Application Brief

ADAS Domain Controller BAW Clock Architecture

Juan Rodriguez, Cris Kobierowski

Clocks and Timing Solutions

BAW Resonator Technology

BAW Resonator Technology (BAW) is a micro-resonator technology that enables the integration of high-precision and ultra-low jitter clocks directly into packages that contain other circuits. In the CDC6C-Q1 BAW oscillator, the BAW is integrated with a collocated precision temperature sensor, an ultra-low jitter, low power integer output divider (IOD), a single-ended LVCMOS output driver, and a small power-reset-clock management system consisting of several low noise LDOs. The LMK3H0102-Q1 and LMK3C0105-Q1 clock generators also integrate the BAW, removing the need for an external crystal while supporting multiple needs for PCIe and reference clocks from a singular device.

Figure 1 shows the structure of the BAW Resonator Technology. The structure includes a thin layer of piezoelectric film sandwiched between metal films and other layers that confine the mechanical energy. The BAW utilizes this piezoelectric transduction to generate a vibration.

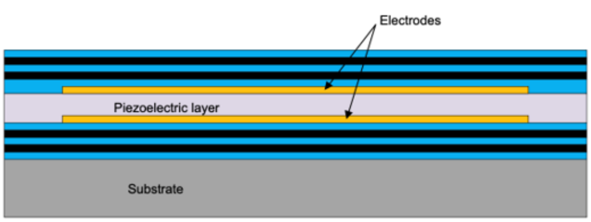

Figure 1. Basic Structure of a Bulk Acoustic Wave (BAW) Resonator

BAW Technology in ADAS Domain Controllers

Modern vehicles are evolving to transmit higher volumes of data with minimal latency. Servers, storage, and input/output peripherals facilitate high-speed data transfer from high-performance processors and SoCs that support the PCIe 5.0 specification and more stringent 6.0 specification. Data transfer in the automotive sector is likely to approach the levels of data centers as ADAS SoCs increase in complexity to improve advanced autonomous driving and embed artificial intelligence. With zonal architecture incorporating PCIe standards, software-defined vehicles are taking over the market where continuous updates maintain and improve performance for drivers.

Both SoC manufacturers and Original Equipment Manufacturers (OEMs) are developing processors to require PCIe 5.0 and 6.0 specification speeds. The LMK3H0102-Q1 supports the PCIe 6.0 requirement of 100fs, with a common clock jitter of 34.5fs. Typically, a High-Performance Computing (HPC) platform consists of a complex clock tree, molding ADAS and IVI systems together. TI is the first manufacturer to support oscillators, clock generators, and clock buffers enabling OEMs to optimize designs for size and cost.

TI Functional Safety-Capable BAW clocks target embedded processing HPC systems that combine ADAS and IVI domains, where sensor input from camera, radar and lidar systems help protect drivers and passengers. Figure 2 illustrates an HPC topology with minimal single clock sources across the system. The LMK3H0102-Q1 is the high-performance version of the LMK3C0105-Q1, supporting LP-HCSL, LVDS, and LVCMOS outputs in comparison to the LMK3C0105-Q1 supporting only LVCMOS outputs.

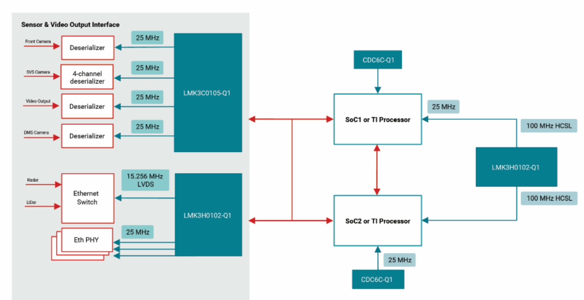

Figure 2. High-Performance Computing Topology

Benefits of the BAW

TI's BAW oscillators have many benefits including the following:

- **Frequency Flexibility:** Many quartz oscillators (XOs) are controlled through mechanical parameters that cannot be modified once cut. The BAW oscillator alleviates supply constraints by being able to support a large range of frequencies with a single IC through OTP programming
- **Temperature Stability:** Uncompensated XO temperature response resembles a parabolic curve with larger ppm variation. The BAW maintains ±10 ppm of temperature stability irrelevant of temperature range (Figure 3).
- **Vibration Sensitivity:** XOs typically do not pass MIL-STD and can be as high as +10 ppb/g. The BAW oscillator passes MIL_STD_883F Method 2002 Condition A with a typical is 1 ppb/g (Figure 4).
- **Mechanical Shock:** Quartz-based clocks typically do not pass MIL-STD and can fail at 2,000g. The BAW oscillator passes MIL_STD_883F Method 2007 Condition B with less than 0.5ppm variation up to 1500g.
- **EMI Performance:** Quartz-based clocks typically have no CISPR-25 data provided from the manufacturer. The CDC6C-Q1 has several slew rate control options up to 4ns. CDC6C-Q1 passes CISPR25 Class 5 standards at the Slow Mode 2 option. The LMK3H0102-Q1 and LMK3C0105-Q1 incorporate Spread Spectrum Clocking, improving EMI performance at the system and device level. Both devices pass CISPR25 Class 5 standards at various trace lengths (see reports: LMK3C0105 EMI Report, CDC6C CISPR-25 EMI Report)
- **PCB Area:** TI's BAW Oscillator family supports 1.8V-3.3V supply voltages and are available in standard 4-pin DLE (3.2mm × 2.5mm), DLF (2.5mm × 2mm), DLX (2mm x 1.6mm), and DLY (1.6mm x 1.2mm) packages with wettable flank, which save space in compact board designs. Figure 5 showcases BAW Oscillator layouts in comparison to typical crystal layouts for several package sizes. Crystals require up to four external components to tune the resonant frequency and maintain active oscillation. Active oscillators such as the CDC6C or LMK6C only require a single capacitor for power supply filtering, which simplifies the BOM and significantly reduces the layout area required. Additionally, parasitic capacitance from PCB traces does not affect the frequency accuracy of an active oscillator, allowing the oscillator to be placed much farther away from the receiver compared to crystal. Both the LMK3H0102-Q1 and LMK3C0105-Q1 are available in a 3x3 package with wettable flank. As both devices can be used in place of 5 single channel clocks, TI offers a 55% size reduction to PCB space per Figure 5.

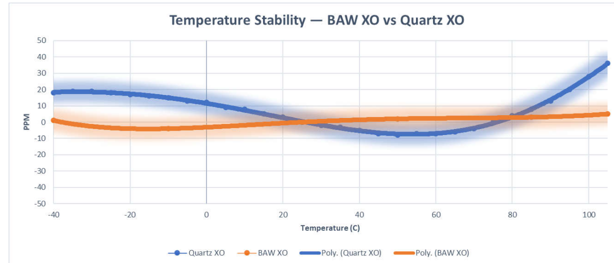

Figure 3. Temperatue Stability - BAW Oscillator vs. Quartz Oscillator

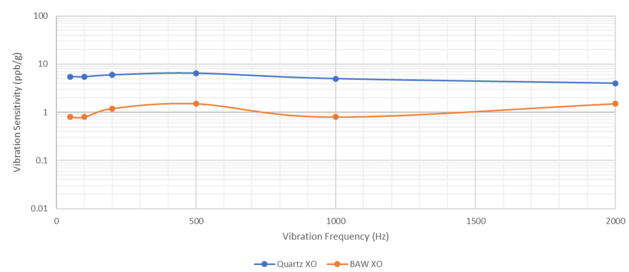

Figure 4. Vibration Sensitivity - BAW Oscillator vs. Quartz Oscillator

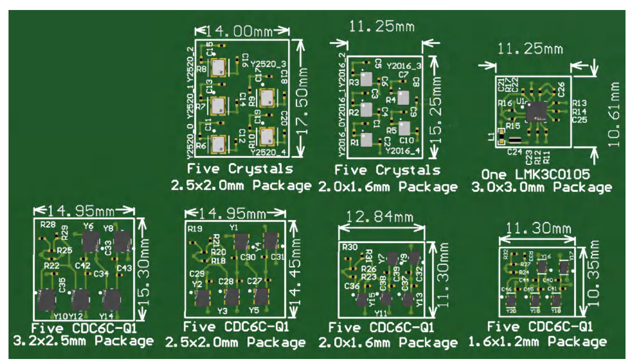

Figure 5. Five Crystal, Five CDC6C-Q1, and LMK3C0105-Q1 Footprint Comparison

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265