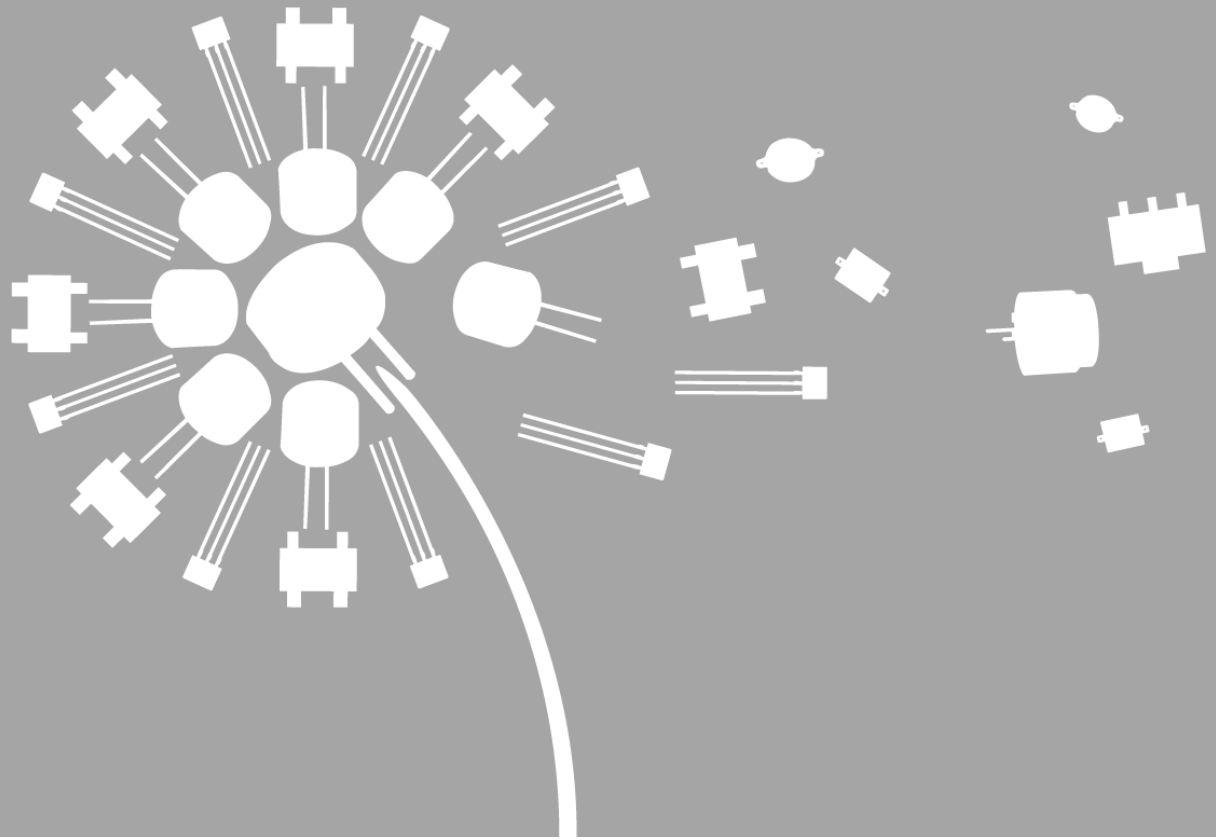
endrich
components of life



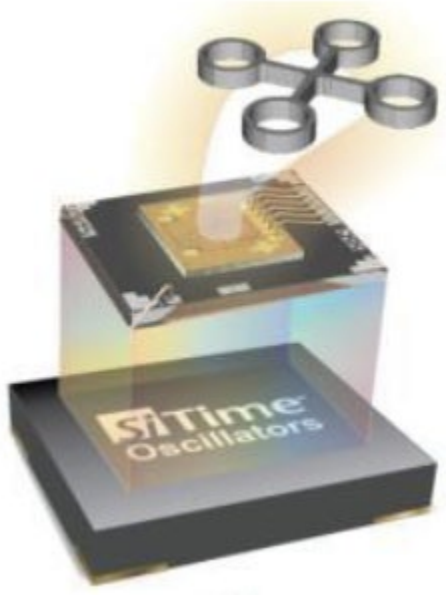
SiTime MEMS oscillators in handheld devices HandsOnTraining

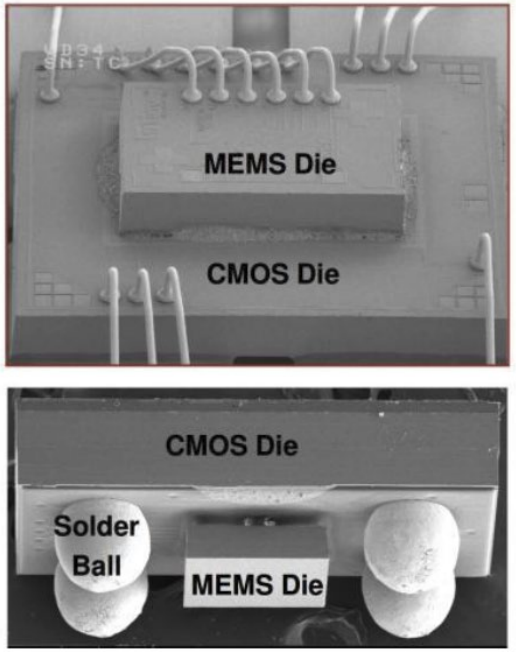
Kiss Zoltán – *export manager, Endrich Bauelemente GmbH*

MEMS technology in timing

SiTime – fabless semiconductor manufacturer of MEMS timing solutions

- MEMS oscillator technology instead of quartz crystal based solution
- MEMS chip + CMOS circuitry in one package

