

## Meeting the Power Challenges of ADAS

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## Abstract

Advanced Driver Assistance Systems (ADAS) technologies have the potential to improve driver safety and comfort, and to reduce car accidents and casualties. The adoption of ADAS technologies creates challenges in electronic solutions size, safety, and reliability.

This white paper reviews the challenges for ADAS electronic components of a smart car and presents a few examples of how power management electronics can come to rescue.



*New ADAS technologies have the potential to improve driver safety and comfort, and reduce automobile accidents and casualties*

## Introduction

The field of solutions for automotive ADAS is rapidly growing. Autonomous emergency-braking systems and forward-collision warning systems will soon be mandatory in the United States and Europe. The list of ADAS features is extensive and includes driver monitoring systems (DMS) to monitor a driver's attention level, autonomous driving, adaptive front-lighting control, automatic parking, traffic sign recognition, and more.

New ADAS technologies have the potential to improve driver safety and comfort, and even more importantly, to reduce automobile accidents and casualties. However, the adoption of ADAS technologies introduces new issues for automotive design especially in electronic solution size, safety, and reliability. This white paper reviews the megatrends underlying ADAS and its associated technological challenges. It then examines new solutions to address these challenges in the area of power management.

## The Megatrends in ADAS

ADAS is a key disruptive technology ushering in a new age of smart mobility in transportation. Automakers increasingly see themselves as both product manufacturers and mobility service companies. In addition to developing next-generation connected and autonomous vehicles that will improve traffic flow and safety, automakers are investing in a wide swath of new mobility services. Urban planners will use the mobility ecosystem to reduce congestion, while generating

related benefits such as fewer traffic accidents, better air quality, and a smaller urban footprint for parking. ADAS, with its emphasis on safety, is even expected to disrupt the automobile insurance industry to the benefit of consumers.

ADAS capabilities are enabled by a plethora of sensors deployed across the car which are networked to I/O modules, actuators, and controllers throughout the automobile. Ultimately, the on-board sensors connected to cloud support functions will provide external data from other vehicles and from cloud infrastructure for connected safety, advanced driver assistance support, and autonomous driving software and functions.

## The Challenges

The proliferation of ADAS functions requires a large number of processors and connectivity interfaces in every controller, sensor, I/O, and actuator in the car. This, in turn, places new requirements on system hardware including: reduced component size to fit additional electronics in the same space, improved energy efficiency to perform within the same or lower thermal budget and increased electrical/mechanical safety and reliability to reduce failures. The ECU's power management electronics must withstand harsh automotive environments (cold/hot crank, load dump, start/stop), have high accuracy, be well protected (short to ground, short to battery, OV, OC, etc.) and be protected from electromagnetic

interference (EMI). This is true for both "safety" modules such as the radar module, sensor fusion and controller area network (CAN) as well as for non-safety modules such as infotainment, clusters, and head units. Additionally, safety modules must conform to Automotive Safety Integrity Level (ASIL) standards, including tighter protections and accuracy, redundant references, fail-safe on open pins and other diagnostics. Accordingly, many power management products are offered in both ASIL and non-ASIL versions. In summary, the primary challenges for the electronic components are:

1. Miniaturization
2. Safety and Reliability

## The Solutions

### Miniaturization

In this section, we discuss space-saving power management solutions for the automobile. First, we will discuss remote cameras located along the automobile periphery, then move on to the ECUs at the heart of the smart car. Finally, we will review the front-end voltage regulators that interface the battery.

#### How to Miniaturize Your Automotive Remote Camera

The remote camera module is typically powered by a power-over-coax (POC) 8V rail and consumes approximately 1W or less (< 125mA). This rail is bucked down to power the on-board electronic loads, including the imager and the serializer (Figure 1). The camera operates in an on/off fashion; either on at full operation

or completely off. For this reason, it is more cost-effective to select streamlined buck converter ICs designed for high efficiency at full load without extra silicon (or costs) devoted to enhancing light-load operation.

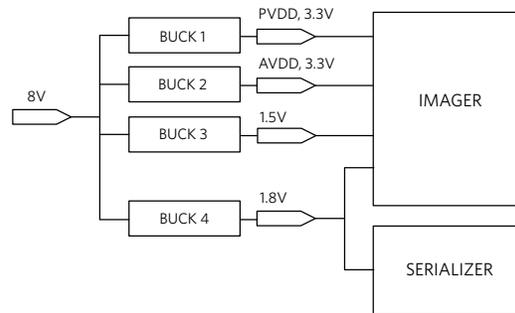


Figure 1. Remote Camera Power-Over-Coax Block Diagram

By covering the four rails with two high-efficiency dual-buck converter ICs, we save space and minimize losses. The [MAX20019](#) is an excellent candidate for this application.

