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WHY DESIGNING ICs FROM THE GROUND UP FOR AUTOMOTIVE APPLICATIONS MATTERS

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Abstract: Today's cars are computers on wheels, with multiple systems talking to each other constantly to deliver intelligence that keeps drivers and passengers safe, comfortable, and entertained while taking them from point A to point B. While we're not quite ready to completely welcome fully autonomous self-driving cars on our roadways, we are experiencing the benefits of Level 2 and Level 3 autonomous driving technologies, which provide partial to conditional automation of steering, acceleration, and braking. These technologies, in turn, are driving up demands for semiconductor content inside vehicles. This paper will examine why it's better from a performance and safety perspective to design automotive ICs from the ground up for automotive applications versus repurposing chips originally designed for other purposes.

Introduction

With the touch of a screen or through a voice command, you can control many of the electronic functions in a modern car: the GPS, heating and cooling, and the entertainment system, for example. The car itself possesses the smarts to do much more on its own, from automatically switching on high-beams to parking itself, detecting blind spots, and pre-emptive braking to avoid a collision. Making all of these capabilities possible are the hundreds of microcontroller units, sensors, and analog ICs inside.

While conventional vehicles contain $330 worth of semiconductor content, on average, hybrid electric vehicles can boast up to $1,000 worth of semiconductors and number up to 3,500 parts, according to the U.S. International Trade Commission (USITC).[1] Analysts at KPMG note that the automotive semiconductor market has the potential to grow from $40B in 2019 to $200B by 2040, driven by trends including electrification, autonomy, connectivity, and mobility as a service. Hybrid and electric vehicles already have twice the semiconductor content as their internal combustion engine counterparts. Fully autonomous vehicles, designed with LiDAR sensors, 5G communications, and image-recognition systems, are projected to contain 8x to 10x as much semiconductor content as non-autonomous cars.[2]

In this paper, we'll discuss the unique demands that vehicles place on the semiconductors that bring so many of their capabilities to life. We'll also highlight why ICs designed specifically for automotive applications—rather than devices repurposed from other use cases—are critical for the safety and reliable operation of these vehicles.

As vehicles offer more autonomous capabilities, their semiconductor content continues to increase in volume. Designing with ICs created specifically for automotive applications mitigates the need to make the performance tradeoffs that chips repurposed from other uses require.

Cars Are Getting Smarter with Each Generation

Peek inside a typical modern vehicle and you'll likely find ICs for:

- Advanced driver assistance system (ADAS) applications. ADAS applications provide automotive functions such as parking assistance, lane positioning, and collision avoidance. Many of these systems use cameras, radar, sonar, and LiDAR monitoring and even video processing algorithms and multiple video cameras to deliver warnings and alerts.

- Power management. Devices such as DC-DC converters and voltage regulators manage power at the point of load in control modules, sensors, and actuators distributed throughout a vehicle.
- The electric vehicle (EV) powertrain. Safe and reliable operation of fully electric as well as hybrid and plug-in hybrid vehicles that use large lithium-ion battery packs for energy storage requires robust battery management ICs to report status, control charging, and balance the batteries.
- Infotainment applications. These applications provide navigation, application links to consumer cell phones, vehicle performance messages, data about the surrounding environment, as well as audio and video playback. These functions call for a variety of analog ICs, including: power management ICs, USB protection, display power ICs, low-noise amplifiers, RF tuners and receivers, high-speed serial links, and sensors.
- LED lighting applications. LED drivers and controllers provide reliable power sources for these vehicle exterior and interior applications.
- Body electronics. These designs consist of systems that provide control functions, implement diagnostics and safety features, and manage power. Power switching and monitoring circuits, sensors, and sensor interface and communication ICs are all integral to these applications.
- Connectivity. The IoT has come to automotive applications, and functions like vehicle-to-vehicle (V2V) communications and vehicle-to-everything (V2X) could make our drivers safer and our traffic flows more efficient.
- Security. Having genuine parts inside a vehicle provides an assurance of safety, as does protecting data communication from the vehicle to the cloud. Secure authenticators can help ensure that automotive components are authentic, safe, and secure.

