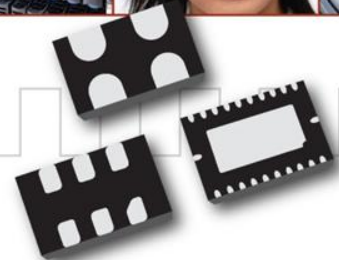




# Elite Platform™ – Transforming the Telecom and Networking Timing Market

September 2016



Confidential Until Sept 26, 2016

# Rich Timing Content in All Electronics

**Only SiTime can Provide Higher Performance, Smaller Size, Lower Power**



**#: 8 - 15**  
**\$6 - \$200**



**#: 4 - 20**  
**\$2 - \$50**



**#: 3 - 13**  
**\$1.5 - \$11.5**



**#: 20 - 40**  
**\$3 - \$10**



**#: 6 - 8**  
**\$3.5 - \$4**



**#: 3 - 5**  
**\$0.5 - \$1.5**



**#: 3 - 7**  
**\$0.5 - \$1.5**



**#: 3 - 7**  
**\$0.3 - \$1.0**

# SiTime - The Timing Leader



## \$6B Timing Market

Market CAGR – 5%  
MEMS CAGR – 65%



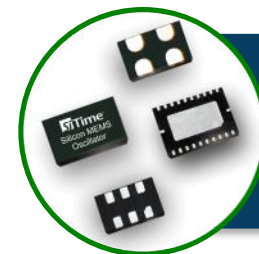
## Technology Leader

100 Patents – MEMS, Analog, Systems  
3-5 years ahead



## Market Leader

500 MU shipped, 1BU by 2018  
1000 Design Wins in 5 market segments  
90% share of MEMS timing



## Product Leader

Programmable – 200k part numbers  
Fabless advantage

# \$6 Billion Timing Market - Fragmented

## Frequency Control

X, XTAL  
XO, VCXO, TCXO, OCXO  
1 output

**\$3.5 B**

**Epson, Kyocera, 100 others**

- Quartz crystals
- Resonators, oscillators
- No analog expertise
- Large capex
- 20% GM

## Si Timing

CG, Buffer  
Multi-output

**\$1B**

**IDTI, SLAB, MSCC, TI,  
ADI, 15 others**

- Analog & PLLs
- Clock Generators, Buffers
- No freq. control expertise
- Low capex
- 60% GM