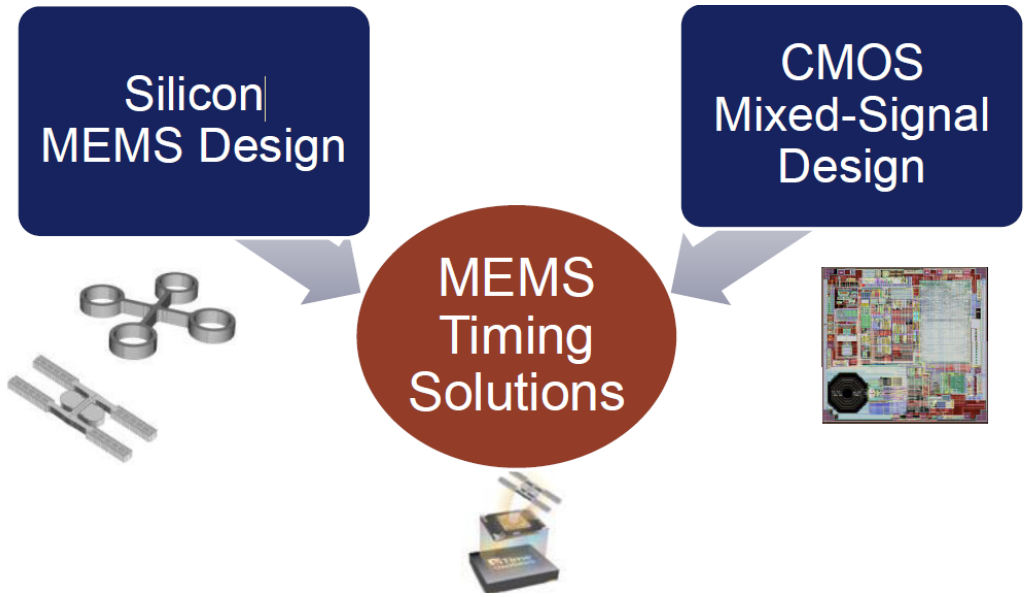




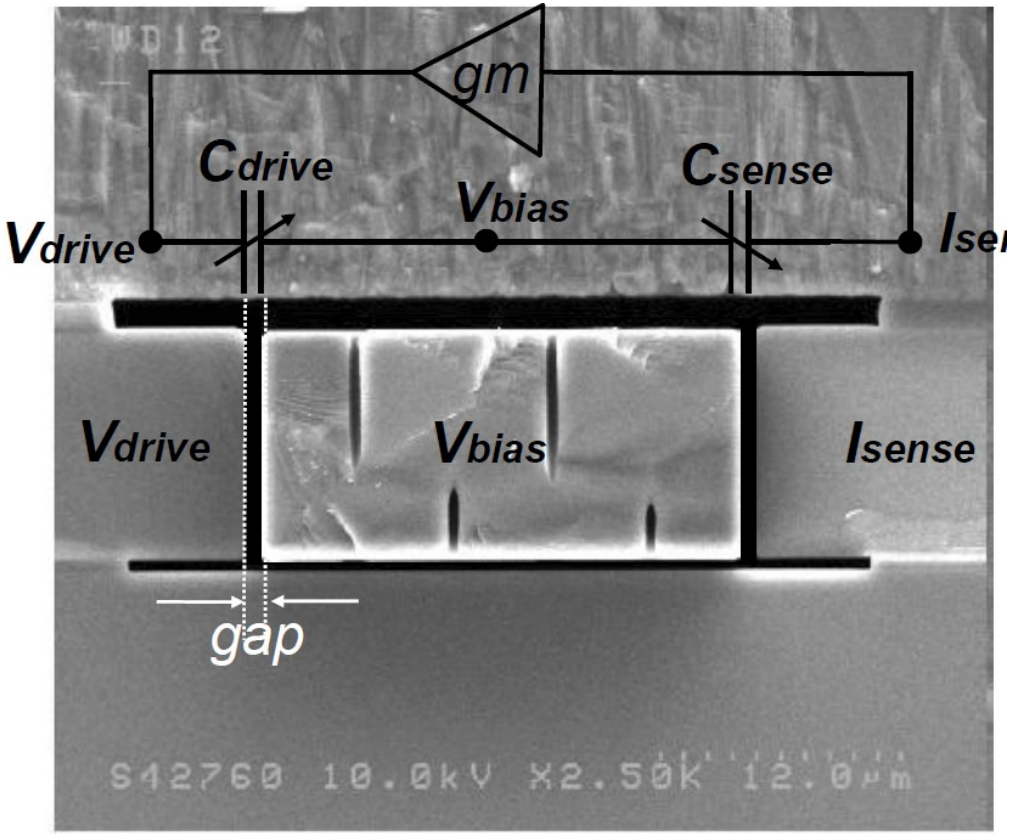
CSP
1.5 x 0.8 mm

SiTime

- Fabless analog IC company, founded in 2005
- Mass production since 2007, 1Bu+ shipped to date
- The leader in MEMS-based silicon timing, with 90% market share
- SiTime's mixed-signal and MEMS IP is 100% designed in-house



Based on capacitive resonator principle



Comparison

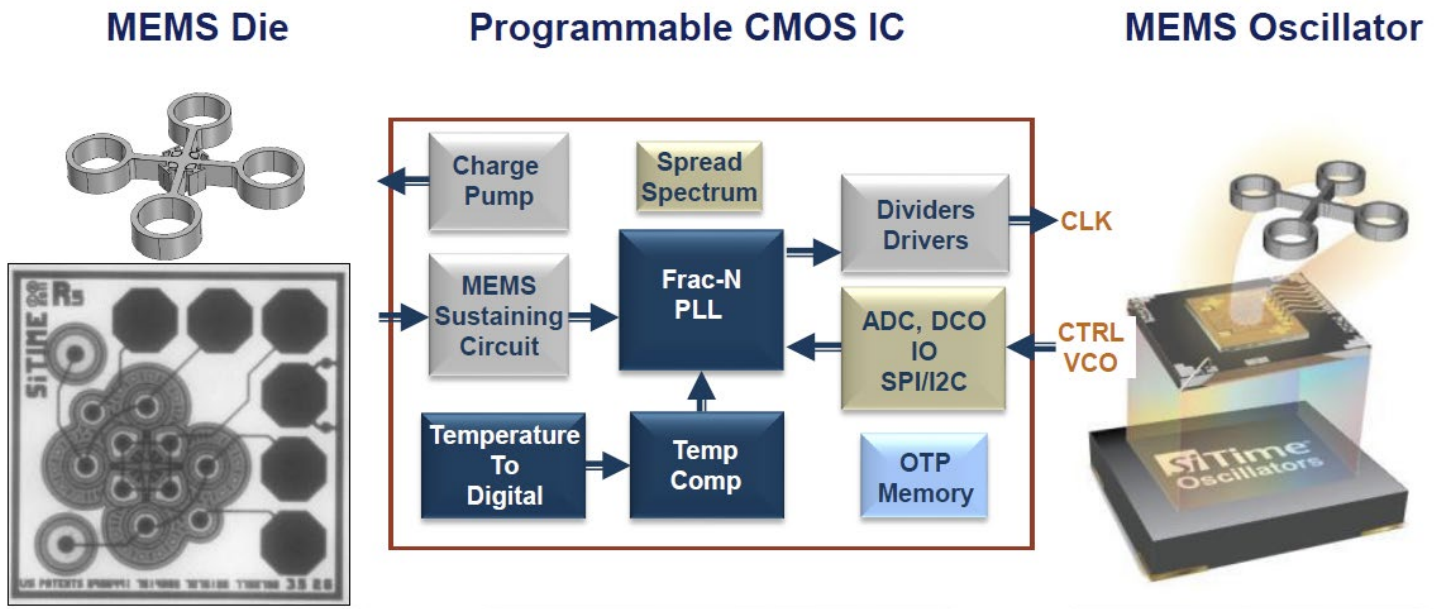
QUARTZ

- Boutique hybrid customized supply chain
- Lower performance
- Long lead times
- Custom part for each frequency
- Sensitive to shock & vibration
- Loss Making

