05/2019

Technical application guide

OPTOTRONIC® constant-voltage LED power supplies and controls

Light is OSRAM

OSRAM

Contents

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1 Introduction

1.1 Purpose and scope of this document

This document is a compact reference guide with technical information on selecting, installing and using OSRAM's OPTOTRONIC® LED power supplies and controls. Always check the OPTOTRONIC® website at www.osram.com/optotronic for additional or updated information and pay special attention to supplementary instruction sheets delivered with our products. The technical information in this document is focused on OPTOTRONIC® power supplies. For system design and configuration please also refer to the data sheets and application notes available at OSRAM's LED Systems website at www.osram.com/flex.

1.2 Driving LED

Dimming

Dimming of an LED can be done by either reducing the current level through the diode (DC dimming, analogue dimming) or by applying PWM dimming (short for Pulse Width Modulation) to the LED.

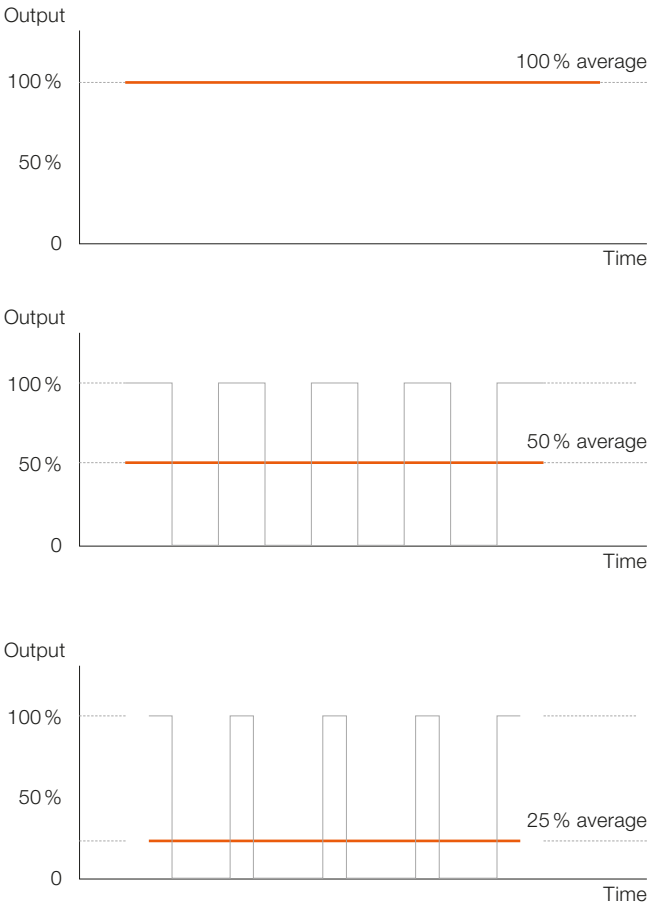
DC dimming

DC dimming is a straightforward solution to reduce the thermal load (and brightness) of an LED. For example, reducing the LED's current from 350 mA down to 250 mA will reduce the thermal load on the LED accordingly. Varying the current of LED may however have sideeffects on the light output of the LED. LED can have a noticeable dependency of the output color on the current that is applied; this is also referred to as a color-shift of the LED. For white LED reducing (or increasing) the LED current may lead to a change of the white-point. It is important to check whether any color-shift occurs with DC dimming and whether it is acceptable in your application.
If the color-shift is too strong, consider using PWM dimming, which can help reduce this effect. In particular for RGB applications it is advisable to use devices with PWM dimming.

PWM dimming

PWM dimming utilizes a different method for reducing the average current through the LED: the current applied to the LED is turned on and off at a high frequency (1 kHz) while keeping the current level fixed (e.g. at 350 mA). The average value of the current flowing through the LED is then determined by the length of the on-period as compared to the off-period (the duty-cycle).

Figure 1: PWM dimming



1.3 LED modules

Figure 1 shows dimming at 25 %, 50 % and 100 % and the resulting, average current flow through the diode. Since the current through the LED remains unchanged at different dimming levels, there is also no color-shift introduced due to a change in current. This ensures best performance of the LED in both RGB and white light applications.

OSRAM LED modules integrate single or multiple LED into one module with optional driving circuits (i.e. for limiting or controlling the current through the LED).

Some of the benefits of using LED modules are:

- Easy installation (through screw mounting or adhesive tape)
- Easy electrical connections (e.g. through plug-and-play connections)
- Simplified thermal management
- Select modules are available with optional optics for adjusting the radiation pattern to suit your application

OSRAM's LED modules are designed and optimized for use with OPTOTRONIC® power supplies with guaranteed performance and lifetime. When using OSRAM LED modules in combination with OSRAM power supplies, OSRAM guarantees up to 5 years of system lifetime (please refer to www.osram.com/cb/services/guarantees for updates).

OSRAM currently offers LED modules in the following colors (in parenthesis the one-letter abbreviation of each color)

- Red (A-amber)
- Green (T-true green or V-verde)
- Yellow (Y-yellow), blue (B-blue), orange (O-orange)
- White (W-white, available with different color temperatures)

OSRAM even produces LED modules with some of this to permit to change the light color:

- RGBW (Red, Green, Blue, White)
- RGB (Red, Green, Blue)
- TW (Tunable White, changeable light temperature)
- TWW (Tunable Warm White)

CV LED modules from OSRAM are designed to be operated on a constant voltage of either 12 V or 24 V. For each LED module OSRAM offers a perfectly matching OPTOTRONIC® power supply.

For further, detailed information on all available CV LED modules, please visit the LED Systems website at www.osram.com/flex.

2 OPTOTRONIC® – benefits and features

2.1 Overview

OSRAM's OPTOTRONIC® devices are easy-to-use power supplies and dimmers specifically designed for operating LED modules and single LED. Power supplies and dimmers of the same type (constant-voltage or constant-current) can be combined flexibly to match your application's need for power and level of control.

Benefits:

OPTOTRONIC® devices offer many convincing benefits for your application:

- OPTOTRONIC® devices have been developed for the lighting industry and meet the requirements of relevant mandatory national and international standards for electronic control gear. This simplifies and minimizes cost for acquiring the necessary approvals for your application.
- OPTOTRONIC® devices are specifically designed for operating LED modules and LED and ensure safe and reliable operation of your application.
- OPTOTRONIC® devices consume a minimum of energy thanks to designs with very high efficiency.
- OPTOTRONIC® devices are compact and require a minimum of space for installation.
- A cable clamp on select OPTOTRONIC® devices enables independent installation from lighting fixtures.
- OPTOTRONIC® devices are designed to allow long cable lengths on the output side, providing greater freedom and flexibility in installation in your application.
- OPTOTRONIC® devices can supply a large number of LED modules, reducing system cost and installation complexity.
- OPTOTRONIC® are protected against short circuits and electrical or thermal overload, ensuring maximum safety of your application.
- OPTOTRONIC® devices and LED modules can be combined flexible as a modular system in which power supply and light source can be selected individually for an optimal system design.
- This also allows updating or modifying individual component of a system e.g. to adapt a system for a different color or to benefit from improved brightness of future LED generations.
- Select OPTOTRONIC® devices are Touch DIM compatible and can be used to integrate LED illumination with Touch DIM systems.
- Smart Power Supply feature to compensate the higher power absorption during thermal stabilization of light engine (start-up phase in low environmental temperature).

2.2 OPTOTRONIC® types

The OPTOTRONIC® product family is divided into the following groups:

- Power supplies
- Dimmable power supplies and dimmers
- All-in-one devices

2.2.1 Power supplies

OPTOTRONIC® power supplies convert line voltage into a constant voltage. These power supplies are available with different combinations of output voltage, total output power, housing and IP protection options. The power supply portfolio is described in detail in section 4. The next paragraphs give you general applicable information in regards to power supplies.

Note:

Power supplies do not provide any mechanism for dimming. OPTOTRONIC® power supplies can also not be dimmed by conventional leading-edge or trailing-edge dimmers. To add dimming capabilities to your system, consider adding suitable dimmers or use a power supply with built-in dimming capabilities.

2.2.1.1 Constant-voltage power supplies

Constant-voltage power supplies are intended to be used with LED modules with matching input voltage, i.e. 12 V or 24 V modules. Please note that it is not possible to connect these power supplies directly to LED, doing so may damage or destroy the attached LED.

Using constant-voltage power supplies in combination with OSRAM LED modules is the easiest way to design and install an LED-based application and offers several benefits:

- Safe-to-touch outputs: All constant-voltage power supplies are SELV or isolated devices with an output voltage of less than 25 V and guarantee that at all times it is safe to touch any part of the installation connected to the output.
- Higher wattage power supplies: For constant-voltage power supplies keeping the output voltage below 60 V does not limit the supplies' output power, which is only limited by the maximum current that can be supplied. Constant-current power supplies on the other hand need to also respect the maximum current of attached LED (e.g. 350 mA) and therefore are limited to a maximum output power of 60 V x I_{out}, resulting e.g. in a total maximum power of 21 W for a 350 mA power supply.
- Parallel wiring: LED modules operated on a constant-voltage power supply can be connected in parallel, same as for other light sources. In many applications and for many users this is the easiest wiring option.

2.2.2 Dimmable power supplies and dimmers

Dynamic lighting can simply provide dimming of the brightness of an application or can provide highly sophisticated control of color in RGB decorative applications. OSRAM offers suitable devices for both uses, either as dimmable power supplies or as external dimmers.

Dimmable power supplies combine power supply and a dimmer in one device. External dimmers are linked in between power supply and the LED light sources (e.g. the LED modules).

An integrated solution as compared to a solution based on a separate power supply and dimmer offers space savings and simplifies installation. A solution based on a power supply with external dimmer on the other hand gives greater flexibility in choosing the amount of power supplied to your application.

Dimmable power supplies and dimmers are available with the following different control inputs.

2.2.2.1 Control inputs

1...10 V

The 1…10 V control input is a well established protocol in the lighting industry and primarily used for easy brightness control in an application.

Features of the 1...10 V interface

- It is insulated.
- The output is controlled by a DC voltage signal from 10 V (maximum light output; control wires open) to <1 V (minimum light output; control wires short-circuited).
- With 1…10 V control input it's possible to reach a dimming up to 1 %.
- The control voltage is supplied by each LED driver itself. Each LED driver can supply a maximum current of 0.1 mA.
- The voltage on the control wires is galvanic separated from the mains cables and it does comply with the SELV requirements.
- Units operated on different phases can be dimmed by one controller.

