Powering the ambition of software-defined vehicles

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Abstract: While entirely invisible to the driver, the software-defined vehicle's power architecture, orchestrated through System Basis Chips (SBCs) and/or Power Management Integrated Circuits (PMICs), is fundamental. The power supply for every component poses sophisticated challenges which require equally sophisticated solutions.

Creating a car from code

A dominant trend in the development of new automobiles is the move towards the 'software-defined vehicle' (SDV). For such vehicles, key aspects of their functionality, behavior and feel are developed in code, rather than by mechanics. The millions of lines of code this requires are programmed onto SoCs and microcontrollers that are deployed into the vehicle. The approach has several benefits, not least that this encoded functionality is able to evolve, with new features, adjustments and customer preferences added or changed through over-the-air updates.

Needless to say, realizing this model of auto manufacturing will require more sophisticated electronic components than were needed historically, and they will need to be integrated and interconnected more tightly so that every function might be monitored and controlled safely. This trend is not just a result of a move to SDVs: For the last two decades, vehicles have acquired many new functions–from assisted driving functionality to cameras and radars–that have continually added to electrical and electronic requirements of the modern vehicle.

Each element of this new electrical/electronic (E/E) architecture requires power, of course, and parallel to the complex network of central compute systems, microcontrollers, Ethernet links, sensors and actuators there is a sophisticated network of power lines, all orchestrated through Power Management Integrated Circuits (PMICs).

How PMICs solve power challenges

The many and varied electronic components in a modern car are not simply connected to the battery. Each has its own requirements for voltage and power, and deviations from these requirements could result in failure with potentially disastrous repercussions. Additionally, components may have timing requirements, a correct activation and shutdown order and procedure, requiring a sequencer. The power supply also needs monitoring, safety and diagnostic controls, and ways to put components to sleep when they are not in use. There may also be a specific controller to deal with any failure, activating backup functionality.

Figure 1: FS26 SBC

Modern PMICs from NXP can cover all these functions, reducing the component count in a vehicle as well as the complexity of the architecture. These PMICs simplify the board design, providing power management building blocks and design flexibility. With innovative features and versatility, NXP power management solution facilitates the customer design experience and brings power management to a new level of integration.

Power management devices must be autonomous, safe, and reliable, reducing a complex power supply sub-system using several discrete components and controllers to an integrated and smart solution seen as one PMIC by the system. This integrated design is called the ByLink™ System Power Platform.

Meeting manufacturers' needs

PMICs help to solve a series of challenges for automotive manufacturers.

Power management efficiency: Vehicles require considerable power, but this must be managed as efficiently as possible to avoid energy waste, especially in electric vehicles. NXP PMICs provide high efficiency buck converters and support various low power modes to satisfy different vehicle use cases.

Low power strategies and wake-up management: PMIC solutions enable the system to enter standby mode to save energy when system is not operating, with different level of energy level to optimize system wake up and boot time.

Functional safety: NXP PMICs support manufacturers' efforts to reach ASIL B or ASIL D standards in their vehicle architectures. They come with built-in system safety mechanisms to detect any unexpected events, and provide high configurability over safety reactions, to adapt to specific system safety goals.

Scalable and flexible: Manufacturers are able to deploy a standard range of components with common power, safety and features in the same footprint, with pin-to-pin compatibility across the range. NXP PMICs are available to cover all types of applications and will work equally well with microcontrollers and SOCs from other suppliers, as well as powering the various peripherals available in each system.

Additionally, the devices allow manufacturers to achieve broader design and commercial goals.

Integration: Beneath the surface, the architectural complexity of modern vehicles is staggering. Where there are opportunities to achieve simplification without any compromise to function or safety, it is welcomed. The ByLink™ platform removes barriers when it comes to a multi-PMIC architecture and simplifies design for customers.

BOM: Fewer, more functional components reduce the complexity and cost of creating a vehicle. Regarding PMICs, one of the challenges is always to find the right balance between performance and cost. NXP PMICs offer high levels of performance without increasing the number of external discrete components (inductors and capacitors), and even reduce them to their strict minimum thanks to specific features and high regulator bandwidth.

Simplification: Beyond the reductions to the size and number of physical components, NXP PMICs are easier for manufacturers to deploy. One Time Programming allows the devices to be fully configurable and aligned with system requirements. Also, the software in a device family can be fully re-used to leverage a platform approach to manufacture.

