8-Bit Mixed-Signal Microcontrollers Reduce Cost and Complexity in Automotive Designs

From safety and chassis systems to body electronics and powertrain management, high-performance microcontrollers (MCUs) provide critical control and intelligence capabilities for today's automotive designs. Mixed-signal MCUs are being designed into automotive systems to control more system features while reducing system design complexity, component count and board space.

Mixed-signal 8-bit MCUs offer a variety of ways to streamline automotive system designs. By integrating a wide range of peripherals and communication protocols, such as controller area network (CAN) and local interconnect network (LIN), mixed-signal MCUs help minimize the need for additional discrete components. Today's high-performance 8-bit MCUs can also be enhanced to increase processing speed, reduce memory size and extend precision analog peripherals. Above all, this sophisticated integration must be accomplished within the very small footprints required by space-constrained automotive applications, such as window lifts, door locks and engine control sensors.

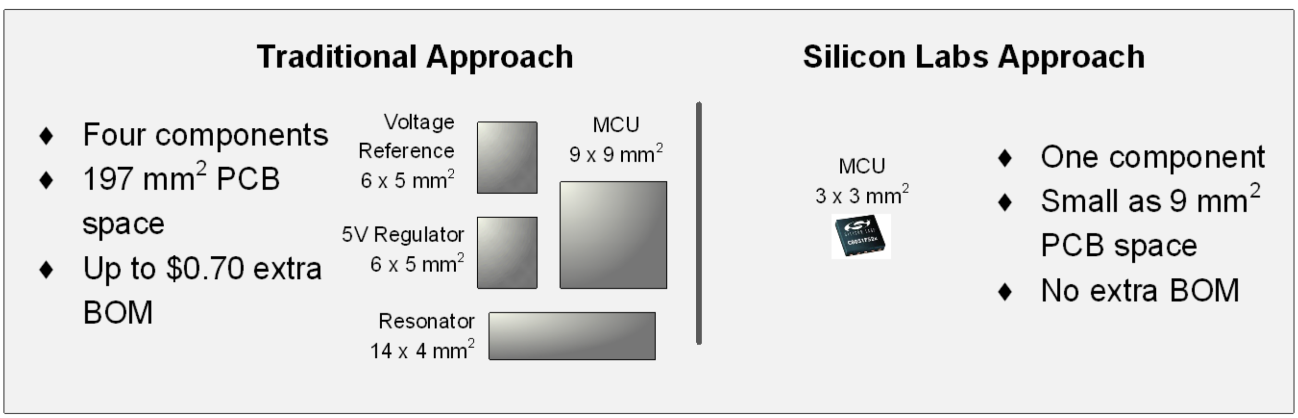

Figure 1. Traditional System Bill of Materials vs. Mixed-Signal, Integrated MCU

In addition to reducing board space, on-chip integration can reduce component costs by as much as $0.70. Mixed-signal MCUs can eliminate the need for external components, such as voltage reference sources, regulators and resonators. A reduction in component count also results in a smaller system footprint, further improving reliability since more components on the PCB usually equates to more reliability problems.

A practical example is the C8051F58x 8-bit MCU family from Silicon Laboratories. This MCU family includes many on-chip peripherals not typically integrated on other 8-bit MCU alternatives. For example, the F58x family includes a high-accuracy oscillator, a high-precision voltage reference, a 5 V regulator, an automatic adjustment feature that replaces the need for costly calibrated sensors, a high-speed MCU core that minimizes memory requirements and an innovative I/O scheme that can reduce manufacturing and testing costs.

Offering up to 128 kB of flash and 50 MIPS of processing power in a 25 mm^2 package, the F58x family provides a combination of memory, performance and small size that enables automotive designers to solve problems that until now were expensive to address. Complex algorithms and computations can now be performed in real time as opposed to using look-up tables, saving memory that can be used to further enhance existing applications.

The F58x automotive MCUs provide internal oscillator accuracy to ±0.5% over the entire automotive grade 1 operating temperature (-40 to 125 °C) and voltage range. By using the on-chip analog-to-digital converter (ADC) and temperature sensor, a designer can further improve the accuracy to ±0.25% across the voltage and temperature range. Off-chip resonators cost an additional $0.20 to perform the same function. This capability enables designers to operate high-speed CAN and LIN networks without external timing components, reducing cost and improving system reliability.

Another unique feature of the integrated ADC is variable attenuation, which enables designers to dynamically attenuate the input signal to match the voltage reference. This technique has two distinct advantages:

- First, analog sensor signals greater than the voltage reference can take advantage of the full range of output codes. This means that desired signals will not be clipped and can take advantage of all output codes for the maximum amount of dynamic range.
- Second, part-to-part variation (i.e., calibration) in sensors can be eliminated, enabling designers to use lower cost sensors, calibrate them in-system and achieve the same performance as expensive precision sensors for a much lower system cost.

Dedicated automotive serial buses can also offer performance advantages to designers. For example, a high-speed CAN 2.0 engine that offers 32 discrete message objects can support heavy network traffic. By using the integrated LIN 2.1 controller (not LIN emulated in software), automotive designers can further improve network performance. The combination of an 8-byte message buffer, hardware synchronization and checksum generation (all performed in hardware) frees valuable CPU resources and enables more complex LIN topologies.

