OSTAR®-Lighting
Application Note

Abstract

The following application note provides insight into the high power light sources of the OSTAR®-Lighting LED product family.
A basic overview of the construction of the light sources, their handling and assembly and the optical, electrical and performance characteristics will be given.
In addition to a compilation of potential driver circuitry for the individual design of a control gear an overview of obtainable power supplies of OSRAM is shown.
Furthermore an approach relating to thermal requirements will be provided in a design example.

OSTAR®-Lighting LED Light Source

The OSTAR®-Lighting LED light source was developed with an emphasis on the areas of general lighting such as:

- Room Lighting
- Architectural/Effect Lighting
- Industrial Lighting
- Radiators and Spot Lighting
- Flashlights

However, it is also suitable for special applications such as:

- Microscope Lighting
- High-quality Flash Lamps
- Traffic Signs
- Operation Lighting in Medical Technology

Above all, the OSTAR®-Lighting is predestined for use in applications where high luminance combined with a low geometric spreading of the illumination area is required. This particularly applies for applications with additional lenses or lens systems.

Due to its flat, compact form, the OSTAR®-Lighting offers lighting manufacturers the possibility to design and develop new illumination concepts as well as lighting designs or lighting systems.

In general, there are four variants of the OSTAR®-Lighting which differ only slightly from each other (Figure 1).
The first two are based on a module with 4 semiconductor chips; one variant is constructed without a lens, the other with a lens. The other two modules are based on a construction with 6 semiconductor chips, and also differentiate themselves by the use of primary optics.

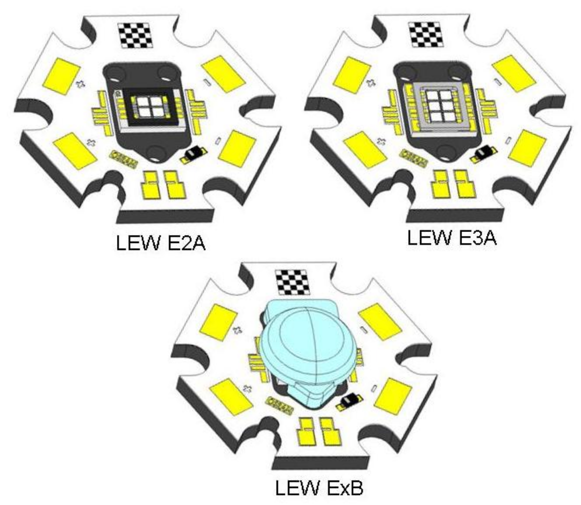


Figure 1: Modules of the OSTAR®-Lighting, with and without primary optics

Construction of the OSTAR®-Lighting

When designing the OSTAR®-Lighting LED light source, special consideration was given to the thermal optimization of the module.
Depending on the module type, the core of the module consists of four or six highly efficient semiconductor chips mounted on a ceramic substrate.
For optimal heat dissipation, the ceramic is directly mounted to the aluminum surface of the isolated metal core board (IMS-PCB).
The hexagonal metal core board serves in heat distribution and additionally provides a significantly large surface for a simple thermal connection to the system heat sink. The hexagonal form also permits a tightly packed layout of multiple light sources, or a simple cluster arrangement such as a ring. A further advantage of the hexagonal form is that thereby the smallest perimeter can be realized. This is especially important for the use in flashlight applications.
Because of the design and construction, the light source itself exhibits a very low thermal resistance of R_{thJS} = 3.6 K/W (LE W E3X).

Equipped with an ESD protection diode, the OSTAR®-Lighting possesses an ESD withstand voltage of up to 2 kV according to JESD22-A114-B.

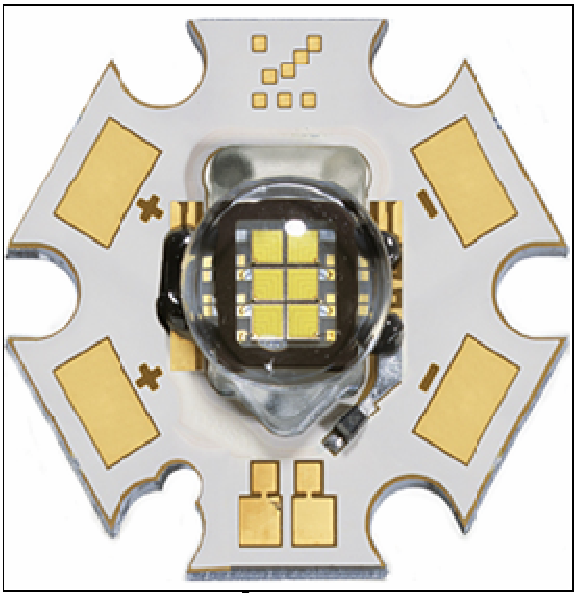


Figure 2: OSTAR®-Lighting with lens (LEW E3B)

In addition, the OSTAR®-Lighting carrier board can also be furnished with an additional NTC resistor (e.g. NTC EPCOS 8502).
The NTC temperature provides a good approximation of the average temperature of the underside of the board (Offset 0,25K/W = $\Delta T_{Board\text{-}NTC}/P_D$). In this manner, it is possible to implement a feedback loop for temperature monitoring of the OSTAR®-Lighting LED in the driver circuitry.

The light source consists of semiconductor chips which emit blue light and are based on the latest highly efficient thin film technology ThinGaN®.
All semiconductor chips are wired in series in order to guarantee an equally high current through all chips and to achieve a uniform brightness across the surface.
In addition to its high efficiency, the new ThinGaN® technology has the decisive advantage that the chip is nearly a pure surface emitter.
For use as a white light source, this means that the wavelength conversion for the creation of white light can be carried out directly at the chip level.
In this case, the converter material is applied directly to the chip surface as a chip coating and not dissolved in the encapsulant as is

the case with other white LEDs (volume conversion).
The advantage of the chip coating is that the converter can be applied to the chip surface in a homogeneous layer with uniform concentration. This causes the converted light to be nearly constant across the entire chip surface.
Typically, the color temperature of the OSTAR®-Lighting lies in the range of 4500 to 7000 K (daylight white), with a color reproduction index (CRI) of 80.

