SiTime University Turbo Seminar Series

December 2012
Reliability & Resilience

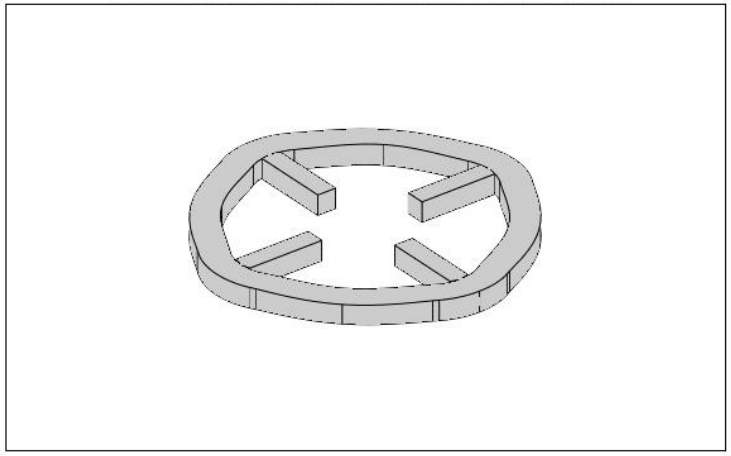
The Smart Timing Choice™

Agenda

- SiTime's Silicon MEMS Oscillator Construction
  - Built for High-Volume Mass Production
- Best Electro-Magnetic Susceptibility (EMS) Performance
- Best Power-Supply Noise Rejection
- Best Resistance to Shock and Vibration
- World Class Reliability

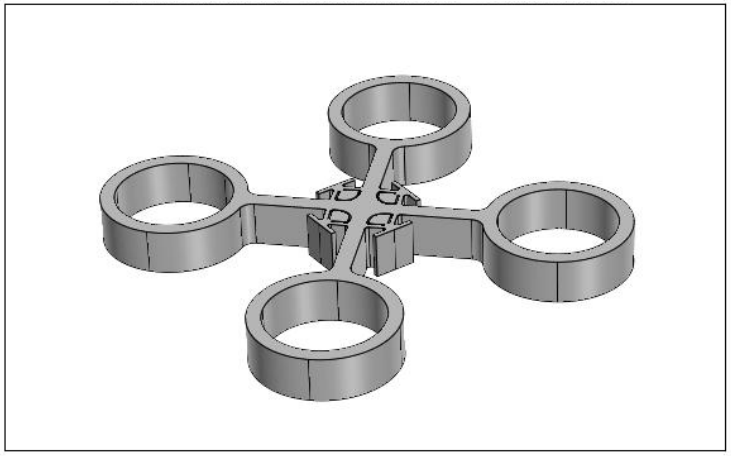
MEMS Resonators For All Clocking

5 MHz Resonator



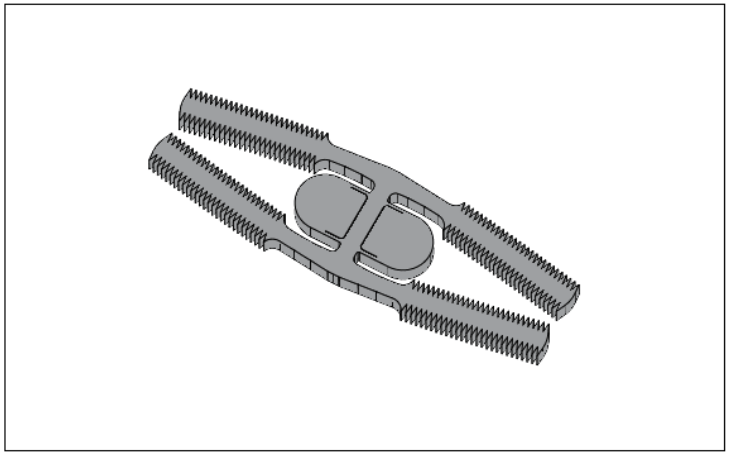
- 5MHz resonator
- In production since 2007

48 MHz Resonator



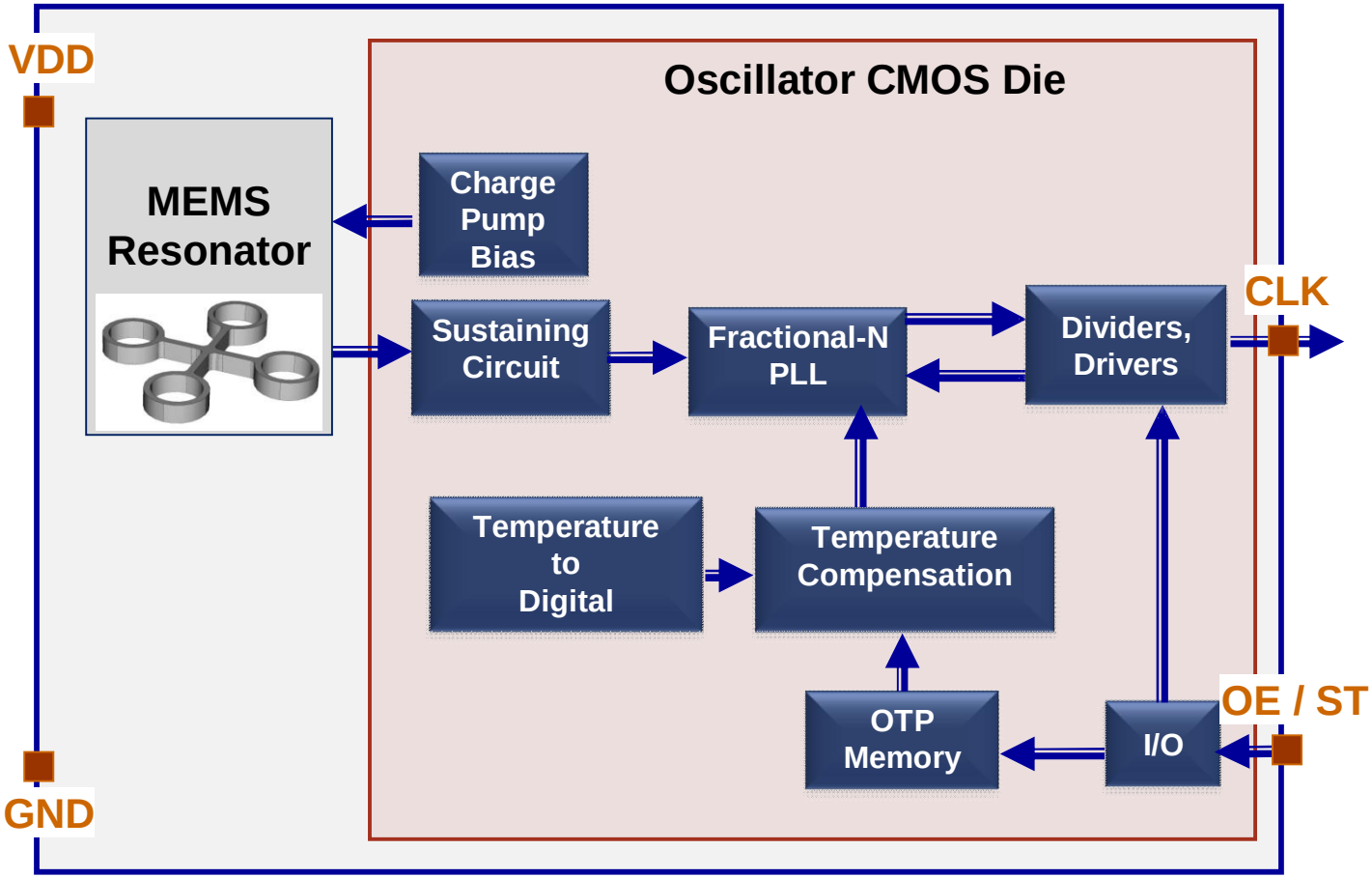
- <1ps phase jitter
- In production since 2011

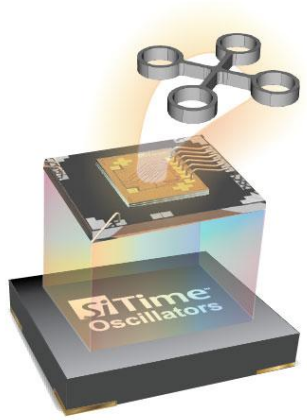
524 kHz Resonator



- For timekeeping, RTC
- In production since 2010

SiTime's MEMS Oscillator has the Most Flexible System Architecture





Stacked Die Plastic Package

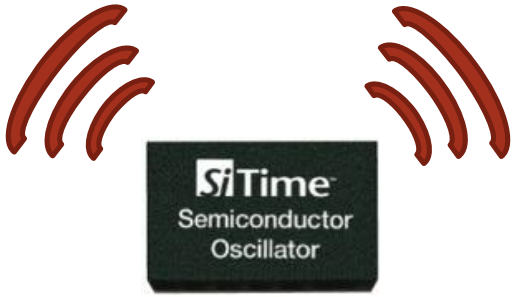
Resilience Performance

Best
Electro-Magnetic Susceptibility
(EMS)
Performance

EMS vs EMI

We are analyzing the oscillator's susceptibility to electro-magnetic radiated fields (EMS)