The output power of the LED drivers can be adjusted by a 1…10 V interface and an external controller (V_{in}) or external resistor.

Table 1 supports you in finding the correct resistor for your desired dimming value. For dimming, you just have to connect the resistor to the dimming wires of the 1…10 V interface.

Table 1: Resistor/Dimming with 1...10V

Desired dimming value	Suitable resistor
0 %	<10 kΩ
9 %	18 kΩ
13 %	22 kΩ
19 %	27 kΩ
26 %	33 kΩ
32 %	39 kΩ
41 %	47 kΩ
51 %	56 kΩ
68 %	68 kΩ
80 %	82 kΩ
100 %	>100 kΩ

Note:

- The dimming interface has basic insulation
- To achieve the most accurate output power, it is recommended to select a low-tolerance resistor
- When no external resistor is connected, the LED drivers operate at nominal power

DALI

DALI (**D**igital **A**ddressable **L**ighting **I**nterface) is a digital protocol for controlling lighting in buildings. DALI is an independent interface standard for dimmable electronic control gear and is standardized in IEC 62386. DALI has been evolved from existing ECG interfaces and offers additional features such as monitoring the status of the lighting system and providing control and real-time feedback.

DALI systems close the gap between conventional 1…10 V and more complex bus systems. DALI can provide easy solutions for local lighting applications as well as complex solutions with integration into building management, all utilizing the same components.

Features of the DALI interface:

Simplified lighting design without hard-wired groups

A DALI controller can control up to 64 LED drivers by a single 2-wire control cable. Control is fully digital und allows addressing of the LED drivers individually, in groups or in broadcast mode.

During setup of an installation each LED driver can be assigned to one of 16 groups available and can also belong to several groups at the same time. This assignment can be changed at any point in time and without rewiring the installation. Thanks to DALI changing the defined groups to match e.g. a change in the floor plan can be done fast and with little cost.

Simple installation

DALI installations are done with commercial installation material used for mains voltage. The two unused wires in a 5-core sheathed cable (i.e. NYM 5x1.5 mm^2) can be used to connect DALI devices together.

When connecting the control inputs of DALI LED drivers, it is not required to observe polarity for proper operation. This eliminates a potential source for errors and reduces installation complexity. The control wires must be approved for mains voltage, otherwise no special requirements apply.

Flexible powering
Controller and ballasts can be connected arbitrarily to the available phases of the mains voltage in order to achieve a better load distribution. Independent of the powering phase all LED drivers can be controlled and switched off by a single controller.

The factory-default of OSRAM's DALI LED drivers is set to 100 % brightness upon initial power-up. This way even without programming by a controller an installation can be switched on and off by a circuit breaker and provides basic illumination during installation and a quick way to verify operation.

DALI controlled switching
No relays are needed for switching DALI units on or off. Switching and dimming is carried out exclusively via the control wires.

Synchronized change of lighting scenes
When DALI units with different start dimming levels are combined (e.g. when individual units are set to a new master value) the change to the master value will be synchronized by DALI so that all light sources reach the new final dimming level at the same time, resulting in a best performing dimming solution.

Lamp status on demand
DALI power supplies can send a lamp status report to the controller on demand so that is possible to remotely detect and report lamp failures or display the current dimming level of each lamp.

Integrated scene storage
The LED drivers store the light levels per lighting scene assigned to a corresponding group. Independent of any definition of groups the individual LED driver can store up to 16 different light levels. Transitions between scenes are synchronized so that all LED drivers start and finish the transition at the same time by operating with different dimming speed.

DALI topology
The topology of a DALI installation is very simple (see Figure 2 on the right). DALI power supplies may be wired either in series or in parallel without having to pay attention to hard-wiring of lighting groups. It is not required to terminate the DALI signal lines.

Lamp failure
When the DALI driver recognizes a lamp failure, output to the faulty item is stopped and, depending on the connected system, the failure is reported to the system (e.g. DALI Pro).

DIP switch
Several DALI drivers offer two DIP switches located close to the output pins. The DIP switches may be used to define the number of channels used by switching them ON or OFF.

DALI 2
The DALI 2 protocol is the result of a number of revisions of DALI standard IEC 62386

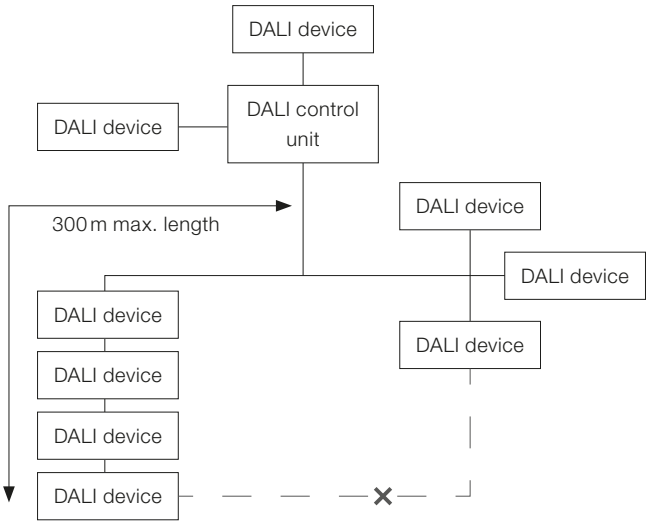
DALI 2 helps fill the gaps in the original standard, resulting in significant improvements in interoperability. DALI 2 adds new features, and introduces standardisation of control devices including the recent addition of input devices, while maintaining backwards compatibility.

New features:
- More detailed description of behavior like fading and power-up
- Extended information in Memory Bank 0
- Some additional commands
- Device Power Cycle Event
- Different command and event encoding
- Allowed feedback from the OTi DALI to the controller for fixture and driver control state

Note:
The total line length between any DALI device and the DALI control unit must not exceed 300 m.

Closed loops on the DALI signal line are not allowed (as marked with X in the diagram below). A closed loop on the DALI signal line may disturb communication and lead to failures in addressing the electronic control gears.

Figure 2: Principle of a DALI topology



Distributed intelligence
During the initialization process, DALI LED drivers store the following data:
- Unique, individual address for each LED driver (0–63)
- Assignment to lighting groups (to a total of 16 groups, multiple assignments are possible)
- Optionally lighting levels for individual scenes (max. 16) plus special settings such as:
  - Global dimming speed
  - Behavior of LED drivers when control signal interrupted (emergency lighting, system failure)
  - Behavior of LED drivers after power-failure

OSRAM offers controllers and accessory parts for designing a DALI-based system, either for fluorescent lamps, compact fluorescent lamps, halogen lamps or LED. OPTOTRONIC® devices are either available with a built-in DALI control port or can be controlled via a DALI gateway.

The brochure “A systematic approach to lighting management: LMS from OSRAM” also gives detailed information about the available OSRAM components for light management systems, including themost important features, functions, applications as well as technical and ordering data. This brochure is also available for download in the DALI section of the OSRAM website www.osram.com/ds.

OSRAM’s DALI devices can also be controlled via Touch DIM. Touch DIM uses only a pushbutton connected to the DALI inputs and allows to control on/off, dimming level and default dimming value of connected DALI LED drivers.

AstroDIM
The AstroDIM feature allows an autonomous dimming without the need for an additional control line. The LED drivers OTi DALI XX/24 V P supports up to five independent dimming levels and flexible settings of fade times between the individual dimming levels.

The output levels can be set to 0 % (OFF) or between 10 % and 100 %.

In addition, switch-on and switch-off fade times can be programmed at the beginning and the end of a switching cycle to allow for further energy savings during the twilight phase. This function is also helpful for installations with a pedestrian crossing where no specific infrastructure is available to switch the pedestrian crossing illumination independently of the rest of the street light illumination.

Two different modes for AstroDIM are supported:

Time-based: The dimming profile defined in the reference schedule is referenced to the switch-on time of the LED driver.

Astro-based: The dimming profile defined in the reference schedule is referenced to the annual average middle of the night, which is calculated based on the theoretical sunrise and sunset times.

The LED driver does not have a real-time clock. The internal reference clock is derived from the mains frequency and the driver detects if it is connected to a 50 Hz or 60 Hz supply system, assuming a time base of 20 ms or 16.6 ms. This allows a synchronized switching of all units. The dimming mode works only when AC voltage is applied.

Warning:
If the output level is set below the minimum physical dimming level of the LED driver (except OFF), the minimum dimming current is used. The software still displays the original value. If the output level falls below the minimum allowed dimming current, the value is visualized in red.

Wiring and feature activation
To activate the AstroDIM mode:
The activation is possible by the Tuner4TRONIC® software.
Selected dimming mode: “AstroDIM (DALI)”

Astro-based mode
In this mode, the LED driver performs a dimming profile based on the daily power-on and power-off times. The dimming schedule is adapted according to the length of the night.

The Tuner4TRONIC® software calculates the annual average middle of the night based on the theoretical sunrise and unset times, which are related to the location selected in the software. Based on this average middle of the night, five independent dimming periods can be defined in the reference schedule. The minimum length of one dimming period has to be longer than the AstroDIM fade time. Valid time values can be set between 12:00 pm and 11:59 am. If less than five output levels need to be performed, two sequenced levels have to be set to the same value. The defined dimming profile is already performed after the second power-off/on cycle after programming.

Fade timing:
- **AstroDIM fade time:** Fade time between the different dimming levels. To achieve further energy savings in the twilight phase, the switch-on and switch-off fade time can be set to up to 60 minutes.
- **Switch-on fade time:** Fade time after the LED driver has been powered on. The output level at the end of this fade time is defined by the output level of the related dimming period (step x).
- **Switch-off fade time:** Fade time prior to the estimated power-off point. The switch-off fading is performed down to the minimum dimming current until the LED driver is switched off externally.

The “schedule by day” in the AstroDIM feature tab calculates the estimated dimming behavior for a specific day based on the theoretical sunrise and sunset times. If daylight saving has to be considered, the corresponding check box needs to be ticked. The LED driver itself is not able to detect summer and winter time and does not have an internal real-time clock.

In case the installation is not powered on and off at the calculated sunrise and sunset times, the correct values can be entered in the manual mode as shown in Figure 4.

The AstroDIM function in astro-based mode relies on an intelligent algorithm. It starts after the first valid night and reaches its maximum precision after 8 valid days. A valid on-time is defined if the duration of the operation is longer than 4 hours and shorter than 24 hours.

