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LED professional Review

LpR

The leading worldwide authority for LED & OLED lighting technology information

Jan/Feb 2014 | Issue 41

Photometry Standardization

Measurement with Integrating Spheres

Standards for Smart Lighting

Voltage Limits for PWM Operated LED Drivers

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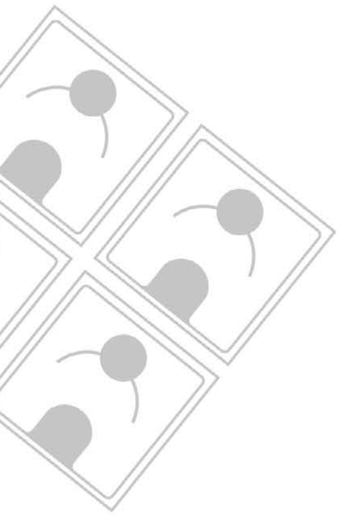

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Safety & Quality

Experience shows that early adoption of many new technology developments into the market goes hand in hand with a lack of quality, and in some cases, a critical lack of safety. There are several reasons for this: One is the balancing of test time and test conditions against proven data before entering the market. Another reason is that every new technology and/or technical system displays “unexpected” or “unknown” behaviors under certain conditions. Third of all, international standards are lagging behind the rapidly changing technologies. Standardization bodies need input and experiences as well as concrete problems in order to be able to adapt and/or expand their standards. Everyone seems to be confronted with a more or less “insecure” situation where quality and safety issues may arise and possibly target LED technology in general.

When looking at lighting systems or luminaires, all components and modules are important and somehow related to safety and quality. In addition to that, the combination and integration of different parts can have unforeseen effects. There is an article in this issue of LED professional Review which covers one aspect of this: How specific conditions in real applications may lead to critical operation behaviors in regards to safety in the PWM mode of LED drivers.

The electronic circuit design can be seen as a very relevant topic for guaranteeing the necessary quality and safety levels. Tests performed in our lab with GU10 LED lamps from different manufacturers, ordered through prominent online shops and labeled by well-known companies showed that about 50% of the lamps were defect due to faulty electronics within 6 months. We also came across E27 socket-based lamps that broke into two parts when we tried to screw them out of the sockets. In this case, the mains voltage was directly touchable.

Performance increase, design and cost optimization are important areas that need to be further developed in LED and OLED technology. In parallel, a lot of effort in research and industry should be made to evolve the quality and guarantee the safety of LED and OLED based lighting. In this respect test-lab activities, state-of-the-art approvals and continuously updated standards are needed to support the market with valuable products.

One of our main objectives this year will be to raise up new quality issues, discuss safety boundaries and get information to you with articles and lectures about state-of-the-art design methodologies for safer lighting products.

This first issue of the year covers the topics of performance, testing and safety issues.

Please let us know if there are additional areas you want to have covered in subsequent issues related to safety & quality.

Have a great read.

Yours Sincerely,

Siegfried Luger
Publisher - LED professional

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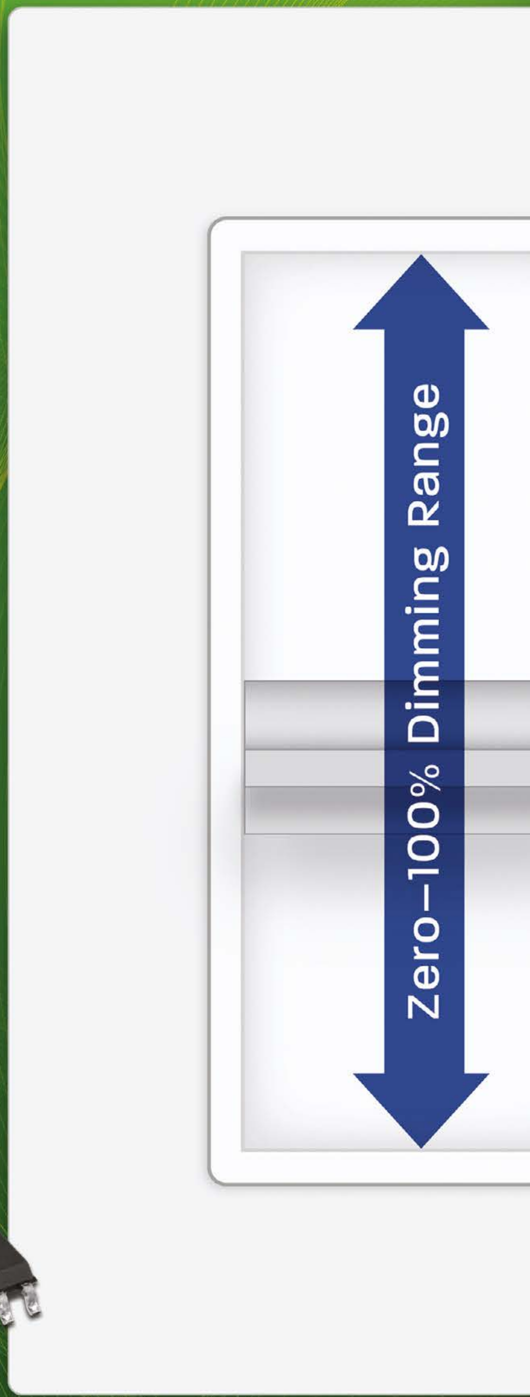
New Lower Cost Single-Stage LED Driver. Best Dimming Performance.

The NEW CS1615A/16A Drive BOM Costs Even Lower



Cirrus Logic LED driver ICs provide smooth, flicker-free dimming to nearly zero light output

Cirrus Logic's new CS1615A and CS1616A LED drivers feature bill-of-material cost reductions that provide an even greater price comparison to competing single-stage products. And reductions in size and complexity further enhance their compatibility with both A19 and GU10 lamps.

Through proprietary digital intelligence, the CS1615A/16A drivers offer smooth, flicker-free dimming which closely matches the dimming performance of incandescent light bulbs. This series offers full functionality with leading-edge, trailing-edge and "smart" digital dimmers, and consistently outperforms competing LED drivers in dimmer compatibility.

- Bill-of-material cost reductions
- Enables zero – 100% dimming range
- Flicker-free operation across all types of dimmers
- Compatible with smart dimmers

Stay current at www.cirrus.com/ledprocs1615 and request a free sample.

CIRRUS LOGIC®

Eric Schwabedissen

Following his physics degree at the Technical University of Munich, Eric Schwabedissen has gained 20 years of professional experience in the field of measurement engineering. Between 2007 and 2012, he worked in sales at Instrument Systems GmbH, a market leader in complete solutions for light measurement technology. In 2012, he moved to Konica Minolta, the parent company of Instrument Systems, where he is a Key Account Manager in charge of sales for the Light & Display product segment in Germany, Austria and Switzerland.

MEASURE THE EXACT BRIGHTNESS AND COLOR OF LEDS AND OBTAIN VALUABLE ADDITIONAL INFORMATION

Due to its multiple advantages, the LED has found its way into many applications, where traditional light sources such as incandescent or gas discharge lamps were previously used. As a result, completely new requirements have arisen, such as sophisticated thermal management, which must be dealt with during the development of new luminaires. But even when the aim is to correctly measure the brightness and color of the light emitted by LEDs during quality assurance tests or on-site, there are now fundamental differences to the measurement of traditional light sources to be taken into consideration.

Often, measuring devices, such as lux meters and colorimeters, are already available. These devices tend to be constructed from one or three light sensors, each with an optical filter fitted in front. As only the highest-quality and as such costly devices are adapted with the maximum level of precision to the provided spectral transmission curves, glaring measuring errors can occur in connection with the narrow-band peaks in the spectrum that are typical to LEDs. Especially those users, who have previously been completely satisfied with their measurement of traditional light sources, such as incandescent lamps, did not anticipate this effect.

Spectrometers elegantly avoid these causes of error. As they determine the spectral distribution of the radiance with a high resolution of wave length, they do not need a filter. The required refinement of the collected signals can take place purely mathematically in the device, which means the filter as a decisive cause of error can be removed, making measuring accuracy possible for LEDs and many other narrow-band light sources.

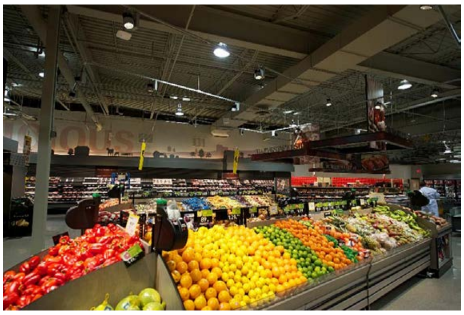
In addition, as well as information such as photometric value, color coordinates, color temperature, distance to the Planck curve, color saturation and dominant wave length, current spectrometers also provide other important information which is not provided by devices based on filter technology. An example of this is the general color rendering index Ra and the sub-indices R1 to R15. The significance of the sub-indices is often underestimated and the Ra is relied blindly upon. But who isn't familiar with the white LEDs with an Ra of more than 80 and poor color rendering in red? The sub-index R9 shows up such deficits mercilessly. As currently discussed, a good color rendering could have an Ra of more than 85 and an R9 of more than 40 for a white LED. I would like to mention the scotopic value as another example. For a lux meter this value states the illuminance, as it is perceived by eyes that have adapted to night-time vision. For street light manufacturers especially, this value is a great possibility to disprove the supposed superior energy efficiency of sodium vapour lamps in comparison with LEDs, which is based on the photopic value, and therefore relates to the light sensitivity of eyes that are adapted to day-time vision. It should be indisputable that carrying out evaluations of a street light based on night sensitivity is more practical than using day sensitivity as a basis. In addition, what bin an LED belongs in can be seen immediately from a spectrometer. All these functions are now integrated into handy, portable spectrometers which even satisfy the quality grading B in accordance with DIN 5032-7 for premium manufacturers. Not only do they have a nominally high measuring accuracy of light intensity and color coordinates, they also satisfy a variety of practical requirements.

In light of the measuring errors possible with conventional photometers and colorimeters as well as the valuable additional information that can be provided by a spectrometer, there should be at least a spectrometer available as a reference device for measuring LEDs. If necessary, existing classic photometers and colorimeters can often be calibrated by users on the basis of the reference values supplied by the spectrometer. However, please note that the achieved calibration will only supply reliable measurements for the spectrum of the LED type measured as part of the calibration. The more variable the measured spectrum, the greater the measuring error will appear. ■

E.S.

New LED Module Development for Retail at Xicato

Xicato, a leading developer of superior light quality from LED modules, announced that it has expanded its Vibrant Series offerings to include both a 1300 lumen and 2000 lumen option alongside its 3000 lumen module. Introduced in July 2013, the Vibrant Series has been quickly adopted by designers, merchandisers and brand managers to support their efforts to differentiate and create compelling experiences for customers.



Xicato's Vibrant Series light in LETO luminaires highlight the naturally vivid colors of fruits and vegetables

"With Xicato's Vibrant Series we've discovered a previously unfulfilled need for light that is crisper, brighter and makes colors really sing," said Rolf Hurbin of Senso Lighting in Canada. "With the new light output options it will be easier to create tailored environments and focus attention exactly as desired by our clients."

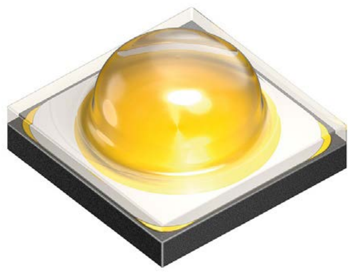
The new 1300 and 2000 lumen modules are fully backward compatible with other Xicato XSM modules. This means that if a luminaire currently uses a 1300 lumen Standard Series module, the new Vibrant Series module can be directly swapped for it without re-engineering which gives the manufacturer a path to instant expansion of their product line.

"A portfolio of 'light' has become essential for designers and specifiers, particularly those working in retail environments where we see the rapid integration of light, sound, visuals and intersection with the connected world," said Joanna Brace, VP Marketing at Xicato. "Our color scientists and engineers work closely with the lighting, design and retail communities to design and produce high quality light that supports their needs and accelerates business growth."

The design of Xicato's Vibrant Series light is based on original research conducted in the lighting laboratory at the Instituut Lichtontwerpen in Amsterdam, by Colette Knight, Ph.D., an independent lighting application specifier and researcher. Color scientists at Xicato were able to use the feedback of more than 60 subjects to design a new light emission spectrum that makes whites, blues and reds, in particular, appear richer and more vibrant. It adds visual depth to textures like denim, leather or lace. ■

Osram Opto Improves Oslon Square for Longer Lifetime at High Temperatures

Excessive heat generation is one of the main reasons why light-emitting diodes fail. With the Oslon Square, Osram Opto Semiconductors presents an LED that withstands high ambient temperatures particularly well.



Osram Opto's new Oslon Square - better heat dissipation, stable color uniformity and a longer lamp life even at high temperatures

Technical data (@ Tj = 85°C):

- Housing dimensions: 3 mm x 3 mm
- Beam angle: 120°
- Typical voltage (at 700 mA): 2.9 V – max. 3.2 V
- Current: max. 1.8 A (previously 1.5 A)
- Typical brightness (at 700 mA): 202 lm (at 3,000 K)
- Color rendering index (CRI): min. 80
- Thermal resistance R_{th}: 3 K/W (previously 3.8 K/W)
- Color temperature: 2,400 – 5,000 K

To ensure that the colors of several LEDs in a luminaire remain uniform even at higher temperatures, they are measured and binned at 85°C, a temperature that comes very close to that encountered in lighting applications within buildings, in everything from spotlights to retrofit light sources.

Osram has optimized the heat dissipation of the Oslon Square to allow an increase in the junction temperature. "With our new conversion technology, we can produce significantly thinner converter layers. The thinner layers better dissipate the heat, thus enabling the higher temperatures in the LED," says Ivar Tangring, SSL Product Development at Osram Opto Semiconductors, explaining the advantages of the innovative technology. With that, the Oslon Square can reach a lifetime of considerably more than 50,000 hours even at high temperatures of up to 135°C in the LED.

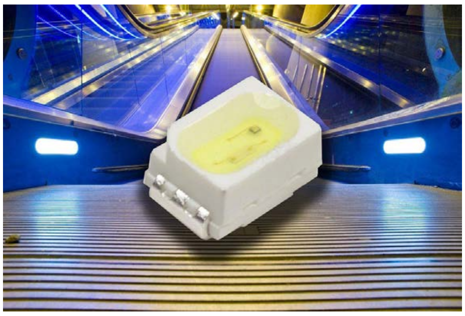
Customers benefit from the properties of the new Oslon Square:
Measuring and binning at operating temperatures of 85°C is of great significance to customers who further process the light-emitting diodes into luminaires. They receive precise information on parameters such as luminous flux or color stability, which they need to optimally define the properties of their products.

Furthermore, the improved temperature behavior leads to higher luminous efficacy in the application. "This luminous efficacy, meaning the ratio of luminous flux to applied electrical power, helps our customers to significantly optimize the price/performance ratio of their luminaire solutions," Tangring emphasizes. Thanks to the higher permitted junction temperatures, fewer large heat sinks are required, and this simplifies the design of lamps and luminaires, because they can be smaller and therefore less costly.

Application in interior lighting:
The Oslon Square is particularly suitable for the various applications in buildings. With a color temperature ranging between 2,400 and 5,000 Kelvin, it can generate either warm- or cold-white light. The color rendering index is over 80 and the luminous flux is an impressive 202 lumens (lm). Product variations with a different color temperature spectrum and higher color rendering indices are to follow. At present, the new LED is undergoing extensive quality testing: The certification process under the LM-80 long lifetime standard is underway. The results of the 3,000 hour test are expected at the end of the year, those of the 6,000 hour test in spring 2014. ■

Plessey Releases New Generation of GaN-on-Si LEDs

Plessey announced availability of its next generation GaN-on-Silicon mid-power LEDs. The product family doubles the efficacy of Plessey's first generation MAGIC™ (Manufactured on GaN-on-Si I/C) products released in February 2013. Using standard silicon semiconductor production techniques, Plessey is able to achieve high flux output LED products at substantially lower cost. The PLW114050 is the first in a family of entry level LED lighting products that will be released.



Plessey's new PLW114050 is a 3020 type PLCC packaged LED with 60 mA nominal drive current

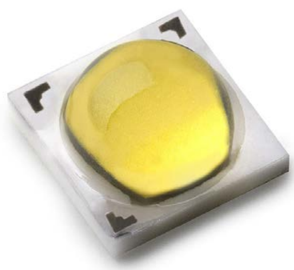
"We have made great strides forward in refining, productizing and improving our patented MAGIC™ technology," said Dr. Keith Strickland, Plessey's Chief Technology Officer. "We have a roadmap that puts MAGIC™ ahead of the efficacies achieved by sapphire-based LEDs and, thereby, sets a new milestone in terms of Lm/$ performance. By approaching efficacy parity, we are accelerating the widespread adoption of GaN-on-Si LED-based lighting products. Our MAGIC™ LED products have a cost advantage over comparable sapphire-based LEDs as we use 6-inch, high yield, standard, automated silicon manufacturing technology."

Dr. Jose Lopez, Plessey's Chief Commercial Officer, said, "Customers are delighted that a European company is committed to developing and manufacturing world class GaN-on-Si LEDs. The market currently has many suppliers of LEDs but the quality and reliability can be variable. Plessey is a trusted brand with a 50-year plus track record of manufacturing products to the highest standards. Our aim is to light the world with MAGIC™ LEDs."

The PLW114050 product is available in a CCT range from 6500 K to 2700 K, with a Lambertian distribution in an industry standard 3020 package. With a drive current of 60 mA, the PLW114050 has a typical forward voltage of 3.2 V. A full datasheet is available on the Plessey website. Plessey also supply the blue LED PLB010050 in sawn-wafer die form. Additional package options will be made available. ■

Philips Lumileds New High-Flux Emitters Transform Directional Luminaires

Philips Lumileds introduces LUXEON TX emitters. This next generation of high-power emitters delivers the highest luminous flux available, with maximum efficacy, for a variety of directional and omnidirectional lighting applications. "These emitters are truly transformative in that they enable customers to achieve performance metrics - such as a true 50 W equivalent MR16 lamp at 2700 K that meets ERP/DIM2 requirements - which LEDs simply could not meet previously," said Kathleen Hartnett, Product Line Director at Philips Lumileds.



Philips Lumileds' new LUXEON TX promises highest luminous flux without compromising efficacy in a very compact dimension

Features:

- Compact 3737 package
- Typical V_f of 2.8 V
- Thermal resistance of 3 K/W
- Hot tested at T_j = 85°C
- Freedom from Binning – 3 & 5 SDCM
- Exceeds ENERGY STAR lumen maintenance requirements
- UL-recognized component [E352519] with level 4 enclosure consideration

Benefits:

- High luminance for directional applications
- Optimized for extreme efficacy
- Excellent color consistency
- Proven reliability

Key Applications:

- Downlights
- High Bay & Low Bay
- Indoor Area Lighting
- Lamps
- Outdoor

"We use the term 'extreme efficacy' because of the remarkable performance customers can expect from these emitters," said Hartnett. "For instance, outdoor fixture manufacturers who need 4000 K at 70 CRI are taking advantage of the LUXEON TX 360 lm output @1.0 A and 85°C to decrease overall system cost, but have the ability to drive the same part @350 mA to deliver 155 lm/W LED efficacy and enable streetlights with a system efficacy of more than 120 lm/W."

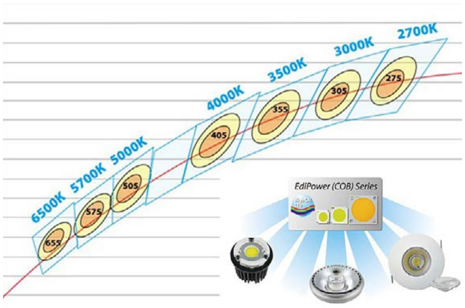
The LUXEON TX platform is available in a range of CCTs and CRIs to satisfy the most exacting requirements of downlights, high bay and low bay lighting, indoor area lighting, outdoor lighting and replacement lamps. In addition, for improved design flexibility, Philips Lumileds has added a minimum 85 CRI option so designers can further differentiate their product lines.

"Designers have typically had to choose between the lower efficacy associated with a 90 CRI LED or the poorer color rendering associated with an 80 CRI LED. Now LUXEON TX 85 CRI emitters bridge that gap by providing high CRI with increased efficacy in a full CCT range from 2700 K to 5000 K.

For applications that require a minimum 90 CRI, LUXEON TX delivers up to 100 lm/W warm white light (3000 K CCT, 90 CRI and 700 mA at 85°C). This level of efficacy at 90 CRI enables superior performance for luminaires that must adhere to increasingly stringent lighting standards such as the CEC's California Quality LED Lamp Specification. ■

Latest Edison Opto COB HM Series Meets the CEC Specification

With the keen competition of the LED market, products of different qualities have flooded the industry. Every manufacturer states that the lifespan of their products can be up to tens of thousands of hours and their efficacy is extremely high. But without specification, the real performance of those products is doubtful. In view of this phenomenon the California Energy Commission (CEC) developed the quality LED lamp specification in 2012. The CEC specification focuses on six key quality attributes for LED lamps, including color temperature, color consistency, color rendering, dimmability, lifetime and light distribution. The CEC standard requires that all lamps have color rendering index (CRI) ≥ 90 and R9 > 50. This specification will become effective in January 2014.



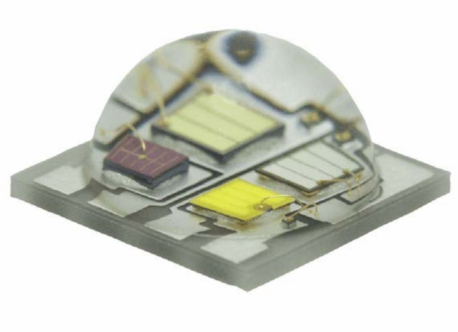
Edison Opto's latest COB HM Series meets the California Energy Commission (CEC) specifications which will become effective in January 2014

To satisfy market demand, since its establishment, the Taiwanese leading LED manufacturer, Edison Opto, has dedicated itself to promote a better living environment and never stop creating high efficacy LED products. By virtue of seven years of experience in COB development, Edison Opto has introduced the high efficiency EdiPower II HM series which has attracted the attention of industry. Recently, in order to respond to market demand, Edison Opto upgraded the CRI value of HM series up to 90 and met the requirement of R9>50. This breakthrough makes the HM series a preferred choice of museum and hospital lighting where high CRI light sources are required to present the actual color of objects.

With high quality standards, Edison Opto's COB components can keep pace with international manufacturers' products.
To help customers and lamp designers to distinguish product chromaticity, Edison Opto refers to the specifications of Energy Star and adjusts the original BIN group. At present, the COB products are grouped in 3-Step and 5-step MacAdam ellipse. The new BIN group makes CCT control more accurate and thus improves the product homogeneity. 98% of Edison COB products are within a 3-Step MacAdam ellipse and 90% are within a 5-step MacAdam ellipse. And that means Edison Opto has achieved the goal of color consistency. Those products are particularly suitable for applications requiring high color homogeneity, such as gallery, printing factory and stage lighting.

SemiLEDs Introduces 10 W Integrated RGBW LED

SemiLEDs Corporation, a world leader in vertical LED technology solutions, announced the introduction and release of the 10-Watt M63 RGBW integrated 6363 LED. The 4-channel M63 RGBW delivers over 410 total lumens of combined red, green, blue and white light output. The compact 6.3mm x 6.3mm dimensions enable the M63 RGBW to fit in a wide range of color-changing applications, including entertainment (stage lights, backdrops and spotlighting), large scale displays, and color-adjustable luminaires for building façades, wall washing or specialized interior luminaires.



SemiLEDs M63 RGBW can be driven with up to 10 W

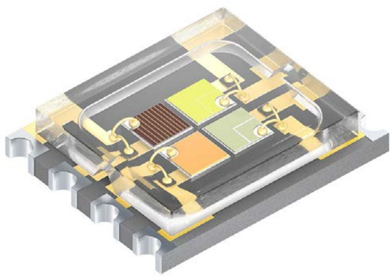
"The M63 RGBW demonstrates a new level of LED product integration from SemiLEDs", commented Dr. Ilkan Cokgor, Executive VP of Sales and Marketing for SemiLEDs. "By combining three colors, plus an independent phosphor-coated white emitter, onto a single LED package, our customers will be able to better optimize the optical and thermal properties of their design, while minimizing the manufacturing complexities of their luminaires or large scale displays. This integrated approach is enabled by our well-validated and robust metal vertical LED product portfolio, which can be reliably driven harder to deliver higher than average lumen density and increase the lumens per dollar," Dr. Cokgor added.

The integrated package is the first to bring together SemiLEDs vertical, white chip, and ceramic packaging technologies. Measuring just 6.3mm on a side (39.7 square mm/.06 square inch), the compact multi-color LED opens the door to arrays with cumulative lumen-densities in excess of 6000 lumens per square inch. Beyond just the size and potential for high-lumen densities, the square footprint also greatly simplifies color mixing and integration with secondary optics, including narrow beam spotlights which benefit from the symmetry and depend upon minimized source sizes. When compared to a strictly RGB source, the addition of discrete white to the color changing LED architecture enables a broader spectrum and more natural white palette to be projected. The white source in the M63 RGB delivers 100 lumens per watt at a correlated color temperature (CCT) of 6300K to 8000K. By its nature, an RGBW LED should include a cool-white source to compliment the additive nature of the colors in the integrated device.

"Every current technology trend is towards higher integration, both to reduce component count and simplify the final design, and that carries with it a ripple effect that continues into process engineering and manufacturing," continued Dr. Cokgor. "As a result of its broad technology offering, SemiLEDs is in a somewhat unique position to reliably deliver these higher levels of integration, as reflected in our new M63 RGBW. High quality LED manufacturers will continue to differentiate and add value to the industry by driving increasing integration at both the component and subsystem level," he concluded.

New "Tunable White" LED With High CRI - Not Just for Medical Applications

When it launches the new Osram Ostar Medical, Osram Opto Semiconductors will be introducing the first LED component with a high color-rendering index (CRI) of 95 and the possibility of adjusting the temperature of the color white. This makes it ideal for medical applications – for instance in operating rooms, where a precisely controlled chromaticity coordinate and high natural color rendering are crucial.



Measuring just 5.9 mm x 4.8 mm x 1.2 mm, the Osram Ostar Medical has a very compact design

Main Features:

- Footprint: 5.9 mm x 4.8 mm
- Height of housing: 1.2 mm
- Thermal resistance R_{th}: 1.8 K/W
- Typical brightness: 80 lm (at 4,000 K)
  325 lm (at 5,000 K)
- CRI: Ra/R9 greater than 95

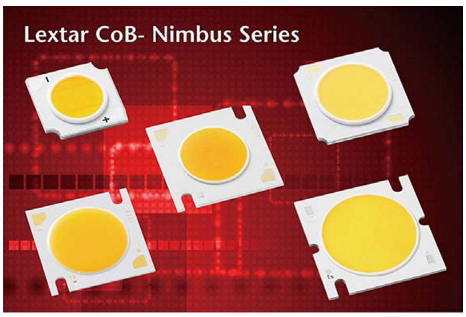
The new Osram Ostar Medical comprises four different LED chips in the colors warm white, ultra white, verde and amber. This permits customers to set the shade of white emitted by the LED according to their individual requirements within a color temperature range of between 3,700 and 5,000 Kelvin – and at a high overall CRI of 95. This combination of precise chromaticity coordinate control and excellent CRI is particularly important for lighting in the medical sector. When optimized for the red spectrum (RaR9), the CRI remains at around 95 so that red shades are particularly true-to-life – ideal for light systems in operating rooms.

