Backlighting in Large-Area Applications: The Implementation of LEDs Beyond Cell Phones and Laptop Computers

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LEDs and LED arrays are being designed and assembled for a variety of backlighting applications. Beyond cell phones and laptop computers, they are being specified for larger applications as well. Indoor/outdoor signage, channel lighting, automotive interior lighting, and gaming machines are just a few of the larger-area backlighting applications in which LEDs are being used. Many applications that currently use incandescent or fluorescent lighting technology are now being evaluated for a possible conversion to LED lighting to meet their backlighting requirements. As the use of LEDs continues to grow, lighting designers are faced with an increasing number of design challenges, including higher demands on lighting specifications, thermal management concerns, and cost issues.

With the advantages of small size and lower power consumption, LED technology has long been accepted as a backlighting source for portable electronic applications, such as cell phones and laptop computers, with these applications consuming roughly 50 percent of all high brightness AlInGap and InGaN LEDs produced. However, improvements in LED brightness have expanded their use into a wider variety of larger applications as a new backlighting source to replace conventional solutions used in equipment such as slot machines and vending machines, as well as televisions.

Signage

As LED capabilities continue to develop, the demands and requirements placed on them in various lighting applications have also increased. For example, LEDs are now being specified for large channel lighting displays on buildings, as well as other backlighting applications in architectural signage. In their most basic uses, white LEDs can be used to replace incandescent or fluorescent light sources in a retrofit of the backlighting system for channel letters in a large sign on a building, such as a corporate logo sign. In this case, the LEDs provide much lower energy consumption as well as significantly longer life, which will in turn reduce maintenance costs. With the other colors, mainly red and yellow/amber, LEDs have significantly replaced more expensive and power hungry neon.

A new signage application may take advantage of an LED's ability to display a nearly infinite spectrum of color (in addition to white light). This ability to "tune" the color of an LED's light output enables lighting designers to more closely match a company's corporate colors, and provides the capability to change the intensity of the sign's backlighting to maintain a constant color output despite changes in ambient light. Prior to the implementation of LED technology, for example, a company that wished to change the colors on its signage for a specific event (such as a red and green scheme for the holiday season or red, white and blue for the Fourth of July), would have required workers to manually change each light bulb, or filters covering the bulb – a time consuming, expensive, and even dangerous task, given the height of most building signs. With an LED-based backlighting system, the color can be altered in minutes by reprogramming the LED light output – without ever sending a worker onto the building.

While the initial cost of an LED backlighting system for signage applications is currently higher than with traditional lighting sources, it provides significant energy savings and reduced maintenance/replacement costs, in addition to the flexibility it provides for colormatching in signage applications.

Automotive

Brand distinction is also driving LED backlighting technology in automotive interior applications. Seeking to create a unique brand identity for their vehicle interiors, automakers are looking to LEDs – and their ability to provide colored light – as a source for backlighting and accent lighting in higher-end automobiles. Traditionally, a car's interior displays – radios, dashboard instruments, etc. -- were illuminated by incandescent bulbs placed on the top or side of the instrument panel, which caused the displays further away from the light source to be dimmer. Also, the failure of a single backlighting bulb in a car's instrument cluster required an expensive and labor-intensive removal of the entire dashboard in order to replace the bulb. By switching to an LED backlighting system, automakers provide much more crisp and uniform lighting of the

instrument panel, as well as ensure that the backlighting will last throughout the life of the vehicle without replacement.

LED technology has also given automotive designers the ability to further their brand distinction through the use of accent color in interior lighting design. Whether their signature color is blue, green or white, an automaker can specify an LED backlight to match it and even have the ability to change colors on-demand.

OPTEK's 1W LED package provides stability and cost savings in automotive interior display applications

Gaming Machines

For some applications, the driving force behind the switch to LED technology is increased reliability and reduced energy consumption. For example, there has been a major push in the casino industry to convert the backlighting of gaming machines to LEDs because of the inherent inefficiency of incandescent bulbs, which have long been used to backlight the colorful slot machines and other casino fixtures. Incandescent bulbs use considerable amounts of energy, generate significant amounts of heat, and require frequent replacement. By some estimates, a single slot machine can consume up to 1 Kilowatt of energy per day. When these energy consumption figures are multiplied by the thousands of machines in a location such as Las Vegas, the potential for energy savings by LED conversion is substantial. In addition, by eliminating the excess heat generated by the incandescent backlighting, LEDs help lower the need for air conditioning – a further energy savings.

Finally, because most gaming machines are expected to run 24/7, any downtime caused by mechanical failure represents a potential revenue loss. Reducing or eliminating the need for bulb replacement through the use of LED technology can reduce downtime, lower maintenance costs, and increase the machines' revenue-generating potential.

LED backlighting can also enhance the safety of certain signage applications. Emergency exit signs in building and parking garages provide critical guidance for people to find exits during an emergency or when walking to their cars. Because LEDs have a significantly longer lifespan than incandescent or fluorescent bulbs, signs with LED backlighting will be more likely to operate reliably when needed. Also, because LEDs are more energy-efficient, an emergency lighting system that operates 24/7 will be less expensive to operate. For outdoor signage applications, extreme temperatures can also affect the reliability of their operation. As the outside temperature decreases, fluorescent lights in particular are more difficult to turn on, and their light output is significantly lowered.

