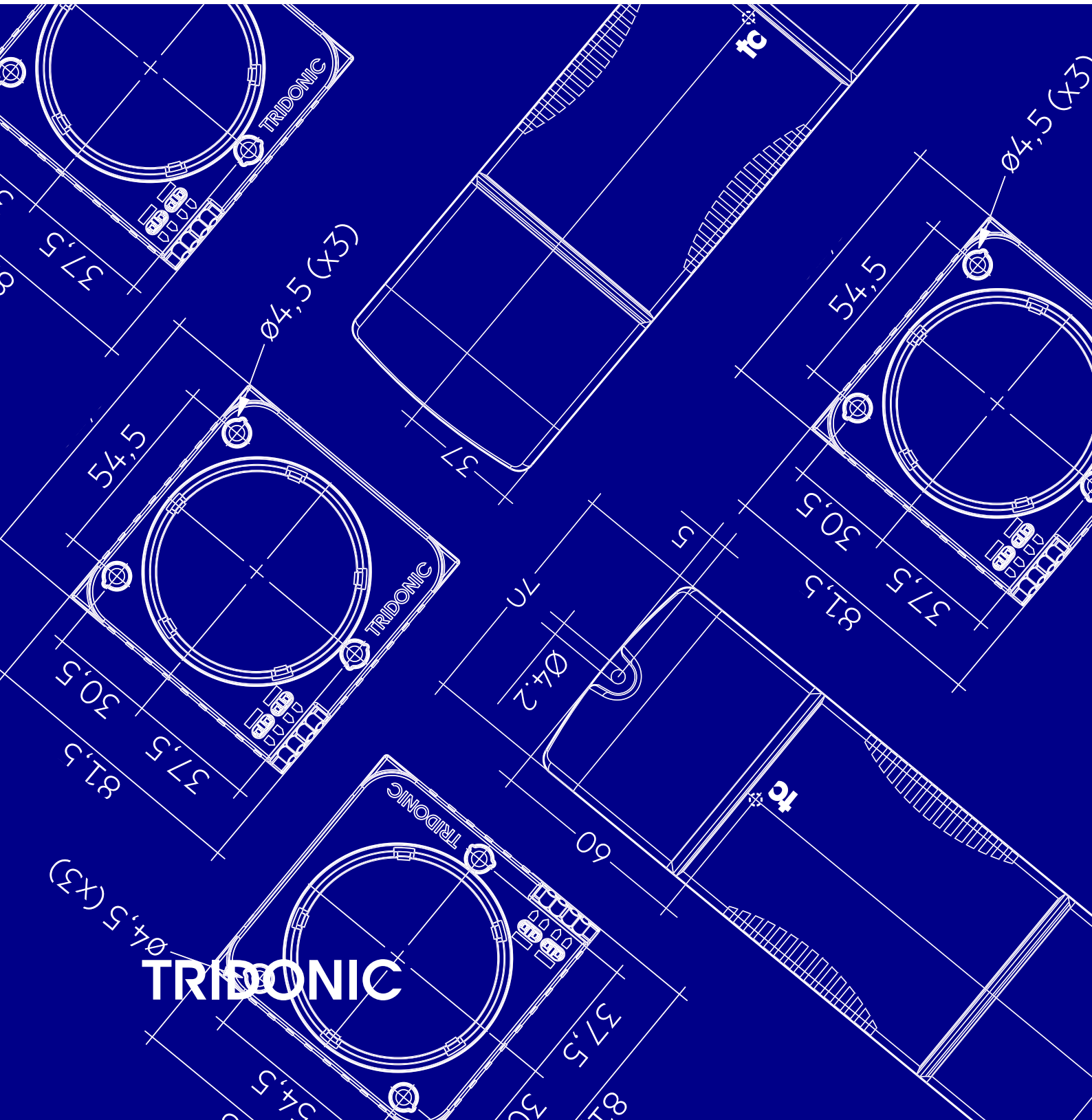
LED Module

Engine DLE G2 PRE KIT

Technical Design-in Guide



TRIDONIC

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Introduction

The versatile system solutions from Tridonic provide the basis for lighting designs that are futureproof, economical and eco-friendly in a wide range of applications. LEDs are showing their strengths in retail outlets, offices, hotels and restaurants.
If you are designing a luminaire to work with LEDs there are certain differences compared to designs with conventional light sources that you need to be aware of. We have written this design guide to help you understand these differences. It answers all the most important questions you may have, such as the right mechanical design, thermal management and optical conditions.

LEDs offer major benefits for general illumination tasks - they are versatile, highly energy-efficient and virtually maintenance-free. With DLE G2 PRE KIT you get a complete system solution for linear and panel lights from a single source, consisting of perfectly matched components: LED module, LED Driver in a kit package.

DLE G2 PRE KIT offers impressive benefits:

- Lineares Tunable White System with adjustable colour temperature from 2.700 to 6.500 K at contant luminous flux
- High system efficiency up to 100 lm/W at tp=65 °C
- Excellent colour rendering (CRI > 90)
- Precalibrated set to ensure light quality and high colour consistency, consisting of LED Driver and LED modules
- Compact LED Driver with digital Interface (DALI Device Type 8, DSI, switchDIM, colourTEMPERATURE)
- LED-modules with 2000 lm and 3000 lm
- Dimming range from 1 – 100 % without change of colour temperature
- Compliance with the mechanical and electrical standards of the luminaire industry
- Energy efficiency class A+

NOTICE

Please note:

DLE G2 PRE KIT components form a matched and calibrated unit. Therefore it is not allowed to separate and operate the components in different combinations!

All information in this guide has been produced with the most care.
However, the guide is subject to change without notice. Errors and omission excepted. Tridonic does not accept liability for possible damage resulting from the use of this guide.
The latest version of this guide can be found at led.tridonic.com or from your sales partner

Summary of the chapters

To make it easier to find your way around the Design-in Guide we have grouped the information on the DLE G2 PRE KIT systems into chapters.
The guide begins with a system overview in which the different versions of the system are presented. The mechanical, electronic, optical and thermal aspects of the components are then described. At the end of the Design-in Guide you will find ordering information and sources.

2.1. System overview

The DLE G2 PRE KIT system is available with different properties and functions. The relevant components can be clearly assigned by their type codes.

2.2. Mechanical aspects

Depending on the particular situation, the LED Driver can be installed in the luminaire casing (in-built) or outside the casing (remote). Dimensional drawings and installation instructions will help you take account of the requirements of the particular situation.

2.3. Electrical aspects

Special Tridonic connecting cable is available to ensure efficient and reliable connection between the modules and the LED Driver.
All the connection options, the connections between the LED Driver and the power supply and the connections of the control lines are shown in relevant wiring diagrams.

2.4. Optical aspects

The overall efficiency of the system is improved by choosing a reflector with suitable optical properties (e.g. beam angle) and dimensions.
This chapter provides information to support customer-specific reflector design.

2.5. Thermal aspects

The system modules have been designed to operate with a passive or active heat sink and can be mounted directly on such a suitable heat sink.
In the case of active cooling the fan can be connected directly to the module or LED Driver depending on the version.

2.6. Ordering information and sources

The ordering information for the components and the sources for heat sinks, reflectors and accessories can be found at the end of the document.

System Overview

3.1. Overview

Properties and functions	DLE G2 PRE KIT
Colour temperature (1)	2,700 to 6,500 K Tunable white (controllable and dimmable colour temperatures)
Luminous flux	2000 lm / 3000 lm
Colour rendering / colour tolerance	CRI > 90 / MacAdam 3 SDCM (at 100 % dim level)
System efficiency	100 lm/W at tp = 65 °C
DALI	Device Type 8 (2)
switchDIM	yes
colourTEMPERATURE	yes

(1) Application-specific changes to the colour temperature are possible. The colour temperature can be varied from 2,700 to 6,500 K.

(2) The system supports DALI device type 8 to change the colour temperature.

3.1.1. Components

A uniform naming concept has been adopted for the components. The system DLE G2 PRE KIT comprises the following components:

- LCA LED Driver
- DLE G2 PRE module

NOTICE

DLE G2 PRE KIT must be operated with the calibrated LCA 38W 350-1050 mA DT8 SR PRE LED Driver from the set!

3.1.2. Efficiency of the modules

The high efficiency of DLE G2 PRE KIT results not only in energy savings but also to a reduction in the thermal load. This means that smaller heat sinks can be used and more compact luminaires can be designed.

System Overview

3.1.3. Area of application

- All the components of the DLE G2 PRE KIT system comply with the protection requirements of IP00. The system is therefore suitable for indoor applications.
- DLE G2 PRE KIT complies with system protection class II.

3.2. Operating functions

DLE G2 PRE KIT offers a wide range of settings for colour temperature and dimming level. Different controllers are available. The controllers are connected directly to the LED Driver.

3.2.1. Central control via the LED Driver

Control via DALI or a switchDIM switch is achieved by connecting these devices to the LED Driver.

NOTICE

The factory preset for colour temperature is 2,700 K, the factory preset for light intensity is 100 %.

Control via DALI

CAUTION!

The control line must be installed in accordance with the relevant directives on low voltage.

NOTICE

The control input is protected against polarity reversal and against accidental connection to mains voltage up to 264 V AC.

For DALI control the light modules are digitally controlled via the DALI signal (16-bit Manchester Code).
The predefined colour temperatures and dimming level can be changed via DALI.

Control via switchDIM

A conventional double pushbutton switch can be used for control via switchDIM. One of the pushbuttons is used to set the colour temperature, the other to set the dimming level. Which button has which function is determined during the installation.

CAUTION!

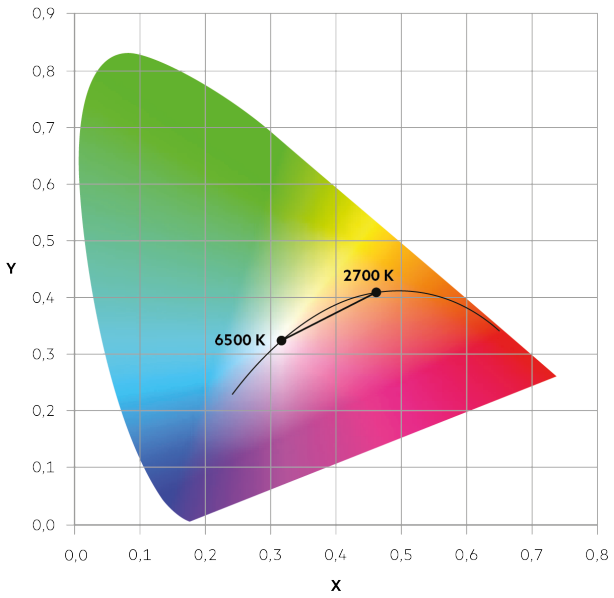
Pushbuttons with glow lamps affect the switchDIM, colourTEMPERATURE functions and should therefore not be used for this purpose.

For control via a switchDIM switch different settings can be made:

- Setting for the colour temperature via colourTEMPERATURE mode with 9 predefined values between 2,700 K and 6,500 K
- Stepless setting for the dimming level between 1 % and 100 %.

colourTEMPERATURE modes differ in the position of the individual colour values along the Planckian curve.
colourTEMPERATURE-Mode is tailored to the requirements of general and shopping lighting,
On start-up the device first activates colour temperature setting in the colourTEMPERATURE mode. The starting values are a colour temperature of 2,700 K and a dimming level of 100 %.

