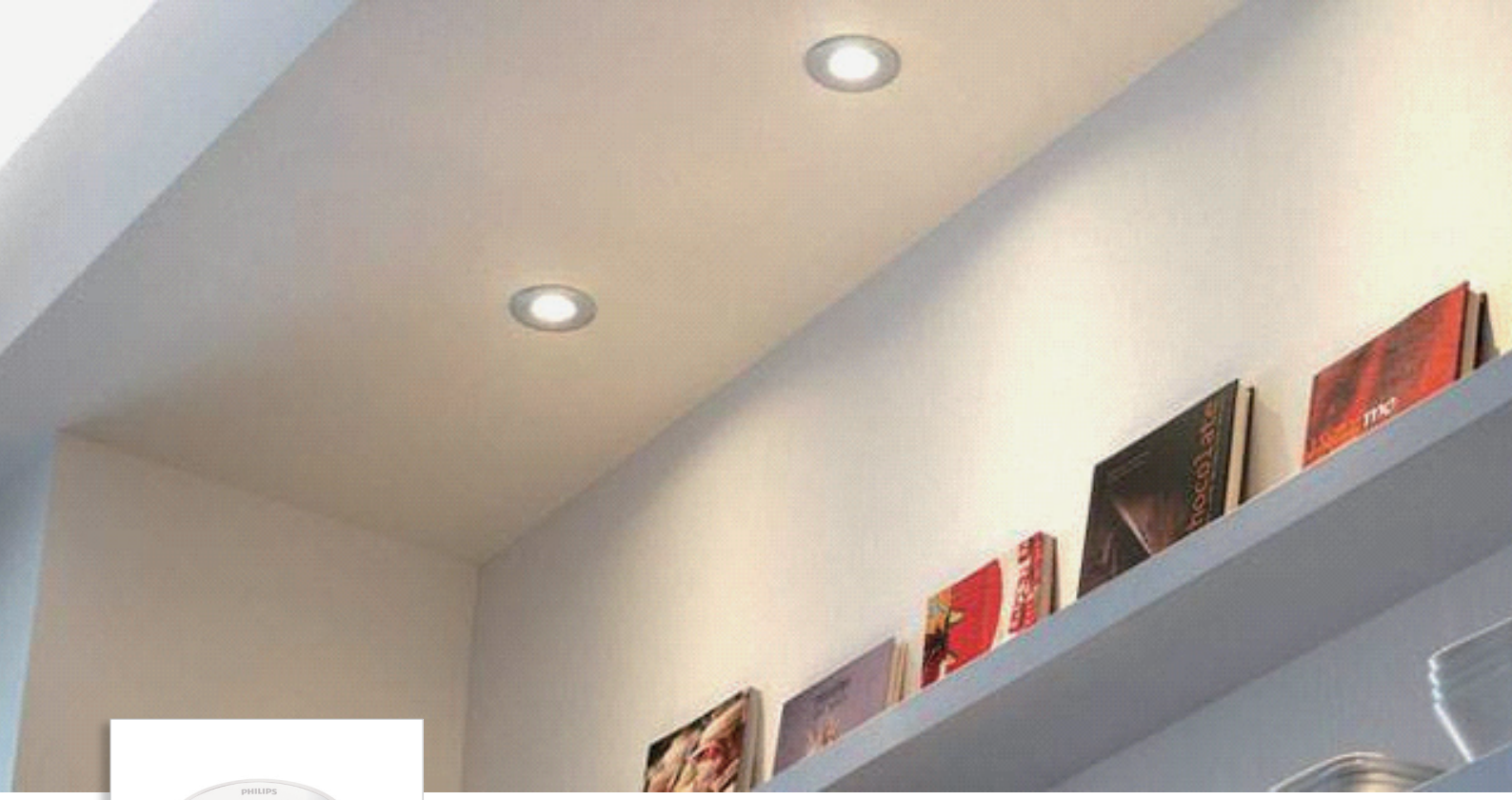


Design-in guide

Fortimo LED Disk non-dimmable GEN4 Module

asimpleswitch.com

PHILIPS

Contents

1. Introduction

Thank you for choosing the Philips LED Disk GEN4 Module system. This guide tells you all about this system. If you require any further information or support please consult your local Philips office or visit: www.philips.com/support.