MEMS

- Scalable All Silicon volume technology
- Highest performance
- 4-8 weeks lead time
- Programmable to ANY frequency
- Robust shock resistant proven
- Complete 5G roadmap, Oscillators, Clocks, Jitter cleaners…
- Programmable rise/fall time to reduce EMI and improve jitter

Structure

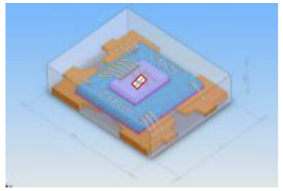


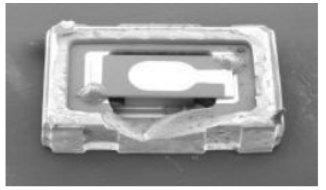
- 0.4 mm x 0.4 mm
- 99% yields
- Vacuum sealed die
- Standard CMOS fab

- Jitter - 250 fs
- Stability - 0.1 PPM TCXO
- Low Power - 1μA @ 32kHz
- 180nm CMOS – fab TSMC

- Plastic packages
- Robust - MSL1
- 99% Yields
- 0.15DPPM, 2Fit

MEMS wins on every metric





Metric	SiTime	Crystal
Supply Chain	Multiple sources	Single Source
Shock and Vibration	30x Better	3000x Larger Mass
Size	Always Smaller	Physically Limited
Lead Time	4-8 Weeks	26-52 Weeks
Quality	0.15 DPPM	50 - 200 DPPM
Reliability	800M Hours	28M Hours
Capacity	Infinite	Capital Intensive
Wide Temp Operation	-55 to +125 °C	-30°C to +85°C
Cost	Always Better	Expensive Process
Flexible Packaging	SOT, Plastic, CSP	Only Ceramic
Flexible Frequency	1Hz – 725MHz	Fixed Mainstream Only
Programmable	In lab (Many parameters)	Fixed Frequency

Technology – Silicon always wins

Best performance

- 30x better than quartz in dynamic, real world conditions
- 70% lower power
- 80% smaller
- 10mK resolution temperature sensor, best

Best Quality & Reliability

- No Aging
- Lifetime Warranty (MTBF 1140 MHrs while quartz<40)

Rapid innovation

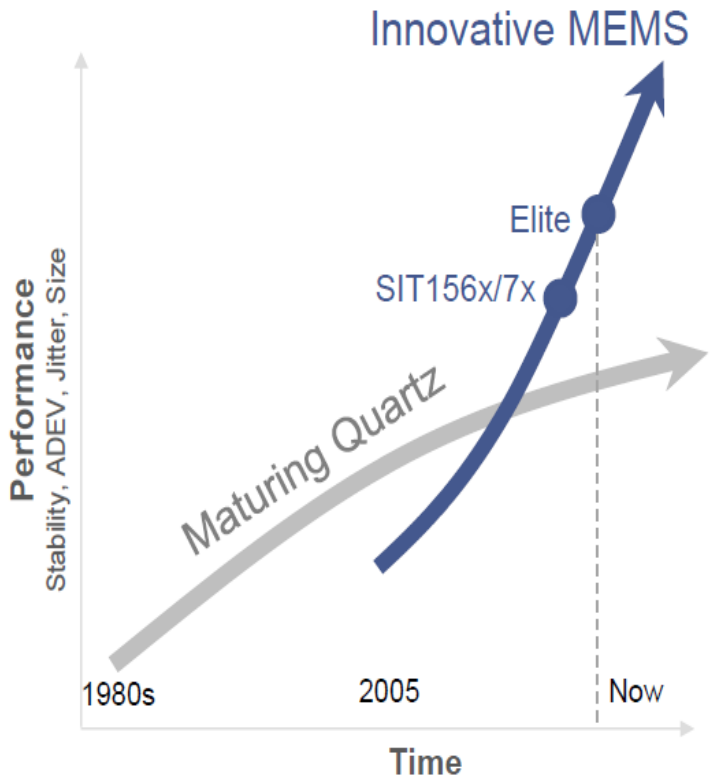
- 200x – 30,000x improvement in 10 years

Scalable manufacturing

- Standard semiconductor process

Best product availability

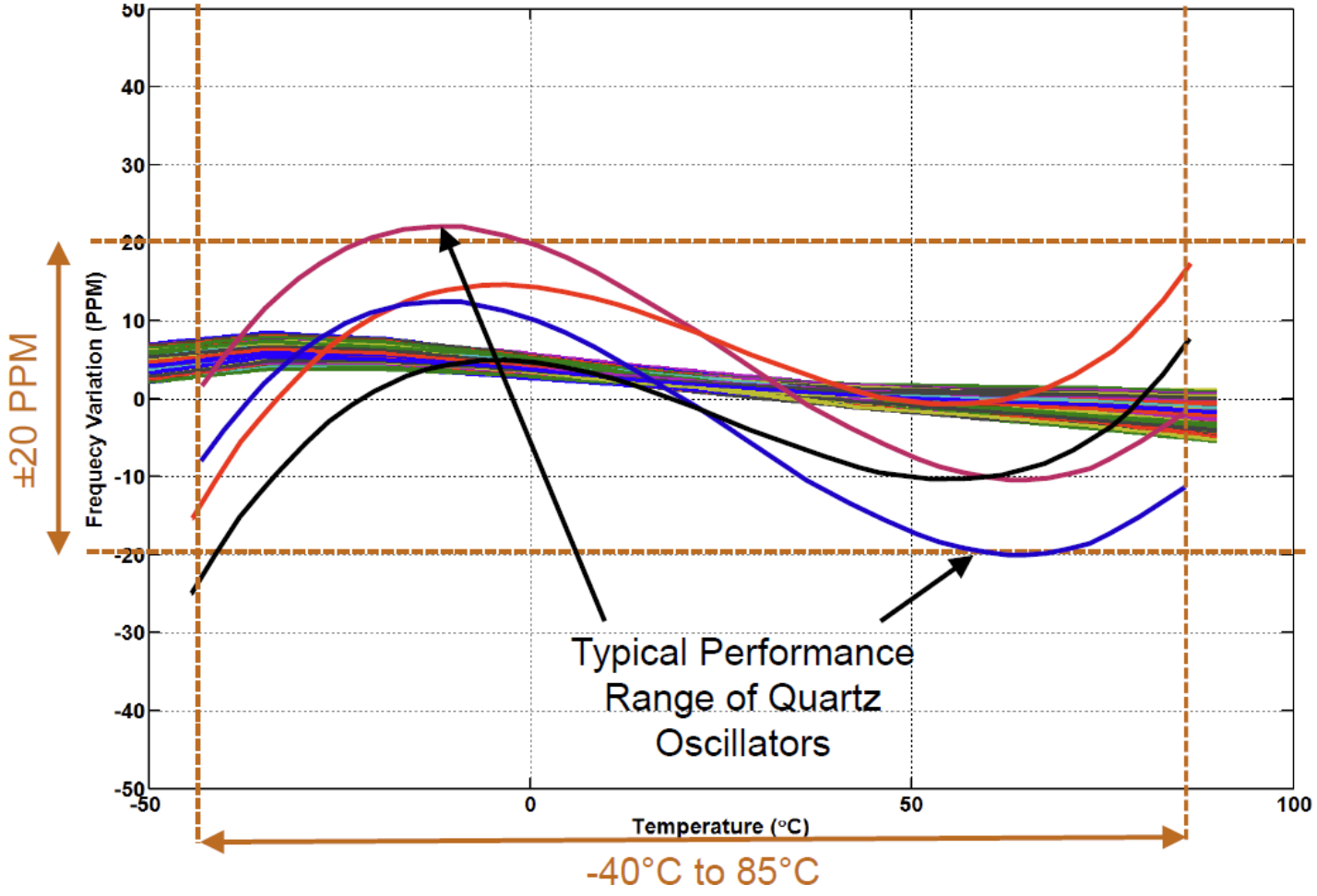
- Shortest leadtimes
- Integration
- Features, efficiency, programmability