Compact dimensions, simple to install:
With a footprint of just 5.9 mm x 4.8 mm and a housing height of 1.2 mm, the design of the Osram Ostar Medical is very compact. Indeed, it is only about one-quarter as high as the components ordinarily used. The product owes its compact design to the flat, antireflex-coated glass cover with which the LED is equipped instead of the usual lens.

"Compact luminaires prevail in the modern medical lighting sector and the low height of the new Ostar Medical makes it the ideal product," explained Wolfgang Schnabel, who is in charge of marketing the product at Osram Opto Semiconductors. "The component is standardized, which means that customers can use the commonly available lenses." As with other members of the LED family, the Osram Ostar Medical is simple to install with standard soldering processes. ■

Simplify Your Design with Lextar's High Quality COB

Lextar has a whole COB product – the "Nimbus" series. Its wide coverage ranges from 500 to 10000 lm and is applicable for bulbs, par lights, down lights, track lights, streetlamps and high bays.



Lextar's new "Nimbus" COB series LEDs are available in various CCTs with different LES and as High CRI version

Lextar COB provides:

- Complete series from 4 W~120 W for all kinds of applications
- Light emitting surface compatible with ZHAGA standard
- High efficacy
- Offering 3 step binning with CRI 70, 80 and 90
- Low Rt_h, good heat dissipation

Application suggestion:

- Down light
- Par20, Par30, Par38
- Track light
- Flood light
- High / Low bay

The COB has recently been widely adopted thanks to its quality light and no multi shadow, low thermal resistance and good uniformity. It brings benefits to manufacturers with its simplified luminaire design and reduced assembly costs.

The Lextar Nimbus COB series is offered in a range of light outputs from 400lm to 10,000 lm. We provide whole high quality solutions for general lighting including down lights, spotlights, track lights and industrial lights. With its high quality standards, the Lextar Nimbus COB series complies with the specifications of Energy Star, offering a CIE bin with 3-step and 5-step MacAdam ellipses to keep the best color consistency for designs that use single light source COB.

The Lextar Nimbus COB series is available with CCTs of 2700 to 5700 K and color quality (CRI) levels of 70, 80 or 90 for different kinds of designs and applications. For applications such as museum or commercial lights that require a minimum 90 CRI, the Lextar Nimbus

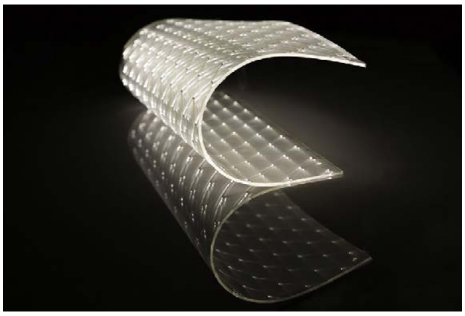
1500 and Nimbus 2000 COB deliver up to 100-lm/W warm white solution (3000K CCT, 90 CRI and R9>50).

For better optical solutions costs, the light-emitting surface (LES) of the Lextar Nimbus COB series is designed as 9, 13.5 and 23 mm which comply with the Zhaga standard.

In addition, the substrate design of Lextar Nimbus COB with low R_{th} (Thermal resistance,K/W) provides an advantage over a mechanical design for a luminaire. It provides better heat transfer and improved reliability of the lighting system. ■

Design LED Products Launched Revolutionary Flexible LED Light Tile

Design LED Products is using Lux Live 2013 as the launch pad for its revolutionary flexible LED light tile technology, offering designers the opportunity to use light in new and unconventional ways. The highly efficient tiles can be designed to be modular and scalable and are ideal for uniform backlighting applications and directional lighting applications requiring low profile, curved or irregular shapes.



One of the big advantages of Design LED Products' new flexible light tile is that it can provide up to 20,000 lm per square meter without the need of an external thermal management system

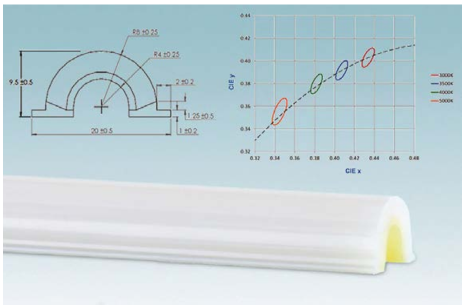
Design LED's patented technology embeds LEDs into a thin, flexible transparent film with printed surface optics to create a lightweight, integrated and modular light engine. The pattern and form of the surface features governs the illumination uniformity and beam angle control for lighting and backlighting requirements. The solution offers high optical efficiency of approximately 90%, up to double that of competitive edge-lit solutions.

The modular light tiles can be produced in any shape or size up to 1m, offering up to 20,000 lumens per square meter. Designers will benefit from single or double sided illumination and with LEDs distributed across the panel, applications are not inhibited by the need for external thermal management.

As standard the tiles are supplied with LEDs offering a color temperature range from warm white to cool white (3000 K – 7000 K) and Color Render Index (CRI) >85. Options are also possible for single or mixed colors as well as a range of low voltage or constant current drive solutions. ■

Intematix Introduced Three New Remote Phosphor Products for LED Lighting

Intematix Corporation, a leading manufacturer of phosphor solutions for LED lighting, announced the commercial availability of ChromaLit® Linear. Just three weeks before, they announced the volume shipments of their remote phosphor componentfor 150 W equivalent LED retrofit lamps, after having announced beginning of November the development of a remote phosphor-based LED lighting module with 203 lumens per watt efficacy, which was done in cooperation with Philips Lumileds.



Intematix's latest product is the ChromaLit® Linear remote phosphor that allows the design of products with a system efficiency of up to 163 lumens per watt

ChromaLit Linear Remote Phosphor:
ChromaLit® Linear is a remote phosphor offering uniform luminance over any length, high flux density and a sleek, white off-state finish. This product received the Lux Award by Lux Magazine for Light Source Innovation of the Year and recognition by the Illuminating Engineering Society (IES) in its Progress Report featuring the most promising new lighting products.

Linear light sources are in widespread use for illuminating commercial and industrial applications worldwide. Office lighting and other commercial applications have been challenging for white LEDs previously because of the need to diffuse the point sources, reducing system efficacy. The ChromaLit Linear product delivers naturally uniform, high quality light with conversion efficacy of up to 215 lumens per radiant watt or up to 163 lumens per system watt when used with the most efficient blue LEDs available.

"ChromaLit Linear transforms industry thinking about LED linear lighting and remote phosphor," said Julian Carey, Senior Director of Strategic Marketing at Intematix. "We can forget about low efficacy and pixelation because this product enables high light output, smooth uniformity, white off-state and new possibilities for applications from under-cabinet to troffers to high bay lighting."

The ChromaLit Linear remote phosphor solution offers flexibility of length. Surface lumen density scales from 500 to 2500 lumens per linear foot and the system presents new design directions not possible with fluorescent and white LEDs. Intematix has also changed how designers think about remote phosphor because ChromaLit Linear has dramatically improved the off-state appearance and illumination quality. ChromaLit Linear offers 3 SDCM color consistency as standard and color temperature options from 3000 K to 5000 K and CRI of 80.

Remote Phosphor and Reference Design for 150 W LED Retrofit Lamps:
This production release for 150 W equivalent LED retrofit lamps adds to the product family already enabling 40 W, 60 W, 75 W and 100 W bulb replacements all using a similar omni-directional form factor.

As global government regulations phase out incandescent lamps, these remote phosphor components streamline access to high quality, efficient lighting in these popular lumen output ranges for use in residential and commercial applications. In addition, this innovative form factor delivers an incandescent-like 325° light distribution pattern in contrast to many LED replacement bulbs on the market.

"By applying this remote phosphor technology to the high end of the light bulb output range, we show 38% higher lumen output than bulbs available today," said Julian Carey, Senior Director of Strategic Marketing at Intematix. "We are already seeing newly available, 2200-plus lumen LED light bulbs worldwide using this technology."

150 W equivalent LED light bulbs utilizing Intematix's patented ChromaLit remote phosphor are now available at major US retail outlets.

Remote Phosphor LED Lighting Module Delivering 203 lpw:
It is believed that this module represents the highest level of efficacy among LED-based light sources commercially available for production in the market today.

"This result is a significant step along our innovation roadmap for phosphor solutions," said Yi-Qun Li Chief Technology Officer at Intematix. "Remote phosphor architectures lower cost, increase efficacy and improve light quality in many of the consumer, commercial, industrial and outdoor area lighting applications commonly deploying LED technology today."

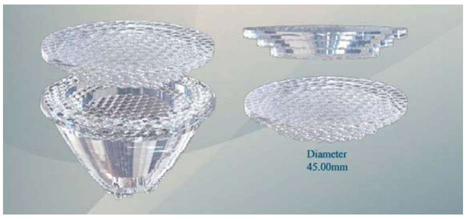
The LED lighting module uses a commercially available, 26 mm diameter dome shaped remote phosphor developed by Intematix that converts blue light to on-the-black-body-line 6000 K daylight spectrum and 70 CRI with conversion efficacy of 267 lumens per radiant watt. The design is applicable for round and linear module configurations and is offered in color temperatures ranging from 2700 K to 6000 K with CRI values from 70 up to 98.

This groundbreaking lighting module uses Philips Lumileds LUXEON T/TX family of royal blue LEDs, achieving industry leading wall plug efficiencies of 76%.

"We're very proud of this landmark performance of 203 lm/W as this was achieved using our latest commercially available LED technology and Intematix's remote phosphor," said Jy Bhardwaj, Senior Vice President of R&D at Philips Lumileds. "This marquee performance simplifies a wide variety of thermally constrained applications such as 100 W A19 bulbs and high lumen candle lamps, and enables downlights with the highest efficacy in the industry." ■

11° to 45° Zoom & Autofocus Lenses from Khatod

Zoom & Autofocus Lenses, available in Ø 45 mm are equipped with a Moving Lenslet Array (MLA) that execute zoom and autofocus performance in a wide range of applications. The beam angles vary in a range of an 11° beam when the MLA is nearly in contact with the lens, up to a 45°wide beam when the MLA is made sliding over the lens. Reach a high optical efficiency over 90% by preserving a perfect light layout in the full range of the beam angles, also in color mixing applications.



Zoom & Autofocus Lenses from Khatod provide the designers of lighting fixtures with unique optical solutions that far exceed the normal performances of standard lenses

Lens - PL1590WI Benefits:
- Available with PL1564 Moving Lenslet Array (MLA), enabling Zoom from 11° to 45° beam angle range
- Innovative design
- High optical efficiency over 90%
- Robust Mounting
- Perfect uniform flux
- Shadows or glare totally eliminated
- Easy fixing onto the PCB

Moving Lenslet Array- PL1564 Benefits:
- To be used with PL1590WI Lenses
- Innovative design
- Zoom Range 11° to 45°
- High optical efficiency over 90%
- Shadows or glare totally eliminated
- MLA and lens fit perfectly as they are complementary, have the same diameter and Lenslet Array

Typical Applications:
- Architectural Lighting
- Stage Lighting
- Entertainment & decorative
- Shop windows, halls & entrances
- Downlights
- Flashlights
- Border/contour
- Lamps, etc.

When equipped with the Moving Lenslet Array (MLA) PL1564, the newest accessory designed by Khatod, the lenses execute Zoom and Autofocus performances in a wide range of applications. The MLA and the lens fit perfectly as they are complementary; have the same diameter and Lenslet Array.

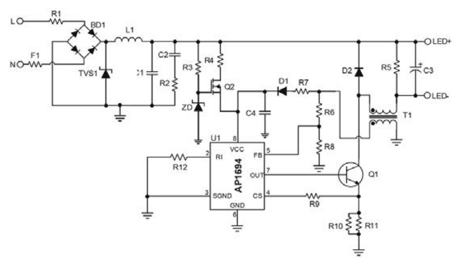
Place the MLA on the top of the lens and make it slide over the lens along the optical axis: beam angles will vary in a range from 11°, when the MLA is nearly in contact with the lens, up to 45°, when the MLA is made sliding over the lens. The beam variation is obtained along 5 mm distance.

These lenses perform an optical efficiency over 90% and preserve a perfect light layout in the full range of the beam angles, also in color mixing applications using multi-color LEDs.

The combination of the lens and the Moving Lenslet Array allows zoom and autofocus applications by just sliding the MLA on top of the lens. ■

New Mains-Dimmable LED Lamp Driver from Diodes

Diodes Incorporated, a leading global manufacturer and supplier of high-quality application specific standard products within the broad discrete, logic and analog semiconductor markets, introduced the AP1694, an AC-DC controller providing a universal high-performance driver solution for a variety of mains-dimmable LED lamp designs. Suitable for both 120 V and 230 V AC inputs, while supporting non-isolated buck, buck-boost and isolated flyback topologies, this part enables between 10% and 50% reductions in total BOM costs.



Typical application circuit using Diodes' AP1694 LED driver

Features:

- Primary side control for output current regulation without opto-coupler
- Boundary conduction mode (BCM) Operation to Achieve High efficiency
- High PF and low THD
- High efficiency without dimmer
- Wide range of dimmer compatibility
- Dimming curve compliant with NEMA SSL6
- Low start-up current
- Tight LED current
- Tight LED open voltage
- BJT transistor driver
- Dynamic base driver control
- Valley-mode switching to minimize the transition loss
- Easy EMI
- Internal protections:
  - Under voltage lock out (UVLO)
  - Leading-edge blanking (LEB)
  - Output short protection
  - Output open protection
  - Over temperature protection
- Flexible for design with small form factor and very low BOM cost

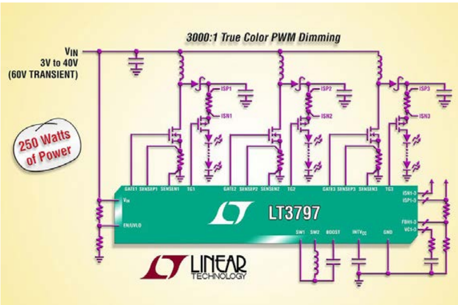
The controller uses Diodes' patented PFM technology to tightly regulate LED current and achieve a high power factor and low total harmonic distortion. By operating in boundary-conduction mode, the AP1684 also assures high efficiency and low EMI driver characteristics. As a primary side controller, this part removes the need for opto-coupler and secondary-side control circuitry, and being inherently stable, eliminates the need for loop compensation.

The AP1694 delivers a 5% initial LED current accuracy, meeting the requirements of most mains-dimmable LED lighting applications and is compatible with a wide range of different dimmers, including both leading edge and trailing edge types. It achieves deep dimming down to 1%, complies with the NEMA SSL6 standard for dimming curves and meets the requirements of the IEC6100-3-2 harmonic standard.

Provided in the small form factor SO-8 package and requiring only 26 external components in buck topology, the AP1694 driver controller offers designers of mains-dimmable LED lamps a higher power density with a simpler and smaller total circuit footprint. The device also integrates comprehensive protection features, including open-load detection, over-voltage, short-circuit and overtemperature protection. ■

Triple Output High Current LED Driver Controller Drives over 250 W of LED Power

Linear Technology Corporation announces the LT3797, a triple output DC/DC controller designed to drive three independent channels of LEDs. Its fixed frequency, current-mode architecture delivers constant, accurately regulated LED current over a wide range of supply and output voltages. Its 2.5 V to 40 V input voltage range with transient ride through to 60 V makes it ideal for automotive applications as well as a wide range of industrial applications, RGB lighting, billboards and large displays.



Linear Technology's new triple output LED driver allows high power applications in a compact footprint

Summary of LT3797 Features:

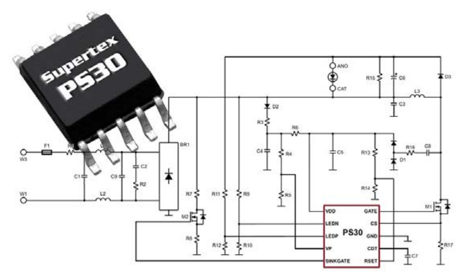
- Three Independent LED Driver Channels
- Wide Input Voltage Range: 2.5 to 40 V with VIN Transient Ride-Through up to 60 V
- Rail-to-Rail LED Current Sense: 0 to 100 V
- 3,000:1 True Color PWM™ Dimming
- TG Drivers for PMOS LED Disconnection
- Operates in Boost, Buck, Buck-Boost, SEPIC or Flyback Topology
- Open-LED Protection
- Short-Circuit Protected Boost Capable
- Fault Flags for Independent Channels
- Programmable VIN
- Undervoltage & Overvoltage Lockout
- Adjustable Switching Frequency: 100 kHz to 1 MHz
- Synchronizable to an External Clock
- CTRL Pins Provide Analog Dimming
- Programmable Soft-Start
- 52-Lead QFN Package

Each of the LT3797's channels can drive a wide range of LED power in either step-up, step-down or SEPIC topologies. In a boost configuration, it powers three channels of up to 90 V of LEDs with LED currents in excess of 1 A, delivering over 250 W of power from a nominal 12 V input with efficiencies as high as 93%. Each of the three channels is operated by an independent True Color PWM™ signal, enabling each channel to be dimmed to ratios as high as 3000:1. Each channel also offers both robust open-LED and short-circuit protection in boost mode, providing high safety and reliability designs required in automotive applications. A frequency adjust pin enables the user to program the frequency between 100kHz and 1MHz to optimize efficiency while minimizing external component size. Its thermally enhanced 7 mm x 8mm QFN package provides a highly compact solution footprint for 20 W to 250 W LED applications.

The LT3797 is designed so that each channel can use the most suitable configuration to drive its LED string, whether step-up, step-down, and SEPIC or a combination of these. Its high-side current sense enables each channel to be used in the same or different configurations while rail-to-rail current sense enables outputs from 0 V to 100 V, offering a wide range of design flexibility. Other features include overvoltage and undervoltage lockout, 20:1 analog diming via the CTRL pin and external synchronization. ■

Supertex Introduces Dimmable Low Cost LED Driver Solution for Bulbs and Tubes

Supertex, a recognized leader in high voltage analog and mixed signal integrated circuits (ICs), introduced PS30, a constant frequency (67 kHz), constant duty cycle LED driver optimized for dimmable off-line LED bulb/tube applications, providing high power factor correction (PFC).



Supertex's new PS30 LED driver is compatible with leading and trailing edge dimmers, as well as two-wire digital dimmers

Ledlink Optics,Inc.

New Product | COB Reflector

LL01CR-AYGxxR49
DxH(mm) 75 x 45
FWHM 15° 24° 38°
For Cree CXA 1507 / 1512

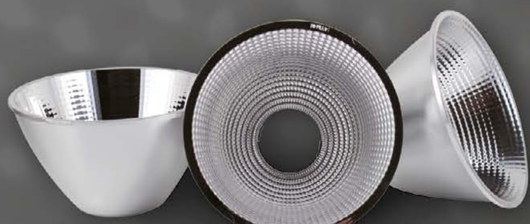
Holder
LL30A00SUSB2-M2

LL01CT-AYXxxR35-P
DxH(mm) 90 x 50
FWHM 15° 24° 38°
For CITIZEN CLL030

Holder
LL38A00SUQB2-M2

LL01CT-AYTxxR35-P
DxH(mm) 75 x 45
FWHM 15° 24° 38°
For CITIZEN CLL020

Holder
LL30A00SUNB2-M2



LL01CR-AYMxxR35-P
DxH(mm) 90 x 50
FWHM 15° 24° 38°
For CREE CXA 2520 / 2530

Holder
LL38A00SUUB2-M2

Our Services

- R & D
- Precision Mould
- Manufacture
- Component solution
- Customerization

Further technical information is available, please contact us for more details.

| www.ledlink-optics.com | service@ledlink-optics.com

LedLink
Linking LEDs to The Real World

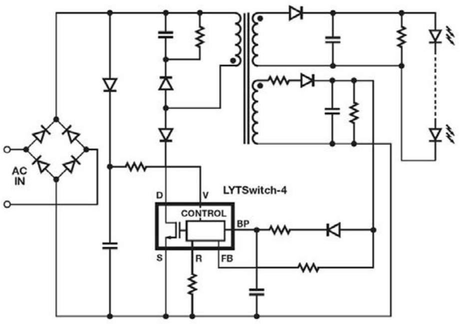
PS30 is intended to drive a single switch, single inductor power converter (flyback for isolated version and buck-boost for non-isolated version) directly from AC line, 110 V or 220 V, for power levels up to 20 W. PS30DB1 demo board provides a 6.3 W design solution, achieving 93% PFC and greater than 81% efficiency with ±4% current accuracy. It can be modified for other power levels up to 20 W.

PS30 offers smooth dimming to extinction for a wide variety of dimmer types such as leading edge dimmers, trailing edge dimmers, and dimmers with microprocessor controls. It implements a PFC LED driver solution, operating from a 10 V shunt regulator derived from the power supply snubber, and provides for a simple design by eliminating feedback components and the optocoupler typical in isolated solutions. It minimizes line induced brightness variation, and protects against open circuit failure with over voltage protection.

Two unique features enhance the value and performance of PS30. It is designed to implement a simpler, lower cost open loop solution. The potential limitation of open loop design is that the output choke tolerance normally results in variation in output current amplitude across product builds in production. PS30 includes proprietary control techniques that largely mitigate this output current variation. It also includes proprietary dimming circuits that ensure proper operation with different triac dimmers. It controls the timing of the power stage and activation of auxiliary loading to eliminate concerns of erratic SCR firing and the resultant flickering. Its circuitry ensures stable operation during light load conditions and a consistent starting point for the zero crossing phase detection.

PI Adds High-Line Parts to LYTSwitch-4 LED-Driver IC Family

Power Integrations, a leader in high-efficiency, high-reliability LED-driver ICs, added devices optimized for high-line applications, completing the roll-out of its LYTSwitch™-4 LED-driver IC family. LYTSwitch-4 ICs deliver accurate output current and high efficiency. The devices simplify design and reduce cost while ensuring that lamps deliver uniform light output and provide exceptional performance in TRIAC-dimmable applications.



Power Integration LYTSwitch™-4 LED-driver IC family - typical schematic

Main Features:

- Better than ±5% CC regulation
- TRIAC dimmable to less than 5% output
- Fast start-up
- <250 ms at full brightness
- <1s at 10% brightness
- High power factor >0.9
- Easily meets EN61000-3-2
- Less than 10% THD in optimized designs
- Up to 92% efficient
- 132 kHz switching frequency for small magnetics

LYTSwitch-4 ICs feature a combined PFC and CC single-stage converter topology resulting in a power factor greater than 0.95 and efficiencies of over 90% in typical applications. Designs based on the new drivers easily meet EN61000-3-2C regulations for total harmonic distortion (THD); optimized designs deliver less than 10% THD. Regulation is better than +/- 5% across load and production spread, reducing the need for over-design to meet minimum luminance targets, cutting system cost. The devices' high switching frequency (132 kHz) enables smaller, lower-cost magnetics to be used, and frequency jittering reduces EMI filtering requirements. These factors enable LED-driver designs to fit easily into space-restricted bulb styles.

Comments Andrew Smith, senior product marketing manager for Power Integrations: "LYTSwitch-4 LED-driver ICs have proven very popular since the initial launch of the low-line parts, due to a combination of efficiency and excellent dimming performance. Even when used with leading-edge and trailing-edge TRIAC dimmers, and at low conduction angles, designs comply with NEMA SSL-7. Start-up is very fast, typically less than 500 ms, even when dimmed to less than 10% light output, and pop-on is virtually eliminated."

Designers can evaluate the new LYTSwitch-4 LED-driver IC family using a new high-line LED lighting reference design that has been co-developed with Cree. DER-396 describes a PAR38 spotlight LED driver design.

ISSI Announces Single Stage High Power Factor AC/DC LED Controller for Retrofit LED Bulbs

Integrated Silicon Solution, Inc., a leader in advanced memory and analog IC solutions, announced the IS31LT3932, a high performance universal AC input LED Controller for the solid-state lighting (SSL) market place. With a universal input voltage range from 85 to 265 VAC, a Power Factor Correction greater than 0.97 and a typical output current accuracy of +/-3%, the IS31LT3932 is ideally suited for a wide range of offline LED retrofit lamp solutions including E26, GU10, PAR and T8. This true constant current LED controller can support LED lighting solutions of up to 30 W with a minimal number of external components.

ISSI's new IS31LT3932 LED driver IC is a single stage high power factor AC/DC LED controller for retrofit LED bulbs

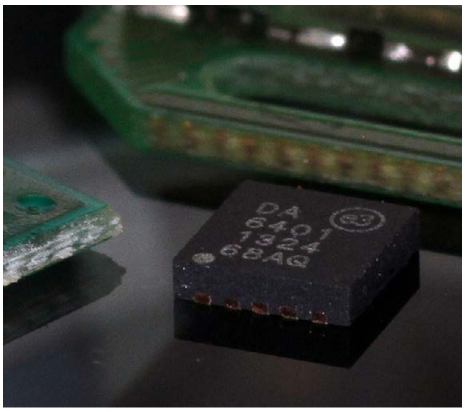
The IS31LT3932 utilizes a patent pending average current mode control scheme to maintain inductor current regulation regardless of variation of input and output voltage. The device implements a Pulse Frequency Modulation (PFM) technology without an optocoupler and secondary side control or loop compensation circuitry dramatically reducing the bill of material (BOM) and overall cost. The controller can be configured to operate in a Non-Isolated Buck or Buck Boost mode or Isolated Flyback mode. The device's unique architecture continuously monitors the output voltage and adjusts the operating frequency to maintain high LED current accuracy.

The IS31LT3932 has special input power line sensing and output voltage sensing circuits operating in primary feedback mode to deliver highly accurate current regulation to the LED load. The IS31LT3932 incorporates many features found in more complex controllers such as soft-start, Vcc under-voltage lockout with hysteresis, and protections against output over-voltage, output open and short circuit, primary side over-current and thermal shutdown with hysteresis. In addition, the versatile high voltage gate drive of the IS31LT3932 will support a wide range of low-cost power MOSFET devices.

"The IS31LT3932 expands our LED controller offering for the retrofit lamp market," remarked Ven Shan, ISSI VP of Analog products. "Lighting manufacturers will benefit from the versatility offered by a high power-factor, universal AC input and constant current output because one design will support multiple LED array load configurations. With design re-use, our customers can truly maximize their design efforts." ■

Revolutionary SmarteXite Technology Driver Platform from Dialog Semiconductor

Dialog Semiconductor announced its smarteXiteTM platform, enabling a new generation of highly flexible, programmable LED driver ICs for smart lighting applications.



The tiny iW6401 smarteXite LED driver IC supports dimming options with multi-interface solution and multi-stage programming

SmarteXite, based on fully configurable logic, is the first LED driver technology to directly and easily support wireless connectivity, light sensor control and allow easy integration into lighting control systems.

The first device from the smarteXite family, the iW6401, supports multiple dimming interfaces, including digital dimming via a simple mains on/off switch, the new Ledotron™ digital dimming protocol and toggle-switch based dimming.

All dimming-curves can be memory-configured to enable a highly optimized end-user lighting experience. The integrated digital load line transmission (DLT) receiver in the iW6401 supports the Ledotron IEC 62756-1 dimming protocol making it the world's first single-chip plug-and-play Ledotron solution.

