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Technical application guide

OPTOTRONIC[®] constant-voltage LED drivers and controls

Light is OSRAM

OSRAM

Contents

1 Introduction	03	3.2 Installation	26
1.1 Purpose and scope of this document	03	3.2.1 Mounting requirements	26
1.2 Driving LED	03	3.2.1.1 Independent mounting	26
1.3 LED modules	04	3.2.1.2 Outdoor mounting	26
		3.2.1.3 Mounting on wooden surfaces	26
2 OPTOTRONIC® – benefits and features	05	3.2.2 Wiring	26
2.1 Overview	05	3.2.2.1 Recommended cables	26
2.2 OPTOTRONIC® types	05	3.2.2.2 Cable stripping	26
2.2.1 LED drivers	05	3.2.2.3 Wiring limitations	27
2.2.1.1 Constant-voltage LED drivers	05	3.2.2.4 1...10V max. control port	27
2.2.2 Dimmable LED drivers and dimmers	06	3.2.2.5 DALI wiring instructions	28
2.2.2.1 Control inputs	06	3.2.2.6 DMX wiring instructions	28
2.3 Type designation	19	3.2.3 Avoiding noise	28
2.4 IP rating	19	3.2.4 Start-up current, maximum number of devices per circuit breaker	28
2.5 Safety and performance	20	3.2.5 Supply requirements	28
2.5.1 Safety	20	3.2.5.1 DC operation	29
2.5.2 Performance	20	3.2.6 Installing control units	29
2.6 EMC compliance	20	3.2.6.1 1...10V	29
2.6.1 Harmonic content of the mains current	21	3.2.7 Thermal management	30
2.6.2 Voltage fluctuations and flickers	21	3.2.8 Output switching	30
2.6.3 Immunity	21		
2.6.4 Emissions (EMI)	21		
2.7 Audible noise	21	4 OPTOTRONIC® portfolio	31
2.8 Temperature and lifetime	22	4.1 Outdoor	31
2.9 Protection against overload, short circuit, no load and partial load and over-temperature operation	22	4.1.1 DALI	31
2.9.1 Overload	22	4.1.2 Outdoor, 24V on/off	31
2.9.2 Short circuit	23	4.1.3 Outdoor, 12V on/off	31
2.9.3 Over-temperature	23	4.1.4 Outdoor, 24V, dimmable with 1...10V	31
2.10 Smart Power Supply feature	23	4.2 Indoor	32
		4.2.1 Indoor, 24V, dimmable, BLE	32
		4.2.2 Indoor, 24V, dimmable, DALI	32
		4.2.3 Indoor, 24V, dimmable, phase cut	32
		4.2.4 Indoor, 24V, on/off	32
		4.3 Dimmers	32
3 Planning, installation and operation	24		
3.1 System planning	24	5 Appendix	33
3.1.1 LED module selection	24	5.1 Abbreviations	33
3.1.2 Level of control	24	5.2 Device labels, symbols	33
3.1.3 Total wattage	24		
3.1.4 Maximum cable lengths	25		
3.1.4.1 Maximum output cable length	25		

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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 drivers 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® LED drivers. 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

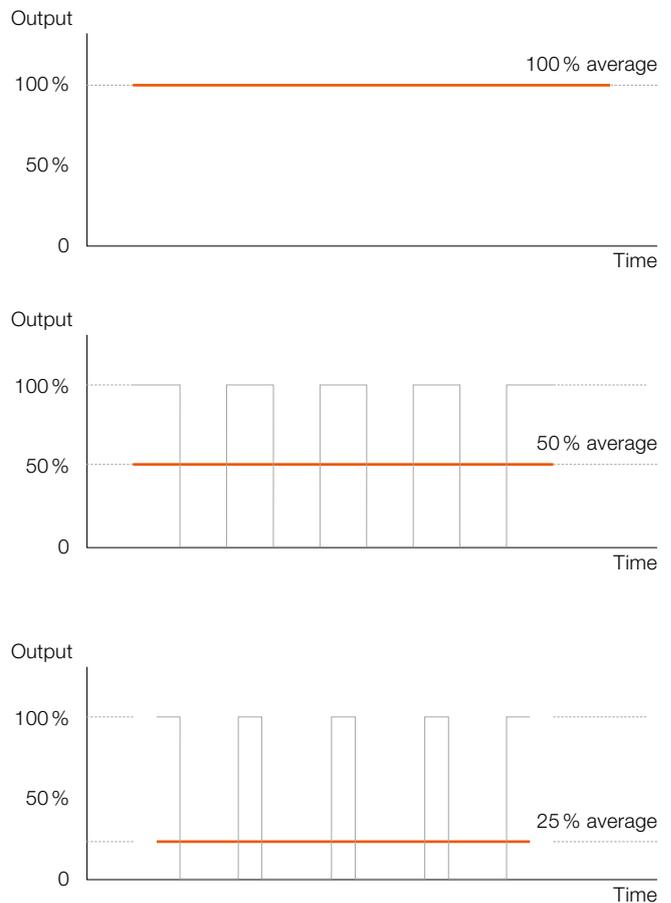
DC dimming is a straightforward solution to reduce the thermal load (and brightness) of an LED. For example, reducing the LED's current from 350 mA down to 250 mA will reduce the thermal load on the LED accordingly. Varying the current of LED may however have sideeffects on the light output of the LED. 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 (i.e. 3 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).

Regardless of the control protocol used to dim the luminous flux, OSRAM constant-voltage LED drivers and dimmers exclusively use PWM as the output dimming method.

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® LED drivers with guaranteed performance and lifetime. When using OSRAM LED modules in combination with OSRAM LED drivers, OSRAM guarantees up to 7 years of system lifetime (please refer to www.osram.com/cb/services/guarantees for updates).

OSRAM currently offers LED modules in the following color combinations:

- White (W-white, available with different color temperatures)
- RGBW (Red, Green, Blue, White)
- RGB (Red, Green, Blue)
- TW (Tunable White, changeable light temperature)
- TWW (Tunable Warm White)

Constant-voltage 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® LED driver.

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

For monochrome versions of LINEARlight FLEX LED modules, please contact OSRAM DS Customer Care: support-ds@osram.com

2 OPTOTRONIC® – benefits and features

2.1 Overview

OSRAM's OPTOTRONIC® devices are easy-to-use LED drivers and dimmers specifically designed for operating LED modules and single LEDs. LED drivers 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 only very little space for installation.
- Cable clamps on a selection of OPTOTRONIC® devices enable independent installation from lighting fixtures.
- A selection of OPTOTRONIC® devices is designed to allow long cable lengths on the output side, providing greater freedom and flexibility for 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, electrical and thermal overload, ensuring maximum safety of your application.
- OPTOTRONIC® devices and LED modules can be combined as a modular system in which the LED driver and the 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 efficiency of future LED generations.
- A selection of OPTOTRONIC® devices is 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:

- LED drivers
- Dimmable LED drivers
- Dimmers

2.2.1 LED drivers

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

Note:

Power supplies do not provide any mechanism for dimming. OPTOTRONIC® LED drivers 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 an LED driver with built-in dimming capabilities.

2.2.1.1 Constant-voltage LED drivers

Constant-voltage LED drivers are intended to be used with LED modules with matching input voltage, i.e. 12V or 24V modules. Not matching the correct voltage between the LED driver and the LED modules may damage or destroy the connected LED.

Using constant-voltage LED drivers 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 LED drivers are SELV or isolated devices with an output voltage of less than 25V and guarantee that at all times it is safe to touch any part of the installation connected to the output.
- Higher wattage LED drivers: Generally, for constant-voltage LED drivers keeping the output voltage below 60V (for SELV reasons) does not limit the drivers' output power, which is only limited by the maximum current that can be supplied by the LED driver itself. Constant-current LED drivers on the other hand need to also respect the maximum current of attached LED (e.g. 350mA) and therefore are limited to a maximum output power of $60V \times I_{out}$, resulting e.g. in a total maximum power of 21W for a 350mA LED driver.
- Parallel wiring: LED modules operated on a constant-voltage LED driver 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 LED drivers 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 LED drivers or as external dimmers.

Dimmable LED drivers combine an LED driver and a dimmer in one device that offers space savings and simplifies installation.

External dimmers are linked in between the LED driver and the LED light sources (e.g. the LED modules). A solution based on an LED driver with an external dimmer, on the other hand, provides greater flexibility in choosing the amount of power supplied to your application.

Dimmable LED drivers and dimmers are available with the following different control inputs.

2.2.2.1 Control inputs

1...10V

The 1...10V control input is a well-established control method 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 10V (maximum light output; control wires open) to <1V (minimum light output; control wires short-circuited).
- With 1...10V control input it's possible to reach a dimming down 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 main phases can be dimmed by one controller.

The output power of the LED drivers can be adjusted by a 1...10V 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...10V 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
- The total line length between any 1...10 V controller device and the control unit should not exceed 300 m

DALI

DALI (**D**igital **A**dressable **L**ighting **I**nterface) is a digital protocol for controlling light. 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...10V and more complex bus systems. DALI can provide easy solutions for local lighting applications as well as complex solutions with integration into building management.