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

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. However, this approach is incompatible with another important requirement of these ubiquitous devices, specifically small size. This section reviews three very



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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.

### ADAS Radar Power Solution

Figure 2 shows a highly integrated solution that reduces the number of ICs 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 back-end 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.

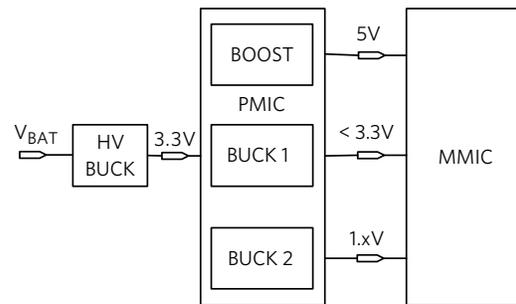


Figure 2. ADAS Radar PMIC

If the ASIL compliance is handled by the microcontroller, a small PMIC that fits this type of ADAS radar application is the [MAX20014](#). It provides three high-efficiency, low-voltage DC-DC converter outputs. A front-end buck converter

(HV BUCK), such as the [MAX20075](#) (600mA/1.2A), interfaces with the battery. In this implementation, the total ADAS radar power management solution area is estimated to be 750mm<sup>2</sup> or about one-third of the available area (vs. half for the non-integrated solution).

### ADAS Camera Power Solution

The previous partitioning solution can be replicated for an automotive camera ECU. Figure 3 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.

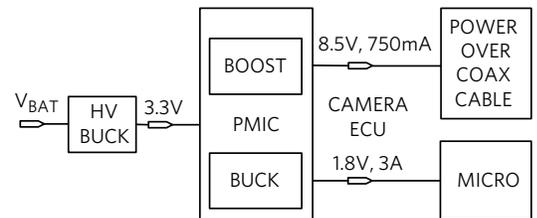


Figure 3. Power PMIC Inside the Camera ECU

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<sup>2</sup>.

### Instrument Cluster Power Solution

The instrument cluster MCU processes the information displayed by the dashboard instrumentation. In Figure 4, the system-on-chip (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<sup>2</sup>.

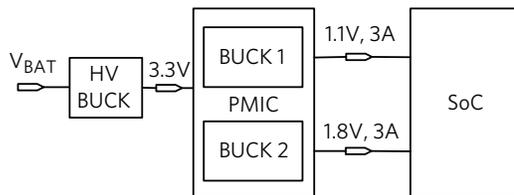


Figure 4. Instrument Cluster PMIC

### Choose the Right Front-End Buck Converter for your Automotive ECU

Gas-powered vehicles rely on a lead-acid battery to supply power to the electronic loads. The interface between the battery raw power and the delicate electronics requires a front-end regulator that can withstand different transient conditions.

The buck converter must withstand the battery voltage, which can be as high as 14.7V on a fully charged battery. Vehicles employing start-stop technology experience large voltage dips when the engine starts, so the lower limit for the power source is well below the typical 12V and can be as low as 4V or lower. A high and well-controlled PWM switching frequency (above the AM band range of 500kHz to 1.7MHz) is required to reduce radio frequency interference while spread spectrum is necessary to meet EMI standards.

If the ECU level of complexity is low, a simple, fully monolithic IC, will suffice for the front-end buck converter. For current

levels below 8A, a monolithic solution can deliver the best efficiency in the smallest possible PCB area. For medium-to-high level system complexity, requiring 8A to 20A of total current, the most convenient solution for the front-end buck converter is a controller IC plus external low- $R_{DS(ON)}$  MOSFETs. The [MAX20098](#) is a 2.2MHz synchronous step-down controller IC with 3.5 $\mu$ A quiescent current. It is intended for applications with mid- to high-power requirements and currents up to 20A. For systems requiring a total current level above 20A, a two-phase interleaved controller is the best solution for the front-end buck converter. The [MAX20034](#) is a 2.2MHz, single-output, two-phase interleaved or dual-output, single-phase synchronous step-down controller.

### Safety and Reliability

In this section, we will first discuss the safety of the electric path from the battery to remote cameras. Electric safety is enhanced using appropriate protectors and the adherence to ASIL-B and ASIL-D safety specifications. Subsequently, we will review motorist safety. Visible LED drivers play a critical role in preserving and enhancing the sophisticated lighting patterns that improve motorist visibility. Similarly, IR LED drivers play an important role in driver monitoring system (DMS) applications, checking the motorist's state of alert. We will highlight the importance of power-efficient solutions that reduce heat generation and keep the electronics cool, thereby improving reliability.