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Thermal Management for Backlighting

Because LEDs and LED arrays for backlighting applications are often sealed in enclosures, designers face thermal management challenges. It is a common misconception that because LEDs run more efficiently than incandescent bulbs, they don't require special thermal considerations. However, because excessive temperature is the leading cause of LED failure, thermal management concerns, such as substrate material, packaging design and power dissipation, are critical and must be given special consideration when specifying LEDs for various high power illumination applications. This is particularly true for the larger-area channel lighting, gaming and architectural backlighting applications in which maintenance costs play a large role.

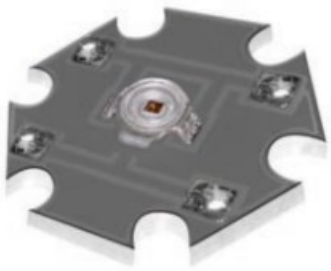
Proper choice of substrates and packaging techniques can result in reduced LED operating temperature, increased operating power, improved reliability and reduced failure due to thermally induced problems. Several available options for thermal management of LEDs include external heatsinks, thermal grease and integrated metal substrates.

For LEDs with power ratings of two watts, or less, standard FR4 PC board is often sufficient as a substrate material. However, when the LEDs power ratings extend to more than three watts, it is usually necessary to use an external heatsink or a metal core substrate to dissipate the heat generated by the LEDs. Most external heatsinks are mechanically attached to the PC board with heat-conductive epoxy or thermal grease.

Overall, the most effective at managing heat in LED applications are integrated substrates – those with an integral insulating layer onto which the LEDs and other components can be mounted. This type of substrate eliminates the additional thermal resistance of a thick insulating layer, and avoids the assembly costs of additional hardware required for external heatsinking. In effect, the integrated metal substrate becomes both the PC board and the heatsink.

One such integrated metal substrate has been patented by TT electronics IRC Advanced Film Division. Known as Anotherm®, it consists of a traditional extruded aluminum alloy substrate, with a special anodized aluminum oxide electrically insulating layer chemically grown on the aluminum core. The anodization layer is extremely thin (35µ or less), yet offers good electrical isolation and excellent thermal transfer. Solderable thick film conductors can be screen-printed directly to the anodized substrate to attach surface mount packaged components as well as wire-bondable die.

Because the insulation layer between the aluminum and the printed traces is so thin, and its composition is aluminum oxide, the thermal performance is very good. This process of thermal management provides a thermal resistance of approximately 0.03 degrees C per watt, allowing for near optimal power dissipation, particularly when compared to metal core PC boards or thermal grease.



LEDs on Anotherm® substrates provide the necessary heat dissipation requirements

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Measuring Light Output

LED designers also face several measurement challenges when shifting from incandescent and fluorescent bulbs to LEDs and LED arrays. When one begins backlighting a graphic, such as with a liquid crystal display, it is measured in nits which is the brightness measured per square meter. Because LEDs are now being used in backlighting applications of televisions to enhance the overall picture experience, the measurement parameters have to be translated into LED flux to correspond with the use of LEDs. Additionally, fluorescent tubes are rated for a certain amount of brightness. Because LEDs typically do not emit directional light in 360° as incandescent and fluorescents do, an LED's total emitted lumens are considered "usable" light. Therefore, the same illumination is provided by only two-thirds the lumens output of traditional lighting.

Cost Considerations

The cost of LEDs is still a major consideration in backlighting applications, particularly in the consumer arena. Currently, LED lighting is two to three times the cost of fluorescent lighting. Even though LEDs typically last for many years, while incandescent and fluorescent light sources may burn out in as little as a few months, it is still somewhat of a consumer mental block to pay the increased expense of the LEDs up front. As LEDs take over more of the market share, manufacturers of older technologies, including fluorescent and incandescent lighting, are reducing their prices to remain competitive.

In commercial markets, however, LED manufacturers can demonstrate the value of replacing incandescent and compact fluorescent lighting because of the overall cost reduction in terms of the energy savings to run a solid state lighting application versus a traditional lighting application, as well as the decrease in maintenance costs. LEDs last twice as long as the best fluorescent and twenty times the life of the best incandescent bulbs. While cost concerns are currently a roadblock to making the LED industry grow faster, it is only a matter of time before it becomes a universal change within the lighting industry.

Conclusion

As LED technology has improved, the overall number of LEDs required per application has decreased as brightness capabilities have increased. In displays of all sizes, manufacturers are able to spread light evenly throughout an entire application. This, in turn has decreased the cost of materials, which has opened the door for a wider variety of backlighting applications, including those in the architectural, industrial and consumer markets, and has allowed for more indirect lighting applications to utilize LEDs. From high definition televisions to the bright lights of Las Vegas, manufacturers are using different technologies to implement LEDs and LED arrays for backlighting, enhancing the overall message and viewing experience.

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