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 and 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 the DALI interface, 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 mm²) 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, no other 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 LED drivers can send a lamp status report to the controller on demand so that it 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 LED drivers 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

DALI drivers may offer DIP switches located close to the output pins. The DIP switches may be used to define the **DALI device type** operation or 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:

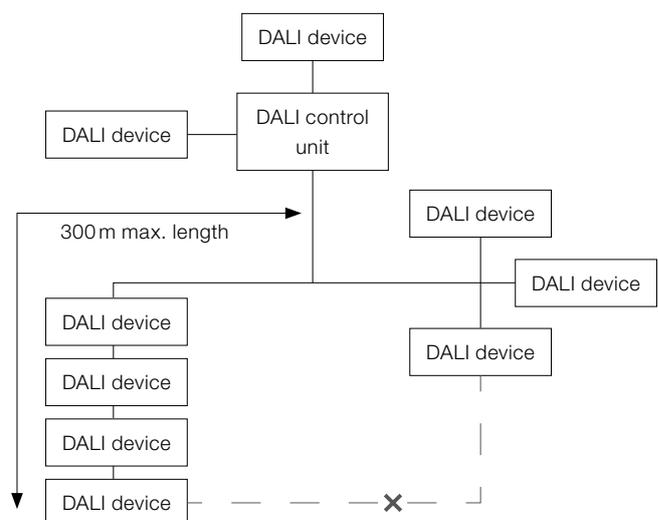
- More detailed description of behavior like fading and power-up
- Extended information in Memory Bank 0
- Some additional commands
- Device Power Cycle Event
- Different command and event encoding
- Allowed feedback from the OTi DALI to the controller for fixture and driver control state

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. 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.

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 the default dimming value of connected DALI LED drivers.

The dedicated Light Management section of the OSRAM DS website (<https://www.osram.com/ds/light-management-systems/>) provides detailed information about the available OSRAM components for light management systems, including the most important features, functions and applications as well as technical and ordering data.

AstroDIM

The AstroDIM feature allows an autonomous dimming without the need for an additional control line. The LED drivers OTi DALI XX/24 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

The AstroDIM mode can be activated 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 sunset 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

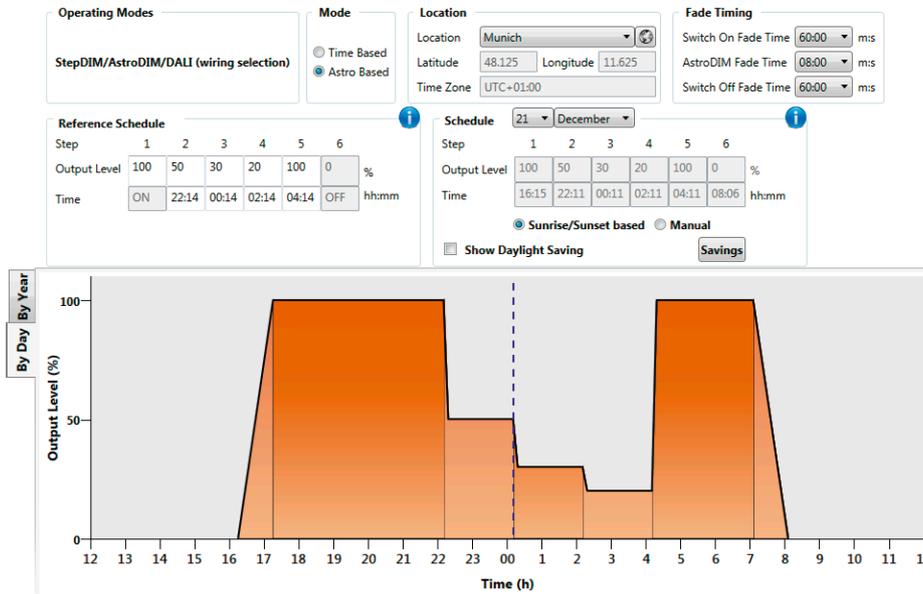


Table 2: Fade timing parameters (astro-based mode)

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

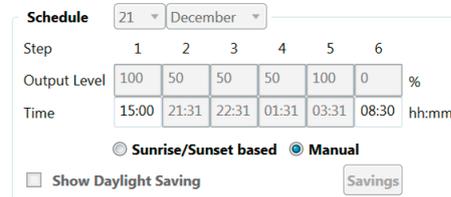
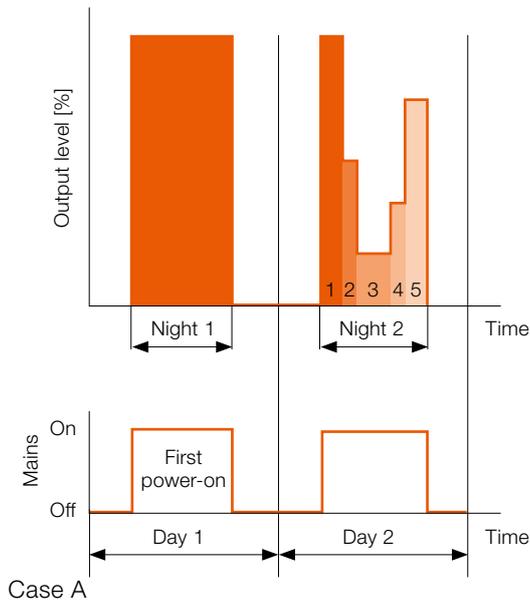
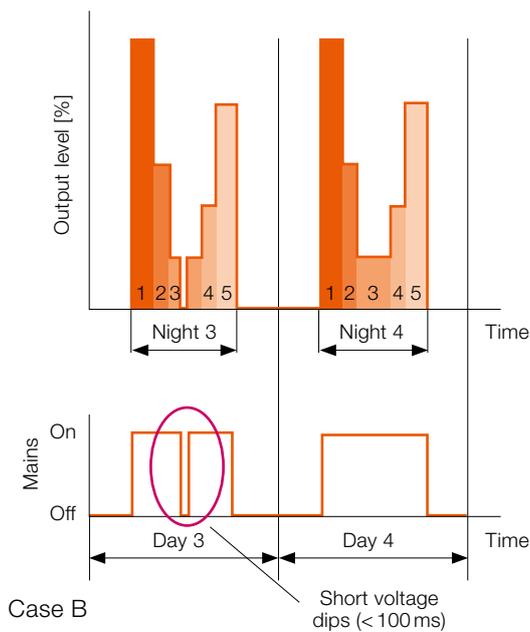


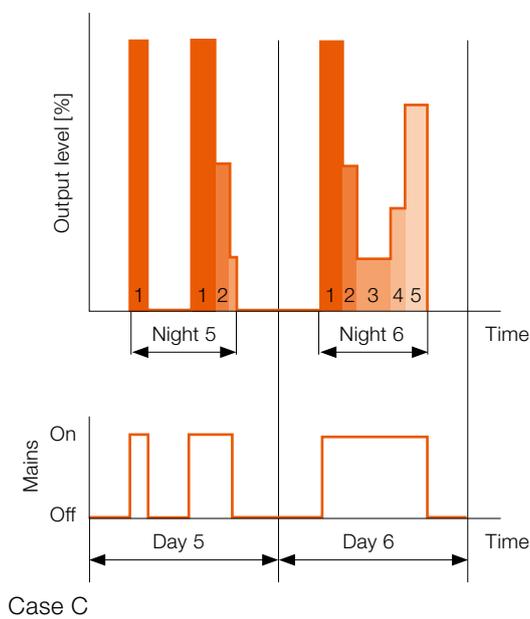
Figure 5: Use cases of AstroDIM mode



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

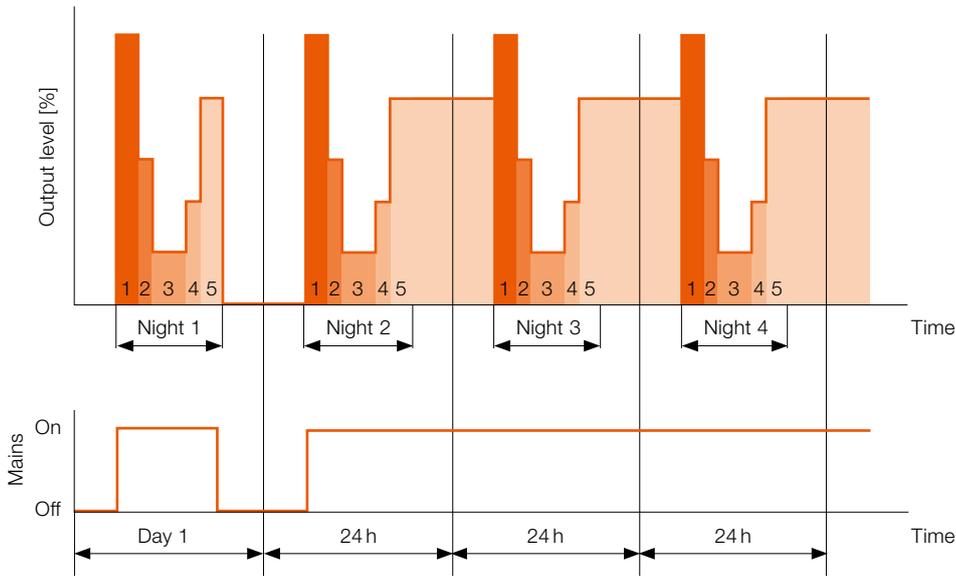


Voltage dips of less than 100 ms do not affect the on-time (case B).



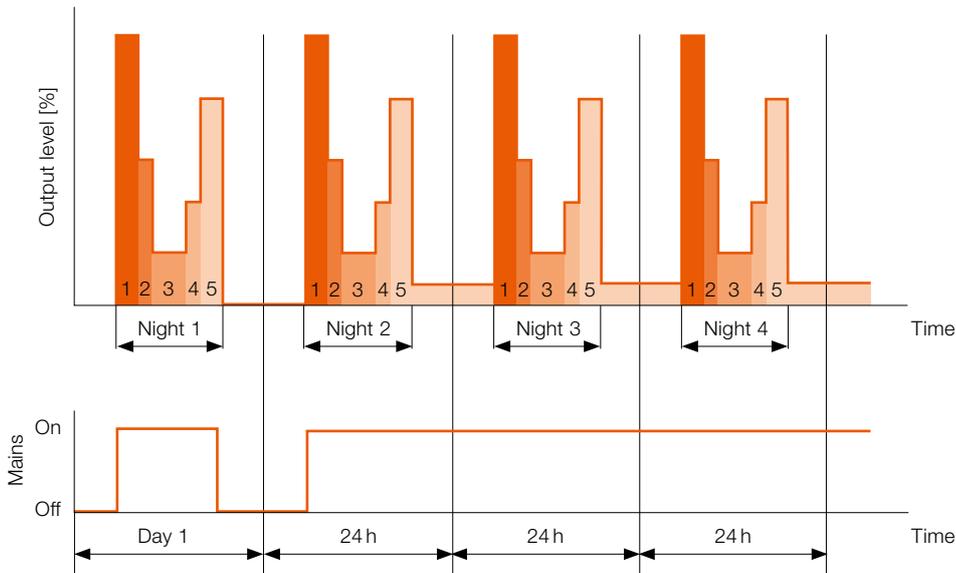
If the on-time of the LED driver is shorter than 4 hours, it is not saved and therefore not used to calculate the next on-time (case C).

