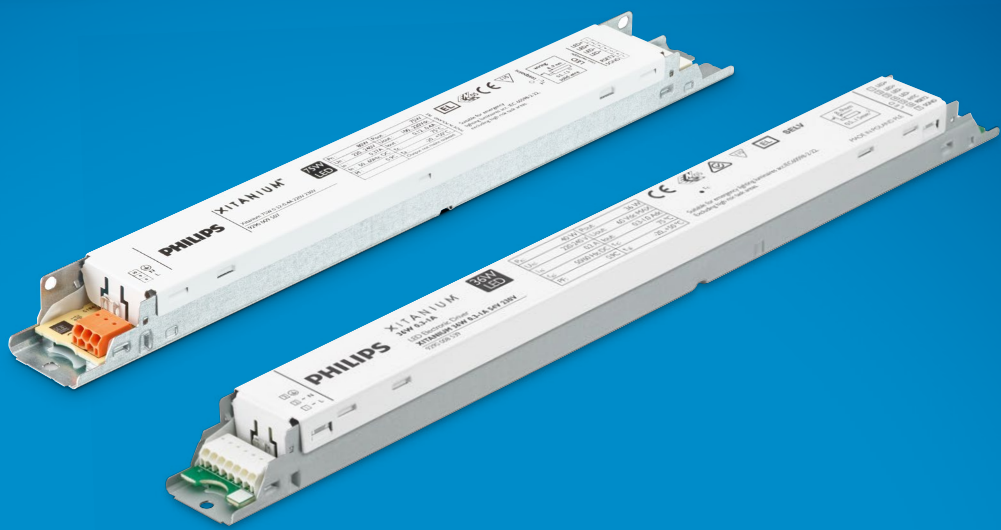
PHILIPS

Xitanium

LED indoor drivers

Linear




**Design-in Guide**

# Enabling **future-proof LED technology** for dynamic LED markets

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Added remark on limited effect of mains fluctuations
Improved information on Touch and Dim behavior

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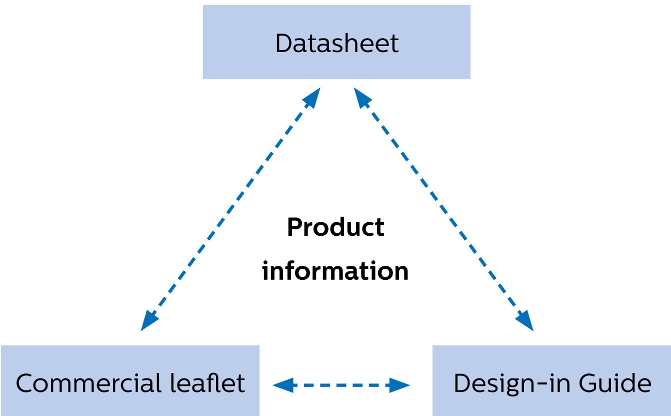
Xitanium Indoor Linear LED drivers




Thank you for choosing Philips Xitanium drivers. In this guide you will find the information needed to integrate these drivers into a LED luminaire or LED system. This edition describes the Xitanium LED drivers optimized for indoor linear lighting. We advise you to consult our websites for the latest up-to-date information.

## Applications

Xitanium Indoor Linear LED drivers are designed to be used built-in, and operate LED solutions for indoor lighting like offices, public buildings, industrial applications and retail environments. If you use Philips LED drivers in combination with Philips LED modules, specific design-in guides are available from www.philips.com/technology

## Information and support

### Downloads and information

Please consult your local Philips office or visit: www.philips.com/technology

### Design-in support

On request Design-in support from Philips is available. For this service please contact your Philips sales representative.

## Determine which documents contain what information

In order to provide information in the best possible way, Philips' philosophy on product documentation is the following.

- Commercial leaflet contains product family information & system combinations
- Datasheet contains the product specific specifications
- Design-in guide describes how the product is to be designed-in

All these documents can be found on the download page of the OEM website www.philips.com/technology. If you require any further information or support please consult your local Philips office.

# Safety precautions

**Warning:**

- Avoid touching live parts!
- Do not use drivers with damaged housing and/ or connectors!
- Do not use drivers with damaged wiring!
- Class I luminaires must be connected to protective earth!

**Safety warnings and installation instructions**
To be taken into account during design-in and manufacturing

- Do not use damaged or defective contacts or housings
- Do not use damaged products
- Do not service the driver when the mains voltage is connected; this includes connecting or disconnecting the LED load
- Cap off all unused wires to prevent accidental contact with the luminaire, driver housing or accidental touching
- Do provide an adequate earth connection when applicable
- The luminaire manufacturer is responsible for its own luminaire design and has to comply with all relevant safety standards
- The Xitanium Indoor LED drivers are intended for indoor use and should not be exposed to the elements such as snow, water and ice. It is the luminaire manufacturer's responsibility to prevent exposure.