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### Providing a Safe Power Path from the Car Battery to Remote Cameras

The current and voltage going into the camera modules via the coaxial cables must be monitored and controlled for various types of faults. Figure 5 shows an example of a surround-view camera system. Here, a buck-boost converter connects to the battery and provides DC power to the remote cameras through a quad protector IC, a bank of AC-blocking coils (L), and four coaxial cables. A quad deserializer connects the microprocessor to the remote cameras via the bank of AC-coupling capacitors (C) and the same coaxial cables.

The [MAX20087](#) quad power camera protector is a compact, efficient protection IC. This ADAS IC effectively provides power and protection along the path from the car battery to the remote cameras.

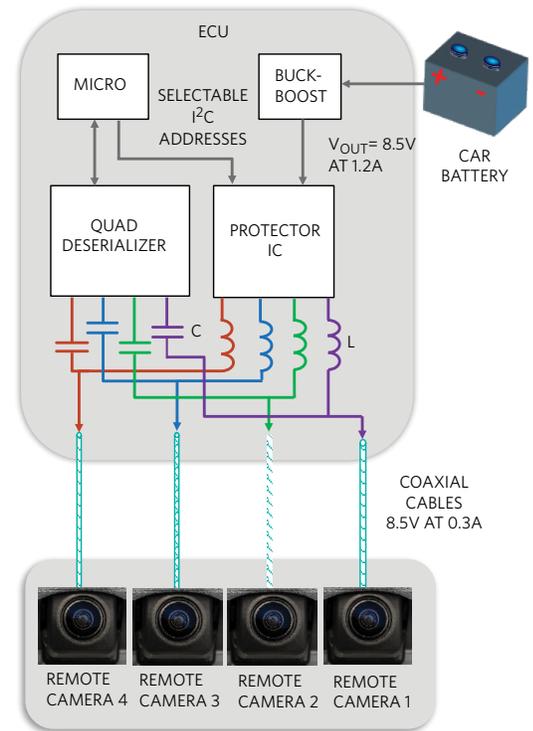


Figure 5. Surround-View Camera System

### Achieve Superior Automotive Exterior Lighting with a High-Power Buck LED Controller

LEDs have significant advantages over traditional technologies. The superior clarity of the white light in LED headlights (Figure 6) improves driver reaction time. Adaptive front-lighting systems (AFS), enabled by LED matrixes, produce fast, complex light pattern changes that improve visibility for drivers in poor light conditions. At night, in response to the beams of an incoming car, AFS can automatically adjust the light pattern,

preventing the oncoming driver from being blinded by harsh lighting. The LED illumination rise-time is twice as fast as that for incandescent sources, so that LED-based brake lights illuminate quicker and provide advanced warning to drivers, increasing road safety. Finally, LEDs consume less power than their incandescent counterparts, leading to substantial advantages in fuel consumption. LED controllers, the electronics that operate LEDs, play an important part in preserving and enhancing the inherent LED qualities of clarity, speed, and efficiency.



Figure 6. LED-Powered Car Headlight

High-brightness LEDs (HB LEDs) require constant current for optimal performance. Since current must be kept constant to preserve color, the best dimming strategy for LEDs is PWM (pulse-width modulation), where the light intensity is modulated by time-slicing the current rather than by changing the amplitude. The PWM frequency must be kept above 200Hz to prevent the LED from flickering.

With PWM dimming, the limit to the minimum LED "on/off" time is the time it takes to ramp up/down the current in the switching regulator inductor.

This may add up to tens of microseconds of response time, which is too slow for LED headlight cluster applications that require fast, complex dimming patterns. Dimming in this case can only be performed by individually switching on/off each LED in a string by means of dedicated MOSFET switches ( $SW_{1-k}$  in Figure 7). The challenge for the current control loop is to be fast enough to recover quickly from the output voltage transient due to switching in and out of the diodes.

Sophisticated headlight systems utilize a boost converter as a front-end to manage both the variabilities of the input voltage (dump or cold-crank) and the EMI emissions. The boost converter delivers a well-regulated and sufficiently high output voltage (Figure 7). Dedicated buck converters, working from this stable input supply, can then handle the complexities of controlling the lamp's intensity and position by allowing each buck converter to control a single function, such as high beam, low beam, fog, daytime running lights (DRL), position, etc.

