Application Brief

BAW Solutions in Automotive Front Camera Systems

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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 singleended LVCMOS output driver, and a small power-reset-clock management system consisting of several low noise LDOs.

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.

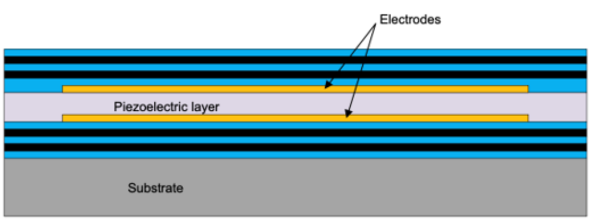

Figure 1. Basic Structure of a Bulk Acoustic Wave (BAW) Resonator

BAW Oscillator in Automotive Front Cameras

Front cameras support color-based object identification such as detecting bystanders, speed-limit signs, feedback for lane-keeping assistance, and parking with a high-resolution image. Front cameras are considered a functional safety end equipment due to the quantity of safety tasks the cameras are responsible for; therefore, meeting ASIL B to ASIL D under ISO 26262 is required. TI's first automotive-grade BAW oscillator solves the reference clock architecture in current and next generation front camera systems by achieving a low FIT rate to help systems reach ASIL D compliance, available in the smallest package on the market of 1.6mm x 1.2mm.

In the current generation of vehicles, the front camera consists of a camera block and an Electronic Control Unit (ECU). The camera side processes raw image data and serializes the refined information to the local ECU for further analysis and decision making. This improves real time responsiveness by separating image processing from higher level vehicle control functions typically handled by a central ECU, like an ADAS Domain Controller. High resolution camera systems opt to use an external clock input to increase the reliability of the reference clock signal. TI's automotive BAW oscillator, CDC6C-Q1 is documented at a FIT rate as low as 3, following the ISO 26262 standard, which specifies 90% confidence level in the mean time before failure of the device. With a startup time of less than 3ms, power on your front camera systems faster than ever before with the CDC6C-Q1 to support critical safety features, sensor features, and overall vehicle control.

Both existing and next-generation front camera architectures follow a similar structure from a clocking standpoint, as shown in Figure 2 and Figure 3.

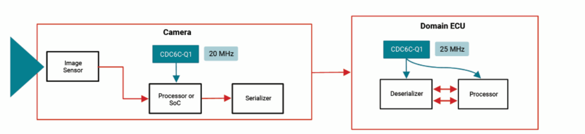

Figure 2. Current Generation Front Camera Architecture

As the next generation of vehicle architectures continue to model designs from zonal architecture concepts, the traditional front camera system design changes.

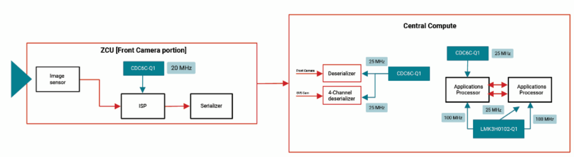

Figure 3. Next Generation Front Camera Architecture

In surround-view cameras, a central computing zone comprises ECUs and deserializers. Unlike quartz, the CDC6C-Q1 can drive two deserializers, reducing component count, board space and total bill-of-materials cost.

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 4).
- **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 5).
- **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 1500 g.
- **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 6 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 6.

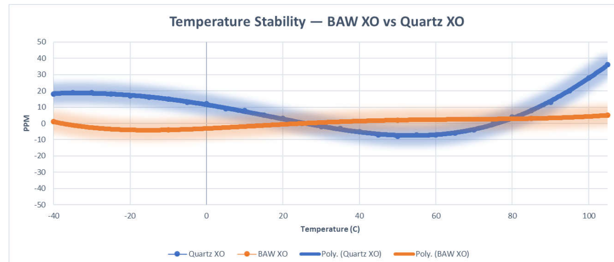

Figure 4. Temperatue Stability - BAW Oscillator vs. Quartz Oscillator

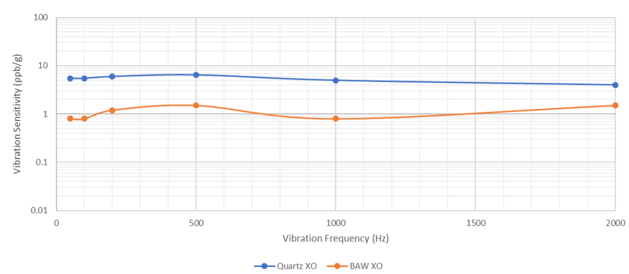

Figure 5. Vibration Sensitivity - BAW Oscillator vs. Quartz Oscillator

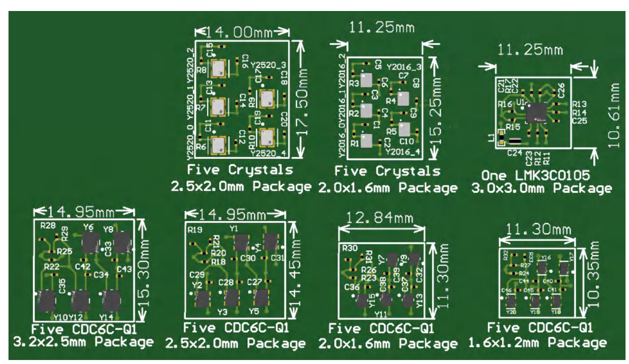

Figure 6. Five Crystal, Five CDC6C-Q1, and LMK3C0105-Q1 Footprint Comparison

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