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JUNE 2013

Technical application guide PrevaLED® Core Z2 light engines

Zhaga

OSRAM

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Please note:
All information in this guide has been prepared with great care. OSRAM, however, does not accept liability for possible errors, changes and/or omissions.
Please check www.osram.com/prevaled-core or contact your sales partner for an updated copy of this guide.

1. Introduction

1.1. System overview

Brightness levels of today's LEDs are opening the door for usage of LEDs in general lighting applications requiring high lumen output levels. Building an LED-based luminaire poses a new set of technical challenges, among them new optical requirements, providing adequate thermal management for stable operation and lastly dealing with the ever-improving performance of LEDs.

OSRAM's PrevaLED® family of LED light engines addresses the challenges of LED-based lighting while at the same time giving the user great performance and flexibility.

The PrevaLED® Core Z2 series of light engines is ideally suited for use in reflector-based, rotation-symmetric applications such as downlights or spotlights. These light engines provide several convincing benefits in the application:

- PrevaLED® Core Z2 light engines are available as a system of matching LED modules and ECGs and deliver maximum performance at very high levels of efficiency.
- These light engines provide superior optical performance, both in terms of their optical efficiency as well as their high quality of light (color rendering).
- A wide range of lumen packages (currently available from 800–5000 lm) allows addressing a wide range of applications based on a single platform. This platform allows, for example, the operation of a sequence of spotlights – ranging from halogen-class up to HID levels – in a row, while at the same time creating a homogeneous overall impression for the end user.
- Thanks to their high thermal and optical performance, luminaires based on PrevaLED® Core Z2 light engines can be realized with minimized size of required heat sink and reflector, giving the user greater design flexibility.
- PrevaLED® Core Z2 light engines provide standardized interfaces for the user, in particular by defining stable lumen packages over time. Independent of future increases in LED efficacy, the luminous flux of an individual LED module will remain constant, but at lower power consumption. In this way, a luminaire designed on the PrevaLED® Core platform will automatically benefit from efficacy improvements without needing a lengthy and costly redesign of the base construction.

At present, PrevaLED® Core Z2 light engines are available as systems in different performance grades:

- Lumen packages of 800–5000 lm are available with a good to very good color rendering (with typ. CRI 83 and typ. CRI 93).
- The lumen packages of 800–5000 lm with CRI 83 are especially well suited for consumer applications.

Movable 3D PrevaLED® Core Z2
(works with Adobe Acrobat 7 or higher)

The PrevaLED® light engine consists of an LED module, dedicated OTp and connection cable.

The high efficacy of the light engines not only results in minimized energy consumption of the luminaire, but also reduces the thermal load on the luminaire, allowing for smaller and lighter designs of the heat sink.

Both the CRI 90 and the CRI 80 types are available with 2700 K, 3000 K, 3500 K and 4500 K CCT; in lumen packages of 800, 1500, 2000, 3000, 4000 and 5000 lm.

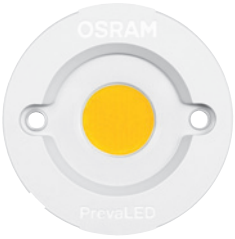
PrevaLED® Core LED modules must be operated with OPTOTRONIC® power supplies of the “OTp” type. Available types are detailed in the next section. All possible system configurations are listed on the latest datasheet.

Additional details on optical, thermal, mechanical and electrical characteristics can be found in the following sections. Additional and updated information (as well as updates of this guide) will be posted at www.osram.com/prevaled-core.

OSRAM also provides an extensive range of energy-saving light management components, such as sensors and room controllers. By use of these products, additional energy savings can be realized. For an overview of these products, please visit www.osram.com/lms.

PrevaLED® Core Z2 – CRI 90: Six lumen packages

800 lm, 1500 lm



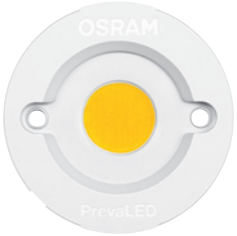
2000 lm

3000 lm, 4000 lm, 5000 lm

PrevaLED® Core Z2 – CRI 90: Six lumen packages				
	2700 K	**3000 K**	**3500 K**	**4000 K**
800 lm	LEP-800-927-C-Z2	LEP-800-930-C-Z2	LEP-800-935-C-Z2	LEP-800-940-C-Z2
1500 lm	LEP-1500-927-C-Z2	LEP-1500-930-C-Z2	LEP-1500-935-C-Z2	LEP-1500-940-C-Z2
2000 lm	LEP-2000-927-C-Z2	LEP-2000-930-C-Z2	LEP-2000-935-C-Z2	LEP-2000-940-C-Z2
3000 lm	LEP-3000-927-C-Z2	LEP-3000-930-C-Z2	LEP-3000-935-C-Z2	LEP-3000-940-C-Z2
4000 lm	LEP-4000-927-C-Z2	LEP-4000-930-C-Z2	LEP-4000-935-C-Z2	LEP-4000-940-C-Z2
5000 lm	–	LEP-5000-930-C-Z2	LEP-5000-935-C-Z2	LEP-5000-940-C-Z2

PrevaLED® Core Z2 – CRI 80: Six lumen packages

800 lm, 1500 lm



2000 lm

(2000 lm), 3000 lm, 4000 lm, 5000 lm

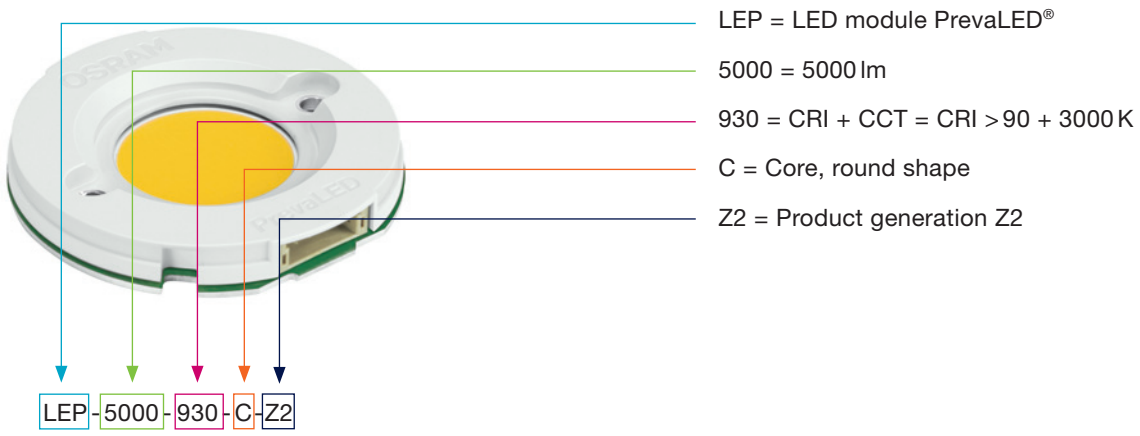
PrevaLED® Core Z2 – CRI 80: Six lumen packages				
	2700 K	**3000 K**	**3500 K**	**4000 K**
800 lm	LEP-800-827-C-Z2	LEP-800-830-C-Z2	LEP-800-835-C-Z2	LEP-800-840-C-Z2
1500 lm	LEP-1500-827-C-Z2	LEP-1500-830-C-Z2	LEP-1500-835-C-Z2	LEP-1500-840-C-Z2
2000 lm	LEP-2000-827-C-Z2	LEP-2000-830-C-Z2	LEP-2000-835-C-Z2	LEP-2000-840-C-Z2
3000 lm	LEP-3000-827-C-Z2	LEP-3000-830-C-Z2	LEP-3000-835-C-Z2	LEP-3000-840-C-Z2
4000 lm	LEP-4000-827-C-Z2	LEP-4000-830-C-Z2	LEP-4000-835-C-Z2	LEP-4000-840-C-Z2
5000 lm	–	LEP-5000-830-C-Z2	LEP-5000-835-C-Z2	LEP-5000-840-C-Z2