The advantages of LEDs have been known for 40 years:

- Long life – low maintenance cost
- Robustness – high reliability
- Saturated colors – maximum visual effect
- Cool beam – no heating of illuminated products
- No UV or IR – wide application possibilities
- Low-voltage operation – increased safety, ease of use
- Mercury-free – care for the environment

The use of LEDs has implications for lighting manufacturers in terms of differences in solid-state lighting usage compared with traditional lamps. For example, how to design given the constant improvements in specifications; how to provide the necessary heat sink, and how to deal with variations in flux and/or color. The Philips LED Disk GEN4 module system addresses these differences and facilitates easy adoption of LED technology for high lumen packages (800 lm+). The system is designed for integration in luminaires (system). This technical application guide addresses the relevant issues to support and facilitate the work of specifiers and lighting system designers.

The Philips LED Disk GEN4 Module system is designed for downlight luminaires. Other applications can be explored by OEMs as long as this does not create a design conflict with the LED Disk GEN4 Module system and European/Chinese or other countries' luminaire standards are respected (EN 60598). Please consult us if you wish to deviate from the design rules as described in this application guide.

Complementary businesses, especially for heat-sink and reflector design, are now also developing products around Philips LED Disk GEN4 Module systems. In this application guide you will also find references to heat sinks (passive cooling).

1.1 Features and benefits

Features	Benefits
Breakthrough LED energy saving	LED solution enabling savings over halogen solutions
Direct white chip	Great performance in color consistency, 5 SDCM at module level
Superior-quality white LED light	An enabler for entry into downlighting
800lm+ CRI 80min	Competes with CFL and halogen downlight systems
Optimized collimator design	Perfect beam angle of 85°
Efficient thermal design	Adaptable for heat sink with smaller form factor
Easy-to-mount heat sink	Faster time to market
Light on instantly	Provides further energy savings
Long lifetime: 25,000 hours	Low maintenance
2700K/3000K/4000K/5000K	Warm to cool color temperature range available for replacing halogen down lights in hospitality or home segment
Integrated driver	For ease of installation; direct mains input
Thin form factor	Easy to design-in and install

1.2 Applications

The LED Disk GEN4 Module system is intended for downlighting applications in the semi-professional hospitality, retail and office markets.

Examples of applications include:

- Hospitality (customer-facing/representational areas such as receptions, boardrooms, restaurants, etc.)
- Public buildings (cinemas, theaters, swimming pools, exhibition halls)
- High-end stores
- Retail (supermarkets, bakery/butcher areas, leather goods, etc.)
- Urban outdoor lighting (ground lighting, post-top lanterns)
- Use in outdoor luminaires (IP rating depending on luminaire design)

LED Disk GEN4 Module has an IP20 classification. If an OEM decides to use the LED Disk system in a luminaire for outdoor applications, the OEM is responsible for proper IP protection and approbation of the luminaire.

LED Disk cannot be stored and used together with oxidizing substances (e.g. sulfur, chlorine, or other halogen compounds) or in such environment, such as kitchen where contains high concentrations of sulfur from cooking gasses, which will result in reduction of lumen output, color shift and an open circuit in some extreme cases.

2. Philips LED Disk GEN4 Module

LED Disk GEN4 Module range:
LED Disk GEN4 Module 2700K 800lm
LED Disk GEN4 Module 3000K 800lm
LED Disk GEN4 Module 4000K 850lm
LED Disk GEN4 Module 5000K 900lm

2.1 Specifications of LED Disk GEN4 800lm at 220/230 V

	2700K	3000K	4000K	5000K
Lumen output	800lm	800lm	850lm	900lm
CCT	2700K 5SDCM	3000K 5SDCM	4000K 5SDCM	5000K 5SDCM
Module efficacy lm/W	69	69	73	78
CRI	80min	80min	80min	80min
input voltage	220 ~240VAC	220 ~240VAC	220 ~240VAC	220 ~240VAC
PF	>0.9	>0.9	>0.9	>0.9
Frequency	50Hz/60Hz	50Hz/60Hz	50Hz/60Hz	50Hz/60Hz
Dimming	non-dimmable	non-dimmable	non-dimmable	non-dimmable
Wattage: W	11.6	11.6	11.6	11.6
Switch cycles	2 cycles/day	2 cycles/day	2 cycles/day	2 cycles/day
Beam angle	85°	85°	85°	85°
*Tcase	70°C	70°C	70°C	70°C
**Tcase max	75°C	75°C	75°C	75°C
Lifetime:B50L70	25k hours @Tcase <70° C	25k hours @Tcase <70° C	25k hours @Tcase <70° C	25k hours @Tcase <70° C

* typical Tcase at which performance and lifetime is specified

** Maximum Tcase for safety

2.2 Basic principle of the LED Disk GEN4 Module system

There is no need for a separate LED driver since the driver is integrated in the LED module.

