Application Brief

System Overview: Telematics Control Units

Cris Kobierowski, Juan Rodriguez

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.

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

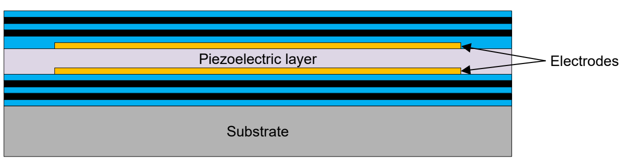

Figure 1. Basic Structure of a Bulk Acoustic Wave (BAW) Resonator

BAW Oscillator in TCU Systems

Telematics Control Units (TCU) control wireless tracking, diagnostics, and communication to and from the vehicle. Cloud services interpret information such as location, speed, engine performance, fuel consumption, and driver behavior to make the data accessible to the vehicle users. Oftentimes, TCUs interacts with vehicle displays and closely works with the In-Vehicle Infotainment (IVI) system to enhance the user experience.

From a clocking perspective, the TCU typically consists of two oscillators of different frequencies to support an Ethernet PHY and an MCU. MCU clocks vary, as many manufacturers require frequencies of 8,16, 20, 24, and 40MHz. Figure 2 shows a typical TCU clock topology. With a frequency stability of ±25ppm through the 10-year aging process, the CDC6C-Q1 is designed to support an Ethernet PHY.

TI's CDC6C-Q1 is functional safety capable, with a FIT rate as low as 3 per the ISO 26262 standard, making the CDC6C-Q1 an excellent choice for a TCU as some systems are required to meet up to an ASIL D standard based on how critical the safety functions are in a particular model. Additionally, the CDC6C-Q1 slew rate control option enables the device to pass CISPR-25 Class 5 EMI requirements.

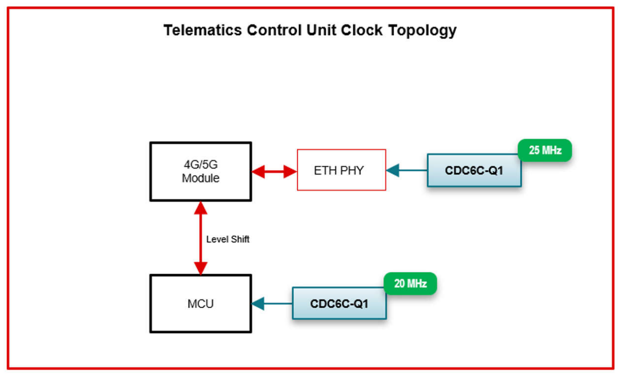

Figure 2. Telematic Control Unit Clock Topology

Benefits of the BAW Oscillator

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 oscillator maintains ±10 ppm of temperature stability irrelevant of temperature range (Figure 3).
- **Vibration Sensitivy:** 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:**XOs typically does 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:** XOs typically have no CISPR-25 data provided from the manufacturer. The CDC6C(-Q1) passes CISPR-25 Class 5 EMI standards (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(-Q1) 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.

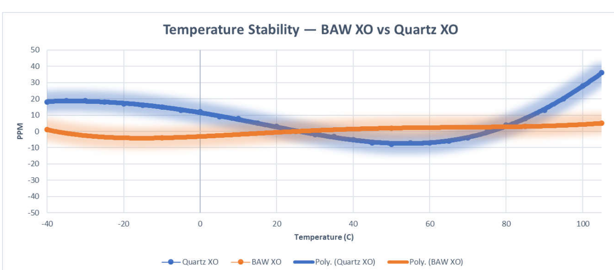

Figure 3. Temperature Stability - BAW Oscillator vs. Quartz Oscillator

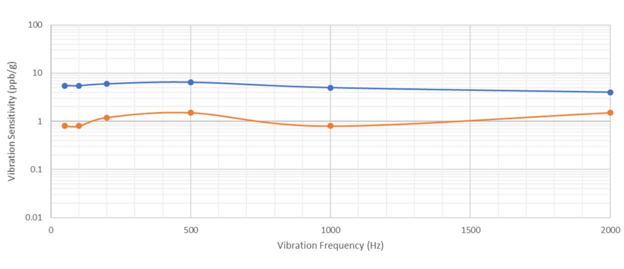

Figure 4. Vibration Sensitivity - BAW Oscillator vs. Quartz Oscillator

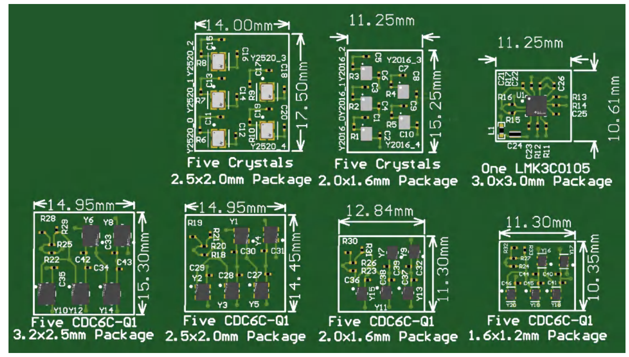

Figure 5. Five Crystal, Five CDC6C-Q1, and LMK3C0105-Q1 Footprint Comparison

Trademarks

All trademarks are the property of their respective owners.

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