Growth

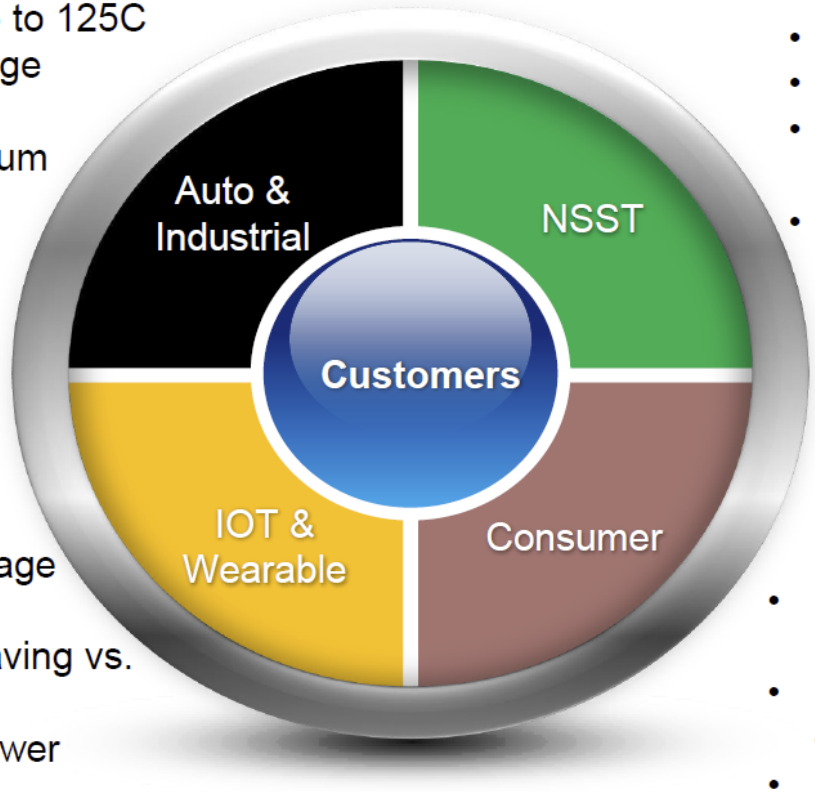
2014	Today	Future
15 families, 200MUnits Oscillator	40 families, 1B Units Oscillator	All timing categories: Oscillator, Resonator, Clock Generators
75 patents Performance = quartz	100 patents Performance 30x higher	Performance 50x higher
1,000 customers 100 applications	5,000 customers 200 applications	5x more

Frequency Stability Low Power MEMS Oscillator (1-150MHz)



Application area

- AEC-Q100 -55 to 125C
- SOT-23 Package
- Low Jitter DE
- Spread Spectrum
- ADAS Video



- Low Phase noise
- Temperature Ramps
- Harsh environments – G Force
- Device Stability - Aging

- Smallest Package 1508 CSP
- 85% Space Saving vs. Quartz
- 30% Lower Power consumption
- Time/Clock accuracy

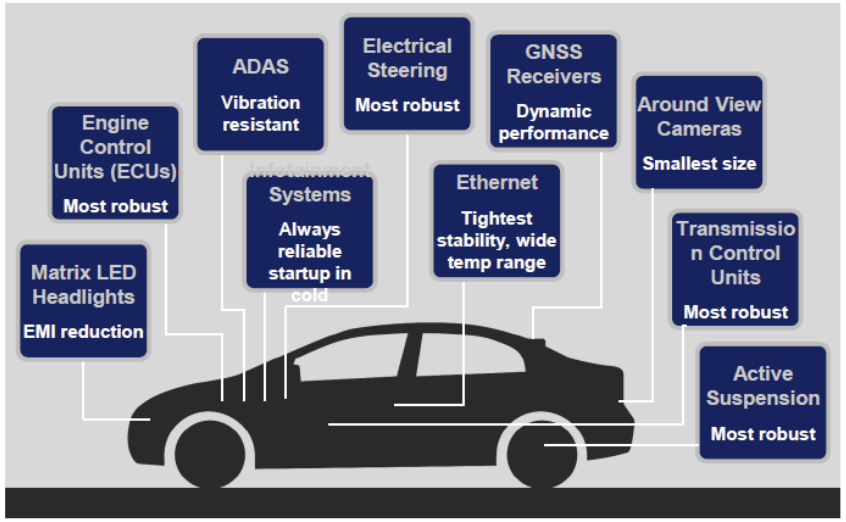
- Signal accuracy - video
- Harsh environments – G Force
- Connectors space savings

Automotive

SiTime Automotive Offering

- AEC-Q100 -55 to 125C
- SOT-23 Package
- Low Jitter DE
- Spread Spectrum
- ADAS Video