1.2. System information

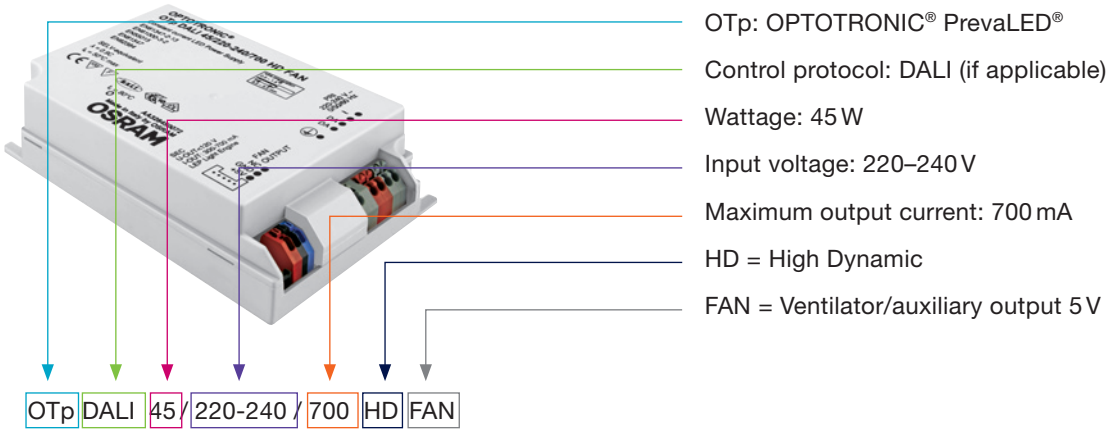
1.2.1. Nomenclature and marking

The PrevaLED® family follows a consistent naming convention for identifying key parameters of the LED module and the power supply. The nomenclature of the LED modules and OPTOTRONIC® ECGs is as follows:

LED module:

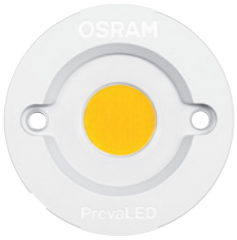


Power supply:



1.2.2. Technical data

Technical data product family PrevaLED® Core Z2:
For current data, please see the PrevaLED® datasheet at www.osram.com/prevaled-core.



PrevaLED® Core Z2

Technical data electronic control gear (ECG):
For current ECG data, please see the OPTOTRONIC® (OTp) datasheet at www.osram.com/prevaled-core.

ECG (OPTOTRONIC®)

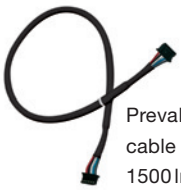
Combinations of LED modules and ECGs:
For current combination possibilities, please see the PrevaLED® datasheet at www.osram.COM/prevaled-core. Within rated power, LED modules and power supplies can be flexibly combined, e.g. according to the favored control option or form factor. A general requirement is that each LED module is connected to an individual ECG.

The connection between the LED module and the ECG should be established by means of the supplied cable kit. Available in lengths 40 cm and 80 cm, please also refer to: 3.2. Wiring information.

Well-established form factors have been utilized for the housings of the ECGs in order to ensure that existing luminaire housings or accessories can be adopted to PrevaLED® technology.

1.2.3. Accessories

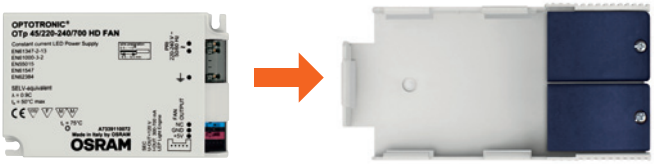
Cable kit
The cable is required for contacting and connecting the individual PrevaLED® Core Z2 LED module with the power supply. It ensures a flexible and safe connection. This cable kit is approved according to UL (Underwriters Laboratories).



PrevaLED® Core Z2-cable kit 800 lm, 1500 lm, 2000 lm, 3000 lm

PrevaLED® Core Z2-cable kit 4000 lm and 5000 lm

Cable clamp for OTp
This cable clamp can be clamped onto the ECG, turning it into an ECG suitable for independent installation. It is available for order for all OPTOTRONIC® OTp 35 and OTp 45 versions.



1.3. Zhaga – interchangeability of light engines

The Zhaga Consortium for the standardization of LED light sources (LED light engines) is a worldwide cooperation of luminaire and lamp manufacturers, producers of LED modules and companies that supply the lighting industry. The interchangeability of LED light engines is achieved by defining fundamental interface parameters while still leaving room for innovation in LED and driver technologies. Zhaga interface specifications cover the physical dimensions, as well as the photometric, electrical and thermal properties of different LED light engines.

The Zhaga Consortium was established in February 2010 and includes more than 180 companies (status: April 2012). OSRAM AG is a full member. The members meet regularly in different regions of the world in order to jointly work out the specifications. Large parts of the new PrevaLED® Core portfolio fulfill the Zhaga specification book 3 for “spotlight systems with separate electronic control gear.”

An updated list of all currently certified PrevaLED® light engines is available at: www.osram.com/zhaga.

For more information, please go to: www.zhagastandard.org.

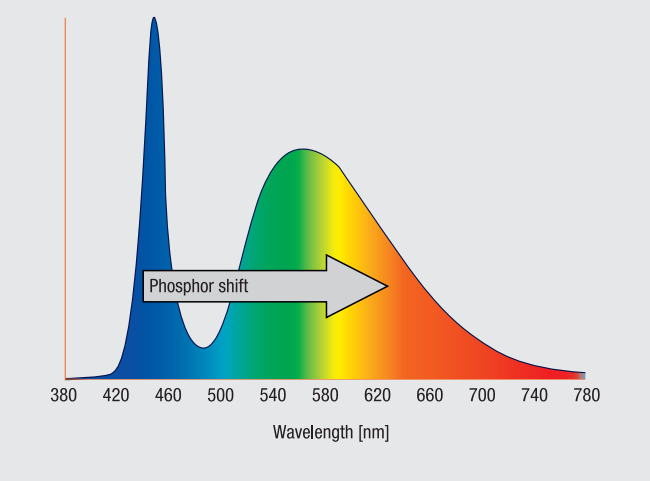
2. Optical considerations

Chip-on-board-design (CoB)
So-called chip-on-board (CoB) light sources without housing and with high-performance chips set very closely next to each other have proven to be especially advantageous. Due to the large amount of applied chips, the size of the light source is flexible and scalable. In the application, the compactness, on the one hand, allows for very high axis light and illumination levels, and, on the other hand, a very high-contrast illumination with high brilliance. Very good homogeneity (with a uniformity factor of 0.93) – combined with constantly Lambertian radiation – additionally simplifies reflector design and facilitates the interchangeability of light sources.

PrevaLED® Core Z2

The CoB design is characterized by a large amount of closely set LED chips, arranged in a certain grid which is covered with luminescent material (cf. the image above). One of the key advantages of this design is its very homogeneous light-emitting surface.

Pure phosphor conversion with CoB
Thanks to the use of pure phosphor conversion, the PrevaLED® Core Z2 module can achieve a color rendering quality of higher than CRI 90, while at the same time providing a very homogeneous light output.

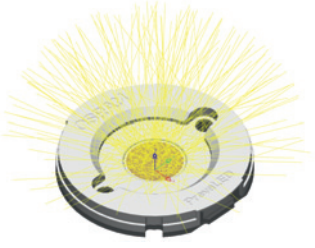


Phosphor conversion: By means of phosphor conversion, the blue light of the LED chip is shifted towards the higher wavelengths of green and red light.

2.1. Reflector
High luminous densities (1.5–4.5 Mcd/m²) are the key factor for LED-based lamps and luminaires in the area of reflector applications such as spotlights, for example. For these, light sources with small light-emitting areas and a high luminous flux are required (as realized with the PrevaLED® Core Z2), because that way, the light can be collimated especially well with reflectors.

Thanks to CoB technology, the PrevaLED® Core Z2 has a uniform light-emitting surface which, due to its great homogeneity, eliminates the need to use diffuser material. The minimized light-emitting surface (LES) and a reflector positioning close to the LES allows for better optical handling. All in all, the properties of the PrevaLED® Core Z2 allow for the prevention of roughness and facets, which in turn allows for minimal overall beam angles of 10° or less.

The high homogeneity of the PrevaLED® Core Z2 means:
- Low complexity in the surface structure of the reflector
- Narrower beam angles <10° FWHM in combination with minimized light-emitting surface



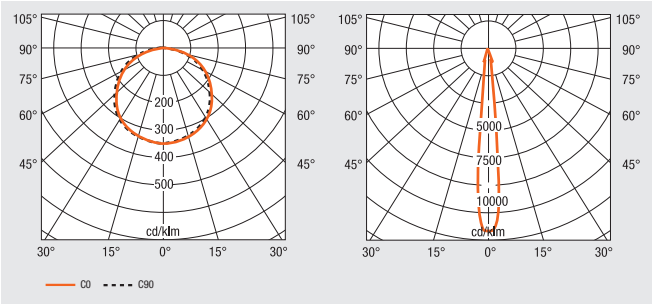
PrevaLED® Core Z2

2.1.1. Reflector design

OSRAM provides mechanical (3D files) and optical simulation data (ray files) to support customized reflector designs. These data are available upon request through your sales partner or for public download at: www.osram.com/prevaled-core.

