



100,000+ G Shock Survivable MEMS Oscillators Enabling Next Generation Fuzing

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Approved for Public Release

SiTime[®]

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SiTime Overview

Enabling the Next Level of System Performance Through Precision Timing

Leader in Precision Timing

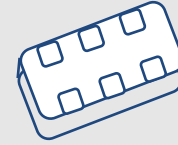


\$202.7M revenue (2024), NASDAQ

Largest XO company, > 3 B units shipped

Serving communications, networking,
consumer, industrial, automotive and
aerospace and defense

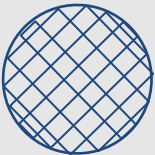
Innovation in Timing



Largest R&D budget in timing (\$107M in 2024)

Silicon MEMS timing with “unbelievable”
performance

Robust Supply Chain



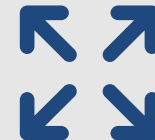
US company, based on Santa Clara, CA

China-free scalable silicon foundry supply chain

Programmable architecture for short leadtime

Semiconductor SPC quality and reliability

Enabling New Designs



The most predictable and robust under the
most demanding environment

Performance enables new applications
Small size

SiTime → Complete Precision Timing Solutions Provider

Largest Supplier of Oscillators, Complete Portfolio

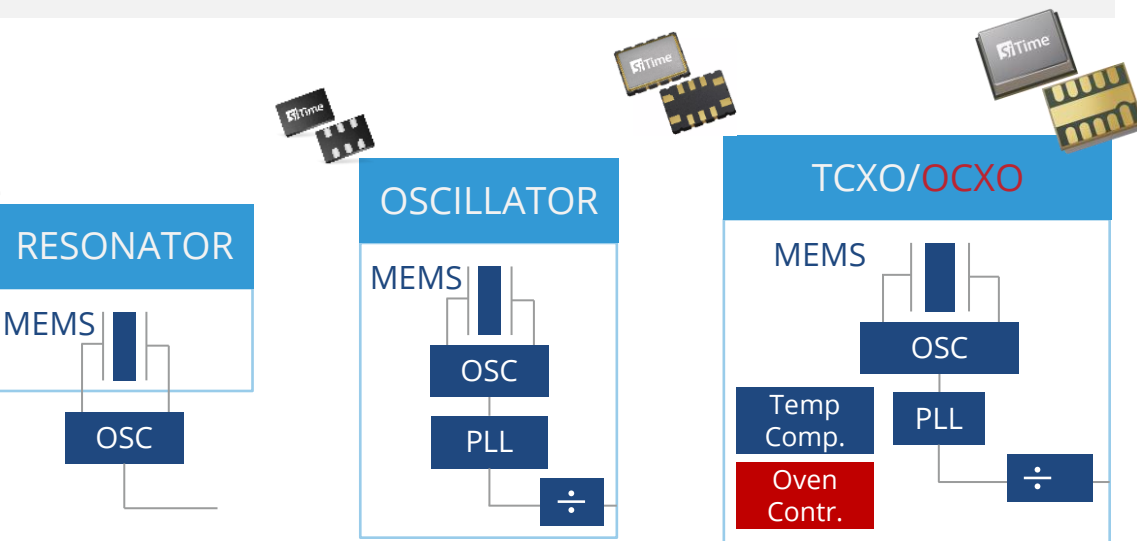
Resonators

XO

TCXO

OCXO

- Greater than 100,000 g shock operation and survivability
- Best phase noise for RF applications under vibration
- Lowest size, weight, and power (SWaP)
- Programmable architecture
- 10x better reliability, 2.2 billion hours MTBF



