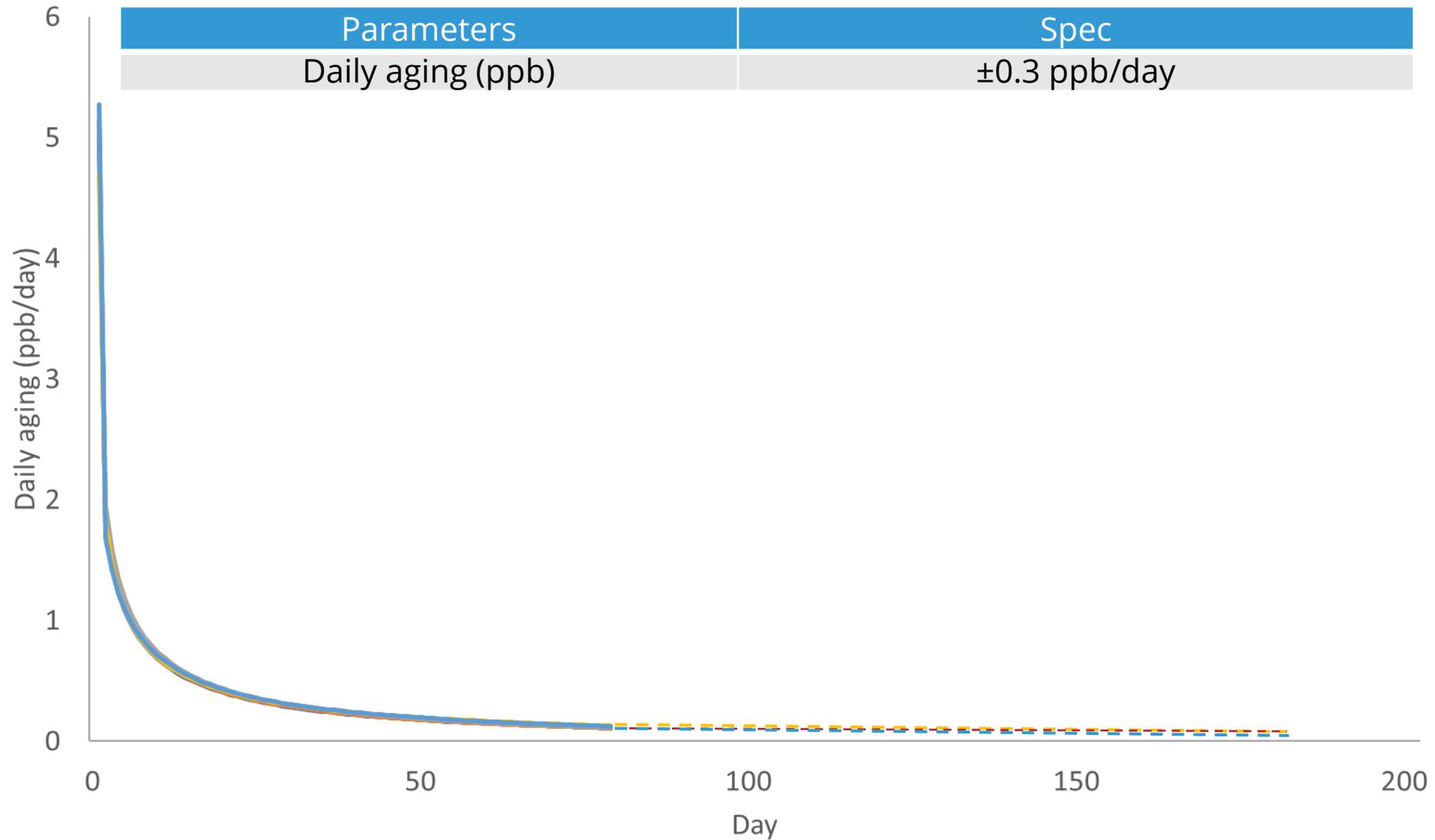
# DualMEMS Delivers Consistent ADEV



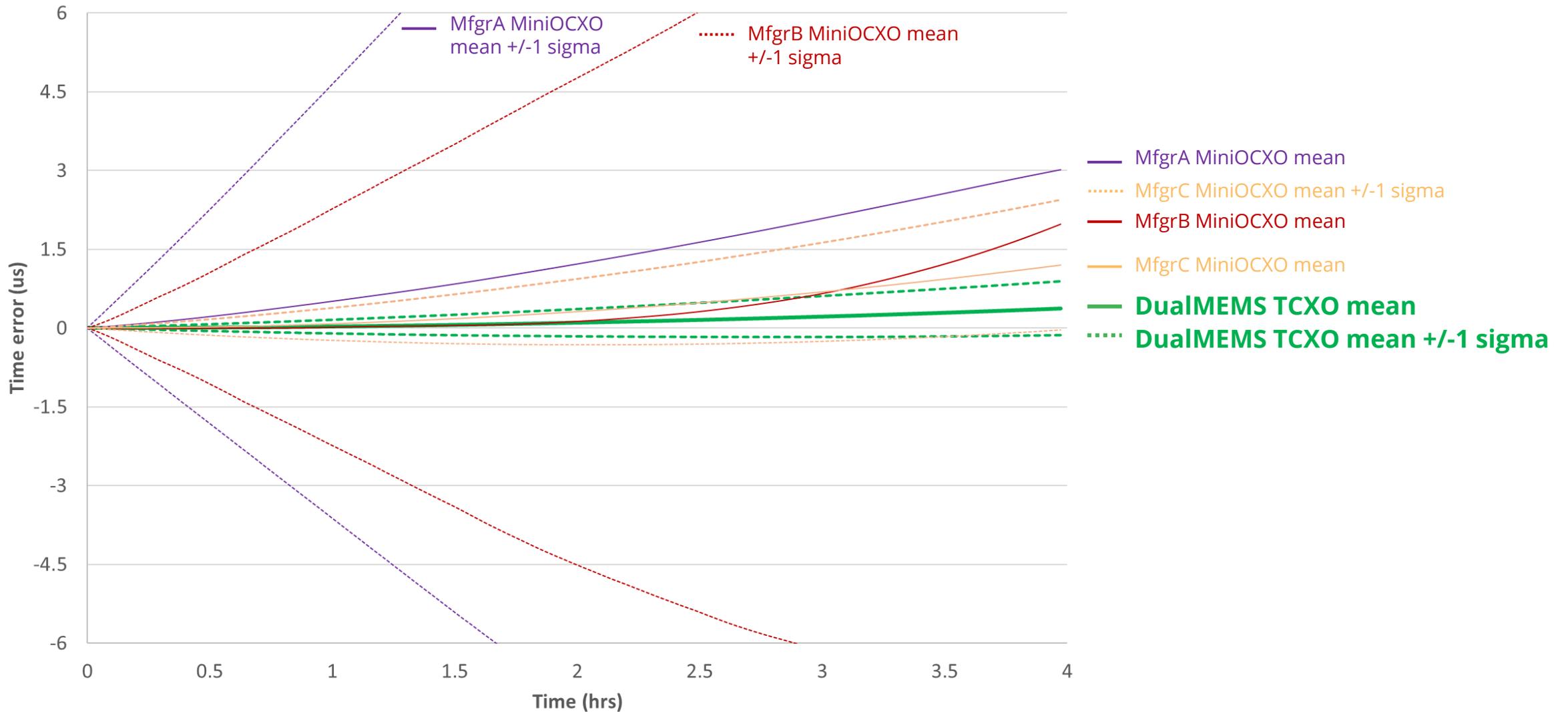
# DualMEMS has Excellent Aging Performance



# DualMEMS has Excellent Daily Aging Performance



# DualMEMS Enables Longer Holdover than MiniOCXOs



# Conclusions

- DualMEMS technology enables TCXO to exceed stability performance previously only achievable with OCXOs
- DualMEMS based TCXO ideally suited for synchronization applications
  - No heating elements
  - $\pm 5$  ppb,  $\pm 0.3$  ppb/°C from -40 to 105 °C
  - 110 mW power
  - 2 billion hour MTBF