Handling the OSTAR®-Lighting

In order to protect the semiconductor from environmental influences such as moisture, the OSTAR®-Lighting is equipped with a clear silicone encapsulant which has an additional positive influence on reliability and lifetime.
In addition, the silicone encapsulant permits operation at a higher junction temperature (150°C) in comparison to that of an epoxy resin.
Due to the elastic properties of the encapsulant, however, mechanical stress to the silicone should be minimized or avoided as much as possible during assembling of the LED (see also the application note "Handling of Silicone Resin LEDs").
Correspondingly, care must also be taken with the black Globe-Top encapsulant of the connection contacts.
Excessive pressure on the Globe-Top can lead to spontaneous failure of the light source (damage to the contacts).
In general, the use of all types of sharp objects should be avoided in order to prevent damaging or puncturing the encapsulant.
Furthermore, it should be guaranteed that sufficient cooling is available for the compact light source during operation.
Even at low currents, prolonged operation without cooling can also lead to overheating, damage or failure of the module.

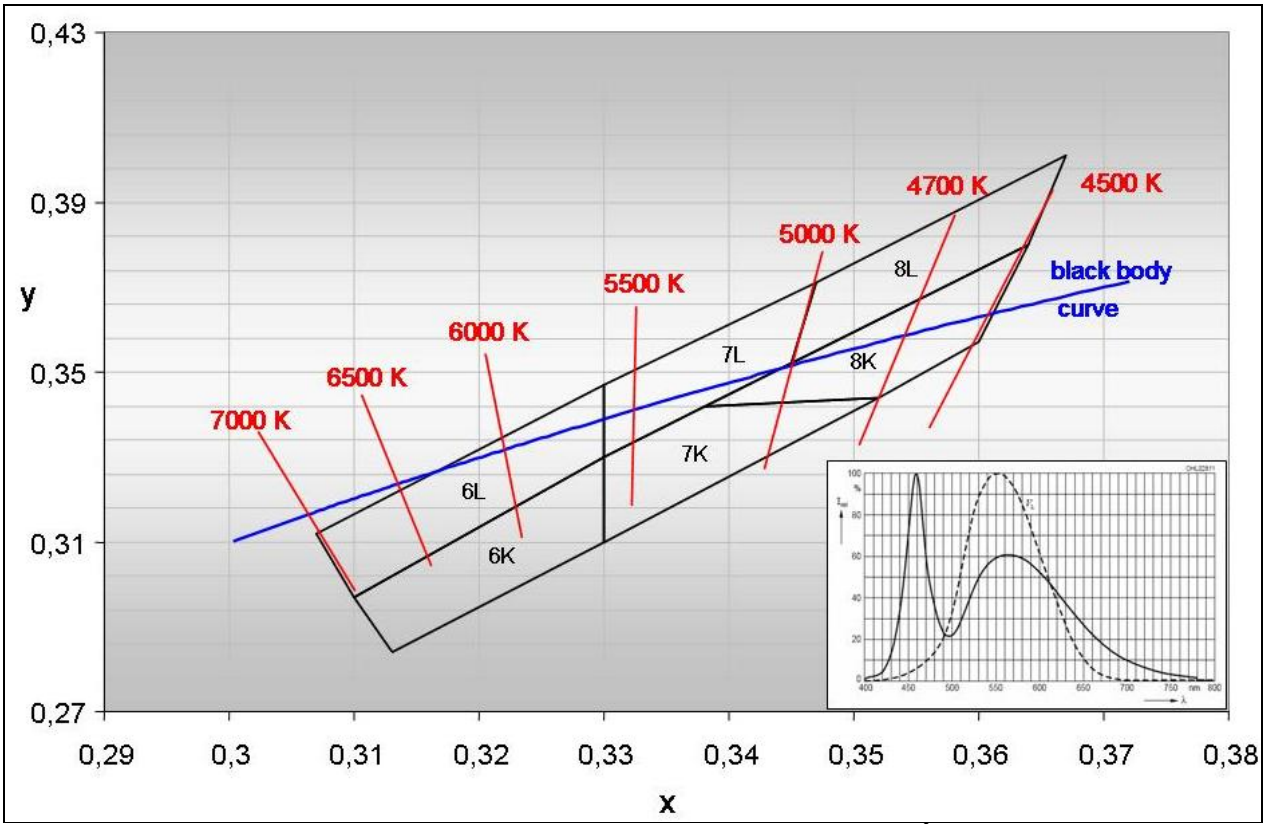


Figure 3: Color groups, color temperature and spectrum of the OSTAR®-Lighting

Mounting the OSTAR®-Lighting

For attaching the LED light source, several mounting methods can be used.
When selecting an appropriate mounting method, one must generally insure that a good heat transfer is available between the OSTAR®-Lighting and the heatsink and that it is also guaranteed during operation.
An insufficient or completely incorrect mounting can ultimately lead to thermal and mechanical problems during assembly.
For most applications, screws should generally be used for mounting the OSTAR®-Lighting light source.
When mounting the LED with M3 screws (min. 3pcs, 120° displaced), a torque of 0.8 Nm should be used to fasten the screws. In order to achieve a good thermal connection, the contact pressure should typically lie in the range of 0.35 MPa.

In addition to mounting with screws, the OSTAR®-Lighting LED can also be attached by means of gluing or clamping.
When mounting with glue, care should be taken that the glue is both adhesive and thermally stable, and possesses a good thermal conductivity.

When mounting a component to a heatsink, it should generally be kept in mind that two solid surfaces must be brought into close physical contact.
Technical surfaces are never really flat or smooth, however, but have a certain roughness due to microscopic edges and depressions. When two such surfaces are joined together, contact occurs only at the surface peaks. The depressions remain separated and form air-filled cavities (Figure 4).
Since air is a poor conductor of heat, these cavities should be filled with a thermally conductive material in order to significantly reduce the thermal resistance and increase the heat flow between the two bordering surfaces.