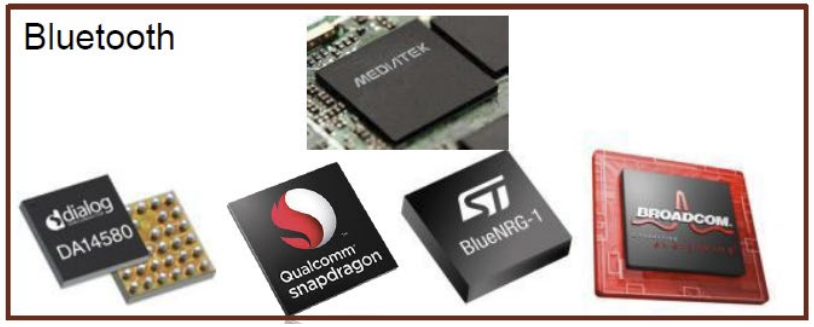
Coming soon 32Khz in SOT 23



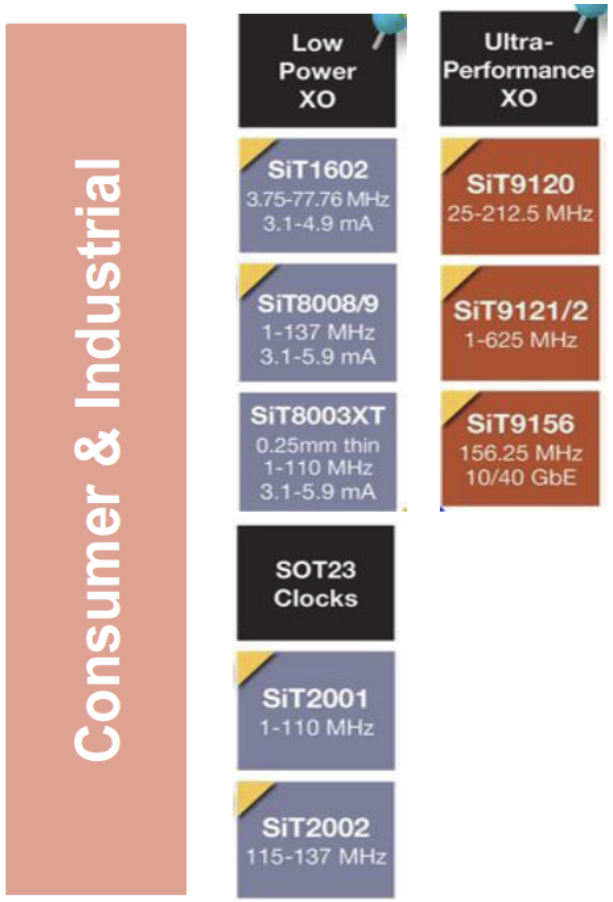
IoT & Wearables

SiTime kHz Offering

- Smallest Package 1508 CSP
- 85% Space Saving vs. Quartz
- 30% Lower Power consumption
- Time/Clock accuracy
- Drives multiple loads



Consumer



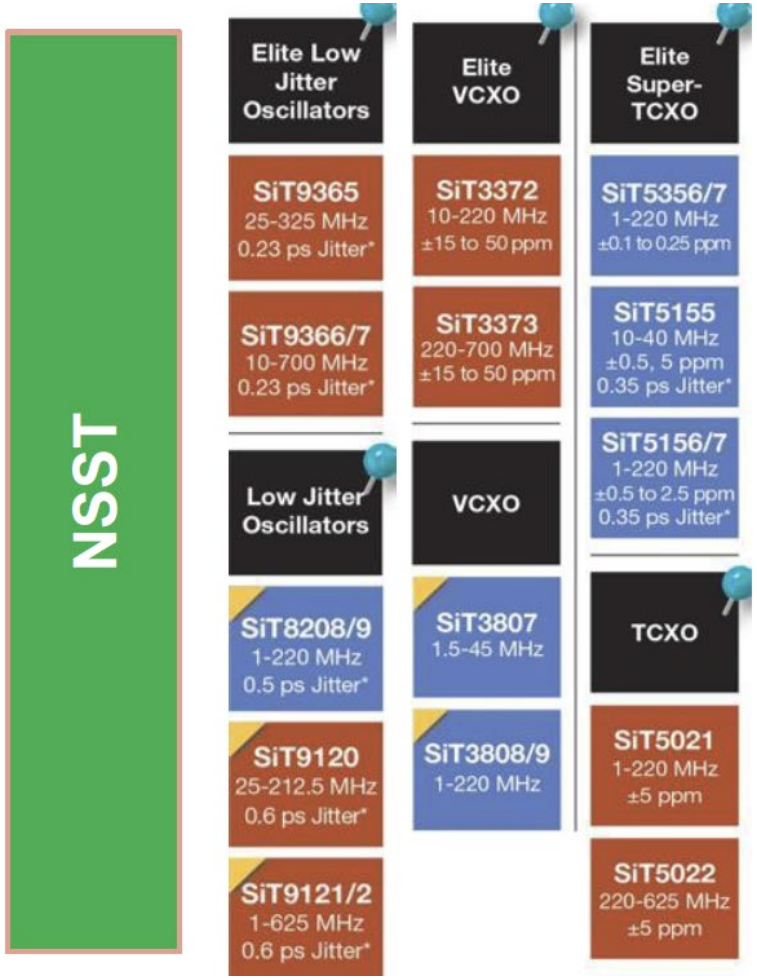
Quartz Crystal Replacement

- Small volumes (1 – 1000) = Price
- Better stability > 50 ppm
- Frequency < 10Mhz or > 50 Mhz
- Smaller Packages – 3225, 2520, 2016
- Better lead-times
- More margin
- Better temperature & shock performance

SiTime MHz in Consumer & Automation

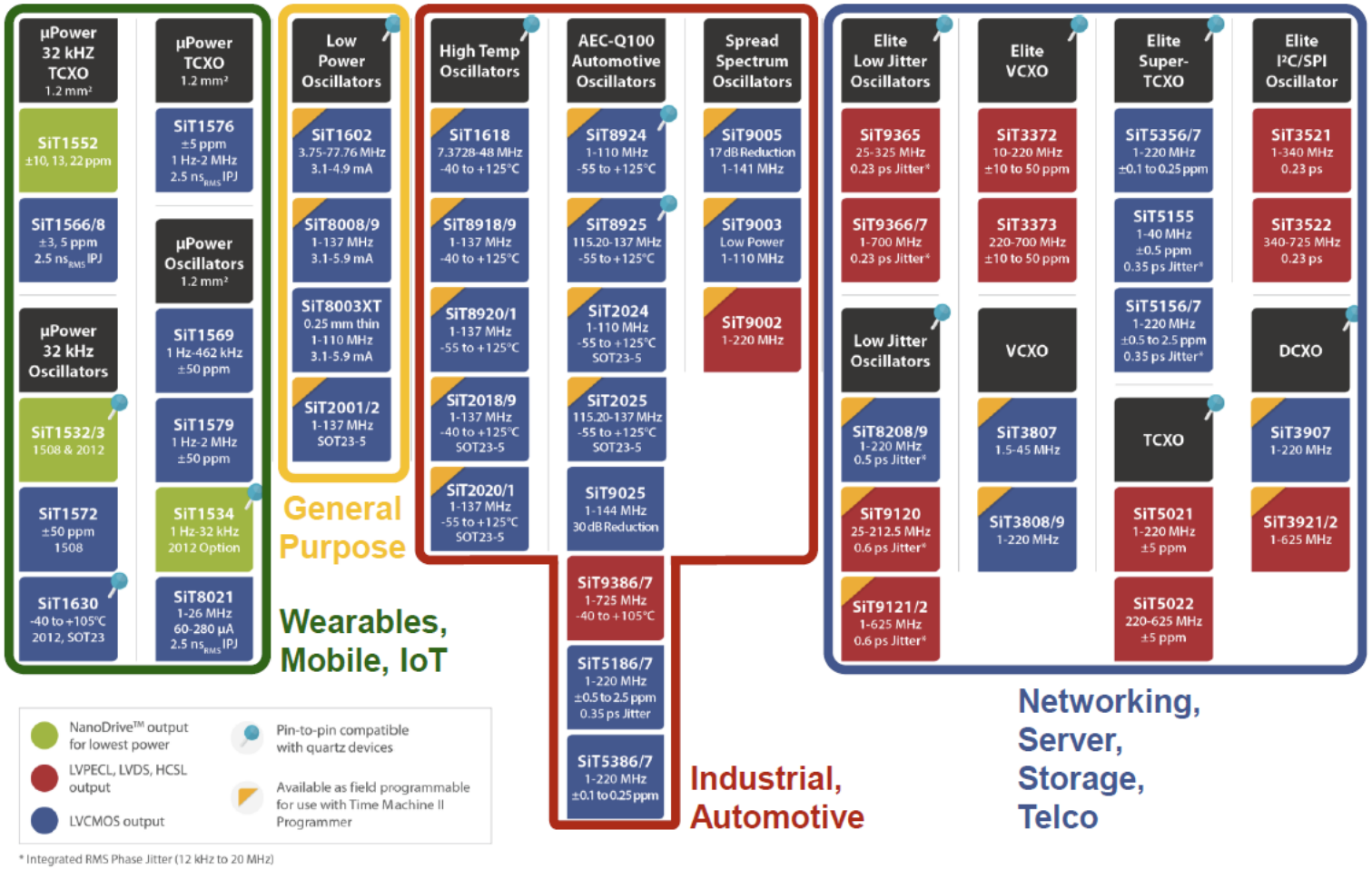
- Signal accuracy - video
- Harsh environments – G Force
- Connectors space savings