2.3 Starting characteristics

The system can be switched on in milliseconds, which is a general characteristic of LEDs.

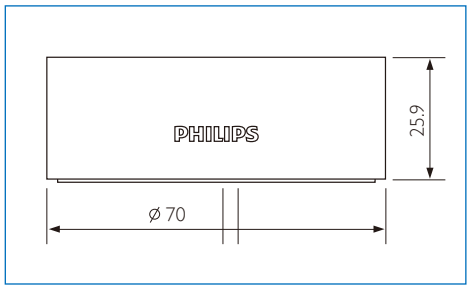
2.4 Lumen maintenance

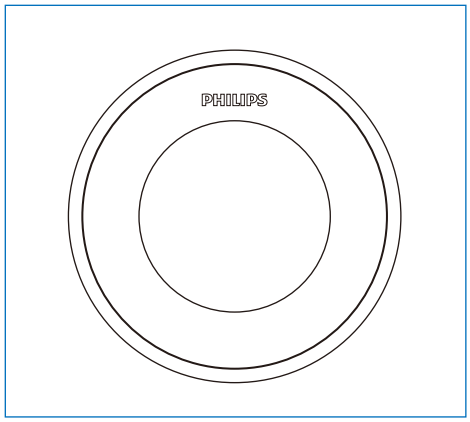
When used within specification (Tc < 70°C@Ta=35°C), lumen maintenance (B50L70) at 25,000 hours is expected for the LED Disk GEN4.0 Module.

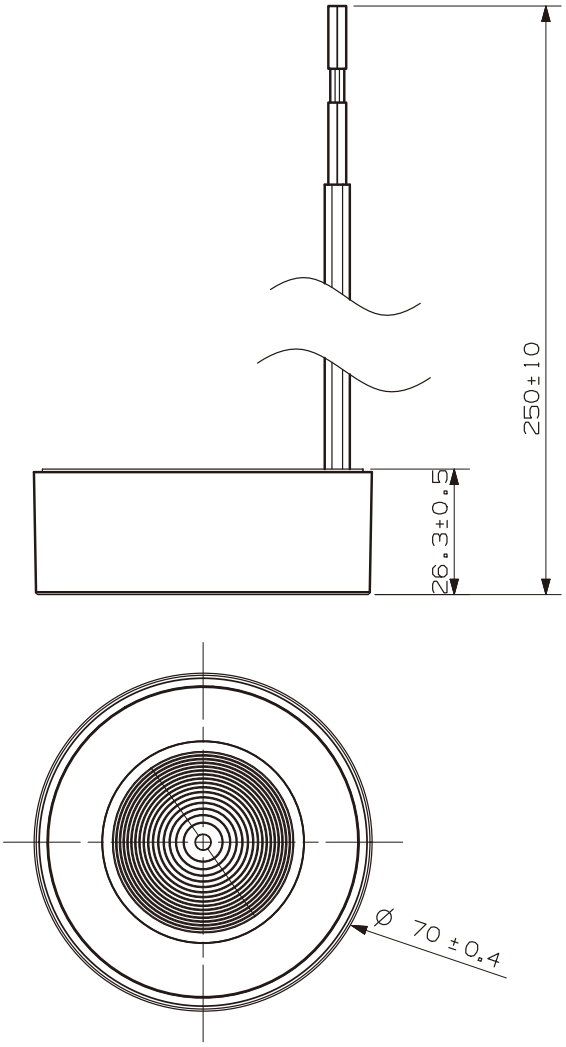
2.5 Dimming

This LED Disk system is not dimmable; the dimmable version is a vailable.

