MEMS-Based Resonators and Oscillators are Now Replacing Quartz

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My purpose is to convince you that MEMS timing is here now. MEMS will replace quartz oscillators in most applications. The value add is strong enough to transform an industry.
Quartz Oscillators:
- Ceramic/metal package
- Quartz plate and driver circuit
- Dedicated factories

MEMS Oscillators:
- Plastic QFN package
- Silicon MEMS die and CMOS die
- Standard IC fabs
Like a 2D bell – held in the center with its outer edges ringing. Motion is a few nanometers.

Buried inside the chip, not on the surface.
- kHz MEMS tuning forks for apps now served by 32kHz quartz tuning forks.
- Driven with sub-microamp supply currents.
MEMS-Based Resonators and Oscillators are Now Replacing Quartz Encapsulation Resonator Chip Surface
MEMS-Based Resonators and Oscillators are Now Replacing Quartz
MEMS-Based Resonators and Oscillators are Now Replacing Quartz
- Tremendous Flexibility
- New features
- Delivered performance
- Short lead times
- Exceptional quality and reliability
- Low cost, high value
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TCXO Frequency v. Temperature

1977 units, 5 lots

± 2.5ppm

-50 to +90°C

Temperature (degC)

Frequency Variation (ppm)
f_{carrier} = 156.25\text{MHz} \\

Int jitter (12k-20MHz)
- no spurs = 493fs
- w/ spurs = 689fs

-125\text{dBc/rtHz}

-152\text{dBc/rtHz}

12k-20MHz
Vibration Induced Spur vs. Acceleration

\[ f_{\text{vibration}} = 100\text{Hz} \]

**Competitive**

**S. MEMS**

![Graph showing vibration-induced spur vs. acceleration for different systems with competitive and S. MEMS performance](image-url)
Phase Jitter Without and With EMI Interference

- **Int Phase Jitter (ps, 12k-20MHz)**
  - **No Interference**
    - S. MEMS: 0.5, 1.6, 0.8, 0.7
  - **Interference**
    - 0.5, 5.9
    - 1.6

- Problematic for electrostatic discharge

**Note:**
- MEMS-Based Resonators and Oscillators are Now Replacing Quartz
4 of the top 5 Computer Makers
3 of the top 5 Consumer Electronics
3 of the top 5 Contract Manufacturers
5 of the top 5 ODMs
Technology has fundamentally helped Humanity.

Engineers make small contributions that are multiplied countless times.

What you do matters to Billions of people!

Dorothea Lang, “Migrant Mother” 1936
Thank You
Abstract

The first commercial MEMS-based timing devices shipped in 2007. In just five years they are transforming the timing industry. The first parts offered XO stability and various advantages like programmability, but lacked the signal quality to support more than the basic applications. Recent parts are dramatically improved, offering TCXO stability, sub-picosecond integrated jitter, high frequency differential outputs, low phase noise for RF applications, low power for portable applications, and ultra low power for real time clock applications. Production rates are increasing exponentially with over 50 million units sold as of June 2011. How does this stuff work? Where will the technology go? Will MEMS replace quartz? What will MEMS timing do for the electronics industry? What will MEMS timing do for Humanity?