**Philips Design-in support** is available; please contact your Philips sales representative.

# Introduction to Xitanium Indoor Linear LED drivers

Xitanium Linear LED drivers.
Top showing non- isolated and bottom showing isolated version.

## Introduction

Xitanium LED drivers are designed to operate LED solutions for general lighting applications such as linear lighting in offices and in industry applications. Reliability is underpinned with 5 year warranty, enhanced by specific features that protect the connected LED module, e.g. reduced ripple current (<4%) and thermal de-rating. Most drivers feature central DC operation.
In the coming years LEDs will continue to increase in efficiency, creating generation and complexity challenges for OEMs. With Xitanium LED drivers, flexibility in luminaire design is assured thanks to an adjustable (selectable) output current. Application-oriented operating windows offer the flexibility required to provide the stable lumen output and light quality levels that lighting specifiers and architects demand. And the adjustable output current also enables operation of various LED PCB solutions from different manufacturers.

The remarkable energy savings and CO2 reductions achieved with LED lighting can be further extended with dimming. Xitanium Indoor Linear LED drivers offer a range of dimming options. The 1-10 V interface allows for simplified, one-way management, while the DALI interface makes any installation with the Xitanium Linear driver ready for a fully networked control system. Alternatively these Dali drivers also are suitable to interface with Touch and Dim dimming.

### Xitanium LED driver versions

The Xitanium LED drivers described in this guide are available in different versions, e.g. both isolated and non-isolated versions, non-dimmable and dimmable (1-10 V and Touch and Dim & DALI (TD)) and come in a wide range of power ratings that enable the most popular light output levels for general lighting applications. We recommend you always check our Xitanium LED driver commercial leaflet for the most up-to-date overview of our range. This leaflet can be found on the download section of www.philips.com/technology.

## Features

### Adjustable Output Current (AOC)

Flexibility in luminaire design is ensured by the adjustable output current (AOC). The adjustable output current enables operation of various LED configurations from different LED manufacturers whilst also ensuring the solution remains “future proof” for new LED generations. The output current can be set with an external resistor (Rset). With the

TD version drivers the output current setting can also be programmed using the Philips MultiOne hardware interface USB2DALI and the matching MultiOne configurator software.

More information about AOC and how to set the output current can be found under chapter "Electrical design". More information on the Philips MultiOne configurator software and hardware interface on www.philips.com/multione.

### Controllability

The Xitanium Indoor Linear LED drivers are available in 3 different versions:

- Non-dimmable
- 1-10 V dimming
- Touch and Dim & DALI (TD)

### Amplitude Modulation (AM) output dimming

Philips Xitanium indoor linear LED drivers dim the output to the LEDs by means of Amplitude Modulation dimming (AM). This means at no stage of the dimming range Pulse Width Modulation dimming (PWM) at the output to the LEDs is involved. AM dimming guarantees the most smooth and flicker-free operation over the entire dimming range.

The way of controlling is shown in the name of the driver. If no dimming protocol is given in the name, the Xitanium driver can only be used as a non-dimmable driver. The output current can be set as described in the Electrical design chapter. More information about the dimming protocols can be found in the Controllability chapter.

### Thermal de-rating

Thermal de-rating of your LED is possible by integrating an NTC (Negative Thermal Coefficient) component on the LED PCB (Printed Circuit Board) and connecting this NTC to the driver's NTC input.

More details about NTC resistor can be found under chapter "Thermal Management".

### Module Temperature Protection (MTP) – adjustable on TD drivers only

This feature helps to protect the LEDs when operated in a hot ambient environment. The driver helps to regulate LED module temperature by regulating the output current. An NTC (Negative Temperature Coefficient resistor) must be present on the LED module and connected to associated pins on the driver in order to be able to make use this feature. Programmable drivers allow the dimming behavior to be changed.

More information on this feature can be found under chapter “Thermal Management”.

### Constant Light Output (CLO) – TD drivers only

Traditional light sources suffer from depreciation in light output over time. This applies to LED light sources as well. The CLO feature enables LED solutions to deliver constant lumen output through the life of the light engine. Based on the type of LEDs used, heat management and driver current, it is possible to estimate the depreciation of light output for specific LEDs and this information can be entered into the driver. The driver counts the number of light source working hours and will increase output current based on this input to enable CLO.

