BAW Resonator Technology

Bulk Acoustic Wave (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 BAW oscillator, the BAW is integrated with a colocated precision temperature sensor, a ultra-low jitter, low-power fractional output divider (FOD), a single-ended LVCMOS and differential LVPECL, LVDS, and HCSL output driver, and a small power-reset-clock management system consisting of several low-noise low dropout (LDOs) regulators.

**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.

BAW Oscillator in Network Interface Card

Some SmartNICs implement a common clock and independent reference PCIe clocking architecture at the same time. The card receives a clock from the motherboard through a PCIe connector. Additionally, the card needs a PCIe clock source in the case the common clock from the connector is unavailable. The PCIe buffer can be necessary since ASIC and FPGA typically needs more than one PCIe clock. The LMK6H BAW oscillator can be used in Network Interface Card (NIC) applications to clock the PCIe buffer and MUX, as well as the Ethernet buffer, which is shown in **Figure 2**.

Every NIC or SmartNIC require an Ethernet oscillator, which can require precise jitter performance. TI's current design, the LMK6H, LMK6P, and LMK6D provides 125 fs maximum at 156.25 MHz (12k- 20M). This Ethernet oscillator serves as the clock source for the Ethernet buffer. The LP-HCSL buffers that are used in PCIe meet the requirements for the Ethernet clock fan-out, that being the CDCDB family.
Benefits of the BAW Oscillator

One of the key benefits of the BAW oscillator in comparison to microelectromechanical systems (MEMs) and quartz oscillators is the exceptional jitter performance. Figure 4 shows the jitter performance for TI's BAW oscillator design.

TI's BAW oscillator family supports 1.8-V, 2.5-V, and 3.3-V supply voltages and is available in DLE (3.2 mm × 2.5 mm) and DLF (2.5 mm × 2 mm) packages, which save space in compact board designs. Figure 3 showcases the two BAW oscillator layouts on the left in comparison to both a typical crystal layout, and a crystal with BAW oscillator combination.

The BAW oscillator is tolerant to temperatures up to 105°C and features a 20 to 30 higher Mean Time Before Failure (MTBF) than competing crystal oscillator designs. Figure 5 shows that through the lifetime of the BAW oscillator, it has a reliable frequency stability of ±25 ppm, inclusive of all aging and environmental factors. Over temperature, the BAW oscillator has a ±10 ppm frequency stability that is significantly better than current quartz-based oscillators.

Figure 6 shows the vibration sensitivity of the BAW oscillator. The BAW oscillator has a typical vibration sensitivity of 1 ppb/g, which is significantly better than the 5–10 ppb/g sensitivity of quartz oscillator designs.

Figure 2. Typical SmartNIC Clock Tree

Figure 3. PCB Footprint Comparison of BAW Oscillator and Crystal
Figure 4. BAW Oscillator 156.25-MHz Phase-Noise Performance (Normalized Spur Mode)

Figure 5. BAW Oscillator vs Quartz XO: Frequency Stability Over Temperature
Figure 6. Vibration Sensitivity Comparison of BAW Oscillator and Quartz
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