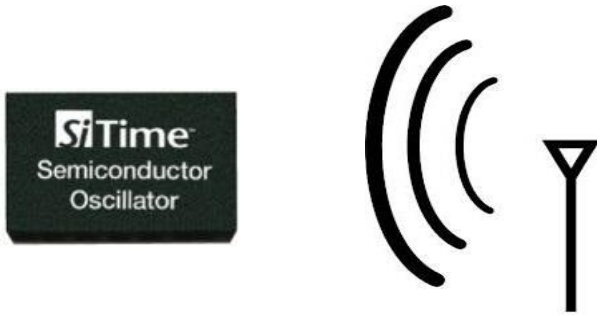
EM-Field Produced by Component



EMI

Electro-Magnetic Interference

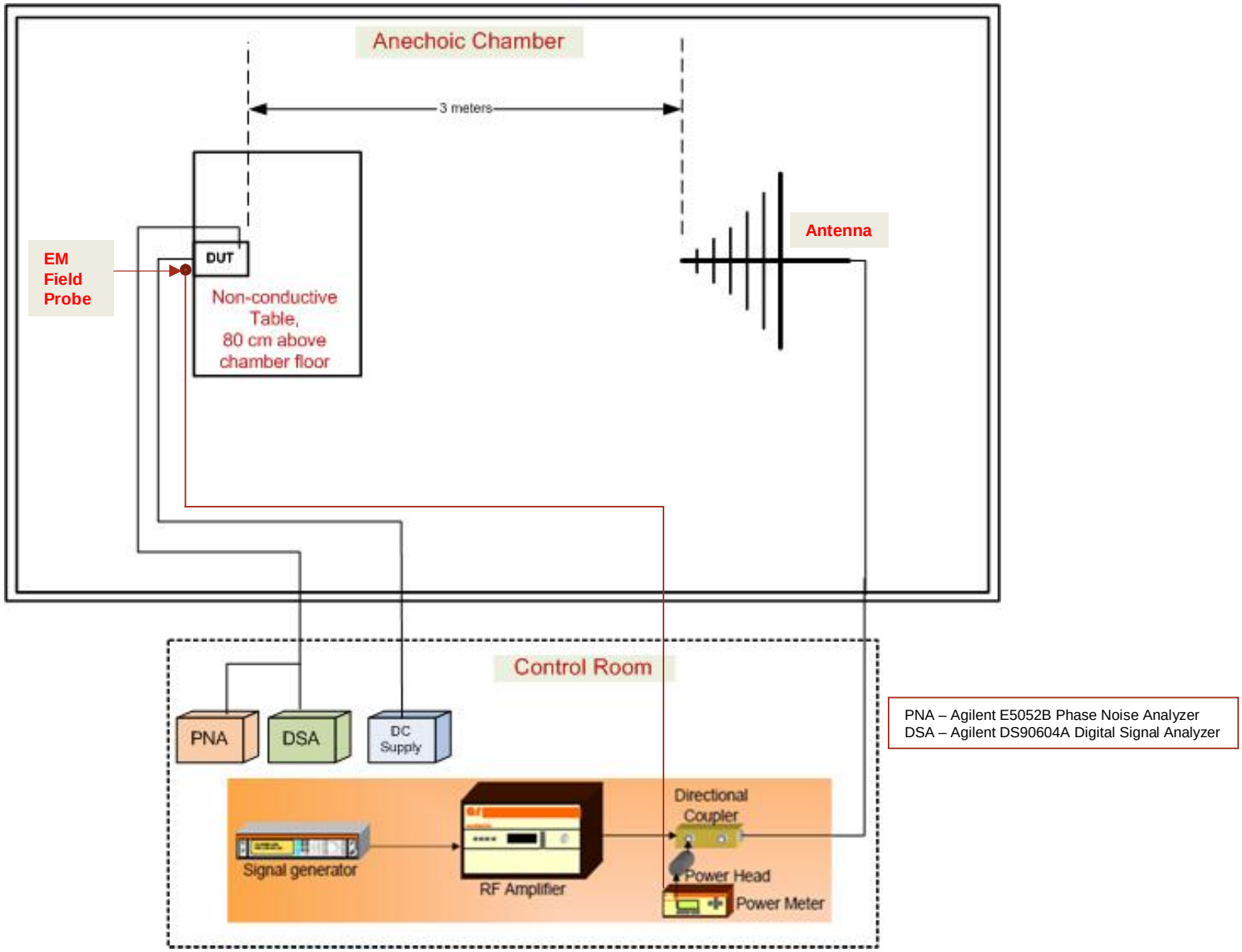
Radiated EM-Field from External Sources (Other ICs, modules, etc.)



