

How to Make LED Concepts More Affordable for Automotive Signal Lighting

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ABSTRACT

Similarly as in other branches of lighting, LEDs caused a revolution in the automotive lighting industry. LEDs have been established as a standard light source for exterior signal lighting in last the decade and the current development shows that a similar trend might continue for the main functions of head lamps. Roadmaps of all the LED producers show us more promising light output for a lower price every year.

However, the LED price itself is just a part of the final price of the additional subassembly which provides proper conditions for the right functionality of the LED. Driving electronics (covering nominal state as well as a wide range of critical states), PCBs, connectors and wiring significantly bump up the price of the whole subassembly. What is more, as TIER2 suppliers are responsible for the LED subassembly, there is just a limited space for the TIER1 price impact and margins. These aspects make LEDs inapplicable for lower car segments or even for certain world regions by implication.

Simplicity in principle, using clever optical systems and the conception of LEDs as light engines should again place higher demands on optical solutions and minimize the complexity of electronics and its price impact. This paper aims to outline the latest challenges of R&D in this area, roughly sum up the cost impact of the LED subassembly on the final price of the product and suggest approaches to make LEDs more affordable for automotive exterior signal lighting worldwide.

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INTRODUCTION

LEDs have settled down as a commonly used light source in automotive lighting, at least for signal functions. Roadmaps of all the LED producers show us the trend of stepwise increasing luminous flux and decreasing price, achieved through a considerable level of unification and necessary package standardization. Although the LED prices have become more and more promising, affordability of bulb versions is still impregnable.

The price contribution of the electronics in an LED lighting subassembly can be coming up to 70% of the product price, depending on functions covered by LEDs. It is not just the LED price itself that has to be considered. The additional subassembly which provides proper conditions for the right functionality of the LEDs can bump up the final price eventually. The Fig.1 shows the pie chart describing the rough price impact of the driving electronics, PCBs, connectors, wiring and holders on the whole subassembly cost.

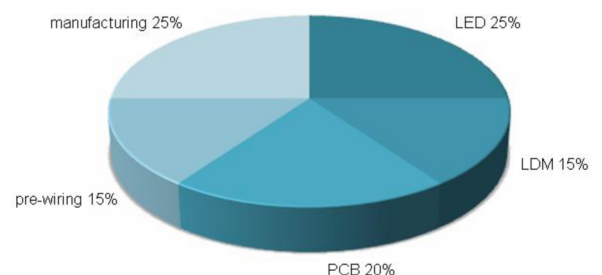


Figure 1. Rough price impact on the electronics subassembly cost

Different parts influence the costs differently. It is always given by complexity of the technical solution. Coupling of electronic, thermal and optical performance is just a starting point. Usually, the styling requirement plays crucial role in the concept development and imposes challenging conditions to find the compromise between appearance, performance and price.

The type and expected performance of LEDs is essential for the driving electronics module (LDM) concept. Basically, there are 3 types of LDMs - resistor based, linear and switching regulator, chosen according to the given power of LEDs, with given price for certain lamp concept. LDM can be either integrated on PCBs with LEDs or populated on separate PCBs. This eventuality and number of LEDs and their positions in the lamp concept gives us the number and shape of PCBs. The Shape of PCBs as well as the substrate (FR4 or IMS) is influenced by LED power or its heat load. The more PCBs combined with the more complicated driving concept - the more complicated and more expensive wiring and connectors. Alternatively, flexible PCBs can be used. Obviously, there are always several iterations of redesigning and recalculation required to reach the optimal solution.

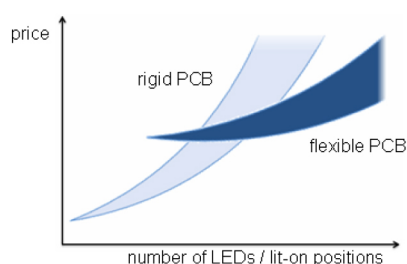


Figure 2. Cost impact of the rigid and flexible PCB according lighting positions

Basically, the LDM concept has just fairly limited possibilities of simplification. Electronics robustness - covering nominal state as well as a wide range of critical states, is usually set by OEM. Electronics providing the role N-1 satisfaction can be avoided by just 1 LED presence in the system or at least one circuit involving 2 or 3 LEDs. With high power LEDs, when current is more than 350mA, a switching regulator is required. At first sight, it is the most expensive solution regarding driving, but with its high efficiency, thermal conditions open space for savings on the PCB side and provide optimal parameters for LEDs.

“LIGHT ENGINE” CONCEPTION

The number of LEDs or lit-on positions are given by geometrical conditions and appearance imposed by OEM. The Only question is, if lit-on positions have to be synonym for LEDs. According to predictions of LED suppliers that are more or less in accordance with Haitz's law (prediction of progress in the field of semiconductors) increasing the power of LEDs recovers the conception of “light engine”. In this case, only one LED source or one series of LEDs is considered. In combination with the lightguide suited for given geometry we can get a “light engine” to feed lighting output of the lamp.

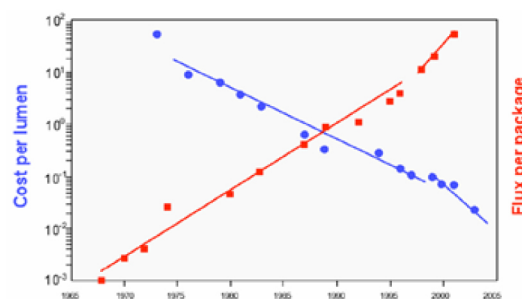


Figure 3. Haitz's law - light output per LED as a function of time [1]

MULTI-CHAMBER TAIL LOOK

The conventional way to create signature in automotive signal lighting is using a number of LEDs in chambers structured according to a certain styling intention. Because of outer lens declination, chambers are usually stepped - creating 3D entity, so flexible PCBs or several steps of rigid PCBs with pre-connecting have to be used. This leads to relatively expensive solutions concerning the price of the whole electronics subassembly.



Figure 4. The “light engine” acts as many LEDs

The use of the “light engine” comprising one powerful LED and the light pipe, see Fig.4, represents a cost effective solution for this kind of signature in the automotive signal lighting. A specially designed light pipe can lead the light into focal points of parabola based chambers and act as many LEDs with their bright spot in the middle.

CONTOURED TAIL

Lit-on contours as TAIL function is a widely spread OEM requirement. There are many approaches to that. The Optical concept, shown in Fig.5, uses 3 powerful LEDs in series as the light source. The light is homogeneously guided through a planar lightguide. The output edge of the lightguide is equipped with graining to achieve a homogeneous lit-on contour according to the required shape of the signature.