03/2024

Technical application guide
OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

OSRAM

Contents

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Technical application guide OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

1 Segmentation, families and features

OSRAM

Segmentation

Having become as popular as fluorescent ECGs, HID ECGs or electronic transformers, LED drivers fulfill similar requirements and thus allow for a highly efficient and reliable illumination in shops, offices and industrial areas. OSRAM constant-current indoor LED drivers are now split into three main segmentation families.

Family segmentation of OSRAM LED drivers

Family	Applications	Output type	Lifetime/Guarantee	Example features within the family
OPTOTRONIC **High performance**	- Standard - Premium - Specialized	- Very wide window - Programmable/LEDset	**Lifetime:** - Up to 100,000 hours **Guarantee:** - 5/8 years - 7/10 years (System guarantee)	- DALI/Wireless dimmable - Touch DIM - Data and Monitoring - Emergency Lighting (EL) - Tunable White - D4i - Constant Lumen - Near-field communication (NFC) - Low Ripple
ICUTRONIC **Mainstream**	- Standard	- LEDset/DIP switch*	**Lifetime:** - Up to 100,000 hours **Guarantee:** - 5 years - 7 years (System guarantee)	- DALI dimmable - Touch DIM** - Phase-cut dimmable - Emergency Lighting (EL) - Constant Lumen - Low Ripple
ELEMENT **Value for money**	- Low-cost	- Fixed current - Single/DIP switch	**Lifetime:** - Up to 50,000 hours **Guarantee:** - 3 years - 5 years (System guarantee)	- Low Ripple

*) Linear ETi DALI are also programmable window drivers

**) From 2nd generation drivers with the Touch DIM logo printed on the housing

The above is a general overview, but there are family-specific differences in the details. Within each family and sub-family, there can be a wide variety of key features. The Linear and Compact families generally differ slightly in some areas.

Compact (non-dimmable)

Product family	ELEMENT	IT FIT CS	OT FIT CS G3	OT FIT CS MINI	OT FIT LT2 LP	OT FIT NFC	OT FIT CS TRACK
Case format	Compact	Compact	Compact	Compact	Compact	Compact	Track
Family	ELEMENT***	IT FIT	OT FIT	OT FIT	OT FIT	OT FIT	OT FIT
Dimming	No	No	No	No	No	No	No
Features and performance							
Ripple (100 Hz) [%]	<5	<3...<5	<5	<3	<5	<5	<5
Output current adjustable [type]		CS	CS	CS	LT2	NFC	CS
Current tolerance [%]	±7.5 to ±10	±5 to ±10	±6.5 to ±7.5	±7.5	±5	±7.5	±7.5
Efficiency (up to) [%]	81 to 90	75 to 89	88 to 90	86 to 90	84 to 87	85 to 89	85 to 88.5
Constant Lumen Output (CLO)	No	No	No	No	No	No	No
Driver Guard	No	No	No	No	No	No	No
Emergency Lighting (EL)	No	No	No	No	Yes	No	No
Strain relief/Fly leads	Integrated	Integrated/ Clip-on	Clip-on	Integrated/ N/A	Clip-on	Clip-on	N/A
Lifetime [h]*	30,000/ 50,000**	50,000	50,000	50,000	50,000/ 100,000**	50,000/ 100,000**	50,000
T_a range [°C]	-20...+50	-20… +45/+50/+55	-20...+50	-20…+55/ +60	-20…+45/ +50	-20...+50	-20...+35
Suitable for luminaire class	I/II	I/II	I/II	I/II	I/II	I/II	N/A

* Operation at T_c max. -10,000 h, maximum failure rate of 10 %
** Operation at T_c max. -10 K, maximum failure rate of 10 %
*** All newer types

AM = Amplitude Modulation
PWM = Pulse Width Modulation
DT6 = DALI Device Type 6
CS = Current Setting

Compact (dimmable)

Product family	OTe PC	OT FIT PC G2	IT DALI CS	OTi DALI LT2	OTi DALI NFC	OTi DALI NFC I (sq)	OTi DALI NFC S + I	OTi DALI NFC LP (I)	OTi DALI TRACK
Case format	Compact	Compact	Compact	Compact	Compact	Compact	Compact	Compact	Track
Family	OTE PC	OT FIT PC	IT DALI	OTi DALI	OTi DALI	OTi DALI	OTi DALI	OTi DALI	OTi DALI TR
Dimming									
Type	PC	PC	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6
Hybrid dimming AM + PWM									
Lowest dimming level [%]	10	5	1	1	1	1	1	1	1
Features and performance									
Ripple (100 Hz) [%]	25...35	<5	<5	<1	<2...<3	<5	<2...<5	<2...<5	<5
Output current adjustable [type]	No	CS	CS	DALI/LT2	DALI/NFC	DALI/NFC	DALI/NFC	DALI/NFC	DALI/NFC
Current tolerance [%]	±10	±7.5 to ±10	±5	±3	±3	±5	±3 to ±5	±3	±5
Efficiency (up to) [%]	79 to 86	79 to 85	81 to 89	88 to 91	88 to 91	88 to 90	82 to 91	82 to 90	86
PMD (DALI -251, -252, -253)	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Touch DIM/Corridor Function	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes
DIM to Dark	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Soft Switch-Off	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Constant Lumen Output (CLO)	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Driver Guard	No	No	No	(Yes)	Yes	Yes	Yes	Yes	Yes
Emergency Lighting (EL)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strain relief/Flyleads	Clip-on	Integrated	Integrated/ Clip-on	Clip-on	Clip-on	Integrated	Integrated/ N/A	Integrated/ N/A	N/A
Lifetime [h]*	50,000	30,000/ 50,000**	50,000	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**
T_a range [°C]	-20...+55	-20...+50	-20… +45/+50	-20...+50	-20...+50	-20…+45/ +50/+60	-20...+50	-20… +45/+50	-20...+35
Suitable for luminaire class	I/II	I/II	I/II	I/II	I/II	I/II	I/II	I/II	N/A

(Yes) = Some versions

* Operation at T_c max., maximum failure rate of 10 %

** Operation at T_c max. -10,000 h, maximum failure rate of 10 %

AM = Amplitude Modulation
PWM = Pulse Width Modulation
DT6 = DALI Device Type 6
CS = Current Setting

Linear (non-dimmable)

Product family	EM FIT (SELV)	IT FIT CS (SELV)	OT FIT CS (SELV)	OT FIT NFC L (SELV)	EM FIT D (non-isolated)	IT FIT D CS (non-isolated)
Case format	Linear	Linear	Linear	Linear	Linear	Linear
Family	EM FIT	IT FIT	OT FIT	OT FIT	EM FIT	IT FIT
Dimming	No	No	No	No	No	No
Features and performance						
Ripple (100 Hz) [%]	<10	<5	<5	<4	<10	<5
Output current adjustable [type]	CS	CS	CS	NFC	CS	CS
Current tolerance [%]	±7.5	±7.5	±7.5	±3	±7.5	±7.5
Efficiency (up to) [%]	84 to 89	up to 87	85 to 87	87 to 90	88 to 92	87 to 93
Constant Lumen Output (CLO)	No	No	No	Yes	No	No
Driver Guard	No	No	No	No	No	No
Emergency Lighting (EL)	No	No	Yes	Yes	Yes	No
Lifetime [h]*	35,000	50,000	50,000	50,000/ 100,000**	35,000	50,000
T_a range [°C]	-20...+50	-25...+50	-25...+50	-25...+60	-20...+50	-20...+50
Suitable for luminaire class	I	I/II	I	I	I	I/II

Linear (non-dimmable)

Product family	OT FIT D (non-isolated)	OT FIT D CS (non-isolated)	OT FIT D LT2 (non-isolated)	OT FIT D LT2 UF (non-isolated)	OT FIT D NFC (F) (non-isolated)	OT FIT D IND (non-isolated)
Case format	Linear	Linear	Linear	Linear	Linear	Linear
Family	OT FIT	OT FIT	OT FIT	OT FIT	OT FIT	OT FIT
Dimming	No	No	No	No	No	No
Features and performance						
Ripple (100 Hz) [%]	<4...<10	<3...<5	<5	<1	<1	<1
Output current adjustable [type]	No	CS	LT2	LT2 / NFC	NFC	LT2 / NFC
Current tolerance [%]	±10	±7.5	±5	±5	±3	±3
Efficiency (up to) [%]	90	86 to 93	89 to 92	93	91 to 95	95 to 96
Constant Lumen Output (CLO)	No	No	No	Yes	(Yes)	Yes
Driver Guard	No	No	No	No	No	No
Emergency Lighting (EL)	Yes	(Yes)	Yes	Yes	Yes	Yes
Lifetime [h]*	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**
T_a range [°C]	-15...+50	-20...+50	-25...+60	-25...+60	-25...+60	-40...+70
Suitable for luminaire class	I	I	I	I	I	I

(Yes) = Some versions

* Operation at T_c max., maximum failure rate of 10 %

** Operation at T_c max. -10,000 h, maximum failure rate of 10 %

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DT6 = DALI Device Type 6
CS = Current Setting

Linear (dimmable)

Product family	ETi DALI (SELV)	OTi DALI LT2 (SELV)	OTi DALI NFC (SELV)	ETi DALI D (non-isolated)	OTi DALI D LT2 (non-isolated)	OTi DALI D NFC FL (non-isolated)	OTi DALI D UF (non-isolated)	OTi DALI D IND (non-isolated)
Case format	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear
Family	ETi DALI	OTi DALI	OTi DALI	ETi DALI	OTi DALI	OTi DALI	OTi DALI UF	OTi DALI
Dimming								
Type	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6	DALI DT6
Hybrid dimming AM + PWM	No	No	No	No	No	Yes	No	No
Lowest dimming level [%]	10	1	1	10	1	1	1	1
Features and performance								
Ripple (100 Hz) [%]	<3	<1	<3	<4	<1	<1	<1	<1
Output current adjustable [type]	DALI/LT2	DALI/LT2	NFC	DALI/LT2	DALI/LT2	DALI/NFC	DALI/LT2/ NFC	DALI/LT2/ NFC
Current tolerance [%]	±7	±3	±3	±5	±3	±3	±5	±3
Efficiency (up to) [%]	86 to 89	90	89 to 91	90 to 94	92 to 94	90.5 to 95.5	93	94 to 96
PMD (DALI 251, 252, 253)	No	(Yes)	Yes	No	Yes	Yes	No	Yes
Touch DIM/Corridor Function	No	Yes	Yes	No	Yes	Yes	Yes	Yes
DIM to Dark	No	(Yes)	Yes	No	No	Yes	No	Yes
Soft Switch-Off	No	(Yes)	Yes	No	No	Yes	No	Yes
Constant Lumen Output (CLO)	Yes	(Yes)	Yes	Yes	Yes	Yes	Yes	Yes
Driver Guard	No	(Yes)	Yes	Yes	No	Yes	No	Yes
Emergency Lighting (EL)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lifetime [h]*	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**	50,000/ 100,000**
T_a range [°C]	-25...+50	-20… +45/+50/+60	-20… +50/+60	-25 °C...+50	-20… +50/+60	-25 °C...+60	-20… +50/+60	-40… +65/+70
Suitable for luminaire class	I	I	I	I	I	I	I	I

(Yes) = Some versions

* Operation at T_c max., maximum failure rate of 10 %

** Operation at T_c max. -10,000 h, maximum failure rate of 10 %

AM = Amplitude Modulation
PWM = Pulse Width Modulation
DT6 = DALI Device Type 6
CS = Current Setting

Specialist

Product family	OTi DALI Tunable White	OTi DALI Tunable White	OTi DALI Tunable White	OTi DEXAL	OTi DEXAL	OTi DEXAL
Case format	Compact (SELV)	Linear (SELV)	Linear (non-isolated)	Compact (SELV)	Linear (SELV)	Linear (non-isolated)
Family	OTi DALI	OTi DALI	OTi DALI	OTi DX	OTi DX	OTi DX
Dimming						
Type	DALI DT6/8	DALI DT6/8	DALI DT6/8	DALI DT6	DALI DT6	DALI DT6
Hybrid dimming AM + PWM	No	Yes	Yes	No	No	Yes
Lowest dimming level [%]	1	1	1	1	1	1
Features and performance						
Ripple (100 Hz) [%]	<2	<1	<1	<3	TBC	<4
Output current adjustable [type]	DALI/NFC	DALI/NFC	DALI/NFC	DALI/NFC	DALI/NFC (LT2 TBC)	DALI/LT2/NFC
Current tolerance [%]	±3	±3	±3	±3	±3	±5
Efficiency (up to) [%]	85 to 90.5	88 to 90	90 to 91	88 to 91	89 to 91	90 to 93
PMD (DALI 251, 252, 253)	Yes	Yes	Yes	Yes	Yes	Yes
DEXAL = D4i (DALI 250-253)	No	No	No	Yes	Yes	Yes
Touch DIM/Corridor Function	Yes	Yes	Yes	No	No	No
DIM to Dark	Yes	Yes	Yes	Yes	No	No
Soft Switch-Off	Yes	Yes	Yes	Yes	Yes	Yes
Constant Lumen Output (CLO)	Yes	Yes	Yes	Yes	Yes	Yes
Driver Guard	Yes	Yes	Yes	Yes	Yes	Yes
Emergency Lighting (EL)	Yes	Yes	Yes	Yes	Yes	Yes
Strain relief/Flyleads	Integrated/Clip-on	N/A	N/A	Clip-on	N/A	N/A
Lifetime [h]*	50,000/100,000**	50,000/100,000**	50,000/100,000**	50,000/100,000**	50,000/100,000**	50,000/100,000**
T_a range [°C]	-25…+50/+60	-25…+50/+60	-25…+50	-25…+50	-25...+50/+60	-25…+55/+60
Suitable for luminaire class	I/II	I	I	I/II	I	I

(Yes) = Some versions

* Operation at T_c max., maximum failure rate of 10 %

** Operation at T_c max. -10,000 h, maximum failure rate of 10 %

AM = Amplitude Modulation

PWM = Pulse Width Modulation

DT6 = DALI Device Type 6

CS = Current Setting

Specialist

Product family	OTi DEXAL	OT Wireless intelligent	OT Wireless intelligent	OT Wireless intelligent	OT Wireless intelligent	OT FIT HC
Case format	Linear (non-isolated) IND	Compact (SELV)	Linear (SELV)	Linear (non-isolated)	Track	Linear/Horticulture
Family	OTi DX	OT Wi	OT Wi	OT Wi	OT Wi TR	OT FIT
Dimming						
Type	DALI DT6	QBM/Casambi	QBM/Casambi	QBM/Casambi	QBM/Casambi	No dimming
Hybrid dimming AM + PWM	Yes	No	No	No	No	No
Lowest dimming level [%]	1	1	1	1	1	N/A
Features and performance						
Ripple (100 Hz) [%]	<4	<3	<1	<1	<5	<1
Output current adjustable [type]	DALI/LT2/NFC	NFC	NFC	NFC	NFC	NFC
Current tolerance [%]	±3	±3	±3	±3	±5	(±5)
Efficiency (up to) [%]	93 to 95	87.5 to 88	89 to 90	92 to 94	86	96 to 97
PMD (DALI 251, 252, 253)	Yes	No	No	No	No	No
DEXAL = D4i (DALI 250-253)	Yes	No	No	No	No	No
Touch DIM/Corridor Function	No	No	No	No	No	No
DIM to Dark	No	Yes	Yes	Yes	Yes	No
Soft Switch-Off	Yes	Yes	Yes	Yes	Yes	No
Constant Lumen Output (CLO)	Yes	Yes	Yes	Yes	Yes	(Yes)
Driver Guard	Yes	Yes	Yes	Yes	Yes	No
Emergency Lighting (EL)	Yes	Yes	Yes	Yes	No	No
Strain relief/Flyleads	N/A	Integrated/N/A	N/A	N/A	N/A	N/A
Lifetime [h]*	50,000/100,000**	50,000/100,000**	50,000/100,000**	50,000/100,000**	50,000/100,000**	50,000/100,000**
T_a range [°C]	-40…+65/+70	-20…+45/+50	-25…+50/+60	-25…+50/+60	-20…+35	-25…+50/+70
Suitable for luminaire class	I	I/II	I	I	N/A	I

(Yes) = Some versions

* Operation at T_c max., maximum failure rate of 10 %

** Operation at T max. -10,000 h, maximum failure rate of 10 %

AM = Amplitude Modulation
PWM = Pulse Width Modulation
DT6 = DALI Device Type 6
CS = Current Setting

Product nomenclature

The various drivers have a logical naming structure which helps to easily identify the basic driver types and some key features. With these details, it is simple to quickly understand the driver concept and some capabilities.

OTi DALI 75/220-240/700 D NFC TW F L

Product segmentation

OT(i) OPTOTRONIC (intelligent)
IT/E Ti ICUTRONIC
EM ELEMENT

Product connectivity

Wi Wireless intelligent
DX DEXAL (D4i)
DALI
DIM (0)1...10V
PC Phase-cut
FiT Non dimmable (excl. PC types)

Power cluster

Input voltage ("typical" mains in territory)

Max. output current

Other features

FAN Integrated output for cooling fan
GX Generation "X"
MINI Extra small
CA Casambi
BL Qualified Bluetooth Mesh

Form factor

L Linear
S Short/"Square"
I Integrated cable clamp
T Track mount

Dimension/Height

UF UltraFlat
F Flat
LP Low Profile

Application

IND Industry
TW Tunable White
HC Horticulture

Programming

NFC Near-field communication
LT2 LEDset2
CS DIP switch/Wiring bridge

Isolation type

D Direct power (non-isolated)

Details of main driver features

CS

Current Selection: Simple output current setting by DIP switches
Using two or three DIP switches, the output current can be easily selected between several pre-set values.

LEDset: Simple current setting by resistor (LEDset2/R_{set})
LEDset2 is a multi-vendor LED module interface which allows to set the correct operating current for the LED module by resistor coding, without the necessity to reprogram the constant-current LED driver, if an LED module has to be replaced by a newer generation. This ensures optimal efficacy and the right amount of light at all times.

NFC: Fast and simple programming without mains voltage
In combination with OSRAM Tuner4TRONIC® software, LED drivers with NFC technology allow fast and contactless programming without connecting mains voltage during and after the luminaire manufacturing process. In the field optionally with the T4T-F app, which runs on mobile devices with an integrated NFC reader (ISO 15693) e.g. for specific outdoor LED drivers.

DALI/DALI-2 interface: For intelligent integration into building management systems
Almost all OSRAM DALI drivers now also meet the requirements of the DALI-2 standard. Any driver carrying the DALI-2 logo has been verified as conforming to this standard and is confirmed compliant by registration with the DALI Alliance (DA).

Optimization of the actual energy consumption: DALI standard part -252
Drivers with this feature provide the actual input power consumption of the device. By using these data, it is possible to visualize the current power consumption of the lighting installation in a light management system, without the manual entry of dimming level/power consumption tables for every light point. Reported data accuracy from the drivers is in line with the DALI-2 standard.

Data for predictive maintenance of luminaires and energy efficiency optimization: DALI standard part -253
LED drivers with this feature offer additional operation and status information that exceeds what is currently offered by the DALI standard (such as energy consumption, power, operating time, overvoltage or undervoltage etc.). By using these data, it is possible to offer predictive maintenance and an overall better lighting service. Moreover, it makes the light management system intelligent. Monitoring Data is an enhancement of the “Smart Grid” feature. The data can also be visualized in the Tuner4TRONIC® software.

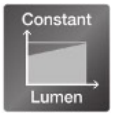
DEXAL: Smart intra-luminaire connectivity: DALI standard parts -250, -253, -DALI Alliance “D4i”
LED drivers with DEXAL® interface are the centerpiece of a digital ceiling that connects luminaires with integrated sensors and RF modules to set up a close-meshed, radio-based network. DEXAL® supplies RF modules and sensors with power and enables the bi-directional data exchange within the luminaire. Most LED drivers with a DEXAL® interface are now compliant to the DALI Alliance standard ”D4i”.

Touch DIM: Easy switching and dimming of up to 20 DALI drivers (may require activation by programming on some drivers)
In addition to the DALI feature, some OSRAM DALI LED drivers support Touch DIM® operation. With Touch DIM®, standard pushbuttons (suitable for mains power) can be used to switch and dim the lighting and save a desired brightness value. A maximum of up to 20 drivers is supported.

Corridor Function: Flexible lighting profiles for maximum convenience and security (may require activation by programming on some drivers)
The Corridor Function available for OSRAM DALI drivers allows configuration of a lighting profile over up to two levels. This defines the extent to which brightness values are retained when a person leaves the room. The brightness values and levels can be modified at any time using Tuner4TRONIC®. A typical area of application is the illumination of stairwells.

DIM to Dark: Dimming down to extremely low light levels
This feature allows dimming below 1 %, which enables steady dimming down to the final switch-off of the device. This feature is suitable for theatres, movie theatres or other special applications. For LED drivers with pure amplitude dimming, the minimal dimming value in percent is determined by the ratio of minimal output current to rated current. The actual possible minimum percent that can be achieved is determined by the physical minimum current of the driver.

Soft Switch Off: Smooth continuous dimming down to off
As soon as the device receives a switch-off command by a control interface (e.g. Touch DIM or DALI), this feature dims the device down to zero nearly logarithmically, and with pre-defined delay times. This function is supposed to simulate the behavior of traditional halogen lamps.

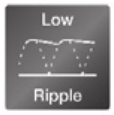


Constant Lumen: Function for improved maintenance cycles
To ensure the maintenance interval of the system, the light level must be achieved also at the end of the entire lifetime. Due to lumen depreciation of the light source over time, the system usually needs to be overpowered at the beginning, which leads to increased energy cost. This is not necessary thanks to the Constant Lumen function, as the operating output is adjusted continuously to compensate for the lumen loss.

Driver Guard: Flexible thermal management, adapted to the luminaire
By default, the internal protection mechanisms of the LED driver are designed for maximum temperature, however, not for those of the luminaire. By means of this feature, you can adjust the temperature derating of the LED driver so that it not only matches the luminaire, but also leads to a higher reliability of the luminaire.

Emergency Light (EL): Optional DC voltage detection
This feature ensures reliable operation in emergency installations in luminaires according to EN 605982-2-22 with central or group batteries. In addition to DALI-compliant functions, such as system failure level (disconnecting the control line), OSRAM DALI LED drivers with this feature offer the automatic detection of DC voltage supply. When DC voltage is detected, a pre-programmed luminous flux level between 0 and 100 % is implemented. Typically, the factory setting for indoor LED drivers is 15 %. This luminous flux value can be additionally protected from unintentional overwriting by setting a locking bit. The settings can be adjusted via the Tuner4TRONIC® software.

Permitted switching cycles
OPTOTRONIC® DALI LED drivers are specified for a minimum of 100,000 switching cycles. When switching 50 times a day, a minimum of five years of reliable operation is possible.



Low Ripple
High light quality and camera-proof light. The variability in the output current (typically at 100 Hz) is at very low levels (e.g. in the region of just +/-1 % to +/-5 %), resulting in excellent perceived light quality.

Industry driver
For reliable long-term operation in industrial areas. Longer lifetimes and enhanced robustness to supply surges, etc.

Window driver
Large operating window to reduce number of LED driver types in luminaire manufacturing and maintenance. Future-proof drivers for new LED generations. Output current adjustable via LEDset, resistor or Tuner4TRONIC® (software) and DALI magic or NFC wireless programming (hardware).

Fully analog dimming
Output dimming is carried out simply by reducing the driver current. This method avoids any possible "flicker" or "stroboscopic" effects in the application.