System Overview



NOTICE

When the maximum value is reached, the next step advances directly to the minimum value. This is signaled by a short blinking.

System Overview

Changing predefined colour temperatures and dimming levels

The predefined colour temperatures and dimming levels in colourTEMPERATURE mode can be changed via the masterCONFIGURATOR. Any fixed values within the two limit values of 2,700 K and 6,500 K can be selected for the colour temperature.
Adjustments could be in the minimum range step of 100 K. Either a colour value along the Planckian curve can be selected. Up to 16 scenes can be individually defined. These scenes are stored in the LED Driver. They can then be recalled via DALI and switchDIM.

A DALI environment is needed for the configuration (power supply, DALI USB). For more information on the procedure see the masterCONFIGURATOR handbook.

Setting the dimming level

- Select that of the two pushbuttons that is used to set the dimming level
- Press the pushbutton briefly (< 1 s) to switch the LED Driver on or off
  -> The last values set for the colour temperature and the dimming level will be recalled when the LED Driver is switched on again
- Hold down the pushbutton (> 1 s) to change the dimming level

NOTICE

The dimming direction (fade direction) changes automatically with each dimming operation.

Synchronising the dimming level

- Select that of the two pushbuttons that is used to set the dimming level
- Hold down the pushbutton (10 s) to synchronise all the connected devices to a uniform dimming level of 50 %

Synchronising the colour temperature

- Select that of the two pushbuttons that is used to set the colour temperature
- Hold down the pushbutton (10 s) to synchronise all the connected devices to a uniform colour temperature of 4,500 K

Control via a floating pushbutton

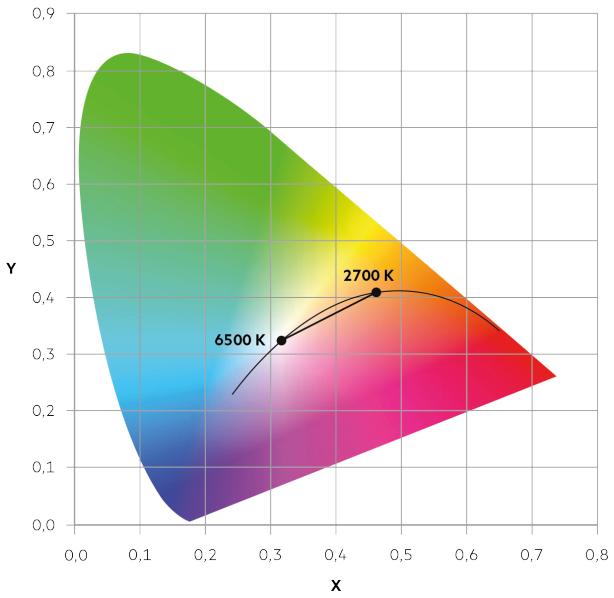
For control via a floating pushbutton (make contact) different settings can be made:

- Setting the colour temperature via colourTEMPERATURE mode with 9 predefined values between 2,700 K and 6,500 K
- Setting the dimming level between 1 % and 100 %.

NOTICE

Once the maximum value has been reached, the next press takes you directly back to the minimum value. The change from maximum to minimum value is indicated by brief flashing of the light module.

System Overview



Colour temperature set

Adjusting the colour temperature

- short press on the switch to increase the colour temperature

Dimmlevel set

- short press on the switchDIM switch increases or decreases the dimmlevel depending on its orientation

System Overview

3.3. Type codes

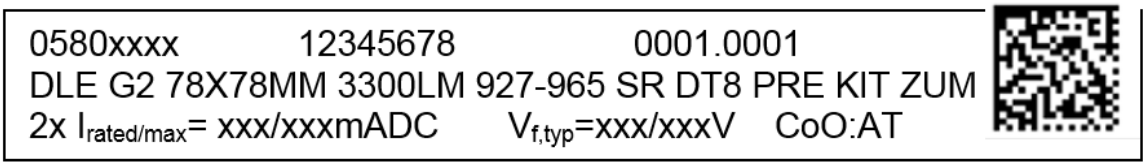
3.3.1. Type code for modules

The following type code is used to identify the modules. The table shows reference codes and their meaning for the DLE G2 PRE KIT.

Reference	DLE	G2	60mm	3000lm	927 - 965	-	SR	-	PRE	-	KIT
Meaning	Form	Generation	Diameter	Lumen	CRI 90 Colour temperature between 2,700 and 6,500 K		Form factor		Version		Bundled with LCA

⚠ CAUTION!

The DLE G2 PRE KIT components form a matched and calibrated unit. Therefore it is not allowed to separate and operate the components in different combinations!
There is a label on the LCA 38W 350-1050mA DT8 SR PRE with the corresponding module information.



3.3.2. Type code for LED Driver

The following type code is used to identify the LED Driver:

Type code of LED Driver for LCA 38W 350-1050mA DT8 SR PRE

Reference	LCA	-	38W	-	350-1050mA	-	DT8	-	SR	-	PRE
Meaning	LED Driver, constant current		Power in W		current in mA		DALI Device Type 8		Form factor		Version

The precise type designation for the LED Driver is given on the type plate on the LED Driver.

System Overview

3.4. Versions

3.4.1. DLE G2 PRE KIT

The DLE G2 PRE KIT system is packed with completely new functions such as tunable white. The colour temperature can be changed smoothly between 2,700 K and 6,500 K to meet the specific needs of the relevant application.

Characteristics:

- A colour temperature between 2,700 K and 6,500 K that can be set along the Planckian curve
- Different functions packed in a system for individual lighting solutions
- Constant colour temperature over the entire dimming range
- Constant luminous flux
- Lumen values: 2000 lm / 3000 lm
- Colour rendering index CRI > 90
- Very small MacAdam 3 SDCM colour tolerance (at 100 % dim level)
- System efficiency of up to 100 lm/W at tp=65 °C with high energy savings
- Temperature monitoring

Control functions:

- DALI Device Type 8
- switchDIM
- colourTEMPERATURE

3.5. Standards and directives

3.5.1. Standards and directives for modules

The following standards and directives were taken into consideration in designing and manufacturing the modules:

CE

Standard	Description
2006/95/EG	Low-voltage directive: Directive relating to electrical equipment for use within certain voltage limits
2004/108/EG	EMC directive: Directive relating to electromagnetic compatibility

RoHS

Standard	Description
2002/95/EC	RoHS(1) directive: Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment

(1) RoHS: Restriction of (the use of certain) hazardous substances

Safety

Standard	Description
DIN IEC 62031:2008	Safety requirements for LED modules
EN 60598-1:2008 und A11:2009	General requirements and tests for luminaires
EN 60598-2-2:1996 und A1:1997	Luminaires - Part 2. Special requirements; Main section 2: Recessed luminaires
EN 62471:2008	Photo-biological safety of lamps and lamp systems

Safety and performance

Standard	Description
EN 61347-1:2009	General and safety requirements
EN 61347-2-13:2007	Special requirements for dc and ac powered electronic operating equipment for LED modules
EN 62384:2007 IEC 62384 A1:2009	Operational requirements

Energy labelling

Standard	Description
EU Regulation No: 874/2012	"Energy labelling of electrical lamps and luminaires"

3.5.2. Standards and directives for LED Drivers

The following standards and directives were taken into consideration in designing and manufacturing the LED Driver:

EMI

Standard	Description
EN 55015 2008	Limit values measurement methods for radio interference properties of electrical lighting equipment and similar electrical devices
EN 61000-3-2:2005 A1: 2008 und A2:2009	Limit values for harmonic currents (equipment input current < 16 A per conductor)
EN 61000-3-3:2005	Limit values for voltage fluctuations and flicker in low-voltage systems for equipment with an input current < 16 A per conductor that are not subject to any special connection conditions
EN 61547:2001	EMC(1) requirements

(1) EMC: Electromagnetic compatibility

Safety

Standard	Description
EN 50172 2005	Safety lighting systems

DALI

Standard	Description
IEC 62386-101:2009	General requirements, system
IEC 62386-102:2009	General requirements, controller
IEC 62386-207:2009	Special requirements, controller; LED modules

Mechanical Aspects

4.1. Installation

4.1.1. Installation details

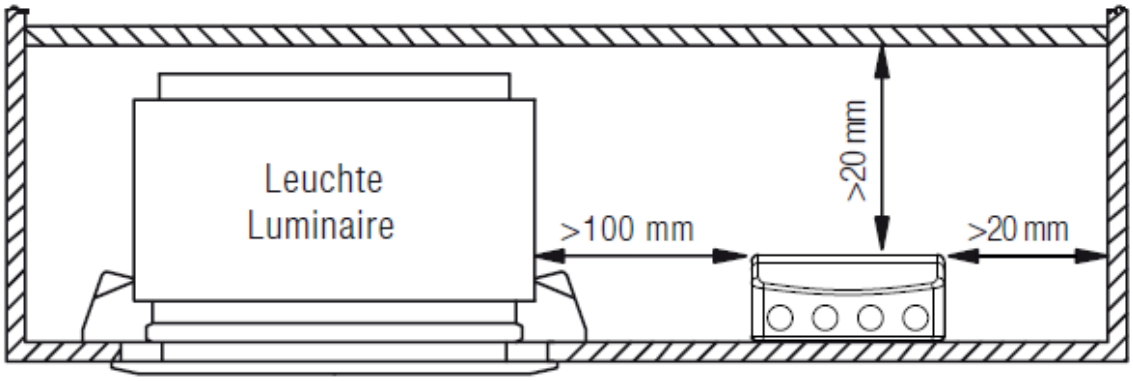
NOTICE

EOS/ESD safety guidelines
The device/module contains components that are sensitive to electrostatic discharge and may only be installed in the factory and on site if appropriate EOS/ESD protection measures have been taken. No special measures need be taken for devices/modules with enclosed casings (contact with the pc board not possible), just normal installation practice.

Please note the requirements set out in the document EOS/ESD guidelines (Guideline_EOS_ESD.pdf) at:

- www.tridonic.com/com/en/download/technical/Guideline_EOS_ESD_en.pdf
- www.tridonic.com/com/en/technical-docs.asp

Installation example



Inbuilt application with LCA 38W 350-1050mA DT8 SR PRE

Mechanical Aspects

Installation details

Depending on the particular situation, the LED Driver can be installed in the luminaire casing (in-built) or outside the casing (remote).

4.1.2. Notes on installation

Depending on the installation situation for the LED Driver and the modules, the following requirements must be met:

- Adequate distance from insulating materials
- Adequate strain relief for closed covering on the LED Driver
- Adequate cooling of the modules (the maximum temperature at the t_p point must not be exceeded)
- Unrestricted exit of light from the modules

Protection measures against damage

Mechanical stress

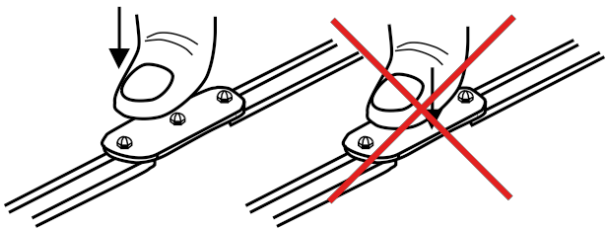
DLE G2 PRE modules contain electronic components that are sensitive to mechanical stress. Such stress should be kept to an absolute minimum. In particular the following mechanical stresses should be avoided as these may cause irreversible damage:

- Pressure
- Drilling,
- Milling,
- Breaking,
- Sawing,
- and similar mechanical processing.