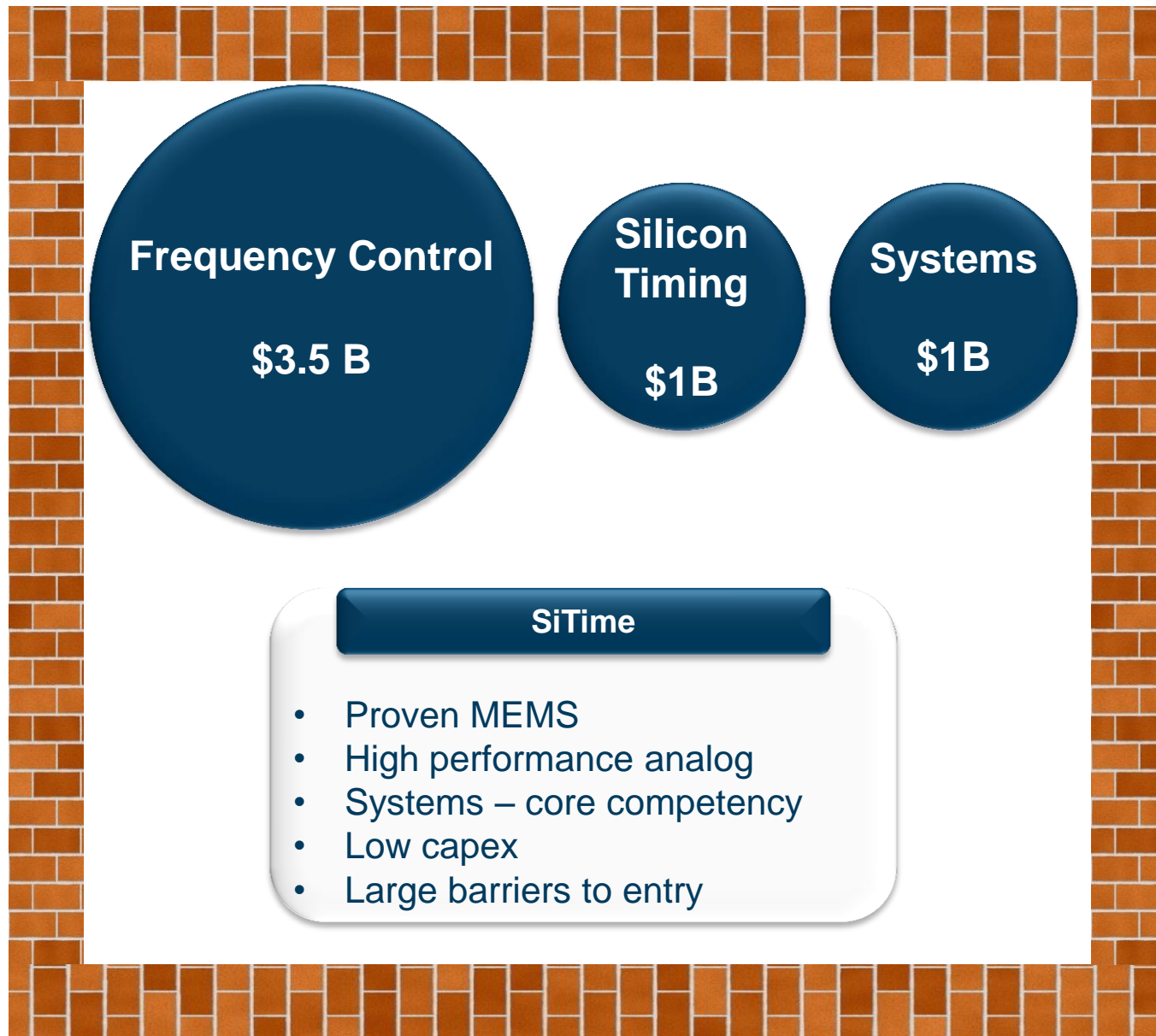
## Systems

**\$1B**

**MSCC,  
5 others**

- Modules, software
- Custom built
- 80% GM

# SiTime Unifies the \$6B Timing Market



# Typical Applications that use SiTime's MEMS Oscillators



**NSST**



**Industrial & Automotive**



**Consumer**



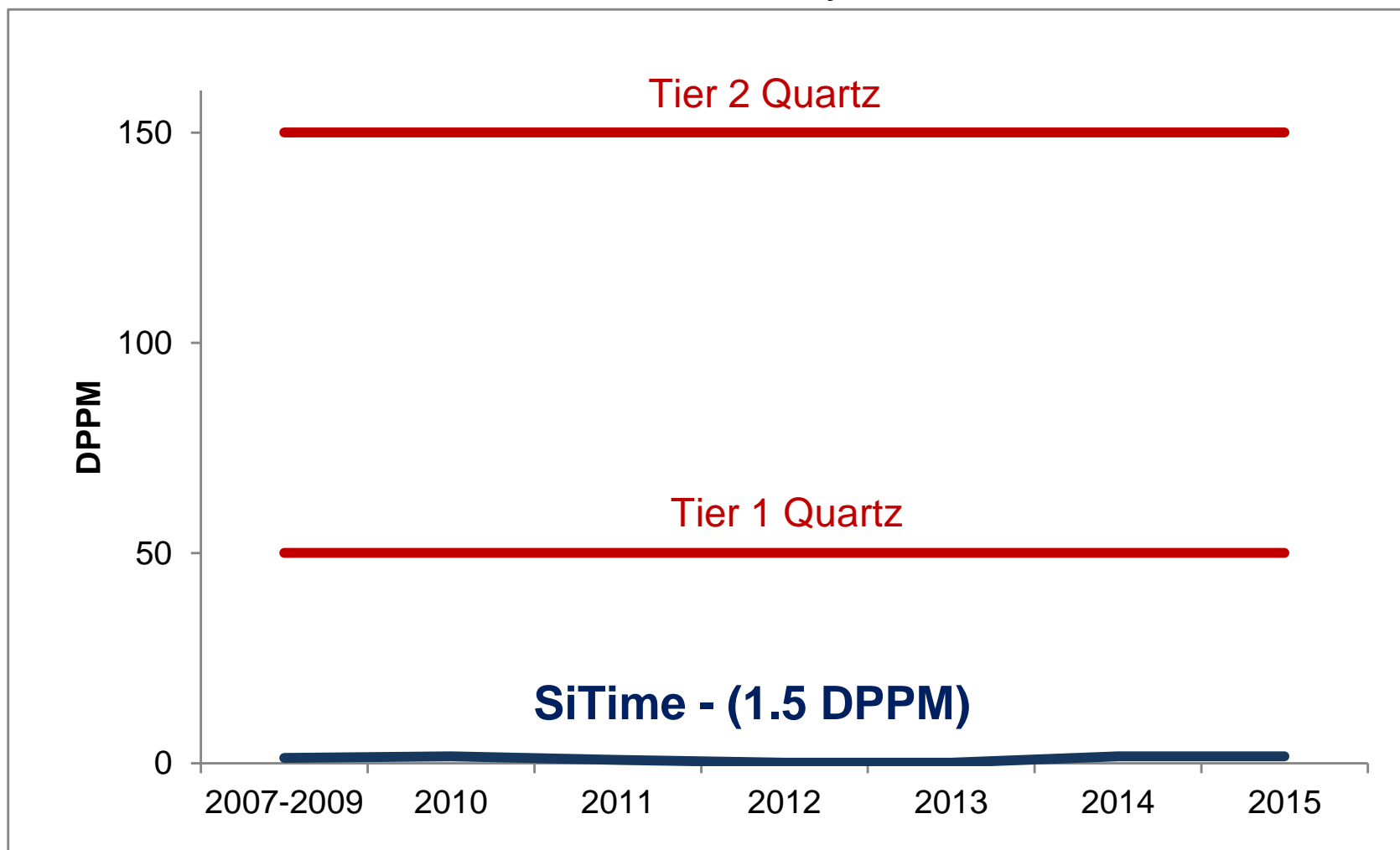
**Mobile, Wearables & IoT**

NSST: Networking, Server, Storage, Telecom

# SiTime – Best Quality Timing Solutions



SiTime – 500 Million Units Shipped  
Zero MEMS Field Failures  
Lifetime Warranty