Functional robustness: new use cases, driven by electrification and autonomous driving, are raising the need for extended mission profile qualifications and methodology, where NXP is driving industry discussions.

Each of these advantages improves time-to-market, reduces the design complexity, and eases the functional safety approach across the vehicle.

The E/E architecture of the software-defined vehicle has evolved from previous approaches to the challenge of integrating thousands of electronic components. Previous incarnations used domain controllers, each dedicated to a specific area of functionality, such as lighting or steering. While this may have seemed logical at the time, the result was that each of these domains then required their own subcomponents and wiring which stretched over the whole vehicle, with each increasing its weight and complexity.

More recently, manufacturers working towards creating SDVs have moved towards a zonal architecture, that has three levels of data and services. Here, much of the processing is handled by a central compute system, the first of these levels. This communicates with the second level, zone controllers that are physically situated close to the third and final level, the components, or end nodes, that they serve. Depending on the sophistication of a vehicle's feature set, and the manufacturer's choices, there is a varying number of these zones.

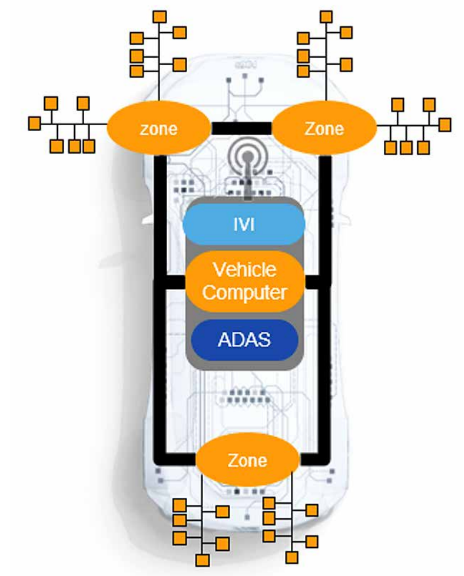

Figure 2: The zonal architecture of the software-defined vehicle

Central compute

Central compute systems allow manufacturers to consolidate functionality from what were previously separate electronic control units (ECUs) across the vehicle in a way that can safely and securely be updated, reconfigured and customized. This super-integration of ECUs also reduces the complexity, cost and weight of vehicles, potentially replacing dozens of components with one.

Needless to say, the central compute system needs to be extremely powerful and sophisticated, with multiple real-time and applications processing cores. These range from real-time operating systems running deterministic vehicle control to high-level operating systems running vehicle management and OEM applications and services. The central compute solution based on the new S32N family of vehicle super-integration processors, with advanced vehicle networking, innovative system power management like the FS04, and pre-integrated software from the S32 CoreRide open partner ecosystem. It allows automakers to safely and easily integrate many cross-vehicle functions, running in isolation-ready execution environments. The use of such processors comes with specific power management schemes and requirements.

The central compute system's complexity, the number of output rails and power requirements mean that multiple PMICs are needed. This is where NXP's ByLink™ platform becomes so vital, combining a battery connected PMIC with one or multiple 5V PMICs, fully synchronized. It provides the capability to synchronize each of the PMICs, supplying various voltages to different parts of the system, together and allows a smooth and controlled transition between them. Even in the event of a failure in one of the rails, it can easily synchronize all of the PMICs, if needed, to initiate a safe power-down sequence of the whole system without input from the processor.

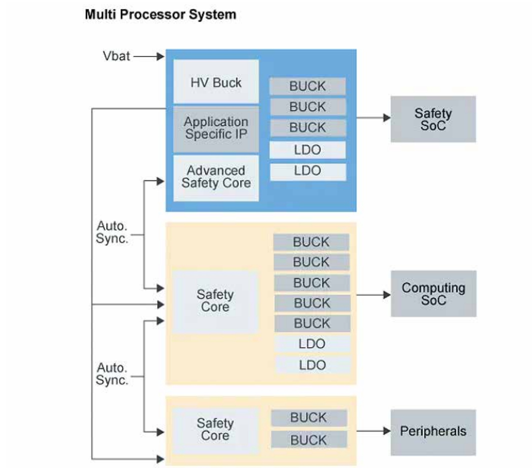

Figure 3: A ByLink™ system comprising three PMICs

The components need to each have tightly controlled, accurate voltages at every moment. In addition, the types of memory chip used in current systems, such as LPDDR5, can present a challenge when it comes to voltage monitoring with asymmetric thresholds. For these reasons, NXP has developed high-precision PMICs such as the FS04, with analog to digital converters to offer improved accuracy, while still meeting the requirements of ASIL D safety standards. The S32N cores are powered by the PF53 POL regulator offering high power solution with an optimized bill of material.