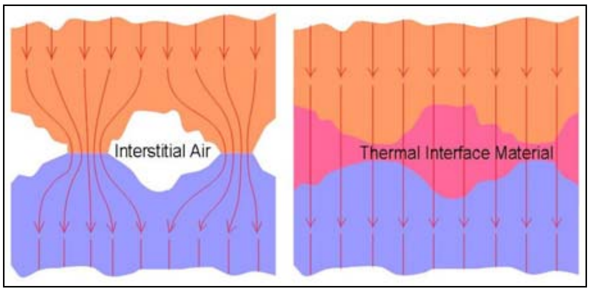


Figure 4: Heat flow with and without heat conductive material

Without an appropriate, optimally effective interface, only a limited amount of heat exchange occurs between the two components, eventually leading to overheating of the light source.

In order to improve the heat transfer capability and reduce the thermal contact resistance, several materials are suitable.
Thermally conductive pastes and compounds possess the lowest transfer resistance, but require a certain amount of care in handling.
Elastomers and foils/bands are easy to process, but usually require a particular contact pressure, even with pretreated surfaces.
The success of a particular thermal transfer material is dependent on the quality, the processing of the material and the thoroughness of the design.
Table 1 shows an overview of the most commonly used heat conductive materials along with their important advantages and disadvantages.

<table>
<tr><th>Description</th><th>Material</th><th>Advantages</th><th>Disadvantages</th></tr>
<tr><td>Thermally conductive paste</td><td>Typically silicone based, with heat conductive particles</td><td rowspan="2">Thinnest connection with minimal pressure

High thermal conductivity

No delamination</td><td rowspan="2">Material discharge at the edges

Danger of contamination during mass production

Paste can escape and "creep" over time

Connections require curing process</td></tr>
<tr><td>Thermally conductive compounds</td><td>Improved thermally conductive paste – rubbery film after curing</td></tr>
<tr><td>Phase change material</td><td>Material of polyester or acrylic with lower glass transition temperature, filled with thermally conductive particles</td><td>Easy handling and mounting

No delamination

No curing</td><td>Contact pressure required

Heat pretreatment required</td></tr>
<tr><td>Thermally conductive elastomers</td><td>Washer pads of silicone-plastic
- filled with thermally conductive particles
- often strengthened with glass fibers or dielectrics</td><td rowspan="2">No leakage or movement

No curing required</td><td rowspan="2">Problems with delamination

Moderate thermal conductivity

Contact pressure required</td></tr>
<tr><td>Thermally conductive tape</td><td>Double sided tape filled with particles for uniform thermal and adhesive properties</td></tr>
</table>

Table 1: Thermal Interface Materials

Thermal Considerations

In order to achieve reliability and optimal performance for LED light sources such as the OSTAR®-Lighting, appropriate thermal management is necessary.
Basically, there are two principle limitations for the maximum allowable temperature.

First of all, the maximum allowable board temperature for the OSTAR®-Lighting must not exceed 85°C. Secondly, the junction temperature must not rise above the allowable maximum of 125°C respectively 150°C.
Both temperature limits are also specified in the individual data sheets.

The warming of the OSTAR®-Lighting generally results from two sources, the first being external in origin (existing ambient temperature) and the second due to internal processes (current-dependent power losses).

This has the consequence that not all operating conditions are suitable or allowed for a particular ambient temperature.
The maximum allowable current for DC operation and various pulse modes of operation for two temperatures (T_A =25°C and T_A = 85°C) are specified in the data sheets.
For all cases in between, the maximum operating conditions can be estimated by interpolation of the curves.

Influence of Junction Temperature

Basically, the maximum allowable junction temperature should not be exceeded, as this can lead to irreversible damage to the LED and spontaneous failures.
Due to underlying physical interdependencies associated with the functioning of light emitting diodes, a change in the junction temperature T_J within the allowable temperature range has an effect on several LED parameters.
As a result, the forward voltage, luminous flux, color coordinates and lifetime of LEDs are influenced by the junction temperature.

Depending on the given requirements, this can ultimately have an effect on the application.

Influence on Forward Voltage V_f and Luminous Flux Φ_v

For LEDs, an increase in junction temperature leads to a decrease in forward voltage V_F (Figure 5), as well as a reduction in luminous flux Φ_v (Figure 6).
The resulting changes are reversible. That is, the original default values return when the temperature change is reversed.

For the application, this means that the lower the junction temperature T_j is, the greater the light output will be.

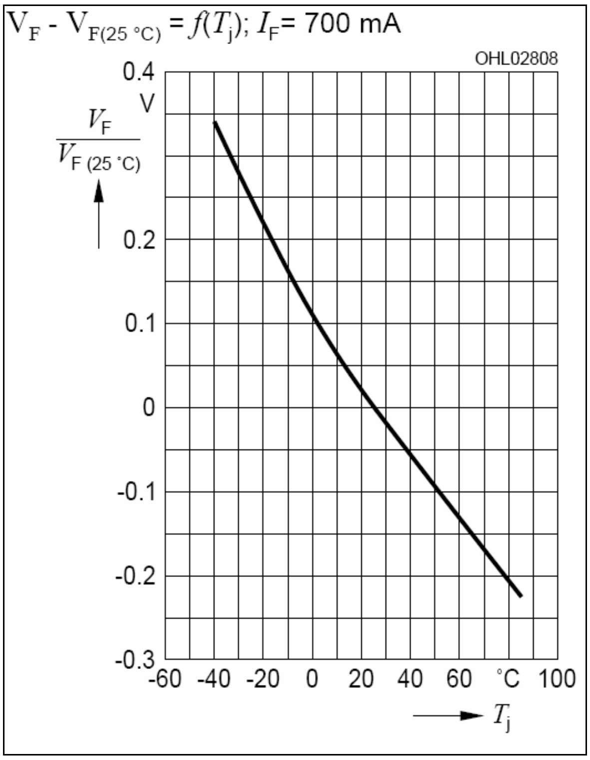


Figure 5: Relative forward voltage in relation to junction temperature (e.g. OSTAR® LE W E2x)