Using a standard I2C digital interface, the iW6401 can serve as a powerful frontend for wireless communication modules like low-energy Bluetooth, Wi-Fi or ZigBee. Additionally, intelligent sensor devices enabling color- or proximity-sensing can be directly connected. When such a peripheral device is used, the integrated power management unit in the iW6401 provides a stable power source, reducing the external component count and cost.

Combining Dialog's strengths in configurable power management with state-of-the-art digital signal processing design, the iW6401 is the world's first programmable AC/DC retrofit LED lamp driver IC, which allows engineers to design and configure the bulb design via software with an optimized bill of material (BOM) versus a time intensive iterative hardware design process. This greatly reduces the time to market and allows a smarteXite-based design to support many different global configurations and lighting requirements.

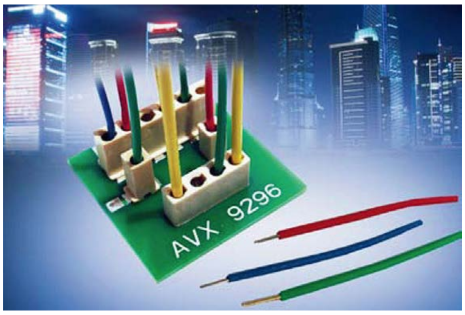
"Solid state lighting components and manufacturing costs have fallen to a level enabling LED bulbs to be sold in retail stores for under 10 dollars; this price point drives consumers to adopt the technology and retrofit their homes," said Mark Tyndall, VP Corporate Development & Strategy and GM Power Conversion Business Group at Dialog Semiconductor. "Market analyst firm McKinsey predicts a 57 percent compounded annual growth rate for LED bulbs units to be sold between 2012 and 2016, with more than 2.6 billion units to be sold in 2016."

SmarteXite supports final stage digital calibration on the production line where the bulb manufacturers can reconfigure the illumination calibration settings like brightness and color via the A/C mains terminals. This allows lower tolerance LEDs to be used with less binning or waste of LED's. Additionally, using this final stage calibration feature, the adjustment of the LED currents can be done even in the installed state making the smarteXite platform also ideal for Zhaga compliant power supplies. The iW6401 can be configured to actively manage lamp temperature using either on-chip or off-chip temperature sensor and a configurable state temperature control.

LEDs are especially suitable to be dimmed in a wide range. Unlike CFLs and other discharge lamps, LEDs can be set to almost zero current by applying digital control principles. With smarteXite, intelligent control algorithms can be employed and configured to provide a wide dimming range. Additionally, the smarteXite platform offers a range of protection and supervision functions, which can be customized for the different bulb requirements. ■

AVX's New Vertical Top Mount SMT Connector for SSL Wire-to-Board Market

AVX Corporation, a leading manufacturer of passive components and interconnect solutions, has introduced the first vertical, top mount, SMT, wire-to-board connector specifically designed to meet the configuration, performance, and cost goals faced by industrial and solid-state lighting design engineers. Featuring AVX's industry-proven dual-beam, 3 mm, high spring force box contacts packaged in a protective insulator, the new 9296 Series vertical, top mount, poke home connectors provide maximum mechanical stability and wire retention in addition to simple strip and insert wire loading and twist and pull wire removal.



AVX's new wire-to-board connector allows connecting 18-26AWG wires directly through the connector's top aperture

Designed to surface mount on the top of a PCB, the new one- to six-way 9296 connectors allow users to insert solid or stranded, plated or un-plated, 18-26 AWG wires directly through the connector's top aperture and are ideal for a variety of industrial applications, including: LED lighting, smart meters, building controls, fire and security systems, and industrial motor controls and drivers, among others.

"We designed our new 9296 vertical top mount SMT connector to satisfy a significant gap we identified in the industrial and solid state lighting wire-to-board markets," said Tom Anderson, product manager at AVX. "No other vertical top mount connectors designed to provide robust performance in industrial grade applications are currently available and, moreover, many of the vertical through-board options that exist are not robust enough to satisfy the unique demands of industrial applications. With this latest addition to the 9296 Series, AVX now offers vertical top mount, bottom mount, and through hole poke home connectors that provide reliable off-the-shelf solutions specifically designed to meet the configuration, cost, and performance requirements for a broad range of industrial applications."

AVX's 9296 Series vertical top mount connectors feature RoHS-compliant coppery alloy contacts with tin over nickel plating and are rated for 300VAC, five-cycle durability, and temperatures ranging from -40°C to +125°C. Available in one to six positions, each connector will accept the entire wire gauge range for either solid or stranded wires at varying current ratings supported by each wire size; and, once inserted, wires can be easily removed or replaced by twisting, unscrewing, or using a small blade extraction tool.

Tape and reel packaged for automatic assembly, each 9296 Series vertical top mount connector is supplied with a small kapton tape on the top to aid with the pick and place process. Post-soldering, the tape should be removed and discarded. ■

Mechatronix Launches ModuLED Xtra and IceLED Xtra

"The whole idea of developing the ModuLED Xtra and IceLED Xtra LED coolers was to create a limited number of products which fitted with all the newest LED modules and COB's which came on the market in the last year" according to Ken Yang, Chief Designer at MechaTronix.

Mechatronix's intention when designing ModuLED Xtra and IceLED Xtra LED coolers was to create a limited number of products for all the latest LED modules

"Bridgelux came out with the Vero LED modules, Philips Lumileds created a whole family of Luxeon COB's, Vossloh Schwabe developed a new 10,000 lumen high bay LED engine with the Luga Industrial, and that's just 10% of all the new developments our ECO partners reported us in the last twelve months. Also a lot of new ECO partners applied for making standard LED heat sinks for them, like GE for their Infusion series, LG Innotek, Lustrous, and TSMC.

Making dedicated standard LED coolers for each of those separately would probably take us two years, and by that time the LED world would look already completely different."

The ModuLED Xtra passive LED coolers come in 50 and 80 millimeter height and give a cooling performance for spot and down light designs from 700 lumen up to 4000 lumen.

The IceLED Xtra 550 is a fan-cooled model that performs up to 10,000 lumen or 100 watts of heat dissipation, while the IceLED Xtra Ultra goes up all the way to 20,000 lumen. With a weight of just 400 grams designers can make major improvements on the overall weight of their high and low bay designs.

The modularity of the ModuLED and IceLED designs are reached through making all the needed mounting holes immediately in the extrusion profile. In this way the LED modules can be mounted without any after work by self-tapping screws.

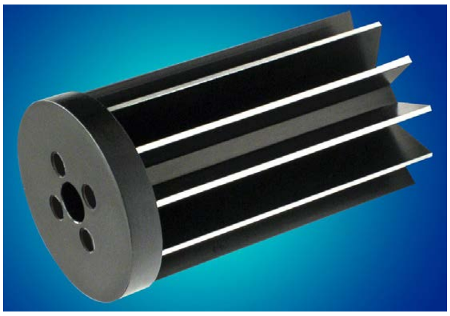
Overview of all LED COB's and LED modules which are standard foreseen on this "Xtra" series:

- Zhaga Book 2 compliant LED engines: Megaman Teco, Philips Fortimo TDLM and Tridonic Talexx Stark DLE twist
- Zhaga Book 3 compliant LED Spot Light modules:
  Edison Edilex SLM, Osram PrevaLED, Philips Fortimo SLM, Tridonic Talexx Stark SLE, Vexica Lumaera and Vossloh Schwabe Luga Shop
- LED COB's for which Zhaga Book 3 LED holders are available:
  Bridgelux ES rectangular LED array,
  Citizen CitiLED CL-L030, CL-L032, CL-L040, CL-L042,
  Cree XLamp CXA18xx, CXA25xx, CXA30xx,
  Edison Opto HM16 and HM30, LG Lighting MCP 10-24W,
  Osram Soleriq E30, Philips Lumileds Luxeon 1204, 1205 and 1208, Luxeon K12 and K16,
  Prolight Opto PABA 10-50W,
  Sharp Mega Zenigata and Tiger Zenigata,
  Tridonic Talexx Stark LES 17
- Zhaga Book 5 compliant LED engines: GE Infusion LED modules M1000, M1500, M2000, M3000, M4500
- Zhaga Book 6 compliant LED engines: Toshiba E-Core LED Light Engine LED LEV11 and LEV16
- Bridgelux Vero 13, 18 and 29 LED engines
- Edison Opto SD, HS, HV and HR COB
- Lustrous X5, DX5, TX5 and XL5 COB series
- Philips Lumileds Luxeon 1204, 1205 and 1208 COB series
- Prolight Opto PABA COB series

With regards to thermal performance MechaTronix runs thermal validation programs from each brand and LED package in combination with the LED cooler and publishes this data online. In this way the lighting designer has immediately an accurate idea of the temperature the Tc/Tp point will reach in his design, what can save a tremendous amount of time during the design stage. ■

Star Heat Sinks Cool High Power LEDs

Advanced Thermal Solutions, Inc. (ATS) has added a series of Star LED heat sinks designed for convection cooling of high heat flux LEDs to its portfolio. Each of the 32 heat sinks provides enhanced heat transfer for effective LED cooling without fans or blowers. Cooling performance reaches more than 60 K (ΔThs-ambient) at 50 W of power dissipation, depending on model.



ATS' new line of Star heat sinks is made from lightweight aluminum

The Star heat sinks are made from lightweight aluminum in a round profile that fits common LED applications. Cooling fins are arrayed in a round, star-like cross section that optimizes thermal performance in local air flow. A flat base at one end allows secure, direct mounting of LEDs. Integral threads on the base perimeter allow attachment of brackets and other hardware. An inner thread on most models allows convenient attachment of LED lens mounts.

ATS Star heat sinks are available in lengths from 25 to 1,000 mm (0.98 to 39.37 in). Standard diameter is 45 mm (1.77 in). Each heat sink features a black anodized finish that provides corrosion resistance, electrical insulation, and improved thermal performance. All heat sinks within the series are RoHS compliant.

GlacialPower Announces Two New Drivers For 9-57 V Indoor LED Lighting

GlacialPower, a division of Taiwanese technology manufacturer, GlacialTech Inc., is pleased to announce two new GlacialPower LED drivers for constant voltage (CV) and constant current (CC) LED lights – GP-RS26P and GP-RS35P – available in several options ranging from 9 V DC to 57 V DC. The drivers are also available with a 3 in 1 dimming (1-10 V/PWM/Resistor) function.

Optionally, both new LED drivers offer GlacialPower's 3 in 1 dimming function

Features:

- Class 2/II plastic housing design
- Double insulated wiring
- Universal AC input 90~305 VAC
- Constant current and constant voltage operation
- Built-in active PFC (Power Factor Correction) function
- 3 in 1 dimming function (optional)
- Protection: OVP / SCP / OTP
- IP67 approved
- Operation from -20°C ~50°C at full load

Both of the drivers are ideal for any indoor LED lighting solutions, as the robust IP67 approved plastic housing protects the drivers from possible dust or water damage such as rusting. In addition, the double insulated wiring design ensures that if the wire is pulled externally, the strain relief bushing to the circuit board will not be exposed, preventing possible electricity leakage.

The GP-RS26P and GP-RS35P LED drivers offer a range of different options for indoor LED lighting needs. The output voltage of the two LED drivers range from 9 V DC to 57 V DC. The GP-RS26P LED drivers deliver up to 25.2 W and the GP-RS35P LED drivers up to 36 W of power to the LED. For LED driver producers — safety standard certification UL8750 Class 2/II has been applied for and is currently under review, however these drivers' specifications fully satisfy the criteria of the UL1598 fixture safety standard. These specifications combined with a two stage design that prevents flicker, as well as durable plastic housing and cables makes these drivers excellent options for practically any constant voltage and constant current LED indoor lighting needs.

These two new LED drivers offer safe and reliable power. In addition to the IP67 approved plastic housing the drivers have three different protections: Over Voltage Protection (OVP), Short-Circuit Protection (SCP) and Over-Temperature Protection (OTP).

GlacialPower's R&D team developed these LED drivers with the aim to eliminate the need for electronic transformers and to provide more energy-saving and environmentally-friendly LED products. GlacialPower's LED driver technology is expected to lead a new trend in innovation and become an essential feature for all LED lighting products. Besides the GP-RS26P and GP-RS35P, GlacialPower also offers the GP-RS45P and GP-RS60P for higher wattage applications. ■

Mean Well Extends Its HVG(C) Series with the HVG(C) 65

After the launch of the high input voltage LED power supplies~ HVG(C)-100/150 series, MEAN WELL announced the extension of its HVG(C)-65 (65W) series. Featuring with 180~528VAC wide range AC input, HVG(C)-65 series are not only fit for the general 230 VAC main input, but also can be operated under 277 / 347 / 440 / 480 VAC input in USA, Canada, and Japan.

Designed with constant voltage (C.V.) plus constant current (C.C.) mode, HVG-65 series are low voltage output models (54 VDC max.) while HVGC-65 are high voltage output models (186 VDC max.).

Mean Well's HVG(C)-65 LED driver is the latest member of the HVG(C) series

Both series are built-in two-stage PFC function, so that they can meet the harmonic current limitation per EN61000-3-2 Class C (>60% load), and they also fulfill PF>0.9 if loading over 60% (>70% load under 480 VAC). In addition, they possess 4 kV surge immunity (EN61000-4-5) ability which complies with the requirements of lighting industry.

Features:

- Wide range input 180~528 VAC
- Aluminum case and potted by glue, comply with IP65 / 67
- Output voltage and current adjustable
- Meet 4 kV surge immunity level (EN61000-4-5)
- Built-in active PFC function
- 90.5% high efficiency
- Cooling by free air convection
- Protections: Short circuit / Overload / Over voltage / Over temperature
- Certificates: HVG-65: UL / CUL / FCC; HVGC-65: UL / CUL / ENEC / CB / FCC / CE
- Dimension(LxWxH): 189 x 61.5 x 36.8 mm
- 5 years warranty

HVG(C)-65 has three options (A/B/D type) in different mechanisms and functions for your selection. In A type of HVG-65, users can adjust DC current range from 60% to 100% and output voltage ±10% by removing the rubber stopper on the cover. In A type of HVGC-65, users can adjust DC current range from 60% to 100%; B type models equip with three-in-one dimming function (0~10 VDC, PWM, resistance) while D type models (optional) equip with "multiple stage timer dimming" function that can be customized by request. In addition, these new series possess up to 90.5% of high efficiency, so they can be cooled by free air convection from -40°C to +70°C ambient temperature.

In order to fit in with the outdoor harsh environment, aluminum case with fully potted by glue (IP65/67 structure) are also designed in these new power units. Beside standard functions of protections for short circuit, over voltage, overload, and over temperature, HVG(C)-65 comply with global certificates of lighting regulations. They are very suitable for LED lighting applications that require high input voltage range. ■

Mean Well Introduces New Boost Type DC/DC Constant Current LED Drivers

After the launch of the DC/DC Buck type LED converters (LDD series), Mean Well further introduced the new Boost type DC/DC constant current LED drivers~LDH-45 series. The new drivers possess 9~18V DC input for LDH-45A-X models and 18~32 VDC input for LDH-45B-X models.

Mean Well's new LDH-45 series possess high efficiency up to 95%

Features:

- Step-up design
- Constant current (C.C.) mode output
- 95% high efficiency
- Built-in EMI filter
- Built-in PWM and Analog dimming function
- Cooling by free air convection
- Working temperature: -40~+70°C
- Protections: Short circuit, over voltage, input under voltage
- UL94-V0 level plastic case
- Approval: CE
- Package type: Pin style and Wire style
- 3 years warranty

Both series feature with 350 mA / 500 mA / 700 mA / 1050 mA output current. In addition, LDH-45 series are built-in PWM and Analog dimming function, thus, the ON/OFF remote control and the output current adjustment can be realized by connecting the external PWM signal or 0.25~1.3 VDC analog voltage, which can satisfy the demand of various energy-saving dimming design of lighting fixtures.

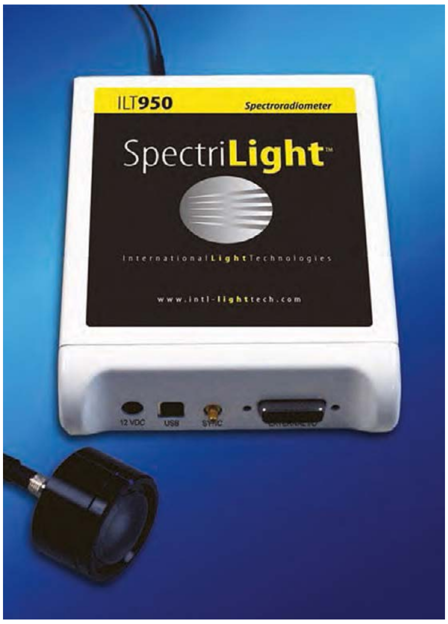
LDH-45 series possess up to 95% of extremely high efficiency and can operate between -40~+70°C of ambient temperature by only free air convection. All series are potted for providing better ability of heat dissipation, anti-dust, and anti-moisture. Furthermore, they offer two kinds of input/ output packages like pin style or wire style for selection. Built-in EMI filter, these LED drivers comply with EMI requirements per EN55015 lighting regulation without connecting any external EMI restraint components. Other standard functions include short circuit, over voltage, and input under voltage protections. Suitable applications include street lighting, landscape lighting, tunnel lighting, household lighting, and all kinds of off-grid LED garden lights or LED street lights that powered by solar charger. ■

ILT Introduces New Portable Spectroradiometer Systems

New ILT950UV / improved ILT950 is now equipped with a higher pixel CCD array for improved performance including nearly 50% more sensitivity and higher S/N ratio increased from 200:1 to 300:1 with larger quantum well depth. This most cost-effective, fully integrated, CCD-based spectroradiometer family is available with ISO17025 accredited calibration.

The ILT950 is equally at home on the production floor as well as the laboratory combining high performance, accuracy, ease of use, and a wide array of features all in a rugged, compact, and portable design.

The excellent performance of the ILT950 has been improved even further with the addition of a new machined optical bench for reduced stray light and improved thermal stability for 2014.



The ILT950 comes standard in two ranges, ILT950 with a spectral range of 250-1050 nm and the ILT950UV with 200-450 nm

Main Features:

- Two Versions
- ILT950: 250-1050 nm
- ILT950UV: 200-450 nm
- NIST-Traceable/ISO17025 Accredited Calibration
- ILT950 Applications include characterization of solar simulation
- Accelerated weathering
- Photostability testing
- UV curing systems
- Photobiology and photochemistry
- LED illumination and color analysis

The new higher pixel SONY CCD array is upgraded for improved performance including nearly 50% more sensitivity over the entire spectral region, and higher S/N ratio increased from 200:1 to 300:1 with larger quantum well depth. This, combined with the new software features included in our powerful SpectriLight III, makes the ILT950 a top performer in the CCD array spectrometers available on the market.

To make ordering easy, ILT offers pre-configured complete measurement systems which include everything you will need to take accurate, calibrated light measurements:

- ILT950 Remote Optic Irradiance System includes the ILT950 spectrometer, FFOSMA2UV1000 2 meter long fiber optic, W2 wide eye diffuser, single source calibration from 250-1050 nm, SpectriLight III software, Tripod and carrying case. (For UV use: ILT950UV version with W diffuser and dual source cal 200-450 nm)

- ILT950CR Clean room "NO UV" verification system includes the ILT950 spectrometer, WD direct mount diffuser, Short pass 500 nm filter, Dual source calibration from 250-500 nm, SpectriLight III software and carrying case. Used to verify the UV blocking filters use in clean room environments..
- ILT950RAA Colorimetry/Right Angle irradiance system includes the ILT950 spectrometer, SC600 600 um fiber optic light guide with RAA4 right angle diffuser, Single source calibration from 250-1050 nm, SpectriLight III software and carrying case. With the new enhances colorimetry features such as Metamerism calculation this is an excellent configuration designed for testing lamp output in light booths used in the graphic arts industry. (For UV use: ILT950UV version with RAA4 diffuser and dual source cal 200-450 nm)
- ILT950P Power/Flux Measurement System includes the ILT950 spectrometer, FFOSMA2UV1000 2 meter long armored fiber optic, INS125 5" integrating sphere, Single source calibration in Watts/Lumens from 250-1050 nm, SpectriLight III software, Tripod and carrying case. For total flux measurements of LED's and many other types of miniature lamps. (For UV use: ILT950UV version with INS125 integrating sphere and dual source cal 200-450 nm)
- ILT950R Luminance/radiance Measurement System includes the ILT950 spectrometer, FF0600SC 600 micron 1 meter long fiber optic, R3 Spot luminance optic, A706 light source, Single source calibration for radiance/luminance from 250-1050 nm, SpectriLight III software, tripod and carrying case. (Not recommended for dual source cal/UV measurements)

The new spectroradiometers come with ILTs SpectriLight™ III control and analysis software, a LabView™ based software package for Windows that allows acquisition of spectral and color data. Analysis of the data is calculated instantly within the same program - no exporting required.

SpectriLight™ III provides easy setting of all operating controls of the ILT950 spectrometer with an integrated data analysis package making your spectral analysis fast and simple. Wavelength range, integration time, scan average and other controls can be easily set through pop up windows, menus and toolbars. Absolute Irradiance and chromaticity are calculated instantly.

Cree Expands LED Bulb Portfolio with an A19 Size 75-Watt Replacement Bulb

Cree, Inc. marks another milestone in LED lighting with the introduction of the new Cree LED 75-watt Replacement Bulb. The game-changing Cree LED Bulb now shines even brighter with the 75-watt option. The revolutionary bulb looks and lights like a traditional incandescent bulb but it uses 82 percent less energy and is designed to last 25 times longer. Conceived from the start to make quality LED lighting accessible to all, the new Cree LED Bulbs retail for $23.97 – delivering consumers a higher output LED bulb in a standard form factor that's priced less than competing 75-watt replacement LED bulbs.

Cree's new 75-Watt replacement bulb delivers more light in the convenient A19 size with unmatched energy savings

"Driving to 100-percent adoption of LED lighting requires continuous innovation to meet even more customer needs," said David Elien, Cree vice president, marketing and business development. "The new Cree LED 75-watt Replacement Bulb gives consumers even more options and yet another reason to switch to LED lighting."

Cree LED Bulbs are the ideal replacement for energy-wasting 75-watt incandescents and compromise-laden CFL lighting. Boasting the same shape and size as the popular A19 traditional bulb, the Cree LED 75-watt Replacement Bulbs can be placed in most lighting fixtures in the home. Unlike many low-priced LED bulbs, Cree's omni-directional LED bulbs turn on instantly and are easily dimmable with most standard incandescent dimmers. The high-performance bulb is illuminated by Cree LED Filament Tower™ Technology and provides a compact optically balanced light source within a real glass bulb to deliver consumers the warm light they love and want.

Green Creative's Crisp Series High CRI Lamp Is the First LEDA Tier 2 Qualified MR16 Lamp

Green Creative, the commercial grade LED lighting manufacturer proudly announces its MR16 7W High CRI lamp as being the only Tier 2 qualified MR16 lamp in the Energy Solutions LED Accelerator Program in California. Featuring a typical CRI 95, R9 95 and R13 95, the MR16 7W High CRI lamp is perfect for applications that demand excellent color rendering.

Green Creative's new LEDA certified MR16 7 W High CRI lamp has exceptional R9-R14 values

Unlike most high CRI LEDs, the Crisp Series MR16 delivers outstanding color accuracy without sacrificing efficiency. With a typical 465 lumens, this 1:1 halogen form factor lamp has an extremely high 66 lpw efficacy. This is over 50% more efficient than any other high CRI 45-50 W replacement MR16. This innovative lamp has already been selected by the Illuminating Engineering Society to appear in the prestigious 2013 Progress Report.

Funded through PG&E, the California LED Accelerator Program (LEDA) works with LED manufacturers and multi-site PG&E customers, primarily in the retail, grocery, restaurant and museum/art gallery sectors, by providing incentives for the replacement of traditional lighting sources with the latest in high-performance LED products. In addition to providing incentives for high-volume retrofit projects, LEDA also offers lighting energy audits, economic analysis, product demonstration, technical product selection, and product specification assistance.

In order to qualify for the LEDA Program, lamps must meet a set of rigorous specification requirements. The lamps are then separated into two tiers, with Tier 2 products achieving a higher performance standard than Tier 1. Green Creative has the most qualified products on the PG&E LEDA list, with a combination of ten PAR and MR models.

The MR16 7W High CRI lamp is the only Tier 2 qualified MR16 on the list which features products from over ten participating manufacturers. This lamp exceeds LEDA's CRI 90 and 50 LPW efficacy requirements, both of which are more stringent than Energy Star. Green Creative'S MR16 7 W High CRI LEDA qualified lamp model comes in 2700 K CCT and a NF beam angle.

"It's impressive that we have hit the Tier 2 mark with our MR16," says Green Creative's Utility Program Manager, Erik Bluvas. "The Tier 2 standards were designed to push the market, and I don't think PG&E expected a manufacturer to reach it so soon. The color quality levels are also exceptional. In my years of field auditing there has always been a strong demand for this, and now Green Creative has clearly set itself apart from the competition with this high CRI MR16." ■

ALT Announced New High-Wattage Floodlights & Street Lights

On the first day of the 2013 Hong Kong International Lighting Fair, Aeon Lighting Technology (ALT) announced the new development of several LED lighting products for specialized markets, including those engineered for extreme environments and high wattage LED floodlights and streetlights.

ALT's new Floodlights can replace HID luminaires up to 1,000 W, delivering 42,000 lm

Introducing All New ALTLED® Lighting

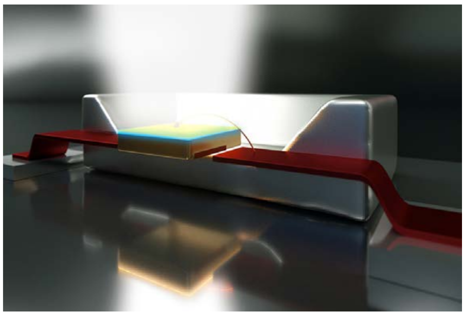
ALT announced the T200 and T500 floodlight, brightness reaching 42,000 lumens. These high wattage LED floodlights are expected to completely replace traditional HIDs that are over 1,000 watts. Completely waterproof, dust-proof, and anti-corrosion, the T200 and T500 are rated IP68 and have the option of installing an anti-fall device, which further guarantees safety for industrial usage. ALTLED® street lights are also IP68 and have passed the salty-spray test; a new feature is they have a CRI of 95, which is unheard of in the lighting industry. The new ALTLED® street lights not only provide uniform brightness for improved nighttime vision, but also bring out the true colors of the objects and environments illuminated.

ALT developed a new 4-inch 20 watt downlight with a brightness of up to 2,000 lumens (true white). The product aims to replace traditional halogen downlights. The ALTLED® downlight utilizes ALT's patented heat dissipation technology for efficient heat transfer which ensures LED stability and lengthens product life. This newly developed downlight has an option of CRI 98, exceeding industry standards. CRI and efficiency are trade-off factors, but ALT has managed to maintain high efficiency with a wide range of color temperatures between 2,200 K and 6,500 K. As with all ALTLED® products, the downlight also comes with a 3-year warranty.