EMS

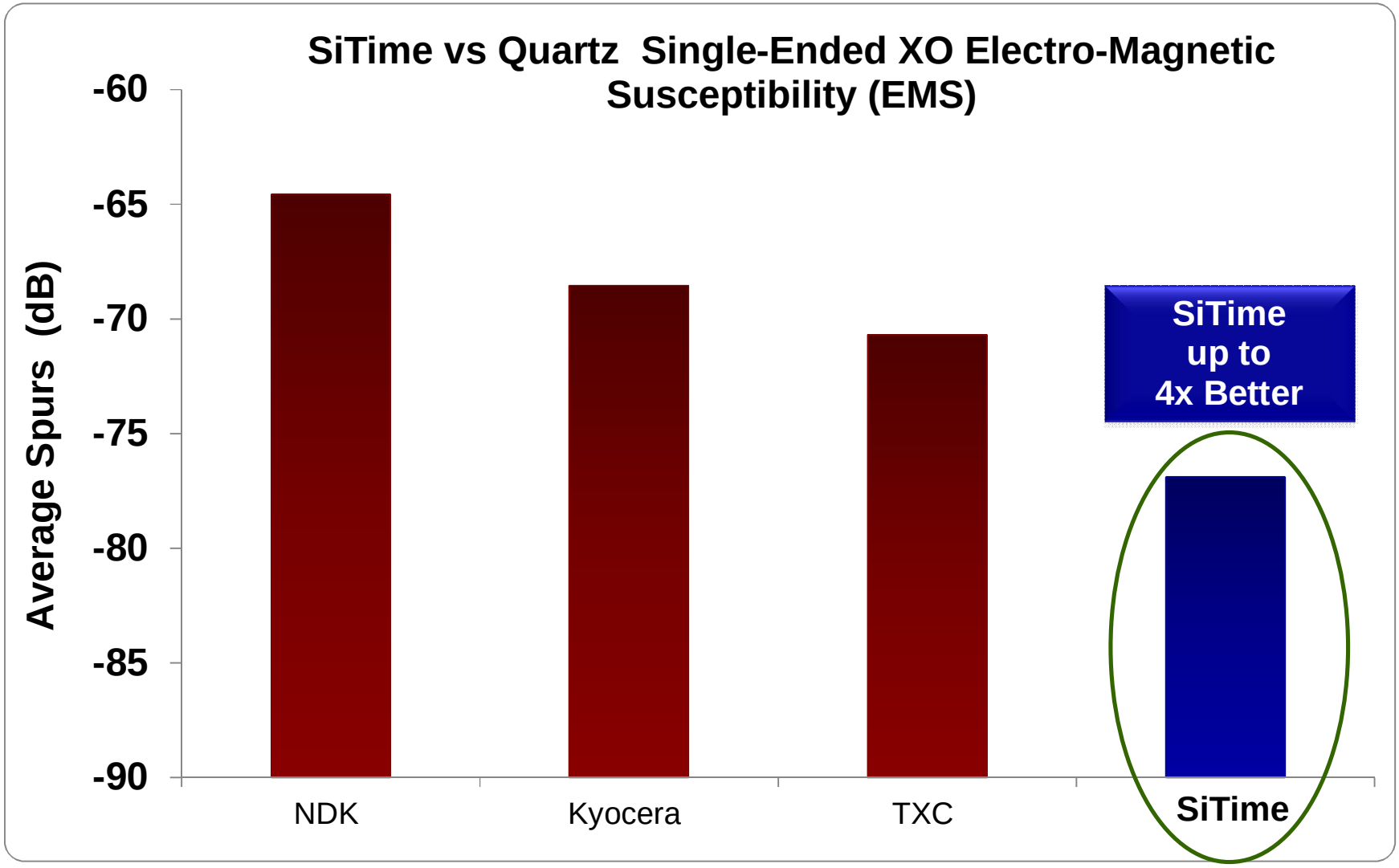
Electro-Magnetic Susceptibility

EMS Test Setup

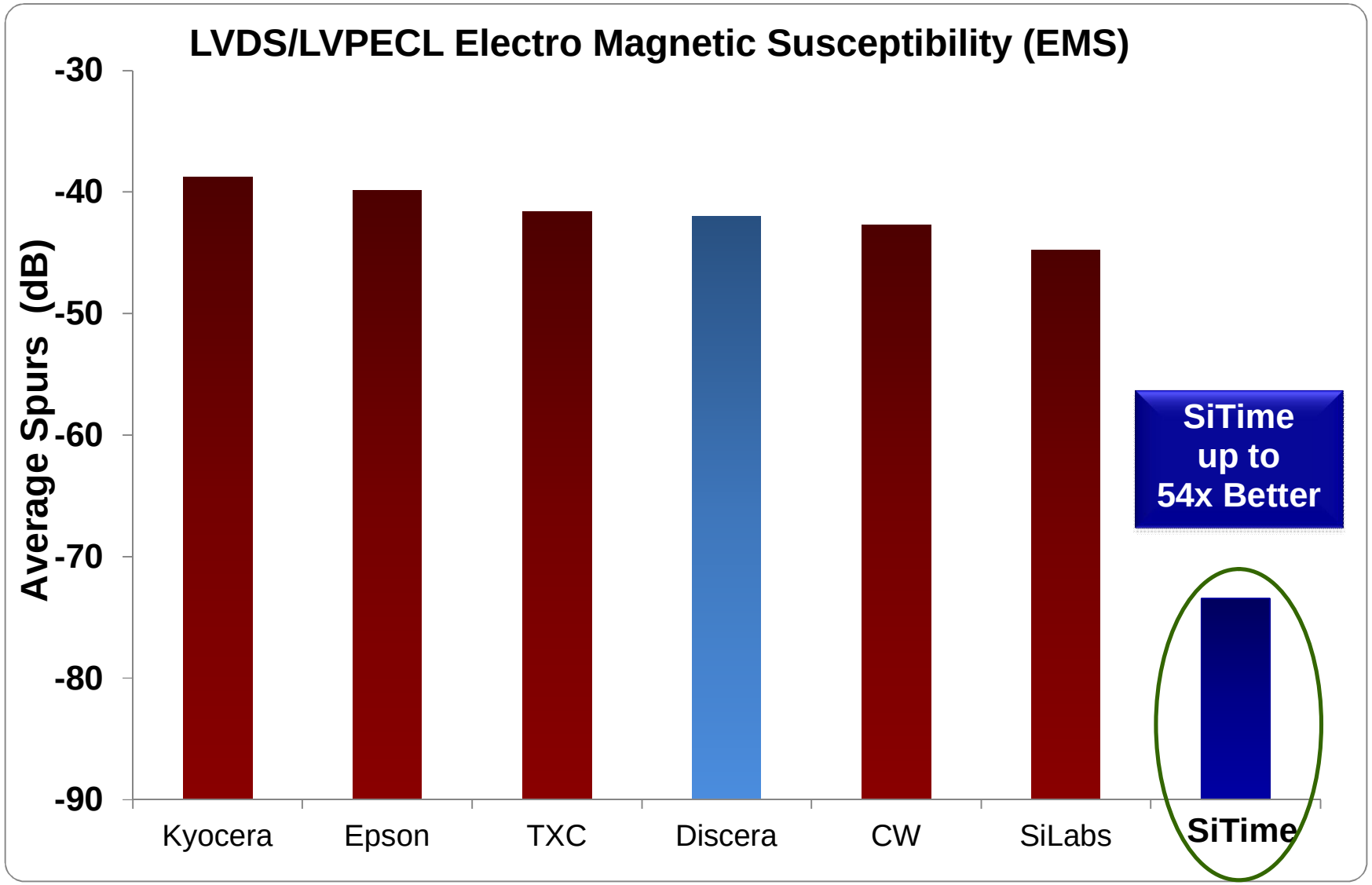


PNA – Agilent E5052B Phase Noise Analyzer
DSA – Agilent DS90604A Digital Signal Analyzer

Best EMS Performance -- LVCMOS



Best EMS Performance – LVDS/LVPECL



How SiTime Delivers the Best EMS Performance

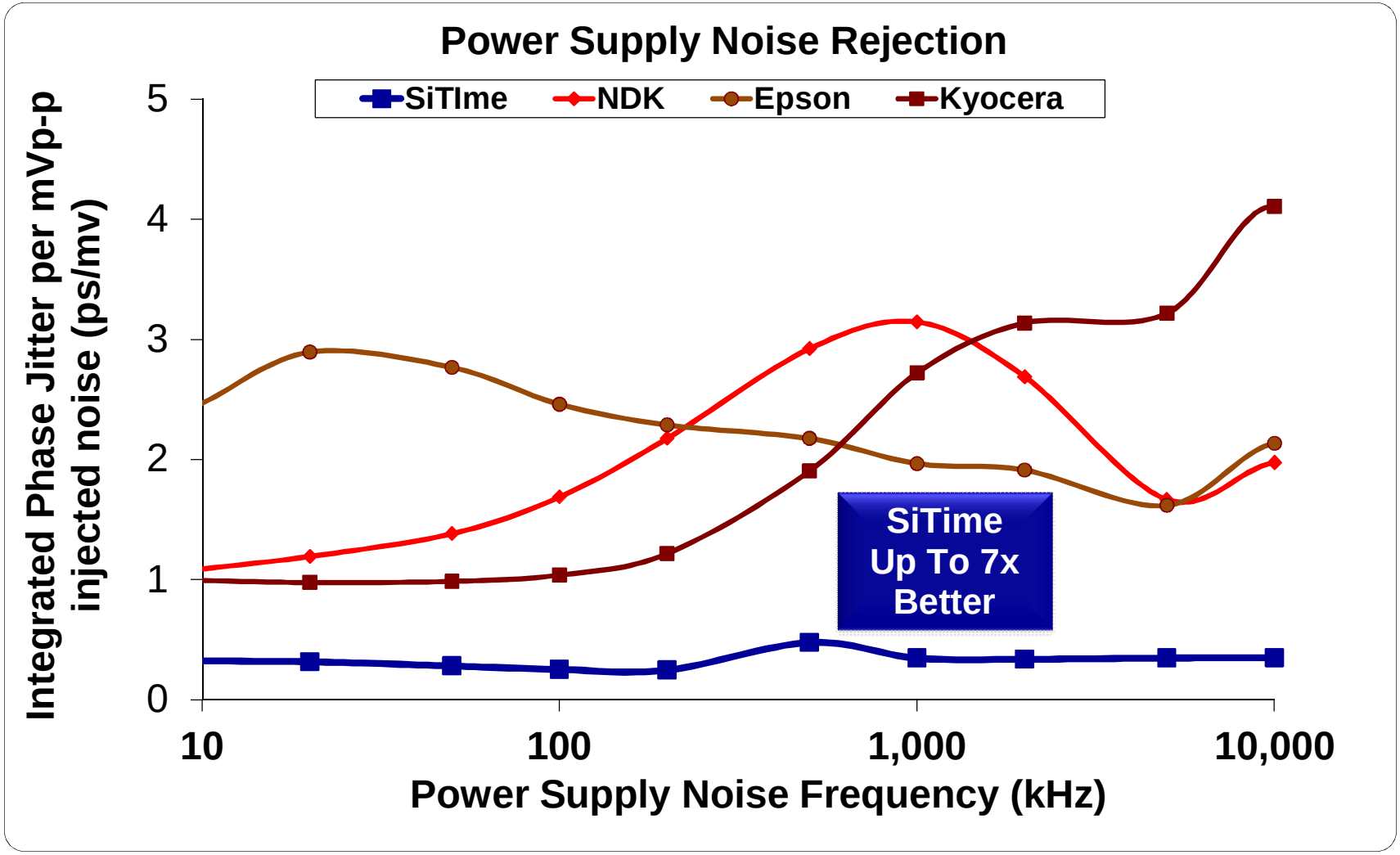
- Design & MEMS Structure
  - Differential architecture for best common mode rejection
  - No sensitive, high-impedance nodes
  - MEMS ultra-small resonator size minimizes antenna pick-up effects compared to larger quartz resonator

- SiTime's MEMS Resonators are Electrostatically Driven—Inherently Immune to EMI
  - Quartz Devices are Piezoelectric and are More Susceptible to EMI

- Definition of EMS
  - EMS is a measure of the timing device's immunity to radiated EMI sources from other electronic components

Best Power-Supply Noise Rejection

Best Power-Supply Noise Rejection-- LVCMOS



How SiTime Delivers the Best Power-Supply Noise Rejection

- Best Oscillator Circuit Design
  - Differential Design for Best Common Mode Rejection
  - 2 Layers of Linear Regulation for Best Supply Noise Immunity
  - Internal Bypass Decoupling for High-Freq. Noise Filtering