Compressive stresses

The components of the DLE G2 PRE modules (circuit boards, glob-top, lenses, electronic components etc.) are sensitive to compressive stresses. The components must not be exposed to compressive stresses.

- If glass or Plexiglas shields are used make sure that pressure is not exerted on the glob-top.
- Only touch the DLE G2 PRE modules at the edges



correct (left) and incorrect (right)

Chemical compatibility

LED modules can be damaged by other materials, if these materials have certain chemical properties. The cause for these damages are different gaseous compounds, which penetrate into the encapsulant of the LED and thereby attack the encapsulant, the colour conversion phosphor or the LED chips and can affect the electrical contacts or the substrate.

Mechanical Aspects

Application areas for chemical substances

The following are known areas in which chemical substances are used:

- use of protective coating in applications with high relative humidity (outdoor applications),
- encapsulation of LED modules,
- cementing of LED modules,
- sealing of luminaires.

The following materials must be checked for their safety:

- All components and auxiliaries used in the assembly of the luminaire:
  - Solvents of adhesives and coatings
  - Other so-called VOC ("volatile organic compounds")
- All other additional substances present in the atmosphere:
  - Outgassing of adhesives, sealants and coatings
  - Cleaning agents and processing aids (e.g. cutting oils and drilling coolants)

HINWEIS

Contact your LED manufacturer for questions about the materials used and possible interactions and risks.

Putting together a "safe list" is not possible due to the complexity of the topic. The following table lists possible contaminants for LED modules, the classes of compounds and examples of possible sources.

Mechanical Aspects

The list shows the most commonly used materials but does not claim to be complete.

Class of compounds	Chemical names	Occurs in
Acids	_ hydrochloric acid _ sulfuric acid _ nitric acid _ phosphoric acid	_ cleaner _ cutting oils
Organic acids	_ acetic acid	_ RTV silicones _ cutting oils _ degreaser _ adhesives
Alkalis	_ ammonia _ amines _ sodium hydroxide	_ detergents _ cleaner
Organic solvents	_ ethers (e.g. glycol) _ ketones (e.g. Methylethylketon) _ aldehydes (e.g. formaldehyde) _ aromatic hydrocarbons (e.g. xylene and toluene)	_ cleaner _ benzine _ petroleum _ paints and varnishes
VOC (volatile organic compounds)	_ acetate _ acrylates _ aldehydes _ serve	_ super glue _ all-purpose glue _ screw locking varnish _ coatings _ paints and varnishes
Mineral oils	_ hydrocarbons	_ machine oil _ lubricants
Vegetable oils and synthetic oils	_ siloxanes _ fatty acids	_ silicone oils _ linseed oil _ fats
Harder, vulcanizer	_ sulfur compounds	_ seals _ sealants _ colours

Mechanical Aspects

Protection measures in regards to sealing

The points above also apply to chemicals used for sealing luminaire casings. If however the LED module is not installed in the luminaire until after the sealing compound has been completely cured (see relevant material information) the above points can be ignored. If the LED modules have already been installed in the luminaire, possible damage to the encapsulant can be reduced to a minimum by ensuring adequate spacing (>10 cm) and ventilation (open casing and air circulation, extraction / fan) during the curing process.

Protection measures in regards to cementing

To avoid damaging the LED modules you must not use any tools or exert any pressure on the electronic components or the encapsulant.

- If glass or Plexiglas shields are used make sure that pressure is not exerted on the encapsulant.
- Only touch the LED modules at the edges

Instructions for cementing DLE G2 PRE modules

Preparation

Clean and durable bonding of two materials requires special attention.
The following cleaning agents are recommended:

- Isopropanol / Water 50/50
- Acetone
- Heptane

Important aspects

- Carrier material
  The carrier material must have adequate thermal conductivity (e.g. aluminium). The size of the cooling surface depends on the power of the LEDs, among other things. For information on the cooling surface required, see the appropriate product data sheet.
- Adhesive material
  The carrier material itself plays an important role in selecting the adhesive material. The crucial factors are the coefficient of expansion and compatibility with the base material of the module board (plastic or aluminium). This must be checked in the application in terms of long-term stability, surface contamination and mechanical properties.
- Surface quality
  The carrier material must be uncoated (thermal transport, adhesion) and level at the connection points.
- Installation temperature
  To achieve optimum adhesion we recommend you carry out this work at room temperature.
- Duration, optimum adhesive strengths
  Maximum adhesion is achieved within 48 hours at room temperature; the process is accelerated by heat. In actual practice this means that at the maximum t_c temperature (approx. 75-85 °C, product-specific) maximum adhesion is reached after about 12 hours. During the curing period make sure that there is no tensile load on the adhesive connection of the module.

Additional information

DLE G2 PRE modules must not be stuck and restuck time and again without replacing the adhesive tape. Damaged adhesive tapes must be completely removed and replaced by new tapes.

Mechanical Aspects

Packaging and transport

DLE G2 PRE Kits from Tridonic are delivered in appropriate packaging. The packaging provides special protection against mechanical damage and ESD (electrostatic discharge). If you need to transport DLE G2 PRE products you should use this packaging.

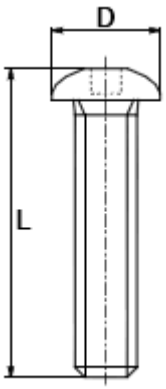
4.1.3. Installation of the modules on the heat sink

The LED modules are mounted onto a heat sink with 3 screws per module. For optimal thermical connection it is important to use all fastening holes. In order not to damage the modules only rounded head screws should be used.

Suitable screws should be selected on the basis of the following dimensions:

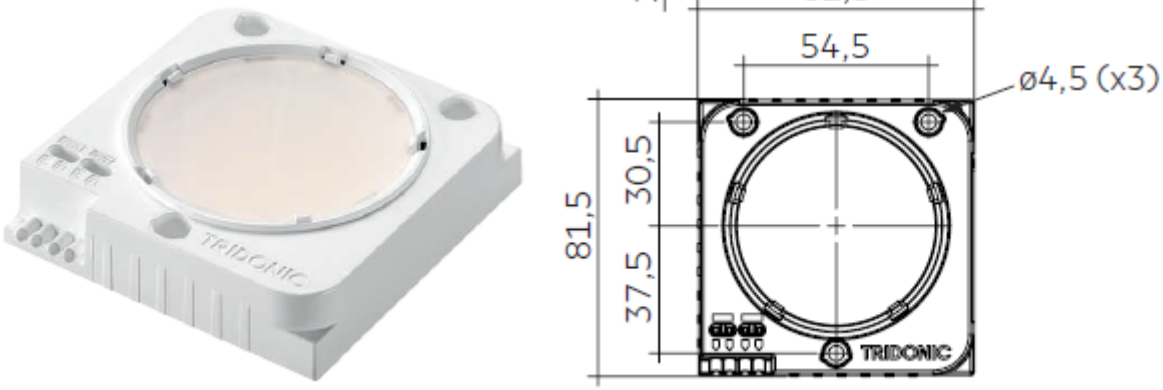
Dimensions of the fastening screws

Parameters	Value
Bolt size	M4
Max. diameter D	7 mm
Min. length L	5 mm
Max. length L	Depending on the design of the luminaire
Max. torque for fixing	0,5 Nm



Mechanical Aspects

4.2. Dimensional drawings modules



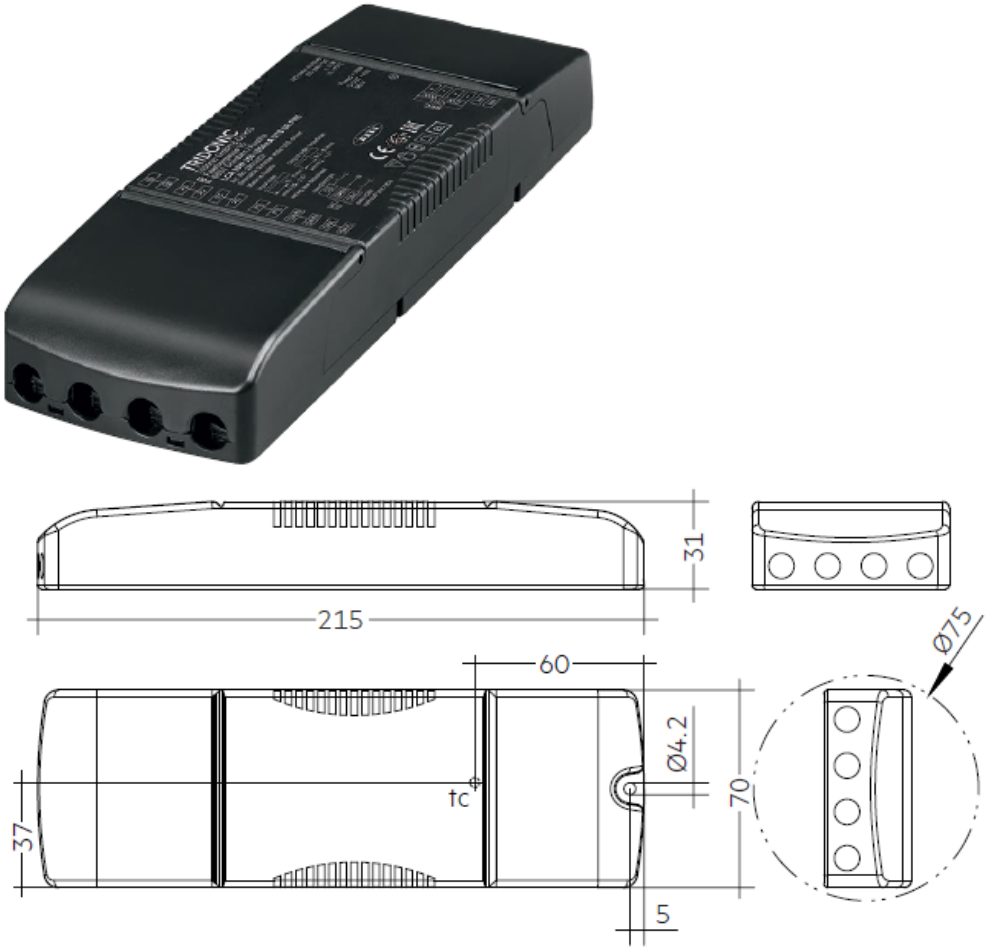
Dimensional drawing of the DLE G2 PRE module

NOTICE

CAD data for the modules can be downloaded from the Tridonic homepage (www.tridonic.com) and the relevant product page.

Mechanical Aspects

4.3. Dimensional drawings LED Driver



Dimensional drawing of the LED Driver LCA 38W 350-1050mA DT8 SR PRE

NOTICE

Detailed information and CAD data for the LED Driver can be downloaded from the Tridonic homepage (www.tridonic.com) and the relevant product page.

