Reimagining the Holdover Oscillator

MEMS-based Precision Timing Delivers Accurate, Reliable, Ultra-Stable Clock Signals for the Era of Intelligent, Connected Electronics. By **Piyush Sevalia, Executive VP Marketing, SiTime**

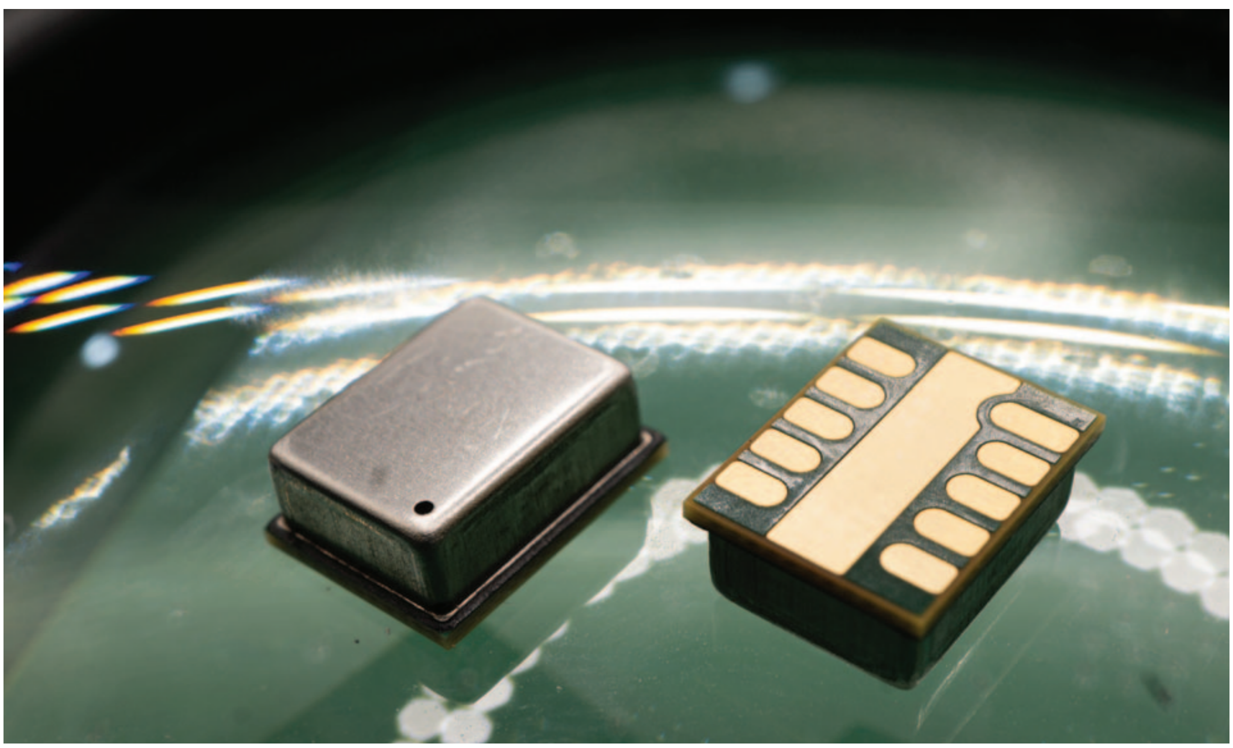
Precision timing provides the heartbeat of all electronics, playing a crucial role in the seamless operation and synchronization of countless devices, systems, and networks. In today's era of intelligent and connected electronics, the demand for precise and reliable timing technology has exponentially increased with the rise of AI computing, 5G networks, cloud data centers and the Internet of Things (IoT). These advancements underscore the importance of precision timing in critical network infrastructure. All nodes in a network must be precisely synchronized with increasing accuracy to maximize performance and reliability. For example, 5G network nodes must be synchronized within hundreds of nanoseconds, which is ten times more stringent than required by 4G LTE networks.

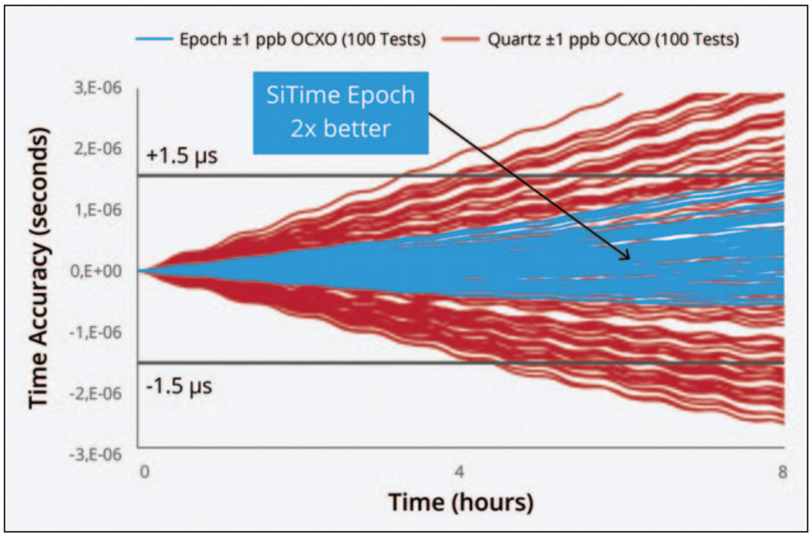
MEMS-based Precision Timing: Disrupting the Century-Old Quartz Legacy

