Application Brief
BAW Oscillator Solutions for Factory Automation

TEXAS INSTRUMENTS

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 BAW oscillator, the BAW is intergated with a co-located 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 LDOs.

Figure 1 shows the structure of the 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.
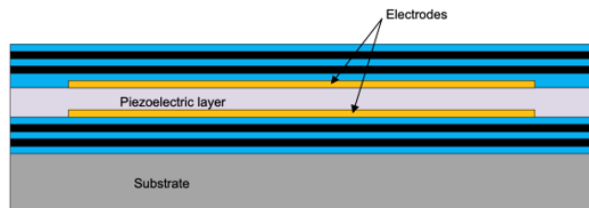

Figure 1. Basic structure of a Bulk Acoustic Wave (BAW) resonator

BAW Oscillator in Factory Automation

The BAW oscillator can be used in factory automation applications to clock the Ethernet PHY, processor (SOC), Wifi, and USB controller as shown in Figure 2.
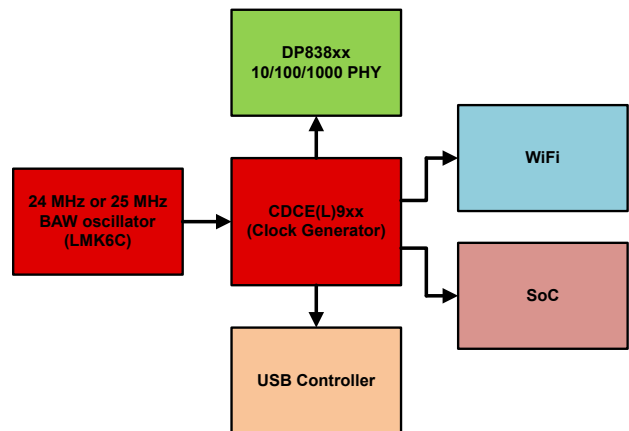

Figure 2. Typical Block Diagram of BAW Oscillator Used in Factory Automation

| Devices	Type	Function	Key Features
LMK6C/D/P/H	Ultra-low jitter XO	Reference clock to Ethernet PHY, Wi-Fi®, SoC, and USB controller	1 MHz to 400 MHz, ± 25 ppm, 200 fs jitter
LMK1C1104	1:4 LVCMOS buffer	Fan out to clock Ethernet PHY, Wi-Fi, SoC, and USB controller in applications where all four require the same frequency	1.8 V - 3.3V supply, ultralow additive jitter of 20 fs
CDCE(L)9xx	Clock Generator	Supports four unique output frequencies	PCIe Gen 1-5, Automotive Grade

Benefits of the BAW Oscillator

The BAW oscillator has three key benefits: high-grade reliability, superb performance, and operates as a flexible solution.
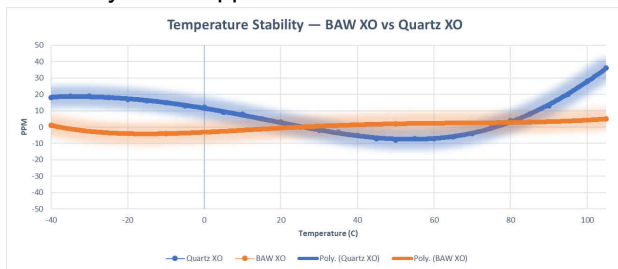
High-Grade Reliability

The BAW oscillator provides:

- A typical vibration metric of 1 ppb/g.
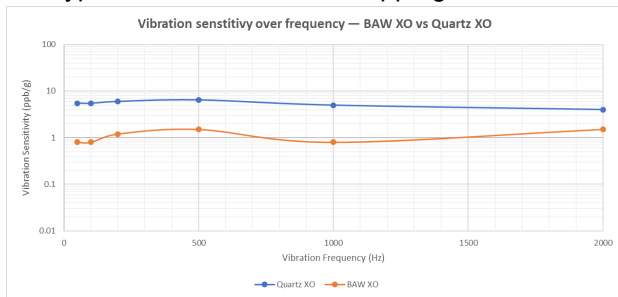
Figure 3. BAW Oscillator Vibration Sensitivity