Complete Clock Portfolio, Integrated MEMS, Programmable

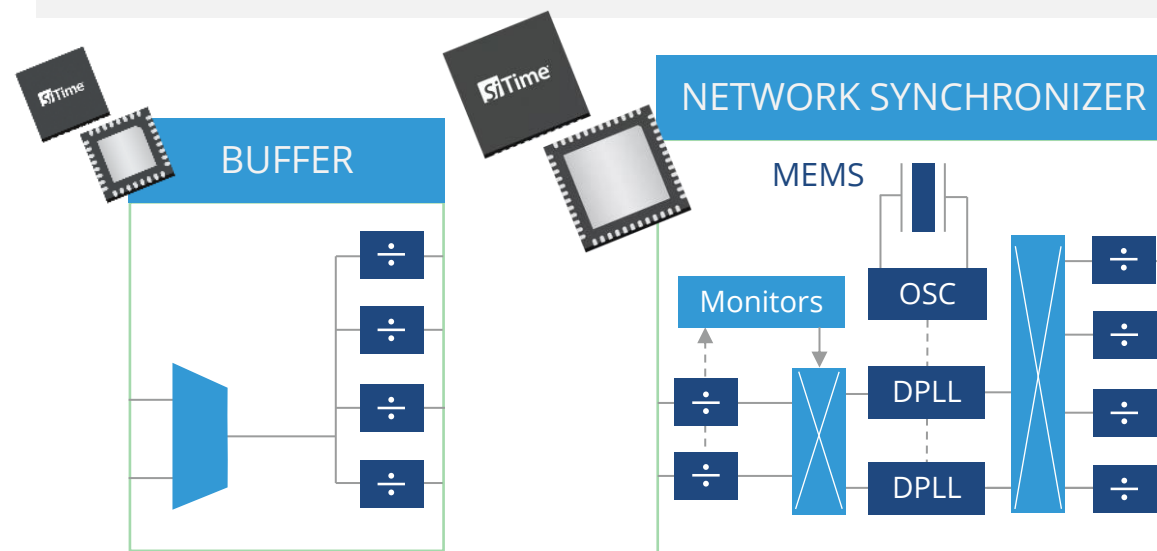
Buffer

ClockGen

Jitter
Cleaner

Network
Sync

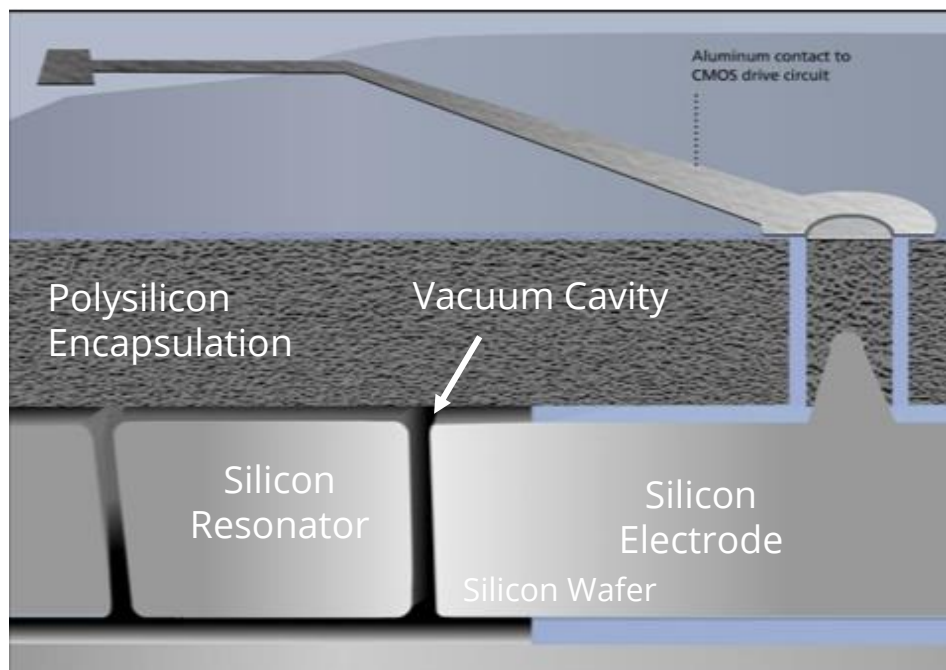
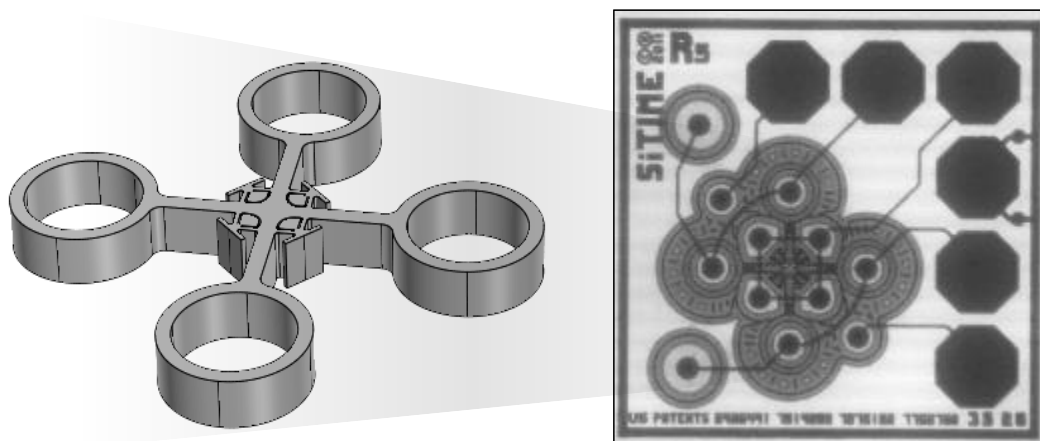
- Integrated MEMS performance / resilience benefits
- Full featured, flexibility with programmability
- Pin compatible with industry standard footprints
- Advanced PLL, PSNR, and hitless switching technology
- IEEE 1588 software with PTP stack





SiTime Technology Overview

A New Approach to Timing: Monocrystalline Silicon MEMS Resonator



- 450 μm x 420 μm vacuum sealed resonator die
- Low mass, $\sim 1,000\times$ lower mass than quartz
- Very Robust Mechanical Properties
 - Tensile Strength 11x Quartz: Up to 550 MPa¹ vs. 48 MPa² for Quartz. Vs. 551 MPa for HY-80 Steel⁵
 - Young's Modulus (Stiffness) 2x Quartz: 130 to 188 GPa³ vs. 72 GPa⁴ for quartz vs. 205 GPa for HY-80⁵
- **Low mass + small area + high stiffness $\rightarrow$ high shock resistance and low acceleration sensitivity**
- 200k Q-factor $\rightarrow$ low noise, low ADEV, excellent stability
- Hi purity Silicon material in ultra clean 10 μBar vacuum $\rightarrow$ high stability & low aging
- High volume scalable process, 100,000 die per wafer