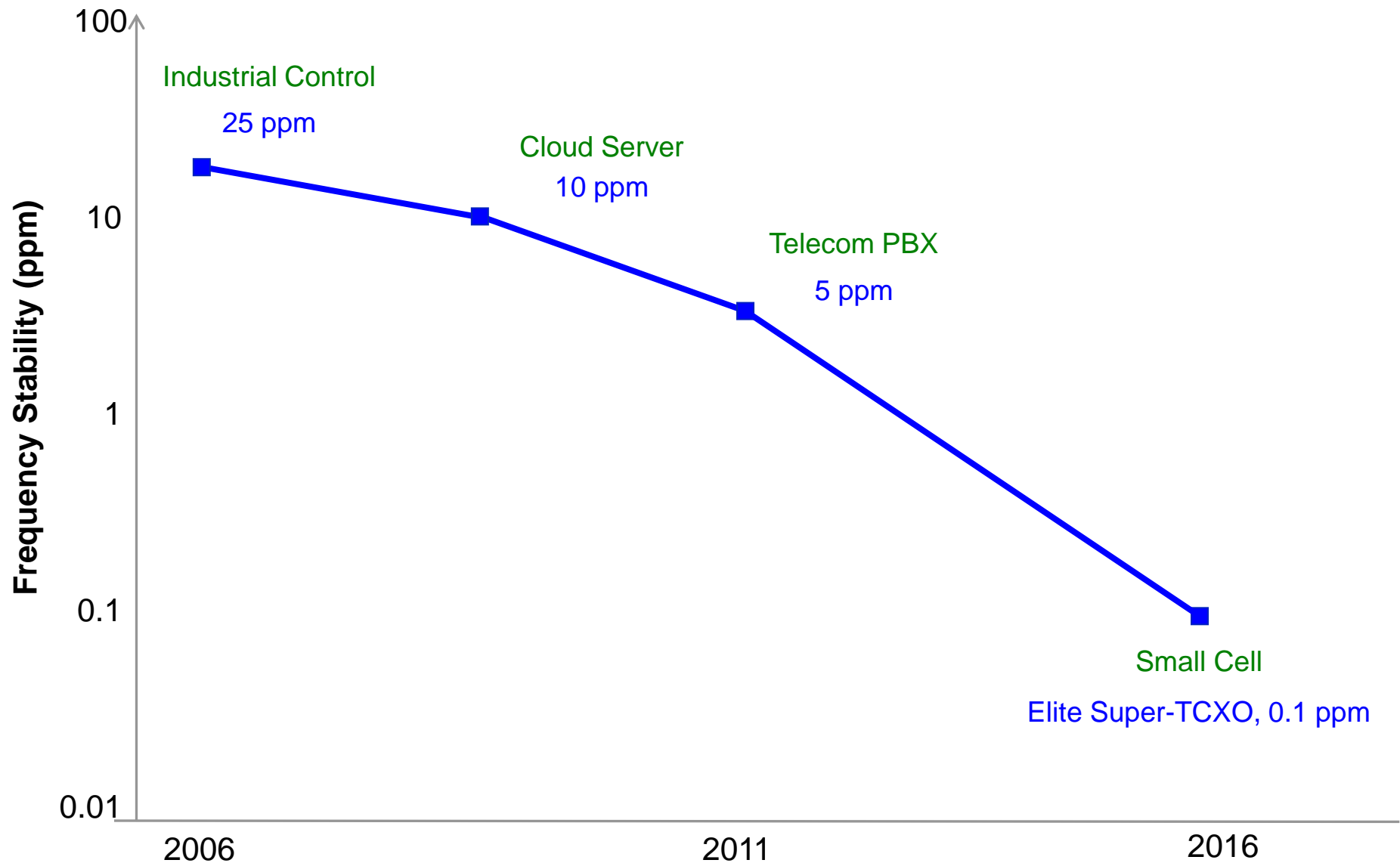


Source: SiTime & customers

Lower DPPM is Better

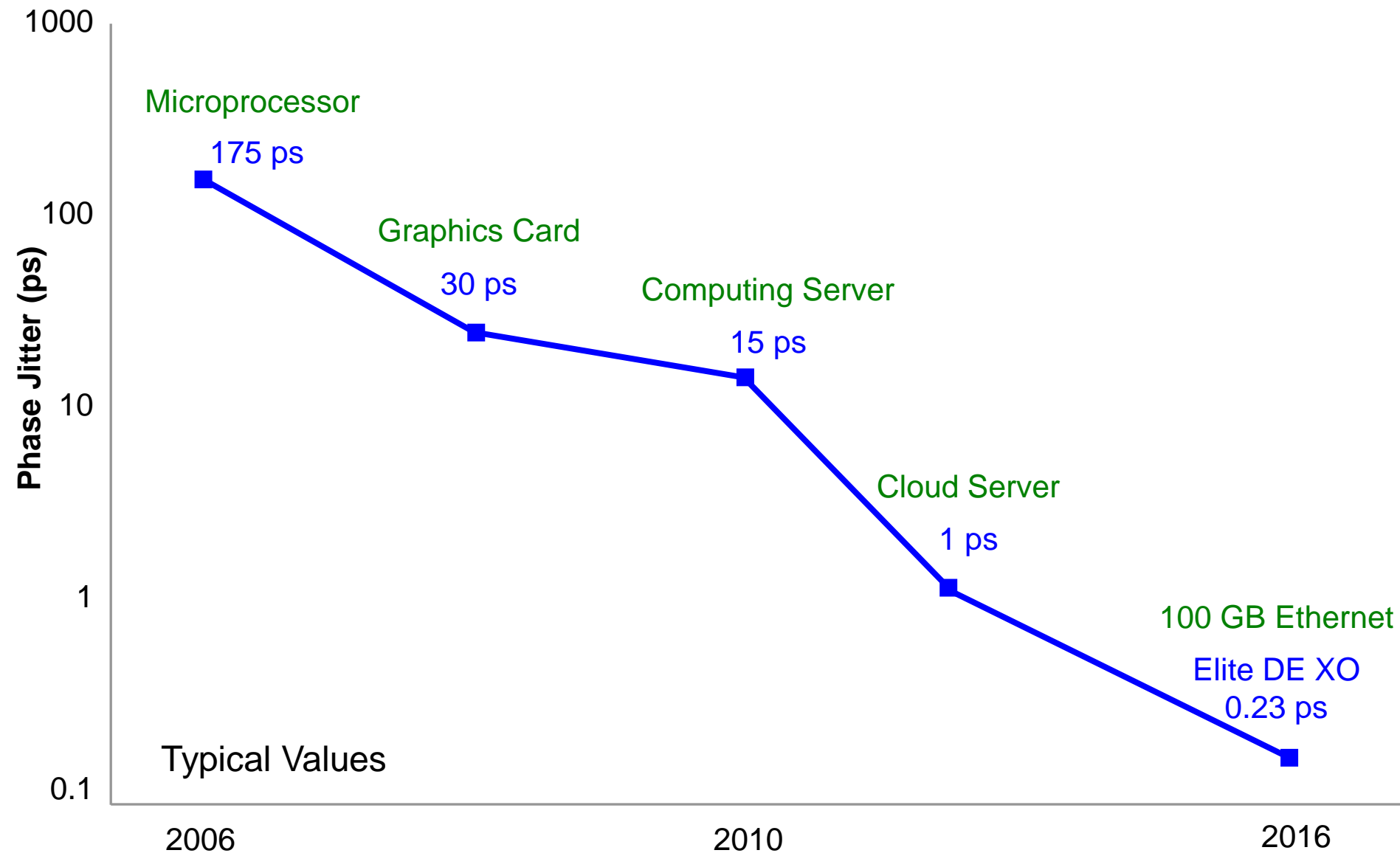


# Semiconductor Expertise Drives 250x Stability Improvement in 10 Years

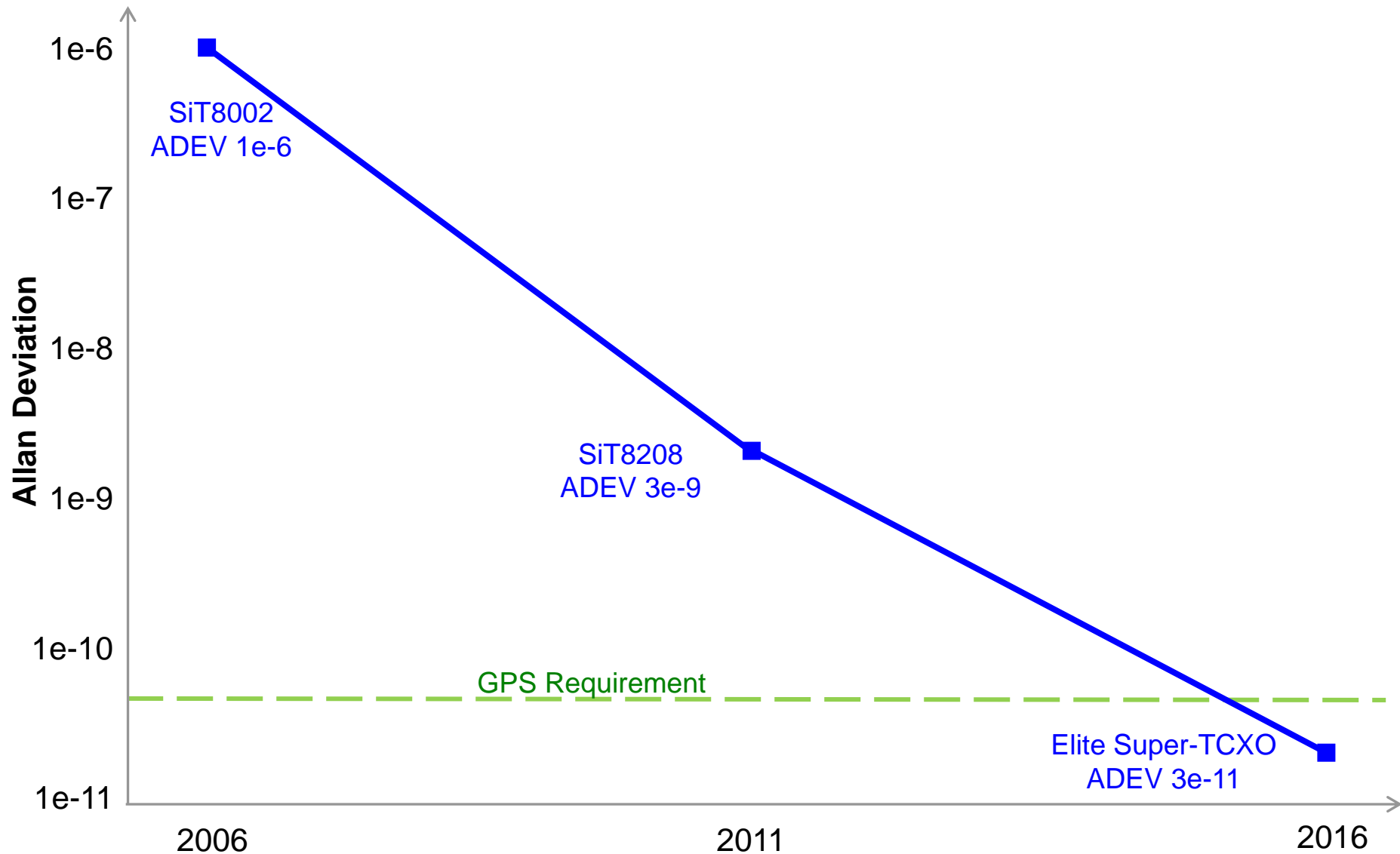




# Semiconductor Expertise Drives 800x Jitter Improvements in 10 Years



# Allan Deviation for Wireless Infrastructure – 30,000x Improvement in 10 Years



**Highest Performance, Best Reliability, Smallest, Lowest Power**



# Elite Platform™

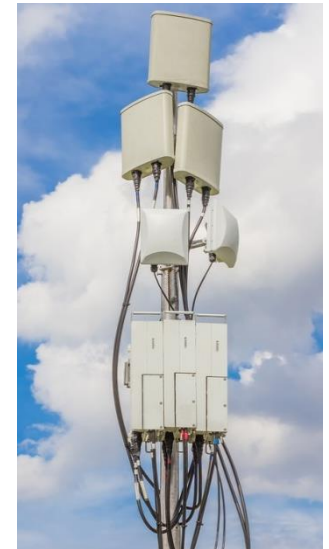
## Super-TCXOs and Oscillators



# MEMS Solutions to Long-Standing Timing Problems in Telecom and Networking

# Network Densification Requires Innovation in Timing Technology

- NSST<sup>[1]</sup> – much higher performance, denser deployment, harsher environment
- Quartz crystal technology suffers in real world conditions<sup>[2]</sup>
- **Dynamic timing performance** is crucial in NSST
  - Maintain performance in airflow, rapid temperature change
  - Vibration immunity for pole-mount / curbside deployment
  - Support 105°C for outdoor environments
  - Minimize impact of EMI and other noise sources



1. NSST – Networking, Server, Storage, Telecom

2. Tim Pearson, Sprint and Tim Frost, Calnex Solutions, “[Providing Reliable, Accurate Time for Mobile Networks](http://www.atis.org/wsts/docs/2014/3-3_Sprint-Calnex_Pearson-Frost_TimeforMobileNetworks.pdf)”, slides 11 and 25, presented at WSTS 2014. [http://www.atis.org/wsts/docs/2014/3-3\\_Sprint-Calnex\\_Pearson-Frost\\_TimeforMobileNetworks.pdf](http://www.atis.org/wsts/docs/2014/3-3_Sprint-Calnex_Pearson-Frost_TimeforMobileNetworks.pdf)

# Elite Platform Uniquely Delivers Best Timing Under Real World Conditions



## Best Stability

- Temperature range
- Temperature ramp
- No activity dips
- Freq. slope over temperature
- VDD / Load