The automotive environment presents some unique demands on these semiconductors. Cars have long lifetimes—the average is 11.6 years on the road—and operate under extreme temperature ranges (-40°F to 300°F). So automotive semiconductors, unlike their counterparts for, say, consumer applications, must maintain high quality and their functionality under these conditions. In fact, considering the safety factor, automotive OEMs expect their semiconductors to have a zero parts per billion failure rate for 15 years and a supply of replacement parts for up to 30 years.[3]

In fact, the very nature of certain automotive applications, such as ADAS and displays, have become so integral to the safety of the vehicle that these systems now must meet automotive functional safety requirements. ISO 26262 provides an international standard for functional safety of automotive electronic/electrical systems. An important component of ISO 26262 is the Automotive Safety Integrity Level (ASIL), which classifies the inherent safety risk in an automotive system. There are four ASIL levels, each determined by these factors: severity (injuries), exposure (probability), and controllability. ADAS applications typically have to meet ASIL D, the highest level, while displays should comply with ASIL B.

Despite all of these demands and requirements, some semiconductor vendors simply reconfigure their ICs, originally designed for other purposes, for automotive applications. The resulting ICs are likely to come with tradeoffs in performance and quality. Considering the essential functions that automotive ICs are providing, this is not a risk worth taking.

Automotive applications like displays and ADAS must comply with functional safety standards, which places demands on their underlying ICs.

A History of Helping You Design Safer, Smarter Cars

Maxim Integrated has a long history in designing automotive ICs from the ground up for use in vehicle designs. Early on, we had experience leveraging blocks designed for another end application to create our automotive ICs, but quickly realized that this approach was not optimal. As an example, let's consider what would happen if a vendor wanted to respin a chip originally designed for a consumer application for an automotive application. Its functional requirements are solid, so then the chip designer moves on to adjust various parameters. But then there's the temperature specification. A chip for a consumer device would need to comply with a range from 0°F to 70°F, while automotive ICs must be able to operate reliably at much higher temperatures (up to 300°F). Clearly, this chip will not be successfully characterized for an automotive environment with strict Six Sigma EC table limits. Maxim Integrated has recognized early on that it's better to focus on understanding the specific issues that our customers face at a system level and subsequently designing automotive solutions that address these particular challenges.

Our process flow is designed to drive products to zero defects.[4] We offer hundreds of products that comply with AEC-Q100. ("Failure Mechanism Based Stress Test Qualification for Integrated Circuits from the Automotive Electronics Council.") We also meet the quality management system requirements defined by the International Organization for Standardization (ISO) for the design, development, and production of automotive products.

We apply a level of rigor to our automotive chip design process that is unique and geared toward performance and quality. For example, we have our own specific digital automotive libraries, unique automotive design rules, unique approaches to metal routing and pad design, and metal interconnects designed with redundancy. We've designed our automotive ICs to deliver robustness in the presence of radiation and electrical noise. We balance the performance required with the unique specifications of the target application, whether it involves efficiency, emissions, immunity, or some other factor. Because we focus on robustness in a radiated environment from the start, it's impractical to respin our automotive ICs from a chip originally created for any other purpose. Maxim Integrated follows this approach even with technologies that originated in other application areas. For example, even though functions like USB charging, displays, voice and gesture control, and GPS had their origins in other types of designs, Maxim Integrated still designs our chips for these functions from the ground up for automotive applications.

Summary

Given the unique demands on cars, as well as their harsh operating environment, it is critical that automotive ICs be designed from the ground up to meet the stringent and unique requirements of automotive applications. While repurposing a chip originally designed for another end market might result in a faster time to market, it comes with tradeoffs that can ultimately hamper the performance and safety of the vehicle. For Maxim Integrated, this is not a tradeoff that's worth making when we're committed to helping you design safer, smarter cars.

Sources

[1] U.S. International Trade Commission (USITC).
[2, 3] Automotive Semiconductors: The new ICE age.
[4] Automotive "V" Flow Drives Products to Zero Defects.

Related Parts		
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