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Tran Quoc Khanh

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11th International Symposium on Automotive Lighting

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Foreword

It is a pleasure to present you the proceedings of the 11th International Symposium on Automotive Lighting, which takes place in Darmstadt on September 28-30, 2015. This conference is the document of a series of successful conferences since the first PAL-conference in 1995 and shows the latest innovative potentials of the automotive industry in the application of lighting technologies.

These proceedings result from the work of a lot of experts in the automotive and optical industry, administrative bodies, research institutes and universities. It summarizes the findings of more than 200 authors and co-authors and gives a scope of their expectations for the future. In 2015, the ISAL Steering Board could identify the following focus topics:

- The blue laser technology with stable phosphor systems giving the highest luminance for the development of the new high beam booster systems with very small size and apertures
- Pixel-light headlamps with two dimensional LED-arrays or glare-free high beam with vertical segments and driver assistance with the interaction between light sources, cameras, digital image processing and headlamp systems
- LED technology generally and the new high-current and high luminance white LEDs are promising solutions for innovative headlamp developments
- Energy efficiency, CO_2 reduction and methods for their realization
- Traffic accident analysis, traffic and automobile regulations
- Optical measurement, human eye physiology and mesopic research.

Besides the modern LED-headlamp developments for higher class vehicles with a luminous flux of about 1100 lm, some headlamps with LED low beam have been demonstrated performing a luminous flux of 600-650 lm on the road using about 11-13 W electrical power. Parallel to the development of LED-array for pixel light headlamps, other technologies like LCD and DMD-systems are subjects of intensive research in order to reach a traffic space resolution of more than 10,000 pixels. This development must be hand in hand with the improvement of the image processing like camera and sensor technology as well as efficient embedded algorithms. Quality of sensors, image processing and sensor fusion will determine the future of driver assistance.

During ISAL 2015, we will have a podium discussion on the test strategy and the acceptance tests for the ADB-headlamps with some contributions of GTB, universities and other institutions. The aim of this podium discussion is to analyze the advantages and some deficits of the current ADB-systems in order to have an acceptance on the American market.

We wish you a very informative and successful ISAL 2015 in Darmstadt. We hope that this year's event and these proceedings will give you inspiration and motivation for your work during the next 24 months.

Yours sincerely,

Prof. Dr.-Ing. habil. Tran Quoc Khanh

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I. General Topics

RENAULT Full LED Headlamp Strategy

BEDU François, RENAULT S.A.S., France

Keywords: Full LED Headlamp, Light signature

1 Abstract

The 1st intention of Lighting LED functions has begun in 2009 in RENAULT. After 5 years of intensive work, the 1st application of Pure LED Vision module has been launched on the market with New Espace. At the same time, this vehicle is emphasizing the brand signature, with the introduction, on the front face, of a lit "C" shape.

RENAULT is the 1st one to propose on the market a full LED headlamp as standard equipment on a D-segment vehicle.

The strategy of development of the full LED headlamp will be more and more visible during 2015 – 2016 with the launch of new vehicles. The Pure LED Vision modules have been developed to replace Xenon headlamps and a high level of standardization has been achieved on the headlamps.

2 Introduction

After the development of rear signaling functions with LEDs at the beginning of last decade, the introduction of LED front signaling functions was the logical 2nd step for CO_2 reduction reason. In this trend of fuel consumption optimization, bulb low beam was the lighting function with the highest remaining consumption [1].

In 2009, for the new generation of C-D segments vehicles, the choice of technology used in the headlamp was a crucial topic. Due to the interdiction of Mercury and lead in the parts, the application of Xenon D1S system was forgotten. An investment in a new ballast with D3S bulb was required. Thus, internal thoughts have begun about LED LowBeam function. Rapidly, the idea has been to replace Dynamic bending light biXenon module by two modules: one for LED lowbeam and another for highbeam.

3 Genesis of full LED Headlamp

The lighting team which has begun to experiment LED lighting development with daytime running lights on different vehicles from B to D segments (Zoe, ClioIV, Espace IV, Megane

III, Scenic III) has decided with styling department to launch an expertise study. Two suppliers were selected with different objectives:

- Define the technical feasibility of what will be called later Pure LED vision modules and optimize the cost [2],[3].
- Improve LED knowledge and update technical requirements to prepare the launch of the multiple RFQ for the new C-D segment line-up.
- Validate the styling intention with the presentation of physical mockups
- Validate the photometric performance of the modules.

Figure 1: First styling intention of full LED modules

4 Lighting Signature origin

In parallel to the LED modules pre-development, the 1st intention of light signature was also evaluated during the expertise phase. Due to a problem of physical packaging, this intention was canceled. The definition of Espace V headlamps has begun with an economical DRL solution.