Hybrid Dimming
Amplitude dimming (between 100 and 30 % of the luminous flux) for high energy efficiency and PWM dimming (between 30 and 1 % of the luminous flux) for consistent light and light color even at lower dimming levels.

DALI Device Type 6 (DT6) and Device Type 8 (DT8)
These are drivers with the ability to be programmed as DT6 (conventional LED driver) or DT8 (multi-channel LED driver). Drivers set as DT8 allow one DALI address to control both brightness and correlated color temperature (CCT) when connected to appropriate Tunable White LED modules. The driver itself performs the necessary calculations to ensure the resulting output is as desired.

Accessories

Some compact indoor drivers can easily be retrofitted with suitable cable clamps, if required. This way, in case an independent installation is required, the same driver can be used with the additional cable clamp. For through-wiring, several "TL" versions are available.

In addition, track driver accessories are available to easily attach the LED module to the driver directly via a supporting rod.


CABLE CLAMP A-Style


CABLE CLAMP B-Style TL


CABLE CLAMP B-Style


CABLE CLAMP D-Style

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Technical application guide OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

2 Flexible current setting for window drivers via resistor, DALI and NFC

OSRAM

Current setting for window drivers via LEDset (R_{set}) interface

LEDset interface

Window drivers offer the adjustment of the LED module current in small current steps. Therefore, adjustment of the required LED module current is done easily via an external resistor (R_{set}).

LED⊳set

The LEDset interface is a standardized LED module interface for setting the right maximum output current and establishing an easy-to-implement and low-cost temperature protection for the connected LED modules.

Today, this interface is used by the majority of European manufacturers of LED drivers. The benefits of a LEDset interface are:

1. Very easy combination of LED modules and LED window drivers
2. Plug & play current setting of LED drivers
3. Same resistors/resistor values used across vendors
4. Standardized, future-proof solution

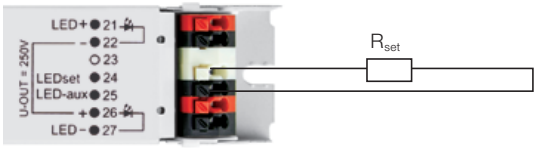
LEDset gives the possibility to manually set the LED current of LED window drivers without the need for additional programming. This multi-vendor interface is suitable for LED modules connected in parallel or series.

LEDset is based on a 3-wire connection between the LED driver and one or more LED modules. Only one additional wire, besides the two LED current supply wires, is used for transferring information from the LED module(s) to the LED driver, provided the R_{set} is mounted on the LED module. Alternatively, a standard resistor can be put directly into the driver's input connector (LEDset and LED-aux; see option 1).

Flexible current setting via LEDset mode (resistor)

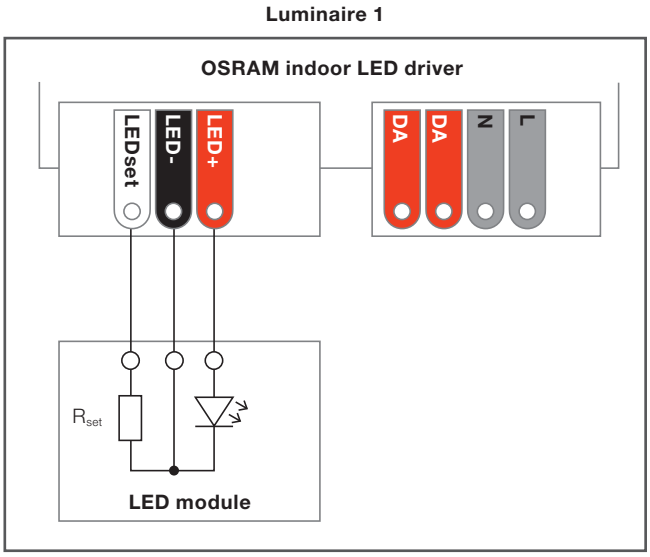
There are three options to place the resistor:

Option 1: Typically between LEDset and LEDset-aux

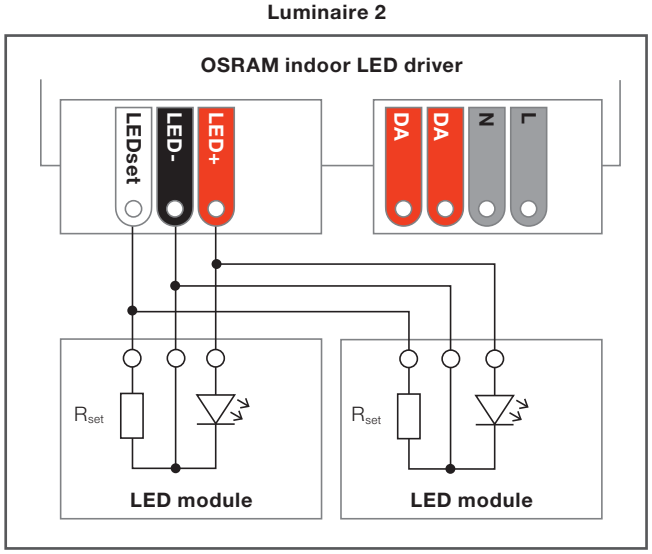


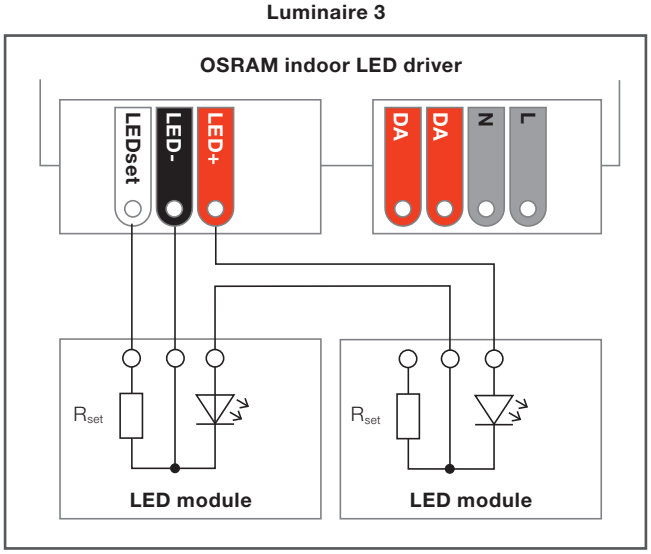
Option 2*: Alternatively between LEDset and LED-; LEDset-aux and LED- are connected/one potential

Option 3: On the LED module



Resistor on the LED module





OSRAM indoor LED driver connected to LED modules in parallel or in series

* For OTi (DALI) 60 and OTi (DALI) 90, option 2 is not recommended as it is not precise enough.

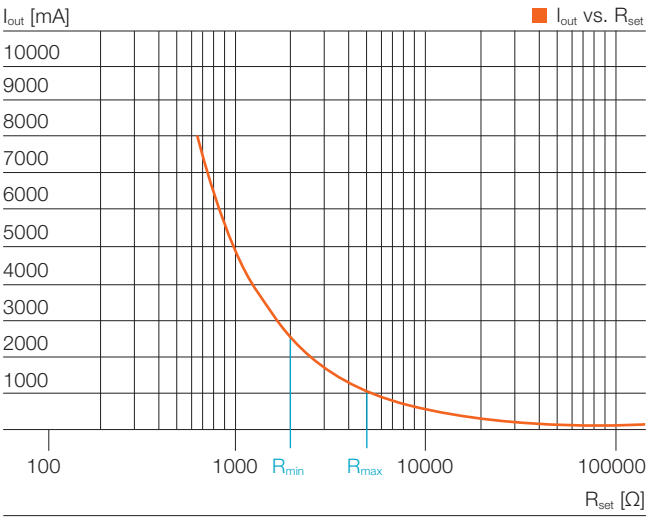
The LEDset interface works with a 5 V constant-voltage source within the LED driver. The LEDset interface measures the current that flows from the 5 V constant-voltage source through the R_{set} resistor(s).

Therefore, the correct LEDset resistor value can be calculated by the following formula:

R_{set} [Ω] = (5 V/I_{out} [A]) x 1000

The output current I_{out}, selected via the R_{set} within the valid LEDset range, must match the driving current of the LED module and the nominal current range of the used LED driver. In the above condition, the maximum nominal LED driver current I_{out_max} is set by the minimum R_{set} value (R_{set_min} = 5 V/I_{max} x 1000) and the minimum nominal LED driver current I_{out_min} is set by the maximum R_{set} value (R_{set_max} = 5 V/I_{min} x 1000). The interface behavior follows the table below.

LEDset characteristics



The figure above shows the standardized I_{out}/R_{set} curve. R_{min} and R_{max} depend on the individual LED window driver.

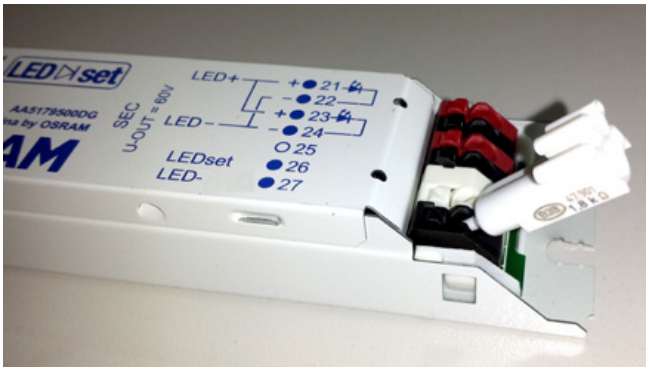
Interface behaviors

R_{set} selection	**I_{out}**
$R_{set} < R_{set\_min}$	For I_{out} behavior, see product datasheet
$R_{set\_min} < R_{set} < R_{set\_max}$	I_{out} [A] = $\frac{5\,V}{R_{set}\,[\Omega]}$ x 1000
$R_{set} > R_{set\_max}$	For I_{out} behavior, see product datasheet

In case that there is no R_{set} connected ($R_{set} > R_{set\_max}$), the factory default current is typically 50 % of the minimum nominal current or the minimum nominal current of the driver. As soon as the LED driver detects a resistor, the output current is adjusted according to the LEDset resistor coding.

Ready-to-use resistors are available from electronics distributors as well as BJB. For non-isolated LED window drivers, the terminals of the R_{set} are not isolated from mains, therefore an additional isolation is required.

Isolated resistor from BJB for non-isolated drivers

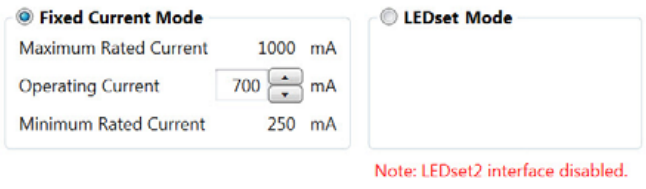


Current setting via programmable interface (Tuner4TRONIC®)

In the Tuner4TRONIC® software, the programming of the current is called “Fixed current mode”.

Fixed current mode (via programmable interface)
For LED drivers where additional parameter settings such as the CLO function can be programmed, current setting is done via a programmable interface to reduce luminaire manufacturing time.

To use the fixed current mode, it has to be selected in the Tuner4TRONIC® software. The minimum and maximum rated output currents are displayed according to the selected LED driver. The output current of the LED driver can be set by changing the value in the “Operating Current” field. Current setting is only possible within the specified current range.



Fixed current mode adjustment/LEDset mode disabled

For further details, please refer to the LEDset application guide, which can be downloaded at **www.inventronics-light.com/application-guides#control_gears_optotronic_indoor**

Default current setting mode (ex factory)
Window driver (ex factory):
As soon as the LED driver detects a resistor, the output current is adjusted according to the LEDset resistor coding.

When the window driver has been programmed in the fixed current mode, the LEDset mode remains disabled even if a resistor is connected.

Warning:
- Tuner4TRONIC® may be used by electrically qualified personnel **only**.
- For a reliably working LED system, the LED module current **must** be adjusted correctly:
  - Either via “Fixed current mode” with T4T
  - Or via “LEDset2 mode”, i.e. by using the correct LEDset resistor
- The maximum T_c temperature of the LED module must not be exceeded during the ajustment.
- **Wrong** currents or currents **accidentally set too high** result in too high temperatures in the LED module and may, at worst, lead to a **combustion of the LED module**.

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3 DALI dimming curves (power consumption depending on dimming level)

OSRAM

DALI dimming curves

IEC 62386 defines the dimming range of a DALI controller from 0.1 to 100 %.

The dependance of the relative luminous flux X (n) on the digital 8-bit DALI value n is described by the following correlation:

$$X(n) = 10^{\frac{n-1}{253/3}-1} \%$$

Where the following applies:

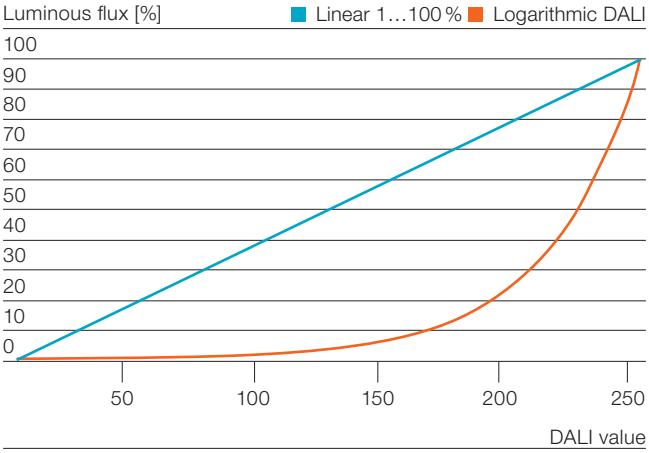
$$\left|\frac{X(n) - X(n+1)}{X(n)}\right| = 2.8\,\% = Const.$$

This results in the following graphical association:

- Logarithmic curve (factory setting) used for standard applications (e.g. daylight control)
- Linear curve: LED drivers according to IEC 62386-207 and other drivers such as OTi DALI additionally provide a linear dimming curve, which is only used in special cases, particularly for easier adjustment of RGB colors in RGB dimming applications

Switching between the curves is possible with Tuner4TRONIC®, DALI Wizard or other tools.

Logarithmic and linear DALI dimming curve



Short overview of the most important DALI dimming values

Luminous flux [%]	Logarithmic	Linear
0	0	0
0.1	1	–
0.5	60	1
1.0	**85**	**3**
3	126	8
5	144	13
10	**170**	**26**
20	195	51
30	210	76
40	220	102
50	229	127
60	235	153
70	241	178
80	246	203
90	250	229
100	254	254

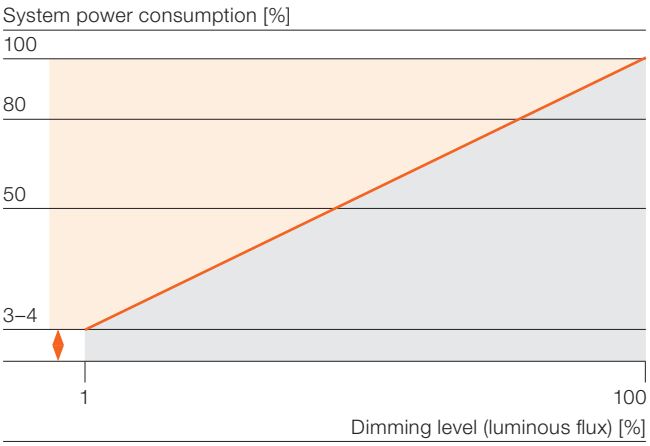
In first estimation, the luminous flux corresponds to the relative electrical power that the LED driver delivers to the LED module. In principle, the DALI standard defines 0.1 % as the lowest luminous flux, which corresponds to the relative DALI value 1. Not all DALI drivers can dim down to 0.1 %. To ensure that the transitions from one digital level to the next are not visible, our DALI drivers feature digital “smoothing”. This is an additional function of OTi DALI drivers for increasing lighting comfort and is not part of the DALI standard.

System energy consumption and dimmer setting

Because there is an approximately linear relationship between the power consumption of the DALI-DIM systems (LED module and driver) and the dimmer setting, the power consumption PN(d) can be calculated for each dimmer setting d (in percent) based on the values PN100% (100 % of nominal power, PN = Power Nominal) and PN1% (1 % of nominal power):

$$PN(d) = PN1\% + \frac{PN100\% - PN1\%}{99\%} \bullet (d - 1\%)$$

Linear correlation: Dimming level and system power consumption



Dimming range and lowest dimming level of a DALI LED driver

For the permitted dimming range and the lowest dimming level of a DALI LED driver, please refer to the corresponding product datasheets.

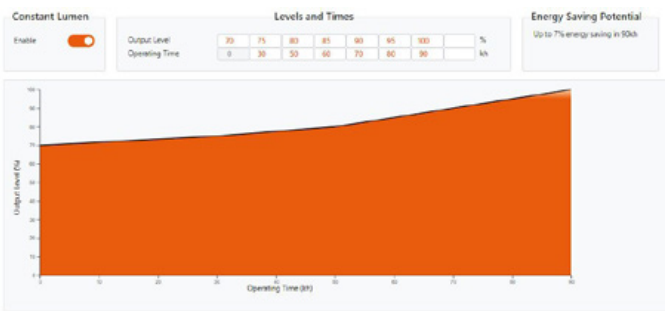
CLO (Constant Lumen Output) function

The CLO function can be used to compensate the lumen decrease over the lifetime of the LED. To achieve a constant light output of the LED module, the LED driver can store the operating hours of the LED module and increase the output current to react on the light output drop. The benefits are:

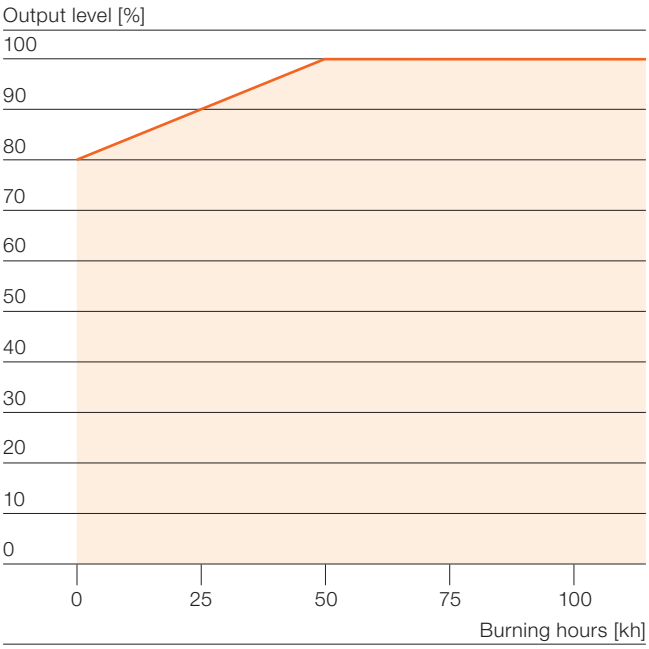
- Energy and cost savings
- Longer lifetime of the LED module
- Same light output und same light color over the lifetime of the luminaire
- Better maintenance due to group change of LED modules

To set this feature according to the applied LED module, the Tuner4TRONIC® software can be used, for example, as shown in the figures below.

Constant lumen programming table



Constant lumen programming graph (operating time = 10 kh)



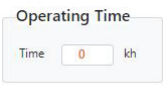
The output levels have to be monotonically increasing from the beginning.

Warning: The output level is indicated as a red number if the level is set higher than 100 %. In this case, the reliability and safety of the module needs to be checked if the nominal operating current is exceeded. It is not possible to achieve a higher output current than the maximum nominal output current of the LED driver.

Lamp operating counter

The LED driver monitors the operating hours of the connected LED module. Operating hours are only counted when the LED module is powered. The lamp operating time also has an influence on the CLO function. It can be set using the Tuner4TRONIC® software as shown in the figure below.

(Lamp) Operating time



For more details, see the Tuner4TRONIC® manual.

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4 Touch DIM® and corridor function for OPTOTRONIC® DALI

OSRAM

Touch DIM® – light dimming with standard push-buttons

With the Touch DIM® operation, smaller installations can be realized without a DALI controller.

When dimming with commercially available mains-compatible push-buttons, a fixed dimming value can be stored. For this, the push-buttons just have to be connected to the DALI drivers (see below).

Please note:
Touch DIM® operation is only avalible with DALI drivers marked with the Touch DIM® logo!

Touch DIM® operation

- Switch the light on/off: Short press (< 0.5 s)
- Dim the light: Long press (> 0.5 s), the dimming direction is changed with each press
- Store the reference value: Double-click (press twice within 0.4 s) when the light is on
- Delete reference value: Double-click when the light is off

Note: Long press when the light is off: The LED module is switched on at the minimum dimmer setting and faded up until the switch is released.

Operating modes of Touch DIM® function

OSRAM OTi DALI LED drivers offer 2 operating modes for Touch DIM® operation. They differ in terms of switch-on behavior.

- **Touch DIM® mode 1*** (default mode): The switch-on value is always the last dimming level before the light was switched off. After a mains voltage interruption, you get the same light level like before.
- **Touch DIM® mode 2:** The switch-on value is stored by double-clicking. After a mains voltage interruption as well, the DALI drivers dim to the stored light value. This means, after a short press of the push-button, the DALI drivers dim to this stored light value.

Switching between modes 1 and 2

Touch DIM® mode 1 is activated by double-clicking when the light is switched off. You can switch to mode 2 by double-clicking when the light is switched on.

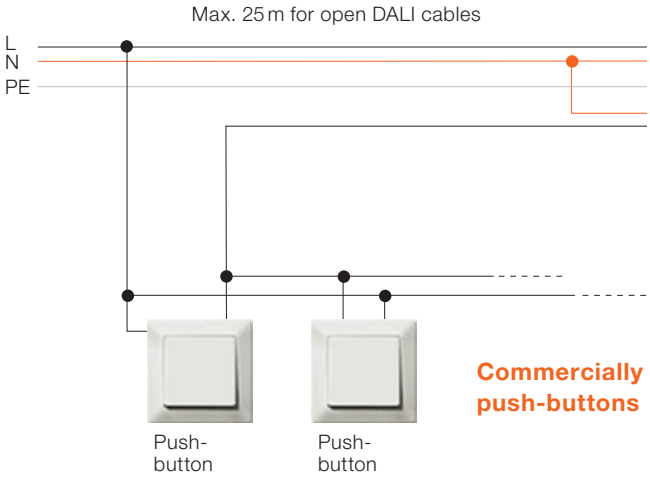
*** Note:**
Because of the different behaviors of QUICKTRONIC® QTi DALI and OPTOTRONIC® OTi DALI, they should not be dimmed with the same push-button.

Touch DIM® settings including controls and operating modes can be easily customized with the Tuner4TRONIC® software.

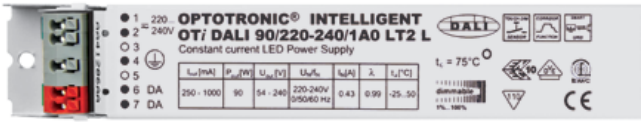
Touch DIM® installations for max. 20 DALI drivers and up to 25 m cable length

By just using simple standard push-buttons, i.e. without additional DALI controllers, the Touch DIM® function allows the dimming of up to 20 drivers with a total open DALI cable length of up to 25 m.