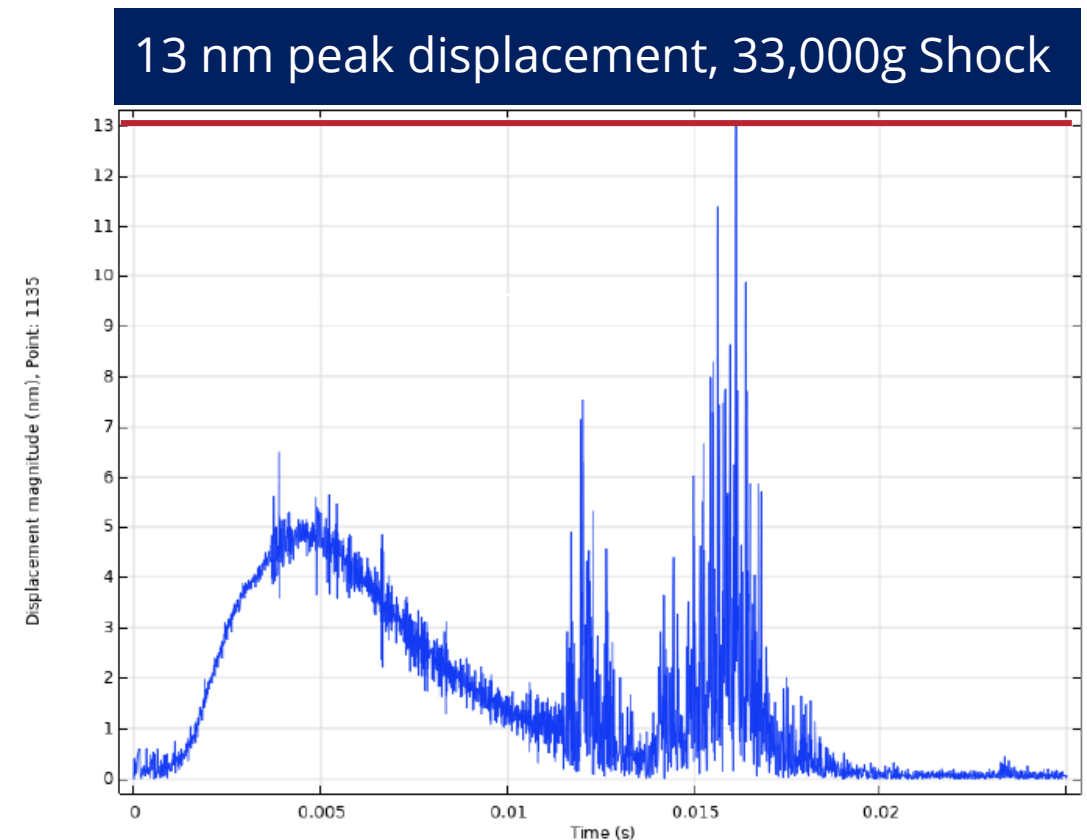
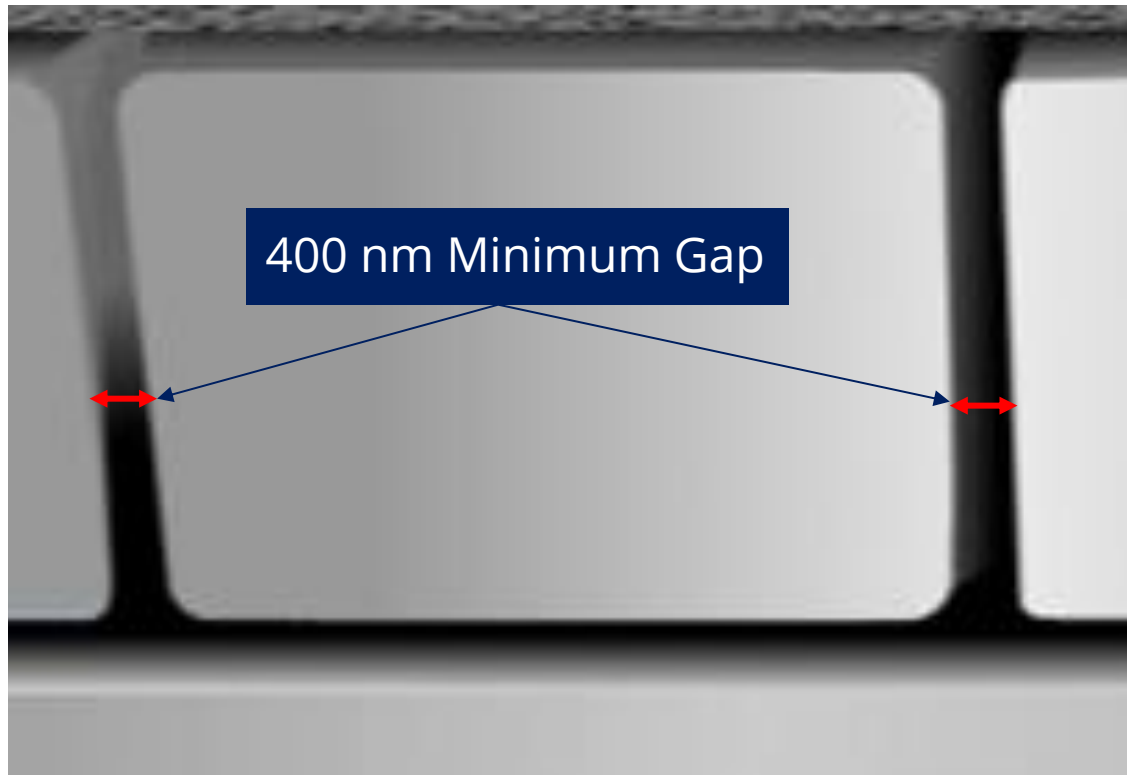