## Best Short Term Stability

- ADEV
- Wander (MTIE / TDEV)
- Static and in airflow

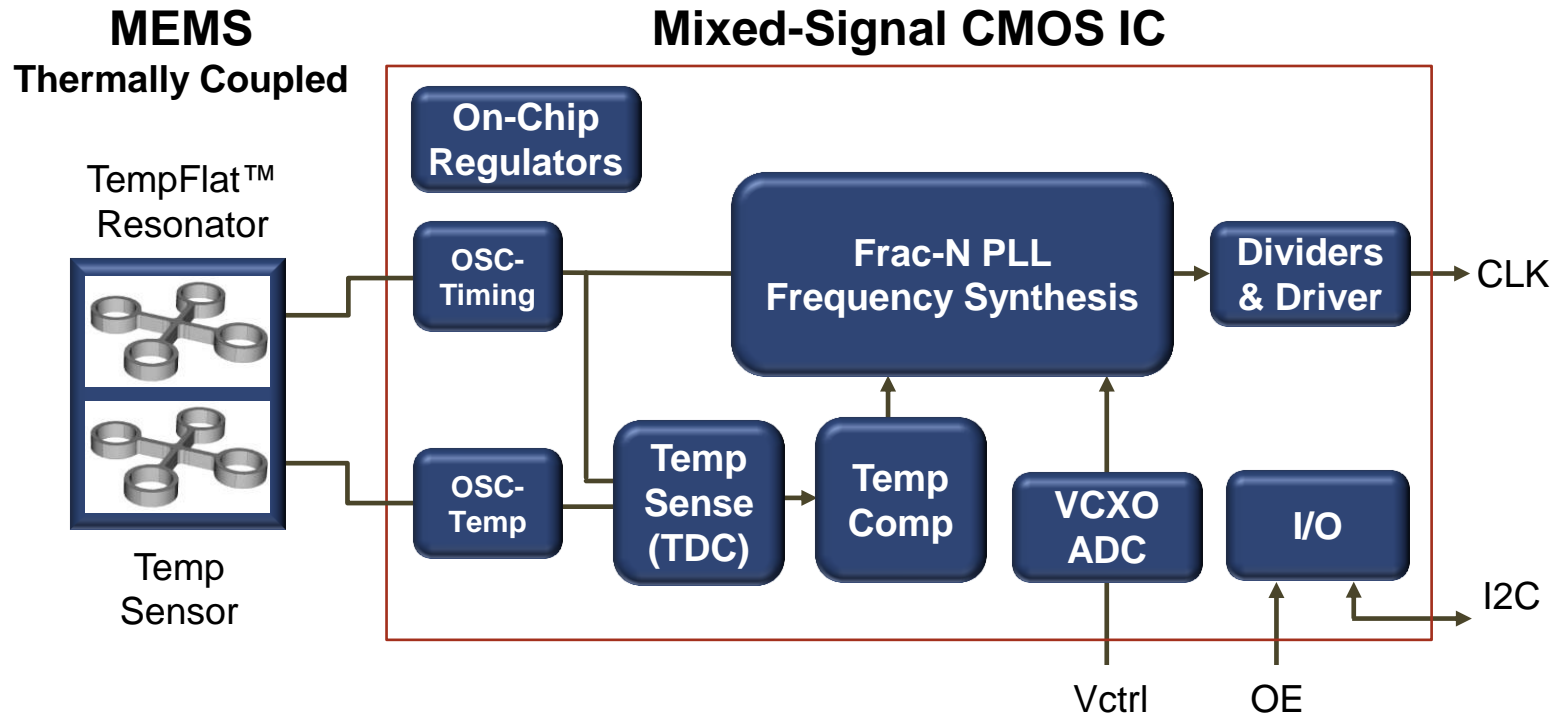
## Best Robustness

- Vibration
- Shock
- PSNR

## Rich Feature Set

- Frequency range
- Differential output
- Digital frequency control

# DualMEMS™ with TurboCompensation™ Enables Highest Dynamic Performance



## TempFlat™ MEMS Resonator

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

## DualMEMS™ Temp Sensing 100% Thermal Coupling

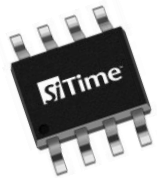
- 30  $\mu$ K, 10x more accurate
- 350 Hz tracking, 40x faster
- Airflow, temp ramp resistant

## Low Noise CMOS Enabling Frequency Agility

- 1 to 700 MHz, steps in mHz
- 0.02 ps/mv PSNR, 5x better
- In-system programmability



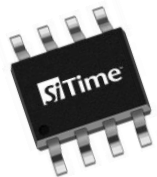
# Elite Platform Based MEMS Timing Solutions for Infrastructure



## ➤ Precision MEMS Super-TCXO

- ❑ 1 to 220 MHz,  $\pm 0.1$  ppm, Stratum 3, +105°C
- ❑ Resilient to rapid temp change or airflow

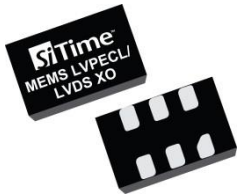
Samples  
1H 2017



## ➤ MEMS Super-TCXO

- ❑ 1 to 220 MHz,  $\pm 0.5$ -2.5 ppm, +105°C
- ❑ No activity dips

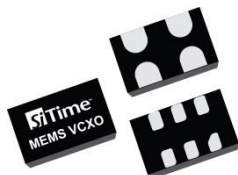
Samples  
1H 2017



## ➤ Ultra-low jitter differential MEMS Oscillator

- ❑ 10 to 700 MHz,  $\pm 10$  ppm, 0.23 ps jitter, +95°C
- ❑ 0.02 ps/mv PSNR, 3.2 x 2.5 mm package

Engg.  
Samples  
Now



## ➤ High Temp, high reliability MEMS VCXO

- ❑ 1 to 700 MHz, +105°C,  $\pm 25$  to  $\pm 3600$  ppm pull range
- ❑ 0.1 ppb/g vibration resistance