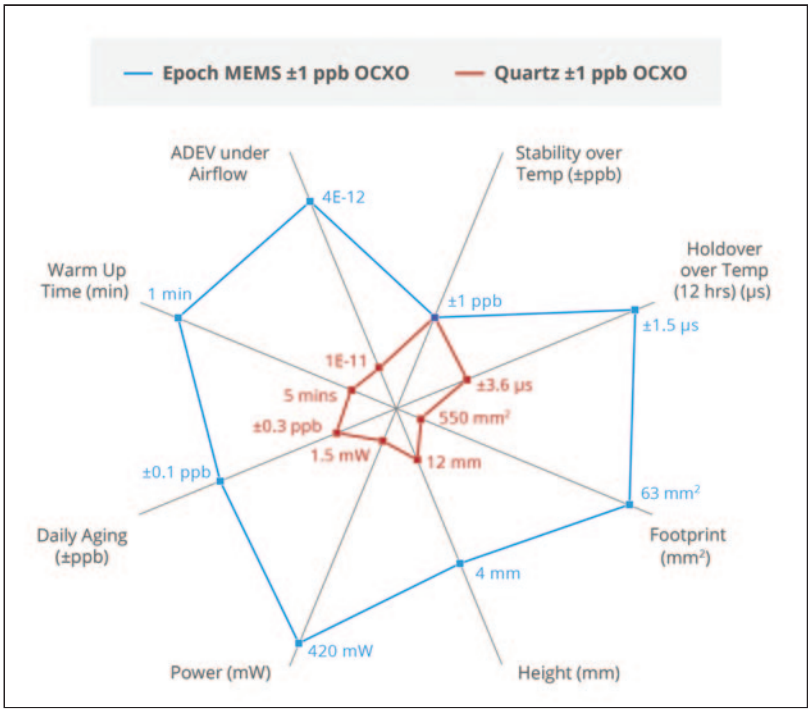
Precision timing technology has evolved rapidly in recent years to meet the demands of high-speed, time-sensitive networks. Microelectromechanical systems (MEMS) technology has emerged as a game-changer in the realm of precision timing. MEMS-based precision timing technology is rapidly gaining traction, disrupting the century-old legacy dominated by quartz-based timing solutions. While quartz crystals have served the electronics industry well for decades, MEMS technology elevates precision timing to new levels of performance and reliability.

MEMS resonators are miniature mechanical systems fabricated on a microscale, typically in the range of micrometers. They integrate electronic, mechanical and electromechanical elements to create highly stable and reliable timing components that offer several advantages over traditional quartz-based systems:

- Miniaturization: MEMS timing components are significantly smaller than their quartz counterparts, facilitating the development of compact, lightweight electronic devices without sacrificing performance.
- Improved resilience: MEMS devices can withstand extreme environmental conditions, including temperature variations, airflow, shock, and vibration, making them ideal for applications that demand robust performance and reliability in challenging environments.
- Lower power consumption: MEMS devices are more energy-efficient than quartz alternatives, contributing to longer







battery life in portable and IoT devices. In our increasingly wireless and mobile world, the low power consumption of MEMS-based timing solutions is a significant advantage.

- Enhanced frequency control: MEMS-based oscillators offer better control over output frequency, enabling more precise, stable timing. This precision plays a pivotal role in enhancing the overall performance and synchronization of electronic systems.
- Customization: MEMS technology enables the development of programmable timing solutions to meet specific application requirements. MEMS timing devices can be programmed for 15 different parameters, such as frequency, operating temperature range and supply voltage, while a crystal is manufactured to have a single, fixed frequency. This adaptability enables MEMS-based precision timing to be deployed across a wide array of industries and use cases.

Maintaining Time Accuracy with Frequency Stability and Holdover

A key metric in precision timing is frequency stability, which directly influences the performance and reliability of electronic systems. Frequency stability is critically important in applications such as GNSS/GPS, radar, aerospace and defense, 5G networks, automotive safety systems, and financial technology (fintech). Real-time networks based on the IEEE 1588 precision time protocol (PTP) also require precision timing devices that excel in frequency stability.