Information on the optical calculation and simulation for reflector designs:
a) First estimation: Assumption of the LES ∅ as an idealized, homogeneous, Lambertian emitter
b) Simulation via raytracing software:
- Ray files available upon request via OSRAM sales department
- Photopia files are lodged under www.lti.com

The light distribution curve (LDC) of the module (without further reflectors, opt. systems) is characterized by a universally applicable Lambertian distribution. Therefore, it is very easy to define and connect further downstream optical systems (reflectors, lenses, …).



LDC PrevaLED® Core Z2 – without reflector

LDC PrevaLED® Core Z2 – with spot reflector

More partners for support in the optics area can be found in OSRAM's LED Light For You network: www.ledlightforyou.com. Moreover, standard components and support for reflector design and reflector brackets are available e.g. through the following partners:

ACL-Lichttechnik GmbH

+49 2173 9753 0
info@reflektor.com
www.reflektor.com

A.A.G. STUCCHI s.r.l.u.s. (Tool-less reflector brackets)
+39 0341 653111
info@aagstucchi.it
www.aagstucchi.it

Alux·Luxar GmbH & Co. KG

+49 2173 279 0
sales@alux-luxar.de
www.alux.de

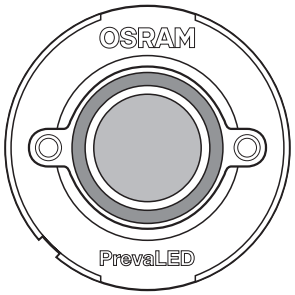
ALMECO S.p.A.

+39 02 988963-1
info.it@almecogroup.com
www.almecogroup.com

Jordan Reflektoren GmbH & Co. KG

+49 202 60720
info@jordan-reflektoren.de
www.jordan-reflektoren.de

Suitable and available reflectors can, for example, be found on the web pages of these partners.



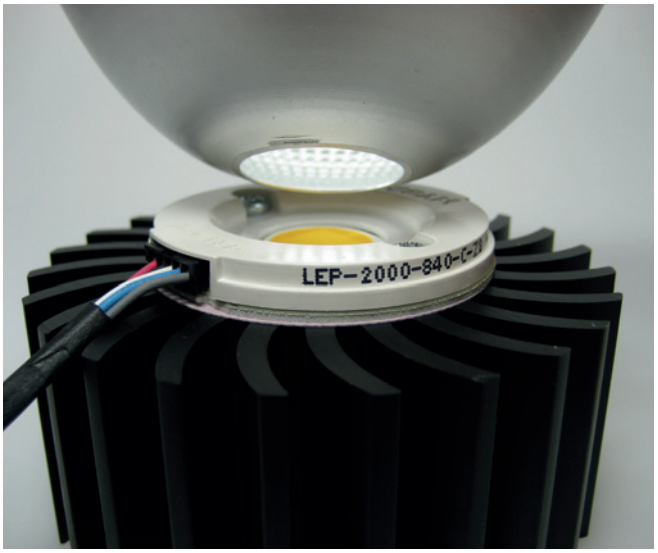
PrevaLED® Core Z2

Please note that strong forces applied to the housing can damage the LED module or the housing, especially if the LED module isn't attached to a heat sink. Attach or remove the reflector only if the LED module is safely connected to a heat sink.

2.1.2. Reflector mounting

The LED modules have a clearly defined optical contact area (OCA) which provides a defined surface for attaching the reflector. In this configuration, the mounting and mechanical support of the reflector must be ensured by the luminaire body or by suitable structures for reflector mounting.

The following has to be considered when mounting the reflector: Due to the “air and creepage distances” specified in the norm (IEC 61347-1/U935, among others), it is recommended to stay within the OCA values of the corresponding category (see PrevaLED® datasheet). 3D files of the PrevaLED® Core Z2 and design support are available on the homepage www.osram.com/prevaled-core.

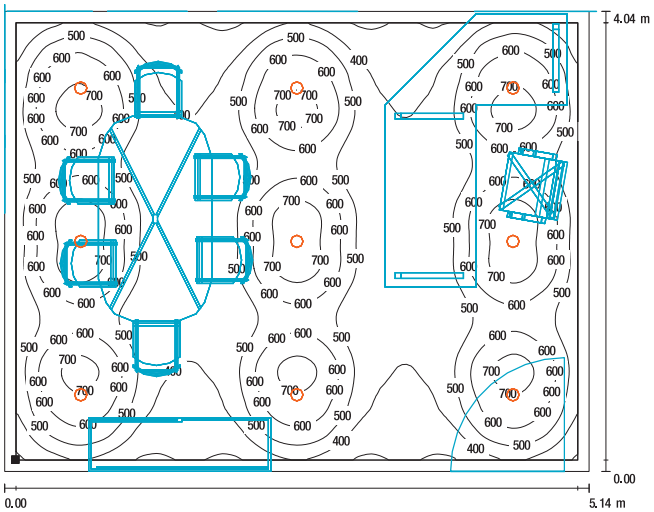


2.1.3. Lighting design information

Computerized lighting design can be carried out with free lighting design software such as DIALux and Relux (www.dial.de or www.relux.biz).
Lighting designers can download or request the necessary numerical luminous intensity distribution curves (= EULUMDAT files in the .ldt format) for PrevaLED® Core Z2 with the corresponding reflector via the web page of the respective reflector manufacturer.

Design example: Conference room

The task here is to illuminate a conference room (approx. 5 x 4 m, height 2.8 m) in such a way that a medium illuminance (E_{medium}) of 500 lux is achieved on the work plane. By means of the EULUMDAT files provided by the reflector manufacturers, lighting design software and an assumed maintenance factor of 0.69, the following example result is achieved (calculated in DIALux with a Jordan flood reflector, article no. 113309010101): Illuminance diagram with 9 PrevaLED® Core Z2-based luminaires (LEP-2000-xxx-C-Z2):

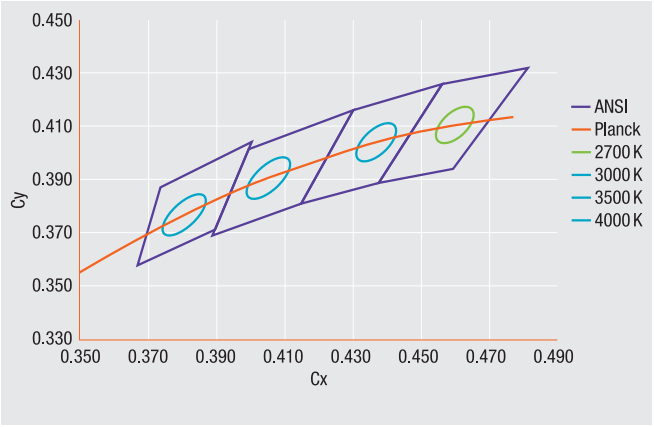


Ceiling height: 2800 mm,
Mounting height: 2851 mm
Figures in lux

Exemplary lighting design with 9 x PrevaLED® Core Z2 2000 lm in a conference room

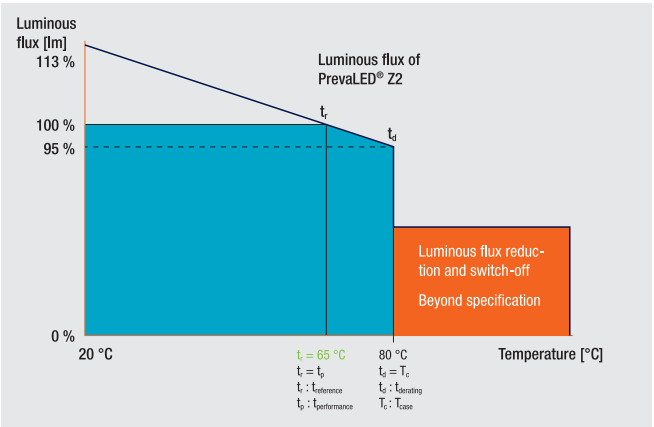
2.2. Luminous flux and color stability

Depending on the type of the LED module, the nominal CCT is 2700 K, 3000 K, 3500 or 4000 K, respectively. Depending on the variant, PrevaLED® Core Z2 modules provide a module-to-module color variation of less than 3 threshold value units (MacAdams steps) on the Planckian locus around this color target. These threshold value units can be shown within the ANSI (American National Standards Institute) norm in the following way:



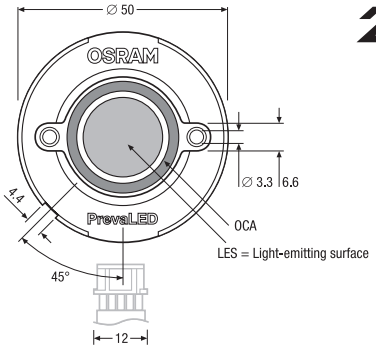
Measuring tolerance for color coordinates: ±0.01

The luminous flux of each LED module depends on its temperature. Therefore, 100 % of the luminous flux are also achieved with the PrevaLED® Core Z2, i.e. until the reference temperature (t_r) is reached. When the reference temperature is exceeded and up to maximum temperature (T_c), the luminous flux is reduced to 95 %. If the maximum temperature is exceeded, a further luminous flux reduction comes into effect until the PrevaLED® Core Z2 module is finally switched off.