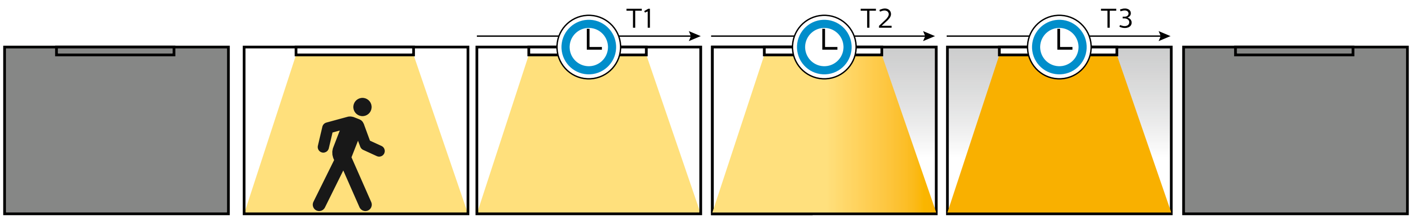
Since the CLO curve is not generic, the OEM needs to determine the appropriate CLO curve. This can be used to differentiate on e.g. lumen output or power consumption over lifetime. The CLO feature can be programmed with the Philips MultiOne configurator software.

More information can be found under chapter “Controllability”. More information can be found on www.philips.com/multione.

### DC mains operation

It is possible to connect the mains input of the Xitanium driver directly to a DC power net (e.g. central emergency system). This leads the driver to continue normal output when switched to DC mains. On selected TD drivers DCemDIM is available, allowing a pre-defined dim level (%) of the driver’s output when switched to DC. More on DCemDIM in section Controllability.

Check for requirements and default values the driver’s datasheet in the download section on www.philips.com/technology.




## Corridor Mode – TD drivers only

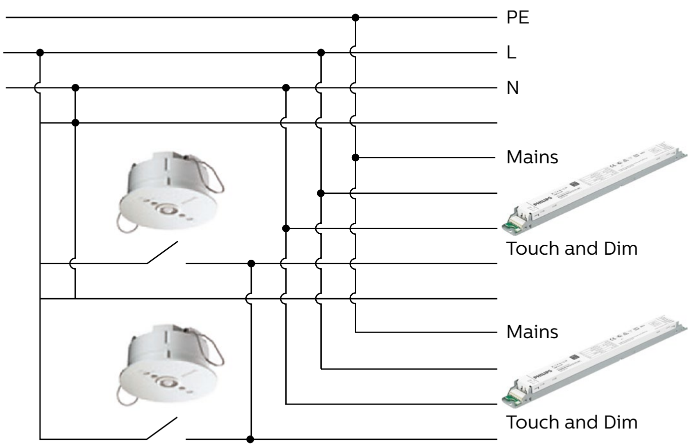
Corridor Mode is typically used in corridors, stairwells, entrance halls, storage rooms, underground car parks, pedestrian underpasses, underground railway stations and lifts. It is a simple function, available with Xitanium indoor linear TD LED drivers, that controls the light level when presence is detected by a simple on/off mains sensor. It is easy to use and can be activated using default parameters, so no programming via software is required.
When the sensor detects presence, the light switches on. When it no longer detects any presence, instead of the light switching off immediately, the TD driver takes over control of the light level and dims it down to a background level. The settings can be customized using the Philips MultiOne configurator software.

## How does it work?

A simple on/off mains sensor (e.g. PIR or micro wave) provides the signal and is connected to the Touch and DIM/DALI connection of the TD driver. When the input detects mains power on the DALI connection, it switches on the light to the normal level. When the mains signal of the sensor is switched on for more than 1 minute (default activation time), the TD driver goes into Corridor Mode.

When the on/off sensor no longer detects any movement, it goes into its delay time. After the delay time of the on/off sensor has elapsed, the TD driver no longer receives a mains signal on the DALI input and takes over control of the light level by going into its Corridor Mode sequence:

1. During the delay time the driver maintains the light at the normal level
2. During the fade time the driver dims the light to the background level
3. During the prolong time the driver maintains the light at the background level, after which the light is switched off.

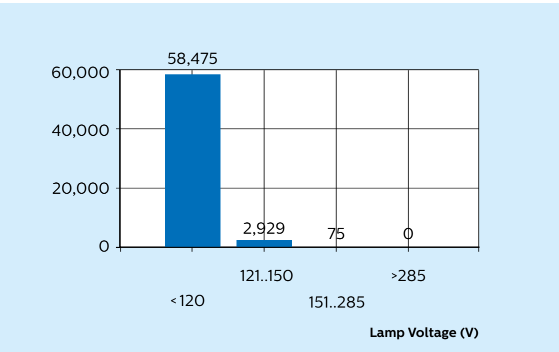



Connecting a sensor to the Dali input to utilize Corridor Mode

If the on/off sensor detects movement at any point during the Corridor Mode sequence, the light will revert to the normal level.

Newly released Xitanium indoor linear TD drivers incorporate the Corridor Mode feature. The datasheet states if for the driver you use this feature is present. For the default settings please check the associated datasheet of the driver you use, to be found in the download section on www.philips.com/technology.