Figure 3: Astro-based AstroDIM

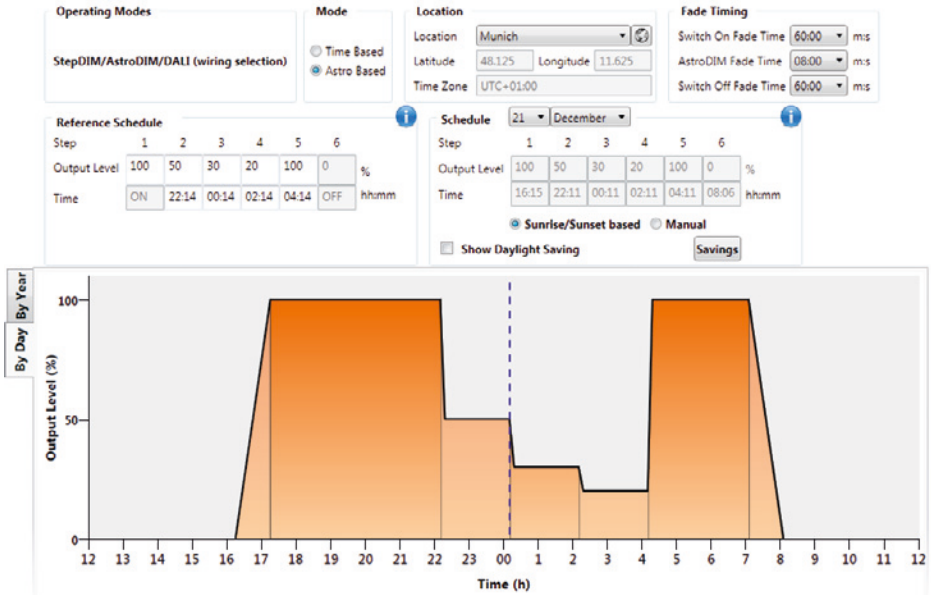


Table 2: Fade timing parameters (astro-based mode)

Parameter	Min.	Max.	Default
AstroDIM fade time	0, 2 s	8 min	3 min
Switch-on fade time	0, 15 s	60 min	0 s
Switch-off fade time	OFF, 0 s	60 min	OFF

Figure 4: Schedule by day

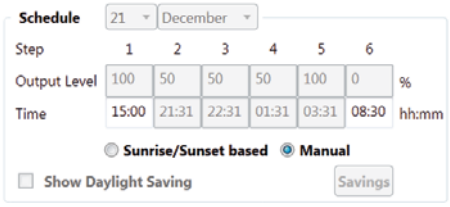
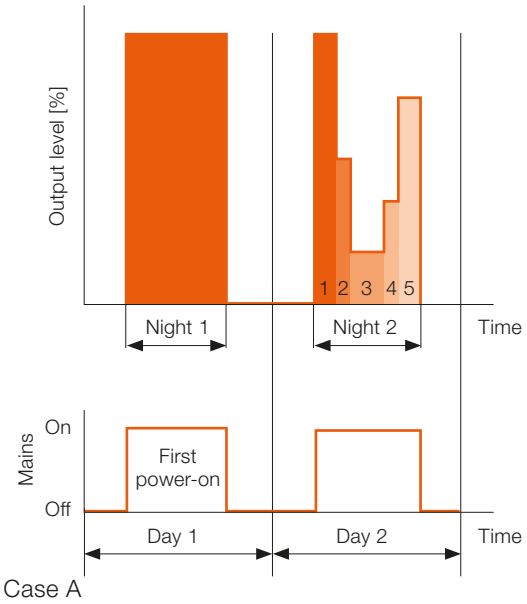
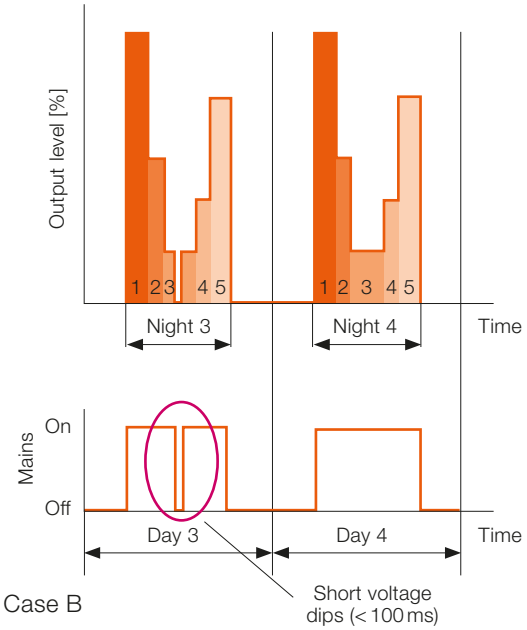


Figure 5: Use cases of AstroDIM mode



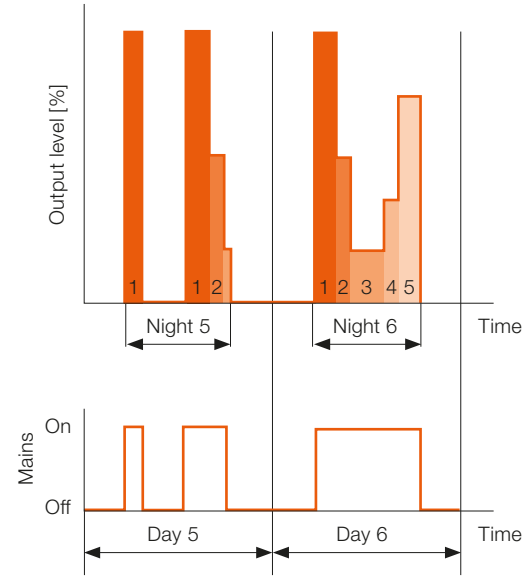
Case A

The AstroDIM profile is performed after the first valid on-time.



Case B

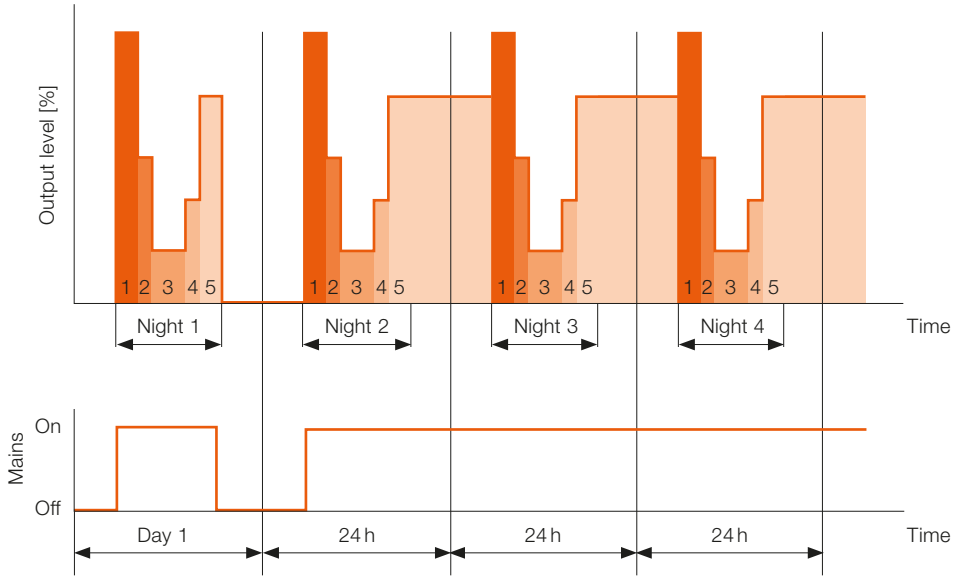
Voltage dips of less than 100 ms do not affect the on-time (case B).



Case C

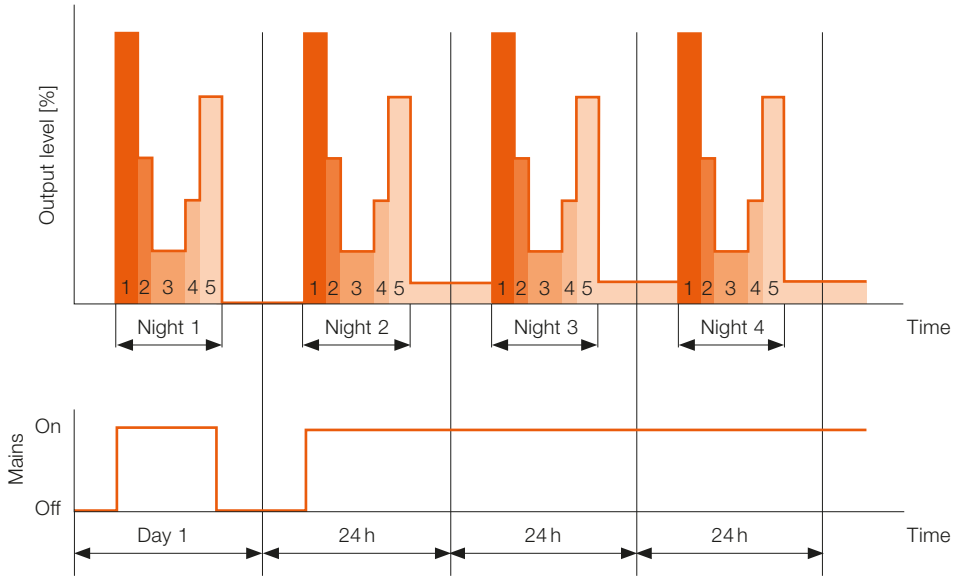
If the on-time of the LED driver is shorter than 4 hours, it is not saved and therefore not used to calculate the next on-time (case C).

Without switch-off fade time:



Case D

With enabled switch-off fade time:



Case E

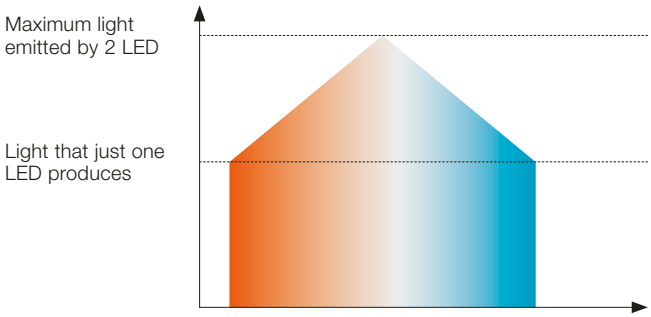
If the on-time of the LED driver is longer than 24 hours, it is not saved and therefore not used to calculate the next on-time.

Note:
If the LED driver is operated longer than 24 hours, it cannot be assumed that the different dimming level will start at the same time, because the time base is affected by the accuracy of the mains frequency over the day, week, month and year.

