Technical Article

Beyond quartz: How BAW clocks are redefining ADAS and IVI

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In the journey toward more autonomous zone architectures, software-driven decision-making requires precise timing and reliable clocking circuits. From advanced driver assistance systems (ADAS) to in-vehicle infotainment (IVI) and high-speed data networks, automakers are implementing the Peripheral Component Interconnect Express (PCIe) 6.0 specification, Gigabit Ethernet, and serializers and deserializers (SerDes) to improve safety and enhance the driving experience. At the heart of these connected systems is the bulk acoustic wave (BAW) clock, beating with precise timing like a heartbeat, synchronizing vehicle subsystems (see Figure 1).

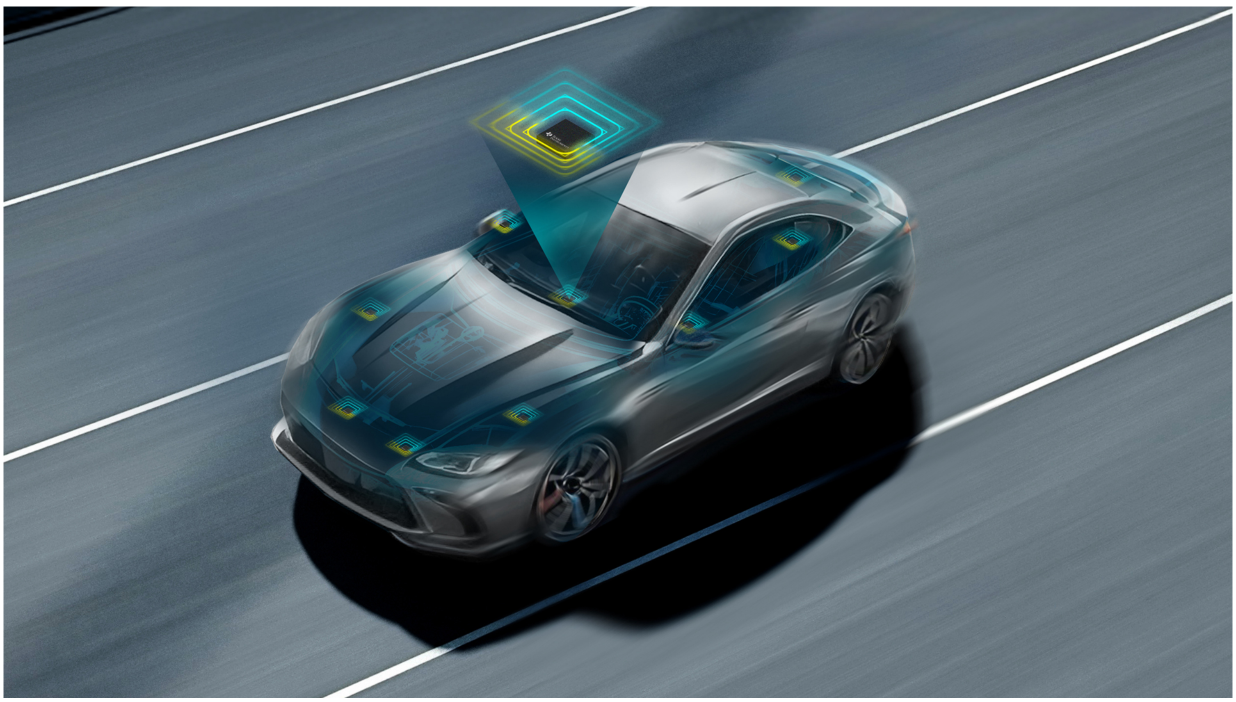

Figure 1. BAW clocking supports ADAS and IVI functions

The adoption of ADAS and IVI to support autonomous driving is increasing demand for microcontrollers and application processors with artificial intelligence, FPDLink™ SerDes, Ethernet physical layers, and lidar and radar sensors to enable sensing and display capabilities.

Comparing traditional quartz to BAW clocks

BAW is a resonator technology that uses piezoelectric transduction to generate a gigahertz frequency and high-Q resonance that can be integrated directly into standard plastic packages that contain other integrated circuits. While quartz has difficulty meeting long-term reliability, vibration resistance and timing requirements, BAW clocks offer ultra-low jitter and enhanced reliability and performance, enabling safer operation, cleaner data communications and faster processing.