The settings can be customized to suit your application using the Philips MultiOne configurator software (see sub section "Programming" under "Controllability").




## Driver diagnostics (actual measurements and logging) – TD drivers only

On selected TD drivers the diagnostics functionality is available. The purpose of Diagnostics is to gather information and help diagnose the history of the driver and connected LED module. The diagnostics consist mainly of counters which keep track of specific variables like for example the number of startups of the driver, temperature of driver and LED modules, current and voltages etc.

When the driver is shutdown the diagnostics data is stored automatically.

## Form factors

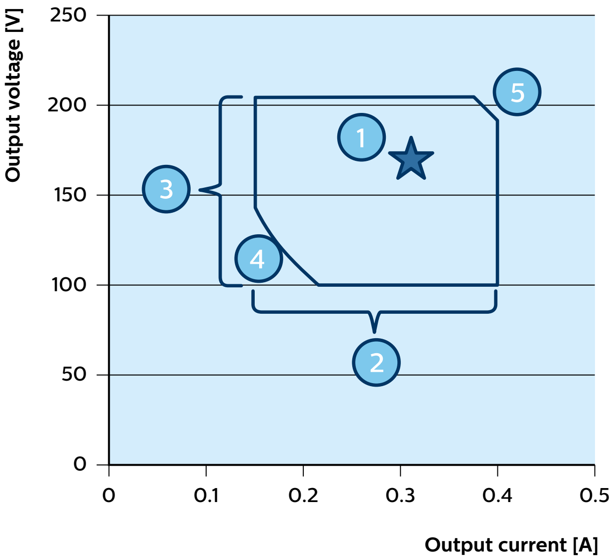
Linear housing
The housing of the Xitanium Indoor Linear LED drivers has a form factor compatible with typical fluorescent driver housing design.

## Explanation of the driver naming

The names of the drivers are defined as shown in the example below.

| | |
|---|---|
| Example | : Xitanium 75 W/0.12-0.4 A 215 V TD 230 V |
| Xitanium | : brand name for highly efficient and extremely reliable LED drivers |
| 75 W | : maximum output power |
| 0.12-0.4 A | : output current range |
| 215 V | : maximum DC output voltage |
| TD | : dimming protocol (Touch and Dim & DALI) |
| 230 V | : mains AC input voltage |

# Electrical design-in




1. Required set point for the LED solution
2. Current can be set to needs within range
3. Driver adapts to required voltage, given it fits range
4. Driver minimum power limit
5. Driver maximum power limit

Example of a Driver Operating Window

Note: by means of dimming it is possible to go below the minimum value of the specified output current.

## Xitanium Driver Operating window

LED technology is rapidly evolving. Using more efficient LEDs in a next generation means the same light output can be achieved with less power, hence lower drive currents. At the same time, LEDs can be driven at different currents levels based on the application requirement. Typically, LED drivers are available in discrete current levels e.g. 350 mA, 500 mA or 700 mA. It is often necessary to replace a driver when more efficient LEDs or different LED boards become available.

One of the key features of the Xitanium LED drivers is the adjustable output current (AOC), offering flexibility, differentiation for the OEM and future-proof luminaire design. The Xitanium drivers can operate in a so called “operating window”. This power window is defined by the maximum and minimum voltage (V), current (A) and power (W) that the driver can handle. An example of an operating window is shown on the left. The area indicates the possible current /voltage combinations. The current you select will depend on the type and manufacturer of the LEDs, the specific LED configuration of the PCB design and the desired output (lm) per LED. The voltage is the sum of the LEDs used (total Vf string). Both the operating window and default current setting of every driver can be found in the datasheets in the download section on www.philips.com/technology.

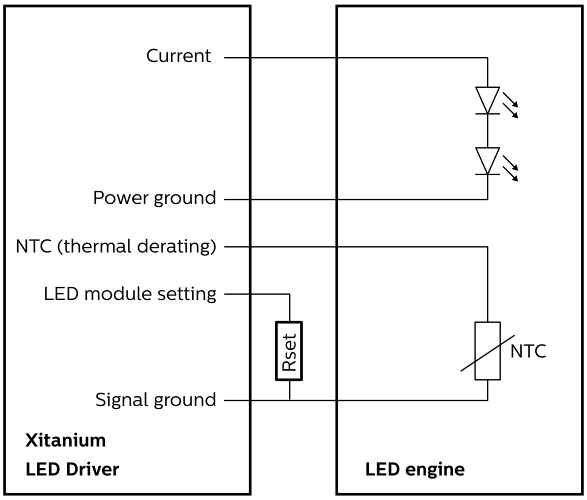
The output current of these drivers can be set in two ways.

1. By connecting a specific resistor value to the driver’s Rset input.
2. TD driver versions can be programmed via MultiOne interface in order to set the desired current. (www.philips.com/multione).