DALI DT6 and DT8

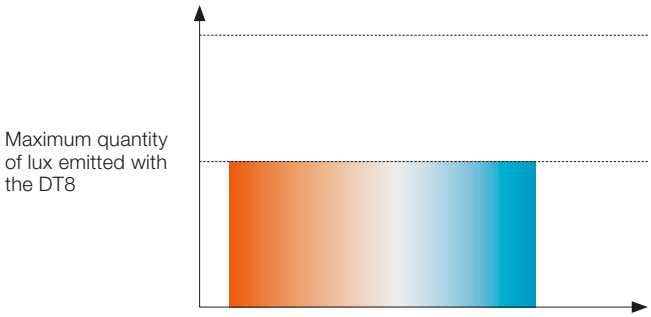
Using RGBW, RGB, TW and TWW LED you can find out a problem: when we need to switch on more than one LED to obtain the color of light we want, the total lux is the sum of the lux emitted by the single LED and it will be higher than how an LED should be able to do.

Figure 6: Lux emitted by a TW with a DALI DT6 controller



So if we want to make some scenes or also if we only have to change quite quickly the color of the light, we have to use a controller by DT8 which by his software restricts the lux at maximum the half of the minimum.

Figure 7: Lux emitted by a TW with a DALI DT8 controller



If it's needed just a color, even made by more than one LED, the DALI DT6 controller is better because it let emit more lux. DT8 is helpful to reduce the numbers of DALI addresses because the ECG requires just 1 address despite the 2 embedded channels.

DMX

DMX is another digital control protocol and originated from applications for stage and effect lighting. DMX can be used for a large variety of devices to control options such as light levels, focus, light color or rotation of lights. Using DMX, even complex and demanding lighting systems can be designed.

In standard configuration DMX controllers can provide up to 512 addresses and are suitable for complex lighting scene sequences and are programmable via software and/or mixing desks.

The DMX512 format is a distribution/control protocol based on the electrical standard RS-485. DMX512 devices can be daisy chained together (i.e. all devices are connected in series, with the DMX signal passed from one device to the next) to form half-duplex DMX512 networks. On a DMX512 network, there is one data path that all devices must share (the DMX512 "bus"). In a typical network, a single device acts as the master device and controls all other slave devices. The DMX512 protocol is extremely fast (compared to serial RS-232 networks used for telecommunications) and can easily control the maximum number of devices at the fastest frame rate (up to 250 kbit/s according to RS-485).

The DMX512 protocol uses packets to transfer information. Each packet contains a synchronization signal followed by device data. Typically, each packet contains sufficient information to update the entire network. That is, the device data payload section contains complete information on the state of every device.

The packet begins with a break condition that must last 88 µs and is followed by a mark condition that must last at least 8 µs and up to 1 sec. The break and mark combine to inform all DMX512 devices that a new DMX512 packet is about to be transmitted. A "start code" follows the break and mark. The interpretation of the start code is vendor dependent, but is expected to be zero in general.

After the synchronization signaling, the actual device data payload is transmitted. As many as 512 bytes may follow; in general each device on the DMX512 network uses a single byte of information to determine, for example, how much to dim a lighting fixture. Most DMX512 devices have a programmable "start address". This start address determines which portion of the payload the unit will interpret. For example, for a device with four channels if the start address is set to seven, the device will read the seventh, eight, ninth, and tenth payload bytes and program the dimmer for each channel accordingly. All this data must go through a DMX booster or splitter at least every 32 devices because along the cable there is a power loss that could make difficult the reading of the signals.

While very powerful, DMX-based solutions however may also incur higher component costs and costs required for design and installation. Furthermore, wiring of a DMX installation requires use of special three-wire cable according to AES-EBU-standard, as compared to a standard NYM-cable which can be used for a DALI installation (more information in section 3.2.2.6).

OSRAM offers several DMX-compatible OPTOTRONIC® devices that can be controlled by a suitable DMX controller. DMX controllers are available in the market from several suppliers.

Both 1…10 V as well as DALI units can also be integrated into DMX installations via suitable gateways (units which "translate" the DMX protocol to another protocol). DMX gateways are available in the market from several suppliers.

RDM

An updating of the DMX protocol introduced the RDM (Remote Device Management). It allow, bi-directional communications and management between a lighting or system

controller and attached RDM compliant devices over a standard DMX line in such a way that does not disturb the normal operation of standard DMX512 devices that do not recognize the RDM protocol. It also introduces the possibility to dim four channels at the same time and a higher frequency to hide the strobo effect. OSRAM's current DMX dimmers support RDM.

2.2.3 OT BLE DIM

The OPTOTRONIC® OT BLE DIM is an indoor device for your illumination system with an intuitive light management via state-of-the-art Bluetooth® and the CASAMBI APP, simply connecting your LED modules or sensors and pair them with your smartphone or tablet.

With its PWM dimming (0-100 %) and control up to 240 W LED load, it provides constant voltage to 4-channel dimmer and it can be connected to other OPTOTRONIC® OT BLE DIM creating a wireless mesh network seeing all devices present in that network. In this way in your hand you have entire control of all lamp and sensor in your home, setting them with the brightness, temperature, color and option wanted.

Features of the OPTOTRONIC® OT BLE DIM interface:

- Light management of constant-voltage LED systems
- Intuitive plug-and-play solution; easy set-up and control via app, no additional professional knowledge for commissioning needed
- Dimming, scene storage, sequences, daylight rhythm
- Multicolor control (RGBW, RGB, Tunable White and Tunable Warm White)
- Time-programmable events
- Reliable mesh network communication based on Bluetooth® Low Energy
- Customizable app elements (such as buttons)
- Autonomous system, constant cloud synchronization available
- Possibility to use 2 dry contacts to control the devices with push button/sensors

2.3 Type designation

OPTOTRONIC® devices are named and labelled according to the following general scheme:

OT x xx/xxx-xxx/xxx xxx, e.g. OT 20/220-240/24 DIM

The meaning of each block is:

- OT
  Abbreviation for OPTOTRONIC®
- 1st block (optional)
  Information on dimming capabilities and control input (where applicable):
  - DALI: control interface matching DALI standard
  - DMX: DMX compatible input
  - i: Device with built-in Touch DIM functionality
- 2nd block
  Maximum output power of the device, e.g. 9 for a total output power of 9 W (note that the exact values are specified in the datasheet).
- 3rd block
  Nominal input voltage range, e.g. 200-240 for a 200-240 V input range.
- 4th block
  Output voltage or current on the output side, e.g. 24 for 24 V or 700 for a 700 mA power supply.
- 5th block (optional)
  RGB or RGB+W for 3 or 4 channel devices.
- 6th block (optional)
  Additional information on:
  - Shape of device:
    S: square, C: circular
  - Devices suitability for outdoor applications
    E: exterior (IP rating can be found in the datasheet)
  - Dimming:
    DIM: Device with dimming capability. Without DALI or DMX in the first block this indicates a device with 1…10 V (or 10 V max.) control input.
    SEQ: Stand-alone sequencer

The labelling of few products may vary from this general scheme due to special requirements.

2.4 IP rating

The IP Code, International Protection Marking, IEC standard 60529, sometimes interpreted as Ingress Protection Marking, classifies and rates the degree of protection provided against intrusion (body parts such as hands and fingers), dust, accidental contact, and water by mechanical casings and electrical enclosures. It is published by the International Electrotechnical Commission (IEC). The equivalent European standard is EN 60529.

The standard aims to provide users more detailed information than vague marketing terms such as waterproof. For example, an LED module rated at IP68 is "dust resistant" and can be immersed in 1.5 meters of freshwater for up to 30 minutes. IP22 or IP2X are typical minimum requirements for the design of electrical accessories for indoor use.

The digits indicate conformity with the conditions summarized in the following tables.

Table 3: First IP number

Level	Effective against
X	X means there is no data available
0	No protection against contact
1	>50 mm
2	>12.5 mm
3	>2.5 mm
4	>1 mm
5	Dust protected
6	Dust tight

Table 4: Second IP number

Level	Effective against
0	None
1	Dripping water
2	Dripping water when tilted at 15°
3	Spraying water
4	Splashing of water
5	Water jets
6	Powerful water jets
6K	Powerful water jets with increased pressure
7	Immersion, up to 1 m depth
8	Immersion, 1 m or more depth
9K	Powerful high temperature water jets

2.5 Safety and performance

All OPTOTRONIC® devices are designed to meet or exceed applicable standards for use in lighting applications. The next sections give an overview of safety and performance features built into OPTOTRONIC® devices. Furthermore all lighting applications have to comply with the luminaire standards IEC 60598.

2.5.1 Safety

The luminaires standard IEC 60598 references the safety standard IEC 61347, for LED converters specifically to IEC 61347-2-13.

OPTOTRONIC® devices meet the requirements of the safety standard IEC/EN 61347-2-13. Devices conforming to this standard are designed to ensure the safety of the user and implement measures to protect against electric shocks and thermal overload of the electronic control gear in case of malfunction.

Almost all OPTOTRONIC® devices are designed as SELV devices, which ensures that attached LED modules can be touched without any risk. SELV devices provide a high level of isolation between the primary side and secondary side and additional features that minimize the risk of electric shock to the user. The dielectric strength (galvanic isolation) between primary and secondary side is specified at 3.75 kV or more for SELV devices and is tested at a voltage of 4 kV by OSRAM. The control port of dimmable power supplies or dimmers is also isolated against the output side, however the isolation level may differ.

To minimize the risk due to thermal overload of a device in case of malfunction, all OPTOTRONIC® devices are furthermore equipped with an over-temperature shut-down feature.

2.5.2 Performance

The performance standard IEC/EN 62384 defines the optimal operation of LED with electronic control gear, ensuring that LED are only operated within their specified operating parameters. This guarantees best performance and maximum lifetime of suitable LED and LED modules.

All OPTOTRONIC® devices labelled with the ENEC mark are already approved according to IEC/EN 62384.

2.6 EMC compliance

EMC (electromagnetic compatibility) is specified as a series of different test criteria. The most important in connection with electronic control gear are radio interference suppression (noise), harmonic content (up to the 39th harmonic) and immunity to interference.

Table 5: EMC compliance overview

	IEC, international	European standard
Radio interference suppression	CISPR 15	EN 55015
Harmonic content	IEC 61000-3-2	EN 61000-3-2
Immunity to interference	IEC 61547	EN 61547

The CE symbol (see section 5.2) on OSRAM devices indicate compliance with immunity to interference, harmonic content and radio interference suppression requirements.