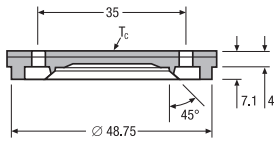


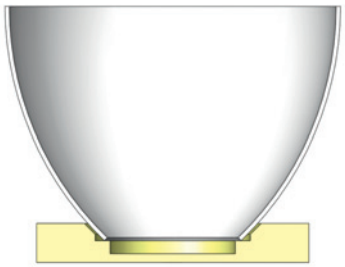
2.3. Zhaga – optical interface

In order to achieve the interchangeability of reflectors for spot applications, Zhaga defines categories for the diameters of the light-emitting surfaces. PrevaLED® Core Z2 modules are available in the categories LES 9, LES 19 and LES 23. With LED modules of the same category, optical systems basically achieve the same beam angles and luminous intensities. With their homogeneity parameter U of more than 90 % (i.e. with their very homogeneous radiation without any additional light diffusion), the PrevaLED® Core Z2 modules facilitate all further optical light shaping by means of reflectors or lenses. Around the light-emitting surface, a ringshaped surface (optical contact area, OCA) with a defined height is specified where reflector optics can be attached. In addition to the surface described in the Zhaga specification, the OCA of PrevaLED® Core Z2 modules is positioned closer to the light-emitting surface, so that reflectors with smaller openings can also be used. All PrevaLED® Core Z2 light engines fulfill the Zhaga-specified requirements in terms of luminous flux, chromaticity coordinates and beam characteristics and partially even exceed these requirements.



Zhaga





LES: Light-emitting surface
OCA (Optical contact area): Attachment and reference surface for optics (e.g. reflectors, lenses)

All figures in mm

3. Electrical considerations

3.1. Safety requirements

All OPTOTRONIC® OTp devices intended for operating PrevaLED® Core LED modules are SELV*-equivalent devices with an output voltage of < 120 V_{DC}.

The design of the LED modules ensures that the requirements of IEC 62031 for LED modules are met. The chips on the LED module do not need to be covered in order to fulfill the requirements of IEC 62031.

Due to its construction, the LED module can be mounted directly on an exposed housing without further insulation.

The luminaire manufacturer is responsible for providing the suitable and mandatory clearance and creepage distances for the luminaire (for a light engine operating voltage of < 120 V_{DC}).

*SELV = Safety extra-low voltage

3.2. Wiring information

The recommended wire cross section on the primary side of the OPTOTRONIC® OTp ECG is 0.5–1.5 mm^2. The connection between the OPTOTRONIC® ECG and the LED module should be established by using the cable kit available for order in lengths of 400 mm and 800 mm.

The cable material is UL-listed (UL E52653, UL E48762, UL 10368) and fulfills flammability requirements according to UL 94 V-0 and UL VW-1. The cables are approved for up to 85 °C.

The maximum diameter of the cable is 5 mm, additional details on the dimensions of the cable kit are specified in the illustrations on the next page.

For support with customizing cable lengths or construction, you can use the manual crimping tool from Hirose Electric or contact your sales partner.

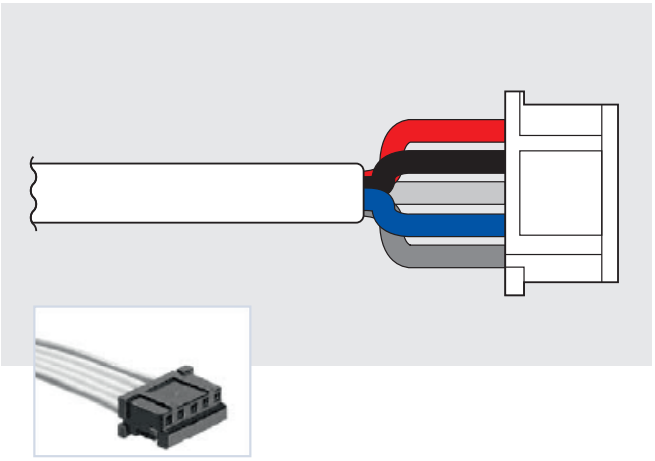
The cable for PrevaLED® Core Z2 has a flat connector on the module side and a higher connector (800 lm, 1500 lm, 3000 lm) on the OTp side, or open cable heads (4000 lm and 5000 lm).

Components of the connection cable between LED module and OTp

PrevaLED® cable sockets:
IN-CONNECTOR-CRIMPING SOCKET-TOP-LS2-5 RL 710
Part#: DF3-5S-2C, supplier: Hirose Electric Europe B.V. (www.hirose.com)

- OTp-side (socket height: 4.6 mm/code#: CL543-0006-6)
- Module-side (socket height: 4.25 mm/code#: CL543-0193-5-00)

The Hirose crimping tool is recommended for customizations of the connection cable.
Part#: DF3-TA22HC/550-0257-4-00



5-pin cable socket in crimped condition

Pin 1	LED+
Pin 2	LED-
Pin 3	Aux. voltage
Pin 4	Sense comm.
Pin 5	Aux. gnd.

PIN assignment of connector

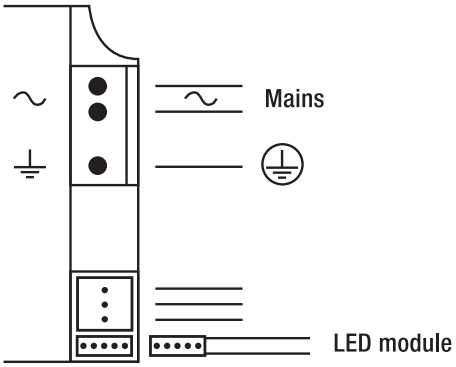
3.3. Wiring in class I and class II luminaires

Depending on the design of the luminaire according to class I or class II requirements, a protective earth connection can be established for the OPTOTRONIC® ECG.

The functional earth (equipotential connection) may be connected to the ECG to improve EMI behavior.

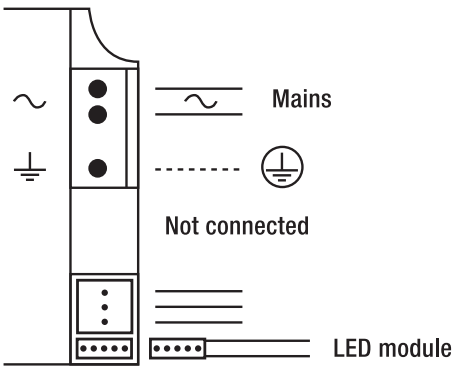
For these requirements, see the illustrations below.

Since the power supplies are SELV-equivalent, no additional electrical insulation has to be provided for the LED module.



Class I connection

Earth connection is mandatory in class I luminaires and improves EMI compliance according to EN 55015.



Class II connection

In class II luminaires do not connect earthing terminal.

3.4. Optional cable clamp

For OPTOTRONIC® OTp 35 and OTp 45 types, an optional cable clamp is available for order. This cable clamp can be snapped onto the ECG and thus turns it into an ECG suitable for independent installation with strain relief.

When using this cable clamp, luminaire design according to IEC 60598-1 class I and class II is possible. In this regard, functional earth may have to be observed as detailed above.

Please also note the installation requirements as supplied with the cable clamp.

For more information on the cable clamp, see chapter 1.2.3. Accessories (p. 7).

3.5. Electrostatic safety measures

In order to safely handle components susceptible to electrostatic discharge (ESD), an adjusted production environment is necessary. This is specified in IEC 61340-5-1 (“Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements”).

