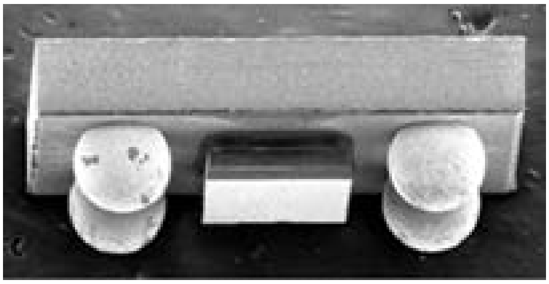
JEAN-JACQUES DELISLE | Technical Engineering Editor

Times Change, and So Do VCOs

In frequency-control products, MEMS and CMOS technology are reaching performance that is on par with quartz crystal resonators.



The MEMS die is located between the solder bump balls of the CMOS chip in a double-flip-chip configuration. (Courtesy of SiTime)

TIMING REQUIREMENTS FOR modern commercial electronics are demanding more for the same cost in a smaller footprint. Conversely, military and aerospace applications are looking for timing products that have advanced in thermal, vibration, and aging stability. To meet these demands while satisfying the increasing need for adaptable microwave/RF solutions, frequency-control companies are producing more advanced voltage-controlled oscillators (VCOs) from a myriad of technologies.

A recent addition to the VCO family is the MEMS VCO. These VCOs use micro-sized mechanical vibrators that can be developed using CMOS processing on chips and in extremely small-footprint packages *(see figure above)*. The VCOs operate from as low as 1 MHz to a few hundred megahertz. MEMS VCOs are generally low-voltage and low-power devices that can be made in large volume, at low pricing, and with very short lead times compared to other VCO technologies. Typically, these benefits have come at the cost of higher jitter and phase noise—several ps-RMS. Manufacturers of MEMS VCOs include Silicon Labs, Vectron, Micrel, and SiTime.

As a function of the highly integrated CMOS technology, MEMS VCOs can be augmented by sophisticated circuit techniques. SiTime recently developed CMOS MEMS VCOs that can supposedly match and even exceed the jitter response of quartz crystal. "MEMS originally had very limited capability. But now, it is at the snapping point where the MEMS capability is exceeding the quartz performance," said Aaron Partridge, founder and chief scientist of SiTime. In packages measuring 5 × 3.2 mm or 7 × 5 mm, the firm's new VCOs provide a pull range from 25 to 1600 ppm with jitter performance under 0.5ps-RMS.

Among the additional benefits of MEMS VCO technology are lower power, a smaller footprint, lower parasitics, and the potential for direct programmability. "One of the factors that limit the quality of signals from oscillators is the stray capacitance," Partridge notes. "With a crystal oscillator in a ceramic package, the capacitance can be very high. With MEMS oscillators, the capacitance is derived from small bond wires and is very low. This low stray capacitance provides advantages in terms of signal quality."

With other VCO technologies, a digital signal traditionally controls an analog-to-digital converter (ADC). That ADC, in turn, uses an analog signal to control the VCO. Another method is to control a PLL with a direct digital stream, which could reach resolutions of parts per billion. This new technique prevents any analog noise from the control signal entering the signal stream. For example, the MEMS resonators in the latest SiTime VCOs are adjusted using a digitally controlled PLL.

With surface acoustic wave (SAW) or crystal-based technologies, the tight integration of advanced control circuitry requires additional and complex manufacturing steps. SAW and crystal resonators also are reliant on specialized manufacturing techniques to construct the resonators. The resulting higher cost and longer lead times are less desirable in a market that continues to demand shorter design and production cycles. It also should be noted that many applications, such as aerospace and military, may require much higher-performing and specialized functionality from their VCOs without being driven by cost, footprint, or fast-paced market needs.

For telecommunications applications specified, the benefits of technologies that can integrate with CMOS processes is becoming increasingly apparent as market demands drive down costs, size, and lead times for almost all commercial RF/microwave components. mw