How to Shrink Your ADAS ECUs: Wrap the Power Management Around the Signal Chain

Advanced driver assistance systems (ADAS) are one of the fastest-growing segments in automotive electronics (Figure 1). The smart car is loaded with ADAS electronic control units (ECUs), each taking power from the car battery. Each ECU supports a specific car function and has its own dedicated power management. With such a high level of variability, using a discrete approach to the ECU's power management implementation might seem like the only option; that is, one ad-hoc IC for each building block, such as in the typical system shown in Figure 2. However, this approach is incompatible with another important requirement of these ubiquitous devices, specifically small size. This article reviews three very different ECU applications and shows that even when multiple building blocks are required, a tailored integrated approach to power management can easily solve this dilemma.

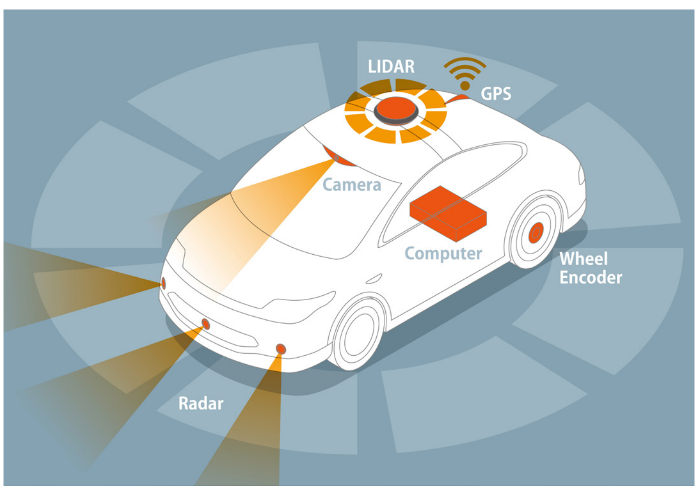

Figure 1. Smart Car Loaded With ADAS Sensors

The Smart Car

Sensing devices in smart, autonomous, or semi-autonomous cars combine millimeter wave radars, micrometer wave lidars, and nanometer wave cameras. When tracking another vehicle in front of the car, the camera is used to find and locate the preceding vehicle, while the radar measures the distance. This information is then used to decide whether it is necessary to slow down or brake the vehicle. In more sophisticated systems the distance is measured with a radar and a lidar. Unlike both lidar and radar, cameras can see color, making them the best for scene interpretation.

Today's ADAS Radar Power Solution

Every ADAS-compliant subsystem in the car, be it the radar, lidar or camera module, employs a number of voltage regulators, monitors, and watchdog ICs for proper operation. The discrete ADAS radar system in Figure 2 shows six different ICs that implement the power management system for the monolithic microwave IC (MMIC) at the heart of the radar module.

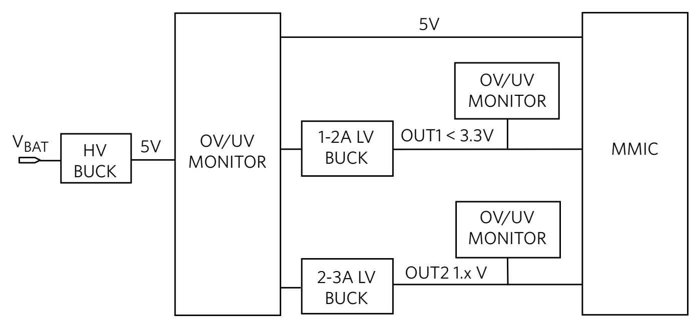

Figure 2. Discrete ADAS Radar Power Management ECU

Often the entire module must be housed on a PCB no bigger than 50mm x 50mm, making it very challenging to accommodate all the necessary components. A non-integrated solution like the one in Figure 2 is space-consuming and expensive.

Another problem is that proper operation requires the battery to never discharge below 6V (5V output plus 1V headroom for the HV buck converter). Hence, for a cold-crank specification requiring operation down to 4V, this scheme needs an additional pre-boost converter IC. It is estimated that the discrete implementation may require a power management total solution area of $1250mm^2$, or half of the available space.

On the other hand, a single power management IC would subject all the blocks to the battery voltage variability. Furthermore, an excessive level of integration may create a monster PMIC that is too big to place in the available niches of the square PCB, where the lion's share of the space is taken up by the signal chain. It is indeed crucial to make the right decision on integration partitioning.

Ideal ADAS Radar Power Solution

An ideal solution should operate with an input voltage at the lowest battery voltage while withstanding load "dump." Figure 3 shows six chips in Figure 2 that are reduced down to two. The high-voltage (HV) buck converter withstands the load dump and takes the battery voltage down to 3.3V, allowing for cold-crank operation near its output (well below 6V). A high-density, low-voltage PMIC integrates the backend voltage regulators. With this partitioning, the required area can be conveniently split into two chunks, one for the front-end buck converter (HV BUCK) and one for the PMIC, making it easy to "wrap" the power management solution around the signal chain circuitry.