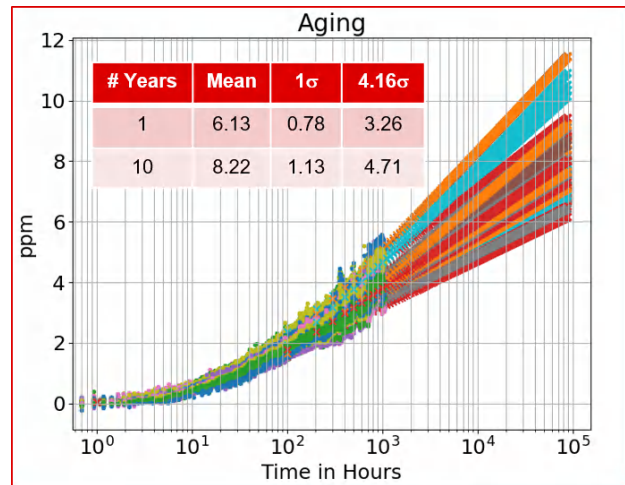- An all-inclusive frequency stability of ± 25 ppm (including 10 years aging) and a temperature stability of ± 10 ppm.

Figure 4. Temperature Stability Comparison of BAW Oscillator and Quartz Oscillator

- 20 - 30 times higher MTBF (mean time before failure)

# Years	Mean	1σ	4.22σ
1	6.67	0.41	1.74
10	9	0.61	2.56
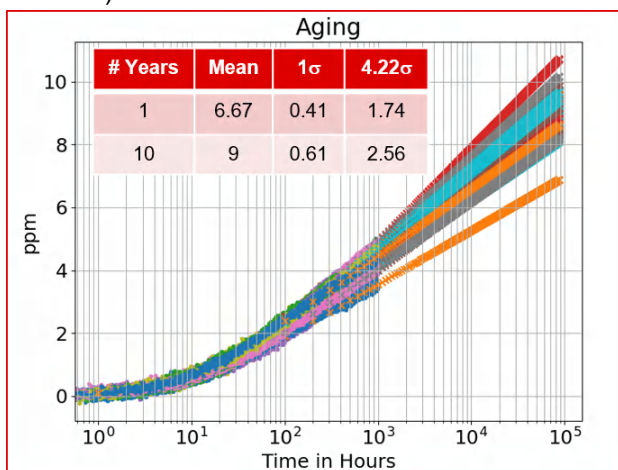
Figure 5. LMK6D/P/H Differential BAW Oscillator Aging

| # Years	Mean	1σ	4.16σ
1	6.13	0.78	3.26
10	8.22	1.13	4.71

Figure 6. LMK6C Single-ended BAW Oscillator Aging

Superb Performance

The BAW oscillator supports both differential and single-ended outputs. The differential BAW oscillators (LVPECL, LVDS, and HCSL) have a typical rms jitter of 100 fs and a maximum rms jitter of 125 fs over the integration bandwidth of 12 kHz to 20 MHz. The single-ended BAW oscillator (LVCMOS) has a typical rms jitter of 200 fs and a maximum rms jitter of 500 fs.

Figure 7 illustrates phase noise plots for the 25 MHz variant of the BAW oscillator, which is the most commonly used frequencies in factory automation applications.
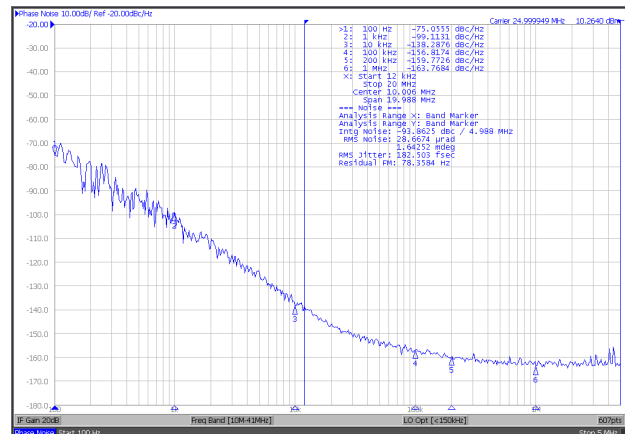
Figure 7. LMK6C BAW Oscillator 25 MHz Phase Noise Performance

Flexible Solution

The BAW oscillator can support any frequency from 1 MHz to 400 MHz, supports LVCMOS, LVDS, LVPECL, and HCSL output formats, comes in two package sizes (3.2 mm x 2.5 mm and 2.5 mm x 2.0 mm), and supports 1.8 V. 2.5 V, and 3.3 V supply voltages.

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