Engg.  
Samples  
Now

# Elite Addresses High Precision Timing Demand in Infrastructure Markets



SyncE, Optical



Small Cell



Basestation



CMTS and Video



Smart Grid



Cloud Servers



Industrial GPS

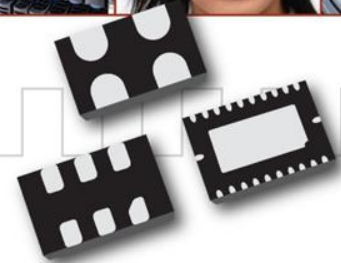


Instrumentation



## Elite Platform Video

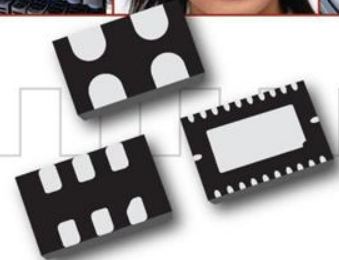
September 2016





## Elite Platform Use Cases

September 2016

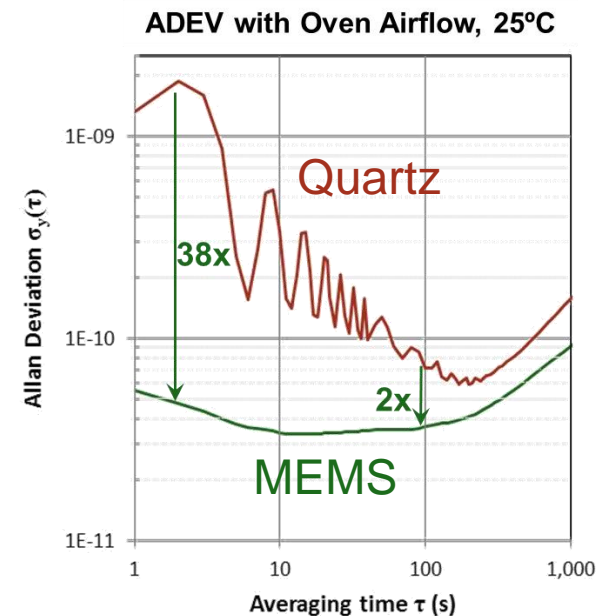
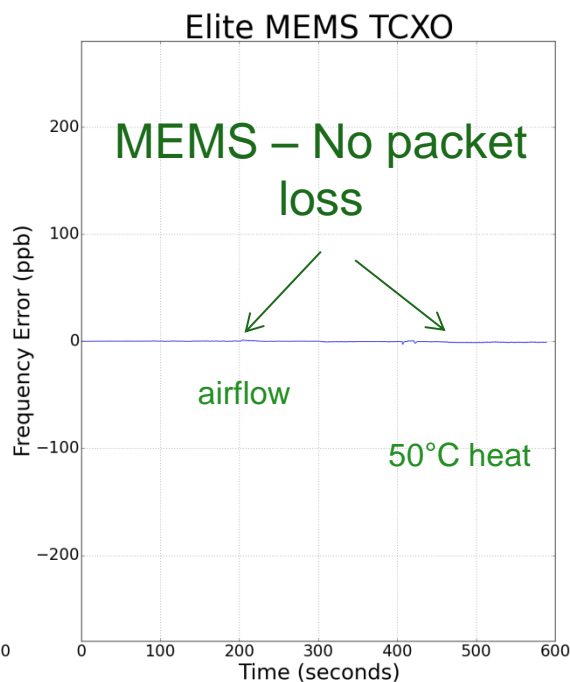
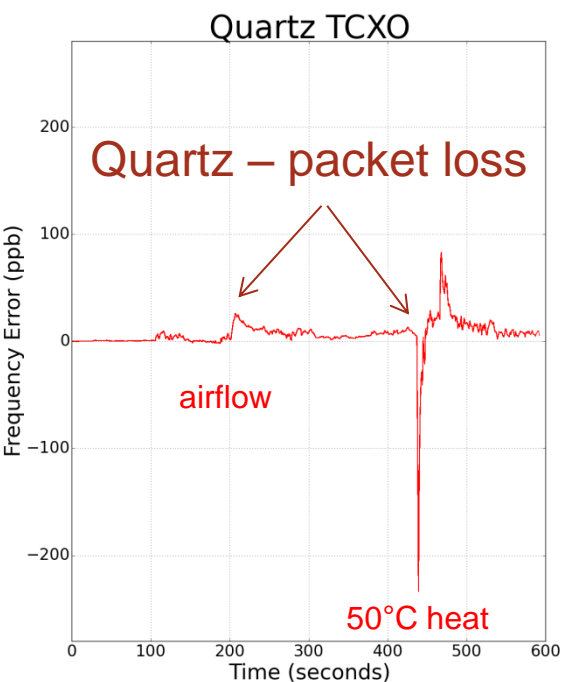


# Elite's Superior Air Flow Immunity Ensures Data Link Robustness

## Core Router Cooling



- Problem: Quartz air flow sensitivity causes data link and packet loss
- Solution: Elite MEMS air flow immunity ensures robust data link and throughput
- Specification: ADEV, up to 38x better





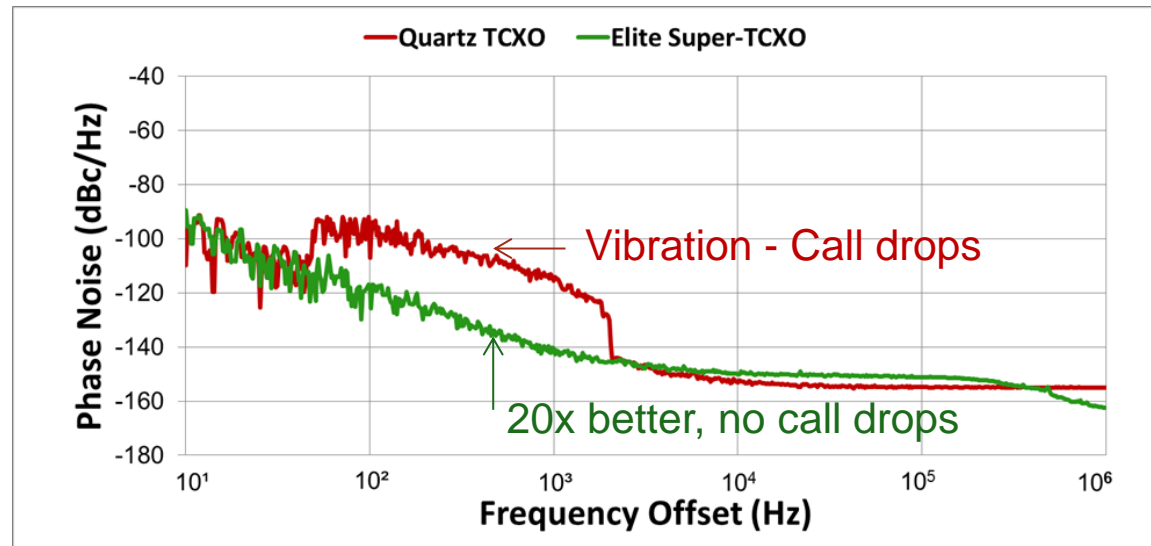
# Elite's Best Vibration Immunity Improves Mobile Quality of Service



## Small Cell



- Problem: Quartz vibration sensitivity causes call drops and loss of data link
- Solution: MEMS vibration immunity enhances QoS (no call drop or link loss)

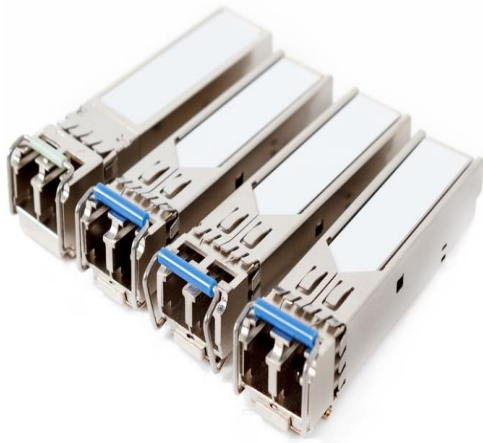


MIL-STD-883F Method 2026, freq. range 15 Hz to 2 kHz, total vibration intensity 7.5 g rms

