Application Brief

BAW Oscillator Solutions for Network Interface Card

Juan Rodriguez *Clock and Timing Solutions*

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.

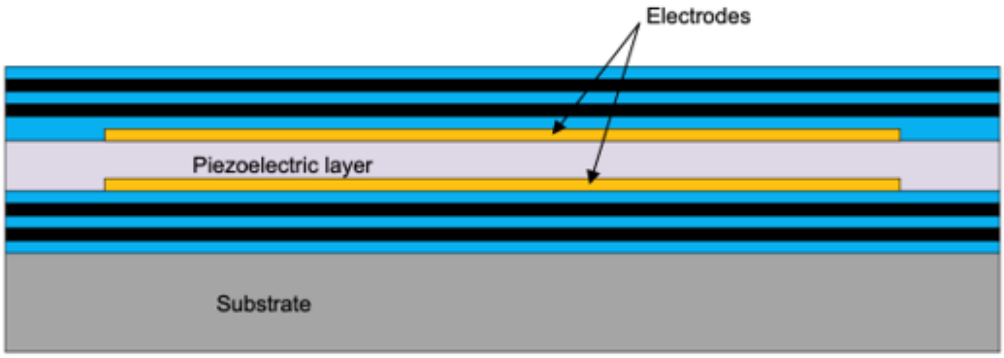

Figure 1. Basic Structure of a Bulk Acoustic Wave (BAW) Resonator

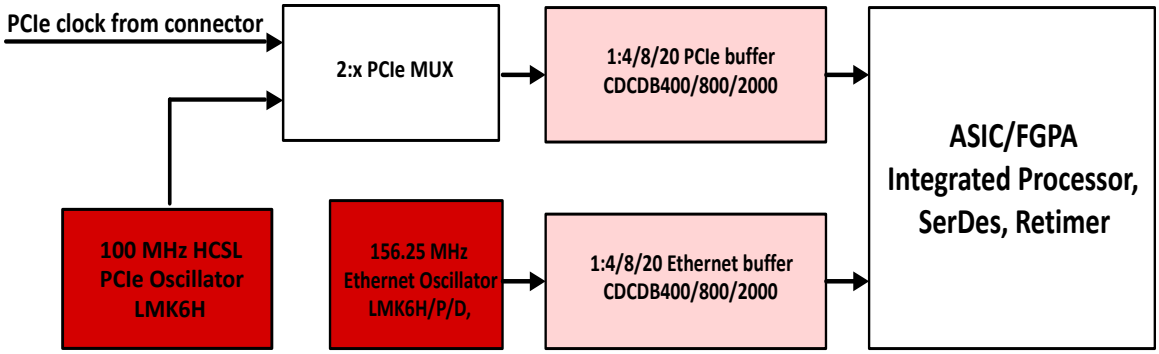

Figure 2. Typical SmartNIC Clock Tree

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.