Immunity to interference and harmonic content is determined solely by the power supply, therefore it is not necessary to repeat any measurement related to these for luminaires equipped with OSRAM OPTOTRONIC® units. This results in a significant cost saving and reduces time required for approval by the luminaire manufacturer. Radio suppression may need to be verified in each particular application.

2.6.1 Harmonic content of the mains current

Lighting equipment is subject to restrictions on harmonics.

The maximum permissible threshold values are defined according to class C of the standard EN 61000-3-2 for the subclasses below 25 W and over 25 W. All OPTOTRONIC® power supplies are designed and approved according to this standard.

Power factor correction

OPTOTRONIC® devices with an input power rated at 25 W or higher are equipped with a power factor correcting feature in compliance with IEC/EN 61000-3-2. Electronic control gear must not disturb the mains supply with an “irregular current drain”, i.e. harmonics.

The power factor of each device is specified in the data sheets on our website:
https://www.osram.com/cb/products/index.jsp

2.6.2 Immunity

All OPTOTRONIC® devices comply with the immunity requirements described in EN 61547 (IEC 61547, VDE 0875 T15-2). This guarantees protection against interference from external high-frequency fields, discharge of static electricity and transient over voltages of the mains supply as defined in EN 61547.

OPTOTRONIC® power supplies and control units (independent, with built-in strain relief) comply with the limit values for radio interference voltage in accordance with IEC/EN 55015. The length of low voltage cables must not exceed the values given in the data sheets to comply with the requirements of radio interference suppression.

Devices for luminaire integration and stand-alone devices are equipped with a high-quality internal filter to ensure compliance with the radio interference values specified in EN 55015.

When installing OPTOTRONIC® in a luminaire of protection class II or plastic installation boxes, no additional measures against radio interference are required.

When installing OPTOTRONIC® units in metal-case luminaires of protection class I or in metal-case installation boxes, radio interference will increase due to higher earth capacities.

Installations which combine OPTOTRONIC® power supplies and OPTOTRONIC® dimmers should also be measured to guarantee that radio interference of the system is not exceeded.

Therefore, it may be necessary to include an additional mains filter with earth connection.

Note:
The luminaire manufacturer is responsible to measure and verify EMI compliance of the complete lighting fixture as the level of radio interference will vary depending on the installation of the power supply. Especially primary and secondary cable lengths and routing may have a significant effect on radio interference.

Maximum cable lengths

OPTOTRONIC® power supplies are tested and verified to be EMI compliant with secondary cable lengths of up to 50 m (shorter cable lengths on some devices, please refer to product datasheet) in accordance with applicable standard testing. When cable length exceeds the maximum declared, EMI emissions have to be verified in the application. When EMI emission exceed the allowed levels it may be possible to reduce the EMI emissions by using ferrite cores.

More information on maximum cable length can be found in section 3.1.4.

Also note that the maximum cable length possible may be reduced due to resistance of the wire, this is also detailed in the section mentioned above.

2.7 Audible noise

The frequency-dependent sound pressure level generated by an OPTOTRONIC® device approximates the audibility threshold, i.e. a person with normal hearing capability will virtually not be able to notice the noise generated by a unit in a room.

The overall sound pressure level is determined by the sound power level of the unit, the number of units in operation and the absorption properties of the room (characterized by its volume and reverberation time).

Note that for mains supplies with a high level of distortion where the mains voltage deviates significantly from a sine wave a “chirping” sound may be heard from the choke coils in the device’s input stage.

2.8 Temperature and lifetime

The lifetime of OPTOTRONIC® devices is determined by the lifetime of the electronic components used in the device. The biggest impact on the lifetime of these components comes from the temperature the components are operated at, in general an increase in operating temperature leads to a reduction of lifetime.

Every OPTOTRONIC® device is marked with a so-called tc-point. The location of the t_c point and the specified maximum allowed temperature at this point have been chosen such that all electronic components within are operated at safe temperatures that do not lead to a reduction in reliability or lifetime of the device.

For safe operation it is mandatory that the temperature at the t_c point does not exceed the specified maximum temperature, this furthermore also ensures that OPTOTRONIC® devices achieve a nominal lifetime of 50,000 hours with a maximum cumulated failure rate of 10 %.

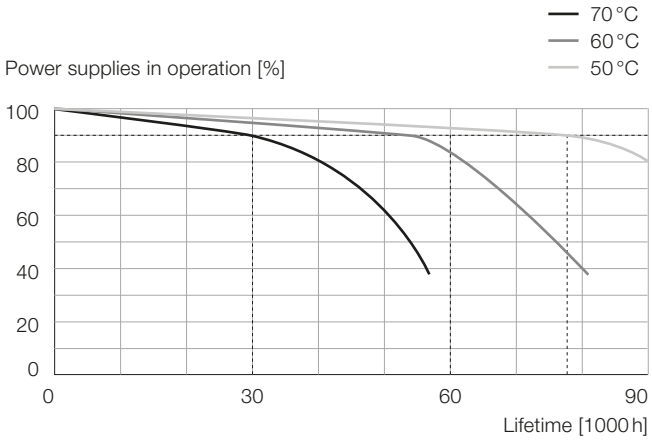
The failure rate of electronic components depends exponentially on the operating temperature. As stated before for safe operation, the permitted t_c temperature must never be exceeded, in addition exceeding this temperature will also reduce the life of an LED driver significantly or may permanently damage the components and lead to a total failure of the device. When installing a power supply outside a lighting fixture, make sure to not install it too close to any other heat source in order to avoid overheating.

We can expect up to double the lifetime for OPTOTRONIC® devices when the temperature at t_c point is kept 10 °C below the maximum permitted temperature at all times.

OPTOTRONIC® devices operate reliably within the temperature range specified for each device (see technical data sheets on our website: https://www.osram.com/cb/products/index.jsp).

Figure 8 below shows the typical life expectancy of an OPTOTRONIC® device (with a nominal lifetime of 30,000 hrs at maximum t_c of 70° C) at various t_c temperatures.

Figure 8: Life expectancy of OPTOTRONIC® power supplies

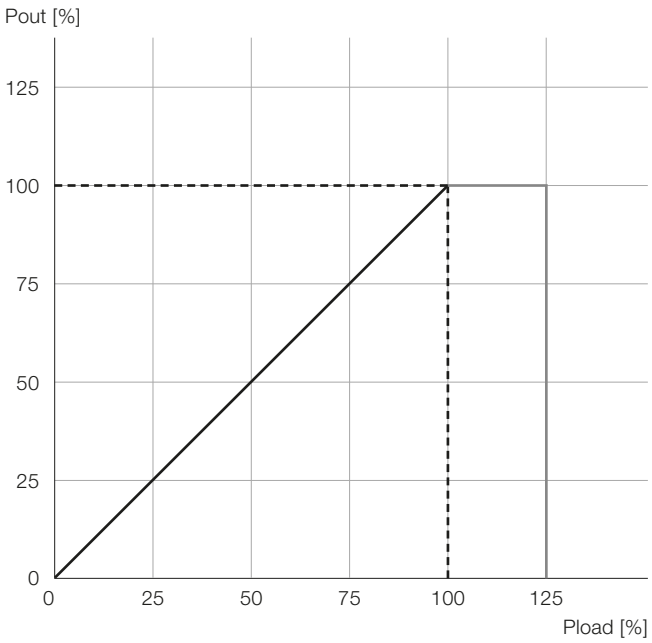


2.9 Protection against overload, short circuit, no load and partial load and over-temperature operation

2.9.1 Overload

OPTOTRONIC® devices are equipped with reversible electronic overload protection, which in case of an overload condition keep the output power at the maximum even if there is a request of more to prevent damage to the device or installation. When the overload condition is removed (i.e. the connected load is reduced) the power supply returns its output to full power.

Figure 9: Output power during an overload



Controlled by the DALI system, when there is an overload naturally the current flow increase but the system starts to dim the output so the average power remains 100 % and it do not cross this percentage.

Exceeding the maximum rated load (P/PN >1) also bears the risk of overheating the power supply and can also lead to a safety shutdown.

If a power supply is shutting down due overload, the power supply may enter a blinking mode, alternating between a complete shutdown and brief power-up of the system (in order to determine whether the overload condition is still present in the installation). This blinking mode will be observed on all constant-voltage power supplies.

Warning

Operating OPTOTRONIC® continuously above maximum rated power will reduce the lifetime of the power supply and may also lead to exceeding of the maximum t_c temperature of the device!

2.9.2 Short circuit

OPTOTRONIC® devices have a reversible electronic protection against damage caused by short circuit on the secondary side. If a short circuit is detected on the output side the power supply will cut off the output power. The power supply will be fully operational again once the cause of the short circuit has been eliminated.

2.9.3 Over-temperature

An OPTOTRONIC® power supply may become overheated due to operation of the device with high load, insufficient cooling or because of close-by heat sources heating up the device beyond the maximum allowed temperature.

Regardless of the source of overheating, OPTOTRONIC® devices are protected against permanent damage from over-temperature. When an over-temperature condition occurs the power supply will reduce output power and eventually shut down to avoid permanent damage.

When the power supply has cooled down to safe levels full output is restored automatically. Note that this may lead to a blinking mode or periodical shut-down of the power supply as once the system starts operating at full output the temperature of the devices will begin to rise again and may lead to over-temperature again.

The OSRAM's outdoor devices, according to the ISO4892-2, are also protected against the sun that besides heating it issues UV rays.

Attention:

For safe and reliable operation and in addition to avoid a reduction in lifetime it is mandatory to keep the value of t_c below the specified maximum value at all times.

2.10 Smart Power Supply feature

Depending on the ambient temperature, LED modules may vary in power consumption (depending on the design of the LED module). For example, at low temperatures (below 0 °C) the required power to operate LED modules may be significantly higher than under standard conditions. This can lead to problems when operating LED installations at these temperatures, such as a reduction of brightness or instable operation of modules due to an overload condition of the power supply.

To address this issue, OSRAM has developed the “Smart Power Supply” (SPS) feature, which within limits can automatically compensate the increase in power consumption. Thanks to this intelligent control, over-power conditions are managed by the OPTOTRONIC® power supplies in order to guarantee optimum system reliability and thermal management even at these low temperatures. Compensation of the increased power demand does not impact the lifetime of these OPTOTRONIC® power supplies.

Note:
Do not overload OPTOTRONIC® devices with Smart Power Supply feature intentionally as this may reduce lifetime or damage the device. To avoid mistakes, please take a look at the user instructions and the online catalogue available at www.osram.com/optotronic.