2.6 Dimensions of the LED Disk module

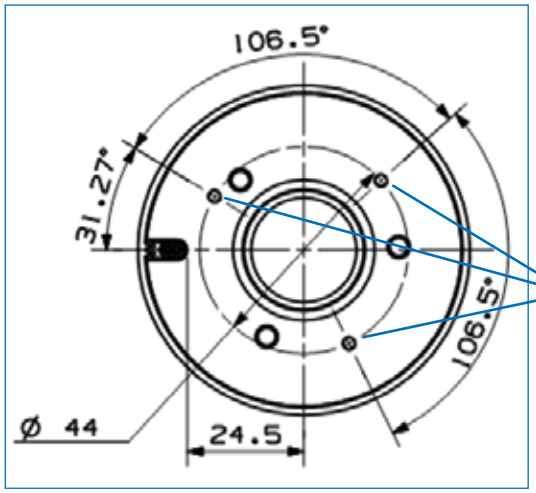




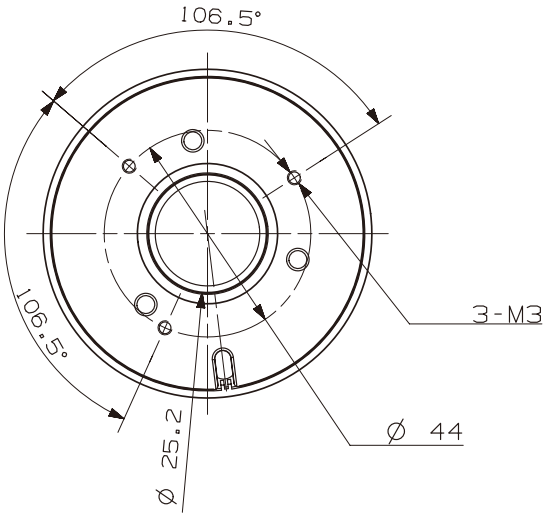


Dimensions of module, top view

Bottom view of module



Screw holes to fix the module to the heat sink



Dimensions of module, bottom view

2.7 About the LED Disk GEN4 Module

The LED module consists basically of six main components:

- MCPCB with 8 LEDs on it
- Driver PCBA
- Mix chamber and Fresnel lens
- Heat spreader
- Plastic housing
- Plastic support

High-quality light with high efficiency is achieved with Liteon MP 5630 3030 LEDs on an MCPCB driven by the integrated driver. The Mix-chamber and Fresnel lens ensures perfectly angled light, resulting in uniform colors and good color consistency. The heat spreader facilitates optimal heat transfer and helps luminaire manufacturers to design their own heat-sink system.
The function of the mixing chamber and diffuser is to shape the light distribution, resulting in a beam angle of 85°. The luminaire manufacturer can design its own secondary optics with this mixing chamber design.

2.8 UV and other hazards

- Free of UV radiation
- The LED modules are also free of infrared radiation in the beam.

3. Lighting performance characteristics

3.1 Photobiological safety aspects

As of March 2007, LEDs and LED-based products for general lighting are no longer included in the scope of the Eye Safety standard for lasers, IEC 60825-1 'Safety of laser products'. The new lamp standard, IEC 62471 'Photobiological safety of lamps and lamp systems', covering incoherent light sources, is now applicable.

This international standard gives guidance for evaluating the photobiological safety of lamps and lamp systems include luminaries. Specifically it specifies the exposure limits, reference measurement technique and classification scheme for for the valuation and control of photobiological hazards from all electrically powered incoherent broadband sources of optical radiation, including LEDs but excluding lasers, in the wavelength range from 200 nm through 3000 nm. In the photobiological safety standard, hazard categories are defined as follows:

Radiance-based

- Blue Light LB 300 - 700 nm
- Retinal Thermal LR 80 - 1400 nm
- Retinal Thermal Weak Stimulus LIR 780 - 1400 nm

Irradiance-based

- Actinic UV Skin & Eye ES 200 - 400 nm
- Eye UVA EUVA 315 - 400 nm
- Blue Light Small Sources EB 300 - 700 nm
- Eye IR EIR 780 - 3000 nm

Measurements on the Fortimo LED Disk Gen4 gave the following results:

- The effective radiance measurement for Blue Light (LB) modules is 'Low', meaning that the LED modules are categorized in Risk Group 1. The permitted exposure time for Blue Light radiance (relevant when looking into the source) is limited to 3 hours. Because of the Law of Conservation of Radiance, integrating the LED module into a luminaire results in either the same radiance or reduced radiance. Final assessment of the luminaire is recommended.
- The measured irradiance-based values (E) for the categorized hazards are all within the exempt group.
- In general the permitted exposure time for irradiance is limited when in the 'low', 'moderate' or 'high' risk group. Limiting the exposure time and/or the distance to the source can reduce the hazard level. However, for the measured LED modules no special precautions are necessary, since they are ranked in the exempt group. Final assessment of the luminaire (including secondary optics, for instance) is recommended.