OPTOTRONIC® Intelligent DALI (< 25 m cable length)



Commercially available push-buttons



DALI driver
Dimmable 1…100 %

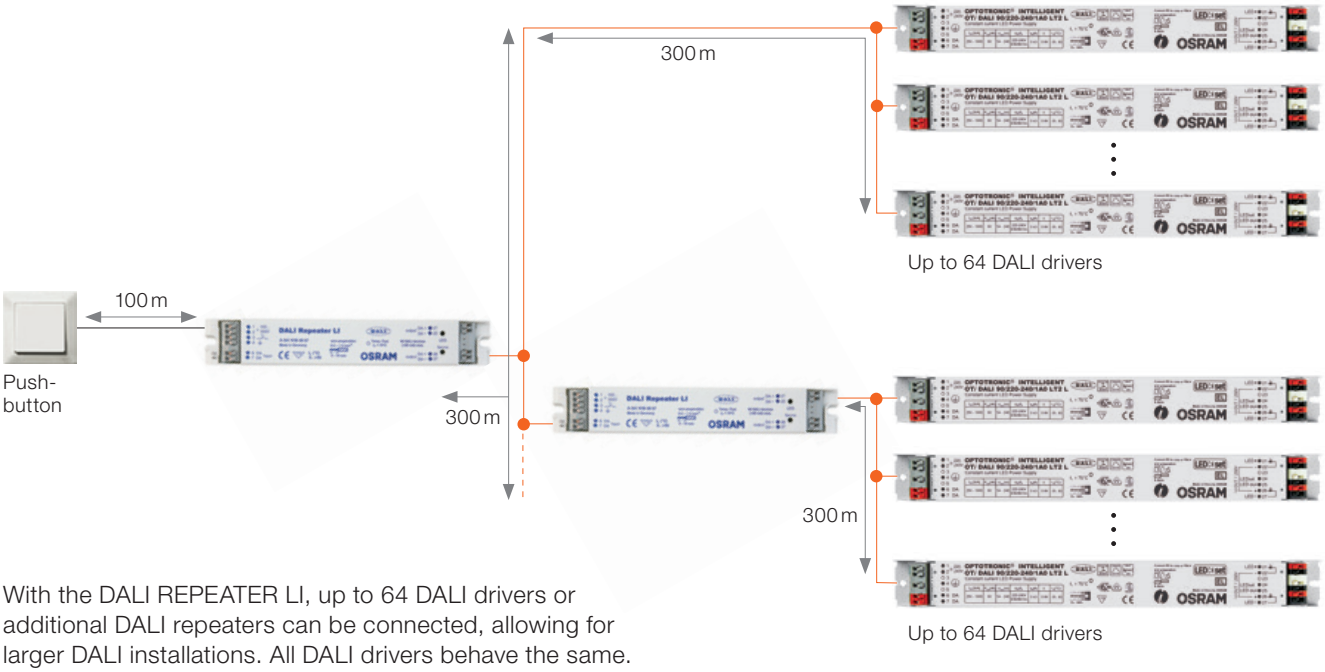
The total length of all wire connections must not exceed 25 m.
For cable lengths of more than 25 m, please use a DALI repeater.

Touch DIM® installations with more than 25 m cable length with DALI repeater

For reliable synchronous dimming in Touch DIM® operation even with an open DALI wire length of more than 25 m, we recommend the use of a DALI repeater. With a DALI repeater, reliable synchronous dimming is even possible for larger distances and a large number of DALI drivers. On the output side of the DALI repeater, DALI commands are sent to the individual DALI drivers. Due to the fact that these DALI commands go to all connected DALI drivers, all DALI drivers behave the same.

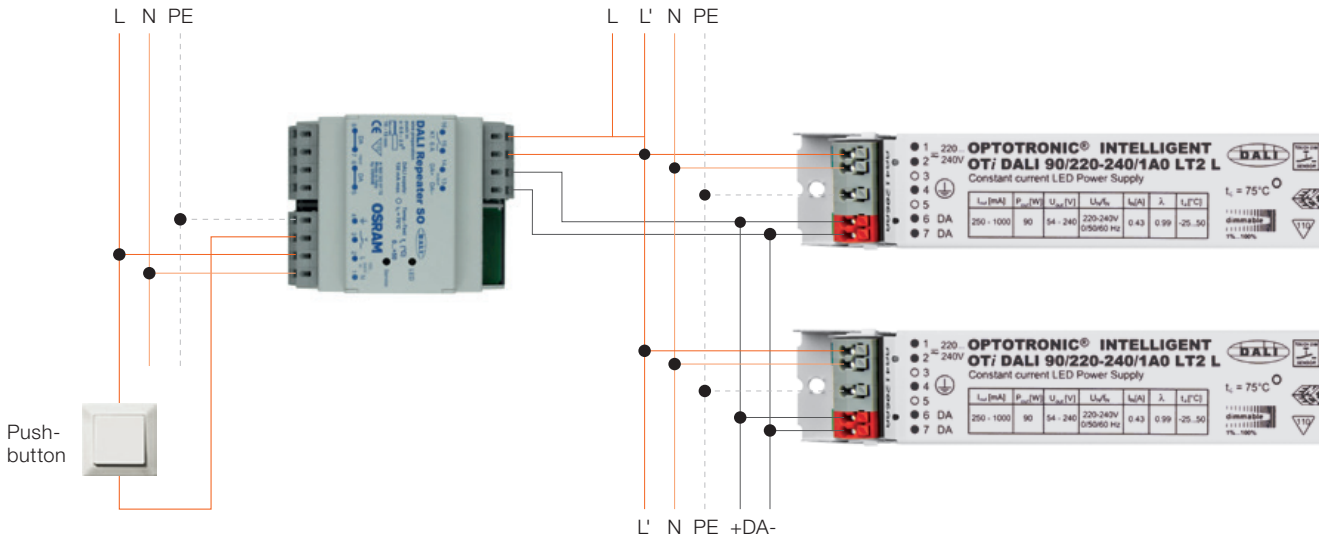
We offer two types of DALI repeaters:
- DALI REPEATER LI – version for luminaire integration
- DALI REPEATER SO – snap-on version with stand-by switch-off possibility

DALI REPEATER LI for luminaire integration



With the DALI REPEATER LI, up to 64 DALI drivers or additional DALI repeaters can be connected, allowing for larger DALI installations. All DALI drivers behave the same. Several push-buttons can be connected in parallel on the input side. The maximum permitted cable length is 100 m.

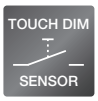
DALI REPEATER SO with stand-by switch-off possibility



→ The stand-by consumption of the connected luminaires is automatically switched off

The benefit of the snap-on version DALI REPEATER SO is the possibility to switch off the stand-by losses in DALI installations with only a few burning hours and long stand-by times. Especially in larger DALI installations, this has a positive impact on the consumed energy in kWh.

Touch DIM® Sensor – effective daylight and presence detection



The optional Touch DIM® Sensor enhances the Touch DIM® function with daylight harvesting and presence detection, which is fully customizable by the user.

Daylight harvesting: The user can simply set the desired lighting level with a push-button. The more natural light is available, the less artificial light will be added.

Touch DIM® Sensor operation

- Adjust lighting level: Long press when light is on
- Set lighting level: Double-press when light is on at desired level

Presence detection: In order to improve energy saving, the light is switched off, if nobody is present, after an adjustable delay time (using Tuner4TRONIC®).

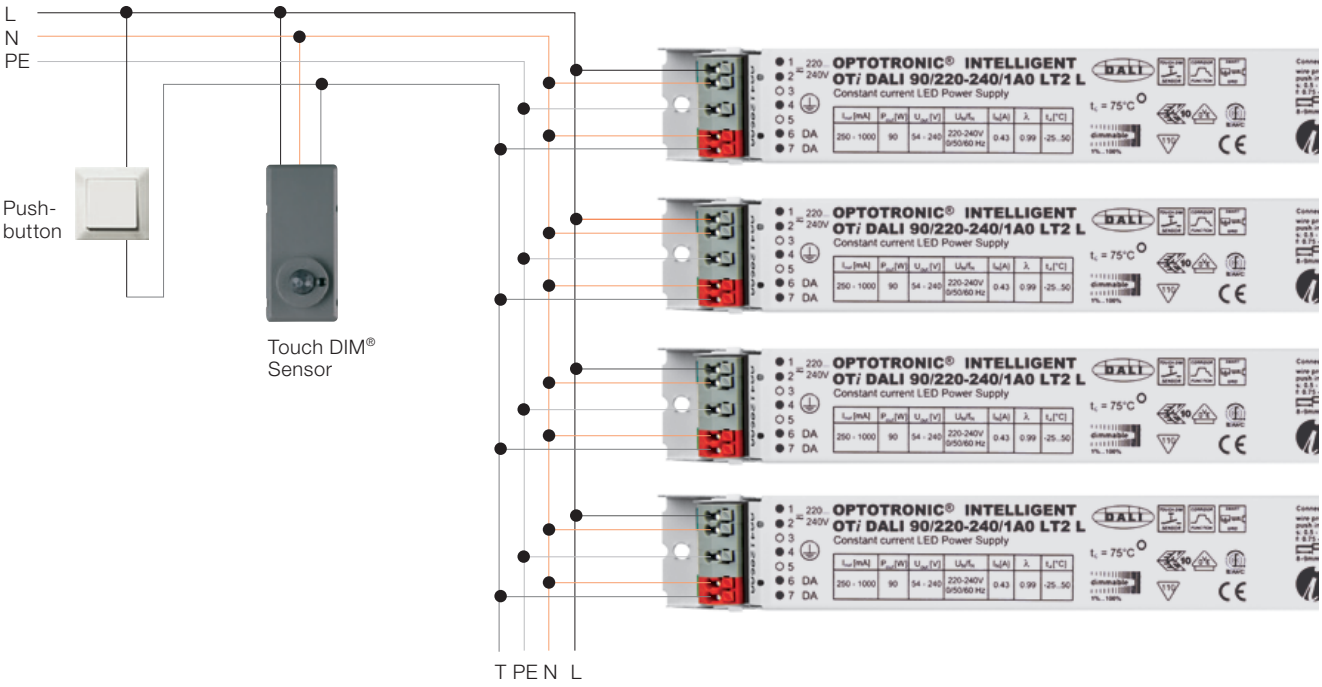
Operating mode with Touch DIM® Sensor

Touch DIM® Sensor operation is a special “control” mode (not mode 1 or 2 of the pure Touch DIM® operation without sensor).

Note: For detailed instructions, please refer to the Touch DIM® Sensor user manual.

With 1 Touch DIM® Sensor, up to 4 DALI drivers can be controlled.

Daylight- and presence-dependent control with Touch DIM® Sensor



Behavior of DALI LED drivers after a mains voltage interruption in Touch DIM® Sensor mode

In any case, the light switches on reliably. If no motion is detected, the light switches off after 15 minutes.

Especially after a mains voltage interruption, there are differences in Touch DIM® Sensor operation of QTi DALI GII ECGs and OTi DALI drivers:

- OPTOTRONIC® Intelligent (OTi) DALI drivers always switch on the connected LED load and start the control mode again.
- QUICKTRONIC® Intelligent (QTi) DALI GII ECGs, however, continue with the last DALI value before the mains voltage interruption (if mains output level = 255).

This means in consequence for mains output level = 255: switch-on of OTi DALI luminaires after a mains voltage interruption and no switch-on of QTi DALI GII luminaires.

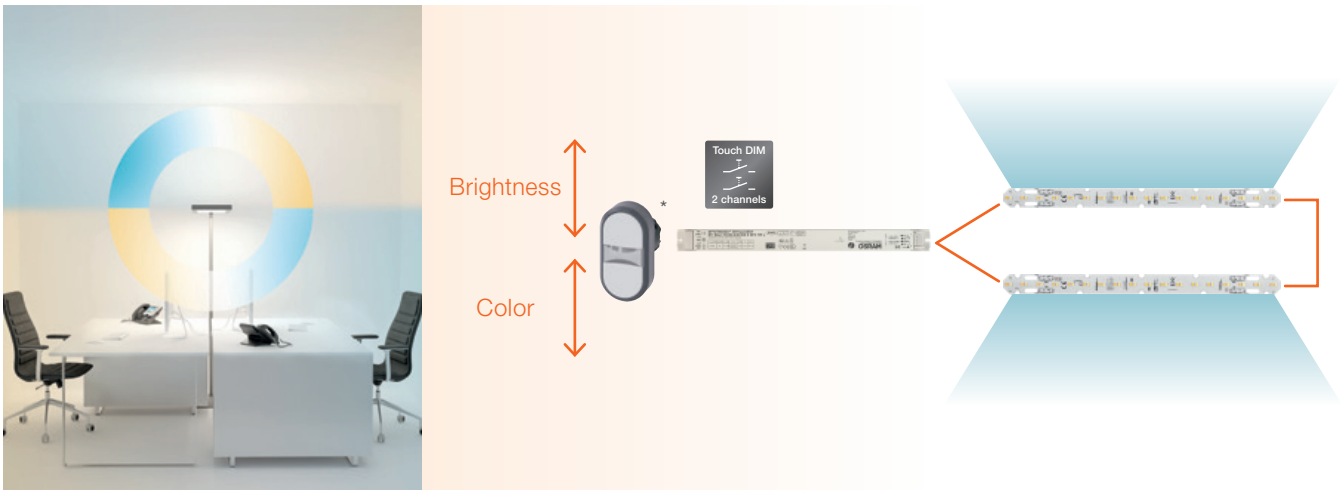
Touch DIM® Sensor settings including controls and operating modes can be easily customized with the software DALI Wizard or Tuner4TRONIC®.

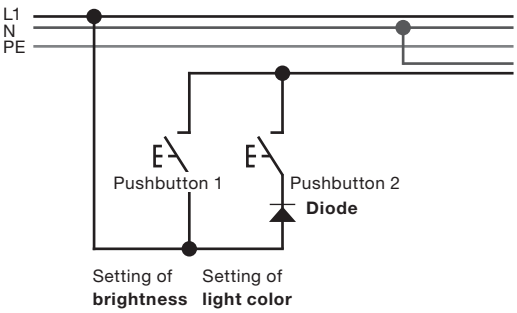
Easy color and brightness control: Touch DIM TW

The functionality Touch DIM TW allows for the intuitive manual dimming, switching and adjusting of brightness and color temperature via double pushbutton. It is particularly suitable for floor-standing luminaires (with integrated pushbuttons) and similar applications.

To use Touch DIM TW, the Tunable White LED driver has to be configured with the software Tuner4TRONIC® in the operation mode "**Tunable White-Touch DIM**".

The maximum length of the control line is 3 m. Brightness and color are stored by double-clicking the corresponding pushbutton.

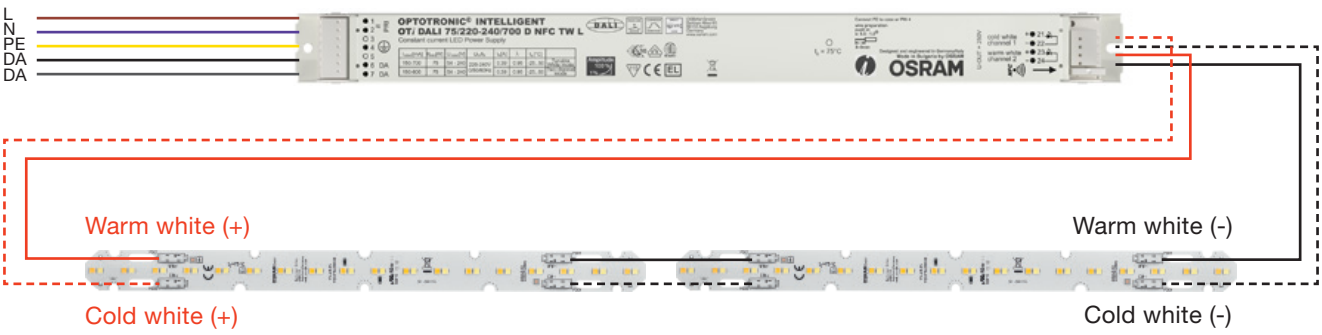




OSRAM OTi DALI ... TW
Dimmable 1...100 %

Diode:
V_{rated} ≥ 700 V, e.g. 1N4007
To be connected in any polarity in series to the pushbutton.
Clearance and creepage distances must be taken into account when installing the diode.

General wiring of the TW driver with OSRAM TW modules

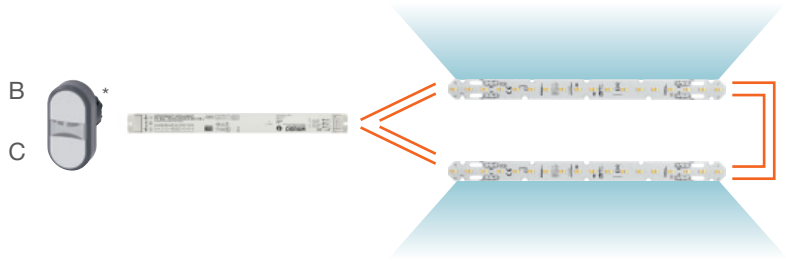


Typical applications of floor-standing luminaires

a) 2 two-color LED modules
1 double pushbutton with 1 diode
1 TW driver

Joint control of brightness and color of direct and indirect light (direct and indirect light synchronized)

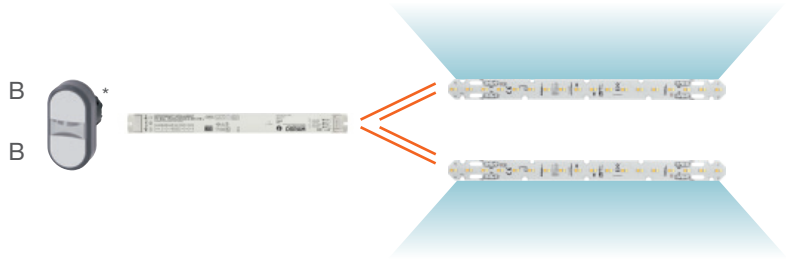
B = Brightness/C = Color



b) 2 single-color LED modules
1 double pushbutton with 1 diode
1 TW driver

Separate control of indirect and direct light – only brightness, no color adjustable

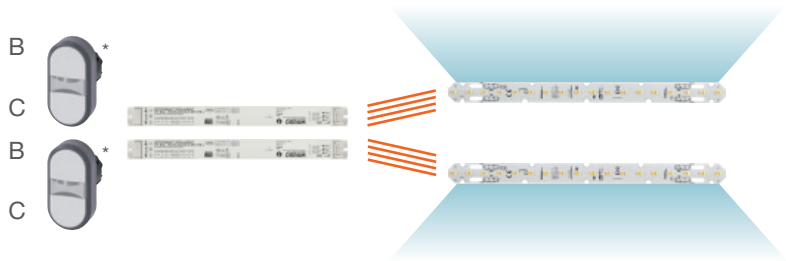
B = Brightness



c) 2 two-color LED modules
2 double pushbuttons with 2 diodes
2 TW drivers

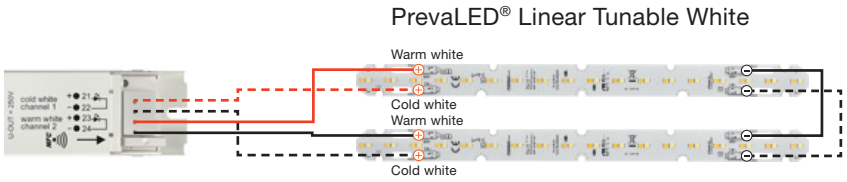
Separate control of brightness and color of both direct and indirect light (independently adjustable)

B = Brightness/C = Color



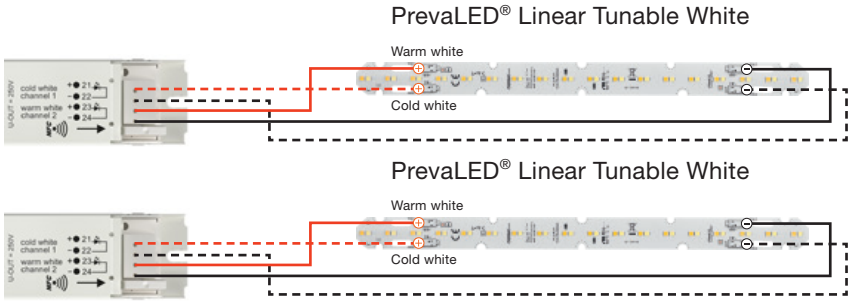
Secondary-side wiring of the TW modules

a) 2 two-color LED modules
1 double pushbutton with 1 diode
1 TW driver



b) 2 single-color LED modules
1 double pushbutton with 1 diode
1 TW driver

c) 2 two-color LED modules
2 double pushbuttons with 2 diodes
2 TW drivers



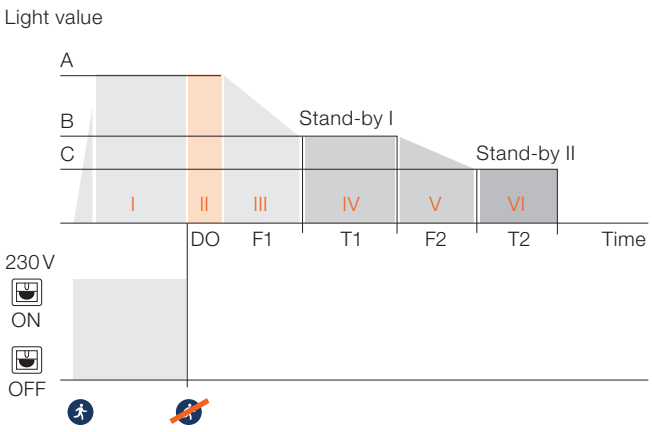
Corridor function – easy time-based lighting profiles for up to 20 DALI drivers

CORRIDOR FUNCTION

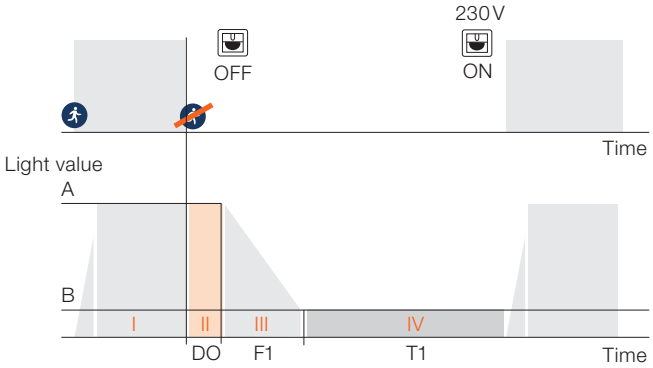
The corridor functionality offers the possibility to light up rooms automatically using standard push-buttons or presence detection sensors (PIR). It is possible to define a time-based lighting profile with up to three different levels, which are fully customizable with the software DALI Wizard or Tuner4TRONIC®.