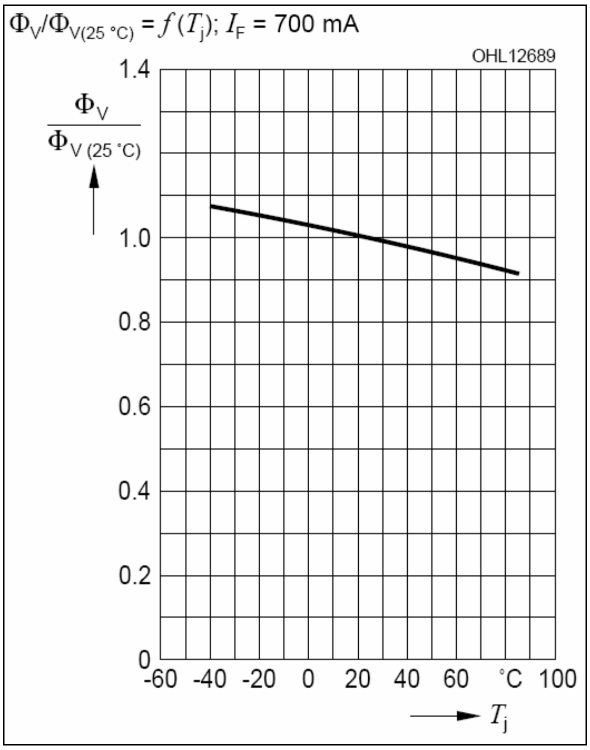


Figure 6: Relative luminous flux in relation to junction temperature (e.g. OSTAR® LE W E2x)

Color Coordinates

The influence on the color coordinates due to a change in junction temperature shows itself as a reversible shift in the default values.
The magnitude of the shift can be calculated from the respective temperature coefficients (Table 2).
An increase in temperature to 40°C, for example, results in a shift in the x-color coordinate of -0.004, and a shift in the y-color coordinate of -0.008.
The shift results in a change in appearance and thus can have an influence on the application, depending on the given requirements.

Temperature coefficient [10^{-3}/K]	
TC_x If= 700mA, -10<T<100°C	-0.1
TC_y If= 700mA, -10<T<100°C	-0.2

Table 2: Typical temperature coefficients of the color coordinates x and y for the OSTAR®-Lighting

Depending on the application, it should be determined whether this shift can be tolerated, or whether the temperature effect can be avoided or compensated by appropriate means.

Reliability and Lifetime

With respect to aging, reliability and performance, it is not recommended to drive the LEDs at their maximum allowable junction temperature. With an increase in temperature, a reduction in lifetime can be observed.

The temperature of the board or light source should also not be allowed to lie below the ambient temperature since this leads to thawing, ultimately damaging the module.

Optical Performance

When characterizing LEDs with respect to brightness, usually two values are specified - luminous flux Φ_V (units of lm) and luminous intensity I_v (units of cd).

The luminous flux of an LED describes the total radiated light, independent of direction. In contrast, the luminous intensity refers to the light emitted within a fixed solid angle (e.g. 0.01 sr = ±3.2°) in the direction of radiation (Figure 7).
Because of the application area and that for conventional illuminants, the specification is usually limited to luminous flux Φ_V, the OSTAR®-Lighting is also characterized and classified by means of luminous flux.

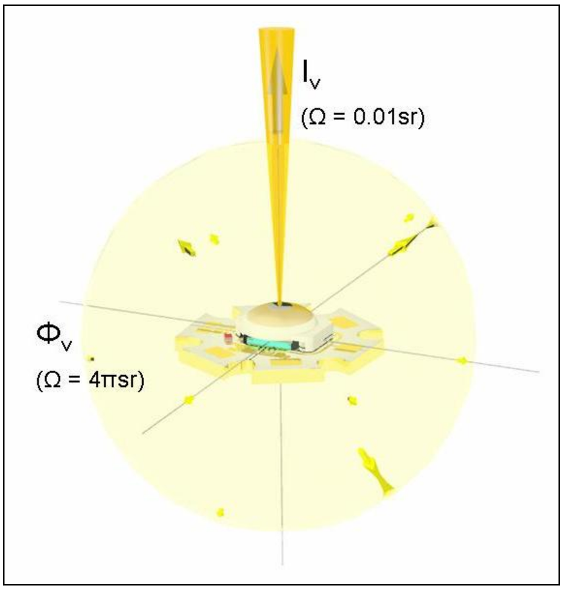


Figure 7: Definition of luminous flux & luminous intensity

Table 3 lists important optical characteristics of the various OSTAR®-Lighting LEDs.

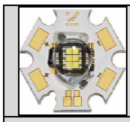
	OSTAR®-Lighting					
LED	LE W E2A / LE W E2B (4-Chip)			LE W E3A / LE W E3B (6-Chip)		
I_f	350 mA	700 mA	1 A	350 mA	700 mA	1 A
Φ_v (typ.)	124lm / 175lm	200lm / 280lm	240lm / 336lm	186lm / 260lm	300lm / 420lm	360lm / 504lm
I_v (typ.)	40cd / 44cd	64cd/ 70cd	77cd / 84cd	60cd / 65cd	95cd / 104cd	114cd / 125cd

Table 3: Optical characteristics of the OSTAR®-Lighting

Due to the physical properties of the semiconductor diode, the brightness of the light source does not increase or decrease linearly with respect to forward current.

The result is that the forward current must be significantly increased in order to double the luminous flux, for example. This effect can also be seen in the following diagram (Figure 8).