3.2 Emission limi

LEDisk 800lm Gen4

Hazard category	Emission Limit
LB	Exempt
ES	Exempt
EUVA	Exempt
EB	Exempt
EIR	Exempt

LEDisk 900lm&850lm Gen4

Hazard category	Emission Limit
LB	Low (Risk group I)
ES	Exempt
EUVA	Exempt
EB	Exempt
EIR	Exempt

* *Exempt means 'no risk'.*

4. Designing a luminaire

4.1 IEC recommendations

The general recommendations for luminaire design given by the IEC (IEC 60598) and national safety regulations are also applicable to LED-based luminaires.

4.2 Electrostatic device (ESD) measures

Fortimo LED Disk GEN4 Module systems do not require special ESD measures in a production environment.

4.3 Installation instructions

Fortimo LED Disk GEN4 Module systems are build-in systems for integration into luminaires.

There are interfaces for:

- Heat sink connected to the module
- Mains input via wire socket connected to the input wires from the module

Note:

This LED Disk is class II, requiring an unnecessarily protective earth connection in the luminaire.

We recommend adding a strain-relief mechanism to make sure the mains cannot be removed and pulled from the module.

4.4 Outdoor luminaires and other applications

Fortimo LED Disk GEN4 Module has only IP20 classification. If an OEM decides to use the LED Disk GEN4 Module in a luminaire for outdoor applications, it is responsible for proper IP protection and approval of the luminaire.

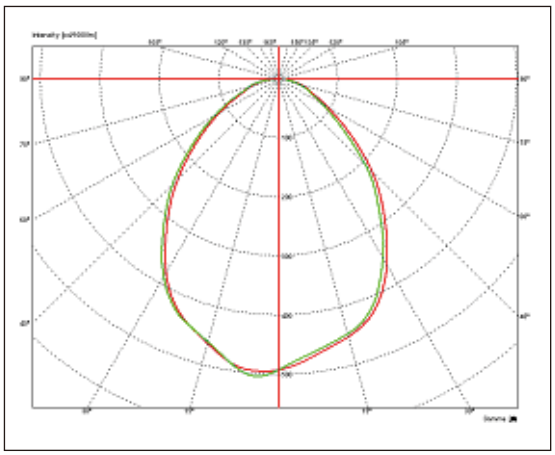
Fortimo LED Disk cannot be stored and used together with oxidizing substances (e.g. sulfur, chlorine, or other halogen compounds) or in such environment, such as kitchen where contains high concentrations of sulfur from cooking gasses, which will result in reduction of lumen output, color shift and an open circuit in some extreme cases.

4.5 Secondary optics

Fortimo LED Disk Gen4 Module provides an 85° beam angle. The customer can have secondary optics for the luminaire, and should also ensure that the thermal design meets the Tc requirement.

4.6 Philips LED Disk light distribution (polar, experiment)

Module: Fortimo LED Disk Gen4

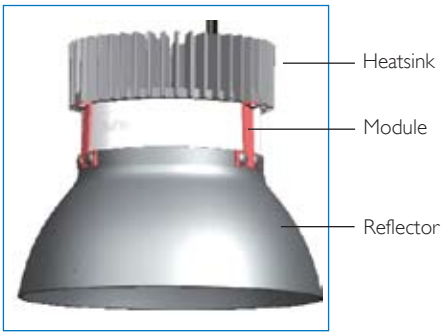


Light distribution (experiment) of LED Disk 85D

5. Heat-sink design and temperature measurement

5.1 General

For optimum performance, the LED Disk GEN4 Module system must operate within specified temperature limits.
A cooling method must be applied during use, since the module contains no over-temperature protection.



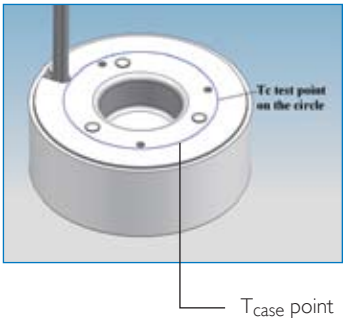
A reference of LED Disk module system application

5.2 Test requirements

Temperature measurements should only be performed when the luminaire is thermally stable, which may take 0.5 to 2 hours, depending on the thermal capacity of the luminaire (see also the relevant clauses in IEC 60598). For all measurements such as temperature, luminous flux and power, a stabilization period of at least half an hour must be allowed before any reliable data can be obtained. Measurements must be performed by means of thermocouples that are firmly glued to the surface (and not, for example, secured with adhesive tape).

5.3 Maximum temperature

Because LEDs are temperature-sensitive, LED modules require a different approach with respect to the maximum permissible component temperature. This is different to most other types of light source.



