From dynamic light to Open System Protocol – intelligence inside the LED

White Paper

ams-OSRAM.com

21.11.23

Sensing is life

Table of Content

Abstract

This document explains the benefit of LEDs for dynamic lighting with intelligence inside. It describes why this integration via an IC with an Open System Protocol is a value-added solution. The presented applications are automotive interior examples, but it is open to be applied to any application.

Valid for:
OSIRE® E3731i

1 Introduction

The OSIRE® E3731i is an intelligent RGB-LED which is based on an Open System Protocol (OSP). The LED integrates an IC into an RGB LED. The following chapters describe how the requirements for an intelligent LED were derived from four user stories and how this resulted in product features and an open-source protocol that is available to everyone.

2 Identifying demands based on user stories

LED light for automotive interior is mainly used for displays and head-up display projection, allowing a high resolution and statical illumination, mainly for decorative purposes. Statical applications are using light to illuminate an area in one fixed color and brightness.

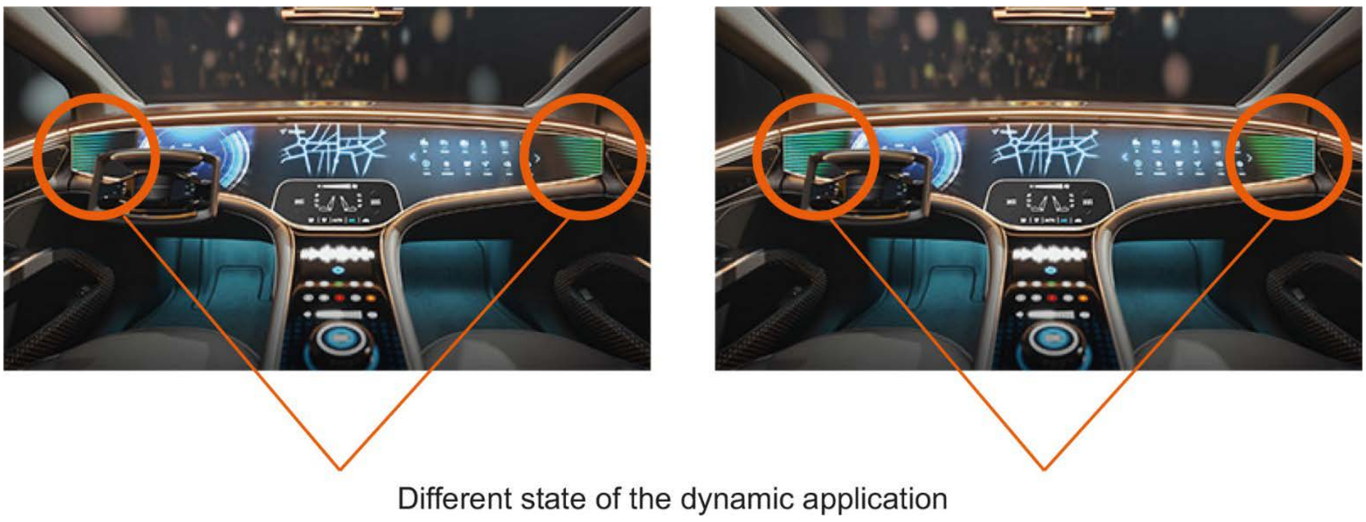
More and more dynamic light will also be used. It allows different colors and different brightness levels in one area at the same time. Compared with a display, the resolution is lower, but compared with static illuminations, additional information or effects can be transported by this dynamic approach.

The following describes some user stories for dynamic applications, which will be evaluated later for their requirements.

User story – Dynamic light for decorating application

A trim part in the interior is "high-lighted" by a backlight. This backlight will not only be static, but dynamically change color and brightness, allowing to present a movement inside the material or extend an already existing display. The pictures in Figure 1 show an extension with dynamic light stripes to the left and right side of a display. The dynamic effect is visualized by the two pictures, showing a different state of the dynamic application.

Figure 1: Dynamic light for decorating application with different states



User story – Dynamic light for warning application

A driver or a passenger is warned not to open a door because someone (e.g. a cyclist) is approaching. The cyclist is detected via separate sensors. The dynamic light application can be installed via a light bar in the door, under the side window as shown in Figure 2. This light bar changes color to red, and a strobe light runs from the B-pillar to the A-pillar. When the driver (or passenger) follows the flashing light with their eyes, they automatically look in the rearview mirror, which may also be surrounded by a flashing light bar, and see the approaching cyclist.