Improvements are made with each generation to reduce the quiescent current while the system is in low power mode or sleep. Our goal is to always reduce the budget of current taken by the PMIC itself, minimizing the impact at module or vehicle level.

Zone control

Zone controllers are the vehicle's big communicators: Each of them can be seen as a bridge between the central compute system and the various actuators, sensors and other end nodes of the vehicle. Their job is to collect and communicate information both ways between the two ends of the system, and also with other zones. A sensor at the rear of the vehicle, for example, might communicate data that is used by a component at the opposite end of the vehicle.

Considerable volumes of data thus flow through the zone controllers, and so, alongside the microcontroller unit, the modules are designed with several Ethernet transceivers and an Ethernet switch alongside the well-established CAN and LIN networking layers.

So, just as with the central compute system, the power requirements for the zone controllers are complex: the system must power each of the communications transceivers separately, along with the MCU, and each may have different voltage and current requirements. NXP PMICs, such as the FS26, are well prepared for this, integrating several Buck and LDO regulators within the same unit. These will still need to be configured for the exact specification required, though, and scalability in this is highly important. The NXP PMICs can be fine-tuned through their One Time Programmable (OTP) functionality, allowing several parameters to be set through code, including the output voltage, the current rates and slew rates (the maximum allowed voltage change over time). This programmability gives manufacturers considerable flexibility to satisfy the needs of different ECUs, multiple processors and peripherals while optimizing for size and cost.

End nodes

A vehicle's end nodes are the final actuators, sensors, functions and the smaller, perhaps simpler ECUs that lie at the outskirts of the E/E architecture, sending and receiving data from the zone controllers. These nodes, at the edge of the E/E network, typically require less power than the central compute or zone controllers. And for this reason, NXP has developed cost-optimized PMICs, like the FS23, with integrated CAN and/or LIN transceivers.

The issue of scalability and programmability is still important, however, with manufacturers seeking to adopt a platform approach to their vehicles, and thus be able to use the same type of PMIC where possible, as well as re-using program code that performs the same function across different use cases. NXP PMICs come in many, scalable variations, in terms of their power handling and their functional safety, but each PMIC family has the same package pinout across each of the devices it comprises, allowing this scalability for manufacturers. Once one of the PMICs has been deployed, much of the work to deploy any number of others from the same family has already been done, enabling the platform scalability across power, safety and software.

Conclusion

The movement towards the software-defined vehicle allows an opportunity to rethink how cars and other vehicles are designed and realized for drivers, and for manufacturers to achieve considerable efficiencies and opportunities for differentiation. Power management is a critical consideration here, underlying every other part of this paradigm shift, and presenting a window for considerable innovation and optimization for manufacturers.

NXP PMICs provide optimal performance and integrate the requirements for multiple power modes to maximize system energy efficiency. The challenge lies in both ensuring that power consumption is extremely low while devices are dormant, but that they are equally able to resume operation swiftly when they are needed. NXP PMICs come with specific features to ensure the quiescent current is optimized and that MCUs are able to run their boot sequence as quickly as possible in response to a wake event. This is achieved while ensuring functional safety: this is the foundation of our components and we build power management components around safety, putting the safety monitoring unit at the heart of our solutions, and are aligned with NXP's SafeAssure™ program.

NXP PMIC solutions create value and bring power performance to a new level across the entire vehicle, from the central compute to the zones and end nodes. Scalable, reliable and efficient, they ease system complexity and reduce time to market with a complete system solution approach. NXP PMICs provide the ideal partner for auto manufacturers in creating the software-defined vehicle.

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Jean-Philippe joined NXP in 1999. He holds a master's degree in microelectronics. With a career in the electronics and semiconductor business focused on the Automotive market, he has held various positions as program manager, system and safety architect and more recently system and safety solution manager. He is now ADAS & Central Compute Product Line Manager for the Advanced Power Systems product line at NXP.

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