3 Planning, installation and operation

3.1 System planning

System planning must take into consideration several important factors:

1. The selection of suitable LED modules.
2. The required level of control in the application.
3. The total wattage and number of LED modules to be installed and limitations due to maximum output voltage (for systems using constant-current modules).
4. Maximum allowed cable lengths.

The importance of these factors for planning a system are first discussed in general in the next sections.

3.1.1 LED module selection

The very first step in planning an application is the selection of the right LED module(s).

For an overview of available CV LED modules for different applications, please refer to the website of OSRAM's LED Systems group, available at www.osram.com/flex.

3.1.2 Level of control

The required level of control in your application determines whether the system will use any OT dimmers or can be realized e.g. based on the OT BLE DIM device.

The level of control in an application can range from no control (i.e. fixed output), simple control (i.e. brightness) or full RGB control (i.e. multiple independently controlled channels). Besides the level of control also the preferred control protocol must be selected, such as 1…10 V, DALI, DALI 2 or DMX.

Combined with the type of LED modules selected in the first step, these requirements can be used to further screen the OPTOTRONIC® portfolio for suitable power supplies and dimmers. Dimmers that are installed in between power supplies and LED modules have to be considered in planning a system for several reasons:

- Dimmers draw additional power from the power supply. Even though this amount in general is much smaller than the power drawn from the LED modules, it should be considered in the calculation.
- Dimmers also introduce a small voltage drop along the cabling to the LED modules, which must also be taken into consideration when calculating maximum cable lengths.
- The maximum current rating of a controller may furthermore limit the number of modules that can be connected to a controller and to a power supply.

3.1.3 Total wattage

At a minimum the number of installed OPTOTRONIC® power supplies must be able to supply the power drawn by the attached modules and any installed controllers.

For normal operating temperatures the maximum number of LED modules which can be operated on one OPTOTRONIC® can be easily calculated by calculating the ratio between nominal wattage of the power supply and the total power consumption of the connected LED module:

$$N_{max} = \frac{P_{N,OPTOTRONIC}}{P_{N,module}}$$

- N_{max}
  Maximum number of LED modules that can be operated on one power supply
- $P_{N,\ OPTOTRONIC}$
  Nominal power of the OPTOTRONIC® power supply. This value can be found in the data sheets (see on our website: https://www.osram.com/cb/products/index.jsp)
- $P_{N,\ module}$
  Nominal power of the connected LED module. The module wattage is specified in the data sheets of the LED module.

In case a dimmer is connected to the OPTOTRONIC® power supply, the available power to drive the LED modules is reduced by the losses of the dimmer. The maximum losses of each dimmer are specified in the device's data sheet (see on our website: https://www.osram.com/cb/products/index.jsp). In this case the maximum number of modules per power supply is calculated using this formula:

$$N_{max} = \frac{P_{N,OPTOTRONIC} - P_{Losses,\ dimmer}}{P_{N,module}}$$

The calculated maximum number of modules per power supply is valid for the best-case in which all modules can be distributed evenly across the power supplies.

For a real-world application the actual number possible may be limited by the maximum allowed cable length on the output side and the desired physical placement of the modules. This may require installing additional power supplies in your application that are not loaded to the maximum but allow the desired physical placement of the modules to be achieved.

3.1.4 Maximum cable lengths

3.1.4.1 Maximum output cable length

Cable length on the output side is limited by EMI and the voltage drop that occurs along the cables.

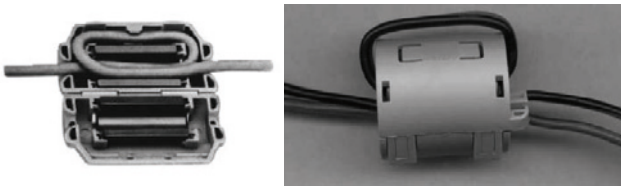
EMI compliance

All OPTOTRONIC® products are tested and comply with the limit values for radio interference according to EN 55015. The maximum cable length leading to the LED modules tested to comply with IEC/EN 55015 is given in the data sheets in our website: https://www.osram.com/cb/products/index.jsp
Please note that this is the maximum cable length between the power supply and the LED modules and includes any dimmers that may be installed in between power supply and LED module.

In some applications it may be required to extend the maximum permitted cable length. In this case special EMC filters can be applied on the secondary side (12 V and 24 V). A ferrite close to the output terminals can reduce the effect of radio interference significantly. If OPTOTRONIC® dimmers are also installed, place the filters on output wires as close as possible to the dimmer device.

Simple and easy-to-use solutions are available in the market, see pictures below. One possible ferrite is available from TDK, part number ZCAT3035-1330-BK.

Figure 10: ZCAT-C TYPE



EMI compliance must be verified and confirmed by the luminaire manufacturer.

Voltage drop

Besides the requirements for electromagnetic compliance the planning of LED lighting installations must also consider the resistance of secondary cables, which leads to a voltage drop along the cable and a reduced supply voltage at the LED-module. If the voltage at the LED modules drops below the minimum specified value, the module may not operate properly.

Constant-voltage power supplies

For constant-voltage power supplies the maximum cable length on the secondary side can be calculated using the following formula:

$$L_{max} \leq \frac{1}{2\rho} \times (V_{OT} - V_{DIM} - V_{LED}) \times \frac{V_{LED}}{P_{LED}}$$

The following table explains the parameters used to calculate the maximum permitted length of secondary cables:

Table 6: Calculation parameters for length of secondary cables

Parameter	Explanation
ρ	Resistance of cable used on secondary side (in [Ω/m]). See table below for typical values of secondary cables.
V_{OT}	OPTOTRONIC® output voltage (10.5 V or 24 V)
V_{LED}	Minimum input voltage of LED modules (typically 10 V or 23 V)
V_{DIM}	Voltage drop of OPTOTRONIC® dimmer (if used). A typical value for e.g. OT DIM is VDIM ~ 0.3 V. Further information about the voltage drop of dimmers is available in the product data sheets.
P_{LED}	Total maximum wattage of attached LED modules

Table 7 below lists typical values for the resistance of copper cables with 1.5 mm² and 0.75 mm² diameter at a copper temperature of 20 °C. These values will also be used in the examples calculated below.

Table 7: Typical resistance of secondary cables

Cable 1.5 mm²		Cable 0.75 mm²	
Ω [Ω/km]	1/ρ [m/Ω]	ρ [Ω/km]	1/ρ [m/Ω]
13.6	73.8	29.1	34.3

Example:

OTi 80/230-240/24, OT DIM, LFD400T-830 G1 06, 0.75 mm² cable

$$L_{max} \leq \frac{1}{2\rho} \times (V_{OT} - V_{DIM} - V_{LED}) \times \frac{V_{LED}}{P_{LED}} = \frac{34.3}{2} \times (24.2 - 0 - 23) \times \frac{23}{43.2} = 11m$$

OT 60/230-240/24, LF500-G1-840-10 1.5 mm² cable

$$L_{max} \leq \frac{1}{2\rho} \times (V_{OT} - V_{DIM} - V_{LED}) \times \frac{V_{LED}}{P_{LED}} = \frac{73.8}{2} \times (24 - 0.3 - 23) \times \frac{23}{39} = 15.2m$$

For both examples the cable length is limited to 10 m due to the limitations of EMI and not because of cable resistance.

To guarantee a reliable and EMI compliant installation – especially when using higher wattages – these factors must be taken into account carefully and may require adapting an installation to the specific circumstances.

Wiring of LED systems as bus systems

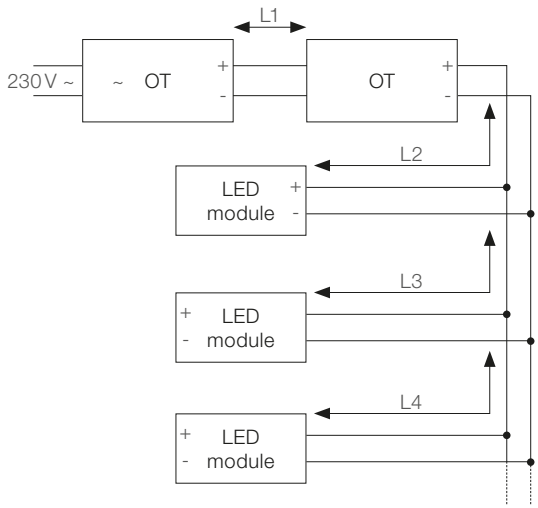
An extension of the maximum length of secondary cables may be possible if the LED modules are wired on a supply bus from which supply cables branch to the individual modules.

As a rule of thumb for such a system the total length of all wired branches may be up to twice the maximum allowed secondary cable length (assuming evenly distributed loads $L_2 = L_3 = \ldots = L_n$):

$L_{total} = 2 \times L_{max}$, where $L_{total} = L_1 + L_2 + \ldots L_n$

Example of a bus system wiring

Figure 11: Bus wiring of LED modules



In this example the total length L_{total} of secondary cables is $L_{total} = L_1 + L_1 + \ldots L_n$

Attention

If the installation is wired in series and not as a bus system, the voltage drops per LED module are added to a total, then L_{total} must be $L_{total} << L_{max}$.

3.2 Installation

3.2.1 Mounting requirements

3.2.1.1 Independent mounting

Select OPTOTRONIC® devices are equipped with built-in cable clamps as a strain relief and are suitable for installation independent of a luminaire. All other devices are intended for luminaire installation and do not provide for strain relief.

3.2.1.2 Outdoor mounting

Most OPTOTRONIC® devices are not designed for unprotected use in outdoor applications and are rated as IP20 products (not protected against moisture). An exception are products marked with the extension E (for “exterior”), which are designed for outdoor application and are available with higher IP protection. The IP protection for each product is also listed in the data sheets.

Devices with IP protection of IP64 and IP65 are VDE approved and protected against dust. They are splash-proof or jet-proof against ingression of water. For an overview of the IP protection offered by OPTOTRONIC® devices refer to section 2.4 on page 13.

3.2.1.3 Mounting on wooden surfaces

Electronic power supplies can be installed in a wide variety of places, including suspended ceilings, furniture, luminaires and tube systems. Installation on wooden surfaces is permitted for products marked with M M. These products fulfil the requirements of VDE 0710 and VDE 0100 part 559.

3.2.2 Wiring

3.2.2.1 Recommended cables

For a safe and reliable operation of OPTOTRONIC® devices, it is mandatory to use only recommended cables on the input and output side and control port where applicable. This guarantees that the cable is suitable for the electrical load and that the mechanical connection of the wire terminals and cable clamp (when available) is safe and working properly.

