ROHM SEMICONDUCTOR

ROHM Automotive Lighting Solutions

White Paper

1. Introduction

Automotive technology is undergoing a major transformation. A greater number of electronic components is needed to support the advancement of sensing and safety functions required for autonomous driving technology.

In the case of exterior lighting such as head and tail lamps, light source technology has continued to evolve from conventional bulbs to LEDs. In recent years, the use of products that not only turn LEDs ON/OFF but control lighting to increase safety have become widespread. Products and technologies for 2-wheeled vehicles are progressing as well, requiring the same level of quality as that of automobiles.

Against this backdrop, ROHM proposes automotive lighting solutions that combine LED driver ICs required for LED lighting control along with compact high reliability LEDs. In this paper, we will introduce ROHM's proprietary products and technologies.

2. Market Needs for LED Driver ICs

2-1. Market needs for LED lamps

Changing exterior lamps from bulbs to LEDs makes it possible to achieve smaller, thinner light sources, allowing more manufacturers to improve lamp design.

To improve design, it is necessary to increase LED output while reducing the power consumption of the LED drive control circuit along with size. At the same time, longer life is needed. Unlike bulbs that break after a certain period and require replacement, LEDs are often integrated with the control circuit, making replacement difficult. In addition, since LEDs are not expected to break, the tendency is to require high reliability at the component level.

At the same time, the demand to reduce costs cannot be ignored. For example, 2-wheeled vehicles are sold at very reasonable prices in India and ASEAN, where they are the mainstream mode of transportation. As a result, cost restrictions for each module are very severe, and LED lamps are no exception.

2-2. The difference between resistor and driver IC circuits

Until recently, resistor circuits were typically used to control LED current due to cost advantages. A resistance circuit can light LEDs using a simple circuit similar to those used with conventional bulbs, making it possible to achieve lower costs. However, disadvantages include lower efficiency due to circuit heat loss and the inability to detect LED failures.

In contrast, circuits using LED driver ICs (LED driver IC circuits) that have been attracting attention in recent years provide a number of advantages, including lower power consumption while ensuring high reliability by incorporating protection circuits that can detect LED failures. However, at the same time, these circuits also increase the cost of components.

The differences are described below.

1) Power Consumption

Resistance and LED driver circuits utilize very different methods of controlling LED current when the battery voltage (that is, the supply input of the drive circuit) rises. In the case of a resistor circuit, the LED current increases along with the battery voltage. But with LED drive circuits, constant current drive is possible at a preset value even if the battery voltage increases. As an example, if the current value when the battery voltage is 13V is matched in each circuit, LED driver ICs consume 50% less power than resistor circuits. This makes LED driver IC circuits advantageous in terms of power consumption. (Fig. 1)

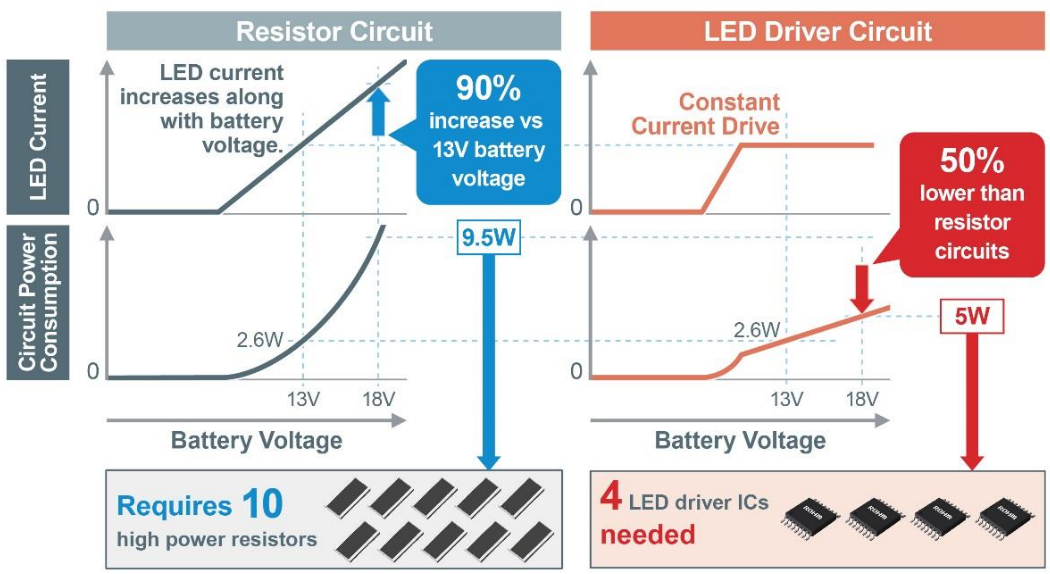

Figure 1. Power Consumption Characteristics Comparison

2) Reliability

LED driver IC circuits are also beneficial in terms of reliability. This is because the number of mounted parts is small, reducing the likelihood of component failure on the control board. In addition, LED driver ICs can detect errors such as LED open/short failures and provide external notification. This makes it possible to detect unsafe conditions such as LED brightness drops due to unstable operation at an early stage and take appropriate measures.