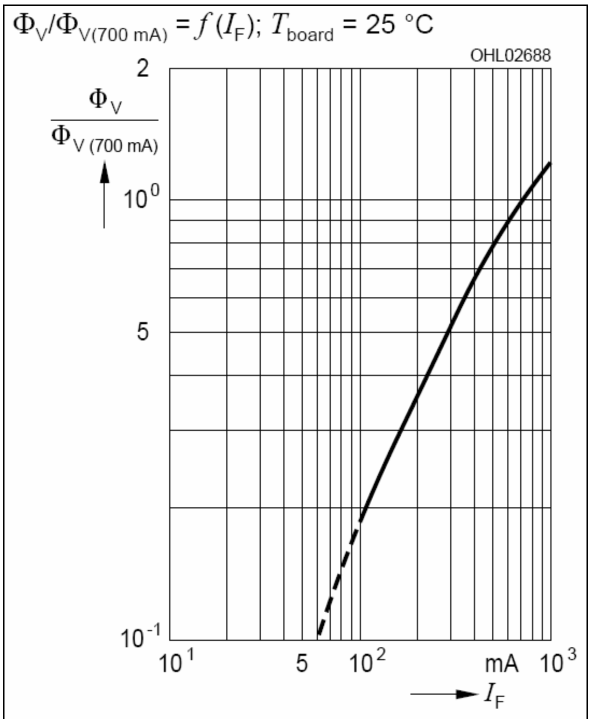


Figure 8: Relative luminous flux in relation to forward current I_F (e.g. OSTAR® LE W E3x)

For general lighting applications, the photometric value of illuminance E_v (units of lx = lm/m²) is also commonly used.
The illuminance describes the luminous flux for a particular area at a given distance (Figure 9).

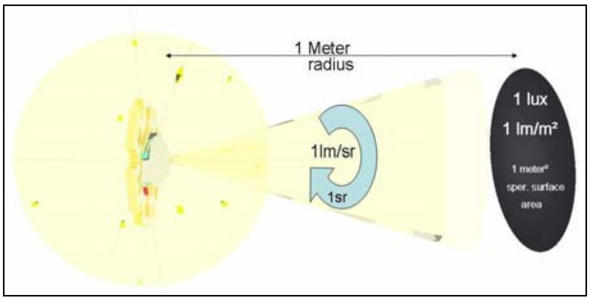


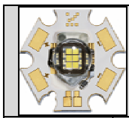
Figure 9: Definition of illuminance E_v

When directly comparing illuminance values of illuminants and LEDs, the distance at which the value was specified should be taken into account, since illuminance is indirectly proportional to the square of the distance.

$$E_v(r) = \frac{I_v}{r^2}$$

(Photometric Distance Law)

This mean, for example, that when the distance is doubled, the illuminance is reduced by a factor of four (Table 4).



OSTAR®-Lighting				
Modul	LE W E2A	LE W E2B	LE W E3A	LE W E3B
	4-Chip		6-Chip	
E_v at 0,5m	265 lx	280 lx	380 lx	416 lx
E_v at 1m	64 lx	70 lx	95 lx	104 lx
E_v at 1.5m	28 lx	31 lx	42 lx	46 lx
E_v at 2m	16 lx	18 lx	24 lx	26 lx

Table 4: Illuminance of the OSTAR®-Lighting @ I_F = 700 mA

For better visualization, one can refer to a so-called illuminance diagram (Figure 10) for the respective illuminant. This describes the illuminance for a particular area at predefined distances.

Here it should be noted, that the measured or specified illuminance only represents the brightness for the center of the LED or illumination field.

In practice, this means that the exact brightness curve in the area is dependent on the radiation characteristics of the light source or LED. The exact curve can be determined with the help of the respective specific radiation characteristics.

The radiation characteristics of the various OSTAR®-Lighting light sources vary due to the attached lens.
Figure 11 shows the radiation characteristics of the LED without a lens; Figure 12 shows the characteristics with primary optics.

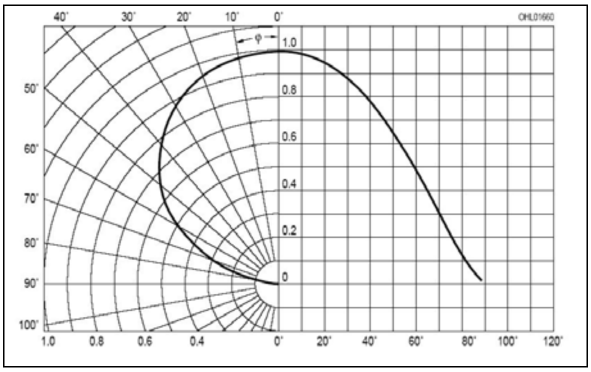


Figure 11: Radiation characteristics of OSTAR®-Lighting without lens (LE W ExA)

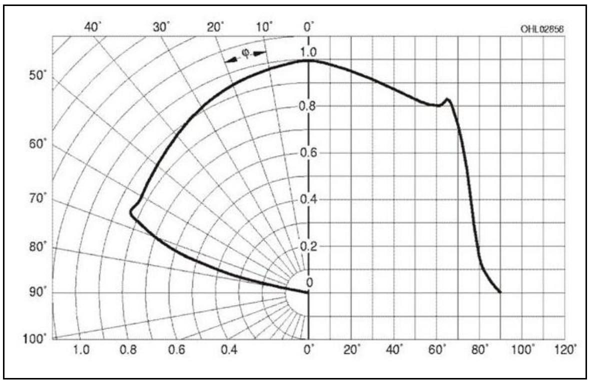


Figure 12: Radiation characteristics of OSTAR®-Lighting with lens (LE W ExB)

Generally, the illuminance can be additionally influenced through the use of appropriate secondary optics.
Secondary optics with a 30° radiation angle, adapted to the radiation characteristics of the OSTAR®-Lighting, would increase the illuminance by about a factor of 3, for example.