33,000g Operational Shock Simulation Comsol FEA Simulation

Simulated MEMS Resonator Displacement through 33,000g Shock Transient

> 30x Margin to Failure

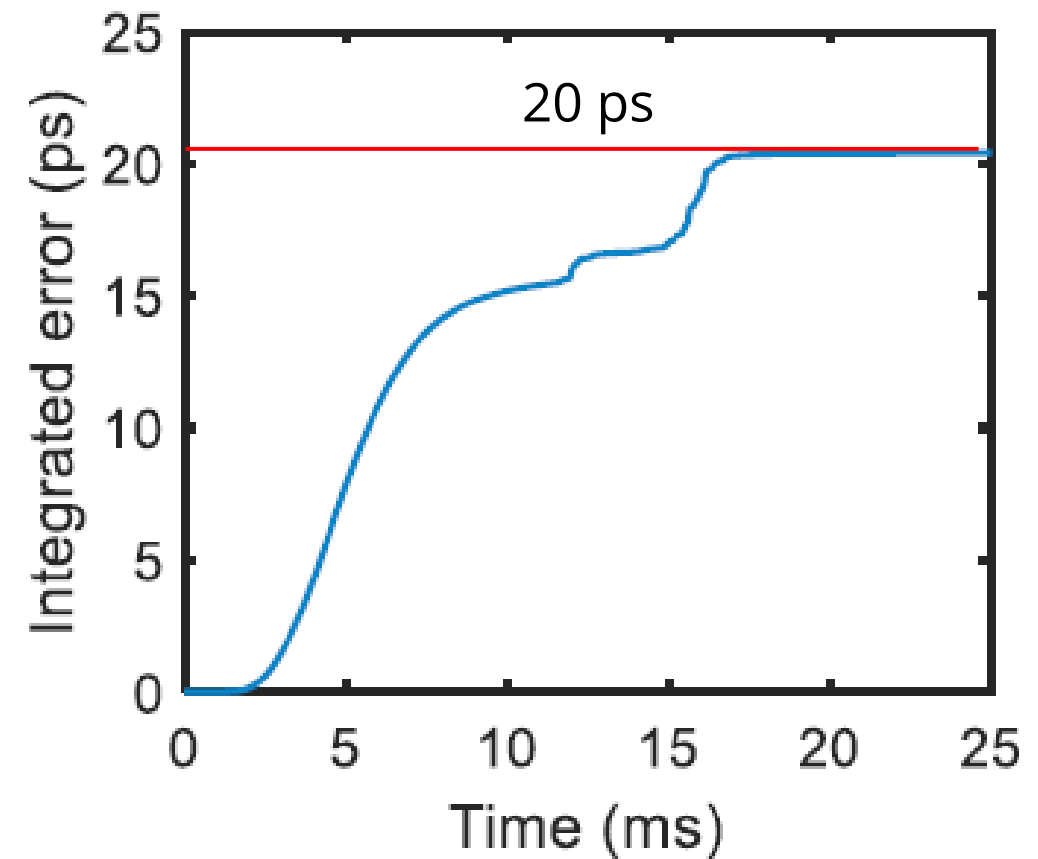
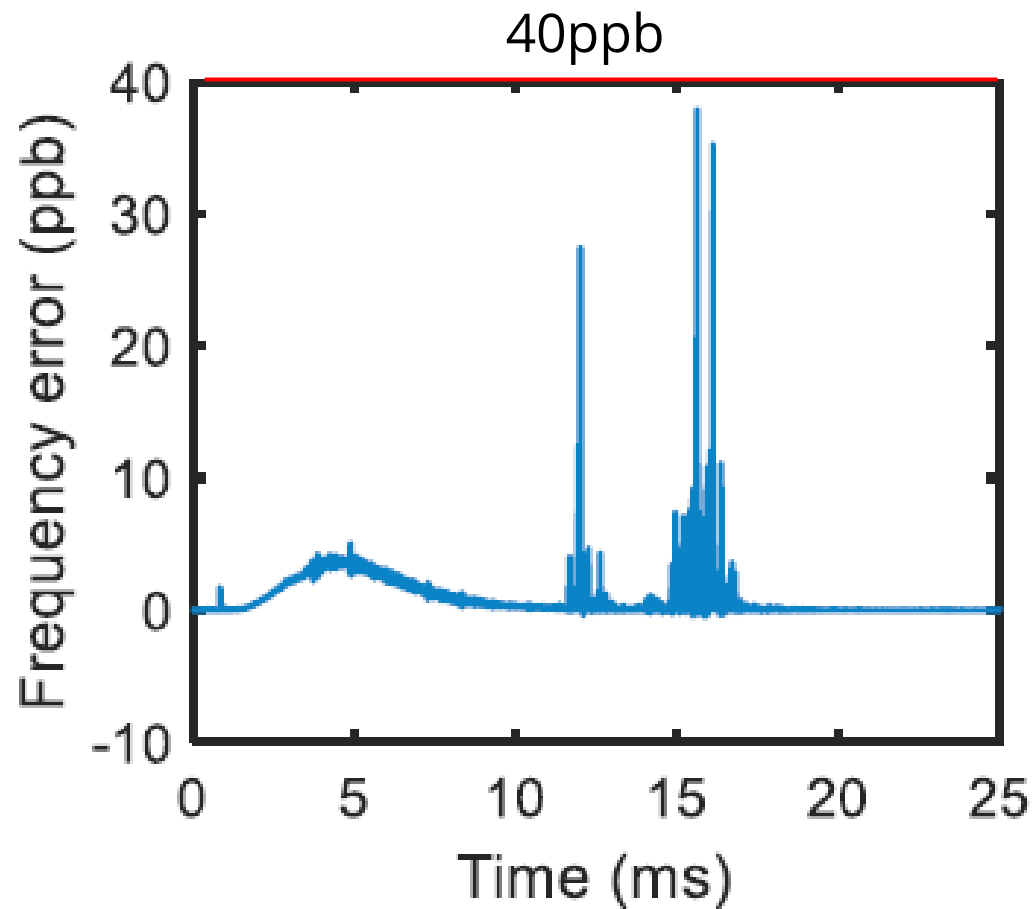
- 400nm Minimum Gap/13 nm Max Displacement = 30.8x Margin
- Implies > **500,000g shock capability**



Lateral ring displacement magnitude vs time (max 13 nm).