Electrical Aspects

5.1. Electrical safety

5.1.1. Basic classification of protection classes

Depending on the design of the luminaire, the requirements of different electrical protection classes are satisfied:

Luminaires in protection class III (also SELV which stands for Safety Extra Low Voltage) have such low internal voltages that a shock current would be inconsequential. AC voltages with an effective value of up to 50 V AC and direct currents up to 120 V DC are referred to as low voltage (also extra-low voltage and weak current).

Protection class II (non-SELV) applies for luminaires with double insulation, with no protective earth, between the mains circuit and the output voltage or metal casing. Even if the luminaires have electrically conductive surfaces, thanks to their insulation they are protected against contact with other live parts.

Protection class I (non-SELV) applies for luminaires with basic insulation and protective earth. All the electrically conductive casing components are connected via a protective conductor system which is at earth potential.

5.1.2. Basic insulation of DLE G2 PRE modules

DLE G2 PRE module features basic insulation against earth, i.e., a clearance/creepage distance greater or the same as 3 mm and can be directly assembled on an earthed metal part of the luminaire.

5.1.3. Luminaire with SELV

When using the LED module DLE G2 PRE with the supplied control gear, the SELV level for the luminaire is reached.

Electrical Aspects

5.2. Electrical safety and connection

5.2.1. Electrostatic safety and EMC protection

The LED modules are tested up to a voltage of 8 KV static discharging. Depending on the ambient conditions, appropriate precautionary measures must be taken in order to avoid higher voltages, for example during production or installation.

For good EMC conduct, the lines should be run separately from the mains connections and lines. The maximum secondary line length on the terminals is 2 metres.

5.2.2. Electrical supply and selection of the LED Driver

⚠ CAUTION!

DLE G2 PRE module are not protected against overvoltages, overcurrents, overloads and short-circuit currents!
Safe and reliable operation of the LED modules can only be guaranteed in conjunction with a LED Driver which complies with the relevant standards.

DLE G2 PREmodule must be supplied by a constant current LED Driver. Operation with a constant voltage LED Driver leads to irreversible damage to the modules! Wrong polarity can damage the DLE G2 PRE module. If a wire breaks or a complete module fails in the case of parallel wiring, the current passing through the other modules increases. This may reduce the service life considerably.

Electrical Aspects

5.3. Electrical connections

5.3.1. DLE G2 PRE module connections

The LED Driver is connected to the power supply and the connections of the control lines and the LED module via push-in and spring terminals:

Line cross-section and stripped length of the insulation on the LED module:

- Permissible line cross-section: 0.2 - 0.75 mm²
- Stripped length of the insulation 7 - 9 mm
- Push-in terminal for solid conductors

5.3.2. Push-in terminal for solid conductors

Line cross-section on the LED Driver:

Mains supply wires:

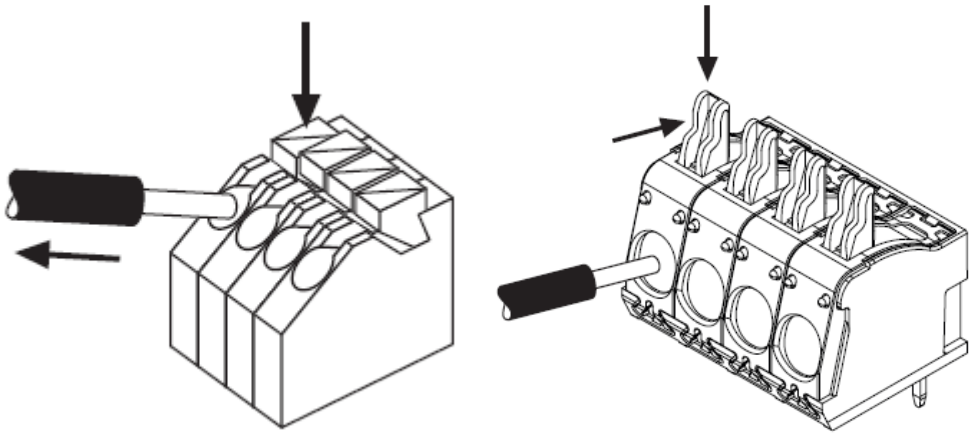
- Permissible line cross-section: 0.5 - 2.5 mm²
- Stripped length of the insulation 10 - 11 mm
- Spring terminal for stranded wire with end splice or solid conductor

Secondary wires (LED module)

- Permissible line cross-section: 0,2 - 1,5 mm²
- Stripped length of the insulation 8,5 - 9,5 mm
- Spring terminal for strandad wire with ferrules or solid conductor

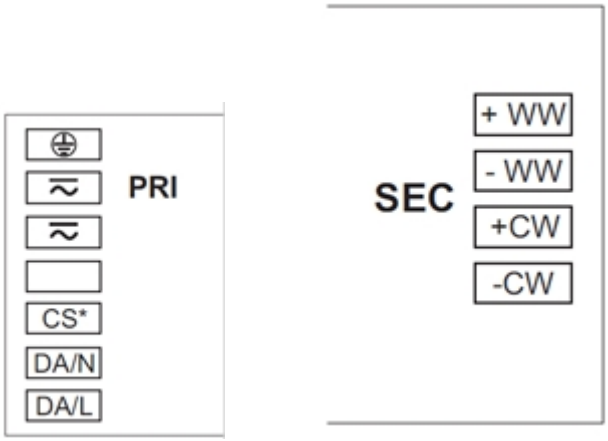
Spring terminal for stranded wire with end splice or solid conductor

Permissible line cross-section and stripped lengths of LED control gear with screw terminals can be found in the respective data sheets of LED control gear.



Electrical Aspects

5.4. Connections on the LED Driver



5.4.1. Connections on the LED control gear for DLE G2 PRE Module

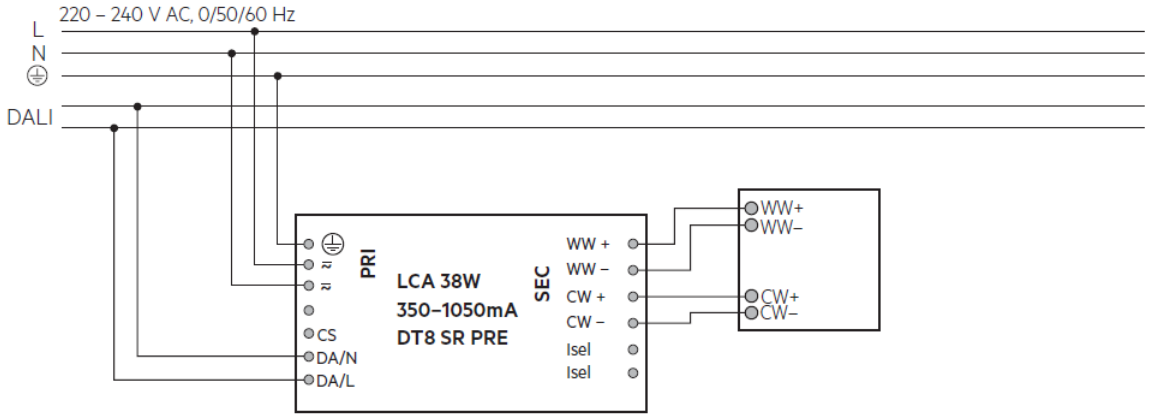
Pin/Connection	Connection on the LED Driver	Design
⏚	Protective earth or functional earth	Spring terminal
~	Power input	Spring terminal
~	Power input	Spring terminal
DA*	Control input DALI / DSI / switchDIM / corridor FUNCTION	Spring terminal
DA*	Control input DALI / DSI / switchDIM / corridor FUNCTION	Spring terminal
CS	colourTEMPERATURE	Spring terminal
WW+	DLE G2 PRE module - warm white PLUS	Spring terminal
WW-	DLE G2 PRE module - warm white MINUS	Spring terminal
CW+	DLE G2 PRE module - cold white PLUS	Spring terminal
CW-	DLE G2 PRE module - cold white MINUS	Spring terminal

