ISELED - A Bright Future for Automotive Interior Lighting

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White Paper

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Contents

More than interior lighting

Interior lighting was originally developed to orient the driver in the cockpit when natural light was not sufficient to support the readability of the instruments and switches. Later, illumination began to play a role in enhancing the car's interior design and became an important brand differentiator. Over time the branding of different car makes has become aligned with a company's overall corporate identity, triggering the application of high standards for brightness and color purity. In the early 1990s BMW introduced a significant shift in lighting when it changed the main light source for all instruments and switches to LED technology. This ushered in a first standard for illumination and defined major requirements on the LED.

The first ambient light effects with indirect lighting were introduced in the early 2000s in several premium cars and interior lighting continues to evolve to create new user experiences and reinforce brand identity in much the same way as exterior lighting developed. In fact, upcoming features for autonomous driving lighting effects promise to deliver new ways of interacting with the driver and passengers inside the cabin, creating another communication channel or a sort of new Human Machine Interface (HMI).

Courtesy of BMW

State of the art

Up to 80 LEDs are in today's car interiors and they support a variety of features. There are technology limitations for supporting the range of brightness and color accuracy required and expected by consumers. Manufacturing efficiency has become a significant challenge; consider that every single LED needs calibration as well as special binning. Additionally, when mounted inside the car, LEDs still require dedicated control/compensation to maintain their brightness and color regardless of temperature changes, and that's just considering static lighting.

These challenges will increase as dynamic lighting effects come on the scene with new functions to assist the driver. Indeed, many more LEDs, along with their associated high-speed communications to

ensure a deterministic and safe rendering of various lighting scenarios, promise to introduce a good deal of complexity

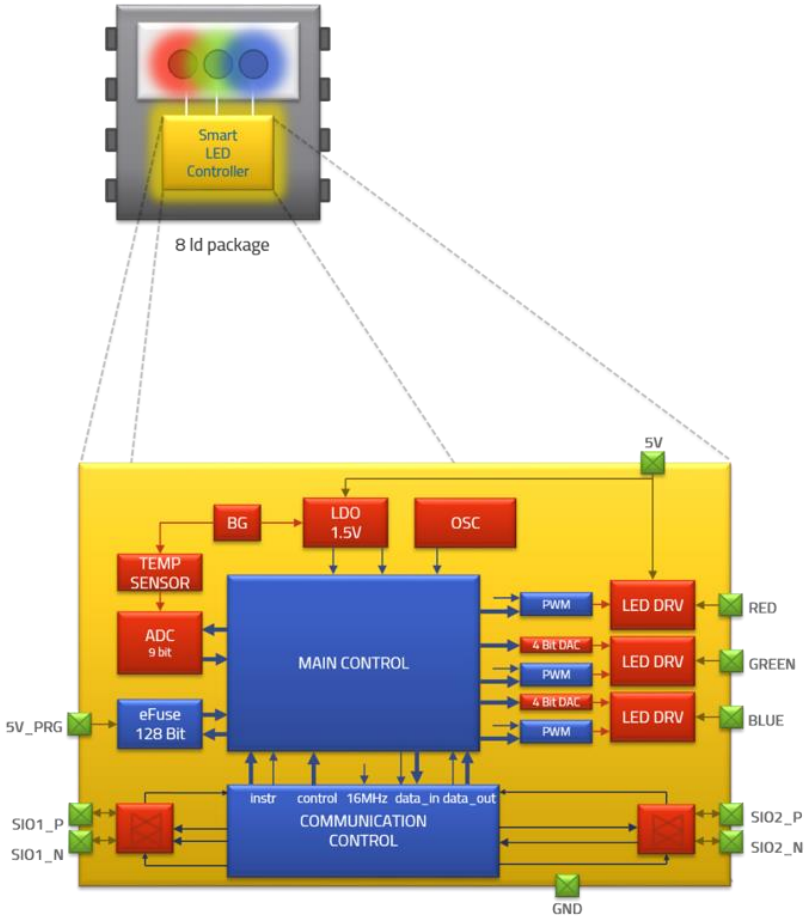
New tools and software components are needed to orchestrate the effects to be deployed on fast light-weight communication links, including safety considerations that are specific to automotive.