33,000g Shock Simulated Frequency & Time Error vs. Time

< 40ppb Frequency Deviation & 20 ps Integrated Phase Error

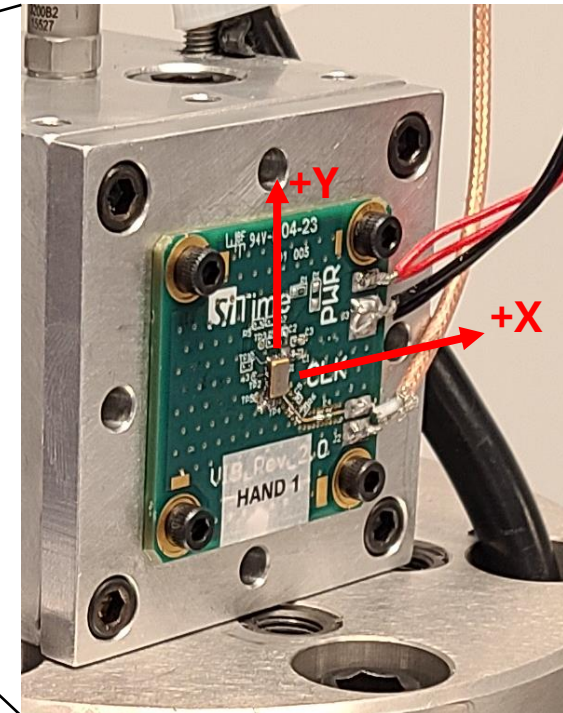
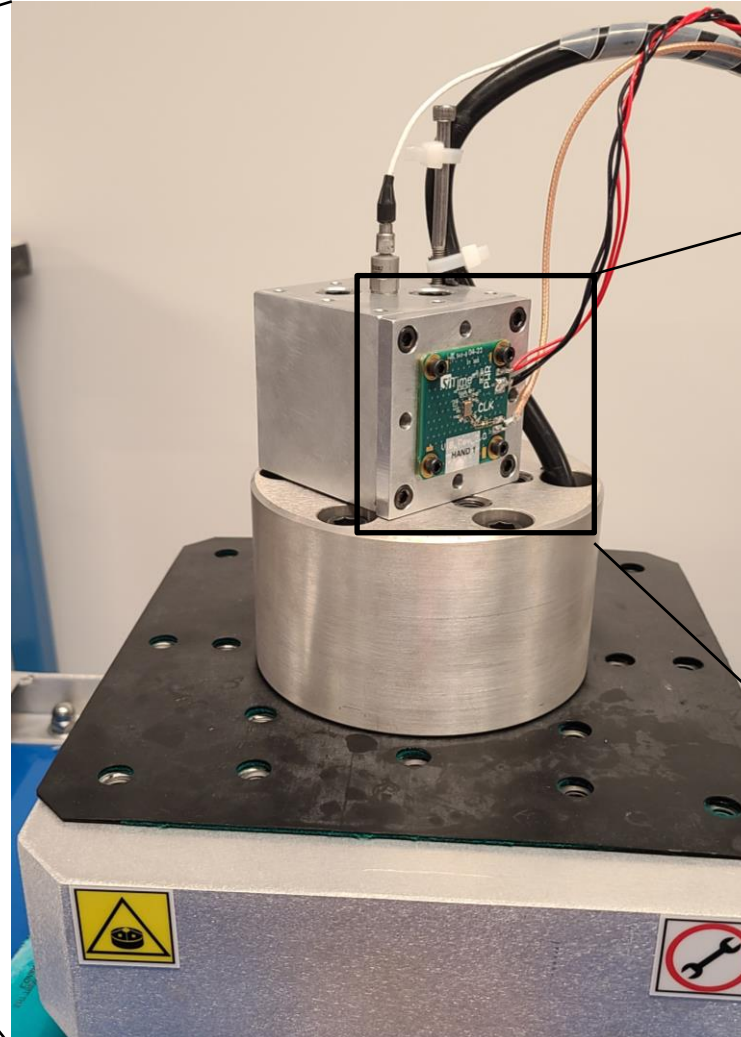




30,000g Operational Shock Measured
Results.