Aiming for a luxury niche market, a special edition of gold MR16 and gold chandeliers were displayed during the product launch. Paired with 2,200 K color temperature, these gold and luxurious MR16s and chandeliers can create a golden-colored ambience for a more regal effect. Furthermore, ALT has developed a 10 watt Grande chandelier light which has lumen output up to 1,200 lumens. The Grande chandelier light has an option of 2,200 K or CRI 98, which is perfect for oversized chandeliers in grand halls, mansions and six or seven-star hotels. The luxurious section is tailored for those who have an eye for beauty but are also environmentally conscious. ■

UC Santa Barbara: Optimizing Phosphors Using Simple Guidelines Improves Efficiency of Solid-State Lighting

By determining simple guidelines, researchers at UC Santa Barbara's Solid State Lighting & Energy Center (SSLEC) have made it possible to optimize phosphors - a key component in white LED lighting - allowing for brighter, more efficient lights.



This illustration demonstrates how bright blue LED light, shone through its complementary yellow phosphor, yields white light

"These guidelines should permit the discovery of new and improved phosphors in a rational rather than trial-and-error manner," said Ram Seshadri, a professor in the university's Department of Materials as well as in its Department of Chemistry and Biochemistry, of the breakthrough contribution to solid-state lighting research. The results of this research, performed jointly with materials professor Steven DenBaars and postdoctoral associate researcher Jakoah Brgoch, appear in The Journal of Physical Chemistry.

LED lighting has been a major topic of research due to the many benefits it offers over traditional incandescent or fluorescent lighting. LEDs use less energy, emit less heat, last longer and are less hazardous to the environment than traditional lighting. Already utilized in devices such as street lighting and televisions, LED technology is becoming more popular as it becomes more versatile and brighter.

According to Seshadri, all of the recent advances in solid-state lighting have come from devices based on gallium nitride LEDs, a technology that is largely credited to UCSB materials professor Shuji Nakamura, who invented the first high-brightness blue LED. In solid-state white lighting technology, phosphors are applied to the LED chip in such a way that the photons from the blue gallium nitride LED pass through the phosphor, which converts and mixes the blue light into the green-yellow-orange range of light. When combined evenly with the blue, the green-yellow-orange light yields white light.

The notion of multiple colors creating white may seem counterintuitive. With reflective pigments, mixing blue and yellow yields green; however, with emissive light, mixing such complementary colors yields white.

Art to science:
Until recently, the preparation of phosphor materials was more an art than a science, based on finding crystal structures that act as hosts to activator ions, which convert the higher-energy blue light to lower-energy yellow/orange light.

"So far, there has been no complete understanding of what make some phosphors efficient and others not," Seshadri said. "In the wrong hosts, some of the photons are wasted as heat, and an important question is: How do we select the right hosts?"

As LEDs become brighter, for example when they are used in vehicle front lights, they also tend to get warmer, and, inevitably, this impacts phosphor properties adversely.

"Very few phosphor materials retain their efficiency at elevated temperatures," Brgoch said. "There is little understanding of how to choose the host structure for a given activator ion such that the phosphor is efficient, and such that the phosphor efficiency is retained at elevated temperatures."

However, using calculations based on density functional theory, which was developed by UCSB professor and 1998 Nobel Laureate Walter Kohn, the researchers have determined that the rigidity of the crystalline host structure is a key factor in the efficiency of phosphors: The better phosphors possess a highly rigid structure. Furthermore, indicators of structural rigidity can be computed using density functional theory, allowing materials to be screened before they are prepared and tested.

This breakthrough puts efforts for high-efficiency, high-brightness, solid-state lighting on a fast track. Lower-efficiency incandescent and fluorescent bulbs - which use relatively more energy to produce light - could become antiquated fixtures of the past.

"Our target is to get to 90 percent efficiency, or 300 lumens per watt," said DenBaars, who also is a professor of electrical and computer engineering and co-director of the SSLEC. Current incandescent light bulbs, by comparison, are at roughly 5% efficiency, and fluorescent lamps are a little more efficient at about 20%.

"We have already demonstrated up to 60% efficiency in lab demos," DenBaars said.

Photometry Standardization Developments for OLEDs and LEDs

Since the introduction of Solid State Lighting the challenges for manufacturers to provide constant high quality light have changed completely. Compared to conventional light sources, many aspects of the characteristics of an LED light source are different. Never before have the characteristics between light sources of the same type differed as much as they do now. Never before was the influence of external parameters as significant for a measurement result as it is now. For this reason, the review of existing standards and, when necessary, their revision, must be done stringently. Tony Bergen, Technical Director of Photometric Solutions International and Secretary of CIE Division 2, and Peter Blattner, Head of the Photometric Laboratory at the Swiss Federal Institute of Metrology and Director of CIE Division 2, introduce the challenges and report about the ongoing work and the expected revision of TC2-71 - the most important measurement standard.

Solid state lighting (SSL) devices such as LEDs and OLEDs have rapidly developed in recent years and are now rivalling traditional light sources as the predominant choice of lighting type for new lighting installations. Their efficiency, versatility and robustness offer an incredible range of benefits and opportunities. But with these opportunities also come challenges:

- Challenges with testing and measurement
- Challenges with harmonization and standardization
- Challenges with product quality and reliability

The International Commission on Illumination (CIE) has risen to these challenges and will soon be publishing an International Standard Test Method for photometry of LED Lamps, LED Luminaires and LED Modules. Additionally, the CIE has other Technical Committees working on various areas relating to testing and measurement of SSL devices. This article looks in detail at some of the issues relating to the photometry of SSL products and the work being done by the CIE solving these challenges.

Introduction of CIE

The International Commission on Illumination – also known as the CIE from its French title, the Commission Internationale de l´Eclairage – is devoted to worldwide cooperation and the exchange of information on all matters relating to the science and art of light and lighting; color and vision; photometry; lighting applications; photobiology; and image technology. With strong technical, scientific and cultural foundations, the CIE is an independent, non-profit organization that serves member countries on a voluntary basis.

Since its inception in 1913, the CIE has become a professional organization and has been universally accepted as representing the best authority on the subject and as such is recognized by ISO as an international standardization body for the field of light and lighting. The Commission is organized in seven divisions covering all topics of light and lighting. Division 2 deals with aspects of the physical measurement of light and radiation. It identifies measurement problems associated with new sources, detectors and materials and gives best practice guidance on measurement techniques and the application of these techniques in practical situations. The new lighting technologies also have an impact on measurement procedures and instrument requirements.

Measurement Issues with LEDs

LEDs have many interesting properties. They are highly efficient, can be modulated, may change their spectral behavior and allow a high degree of freedom in the geometric design of lamps and luminaires. The measurement of the photometric parameters such as luminous flux or

CIE DIVISION 2 TECHNICAL COMMITTEES AND THEIR ACTIVITIES

Beside the technical committees cited in the article about developing an international standard test method for LED lighting products, there are several additional activities going on. The other Division 2 TCs are currently working specifically on different aspects of LED photometry. Some TCs are not specifically relating to LEDs but also contribute with very relevant work for the Solid State Lighting community.

TCs Relating to LED Photometry

TC2-50: Measurement of the Optical Properties of LED Assemblies

(Chair: Richard Distl, DE)

TC2-50 is working on a technical report to give recommendations for laboratory measurements of optical properties of LED assemblies such as LED modules and LED light engines. This includes environmental conditions, power supply and control equipment, and pre-measurement precautions. It will give guidance for measurement of Luminous Intensity; Luminous Intensity Distribution; Total Luminous Flux; Partial Luminous Flux; and Luminance.

TC2-63: Optical Measurement of High Power LEDs

(Chair: Yuqin Zong, US)

The measurement results of high-power LEDs depend strongly on their thermal conditions. In order to achieve reproducible results with small uncertainties it is critical to accurately set and control the junction temperature of an LED during the time for optical measurement. This TC is working on a technical report to describe the methods and procedures for measurement of high-power LEDs under DC operation to acquire photometric, colorimetric, and radiometric quantities at a specified junction temperature.

TC2-64: High speed Testing Methods for LEDs

(Chair: Günther Heidel, DE)

The report to be produced by TC2-64 is intended to extend CIE 127:2007 (Measurement of LEDs) for precise, high speed testing of large numbers of single LEDs, including high-power LEDs. It is primarily focused on the measurements during LED production, which is where the LEDs are binned. It is being prepared in collaboration with TC 2-63. The fact that all optical and electrical parameters of solid state light sources are highly dependent on the temperature makes some definitions for the test environment and driving conditions necessary to get results which can be reproduced in other laboratories with low uncertainty, and can be used to calculate optical values for the later applications.

TC2-68: Optical measurement methods for OLEDs used for lighting

(Chair: Thorsten Gerloff, DE)

TC2-68 is producing a Technical Report on the measurement methods of the optical properties and the terminology of OLEDs used for lighting. This includes effects such as temperature, orientation of operation and current density and measurement effects including uniformity (homogeneity) and a comparison of measurement in integrating sphere with goniophotometry/goniospectroradiometry. It is currently working on a technical note for terms and definitions that are hoped to be released in late 2014.

TC2-75: Photometry of Curved and Flexible OLED and LED Sources

(Chair: Hsueh-Ling Yu, TW)

TC2-75 is working on preparation of a CIE recommendation on methods for characterization of the photometric and colorimetric quantities of curved and flexible sources: especially for OLEDs and LEDs. The aim is to make measurements accurate and repeatable and to include measurement traceability. It includes aspects such as terminology; luminance; uniformity; luminous flux; color; viewing angle; and reflectance.

TC2-76: Characterization of AC-Driven LED Products for SSL Applications

(Chair: Pei-Ting Chou, TW)

TC2-76 is preparing a technical report dealing with methods and procedures for testing and calibration laboratories to characterize AC-driven LEDs for physical quantities related to lighting including electric, photometric, colorimetric, and radiometric quantities. It is focused on those properties influenced by the effect of flicker, and there is also a corresponding reportership (i.e.: a detailed study) within CIE Division 2 that is looking at flicker measurement and a flicker index study on solid-state lighting.

TCs Relating to Measurement Instruments and Laboratory Practices

TC2-51: Calibration, Characterization and Use of Array Spectroradiometers

(Chair: Richard Young, GB)

TC2-51 is working on a technical report for the calibration of detector array spectroradiometers, such as CCD spectroradiometers, primarily for the determination of colorimetric and photometric quantities. It includes performance characteristics, evaluation of these characteristics, calibration methods and guidance in the application of methods for the determination of uncertainty.

TC2-59: Characterization of Imaging Luminance Measurement Devices

(Chair: Udo Krueger, DE).

TC2-59 is preparing a Technical Report on methods for the characterization of imaging luminance measurement devices (i.e. CCD cameras used to measure luminance). These devices are important for applications such as measurement of the luminance distribution of LEDs and LED arrays; measuring the uniformity of OLED panels; glare evaluation; and measuring the luminance of lighting installations such as roadway and tunnel lighting.

TC2-62: Imaging-Photometer-Based Near-Field Goniophotometry

(Chair: Walter Steudtner, DE)

This TC is working on a CIE recommendation on the methods for characterization and calibration of imaging-photometry-based near-field goniophotometers and for determination and conversion of photometric data of lamps and luminaries for both near-field and far-field applications.

TC2-72: The Evaluation of Uncertainties in Measurement of the Optical Properties of Solid State Lighting Devices, including Colored LEDs

(Chair: Richard Young, GB)

The CIE recently published CIE 198:2011 Determination of Measurement Uncertainties in Photometry, which provides guidance on how to model measurement procedures in a measurement equation, combine uncertainties in a budget and convert to the presentation of expanded uncertainty and it has a wide selection of examples. TC2-72 is working on expanding the supplements of CIE 198:2011 to include further principles and examples for evaluation of the uncertainties associated with the measurement and testing of LEDs and other solid state lighting devices. Examples include distribution photometry, spectral measurement and derived quantities, goniospectroradiometry and other priority measurements as advised by industry.

TC2-74: Goniospectroradiometry of Optical Radiation Sources

(Chair: Jiangen Pan, CN)

LEDs frequently display a spatial and angular non-uniformity of chromaticity – i.e., they change color with angle. So it is usually not sufficient to take a single color measurement in a single direction and assume it to be representative of the total light source like could often be assumed with other traditional light sources such as incandescent and fluorescent sources. Thus goniospectroradiometry is becoming increasingly important in characterization of SSL devices. This TC will produce a technical report on goniospectroradiometry, including measurement principles for evaluating radiometric, photometric and colorimetric quantities and related traceability.

TC2-78: Goniophotometry of Lamps and Luminaires

(Chair: Tony Bergen, AU)

This TC is updating CIE 070:1987, CIE 121:1996 and the relevant parts of CIE 084:1989 relating to goniophotometry. It will produce an up-to-date technical report on goniophotometry including the absolute goniophotometry of LED lamps and luminaires.

TC2-79: Integrating Sphere Photometry and Spectroradiometry

(Chair: Dong-hoon Lee, KR)

TC2-79 is updating the relevant parts of CIE 084:1989 Measurement of Luminous Flux that relate to integrating sphere photometry and spectroradiometry. It will take into account current day techniques, practices, test geometries and light sources.

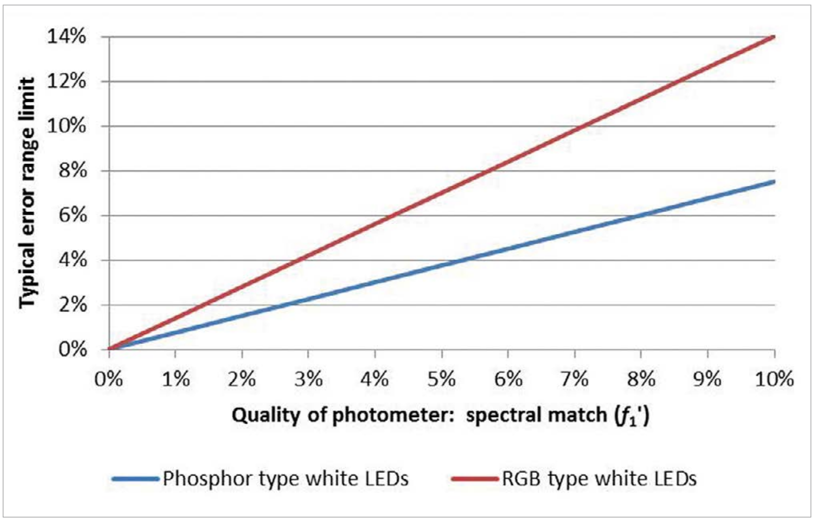


Figure 1:
Typical errors that could be encountered when measuring white LEDs as a function of the quality of the photometer

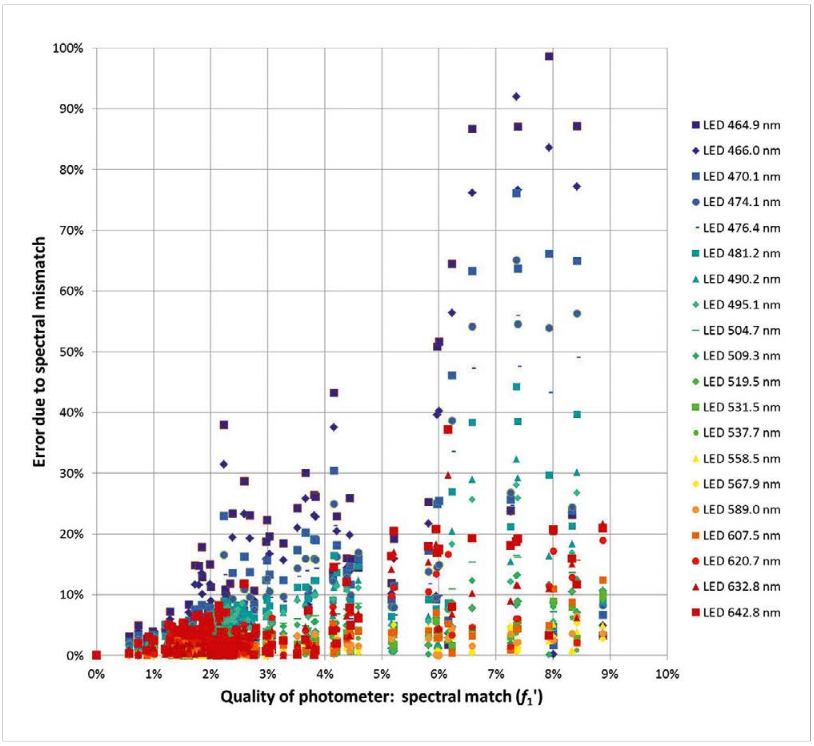


Figure 2:
Example of errors encountered for 120 photometers of different quality when used to measure a variety of single-color LEDs

luminous intensity distributions isn't fundamentally different to traditional light sources. However, several aspects need closer considerations.

Spectral aspects

All photometers, for example, illuminance meters (lux meters) and luminance meters, need to have a spectral responsivity which is the same as the "standardized" human eye – the relative spectral luminous efficiency function known as the V (λ) curve which is defined in CIE S010/E:2004. Deviations from this ideal spectral response results in what is referred to as spectral mismatch errors. Depending on the quality of the photometer, the match to the reference curve can range from very poor to very good.

For traditional white light sources, such as incandescent, fluorescent and HID lamps, the relative measurement error due to the spectral mismatch for very good photometers is typically less than 1%. For more general-purpose photometers this error is still typically less than 3%. The spectral distribution of LEDs, however, may be quite different from traditional sources. In particular it is possible to generate white using the RGB-technology, i.e. the light is emitted at three spectrally narrow wavelengths. For this type of white light source the error is about double to that of traditional white light sources.

CIE S023/E:2013 defines a quality index, f1', which is a measure of the spectral mismatch of a photometer to the V (λ) curve. An f1' of 0 is a perfect match (ideal and not achievable in practice) and a higher number indicates a poorer match. Generally speaking, an f1' < 1.5% is considered an excellent match and f1' < 3.0% is a very good match. While not directly a measure of error, a photometer's f1' can be used to have an idea of the magnitude of spectral mismatch error likely to be encountered in practice, as shown in Figure 1.

The situation is even worse for single-color LEDs as they emit light over one narrow spectral region only. Even for very good photometers, the error due to the spectral mismatch can be in the order of 10%, while for general-purpose photometers the error can be more than 50%! This is shown in figure 2, where the error is shown for a range of photometers of different quality and each with a range of different colored LEDs.

Measuring the luminous flux of blue and red LEDs is therefore challenging and spectral mismatch corrections need to be made according to CIE S023/E:2013. For this purpose the spectral distribution of the light source and the spectral response of the photometer need to be known.

Temporal aspects

The light waveforms of LED lighting and signaling products are often deeply modulated depending on the design of the LED control gear, for example, the use of pulse width modulation. As the rise and fall time of LEDs is very short, the light output is effectively fluctuating very quickly between fully on and fully off. Care has therefore to be taken when measuring these devices. The integration time should be considered according the modulation period of the light source. This is particularly true for imaging luminance measurement devices (luminance cameras) and spectroradiometers where very short integration times are possible. If by coincidence the device measures during the “off” time of the pulse then wrong results are possible.

Thermal aspects

It is well known that the photometrical performance of LEDs depends on their junction temperature. The junction temperature depends on many aspects including the injected electrical current, the thermal connection to the heat sink, the thermal capacity and inertia of the heat sink, etc. It has been found that depending on the design the thermal conductivity of the lamp/ luminaire holder can also have an influence on the junction temperature and thus also the luminous flux of the LEDs. Laboratories also need to be careful that they don’t attach any thermally conductive mechanical support structure to the heat sink because that may also affect the output of the LED device under test.

Other aspects

In addition to the points mentioned above, many new quantities have to be determined for LEDs. In particular, spectral measurements will increase significantly in the coming years as important quantities such as the color rendering indices or correlated color temperatures need be determined. CIE Division 2 addresses these points by drawing up technical recommendations and measurement standards.

Development of an International Standard Test Method

Currently there is no single international standard test method for photometry of SSL devices. This creates trade barriers and difficulty in comparing results obtained for testing at different laboratories. In response to this deficiency, in 2011 CIE Division 2 established a new Technical Committee (TC) to develop an International Standard Test Method for LED Lamps, Luminaires and Modules. This new TC, TC2-71, is chaired by Yoshi Ohno (US) and its aim is to develop a unified global Standard for harmonization of testing of LEDs and SSL products.

TC2-71 has been developing the Standard in conjunction with CEN-TC169-WG7, and the Standard will be technically identical to the CEN Standard EN13032-4 which will be released soon. The TC comprises 37 members from 16 countries in 5 continents and has a good representation from different industry sectors such as public testing laboratories; LED/lighting manufacturers; laboratory test equipment manufacturers; regulatory bodies; and National Measurement Institutes. In fact, the very diversity that is needed to ensure that all interests and stakeholders are represented itself creates difficulties: the TC has needed to balance different expectations. Aspects that have caused the greatest discussion include whether or not test parameter boundary conditions should be imposed; the stringency of requirements for some test parameters; whether reporting of measurement uncertainty should be mandatory or not; and the possibility of including default uncertainty values for laboratories new to evaluation of measurement uncertainty.

TC2-71 has met in person four times: in South Africa; China; France; and Slovenia, as well as several online Webex meetings. Because the Standard is being developed in conjunction with CEN-TC169/WG7, several TC2-71 members from outside of Europe have also attended some of the CEN-TC169/WG7 meetings as observers when they have been discussing the standard. While there have been a large number of disagreements and revisions over the course of the development of the Standard, it is now nearing completion and has near-unanimous agreement amongst the TC members.

The Standard defines standard test conditions for operating the LED device under test. Some of these conditions have boundaries that take into account practical laboratory situations. For example, the standard condition for ambient laboratory temperature is 25°C, but in practice it is allowed to be in the range 25 ± 1°C. If the boundary condition is not met then a correction must be made to correct the measured value to the standard condition. For example, say a test is made with an ambient temperature of 23°C, which is outside the range 25 ± 1°C, then an additional test must be made (e.g. with the device in a temperature-controlled chamber) to correct the measured value to what it would be if the test were performed at 25°C. Likewise there are requirements for the properties of the electrical supply and electrical measurement equipment. For example, the test voltage at the supply terminals must be within ± 0.2 % of the rated circuit voltage for RMS AC or within 0.1% for DC.

In reflection of the increasing demand worldwide for measurement quality and accountability, the Standard also requires that all test results be accompanied by a statement of the uncertainty of measurement. To assist laboratories unfamiliar or inexperienced with this, a TC2-71 subcommittee is currently preparing a Technical Note that will provide guidance on the determination of uncertainties of measurement for photometry and spectroradiometry of SSL devices. Furthermore, the measurements must be traceable: all equipment must be properly calibrated and the traceability chain must be maintained back to a national laboratory (National Measurement Institute).

It is expected that the Standard will be published in draft form in the first half of 2014.

Uncertainties

As mentioned above, the CIE gives special attention to the evaluation of measurement uncertainty. This is for good reason, since the understanding of the measurement process has changed over the past two decades. It needs to be recognized that no measurement is exact. When a quantity is measured, the outcome depends on the measuring system, the measurement procedure, the skill of the operator, the environment, and many other effects. It is therefore an integral part of a measurement process that dispersion of the quantity value is determined and stated. It gives an indication of the quality of the measurement and measurement devices and allows people to judge if two measurements done by two different laboratories are compatible.

Measurement uncertainties play a central role in quality assessment and quality standards. In conformity assessment, a measurement result is used to decide if an item of interest conforms to a specified requirement typically defined through a tolerance interval. In order to minimize the risk of putting a product on the market which is outside the specification, the producers will define an acceptance interval which is smaller than the tolerance interval. In order to quantify the risk of wrong decisions the producer needs to know the uncertainty of the measurements that have been performed.

CIE Division 2 has published a fundamental document on measurement uncertainty evaluation in photometry (CIE 198:2011) and continues to generate guidelines and recommendations on practical aspects of measurement uncertainties.

Conclusion

We have seen in this article that Solid State Lighting devices pose significant challenges for photometry and spectroradiometry and that a lot of work is going on to create accurate, repeatable and transferrable measurements of a wide variety of types of these devices and their applications. Uncertainty of measurement and measurement traceability are becoming more and more important as there is greater emphasis on labs taking responsibility for their quality of measurement. The CIE continues to take a leading role in the development of these standards and testing methods. ■

Annotations:

All information in regard to the Standard is correct at the time of writing this article.

Many of the Technical Committees mentioned in this article will be meeting at the next CIE Division 2 annual meeting, which will be held in conjunction with the CIE 2014 "Lighting Quality and Energy Efficiency" conference in Kuala Lumpur, Malaysia in April 2014. For more information or to join one of these Technical Committees, please get in touch with your National Committee of the CIE or see www.cie.co.at.

New EC Regulation – How to Measure Directional Light Sources

In many ways LEDs are a game-changer for the lighting industry and even more so for the end-users. Especially the latter now need to deal with light intensity values like lumens and even candelas that are confusing for them. A new EC regulation regarding the measurement of directional light sources promotes lumens as the only value. Christian Krause, director of Viso Systems Aps, explains what this regulation means to manufacturers and gives an example.

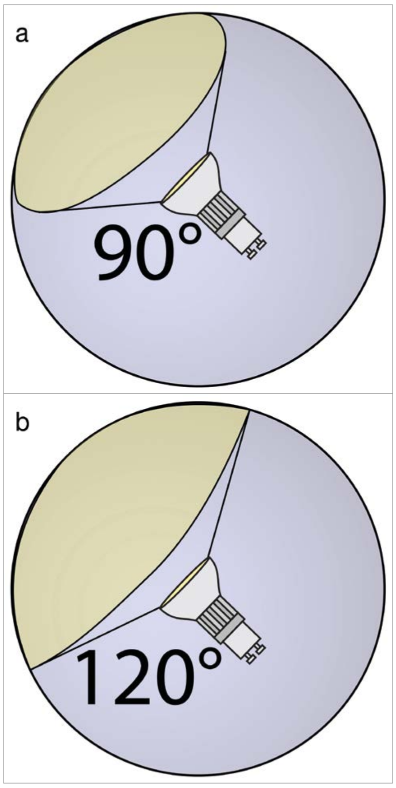


Figure 1: Measured in 90° cone (a), measured in 120° cone (b)

In September the EC introduced a new regulation as part of regulation No. 1194/2012 for directional light. This means that the common method of measuring light sources has to be reviewed because only luminous flux within a fixed beam angle, or more correctly – within a cone, should be defined; whereby the amount of luminous flux that exists inside the cone is what should be measured.

The new regulation means that the common measurement method using an integration sphere is rendered invalid for directional light sources, as directional light sources should be measured within a 90° or 120° cone instead.

Why Measuring Within a Cone

This new method of specifying the lumen value only within a cone might not make sense at first glance but one of the reasons for measuring directional light sources in this way is to make it easier for the end user to understand light output of directional light sources. Because the lumen value would be defined as a directional value, in a sense it would eliminate the need for the peak candela values.

Peak candela and beam angle values are currently the most common way of defining the intensity of a directional light source. But having two different light intensity values (lumen and candela) to represent the amount of light confuses many customers. Therefore, the new regulation promotes the lumen value as the only value.

Furthermore, you would expect a directional light source to be "directional". Therefore the light being measured within a 90° or 120° cone will give a more accurate lumen value because non-directional light would be discarded from the measurement and thus allow for a more accurate efficiency number to be calculated.

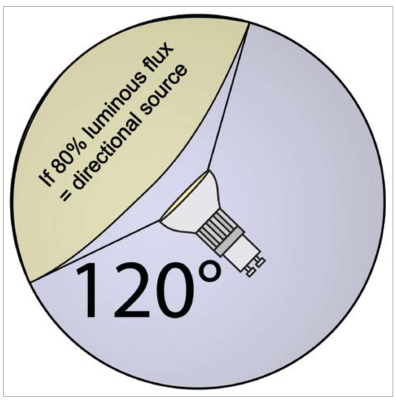


Figure 2: Definition of directional lamp according to the new EC regulation

What Is a Directional Lamp?