The car needs smarter LEDs!

Why ISELED?

The smart LED concept

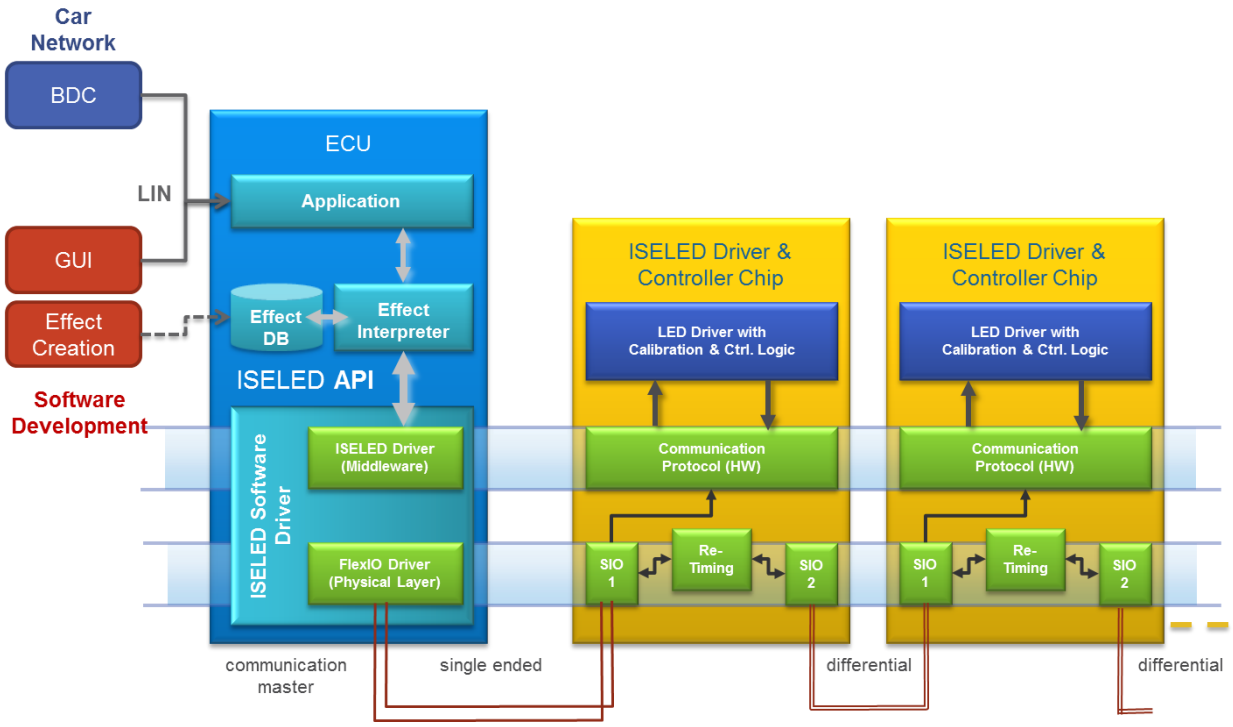
To overcome the limitations in existing in-vehicle LED lighting architectures and specific issues with calibration and communication, Inova Semiconductors joined forces with BMW to develop alternative solutions. The result of the collaboration was a new concept called ISELED. The basic idea behind ISELED is to shift the costly external processes for ensuring stable light parameters – brightness and color stability to embedded processing in the RGB LED itself. This means that the LED is “digitized” so that it can be addressed via a “lean” protocol – just like any other digital component – using only the target parameters for color and brightness.