* Note: when connecting Philips LED Lines to the driver, the type of LED board (**LV** or **HV**) determines this requirement. **Hybrid** LED boards can be used on both type of drivers, indicated in **commercial leaflet LED Lines**, to be found in the download section of
www.philips.com/technology

**Note: for Philips LED Lines standard system configurations, driven at nominal current, are stated in the **commercial leaflet LED Lines**, to be found in the download section of www.philips.com/technology

Note: for a HV scenario that allows a 2 chain parallel solution, you are likely to find with steps described a lower rated driver power (e.g. 75 W for 1 chain versus 36 W for 2 chain solution)




Schematically representation of the driver's output interfaces

## How to... Select an appropriate driver

Depending on you requirements several drivers can be found as a solution for you. The following steps can help selecting the preferred driver.

For a full overview of available driver models, please refer to the commercial leaflet Xitanium indoor linear LED drivers, to be found in the download section of www.philips.com/technology, as are the datasheets associated with the drivers you intend to use.

1. Determine your required drive current (Idrive) and voltage (Vf)
2. Calculate required power via Pdrive = Vf x Idrive (W)
3. Determine which type* of driver do you need; Isolated or Non-isolated
   Collect the associated datasheets from the website.
4. Does required current fit current range of driver?
   – Idriver minimum ≤ Idrive ≤ Idriver maximum?
5. Does required voltage fit voltage range of driver?
   – Vdriver minimum ≤ Vf ≤ Vdriver maximum?
6. Does required power fit power range of driver?
   – Pdriver minimum ≤ Pdrive ≤ Pdriver maximum?
7. Choose your type** of dimming (TD/Dali, 1-10 V or non-dimmable)

## Driver wiring and connections

Examples of driver lead wires with corresponding functions can be seen in the figure on the left. Please check the driver's pinning in the associated datasheet on www.philips.com/technology. The function of each wire will be discussed further in detail in the following chapters.

### Single channel driver

Currently all the Xitanium Indoor Linear LED drivers are single channel drivers. This means for drivers with a double "+" and "–" output that these outputs are in parallel inside the driver. So you can only set one current.

Examples of what solutions could look like for pairing wires

### How to... Use wires and cables

In the datasheet of the driver you use it is stated what

- Wire diameters are accepted
- Strip length of the wires are accepted
- Up to what wire length the drivers are tested on EMC

#### Direct wiring between driver and LED boards

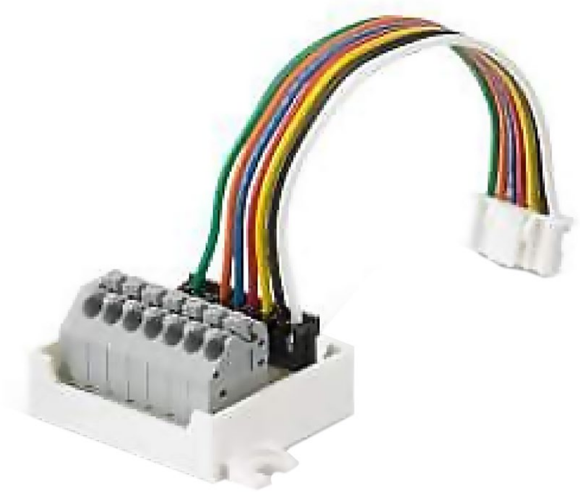
Be informed that no components are allowed between the LED driver and LED boards other than connectors and wiring intended to connect the LED driver to the LED board. For example it is not allowed to install a switch between the driver and LED boards.

#### 2 wires into one connector hole

In some scenarios two wires need to be connected to one connector hole. In this case the pairing has to be done outside the driver, resulting in only one wire going into the driver. Two wires into one connector hole are not supported.

#### Ferrules

The reliability of twin-wire ferrules (or wire end stop), accepting the wires intended to use, should be checked with the supplier of these ferrules.



Example of the JST to Push-in adapter

| Pin | Color | Function |
|---|---|---|
| 1 | White | IDC HV (+) (LED +) |
| 2 | Black | IDC LV (+) (not used for linear) |
| 3 | Yellow | Power Ground (-) (LED -) |
| 4 | Red | NTC |
| 5 | Blue | Iset1 (Rset1) |
| 6 | Orange | Iset2 (Rset2) |
| 7 | Green | Signal Ground (for NTC & Rset) |

## How to... Connect to a driver with JST connector on output

Some Xitanium Indoor Linear LED Drivers carry a JST output connector (non-isolated models only). Until these drivers get updated with a push-in connector be advised to use the JST-to-push-in adapter.

### 1. Connecting the LED board to the adapter

On the adapter IDC HV (+) and PGND (-)
are indicated (pin 1 and 3).
Connect IDC HV (+) to LED board IN+, PGND (-)
to LED board IN-.