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.

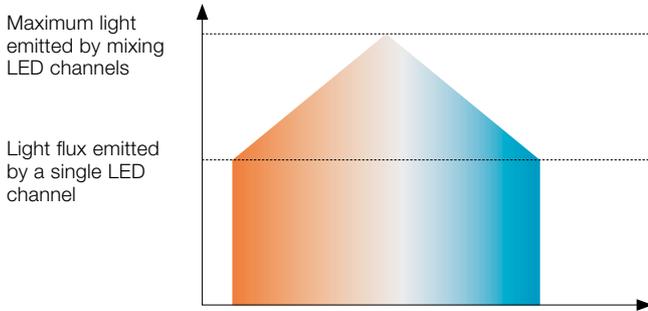
Note:

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

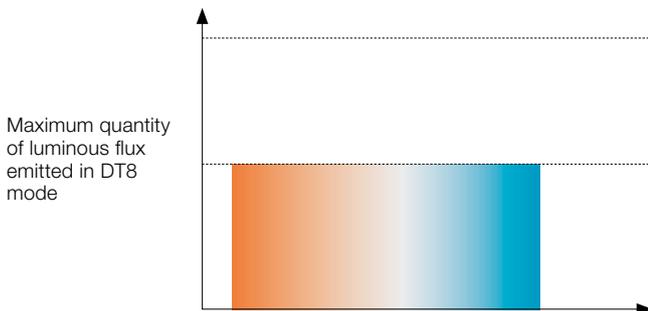
Using TW and TWW LED you can find out a problem: when we need to switch on more than one LED channel to obtain the color of light we want, the total lux is the sum of the lux emitted by the single LED channel and it will be higher.

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



So, if we want to keep the output flux steady while shifting the light color temperatures, we have to use a controller by DT8 which by software restricts the output flux as the one emitted by a single LED color.

Figure 7: Luminous flux emitted by a TW with a DALI DT8 controller



With its CV portfolio, OSRAM offers two different ways to configure a DT8 system:

OTi DALI DIM 1-4CH D

This is a DALI dimmer that can work in DT8 or in DT6 just by correctly setting the inner DIP switches. Once DT8 is selected, the selection of the LED driver has to be based on the sum each LED module channel power and the dimmer absorption.

Figure 8: Power consumption in DT6 or DT8 mode



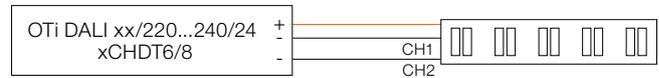
In DT6: $P_{tot} \geq P_{CH1} + P_{CH2} + P_{CH3} + P_{CH4} + P_{dimmer}$
 In DT8: $P_{tot} \geq P_{CH1} + P_{CH2} + P_{dimmer}$

OTi DALI xx/220-240/24 xCHDT6/8

These are three different OT DALI (50-80-160W) that can work in DT8 or in DT6 just by correctly setting the inner DIP switches. Once DT8 is selected, the installed LED driver

has to provide enough power to light up the channel of the LED module with the highest power consumption.

Figure 9: Power consumption in DT8 mode



In DT6: $P_{tot} \geq P_{CH1} + P_{CH2} + P_{CH3} + P_{CH4}$
 In DT8: $P_{tot} \geq \text{MAX} [P_{nomCH1}; P_{nomCH2}]$

DT8 is also helpful to reduce the numbers of DALI addresses because the ECG requires just 1 address despite the 2 embedded channels.

DALI DT6 and DT8 in TW applications

Let's see now in more detail how DT6 and DT8 operation modes handle the total luminous flux and total power consumption in a different way and how load is registered by the LED driver in a TW application. This is a special feature of OTi DALI 50/220-240/24 4CH DT6/8, OTi DALI 80/220-240/24 4CH DT6/8 and OTi DALI 160/220-240/24 2CH LED drivers which will permit to address a specific issue in the DT8 mode.

Application characteristics in the following examples:

- Nominal 100 W Tunable White LED strip, 1000 lm/m
- 50 W nominal on WW 2700 K channel (500 lm/m), 50W nominal on CW 6500 K channel (500 lm/m)
- 100 % dimming condition setting (full power)

DT6 operation

Example 1 – desired CCT is Warm White – 2700 K

- To achieve this CCT, Warm White channel dimming has to be set to 100 %, while Cold White channel dimming has to be set to 0 %.
- Light output is fully provided by the Warm White channel, hence 500lm/m.
- The power consumption is 50W, fully generated by the Warm White channel, while the power absorbed by the Cold White channel is 0W.
- The load registered by the LED driver is 50W.

The opposite, but with the same lumen output and power/load registered by the device, happens when we select 6500 K (CW) as the desired CCT.

Example 2 – desired CCT set to 4600 K

- To achieve this CCT, the WW and CW channels have to be switched on together at 100 %.
- The light output is the sum of the light output of each channel: 500lm/m for CW + 500lm/m for WW = 1000lm/m.
- The power consumption is the sum of the power consumption of each channel, therefore: 50W for CW (100 % on) + 50W for WW (100 % on) = 100W.
- The load registered by the LED driver is 100W.

Example 3 – desired CCT set to 5250 K

- To achieve this CCT, the CW channel has to be switched on at 100 %, while the WW channel has to be dimmed to 50 %.

- The light output is the sum of the light output of each channel: 500lm/m for CW (100% on) + 250lm/m for WW (dimmed to 50%) = 750lm/m
- The power consumption is the sum of the power consumption of each channel, therefore: 50W for CW (100% on) + 25W for WW (dimmed to 50%) = 75W.
- The load registered by the LED driver is 100W: Although the WW channel is set to 50%, with the PWM dimming, for half of the time of the PWM duty cycle, both channels are fully switched on and for the remaining time, one channel is on (CW) while the second one is switched off (WW). More details visually provided in figure 10.

This means that, although the average absorbed power in this use case is 75W, because the load registered by the LED driver is 100W, a driver able to handle at least 100W must be selected to run this application.