Corridor function phasing (general and factory setting)

General curve:



Factory setting:



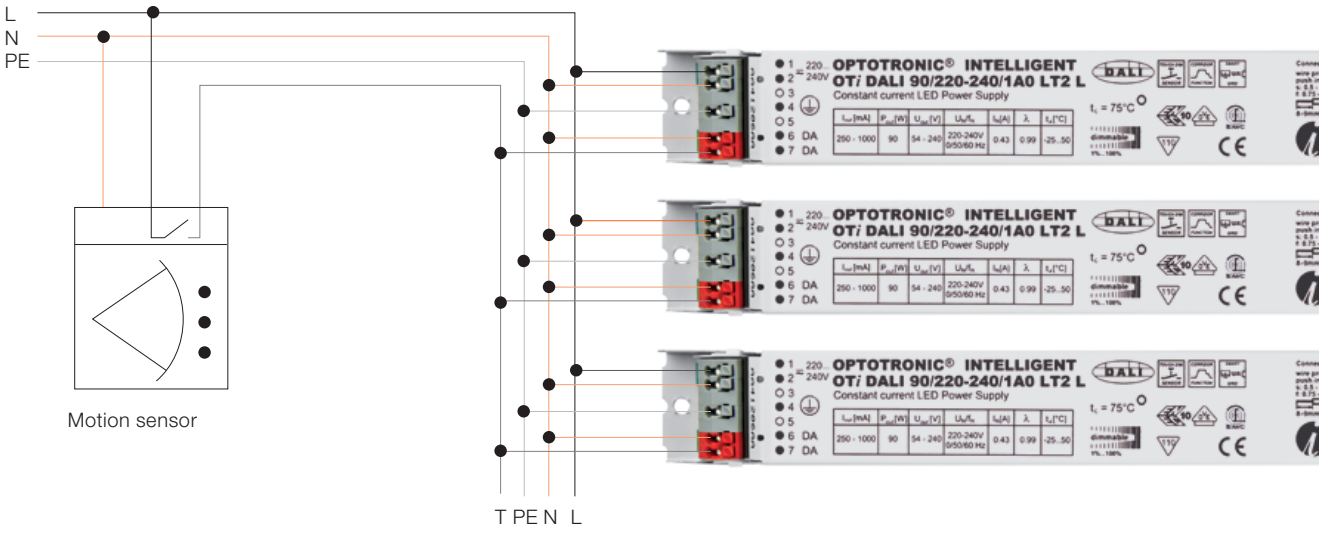
Three dimming ranges (1…100 %), free parameterization of time (I…VI) using DALI magic.

Factory-set parameters:
A: 100 %, D0: 120 s, F1: 32 s
B: 10 %, T1: unlimited

It is possible to connect the DALI LED drivers directly to commercially available motion sensors. The corridor function is triggered by a switching signal, i.e. the voltage of the supply line (220–240 V, 50/60 Hz) is switched to the DALI control line inputs (DA, DA; see diagram below). A preset "out-of-the-box" control profile is activated upon triggering. This can be individually adjusted via Tuner4TRONIC®, DALI magic or NFC tool. Three light levels and six time and fade settings are available for this purpose.

Advantage: New applications (stairwells, corridors, large storage facilities etc.) can be developed with the possibility to save energy and achieve high energy efficiency.

Wiring diagram for corridor function (up to 20 DALI drivers permitted)



Activation of the corridor function

The corridor function is activated when the supply voltage (220–240 V) is permanently applied to the DALI input of the driver for at least 120 seconds (50 Hz) or when the motion sensor detects movement for at least 120 seconds. For the current DALI LED drivers (version DALI 2), the corridor function has to be activated by the Tuner4TRONIC® software.

Switching from the corridor function to the Touch DIM® function and vice versa

It is possible to switch from the corridor function to the Touch DIM® function by briefly pressing a push-button 5 times (at the DALI input, 220–240 V) within 3 seconds. For a reliable exit of the corridor function, it is a must to have a minimum time of 0.5 s between the 5 individual push-button presses. The same recommendation applies to the Touch DIM® RC (radio-controlled) solution. For DALI LED drivers (version DALI 2), the Touch DIM® function is not available when the corridor function is activated.

Synchronization (Touch DIM® and Touch DIM® Sensor operation)

If a large number of DALI drivers with Touch DIM® are operated in a system, there is a chance that a DALI driver will operate out of sync with the others (= different dimming level setting or different switching state).

Synchronization can be restored as follows:

Step 1: **Long** press of the push-button (> 0.5 s) →
All the LEDs are switched on

Step 2: **Short** press of the push-button (< 0.5 s) →
All the LEDs are switched off

Step 3: **Long** press of the push-button (> 0.5 s) →
All the LEDs are switched on at minimum dimmer setting and fade up

After the first three steps – **long-short-long** – all drivers are synchronized.

Note: Touch DIM® is designed for manual control.
It is not suitable for a connection to a PLC (Programmable Logic Control; SPS) or BMS control system.

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5 Combination of LED module and LED driver in constant-current systems

OSRAM

Matching of LED module and LED driver in constant-current systems

Matching the driver and the LED module is associated with a number of possible errors. Therefore, we offer not only components but also released systems of module/driver combinations, which solve all the issues described on the following pages.

Safety first

Drivers providing an internal SELV isolation barrier are the most frequently used drivers. They allow for a simpler construction of the luminaire. Drivers without mains isolation, however, are gaining in market share because they excel in costs, efficacy and size. When a non-isolated driver is used, the LED chain shows a high voltage against earth. Consequently, a safety isolation has to be established between the LEDs and touchable parts of the luminaire. In order to support realistic constructions of the luminaire, safety issues already have to be considered during the construction of the module. This requires detailed knowledge of safety standards, drivers and LEDs.

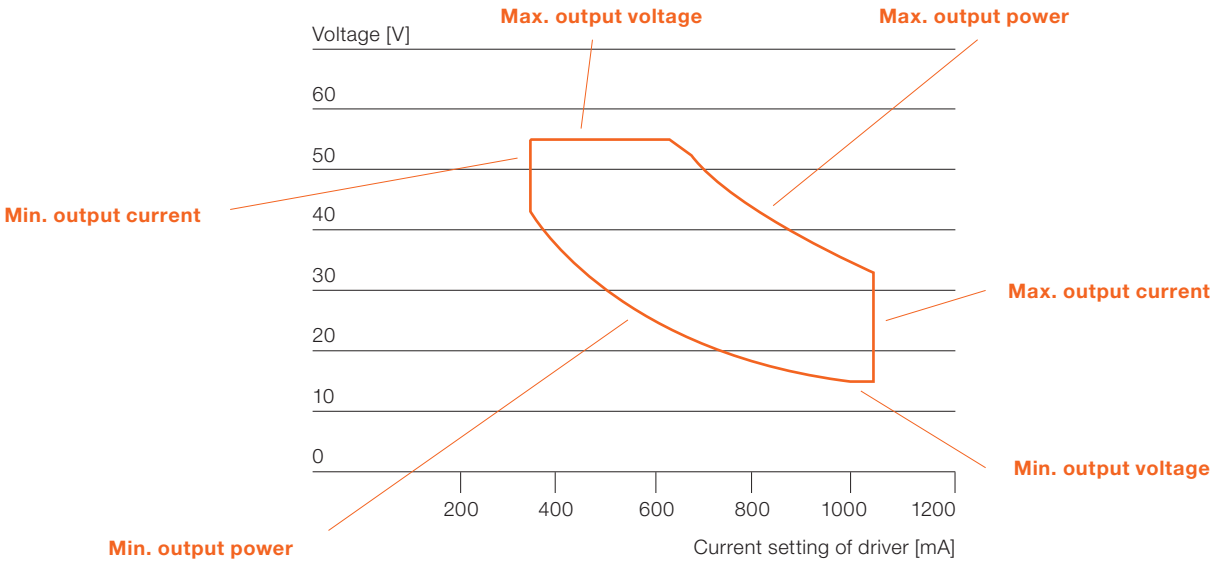
Immunity/surge

Transient voltages from the mains can travel through the driver to the module. Common mode transients can cause high stress to the isolation between LED and PE. If a driver offers an earth terminal, it is always advisable to implement the earth connection. The earth connection of the driver greatly reduces the common mode transients that are transferred to the module. This recommendation is valid also for luminaire constructions that would meet safety regulations even without connecting the driver to earth.

Operating points

The operating point of the LED module must be within the operating range of the LED driver. Due to natural parameter variations of modules and drivers, multiple pitfalls have to be avoided to meet this simple requirement.

Operating window of an LED driver



Note: In case a module exceeds the limits of the LED driver operating range, shutdown or blinking may occur with some drivers.

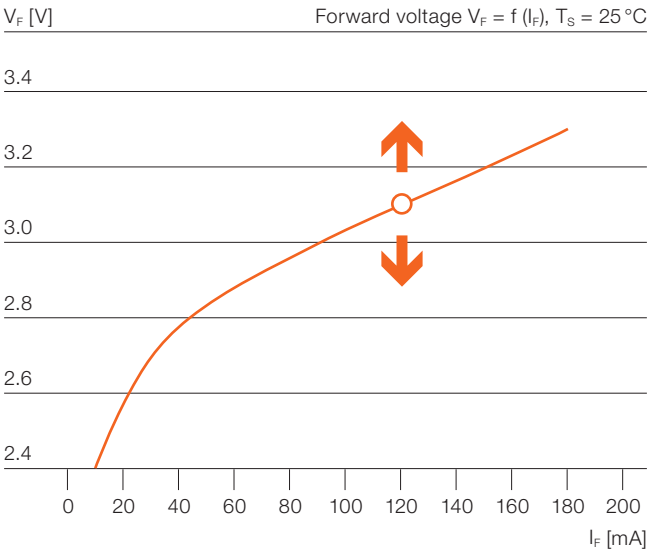
Voltage-current characteristic of a single LED

The characteristic of the single LED can be visualized in a V-I graph.

- V_F depends on binning
- V_F depends on temperature
- V_F depends on current
- V_F depends on aging

Already in pure DC operation, the prediction of the operating point is not a point but a line.

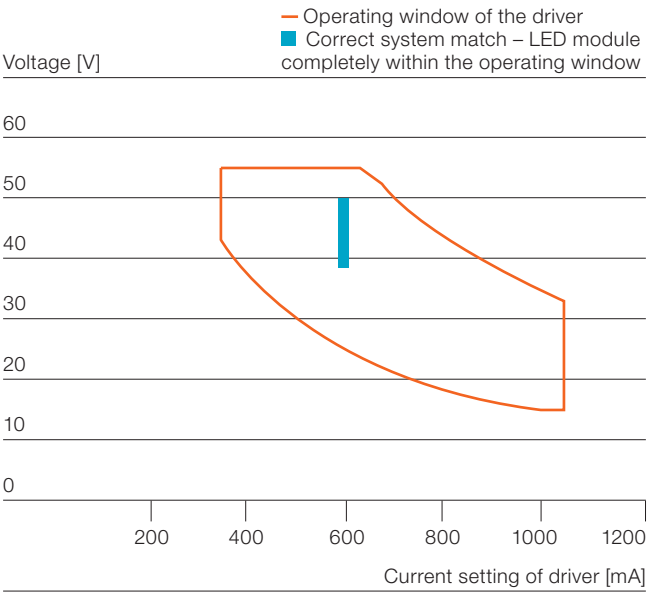
Voltage-current characteristic of LEDs



Module meets LED driver

By drawing the parameters of the LED module and the LED driver in the same V-I graph, the situation can be visualized.

V-I graph



The above V-I graph shows a correct system match. The predicted line of the operating points is completely within the operating range of the LED driver.

Influence of the LED module on V_F

The forward voltage can differ from the rated values and has the potential to cause an undesired shutdown or blinking.

It is influenced by the following effects.

Forward voltage influencing factors

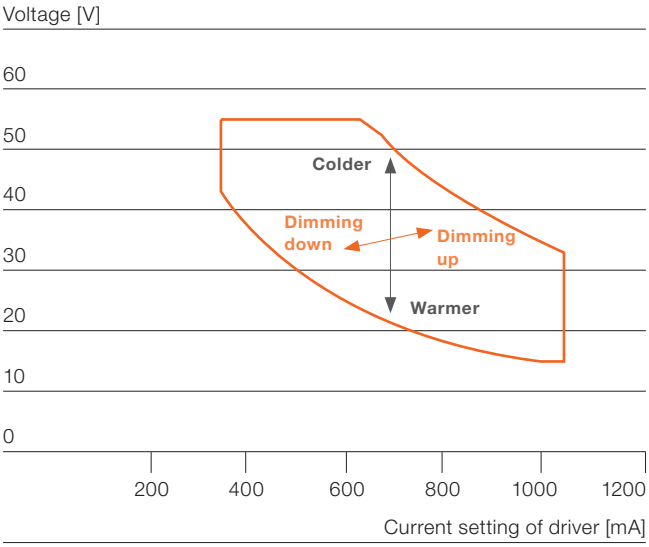
- LED driver does not deliver pure DC (→ ripple current)
- LED driver output current deviates from selected value
- Voltage binning of module
- Aging of module
- Temperature of module

In addition to the correct selection of the forward voltage, it is important to avoid an overload of the LED module. Check the module current load by taking into account the current accuracy of the LED driver and system ripple current.

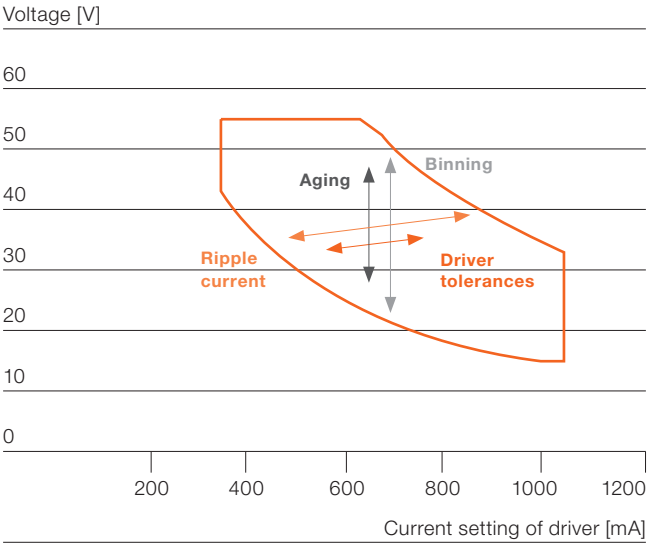
Additional requirements on driver/module matching for dimming

The real number of supported LEDs needs to be checked according to the minimum and maximum forward voltage in the worst case conditions. The respective forward voltage must not fall below/exceed the minimum/maximum output voltage of the used LED driver. The forward voltage of the connected LED module in dimming condition is lower than the forward voltage in nominal condition but still has to be above the minimum output voltage of the LED driver.

Influence of dimming and temperature on the forward voltage



Influence of binning, aging and driver tolerances on the forward voltage



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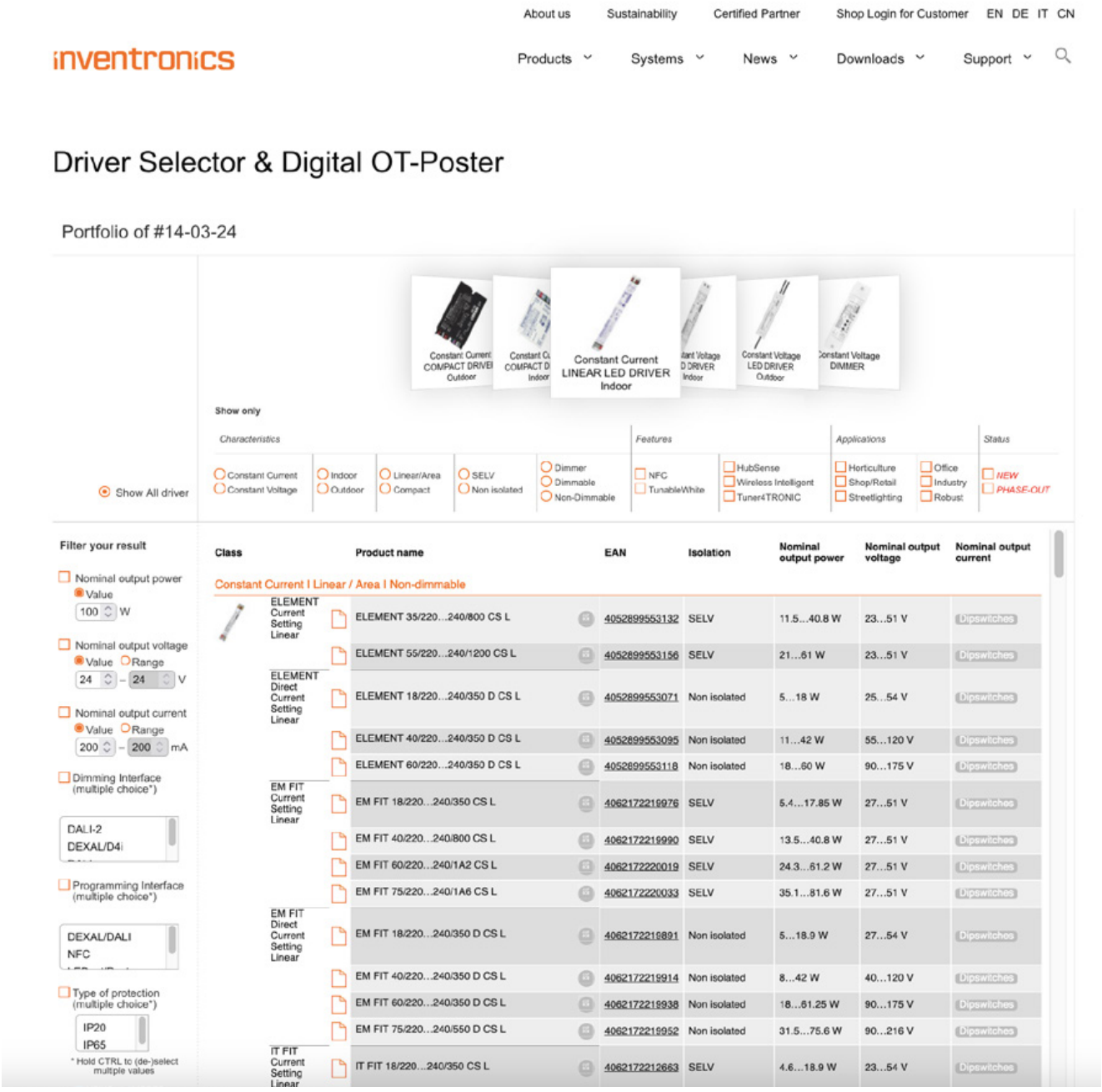
6 Online tools

OSRAM

Driver Selector & Digital OT-Poster

With the new Driver Selector & Digital OT-Poster, you can easily find your desired LED driver and create your individual driver overview by selecting the product families, characteristics, features and applications. Or simply filter by attributes for your needs – always with the latest product portfolio.

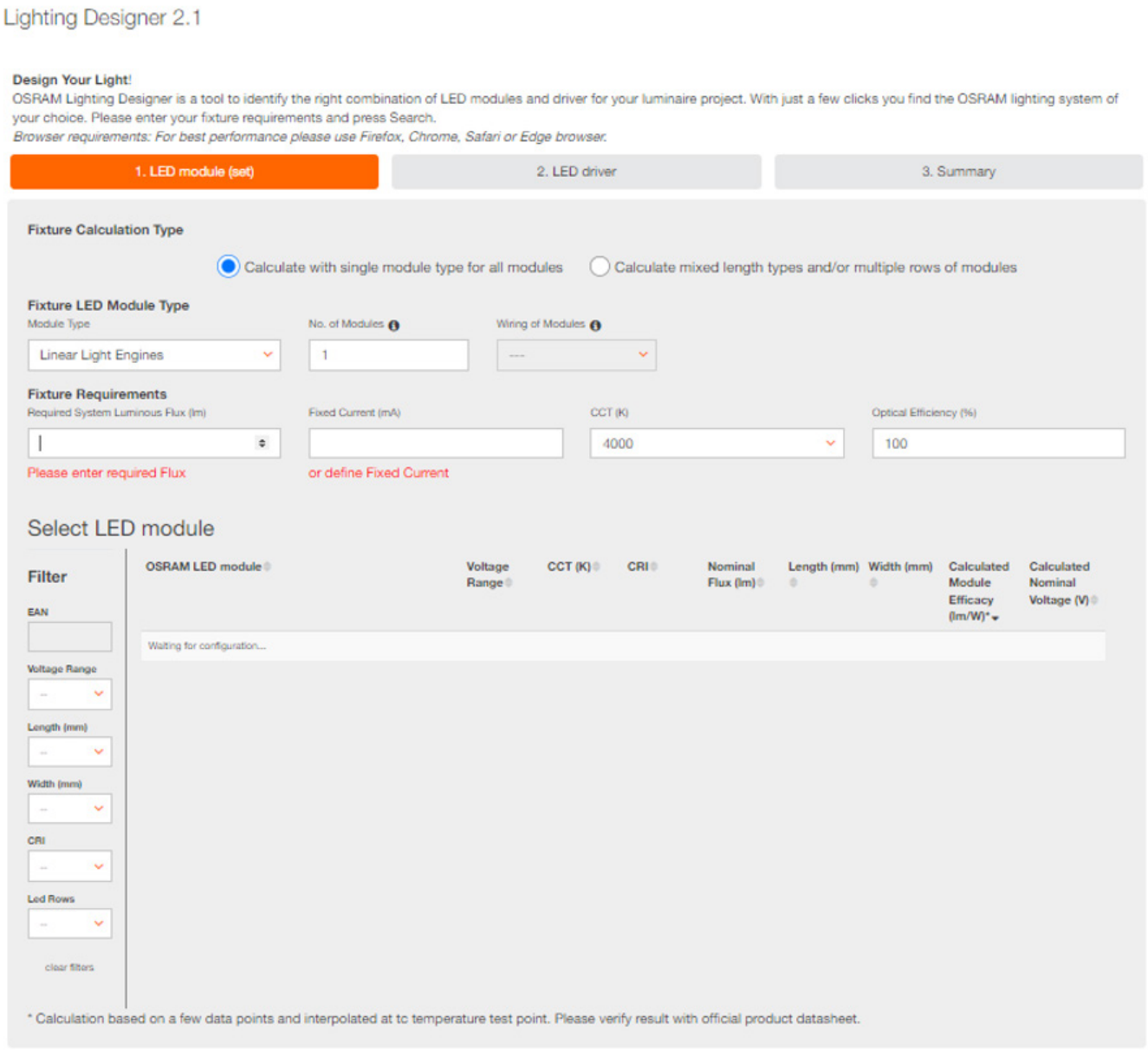
https://www.inventronics-light.com/driver-selector



Lighting Designer

The Lighting Designer online tool helps to identify the right combination of LED modules and LED drivers, based on the technical specifications for your luminaire project.

https://www.inventronics-light.com/lightingdesigner



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OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

7 Planning, installation and operation

OSRAM

System planning

The planning of an LED system (e.g. an LED-based luminaire) must take into consideration the following important factors:

- The selection of suitable LED modules.
- The selection of suitable OPTOTRONIC® (OT) LED drivers that cover all the requested functions (e.g. DALI) and parameters (e.g. SELV).
- The selection of suitable sensors and LMS components.
- The proper wiring of the OT LED drivers and the LED modules and their integration into a luminaire.

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

LED module selection

The very first step in planning an application is the selection of the appropriate LED module(s). For an overview of available LED modules for different applications, please go to www.inventronics-light.com.

Our LED modules can be divided into four categories:

1. Constant-voltage (CV) modules
Constant-voltage modules, even of different types, can be easily connected to constant-voltage OTs without paying attention to current settings (the constant-voltage values of the OT and the LED module, of course, have to be equal, e.g. 24 V). Multiple modules can be connected in parallel to one OT. The most important factor when choosing the LED driver is the maximum wattage needed for all modules connected to the driver.

2. Constant-current (CC) modules with 1-to-1 arrangement of OT and LED module (each LED module has its own OT)
Many OSRAM LED modules are designed to be directly connected to their own OT (e.g. spotlights in retail lighting). The datasheet of the LED module lists different OTs that can be used together with the module. One can choose between different OT variations (e.g. on/off or dimmable) and current settings. The adequate current is often set via LEDset by a resistor directly assembled on the LED module.