Based on the human body model (HBM), the following maximum voltages apply for the PrevaLED® Core Z2:

Material	HBM	Class
LEP-800-xxx-C-Z2	4 kV	2
LEP-1500-xxx-C-Z2	8 kV	3B
LEP-2000-xxx-C-Z2	8 kV	3B
LEP-3000-xxx-C-Z2	8 kV	3B
LEP-4000-xxx-C-Z2	8 kV	3B
LEP-5000-xxx-C-Z2	8 kV	3B

3.6. Inrush current limitation

Electronic drivers are subject of a certain inrush current. For the OPTOTRONIC® control gears for the PrevaLED® Core Z2, this current is very low. That is why up to 15 OTp (35/45) can be applied at one 16-A circuit breaker.

3.7. Connection information

The energized light engine system must not be serviced. This includes disconnecting or connecting the electrical contact of the LED module and the ECG. In exceptional cases, such as final assembly, the connection cable can be disconnected from the LED module or the OTp and then reconnected (20 times max. with one-minute intermissions).

3.8. Zhaga – electrical interface

Zhaga defines no requirements for the electrical interface between the ECG and the module. For Zhaga categories and the dimensions of the control gears, please see the technical datasheet.

Zhaga

4. Thermal considerations

The proper thermal design of an LED luminaire is critical for achieving the best performance and ensuring the long lifetime of all components. Because the PrevaLED® Core Z2 ensures high efficiencies, only a partial amount of the introduced electrical power still has to be dissipated through the back of the light engine (see also: 1.2.2. Technical data (p. 7)).

Depending on the application and the chosen LED module, passive cooling can be sufficient. In critical applications (e.g. small available heat sink size in combination with high-power LED modules), active cooling by means of a ventilator may be needed. Active cooling combines a heat sink with a fan or a similar device to maximize the cooling power out of an existing, passive heat sink.

4.1. Thermal interface material and other accessories

When mounting a PrevaLED® Core Z2 within a luminaire, it is highly recommended to use thermal interface material (TIM) between the back of the LED module and the luminaire housing. Either heat-conductive paste or foil can be used. In order to balance possible unevenness, the material should be applied as thinly as possible, but as thickly as necessary. In this way, air inclusions, which may otherwise occur, are replaced by TIM and the required heat conduction between the back of the LED module and the contact surfaces of the luminaire housing are achieved. For this purpose, the planarity and roughness of the surface should be optimized.

For initial application designs, applicably pre-pierced thermal interface material (e.g. Kerafol's Keratherm 86-82) with a diameter of 50 mm and matching mounting holes can be ordered through the Alfatec company (see the partner information below). The list below shows a selection of suppliers of passive and active cooling solutions as well as thermal interface materials.

Additional partners for thermal management support can also be found in OSRAM's LED Light For You network: www.ledlightforyou.com.

Active cooling systems:	
AVC	www.avc-europa.de
Cooler Master	www.coolermaster.com
Nuventix	www.nuventix.com
Sunon	www.sunoneurope.com
Heat sinks:	
Aavid Thermalloy	www.aavidthermalloy.com
Cool Innovations	www.coolinnovations.com
Fischer Elektronik	www.fischerelektronik.de
Meccal	www.meccal.com
Pinbloc	www.pinbloc.de
Radian	www.radianheatsinks.com
R-Theta	www.r-theta.com
Wakefield	www.wakefield.com
Thermal interface materials:	
Aavid Thermalloy	www.aavidthermalloy.com
Alfatec	www.alfatec.de
Arctic Silver	www.arcticsilver.com
Bergquist	www.bergquistcompany.com
Chomerics	www.chomerics.com
Dow Corning	www.dowcorning.com
Electrolube	www.electrolube.com
Kerafol	www.kerafol.de
Kester	www.kester.com
Kunze Folien	www.heatmanagement.com
Laird	www.lairdtech.com
MG Chemicals	www.mgchemicals.com
Thermaflo	www.thermaflo.com
Thermagon	www.thermagon.com
Wakefield	www.wakefield.com
Heat pipes:	
DAU	www.dau-at.com
MB Electronic AG	www.mb-electronic.de
Simulation software:	
Comsol	www.comsol.de
Flotherm	www.mentor.com
SolidWorks	www.solidworks.com
Thermal probes/thermocouples:	
B+B Thermo-Technik	www.bubthermo.de
OMEGA	www.omega.de

4.2. Heat sink

Basically, the heat sink has to fulfill two tasks:

a) Heat spreading through heat conduction

The task here is to spread the heat as uniformly as possible from the contact surface of the LED module through the heat sink material and into the cooling fins. In this respect, the thermal conductivity and the material cross sections of the heat sink play a decisive role (cf. the thermal conductivities table below).

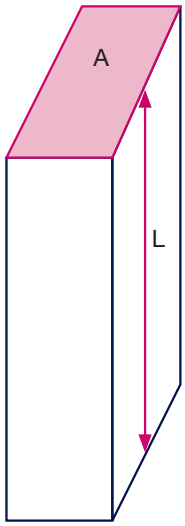
b) Heat dissipation to the surrounding medium (usually ambient air)

For this task, the heat sink design in terms of fin and surface configuration is decisive. By adequate geometrical forming, heat conduction through convection and IR radiation can be significantly influenced and improved (cf. the table with the IR emission coefficients on the next page).

Thermal conduction resistance (R_{th}) formula:

$$R_{th} = \frac{L}{A \cdot \lambda}$$

L: Length through the material in flow direction [m]
A: Material cross section/surface of the heat sink [m^2]



Thermal conductivities of selected materials	
Material	**Specific heat conductance value λ [W/(m·K)]**
Copper	380–401
Aluminium	200–220
Brass	120
Steel	42–58
Stainless steel	15
Glass	1
Wood	0.13–0.18
Air (dry at 1013 mbar, no dissipation)	0.0256 at 20 °C

Very good heat conduction

Bad/no cooling

For necessary heat transfer and good cooling, the surface of the applied heat sink material, with regard to heat emission, must be considered. In order to achieve very good radiation behavior to the ambient space, it can be advantageous to use heat sinks with a matt black finish.

Within typical applications such as downlights in recessed ceilings, it can be an advantage to use black anodized heat sinks.
For the optimization of the radiation, special lacquers with a high emission ratio, as typically used for radiators instead of anodization, are available.

Overview of selected materials with different surfaces

Material	Emission ratio ϵ	Temperature* [°C]
Aluminium plate, blank, rolled	0.022	25
	0.040	170
Aluminium, die-cast surface, blank	0.4	170
Aluminium, black anodized	0.600	40
Steel, powder-coated	0.85	25
Aluminium, matt black finish	0.970	80

*) Temperature of the material at which the emission ratio was measured

Low cooling effect

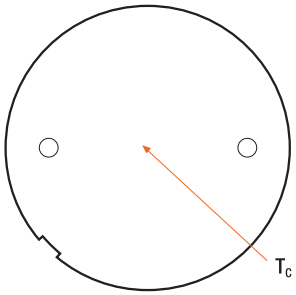
High cooling effect

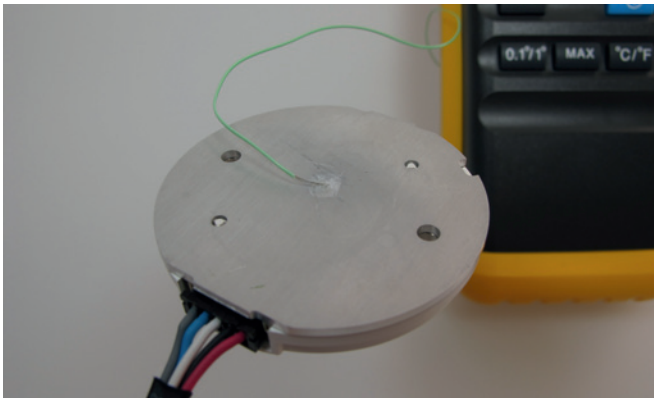
4.3. Temperature measurement

Measuring the temperature helps controlling the LED module's operating parameters. After fixing the LED module into the luminaire, the temperature has to be measured at the thermal interface point (T_c point), within the planned ambient and operation conditions.

In order to do so, a thermocouple has to be affixed to the T_c point, preferably by gluing (e.g. by means of a heat-conducting adhesive such as "Arctic Silver").

Thermal interface point (T_c point)





T_c is measured in the center of the back of the LED module

The thermal interface temperature (case temperature/T_c) is measured in the center of the back of the LED module, by means of a thin milled channel (in the LED module or the luminaire) or hole (∅ approx. 2 mm) which is drilled into the luminaire prototype for the thermocouple.