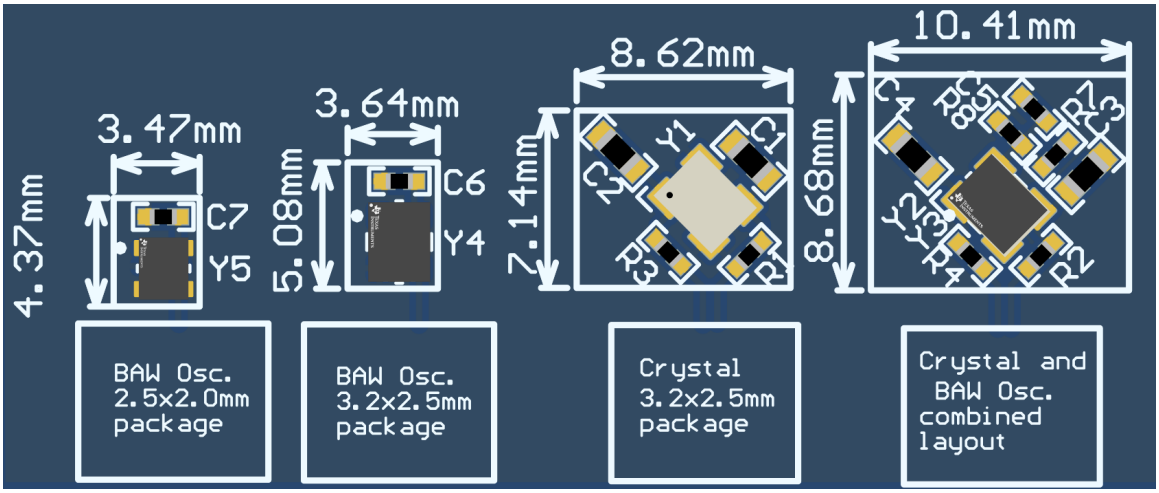

Figure 3. PCB Footprint Comparison of BAW Oscillator and Crystal

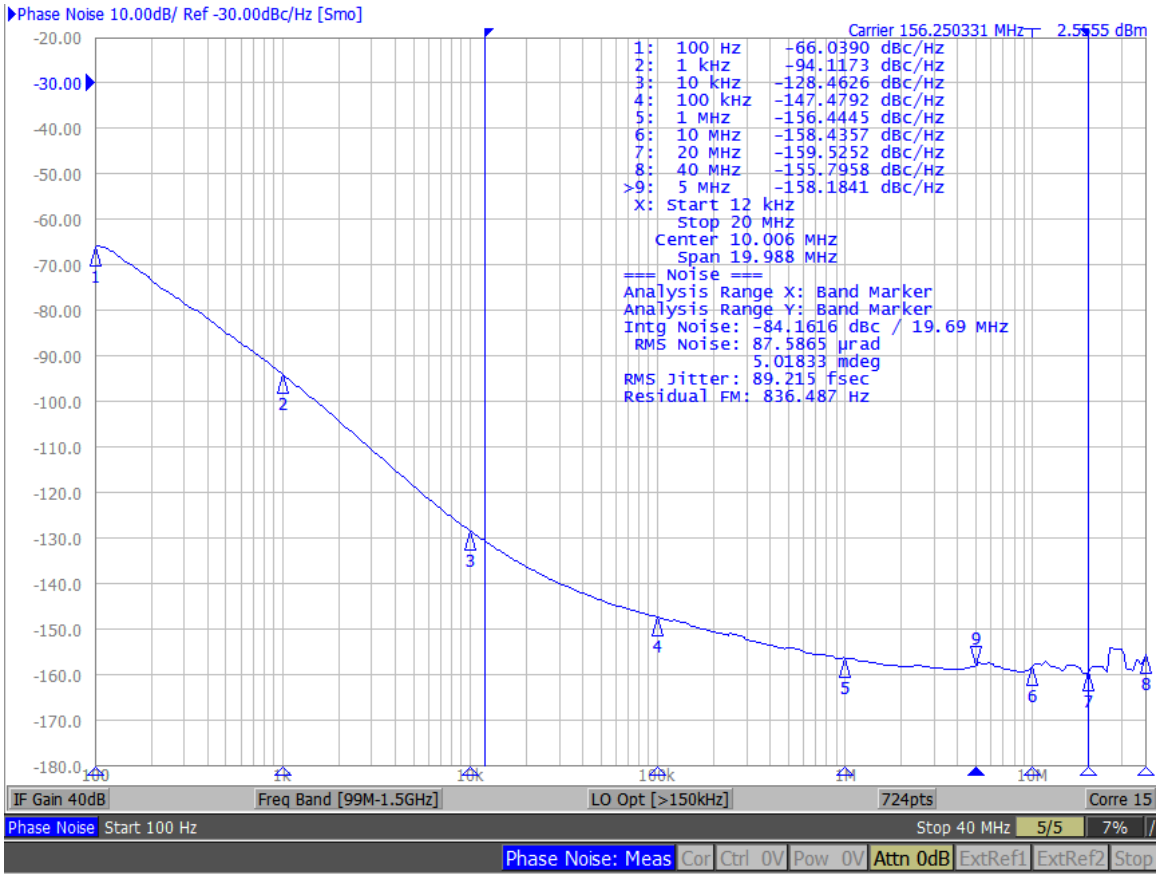

Figure 4. BAW Oscillator 156.25-MHz Phase-Noise Performance (Normalized Spur Mode)