# Elite's Dynamic Stability Enables Smaller, Lower Power IEEE1588 Systems

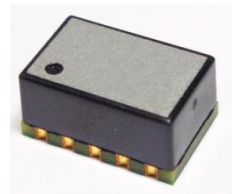


## Small Form Factor IEEE1588 Grandmaster



- Problem: 1 ppb/°C spec for IEEE1588, OCXO required
  - Power hungry
  - Large size
- Solution: Elite Super-TCXO, 1 ppb/°C
  - 70% lower power
  - 50% smaller

±20 ppb Quartz OCXO  
1 ppb/°C  $\Delta F/\Delta T$



9 mm x 7 mm

±100 ppb Elite Super-TCXO  
1 ppb/°C  $\Delta F/\Delta T$



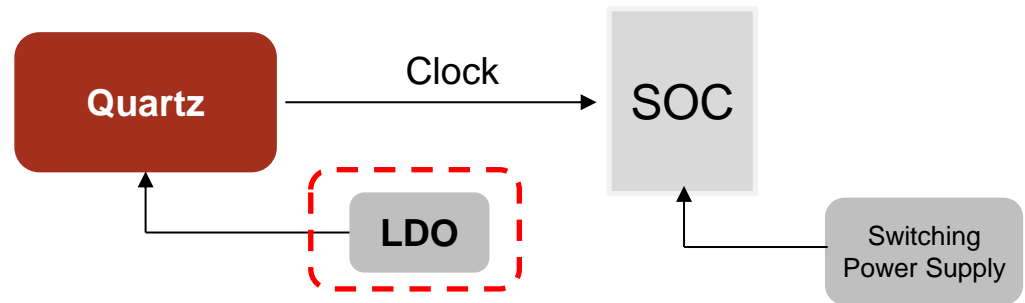
6 mm x 4.9 mm



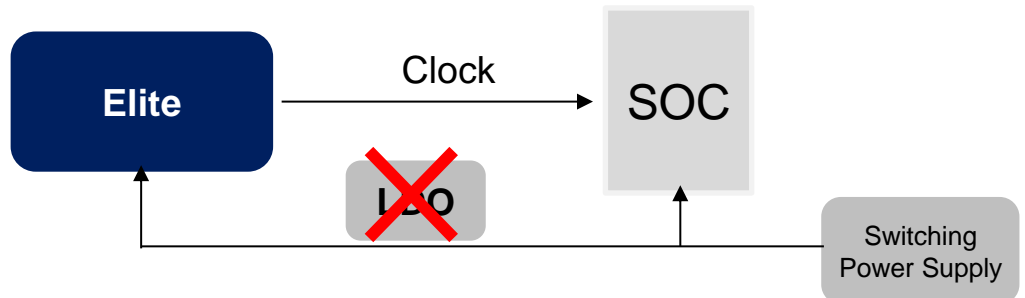
# Elite's Exceptional PSNR Eliminates LDO

- Problem: Quartz accuracy prone to power supply noise, requiring dedicated LDO

## High Performance Switch



- Solution: Elite – no LDO required
  - 0.2 - 0.02 ps/mv PSNR
  - Accurate clock with low cost switching power supply

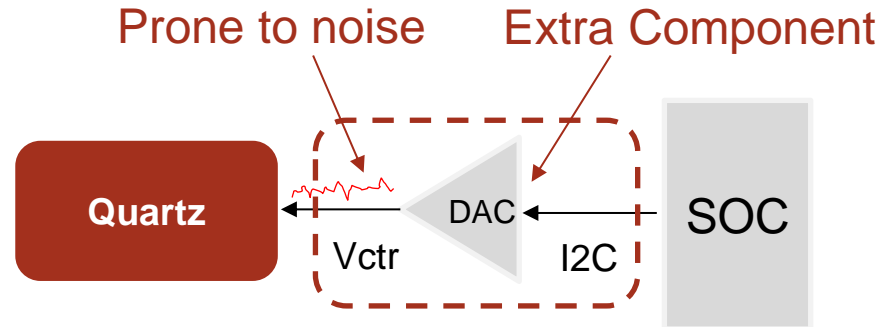


# Elite's In-system Programmability Improves System BOM, Noise Immunity

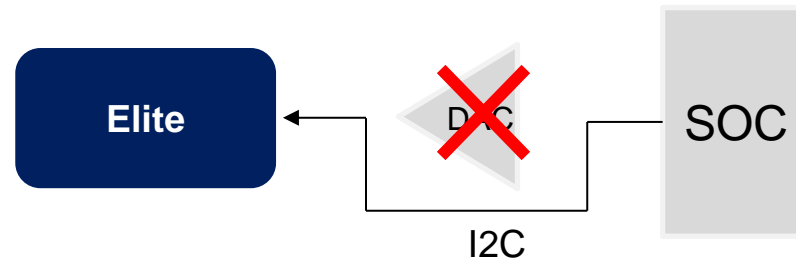
## Small Cell System With Frequency Tuning



- Problem: Legacy designs require a DAC



- Solution: Elite MEMS
  - Eliminate DAC with I2C
  - Immune to board noise with digital control



# Additional Performance Advantages

Specification	Elite Super-TCXO	Quartz TCXO
Frequency Stability vs. VDD	< 10 ppb for $\pm 10\%$	10 ppb for $\pm 1\%$
Frequency Stability vs. Load	< 5 ppb for $\pm 2$ pF	10 ppb for 1.5 pF
$\Delta F/\Delta T$ (Frequency vs. Temp. Slope)	1-5 ppb/ $^{\circ}\text{C}$	10 ppb/ $^{\circ}\text{C}$
PSNR	SE: 0.2 ps/mV DE: 0.02 ps/mV	SE: 0.4 ps/mV DE: Not known
f-vs-Vctrl Linearity (VC-TCXO)	0.1%	5%
Vctrl Tuning Effect (f-vs-Temp Degradation Across Vctrl Values)	10 ppb	200 to 2000 ppb (VCTCXO)