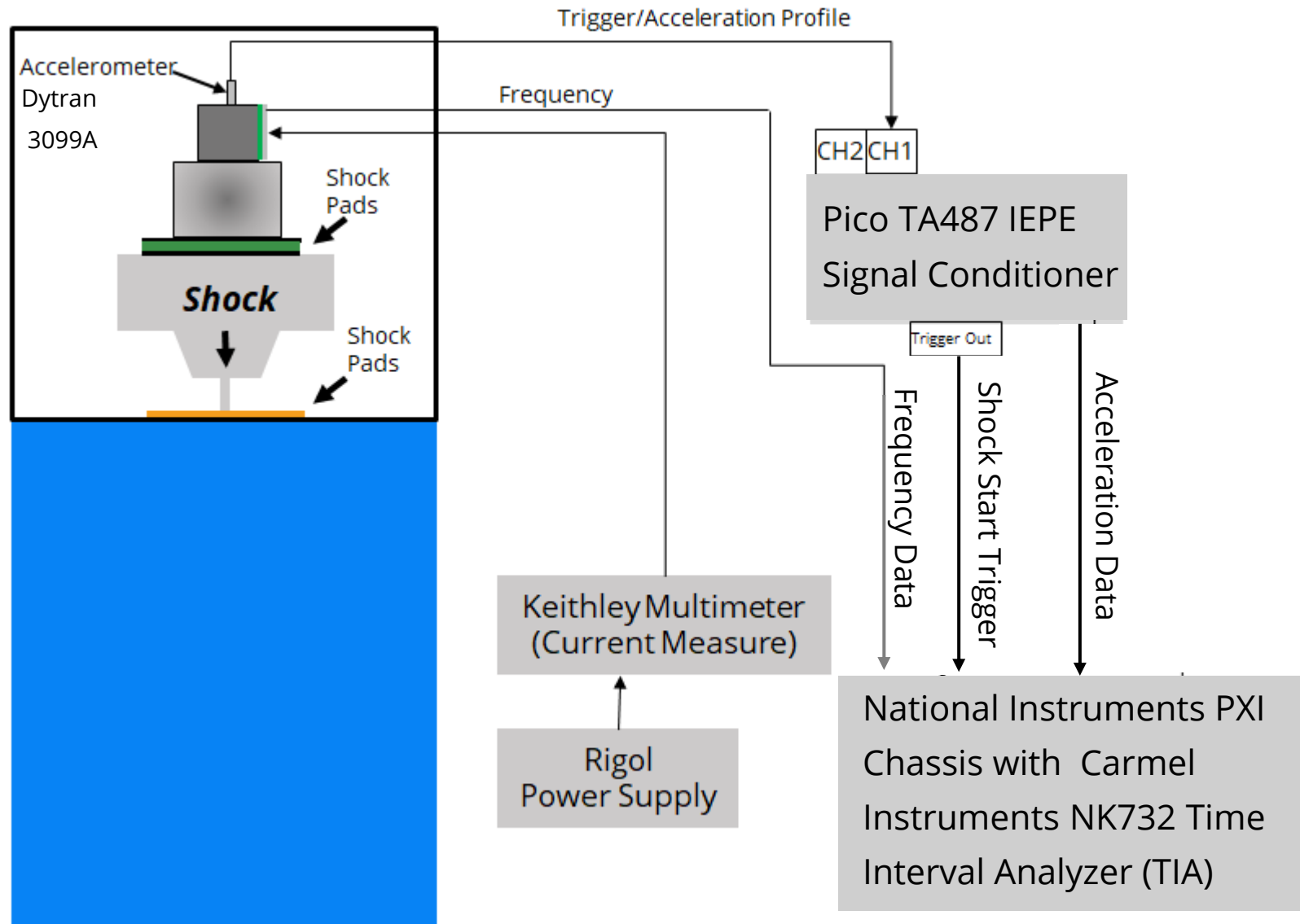
MIL-STD-883 Method 2002 Condition G

Shock Test Physical Set-up



Shock Test Instrumentation Set-Up.