Network and storage server



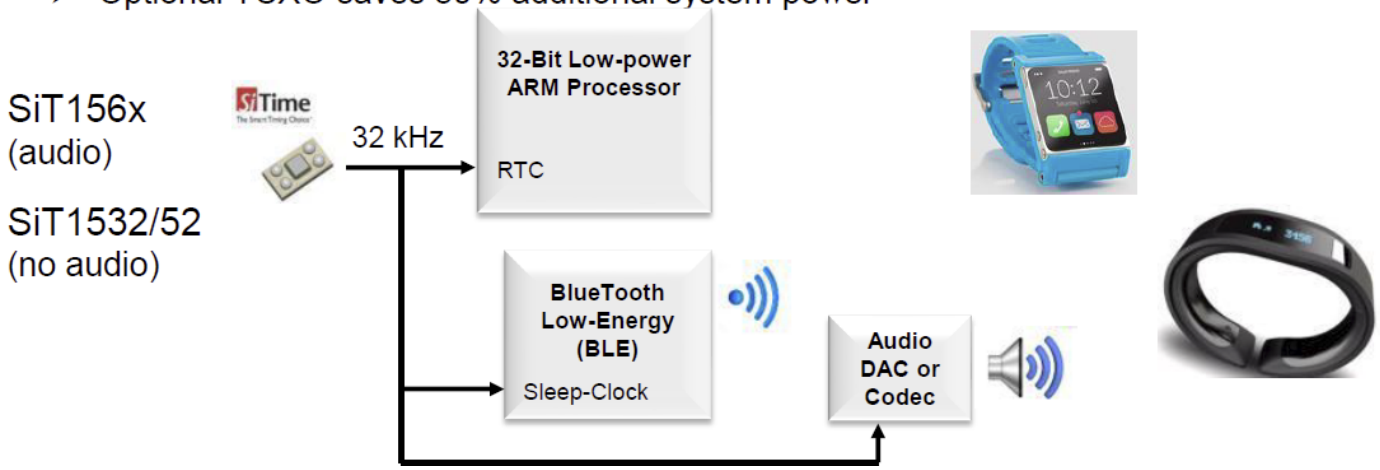
- Low Phase noise
- Temperature Ramps
- Harsh environments – G Force
- Device Stability - Aging

Product portfolio

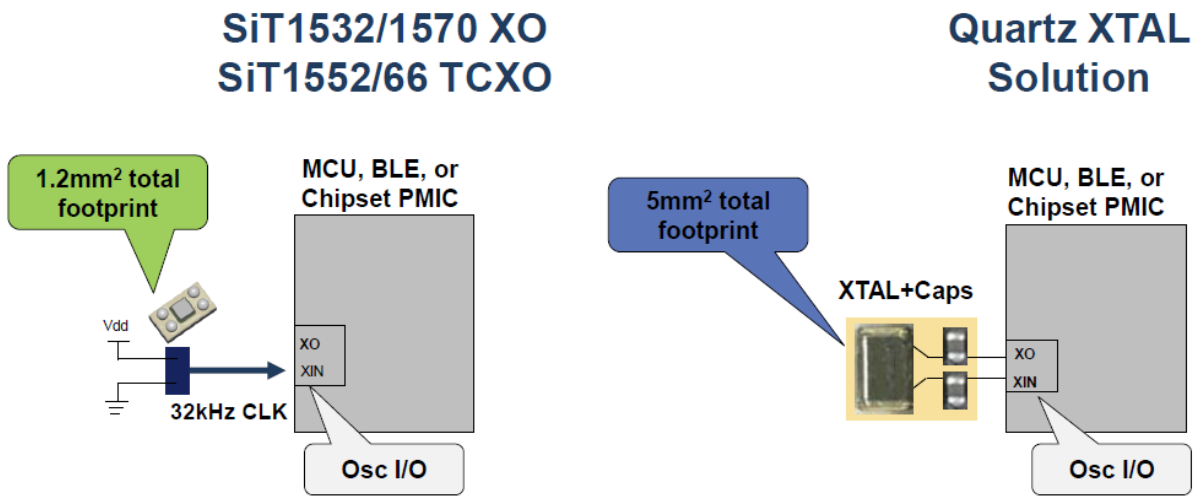


Appl. Example: Single 32kHz XO/TCXO Drives the RTC, BLE, and Audio DAC

- Problem: Too many reference clocks, need to reduce BOM
- Solution: SiT1532/52 or SiT156x XO/TCXO drives multiple loads including audio
- Key Advantages:
  - 32kHz XO/TCXO drives multiple loads
  - Smaller footprint than 2 x 32kHz XTALs + 4 load caps and one MHz XTAL + load caps
  - Acceptable Integrated Phase Jitter (IPJ) performance, 2.5ns$_{RMS}$, to drive audio SoC
  - Optional TCXO saves 30% additional system power



When the size matters….



