LUMISSIL MICROSYSTEMS

Lumissil Powers Infrared LEDs for Driver and Occupant Monitoring Systems

Driver drowsiness and fatigue significantly affect vehicle safety and are major contributors to road accidents. To address these risks, many top automotive manufacturers are increasingly incorporating Driver Monitoring Systems (DMS) and Occupant Monitoring Systems (OMS). DMS is designed to track the driver's physical and attentional state to help prevent unsafe driving, while OMS observes the presence and status of passengers for enhanced safety and comfort. These systems continuously monitor both the driver and road conditions, providing alerts to capture the attention of the driver and passengers. DMS and OMS use a combination of components: a camera to capture visual data, infrared LEDs (IR-LEDs) for non-intrusive illumination, haptic devices for tactile feedback, and speakers for audible alerts. Together, these elements enable real-time detection and response to unsafe driving behavior.

Packing all these electronic components into a car isn't easy, See Figure 1 where these IR LEDs are placed in current automotive applications. They need to fit cleanly, work together seamlessly, and still handle the tough automotive environment and EMC requirements. That's where smart, compact solutions come in. In this article, we break down the flaws in a commonly used approach, share what to look for when choosing an IR-LED Driver, and introduce a compact, high-performance IR-LED Driver IC that connects directly to a 12V or 24V battery.

Shorter-range:
- Steering wheel
- Instrument panel
- Center console
- Seat backs
- Rearview mirror
- Pillars

Long-range:
- Dome/ceiling
- Rearview mirror
- Pillars

Figure 1: IR LED integration areas

WHY IR-LEDS?

One of the primary methods of sensing the drivers eye/face position status is through Infrared Lights, An IR LED operates at a wavelength between 780nm and 1400nm; some can go all the way up to 2500nm. Since these wavelengths are invisible to the human eye, they are not distracting and are the optimal solution to track the driver during lowlight (night) conditions. This way the DMS and OMS can see the driver and the passengers during low-light (night) conditions and make proper computations.

HOW DOES FACE MONITORING WORKS?

The IR LED shines light onto the driver's face (see figure 2), and that light gets reflected to an IR-sensitive camera to help it "see" the environment. When pulsed or projected in a pattern, the IR LED can detect depth, curvature, shape, and size of objects. Today's systems can even track eye movement with impressive precision, all thanks to the capabilities of IR LEDs.

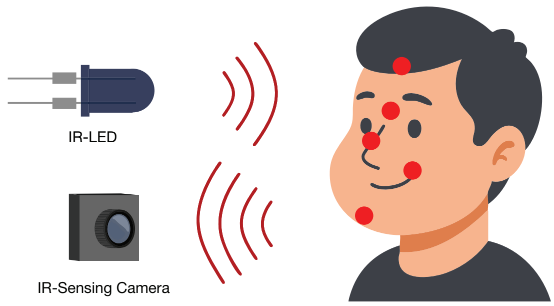


Figure 2: IR-LED and IR-sensing Camera in action

COMMON SOLUTION AND FACTORS TO CONSIDER WHEN CHOOSING AN IR-LED DRIVER

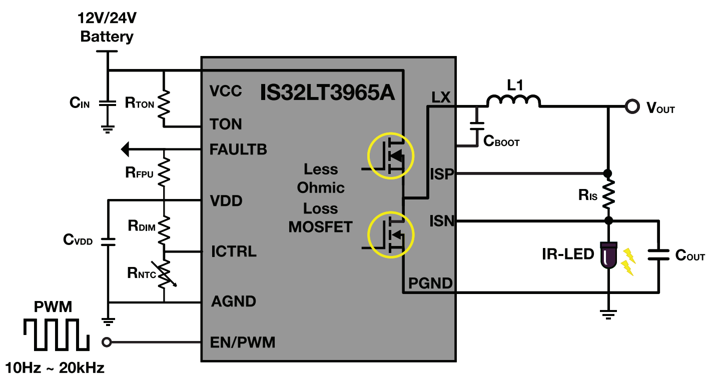
The LED Driver controls the IR light intensity and pulses it at the right frequency and duty cycle, depending on what the system is trying to track. Getting the duty cycle and frequency right is critical, because keeping the IR LED on too long can pose a risk to the human eye. Ideally, the driver should run directly off a 12V or modern 24V battery system and be built to handle the harsh automotive environment. Vehicles with start-stop technology often experience voltage dips during engine start, which can drop the battery below 12V or 24V. That's why the LED Driver needs to maintain stable output during cranking, while also managing the EMI spikes caused by ignition noise. A well-designed IR-LED circuit using a Buck LED Driver has enough headroom to regulate current accurately during these conditions. It also needs to withstand dump voltage, handle EMI, and increasingly meet ASIL safety integrity standards that are becoming more common across the automotive industry.