By maintaining ±25ppm stability over 10 years, BAW clocks provide precision over system lifetimes, reducing the risk of frequency drift that can affect sensor accuracy. BAW clocks' 1ppb/g vibration and shock resistance, validated by Military Standard-F Methods 2007 and 2002, increase resiliency in harsh automotive environments.

Additionally, a <3ms startup time improves real-time vision analysis and response times to support ADAS functions with greater distance detection, sensor fusion and faster processing, whereas quartz is traditionally <6ms.

Finally, zone architectures increase clock-tree complexity, and BAW clocks can reduce board space by as much as 55% compared to quartz, while helping designers meet functional safety requirements with the added benefit of a geopolitically stable supply chain.

BAW clocking: A better FIT for automotive

TI's automotive BAW technology is TI Functional Safety-Capable, helping designers meet Automotive Safety Integrity Level (ASIL) D standards with a lower failure-in-time (FIT) rate compared to quartz, providing longer-term reliability in ADAS, IVI, and radar and lidar systems.

FIT rate measures the expected failure per billion hours of operation, and a lower total system FIT rate simplifies ASIL certification. In International Electrotechnical Commission TR 62380 and International Organization for Standardization ISO 26262 standards, the CDC6C-Q1 oscillator has a FIT rate as low as 3. Per Joint Electron Device Engineering Council JESD85 standards, the BAW oscillator is 100 times more reliable than quartz, with a FIT rate of 0.3 compared to 30, thus reducing unexpected failures and improving long-term functionality.

With a low FIT rate, resilience to harsh conditions, and precise clocking capability, TI's BAW clocks provide a more reliable and efficient solution for subsystems across the vehicle.

The following end-equipment examples highlight how BAW technology can enhance performance, simplify designs, and improve functional safety.

Front cameras: Improving safety in various architectures

In an ADAS, the 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 must meet ASIL B to ASIL D under ISO 26262.

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

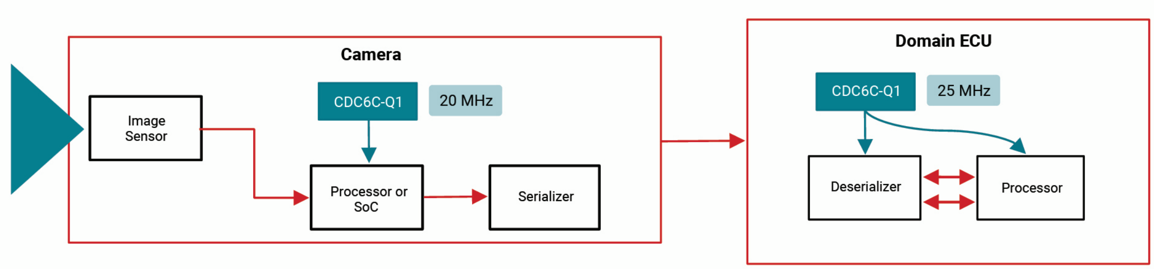

Figure 2. Existing front camera architecture includes a CDC6C-Q1 oscillator to support the system on a chip (SoC), and two clocks in an electronic control unit (ECU)

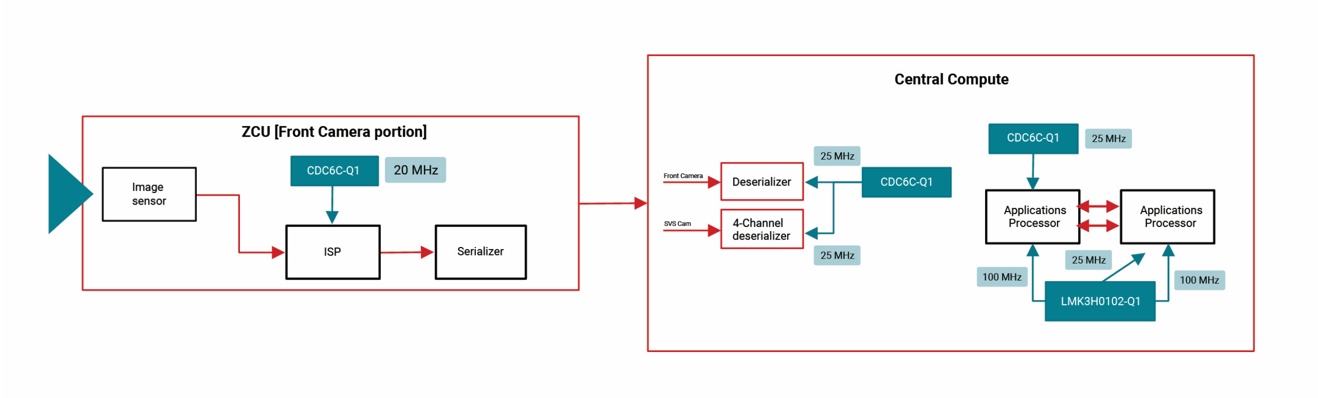

Figure 3. Next-generation architecture features CDC6C-Q1 oscillators supporting processing and deserializers

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.