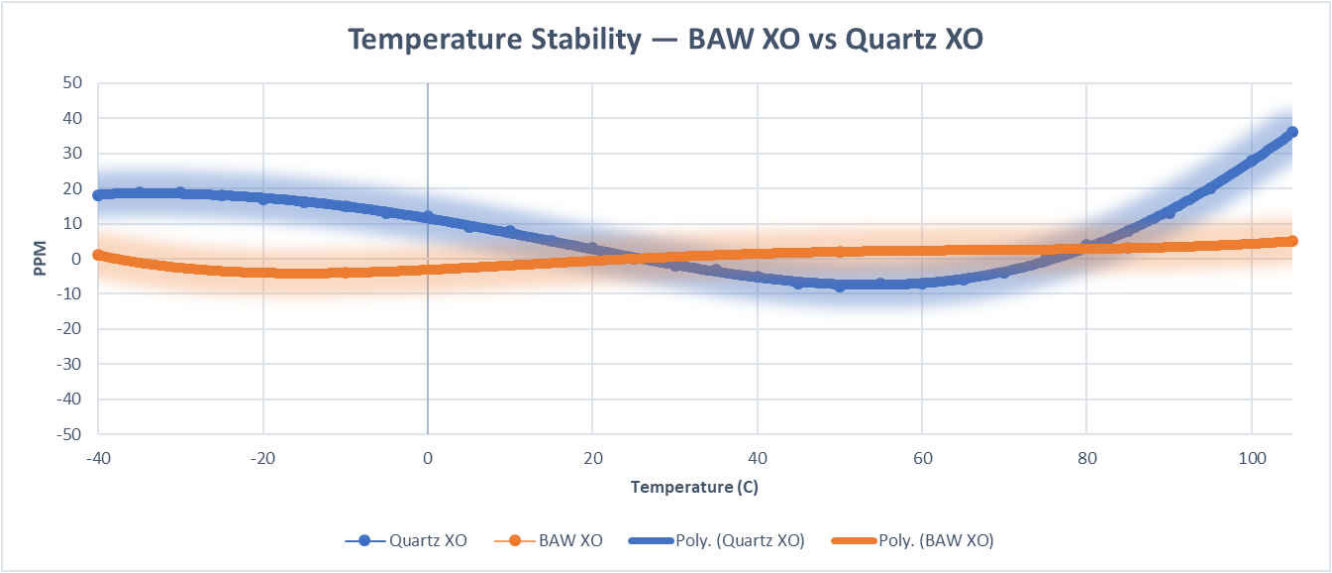

Figure 5. BAW Oscillator vs Quartz XO: Frequency Stability Over Temperature

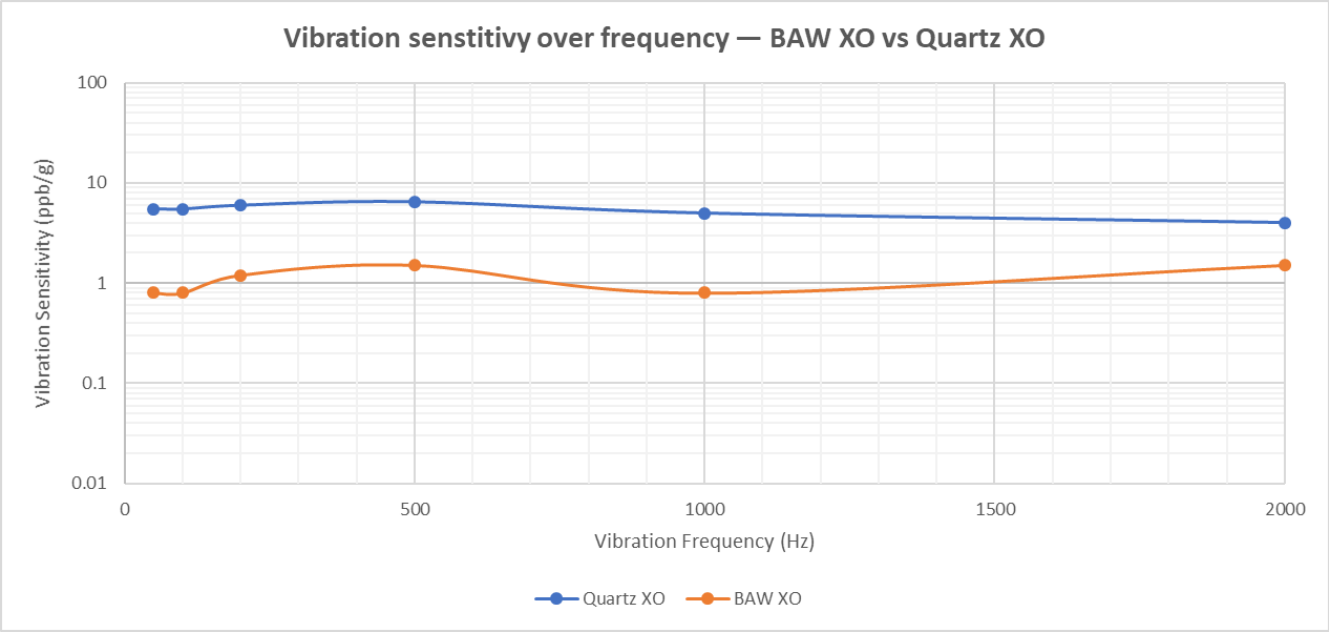

Figure 6. Vibration Sensitivity Comparison of BAW Oscillator and Quartz

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

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