A common way to drive IR LEDs in automotive applications is by using Buck (Step-down) LED Driver. There are two main topologies used for IR-LED applications: asynchronous and synchronous buck drivers. In asynchronous, a freewheeling diode is typically used to provide a path for current when the switch is off. In synchronous designs, this freewheeling diode is replaced with a low-side MOSFET to cut down power loss from the freewheeling diode voltage drops. In IR LED driver circuits (e.g. for **driver monitoring systems** in automotive), the output voltage is quite low (~1.2–1.5 V for an IR LED) while input might be 12 V or higher. This means the buck converter operates at a **low duty cycle** (e.g. ~10–15%). In a non-synchronous design, the freewheeling diode conducts during the large portion of the duty cycle when the high-side MOSFET is off. This has major impacts on efficiency and heat. Certainly, in a synchronous design, there are two MOSFETs that need to be driven so there are the conduction losses that need consideration.

Thermal management also benefits from the synchronous design thanks to its higher efficiency. For a given IR LED current, the synchronous driver dissipates less power, reducing thermal stress on the system. Automotive components like the IS32LT3965A take this a step further by combining a faster rise time with integrated low-loss MOSFETs, which minimize conduction losses. This allows the driver to deliver up to 3A peak IR LED current, particularly during low duty cycle operation (<40%), while maintaining safe thermals when paired with a well-designed PCB layout. In contrast, older non-synchronous solutions often require a bulky diode and may struggle to handle these higher currents and fast transitions.

HOW DOES IS32LT3965A HELP WITH DESIGNING BETTER IR-LED CIRCUITS?

Lumissil's IS32LT3965A is a 3A synchronous Buck LED Driver designed with minimized Conduction Losses on integrated high and low side MOSFETs. Operating up to 2.2MHz, it allows for small inductors and output capacitors. The peak IR-LED current is set with a single resistor, supporting up to 1.5A continuous and 3A peak at low dimming frequencies in small duty cycles conditions below 40%. Forced Continuous Conduction Mode (FCCM) ensures fixed frequency operation, while cycle-by-cycle on-time control delivers fast transient response and maintains output current accuracy within +/-2.5%. The integrated current sense circuit and high switching frequency help reduce BOM cost and minimize EMI, which is vital for PCB designs with sensitive components like cameras.



DIMMING

The IS32LT3965A supports PWM dimming, allowing an external MCU waveform on the EN/PWM pin at frequencies from 10Hz to 20kHz. It requires an EN/PWM signal of about 100ms to fully shut down, enabling compatibility with dimming rates for 30fps, 60fps, and 120fps. Users can set the switching frequency (FSW) via an external resistor, RTON, between VCC and the TON pin. Operating in FCCM, the device automatically regulates output at the chosen frequency. Analog dimming is available through the ICTRL pin, allowing precise current amplitude adjustment; this pin should be tied to a voltage between 2.6V and 6V if unused. The ICTRL pin is also useful for fine-tuning LED binning during mass production.

EMC FEATURES

The device uses Constant on-time mode, this control method uses the output ripple as PWM ramp signal to compare with the reference to regulate, it has several advantages over current mode. Firstly, it does not require an external compensation network and makes design easier. The driver also has optional Spread Spectrum (SS) modes which has a 600Hz with ±5% operating frequency jitter to distribute EMI over a wider range that significantly reduces the EMI energy peaks; this helps meet CISPR-25 class 5 standards with compact sized and cost-effective filter circuit.

FAULT DETECTION AND REPORTING

To help meet ASIL requirements, the IS32LT3965A provides a dedicated fault pin FAULTB as well as protection features including PIN open, PIN-to-GND Short, Output LED String open/short, External component open/short, Thermal shutdown and Thermal Roll-off. The FAULTB pin works as both input and output, pulling it low externally can disable the device, supporting a one-fail-all-fail approach for lighting systems using multiple drivers. It's important to note that ASIL requirements are more stringent for fully autonomous vehicles compared to basic driver distraction alerts. To further support your system evaluation, we provide a comprehensive Safety Manual covering failure modes and safety-related assumptions.

Automotive IR LED systems typically opt for synchronous buck LED Drivers as they provide clear advantages in efficiency (especially at the low duty cycles inherent to stepping down from vehicle battery to IR-LED forward voltages). They waste less energy as heat and can operate at higher frequencies, which leads to smaller components and often easier EMI compliance. Although both topologies synchronous and asynchronous can be made to meet the pulsing requirements of IR-LED at needed frequency and duty cycle. What differs is how the power conversion behaves at the low PWM frequency(10Hz) and low duty cycle period that is needed to drive the IR-LED safely and efficiently for applications like DMS and OMS.

Lumissil offers a wide portfolio of LED Drivers for automotive and industrial applications, and offerings for automotive IR-LED applications are continually in research and development in response to consumer requirements. For a detailed demonstration of how Lumissil components can be integrated to build an operative DMS solution, refer to this article.