* only with LED Driver with the corresponding functionality

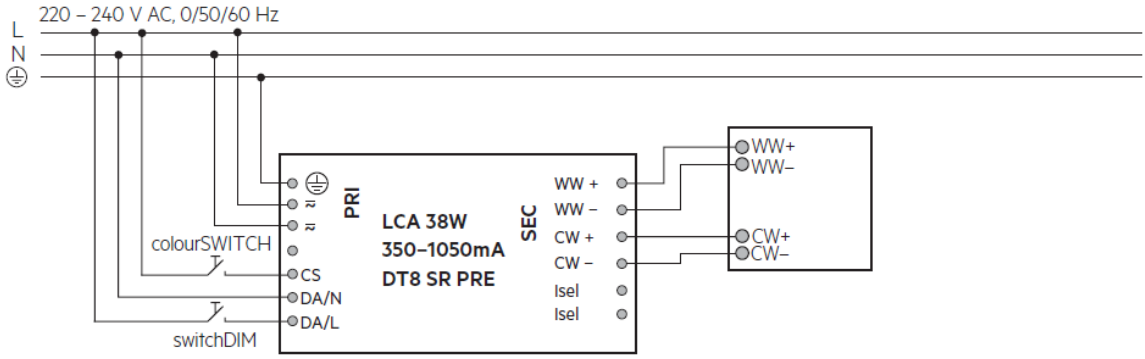
Optical Aspects

5.5. Wiring diagrams

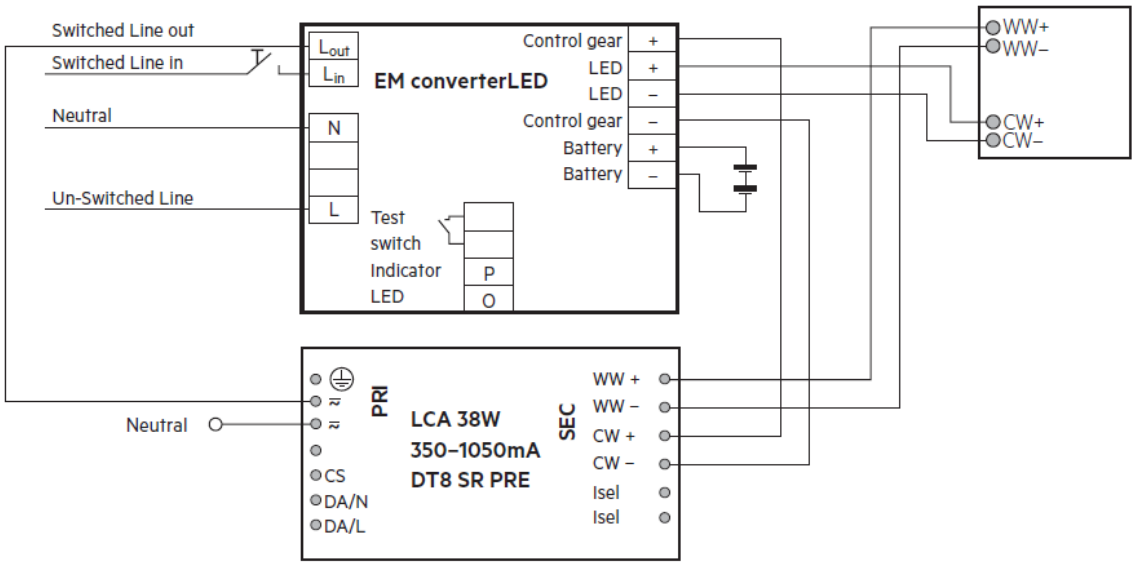
5.5.1. Wiring diagram DALI



5.5.2. Wiring diagram switchDIM and colourSWITCH



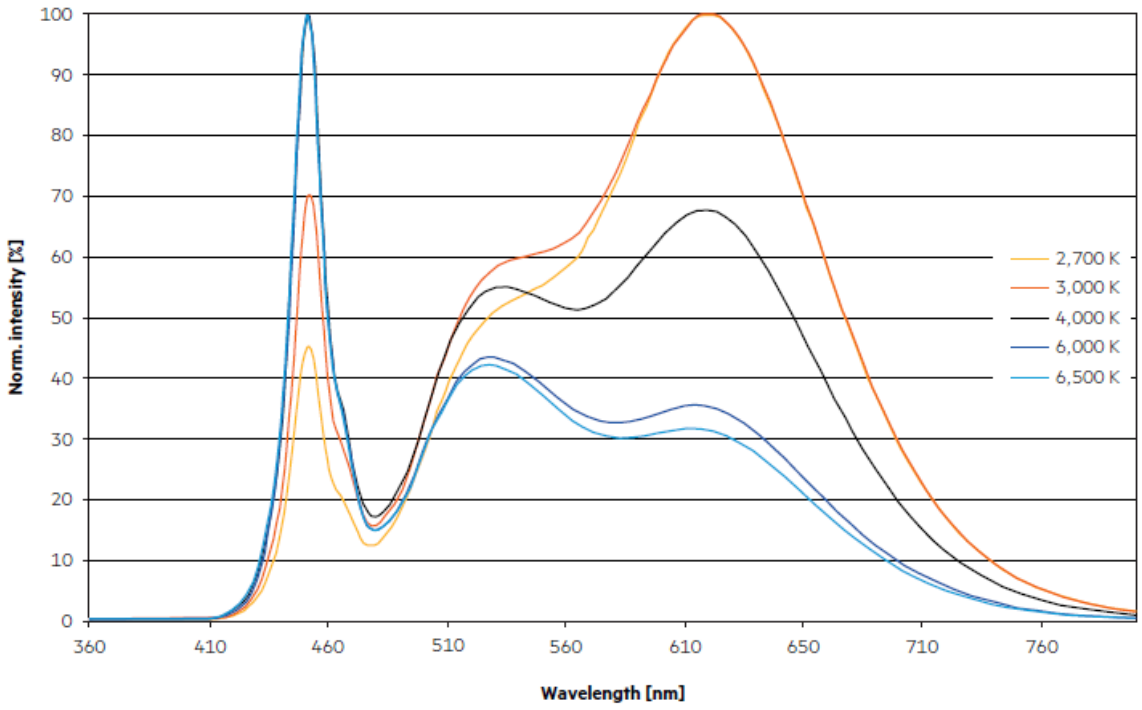
5.5.3. Wiring diagram Emergency



Optical Aspects

6.1. Colour spectrum

The used technology enables LEDs to be produced in special light colours or colour temperatures. This means that lighting systems can be created that are not only energy-efficient but also have excellent colour rendering.



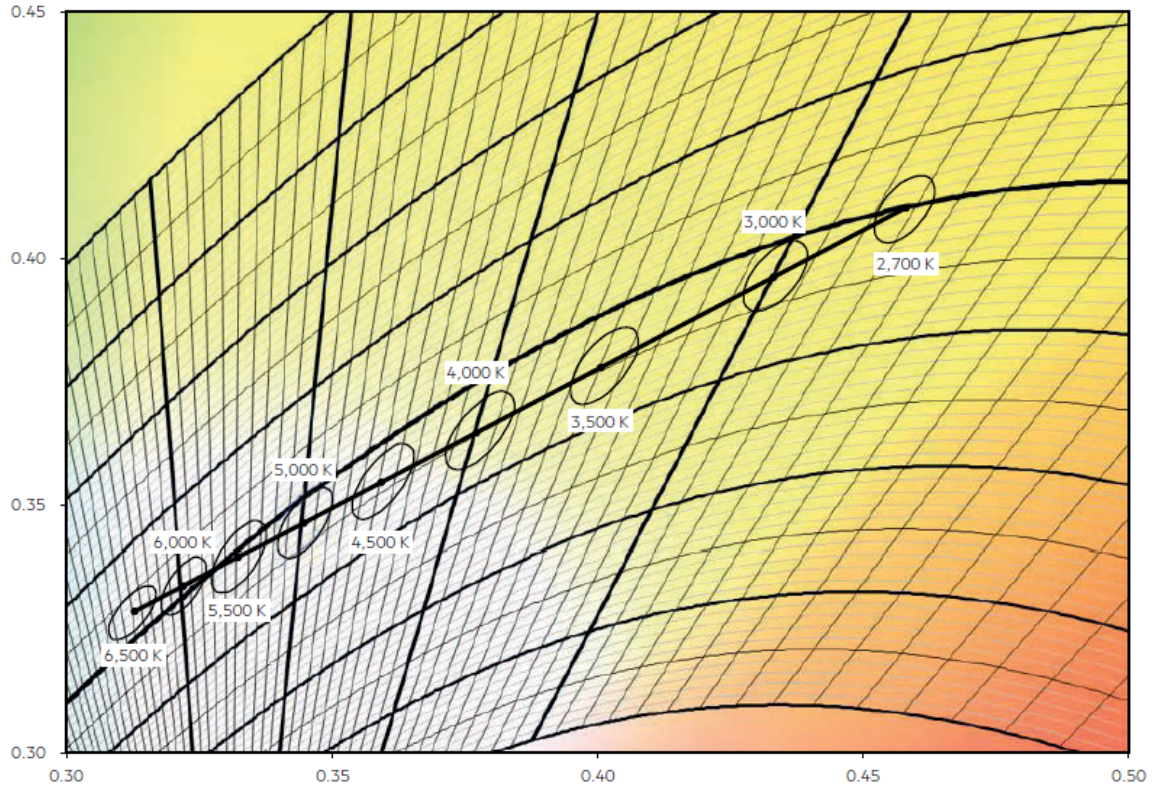
Colour spectrum at different colour temperatures

The diagram shows the normalised intensity in percent over the wave length in nm at different colour temperatures.

6.1.1. Coordinates and tolerances (to CIE 1931)

Thanks to the proximity to the Planckian curve there are no annoying colour discrepancies.
Every module is automatically tested at the final inspection stage to ensure that all the supplied products fall within the agreed specification.

Optical Aspects



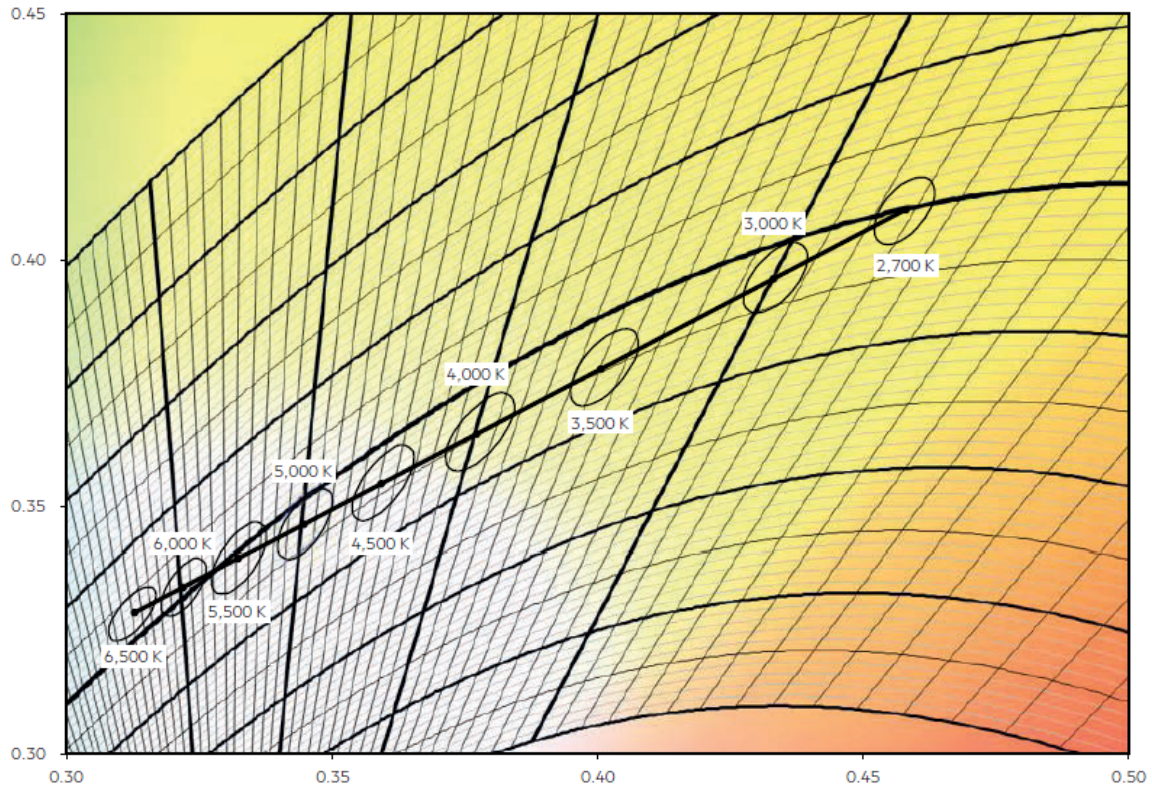
Light colour [K]	2,700	3,000	3,500	4,000	4,500	5,000	5,500	6,000	6,500
Centre x0	0.4578	0.4335	0.4013	0.3778	0.3596	0.3448	0.3324	0.3220	0.3123
Centre y0	0.4101	0.3964	0.3783	0.3651	0.3548	0.3465	0.3395	0.3336	0.3282
MacAdam ellipse 100 – 50 % dimming level	3 SDCM								
MacAdam ellipse 50 – 10 % dimming level	4 SDCM								
MacAdam ellipse 10 – 3 % dimming level	6 SDCM								
MacAdam ellipse 3 – 1 % dimming level	not specified								

Optical Aspects

6.2. Coordinates and tolerances

6.2.1. Light colours

DLE G2 PRE KIT covers all of the below light colours.



Light colour [K]	2,700	3,000	3,500	4,000	4,500	5,000	5,500	6,000	6,500
Centre x0	0.4578	0.4335	0.4013	0.3778	0.3596	0.3448	0.3324	0.3220	0.3123
Centre y0	0.4101	0.3964	0.3783	0.3651	0.3548	0.3465	0.3395	0.3336	0.3282
MacAdam ellipse 100 – 50 % dimming level	3 SDCM								
MacAdam ellipse 50 – 10 % dimming level	4 SDCM								
MacAdam ellipse 10 – 3 % dimming level	6 SDCM								
MacAdam ellipse 3 – 1 % dimming level	not specified								

6.3. CRI, Ra and Ri - different colour rendering values

The CRI (colour rendering index) and Ra (arithmetic average) value are different names for the same thing. They are defined as the “effect of an illuminant on the colour appearance of objects by conscious or unconscious comparison with their colour appearance under a reference illuminant”.