Use Time Interval Analyzer (TIA) to Capture Oscillator Frequency vs. Time



Measured < 0.01 nsec TYP Time Error Through Eight 30,000g Shocks

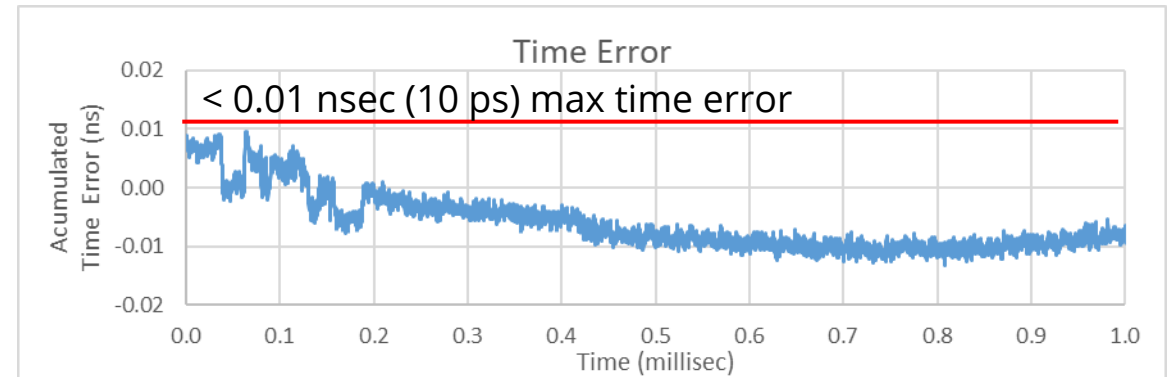
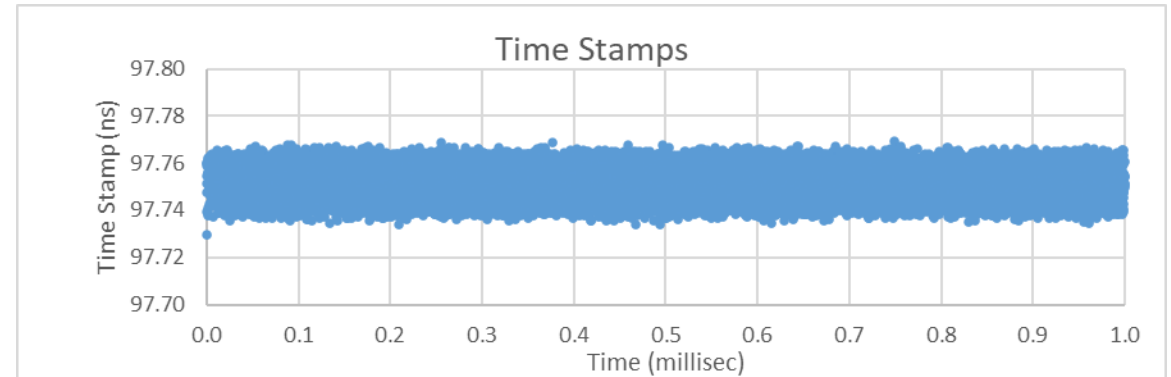
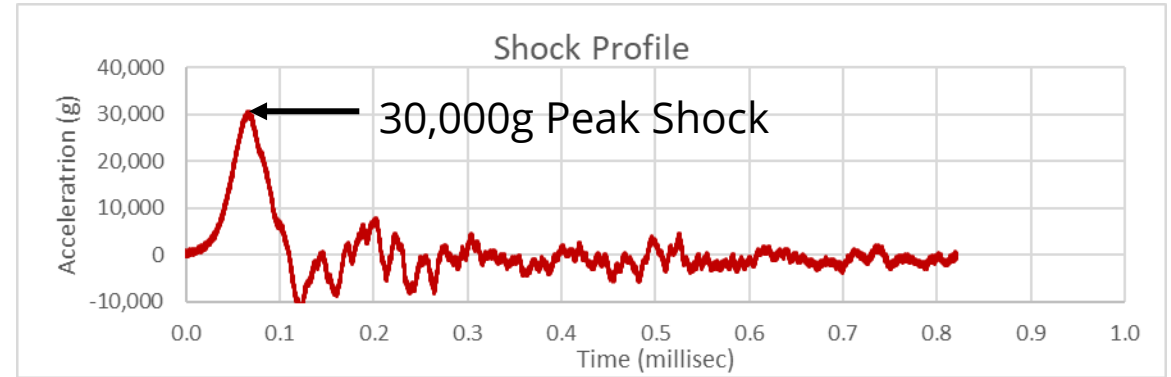
Each of the two units operated through more than 20 Shocks Total

Number of Shocks Each Axis (Unit 1)

	X	Y	Z
10,000g	3	1	3
20,000g	3	3	3
30,000g	2	3	3

Number of Shocks Each Axis (Unit 2)

	X	Y	Z
10,000g	3	3	3
20,000g	3	4	3
30,000g	2	3	3



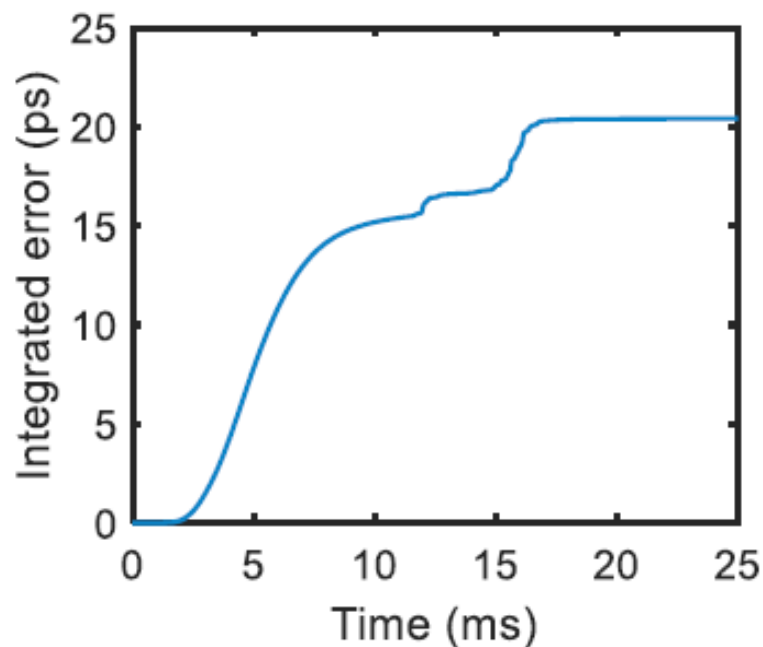


Ultra High Shock, 100,000g+

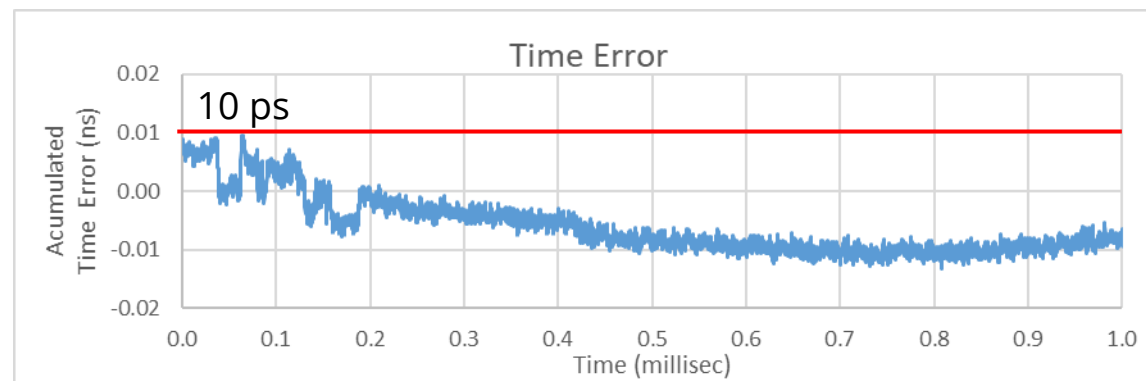
Time Error Agreement Between Simulation & Measurement within 10 ps