# Elite Offers the Best Features



Specification	Elite	Quartz
Frequency Range	SE: 1 - 220 MHz DE: 10 - 700 MHz Programmable	SE: 10 - 52 MHz DE: 10 - 200 MHz Fixed frequencies
Differential Outputs	LVPECL / LVDS / HCSL	LVPECL
Single-Ended Outputs	LVC MOS and Clipped-Sine Programmable	LVC MOS and Clipped-Sine Fixed
Temperature Readout	Yes	No
High Resolution Digital Frequency control	I2C	I2C
Programmable Rise / Fall Time (LVC MOS) for Lower EMI	Yes	No
Frequency Select	Yes	No

# Elite's Industry Firsts - Solve Deep-Rooted Timing Challenges in Telecom / Networking



**30x Higher Dynamic Performance  
No Activity Dips**

Best performance under airflow, rapid temperature change

**10x Better Dynamic Stability,  
1ppb/°C  $\Delta F/\Delta T$**

Replace OCXO in IEEE1588  
66% lower power, 50% smaller

**30x greater vibration resistance  
0.1 ppb/g**

Ensure continuous operation in high vibration environment

**-40 to 105 °C Operation  
 $\pm 100$  ppb stability**

Uniquely enables fanless outdoor equipment

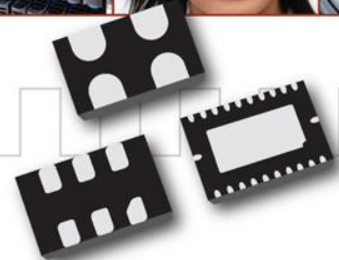
**Stratum 3 with  
In-system Programmability**

Improve system BOM, multi-protocol support and noise immunity



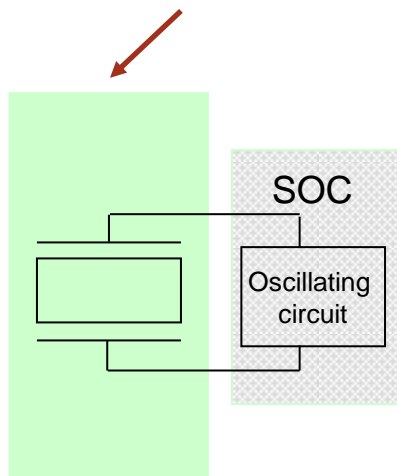
# Types of Timing Devices

Additional Information



# Resonator, Oscillator and Clock Generator

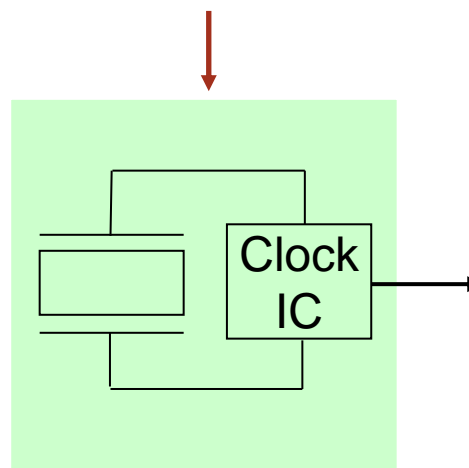
## Resonator or Crystal (X, XTAL)



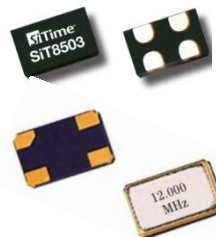
Passive device  
Need ext. oscillating circuit  
2 terminals used



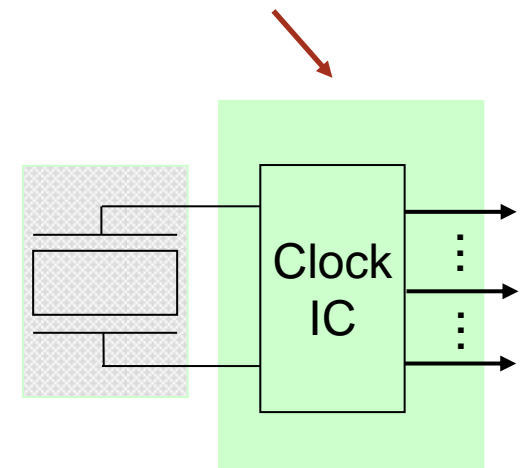
## Oscillator (XO, TCXO, VCXO, ....)



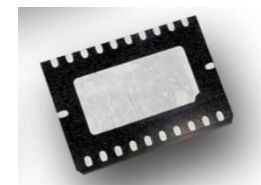
Active device  
2 chips in pkg.  
4, 6, 10 terminals



## Clock Generator (CG)



Active IC  
Need ext. clock reference  
Many terminals / outputs





# Frequency Control – Types of Products

Product Type	kHz or MHz	Stability (PPM)	Market Price	SiTime
XTAL (Resonator)	Both	20 – 100	\$	√~
XO / SPXO (Oscillator)	Both	10 – 100	\$ - \$\$	√
VCXO (Voltage Controlled Oscillator)	MHz	10 – 100	\$ - \$\$\$	√
Mobile TCXO (Temperature Compensated Oscillator)	MHz	0.5 – 2.5	\$ - \$\$	√~
Infrastructure TCXO (Temperature Compensated Oscillator)	MHz	0.28 – 10	\$\$\$\$	√
Super-TCXO (TCXO with best dynamic stability)	Both	0.1 – 5	\$\$ - \$\$\$\$	√
OCXO (Oven Controlled Oscillator)	MHz	0.001 to 0.05	\$\$\$\$\$	√~

- Stability / Accuracy – Lower PPM is Better
- √~ – Future Product

# Oscillator Type – End Applications

Oscillator Type	Special Function	End Applications
XO or SPXO	N/A	Everywhere a clock is needed (consumer, industrial, etc.)
VCXO	Output fine-tuned by up to 3600ppm	Clock synchronization in Telecom, Broadband, Video & Instrumentation
Mobile TCXO	N/A	Mobile phone, tablet, data cards, wearables
Super VCTCXO / TCXO	Dynamic performance	High performance equipment (Networking, small cell, industrial GPS, Satellite, SyncE, Microwave backhaul)
OCXO	Oven-controlled, ultra low noise	High performance equipment (Networking, small cell, industrial GPS, Satellite, IEEE1588, SONET)
SSXO	Spread %	Reduce EMI in system – industrial, Office automation, Consumer
DCXO	Digital control	Replaces VCXO, control via I2C / SPI
FSXO	Pin-selectable Frequency	Low volume, high mix, BOM reduction
ISPXO	I2C/SPI programmable	Prototyping, Low volume, high mix