In 2012, with new Megane's research of concept, Product planning proposes to focus on lighting with an emphasized light signature. Very quickly a theme emerged of the discussions between styling and Lighting teams. A new expertise study is launched with the objective to define optical concept to fulfill the request: An "out of the box" signature at the front end and a 3D signature at the rear end inspired from lightbrush images are decided.

After discussions with Project management, these signatures are carried back completely or partially on the different preceding vehicles like Espace, Kadjar and Laguna.

Figure 2: ***RENAULT ESPACE 5*** *full LED headlamp with light signature*

Figure 3: RENAULT KADJAR full LED headlamp with light signature

5 Strategy of development and standardization

In order to minimize the R&D cost and the price of the parts, a complete strategy of development has been defined.

First of all, the low beam and high beam modules are unique for the 2 suppliers nominated on C-D segments line-up in order to avoid multiple developments for the different projects.

Secondly, an outsourcing of a complete line-up of LED driver is decided due to a lack of efficiency from Tier one supplier. Renault defines the specification and interface of the driers and give the development and production to an electronician company. This LED driver line-up is able to manage from 1 to 3 functions. One of this driver is used for the full LED headlamp and all of them are shared in the Alliance with Nissan.

Finally, a new automatic levelling system is integrated in the platform CMF-CD. Instead of a dedicated ECU with two height sensors, RENAULT has developed a software and integrated it in a standard ECU of the vehicle. A unique rear height sensor is used. This system is also shared with Nissan for their models using the same platform [4],[5].

6 Lighting Performance

For the photometric performance, the target is linked to the 1st goal: replace all the Xenon headlamps. Due to the difference of color, the flux target was 20% lower than Xenon but significantly higher than Halogen.

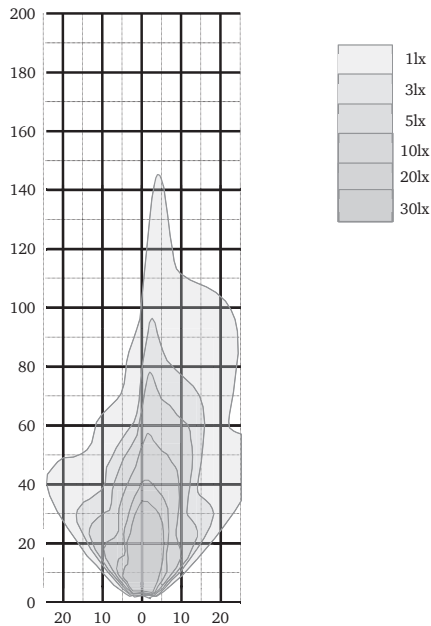
During the development, the light distribution has been focused on homogeneity and width of the beam. This can be seen in the table below based on TC4-45 criteria

	Zone A	Zone B	Zone C	Zone D	Zone E	Light Flux	Opp. glare
HAL	81m	86m	54m	13m	13m	753lm	0,35lm
XEN	**95m**	103m	**64m**	16m	**18m**	**1295lm**	0,51lm
LED	86m	**110m**	59m	**18m**	15m	974lm	0,62lm

Figure 6: Low beam performance comparison between Halogen headlamp, Xenon headlamp and Espace V full LED headlamp

	Zone A	Zone B	Zone C	Zone D	Zone E	Ped. Width	Light Flux
HAL	191m	57m	32m	79m	125m	15m	1459lm
XEN	**205m**	**61m**	32m	55m	**166m**	17m	**2220lm**
LED	188m	51m	**63m**	**84m**	162m	**18m**	2150lm

Figure 7: High beam performance comparison between Halogen headlamp, Xenon headlamp and Espace V full LED headlamp



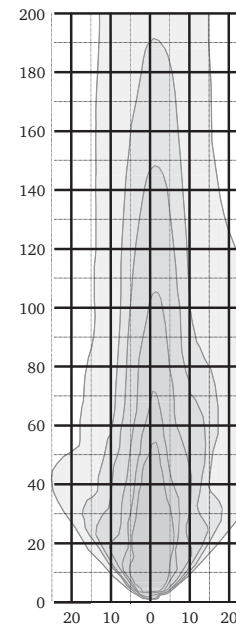


Figure 4: Espace V Lowbeam isolux

Figure 5: Espace V Highbeam isolux

7 Summary and Outlook

The 1st generation of Pure LED Vision Module are now developed and under deployment on numerous vehicles. This wide application has become feasible for due to a limited cost increase and a clear adhesion to this strategy of the styling department. The strategy of standardization exposed and shared with Tier1 suppliers on the modules, the separated sourcing of the LED driver and its communization with Nissan to increase volume effect and finally the optimization of the automatic levelling system are the three main factors from technical point of view.

The 2nd generation of Full LED headlamp is now under development and will arrive soon on the market with the difficult objective of decreasing cost for lower range models.