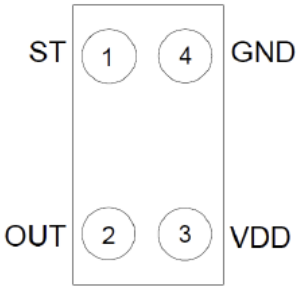
Features	SiT1532	Quartz XTAL
Package Footprint w/ Load Caps	1.2mm² (80% smaller)	5.5mm²
Load Capacitors	No	Yes
Load Dependent Start-up	No	Yes
Bypass Caps	No	NA

Appl. Example : SiT802x µPower MHz Oscillator Highlight

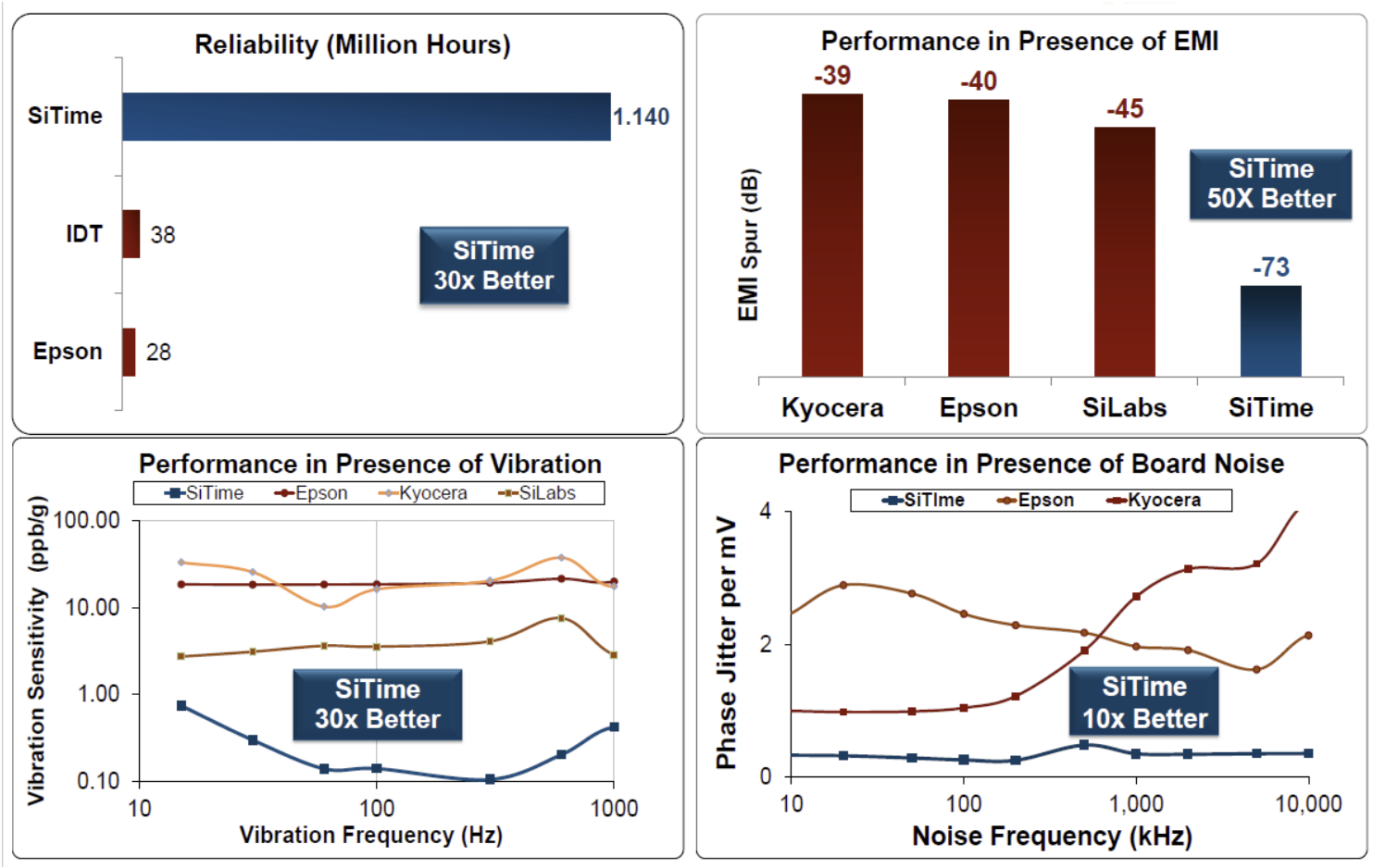
Frequency Range	Frequency Stability	Supply Voltage	Package	Temp. Range	Active Current	Resume Time	Output
1 - 26 MHz	100 PPM	1.8 V ±10%	1.5 x 0.8mm CSP	-40 to +85 C	110 µA @ 3.072 MHz	5 ms	LVCMOS

- World's lowest power MHz oscillator
  - 110 µA active current (3.072MHz)
- Ultra-small package (1.5 mm x 0.8mm) at low frequency, not easily available from quartz
- Programmable drive strength for best EMI or driving multiple loads
- Low Jitter for portable audio: 2.5ns$_{RMS}$ IPJ (20Hz – 40kHz)

Production Now



Reliability measures

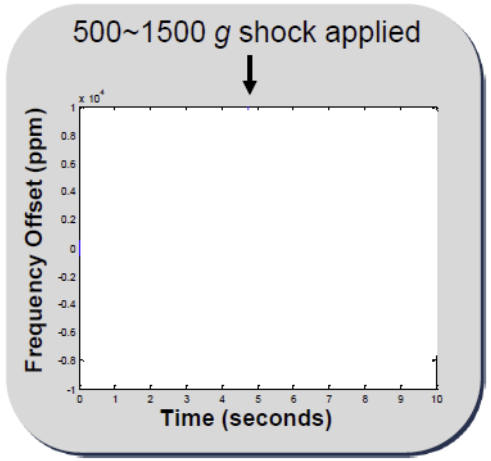


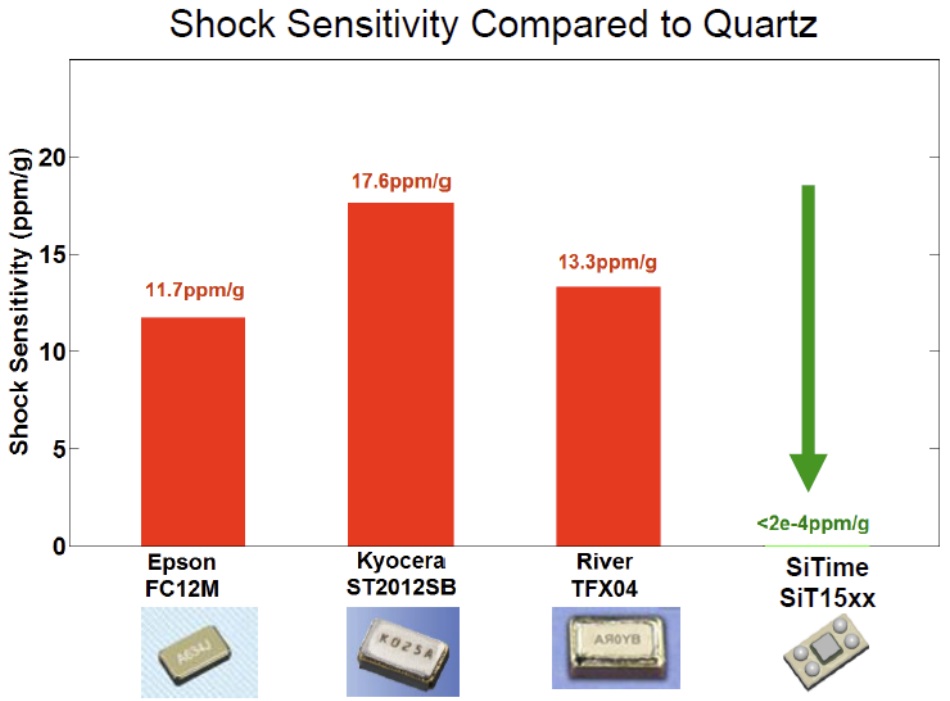
SiTime MEMS Oscillators are Inherently Robust Against Shock & Vibration