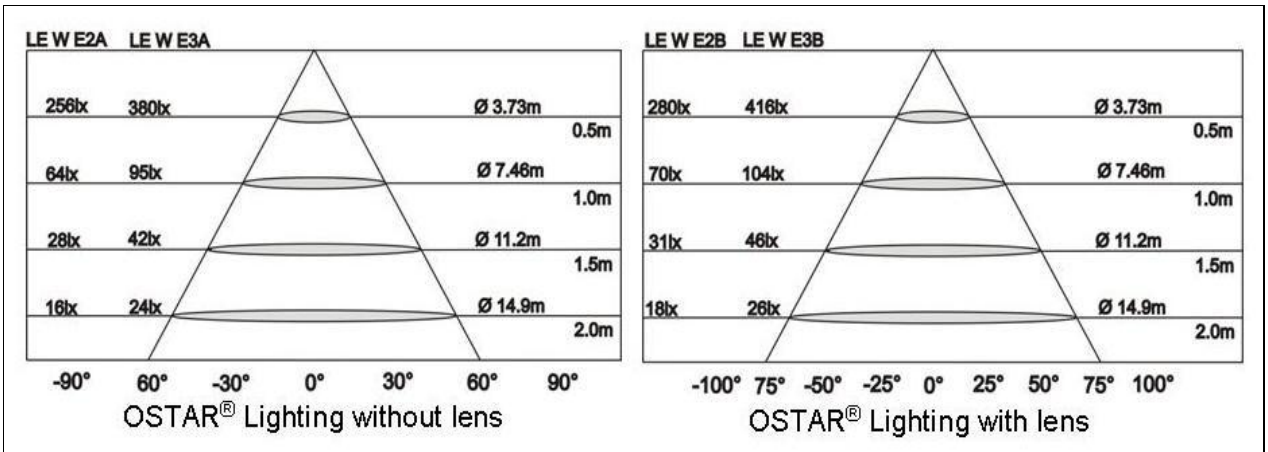


Figure 10: Illuminance of the OSTAR®-Lighting LED light sources @ I_F = 700 mA

Electrical Performance and Operation of the OSTAR®-Lighting

In addition to optimized optical performance, the new ThinGaN technology exhibits improved electrical characteristics in comparison to those of customary standard chip technology. These improvements have led to a significantly reduced forward voltage and higher allowable currents, for example. Table 5 shows the electrical characteristics of the OSTAR®-Lighting light source.

Like all white LEDs which create white light from a blue LED with phosphor conversion, the OSTAR®-Lighting exhibits a dependency of the color coordinates on the forward current applied (Figure 13).
The result is that a change in the forward current also causes a shift in the x-y color coordinates. Relative to the default color coordinates for the grouping current (I_F = 700mA), a reduction in current leads to a slight shift in the yellow direction; an increase leads to a shift in the blue direction.

In the application, this can ultimately mean a modified appearance. Particular attention must be dedicated to this parameter when dimming the OSTAR®-Lighting light source (see also the application note "Dimming InGaN").
Since the OSTAR®-Lighting LED light source should be driven with constant current, it is recommended that when selecting or developing an appropriate power supply unit, that pulse width modulation (PWM) functionality is present.

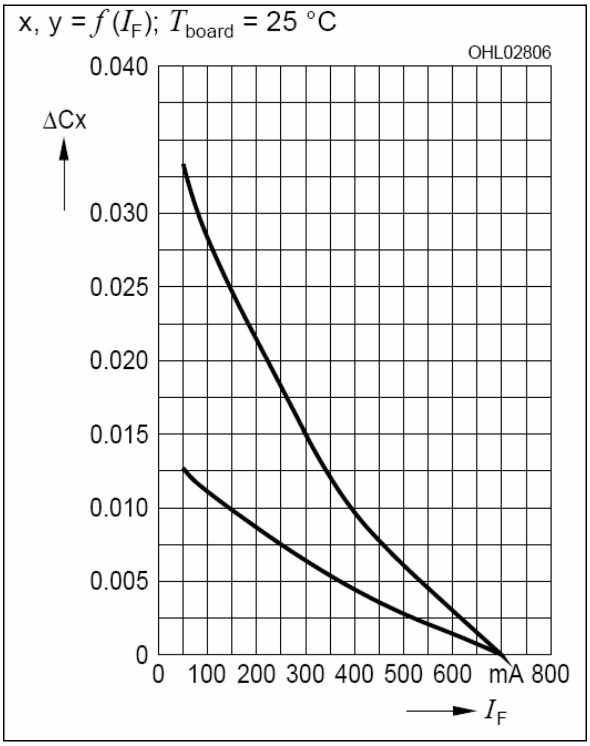


Figure 13: Color coordinate change in relation to forward current I_F (e.g. OSTAR® LE W E3x)

The PWM function offers the distinct advantage that when dimming, the color coordinates remain constant since the current level remains constant and only the pulse duration varies.

Table 6 gives a compilation of possible driver components for the individual design of a control gear for the OSTAR®-Lighting LED light sources. Additionally, the respective number of OSTAR®-Lighting LEDs per component depending on output voltage and maximum operating current is listed.

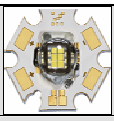
	OSTAR®-Lighting					
Module	LE W E2A / LE W E2B (4-Chip)			LE W E3A / LE W E3B (6-Chip)		
I_f	350mA	700 mA	1.0 A	350mA	700 mA	1.0 A
U_f (typ.)	13 V	15.2 V	16.2 V	19.5 V	22 V	24.5 V
U_f (max.)	14.5 V	17.2 V	19.8 V	22 V	25.8 V	29.8 V

Table 5: Electrical characteristics of the OSTAR®-Lighting light sources

Table 7 shows an overview of the obtainable power supplies of OSRAM for driving the OSTAR®-Lighting LED light sources.

In Figure 14 examples of a driver circuit for OSTAR®-Lighting light sources are shown by means of power supplies from OSRAM.