The strategy of the 3rd generation is ongoing and will be more challenging with several objectives:

- Which concept of full LED headlamps can replace halogen headlamps in terms of cost
- which new features with high customer value must be integrated in the headlamps
- which improvement in the standardization must be done to create new opportunity of cost saving.

8 References

[1] **BEDU François**: IAL2012, LED low beam: Advantages and disadvantages of LEDs technology, 2012

[2] **BEDU François**: IAL2015, New Renault Espace – a breakthrough in Lighting technology, 2015

[3] **BEDU François**: Shanghai DVN Workshop 2015, Innovative Lighting System in RENAULT, 2015

[4] **MATHA Paul-Henri**: VISION2010, Reality of car production tolerances and automatic levelling involvement, 2010

[5] **BALL Mamoudou**: ISAL2015, Leveling simulation – How simulations help to design a levelling system according regulation and performance for customer, 2015

Future of lighting: Aesthetic, Dynamic and Interaction

Stephan Berlitz, Vesna Krstajic, AUDI AG, Germany

Keywords: Aesthetic, Dynamic and Interaction

1 Abstract

Aesthetics, dynamics and interaction – these terms characterize future lighting technologies. How to put vehicle lighting into motion to create new, dynamic forms of expression. The light interacts intensely with the driver and the surroundings.
Aesthetics: design is more than just styling, it is the aesthetic expression of the brand values.
Dynamics: The light comes alive; it moves and takes on new forms of expression and differentiation. A chip with hundreds of thousands of micro mirrors that can be individually controlled extremely quick divides the light into tiny pixels. This will enable the ideal light pattern for virtually every situation, such as special lighting for construction zones and similar bottlenecks. Organic light-emitting diodes (OLED) at the rear or on the flanks will also enable novel functions in the future that clearly indicate to other road users the intentions of the driver in front of them. When braking, for example, their light flows quickly forward, augmenting the brake light at the back of the car.
Interaction: The lighting of the future will interact with other road users and with the driver. It will increasingly become an information medium. In the future, a novel laser tail light that assumes the shape of a warning triangle in the fog or rain could effectively keep trailing vehicles at a safe distance.

2 Introduction

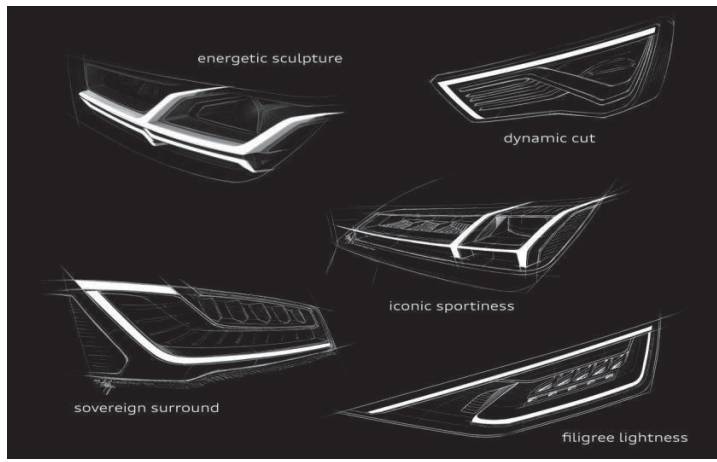
Lighting technology is a field in which there is a big competition. Audi already offers LED headlights in many model series. They define the appearance of the cars, and because they illuminate the road so well, they also make a major contribution to active safety.
The automotive industry is already developing the lighting technologies of tomorrow. Three central themes are emerging. The lighting of the future will react even more intensively to environmental conditions, it will communicate in various ways with its surroundings and thereby help to further increase active safety.
With the Matrix LED headlights, Audi has already indicated that the lighting of the future will feature full-electronic control, making new dynamic features even more versatile.
The next steps will be laser headlights for the high beam and innovative interior lighting.

3 Aesthetics

Design means more than just styling – it is the sensuously tangible expression of the characteristic values. Audi lighting gives Vorsprung durch Technik an aesthetic form and underscores the progressiveness, sportiness and sophistication of the brand.

Exterior lighting as a signature

In each model, the headlights and rear lights comprise an integral, characteristic element of the sculpture. The make the Vorsprung durch Technik particularly apparent – by day and by night. The daytime running lights are a powerful signature, complemented by the rear lights and – in the most recent models – the dynamic turn signals. Even at a great distance an Audi is recognizable as an Audi. As the car gets closer it quickly becomes apparent which model it is. No other brand works with such a large number of signatures. The concept of lighting signatures began with the introduction of LED daytime running



lights in 2004, one of the brand's first lighting innovations. In what at the time was the top model, the A8 W12, five LEDs inside the headlight formed a graphic resembling the five on a die. Two years later the new A6 Avant was given an eye-catching signature for the rear lights: 27 separate light-emitting diodes formed a flat trapezoid. They changed the streetscape permanently – as did the A4/A5 family, which followed somewhat later with distinctive LED signatures at the front and rear.