CRI and Ra are determined by a test procedure. In this procedure eight colour samples (R1-R8) are illuminated both by the light in

Optical Aspects

question and by a reference light source and the appearance of the samples under the different lights is compared.

If there is no perceivable difference the light in question will be rated with a maximum value of 100. Differences in appearance result in a deduction from the maximum value. The resulting number is the Ri value and describes the colour rendering for one specific colour sample. The average of all eight Ri values is the CRI or Ra value and describes the general colour rendering of the tested light source.

The eight colour samples consist of different pastel colours and can be found in the table below as TCS (test colour samples) 01-08.

There are six more colour samples: R9 to R14 or TCS09 to 14. They consist of different saturated colours and are not used for the calculation of the Ri, Ra and CRI value. However, these colours, especially R9, do have a special importance in the illumination of meat, fish, vegetables and fruit in retail areas.

Name	Appr. Munsell	Appearance under daylight	Swatch
TCS01	7,5 R 6/4	Light greyish red	
TCS02	5 Y 6/4	Dark greyish yellow	
TCS03	5 GY 6/8	Strong yellow green	
TCS04	2,5 G 6/6	Moderate yellowish green	
TCS05	10 BG 6/4	Light bluish green	
TCS06	5 PB 6/8	Light blue	
TCS07	2,5 P 6/8	Light violet	
TCS08	10 P 6/8	Light reddish purple	
TCS09	4,5 R 4/13	Strong red	
TCS10	5 Y 8/10	Strong yellow	
TCS11	4,5 G 5/8	Strong green	
TCS12	3 PB 3/11	Strong blue	
TCS13	5 YR 8/4	Light yellowish pink	
TCS14	5 GY 4/4	Moderate olive green (leaf)	

In the production of modules chips with different wavelengths and chip performances are used.

Because of this, different phosphor mixtures are needed to achieve the required target coordinates and single Ri values can differ between orders. This is not problematic. What is decisive for the overall impression of the LED module is its CRI value. But if specific single Ri values are required for an application, it must be made clear that these values may change for the reasons stated above. It is also not possible to specify tolerances.

Special LED modules are optimised to illuminate a particular product group (for example, MEAT+ is designed for the illumination of beef). In this case, specifiying the CRI or single Ri values does not make sense. For special LED modules the subjective human perception is the most important factor. The colour coordinates for GOLD, GOLD+, Fresh Meat and MEAT+ are the result of appropriate tests. Single Ri values or the CRI value are not assessed.

Optical Aspects

6.4. SDCM

The human eye can not only recognise different colours along the black body curve, but also deviations above or below this line. If an LED has a colour temperature of 2,700 K , but is not directly located on the black body curve, it can be perceived as different from another LED with the same colour temperature. To prevent such differences and to assign an LED unambiguously, the chromaticity coordinate must be specified using the x, y coordinates in the colour space chromaticity diagram .

An even more accurate approach is to specify the standard deviation from the target colour, based on levels of MacAdam ellipses. The unit for this is called "SDCM" (abbreviation for "Standard Deviation of colour Matching"). When looking directly into a light source, these differences are perceived more strongly than in a "normal" situation where light is mainly perceived because of its reflections from illuminated surfaces.

Colour differences within one level of the MacAdam ellipses are not visible even when looking directly into the light source. Deviations of two to three levels (<= 3 SDCM) are considered barely perceptible. A value of 3 SDCM is good for LED light sources. For most applications a value of 5 SDCM is still sufficient .

6.5. Binning

Chips and packages from the same production can still show small variations in colour temperature and forward voltage . If the chips are used without pre-selection, these differences can be noticable and interfere with the appearance.

Binning means that the chips and packages are classified according to their colour temperature and forward voltage. This leads to groups of chips or packages that fall into a very narrow window of tolerance. If LED modules are equipped with such chips and packages differences in appearance can be prevented.

6.6. Secondary Optics

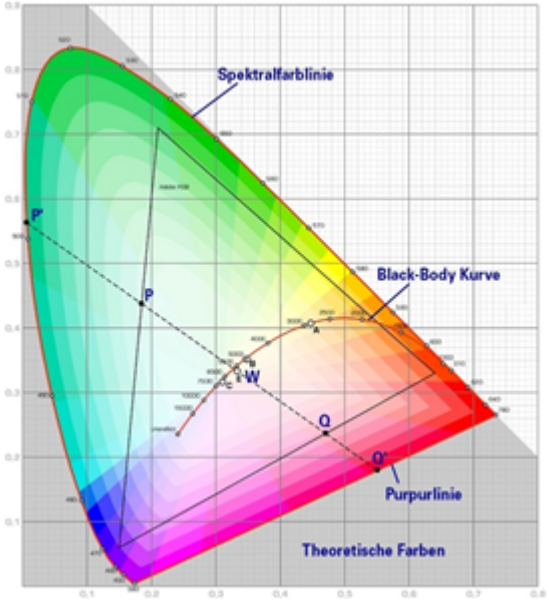
The term Secondary Optics refers to additional optical elements that shape the light output in different forms. Secondary Optics include e.g. reflectors, lenses or covers.

6.7. Coordinates and tolerances (to CIE 1931)

As before, the production process for TALEXX LEDs does without binning. As a result, white LEDs can be produced with normal distribution in the range of a MacAdam-Ellipse 3. Thanks to the proximity to the Planckian curve there are no annoying colour discrepancies.
Every module is automatically tested at the final inspection stage to ensure that all the supplied products fall within the agreed specification.

Optical Aspects

6.7.1. Chromaticity coordinate



LEDs exhibit variations in terms of their exact shade of colour. This means that different “white” LEDs will all shine in a colour that is within the white colour spectrum. But the colours won’t be exactly the same.

These colour differences between LEDs are problematic in areas where the lighting must produce a specified and uniform colour and deviations from that can impair the visual appearance of an installation. Using the chromaticity coordinate helps to avoid such problems by defining the exact shade of colour of an LED.

Technically speaking, the chromaticity coordinate is defined by its three coordinates (x, y, z) within the so called CIE 1931 colour space chromaticity diagram.
The CIE 1931 colour space chromaticity diagram represents all the colours that are discernible for humans. Since the three coordinates sum up to 1, two coordinates are sufficient to define a colour and so one one coordinate is sometimes left out.

6.7.2. Colour temperature and Black Body Curve

The Black Body Curve within the colour space chromaticity diagram represents the colours that show when a so-called "black body" is slowly heated.

A "black body" is an "idealised" body which absorbs all light and has no reflected radiation.
If a "black body radiator" is slowly heated, it passes through a colour scale from dark red, red, orange, yellow, white to light blue. The definition for the colour temperature of a light source is the temperature where the “black body radiator” shows the same colour.

The colour temperature is measured in Kelvin (K). The most common luminaires have colour temperatures below 3,300 Kelvin (warm white), between 3,300 and 5,300 Kelvin (neutral white) or above 5,300 Kelvin (daylight white).

Optical Aspects

6.7.3. Eye safety

Risk group	Evaluation
Actinic UV E_S (200 - 400 nm)	Risk group 0[1]
Near UV E_{UVA} (315 - 400 nm)	Risk group 0[1]
Blue light L_B (300 - 700 nm)	Risk group 0[1]
Retina, thermal L_R (380 - 1,400 nm)	Risk group 0[1]
IR radiation, eye E_{IR} (780 - 3,000 nm)	Risk group 0[1]

[1] The evaluation of eye safety is based on EN 62471:2008 (photo-biological safety of lamps and lamp systems):

- Risk-free (risk group 0): The LEDs do not pose any photo-biological risk.
- Low risk (risk group 1): The LEDs pose a small risk because of normal limitations.
- Medium risk (risk group 2): The LEDs pose a small risk because of reactions to bright light sources or thermal discomfort.
- High risk (risk group 3): The LEDs pose a risk even with just momentary or temporary exposure.

Optical Aspects

6.8. Beam characteristics

6.8.1. Reflector design

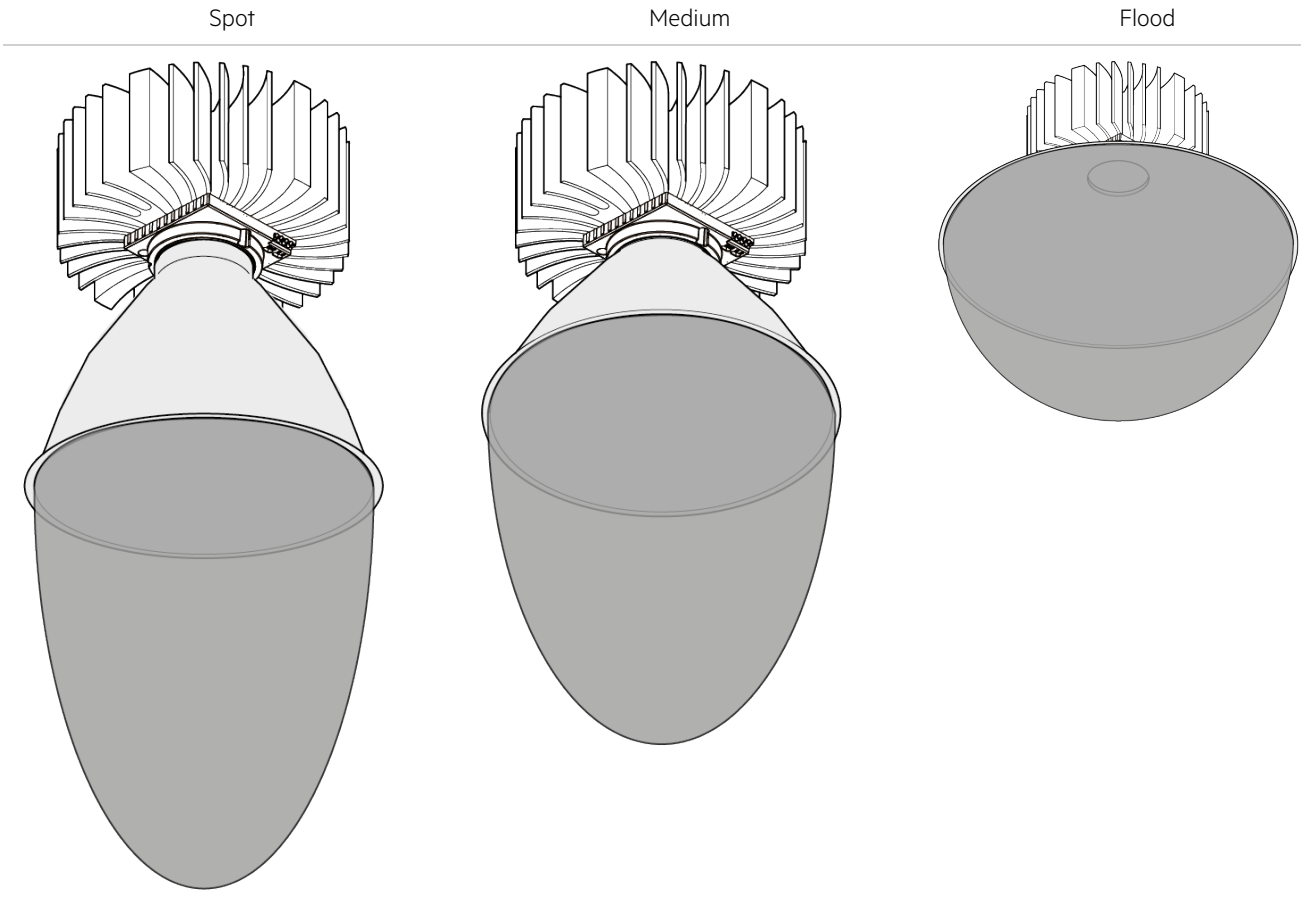
The mechanical and optical properties of the modules DLE G4 ADV offer the best conditions for using reflectors. The overall efficiency of the system can be optimised by choosing a reflector that directs the light appropriately.