The smart LED concept

Key features and benefits

- The serial protocol with embedded clock reduces the wiring effort. Only one differential line is required (SPI requires five).
- Differential communication in the chain (in contrast to single-ended SPI) maximizes robustness against EMC disturbances.
- Single-ended communication with the microcontroller is automatically recognized, which simplifies the interfacing and supports the usage of every microcontroller.
- No power consumption when there is no data communication. The LEDs maintain their brightness and color without the need of a refresh. So, if the color does not change, then no power for communication is required.
- As only changes in color are transmitted, with no refresh required, this minimizes communication bandwidth.
- Optional CRC protection detects communication errors.
- The half-duplex, bidirectional communication enables diagnostic data reads.



ISELED software architecture

The ISELED Alliance

The ISELED Alliance was started in autumn 2016 with the founder members Dominant Opto Technologies (LED manufacturer), NXP (system controller), TE Connectivity (connectivity) and Pforzheim University of Applied Sciences (optical measuring systems).

Inova's goal for ISELED was not just to create an innovative LED concept; Its objective was to offer customers an all-inclusive system solution with compatible hardware components and the corresponding software. The software includes the matching driver for the NXP controller and ISELED now comes with the first user software designed by LucieLabs, a French IoT start-up and a new member of the alliance. It allows for the design of individual light scenarios and the convenient control of these via smartphone.

More recently, French automotive supplier Valeo joined the alliance. With its strong focus on LED lighting in the car interior, it contributes important aspects from a user's perspective to the alliance, and therefore participating to the development of smart LEDs for smarter cars.

LED chains

The centerpiece of the new digital LED is a tiny controller chip of just 1 mm^2 area designed by Inova. The three color LEDs – red, green and blue – are embedded by Dominant Opto Technologies in a compact housing measuring just 3 * 4 * 0.6 mm. This provides the required current sources and communication logic for driving and addressing the LEDs, and also includes all circuits and control functions required for calibrating the three individual LEDs precisely to the color and brightness reference values during final test at Dominant. This can all be carried out without the need for the usual binning and barcoding of the LEDs.

The characteristics are then stored in a small memory directly in the LED controller so that they can be used as corrective values when addressing the LEDs. In addition, a temperature sensor is integrated and calibrated during the chip test, which determines the current temperature of the LEDs and adjusts the brightness based on it.

Since the entire "data overhead" of all LED characteristics during the data transfer between the system controller and the LED strips falls away, the only remaining task of the communications protocol is to transmit the actual light control commands, which is not too different from addressing pixels on a display. Data is transmitted in a differential and highly EMC-friendly manner using only 2 Mbit/s, via an unshielded two-wire line woven into the vehicle cable harness.

Despite the relatively low data rate, it is theoretically possible to accommodate up to 4,096 LEDs. The control commands are virtually present quasi-simultaneously at each RGB module, which forwards the data stream to the next module in the chain, delayed by only 4 clock cycles or approximately 2 µs.

It is thus possible to address all RGB LEDs at video speed and to use these as individual pixels of large LED screens or displays with 24 (3 times 8) bit resolution.

A bright future

Interior lighting is more than mere lighting, and ISELED is more than smart LEDs. It is a true system solution that addresses challenges spanning manufacturing through in-vehicle networking and software architectures. The alliance was created to bring multiple competencies together to prove this powerful new approach.

ISELED will lower the total system cost for current solutions at iso-functionality, and will enable new features that are not possible with current state-of-the art solutions. Its node and bandwidth scalability creates a lot of room for new functionality and use-cases yet to be discovered/invented.

It is no coincidence that the maximum number of 4,096 LEDs per line is equivalent to the horizontal resolution of the UHD (Ultra High Definition) format: the possible applications of this LED concept can thus go far beyond interior lighting in passenger vehicles. In fact, it opens opportunities for car-to-car or pedestrian communication via exterior lighting scenarios. Even beyond automotive, this concept can be applied to a broad range of applications from facade illumination and aircraft cabins through to cruise liners.

The possibilities are so varied that bright minds will surely come up with unexpected innovations, and create a bright future for ISELED!