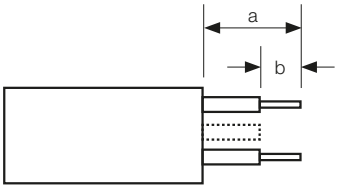
Recommended cables for input and output are specified in each product’s data sheets, which are listed on our website: https://www.osram.com/cb/products/index.jsp

Also check the instruction sheets that are delivered with the product for updated or additional information.

3.2.2.2 Cable stripping

Furthermore, to ensure a safe electrical and mechanical connection of the cable in the electrical terminals and the cable clamp respectively, it is mandatory to observe the cable stripping lengths as shown in Figure 12 below. The stripping lengths for (a) and (b) are specified for each product (where applicable) in the data sheets on our website: https://www.osram.com/cb/products/index.jsp, also check the instruction sheet that is delivered with the product for additional or updated information.

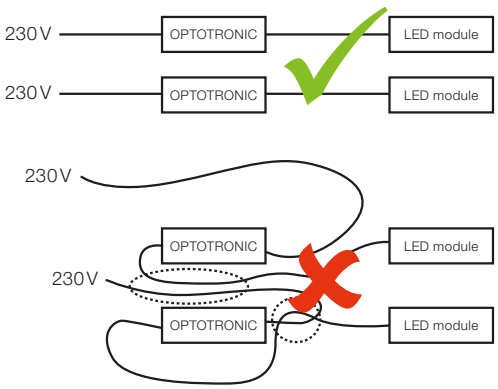
Figure 12: Recommended cable stripping



To ensure good radio interference suppression and maximum safety the following rules for cable routing should be observed:

1. Mains and LED-module cables should never be routed in parallel. Keep output cables and mains cables as far away from one another as possible (e.g. 5 to 10 cm). This avoids mutual interference between mains and secondary-side cables.
2. Place output cables away from earthed metal surfaces (if possible several cm) to reduce capacitive interference.
3. Keep mains cables in the luminaire as short as possible to reduce interference.
4. Don't route mains cables too close to the power supply (this applies in particular to through-wiring).
5. Avoid crossing mains cables and LED-module cables. Where this is not possible, cables should cross at right angles (to avoid HF interference on the mains cable).

Figure 13: Cable routing of OPTOTRONIC® and LED modules



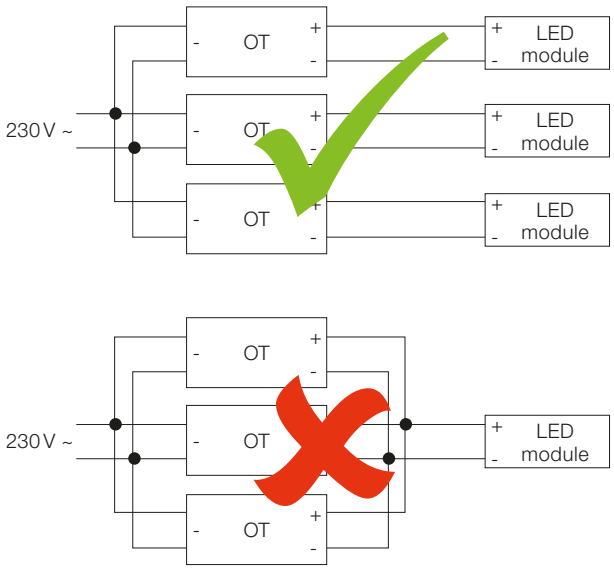
6. Cable penetrations through metal components must never be left unprotected and should be fitted with additional isolation (sleeve, grommet, edge protector, etc.).

Dimming units on the secondary side such as OT DIM usually do not affect the radio interference.

3.2.2.3 Wiring limitations

Parallel connection, wiring limitations supplies can be connected in parallel on the primary side. However, unlike conventional transformers, OPTOTRONIC® power supplies cannot be connected in parallel on the secondary side as this may lead to unequal load distribution and overload of individual power supplies. Series connection is also not permitted.

Figure 14: Parallel connection of OPTOTRONIC®



System installations

In system installations, limiting the number of devices connected in parallel on the control port or sharing a cable for one of the poles on the output side, ensures that LED or LED modules connected to the output are safe to touch at all times. Exceeding this number may lead to touch currents on the output side that exceed the maximum values as defined in the IEC/EN 61347.

The maximum number of devices that can be wired in parallel device-dependent can be verified on the instruction sheets delivered with all products.

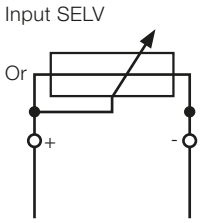
3.2.2.4 1...10V max. control port

Select OPTOTRONIC® devices are equipped with control port that match the characteristics of 1…10 V devices, but are not intended to be operated with standard 1…10 V components connected to line voltage due to possible differences in the isolation present between control port and output voltage in the device.

1…10 V components suitable to control these OPTOTRONIC® devices must provide double isolation between control port and their connection to line voltage. With "10 V max." devices OSRAM's DIM MCU may be used only as a potentiometer (i.e. the mains input on the DIM MCU must not be connected).

Always ensure a distance of at least 6 mm between control input and line voltage to ensure the requirements of double isolation.

The control port of these devices is marked with the following symbol:



Always check the instruction sheets for additional or updated information.

3.2.2.5 DALI wiring instructions

Overall, the requirements that the transmission line has to meet are very modest. When choosing a cable, make sure that the voltage drop on the line does not exceed 2 V at 250 mA. As with 1...10 V systems, the power supply and the control line can be run in the same cable.

The maximum permitted length of cable between the controller and the connected ECGs is 300 m in total, the required cable cross-section depending on cable length is listed in Table 8 below.

Table 8: Recommended cable cross-sections for DALI control wire

Cable length	Up to 100 m	100 to 150 m	150 to 300 m
Cable cross-section	0.5 mm²	0.75 mm²	1.5 mm²

3.2.2.6 DMX wiring instructions

The DMX512 protocol uses XLR style connectors (see below) to transmit RS-485 data. When running DMX512 cabling, be sure to use twisted pair wire (the differential RS-485 standard performs best with twisted pair). Also, the final unused XLR connector in a DMX512 daisy chain network should be terminated with a 120 Ω resistor (to prevent ringing and device malfunction).

Figure 15: Typical DMX connector

Table 9: DMX pins

Pin	Function
1	Ground (shielding)
2	DMX-
3	DMX+
4	NC or 2nd link (optional), DMX-
5	NC or 2nd link (optional), DMX+

3.2.3 Avoiding noise

To avoid noise from dimming, OPTOTRONIC® devices that provide dimming capability should be installed in a way that prevents vibrations to be transferred to any resonance surface.

3.2.4 Start-up current, maximum number of devices per circuit breaker

When switching on an ECG, a starting current pulse Ip of very short duration (TH < 1 ms) is generated as the storage capacitor used for internal power supply is charged. When a large number of units are switched on simultaneously (particularly if they are switched on at the peak of the AC input voltage) a large starting current will flow that may falsely trigger automatic circuit breaker. To avoid false tripping of the circuit breakers, the number of OPTOTRONIC® devices connected may therefore have to be limited.

The maximum possible number is device-dependent and listed in the respective data sheet in our website: https://www.osram.com/cb/products/index.jsp

This maximum number is based on the following assumptions:

- Switching is assumed to occur at the peak of the rated AC input voltage, which is the worst-case in terms of the starting current pulse.
- The type of circuit breakers is “N” automatic circuit breakers (e.g. Siemens type 5SN I-2 and 5SX) with “B” tripping characteristics.
- The specified maximum number listed applies to single-pole automatic circuit breakers. When using multi-pole automatic circuit breakers (2-pole, 3-pole) the permitted number of units is reduced by 20 %.

3.2.5 Supply requirements

OPTOTRONIC® devices are available with different nominal input voltage ranges of e.g. 120 V to 277 V or 220-240 V AC at 50 or 60 Hz. Please refer to the data sheets available on our website: https://www.osram.com/cb/products/index.jsp for individual ratings of each power supply.

OPTOTRONIC® devices operate reliably within -5 % / +10 % of the nominal input voltage range. Supply voltage variations within this range do not affect the output voltage or current as it is electronically controlled.

Warning:
Operating OPTOTRONIC® devices outside the rated voltages may reduce lifetime, lead to reliability problems or damage the device.

All OPTOTRONIC® devices are protected according to IEC/EN 61547 against short-time (transient) over-voltages, for example as occurring when inductive loads such as fluorescent lamps operated with magnetic ballasts are switched off.

3.2.5.1 DC operation

OPTOTRONIC® devices marked with "~=" or listed with 0 Hz as acceptable mains frequency in the data sheet section can be operated with DC voltage. Please note that EMI compliance for DC operation is not guaranteed to be same as for AC operation and must be verified by the luminaire manufacturer in addition to compliance in AC mode.

The output power of these devices remains constant, regardless of whether they are operated on an AC or DC supply, guaranteeing that the light output of attached LED modules remains constant.

3.2.6 Installing control units

3.2.6.1 1...10 V

Control units for 1…10 V devices are easy to install and operate, however a few points should be considered for installation:

1. Control wires must be connected with right polarity (+/-) and must not switch polarity between devices.
2. All components of the main circuit and the control circuit must be designed for 250 V against earth.
3. Do not use telephone or "bell wires" like 2 x 2 x 0.6 J-Y(St)-Y or YR as control wires, because the 1…10 V control voltage does not comply with SELV.

   Detailed information regarding selection of cables and installation can be found in the latest editions of the international or national standards for electrical installations. According to DIN VDE 0100 part 520 section 528.11 main circuits and auxiliary circuits can be routed in parallel even if the voltage of the auxiliary circuits is lower than the voltage of the main circuits.

4. The control wires are galvanic separated from the mains cables, however may not comply with SELV requirements. For installation purposes use only cables and terminals approved for 230 V.
5. The control voltage can be limited upwards and downwards; several controllers can be combined.
6. The 1…10 V interface only allows for control of the OPTOTRONIC® dimming level, switching must be done via mains cables.

   If the control unit provides built-in switching, ensure that the maximum rated load of the control unit's relay is not exceeded.

7. The installed control unit must be able to carry the current provided by the ECGs (0,6 mA, for calculation purposes this is typically assumed to be 1 mA) into the control wires and reduce the control voltage to " 1 V.

This requirement is fulfilled by a potentiometer dimensioned accordingly (see section Potentiometer on the right) and by OSRAM control gear used according to data sheet.
To verify an installation is working properly the following should be tested:

1. With open control wires (not connected to any control gear) the LED modules should operate at full brightness.
2. With short-circuited control wires, the LED modules should be dimmed to the minimum output level.
3. With the control gear set to the lowest dimming value the voltage on the control cables should be reduced to less than 1 V. If a voltage higher than 1 V is measured, the control gear will not be able to set the LED drivers to the lowest dimming value.