3. Constant-current (CC) module arrangements that consist of more than one LED module (multiple LED modules connected to the same OT)
In many applications, multiple LED modules are used with the same driver (e.g. longer chains of linear LED modules in a trunking system). In that case, the modules can be connected to the LED driver in series, in parallel or in a combination of series and parallel. The total power, voltage and current of the LED system have to fit to the chosen LED driver. One can again choose between different OT variations (e.g. on/off or dimmable) and current settings. Additionally, depending on the way the modules are connected, it is possible to select either SELV or non-isolated LED drivers.

4. AC LED modules
AC LED modules can be directly connected to mains and do not need an additional OT. They are also available with different configurations (e.g. on/off or dimmable).

LED driver selection

System wattage and forward current in CC systems
At a minimum, the installed OTs must be able to supply the power drawn by the connected modules and any installed controllers. A first orientation in terms of which power level of the driver is required can be derived from the rated power of the connected modules. In order to reach the rated luminous flux, the sum of rated module power shall not exceed the rated power of the driver. Knowing this value and your required feature set, you can go for a first selection of drivers from our OT portfolio. In a second step, a detailed analysis of matching LED voltage and LED current with the output parameters of the driver is required.

CC LED systems can be driven at different current levels that result in different luminous flux levels of the system. Datasheets of CC LED modules always mention at least the rated current of the connected module with the rated luminous flux and a maximum current level with the maximum luminous flux level. When choosing the LED driver for a CC system, one has to know the current required to fulfill the lumen output requirements.

SELV or non-isolated drivers for linear and area CC systems
For systems of linear and area modules, it is possible, depending on the total voltage of the installed system, to choose between SELV (“Safety Extra Low Voltage”, ≤ 60 V) and non-isolated operation. For SELV operation, the modules are connected in parallel, for non-isolated operation, they are mainly connected in series. Using either a SELV or non-isolated system has a strong impact on the luminaire design. Some of the most relevant facts are summarized in the table below.

Comparison of SELV and non-isolated LED drivers

	SELV	Non-isolated
Luminaire classes	Classes I, II and III	Only classes I and II
System efficiency	Around 5 %, worse than for non-isolated systems	Around 5 %, better than for SELV systems
Luminaire design	Easier, e.g. no touch protection of the light source needed	More challenging
Wiring of the modules	Mainly in parallel	Mainly in series

The examples below illustrate the difference in building up a system in SELV or non-isolated operation. PrevaLED® Linear Slim 2 modules with the following nominal parameters are primarily used as light source.

Typical technical data of PrevaLED® Linear example modules (according to datasheet)

Product name	Flux [lm]	CCT [K]	CRI	SDCM	V_F [V]	I_F [mA]	P [W]	Efficacy [lm/W]
PL-LIN-example-650-840-280	640	4000	> 80	3	32.8	125	4.1	156
PL-LIN-example-1100-840-280	1080	4000	> 80	3	41.7	175	7.3	148
PL-LIN-example-2000-840-280	1920	4000	> 80	3	40.3	350	14.1	136
PL-LIN-example-2200-840-560	2150	4000	> 80	3	41.7	350	14.6	147
PL-LIN-example-4000-840-560	3820	4000	> 80	3	40.3	700	28.2	135

Typical values valid for T_c = 65 °C

Example A: Parallel connection

Requirements: 5-ft luminaire in SELV mode, a parallel connection of LED modules, luminous flux of the LED system of 5 500 lm, CCT of 4 000 K, luminaire should be dimmable via DALI.

For these requirements, either five 1-ft modules (see image on page 7.4) or two 2-ft modules and one 1-ft module can be connected in parallel to the LED driver. To achieve a total luminous flux of 5 500 lm, five PL-LIN-1100-840-280 or two PL-LIN-2200-840-560 and one PL-LIN-1100-840-280 can be used.

Both configurations lead to the following electrical parameters:

For 5 x PL-LIN-1100-840-280:
- $I_{F\,total}$ = 5 x $I_{F\,PL\text{-}LIN\text{-}1100\text{-}840\text{-}280}$ = 5 x 175 mA = **875 mA**
- $V_{F\,total}$ = $V_{F\,PL\text{-}LIN\text{-}1100\text{-}840\text{-}280}$ = **41.7 V**
- P_{total} = $I_{F\,total}$ x $V_{F\,total}$ = 875 mA x 41.7 V = **36.5 W**

For 2 x PL-LIN-2200-840-560 and 1 x PL-LIN-1100-840-280:
- $I_{F\,total}$ = 2 x $I_{F\,PL\text{-}LIN\text{-}2200\text{-}840\text{-}560}$ + 1 x $I_{F\,PL\text{-}LIN\text{-}1100\text{-}840\text{-}280}$ = 2 x 350 mA + 1 x 175 mA = **875 mA**
- $V_{F\,total}$ = $V_{F\,PL\text{-}LIN\text{-}1100\text{-}840\text{-}280}$ = $V_{F\,PL\text{-}LIN\text{-}2200\text{-}840\text{-}560}$ = **41.7 V**
- P_{total} = $I_{F\,total}$ x $V_{F\,total}$ = 875 mA x 41.7 V = **36.5 W**

It is easy to see that all relevant electrical parameters are the same independent of the chosen configuration.

To use these configurations and ensure a SELV operation, the next step is to choose a suitable LED driver from the OT SELV portfolio. The LED driver has to fulfill the following parameters (if only the nominal parameters are considered and no attention is paid to the aging of the LEDs, temperature dependency etc.):

I = 875 mA (either as fixed value or as a set value via LEDset or programming)

U_{max} ≥ 41.7 V (maximum output voltage has to be higher than $V_{F\,total}$ of the LED system)

U_{max} ≤ 54 V (maximum output voltage of OT SELV LED driver is not higher than 54 V)

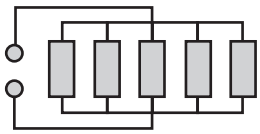
P_{max} ≥ 36.5 W (maximum output power of the LED driver has to be higher than P_{total} of the LED system)

To make things easier, we provide tables of module/driver configurations in the datasheets of the LED modules. The table on the next page shows a part of the possible SELV configurations for the PrevaLED® Linear modules.

OTi DALI (window driver – SELV)
PrevaLED® Linear LED modules are designed to be operated by OTi DALI drivers in parallel connection. Current setting is carried out via the software Tuner4TRONIC® and DALI magic.

5-ft SELV luminaire

Equipped with: **PrevaLED® Linear "PL-LIN-1100-840-280" OTi DALI 50/220…240/1A4 NFC L 27-54 V**



Configuration: **1s5p**

DC current [mA]: 875
DC voltage [V]: 41.7
Luminous flux [lm]: 5400

Example B: Series connection

Requirements: 5-ft luminaire in non-isolated mode, a series connection of LED modules, luminous flux of the LED system of 5 500 lm, CCT of 4 000 K, luminaire should be dimmable via DALI. Same conditions as in example A, only the SELV mode is changed to the non-isolated mode.

Note: In the non-isolated mode, it is only possible to use five 1-ft modules connected in series to build up a 5-ft LED system. It is not possible to use two 2-ft modules and one 1-ft module connected in series to the LED driver.

To achieve a total luminous flux of 5 500 lm, PL-LIN-1100-840-280 can be used, connected in series to the LED driver.

This leads to the following electrical parameters:
$I_{F\ total} = I_{F\ PL\text{-}LIN\text{-}1100\text{-}840\text{-}280} = 175\,mA = \mathbf{175\,mA}$
$V_{F\ total} = 5 \times V_{F\ PL\text{-}LIN\text{-}1100\text{-}840\text{-}280} = \mathbf{208.5\,V}$
$P_{total} = I_{F\ total} \times V_{F\ total} = 175\,mA \times 208.5\,V = \mathbf{36.5\,W}$

Now, as in example A, a suitable LED driver has to be selected, this time from the non-isolated part of the OT portfolio. It has to fulfill the following parameters (if only the nominal parameters are considered and no attention is paid to the aging of the LEDs, temperature dependency etc.):

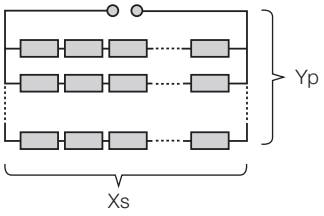
I = 175 mA	(either as fixed value or as a set value via LEDset or programming)
$U_{max} \geq 208.5\,V$	(maximum output voltage has to be higher than $V_{F\ total}$ of the LED system)
$U_{max} \leq 250\,V$	(maximum allowed voltage for the PrevaLED® Linear family)
$P_{max} \geq 36.5\,W$	(maximum output power of the LED driver has to be higher than P_{total} of the LED system)

The tables shown in example A for the SELV configuration are also provided in the datasheets for the non-isolated case.

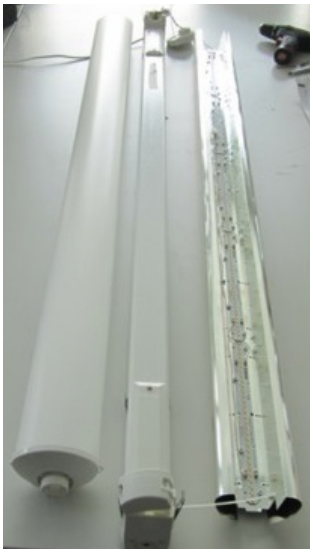
OTi (window driver – non-isolated)

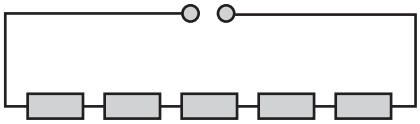
PrevaLED® Linear LED modules are designed to be operated by OTi and OTi DALI drivers in series or combined series/parallel connection. Current setting is carried out via resistor coding (LEDset) in case of OTi and via the software Tuner4TRONIC® and DALI magic in case of OTi DALI.

Explanation:
- Xs1p: all modules in series connection
- Xs2p/2sYp: parallel connection of X modules in series connection/series connection of Y modules in parallel connection



5-ft non-isolated luminaire





Equipped with: **PrevaLED® Linear "PL-LIN-1100-840-280" OTi DALI 60/220-240/550 D LT2 L**

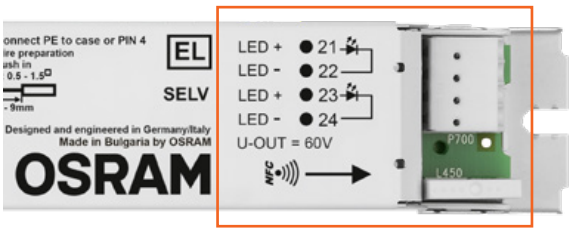
Configuration: **5s1p**

DC current [mA]: 175 (set by LEDset/Tuner4TRONIC®)
DC voltage [V]: 208.5
Luminous flux [lm]: 5400

The figure above shows a typical application example for a 1.5-m luminaire with a linear non-isolated driver OTi DALI 60/220-240/550 D LT2. All PrevaLED® Linear PL-LIN-1100-840-280 modules are connected in series.

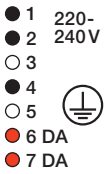
Example C: Series connection by use of terminals

The figure below shows an application of a floor-standing luminaire with a linear non-isolated driver OTi DALI 90/220-240/1A0 LT2 L. It is an example for a series connection by optimal use of the terminals of the OTi (DALI) non-isolated family. All PrevaLED® Linear PL-LIN-1100-840-280 modules are connected in series.

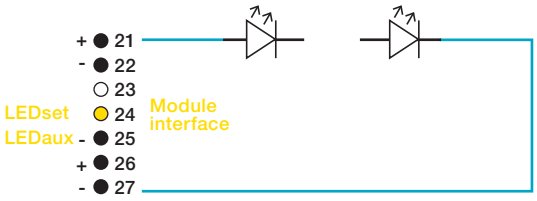


The split of the LED modules does not need to be symmetric as shown below.

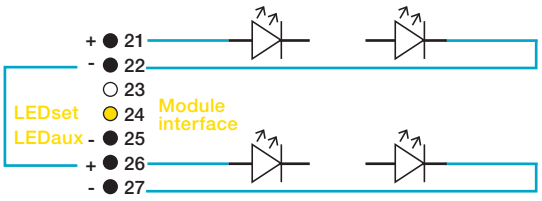
Pinning/connection diagrams: OTi DALI 90/220-240/1A0 LT2 L



Input pinning

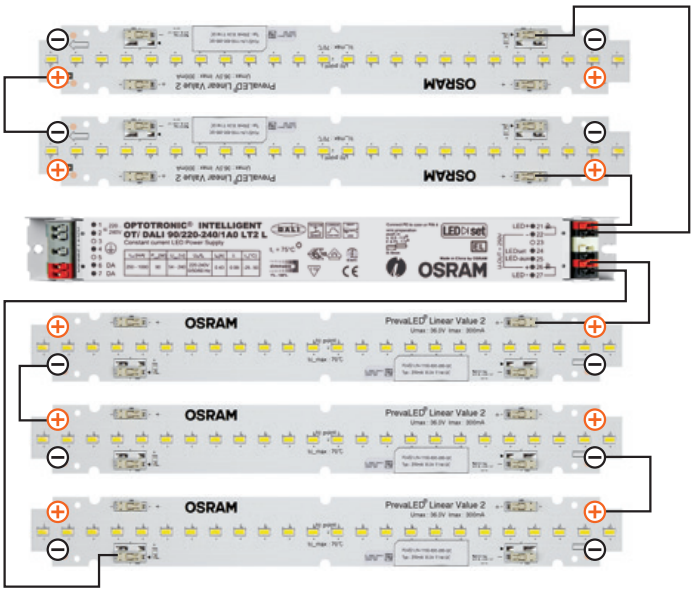


Output pinning



Output pinning with LED driver internal through-wiring

Asymmetric LED module (load) wiring permitted

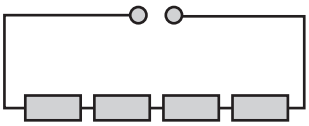


Example D: Combined series/parallel connection

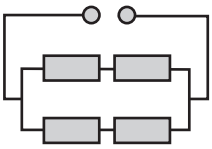
Depending on the electrical parameters of the LED module and the selected OT LED driver, different numbers of modules can be connected in series/in parallel to the LED driver.

In the non-isolated case, it is possible to combine parallel and series wiring of LED modules. In a 4-ft luminaire, for example, there are two options to connect the modules:

a) All in series

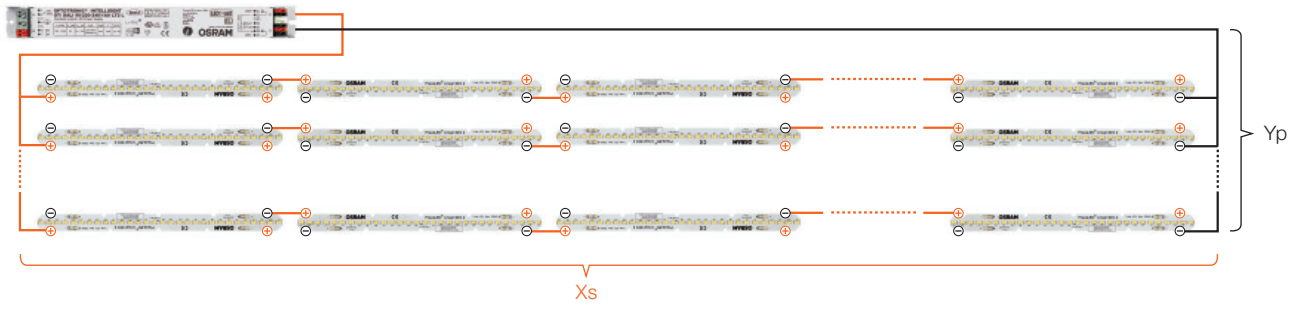


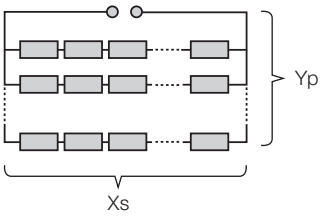
b) Two in series and two in parallel



The electrical parameters change with the chosen condition. In case a), the total voltage of the LED system is four times the module voltage and the system current is the same as the module current. In case b), the total voltage of the LED system is two times the module voltage and the system current is also two times the module current. These two different scenarios of wiring can strongly impact the selection of a suitable LED driver.

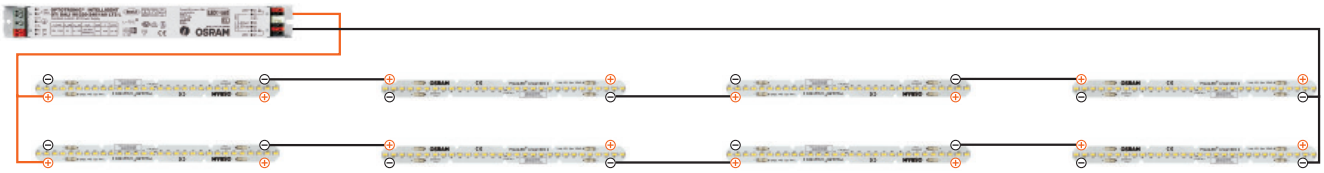
The XsYp notation used in our datasheets gives information on how many modules can be connected to the LED driver. X stands for the number of modules connected in series and Y for the number of modules connected in parallel. For cases a) and b) in a 4-ft luminaire, the corresponding XsYp notations are:
a) All in series → 4s1p
b) Two in series and two in parallel → 2s2p
In addition, the datasheets also provide exact wiring diagrams (see figures below).

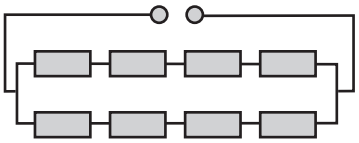




Corresponding circuit diagram

4-ft non-isolated luminaire – twin lamp





Equipped with: **PrevaLED® Linear “PL-LIN-650-840-280” OT FIT 50/220-240/250 D L**

Configuration: **4s2p**

DC current [mA]: 250
DC voltage [V]: 132
Luminous flux [lm]: 5120

The figure above shows a typical application example for a 1.2-m luminaire with a linear non-isolated driver OT FIT 50/220-240/250 D L. The PrevaLED® Linear Slim 2 modules are connected in combined series/parallel connection (4s2p; 4 modules in series, 2 strings in parallel).

Light control (on/off, different dimming mechanisms)

The level of light control in an application ranges from no control (i.e. fixed output) to simple control (i.e. brightness) to full RGB or TW control (i.e. multiple independently controlled channels). Besides the level of control, the preferred type of control interface, e.g. 1…10 V, DALI or DMX, must also be selected.

Combined with the type of LED modules selected in the first step, these requirements can be used to further search the OPTOTRONIC® portfolio for suitable LED drivers and to look for additional light management systems.

CV LED drivers

There are three different categories of OT CV LED drivers:

- Non-dimmable drivers (on/off)
- Drivers with 1…10-V interface
- Drivers with DALI interface

CC LED drivers

Dimmable OT CC LED drivers mainly use the DALI interface. There are also some CC LED drivers in the portfolio that use a 1…10-V and phase-cut. OT CC LED drivers are also available as non-dimmable (on/off) versions.

For the DALI interface, in particular, we offer many light management systems that can be used together with OT DALI LED drivers. The available light management system components range from easy systems that, for example, are used in small offices to professional systems for entire buildings or complexes of buildings.

Additional information on light management systems can, for example, be found at www.inventronics-light.com.

Some simple light management features are already included in many OT LED drivers, e.g. Touch DIM® or smart grid functionality. For more detailed information on features included in different OT LED drivers, please consult the corresponding technical datasheets.

Wiring

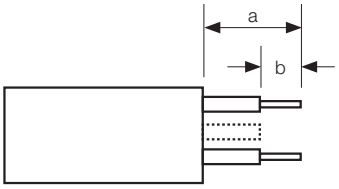
Recommended cables

For a safe and reliable operation of OT LED drivers, it is mandatory to use only recommended cables on the input and output side and control port where applicable. This ensures that the cable is suitable for the electrical load and that the mechanical connection of 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 datasheets, which can also be found at www.inventronics-light.com. Please also check the instruction sheets that are delivered with the product for additional information.

Cable stripping

Furthermore, to ensure a safe electrical and mechanical connection of the cable in the electrical terminals or the cable clamp, it is mandatory to observe the cable stripping lengths as shown in the figure below. The stripping lengths for (a) and (b) are specified for each product (where applicable) in the respective datasheets.

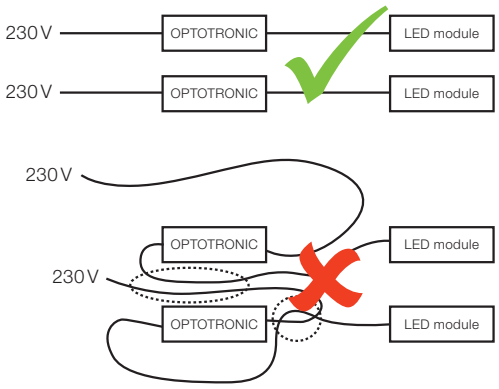


Recommended cable stripping

Cable routing

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

1. Mains and LED module cables should never be routed in parallel. Keep output cables and mains cables as far away from one another as possible (e.g. 5 to 10 cm). This avoids mutual interference between mains and secondary-side cables.
2. Place output cables away from earthed metal surfaces (if possible several cm) to reduce capacitive interference.
3. LED module cables (to and from the LED driver) have to be kept parallel to reduce radiated emissions.
4. Keep mains cables in the luminaire as short as possible to reduce interference.
5. Do not route mains cables too close to the LED driver (this applies in particular to through-wiring).
6. Avoid crossing mains cables and LED module cables. Where this is not possible, cables should cross at right angles (to avoid HF interference on the mains cable).
7. Cable penetrations through metal components must never be left unprotected and should be fitted with additional insulation (sleeve, grommet, edge protector etc.). Dimming units on the secondary side such as OT DIM usually do not affect the radio interference.



Cable routing of OPTOTRONIC® and LED modules

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Technical application guide
OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

8 Insulation types

OSRAM

Updated and new standards for LED drivers

For our indoor LED drivers, the following insulation classes apply:

- Non-isolated (previously “non-SELV”)
  - No isolation between input and output circuits (LED, LEDset etc.)
- SELV (double/reinforced-isolated):
  - Voltage range:
    - SELV 0–60 V_{DC}, all poles touchable, no distance requirements to touchable parts
    - SELV 60–120 V_{DC}, one pole touchable
  - Isolating transformer > 120 V_{DC}, no pole touchable

Non-isolated drivers

Non-isolated (previously “non-SELV”) drivers have no isolation between the primary and secondary side and a basic insulation (single isolation foil) between all the electronic circuits and the driver casing. The corresponding insulation classes are similar to those of typical fluorescent ECGs.

Earth leakage/Protective earth current

With most drivers that have a connection to earth, there will be a very small apparent leakage current from the mains input to earth. Since these currents will add up as the number of drivers is increased, it is important to consider these for the overall electrical installation and any effect on, for example, MCB devices to avoid unwanted tripping. Typically, values are less than 0.5 mA, but the individual LED driver datasheets should be checked for confirmation.

Typical example of a non-isolated driver

Note:

- All output connections of these drivers are not safe to touch
- This also applies to the LEDset interface (R_{set} must have basic insulation)

Hints for the use of non-isolated drivers in class II luminaires

Metal luminaires of class II

LED drivers have basic insulation. LED modules should also have basic insulation. In addition, both LED driver and LED modules should be additionally isolated by supplementary insulation. All isolations should be designed according to U_{out} of the LED driver.

Plastic luminaires of class II

All active parts (LED modules) should be protected by at least a basic insulation if the luminaire can be opened for maintenance. The best solution is a sealed luminaire where the LED modules and the driver are not touchable – ideally with a separated connection area.