Driver -IC					
Manufacturer	Type	Voltage	Current (max.)	# OSTAR® @ If = 700mA	
				4 Chips	6 Chips
National	LM3478	V_{in} = 3 - 240V			
	(DC/DC)	V_{out} = 1.24 - 36V	I = 1A	2x	1x
	LM5000	V_{in} = 3.1 - 40V			
	(DC/DC)	V_{out} = 3.1 - 80V	I = 2A	4x	3x
	LM5010	V_{in} = 8 – 75V			
	(DC/DC)	V_{out} = 2.5 - 60V	I = 1A	3x	2x
	LM5021	V_{in} = 90 – 270V	(max. 80% duty cycle)		
	(AC/DC)	V_{out} = 12 - 270V	I = 1A	15x	10x
STMicroelectronics	VIPer 22A	V_{in} = 90 - 265V			
	(AC/DC)	V_{out} = 5 - 18V	I = 700 mA	1x	---
	VIPer 53A	V_{in} = 82 - 265V			
	(AC/DC)	V_{out} = 5 - 40V	I = 1 A	2x	1x
	L6562 (L6565)	V_{in} = 82 - 265V			
	(AC/DC)	V_{out} = 12 - 270V	I = 1 A	15x	10x
	L4976D	V_{in} = 8 - 55V			
	(DC/DC)	V_{out} = 0.5 - 50V	I = 1 A	2x	1x
	L5970D	V_{in} = 4.4 - 36V			
	(DC/DC)	V_{out} = 0.5 - 35V	I = 1 A	2x	1x
	L6902D	V_{in} = 8 - 36V			
	(DC/DC)	V_{out} = 1.2 - 34V	I = 1 A	1x	1x
Texas Instruments	TPS40200	Vin: 4.5 – 52V			
	DC/DC	Vout: 0.7-46V	I = 3A	2x	1x
	TPS5430	Vin:5.5-36V			
	DC/DC	Vout: 4.75 - 31V	I = 3A	1x	1x
	UCC3813	Vin: 85 – 265V			
	AC/DC	Vout: 4 - 400V	I = 1A	23x	15x
Supertex	HV9910	V_{in} = 8 - 450V			
	(AC or DC)	$V_{out} < V_{in}$	I = 2 A	24x	16x
	HV9931	V_{in} = 8 - 450V			
	(AC or DC)	$V_{out} > 3V$	I = 1 A	12x	8x
	HV9930	V_{in} = 8 - 200V			
	(DC/DC)	$V_{in} < V_{out} < V_{in}$	I = 1 A	12x	8x
	HV9911	V_{in} = 9 - 250V			
	(DC/DC)	$V_{out} > V_{in}$	I = 2 A	24x	16x

Table 6: Compilation of driver components for driving the OSTAR®-Lighting light sources

Operating / Control Devices				
Typ	Voltage	Current (max.)	# OSTAR® @ If = 700mA	
			4 Chips	6 Chips
OT 9/100-120/350E	Vin = 100 - 120V			
(AC/DC)	Vout= 1.8 - 25V	I = 350mA	1x	1x
OT 9/200-240/350	Vin = 200 - 240V			
(AC/DC)	V_{out}= 1.8 - 25V	I = 350mA	1x	1x
OT 9/10-24/350 DIM	Vin = 10 - 24V			
(DC/DC)	Vout= 0 – 24.5V	I = 350mA	1x	1x
OT 35/200-240/700	Vin = 200 – 240V			
(AC/DC)	Vout ≤ 50V	I = 700mA	3x	2x
OT 18/200-240/700 DIM	Vin = 200 - 240V			
(AC/DC)	V_{out} ≤ 25V	I = 700mA	1x	1x

Table 7: Operating and Control Devices of OSRAM (product family OPTOTRONIC)