5.4 Critical measurements point

For LEDs the junction temperature is the critical factor for operation. Since there is a direct correlation between the case temperature and the LED junction temperature, it is sufficient to measure the bottom of the module. The critical point is on the rear surface of the LED module. If the case temperature (Tc) at the critical measurement point is too high (exceeding the recommended maximum temperature), the performance of the LEDs will be adversely affected, for example in terms of light output, lifetime or lumen maintenance.

In the reference heat-sink design there is a hole which allows thermal couples to come into contact with the Tc measurement point.

5.5 Operation under built-in conditions

The heat produced by the LED module in the luminaire (or similar housing) must be dissipated to the surroundings. If a luminaire is physically insulated by a ceiling, wall or insulation blanket, the heat produced cannot easily be dissipated. This will result in the LED module in the luminaire heating up, this can have an adverse effect on system performance and lifetime. For optimum performance and lifetime it is important that air can flow freely around the luminaire: this airflow through the luminaire, around the modules, has a positive effect on temperature control and hence on performance and lifetime.

Note:
We recommend not to connect the module to presence detection sensors as this will impact the lifetime of the product

5.6 Case temperature and LED module performance

To assure the performance of the LED Disk GEN4 Module system we have defined a Tcase at the rear surface of the LED module. A typcial Tcase is 70 °C, which assures both the module color temperature at the targeted CCT within 5 SDCM, and the targeted flux. The typical Tcase 70 °C at Ta 35 °C can guarantee a lifetime of 25,000 hours. At that conditioncase temperature the junction temperature of the LEDs is assured and the indicated performances (lifetime, light output, lumen maintenance) can be guaranteed. Above a Tc of 70 °C, the module lifetime and flux will be reduced accordingly till max Tc 75 °C is reached.

In terms of light output, light maintenance and lifetime, performance is related to the Tc value. Depending on the application conditions, the heat-sink design in this case can be reduced as long as the Tc remains at the above-mentioned targeted temperature.

5.7 Heat-sink design

To ensure that housing temperatures do not exceed the specified maximum values, a luminaire can act as an additional heat sink. The applicable heat transport mechanisms are conduction via the heat sink and convection and thermal radiation to the surroundings. The objective of this chapter is not to indicate exactly how to calculate a heat sink, but to give some guidelines on how to improve its performance. Although a heat sink can have many (complex) shapes, the following discussion is based on a disk type of heat sink. The results for square plates, etc., are more or less the same provided the surface areas are equal. The type of material used has a relatively large influence on the final result. For example, a comparison of the thermal conductivity (k) of copper with that of corrosion-resistant steel (see table left) shows that a substantially smaller heat sink can be made with copper. In practice the best material for heat sinks is (soft) aluminum. The thickness (d) of the heat-sink disk is also of major importance. Assuming the use of different heat sinks of the same diameter but made from different materials, the same effect in terms of temperature difference will be achieved if the product of thermal conductivity (k) and disk thickness (d) is constant. This means more or less the same result is obtained with a disk of 1 mm copper, 2 mm aluminum, 4 mm brass, 8 mm steel or 26 mm corrosion-resistant steel. Increasing the diameter, and thereby also the surface area, of the heat-sink disk also leads to an improvement, but the effect is smaller for larger diameters and depends on the thermal conductivity (k) and thickness (d) of the material. Thermal radiation can also form a substantial part of the total heat transfer, and is of the same order as for convection. This depends strongly on the emission coefficient (see table) of the surface, which lies between 0 and 1. For example, a polished aluminum surface has a very low emission coefficient, while that of a painted surface is very high. For passive cooling a high emission coefficient is preferred.

Material	W / mK
Copper	400
Aluminum	200
Brass	100
Steel	50
Corrosion-resistant steel	15

Thermal conductivity

Material	Surface	Emission coefficient
Aluminum	New/polished	0.04 - 0.06
	Oxidized	0.2 – 0.3
	Anodized	0.8
Steel	Painted	0.8 – 0.95
	New/polished	0.03 – 0.07
	Heavy oxidized	0.7 – 0.8