Figure 2: Dynamic light for warning a driver or passenger

User story – Dynamic light for communication application

As already installed in some vehicles, a light strip under the front windshield extending from the A-pillar to the A-pillar can provide minimalist communication: A blue bar moving to the left, for example, supports navigation and indicates that the driver should now turn into the next possible street (Figure 3 left image). A green bar that pulses dynamically indicates the charge level of the vehicle (Figure 3 right image).

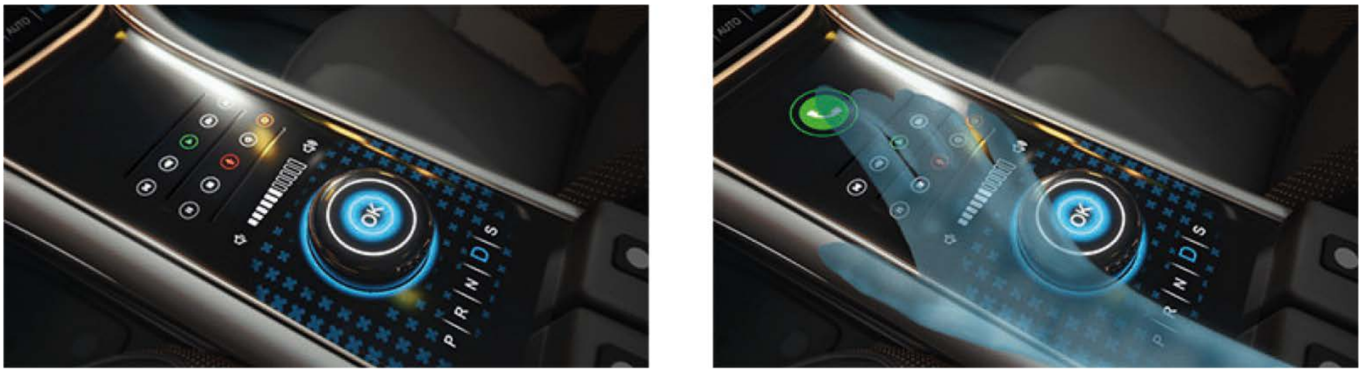
Figure 3: Dynamic light for communication applications

User story – Dynamic light for interaction application

The dynamic light is combined with sensors that enable interaction with the user (driver or front passenger). In this example, the user can answer an incoming call, change the volume and end the call.

The left image in Figure 4 shows the center console in its standard state. The right image in Figure 4 shows the interaction application with a green phone key when a call is received.

Figure 4: Dynamic light for interaction application



From these four user stories, requirements for the light source can be derived, which can be grouped into three areas, also shown in Figure 5:

- Ease electrical and physical integration
- Ease optical integration
- Ease integration of electronics and software

Figure 5: Requirements for the light source, derived from the use cases

Decorating | Warning | Communicating | Interacting

<table>
<tr><td>Backlit areas
Thin lightdesign</td><td>Slim lines to be illuminated Light should follow contours and allow bending</td><td>Illuminated icons with high resolution</td><td>Ease electrical and physical integration</td></tr>
<tr><td colspan="3">High color homogeneity
Brightness supporting in night and day mode
Adequate dimming over full brightness range</td><td>Ease optical integration</td></tr>
<tr><td colspan="3">Coordinated appearance between different lighting applications and in conjunction with sensor inputs (e.g., rear camera warning when a cyclist is detected)</td><td>Ease integration of electronics and software</td></tr>
</table>

3 Identifying LED requirements based on demands

The demands of the user cases from chapter "2 Identifying demands based on user stories" are transferred into requirements for the LED in Table 1. Divided into the previously defined clusters, the demands are defined first. From these the requirements for the LED are then derived.

Table 1:

Cluster	Demands	Requirements on LED
Ease electrical and physical integration	• Slim package design • Thin bending or curved design • Line, area, and graphs to be backlit	• Small PCB layout - Reduced number of pins to reduce the number of connections to the LEDs - Serial bus allowing a chain of devices and thus reducing the number of connections • Support layout on flex substrates (bending, curved) - Single layer PCB layout by clever pin-out of the LED - Serial bus allowing a chain of devices to be digitally controlled, thus avoiding the need for individual analog driving of the LEDs • Support small pitch - Small package with small optical window - Serial bus with low number of connections and without additional components between the LEDs thus allowing tight packing of LEDs
Ease optical integration	• Seamless dimming capability • Homogeneity of colors • Large and/or adjustable range of colors to cover all customer demanded color points • Brightness sufficient for daylight applications • No flickering • • Smooth dynamic appearance	• PWM resolution of at least 15-bit • Color accuracy better than $\Delta u'v' < 0.01$ • Excellent stability over temperature, supported by a built-in temperature sensor • Selectable gamut by choice of color bin • Supporting night and day mode (either higher PWM resolution or multiple currents) • PWM frequency of at least 1000 Hz to avoid flickering • Update rate < 10 ms for 100 nodes
Ease integration of electronics and software	• Easy integration in vehicle network • Over-the-air (OTA) update capability • EMC stability and automotive quality	• Easy vehicle integration - Free choice of vehicle network (CAN-FD, Ethernet, etc.) - Free choice of supplier and type of µC - Open and freely accessible communication protocol without license fees • OTA support - Full access of user to all features (firmware, protocol) - Free choice on algorithm and software - Free addressing / auto-addressing of devices • Automotive conformity - EMC ZVEI class III conformity - Diagnostic features incorporated - AEC Q102 – Annex 3 compliance

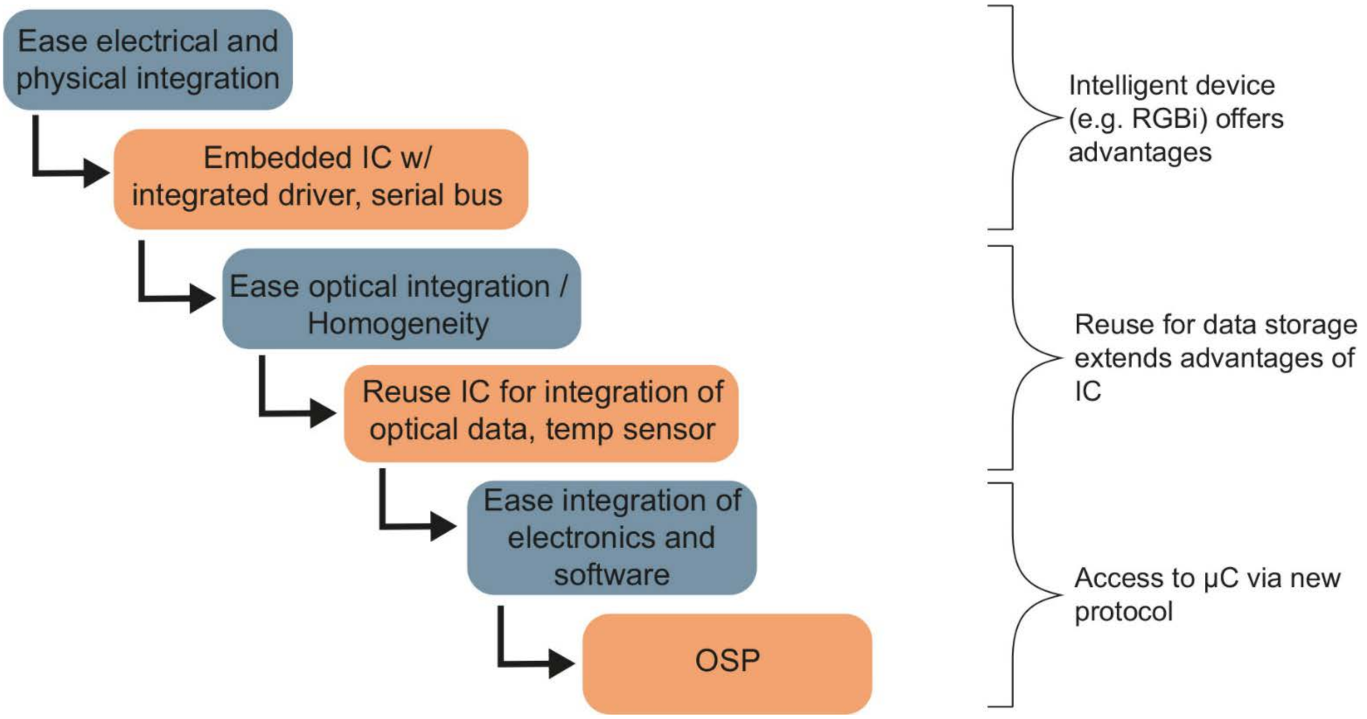
From this it can be concluded that the following solutions best meet these requirements:

- Reduced number of pins and a serial bus connection
- Integration of a temperature sensor and optical calibration data supporting night- and daytime
- A free and open protocol, without limitation on usage

4 Product solution – The RGBi

Based on the previously determined requirements for an LED, the intelligent RGB (RGBi) was developed.
Figure 6 summarizes these requirements once again.