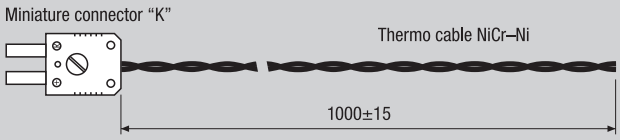
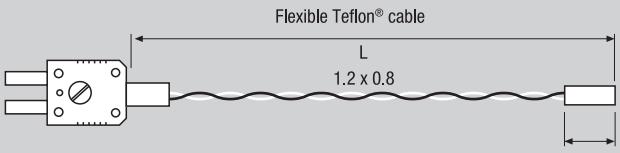
With this temperature measurement, as applied at the measuring point of the LED module, the actual T_c temperature can be determined. By means of suitable cooling methods (active or passive cooling), this temperature must be maintained under the maximum temperature specified in the datasheet.

Based on the measured interface temperature (T_c) of the ambient temperature (t_a) and the thermal module performance ($P_{th,mod}$), you can determine the necessary thermal resistance of the cooling system (R_{th} KS).

Formula for calculating the T_c temperature

$$R_{th}\,KS = \frac{T_c - t_a}{P_{th,\,mod}}$$

R_{th} KS = Thermal resistance cooling system
T_c = Temperature T_c point
t_a = Ambient temperature (usually air temperature of the room)
$P_{th,\,mod}$ = Thermal module performance

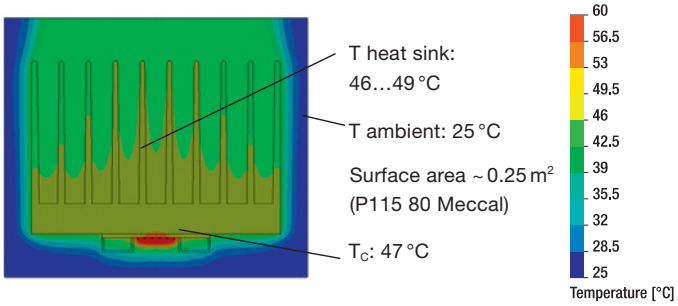
Recommended thermocouples			
	Description	**Temperature [°C]**	**Length [mm]**
	Thermal probe	-10…+100	2000 cable
	Adhesive foil probe	-50…+250	1000 wire

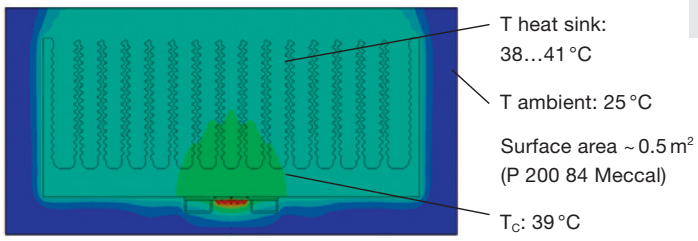
All figures in mm

4.4. Thermal simulation

Using a computer, matching heat sink housing forms and occurring maximum temperatures can be calculated by means of numerical heat simulation.

Two thermo simulation examples:

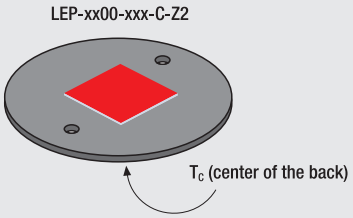




PrevaLED® LEP-2100 on heat sink with extruded profile – 150 mm in downlight orientation

3D files for thermal simulation can be found at: www.osram.com/prevaled-core.

Thermal model description: PrevaLED® Core Z2



1. Assign the heat flow of the light engine to the red surface
2. Determine the properties of the thermal interface material (TIM, on the bottom side)
3. As the conductivity of the carrier board, assume that of Al5052 (137/m·K)
4. Start the simulation
5. Measure the T_c temperature at the center of the back
6. Verify the results with a prototype

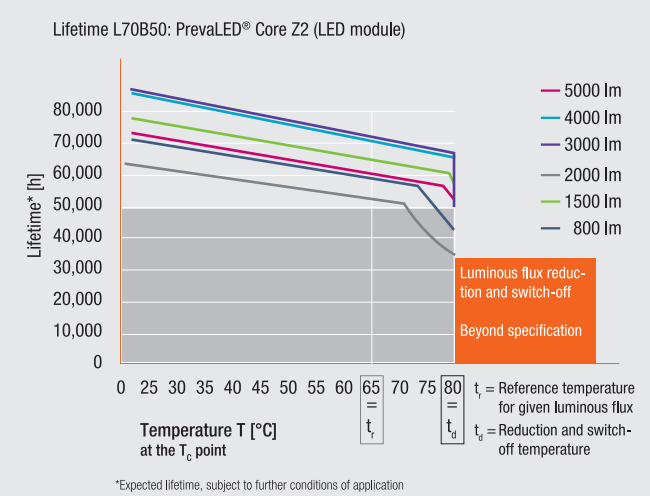
4.5. ECG thermal considerations

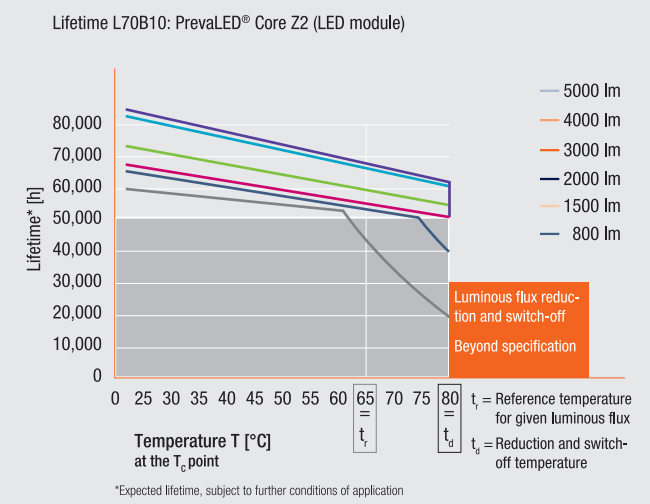
The installation of the ECG must ensure that the maximum temperature at the T_c is not exceeded. Further details on thermal considerations for OPTOTRONIC® devices can be found in the technical guide for OPTOTRONIC®, available at: www.osram.com/optotronic.

*) L70B50 definition: After 50,000 h, at least 50 % of the observed LED modules still show 70 % of the initial luminous flux.
**) The guarantee conditions can be found at www.osram.com/system-guarantee.

4.6. Thermal management and lifetime

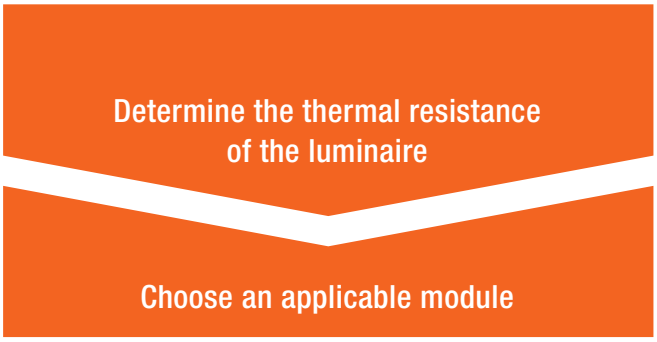
The PrevaLED® Core Z2 has a lifetime of 50,000 h (L70B50*). If the temperature is exceeded, the specification is left and, after further heat-up, the LED module is switched off. Liftetime information (see datasheet) as well as guarantee information for LED modules combined with ECG at: www.osram.com/prevaled-core.

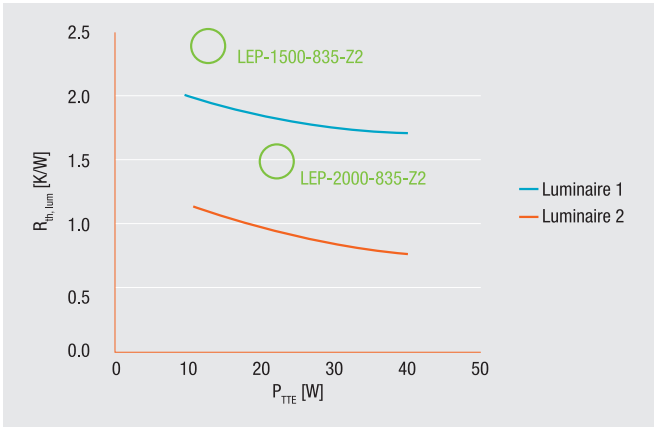




4.7. Zhaga – thermal interface

Verification of thermal interchangeability according to Zhaga:





Examples for luminaire R_{th} curves

Zhaga

The thermal test engine (TTE) for the determination of thermal resistance:
With the TTE according to Zhaga specification, the introduction of the heat output into an existing luminaire can be simulated. To do so, the following work steps need to be taken:

1. Installation of the TTE with thermal interface material (TIM) into the luminaire prototype to be measured
2. Introduction of different heat outputs P_{TTE} (e.g. in 10-W steps)
3. Measurement of the reference temperature $t_{r, TTE}$ after temperature stabilization, by means of the thermocouple attached in the TTE
4. Thermal resistance calculation

$$R_{th, lum} = \frac{t_{r, TTE} - t_a}{P_{TTE}}$$

5. Draw the graph of $R_{th, lum}$ dependent on P_{TTE}, as shown in the diagram

Choosing the suitable module:
The datasheet shows heat output values of the module ($P_{th, mod}$) for all versions of the PrevaLED® Core Z2 as well as the maximum permissible thermal resistances ($R_{th, mod, max}$). Two examples are shown in the diagram. The datasheet values are specified for t_a = 25 °C, in case of a differing ambient temperature t_a', the corresponding $R_{th, mod, max}$ can be calculated according to the following formula:

$$R_{th, mod, max\ (t_a')} = R_{th, mod, max\ (25\ °C)} - \frac{t_a' - 25\ °C}{P_{th, mod}}$$

All modules of which the data points are located on or above the curve are suitable for application in the luminaire. In the example shown in the illustration above, LEP-1500-835-Z2 is suitable for application in both luminaires, whereas LEP-2000-835-Z2 is suitable for luminaire 2 only.

