Application Brief

BAW Clocking Solutoins for In-Vehicle Infotainment

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Clocks and Timing Solutions

BAW Resonator Technology

Bulk Acoustic Wave (BAW) Resonator Technology 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), LMK3H0102-Q1 (differential clock generator) and LMK3C0105-Q1 (LVCMOS clock generator), the BAW is integrated with a collocated precision temperature sensor, ultra-low jitter low power output dividers, and a small power-reset-clock management system consisting of several low noise LDOs. These integrated-BAW clock generators move the need for an external crystal while supporting needs for PCIe and reference clocks from a single 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.

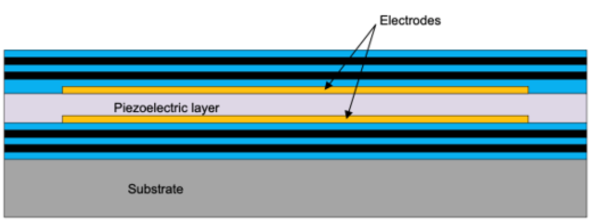

Figure 1. Basic Structure of a Bulk Acoustic Wave Resonator

BAW in In-Vehicle Infotainment Systems

The consumer driving experience molds the requirements for in-vehicle infotainment systems, as the integration of personal electronics and Advanced Driver-Assistance Systems (ADAS) feature feedback demands several components requiring a clocking source. The automotive industry is entering an era where In-Vehicale Infotainment (IVI) and ADAS seamlessly connect, while prioritizing total PCB size and component cost. Current generation and next generation IVI architecture follow the same clocking topology with the need for data transmission and processing.

TI is the first manufacturer to offer BAW-based clocking devices, with oscillators and clock generators that support any processing-based architecture in a software-defined vehicle. Designers can simplify systems by reducing the number of clocks in a complex IVI platform. Figure 2 shows how these devices are used to generate frequencies for different individual components.

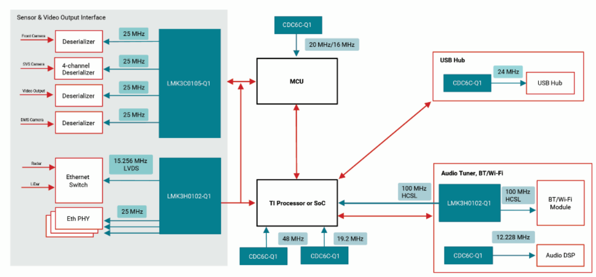

Figure 2. IVI Clocking Block Diagram

The LMK3H0102-Q1 and LMK3C0105-Q1 are TI Functional Safety-Capable, with a Failures In Time (FIT) rate of 9 under the ISO 26262 standard. These devices pass Comité International Spécial des Perturbations Radioélectriques (CISPR) 25 Class 5 compliance for all bands at trace lengths up to 300mm, maintaining stable clocking and reduced emissions with Spread-Spectrum Clocking (SSC). The CDC6C-Q1's slew-rate control allows for control of emissions in designs while benefiting from the improved reliability compared to quartz, maintaining a FIT rate as low as 3 under the ISO26262 standard. The BAW clocks are built to support various receivers with a reduced risk of failure in comparison to quartz technology, optimizing IVI platforms with minimal components and lower BOM cost.

BAW Architecture Benefits

TI's BAW oscillators and clock generators have many benefits including:

- **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 one-time programmable (OTP) memory.
- **Temperature Stability**: Uncompensated XO temperature response resembles a parabolic curve with large ppm variation. Figure 3 shows that the BAW maintains ±10 ppm of temperature stability regardless of temperature.

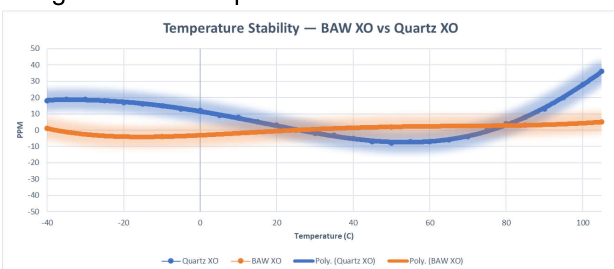

Figure 3. BAW Oscillator vs. Quartz Temperature Stability Comparison

- **Vibration Sensitivity**: XOs typically do not pass MIL-STD and can be as high as +10ppb/g. Figure 4 shows that the BAW oscillator passes MIL_STD_883F Method 2002 Condition A with a typical performance of 1 ppb/g. Vibration and Mechanical Shock Performance of TI's BAW Oscillators details the performance of TI's BAW oscillators in detail.

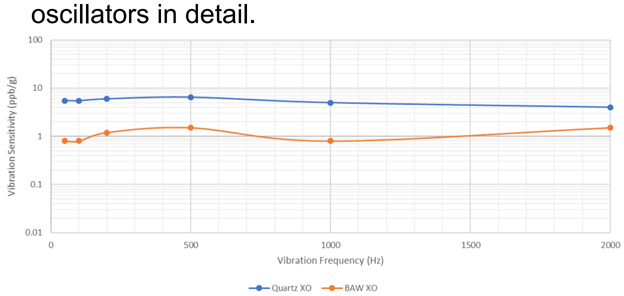

Figure 4. BAW Oscillator vs. Quartz Vibration Sensitivity Comparison

- **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 using 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 over various trace lengths.
- **Small PCB Footprint**: TI's BAW Oscillator family supports 1.8V to 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 do not affect the frequency accuracy of an active oscillator which allows for placement 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 30% size reduction to PCB space per Figure 5.

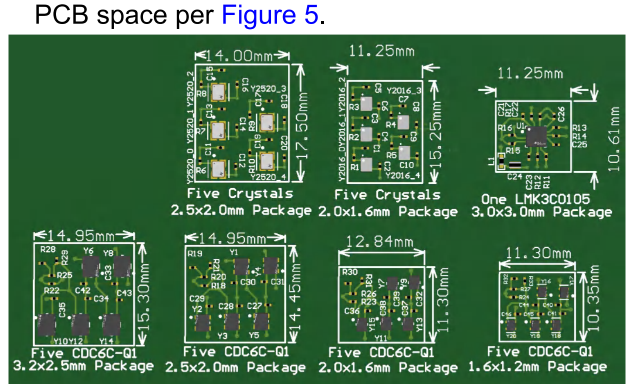

Figure 5. Five Crystal, Five CDC6C-Q1, and LMK3C0105-Q1 Footprint Comparison

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