Figure 6: Summarize requirements for an intelligent LED



This results in the following product features:

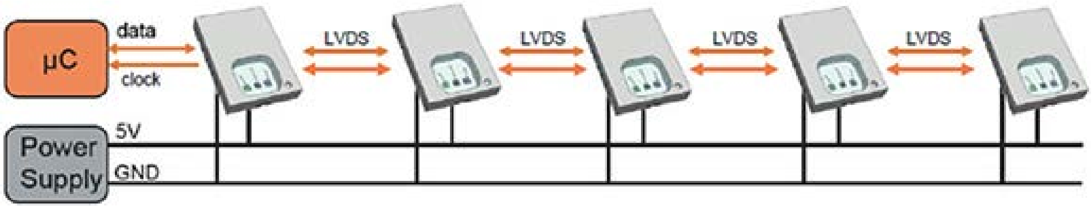
- The need for integrating the LED driver and a serial bus to accommodate the physical integration demands best
- Integrating optical data and a temperature sensor to obtain the best possible optical performance
- A new, open protocol to control the LED (to support software integration, this protocol should be open and transparent)

These new requirements for dynamic lighting applications were the basis for the intelligent light source RGBi. The little "i" should indicate the integrated IC or the “intelligence”. In last consequence, the communication to this RGBi is done with a new Open System Protocol, short OSP.

4.1 Integration of driver and serial bus

Figure 7 shows a typical implementation with one master and several slaves (RGBi devices in this case) connected in a daisy chain.

Figure 7: Typical implementation with one master and several slaves



The OSP now defines the communication of a master-slave architecture, the µC being the master, with the light-sources connected as daisy chain as slaves. The chain uses a 5-V LVDS connection. In case the chain needs to be extended physically by a cable, OSP can be extended with off-the-shelf CAN-FD transceivers.

The OSP allows automatic addressing of up to 1000 devices. The data rate is 2.4 Mbps and ensures, together with the message length of maximum of 96 bits, to meet the requirements on update rate of the individual light sources.

4.2 Integration of optical data and temp sensor

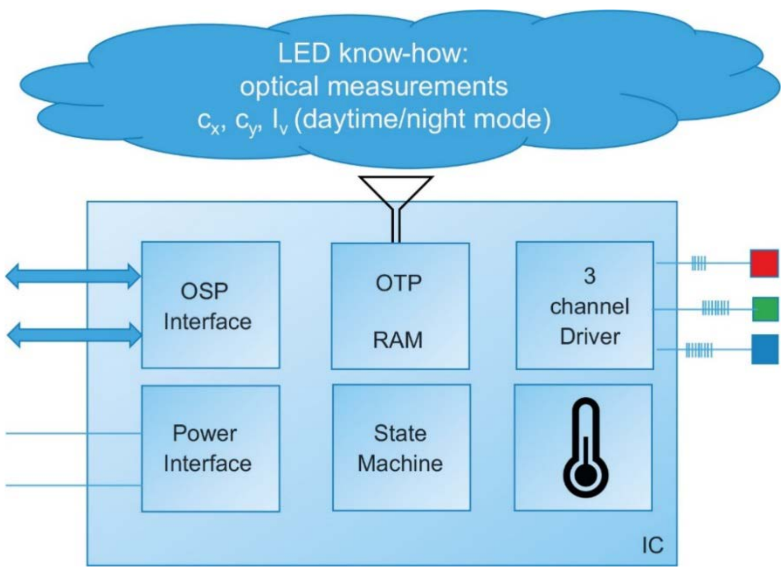
Besides serial bus and driver, the LED also needs:

- A memory
- A state machine
- A temperature sensor

The memory is the heart of the IC and includes the "knowledge" of the LED manufacturer about the optical characteristics of the used chips (Figure 8). During production this memory will be used to store LED specific and individual relevant data like color coordinates (cx, cy) and brightness at dedicated currents for the three RGBi LED chips.

The state machine is the brain of the IC and takes care of the LED functionality including communication, LED control and failure handling. Finally, the temperature sensor delivers the data needed to compensate thermally induced color shifts over the whole accessible gamut.