Figure 10: Power consumption by a TW LED strip with a DALI DT6 controller

DT6 TW: Power distribution per channel and in total @ max load / 100% dimming

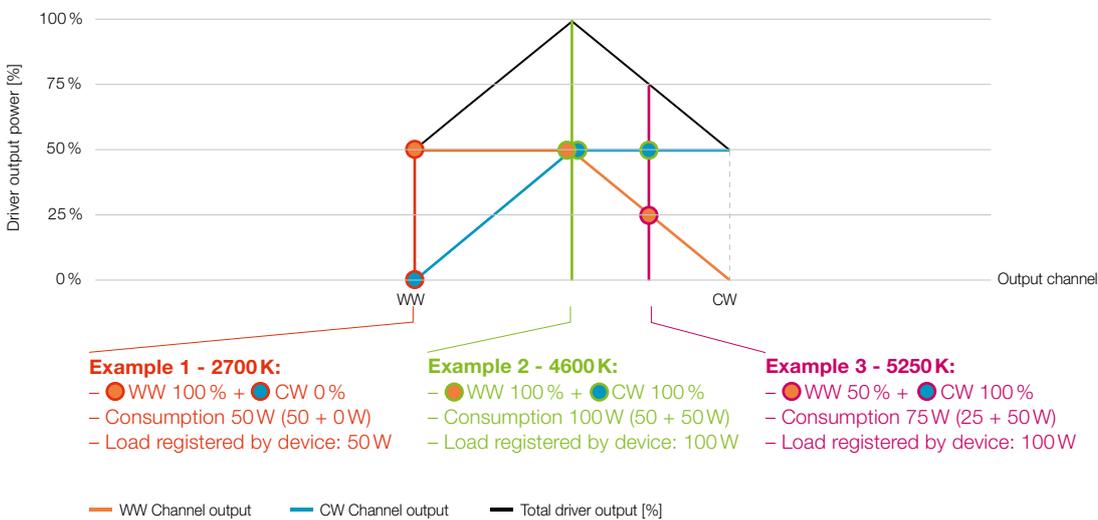


Figure 11: Luminous flux emitted by a TW LED strip with a DALI DT6 controller

DT6 TW operation: Luminous flux output @ max load / 100% dimming

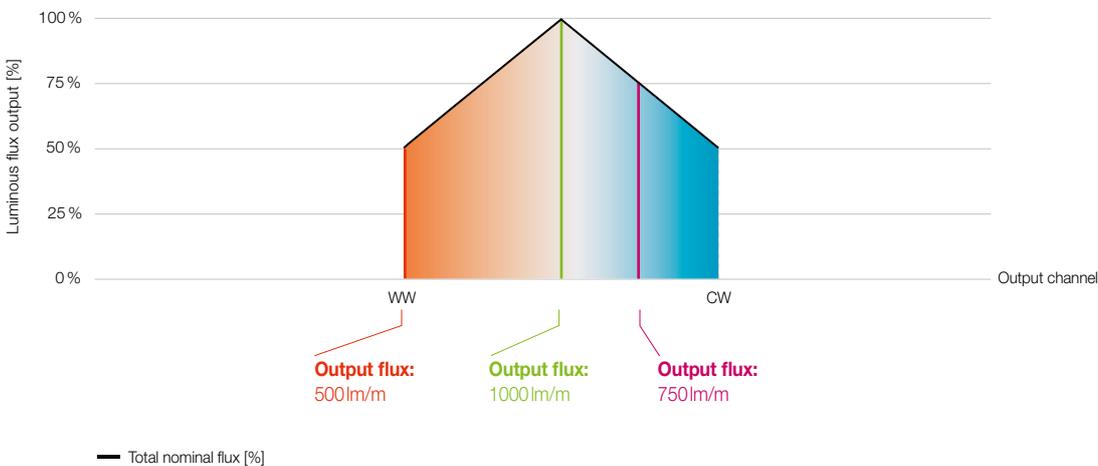
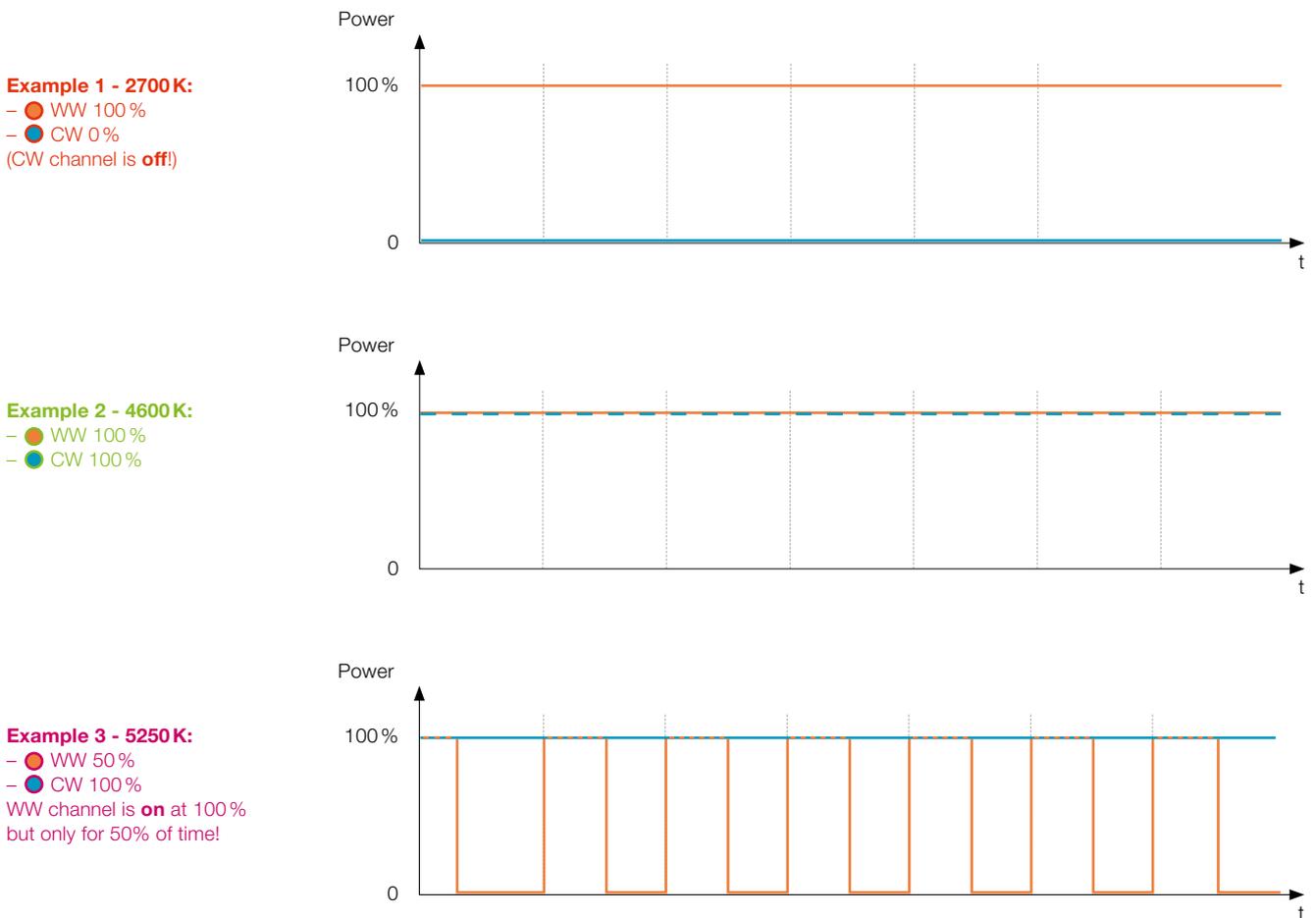


Figure 12: Power consumption of each channel by a TW LED strip with a DALI DT6 controller

DT8 operation

With the following examples we will see how, with an identical TW LED strip as in the DT6 operation use cases, the outcome in terms of performance and power management is different. It will also be shown how the new OTi DALI 50/220-240/24 4CH DT6/8, OTi DALI 80/220-240/24 4CH DT6/8 and OTi DALI 160/220-240/24 2CH LED drivers will permit to address a typical DT8 issue in terms of LED driver power selection.

Example 4 – desired CCT is Warm White – 2700 K

- To achieve this CCT, Warm White channel dimming has to be set to 100 %, while Cold White channel dimming has to be set to 0 %.
- The light output is fully provided by the Warm White channel, hence 500lm/m.
- The power consumption is 50W, fully generated by the Warm White channel, while the power absorbed by the Cold White channel is 0W.
- The load registered by the LED driver is 50W.

The opposite, but with same lumen output and power/load registered by device happens when we select 6500 K (CW) as the desired CCT. When working on a single channel, there are no differences between a DT6 and a DT8 operation.

Example 5 – desired CCT set to 4600 K

- To achieve this CCT, both channels have to be dimmed to 50 %.
- The light output is the sum of the light output of each channel: 250lm/m for CW (dimmed to 50 %) + 250lm/m for WW (dimmed to 50 %) = 500lm/m. **Please note that in DT8 operations, the light output is controlled in order to be constant over the CCT range.**
- The power consumption is the sum of the power consumption of each channel, therefore: 25 W for CW (dimmed to 50 %) + 25 W for WW (dimmed to 50 %) = 50 W.
- The load at the LED driver is 100W because the impulses (for PWM dimming) generated on both channels begin at the same time, requiring the driver to be able to provide, momentarily, an electrical power that is the sum of the maximum power of the two channels (50 W + 50 W = 100W). This means that, although the average absorbed power in DT8 is 50W, because the load registered by the LED driver is 100W, a driver able to handle at least 100W must be selected to run this application. The issue hereby presented can be easily addressed using the new OTi DALI 50/220-240/24 4CH DT6/8, OTi DALI 80/220-240/24 4CH DT6/8 and OTi DALI 160/220-240/24 2CH DT6/8 multi-channel LED drivers. In such drivers, the PWM impulses on each channel are generated

in order to not overlap each other during DT8 operation (see figure 6), enabling the LED driver to register only the maximum power at each channel and thus avoiding an over-designed LED driver selection.

Example 6 – desired CCT set to 5250 K

- To achieve this CCT, the WW channel has to be dimmed to 33 %, while the CW channel has to be dimmed to 67 %.
- The light output is the sum of the light output of each channel: 335lm/m for CW (dimmed to 66 %) + 165lm/m for WW (dimmed to 33 %) = 500lm/m. *Please note that in DT8 operations, the light output is controlled in order to be constant over the CCT range (indeed, this is the same output as in examples 4 and 5).*
- The power consumption is the sum of the power consumption of each channel, therefore: 37.5W for CW (dimmed to 67 %) + 12.5W for WW (dimmed to 33 %) = 50W.
- The load registered by the LED driver is 100W instead, exactly as in example 5, because the PWM impulses generated on both channels begin at the same time, requiring the driver to be able to provide, momentarily, an electrical power that is the sum of the maximum power of the two channels (50W + 50W = 100W). What has changed here is the number of impulses, in a given time, of the single channels: This number will be higher

for the CW in order to achieve the desired light output; and lower for the WW. This means that, although the average absorbed power in DT8 is 50W, because the load registered by the LED driver is 100W, a suitable 100W driver must be selected to be able to run this application. The issue hereby presented can be easily addressed using the new OTi DALI 50/220-240/24 4CH DT6/8, OTi DALI 80/220-240/24 4CH DT6/8 and OTi DALI 160/220-240/24 2CH DT6/8 multi-channel LED drivers. Exactly as in example 5, the PWM impulses on each channel are generated in order to not overlap each other during DT8 operation (see figure 6), enabling the LED driver to register only the maximum power at each channel and thus avoiding an over-designed LED driver selection.

As a final note, OTi DALI DIM 1-4 CH D doesn't have the same feature as OTi DALI 50/220-240/24 4CH DT6/8, OTi DALI 80/220-240/24 4CH DT6/8 and OTi DALI 160/220-240/24 2CH DT6/8. Therefore, the power evaluation in a DT8 operation must consider the nominal power of the LED module load at full power.