Design flexibility is typically a key concern for automotive engineers. Traditionally, MCUs use a fixed multiplexing scheme that forces designers to choose which resource they are going to use for a particular pin. Mixed-signal MCUs feature a digital crossbar that functions like a programmable switch-fabric, allowing designers to route digital peripherals to available I/O pins. This technology greatly simplifies system design efforts and allows resources to be multiplexed (even on the same I/O pin). For example, a designer could have two independent LIN buses and re-map the pins dynamically during run-time, reducing system cost and enhancing design flexibility.

Crossbar technology can also be used to reduce programming and calibration costs. Many designers must calibrate their systems using some test text fixture at the end of the PCB assembly. During this step, a special “calibration firmware” can be programmed in the device to provide an interface to the test fixture. MCU resources can be used in conjunction with the test fixture to accelerate calibration and greatly reduce the overall programming time. Once the system is calibrated, the parameters are stored in flash memory, and the application firmware is programmed into the MCU.

Taking the design a step further, a digital isolator enables an isolation stage between the CAN physical layer and the MCUs running on the bus. This further enhances performance by isolating the MCUs from the effects of noise commonly found in automotive systems. This helps eliminate ground loops present in automotive CAN and LIN networks and is ideal for applications in electrically noisy environments. Digital isolation is also required for HEVs and EVs. Isolation is integrated into every high-voltage module and provides the bridge for communication and control across high-voltage boundaries. Examples include battery pack management, A/C compressors, Stop/Start motor-generators, and electric power steering.

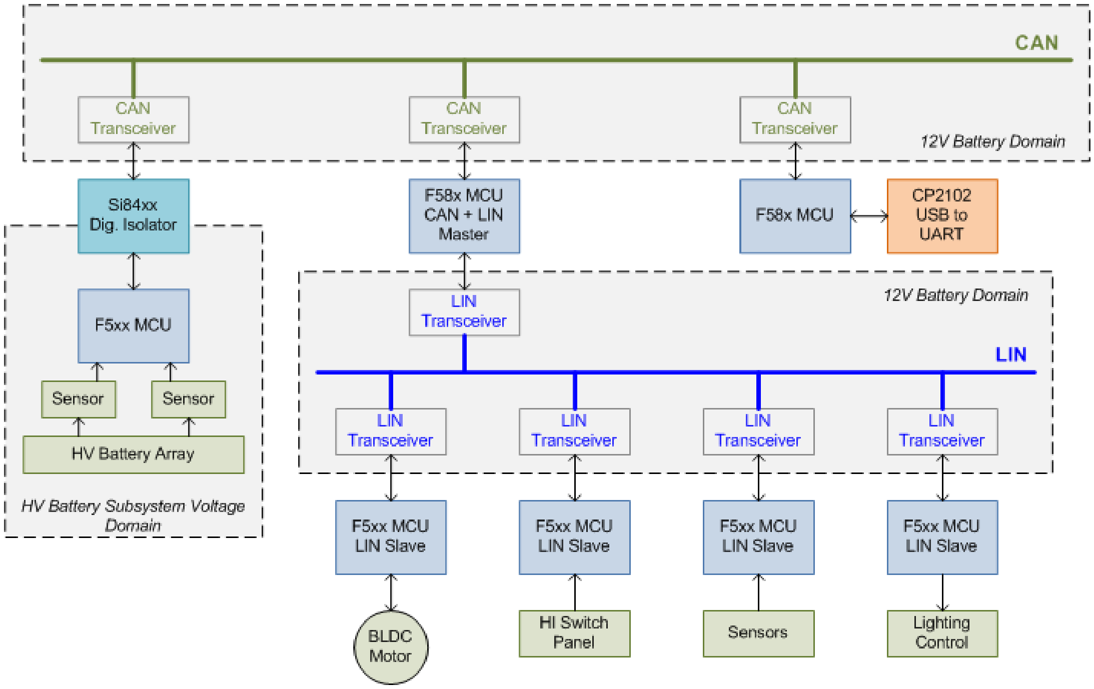

Figure 2. Automotive System Example using CAN, LIN and Digital Isolation

Automotive electronics engineers face more design options, more system performance requirements and more design complexity than ever before. Mixed-signal 8-bit MCUs can play an important role in simplifying the overall design effort, improving performance, reducing costs and addressing space constraints.

The ability to integrate noisy digital circuits with sensitive analog circuits without degrading performance is an enormous benefit to automotive system designers who work with both digital and analog components. Integrating analog-intensive, mixed-signal capabilities on 8-bit MCUs results in cost-effective system-on-chip devices with smaller footprints that enable reduced system cost and complexity. These benefits are particularly helpful for body electronics on modern vehicles that increasingly rely on MCUs to deliver greater intelligence and connectivity.

For more information about Silicon Laboratories' automotive solutions including automotive-qualified 8-bit mixed-signal MCUs, visit www.silabs.com/automotive.