Insulation matrix for non-isolated indoor drivers

Port	L/N	EQUI or F.E. (functional earth)	Control (DALI, Touch DIM®, 1...10V)	LEDset/ NTCset	Output LED	Casing/PE
L/N	–	Double/ reinforced	Basic	–	–	Basic
EQUI or F.E. (functional earth)	Double/ reinforced	–	Basic	Double/ reinforced	Double/ reinforced	Supplementary
Control (DALI, Touch DIM®, 1...10V)	Basic	Supplementary	–	Basic	Basic	Basic
LEDset/ NTCset	–	Double/ reinforced	Basic	–	–	Basic
Output LED	–	Double/ reinforced	Basic	–	–	Basic
Casing/PE	Basic	Supplementary	Basic	Basic	Basic	–

Basic + Supplementary = Double/reinforced
Controller already with basic insulation

SELV (isolated) drivers

For SELV drivers with up to 60 V_{DC}, there are lower isolation requirements for luminaire constructions because 60 V_{DC} is touchable.

All built-in SELV drivers with plastic casing:
- fulfill the requirements of IEC 61347-1, annex O, for double or reinforced insulation
- can also be used independently with an additional cable clamp*
- can be used both in class I and class II luminaires

Insulation matrix for SELV indoor drivers

Port	L/N	EQUI or F.E. (functional earth)	Control (DALI, Touch DIM®, 1...10V)	LEDset/ NTCset	Output LED	Casing: protection class I	Casing: protection class II
L/N	–	Double/ reinforced	Basic	Double/ reinforced	Double/ reinforced	Basic	Double/ reinforced
EQUI or F.E. (functional earth)	Double/ reinforced	–	Double/ reinforced	Basic	Basic	Supplementary	Double/ reinforced
Control (DALI, Touch DIM®, 1...10V)	Basic	Double/ reinforced	–	Double/ reinforced	Double/ reinforced	Basic	Double/ reinforced
LEDset/ NTCset	Double/ reinforced	Basic	Double/ reinforced	–	–	Basic	Double/ reinforced
Output LED	Double/ reinforced	Basic	Double/ reinforced	–	–	Basic	Double/ reinforced
Casing: protection class I	Basic	Supplementary	Basic	Basic	Basic	–	N/A
Casing: protection class II	Double/ reinforced	Double/ reinforced	Double/ reinforced	Double/ reinforced	Double/ reinforced	N/A	–

Basic + Supplementary = Double/reinforced
Controller already with basic insulation

*) Depending on the model

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Technical application guide OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

9 Dimming principles

OSRAM

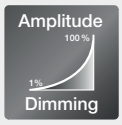
Hybrid dimming

OPTOTRONIC® DALI drivers can be dimmed between 100 % and 1 %. And by programming, many can also dim below 1 %, sometimes down to levels as low as 0.1 %, depending on the physical minimum current capability of the driver. In order to cover this wide range (while avoiding potential appearance differences of the attached LEDs at very low current levels), some OPTOTRONIC® drivers have two dimming methods (hybrid dimming) in their features:

- **Dimming by amplitude modulation**
  The dimming range between 100 % and about 30 % (depending on LED driver) is controlled by adjusting the amplitude of the current. The current value specified for the device corresponds to a dimming level of 100 %. The amplitude of the current is reduced to dim the lighting down.
- **Dimming by Pulse Width Modulation (PWM)**
  The dimming range between about 30 % and the minimum dimming level is controlled by pulse width modulation. PMW dimming is beneficial at lower dimming levels as there are no color and brightness differences between the individual LEDs.

The transition between the two dimming methods is seamless.

What's new



A good choice for professional lighting applications: The **OSRAM OPTOTRONIC® Intelligent DALI Compact** LED drivers dim down from 100 % to 1 % via amplitude dimming.

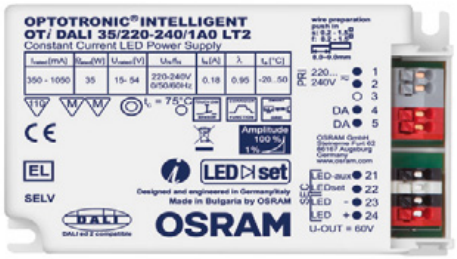
- Mobile camera-friendly light thanks to amplitude dimming from 100 % to 1 %
- DALI ed2 compatible
- Soft switch-off (dimming from 1 % to 0 % when switched off)
- Reduced stand-by consumption

Phase-cut dimming

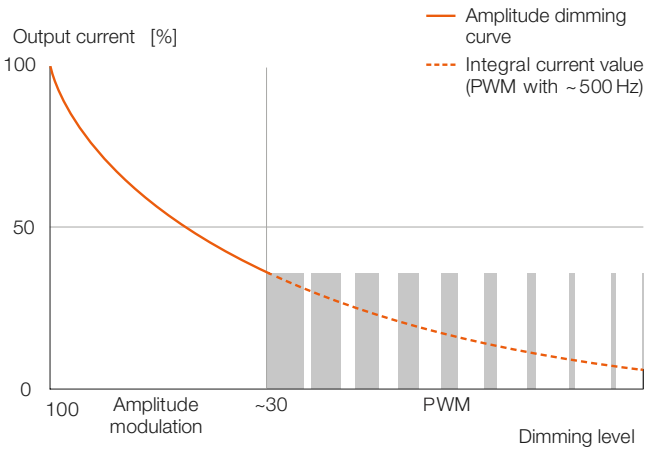
Phase-cut dimming is a popular kind of dimming. OPTOTRONIC® Phase Cut (OTe...PC and OT...PC) drivers allow LED modules to be dimmed with phase-cut dimmers. Both trailing-edge and leading-edge phase-cut dimmers can be used. An up-to-date list of suitable dimmers can be found in our OEM Download Center at www.inventronics-light.com/oem-download.

Driver for phase-cut dimming

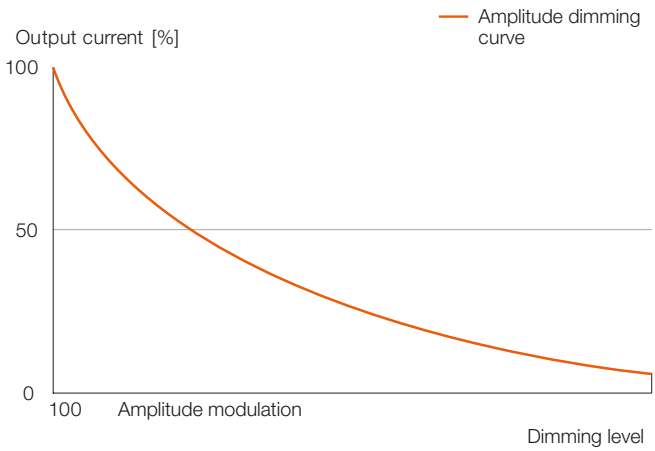
The phase-cut dimmable OT LED drivers can be integrated into DALI installations with a DALI dimmer (HTi DALI 315 DIM), which converts the DALI dimming commands into trailing-edge dimming signals.



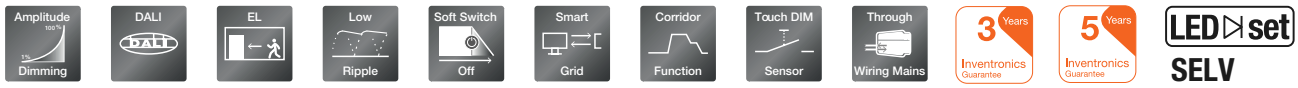
Hybrid dimming



Amplitude dimming



In the lower dimming range (from 30 % to 1 %), amplitude dimming delivers a significantly lower light modulation than hybrid dimming.



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Technical application guide
OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

10 Ripple current and “light modulation”

OSRAM

Light modulation as quality criterion

The quality of a lighting installation is determined by various factors: illuminance, color rendering, glare, homogeneity and light color are just a few major criteria. State-of-the-art LED technology now offers entirely new possibilities in terms of energy savings and lighting design. However, the light emission of LEDs responds to temporal fluctuations and other influences of your power supply almost immediately. The resulting temporal modulations of light are another key quality criterion for the design and assessment of lighting applications. Human well-being and health aspects play the most important role in this context, but the proper functioning of optical devices, such as bar code scanners or cameras, can also be affected.

Temporal light artefacts (TLA)

TLAs are all visual effects (i.e. effects visible to the human eye) created by light sources with varying intensity or spectral distribution over time. Two well-known examples of such effects are flicker and the stroboscopic effect.

The latter refers to a change in the perception of motion of a static observer in a non-static environment caused by a light stimulus, the brightness or spectral distribution of which fluctuates over time. The average observer only perceives this effect when a moving or rotating object is illuminated. Light modulation frequencies in the range from approx. 50 Hz to approx. 2 kHz are relevant in this context.

In contrast to this, light flicker also becomes visible without any moving objects, provided that the modulation frequencies of the light are below approx. 80 Hz (more precisely, this is the impression of fluctuation in visual sensations caused by light stimuli with varying luminance or spectral distribution over time).

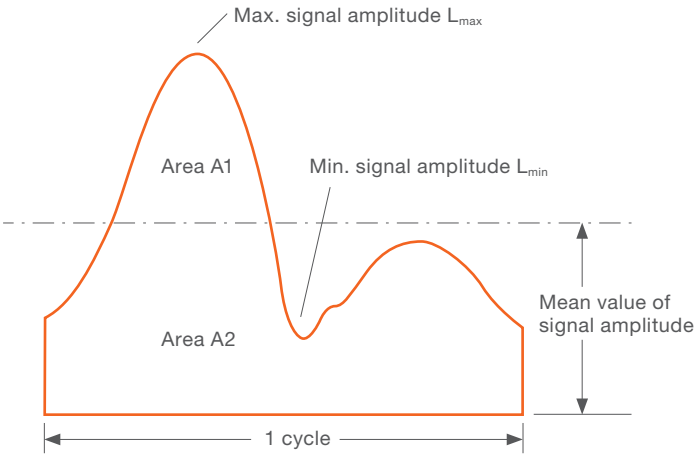
Measurement procedures for the assessment of modulated light

Suitable metrics or physical criteria as well as measurement procedures are required for the proper detection and analysis of modulated light effects.

Modulation depth (MD), flicker index (FI) and ripple current

The modulation depth and flicker index frequently serve as a basis for the assessment of flickering or light modulation. Figure 1 shows an example of the modulated luminous flux from a light source and the relevant parameters for calculating the modulation depth and flicker index.

Figure 1: Example of the modulation depth (MD) and flicker index (FI) metrics



Modulation depth (MD) is defined as follows:

$$MD = \frac{(L_{max} - L_{min})}{(L_{max} + L_{min})} \cdot 100\%$$

This formula corresponds to the classic formula for calculating the modulation depth, which is well known from electrical engineering.

The flicker index (FI) is calculated according to the following formula:

$$FI = \frac{A1}{(A1 + A2)}$$

Here, the areas A1 and A2 enclosed by the curve (modulated light) are considered. The ratio between the area A1 above the mean line and the total enclosed area (A1 + A2) is calculated.

However, the modulation depth (MD) and flicker index (FI) metrics are only of limited use in assessing the effect of modulated light on human beings. This also results from the fact that the shape of the modulation curve and the modulation frequency are not considered.

Instead of the modulation depth for the modulated light, the modulation depth of the electric current flowing through the LEDs can be measured and in most cases serves as a basis. This so-called “ripple current” indicated in % can therefore only be used for the assessment of visual effects when combined with additional information, for example about modulation frequencies. Generally speaking, a low-frequency ripple current at 100 Hz mainly influences the visibility of the stroboscopic effect as well as possible image interference during the use of digital cameras.

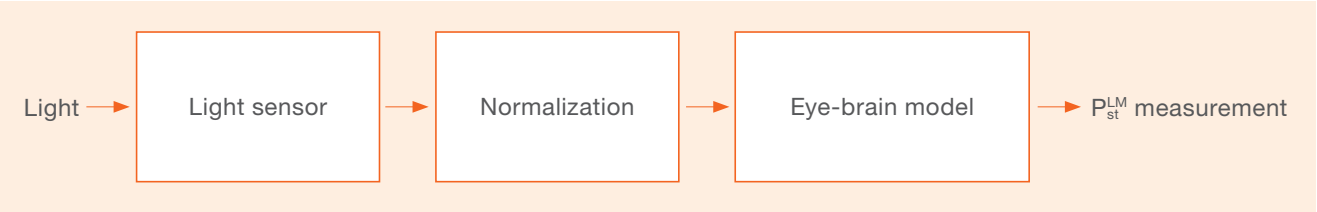
Although high-frequency ripple currents > 20 kHz do not play a role for human visual perception, they can cause functional interference impacting bar code scanners or special cameras.

New, improved metrics for the assessment of TLA

P_{st}^{LM} metric

The purpose of this metric (P_{st}^{LM} for short-term light modulation) is to measure the visible flicker that is caused by light modulation in the frequency range from 0.3 to 80 Hz. Figure 2 shows a simplified block diagram of the P_{st}^{LM} measurement setup.

Figure 2: Block diagram of the P_{st}^{LM} measurement setup



A P_{st}^{LM} measured value of 1 means that the flickering of the measured light source is just at the perception threshold. This means that half of a group of normal observers is still able to perceive the flickering of the light source, whereas the other half can no longer perceive this effect.

A P_{st}^{LM} measured value > 1 indicates that more people can perceive the flicker effect; if the P_{st}^{LM} measured value is < 1, it is perceived by fewer people or no one at all. A P_{st}^{LM} limit value of 1 is therefore recommended for most general lighting applications.

OSRAM LED drivers do not produce visible flicker.[1)]

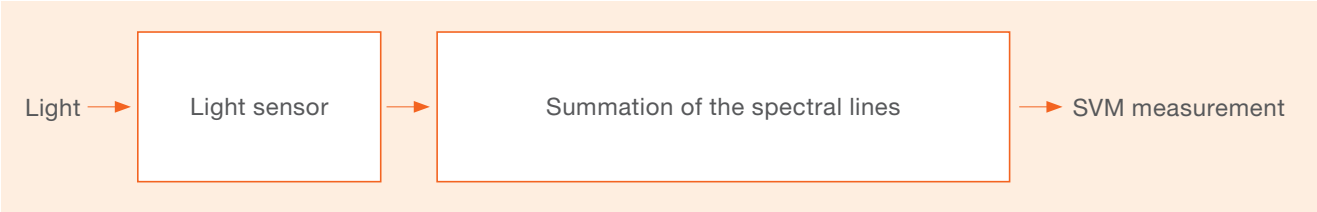
This applies to the following product families: OTi DALI, OTi DALI Industry, OTi DALI TW, OT FIT and OT Outdoor 1DIM and 4DIM. The P_{st}^{LM} value for all mentioned product families is below 1, evaluated according to the test conditions of IEC TR 61547-1 ED2.

1) This statement refers to a majority of average observers.

SVM metric

The stroboscopic visibility measure (SVM) metric assesses the stroboscopic effect, which can occur in relation to moving or rotating objects.

Figure 3: Block diagram of the SVM measurement setup



Similar to the P_{st}^{LM} metric, an SVM measured value of 1 indicates that half of a group of normal observers can still perceive a stroboscopic effect, whereas the other half is no longer able to perceive the interaction between light modulation and moving objects. High SVM values of e.g. > 5 indicate clearly visible stroboscopic effects.

However, it is still too early to provide general recommendations with regard to possible SVM limits, because the requirements for various light application areas can differ significantly and no extensive experience is available up to now.

Even though there are no generally accepted limit values for the SVM metric so far, OSRAM LED drivers with low SVM values from the OTi DALI[2)], OTi DALI Industry, OTi DALI TW[2)] and OT FIT families should be used for demanding lighting tasks, e.g. for office workstations or work areas with challenging visual tasks – especially in combination with moving objects.

In non-critical areas of application (corridors, stairwells, warehouses, decorative lighting etc.), high SVM values are usually of lesser importance.

In workplaces where there is a danger from rotating machines and possible stroboscopic effects, a risk assessment adapted to this workstation is required. An evaluation of the used lighting systems with the help of the SVM metric can provide useful information but is not sufficient on its own.

2) Exceptions: OTi DALI CV and OTi DALI TW in preselected PWM mode.

Light modulation interactions with technical devices and machinery

Bar code scanner

As a result of interference in environments with modulated light, certain bar code scanners can have problems capturing bar code information in a reliable way.

Widely used laser scanners include types with the laser beam moving quickly along a thin line over the bar code in order to capture the reflected lighting intensity over time. This scanner technology is far more sensitive to temporally modulated ambient light than CCD-based bar code scanners, which scan the entire bar code more or less simultaneously.

In addition to the scanner technology, the modulation frequency of the ambient light, the modulation depth and the illuminance are important factors.

Figure 4 illustrates the areas in which interference may occur due to modulated ambient light. However, this illustration refers to rather critical testing conditions with an illuminance of 1,300 lx as well as 500 lx on the scanned object generated by only a single modulated light source.

This graphical representation shows that the interaction of LED lighting systems with bar code scanners depends primarily on the high-frequency ripple of the LED drivers, whereas the low-frequency 100 Hz ripple plays practically no role in this context.

As a rule, CCD bar code scanners do not cause any malfunctions due to the interaction with modulated light. The selection of OSRAM LED drivers is therefore not restricted.

When using laser scanners, malfunctions can theoretically occur under unfavorable operating conditions, which depend on many parameters[1)] (type of LED driver, operating parameters, illuminance at the bar code etc.). In practice, however, no problems are known.

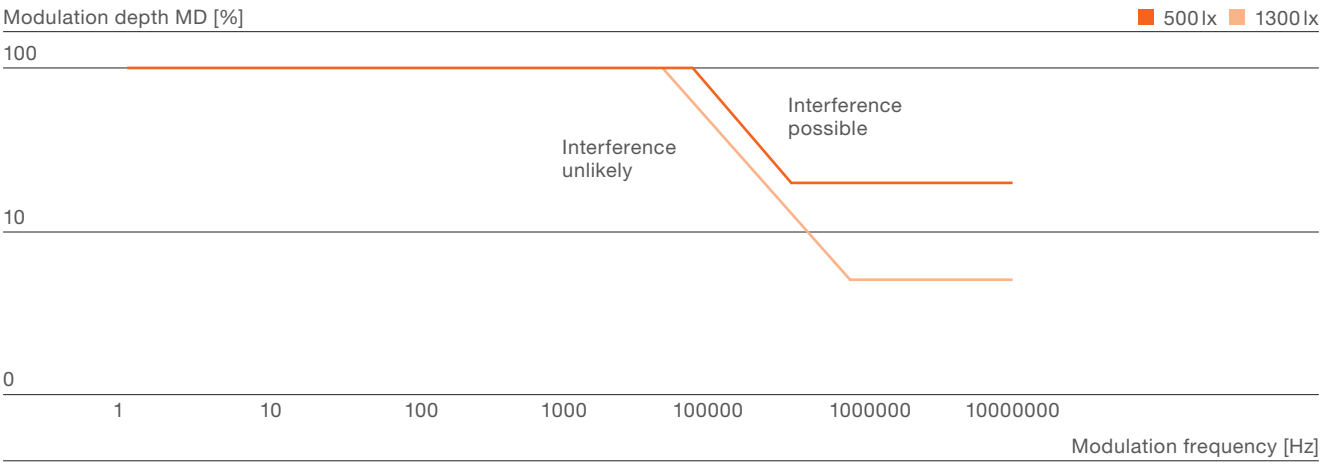
Digital cameras

In order to better assess the effect of modulated light on camera images, it is necessary to make a distinction between standard cameras for conventional photos or videos and high-performance cameras for professional studio and sports images. The following considerations refer mainly to the first category of standard cameras including, for example, compact cameras, reflex cameras, smart device cameras and web cams as well as monitoring cameras.

Certain image artifacts are due to the image capturing technology used by the cameras. Whereas striped image interference can occur with customary CMOS cameras with rolling shutters, cameras with global or mechanical shutters enable different lighting levels for consecutive single images.

1) In particularly critical individual cases, detailed information can be given according to the specific operating conditions.

Figure 4: Possible interference areas of bar code scanners in environments with modulated light



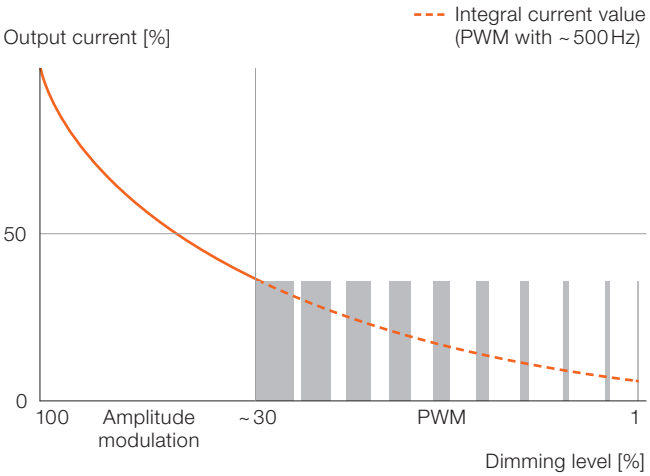
Note:
Some dimmable drivers use hybrid dimming.
This is combined amplitude and PWM dimming.

Advantages and disadvantages of PWM

Advantages of PWM dimming:
- Dimming without color differences among all LEDs
- Same brightness of all LEDs

Disadvantages of PWM dimming:
- Remaining risk of stroboscopic effects when rotating or fast-moving parts are illuminated; this risk can be reduced by increasing the PWM frequency to over 400–500 Hz
- Interference effects with cameras are reduced with higher frequency, but for high demands on image quality or high-speed imaging, PWM is not recommended

Hybrid dimming



Segments of ripple current (application clustering)

Ripple current	Applications
a) 0–10 %	Factories with rotating machines, camera-controlled areas, scanner applications, film recording, hospitals
b) 10–35 %	Offices and standard illumination applications
c) 35–50 %	Corridors, car parks, outdoor and peripheral areas

Figure 5: Example of striped image interference with a rolling shutter camera

State-of-the-art smartphone cameras increasingly use software solutions to reduce the image artifacts caused by modulated ambient light.

Lighting systems emitting modulated light in a frequency range below approx. 5 kHz can cause more or less pronounced image artifacts in standard cameras, in which the permissible modulation depth depends strongly on the modulation frequency. The 100 Hz ripple current of the LED driver used plays a key role in this context. The behavior of standard cameras with regard to the influencing frequency spectrum is therefore almost complementary to the behavior of bar code scanners.

Figure 6 illustrates the modulation depth and modulation frequency ranges in which image artifacts can occur in standard cameras in the event of lighting with temporally modulated light or in which no negative impact is to be expected. In the area of the “visibility limit” (in the center of the graph), perceivable image artifacts can theoretically occur with special exposure times. These, however, are hardly perceived in practice. This diagram is based on a minimum camera exposure time of 1/100 s.