- Agreement between 33,000 shock simulation & 30,000g Shock Measurement Within 10 ps
- Difference in plot shapes may be due to Different Shock Response Spectrum
- Agreement gives some confidence for ultra high-g shock simulation which follows

Simulated: Max Time Error: 20 ps



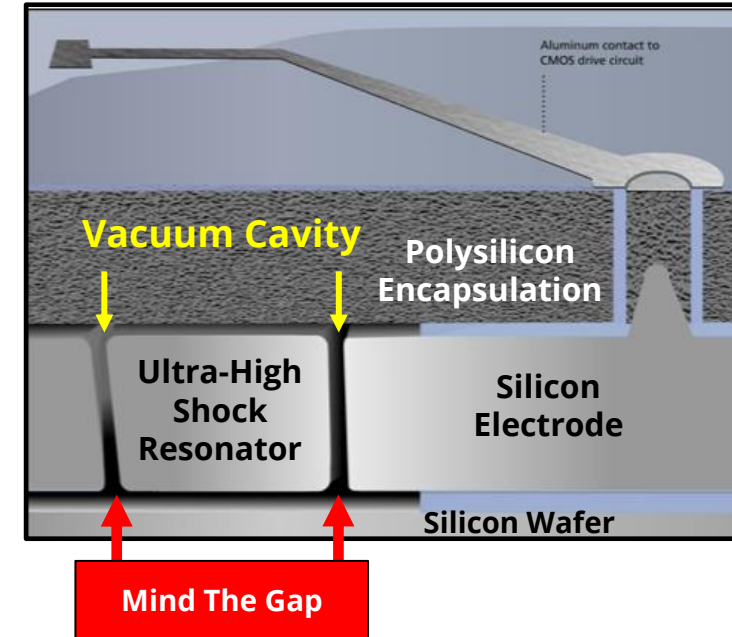
Measured: Max Time Error: 10 ps



Simulation Results: Ultra-High Shock Resonator @ 510,000 g

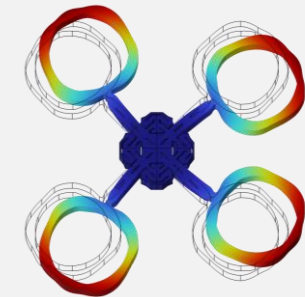
- Shock Response Spectrum (SRS) calculated for the ultra-high shock resonator @ 510,000 g
 - Maximum displacement of the cavity gap was 80% (20% margin remaining)
 - **Simulation indicates 100,000g+ Shock can be supported with good margin**
 - **Working with commercial partners to perform 100,000g+ testing.**
 - **Successful Customer Testing**
 - 100,000g gun test
 - 95,000g bomb test
 - **Ongoing Collaboration with DMEA for high shock testing.**

Side-View of Ultra-High Shock Resonator



Simulation of 510,000 g Shock

←
Direction of acceleration



SiTime Products for Fuze Applications

Root Part Number	Application	Frequency	Supply Voltage Range	Stability Class	IDD	Package	Operating Temp. °C	Start-up Time	He/H ₂ resistant
SiT1534	Timer for Gun/Bomb Fuze	32.768 kHz 16.384 kHz	1.5 to 3.63	XO	1.4 µA	2012 QFN	-55 to 85	500 msec	No
SiT1581	Timer for Gun/Bomb Fuze	32.768 kHz	1.62 to 3.63	XO	5.5 µA	1508 CSP	-40 to 85	300 msec	Yes
SiT7910	Timer for Gun/Bomb Fuze	32.768 kHz	1.62 to 3.63	TCXO	6.7 µA	2520 Ceramic	-55 to 105	300 msec	Yes
SiT8021	Proximity Fuze Gun/Artillery	1 to 26 MHz	1.62 to 3.63	XO	0.25 mA	1508 CSP	-40 to 85	150 msec	No
SiT8944	Proximity Fuze Gun/Artillery	1 to 110 MHz	1.62 to 3.63	XO	4.8 mA	2016 QFN	-55 to 125	5.5 msec	No
SiT7601	Proximity Fuze Gun/Artillery	44 Frequencies. 4 to 125 MHz	1.35 to 3.63	XO	3.0 mA	2016 QFN	-55 to 125	1 msec	Yes



Thank You!
Questions?

References

1. *Study on Anisotropic Mechanical Properties of Single-Crystal Silicon at Different Strain Rates*. Micromachines. Zhongwang Tian, Wei Xue, Wenzhong Lou, Min Liu Hengzhen Feng, Xiaoxia Wang, Shiteng Li
2. <https://qqe.com/quartz-properties/>
3. *What is the Young's Modulus of Silicon?* Journal of Microelectromechanical Systems VOL. 19, NO. 2, APRIL 2010, Matthew A. Hopcroft, William D. Nix, and Thomas W. Kenny
4. <https://qqe.com/quartz-properties/>
5. <https://www.metalsusa.com/hy80-grade-steel/>