The definition of a directional light source in the regulation No 1194/2012 is defined as a “lamp having at least 80% light output within a solid angle of π sr (corresponding to a cone with an angle of 120°)”.

Calculating the EEI (Energy Efficiency Index)

Furthermore, the efficiency of a directional light source will no longer be labeled as “lumen/watt”, but rather, it will be replaced by the EEI (Energy Efficiency Index). This may cause confusion because the lower the EEI value, the higher the efficiency and vice versa.

The EEI is calculated based on measurements made in a 90° or 120° cone. Luminous flux / lumen should be measured within a 120° cone if the beam angle of the light source is equal or above 90°, otherwise luminous flux should be within the 90° cone.

The measured luminous flux [lm] is called Φ_{use}, indicating the useful lumens. For example is Φ90 is the amount of lumens in a 90° cone and Φ120 is the amount of lumens in 120° cone.

Table 1: **Correction factors to calculate P_{cor} for EEI = P_{cor} / P_{ref}**

Scope of the correction	Corrected power (P_{cor})
Lamps operating on external halogen lamp control gear	P rated × 1.06
Lamps operating on external LED lamp control gear	P rated × 1.10
Fluorescent lamps with a 16 mm diameter (T5 lamps) and 4 pin single capped fluorescent lamps operating on external fluorescent lamp control gear	P rated × 1.10
Other lamps operating on external fluorescent lamp control gear	P rated × $\frac{0,24\sqrt{\Phi use}+0,0103\Phi use}{0,15\sqrt{\Phi use}+0,0097\Phi use}$
Lamps operating on external high-intensity discharge lamp control gear	P rated × 1.10
Compact fluorescent lamps with a color rendering index ≥ 90	P rated × 0.85
Lamps with anti-glare shield	P rated × 0.80

In addition, the type of light source and how the driver gear is connected must be defined. A table (Table 1) is provided to select the right correction values for calculating the EEI.

P_{ref} can then be calculated as shown below:

For models with Φ use < 1.300 lumen:

$$P_{ref} = 0.88\sqrt{\Phi_{use}} + 0.049\Phi_{use}$$

For models with Φ use ≥ 1.300 lumen:

$$P_{ref} = 0.07341\Phi_{use}$$

The regulation is being launched in three steps:

- The first step took effect in September 2013
- The second step will be launched in September 2014
- The last step will come into effect in September 2016

For general LED spots such as the GU10, the requirements will be:

- Sept. 2013: EEI must be below 0.50
- Sept. 2014: EEI must be below 0.50
- Sept. 2016: EEI must be below 0.20

(This regulation may differ for non-LED light sources, e.g. halogen spots)

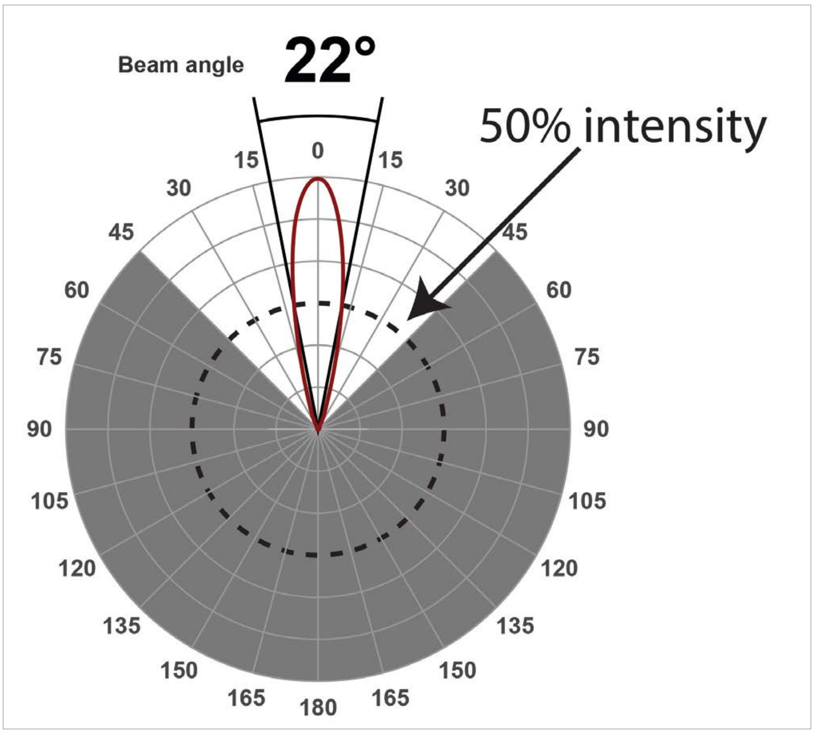


Figure 3: **Beam angle defined at 50% intensity**

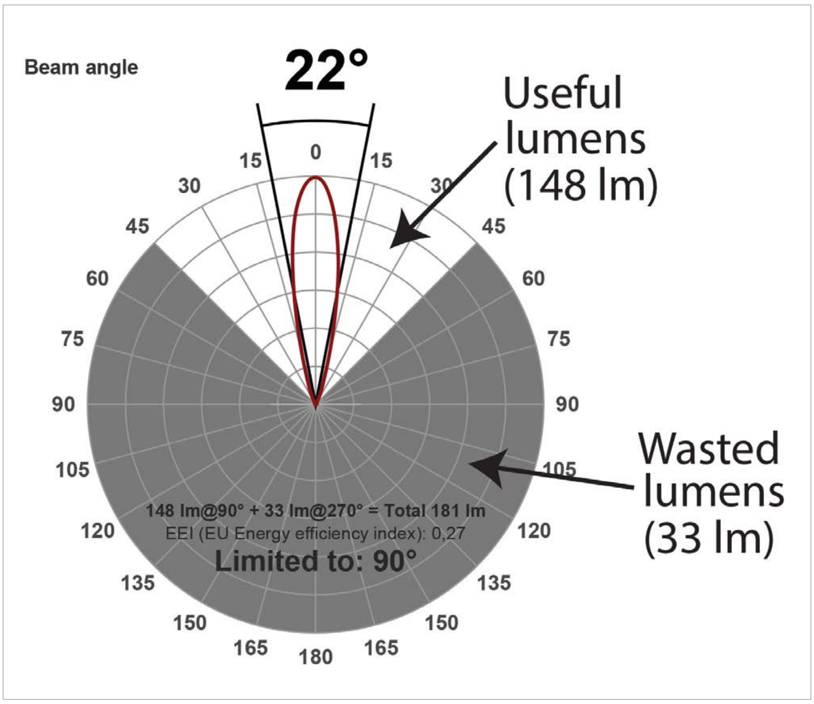
Defining the Beam Angle

To make the EEI calculation, is it necessary to measure the beam angle. The angular distribution from a goniometer measurement can be used to define the beam angle. The beam angle is defined when the light intensity has reached 50% of the peak value, as shown in figure 3.

Measurement Example GU10 LED

The measurement example of figure 4 shows a typical LED GU10 lamp measured using the EC standard. The lamp has been limited to a 90° cone as the beam angle is 22°. Furthermore, the measurement shows that quite a

Figure 4:
LED GU10 with EEI at 0.27



lot of light is wasted as 33 lumen out of a total of 181 lumen is considered wasted light. The optical design of the lamp is important to ensure a low amount of wasted light.

The result for the example lamp is as follows:

- Sept. 2013 EEI must be below 0.50, therefore the result is "OK"
- Sept. 2014 EEI must be below 0.50, therefore the result is "OK"
- Sept. 2016 EEI must be below 0.20, therefore the result is "FAILED"

The measurement shows that the GU10 lamp will fail EEI requirements in September 2016. This indicates that it will mostly be halogen type directional light sources that will be affected by the steps in 2013 and 2014 and LEDs will mostly be affected by the step in 2016.

Future of Measuring Light

New methods must be used to measure directional light sources. This raises a lot of questions as to how measurements should be made in the future since the conventional method of using an integration sphere will no longer meet the requirements.

At the same time, the integration sphere doesn't give a high accuracy value when measuring directional light sources. This is because a high amount of light concentrated into one location is not always completely equally distributed along the surface inside the sphere.

The use of a photo goniometer is therefore necessary to measure the angular distribution of light in order to define the amounts of luminous flux within the 90° or 120° cone.

Furthermore, goniometer measurements are also necessary for measuring the beam angle of the light source.

A goniometer typically measures the intensity of the light radiated at different angles. The intensity values are represented as candela values for a certain number of angles. These candela values can then be used to calculate the complete luminous flux of a lamp, eliminating the need for the integration sphere to measure luminous flux / lumen.

Adding a spectrometer to a goniometer system would basically mean measuring all light source photometric data including CRI, color temperature, color deviation and much more. This would make it possible to eliminate the integration sphere altogether.

LED light sources also have more uniform light distribution compared to the old-fashioned tungsten source. This means that even fewer measurements are necessary to make sufficient accurate measurements, thus making goniometer measurements competitive and fast compared to previous methods.

Conclusion

There is no doubt that the new regulation introduced by the EC might raise a lot of questions by lighting manufacturers but new innovations will also change the way light is being measured. This will spur new light measurement technologies, making it easier and faster to measure light by using smarter goniometer systems in the future.

QFN LED FEATURES

EMC lead frame,
Small size, high power,
Max Ta:105℃,Typical R_{th}:10℃/W.

QFN-2835 series 1W

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QFN-3030 series 1W、2W

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About Wireless Standards for Smart Lighting

Smart Lighting is an increasingly important issue, clearly bolstered by the maturation of LED lighting. Both wired and wireless controls are available with each based on very different and often incompatible technologies. This confuses consumers and curbs market introduction. LED professional talked with Simon den Uijl, Secretary General at The Connected Lighting Alliance, about their first proposal, technologies, future plans and strategy to endorse the proposed wireless standards.

LED professional: TCLA is a relatively young organization. Could you please give us an idea of why TCLA was founded, why it is necessary to have another lighting organization, and what the mission and goals of TCLA are?

Simon den Uijl: TCLA was founded in August 2012. It was established when six leading lighting and controls companies realized that LED lighting could benefit from smart controls options and especially wireless controls. They also found that the framework conditions were not ideal.

There are currently different several incompatible wireless connectivity standards being implemented in lighting products. Due to these different "ecosystems", the industry is facing the problem of becoming fragmented and the user is uncertain which system to choose (Figure 1).

TCLA aims to minimize these risks by proposing and promoting wireless connectivity based on an open standard. The open standard is very important because it is developed in a cooperative process and any party that wants to use it can. Meanwhile 20 members are supporting these goals.

LED professional: Initially TCLA announced its proposal for residential lighting. Why is TCLA focusing on this area?

Simon den Uijl: The TCLA members saw the biggest need and benefits for a wireless infrastructure in the residential area where it could offer new functions and opportunities for consumers. But in order to be accepted in this market a common standard and interoperability are required.

LED professional: Can you name the benefits and reasons that influenced the decision to focus on the residential area in more detail?

Simon den Uijl: Among the exciting and beneficial new functionalities are easy switching, dimming, colors changes and making group color settings. But there are also value added benefits like reduced energy consumption or integration into the complete home automation as well as reduced installation effort.

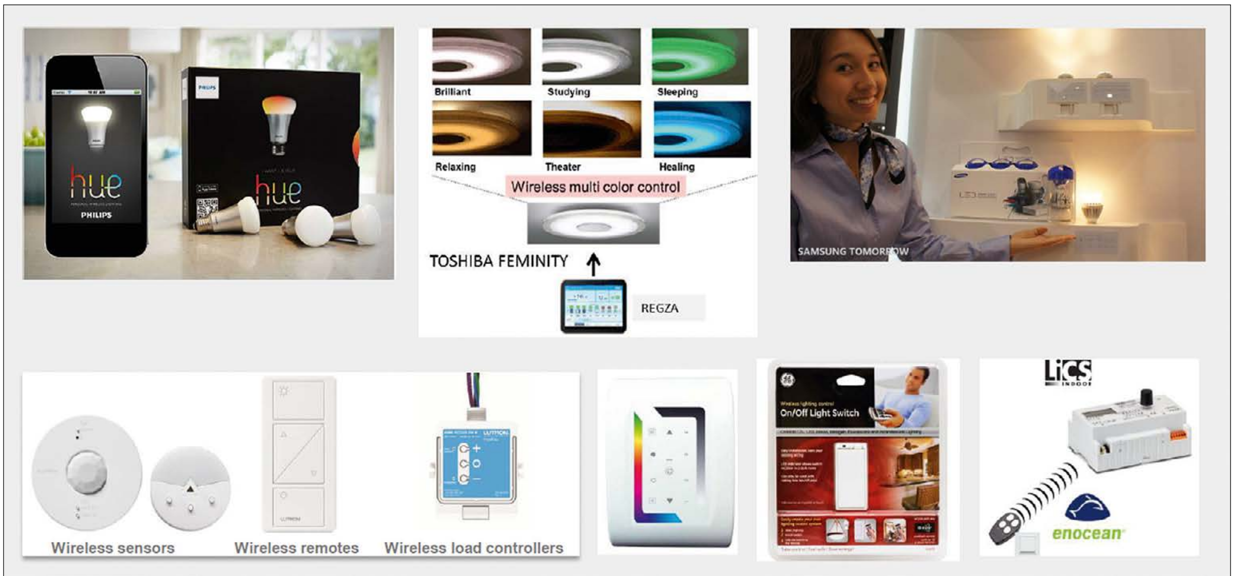


Figure 1: **All the products shown here offer wireless control but they are all based on different technologies. This hinders interconnectivity and therefore limits usability for customers**

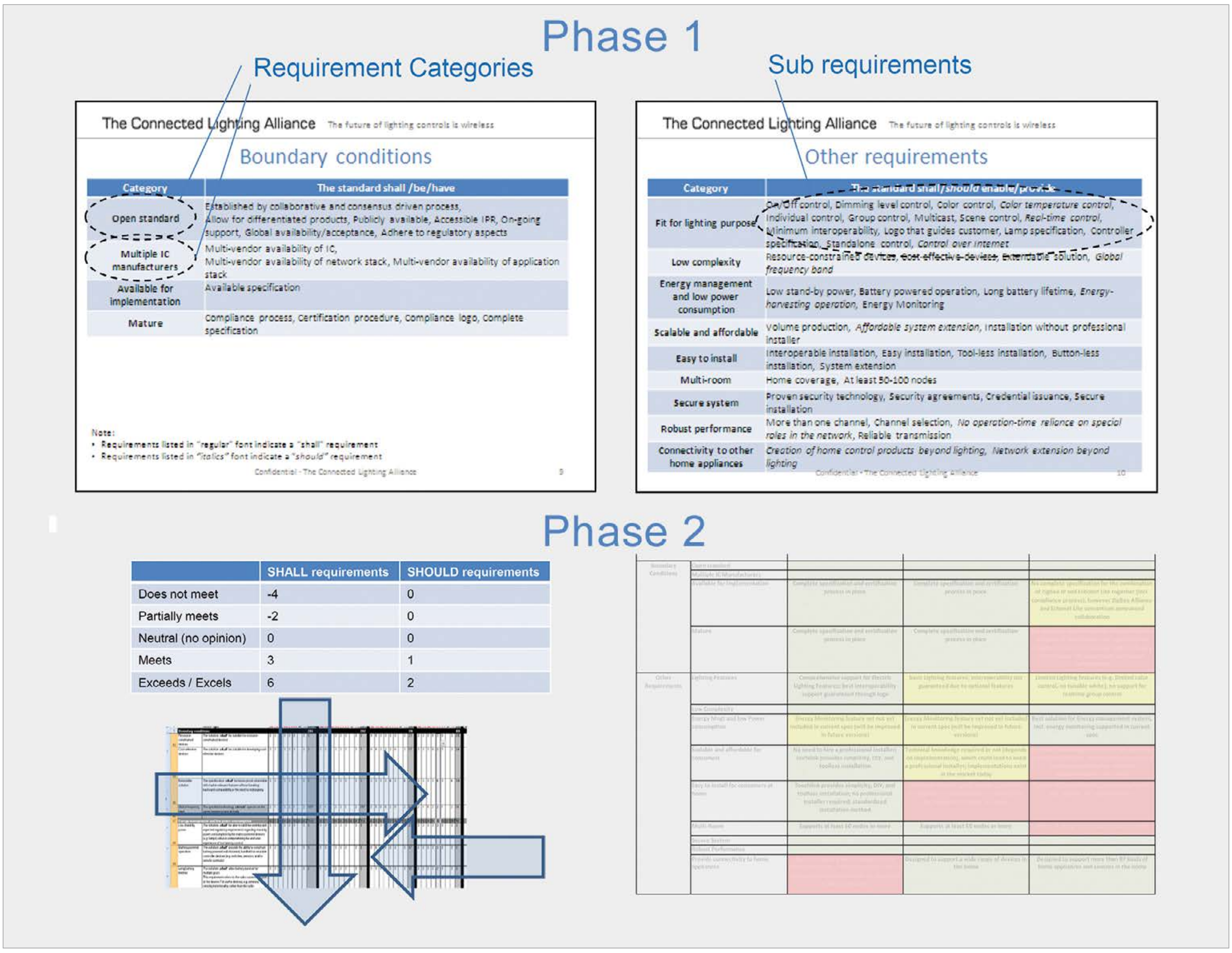


Figure 2:
The selection process is clearly defined and guarantees the best results while providing a high level of agreement amongst the members

It is also very important to mention that the technology used to provide these advantages is now mature and a very low cost target can be reached.

LED professional: TCLA is promoting ZigBee Light Link for residential lighting. Why and how did TCLA select this standard?

Simon den Uijl: I think this is a very important point. To obtain a broad acceptance for a standard it needs to be the best possible solution. To ensure this, TCLA has set up its Technical Advisory Working Group. This group evaluates existing open standards and selects the ones best suitable for the given area. The evaluation is done using objective criteria. The criteria are weighed depending on their importance in the market. Finally, the technology with the best overall score is selected.

LED professional: How did you define the parameters to guarantee the correct selection? What about the process?

Simon den Uijl: The first question to answer is, "what are the market requirements" – in this case for residential applications. So first the market demands are ascertained. These are requirements like the number of nodes that the standard has to support, security, energy management options, or ease of installation.

The latter is of extraordinary importance for the residential application. In fact, this market requires that an installation can be made without any technical skills. Ideally, even a grandmother should be able to buy the product and install it. And then it has to work.

System simplicity is another important point. This helps to hold costs and failure rates down.

The entire work group had to agree on the evaluation process and the influence of the different parameters before the selection of the possible candidates for the evaluation was done. These candidates had to meet some boundary conditions. They had to be open standards and they had to have been available and ready for implementation.

At that point the tough work (the evaluation) could start. The experts had to meet a number of times in order to be able to come to a conclusion. The first thing they did was to score the different candidates. The goal was to achieve a consensus. In order to be able to come to a common recommendation, a deeper analysis was carried out category by category. This sometimes led to longer discussions before an agreement was reached. In the end the scores were averaged and these averaged scores were accumulated per candidate. In the case of a residential application it meant that all in all, the ZigBee Light Link had the best score.

The decision-making in June 2013 at a meeting in Osaka, to promote ZigBee Light Link for residential lighting

Figure 3:
The TCLA Technical Advisory Working Group recognized that ZigBee Light Link, while offering the best overall match for the defined requirements, also has some potential to improve

Requirements		ZigBee Light Link
Boundary Conditions	Open standard	At least 9 companies contributed to the ZLL specification development , ZLL is available to all ZigBee Alliance members, and available to the public upon request , all parties involved in ZLL development have agreed to license their essential IPR on RAND conditions
	Multiple IC Manufacturers	At least 4 stack vendors offer a certified ZLL solution (IC + application stack)
	Available for Implementation	Available for implementation and certification since April 2012.
	Mature	Complete specification (transport, application, security and commissioning) and certification process in place
Other Requirements	Lighting Features	Comprehensive support for Electric Lighting Features; best interoperability support guaranteed through logo
	Low Complexity	ZLL is designed for resource-constrained devices like light bulbs
	Energy Mngt and low Power consumption	Energy Monitoring feature set not yet included in current spec (will be improved in future versions)
	Scalable and affordable for consumers	ZLL supports system extension or home coverage without the mandatory need for additional wiring or range extenders. Installation, operation and control can be done without the need to hire a professional installer
	Easy to install for consumers at home	Touchlink provides simplicity, DIY, and toolless installation; no professional installer required; standardized installation method
	Multi-Room	Supports at least 50 nodes or more
	Secure System	ZLL uses enhanced security mechanisms, based on secret keys that are only handed out to officially certified ZLL products
	Robust Performance	ZLL supports multiple radio channels, and does not require a controller/coordinator
	Provide connectivity to home appliances	Focus on lighting only; connectivity to home appliances is not guaranteed (expected to be improved in future versions)

applications was a real milestone, because it showed that the members are willing to set aside their differences in order to benefit the customer.

LED professional: Can you give a comparison between ZigBee Light Link and its competitors?

Simon den Uijl: Unfortunately not. I cannot disclose details because it is our policy to point out the positive properties of the promoted standard and not to talk badly about or show the weaknesses of other, alternative standards. But I can show you where ZigBee Light Link scored well and where it was not a top scorer. You can see that the results shown on your screen clearly demonstrate we found ZigBee Light Link to performs very well in most requirements, especially on the highly priorized lighting features, scalable and affordable for consumers. Furthermore it is easy to install for users at home (Figure 3).

LED professional: While you are not allowed to show a detailed comparison, can you tell us something about other tasks and plans of the Technical Advisory Working Group?

Simon den Uijl: Of course. We have started a new activity that focuses on the indoor professional lighting market, which will be a huge task. When I said before that the wireless market for residential is very fragmented, it is, in fact, even worse for the professional indoor market. This makes the evaluation task more demanding and challenging. In the first stage we will again focus on the market requirements.

At the first meeting in November we concentrated on the question of how to define the professional indoor market. The outcome of this discussion determines if subcategories with different requirements need to be defined, or if it is possible to find a common view and define common requirements. This clear definition is crucial for evaluating the existing standards and deciding if there is an appropriate existing standard available or if a new standard needs to be created. In such cases TCLA only gives their input to other standardization bodies like IEEE to create the desired standard.

LED professional: If I understand you correctly, the first thing you look at are existing wireless systems and standards. In many professional indoor lighting cases there are still wired systems like KNX, LON or BacNet available. Do you take these wired standards and the interoperability into account as well?

Simon den Uijl: Connectivity to existing building management systems has to be taken into account for our proposal. But while discussions are going on it's too early for details about things like how to connect.

LED professional: You just mentioned that existing standards for other building management systems and home appliance networks have to be taken into account. Therefore I assume that compatibility, or at least connectivity, to these systems was an important criterion for evaluation. But how important was it? And how well is ZigBee Light Link performing regarding this requirement?

Simon den Uijl: This question can be answered by looking again at the outcome of the analysis (Figure 3). We have found that ZigBee Light Link has been developed specifically for lighting purposes, but the drawback is that connectivity to home appliances is not guaranteed. However, it is expected to be improved in future versions. The TCLA members believe that in the future lighting will become a part of a fully connected home. The second task currently set up for the Technical Advisory Work Group is to address this issue. To put it precisely, this activity aims to enhance interoperability between ZigBee Light Link and ZigBee Home Automation. The request to enhance interoperability between these two profiles has also been forwarded to the ZigBee Alliance, and they have already responded that they have started to work on the matter.

Simon den Uijl

Simon den Uijl is the Secretary General of The Connected Lighting Alliance, and a Standardization Director with Philips. Simon holds a MSc. in Business Administration from Rotterdam School of Management, and has published several articles on standards in top ranked academic journals. Before joining Philips, Simon co-founded Epyon, a company specialized in fast charging lithium-ion batteries which was acquired by Swiss multinational ABB.

Another activity is to provide interoperability with ECHONET lite, a global standard that is very popular in Japan, which offers connectivity to various home appliances - especially energy management with demand response. Functions that are currently not covered with ZigBee Light Link.

LED professional: These activities suggest that while being the best overall solution, ZigBee Light Link may not completely satisfy all demands; especially demands in the future. Does it already cover all requirements regarding light control? Or are there current or future additional requirements that need to be satisfied? And is there space to prepare for future demands?

Simon den Uijl: The group defined "SHALL requirements" and "SHOULD requirements". ZigBee Light Link covers all currently defined must have requirements for residential lighting. These are, for instance, on/off, dimming, CCT and color control, individual control, group control, scene control and real time control without any delay.

The ZigBee standard is currently being updated. One of the big advantages of ZigBee is that the standard is tight enough to guarantee interoperability, but most importantly, allows manufacturers to differentiate on products without compromising interoperability.

LED professional: While these, partly early stage, ongoing activities are being carried out, the ZigBee Light Link standard that the members agreed on is ready to be promoted. How is that done?

Simon den Uijl: Correct, the standard for residential lighting is ready for promotional work, and that is the moment when the Promotion Work Group takes over. They plan, coordinate and perform the different promotional activities.

LED professional: These are two different tasks. We should probably discuss both. Maybe you could give us an idea about why someone should become a member. From the time TCLA promotes an open standard the most critical information is available for everybody, like now with ZigBee Light Link so what types of memberships are there and what are the benefits for a member?

Simon den Uijl: Companies can become regular or associated members. Regular members can be part of the work groups whereas the associated members receive information about what's going on, on a regular basis. Members get all the reports and information available. They receive a detailed analysis of the competing standards, the complete scores and other results that are not available to the public. They also see the pros and cons of the selected standard in detail and not just a summary. In addition, they are informed much earlier about what is going on. Therefore, they are better able to handle these issues.

LED professional: That brings us back to the promotion of selected standards. At the current stage your standards are a kind of recommendation from an industry consortium for the industry. How will TCLA manage to become accepted? Is it a viable way of bringing these proposals to an international standardization body to make it mandatory? Or what is your strategy?

Simon den Uijl: There are several reasons why it is almost impossible to make it a standard that is mandatory. This may not even be desirable. What we can and will do is make all the different parties in the value chain aware that ZigBee Light Link is the best option for this field of application. To succeed it is very important not only to inform about the lighting industry, but also to include the different sales channels and to make the end-user aware of it. Once, for instance, retailers and consumers realize that ZigBee Light Link based residential lighting solutions offer the best promise for future interoperability, they will demand such products. We believe this will motivate an increasing number of manufacturers to provide differentiating, but interoperable products using this standard.

We believe that it is a strong and convincing argument for the industry that the leading lighting companies, as member of TCLA, are endorsing a common open wireless connectivity standard.

To promote our recommendations, we will attend the major events around the world, like Light+Building in Europe, LightFair in the US and Hong Kong Lighting Fair in Asia, and the LED professional Symposium +Expo in Austria, just to name a few.

LED professional: Thank you very much for your time. All these explanations sound very reasonable. We'd like to wish TCLA success with their activities.