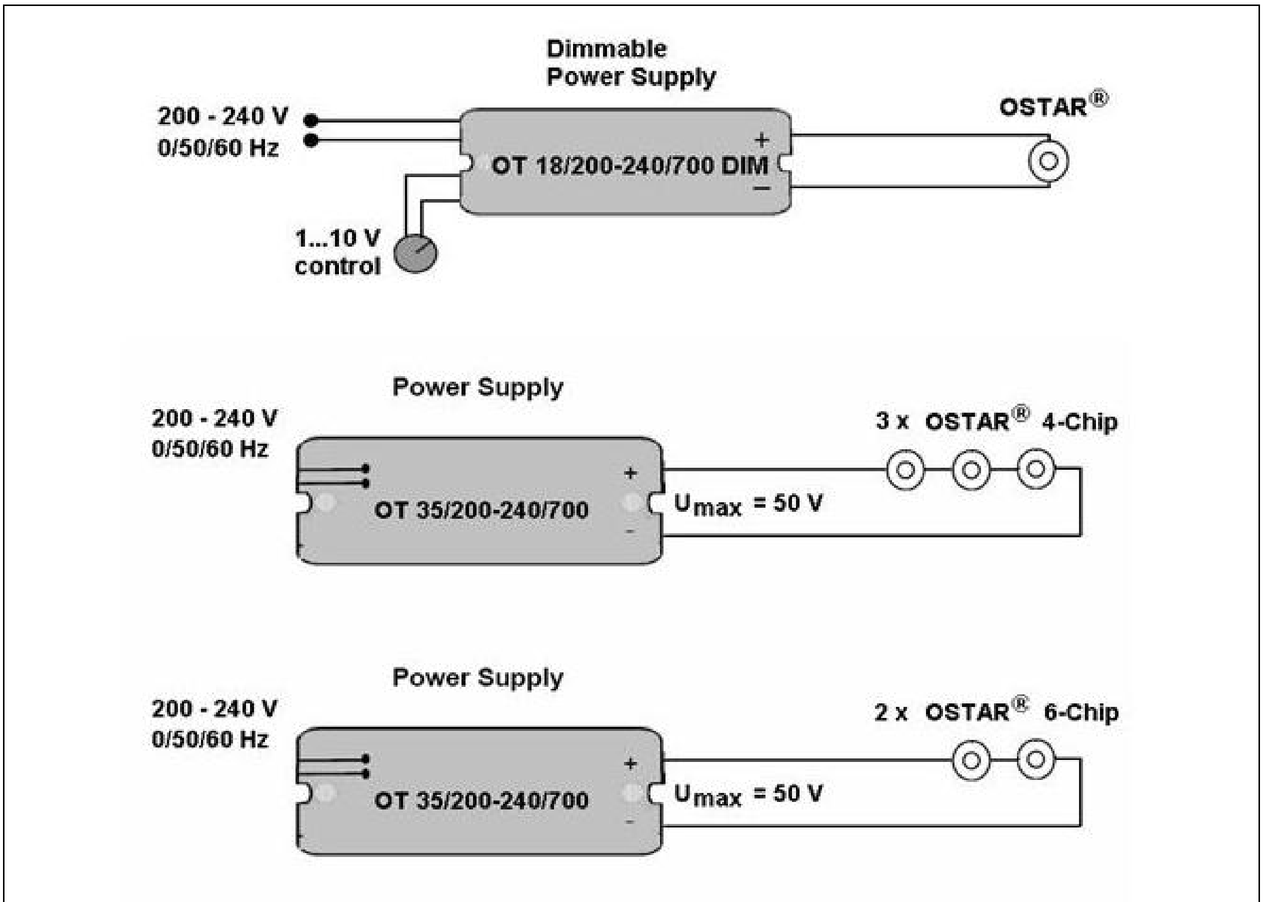


Figure 14: Examples of a driver circuit with power supplies from OSRAM

Design Example

In the following example, a hanging lamp with three OSTAR®-Lighting LEDs serves to illustrate the procedures related to the thermal requirements.

The starting point for the thermal observation is the three OSTAR®-Lighting LEDs (LEW E2B, 4x Chip Module with Lens) at an operating current of 700 mA and a maximum ambient temperature of T_A= 25°C.

With a typical brightness of 280 lm at 700 mA per module, the total brightness is 840 lm for the lights.

From these given values and the information from the data sheet, the cooling requirements can be found by the following formula:

$$\frac{\Delta T}{P_{Diss,\ Modul}} - R_{th,Interface} - R_{th,\ JB} = R_{th,Heatsink}$$

where

$$\Delta T\,[K] = T_{J(unction)} - T_{A(mbient)} - T_{Safety-Factor}$$
$$P_{Diss,Modul\ LEW\ E2X}\ [W] = 4 \cdot U_f[V] \cdot I_f[A]$$
$$P_{Diss,Modul\ LEW\ E3X}\ [W] = 6 \cdot U_f[V] \cdot I_f[A]$$

with

$T_{Junction}$ = max. junction temperature (from data sheet T_J = 125°C)
$T_{Ambient}$ = ambient temperature (T_A = 25°C)
$T_{Safety-Factor}$ = safety factor (typ. 10 - 20°C)
U_f = forward voltage (from data sheet U_f = 3.8 V)
I_f = forward current (I_F = 700 mA)
$R_{th,Interface}$ = thermal resistance of the transition material (e.g. thermally conductive paste 0.1 K/W)
$R_{th,JB}$ = thermal resistance of the OSTAR Lighting (from data sheet LEW E2B $R_{th,JB}$ = 5 K/W)
$R_{th,Heatsink}$ = thermal resistance of the cooling/heatsink

The thermal resistance for the required cooling per LED yields:

$$R_{th,Heatsink} = (\frac{125-25-10}{10.64} - 0.1 - 5) K/W$$
$$R_{th,Heatsink} = 3.35\ K/W$$

With the calculated value for the thermal resistance, an appropriate heatsink can be selected from a manufacturer.

Because the light fixture housing, an aluminum plate, is also used for cooling in the previous example, a second step is needed to calculate the required cooling area.

$$R_{th,Heatsink} = \frac{1}{A \cdot \alpha}$$
$$A = \frac{1}{R_{th,Heatsink} \cdot \alpha} = (\frac{1}{3.35 \cdot 7})\ m^2$$
$$A = 0.0426\ m^2$$

A = cooling area of a planar heatsink
α = coefficient for free convection ($7\ Wm^{-2}K^{-1}$)

For the lighting example with three OSTAR®-Lighting LEDs, this results in a total cooling area of about 0.1280 m² (1280 cm²).
With a ring-formed design, a light fixture with an outside diameter of 52 cm, a width of 9 cm, and a thickness of 4 mm can be realized (Figure 15).

In addition to thermal evaluation by means of simulation or calculations, it is generally recommended to verify and safeguard the design with a prototype and thermal measurements.

Figure 15: Design Example
Hanging lamp with 3 OSTAR-Lighting LED light sources

The power supply for the hanging lamp is located in the ceiling fixture; the wires to the OSTAR®-Lighting LEDs are integrated into the support cables.

Conclusion

Developed for high power operation with currents of up to two Amperes, the OSTAR®-Lighting LED light sources achieve a luminous flux of a few hundred to a thousand lumens, depending on operational parameters.

The OSTAR®-Lighting LEDs reach brightnesses similar to those of halogen lamps (typ. 500-700 lm) rated at 35 Watts of power.

Because of the high power operation, suitable thermal management is mandatory in order to achieve and guarantee optimal performance and reliability of the module.

When developing new lamp designs based on the OSTAR®-Lighting, it is generally recommended that in addition to performing a thermal simulation, the design should be verified and safeguarded with a prototype and thermal measurements.

Appendix

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Don't forget: LED Light for you is your place to be whenever you are looking for information or worldwide partners for your LED Lighting project.

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About Osram Opto Semiconductors

Osram Opto Semiconductors GmbH, Regensburg, is a wholly owned subsidiary of Osram GmbH, one of the world's three largest lamp manufacturers, and offers its customers a range of solutions based on semiconductor technology for lighting, sensor and visualisation applications. The company operates facilities in Regensburg (Germany), San José (USA) and Penang (Malaysia). Further information is available at www.osram-os.com.