Figure 13: Power consumption by a TW LED strip with a DALI DT8 controller

DT8 TW: Power distribution per channel and in total @ max load / 100 % dimming

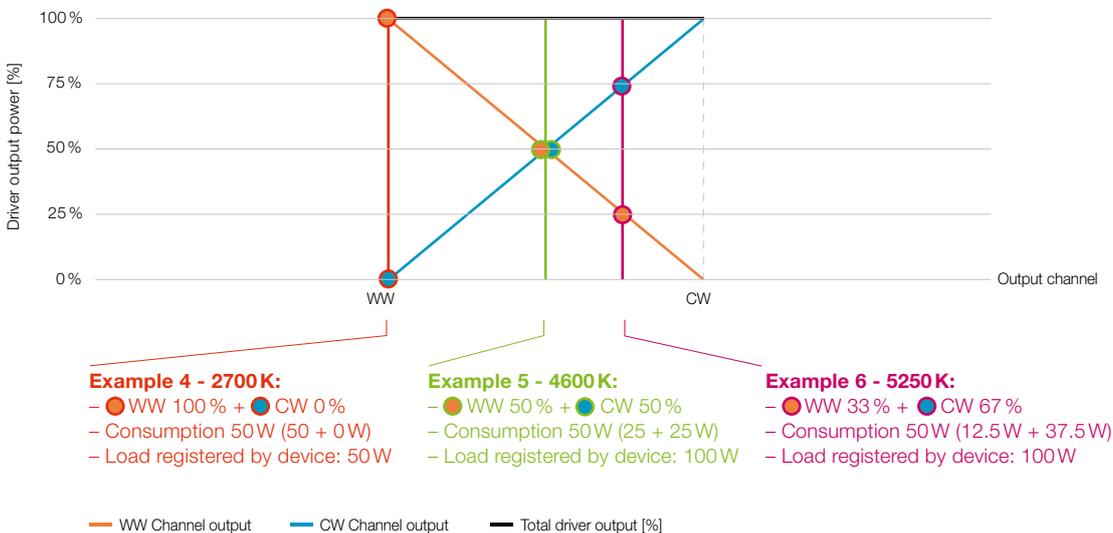


Figure 14: Luminous flux emitted by a TW LED strip with a DALI DT8 controller

DT8 TW operation: Luminous flux output @ max load / 100% dimming

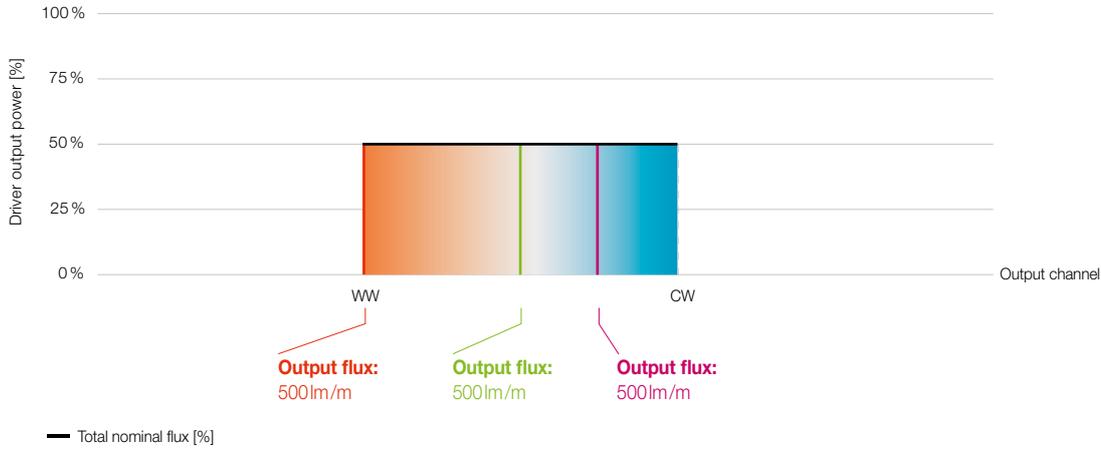


Figure 15: Power consumption of each channel by a TW LED strip with a general DALI DT8 LED driver

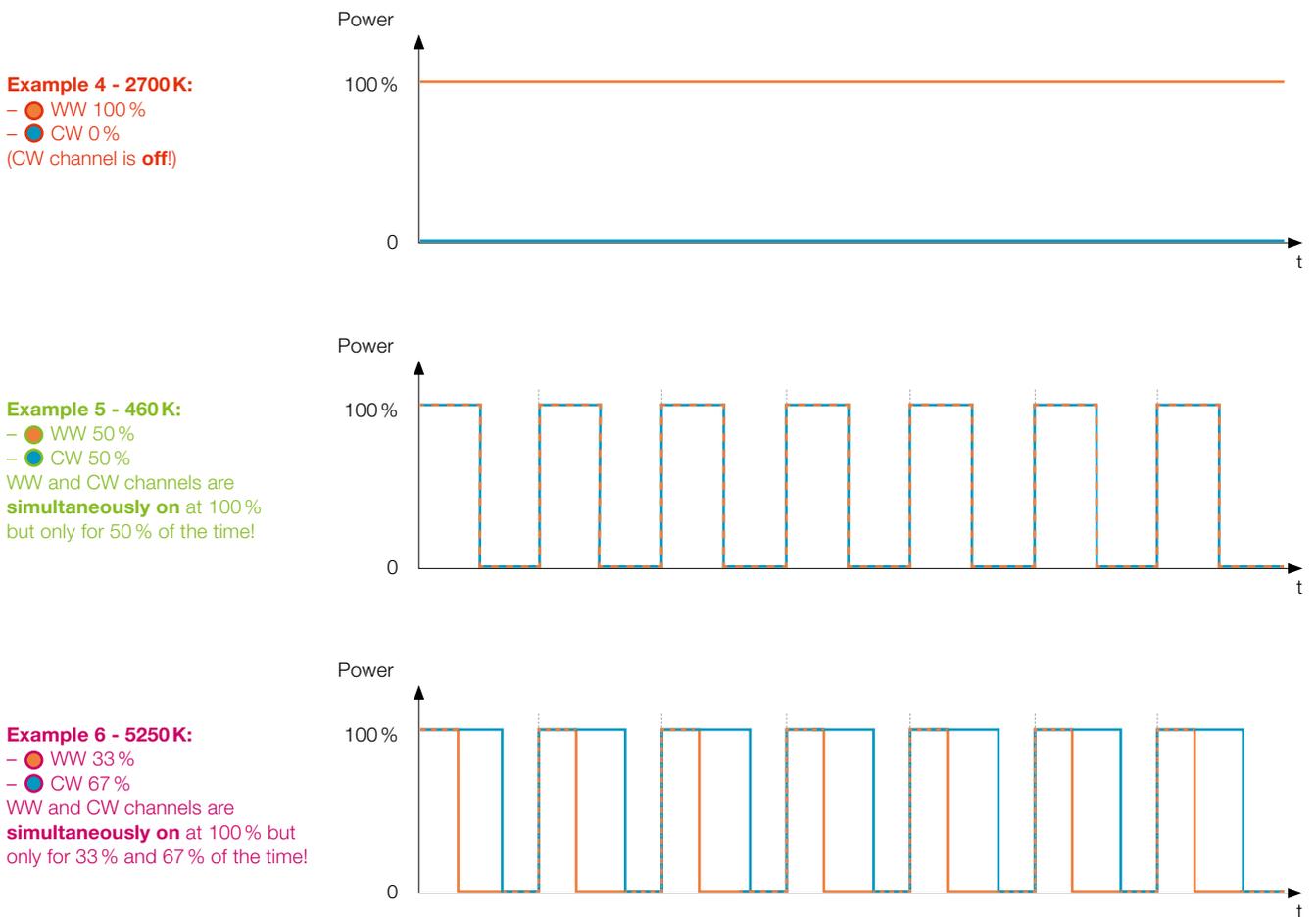
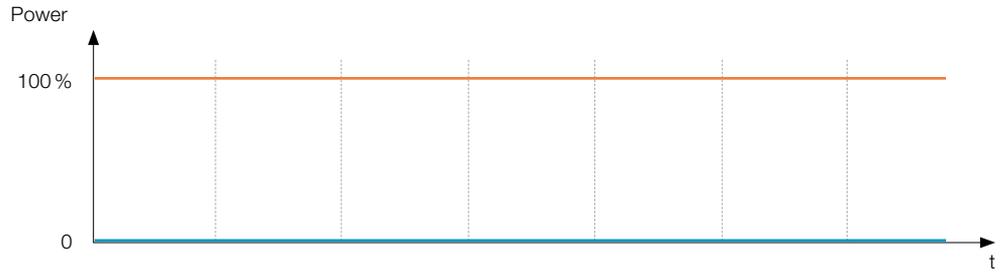


Figure 16: Power consumption of each channel by a TW LED strip when using OTi DALI 50-80/220-240/24 4CH DT6/8 and OTi DALI 160/220-240/24 2CH

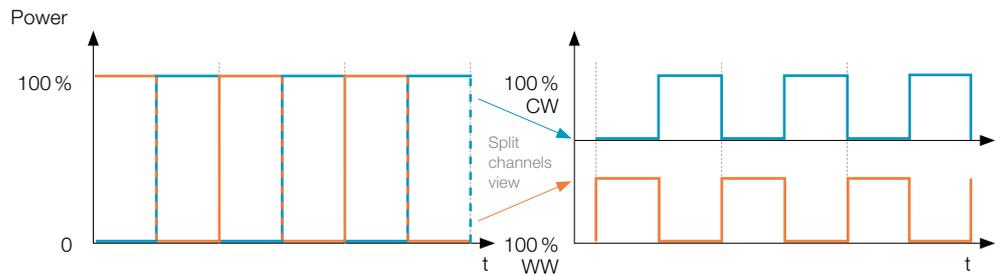
Example 4 - 2700 K:

- ● WW 100 %
 - ● CW 0 %
- (CW channel is **off!**)



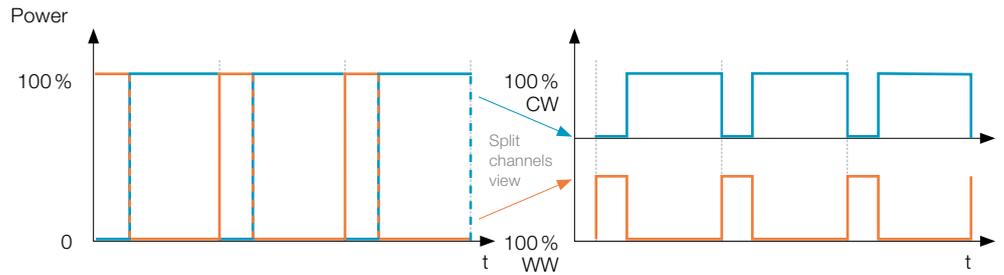
Example 5 - 4600 K:

- ● WW 50 %
 - ● CW 50 %
- WW and CW channels are never simultaneously **on** at 100% at the same time!