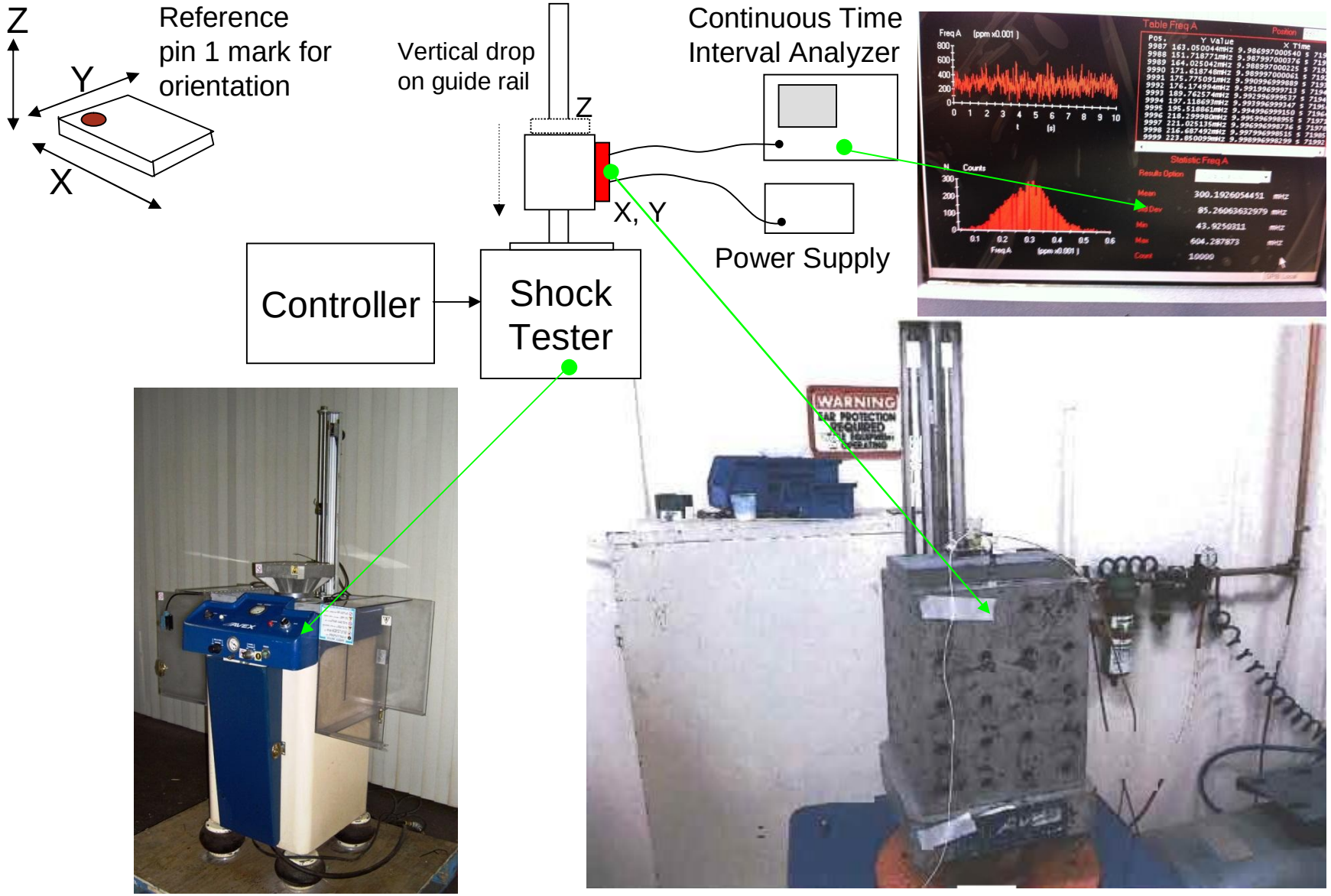
- 100% In-House Mixed-Signal Design

  (not available from quartz)
  - Continuous improvement and optimization

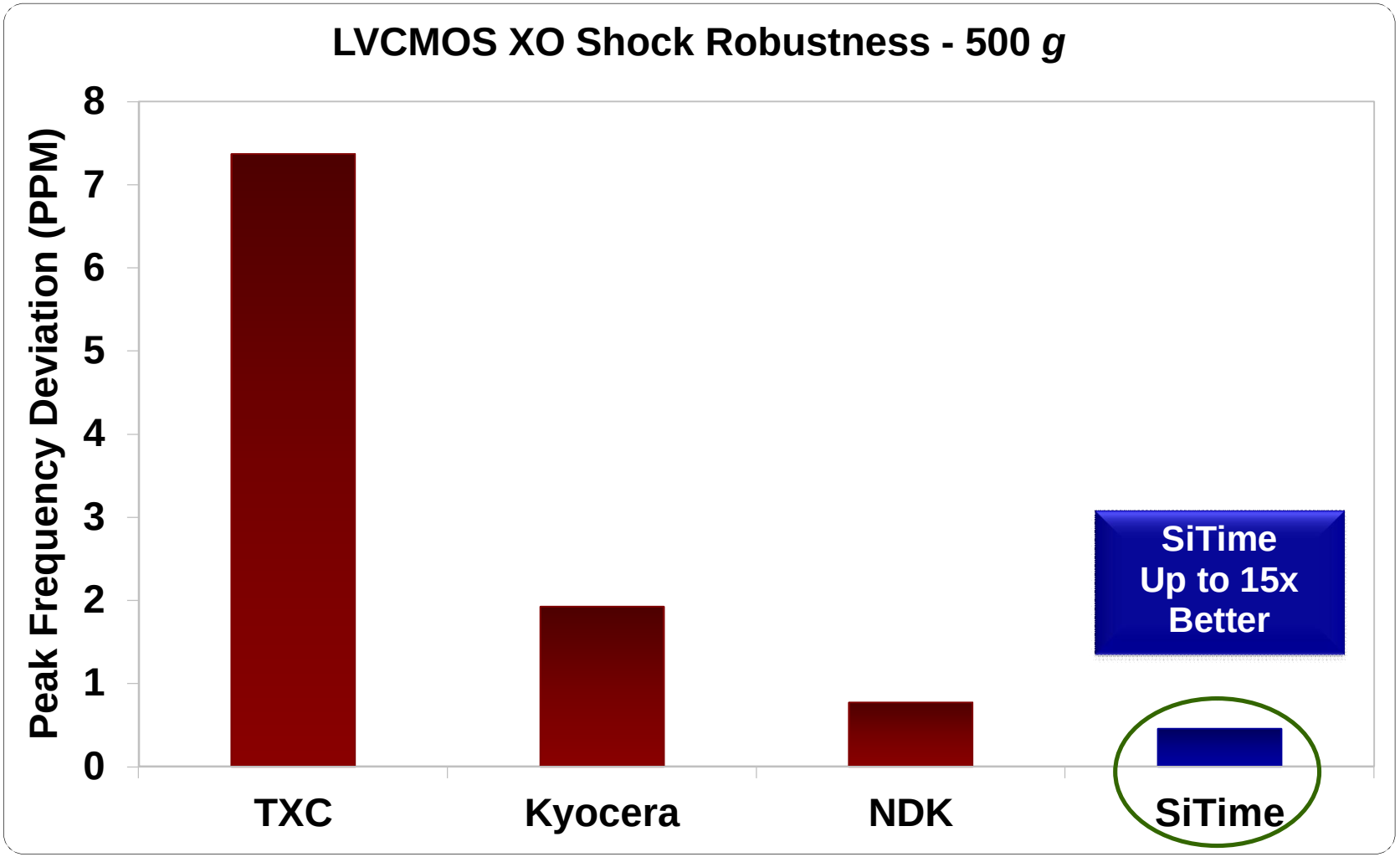
- Definition of Power Supply Noise Rejection and test condition
  - Noise on the power supply increases jitter on the clock output. The ability of a timing device to reject this power supply noise is Power Supply Noise Immunity
  - 50mVpp noise injected onto power supply, changing freq. DUT Vdd supply bypassed with 0.1µF//10µF

Best Shock and Vibration Performance

Mechanical Shock Test Setup

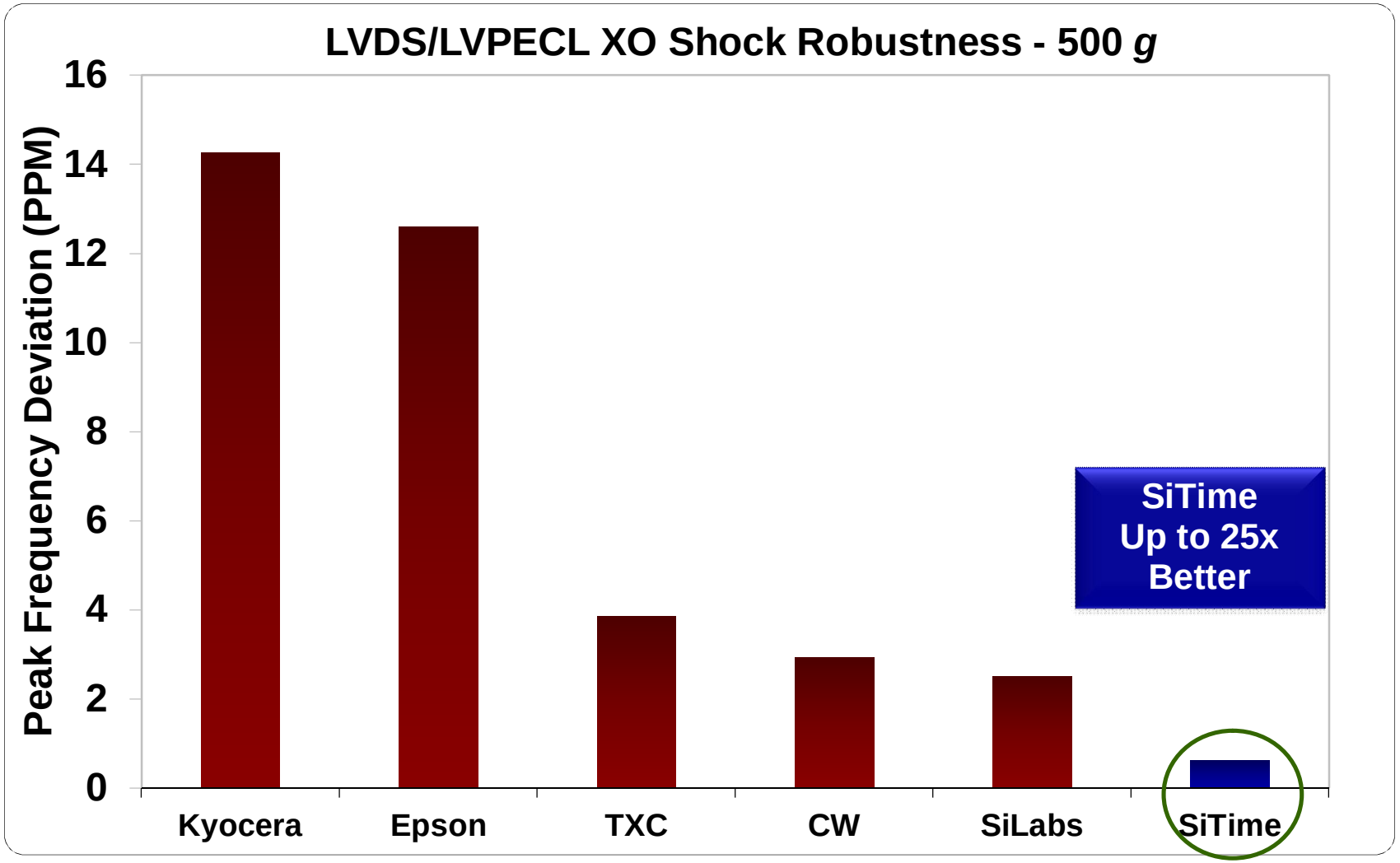


Best Performance Under Shock — LVCMOS (500 *g*)