IVI: Simplifying clock architectures

TI oscillators, clock generators and clock buffers support any processing-based architecture in a software-defined vehicle. Designers can simplify their systems by reducing the number of clocks in a complex IVI platform. The integrated BAW resonator in the LMK3H0102-Q1 clock generator (with low-power high-speed current steering logic outputs) and the LMK3C0105-Q1 low-voltage complementary metal-oxide semiconductor clock generator eliminate the need for an external clock to function and generate outputs from fractional output dividers at required frequencies for individual components, as shown in Figure 4.

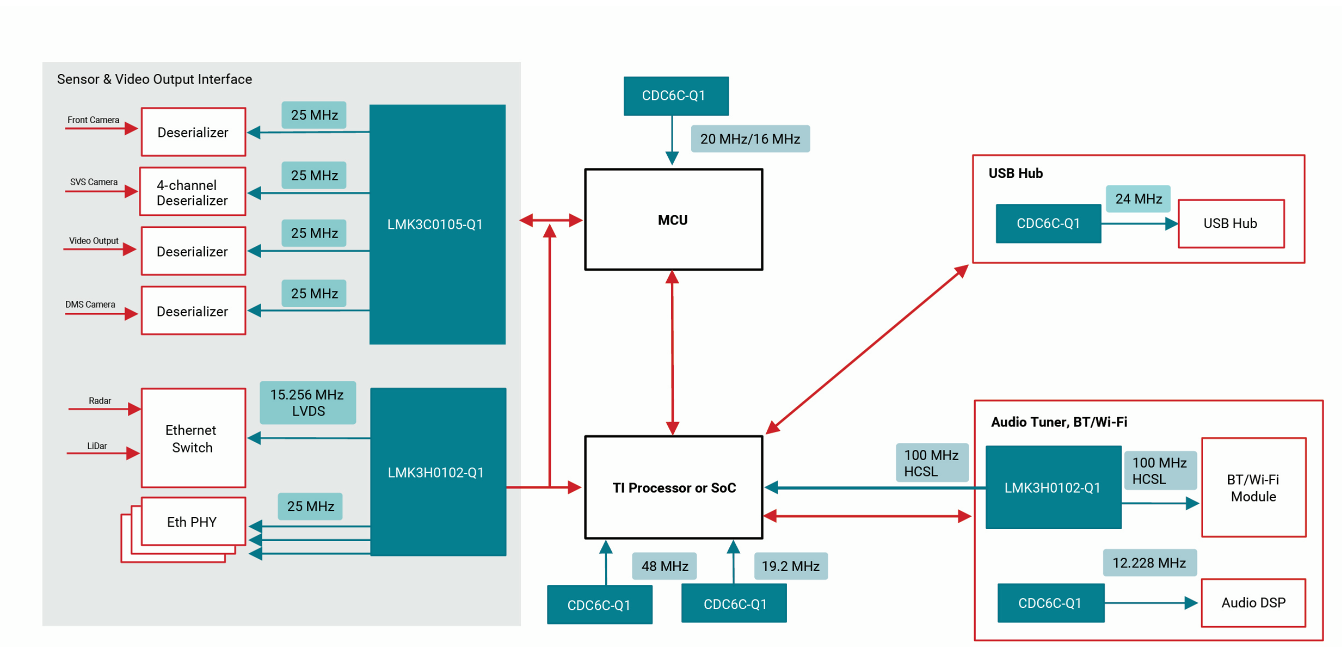

Figure 4. IVI clock topology

The LMK3H0102-Q1 and LMK3C0105-Q1 are TI Functional Safety-Capable, with a Failures In Time (FIT) rate of 9 under the ISO 26262 standard. These devices pass Comité International Spécial des Perturbations Radioélectriques (CISPR) 25 Class 5 compliance for all bands at trace lengths up to 300mm, maintaining stable clocking and reduced emissions with the spread spectrum clocking option. The CDC6C-Q1's slew-rate control option enables control of the emissions at the device level while benefitting from the improved reliability compared to quartz, maintaining a FIT rate as low as 3 under the ISO26262 standard. The BAW clocks are built to support various components at a reduced risk of failing in comparison to quartz technology, optimizing IVI platforms with minimal components and lower BOM cost.