Example 6 - 5250 K:

- ● WW 33 %
 - ● CW 67 %
- WW and CW channels are never simultaneously **on** at 100% at the same time!



DMX

DMX is another digital control protocol. Originally, it was developed for use in stage and effect lighting applications. 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.

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.

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, eighth, 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).

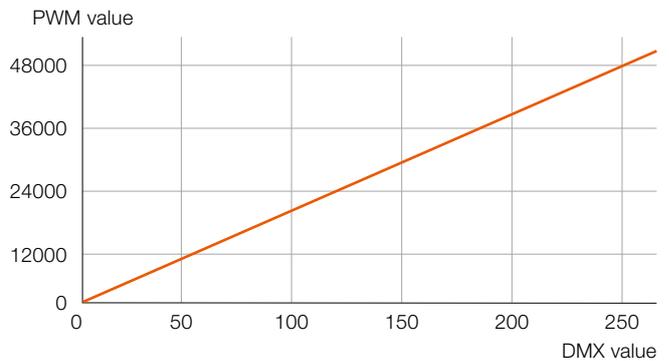
OSRAM offers DMX-compatible OPTOTRONIC® devices that can be controlled by a suitable DMX controller. DMX controllers are available in the market from several suppliers.

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.

OT DMX RGBW DIM dimmer implements a linear dimming technology, as shown in the next graph. The PWM resolution is 16 bit.

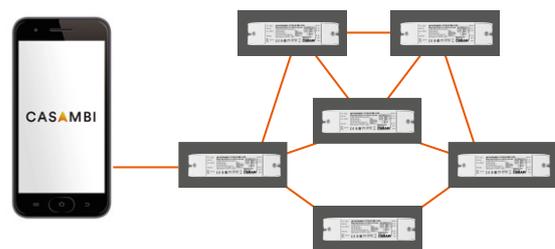
Figure 17: DMX and PWM correlation on OT DMX RGBW DIM



RDM

An updating of the DMX protocol introduced the RDM (Remote Device Management). It allows 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.

Figure 18: OT BLE wireless mesh network via Casambi



OT BLE DIM

OPTOTRONIC LED drivers and dimmers based on Bluetooth Low Energy (BLE) implement Casambi lighting control solution. Bluetooth Low Energy is a low-power wireless technology used in most of our devices (smartphones, tablets etc.)

Casambi technology implemented in OPTOTRONIC BLE devices permits an easy integration into LED drivers and a fast application set-up with minimal deployment costs.

OPTOTRONIC BLE drivers and dimmers are compatible with Casambi ecosystem.

OPTOTRONIC BLE drivers and dimmers use a mesh network where the intelligence of the system is replicated in every node, creating a system without single points of failure.

Such set-ups based on self-organizing wireless mesh networks enable the control of a large number of luminaires from several points. It also allows for firmware updates over the network, permitting any kind of changes to be made over the air.

Thanks to the distributed and symmetric system architecture, any unit can go offline and catch up from others when it comes back online.

An Internet connection is not necessary for normal operation. It is only required for user interface configurations to be sent or recalled from the cloud service (provided by Casambi).

For the end user, the Casambi app acts as:

- User interface
- Commissioning tool
- Remote gateway (optionally, in case Casambi cloud solutions are used)

The Casambi app works with iOS as well as Android mobile devices, such as smartphones, tablets etc. The app can be downloaded free of charge from Google Play and the Apple App Store. The minimum requirements for the usage of the Casambi app are specified in the respective app stores.

The OPTOTRONIC® BLE devices consist of a BLE dimmer and a dimmable driver, offering 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 240W LED load, they provide constant voltage to 4-channel outputs and can be connected to other OPTOTRONIC® BLE devices, creating a wireless mesh network seeing all Casambi-driven devices present in that network. In this way in your hand you have entire control of all lamps and sensors in your building, setting them with the brightness, temperature, color and option wanted.

Features of the OPTOTRONIC® BLE interface:

- Wireless 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, Tunable Warm White and DIM-to-Warm)
- 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 (on OTi BLE DIM)

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 in W, e.g. 160 for a total output power of 160 W (note that the exact values are specified in the datasheet).
- 3rd block
Nominal input voltage range, e.g. 220-240 for a 220-240V input range.
- 4th block
Output voltage or current on the output side, e.g. 24 for 24 V or 700 for a 700 mA LED driver.
- 5th block (optional)
1-4 CH or RGBW for 4 channel devices.
- 6th block (optional)
Additional information on:
 - Shape of device:
S: square, C: circular
 - Devices suitability for outdoor applications
E: exterior, P: protected (the IP rating can be found on the datasheet)
 - Dimming:
DIM: Device with dimming capability. Without DALI or DMX in the first block this indicates a device with 1...10V (or 10V max.) control input.

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 driver rated IP67 does not permit the ingress of dust (6x) and is protected against the effects of temporary immersion in water under standardized conditions of pressure and time (x7). IP20 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	Non-protected
1	Vertically falling water drops
2	Vertically falling water drops when enclosure tilted up to 15°
3	Spraying water
4	Splashing of water
5	Water jets
6	Powerful water jets
6K	Powerful water jets with increased pressure
7	Temporary immersion in water, up to 1 m
8	Continuous immersion in water
9K	Powerful high temperature water jets

For more details on IP rating, please refer to “Technical application guide – IP codes in accordance with IEC 60529 and external environment impacts” in the following OSRAM DS website section:

<https://www.osram.com/ds/app-guides/index.jsp>

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.

All OPTOTRONIC® LED drivers for constant-voltage LED modules have a double/reinforced insulation between the primary and the secondary side, providing a SELV output with galvanic insulation and additional safety features that minimize the risk of electric shock to the user.

OSRAM is testing the galvanic insulation of 100 % of production at 3 kV according to the safety standard requirements for SELV LED drivers.

The control port of dimmable LED drivers or dimmers is also insulated against the output, according to the safety standards with levels depending on the kind of control port.

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.

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

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
Voltage fluctuations and flickers	EC 61000-3-3	EN 61000-3-3

Immunity to interference and harmonic content is determined solely by the LED driver, 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 25W and over 25W. All OPTOTRONIC® LED drivers are designed and approved according to this standard.

Power factor correction

OPTOTRONIC® devices with an input power rated at 25W 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/optotronic>

2.6.2. Voltage fluctuations and flickers

Our OPTOTRONIC® devices comply with EN 61000-3-3 limits of voltage change fluctuations and flickers.

2.6.3 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.

2.6.4. Emissions (EMI)

OPTOTRONIC® LED drivers 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® LED drivers 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 LED driver. Especially primary and secondary cable lengths and routing may have a significant effect on radio interference.

Maximum cable lengths

OPTOTRONIC® LED drivers are tested and verified to be EMI compliant with secondary cable lengths of up to 50m (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 EMI external filters, e.g. 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 an excessive voltage drop caused by the 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.

Audible noise is potentially generated when heavy dimming operation is required to set the light output at the desired level. This often depends on incompatibility between the LED modules and the LED driver at a given operation setting. Changing the dimming setting will often let the noise disappear. Please see the product datasheets with regards to system matching and compatibility.

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 t_c point. The location of the t_c point and the specified maximum allowed temperature measured 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 an LED driver 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. The maximum permitted t_c for OPTOTRONIC® devices is specified in the technical data sheet on our website:

<https://www.osram.com/cb/products/index.jsp>

OPTOTRONIC® constant-voltage devices lifetime expectation as a function of t_c can be retrieved from downloadable technical datasheets on our website:

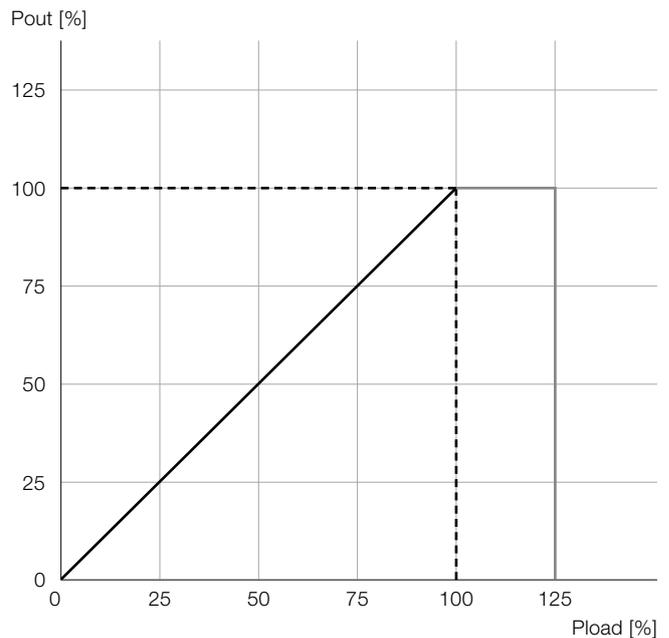
<https://www.osram.com/optotronic/>

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 within the maximum limit to prevent damages to the device or to the system. When the overload condition is removed (i.e. the connected load is reduced) the LED driver supply will continue to work regularly.

Figure 19: Output power during an overload



On DALI-controlled systems, in case of an overload situation, the current flow increases, but the system automatically dims the output so the average power remains at 100 % without exceeding this limit.

Exceeding the maximum rated load ($P/P_N > 1$) also bears the risk of overheating the LED driver which can also lead to a safety shutdown.

If an LED driver is shutting down due to an overload condition, the LED driver may go into 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 LED drivers.

Warning

Operating OPTOTRONIC® continuously above maximum rated power will reduce the lifetime of the LED driver 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 LED driver will cut off the output power. The LED driver will be fully operational again once the cause of the short circuit has been removed.