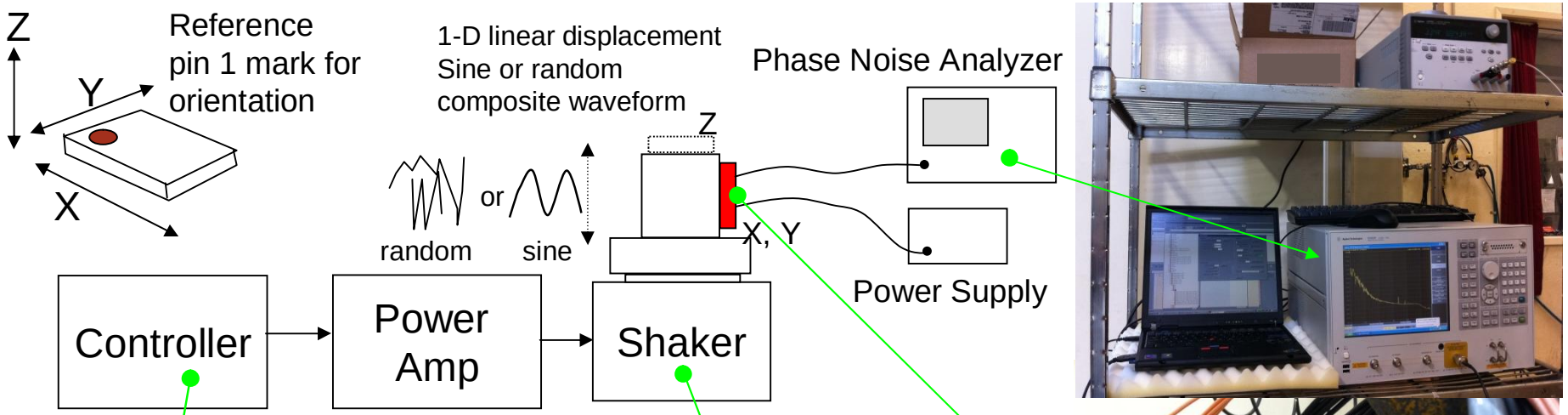
MIL-STD-883F Method 2002, condition A: half sine wave shock pulse, 500 *g*, 1ms.

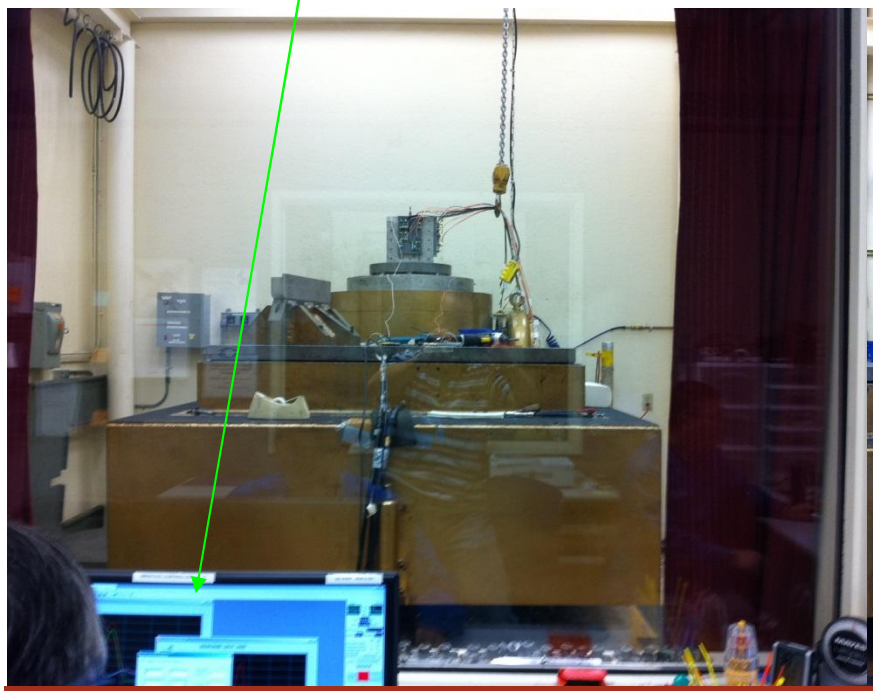
Best Performance Under Shock — LVDS/LVPECL (500 *g*)

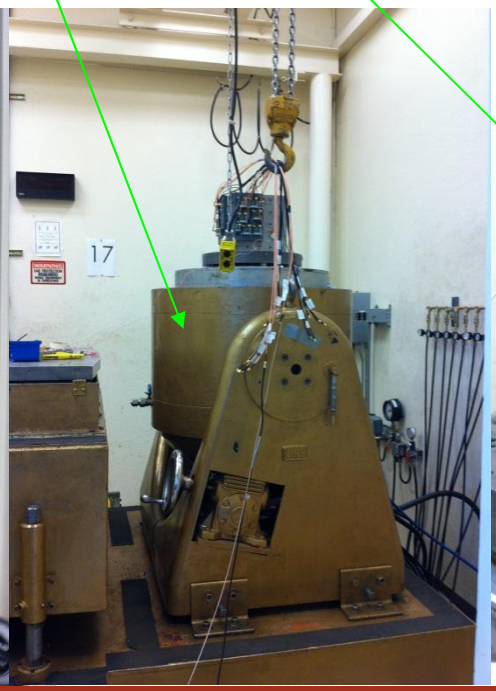


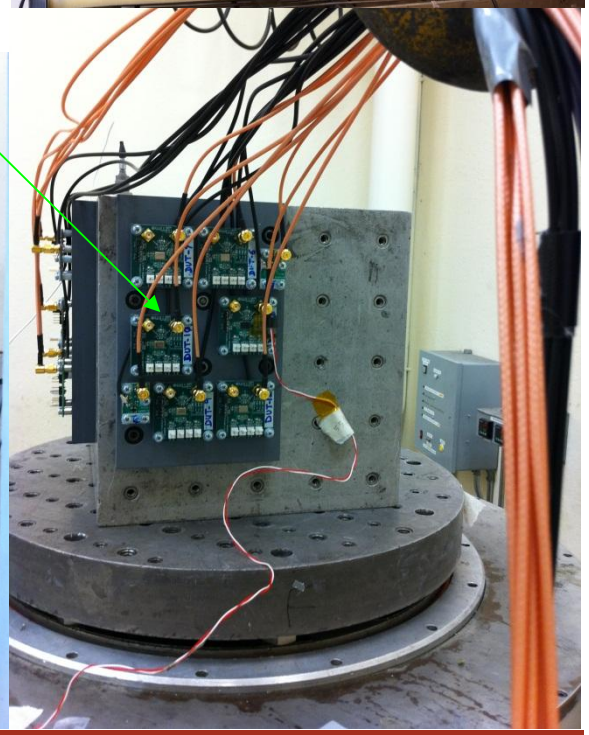
MIL-STD-883F Method 2002, condition A: half sine wave shock pulse, 500 *g*, 1ms