Emission coefficients

5.8 Size of heat sink

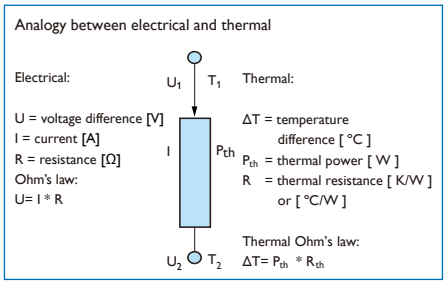
Fortimo LED Disk GEN4 Module products typically consume up to 11.6W for all CCTs, and contain a built-in heat spreader. The module must be connected to the heat sink with a thermal interface material (TIM) in between, which ensures a perfect contact between the module and the heat sink. The module generates 7.8W for 2700K, 7.8W for 3000K, 8.0W for 4000K, 8.1W for 5000K thermal power, which needs to be removed. The spreader at the back of the module is the contact area for the external heat sink. The performance (lifetime and amount of light) of the module depends heavily on the thermal management. This means that the temperature of the test point (Tc) is important. During the thermal design process the aim is to keep the Tc temperature within the stated range (<70 °C). Although the LED Disk module will not fail due to a higher Tc (not exceeding Tc max 75°C) , the effect of insufficient cooling will be that the light output of the LEDs is automatically step-dimmed and lifetime could be reduced.

5.9 Air flow

Before starting any calculation, an important point to consider is the airflow. In general, hot air moves upwards at a relatively low speed. The shape and position of the heat sink influence the airflow. If the fins are perpendicular to the airflow this reduces the efficiency of the heat sink. This situation should be avoided.
A better way to position the fins is to have them parallel to the direction of airflow. Closing the top of the profile will also reduce the efficiency of the heat sink, and this should be avoided during design and installation.

5.10 Thermal model

Standard STATIC thermal situations can be modeled with so-called thermal resistors. These resistors behave like electrical resistors. The analogy between electrical and thermal resistors is explained below. The electrical units are given on the left and the thermal equivalents are shown on the right. With a known voltage difference at a given current it is possible to calculate an electrical resistance with Ohm's law. The same is possible with a thermal resistance. If the temperature difference and the thermal power are known, the thermal resistance can be calculated using thermal Ohm's law.



Electrical and thermal analogy

5.11 Calculating your heat sink

We start a thermal calculation formula:

- Formula f1 gives the relationship between temperature difference, thermal power and thermal resistance. With this formula the required thermal resistance can be calculated when the thermal power and temperature difference are known.

Formulas:

Thermal: $\Delta T = R_{th} \times P_{th}$ (f1)

Next we gather all the available information, as can be found in the datasheet, application details and design choices.
Below we calculate the required thermal resistance of the heat sink, such that in typical situations the typical temperature of the test point Tc is below its maximum.

Available information:

Tc-typ	= 70 °C
Pth LED Disk 800 lm	= 7.84 W
Tambient-typical	= 35 °C

From the data sheet:

Maximum test point temperature:	$T_{c\text{-}max}$ = 70 °C
Thermal power LED Disk 800 lm:	P_{th} = 7.84 W

Maximum temperature in application. In this case we install the product below ceiling, which is where the ambient temperature of the product is:

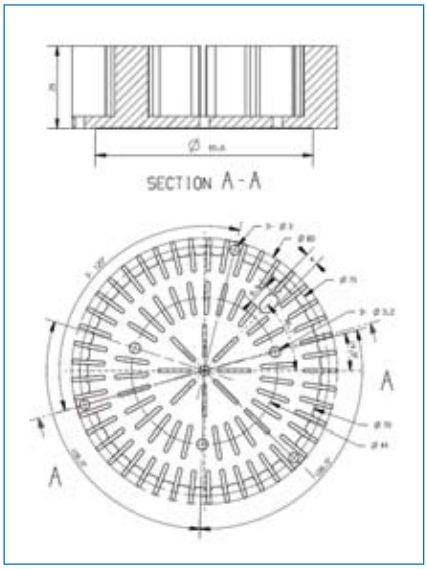
$T_{ambient}$ - typ = 35 °C
in this case

Below we calculate the required thermal resistance of the heat sink, such that even in worst-case situations the actual maximum temperature of the test point Tc remains below its defined possible maximum.

Calculation of total maximum thermal resistance: (f1)

ΔT ambient - Tc = 70 – 35 = 35 °C
Rth Tc - ambient = (Ttambient - Tc)/ P_{th} = 35/7.84 = 4.49 K/W

Calculation of the total thermal resistance: Rth-from-Tc-to-ambient with formula f1. This gives 4.49 K/W.



Philips reference heat-sink design of LED Disk

Now we know the thermal resistance of the required heat sink. This heat-sink dimension is such that at maximum power and typical ambient temperature the temperature of the test point Tc should be below 70 °C. This ensures that lifetime, color temperature and light output will be according to specifications. If Tc cannot meet the 70°C requirement, the module can also work at a Tc of 75 °C without any safety issue. However, in that case we can no longer guarantee the lifetime of 25,000 hrs.