2.9.3 Over-temperature

An OPTOTRONIC® LED driver may become overheated due to high load operations, insufficient device cooling or because a close-by heat source is heating up the LED driver causing an excessive t_c .

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

When the LED driver 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 LED driver once the previous operational conditions that have led to overheating are still present. Should this be the case, the root source of overheating must be found and removed.

OSRAM's outdoor devices, according to ISO4892-2, are also protected against sun radiation (including issues caused by UV light).

Attention:

For safe and reliable operation and 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

The power consumption of LED modules is related to the ambient temperature. 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 LED driver.

To address this issue, OSRAM has developed the "Smart Power Supply" (SPS) feature, which, within certain limits, can automatically compensate the temporary increase in power consumption. Thanks to this feature, over-power conditions are managed by the OPTOTRONIC® LED drivers in order to guarantee optimum system reliability and thermal management even at these low temperatures. The "Smart Power Supply" feature does not impact the lifetime of these OPTOTRONIC® LED drivers.

Note:

Do not use the Smart Power Supply feature to intentionally overload an OPTOTRONIC® device, as this may reduce its lifetime or damage it. To avoid damages, please have a look at the user instructions and the online catalogue available on 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.

All these important system planning factors are discussed in the next sections of this chapter.

3.1.1 LED module selection

The very first step when 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 “Flexible Light Systems” section of the OSRAM website: 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 in addition to OPTOTRONIC® LED drivers.

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

Both the LED modules’ characteristics and the desired level of control are used for the selection of OPTOTRONIC LED drivers and dimmers best matching the application. Dimmers have also to be considered in planning a system because:

- They draw additional power from the LED driver. 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 cable length between the LED driver and the dimmer has to be considered as part of the maximum cable length to the LED load.
- The maximum current rating of a controller may furthermore limit the number of modules that can be connected to a controller and to an LED driver.

3.1.3 Total wattage

The overall installed power must be higher than the power absorbed by the connected LED modules and controllers.

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

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

- N_{\max}
Maximum number of LED modules that can be operated on one LED driver, rounded down (i.e. 18.8 becomes 18)
- $P_{N,\text{OPTOTRONIC}}$
Nominal power of the OPTOTRONIC® LED driver. This value can be found in the technical product data sheet (see our website: <https://www.osram.com/cb/products/index.jsp>)
- $P_{N,\text{module}}$
Nominal power of the connected LED module. The module wattage is specified in the data sheets of the LED module.

In case a controller is connected to the OPTOTRONIC® LED driver, the available power to drive the LED modules is reduced by the power absorbed by the controller itself. The power absorbed by the controller is specified in the device’s data sheet (see: <https://www.osram.com/cb/products/index.jsp>). The formula to be used in case a controller is connected is the following one:

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

The above calculation is a best-case scenario in case all LED modules could be evenly connected (in terms of absorbed power) to the LED drivers.

In a real-world application, the distance between the LED driver and the LED module and the cross-section of the cables may have an impact on the system configuration and therefore the quantity of drivers needed.

3.1.4 Maximum cable lengths

3.1.4.1 Maximum output cable length

Cable length on the secondary 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 to comply with IEC/EN 55015 is given in the technical product data sheet in our website:

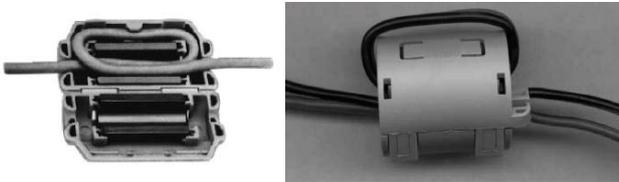
<https://www.osram.com/cb/products/index.jsp>

Please note that this is the maximum cable length between the LED driver and the LED modules and that this includes any dimmers and controllers that may be installed in between LED driver 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 (12V and 24V). 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 as a possible example.

Figure 20: Ferrite example



In any case, the 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 LED drivers

For constant-voltage LED drivers 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 $[\Omega/m]$). See table below for typical values of secondary cables.
V_{OT}	OPTOTRONIC® nominal output voltage as specified in the datasheet (i.e.: for OT SLIM 100/220-240/24, V_{OT} to be considered is 24.2V)
V_{LED}	Minimum input voltage of LED modules (i.e. for LF1200-G3-865-09 L2, it is 23V)
V_{DIM}	Voltage drop of OPTOTRONIC® dimmer (if used). A typical value is ~ 0.3V. Further information about the voltage drop of dimmers is available in the product data sheets.
P_{LED}	Total maximum wattage of the connected 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 for the calculation examples below.

Table 7: Typical resistance of secondary cables

Cable 1.5 mm ²		Cable 0.75 mm ²	
Ω [Ω/km]	$1/\rho$ [m/Ω]	ρ [Ω/km]	$1/\rho$ [m/Ω]
13.6	73.8	29.1	34.3

Example:

OTi DALI 80/220...240/24 1...4 CH, LFD400T-830 G1 06, 0.75 mm² cable

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

ELEMENT 60/220...240/24 G2, OT DIM, LF500-G1-840-10 L2, 1.5 mm² cable

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

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 EMI and voltage-drop requirements.

Wiring of LED systems as bus systems

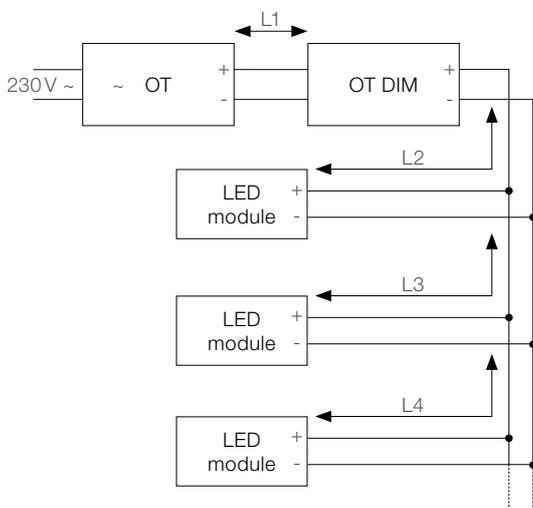
An extension of the maximum length of secondary cables may be possible if the LED modules are wired on a supply bus from which supply cables branch to the individual modules.

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 $L_2 = L_3 = \dots = L_n$):

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

Example of a bus system wiring

Figure 21: Bus wiring of LED modules



In this example the total length L_{total} of secondary cables is $L_{\text{total}} = L_1 + L_2 + \dots + L_n$

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 $L_{\text{total}} \ll L_{\text{max}}$.

3.2 Installation

3.2.1 Mounting requirements

3.2.1.1 Independent mounting

A selection of OPTOTRONIC® devices is equipped with built-in cable clamps as a strain relief and therefore suitable for independent installation. All other devices are intended for luminaire installation are not provided with a strain relief.

3.2.1.2 Outdoor mounting

Not all OPTOTRONIC® drivers are designed for use in outdoor applications. This is not the case for products marked with the extension P or E, which are designed for outdoor application and are available with higher IP protection. The IP protection for each product is always specified in the data sheets.

For a better understanding of IP codes in accordance to IEC 60529, please download the related technical application guide available on our website at this link: <https://www.osram.com/ds/app-guides/index.jsp>. For an overview of the IP protection offered by OPTOTRONIC® LED drivers, please see chapter “2.4 IP rating” in this technical application guide.

3.2.1.3 Mounting on wooden surfaces

OPTOTRONIC® LED drivers 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 . 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, use only recommended cables on the input and output side and on the control port where applicable. This guarantees that the cable is suitable for the electrical load and that the mechanical connection between the wire terminals and the cable clamp (when available) is safe and working properly.

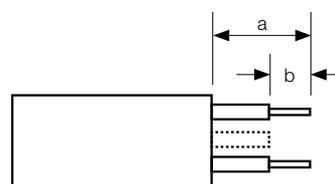
Recommended cables for input and output are specified in each product’s data sheets, which are listed on our website: <https://osram.com/optotronic>.

For additional information, please also check the user instruction sheets that are provided with the product packaging or that can be downloaded from the product landing page on our website.

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 15 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>, or the user instruction sheets to acquire additional product information.

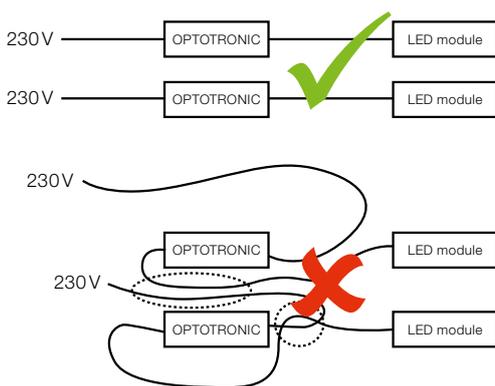
Figure 22: Recommended cable stripping



To ensure a good suppression of radio interferences 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. Position output cables away from earthed metal surfaces (if possible several cm) to reduce capacitive interferences.
3. Keep mains cables in the luminaire as short as possible to reduce interference.
4. Don't route mains cables too close to the LED driver (this applies in particular to through-wiring).
5. Avoid crossing mains cables and LED module cables.
6. Cables passing through metal components must never be left unprotected and should be installed with additional isolation (sleeve, grommet, edge protector, etc.).