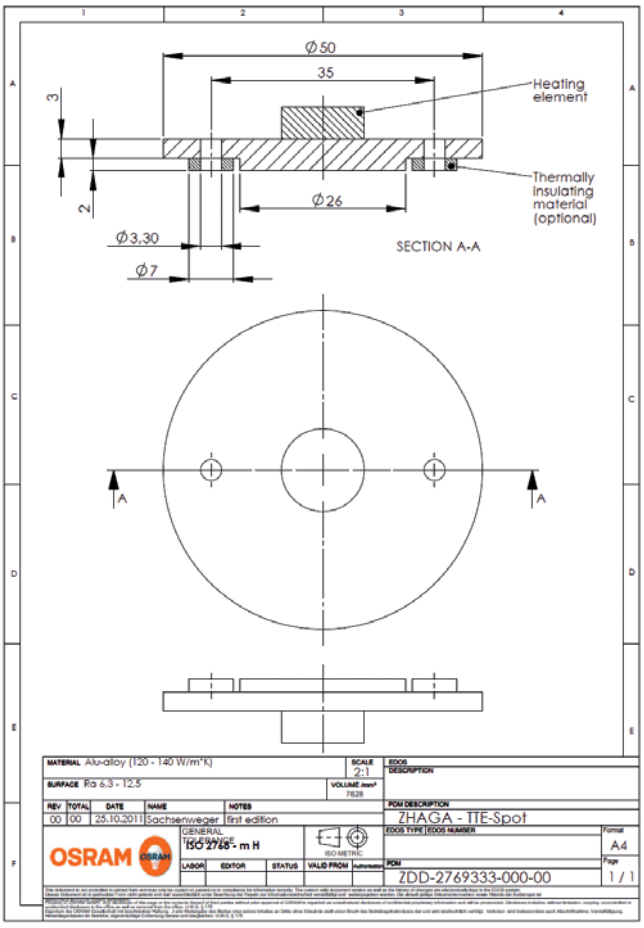
Although suitable modules can be easily and clearly determined with this method, we nevertheless recommend verifying the thermal design by means of measurements with real modules, as outlined in chapter 4.3.

The TTE serves the thermal measurement of an existing cooling method or housing.

By means of their maximum cooling performance [W] as based on T_c max. [°C], it is therefore easily possible even in the future to equip once thermally measured luminaires with standardized light engines.

Additionally, a simple thermal ECG dummy can be used for the simulation of the thermal power loss in the application (simulation of additional heat input, e.g. in case of suspended ceilings).

Thermal OTp tester



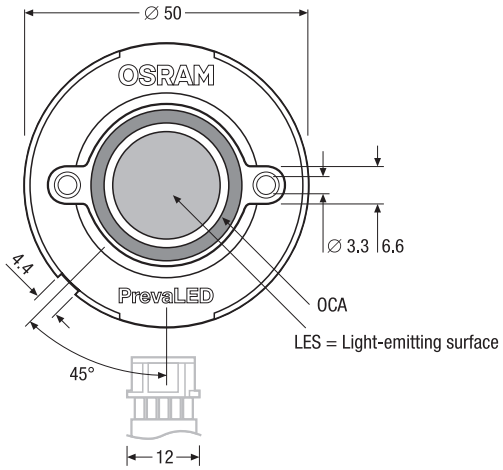
TTE engineering drawing at: www.osram.com/prevaled-core

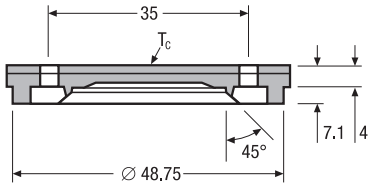
5. Mechanical considerations

5.1. LED module dimensions

This schematic drawing contains further details on the dimensions of available PrevaLED® Core Z2 LED modules.

For 3D files, LES and OCA categories, see the datasheet at: www.osram.com/prevaled-core. These 3D files in different formats may be used for the construction of luminaires.





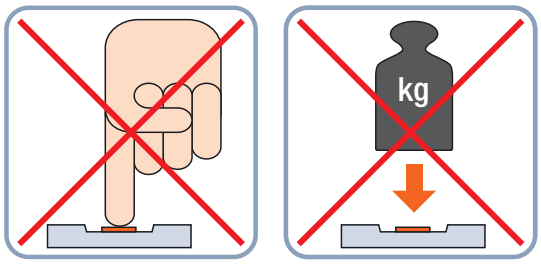
LES: Light-emitting surface
OCA (Optical contact area): Attachment and reference surface for optics (e.g. reflectors, lenses)

All figures in mm

5.2. Mechanical protection of the LED module

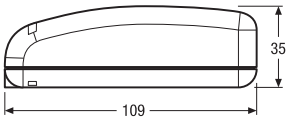
The pressure-sensitive LES (light-emitting surface) of the LED module is protected against mechanical influence by a protective foil. The LED module must not be switched on if the protective foil is still in place because it could be destroyed. Please do not apply pressure on the LES, neither before nor after installation and removal of the protective foil.

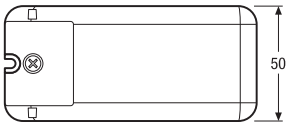
For operation in damp, wet or dusty environments, the user has to make sure that an adequate ingress protection and the protection of the LED module and the ECG is warranted by means of a suitable IP classification of the luminaire housing (in due consideration of the luminaire standard IEC 60598-1, irrespective of the different requirements in indoor and outdoor areas).



5.3. ECG dimensions

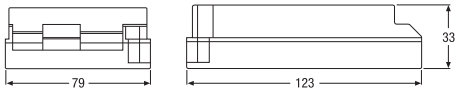
Detailed mechanical drawings and 3D files are available at our website.

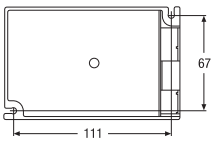




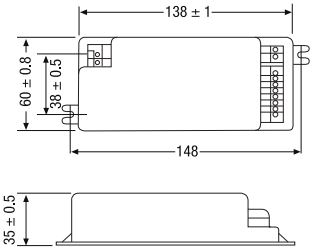
OTp 15
(acc. to Zhaga: Driver category CS1)

All figures in mm





All OTp 35 and OTp 45 types
(acc. to Zhaga: Driver category AM3)



OTp 60

- The housing material of these devices (OTp 15/35/45) is PBT and complies with UL 94 V-0.
- For input wiring on the network side, the housing provides push-in terminals.
- It is recommended to use screws with washers when attaching the ECGs to the luminaire.

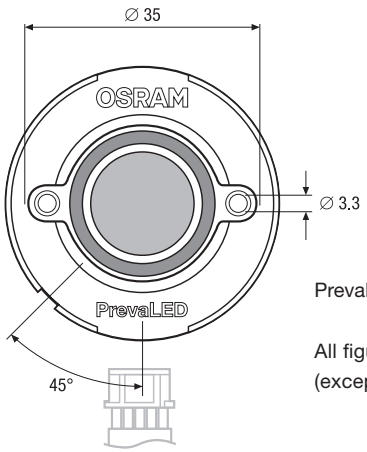
5.4. LED module attachment

PrevaLED® Core Z2 modules are attached to a heat sink with two M3 screws through the mounting holes within the LED module. The mounting holes are reinforced with metal. Only in this way can a sufficient thermal contact be ensured throughout the lifetime of the module, because synthetics will, due to the influence of pressure and temperature, give way after some time.