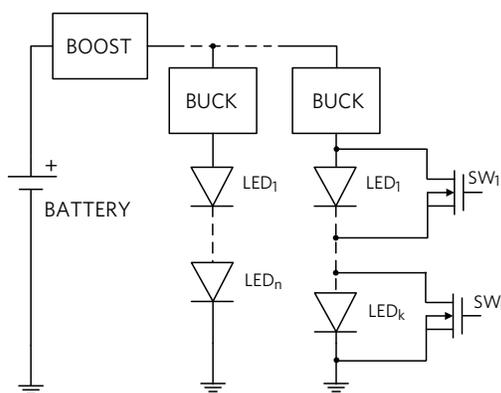


Figure 7. Advanced LED Lighting System



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An ideal solution should meet the requirements of a wide input voltage range, fast transient response, high and well-controlled switching frequency, all while enabling high efficiency with synchronous rectification. The [MAX20078](#) buck LED controller enables such a solution. For compact lighting applications with currents up to 2A, the [MAX20053](#) buck LED converter is an ideal solution. The fully synchronous 2A step-down converter integrates two low  $R_{DS(ON)}$  0.14 $\Omega$  (typ) MOSFETs, assuring high efficiencies up to 95%. The high level of integration yields minimum PCB area occupation. The boost converter in Figure 7 can be implemented with the [MAX16990/](#) [MAX16992](#) 36V, 2.5MHz automotive boost/SEPIC controllers.

#### **IR Camera for DMS**

Infrared (IR) cameras, utilizing an IR-LED diode in combination with a CMOS sensor, help recognize hazardous microsleep that affects motorists. The advantage of using infrared is its invisibility to the human eye and its ability to operate day and night. Image analysis processes information to determine if the driver is fatigued or distracted. With an IR-LED diode typical forward voltage of 2.8V and a forward current of 1A, the electronics that drives it is directly connected to the battery.

As an example, the [MAX20050](#) buck LED driver is an ideal solution. The fully synchronous, 2A step-down converter integrates two low  $R_{DS(ON)}$  0.14 $\Omega$  (typ) MOSFETs, assuring high efficiencies up to 95%. With its 4.5V to 65V input supply range, the MAX20050 can easily withstand battery load dump, making it ideal as a front-end buck converter in DMS applications.

## Power Summary

Table 1 is a summary of an example power management approach for ADAS.

| Application           | Products   |
|-----------------------|--|
| Remote Camera Module  | <a href="#">MAX20019/</a><br><a href="#">MAX20020</a> Dual Buck Converters   |
| Camera ECU Front-End  | <a href="#">MAX20087</a> Camera Protector  |
| Camera ECU            | <a href="#">MAX20414</a> PMIC  |
| Radar                 | <a href="#">MAX20014</a> PMICs<br><a href="#">MAX20075/</a><br><a href="#">MAX20076/</a> Buck Converters   |
| Cluster ECU Front-End | <a href="#">MAX20075/</a><br><a href="#">MAX20076</a> Buck Converter<br><a href="#">MAX20098</a> Buck Controller<br><a href="#">MAX20034</a> Two-Phase Buck Controller |
| Cluster ECU           | <a href="#">MAX20416</a> PMIC  |
| Headlight ECU         | <a href="#">MAX20078</a> LED Buck Controller<br><a href="#">MAX16990/</a><br><a href="#">MAX16992</a> Boost Controller<br><a href="#">MAX20053</a> Buck Converter      |
| IR DMS                | <a href="#">MAX20053</a> Buck Converter  |
| Ideal Diode           | <a href="#">MAX16141/</a><br><a href="#">MAX16126/</a><br><a href="#">MAX16127</a>   |

## Summary

ADAS technologies have the potential to improve driver safety and comfort, and to reduce car accidents and casualties. The adoption of ADAS technologies creates challenges in electronic solution size, safety, and reliability. For each challenge, we showed examples of how power management can effectively help users realize ADAS systems. For the miniaturization challenge, we proposed highly integrated solutions for remote camera modules, cameras, radars, and cluster ECUs. For better safety and reliability, we proposed solutions for lighting, ECU front-ends, IR, and radar applications. Finally, for safety modules, we highlighted the availability of ASIL-qualified ICs. These power management solutions overcome the critical challenges faced by today's ADAS implementations.

## Related Resources

### White Papers

[Choosing the Right Automotive ICs for Next-Generation Vehicles](#)

[Balancing Power Supply Requirements in ADAS Applications](#)

### Design Solutions

[Achieve Superior Automotive Exterior Lighting with a High-Power Buck LED Controller](#)

[Improve Your Automotive ECU Design with a Low-IQ Buck Converter](#)

### Blogs

[Choosing the Right Power Management ICs For Automotive Designs](#)

### Design Guides

[Gigabit Multimedia Serial Links \(GMSL\) for ADAS](#)

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