3) Cost
Resistor circuits are generally more cost efficient. For example, as shown in Fig. 1, in the case of driving 9 LEDs (3 rows of LEDs with 3 LEDs in each row, approx. 150A/row), a typical resistor circuit requires at least 10 1W resistors, while an LED driver IC circuit needs just 4 ICs, depending on the package. So while it seems that the more components used in resistor circuits should result in higher costs, it is possible to significantly reduce costs by adopting multiple high power resistors, which are much cheaper than ICs. Conversely, LED driver ICs require more ICs as the number of LEDs increases, leading to higher costs compared with resistor circuits.

As a result, conventional resistor and LED driver IC circuits only satisfy either the requirements for low power consumption, high reliability, or low cost. Therefore, in order to achieve the increased adoption of LED lamps, it is necessary to develop an LED driver IC that balances these 3 demands.

3. ROHM's New LED Driver IC

ROHM offers a number of products and technologies for lighting up LEDs in cars and 2-wheeled vehicles, ranging from LED driver ICs for speedometers and indicator lighting, CID (Center Information Displays), and white backlight LED driver ICs for LCD instrument panels to LED driver ICs for headlights and rear lamps.

In response to the recent market demands as mentioned above, ROHM developed the BD183x7EFVM series of 4ch LED driver ICs (BD18337EFV-M/BD18347EFV-M) that utilize a new control method called Energy Sharing in which power consumption is distributed from within the LED driver IC to external resistors. As such these products are ideal for LED lamps (i.e. stop/tail lights, fog lamps, turn signals) for automotive use.

ROHM's Energy Sharing control method is described below.

3-1 Challenges in reducing LED driver IC power consumption

Fig. 2 shows a general driver IC, comprised of a constant current circuit that supplies current to the LEDs, an input that connects to the battery power supply, and an output that connects to that connects to the LEDs. When Power Supply A to which the input voltage from the battery is connected rises to some extent, the constant current circuit within the LED driver IC can output a constant LED current. So as a result, the output terminal voltage is equivalent to the forward voltage characteristics of the connected LEDs.

Since the power consumption of the LED driver IC is the product of the input-output voltage difference of the constant current circuit and LED current, the power consumption will increase as the input voltage from the battery rises. Therefore, to decrease LED driver IC power consumption it is necessary to reduce either the input-output voltage difference of the constant current circuit or LED current. However, customer requirements and other factors make it difficult to change the LED current, so ROHM developed a method for controlling the voltage between the input and output of the constant current circuit.

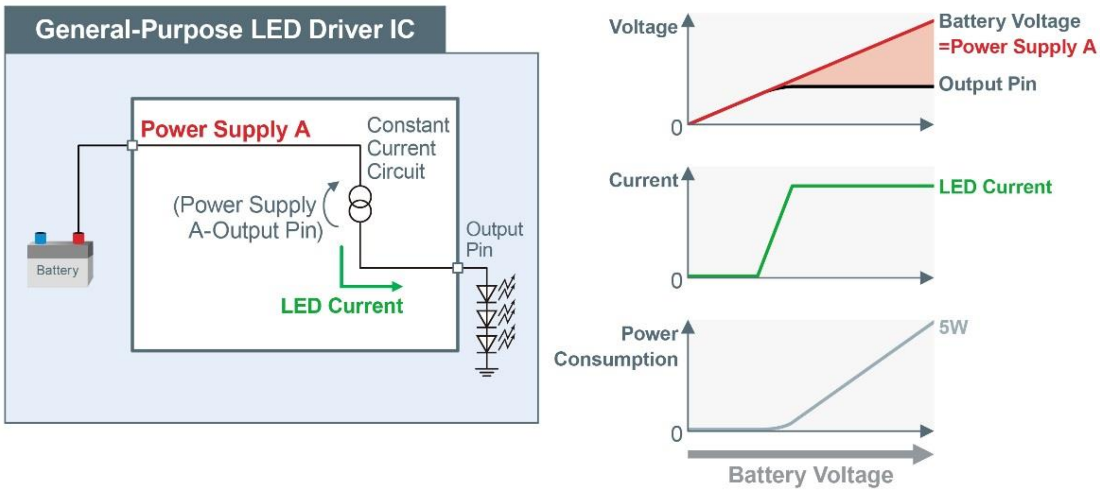

Figure 2. General LED Driver IC and Its Characteristics

<u>3-2. ROHM's Energy Sharing control method reduces costs by decreasing IC power consumption</u>