### 2. Placing the Rset component into the adapter

- Rset2: place resistor into Rset2 connections (SGND and ISET2, pin 7 and 6).
- Alternatively, when using Rset1: place resistor into Rset1 connections (SGND and ISET1, pin 7 and 5).

### 3. Wire diameters accepted by the adapter

- AWG 24-16
- 0.2-1.5 mm2 solid and stranded
- 0.25-1 mm2 with ferrule
- Lead wires of the resistor component

Ordering information can be found in the **Commercial Leaflet of the Xitanium** indoor linear LED drivers, located in the download section on www.philips.com/technology.

### JST cable developed by OEM

Any luminaire design needs its own approval, organized by the responsible OEM, irrespective of the length of cable used. If you prefer to develop a JST-cable the specification should meet IEC/EN requirements. When selecting wiring, it must be borne in mind that the cable must not emit hazardous gases or catch fire when exposed to high temperatures (e.g. PVC, Halogen).

The following cable/connector specifications can be used, using a JST connector:
- housing JST PAP-07V-S
- contact JST SPHD-001T-P0.5
- diameter of the cable: 24AWG

### Adjustable Output Current (AOC) – set the driver output current

Output current can be set by placing an external resistor (LEDset and Rset) into the driver’s Rset input. Next to that TD driver versions allow also setting of the output current via software configuration.

Note: Rset is used as generic indication for Rset1, Rset2 or LEDset.

Note: LEDset and Rset-interface are not meant to be used as a control or dimming interface (for instance 1…10 V). If this is not observed, both performance and safety requirements of the installation may be affected.

### Default driver output current

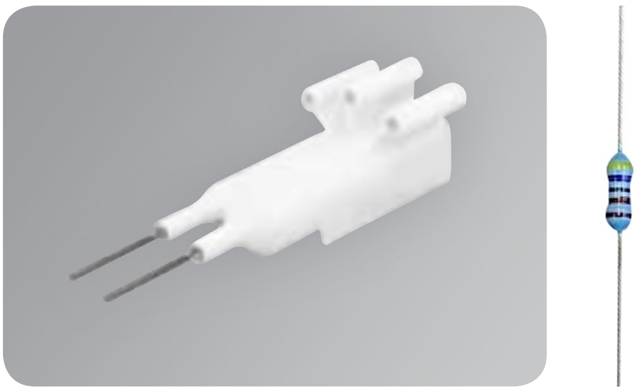
Because of safety requirements Philips decided to structurally implement the minimum output current as default setting for Philips’ LED drivers. In addition the LED driver will go into a safe state if the Rset resistor is not functioning well (e.g. broken or disconnected). However, as a result of the LEDset standard the default minimum is not an absolute minimum current anymore. For instance, for linear LED drivers a minimum of 120mA will now become ≤ 120mA. Reason for this specification (“≤” means ‘equals or less than’) is to allow thermal derating functionality on the LED module, which is part of the new LEDset standard. An ‘open’ situation (no resistor placed) should therefore be avoided.

In case the LEDset connections are being short circuited, the output of the driver will go to the maximum output power (Pout-max). In this case the required Vf of the LED load defines if at Pout-max also the maximum output current (I-max) is reached. The accuracy in this situation is less than when using a resistor to select and set the output current. an excess in this case are the non-isolated 36W and 75W Fixed Output drivers, potentially reaching up to 133% I-max (530mA).

Strong advice is to always use a well-connected resistor, which will result in a well-defined output current.

<table>
<tr><th colspan="3">Programming enabled</th></tr>
<tr><td>Yes</td><td colspan="2">No</td></tr>
<tr><td rowspan="3">$I_{nom}$ = Programmed value</td><td colspan="2">Rset connected</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>$I_{nom}$ = Rset Determined value</td><td>$I_{nom}$ = $I_{default}$</td></tr>
<tr><td colspan="3">Driver output current $I_{nom}$ should always be $I_{driver\ min} \leq I_{nom} \leq I_{driver\ max}$</td></tr>
</table>

Priority selection citeria for Group 1 - 1% minimum dim level



Example of a Set'n'drive resistor featured by BJB, fitted with a leaded resistor inside and allowing both manual or robot placement

### How to... Determine AOC priority with TD drivers

Since the TD drivers allow two methods to set the output current (AOC), it is good to take note of the priority of each method with respect to the other.

Historically there are two groups of TD drivers; those which can dim down to 1% (newer) and those which can dim down to 10% (older).

Group 1: 1% minimum dim level (newer drivers)

AOC programming has priority over Rset. For the priority selection criteria see table on the left.

Group 2: >1% minimum dim level (older drivers, 5% or 10% minimum dim level)

The value that sets the lowest current has priority over the other.