Random Vibration Test Setup

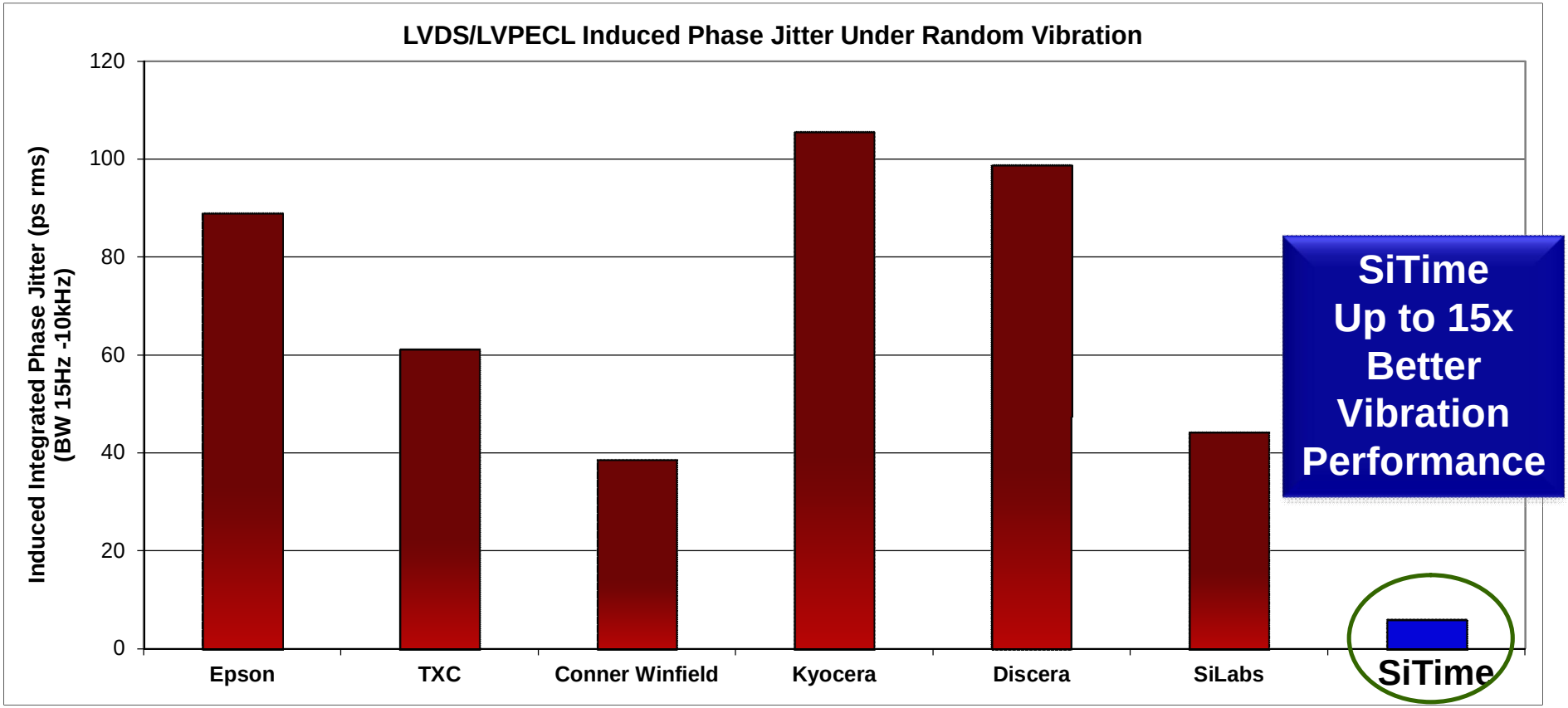








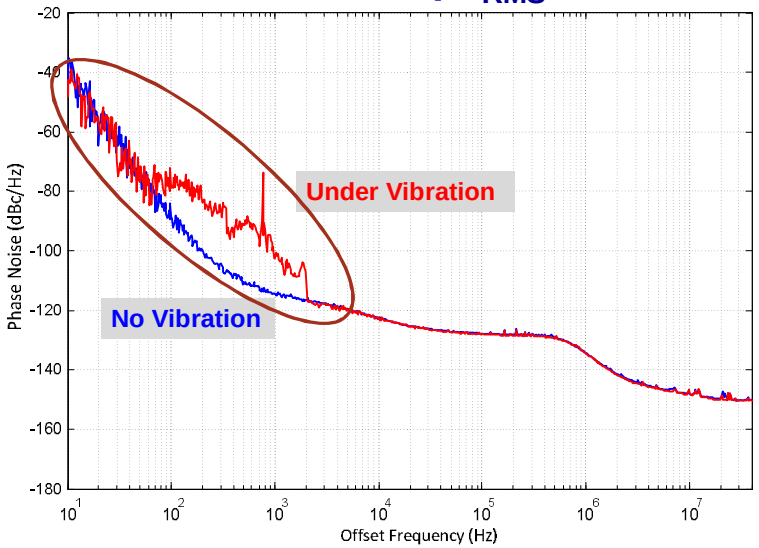
Best Phase Jitter Performance Under Vibration – LVDS/LVPECL



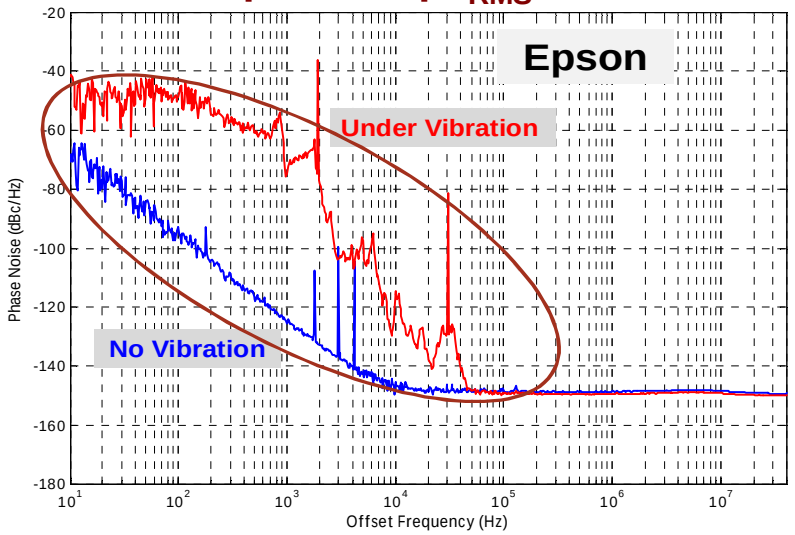
Random vibration profile: MIL-STD-883F Method 2026, Condition B at 7.5g rms. Data plot shows the induced jitter under vibration. Initial phase jitter (no vibe) is subtracted.

Best Phase Jitter Performance Under Random Vibration

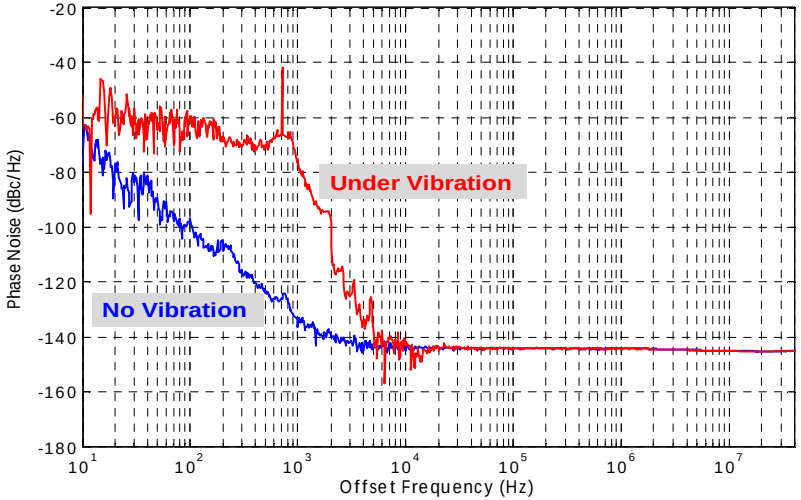
SiTime: 5.72ps$_{RMS}$ IPJ[1]



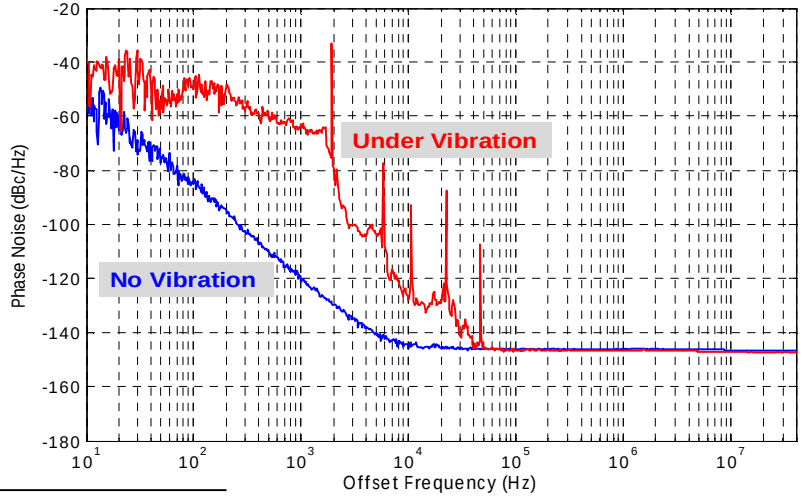
Epson: 89ps$_{RMS}$ IPJ[1]



TXC: 61ps$_{RMS}$ IPJ[1]