PWM dimming

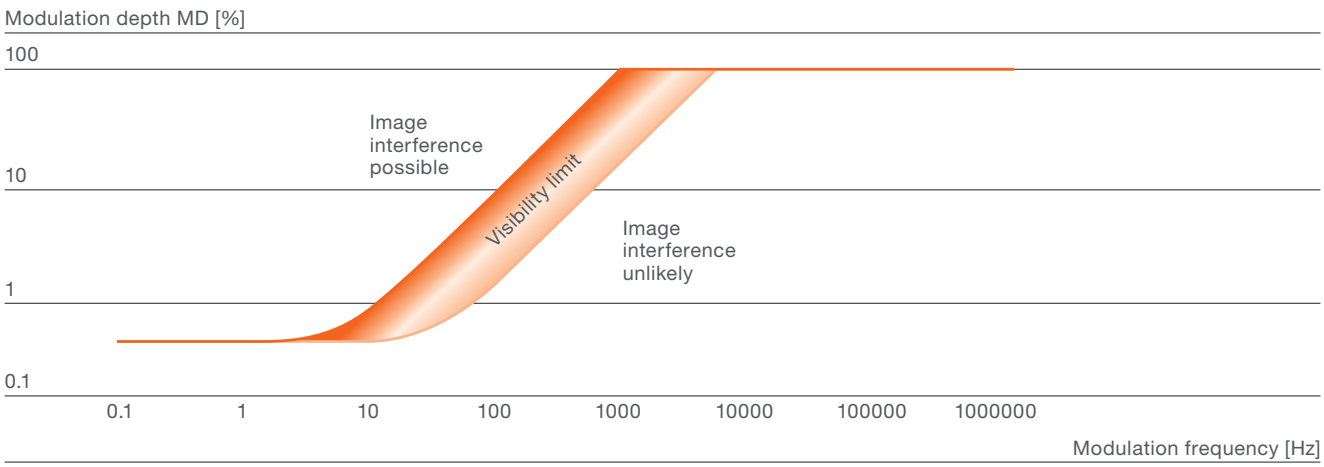
Certain lighting systems dim LED light sources by employing a procedure that interrupts the LED current in time packages. The repetition frequency of these packages is in the range from 100 Hz to approximately 2,000 Hz, which the human eye cannot directly perceive. Since the brightness of the dimmed light sources depends on the switch-on/switch-off time ratio of the LED current, this method is also referred to as PWM dimming.

With PWM dimming, the light modulation depth for camera shots reaches 100 % in the above-mentioned frequency range, i.e. in a corridor that can cause image artifacts. However, perfectly matched lighting and camera systems with high PWM frequencies enable successful use, for example for professional studio applications.

Lighting installations with OSRAM LED drivers from the OTi DALI[2)], OTi DALI Industry, OTi DALI TW[2)] and OT FIT families generally lead to no or only weakly pronounced artifacts with standard cameras.

2) This does not apply to devices with PWM dimming (e.g. first-generation DALI device types and dimmable CV devices).

Figure 6: Modulation depth and modulation frequency areas of lighting systems in which image artifacts in standard camera systems are possible or unlikely



03/2024

Technical application guide
OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

11 Emergency lighting with central and local battery systems

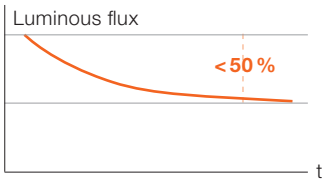
OSRAM

Emergency lighting with central battery systems

General

OPTOTRONIC® constant-current LED drivers such as OTi DALI, OTi and OT FIT are suitable for DC operation (e.g. central emergency system) in compliance with IEC 61347-2-13, annex J, which is stated with the EL mark. Additionally, all OPTOTRONIC® LED drivers are tested according to IEC 60598-2-22 (standard for luminaires for emergency lighting), where the luminaires have to operate reliably at an ambient temperature T_a of 70 °C within half of the rated duration.

1. For the total test of the luminaire at an ambient temperature T_a of 70 °C.
2. In case of an emergency, the luminous flux is not allowed to fall below 50 % within half of the rated duration (e.g. 3 h → 1.5 h or 1 h → 30 min). The luminous flux at the beginning of the emergency operation is of main importance. This "emergency" luminous flux can be much smaller than 100 % of the general lighting level, e.g. 15 %.



Voltage ranges and switch-on/switch-over times

	Permitted DC voltage range	Switch-over times: Maintained supply is switched from AC to DC	Switch-on times: Non-maintained emergency luminaires are switched on from cold	Driver output current in DC mode/ not locked
OTi DALI	176–276 V[1)]	0.2 s	0.3 s[2)], 0.6 s[3)]	15 %[4)]
OTi	176–276 V[1)]	< 0.5 s	< 0.5 s	15 %[4)]
OT FIT	176–276 V[1)]	< 0.5 s	< 0.5 s	100 %

1) DC or pulse DC (> 198 V for starting)
2) Switch-on time when emergency mode is activated
3) Switch-on time when emergency mode is not activated (at 230 V, 50 Hz, full load, according to DALI standard)
4) Output current/not locked

Output current in DC mode

Depending on the LED driver type, there are different output current and light levels in DC operation.

OTi DALI and OTi (non-dimmable) drivers can detect DC voltage and operate at a default output current of 15 % in DC mode to reduce battery consumption. If a higher output current is required, the default value can be adjusted via DALI magic/Wizard or DALI magic/Tuner4TRONIC®.

In DC operation, non-dimmable OSRAM LED drivers such as OT FIT typically have the same output (100 % output current) as in AC operation.

Note: INVENTRONICS can only provide data for the LED drivers. As the IEC requires luminous flux specifications (lm), the luminaire manufacturer has to validate his emergency luminaires (influence of LED module and luminaire construction).

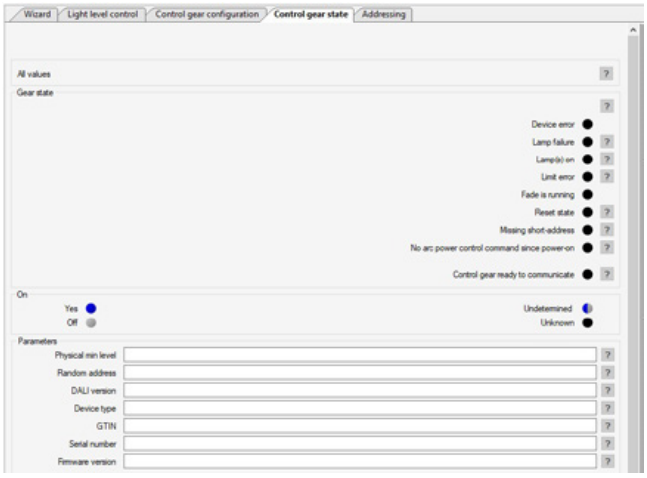
For more detailed information about IEC 60598-2-22 in respect to LED drivers, please refer to the OEM News "OEM-Information for emergency fittings acc. to IEC 60598-2-22" (02.09.2014) or our OEM Download Center at www.inventronics-light.com/oem-download.

Adjustment of the emergency lighting parameters

As mentioned above, DALI LED indoor drivers have a default output of 15 % and are not locked. This means that if the DALI LED drivers detect DC voltage, they automatically change to an output of 15 % and do no longer accept DALI commands to avoid unwanted output levels. Connected sensors are also ignored.

For central battery emergency installations where the factory settings do not fit, it is possible to adjust the emergency lighting parameters of OSRAM DALI LED drivers. For this adjustment, we offer two options:

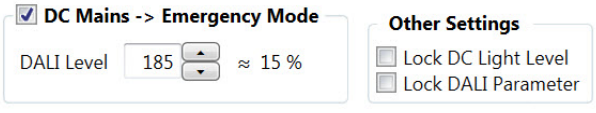
1. The software DALI Wizard in combination with the hardware DALI magic



DALI magic hardware

DALI Wizard software

2. The software Tuner4TRONIC® in combination with the hardware DALI magic or suitable NFC programming devices (more details can be found in the Tuner4TRONIC® Development manual)



Possible adjustments in the emergency mode

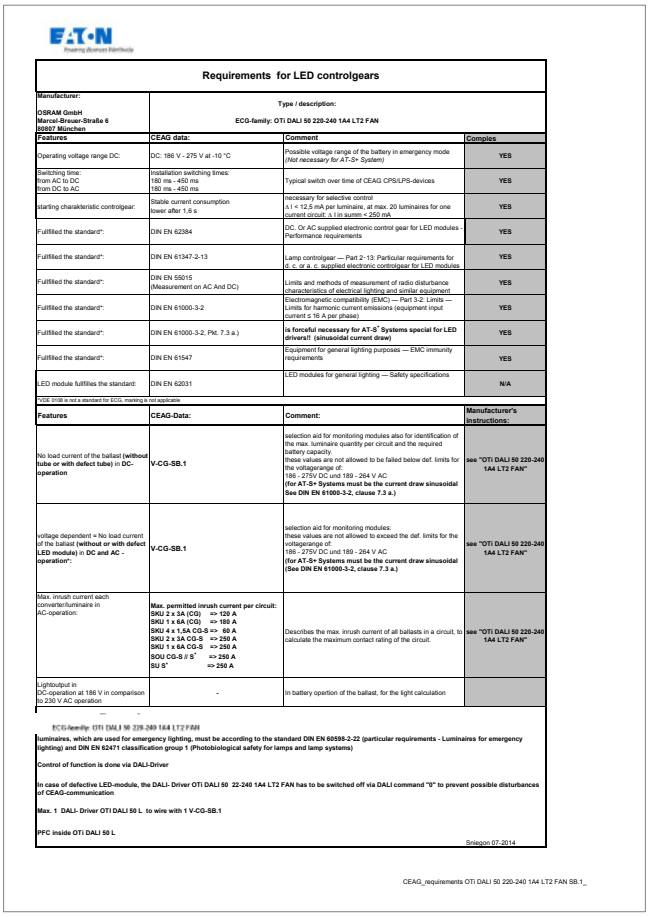
Compatibility with central battery systems

In many emergency lighting installations with central battery systems, compatibility of LED drivers with established emergency lighting monitoring systems is a must. Therefore, we and, for example, EATON-CEAG and INOTEC have tested the compatibility of OSRAM LED drivers and DALI LED drivers with emergency luminaire monitoring modules.

For DALI installations, EATON-CEAG and INOTEC recommend their DALI-addressing components.

Emergency lighting standards permit direct DALI communication for emergency luminaires in DALI installations

Due to the increasing attractiveness of DALI installations, DALI communication is used more and more in emergency lighting installations. The benefits are that general lighting luminaires and emergency luminaires use the same components and emergency luminaires do not lose CE approval, e.g. when adding luminaire monitoring modules. Depending on the application, each emergency luminaire can easily be adjusted via DALI, i.e. each emergency luminaire is controllable and can easily be monitored.



EATON

Requirements for LED controlgears

Manufacturer:	Type / description:		
OSRAM GmbH Marcel-Breuer-Straße 6 80807 München	ECG-family: OTi DALI 50 220-240 1A4 LT2 FAN		
Features	**CEAG data:**	**Comment**	**Complies**
Operating voltage range DC:	DC: 186 V - 275 V at -10 °C	Possible voltage range of the battery in emergency mode *(Not necessary for AT-S+ System)*	YES
Switching time: from AC to DC from DC to AC	Installation switching times: 180 ms - 450 ms 180 ms - 450 ms	Typical switch over time of CEAG CPS/LPS-devices	YES
starting charakteristic controlgear:	Stable current consumption lower after 1,6 s	necessary for selective control Δ I < 12,5 mA per luminaire, at max. 20 luminaires for one current circuit; Δ I in sumn < 250 mA	YES
Fulfilled the standard*:	DIN EN 62384	DC, Or AC supplied electronic control gear for LED modules - Performance requirements	YES
Fulfilled the standard*:	DIN EN 61347-2-13	Lamp controlgear — Part 2-13: Particular requirements for d. c. or a. c. supplied electronic controlgear for LED modules	YES
Fulfilled the standard*:	DIN EN 55015 (Measurement on AC And DC)	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment	YES
Fulfilled the standard*:	DIN EN 61000-3-2	Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	YES
Fulfilled the standard*:	DIN EN 61000-3-2, Pkt. 7.3 a.)	**is forceful necessary for AT-S+ Systems special for LED drivers!! (sinusoidal current draw)**	YES
Fulfilled the standard*:	DIN EN 61547	Equipment for general lighting purposes — EMC immunity requirements	YES
LED module fulfilles the standard:	DIN EN 62031	LED modules for general lighting — Safety specifications	N/A

*NOTE: 0/10 is not a standard for ECG, marking is not applicable

Features	**CEAG-Data:**	**Comment:**	**Manufacturer's instructions:**
No load current of the ballast **(without tuba or with defect tuba)** in **DC-operation**	**V-CG-SB.1**	selection aid for monitoring modules also for identification of the max. luminaire quantity per circuit and the required battery capacity these values are not allowed to be failed below def. limits for the voltagerange of: 186 - 275V DC und 189 - 264 V AC **(for AT-S+ Systems must be the current draw sinusoidal See DIN EN 61000-3-2, clause 7.3 a.)**	**see "OTi DALI 50 220-240 1A4 LT2 FAN"**
voltage dependent = No load current of the ballast **(without or with defect LED module)** in **DC and AC - operation*:**	**V-CG-SB.1**	selection aid for monitoring modules: these values are not allowed to exceed the def. limits for the voltagerange of: 186 - 275V DC und 189 - 264 V AC **(for AT-S+ Systems must be the current draw sinusoidal (See DIN EN 61000-3-2, clause 7.3 a.)**	**see "OTi DALI 50 220-240 1A4 LT2 FAN"**
Max. inrush current each converter/luminaire in AC-operation:	**Max. permitted inrush current per circuit:** **SKU 2 x 3A (CG) => 120 A** **SKU 1 x 6A (CG) => 180 A** **SKU 4 x 1,5A CG-S => 60 A** **SKU 2 x 3A CG-S => 250 A** **SKU 1 x 6A CG-S => 250 A** **SOU CG-S // S+ => 250 A** **SU S+ => 250 A**	Describes the max. inrush current of all ballasts in a circuit, to calculate the maximum contact rating of the circuit.	**see "OTi DALI 50 220-240 1A4 LT2 FAN"**
Lightoutput in DC-operation at 186 V in comparison to 230 V AC operation	-	in battery opertion of the ballast, for the light calculation	

ECG-family: OTi DALI 50 220-240 1A4 LT2 FAN

luminaires, which are used for emergency lighting, must be according to the standard DIN EN 60598-2-22 (particular requirements - Luminaires for emergency lighting) and DIN EN 62471 classification group 1 (Photobiological safety for lamps and lamp systems)

Control of function is done via DALI-Driver

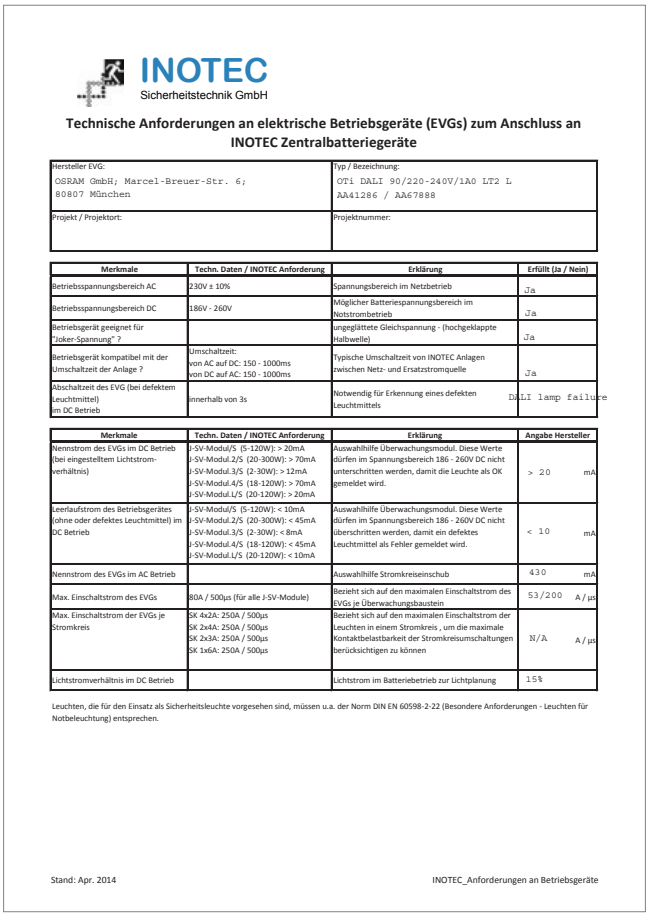
In case of defective LED-module, the DALI- Driver OTi DALI 50 22-240 1A4 LT2 FAN has to be switched off via DALI command "0" to prevent possible disturbances of CEAG-communication

Max. 1 DALI- Driver OTi DALI 50 L to wire with 1 V-CG-SB.1

PFC inside OTi DALI 50 L

Sniegon 07-2014

CEAG_requirements OTi DALI 50 220-240 1A4 LT2 FAN SB.1_



INOTEC
Sicherheitstechnik GmbH

Technische Anforderungen an elektrische Betriebsgeräte (EVGs) zum Anschluss an INOTEC Zentralbatteriegeräte

Hersteller EVG:	Typ / Bezeichnung:
OSRAM GmbH; Marcel-Breuer-Str. 6; 80807 München	OTi DALI 90/220-240V/1A0 LT2 L AA41286 / AA67888
Projekt / Projektort:	Projektnummer:

Merkmale	Techn. Daten / INOTEC Anforderung	Erklärung	Erfüllt (Ja / Nein)
Betriebsspannungsbereich AC	230V ± 10%	Spannungsbereich im Netzbetrieb	Ja
Betriebsspannungsbereich DC	186V - 260V	Möglicher Batteriespannungsbereich im Notstrombetrieb	Ja
Betriebsgerät geeignet für "Joker-Spannung" ?		ungeglättete Gleichspannung - (hochgeklappte Halbwelle)	Ja
Betriebsgerät kompatibel mit der Umschaltzeit der Anlage ?	Umschaltzeit: von AC auf DC: 150 - 1000ms von DC auf AC: 150 - 1000ms	Typische Umschaltzeit von INOTEC Anlagen zwischen Netz- und Ersatzstromquelle	Ja
Abschaltzeit des EVG (bei defektem Leuchtmittel) im DC Betrieb	innerhalb von 3s	Notwendig für Erkennung eines defekten Leuchtmittels	DALI lamp failure

Merkmale	Techn. Daten / INOTEC Anforderung	Erklärung	Angabe Hersteller
Nennstrom des EVGs im DC Betrieb (bei eingestelltem Lichtstrom-verhältnis)	J-SV-Modul/S (5-120W): > 20mA J-SV-Modul.2/S (20-300W): > 70mA J-SV-Modul.3/S (2-30W): > 12mA J-SV-Modul.4/S (18-120W): > 70mA J-SV-Modul.L/S (20-120W): > 20mA	Auswahlhilfe Überwachungsmodul. Diese Werte dürfen im Spannungsbereich 186 - 260V DC nicht unterschritten werden, damit die Leuchte als OK gemeldet wird.	> 20 mA
Leerlaufstrom des Betriebsgerätes (ohne oder defektes Leuchtmittel) im DC Betrieb	J-SV-Modul/S (5-120W): < 10mA J-SV-Modul.2/S (20-300W): < 45mA J-SV-Modul.3/S (2-30W): < 8mA J-SV-Modul.4/S (18-120W): < 45mA J-SV-Modul.L/S (20-120W): < 10mA	Auswahlhilfe Überwachungsmodul. Diese Werte dürfen im Spannungsbereich 186 - 260V DC nicht überschritten werden, damit ein defektes Leuchtmittel als Fehler gemeldet wird.	< 10 mA
Nennstrom des EVGs im AC Betrieb		Auswahlhilfe Stromkreiseinschub	430 mA
Max. Einschaltstrom des EVGs	80A / 500µs (für alle J-SV-Module)	Bezieht sich auf den maximalen Einschaltstrom des EVGs je Überwachungsbaustein	53/200 A / µs
Max. Einschaltstrom der EVGs je Stromkreis	SK 4x2A: 250A / 500µs SK 2x4A: 250A / 500µs SK 2x3A: 250A / 500µs SK 1x6A: 250A / 500µs	Bezieht sich auf den maximalen Einschaltstrom der Leuchten in einem Stromkreis , um die maximale Kontaktbelastbarkeit der Stromkreisumschaltungen berücksichtigen zu können	N/A A / µs
Lichtstromverhältnis im DC Betrieb		Lichtstrom im Batteriebetrieb zur Lichtplanung	15%

Leuchten, die für den Einsatz als Sicherheitsleuchte vorgesehen sind, müssen u.a. der Norm DIN EN 60598-2-22 (Besondere Anforderungen - Leuchten für Notbeleuchtung) entsprechen.

Stand: Apr. 2014

INOTEC_Anforderungen an Betriebsgeräte

Typical confirmation papers from EATON-CEAG and INOTEC

Emergency lighting companies for central battery systems

OSRAM DALI LED drivers	Emergency lighting company	Recommended emergency lighting device	Comment
	EATON-CEAG	V-CG-SB.1	
	INOTEC	DALI SV-Modul 851 032	
	Gessler, Rodgau	LB01/009 DD	
	Gessler, Rodgau	No need	**SIBE**LON – directly addressing DALI drivers
	Schuster, Grevenbroich	SET 009 DD SET 010 DD	
	Schuster, Grevenbroich	No need	**SET**LON – directly addressing DALI drivers
	ASE, Kaarst	SET 010 DD	
	ASE, Kaarst	No need	**SET**LON – directly addressing DALI drivers
	Siemens, Regensburg	No need	KNX/DALI Gateway, Plus/Twin plus directly addressing DALI drivers monitoring the AC installation

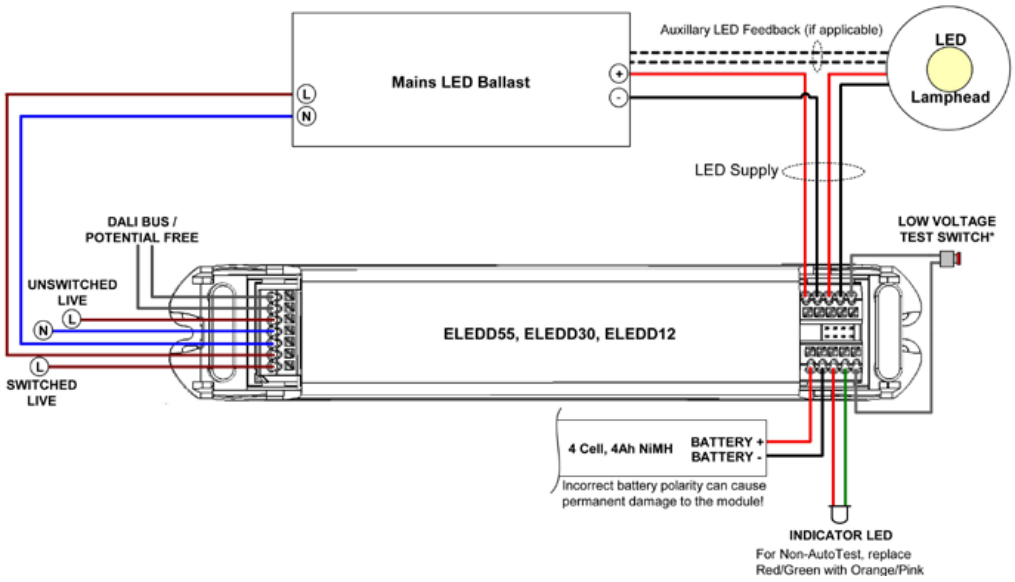
Additional compatibility information of other OSRAM LED drivers can be found in our OEM Download Center at www.inventronics-light.com/oem-download.