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

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

Silicon MEMS Shock Sensitivity is 60k Times Better Than Quartz





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

SiTime device tested at 1500-g and quartz XTAL+RTC tested at 500-g

Time Machine II – Program Oscillators to Your Exact Specification Instantly

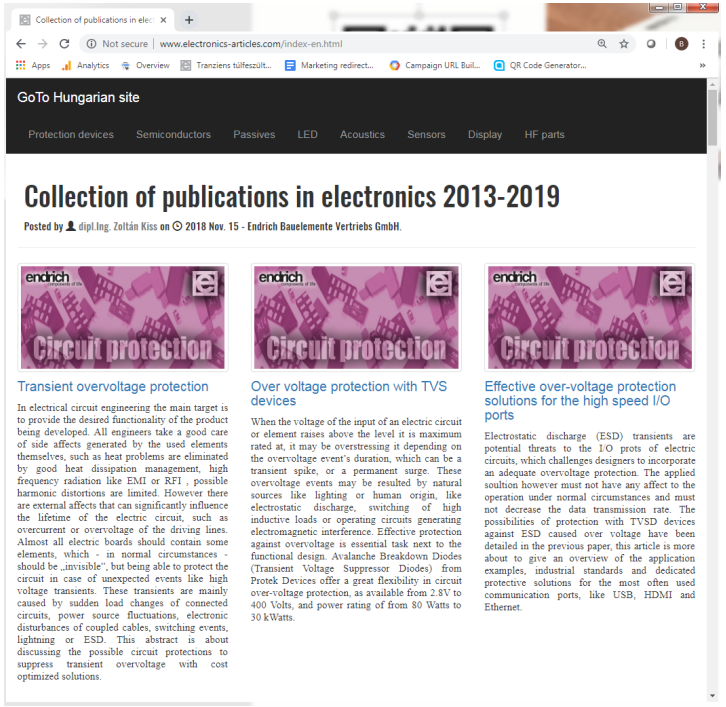
Instant Oscillators – Create Quartz XO Replacement in Seconds

- Any frequency
- Any stability
- Any Voltage
- Any package

Features and Benefits

- Fast: One-click programming of SiTime oscillators
- Convenient: USB powered, compatible with all PC
- Portable: Small, thin and easy to carry
- User Friendly: Intuitive UI, built-in part # generator, history
- Auto Update: Hassle free upgrade to latest software
- Future Proof: Support future devices
- Durable: Connectors and sockets are rated for 5000 insertions

Literature



English technical knowledgebase in Electronics

- Collection of publications in Electronics I-II-III-IV-V (2013-2019)
- http://electronics-articles.com
- Get your own copy at z.kiss@endrich.com

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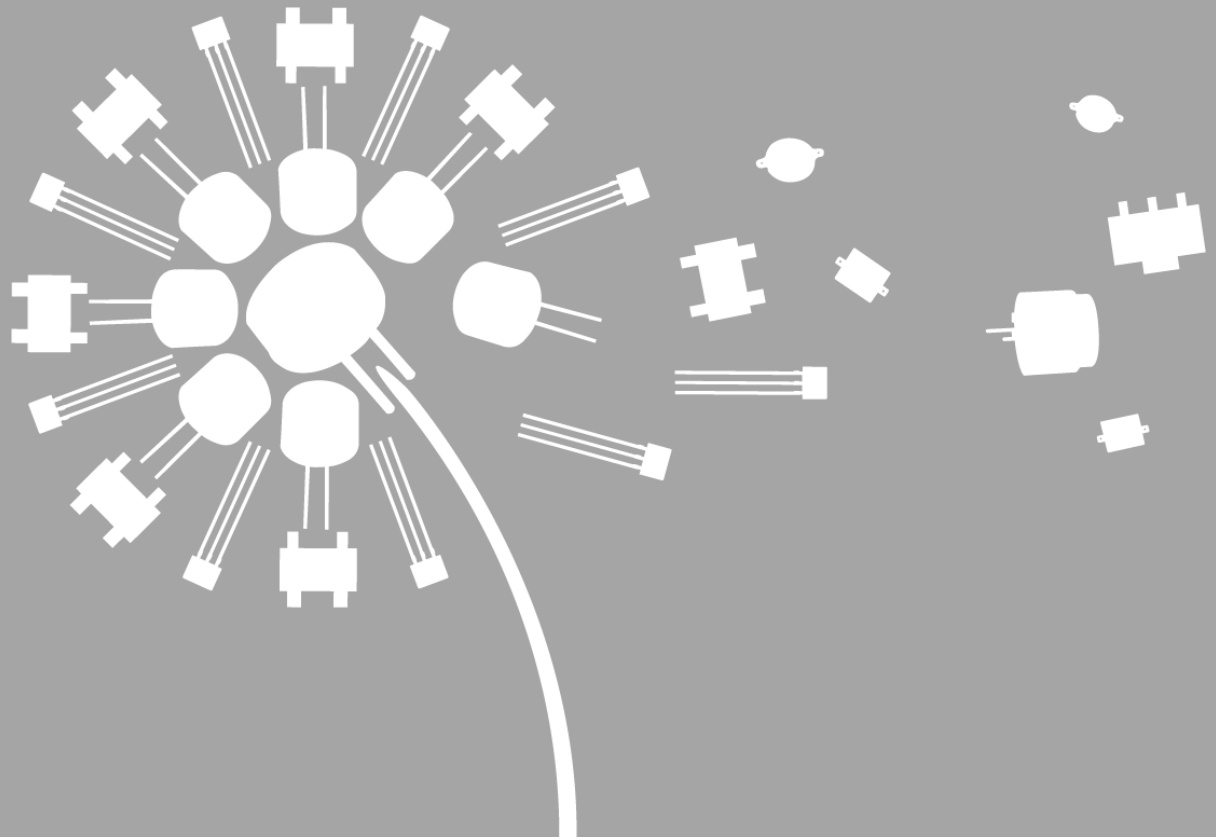
components of life



Thnx for attention