1. $I_{programming} < I_{Rset}$ ? => priority for $I_{programming}$
2. $I_{Rset} < I_{programming}$ ? => priority for $I_{Rset}$

E.g. programming 200 mA has priority over Rset which would generate 250 mA.
And Rset that generates 200 mA has priority over programming 250 mA.

Note: default current is stated in the driver's datasheet in the download section on www.philips.com/technology.

### How to... Set the output current via Rset

Your lumen, your current

1 resistor value generates 1 current only at all window drivers as long as it fits within the driver window. That is 1 philosophy for all window drivers.

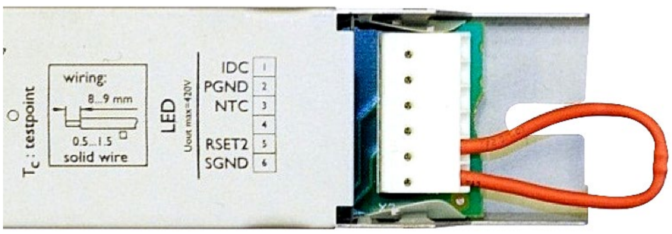
Why a resistor?

a) Worldwide standardized building block
b) Worldwide availability and well documented
c) Freedom for OEM to choose the value and supplier

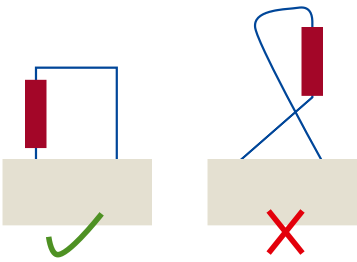
Resistor placed into driver enables you to

1. Connect different configurations, not just a unique solution
2. Drive different type of LED boards, not restricted to one type
3. Select and tune the current, hence flux or Tc


Example of an Rset2 resistor placed into an isolated driver




Example of an insulated Rset2 resistor into a non-isolated driver



## Resistor characteristics

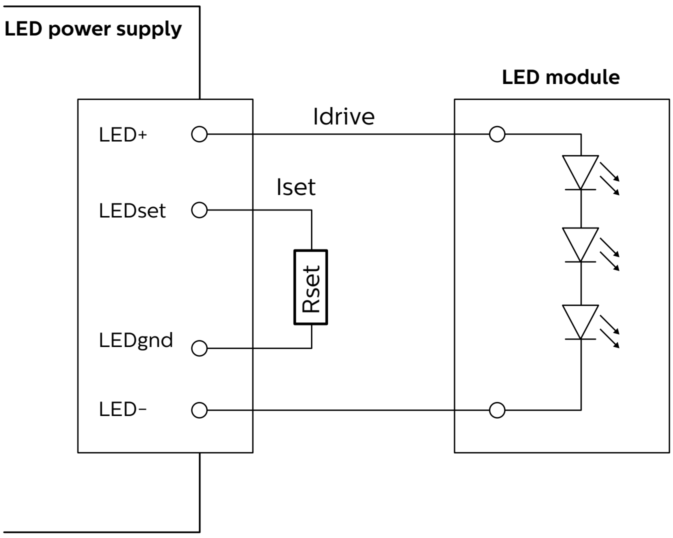
By making use of a resistor component with a determined Ohm value you can set the required current for your LED module. This component can be a leaded standard 1% tolerance resistor of e.g. 0.125 W or 0.25 W, 50 V. Rset will not be part of the electrical chain driving the LEDs, meaning it does not dissipate power.
However, make sure it does not come into contact with the driver's housing. For safety reasons with non-isolated drivers the resistor must be insulated. Advice is to always insulate the resistor.

Examples of a resistor placed into the drivers' input is shown on the left.
Different Rset resistors are utilized in the Indoor Linear LED driver portfolio;

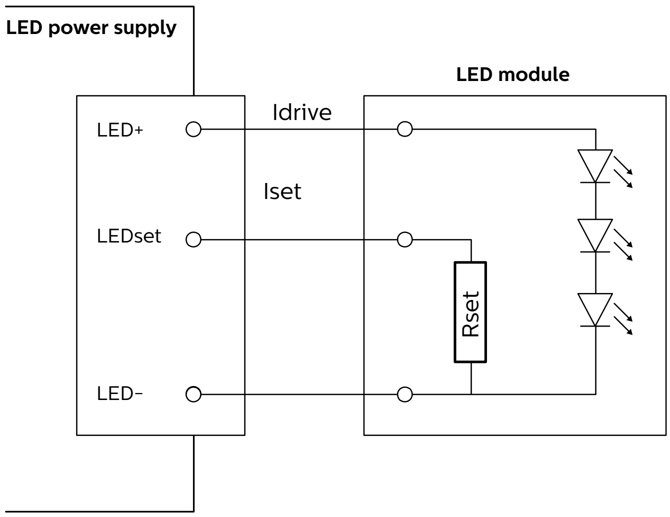
- Rset1 (older drivers); allows output current setting up to 700 mA
- Rset2; allows output current setting up to 2000 mA
- LEDset; industry standard, allows current setting up to 8000mA In all documentation.