Figure 8: The "knowledge" of the LED



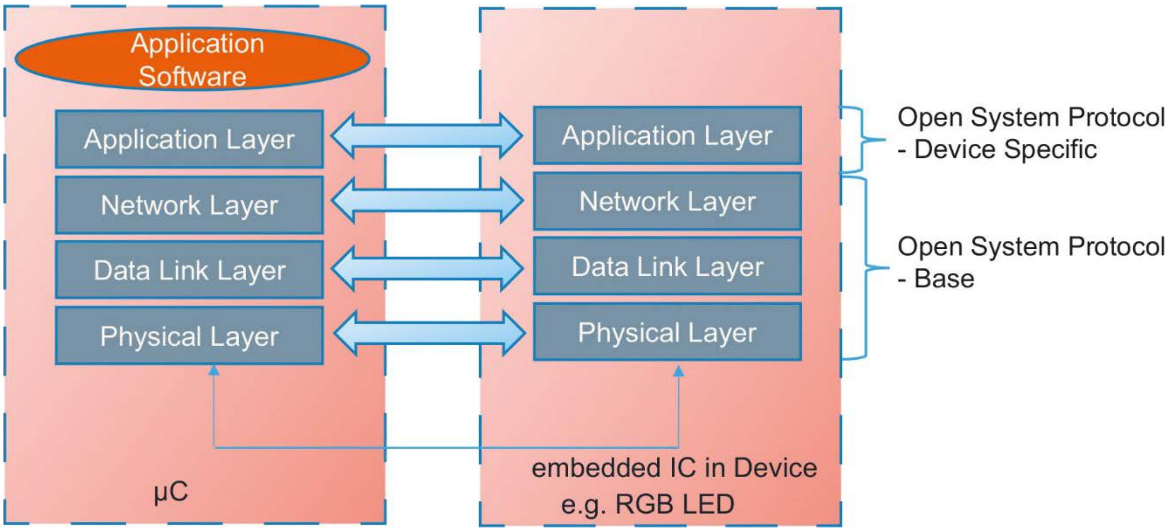
4.3 The new open protocol

To support the software integration an open protocol to connect the light-sources with the µC is needed. An open (eco)system, called "Open System Protocol" (OSP) was created based on the following key arguments:

- An open protocol is essential for a software-defined lighting application
- The application software (in the µC) includes the knowledge about the application
- Full transparency on each of the protocol layers (see below) is necessary to:
  - allow free choice of µC (left side) with performance adjusted to the individual needs of the application
  - allow anybody to build a compatible slave device (on the right side)
  - to improve the application using his/her own intelligence and know-how

The relevant protocol layers of the ISO/OSI model are shown in Figure 9.

Figure 9: Relevant protocol layers of the ISO/OSI model



The OSP is covering those protocol layers in two steps:

- A base protocol, which needs to be the same for all devices to ensure that communication along the chain is working
- A device-specific application layer, which includes the specific device features

The last one also needs to be open but may differ from device to device depending on its specific features.

The application note "OSIRE® E3731i - Open System Protocol 1.0" can be downloaded from the ams OSRAM web page and is open to be used without any license fees.

5 Summary

In summary, this document has described the following topics:

- Introduced the four user stories “Decoration”, “Warning”, “Communication” and “Interaction” and derived the requirements for an LED from them.
- Created an integration of intelligence to the light source as a requirement.
- It was shown that this requirement can be implemented by a chain of intelligent devices with an OSP as an open system protocol.

ams OSRAM has developed and published an application note for the OSP base specification as shown in the Figure 9. Please check the ams OSRAM webpage for access to this document. Anybody can now implement OSP Base – and extend it by application specific commands. Partners of ams OSRAM are offering microcontrollers and libraries which support the OSP and allow an easy start with the first product.

The first device ams OSRAM offers is called OSIRE® E3731i, which implements the OSP base plus the device specific commands of a RGBi device. The technical specification is included in the affiliated data sheet and application note of this device.

ABOUT ams OSRAM Group (SIX: AMS)
The ams OSRAM Group (SIX: AMS) is a global leader in optical solutions. By adding intelligence to light and passion to innovation, we enrich people's lives. This is what we mean by Sensing is Life. With over 110 years of combined history, our core is defined by imagination, deep engineering expertise and the ability to provide global industrial capacity in sensor and light technologies. Our around 24,000 employees worldwide focus on innovation across sensing, illumination and visualization to make journeys safer, medical diagnosis more accurate and daily moments in communication a richer experience. Headquartered in Premstaetten/Graz (Austria) with a co-headquarters in Munich (Germany), the group achieved over EUR 5 billion revenues in 2021. Find out more about us on https://ams-osram.com

Published by ams OSRAM AG
Tobelbader Strasse 30,
8141 Premstaetten, Austria