HPC: ADAS domain controllers

Modern vehicles are evolving to transmit higher volumes of data with minimal latency. Servers, storage and input/output peripherals facilitate high-speed data transfer from high-performance processors and SoCs that support the PCIe 5.0 specification and more stringent 6.0 specification. Data transfer in the automotive sector will likely approach the levels of data centers, as ADAS SoCs increase in complexity to improve advanced autonomous driving.

Both SoC manufacturers and original equipment manufacturers are developing their own processors to require PCIe 5.0 and 6.0 specification speeds. The LMK3H0102-Q1 supports the PCIe 6.0 requirement of 100fs, with a common clock jitter of 34.5fs.

TI Functional Safety-Capable BAW clocks target embedded processing high-performance computing (HPC) systems that combine ADAS and IVI domains, where sensor input from camera, radar and lidar systems help protect drivers and passengers. Figure 5 illustrates an HPC topology.

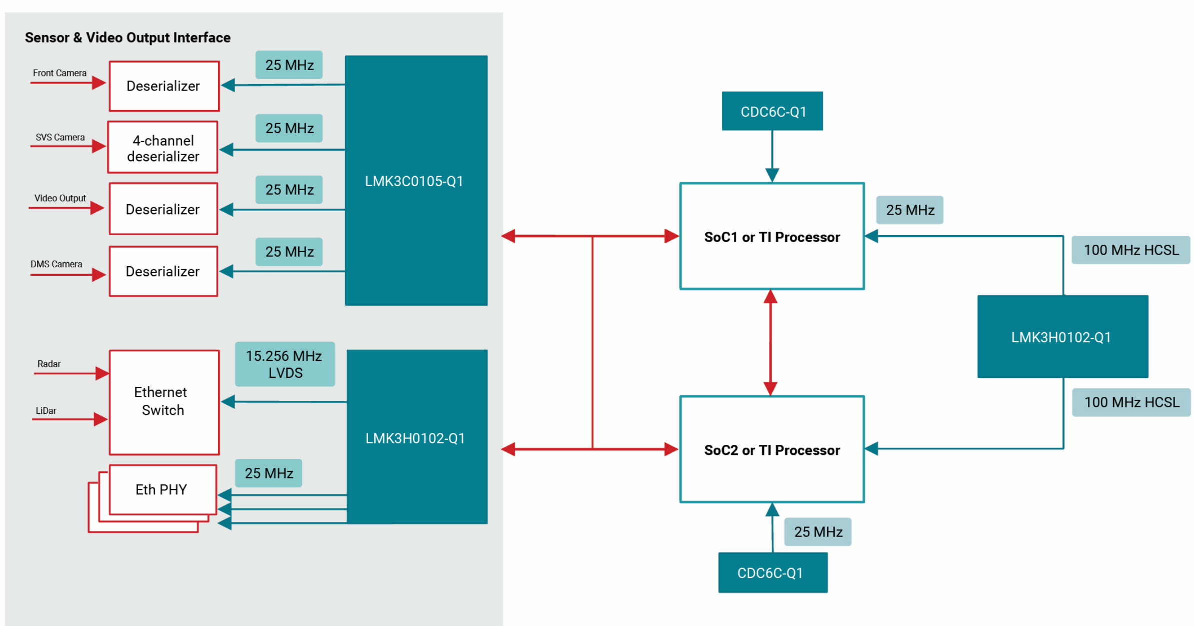

Figure 5. HPC clock topology

Conclusion

The adoption of ADAS features to enable a collision-free future is accelerating the need for precise clocking solutions that can consistently operate over a vehicle's lifetime. Automakers will continue to shift from quartz-based solutions to BAW clocks that pave the way for safer, smarter and more resilient vehicle architectures.

Additional resources

- Order one of the CDC6CEVM and LMH3H0102EVM evaluation modules.
- Start your BAW clocking design today with the Clock Tree Architect online tool.

Trademarks

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