The optical properties (e.g. beam angle) and the dimensions of the reflector play a crucial role.

The overall height of the luminaire can be reduced by selecting a low-profile reflector, depending on the beam angle required. This may improve the thermal output of the luminaire by increasing the height available for the heat sink.

To achieve uniform illumination a reflector withy an integrated diffuser is recommended for LED modules with multicolour LEDs. This ensures that the colours are properly mixed. Some reflectors have the option of faceting for the reflector wall. Depending on the position of the homogenising element, different efficiencies and different colour mixing results can be achieved.

Examples of reflectors with different beam angles



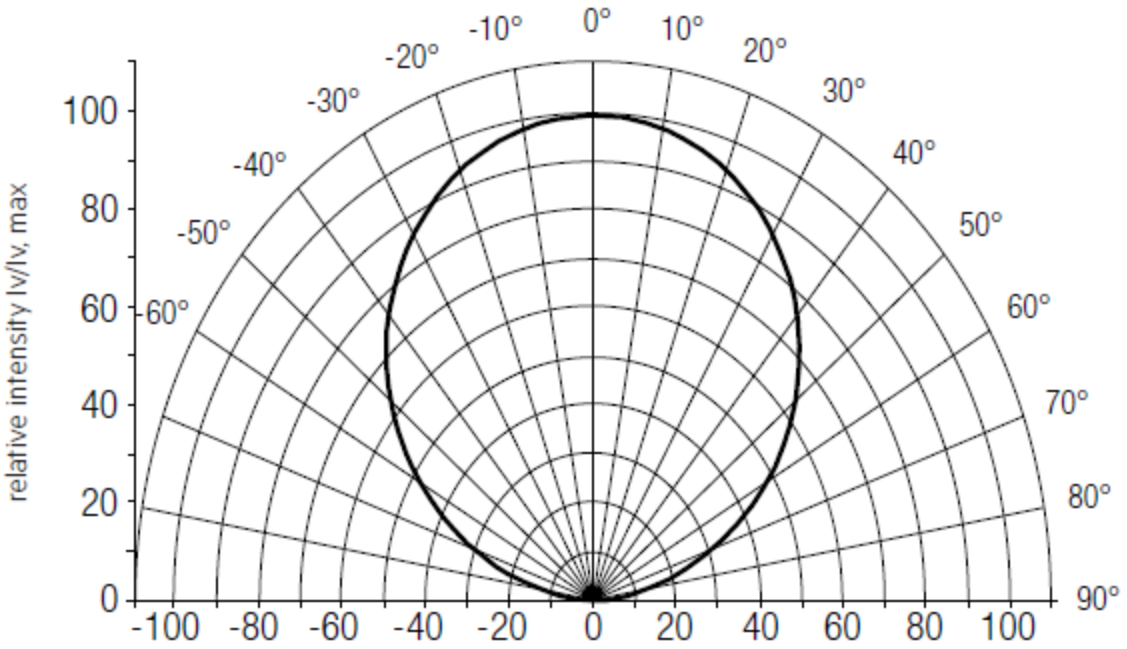
Optical Aspects

NOTICE

To help create customised designs and to carry out optical simulations CAD data and Rayfiles are available for download from the Tridonic website.

- Go to the produkt page on the Tridonic homepage
- Choose the desired product
- Click on CAD/RAY slide at bottom of the page

6.8.2. Beam characteristics



6.8.3. Photometric cod

Key for photometric code, e. g. 930 / 349

1st digit	2nd + 3rd digit	4th digit	5th digit	6th digit
Code CRI	Colour temperature in Kelvin x 100	MacAdam initial	MacAdam after 25% of the life-time (max.6000h)	Luminous flux after 25% of the life-time (max. 6000 h)
				Code Luminous flux
7 70-79				7 >= 70 %
8 80-89				8 >= 80 %
9 >= 90				9 >= 90 %

Thermal Aspects

7.1. Decrease of luminous flux

7.1.1. Lifetime, luminous flux and failure rate

The luminous flux of an LED module decreases over lifetime. The L value describes this behaviour.

L70 means that the LED-module delivers 70% of the initial luminous flux. This value is always linked to a certain operation time and defines the lifetime of the LED module.

The L value is a statistical value. The actual reduction of the luminous flux may vary within the supplied LED modules. For this reason, the B value specifies how many modules fall below the given L value, e.g.. L70B10 means that 10% of the LED modules fall below 70% of the initial value (or 90% of the LED modules stay above 70% of the initial value).

Additionally, C value specifies the percentage of total failures.

The F value describes the linkage of B and C value and takes both total failures and degradation into account. L70F10 means that 10% of the LED modules have either shown total failure or fallen below 70% of the initial value.

There are two reasons for the limitation of the lifetime data with 50,000 h:

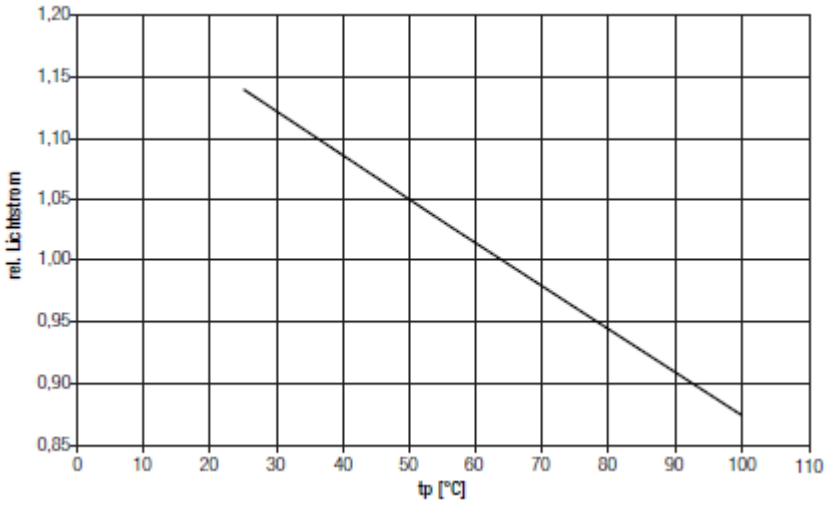
1. The LED modules have been tested for 9,000 hours. According to LM80, it is possible to make a 6-fold extrapolation. The lifetime of the LED modules is by no means limited to 50,000 h. But due to the diversity and the rapid generational changes it is not possible to conduct tests over a period of several hundred hours. Before the tests had been completed, the tested chips were no longer available on the market. Due to the tested data, we can specify 50,000 h. The LED lifetime is certainly higher!
2. The switching cycles of the LED modules must be tested according to standard IEC 62717 / 10.3.3. If a lifetime of 50,000 h is communicated, the LED modules must have been tested for at least 25,000 switching cycles. Our LED modules meet the requirements of standard IEC 62717 / 10.3.3 and have been tested for 25,000 switching cycles.

7.1.2. Effect of cooling on the life of the modules

The life of the module depends to a large extent on the operating temperature. The more that the operating temperature can be reduced by cooling, the longer the expected life of the module. If the permitted operating temperature is exceeded, however, the life of the module will be significantly reduced.

Thermal Aspects

Figure: Lifetime characteristic

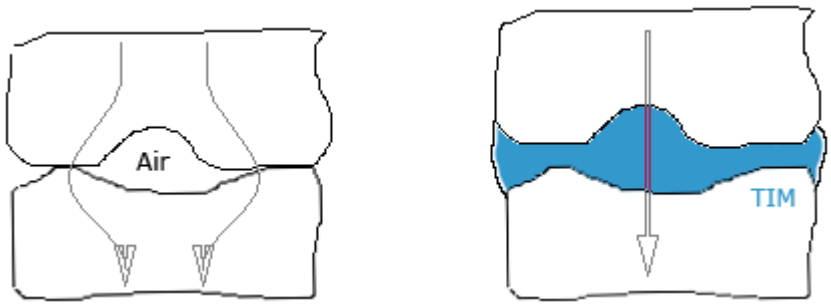


NOTICE

Please check the information on the operating temperature and the requirements for cooling in the module data sheets.

7.1.3. Thermal Interface Material

Figure: Heat transfer without TIM (left) and with TIM (right) (magnified illustration)



Thermal Interface Material (TIM) helps to reduce the thermal impedance between LED module and heat sink and thus improves the heat transfer between the two components.

When LED module and heat sink are joined together, uneven surfaces can be the cause for trapped air. Since air is a thermal insulator trapped air obstructs the heat transfer. TIM replaces the trapped air and improves the heat transfer.

In general:

- The lower the thermal impedance, the better the heat transfer and thus the cooling of the modules.
- The thickness of the TIM relates to the unevenness of the surfaces: the more uneven the surface is, the thicker the TIM must be.

Thermal Aspects

7.1.4. Rth

The lifetime of LED products is highly dependent on the operating temperature. Exceeding the permissible temperature limits results in a significantly reduced lifetime or the destruction of the LED module DLE G2 PRE. Therefore, it is necessary to mount the LED module DLE G2 PRE on an appropriate heat sink, which do not exceed the Rth_{max} value. The Rth values can be found in the data sheet of the respective products. The data sheets can be found on the Tridonic website at the following link:
http://www.tridonic.com/com/en/data-sheets.asp

7.1.5. tp point, ambient temperature and lifetime

The temperature at the tp point is crucial for the luminous flux and the lifetime of a LED product.

The thermal limits can be checked at the tp/tc point and the tr point.

- tp is the temperature at which the rated values are obtained.
- tc is the threshold temperature which ensures the security of the module and must not be exceeded under normal conditions.

For the DLE G2 PRE tp a temperature of 65 °C must be maintained in order to achieve an optimum between heat sink requirements, luminous flux and lifetime.

Adherence to the permitted tp temperature must be checked under operating conditions in a thermally stable state. For this the max. ambient temperature of the relevant application must be taken into account.

Explanatory note

The actual cooling may deviate due to the material, the design, external and situative influences. A thermal compound between DLE G2 PRE and heatsink using thermal paste or thermally conductive adhesive foil is absolutely necessary.

Additionally, in order to optimize the thermal connection, the DLE G2 PRE has to be mounted on the heat sink with M3 screws.

The calculation of the heat sink information is based on the use of thermally conductive paste with a thermal conductivity of > 1 W / mK and a thickness of max. 50 µm or a thermally conductive adhesive foil with b <50 µmmK/W.

7.1.6. Requirements for the heat sink

Although the operating temperature of the modules is continually monitored during operation and the power is automatically reduced in the event of excess temperature, the modules should not be operated without a heat sink.
The heat sinks must be dimensioned to provide adequate cooling capacity.
The R_{th} value is important for selecting an appropriate heat sink. This value depends on the light output of the module and on the ambient temperature in which the module is to be operated. The R_{th} value of the heat sink must be smaller than the required R_{th} value.