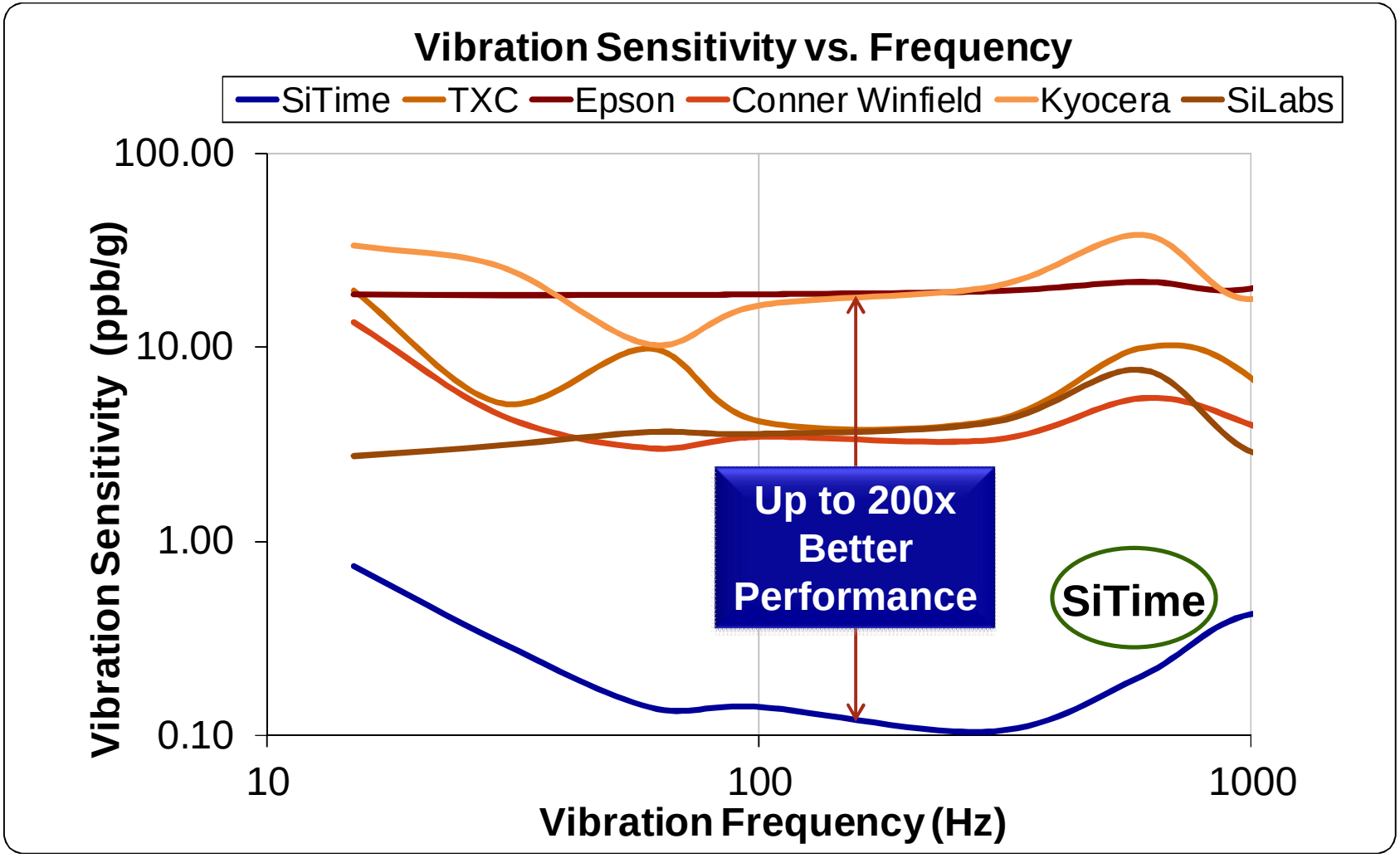


Kyocera: 100ps$_{RMS}$ IPJ[1]



IPJ = Induced Phase Jitter: $\sqrt{(Jitter_{vibe})^2 - (Jitter_{no\ vibe})^2}$

Best Stability Performance Under Vibration—LVCMOS & LVDS/LVPECL

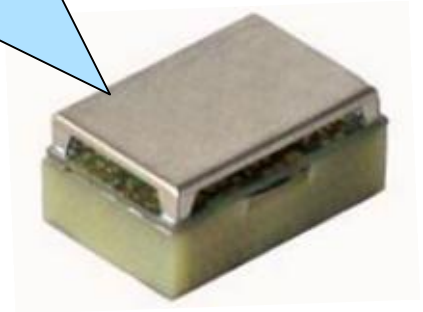


ppb/g error is calculated from the measured phase noise spurs at different vibration frequencies.

SiTime Delivers 0.1ppb/*g* Performance in a Plastic Package

- Putting 0.1pppb/*g* sensitivity in perspective
- Quartz requires very specialized packaging to achieve low G-sensitivity performance.
- All SiTime parts are highly resistant to shock and vibration in a standard plastic package—no special packaging requirements!

Quartz Low G-Sensitivity Solution



Quartz 0.4 ppb/*g* device
9 x 14 x 6.2 mm

SiTime Standard MEMS XO

SiTime 0.1 ppb/*g* Device
2.0 x 1.6 x 0.75 mm

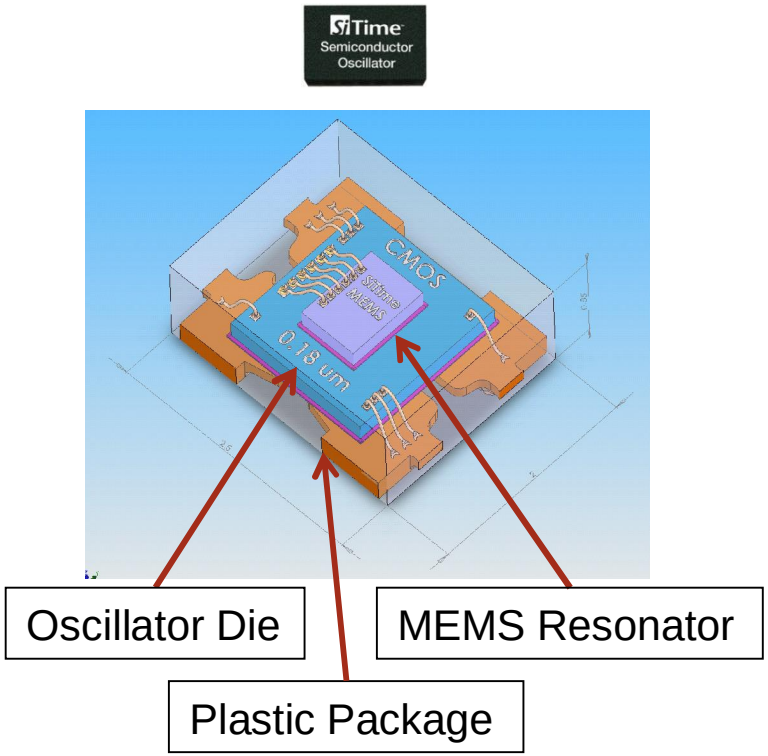
What Makes SiTime's Silicon MEMS Reliability and Resilience Superior?

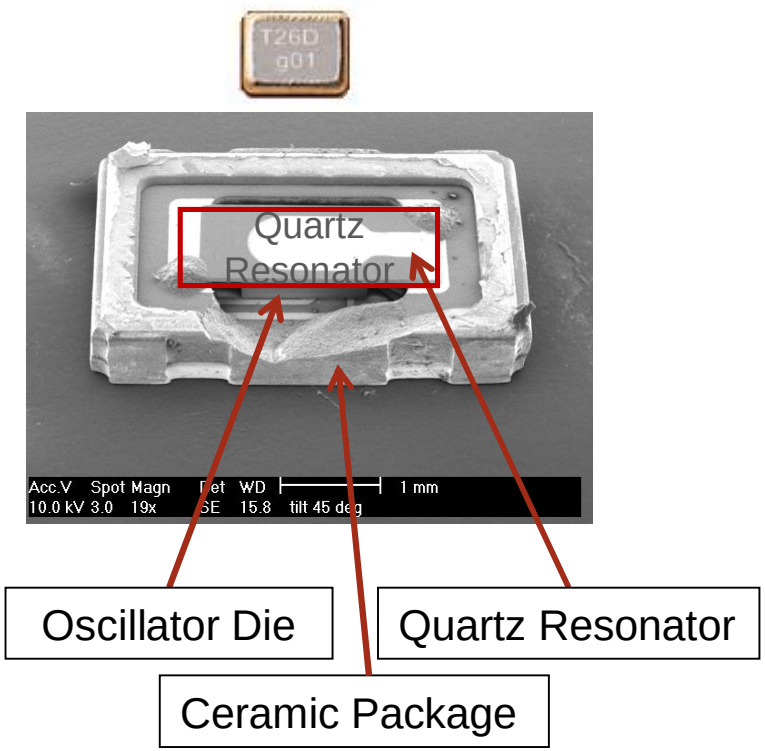
SiTime's Silicon MEMS XO vs. Quartz XO

Functionally Similar…

- Ø Both Require a Resonator…
- Ø Both Require an Oscillator Die…

…But Different!