The following points are important for cable routing:

1. Only cables may be used which are isolated according to the highest operating voltage used in the particular installation. Alternatively, each conductor in a multi-wire cable is isolated against the voltage carried in the cable next to it.
2. When routing wires in tubes or ducts for electrical installation only cables of a main circuit and related auxiliary circuit may be routed together.
3. In one cable several main circuits including the according auxiliary circuits may be combined.

Note:

- OPTOTRONIC® power supplies cannot be dimmed via mains cables (for example it is not possible to dim by leading edge phase cutting or control impulse)!
- More information on OPTOTRONIC® devices with a "10 V max." port can be found in section 3.2.2.4.

Potentiometer

Commercial potentiometers designed for use in lighting control (available through electric wholesale) can be used for easy control of 1…10 V and 10 V max. devices. When connecting more than two 1…10 V and 10 V max. units the installation of OSRAM's manual controller DIM MCU is recommended (see DIM MCU on next page).

The OPTOTRONIC® device interface is providing the control voltage required for the potentiometer. The resistance depends on the number n of the units connected; for general applications a suitable resistance can be calculated using the formula below:

$$R_{potentiometer} = \frac{100\,k\Omega}{n}$$

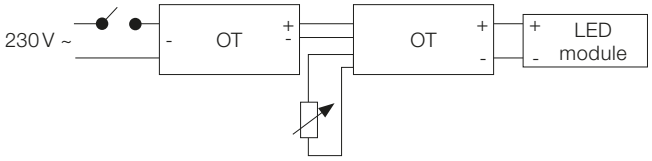
If the calculated value is not available, a potentiometer with higher resistance should be chosen. Otherwise it may not be possible to reach the full output power of the LED modules. To properly match the dimming characteristic of the OPTOTRONIC®, it may be necessary to limit the mechanical range of the potentiometer.

Both linear or logarithmic potentiometers can be used. To mimic the sensitivity of the human eye, a logarithmic potentiometer is recommended.

The potentiometer must be at least designed for a total wattage of n x 2.8 mW.

The following diagram gives an example for a wiring with potentiometer connected to the control input of an OT DIM.

Figure 16: Dimming of OT DIM with a potentiometer



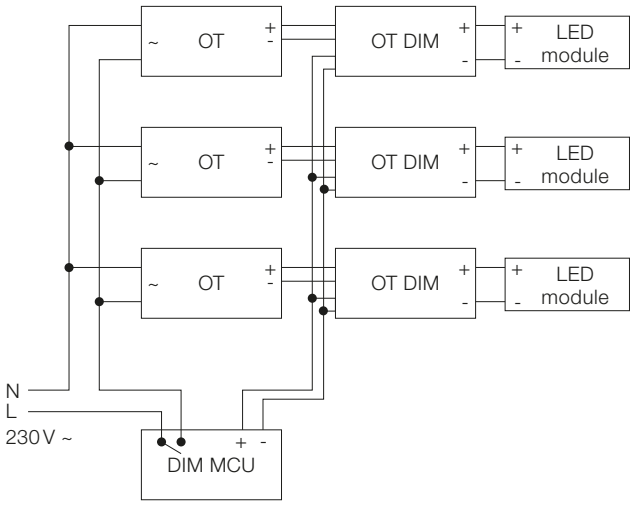
Note:
Find more information about OPTOTRONIC® devices with 1…10 V and 10 V max interface on our website www.osram.com/optotronic.

DIM MCU
When connecting more than two 1…10 V units, the installation of OSRAM's manual controller DIM MCU is recommended. The DIM MCU is a standard solution for lighting control with one control point (for example in small to mid-size rooms with one door). One DIM MCU can control a maximum of fifty 1…10 V units.

A pushbutton is integrated into the DIM MCU (galvanic insulated from the lighting control, however not complying with SELV requirements) which can be used to switch line voltage. This contact can also be used to control relays in order to simultaneously switch units on different circuits.

The following diagram shows the wiring of a DIM MCU controlling multiple OT DIM in parallel.

Figure 17: Controlling multiple OT DIM with DIM MCU



Note:
Not all OPTOTRONIC® devices are suitable to be connected to 1…10 V controllers. For details please refer to the instruction sheets delivered with the products.

3.2.7 Thermal management

OPTOTRONIC® power supplies are designed for very high efficiency and reliable operation even at elevated ambient temperatures. Thermal management of these devices is nonetheless important and can greatly improve the lifetime of the power supplies in an installation.

To avoid overheating, the electronic converter should be installed as far away as possible from any external heat source (e.g. the LED modules, other ECGs) as possible. When installing OPTOTRONIC® in a luminaire, a good thermal connection between the power supply and the housing of the lighting fixture is required. An installation in a sealed plastic IP-box without ventilation may lead to overheating, to improve thermal behavior use a metal base plate connected to the outside or metallic boxes altogether.

Proper thermal management is best verified by measuring the temperature at the OPTOTRONIC®'s t_c point in steady-state operation at maximum load. The measured temperature must not exceed the maximum specified value of the OPTOTRONIC® device for the operating temperature of the luminaire.

3.2.8 Output switching

In certain applications it may be necessary or useful to implement switching on the secondary side, i.e. disconnecting all or parts of the connected LED modules by means of switching.

For constant-voltage based systems this can be done, however the following points should be considered:

1. Even when the complete load is disconnected on the secondary side, there is still a small amount of energy used by the OPTOTRONIC® in stand-by operation. This is a loss of energy that can be avoided by switching the power supply on mains line.
2. EMI compliance of the luminaire may change at different load level and should be checked by the luminaire manufacturer.

4 OPTOTRONIC® portfolio

This section provides an overview of the OPTOTRONIC® portfolio and highlights special features and specific information for each device.

For detailed technical specifications please refer to the datasheets on our website:
https://www.osram.com/cb/products/index.jsp

4.1 Outdoor

4.1.1 DALI

Available as:
OTi 210/220…240/24 1…4 Ch

4.1.2 Outdoor, 24 V on/off

OT 20/220-240/24 P

OT 130/220-240/24 P

Available as:
- OTi 210/220…240/24 P
- OT 40/220…240/24 P
- OT 60/220…240/24 P
- OT 100/220…240/24 P
- OT 130/220…240/24 P
- OT 250/220…240/24 P

4.1.3 Outdoor, 12 V on/off

OT 15/220-240/12 P

OT 60/220-240/12 P

Available as:
- OT 15/220-240/12
- OT 30/220-240/12
- OT 60/220-240/12
- OT 120/220-240/12

4.1.4 Outdoor, 24 V, dimmable with 1…10 V

OT 20/220-240/24 DIM P

OT 130/220-240/24 DIM P

Available as:
- OT 20/220-240/24 DIM P
- OT 40/220-240/24 DIM P
- OT 60/220-240/24 DIM P
- OT 100/220-240/24 DIM P
- OT 130/220-240/24 DIM P
- OT 250/220-240/24 DIM P

4.2 Indoor

4.2.1 Indoor, 24 V, dimmable, DALI

OTi DALI 50/220-240/24 1-4 CH

OTi DALI 160/220-240/24 1-2 CH

Available as:
- OTi DALI 50/220-240/24 1-4 CH
- OTi DALI 50/220-240/24 TW DT8
- OTi DALI 80/220-240/24 1-4 CH
- OTi DALI 80/220-240/24 TW DT8
- OTi DALI 160/220-240/24 1-2 CH
- OTi DALI 160/220-240/24 TW DT8

4.2.2 Indoor, 24 V, on/off

OT 75/220-240/24

Available as:
- OT 6/200-240/24 CE
- OT 20/200-240/24
- OT 50/200-240/24
- OT 75/200-240/24

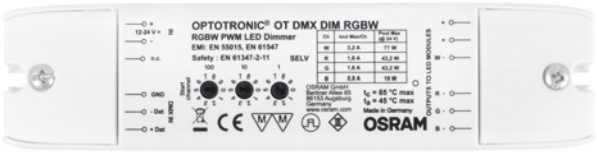
4.3 Dimmers

OT BLE DIM

Bluetooth mesh technology with CASAMBI system

OTi DALI DIM

DALI interface for device control



OT DMX RGBW DIM

DMX interface for device control

OT DIM

1…10 V interface for device control

5 Appendix

5.1 Abbrevations

AlInGaP:
Aluminium **In**dium **Ga**llium **P**hosphate

DALI:
Digital **A**ddressable **L**ighting **I**nterface

DMX:
Digital **M**ultiple**X**

RDM:
Remote **D**evice **M**anagement

ECG:
Electronic **C**ontrol **G**ear

InGaN:
Indium **Ga**llium **N**itrite

IP:
Ingress **P**rotection

LED:
Light **E**mitting **D**iode

LMS:
Light **M**anagement **S**ystem

OT:
OPTO**T**RONIC®

PWM:
Pulse **W**idth **M**odulation

RMS:
Root **M**ean **S**quare

SELV:
Safe **E**xtra **L**ow **V**oltage

SPS:
Smart **P**ower **S**upply

5.2 Device labels, symbols

The following information can be found on OPTOTRONIC® product labels.

Standards:	IEC/EN 61347	Safety
	EN55015	Radio interference
	IEC/EN 61000-3-2	Harmonic content
	IEC/EN 61547	Immunity
	IEC/EN 62384	Performance

Conformity with European standards

VDE approval mark (electrical safety)

VDE approval mark for EMC (electromagnetic compatibility)

OSRAM labels

Can be connected in parallel on the secondary side

Units with electronically controlled constant output voltage

Other labels

Earth connector

Luminaire with discharge lamps for installation on hardly inflammable material

Installation on inflammable materials with unknown properties where temperatures under normal conditions do not exceed 95 °C and under abnormal conditions do not exceed 115 °C

Max. housing temperature in case of abnormal operation (110 °C)

Double insulation and does not require a safety connection to electrical earth (ground)

To identify a short-circuit-proof safety isolating transformer

Product ready to use without any other devices

Product that demonstrates compliance with European standards

Products that conform to all technical regulations of the Eurasian Customs Union

Product that demonstrates compliance with Chinese standards

Product that demonstrates compliance with Indian standards

Product that demonstrates compliance with Australian standards

It works with DALI system

It works with DALI 2 system

Dimmable with just a button

Dimmable from 0.1 % to 100 %

Lambda λ	Power factor
t_a	Ambient temperature in °C
t_c	Case temperature in °C

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