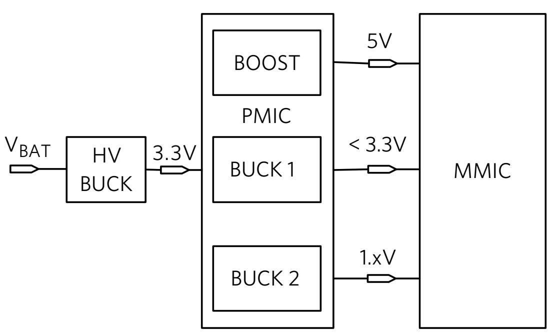

Figure 3. ADAS Radar PMIC

A small PMIC that fits this type of ADAS radar application is the MAX20014, which provides three high-efficiency, low-voltage DC-DC converter outputs. VOUT1 boosts the input supply up to 8.5V at up to 500mA, while two synchronous step-down converters operate from a 3.0V to 5.5V input voltage range and provide a 0.8V to 3.8V output voltage range up to 3A.

A front-end buck converter (HV BUCK), such as the MAX20075 (600mA/1.2A), interfaces with the battery. A 2.5A version of that device (MAX20077) is also available.

In this implementation, the ADAS radar power management total solution area is estimated to be 750mm^2 or about 1/3rd of the available area (vs. half for the non-integrated solution). Additional pin-compatible versions of the IC can support different system requirements.

Ideal ADAS Camera Power Solution

The previous partitioning solution can be replicated for an automotive camera ECU. Figure 4 shows the PMIC inside the ECU, comprised only of an 8.5V boost converter and a 1.8V buck converter. The 1.8V rail powers the microprocessor. The 8.5V rail is routed through coaxial cables to power the remote cameras.

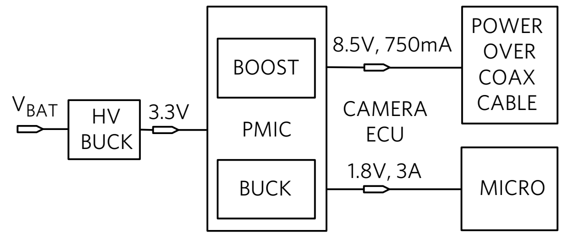

Figure 4. Power PMIC Inside the Camera ECU

A PMIC tailored for ADAS camera ECU applications is the MAX20414, which integrates one sync boost and one step-down converter. The total solution area (PMIC + HV BUCK) is estimated to be about 550mm^2.

Ideal Instrument Cluster ECU Power Solution

The instrument cluster MCU processes the information displayed by the dashboard instrumentation. In Figure 5, the SoC microcontroller needs two power sources, 1.1V to power its core and 1.8V for the periphery. Here, a dual-buck PMIC like the MAX20416, which has a dual-output, low-voltage step-down converter, fits the ADAS microprocessor core and periphery power-supply application. The total solution area (PMIC and HV BUCK) is estimated to be about 560mm^2.

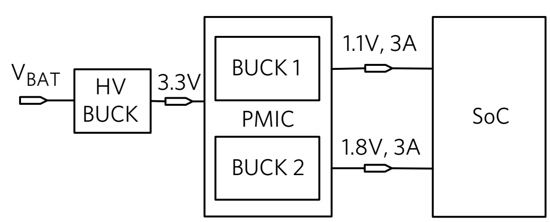

Figure 5. Instrument Cluster PMIC

In each case, the level of PMIC integration needed to fit the solution into a small available space (along with a load-dump tolerant, high-voltage front-end buck converter) is achieved with a tailored approach. This leads to better efficiency in terms of cost as well as PCB area.

Additional requirements that these ICs must meet for ADAS applications include: compliance to automotive standards, the ability to operate at high frequency to avoid AM radio-band noise interference, output voltages with ±1.5% accuracy to meet SoC power supply requirements, spread spectrum for low EMI emissions, and integrated overvoltage and undervoltage monitoring features.

Conclusion

We reviewed three very different automotive ADAS ECU applications. In each case, a tailored approach to integration was proposed. Each system was partitioned into a high-voltage front-end IC and a low-voltage back-end PMIC. The entire power management system was reduced to two ICs, a level of complexity that is small enough to fit into the limited board space required by ADAS applications, by "wrapping" it around the signal chain circuitry.

Glossary

ADAS: Advanced driver assistance systems

CAN: Controller area network. Serial bus for mainstream powertrain communications.

ECU: Electronic control unit

FlexRay: Automotive serial bus for higher-end applications

HV: High voltage

Lidar: Light detection and ranging

LNA: Low-noise amplifier

LV: Low voltage

MMIC: Monolithic microwave IC

OV: Overvoltage

PMIC: Power management integrated circuit

Radar: Radio detection and ranging

RF: Radio frequency

UV: Undervoltage

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