Simon den Uijl: Thank you! ■

Optimization of SSL LED Devices

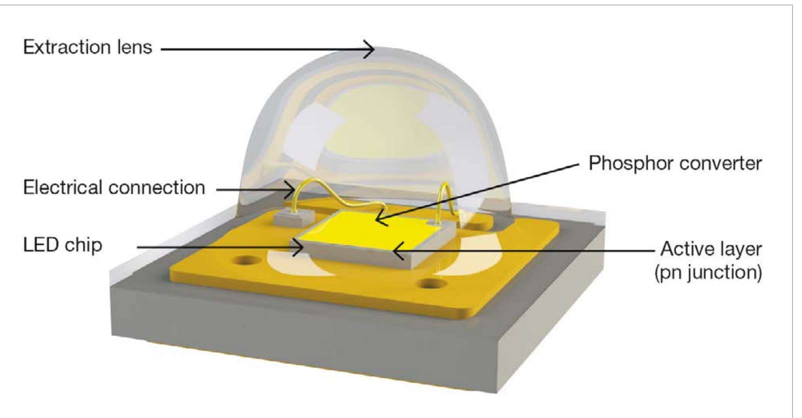
There are different levers to improve LED performance. Ralph Bertram, application engineer for SSL products, and Alexander Wilm, key expert in the SSL application engineering department at Osram Opto Semiconductors, have a look into the device itself and explore the principal limitations of the different contributors to device efficacy. They show how to balance driving current and chip size to define the right LED, and explain the impact on performance and system costs of LED packages for the intended lighting task approaches for lighting strategies.

The performance of LEDs depends on different parameters such as electrical efficiency, internal quantum efficiency and package extraction efficiency. All of these aspects have limitations in principle that have to be examined to optimize LED performance. The right balance between driving current and chip size is the key to reconciling efficacy and cost targets. Other parameters such as luminance and package sizes must also be taken into account when identifying the right LED for the intended lighting task.

The most prominent and also the most important performance parameter is the efficacy of an LED. Although LEDs are small, there are lots of technological challenges inside and many small steps lead to constant improvements in LED efficiency.

When assessing the efficiency of an LED, we need to consider what is known as the efficiency chain, which is shown in figure 1. It consists of five parameters, namely electrical efficiency (ηelectr), internal quantum efficiency (ηint), extraction efficiency (ηextr), phosphor conversion efficacy and package extraction efficiency (ηpackage). Every LED manufacturer possesses strengths and weaknesses in these parameters. It is reasonable to assume all efficiencies to be at 90% (except that phosphor conversion cannot exceed around 80% due to Stokes Shift). Multiplying all these contributions yields an efficiency of 52% for a white LED, which is a value that can be achieved by R&D level LEDs already.

Typical spectral efficacy of white LEDs is 330 lm/W, meaning that the radiated spectrum of one watt optical power contains 330 visible lumen. This results in a total efficacy of 172 lm/W for the complete LED if all efficiencies are at 90 percent. As always, extracting the last few percentage points from a parameter requires a tremendous effort.

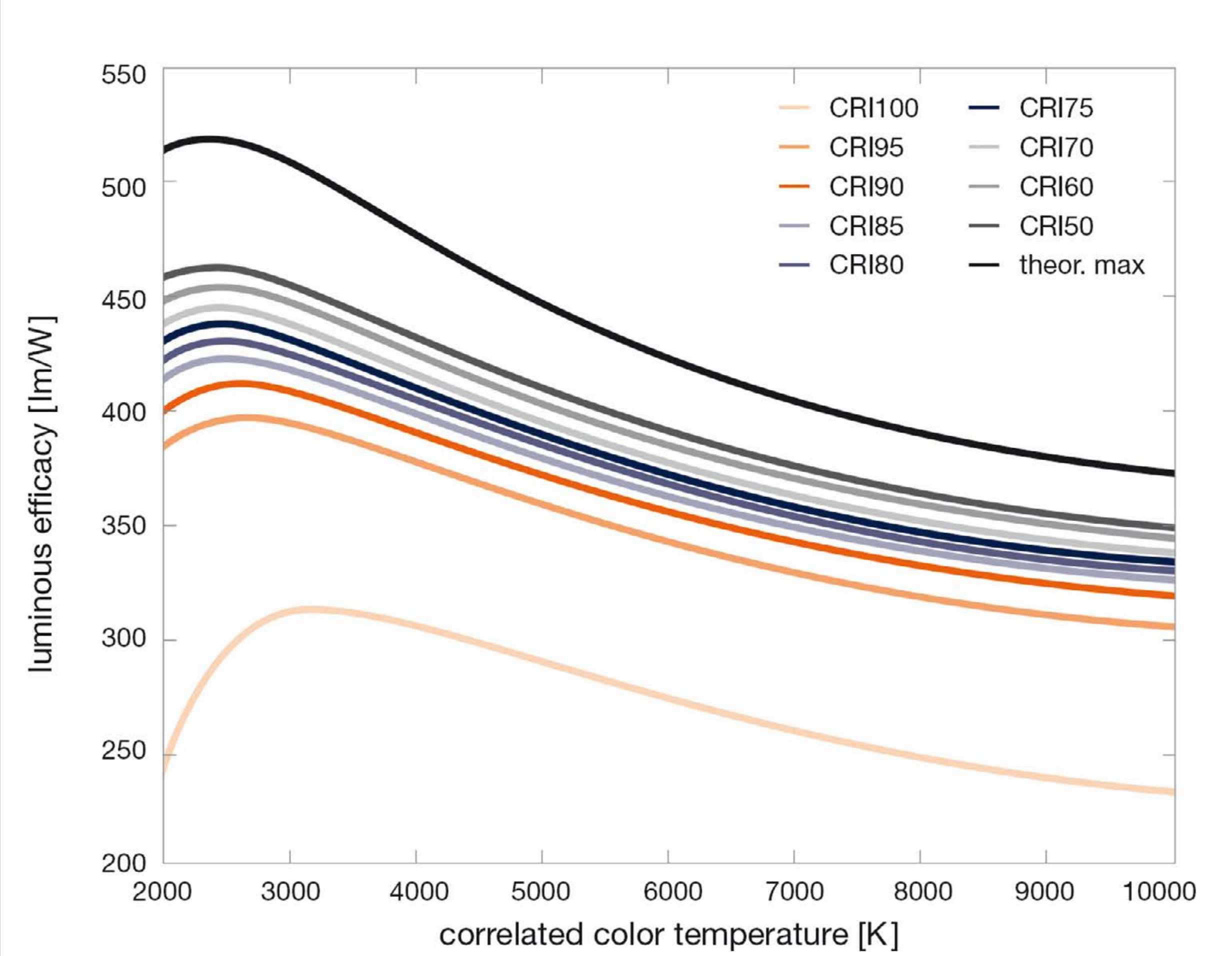


$$\eta_{\text{Wall plug}} = \eta_{\text{electr}} \cdot \eta_{\text{int}} \cdot \eta_{\text{extr}} \cdot \eta_{\text{package}}$$

electrical losses · internal quantum efficiency · light extraction from chip · phosphor conversion (incl. stokes losses), package extraction

Figure 1: **Features of an LED including the efficacy chain**

Figure 2:
The maximum achievable spectral efficacy of an LED for different CRIs



Paths of Optimization

To improve the performance of LEDs several levers can be used.

Electrical efficiency (η_{electr})

All electrical contacts and conductive parts are ohmic resistors that heat up upon current flow. For better electrical efficiency the conductivity of current-conducting layers and interfaces between different materials has to be improved. The conductivity of transparent conduction layers, in particular, is a field for constant optimization. A trade-off between transparency and conductivity is therefore needed, typically using Indium Tin Oxide (ITO) as the conducting material.

Internal quantum efficiency (η_{int})

Another path of optimization is increasing the internal quantum efficiency ηint. The conversion of electrons and holes to photons ("recombination") is the central process in an LED, taking part in the p/n junction of the diode. ηint depends largely on crystal quality. The key for best quality is the elaborated crystal growth process using MOVPE epitaxy. The thickness of the active layer is defined by the doping profile in the semiconductor. Structures to trap electrons and holes together in the crystal area ("Quantum Wells") facilitate the recombination process and generate high quantum efficiencies. So optimizing these structures has the greatest impact on the efficacy of an LED.

Light extraction efficiency (η_{extr})

Once the photons are generated they need to get out of the semiconductor. However, the refractive index of GaN (gallium nitride, used for blue and green LEDs) is about 2.5 and GaAlP's index (gallium aluminium phosphide, used for yellow and red LEDs) is about 3.5. Together with the typical refractive index of the encapsulating material of around 1.5 it forms a interface of a refractive index difference resulting in a high amount of total internal reflection that hinders light from getting out. Strategies to improve light extraction include structuring of surfaces, introduction of mirrors or diffuse reflecting surfaces. Also, the geometry of the chip plays an important role: Volume emitting chips have larger surfaces to enable light to exit in different paths. The reduction of refractive index differences by using high-index silicones helps light to exit the chip. Only the right combination of all these improvements will significantly enhance light extraction ηextr.

Light conversion efficiency

In terms of phosphors, there is also room for improvement. Part of the blue light from the LED chip is converted to yellow, green and red wavelengths to generate white light. Here, efficient phosphor materials must be developed and embedded in suitable materials to enhance the conversion efficiency. The converted light is emitted in all directions, including back to the chip and to all package surfaces. Engineering the whole system to recycle as much of this light as possible before it hits absorbing surfaces is essential to improve the conversion process. Although the photon conversion process itself can be very efficient (near unity), around 20 to 30 percent of the light energy is irrecoverable due to the inevitable loss of photon energy in the conversion process. The exact amount depends on the color target. Warm white and high-color rendering LEDs need plenty of red light, having higher losses.

Up to now, only physical parameters have been addressed. In order to match the light spectrum to the sensitivity of the human eye ("spectrum engineering"), the right mixture of phosphors needs to be found. Concentrating the light in the green part of the spectrum where the eye is most efficient, and reducing the red and blue content results in higher spectral efficacies. However, a color target on the Planckian locus ("white light") is desired as well as good color rendering. A trade-off between efficacy and light quality is therefore needed. In figure 2, the maximum achievable spectral efficacy is shown for different CRIs, calculated for a theoretical optimum light spectrum. A realistic spectral efficacy for the widely used CRI 80 is 300-330 lm/W.

In addition to all the issues mentioned above, parameters such as internal quantum efficiency, phosphor efficiency and, to a lesser extent, resistive losses, deteriorate with increasing temperature. Proper thermal management of the LED chips as well as phosphors therefore help to maintain high efficacy during operation. To facilitate thermal design, LED manufacturers are working on chips and phosphors that can be operated at higher temperatures as well as on packages with enhanced stability. LEDs with an efficacy maintenance of more than 95 percent at 100°C compared to 100 percent at 25°C will soon hit the market and enable tight packing with minimum efficacy impact.

Figure 3:
LED efficiency as a function of current density (droop)

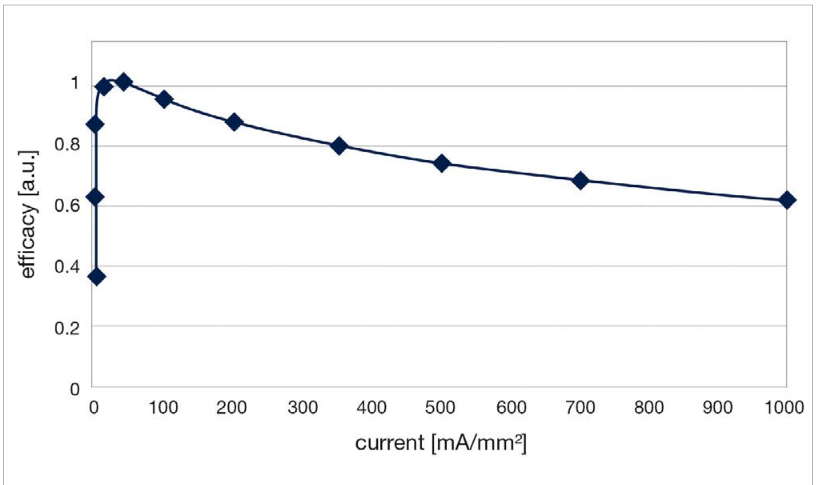
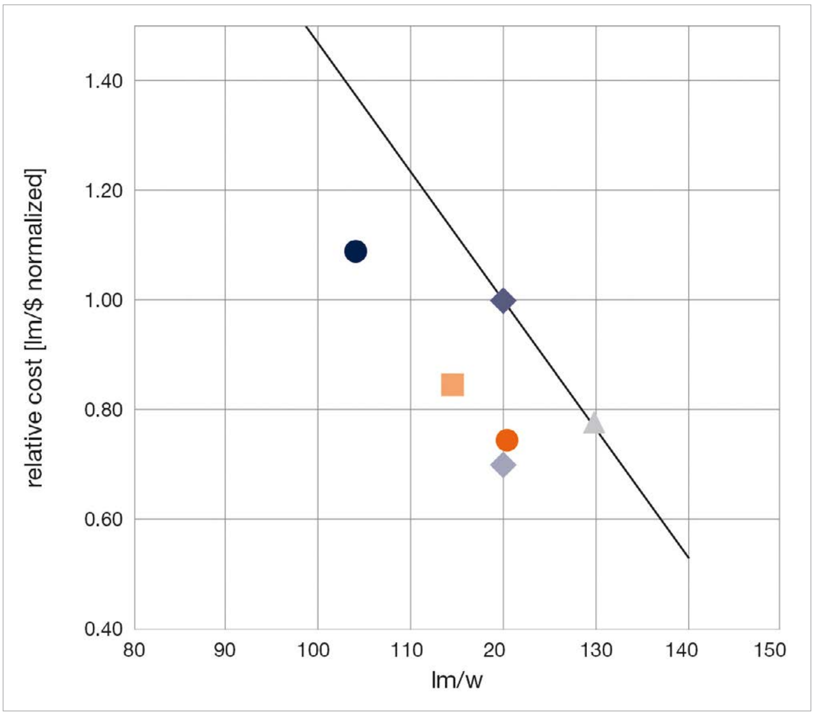


Figure 4:
Impact on cost and efficacy by underdriving/ overdriving typical LEDs



The Importance of Current Density

The biggest lever in LED efficacy, however, is the current density. The reduction in the number of electrons and holes in the device results in stronger confinement of charge carriers in the active region. Because of this, there are few ways for them to escape without generating a photon. LED efficacy consequently increases at lower currents. Below a certain threshold there are not enough electrons and holes to recombine, so efficacy drops again at extremely low current densities. The loss of efficacy with increasing current density is known as "droop" (see figure 3).

The latest research results demonstrated the physical effect responsible for the droop. Although the physical mechanism of the droop effect has been well understood, it is far from being overcome. However, the scope of future research projects can now be narrowed, with the focus particularly on measures to eliminate the Auger effect. In LEDs based on the indium gallium nitride (InGaN) material system, the "bipolar Auger effect" is limiting the efficiency that converts charge carriers into light.

By using a bigger chip surface for a required lumen package, the LEDs can be driven in the low current density regime ("underdrive") to greatly improve efficacy with respect to standard currents. This is most obvious in the following diagram showing the requirements in cost (lm/$) versus LED efficacy (lm/W) of an LED retrofit lamp. The different points that are located around the black line symbolize one LED driven at different currents. Located top left, the LED is overdriven to get more light at the expense of efficacy. If the LED is located bottom right, it is underdriven. This means that a greater efficacy is possible, but also that more LEDs are required to achieve the same light output.

Knowing this, an LED chip manufacturer has two ways to improve the efficacy of LEDs: Either by improving the LED efficacy itself at a given current density or by reducing production costs to get more chip surface for the same price, allowing underdriving to achieve acceptable efficacy.

Evidently, both ways need to be used in parallel, but the focus may lie more on one or the other side for different manufacturers and applications. Most renowned LED manufacturers offer several variants of LED packages containing different chip sizes to enable the customer to choose their optimum operating conditions and light output.

LEDs with High Luminance

There are applications where underdriving is not reasonable, simply because a lot of light has to come from a very small source. Examples are LEDs used for tight spotlights, and LEDs embedded in automotive headlamps or in street lighting applications, where luminance and controllability of the light distribution are even more important than luminous flux. But how can the luminance be improved? There are several technologies available to provide white LED light. In the case of phosphor-converted LEDs, two different concepts prevail in the market:

- The first concept uses many volume-emitting blue chips mounted on a mirror, embedded in a phosphor-filled silicone matrix. Since light from volume-emission is also directed to the sides, the chips cannot be packed closely but need space between them to allow the light to escape and be converted by the phosphor. This fundamentally limits the luminance achievable with this type of LED.
- The second concept is based on surface-emitting blue chips with a phosphor-containing layer on top of the chip. Almost 100 percent of the light is emitted from the top surface only. Here, the single chip has the highest luminance achievable and, for example, embedded in automotive headlamps they are driven at extremely high current densities to generate even higher luminance. However, in general lighting applications many of these chips have to be closely packed and driven at normal current densities in order to maintain sufficient efficacy and high light output.

Both volume and surface emitters are available in SMD LED packages; high-power LEDs in both concepts use Chip-on-Board technology (CoB).

As an exemplary calculation, for a 4,000 lm light source 42 packaged LEDs with a common chip size are necessary, covering a light emitting surface (LES) of 28 mm in diameter. To achieve a 24° beam angle, a reflector of 120 mm in diameter would be necessary. Moving to larger chip sizes or, alternatively, to volume-emitter CoBs, a reduction of the LES to 19 mm can be achieved, enabling 24° optics to be smaller than 100 mm. As discussed above, only direct mounting of surface-emitters on a metal core board enables tighter spacing of the chips. This results in the same flux at 13 mm in diameter, enabling the optics to be 60 mm or tighter beam angles to be achieved. Due to the space required for the placement and wire-bonds, they are still not packed with maximum density. Further improvements in chip assembly and connection technologies have been developed at a research level and 4,400 lm from an LES of 9 mm has been demonstrated recently.

The Right LED Package for Each Application

With this overview of the factors that influence LED efficacy right now, there is still a variety of packages to choose from. In order to decide on the perfect solution, the following questions have to be answered:

- Is the focus more on efficacy or on cost?
- Are there special requirements with regard to optics?
- Are high operating temperatures and/or is long lifetime important?
- What is the required level of robustness? Are extreme conditions expected (humidity, pollution, high temperature differences)?
- Are there restrictions to the assembly process? Is SMD soldering an option?

Starting from the easiest conditions, if there are no special requirements Sapphire-based volume emitters currently perform best in terms of the

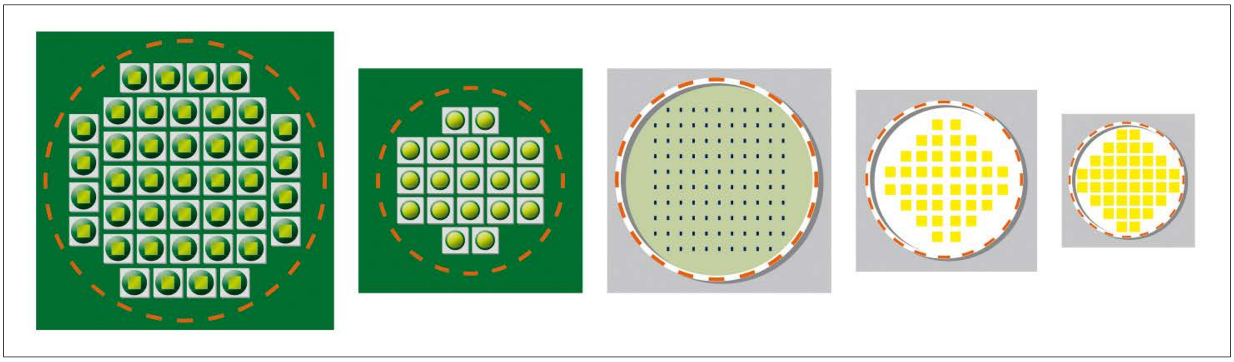


Figure 5: **Light emitting surfaces (LES), when using different LED types, indicated by dashed lines – from LES 28 to LES 19 down, to LES 13, and to the LES 9 lab demonstrator (from left to right).**

cost/efficacy ratio. Built into high-volume backlighting packages there is almost no match in lm/W versus lm/$. Is it really? Currently, multi-chip SMD packages can save even more on both package costs and assembly costs. Delivering up to 500 lm from one package, they are more cost-effective than most CoBs. In addition, the package material is more stable and can withstand higher temperatures, and they achieve longer lifetimes.

If higher luminous flux levels are required or SMD assembly is not an option, CoB LEDs are the right choice. They also offer good optical properties and many accessories such as holders and lenses that are available as standard components.

However, if it comes to very long lifetimes and rough conditions, there is almost no alternative to ceramics based high power LEDs. These exhibit almost perfect stability against outdoor conditions, and even in tunnel lighting applications, where corrosive gases are present, they show no signs of corrosion. Unlike volume-emitter chips, they do not need a highly reflective mirror below the chip, which is usually made out of corrosion-sensitive silver. Instead, the complete LED is made from inorganic material such as ceramics and silicone, and the electrical contacts are gold-plated.

The Best Ways to Improve LED Performance

As already stated, there are many levers that can be used to improve LED performance. On the one hand by improving LED efficacy using physical parameters such as electrical efficiency η_{electr} and phosphor conversion efficacy $\eta_{package}$ that influence LED efficacy. These parameters get worse with increasing temperatures so manufacturers are working on LED chips and phosphors that can be used at higher operating temperatures. The most important aspect for improving LED efficacy is the current density: LED efficacy increases at lower currents but may not fall under a certain threshold because of the droop effect. Better LED efficacy can therefore also be achieved by reducing production costs to get a greater chip surface for the same price. On the other hand, the best package for an LED is needed to get the best performance. For up to 500 lm one can choose a multi-chip package that is more cost-effective than most CoB LEDs. For higher luminous fluxes or to avoid SMD assembly, CoB LEDs are the right choice because of their excellent optical properties and standardized accessories. For maximum lifetime and harsh conditions there is no alternative to ceramics-based packages.

As can be seen, there is no one way to optimize LED performance, but many, depending on the applications and the conditions. One can therefore focus on one or two parameters or exploit as many as possible to get the best performance from the LEDs. ■

Safety Issues for LED Drivers with PWM Operation Modes

In many cases LED drivers manage their output power with PWM controlled switched mode power supply-topologies. The output voltages are filtered and normally DC voltages with low ripple apply at the output connectors of LED drivers. During dimming these circuits can behave very differently and therefore safety issues may arise. Siegfried Luger, CEO at Luger Research e.U. and John Showell, Product Safety Consultant at Product Approvals Ltd. have a closer look at those operation modes and the requirements on voltage limits.

LED lighting technologies are developing very quickly. As the light-sources themselves evolved, new sophisticated and enhanced electronic concepts were developed to drive and control LEDs. These developments are very important for fulfilling market requirements but safety and standardization aspects are lagging behind. One issue related to LED drivers concerns the output voltage limitations for LED drivers. The following considerations summarize the latest developments and point out possible safety issues.

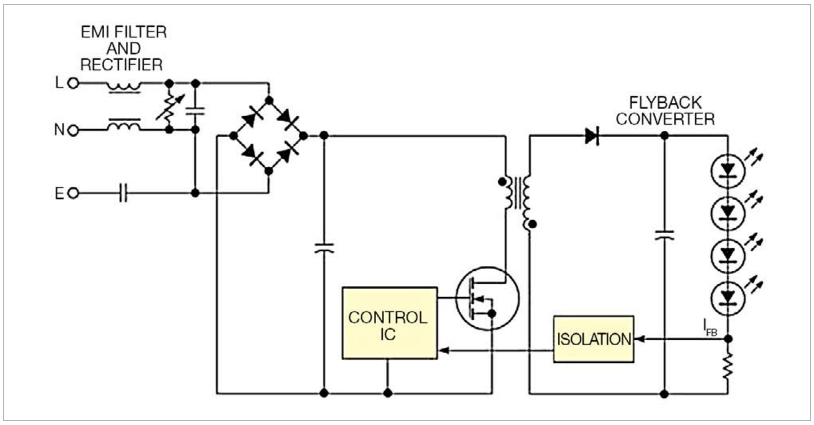


Figure 1: **Typical AC to DC LED driver topology with a single-stage flyback converter**

Basic LED Driver Topology

LED drivers can be categorized into DC to DC converters and AC to DC converters. Where AC to DC converters are concerned, in most cases, they operate directly from the mains (e.g. 240 V_{rms} / 50 Hz). AC to DC converters for mains applications consisting of an EMI filter, a bridge-rectifier and a single-converter stage, are mostly built up as a flyback converter to transform the rectified AC voltage into a constant DC current to perform the powerfactor-correction and to isolate the output LED circuit from the mains. Finally the output current is also rectified and the energy is stored in an output capacitor (Figure 1). LED strings in serial or in serial/parallel are connected to the LED driver output poles.

The output stage of such an AC to DC converter is galvanically isolated through the flyback-transformer. Therefore the feedback circuit has to be isolated to sense the LED string cur-rent. This might be done through an optocoupler but more advanced sensing schemes use the primary side of the transformer or an additional sensing winding to detect the output LED current.

The switching frequency of the flyback converter may vary between 10 kHz up to some MHz. To control the output power/current for dimming the light output, PWM schemes are used.

Nowadays, to reduce flickering and stroboscoping effects on human eyes, the PWM frequencies are chosen above some hundred Hertz (e.g. 300-500 Hz). Under standard operation conditions the PWM signal will not be seen at the output, because of the rectifying and buffering output circuit. Figure 2 shows the output voltage (Ch2) as a DC voltage with a small part of AC ripple.

Possible Safety Issue - Chopped DC

Assuming that the LED driver and the output stage are designed as an SELV (Safety Extra Low Voltage) converter it is allowed to touch the output lines, bridging the positive to the negative pole of the output with the human body impedance.

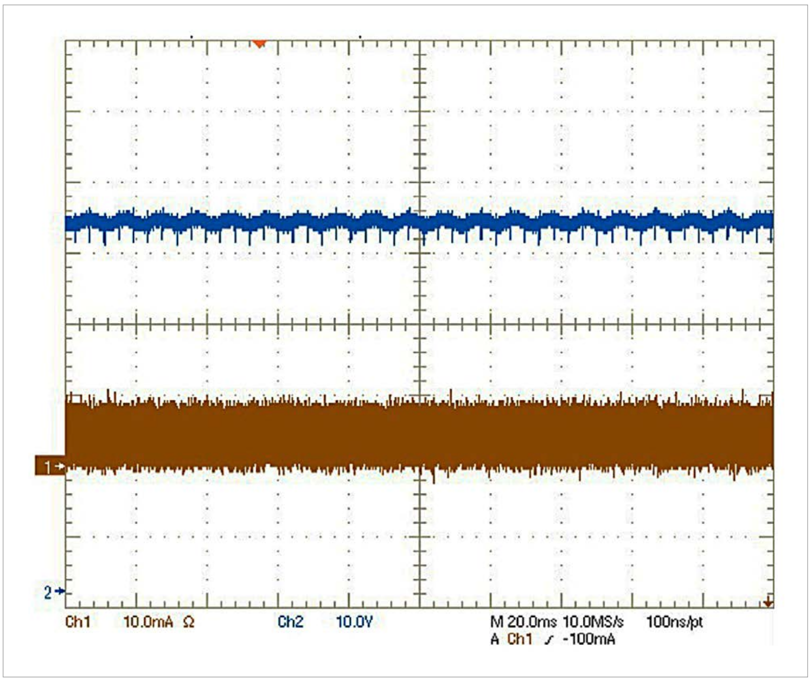


Figure 2: **DC output voltage of an LED driver (Ch2, approx. 55 V_{DC}) overlaying with a small part of AC ripple voltage (approx. 4 V_{pp}). Ch1 shows the high-frequency ripple-current from one output pole to earth (10 mA/Div). Time base is 20 ms/Div**

When operating in dimmed modes (power reduction), the energy delivered to the output storage capacitor is reduced. Touching the output lines under this condition can lead to a change in the output voltage signal from a DC voltage to a chopped DC voltage in which the PWM frequency can be seen at the output (Figure 3). This might happen especially when sensing the output current similar to the concept shown in figure 1. Bypassing the sensing resistor with the load of the human body would not lead to a regulation of the LED driver system.