Fig. 3 shows ROHM's new Energy Sharing control method that achieves lower costs by reducing LED driver IC power consumption. The voltage between the input and output of the constant current circuit is controlled by passing a part of the LED current through the external resistor of the LED driver IC to suppress heat generation. At the same time, a newly added block monitors the output pin voltage to control Power Supply A to a constant voltage. The current flowing through the resistor is represented by the external resistor R and the voltage difference between the battery voltage generated at both ends of the resistor and Power Supply A voltage (Battery Voltage - Power Supply A Voltage). Power Supply A voltage is controlled to a constant value by increasing the resistance current as the battery voltage rises.

Using this control method allows most of the power previously consumed by the LED driver IC itself to be consumed by the external resistor R, reducing LED driver IC power consumption by approx. 75% vs conventional solutions. So by sharing power consumption between the LED driver and external resistor, the power achieved by 4 conventional ICs can be handled with a single IC and high power resistor.

ROHM achieves this function by simply adding an extra input pin to a conventional LED driver IC. And since lighting modes unique to 2-wheeled vehicles is supported, most of the necessary functions can be covered by the IC alone.

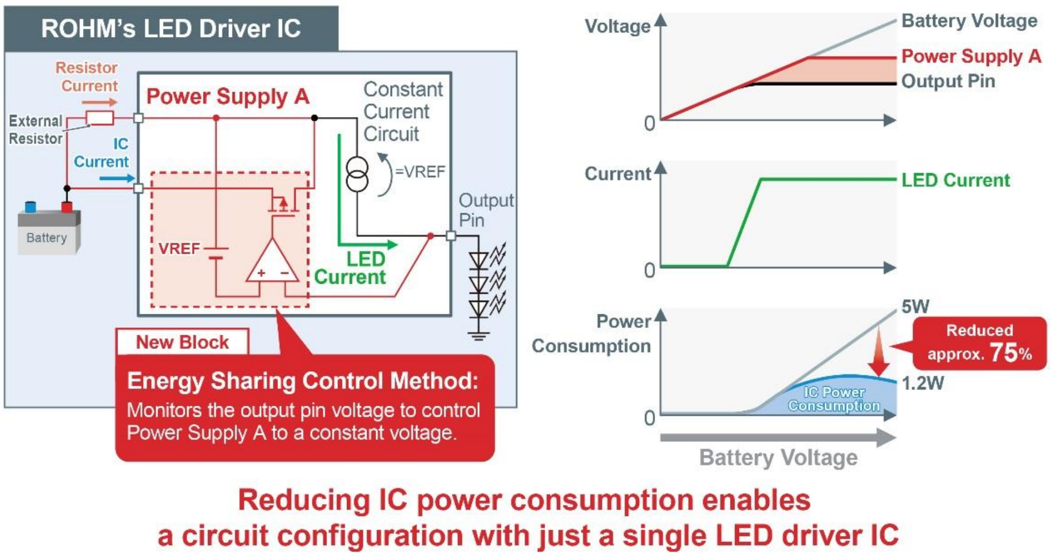

Figure 3. ROHM's LED Driver IC and Its Characteristics

Although circuits equipped with ROHM's new LED driver IC are slightly more expensive than resistor circuits, a cost savings of approx. 40% can be realized over conventional LED driver circuits. As a result, in addition to lower power consumption and greater reliability, lower cost on par with resistor circuits is possible by pairing with an external resistor. In addition, ROHM allows making this function available by only adding the input terminal with one pin to a conventional LED driver IC. Furthermore, most of the necessary functions can be covered with only this IC since it is able to support the specific feature for 2-wheeled vehicles, the lighting on/ off mode.

4. ROHM LEDs Optimized for Automotive Applications

Lastly, we will introduce ROHM's automotive-grade LEDs.

Ever since producing shell-type LEDs in 1973, for over 45 years ROHM has been at the forefront of the industry. ROHM's greatest strength is the ability to implement product development with thorough quality control utilizing a vertically integrated production system in which every process, from element fabrication to packaging, is carried out in-house. One of our advantages is the ability to supply high quality products, through measures such as implementing an easy-to-manufacture chip design during the assembly process, introducing traceability for ultra-compact components, and carrying out process management for automotive-grade products.

4-1 LEDs for vehicle indicator light sources in instrument clusters

In recent years, compact LEDs are increasingly being adopted as indicator light sources for instrument clusters. To cope with the severe temperature changes that occur in automotive environments, a gap is provided between the light shield and substrate to prevent contact. But this results in light leakage from the LED to adjacent areas, which can become problematic. What's more, in applications utilizing compact LEDs, particularly automotive systems exposed to severe conditions, high reliability products that incorporate measures against aging due to environmental stress are required.