Emergency lighting with local battery sytems

Compatibility with local battery systems

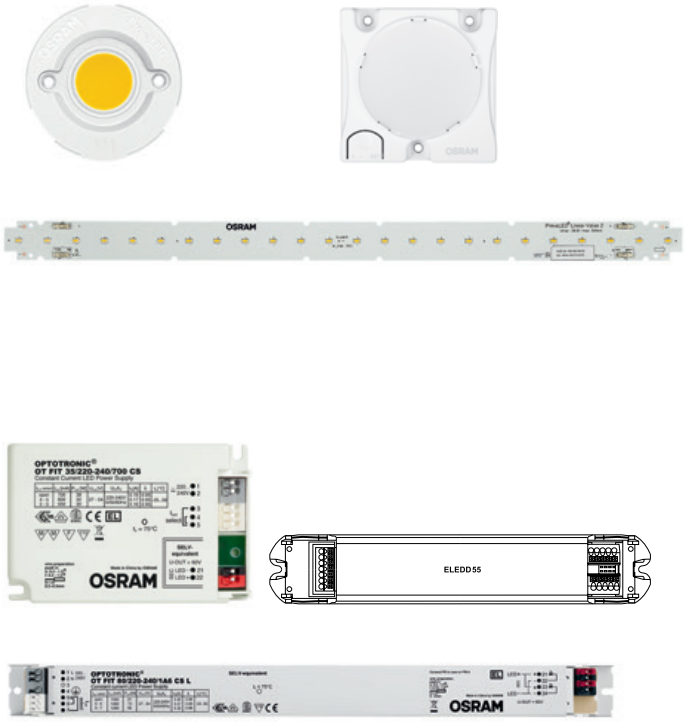
In order to achieve compatibility with local battery systems, topics such as compatibility of the output voltage range, switch-over sequence and the fulfillment of the SELV requirements of the system are important.

Wiring diagram example for LED driver, LED module and EL-kit



Functional description and wiring of the emergency lighting unit

The emergency lighting unit detects the level of the mains supply and switches the LED operation from regular operation (mains-powered LED driver) to emergency operation (DC/DC converter integrated in the emergency lighting unit). If the mains supply drops below a threshold, the unit switches off the mains-powered LED driver and operates the LED module at 50–90 mA from the integrated converter. If the mains recovers above the threshold, the unit switches back to the mains-powered LED driver. Switching between regular and emergency operation involves two relays: A primary-side relay that opens/closes the L supply for the mains-powered LED driver and a secondary-side multi-contact relay that switches the load connection from the mains-powered LED driver to the DC/DC converter or vice versa. The secondary-side relay is a dual-pole type.



To-dos for the luminaire manufacturer

The following documents and tests have to be prepared/carried out by the luminaire manufacturer to ensure compliance:

1. Test report safety according to EN 60598-2-22
2. Test report EMI according to EN 55015
3. Test report immunity according to EN 61547
4. Test report EMF according to EN 62493 (electromagnetic fields)
5. CE declaration, battery pack is compliant with EN 61951-1/-2 (or test report)
6. CE declaration, EL converter is compliant with EN 61347-2-7 (or test report)
7. CE declaration, EL converter is compliant with EN 62034 (or test report)
8. Test report harmonics according to EN 61000-3-2
9. Colors of status LEDs are compliant with EN 60073
10. Light distribution curve in emergency mode

If ENEC approval is required, the safety documents of point 5, 6 and 7 have to be given to a certified testing institution such as VDE, ÖVE or TÜV.

Further information can be found in our OEM Download Center at www.inventronics-light.com/oem-download.

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Technical application guide OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

12 Abnormal conditions

Overload

OPTOTRONIC® LED drivers are equipped with a reversible electronic overload protection, which, in case of an overload condition, automatically reduces the output power or switches off to prevent damage to the LED driver or installation.

When the overload condition is removed, the LED driver returns to its full output power or requires a mains reset. Exceeding the maximum rated load (P/PN > 1) also bears the risk of overheating the driver and can also lead to a safety shutdown.

If an LED driver shuts down due to an overload, it may enter a blinking mode, alternating between a complete shutdown and a brief power-up of the system in order to determine whether the overload condition is still present in the installation.

Warning: Operating OPTOTRONIC® LED drivers continuously above the maximum rated power reduces the lifetime of the driver and the maximum T_c temperature of the driver may also be exceeded.

Short circuit

Short circuit between both output wires (LED+ and LED-)

OPTOTRONIC® LED drivers have a reversible electronic protection against damage caused by a short circuit between LED+ and LED-. If a short circuit is detected, the LED driver limits the output power or switches off.

Short circuit from any output wire to PE

A short circuit from any output wire to PE means shorting a basic isolation, which is generally not allowed. The functional consequences for non-isolated drivers are different from the consequences for SELV drivers.

- Non-isolated drivers will switch off. The internal fuse of non-isolated OT drivers will blow in compliance with the safety standards.
- SELV drivers will typically tolerate such a short circuit without dramatic malfunction.

Partial/no load

OPTOTRONIC® LED drivers ensure safe and reliable operation of LED modules within the complete rated load range. Behavior outside of the rated load range is specified in the individual product datasheet.

Overtemperature

OPTOTRONIC® drivers may become overheated due to high-load operation, insufficient cooling or close-by heat sources. Regardless of the source of overheating, OPTOTRONIC® drivers are protected against permanent damage from overtemperature, within certain limits.

Depending on the OPTOTRONIC® family, the driver reduces the output power in case of overtemperature and, also depending on the family, eventually shuts down in order to avoid permanent damage.

Warning: For safe and reliable operation and also to avoid a reduction in lifetime, it is mandatory to keep the T_c temperature below the specified maximum value at all times.

Input overvoltage

OPTOTRONIC® drivers are able to withstand high and low mains voltages for a limited time.

1. A high mains AC voltage stresses the driver and has a negative impact on the driver lifetime. Typically, the permitted voltages are 275…350 V for a period of 2 to 48 hours.
2. Up to a certain limit, OPTOTRONIC® drivers have a built-in surge protection. A typical surge transient protection is 1 kV between L and N and 2 kV between LN and PE according to EN 61547, clause 5.7. For detailed values, see the individual product datasheets.

Depending on the requirements, an additional surge protection device may be neccessary for the protection against high or repeated surge pulses.

03/2024

Technical application guide OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

13 Installation notes

OSRAM

Residual-current circuit breakers

Problem
For LED drivers with protective earth (PE), the high short-term inrush current or also the low leakage current from the interference suppression capacitors in the LED drivers can trigger the residual-current circuit breakers.

Solution
- Distribute luminaires across 3 phases and use 3-phase residual-current circuit breakers
- Use surge-current-resistant, short-delay residual-current circuit breakers
- If permissible, use 30-mA residual-current circuit breakers

Inrush current/maximum number of LED drivers per miniature circuit breaker (MCB)

A starting current pulse of very short duration (< 1 ms) is generated as the storage capacitor used for internal power supply is charged.

In this case, the simultaneous charging of these capacitors in the LED drivers means a higher system inrush current than with the choke/starter fittings installed before. This reduces the maximum number of LED drivers permitted per MCB.

When using the values in the table on the next page, please note the following:
- Switching is assumed to occur at the peak of the rated AC input voltage, which is the worst case in terms of the inrush current pulse.
- The type of circuit breakers (e.g. Siemens type 5SN I-2 and 5SX) has “B” tripping characteristic.
- If circuit breaker types with “C” characteristic are used, the permitted number of LED drivers is 70 % higher than with “B” characteristic (please observe VDE-0100-410).
- The specified maximum number applies to single-pole automatic circuit breakers. When using multi-pole automatic circuit breakers (2-pole or 3-pole), the permitted number of units is reduced by 20 %.
- Circuit impedance: The specified loading applies with reference to a line impedance of 800 mΩ. This corresponds to a 15-m-long cable with a diameter of 1.5 mm^2 from the distribution board to the first luminaire and a further distance of 20 m to the middle of the circuit. At a line impedance of 400 mΩ, the permitted values are reduced by 10 %. At 200 mΩ, they are reduced by 20 %.

Maximum permitted length of control cables

If dimmers or dimmable drivers are used, every type of dimming has a maximum permitted cable length that must be observed. The table below lists the typical maximum cable lengths that can be achieved with different control protocols without the use of repeater devices.

Typical maximum control cable lengths

	Typical maximum cable length
1…10 V	Depending on type of control cable
DALI	300 m
Touch DIM®/ Touch DIM® Sensor	25 m (up to 20 devices), 100 m with DALI repeater/25 m (up to 4 devices)
DMX	300 m

We offer repeater devices for the 1…10 V and DALI control protocols. For further details, please refer to www.inventronics-light.com/lms.

Warning: DALI LED drivers with Touch DIM® function must not be operated with open DALI wires!

Recommendation

As long as no DALI controller is connected to the DALI LED drivers, short-circuit the DALI wires in the sub-distribution cabinet. This is also valid for installations with Touch DIM®/ corridor function. Reason: To avoid unwanted switching or unsynchronized dimming caused by electrical distortions or coupling into open DALI wires.

Technical background

Even low induced voltages can trigger the Touch DIM® mode on the DALI input connector of the DALI LED drivers. This antenna effect depends on the length and position of the open DALI line. With an open DALI line of more than 10 m, we recommend to short-circuit the DALI line.

How to repair (reset)

If the DALI drivers are already triggered incorrectly into Touch DIM® mode:

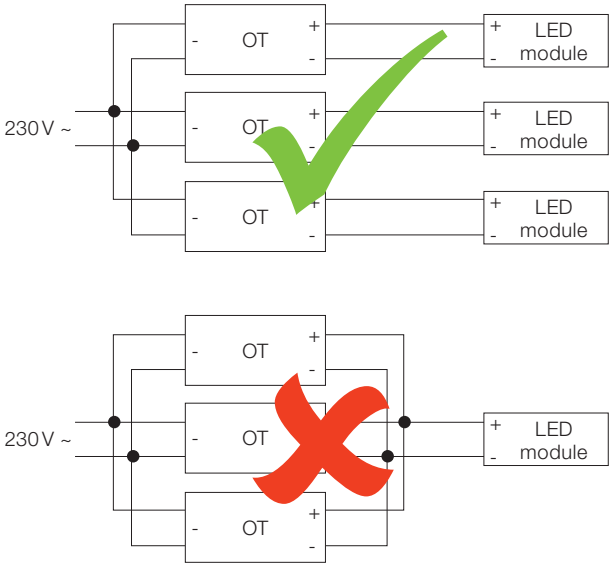
1. Interrupt the mains to the DALI drivers and connect a DALI control unit to the DALI input of the DALI LED drivers (e.g. OSRAM DALI Repeater or DALI MCU).
2. After powering up the DALI LED drivers again, the DALI drivers will check if a DALI signal is connected to the DALI input of the driver and will switch back into DALI mode again.
3. Interrupt the mains again, disconnect the DALI control unit.
4. Short-circuit the DALI line.
5. Then power on again.

This information is valid for DALI LED drivers with Touch DIM®/corridor function and for DALI ECGs for fluorescent lamps.

No parallel connection on the output side

OPTOTRONIC® LED drivers cannot be connected in parallel on the secondary side as this may lead to unequal load distribution and overload of individual drivers. Series connection is also not permitted.

Parallel connection of OPTOTRONIC® drivers



Output switching (switching between driver and module)

Typically, OPTOTRONIC® constant-current drivers are not switched on the output side during operation. Only a few SELV Compact LED drivers such as OTi DALI and OT FIT having the hot-plug function allow this way of switching to the LED module. Non-isolated drivers do not allow this when voltage is applied.

Please note:

We advise against hot-plugging because the drivers are not designed for it.

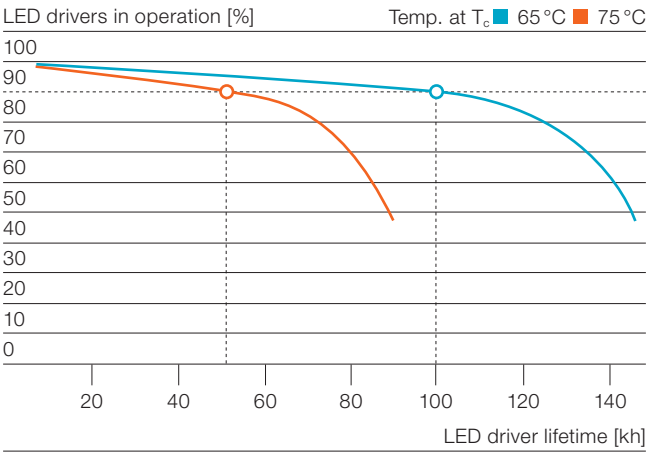
OSRAM SELV drivers: OTi DALI SELV and OT FIT SELV

Temperature and lifetime

The lifetime of OPTOTRONIC® drivers is determined by the lifetime of the used electronic components and their individual electric and thermal loading. Every OPTOTRONIC® driver is marked with a so-called T_c point. For safe operation, it is mandatory that the temperature at the T_c point does not exceed the specified maximum temperature. This also ensures that OPTOTRONIC® drivers typically achieve a nominal lifetime of 50 000 hours at a maximum failure rate of 10 %.

When installing an LED driver outside of a luminaire, make sure not to install it too close to any other heat source in order to avoid overheating. The exponential dependency of the lifetime on temperature, however, also means that the lifetime of an LED driver can be extended by operating it below the specified maximum temperature at the T_c point at all times. As a rule of thumb, you can expect up to double the lifetime for OPTOTRONIC® drivers when the temperature at the T_c point is kept 10 °C below the maximum permitted temperature at all times. The diagram on the right shows the typical life expectancy of an OPTOTRONIC® driver (with a nominal lifetime of 50 000 hours at a maximum T_c temperature of 75 °C) at various T_c temperatures.

Expected lifetime of OPTOTRONIC® drivers



Audible noise

The frequency-dependent sound pressure level generated by an OPTOTRONIC® driver approximates the audibility threshold, i.e. a person with normal hearing is virtually not able to notice the noise generated by an OPTOTRONIC® driver 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.

Note: For LED drivers where the mains voltage deviates significantly from a sine wave, a “chirping” sound may be heard from the choke coils in the driver’s input stage.

To avoid noise from dimming, dimmable OPTOTRONIC® drivers should be installed in a way that prevents the transfer of vibrations to any resonance surface.

Permitted switching cycles and use of motion/presence detectors

OPTOTRONIC® constant-current LED drivers and OSRAM LED modules are specified for a minimum of 100 000 switching cycles. This means that when switching 50 times a day (about 18 000 switching cycles per year), a minimum of 5 years of reliable operation is possible with our systems in areas with more frequent switching, such as car parks, corridors, lifts and logistic areas.

Our internal tests have even shown much higher possible switching cycles without any failure of the tested OPTOTRONIC® drivers and OSRAM LED modules.
An additional benefit of the LED solution is the fact that a minimum “burn-in” time – as with fluorescent lamps – is not necessary.

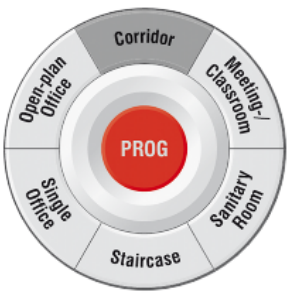
Permitted switching cycles per LED driver families

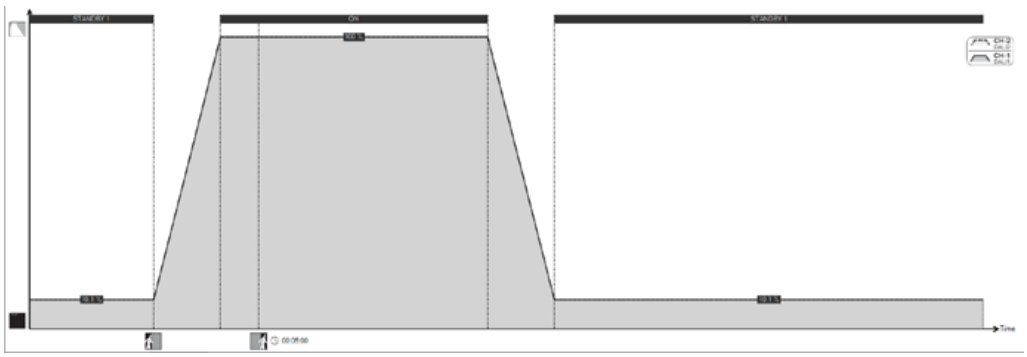
Number of switching cycles	LED driver	LED driver reference	Comment
> 1 000 000	DALI LED driver OPTOTRONIC® Intelligent DALI	OTi DALI …	DALI driver in stand-by mode, switching via DALI commands
> 150 000	DALI LED driver OPTOTRONIC® Intelligent DALI Window driver OPTOTRONIC® Intelligent	OTi DALI … OTi …	Switching on the primary side ON/OFF
> 150 000	LED driver OPTOTRONIC® FIT with 3 currents or fixed output	OT FIT … CS/OT FIT …	Switching on the primary side ON/OFF
> 100 000	LED driver OPTOTRONIC® ECO	OTe/OTe PC (Phase Cut)	Switching on the primary side ON/OFF
> 20 000	Constant-voltage drivers	OT 24 V or OT 12 V	Switching on the primary side ON/OFF

For applications where a higher number of switching cycles is required, we recommend the use of OPTOTRONIC® DALI LED drivers, which are permanently in stand-by mode (on mains voltage) and only switch with the DALI commands (0* = 0 % luminous flux and 254 = 100 % luminous flux) or other required light levels. Because of this, no ON/OFF switchings of the driver and no inrush currents can influence the lifetime of the DALI LED driver or LED module. This operating mode therefore allows 1 000 000 switching cycles.

Another option to use DALI LED drivers is in corridors – with a low permanent light level of 5–10 % for orientation and a light level of 100 % when presence is detected.

Possible DALI solution for corridor application: DALIeco in corridor function mode (2 alternating light levels)





For more details about DALIeco, please see: www.inventronics-light.com/dalieco. For similar light management systems, please see: https://www.osram.com/ecat/Light%20management%20systems-Digital%20Systems/com/en/GPS01_1027355/

* DALI dimming value

03/2024

Technical application guide
OPTOTRONIC®, ICUTRONIC® and ELEMENT LED drivers for indoor application

14 Standards for LED drivers, LED modules and LED luminaires

OSRAM

General information on standards

All OPTOTRONIC® drivers are designed to meet or exceed applicable standards for their use in lighting applications.

Safety

The safety requirements for LED drivers are specified in EN 61347-2-13.

OPTOTRONIC® indoor drivers are available in two insulation classes:

- SELV drivers (double/reinforced isolation between input and output, LEDset)
- Non-isolated drivers (no isolation between input and output, LEDset)

OPTOTRONIC® LED drivers have the following safety features:

- Overload protection
- Short-circuit protection
- Partial-load/no-load-safe
- Overtemperature operation
- Input overvoltage and surge protection

Performance

The performance standard EN 62384 specifies, provides requirements for and tests the optimal operation of LEDs with LED drivers, ensuring that LEDs are only operated within their specified operating parameters. This ensures best light quality and maximum lifetime of suitable LED modules. All OPTOTRONIC® drivers with the ENEC mark are approved according to EN 62384.

EMC (electromagnetic compatibility)

EMC is specified as a series of different test criteria. These are radio interference suppression (EMI), immunity to interference and voltage fluctuations, flicker and harmonic content (up to the 39th harmonic).

Harmonic content of the mains current

Lighting equipment is subject to restrictions on harmonic current emissions harmonics. The maximum permissible emission limits are defined in the standard EN 61000-3-2, classification in class C for lighting equipment. All OPTOTRONIC® drivers fulfill the strict harmonic limits between 5 W and 25 W, and above 25 W.

Immunity

The immunity requirements are specified in EN 61547. This ensures protection against interference from external high-frequency fields, discharge of static electricity and transient overvoltages on the mains supply.

Radio interference

The requirements, e.g. limits for conductive and radiated disturbances, are specified in EN 55015. The length of output cables must not exceed the values specified in the product datasheets to meet the requirements of radio interference suppression.

Note: The luminaire manufacturer is responsible for measuring and verifying EMI compliance of the complete luminaire as the level of radio interference will vary depending on the luminaire construction. Especially primary and secondary cable lengths and their routing may have a significant effect on radio interference.

EU directives

EU directive	
Low-voltage directive 2014/35/EU	Product-related safety, photobiological safety, EMF
Electromagnetic compatibility 2014/30/EU	EMC: EMI, immunity, harmonics and flicker
Energy-related products 2009/125/EC (ecodesign)	Requirements in the directive
Hazardous substances 2011/65/EU (ROHS, REACH)	Requirements in the directive

Standards for LED products

Drivers for LED modules

	International	Europe
Safety driver	IEC 61347-2-13	EN 61347-2-13
Safety luminaires[1]	IEC 60598-1	EN 60598-1
Performance of LED drivers	IEC 62384	EN 62384
EMC – electromagnetic interference (EMI)	CISPR 15	EN 55015
EMC – immunity	IEC 61547	EN 61547
EMC – harmonics	IEC 61000-3-2	EN 61000-3-2
EMC – flicker	IEC 61000-3-3	EN 61000-3-3
EMF (electromagnetic fields)[1]	IEC 62493	EN 62493

1) Independent LED driver

LED modules

	International	Europe
Safety LED modules[4]	IEC 62031	EN 62031
Safety luminaires[3]	IEC 60598-1	EN 60598-1
EMC – electromagnetic interference (EMI)[1]	CISPR 15	EN 55015
EMC – immunity[1][2]	IEC 61547	EN 61547
EMC – harmonics[1]	IEC 61000-3-2	EN 61000-3-2
EMC – flicker[1]	IEC 61000-3-3	EN 61000-3-3
Performance of LED modules	IEC 62717	–
EMF (electromagnetic fields)[1][3]	IEC 62493	EN 62493
Photobiological safety	Fully covered by IEC 62031	EN 62031

1) LED modules with built-in driver
2) LED modules with external driver, ESD and immunity tests (high energy pulses L-N, PE) apply
3) Independent LED modules or if parts are accessible (outside of the luminaire)

LED luminaires

	International	Europe
Safety luminaires – general requirements	IEC 60598-1	EN 60598-1
Safety luminaires – additional requirements	IEC 60598-2-xx special luminaires	EN 60598-2-xx special luminaires
Performance of LED luminaires	IEC 62722-2-1	–
EMC – electromagnetic interference (EMI)	CISPR 15	EN 55015
EMC – immunity	IEC 61547	EN 61547
EMC – harmonics	IEC 61000-3-2	EN 61000-3-2
EMC – flicker	IEC 61000-3-3	EN 61000-3-3
EMF (electromagnetic fields)	IEC 62493	EN 62493
Photobiological safety	IEC 60598 (series)	EN 60598 (series)

Appendix: Driver symbols and labels


Conformity with European standards


Conformity with United Kingdom standards


Conformity with Eurasian standards


Conformity with India BIS standards


Conformity with Australia RCM scheme


China certification


Independent lighting auxiliary (independent gear)


VDE approval mark (electrical safety)


VDE approval mark for EMC (electromagnetic compatibility)


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)

λ (Lambda)	Power Factor
T_a	Ambient temperature
T_c	Case temperature (measuring point)


ENEC (10) independently tested and approved (10 = country code)

Functional Earth / Protective Earth

Mains (primary) inputs – not polarised

Suitable for Emergency Lighting (DC mains)

WEEE marking – not disposable in general waste – electronic equipment

SELV (Safety Extra-Low Voltage) output isolation

Short-circuit-proof with safety insulation

Reinforced insulation for class II applications, does not need protective earth

Protection class II device including double or enhanced isolation

Do not cover independent gear with insulating materials.

NFC programming antenna (location)

Underwriters Laboratory (UL) related markings

Electrostatic sensitive devices

Disclaimer

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