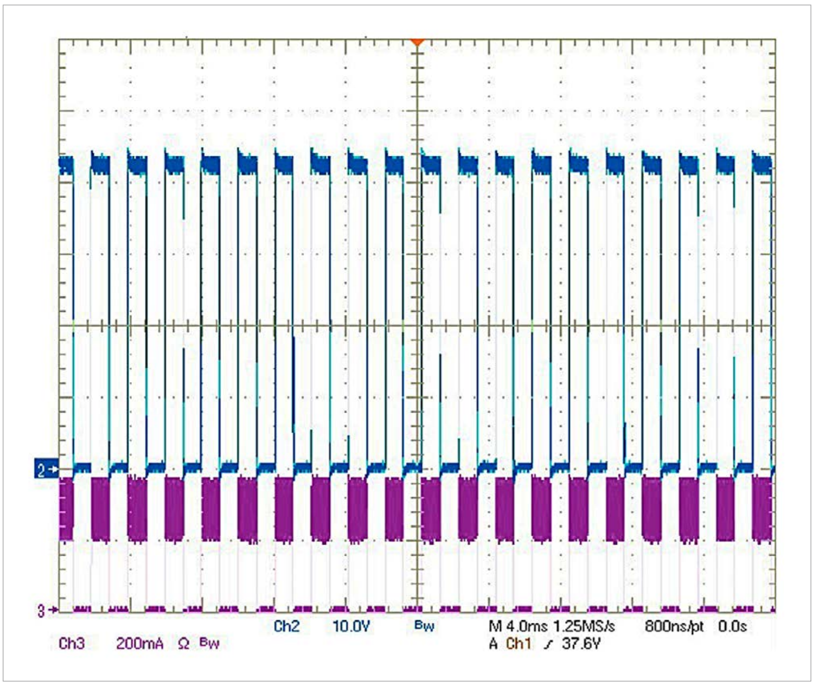


Figure 3: **Measurement of an LED driver output under 2kOhm load and 50% duty-cycle. Ch2 showing the voltage above the output terminals. Ch3 showing the LED current**

Under this condition critical operation modes for these LED drivers may occur when the driver is not designed for additional low ohmic loads, e.g. too low capacitor values and/or insufficient regulation algorithms.

The main topic is that the change from "pure DC" output voltages to alternative voltages, here chopped DC signals means that the safety voltage limits for these drivers may change automatically to lower values due to the change of the voltage signals!

Backgrounds - Human Body Model

There are different impedance models for the human body available and also defined in international standards. The model shown in figure 4 known as Perception / Reaction network is defined by a resistive load of 1.5 kΩ and 0.5 kΩ in series and a capacitor of 220nF in parallel to the 1.5 kΩ resistor. The input impedance at 50 Hz is 1,990 Ω, at 500 Hz 1,433 Ω and it drops down to 476 Ω at 1 MHz. The output stages of an SELV LED driver, therefore, might be bridged with a human body impedance between 1.5-2.0 kΩ under real conditions, when touching the output

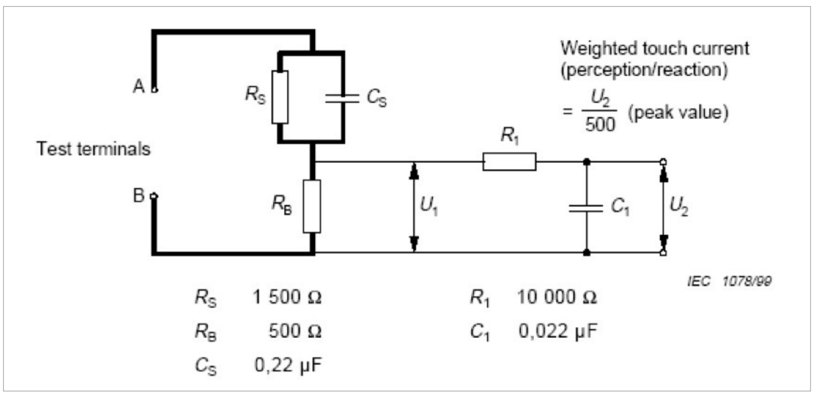


Figure 4: **Perception / Reaction network (according to IEC 60990, 1999 - Figure 4). The human body model with perception / reaction network is the most realistic test method, but usually just applied if a standard test with 50 kOhms fails**

lines. This "load" is responsible for changing the output signal from a DC voltage to a chopped-DC voltage.

The touch current limits are measured across the 500 Ω resistor R_b (voltage U_1). The measuring

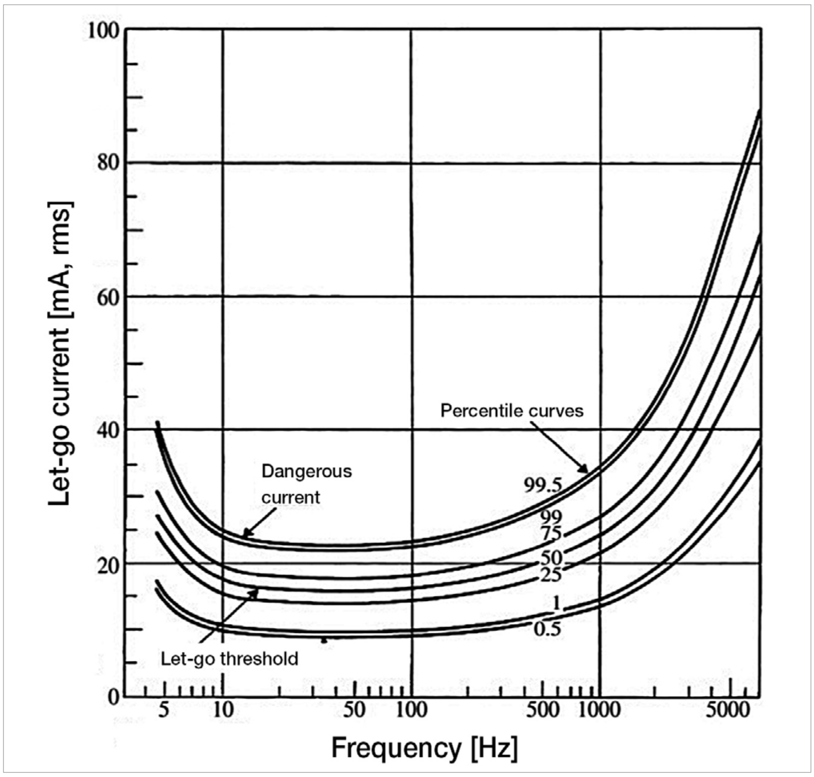


Figure 5: **Let-go thresholds and dangerous current limits as a function of frequency (C.F. Dalziel, "Electrical Shock", Advances in Biomedical Engineering, edited by J. H. U. Brown and J. F. Dickson III, 1973, 3, 223-248)**

network R_1 and C_1 showing in figure 4 are used for a weighted touch current. So the measuring voltage U_2 does include frequency ependencies as well. The variation of the threshold of perception, for example, is increased by the factor of 1.5 between 50/60 Hz and 500 Hz, the base operation frequency of PWM drivers (see IEC TS 60479-2:2007 - Figure 1 for further details). Earlier studies, as shown in figure 5, were the basis and documented the principle relationship between the thresholds and the frequency.

Safety Issues - Consequences of Changing the Mode of Operation

As described above LED drivers might change their mode of operation when touching the output terminals. With the human body model this behavior can be tested with LED drivers, bridging the output. The question which then arises is: "What does this mean to safety?"

There are various US and EN standards which answer this question. In regards to safety the maximum or peak voltage level is interesting, because of the ability of the voltage to drive current through the body - which is the mechanism of the electric shock. There are some differences between voltage magnitudes for DC and AC signals. Peak voltage is commonly referred to, such as quoted in the LED professional Review (LpR) article Issue 39, e.g. 42.4 V_{peak} (30 V_{rms}) is a common UL figure but not universal across UL standards. The differences come in because of US UL standards and those of UL standards which are based on an IEC standard and have some commonality with EU voltage levels.

The UL standard groups for LEDs recognize the guidance needed for certain scenarios. As such, UL 8750 (other UL end-product standards may apply) covers products intended for installation on branch circuits of 600 V or less. UL also noted that many LED products are designated for Class 2, which refers to supply characteristics specified in Article 725 of the National Electric Code (NEC).

Please note that in brief, Class 2 circuits are isolated and have maximum voltage ratings of 60 V_{DC}, 30 V_{rms}, maximum current ratings of 8 A and maximum power ratings of 100 W. Electrical systems obeying Class 2 specifications may afford additional design freedom that includes the selection of material to address flammability concerns and accessibility of other circuits. Such affordability makes Class 2 compliance popular among LED luminaire designers and manufacturers. Table 1 shows reduced maximum voltages for wet locations compared to dry/damp locations defined in UL 8750 for the risk of shock.

The values for chopped DC or interrupted DC signals as proposed in UL 8750 (Table 1) are based on studies done by W. B. Kouwenhoven in 1936. He found out that the peak voltage limits for fibrillating currents at 60 Hz has to be lowered by the factor of 1.69 compared to alternating currents.

$$50\ V_{rms} * \sqrt{2} = 70.7\ V_{peak}$$
$$70.7\ V_{peak}/1.69 = 41.7\ V$$
(max. interrupted DC voltage)

A. Mörx who found out that the reduction of the human body impedance has to be considered for higher voltages performed a further analysis for safety voltage limits.

	Maximum Voltage	
Waveform Type (a)	Dry and Damp Locations	Wet Locations
Sinusoidal AC	30 V_{rms}	15 V_{rms}
Non-Sinusoidal AC	42.4 V_{peak}	21.2 V_{peak}
DC (b, c)	60 V	30 V

Table 1: **Reduced maximum voltages for wet locations compared to dry/damp locations defined in UL 8750 for the risk of shock:**
a) For a combined ac + dc waveform, the wet location voltage limit shall be the non-sinusoidal ac limit where the dc voltage is no more than 10.4 V, and shall be (16 + 0.45*dc voltage)V where the dc voltage is greater than 10.4 V. The dry and damp location voltage limit shall be twice these amounts
b) If the peak-to-peak ripple voltage on a DC waveform exceeds 10 percent of the DC voltage, the waveform shall be considered a combined waveform per footnote above
c) DC waveforms interrupted at frequencies between 10-200 Hz shall be limited to 24.8 V in dry and damp locations, and 12.4 V in wet locations

Table 2: **Column A shows the SELV limit voltages acc. IEC 60449:1973 calculated based on Kouwenhoven studies. Column B shows the UL proposal for Class-2 power supplies in reference to NFPA 70 - 2011 (Note: The 30 V_{rms} limit in UL 8750 corresponds to 25 V_{rms} limit according to EN 61347-1 (10.4))**

Waveforms	A SELV proposal Voltage limits	B UL 8750 proposal Voltage limits	Notes
DC ave 10% ripple voltage	120 V	60 V	Standard definition DC voltage limit
DC max 10% ripple voltage	140 V	70 V	Max. voltage peak including the ripple voltage U_{dc_max}= U_{dc_ave} (1+0.1*√2)
AC sinusoidal	50 V_{rms}	30 V_{rms}	RMS voltage limit equivalent to the DC value
AC non-sinusoidal	84.9 V_{peak}	42.4 V_{peak}	Peak voltage (*√2)
Interrupted DC (iDC_l) 10-200Hz	41.7 V	24.8 V	“Kouwenhoven limits”
Interrupted DC (iDC_h) 500 Hz	62.6 V	37.2 V	“Kouwenhoven limits” increased by frequency factor 1.5 for 500 Hz
DC_{ave}/iDC_l factor	2.88	2.42	PWM mode - reduction factor

According to IEC TS 60479-1:2005 the impedance at 50 V_{DC} is 2900 Ω and drops down to 1625 Ω at 125 V_{DC}. These recognitions are not covered in details within this report but may be important for further analysis.

Table 2 shows the different voltage limits in a comparison between the UL and IEC for 120 V_{DC} and 60 V_{DC} levels and gives indications for possible “new voltage limits” which are in consideration right now. The 120 V_{DC} value shown in table 2 is valid for single pole touchable SELV. It is important to recognize that an SELV LED driver, for example, designed with 60 V_{DC} voltage limit, would fall immediately out of the safety limits when changing the output mode from DC to chopped DC because the limit for DC falls from 60 V to 24.8 V (frequencies between 10 - 200 Hz)!

Higher frequencies would help because the limits for higher frequencies go up. On the other hand, new research on the human body model also works against this. Therefore, it’s a very undefined and unclear situation. In general, it can be stated that the change from DC to AC will lead to a reduction of the limits to some extent. This is an important issue for designing safe LED drivers for the future.

Conclusion

Output lines of SELV/Class-2 LED drivers are allowed to be touched. Depending on the operation mode, the LED driver design and the used component values, LED drivers may “switch” from DC output mode into AC output modes, mostly with chopped-DC signals. Since AC voltage limits are below the DC voltage limitations, the safety requirements of these drivers are changing with the operation mode. On the other hand, LED drivers operating with PWM control are using higher frequencies then the standards normally cover. Instead of DC, 50 or 60 Hz they are operating the PWM at some hundreds of Hertz (e.g. 500 Hz).

The global discussions going on about these limits are important in respect to safety to cover all critical conditions which might occur in applications. For manufacturers of LED drivers it is important to know that the limits for PWM controlled LED drivers might be reduced and tested under given conditions and that the limits might be lowered against the pure DC limits by a factor of 2.4 - 2.9. New designs should take care of this fact and even if further investigations have to be made to define the correct limits. ■

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Using Integrating Spheres Correctly to Measure LEDs

LEDs have opened up new dimensions of design freedom, allowing architects and designers to give free rein to their creativity. Light-emitting diodes permit manifold design solutions as a light source in illumination products. However, a suitable measuring method for comparing key technical data is required in order to get the best out of the diversity of illumination products available. Mikolaj Przybyla from GL OPTIC, a Just Normlicht GmbH division, explains crucial product requirements and what to take care about when calibrating a measurement system.

A generally reliable and suitable measurement method for a wide range of lighting products is to measure the luminous flux and radiant power with an integrating sphere. A high-resolution spectrum analyzer can be used to measure transmission and emission spectra, but the so-called integrating sphere can determine the radiant power or luminous flux of light sources. Therefore the integrating sphere, also known as the Ulbricht sphere after its inventor, is among the most important instruments used in spectrometer applications (Figure 1).

German engineer Richard Ulbricht was commissioned to construct a three-phase power station for the train stations in the city of Dresden. In connection to this, he also became involved with the illumination of the stations. For his photometric investigations Ulbricht utilized the multiple reflections produced by light, and it was in the course of this work that he developed the integrating sphere. Essentially, the integrating sphere is a hollow sphere whose inner surface is coated with a diffuse reflecting material and is completely opaque and closed on all sides. The radiation is fully integrated and mixed inside the integrating sphere before being decoupled for measurement by a detector. In practice the test object is secured at the center of the sphere so that the luminous flux can be quantified in all directions. The overall energy emitted by a source can thus be determined regardless of the source's structure or the spatial distribution of the emission. With this method it is possible to obtain reliable results for many different types of light source and to take all designs, illumination angles and types into account. Integrating spheres are used successfully for measuring incandescent and electroluminescent light sources. They are also suitable for characterizing light sources comprised of LEDs or OLEDs.

Figure 1: **Typical measurement setup with a large integrating sphere calibrated with a laboratory grade spectrometer**

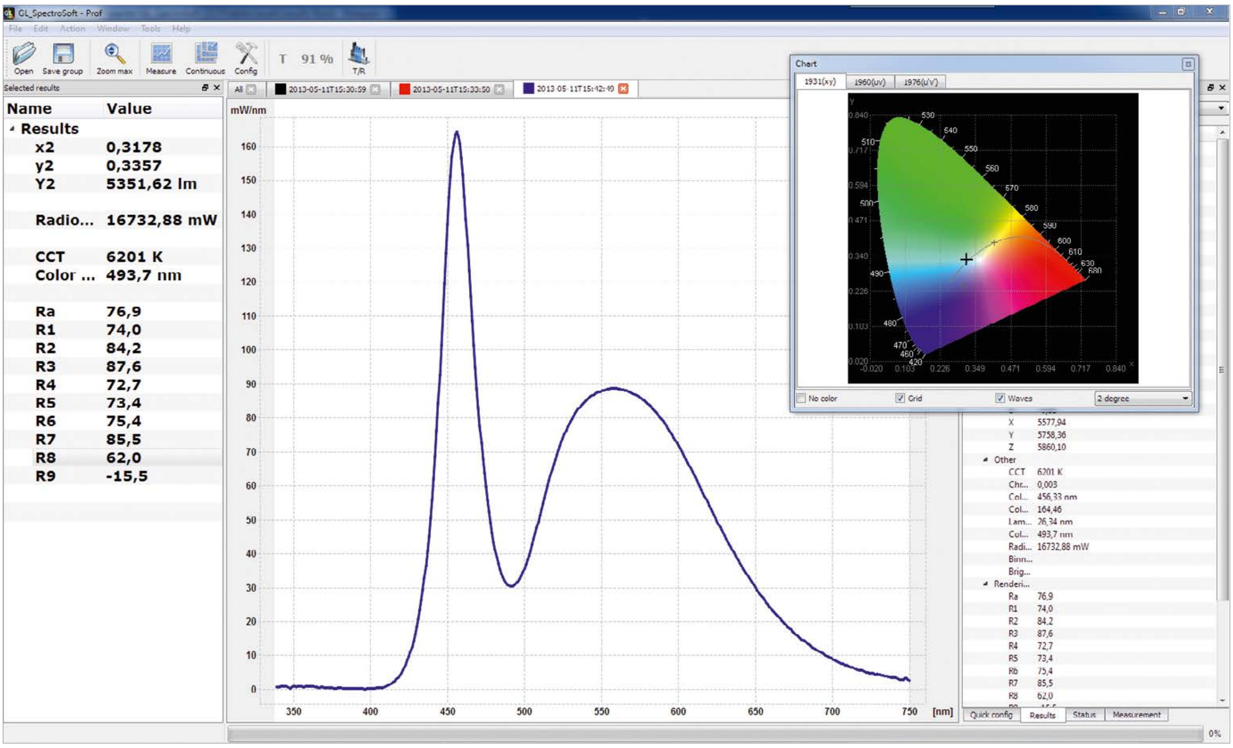

Figure 2: **Typical measurement plot of a cold white LED, with the required figures: Lumen output, rendering indices R1 - R15 and Ra (CRI), Color coordinates and correlated color temperature. Additionally radiometric value of radiant power [mW] is calculated**

The Right Detector – Photometer or Spectrometer

An integrating sphere is just one part of the overall measuring system – a detector is also required to quantify the intensity of the signal. The detector is a measuring device that is connected to the sphere. An integrating sphere and photometer were typically used to measure conventional incandescent light sources that emit a continuous spectrum across a broad spectral range. With the help of photometry it is possible to determine the energy-efficiency classes and average service life of lamps as well as the spatial distribution of light. A photometer mounted to the inner wall measures the light level inside the sphere. This device frequently comes with an optical correction filter (V, λ) that adapts the sensitivity of the device to the characteristic sensitivity of the human eye. Measuring the integrated radiation accordingly provides a basis for assessing how the light source will be perceived by the human eye.

For the measurement of LEDs and other light sources that emit a non-continuous spectrum, a spectral measurement device must be used. While photometric measurement systems specify parameters in lux, candela, cd/m^2 or lumen, spectroradiometric measuring equipment is capable of indicating additional parameters such as the dominant wavelengths, peak wavelengths, bandwidth, CCT (color temperature), and CRI (color rendering index). Spectral measurements achieve very accurate results because they quantify the spectral power distribution of a light source. Luminous flux is measured by a spectrometer in conjunction with a diffuser and a suitable cosine corrected head. The spectrometer is connected to the integrating sphere and it measures the integrated signal level in lumen [lm]. The application software installed then calculates the photometric and colorimetric values that cannot be ascertained with a traditional photodetector. The basis for the measurement data continues to be the energy emitted by a source. This measurement method also eliminates the errors that can result when a detector incorrectly renders the sensitivity of the human eye across different wavelengths.

This aspect is especially important for LED measurements, as these sources emit light in a limited wavelength range that contains sharp and narrow peaks. In this case, the detector is influenced by different illuminants, with high energy in several wavelength ranges and lower or near-zero signal strengths in other ranges. LEDs have a somewhat gaseous spectral distribution pattern with a specific peak wavelength and a halfwidth of fewer than ten nanometers. Blue, red and white LEDs, in particular, are affected by pronounced deviations in luminous intensity and the dominant wavelength due to the relatively poor adaptation of the filters to the defined flanks of the V(l) function. For example, error rates of several hundred percent are not uncommon for blue LEDs. In the case of white LEDs, on the other hand, correct evaluation of the blue peaks is extremely important for the accuracy of the color coordinates. Another problem is that different photometers deliver different results depending on the respective filter parameters and optical correction (V, λ). A precision spectroradiometer avoids this pitfall because a computer-based analysis of the spectrum (Figure 2) uses precisely defined functions in accordance with the CIE 127:2007 standard issued by the International Commission on Illumination (CIE). Spectroradiometers are therefore the recommended choice for measuring LED light sources.

FACTBOX:

What is luminous flux?

Luminous flux describes the total light output perceived in relation to the spectral sensitivity of the human eye.

How is it measured?

Luminous flux is measured using a spectrometer connected to an integrating sphere. With this method it is possible to determine the total amount of energy emitted in all directions by the light source. Luminous flux is specified in lumens [lm].

What is the significance of this measurement method?

This method is very practical for quantifying the total light output or radiant flux of a light source or illumination system so that the energy efficiency or power rating of lamps can be determined and lamps with sufficient illumination can be chosen for a given room.

The Appropriate Sphere

The inside of an integrating sphere is coated with a special material designed to diffuse the reflected light. Barium sulfate (BaSO4) is often used for this application. Optical PTFE (polytetrafluoroethylene) offers ideal reflection characteristics across a broad wavelength range, and a gold coating is applied for infrared radiation values in excess of 700 nm.
The coating used in older spheres had a light reflection coefficient of 80%, which produced good results in conjunction with the detectors of previous generations. A spectrometer allows materials with a light reflection coefficient of 97% to be used.
This enables better integration and higher signal strength at the detector entry point, and it makes the measurement results much more accurate.

An important CIE requirement is to consider the self-absorption. The methods used should be able to determine which part of the signal emitted by a specific source is also absorbed by this source. The absorption can be due to the housing or to all the elements within a sphere that are used to install a sample. The CIE requirement can be met by installing an auxiliary source in the sphere to measure the absorption of the tested light source. This is then factored into the final measurement results.

It is important to choose an appropriate sphere diameter when designing a measurement setup (Figure 3). Specific requirements prohibit the maximum physical size of a light source from exceeding 10% of the inner diameter of a sphere.
Until recently, this meant that a sphere with a diameter of at least 1 meter had to be used to measure a source spanning 10 cm in diameter. Accordingly, a 4-meter sphere was required to measure objects of 40 cm in size, and so on. By compensating for self-absorption, it is now possible to measure light sources twice as large without compromising measurement accuracy. The results also depend on the shape of the source. In a sphere with a diameter of 500 mm, objects measuring up to 16 cm x 16 cm can be measured. A sphere with a diameter of 2,000 mm can therefore be used to measure sources of up to 60 cm x 60 cm in size. In the case of fluorescent lamps, the length of the source can have a diameter that is almost as wide as the sphere itself.

Calibrated Measurement Setup

To guarantee the desired level of reliability, the instrumentation used must be calibrated. Every measurement system comprising an integrated sphere and a spectrometer requires

Figure 3: Small integrating spheres are also used in high quality handheld instruments for single LED measurements

calibration. The calibration source is a reference lamp with known spectral distribution and luminous flux values. These light sources are calibrated by certified laboratories that use an ideal black body radiator and a monochromator as a reference for determining the spectral distribution and luminous flux of a reference lamp. The manufacturer normally calibrates measurement setups, which should be repeated every 12 months.

Spectrometers are calibrated in three steps:

- Wavelength calibration
- Spectral calibration
- Absolute calibration

Since the blue spectral component in halogen lamps accounts for only about 10% of the energy available along an 800 nm wavelength, it is frequently recommended that a corresponding LED be used for absolute calibration when measuring white LEDs with a pronounced blue component in their light. This should avoid calibration errors that can occur in conjunction with the scattered light of a white LED.

However, this is not required for devices that feature optical stray light reduction (OSR) that are used in high quality spectroradiometers. Applying suitable filters and mathematical models reliably prevents calibration errors caused by stray light.

Summary

The combination of longevity and extremely robust internals as well as the high light output expected of LEDs makes this illumination technology truly unique. It therefore comes as no surprise that the requirements for a color consistency are very high when LEDs are being binned into the color groups. Adding to this is the increasing need to optically characterize LEDs, since their illumination characteristics are critical to safeguarding compliant product quality. Integrating spheres have proven to be versatile and effective measuring tools and are even essential for some applications. ■

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Lighting Mona Lisa with LEDs - Details Concerning Innovating Techniques

As part of Toshiba's patronage of the Louvre Museum, it was decided to develop a new, very high performance lamp in order to add complementary lighting to the Mona Lisa. A special development team was formed and the company ARKANZ dealt with the execution of the product. The new LED lighting equipment was installed on June 4th, last year. In the following article, Marc Fontoynont, Jean Pierre Miras, Marco Angelini, Jean Chanussot, Christophe Marty, Grégory Duchêne, Leonid Novakovski, Kazuaki Makita and Tokayoshi Moriyama present the solutions developed by this team.

An LED lamp was designed exclusively with the purpose of providing the Mona Lisa in the Louvre Museum in Paris, with the highest possible quality of lighting. The Japanese company, Toshiba, financed the innovative design. The new lamp is installed in a shelf designed by the room's architect (Lorenzo Piqueras, 2005) and works upward. It is composed of 34 LEDs (single chip and multi chips) and replaces the former lamp from 2005, containing 7 LEDs. Three optical systems have been developed in order to obtain a high uniformity of luminance on the painting: primary optics on the LEDs, a "Scheib" mixing the colors, and a third system consisting of a double lens with an integrated filter, focusing the light on the painting and regulating its quality. A framer was also incorporated. The other aim of this lamp is to freely control the color temperatures, keeping a high CRI (>95) with a maximum Gamut Area (in relation to the scientific research of the International Lighting Commission).

This is realized without producing any infrared or ultraviolet radiation. A smart command system was developed which allows the Louvre Museum to adjust the spectrum of the light (deviation Duv), with an easy and precise process.

These changes are mainly useful for adjusting the coloration caused by the protection glass and to the surrounding luminous environment, and for obtaining the best rendering.

Finally, the lamp benefits from an extremely powerful cooling system that stabilizes the mixing of color and offers a life of 80,000 hours. Owing to the use of the last generation of LEDs, this lamp consumes only about 20 watts when operating.