5.12 Philips reference heat-sink design of LED Disk

The drawing on the left is the Philips reference heat-sink design of the LED Disk.

5.13 Heat-sink supplier contact

The heat-sink partners with which Philips has been working are Wisefull and AVC. Both companies made the heat sink specifically for the LED Disk products according to the reference heat-sink design from Philips. For a general recessed-luminaire application the heat sink assures a Tc-typ of 70 °C. However, the Tc measurement is necessary even when using such a heat sink, since the luminaire application varies.
The heat sink already has screw holes for fixing the reflector directly onto it.

If you need more information please contact Wisefull and/or AVC:

Wisefull Technology Ltd.
Contact person: Mackey Ma
E-mail: LED@wisefull.com
Tel: +86-769-86853888, Ext: 868
Fax: +86-769-87724315, 86853395
www.wisefull.com

Asia Vital Components (AVC) CO., Ltd
Contact person: Beatrice Tseng
E-mail: beatrice_tseng@avc.com.tw
Tel: +31 64 66 88 175 (NL)
www.avc.com.tw

6. Approbation

6.1 Electromagnetic compatibility

Electromagnetic compatibility, EMC, is the ability of a device or system to operate satisfactorily in its electromagnetic environment without causing unacceptable interference in practical situations. Fortimo LED Disk GEN4 Module systems fulfill the requirements with regard to electromagnetic compatibility as laid down in European Norms EN 55015, EN 61000-3-2, EN 61000-3-3 and EN/IEC 61547.

6.2 Humidity

Fortimo LED Disk GEN4 Module has IP20 classification. The OEM is responsible for proper IP classification and approbation of the luminaire.

6.3 Exposure to direct sunlight

Exposure to direct sunlight during operation may have severe temperature or UV effects. Where this situation is likely, extensive temperature testing is recommended. Fortimo LED Disk GEN4 Module systems are build-in systems (except independent versions), so this is expected to be negligible.

6.4 Vibration and shocks

Shock resistance: 50 g @ 6 ms half-sine
Vibration resistance: sweep 10-500 Hz, 5 g, 2 hours at all axes without failure

6.5 Standards and approvals

Fortimo LED Disk GEN4 Module systems comply with the following international rules and regulations, among others:
Safety EN/IEC 62031, EN/IEC 60598-1, EN/IEC 62471, EN/IEC 62384, CB/CE:
Fortimo LED Disk GEN4 Module systems carry the CQC, RCM, CE/CB marking. CE is the abbreviation of Conformité Européenne. It expresses conformity of products to mandatory requirements of the European Community Directives. CB is the abbreviation of Certification Bodies Scheme. The CB/CE mark acts as a 'passport' that allows goods to circulate freely throughout the European Union and Asia Pacific region. RCM is the certificate for Australia and New Zealand application; CQC is used for Chinese market application certificate.
Furthermore, it simplifies inspection by Market Controlling Bodies. Two European directives cover lighting products: the Electromagnetic Compatibility (EMC) Directive and the Low Voltage Directive (LVD). Fortimo LED Disk GEN4.0 Module system carries the CE marking on the basis of compliance with the following standards: EN/IEC 61547, EN/IEC 61000-3-2, EN 61000-3-3,EN 55015.

6.6 IP codes, dust and moisture protection

Fortimo LED Disk GEN4 Module IP20 rating.

6.7 Glow-wire test

Fortimo LED Disk GEN4 Module systems conform to the 850° glow- wire test. Reference test: in accordance with additional national deviations for clause 13.3 (Annex 2c of EN 60598-1). An exception is made for France, where local regulations are stricter.

6.8 End-of-life behavior

Unlike typical conventional light sources, LEDs are not subject to sudden failure or burn-out. There is no time at which the light source will cease to function. Instead, the performance of LEDs shows gradual degradation over time. When used according to specification, LED Disk GEN4 Modules are predicted to deliver an average of 70% of their initial intensity after 25,000 hours' operation at a Tcase of 70 °C.

6.9 Fortimo LED Disk DLM system disposal

At the end of their (economic) lifetime, appropriate disposal of the LED Disk GEN4 module is recommended. The modules are basically normal pieces of electronic equipment containing components that at present are not considered to be harmful to the environment, or which can be disposed of with normal care.
It is therefore recommended that these parts be disposed of as normal electronic waste, according to local regulations.

7. Index of visuals

For more information please visit:

www.philips.com

08/2014
www.philips.com