Figure 23: Cable routing of OPTOTRONIC® and LED modules

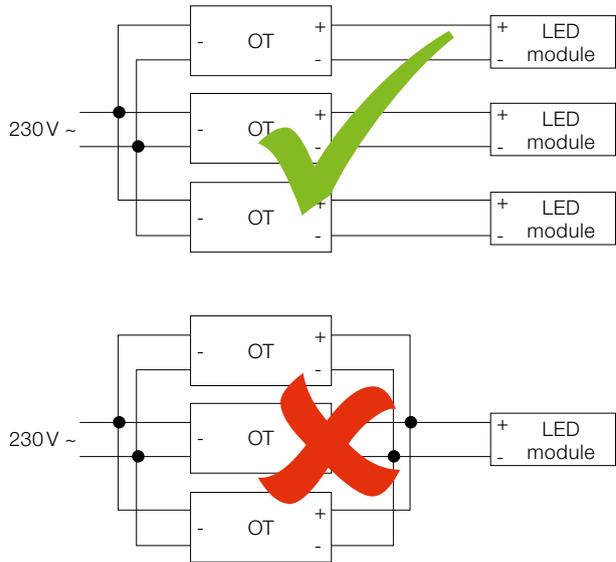


Dimming units on the secondary side, such as OT DIM, are usually not EMI-relevant.

3.2.2.3 Wiring limitations

LED drivers can be connected in parallel on the primary side. However, OPTOTRONIC® LED drivers cannot be connected in parallel on the secondary side as this may lead to unequal load distribution and overload of individual LED drivers. Series connection is also not permitted. See figure 17 for further visual details.

Figure 24: Parallel connection of OPTOTRONIC®



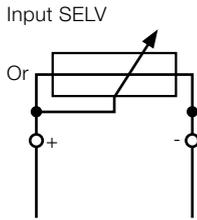
3.2.2.4 1...10V max. control port

OPTOTRONIC® drivers that are equipped with a 1...10 V control port are not intended to supply on such port standard 1...10 V devices due to possible isolation issues.

1...10V devices suitable to be controlled by OPTOTRONIC® drivers and dimmers must have double isolation between control port and their connection to line voltage, where present. For a connection with potentiometers such as OSRAM DIM MCU, please check the product user instruction.

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 information.

3.2.2.5 DALI wiring instructions

When choosing a cable for a DALI communication line, make sure that the voltage drop does not exceed 2 V at 250 mA. As for 1...10 V systems, the LED driver and the control line can use the same cable.

The maximum permitted cable length between the controller and the driver is 300 m in total. The recommended cable cross-sections are listed below (table 8).

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

Cable length	Up to 100m	100 to 150m	150 to 300m
Cable cross-section	0.5 mm ²	0.75 mm ²	1.5 mm ²

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 25: 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 during dimming, OPTOTRONIC® devices with a dimming feature should be installed on vibration blockers or dampeners.

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

When switching on a driver, a starting current pulse I_p of very short duration ($T_H < 1$ ms) is generated as the storage capacitor used for internal power supply is charged. When a large number of units are switched on simultaneously, a higher-than-expected level of current is requested that may lead to an automatic circuit breaker activation. 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 datasheet in our website:

<https://www.osram.com/cb/products/index.jsp>

The above-mentioned 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 (e.g. 120V to 277V or 220-240V AC) at 50 or 60Hz. Please refer to the datasheets available on our website: <https://www.osram.com/cb/products/index.jsp> for individual ratings of each LED driver.

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 0Hz 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 the same as for AC operation and must be verified by the luminaire manufacturer, in addition to EMI 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...10V

Control units for 1...10V devices are easy to install and operate. However, a few points should be considered when planning an installation:

1. Control wires must be connected with right polarity (+/-) and polarity must be maintained between devices.
2. All components of the main circuit and of the control circuit must be designed to withstand 250V 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...10V 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. For installation purposes use only cables and terminals approved for 230V.
5. The control voltage can be limited upwards and downwards; several controllers can be combined.
6. The 1...10V interface only allows for control of the dimming level in the OPTOTRONIC® driver, 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 (0,6mA, for calculation purposes this is typically assumed to be 1 mA) into the control wires and reduce the control voltage to 1V.

This requirement is fulfilled by a potentiometer dimensioned accordingly (see section “Potentiometer”) and by an OSRAM control gear used according to data sheet.

To verify that 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 1V. If a voltage higher than 1V 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 use cables with an isolation level according to the highest operating voltage used in the specific installation. Alternatively, each conductor in a multi-wire cable has to be isolated against the voltage present in the closer one.
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 related auxiliary circuits, may be combined.

Note:

- OPTOTRONIC® LED drivers 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 “10V 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...10V and 10V max. devices. When connecting more than two 1...10V and 10V max. units the installation of OSRAM's manual controller DIM MCU is recommended (see DIM MCU device 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:

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

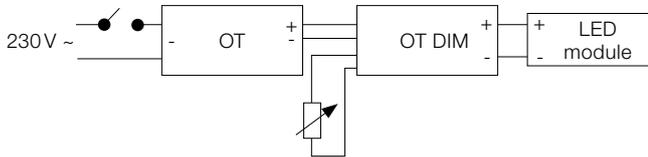
If the calculated value is not available, a potentiometer with higher resistance should be chosen. Otherwise it may not be possible to reach the full output power of the LED modules. To properly match the dimming characteristic of the OPTOTRONIC®, it may be necessary to limit the mechanical range of 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 $n \times 2.8 \text{ mW}$.

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

Figure 26: Dimming of OT DIM with a potentiometer



Note:

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

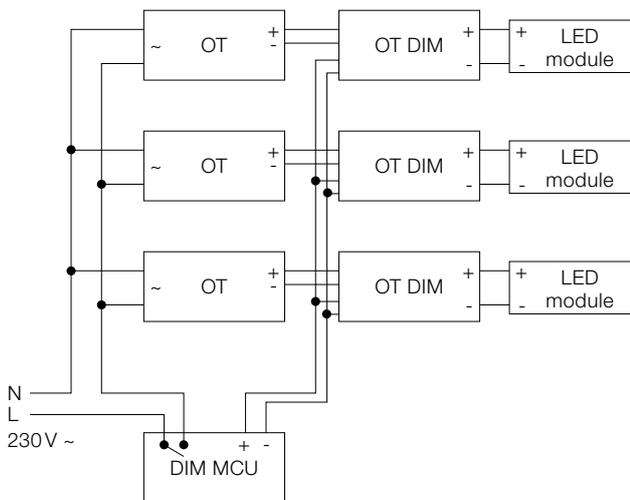
DIM MCU

When connecting more than two 1...10V 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 up to 50 electronic control gears (external load contact required).

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 27: Controlling multiple OT DIM with DIM MCU



Note:

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

3.2.7 Thermal management

OPTOTRONIC® LED drivers are designed for very high efficiency and reliable operation even at high ambient temperatures. Thermal management of these devices is nonetheless important and can greatly improve the lifetime of the LED drivers 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 LED driver 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't be done. Secondary-side switching is never allowed.

Please note that a dimmer device in stand-by operation between the OPTOTRONIC® LED driver and the LED modules is not considered as a secondary side switch, but a control unit, as even when the LED modules are completely switched off, the dimmer still has a small consumption fed by the OPTOTRONIC® LED driver.

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 DALI 210/220...240/24 1-4CH P
- OTi DALI 100/220...240/24 1-4CH P

4.1.2 Outdoor, 24V on/off



OT 20/220...240/24 P



OT 130/220...240/24 P



OT FIT 300/220...240/24 P

Available as:

- OTi 20/220...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
- OT FIT 80/220...240/24 P
- OT FIT 150/220...240/24 P
- OT FIT 200/220...240/24 P
- OT FIT 300/220...240/24 P

4.1.3 Outdoor, 12V on/off



OT 15/220...240/12 P



OT FIT 150/220...240/12 P

Available as:

- OT 15/220...240/12
- OT 30/220...240/12
- OT FIT 60/220...240/12 P
- OT FIT 150/220...240/12 P
- OT FIT 300/220...240/12 P

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



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, BLE



OTi BLE 80/220...240/24 1-4CH

4.2.2 Indoor, 24V, dimmable, DALI



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

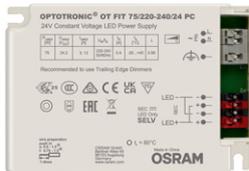


OTi DALI 160/220...240/24 1-2 CH

Available as:

- OTi DALI 50/220...240/24 1CH
- OTi DALI 50/220...240/24 4CH DT6/8
- OTi DALI 80/220...240/24 1CH
- OTi DALI 80/220...240/24 4CH DT6/8
- OTi DALI 160/220...240/24 1CH
- OTi DALI 160/220...240/24 2CH DT6/8

4.2.3 Indoor, 24 V, dimmable, phase cut



OT FIT 75/220-240/24 PC

Available as:

- OT FIT 36/220-240/24 PC
- OT FIT 75/220-240/24 PC
- OT FIT 150/220-240/24 PC

4.2.4 Indoor, 24V, on/off



OT 75/220-240/24

Available as:

- OT 6/200...240/24 CE
- OT 20/200...240/24
- OT SLIM 30/220...240/24
- OT SLIM 60/220...240/24
- OT SLIM 100/220...240/24
- OT SLIM 160/220...240/24
- OT SLIM 250/220...240/24

4.3 Dimmers



OT BLE DIM

Bluetooth mesh technology with Casambi system



OTi DALI DIM 1-4CH D

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 Abbreviations

AlInGaP:

Aluminium **I**ndium **G**allium **P**hosphate

DALI:

Digital **A**dressable **L**ighting **I**nterface

DMX:

Digital **M**ultiplex

RDM:

Remote **D**evice **M**anagement

ECG:

Electronic **C**ontrol **G**ear

InGaN:

Indium **G**allium **N**itride

IP:

Ingress **P**rotection

LED:

Light **E**mitting **D**iode

LMS:

Light **M**anagement **S**ystem

OT:

OPTOTRONIC®

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



Product that demonstrates compliance with United Kingdom 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 2 system



Dimmable with just a button



Dimming and changing CCT on TW applications with two buttons



Dimmable from 0.1 % to 100 %



Suitable for applications on wooden surfaces

Lambda λ Power factor

t_a Ambient temperature in °C

t_c Case temperature in °C

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