Depending on the thermal interface material and contact surface conditions, the recommended screwing torque can be between 0.4 and 0.6 Nm. A higher torque level does not necessarily lead to significantly better heat transfer, but may lead to damage of the LED module.

The recommended counter sink diameter of the mounting holes for good thermal performance should be 3.5 mm max. A bigger counter sink can lead to mechanical deformation of the PCB and thus to a deterioration of the thermal connection to the heat sink. When mounting the module with self-cutting screws, an additional torque may be required to prepare the thread.

Due to a large number of possible combinations when choosing thermal interface material, heat sinks and screws, any chosen combination should be carefully checked and tested in order to maximize the heat transfer between the LED module and the heat sink. Optimal mounting can lead to a lower operating temperature of the LED module and thus to an improved performance of the system.



PrevaLED® Core Z2

All figures in mm
(except where noted otherwise)

5.5. Zhaga – mechanical interface

In order to ensure the interchangeability of spot LED light engines, Zhaga has defined maximum dimensions as well as the screw positions for mounting the module. The planarity of the luminaire side of the mounting surface, for example, is not defined. For a fairly good heat transfer to the heat sink, we recommend a planarity of < 0.1 mm and a roughness of < 3.2 µm, as usually achieved by surfaces with a milling finish.

Zhaga

6. Assembly in a reference luminaire

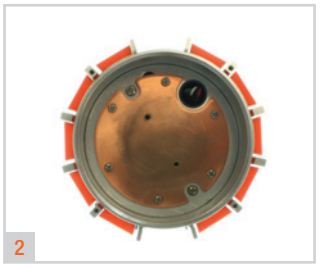
To demonstrate the light engine concept and the design of a luminaire, the following pages will lead you through an exemplary assembly of a reference luminaire, using the 2000-lm PrevaLED® light engine.

The first picture shows the different components of the complete system:

- Housing (acts as a heat sink)
- Reflector
- Cover
- Decorative ring
- Mounting ring
- Main connection wire
- Cable kit
- Thermal interface material
- Light engine

As a first step, the thermal interface material has to be applied within the light fixture housing and/or the heat sink.


1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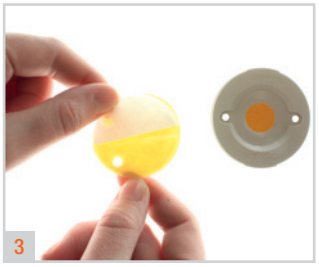
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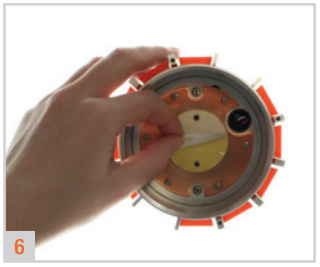
6.1. Preparation

After applying the thermal interface material, the LED module has to be attached to the surface. For mounting instructions and screw selection, please see the instruction in chapter 5.4. LED module attachment.

To ease the centering of the LED module, small plastic sticks or pins can be inserted into the screw holes in the heat sink to guide the LED module into the right place. After centering, these guiding pins can be removed and replaced by the screws.


5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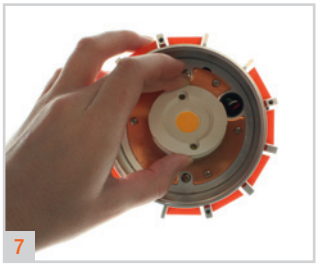
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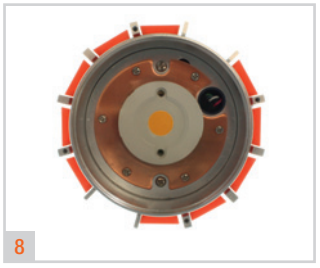
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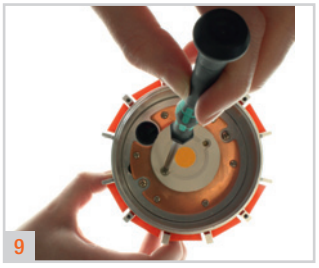
6.2. Wiring and reflector/cover
The corresponding cable kit can be used to connect the LED module to the power supply. To get the connector easily into the housing, we recommend a through hole with a minimum diameter of 10 mm.

Once the LED module is connected, the reflector can be attached to the housing and the diffuse cover can be placed on top of the luminaire.

Both components have to be properly centered above the LED module.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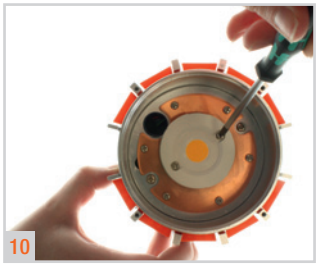
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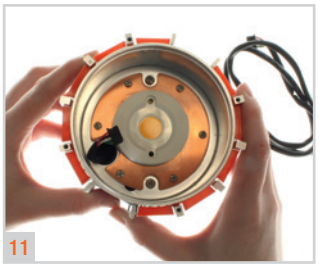
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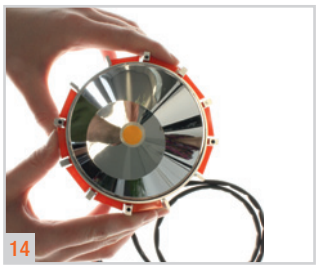
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6.3. Commissioning the PrevaLED® light engine
After the fixation of the mounting ring, the optional decorative ring can be attached.

As an example for an electrical connection within a class II installation, the two wires for the main connection have to be connected to the OPTOTRONIC® power supply.

In a class I installation, the protective earth has to be connected additionally.

Finally, the complete system can be connected to the mains and powered up.


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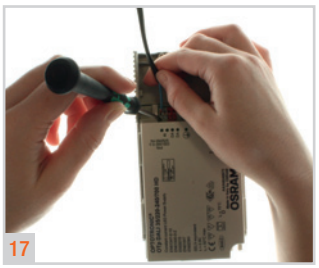
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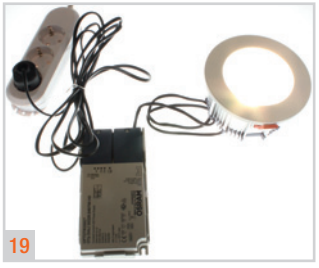
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7. Norms and standards

7.1. Norms and standards for PrevaLED® LED modules and light engines

PrevaLED® Core Z2 complies with the following standards:

Zhaga-specification book 3:	Spotlight systems with separate electronic control gear

Zhaga

According to the EC declarations (European directive: 2006/95/EC, European directive: 2004/108/EC), PrevaLED® Core Z2 complies with the following norms:

Safety of LED modules:	IEC 62031
Photobiological safety:	IEC/TR 62471-2 (typenabhängig)
Electromagnetic compatibility:	DIN EN 55015 DIN EN 61547 DIN EN 61000-3-2 DIN EN 61000-3-3
Ingress protection:	IP 20
Vibration, shocks, tensile strength:	IEC 60068-2-6 IEC 60068-2-27 IEC 60068-2-21

7.2. Norms and standards for control gears

Safety:	IEC 61347-1, IEC 61347-2-13
Performance:	IEC 62384
Radio interference:	EN 55015 (A1:2007, A2:2009)
Harmonic content:	IEC 61000-3-3:2008
Immunity:	IEC 61547:2009
Temperature range:	See corresponding value within the datasheet
Galvanic insulation between primary and secondary side:	3 kV_{rms}
No-load proof:	Yes
Short circuit proof:	Yes
Overload protection:	Automatic shutoff, reversible
Overheating protection:	Automatic shutoff, reversible
Connection, primary:	For OTp 15 HD: screw-terminals For OTp 35 HD and OTp 45 HD: push-in terminals
Cross section, primary:	0.5 mm^2–1.5 mm^2
Connection, secondary:	5-pin connector, for use with cable kit
Cross section, secondary:	Only for use with special cable kit
Dimensions (L x W x H):	123 x 79 x 33 mm for all OTp 35 and all OTp 45 109 x 50 x 35 mm for OTp 15 HD
Approvals:	

For test and certification measurements, a mains voltage of 230 is recommended.

7.3. Photobiological safety
Looking directly at high-performance light sources can (just approximate classification of safety classes like looking directly at the sun) be a hazard to the retina of the human eye. This is why the PrevaLED® LED modules have been tested regarding the risk group definition within the framework of EN 62471:2008.

According to EN 62471-1, PrevaLED® Core LED modules have to be classified in risk group 1. In absence of UV and IR radiation, no labeling is required in RG 1 (TR 62471-2).

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