The next step in this development were the homogenous daytime running lights introduced in the new Audi A6 in 2011. LEDs behind thick-wall optics formed an elegant

wave in the headlights oriented on the outer contour. The tail lights in the form of a flat U-bend were also continuous.
Audi is making another statement with the new third-generation TT: The tail lights, which are continuously active once the ignition is switched on, follow the design of the daytime running lights for the first time. Both are grille-shaped structures with emphasized verticals, a motif derived from the R18 e-tron quattro Le Mans race car. In the new Q7, Audi has further refined this look to a double arrow.
Besides the design aspect, the daytime running lights and the tail lights are also very important for safety, and the same is true for the turn signals. The dynamic turn signals, which send unequivocal signals to the surroundings, quickly moved into additional models following their 2012 debut in the Audi R8. As an animated element, it represents a new highlight. Furthermore, other road users recognize the situation as much as one second sooner.
The lighting signature strengthens the presence of Audi models in the streetscape. It gives the cars a self-confident and focused look – with different nuances. Compact models such as the A1 have a more youthful signature, whereas that of the flagship A8 emphasizes the car's supreme control.

Matrix LED technology
The Matrix LED headlights available for several model series underscore the groundbreaking expertise in automotive lighting technology. They illuminate the street extremely well in any situation without blinding other road users. The high beam comprises small light-emitting diodes – twelve per headlight in the Audi TT and 25 in the Audi A8 – with groups of five LEDs shining through a common reflector.
When the light switch is set to Automatic and the high beams are on, navigation data are used to switch the system on outside of urban areas at speeds of just 30 km/h (18.6 mph) and above. As soon as the camera with which it works detects other vehicles, the controller immediately switches off individual LEDs or dims them in 64 stages, creating several million possible light patterns. Oncoming and preceding vehicles are excluded from the light pattern, while all other areas between and adjacent to them continue to be fully illuminated. As soon as the oncoming traffic has passed, the high beam once again shines homogenously and at full power.
The LEDs in the Matrix LED headlights also assume the function of cornering lights, selectively brightening or dimming to shift the focal point of the light along the curve. They do this shortly before the wheel is turned based on predictive route data provided by the MMI navigation plus. Audi is the first manufacturer to completely replace the otherwise mechanical elements with software. This will be the major trend in front lighting for the future.

4 Dynamic

Audi brings vehicle lighting to life. New luminous surfaces and flowing movements transform light from static to dynamic. This creates entirely new forms of expression, perception and differentiation. They enhance safety while also honing the brand's appearance.

Dynamic turn signals
The dynamic turn signals send clear, unequivocal signals to the surroundings regarding the intended turning direction. Other road users can quickly detect this even if visibility is poor or with their peripheral vision – an important contribution to safety.
Depending on the model, the turn signals are either individual LEDs or LED blocks. When the driver activates the turn signal, these light up sequentially from the inside out. After 150 milliseconds, all segments are bright; for another 250 milliseconds they illuminate with full intensity. The LEDs then go dark before repeating the lighting sequence.

Laser spot
In summer 2014, the laser spot for the high beam made its production debut in the Audi R8 LMX high-performance sports car, the exclusive special-edition model in the R8 series. It was used shortly before that in the Audi R18 e-tron quattro race car at the 24 Hours of Le Mans.
With the new laser high beam spot, which will be available in additional models in the future, one laser module per high beam generates a cone of light extending several hundred meters. There are four powerful laser diodes in each module, each only three-tenths of a millimeter (0.01 in) in diameter. They generate a monochromatic and coherent blue laser beam with a wavelength of 450 nanometers. A phosphor converter converts it into white light suitable for roadway use with a color temperature of 5,500 Kelvin.

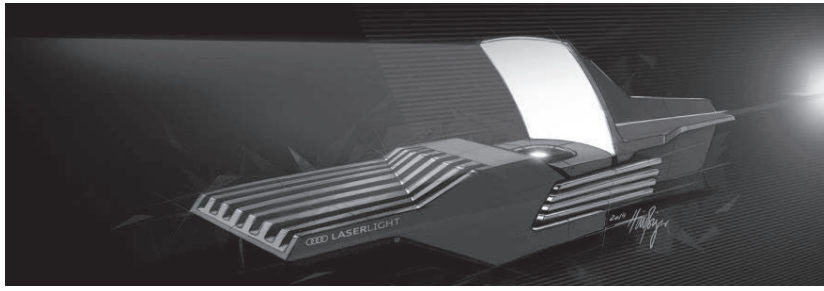


Figure 2: Audi Laser spot