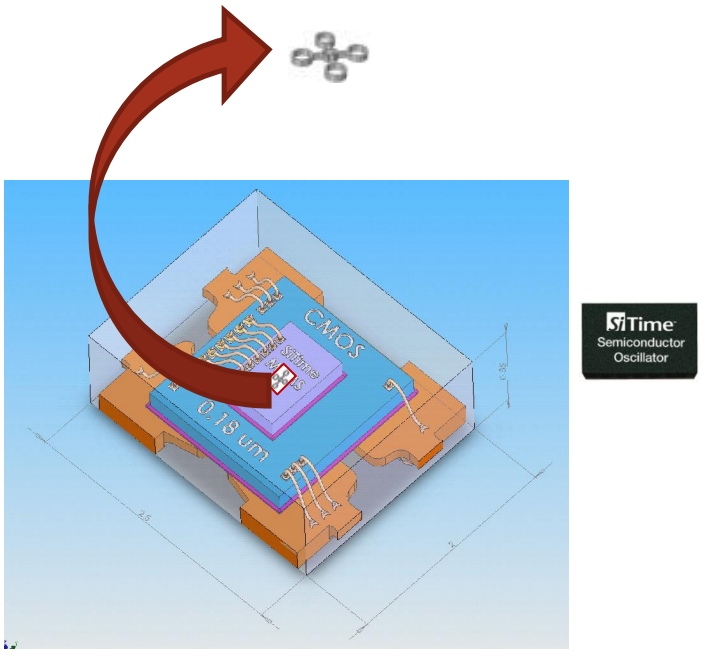


SiTime MEMS Oscillators are Inherently Robust Against Shock & Vibration

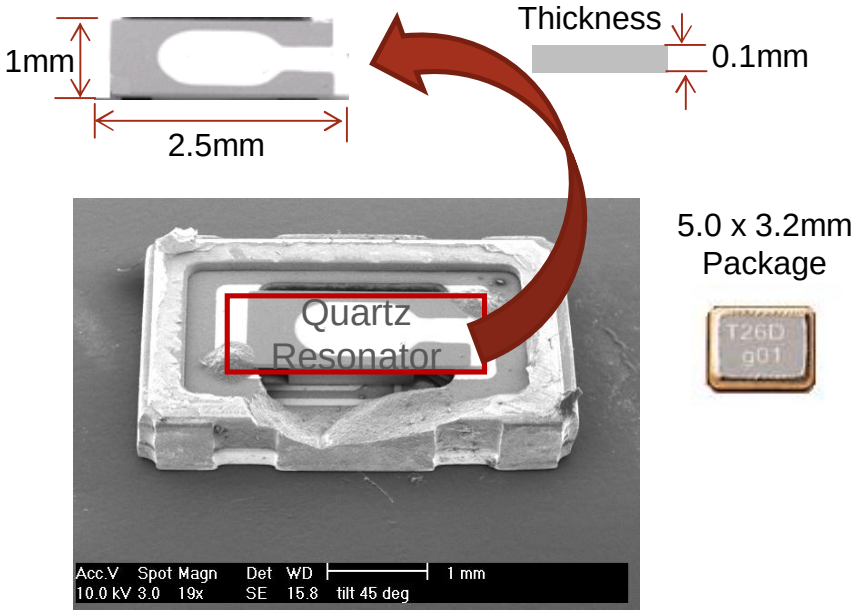
1. The resonator moving mass is extremely small à Large acceleration needed to cause sufficiently large force

SiTime MEMS Resonator Mass is 1000-to-3000 Times Smaller Than Quartz!

Silicon MEMS Resonator Mass Independent of Package



Quartz Resonator Mass Varies with Pkg Size



SiTime MEMS Oscillators are Inherently Robust Against Shock & Vibration

2. The resonator structure operates like a very stiff spring à Very difficult to affect through external force.

   >1M *g* needed before resonator touches any surfaces. 55,000 times greater than a Howitzer Cannon!

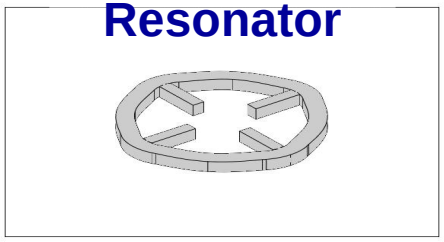
Howitzer Cannon Launches a Ballistic with a Force of 18k *g*

SiTime MEMS Oscillators are Inherently Robust Against Shock & Vibration

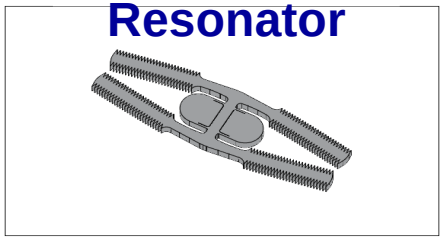
3. Proprietary Design

- Our Resonators are Designed Specifically for Low Sensitivity to Any External Mechanical Acceleration
- Single-Point, Center Anchored MEMS Resonator Virtually Eliminates Stress Error Sources

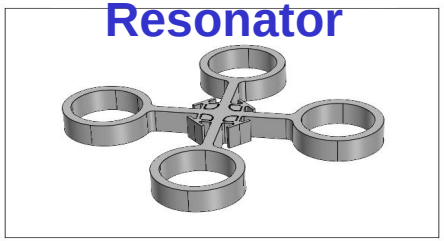
5 MHz Resonator



524 kHz Resonator

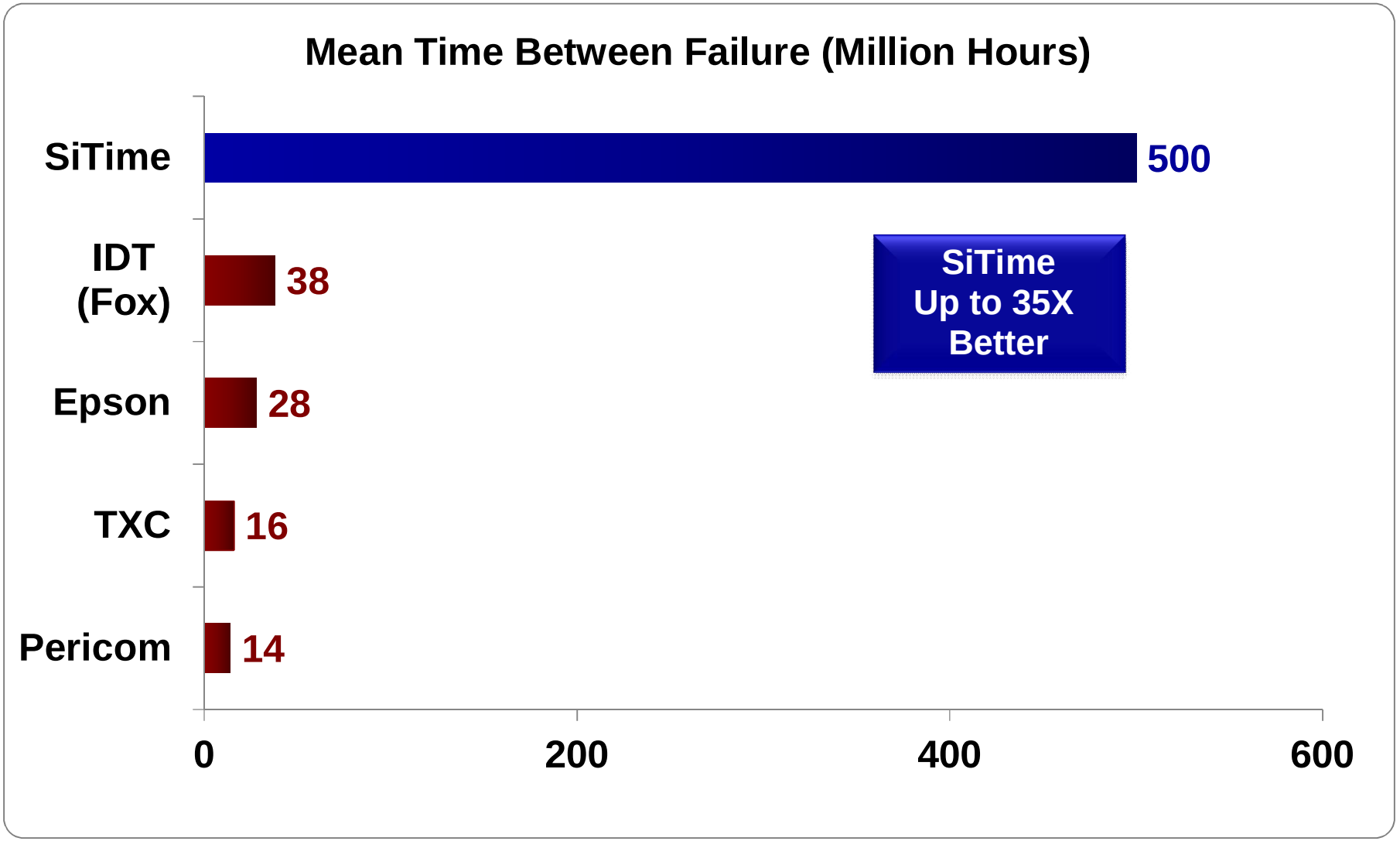


48 MHz Resonator



Putting it All Together With World Class Reliability

Up to 35X Better Reliability Than Quartz



Summary

- Best EMS Performance Because…
  - Best Mixed-Signal Design Methodology and MEMS structure
  - Electrostatically driven MEMS is more resistant to EMS
- Best Power-Supply Noise Rejection Because…
  - In-House Analog Design Expertise
  - Differential Oscillator Design
- Best Shock & Vibration Because…
  - Smaller and Stiffer MEMS resonator vs Quartz
  - Single-point, Center Anchored MEMS Design
- Best Reliability—Because we are 100% Silicon
  - 500MHr MTBF (2 FIT)

Contact Information

- **For Questions, contact SiTime Technical Support**
  Technicalsupport@sitime.com

- **For *Turbo Webinar* pdf Downloads on SiTime's Web Site**
  www.sitime.com/support/sitime-u/turbo-webinars

  •All new webinars will be posted within 1-week

  •For a list of part numbers used for each test, contact SiTime Technical Support at the email address listed above.