NOTICE

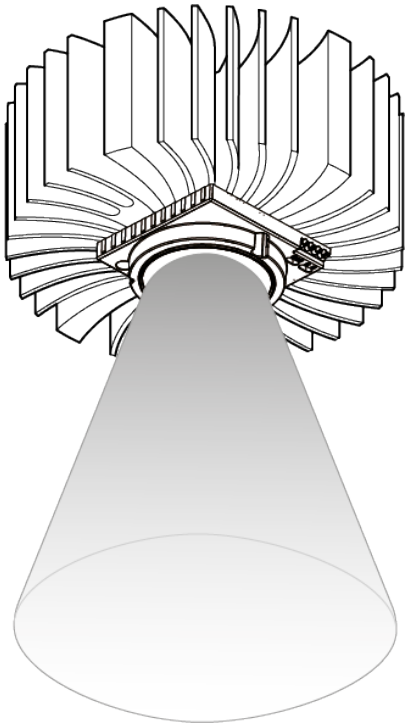
Please check the information on heat sinks in the module data sheets.

Thermal Aspects

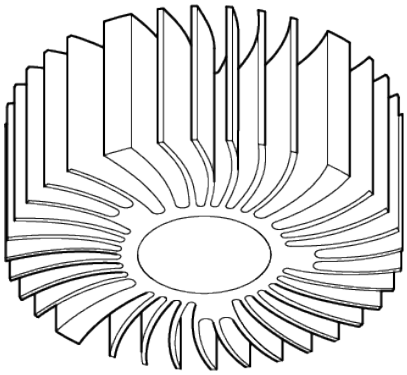
7.2. Passive and active cooling

7.2.1. Passive cooling

Example of passive cooling for the module



Passive cooling module



Heat transfer from a heat source to the surrounding cooling medium (e.g. air) depends primarily on the difference in temperature, the effective surface area and the flow rate of the cooling medium. The function of a heat sink is to increase the surface area over which the heat can be dissipated. This lowers the thermal resistance.

A passive heat sink works mainly by convection. The surrounding air is heated, which makes it rise, and is replaced by cooler air. Heat pipes can be used as an alternative to cooing with fans. If space is particularly tight, the heat is first conveyed away. The actual heat sink is located at the other end of the heat pipe.

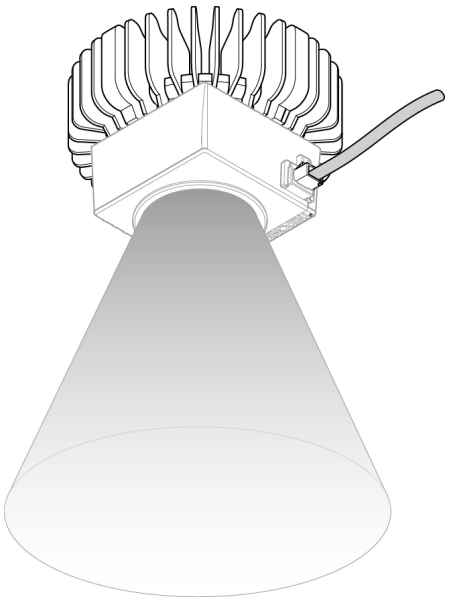
Benefits of passive cooling

- Energy savings
- Silent
- No mechanical wear
- No maintenance

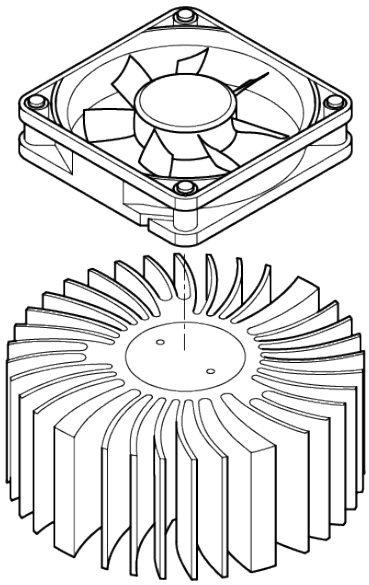
Thermal Aspects

7.2.2. Active cooling

Example of active cooling for the module



Round active cooling module



An active heat sink consists of the heat sink itself and an electrically powered fan. The fan dissipates heat from the heat sink by blowing a sufficient quantity of air along the surface of the heat sink. To reduce the power draw and noise, the fan speed can be controlled from the active cooling system on the basis of temperature.(1) A diaphragm can be used as an alternative to fans to produce active air movements.

Active heat sinks with fan cooling achieve around six times the performance of passive heat sinks for the same amount of material used. Active heat sinks can therefore be made very compact.

(1) The fan speed is not controlled from the LED engine system.

Benefits of active cooling

- Space savings
- Effective cooling
- Professional design

7.3. Fan connection and temperature measurement

7.3.1. Fan driver

Fan drivers drive active heat sinks in order to make sure that the LED modules are sufficiently cooled.

Thermal Aspects

NOTICE

The fan driver must be operated with suitable KTY sensors and wiring!
For more information please consult the corresponding LED control gear data sheet.

7.3.2. KTY-Sensor

The Intelligent Temperature Management (ITM) function protects the LED light modules against short-term thermal overloads.

To monitor the temperature of the LED, a silicon-based temperature sensor (KTY81-210, KTY82-210) can be connected to the LED control gear.

If certain temperature thresholds are exceeded the LED output is gradually reduced or completely switched off. As a result of this, the dimm level and the temperature decreases. If the temperature falls below the the threshold temperature, the LED control gear automatically returns to nominal operation.

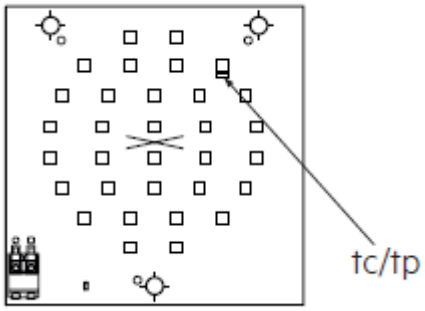
The use of an NTC or PTC resistor is not possible. The device can also be operated without sensor (default setting). The function can be adjusted via the masterCONFIGURATOR.

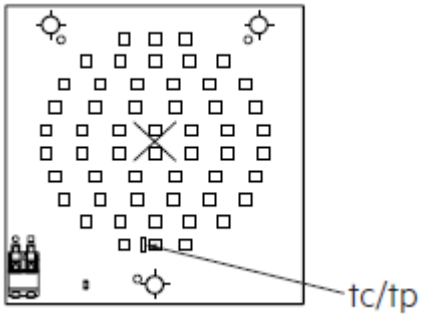
7.3.3. Temperature measurement on the module

The temperature of the module must be measured at the t_c/t_p point. As shown in the drawing of the DLE G2 PRE beside the t_c/t_p point is marked on the module.

The temperature can be measured with a simple temperature probe. In actual practice, thermocouples (e.g. B & B Thermotechnik thermocouple, K-type) have been successfully used for taking measurements. Such thermocouples can be attached directly to the t_c/t_p point with heat-resistant adhesive tape or a suitable adhesive. The measured values are recorded by an electronic thermometer (e.g. "FLUKE 51", VOLTCRAFT K202 data logger).

The maximum possible temperature must be determined under worst-case conditions (ambient temperature of the luminaire, installation of the luminaire) for the relevant application. Before the measurement is taken the luminaire should be operated for at least 4 hours in a draught-free room.





Thermal Aspects

7.3.4. ta, tp rated, tc max

- ta ... ambient temperature: The ta temperature is the ambient temperature at which the LED module is operated.
- tp rated ... performance temperature: The tp rated temperature is the temperature at which the photometric and electrical data are given. This is the temperature that the LED module has when it is in operation.
- tc max ... max. case temperature: Tc max temperature is the max. temperature that the LED module is allowed to have. The tc max temperature is safety relevant. This is the max. temperature at which the LED module can be operated without compromising security.

7.3.5. Temperature management of the LED control gear

To protect the LED module from thermal damage, LED control gear with integrated temperature management automatically dim down if a certain temperature is exceeded.
The temperature at the t_c point on the LED control gear can be measured with a simple temperature probe. The t_c point on the LED control gear is indicated by a sticker on the casing.

NOTICE

Measurement conditions, sensors and handling are described in detail in standard EN 60598-1 "General requirements and tests for luminaires".

Ordering information and sources

8.1. Article numbers

8.1.1. DLE G2 PRE KIT CRI > 90 (calibrated kit)

Type	Colour-temperature (K)	Typ. luminous flux[1] (lm)	CRI	Typ. power draw[1] (W)	System efficacy (lm/W)	Order No.
DLE G2 60mm 2000lm 927-965 SR PRE KIT (1 LED-Driver + 1 LED-Modul)	2,700-6,500 Tunable White	2,000	> 90	20.1	up to 100	89603257
DLE G2 60mm 3000lm 927-965 SR PRE KIT (1 LED-Driver + 1 LED-Modul)	2,700-6,500 Tunable White	3,000	> 90	31.2	up to 97	89603258

All of the above DLE G2 PRE KITs meet MacAdam (SDCM 3) and have a uniform size of 81 x 81 mm.

[1] Tolerance range for optical data over the CCT range: ±5 % and tolerance range for electrical data: ±5 %. All values for tp=65°C.

8.1.2. Suitable controllers

Tridonic offers a comprehensive range of DALI-compatible products. All the devices specified here support DALI Device Type 6 and therefore guarantee effective use of DLE G2 PRE KIT.

Product name	Article No.
DALI MSensor 02	28000896
DALI SC	24034263
DALI MC	86458507
DALI TOUCHPANEL 02	28000022
DALI x/e-touchPANEL 02	28000005
DALI PS	24033444
DALI USB	24138923

NOTICE

Go to www.tridonic.com to see the current range of products and the latest software updates.

Ordering information and sources

8.2. Product application matrix

Whether you are looking for wide-area lighting or focused accent lighting, our wide range of PRE products will help you create an individual atmosphere and highlight specific areas exactly as you want. Our product portfolio includes individual light points, round, rectangular and strip versions. Specially matched operating equipment such as LED Driver, amplifiers and sequencers round off the components for a perfect system solution: They guarantee ideal operation and maximum efficiency.

8.2.1. Luminaire application PRE KIT

PRE KIT	Downlight	Spotlight	Linear / rectangular	Decorative	Surface	Outdoor (street)
PRE KIT DLE	✅					
PRE KIT SLE	✅	✅		✅	✅	
PRE KIT LLE			✅		✅	
PRE KIT FULMEN		✅				
PRE KIT LINE			✅	✅		

8.2.2. Luminaire application PRE module

PRE module	Downlight	Spotlight	Linear / rectangular	Decorative	Surface	Outdoor (street)
PRE module SPOT	✅	✅		✅	✅	
PRE module RECTANGULAR						✅
PRE module EOS	✅	✅	✅	✅	✅	✅
PRE module STRIP			✅	✅		
PRE module TAPE			✅	✅		

For more information and technical data on the entire PRE product portfolio go to led.tridonic.com or see our PRE catalogue.