In response, ROHM developed the CSL0901/0902 series of compact, high output, surface-mount lens-type LEDs optimized for indicator light sources in vehicle instrument clusters that are expected to be exposed to harsh conditions. Raising the position of the light source to 0.49mm virtually eliminates light leakage. This enables the use of smaller LEDs – approximately 18x smaller (in volume) than conventional reflector-type LEDs, contributing to greater application space savings. In addition, ROHM developed a new molded resin that significantly reduces brightness degradation at high temperatures, even for short wavelength high brightness products. For example, in accelerated high temperature conduction testing with blue LEDs (85°C, IF= 20mA, 1,000hrs energization), ROHM succeeded in improving the residual luminosity rate by approx. 80% over conventional products. ROHM has also taken measures against sulfuration, one of the sources of age-based deterioration in automotive environments.

4-2. LEDs for in-vehicle illumination

In addition to icon display for in-vehicle systems such as instrument clusters, expanding set functionality is demanding compact LEDs for illuminating the entire panel as well (i.e. infotainment/navigation systems).

To respond to these market needs, ROHM is developing compact, high brightness LEDs by optimizing a variety of factors, including the package shape, reflector material, elements, and surface plating. Furthermore, chromaticity variations are significantly reduced by carrying out high accuracy element and phosphor adjustment, making it possible to achieve high brightness equivalent to larger conventional packages in a compact 1608 size.

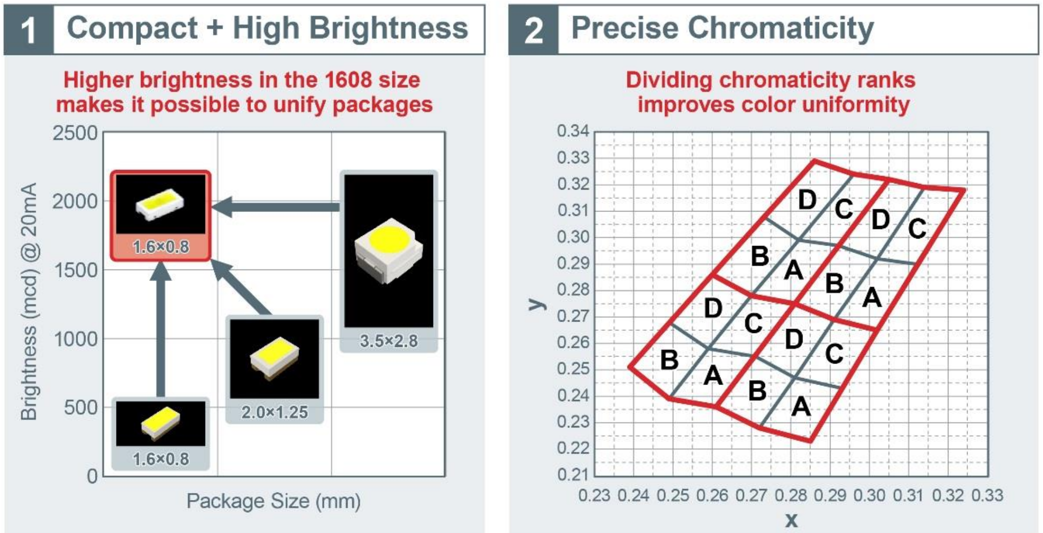

Figure 4. Trend of LEDs used for in-vehicle illumination

<u>4-3. LEDs for exterior vehicle lamps</u>

For exterior vehicle lamps, from a design perspective there is an increasing demand for smaller, thinner LEDs while improving power to reduce the number of mounted components. Also, as vehicle stop lamps are often used under harsh conditions, measures against sulfuration are needed to ensure reliability. For this reason, ROHM is currently developing high power LEDs that deliver superior sulfuration resistance while maintaining high brightness. Combining these with ROHM’s LED driver IC introduced earlier will allow users to achieve optimal performance for automotive exterior lamps.

5. Future Developments

ROHM has been developing industry-leading products ideal for vehicle lighting based on our corporate objective of ‘Quality First’. In this paper, we have introduced key products from among our broad lineup, including a driver IC that meets the 3 market needs along with breakthrough compact, high reliability LEDs.

Following the proliferation and advancement of autonomous driving, automotive lighting is likely to play a role not only for illuminating the front at night and alerting drivers of braking from the rear, but also for providing external notification of vehicle conditions. Therefore, in addition to high power LEDs, LED driver ICs are required that utilize a control method capable of dynamically controlling the light source to transmit information externally. And, ROHM will continue to provide products and solutions that meet the needs of customers and society by quickly responding to market trends.

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