Defined by low phase noise and negligible drift over time, frequency stability is crucial for an important timing capability known as holdover. A synchronized network relies on multiple, redundant timing sources to ensure continuous operation. One of these timing sources is an ultra-stable local oscillator, typically an oven-controlled oscillator (OCXO), which will "holdover" the network and ensure continued, seamless network operation when upstream timing sources are disrupted and temporarily unavailable. The length of the holdover period is directly proportional to the stability of the local oscillator., highlighting the importance of using a highly stable precision timing solution. The more stable the oscillator, the longer the holdover period, and the longer the system can operate until the upstream timing reference (such as a GPS signal) is restored.

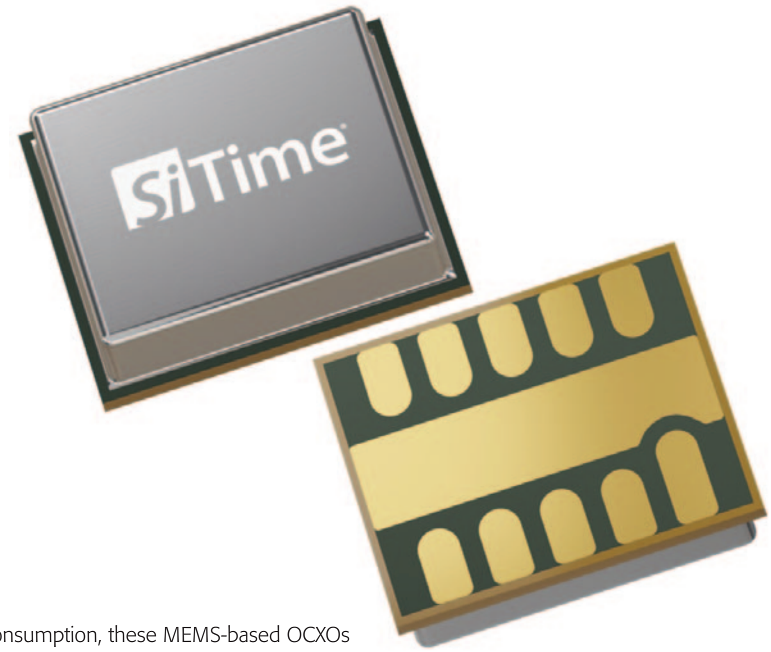
System developers can enhance frequency stability and minimize drift by choosing specialized timing devices, such as OCXOs and temperature-compensated oscillators (TCXOs), which are designed to minimize the negative impact of temperature change on frequency stability. High-precision OCXOs and TXCOs are designed to generate more stable frequencies than conventional oscillators when exposed to rapid temperature changes.

New Ultra-Stable Holdover OCXOs Outperform Quartz

Recognizing the critical need for greater stability and longer holdover in today's demanding electronics applications, SiTime reimagined the holdover oscillator by developing the Epoch Platform. The Epoch Platform distinguishes itself by offering twice the holdover period of conventional quartz-based solutions under common environmental stressors, enabling telecom and cloud service providers to ensure service continuity in real-world conditions.

In contrast to the Epoch Platform, legacy quartz OCXOs are inherently unreliable and prone to performance degradation in the presence of environmental stressors such as temperature changes and vibration. To date, OCXO vendors have compromised on real-world performance, reliability, size, power, and warm-up time to achieve the one attribute most OCXOs are designed to deliver – a stable clock reference.

The Epoch Platform overcomes the limitations of quartz OCXOs by integrating two MEMS resonators through SiTime's DualMEMS temperature sensing technology, resulting in 100 percent thermal coupling. This ensures 40x faster temperature tracking, a crucial timing attribute, especially under conditions of fluctuating airflow and rapid temperature changes. In addition, SiTime's TempFlat



MEMS has 10x the resilience to temperature variations compared to traditional quartz resonators, while also eliminating activity dips. The ultra-small MEMS resonator, with its extremely low mass, mitigates the effects of g-force, resulting in 30x better vibration immunity than quartz. Pairing innovative MEMS technology with SiTime's advanced analog circuitry results in exceptional dynamic stability, ultra-low phase noise, and a broad frequency range.

Epoch Platform OCXOs enable 12 hours of holdover, support any frequency between 10 and 220 MHz, are programmable up to six decimal places of accuracy, and offer digital control with I2C and SPI interfaces for unparalleled flexibility. Designed for low power consumption, these MEMS-based OCXOs consume just 420 mW, 3x less than quartz devices. The Epoch Platform's small footprint (9 mm x 7 mm x 3.73 mm) occupies 9x less area and is 3x times thinner than comparable quartz-based timing solutions, enabling a greater degree of freedom for hardware designers.

SiTime's Epoch Platform is setting new standards in MEMS-based precision timing technology, ensuring nanosecond accuracy in critical network infrastructure. With its exceptional stability, longer holdover, high reliability, and low power consumption, the Epoch Platform is poised to revolutionize the world of precision timing, making it an indispensable technology for today's intelligent, connected electronics.