Figure 1: **Toshiba lamp 2013 with 34 LEDs designed to light the Mona Lisa**

Original Lighting Principles and Functional Requirements of the New Lamp

Marc Fontoynont, Consultant, Professor, Aalborg University, Copenhagen, Danemark

In 2005, Architect Lorenzo Piqueras was in charge of the renovation of the "La Joconde Room" at the Louvre Museum and Marc Fontoynont was responsible for the lighting. It had been decided that the Mona Lisa should not be lighted in an ostentatious way, and that the way it is represented should closely resemble the one used for the neighboring paintings. The painting's position on a specific wall and behind a thick plate of laminated glass required a lighting system providing color adjustments to be added. The upward lighting from the shelf allows the lamp to be hidden and avoids risks of reflections.

In the renovation conducted in 2005, we realized that a lighting system based on multiple LEDs could efficiently provide the chromatic corrections needed (optimal rendering of colors, compensation of coloration due to the thickness of the glass plate and the need to take into account the surrounding lighting). Designing an LED lamp short enough to be inserted in the shelf was a major constraint. The lamp designed in 2005 was composed of 7 LEDs and had already been the subject of a detailed colorimetric study.

In 2013, lighting techniques have progressed, so did knowledge in colorimetry. Consequently, it has been possible to push the challenge even further:

- With LEDs of high luminous efficacy, and better spectral distribution
- With more precise optics to significantly improve uniformity of illuminance distribution over the painting
- With an integrated framing with sharp edges
- With an integrated color adjustment system, to allow simple and precise spectral adjustment
- With an increase of "Gamut Area", to extend quality of display (based on CIE work)
- With a selection of techniques which could be deployed to all museums

A State-of-the-Art Lamp that Draws on the Best Available Technology and Know-How

Jean–Pierre Miras, CEO, Arkanz Lighting GmbH / Sklaer GmbH, Frankfurt, Germany

The first lamp developed for La Joconde by Sklaer GmbH (an Arkanz affiliate) in 2005 had 7 LEDs, a FOCON type color mixer-converter (Fiber Optics Converter), and an active cooling system using a permanently functioning fan.
Each channel was driven individually in constant current. It operated for over 70,000 hours without failure.

The development of the new lamp, managed by Arkanz Lighting in close cooperation with Toshiba Lighting, has called for innovative technological solutions: 34 LEDs are positioned in a star configuration in order to ensure chromatic homogeneity across the painting. The spectral distributions of the LEDs have been carefully chosen in order to achieve a very high Color Rendering Index (CRI) of up to 98 on the required temperature color range. The cooling of the lamp is ensured by a massive copper heat sink in combination with a fan to limit the chromatic variations as much as possible and to guarantee the spectrum over the required lifetime.

One of the major challenges was to mix colors over a very short 12 cm distance. This was made possible by Partner Company Fraen srl integrating a Scheib optical fiber mixer in the mixing and projection optical system. (See following articles).

The current driving system was designed by the company DEF srl (Lombardy, Italy). DEF was also responsible for the assembly and the quality management with UL International Italy. Two D-LED Push type constant current DALI drivers have been used for color mixing and interference free dimming. The Push is a very compact multi-channel current driver specially adapted for LEDs lamps; it has a DALI or 0-10 V interface and an overheating control loop.

Figure 2 (left): **Lamp with 7 LEDs developed by Arkanz-Sklaer GmbH in 2005 (Project - Arch. L. Piqueras / Lighting - M. Fontoynont)**

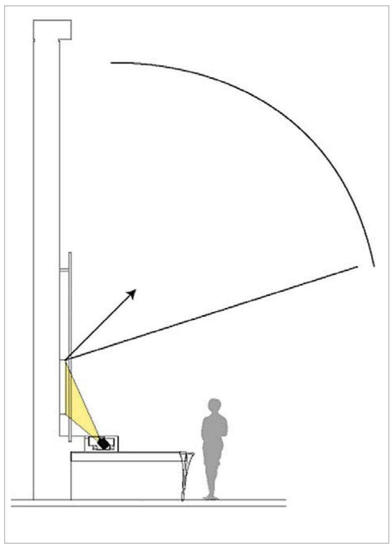


Figure 3 (right): **Upward lighting principle of Mona Lisa developed in 2005 (Architect Lorenzo Piqueras, Lighting Designer Marc Fontoynont)**

Figure 4:
The new Toshiba Mona Lisa projector, Design Vittorio Ferri, 2013

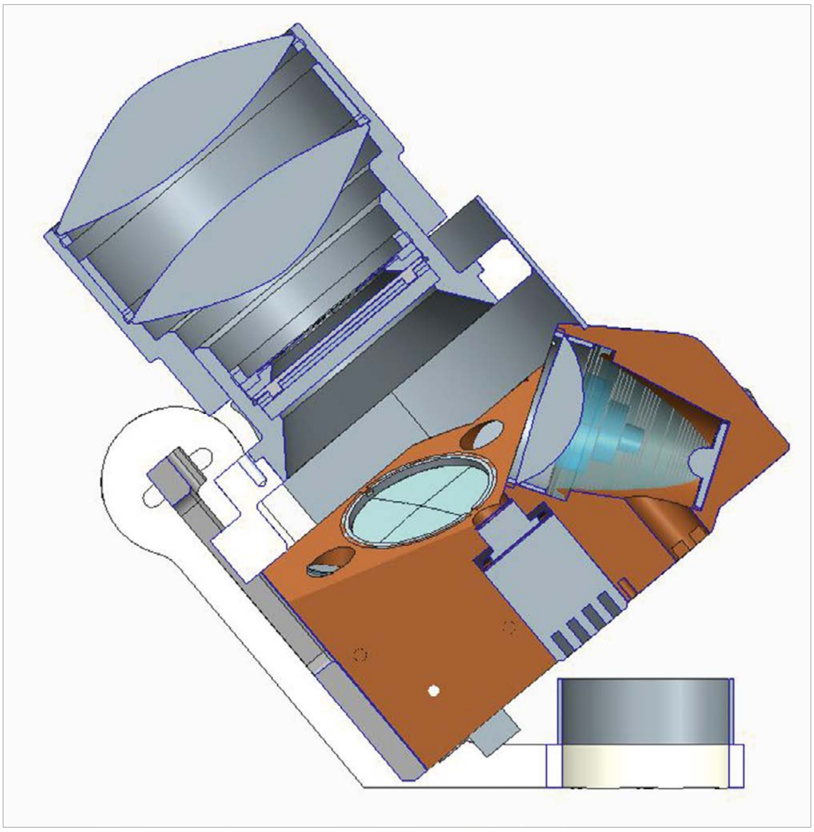
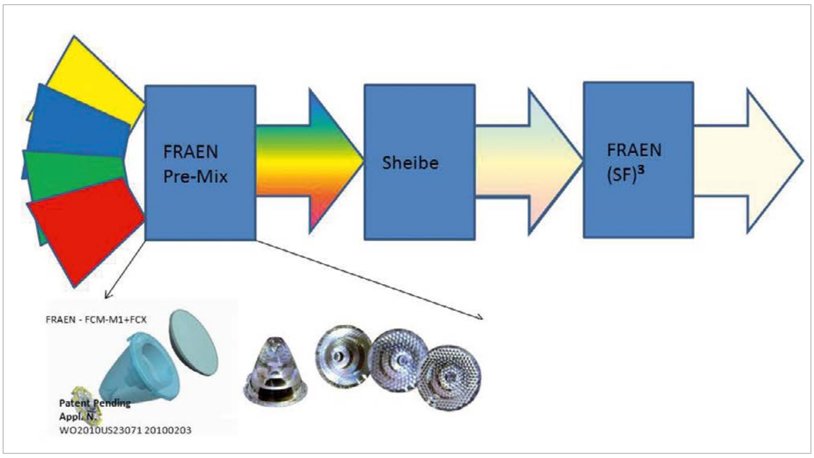


Figure 5:
Details of the color mixing optical train that guarantees lighting uniformity across the screen



A CP64-LX-C standard controller from the Company AELSYS (PACA region, France) is used to control the drivers and store the scenarios. Aelsys develops and manufactures DALI and DMX controllers that can be interfaced with external sensors as light control and presence detectors. In Le Louvre, the controller is connected via an Ethernet link to the main bus of the Museum

The configuration software (WINCIP) has been modified to integrate a colorimetric module; this module can automatically set the levels in the 7 groups of LED modules once you have chosen the following three parameters: color temperature, luminous intensity and deviation from the black body locus. AELSYS has developed an application on Windows 8 to link the CP64-LX-C with a Toshiba tactile PC/Tablet, via Wifi or an USB3 link.

With this „concept lamp" Arkanz Lighting and its partner companies have studied and implemented a number of technological solutions that are the subject of patents and open the way for new, powerful and high-performance museum projectors.

Optical Optimization for an Excellent Uniformity across the Painting

Marco Angelini, MD & CTO, Fraen Corporation Srl, Italy

In the former 2005 LED lamp model, the projection lens was a single aspheric lens with a 0.8 numerical aperture. The shape of the beam was created using a fiber optics converter with a trapezoidal output whose rectangular projection coincided exactly with the painting of La Jocund.

For the new 2013 LED lamp, the main multi-sources structure has been retained although the spatial distribution has been improved to increase the homogeneity of both color and intensity.

The number of LEDs has been increased from 7 to 34, set up as 7 "single-chips" and 3 "multi-chips" each one consisting of 9 chips.

The color mixing is achieved through three successive steps:

- The first "pre-mix" step is based on specific Fraen optical components for LED color mixing (Fraen - FCM-M1+FCX Patent Pending Appl. N. WO2010US23071 20100203)
- The second step uses a "Scheib" optical system (see colors/Scheib mixture section)
- The third step uses a special (SF)3 diffusing filter

A "Pre-mix" optical system allows the beam from the 34 LED-source to focus on a disk that creates a high-homogeneity luminous spot. The dimensions of the luminous spot are optimized in relation to the size of the La Jocund painting.

Downstream of the "Scheib" mixer we have chosen to position a trapezoidal cut-off diaphragm in the focal plane of the projection system. This allows a rectangular-form spot to be projected on to the screen plane that is not orthogonal to the optical axis of the lamp.

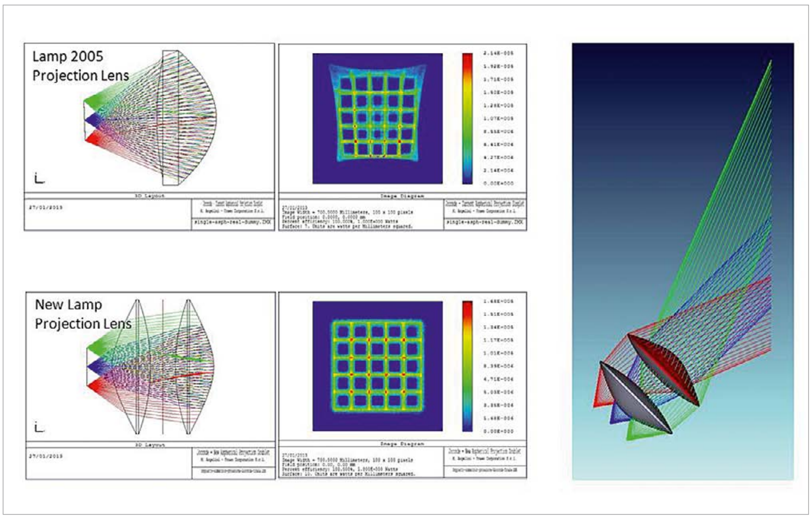


Figure 6:
Asymmetric projection doublet guarantees uniform light distribution properly shaped on the screen

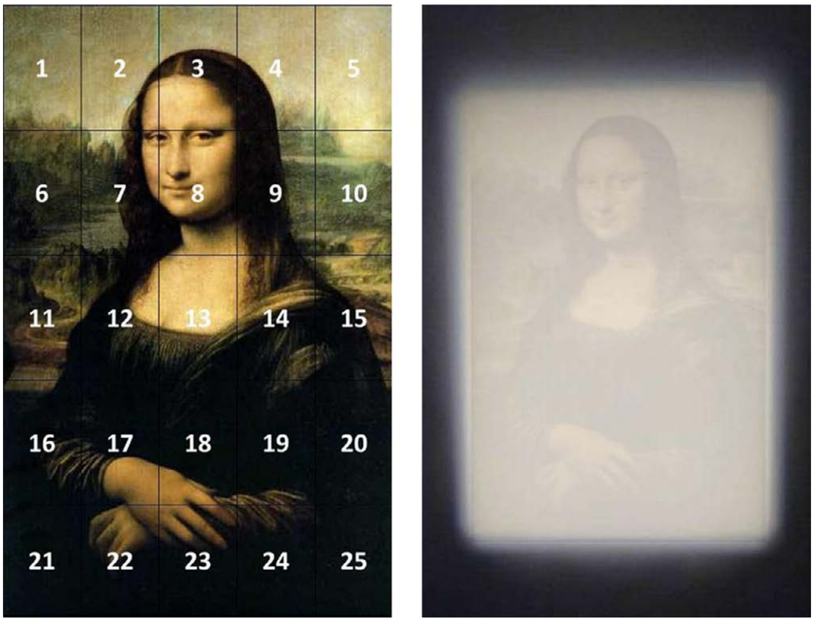


Figure 7:
The light measurements on the painting show a uniformity of 0.85 with the lamp alone and 0.92, taking the ambient light into account

The former lamp used an aspheric single projection lens. The new lamp is equipped with a special-design aspheric-symmetrical doublet. This doublet has a numerical aperture of 0.7. The design of this new two-lens system was necessary to eliminate the distortion on the upper side of the asymmetrical projection of the beam. This resulted in obtaining a very well defined rectangular spot on the painting. Furthermore, careful fine-tuning of the system offers the possibility of monitoring the contrast between the illuminated part (the painting) and its frame.

To manage the luminous fade from the illuminated area to the dark area, the team decided not to light up the frame but to make a slightly fuzzy "cut-off edge" to create a "soft" profile.

The uniformity of the screen lighting is one of the most noticeable spot performances of the 2013 model.

Because the lamp optical axis forms an angle of approximately 60 degrees with the normal painting plane, the risk was to have the lower part significantly brighter than the upper part. To avoid this problem, in addition to the pre-mix, the Scheib and the doublet systems, it was necessary to develop an additional special filter, named (SF)3, to balance more precisely the distribution of light on the painting. This (SF)3 filter can be designed for a wide variety of angles of incidence along both X,Y directions and for different optical specifications.

LED Color Mixing - Technology Using Fiber-Optic Parallel-Sided Plate

Leonid Novakovsky, Pharos-Alef, Moscow

Color mixing of 34 LED sources in the new spotlight for the Mona Lisa is carried out by means of the device that enables the spotlight size to be reduced. It represents a fiber-optic parallel-sided plate ("Scheib") and uses the same principle of operation as in the FOCON of the previous spotlight, but with more sophisticated diaphragms. It consists of a bunch of optical fibers with both a high fill factor and a high angular aperture which is 4 mm thick. The big aperture (0.5) allows LED modules to be arranged in a wide cone of +/- 32°. Testing this device shows that color mixing of very high quality takes place there, and as a result of that the uniformity of illumination would run close to 95%.

The fiber-optic plate ("Scheib") is used for light beam transmission and image shaping when an application demands precise light distribution in a small space. This elegant technology is successfully used for shaping a mobile light beam pattern in original headlight designs and is the subject of a patent application submitted by Pharos-Alef Ltd. and Sklaer Gmbh (patent N 2283986).

Figure 8:
Fiber-optic plate "Scheib" (Photo by Sklaer GmbH)

Total Control of Spectra and Luminous Power

Christophe Marty, Gregory Duchêne, INGELUX, Lyon, France

Two different pilot modes were suggested: the first one dedicated to colorimetric adjustments before the final on-site delivery and the second one for current operation, and interfaced with the DALI protocol employed in the Louvre Museum.

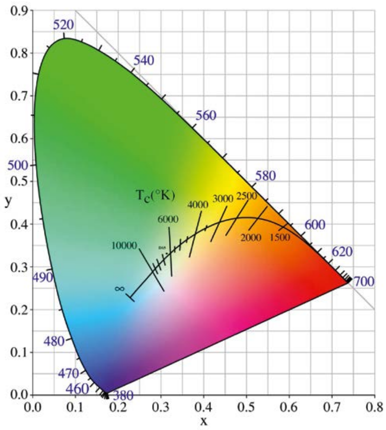


Figure 9:
The controlling system offers the highest quality of lighting for all the operating points situated on a wide range of temperatures. A high Gamut Area is reached with a large number of LEDs (34). The navigation on the diagram is made by the Ingelux designed pilot, based on established knowledge

The first aspect was particularly relevant concerning innovation.

We have designed a colorimetrical tool, in line with the ongoing research of the International Council of Museums (ICOM) and the International Lighting Commission (CIE). This tool allows us to navigate in the colorimetric space, to freely control the chromatic coordinates of emitted light while disposing at any time of a light with an optimal quality (high Color Rendering Index and maximal Gamut Area). The development of this software has required spectral calibration of each color channel, corrections due to optical systems, using an integrating sphere.

However, the conservation department of the Louvre Museum had to make final decisions concerning these adjustments. We have elaborated a protocol for on-site adjustment in front of the Mona Lisa. The final adjustment was decided by the curator, Vincent Delieuvin, assisted by the architect of the "La Joconde Room" Lorenzo Piqueras, under mixed general lighting conditions (fluorescent light with a little bit of natural light).

It is essential to insist on the innovative process, allowing the curator to adjust the light and colors on a painting, to render with high fidelity, the exact colors of the work.

The process that we elaborated would deserve to be in many museums, at least where the art curators would like to adjust the lighting:
a) because of the deterioration of the painting,
b) because the general lighting conditions are inappropriate and need a localized chromatic correction.

The Highest Quality LED Lamp in the World

Kazuaki Makita, Toshiba Corporation, Chief Specialist

The Toshiba group started new activities regarding lighting in April 2010 in order to create a new worldwide "lighting culture". Within the framework of the first renovation project of lighting outside the museum, we signed a contract in partnership with the Louvre Museum (from June 30, 2010 to December 31, 2013). The lighting of the Pyramid, the Pyramidions and the Colbert Pavilion was replaced by LED lamps on December 6, 2011, whereas the LED retrofit lamps at the Cour Napoléon were installed on May 24, 2012. Today, the work is progressing in order to deliver the Cour Carrée lights by the end of 2014.

This renovation project of external lighting is not limited to a simple technological support job, but has maintained a worldwide cultural heritage in a "more sustainable and nicer way", to achieve the "fusions of arts and technology" and to reduce electrical consumption to 73%.

The Louvre Museum acknowledges that we have succeeded in combining the "reduction of environmental charges and the revalorization of arts". This explains why we could sign a new partnership contract on the renovation project dealing with the lighting of the interior of the Museum in May 2012.

This time, a series of lights will be replaced by LED lamps, starting with the lights of the Mona Lisa, called the treasure of the Louvre Museum, the ones in the "Red Room" where we find famous large-scale paintings (for example the Couronnement de l'Empereur et de l'Imperatrice).
We will also replace the light situated at the entrance of the Napoleon Hall, more precisely at the entrance of the Museum.

The specific Mona Lisa light was expected to be replaced in June 2013 together with the luminaires of the Red Room. The lighting in the Napoleon Hall will be renovated before mid-2014.

At the beginning Toshiba had planned to design a new lamp to replace the specific lamp developed in 2005 by the German company Arkanz-Sklaer that lights the Mona Lisa. They decided to develop an innovation lamp based on the latest technology of LEDs and benefiting from progresses in optics. Toshiba then launched a project to gather the best available technologies to develop a lamp of the best possible quality.

Close Monitoring of the Technical Team

T. Moriyama, Toshiba Lighting & Technology Corporation, Senior Specialist

Toshiba began to investigate the possibility of developing a new lamp to light the Mona Lisa in 2012. To improve the performance of the former lamp we conducted a feasibility study that ran for two months after June 2012, together with the German company Arkanz GmbH, and we began to launch technological developments on the following points:

- Assess possible technologies to control fluxes, CCT, Duv and CRI
- Investigate technical solutions to improve uniformity of illuminance of the Mona Lisa, as well as the uniformity of spectral distribution over the painting
- Investigate solutions to provide a perfect framing at the edge of the rectangular painting
- Identify ways to limit drastically any production of UV radiation and infra-red light

In January 2013 a prototype was built. The operation of the lamp was tested in real conditions in front of the Mona Lisa with the participation of the curator of the XVIth century Italian painting, Vincent Dieulevin, and the Architect of the "Salle de la Joconde", Lorenzo Piqueras. In February, the final spectral distribution of the lamp as well as the luminous flux was determined through on-site tests.

Table 1:
Performances of the Toshiba lamp

Parameters	Specifications	TOSHIBA Lamp
CCT with high CRI	2700 to 3800 K	Adjustable from 2700 K until 3800 K - 3200 K selected for Mona Lisa
Color shift from locus	N/A	Adjustable from -0.02 to 0.01
Luminous Flux (lm)	N/A	88 lm selected from Mona Lisa (can be boosted to 400 lm)
CRI	> 90	CRI between 95 and 98 when on locus
Color Quality Scale (CQS)	> 85	> 95 for Mona Lisa > 85 maintained for various CCT between 2700 K and 3800 K
Ultra Violet radiation	< 5 μW/lm	< 3 μW/lm
Infra-Red Radiation	< 0.1 W	< 0.05W
Uniformity on painting Emin/Eaverage	> 0.6	0.85 (with 16 points) > 0,92 with ambient lighting
Vertical Uniformity on painting	> 0.9	0,93 $E_{half\ top}$ over $E_{average}$
Average Illuminance	100-250 lx spot + ambient	180 lx on glass / 108 lx on painting (spot only)
Luminous Flux projected outside frame	< 1%	< 0.5%
Lamp Life	> 50,000 hours	~ 80,000 hours

Statement by the Curator of the XVI Century Italian Paintings

Vincent Delieuvin, Louvre Museum

In the Louvre Museum, particular attention is paid to the lighting so that every object of art receives proper lighting. Each painting deserves to be looked at in the best conditions of lighting which, in turn, might be useful for understanding the pictorial technique of the artist or to admire the subtlety of his palette.

However, the lighting has to adapt to multiple constraints. For example: time could have deformed the structure, altered the pigments or damaged the varnish.

Furthermore, the glass protection of certain pieces of art, necessary for their security, can disturb the visibility if the surrounding space reflects into the glazing.

More or less all these constraints are present in the case of the Mona Lisa and in a very acute manner.

Over the past 500 years the wooden panel has lost its shape and taken a convex form. As a result, a complex network of cracks has appeared, damaging the subtle work of Leonardo da Vinci. The different coats of varnish laid down on the painting had oxidized, darkened and yellowed the color range. Finally, the protective glazing, particularly thick for this painting, adds a colored filter, which lighting has to Compensate.

The Louvre Museum would like this major artistic world heritage to benefit from the best available lighting techniques.

We are delighted that the painting has benefited from the latest innovations in the lighting domain, thanks to the partnership with Toshiba. This approach is part of the spirit of experimentation and the spirit of Leonardo de Vinci.

Statement by the Director of the Architecture

Sophie Lemonnier, Louvre Museum

The building of the Louvre Museum is in permanent change. Even today, the special design of the new lamp for the Mona Lisa is the result of an interactive collaboration between renowned specialists.

If in 2005 a new modern spot for the Mona Lisa was designed for the reopening of the Salle des États, today it is thanks to Toshiba's involvement, famous specialists gather again. We are delighted to present the painting showing the benefits of the latest of lighting technology.

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Cover-page

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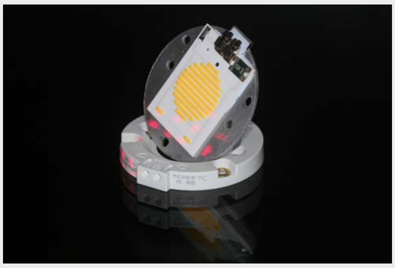
Product: Vossloh Schwabe Zhaga Book 3 LED Module



Zhaga compatible PCB core with Vossloh Schwabe's COB Array LED and its plastic housing

Next LpR

Performance & Standards Issue 42 - March/April 2014 - Short Overview

Technology:
LED Light Tile Technology for Lighting and Backlighting

The LED Light Tile technology is mechanically flexible, transparent and uniquely forms a light-guide with integrated optics. The integration of the optics on the surface enables functional, narrow asymmetric beam formation and a uniform spread of light across the surface for lighting applications. The technology will be a benchmark against conventional LED solutions regarding system efficacy and form factor. Furthermore, it will be explained how the technology can be deployed to best effect. ■

Technology:
Solder Joint Failure Mechanism Analysis

LED manufacturers have compiled a great deal of data on what happens to LED components. But the information on what failures can happen at temperature, voltage, current and humidity extremes, when, why, and how they can happen at a metallurgical level over extreme luminaire temperatures is rarely published. Based on the results of failure analysis scientists and peers from multiple engineering disciplines show the failures and mechanisms. ■

Electronics:
Protect LEDs from Electrical Overstress with Proper Circuit Design and Layout Practices

LED circuits operating in the real world can be subjected to various abnormal electrical overstress (EOS) situations. Carefully placed capacitors and protection circuits can prevent the most common of these failures in LED luminaires. Background information regarding some overstress modes and recommendations to minimize the potentially destructive effects of EOS on LED-based luminaires will be presented. ■

Optics:
Interactive Optimization Utilities to Improve LED Light Pipe Designs

The optimization of LED light pipes is uniquely challenging due to the complexity of singular or multiple LEDs, geometric shapes, and surface and material properties. Some of the latest design software offer improved tools to optimize designs that can help solve this issue. It will be explained how a new, useful feature that interactively monitors parameter changes, can help design engineers with any level of lighting simulation software experience, to produce a design that achieves the target results. ■

subject to change

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Publishing Company
Luger Research e.U.
Institute for Innovation & Technology
Moosmahdstrasse 30
A 6850 Dornbirn, Austria / Europe
phone +43 5572 39 44 89
fax +43 5572 20 60 70
info@lugerresearch.com
www.lugerresearch.com

Publisher
Siegfried Luger +43 5572 39 44 89-70
s.luger@led-professional.com

Editor-in-Chief
Arno Grabher-Meyer +43 5572 39 44 89-18
a.g-m@led-professional.com

Int. Account Manager
Theresa Koenig +43 5572 39 44 89-20
theresa.koenig@led-professional.com

Marketing & Sales Manager
Katharina Fink +43 5572 39 44 89-43
katharina.fink@led-professional.com

Your Local Contacts

China, Hong-Kong
Iris Yuen +86 1380 27 01 367
irisyuen88@gmail.com

Germany
Armin Wezel +49 30 526 891 92
armin@eurokom-media.de

Japan
Eiji Yoshikawa +81 3 6751 0090
scala@s3.dion.ne.jp

South Korea
Jung Won Suh +82 2 78 58 222
sinsegi-2@sinsegimedia.info

Switzerland
Monika B. Ailinger +41 41 850 44 24
m.ailinger@marcomedia.ch

Taiwan
Leon Chen +886 2 256 81 786-10
leon@jkmedia.com.tw

United Kingdom & France
Zena Coupé +44 1923 85 25 37
zena@expomedia.biz

US East
Karen C Smith-Kernc +1 717 397 7100
KarenKCS@aol.com

US West & Canada
Alan A. Kernc +1 717 397 7100
AlanKCS@aol.com