**Rset** may refer to Rset1, Rset2, or LEDset depending on the driver type. Please check the **driver datasheet** for which Rset the driver you use reads.

Note: While inserting the resistor, please refer to the image on the left. The resistor must be inserted such that there is no possibility of a short caused by the leads. Especially when using non-isolated drivers, make sure the leads of the resistor are insulated. This way they cannot generate a potential safety risk, nor can the trip the earth leakage circuit breaker.



Rset resistor mounted directly onto the driver



Rset resistor mounted onto the LED module

### Rset1 and Rset2 use different pins on the driver (and on the JST connector).

The Rset1 and Rset2 values with the corresponding drive currents are shown in following tables. It is advised to select the nearest lower resistor value that is available to you, if the exact determined value is not at hand.

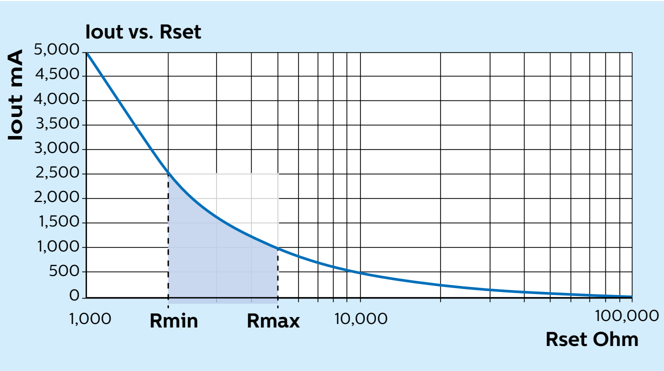
### How to... Set the output current via LEDset

Rset 1 and Rset 2 have been the traditional ways to set the current in the Xitanium window drivers. Next generation drivers will now be introduced with LEDset. LEDset is introduced by several vendors in the market to provide an industry standardized Rset interface. LEDset is, in essence, like Rset1 and Rset2, where one resistor value leads to one output current value only, differing only in the look-up table. Please find the table for E96 resistor values in the next section.

### What does LEDset offer

Like Rset1 and Rset2, LEDset is an analogue interface, allowing basic output current setting. The interface supports the following functions:

- Output current setting of the constant current LED driver to LED modules
- Thermal protection of the LED module(s) via thermal dynamic resistors circuit




## How does LEDset work

LEDset is based on a 3 wire connection between LED driver and one or more LED modules as shown in the figure on the left. 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 Rset is mounted on the LED module.
Alternatively a standard resistor can be put directly into the driver's LEDset input connectors.

The LEDset interface measures the current Iset which flows from a 5V constant voltage source within the LED driver through the setting resistor(s) Rset which is/are located either on the LED modules or directly into the driver's Rset-input.

The current Iset flowing through one setting resistor Rset is determined by the equation:

Iset [A] =5 [V] / Rset [Ω]

A LED driver with LEDset interface is able to measure Iset and to set the LED driver output current Idrive dependent on the measured value of Iset according to the equation

Idrive=Iset x 1000 [A]

Therefore the overall relationship between the setting resistor and the LED driver output current Idrive is then given by

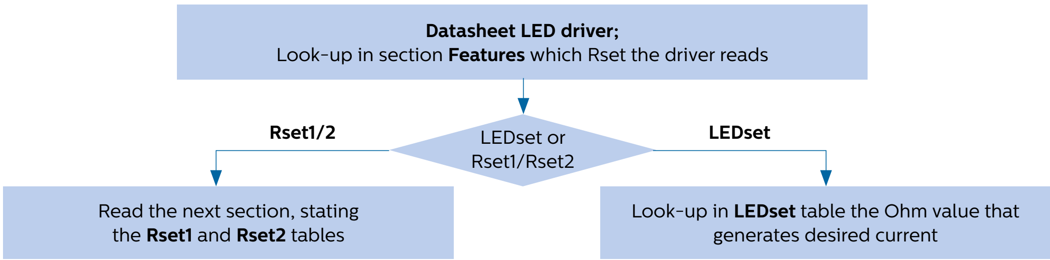
Idrive [A] =(5 [V] / Rset [Ω]) x 1000

To calculate the required resistor value for a desired drive current Idrive use:

Rset [Ω] = (5 [V] / Idrive [A]) x 1000

The LEDset interface is intended to cover a LED driver output current range from 0.05 A to 8 A. The corresponding resistor Rset is therefore within the range 100 kOhm to 625 Ohm.

In addition, it is possible to add an over temperature protection circuit on the LED module which decreases the setting current in case of an over temperature event and thus limits or folds back the LED driver output current.



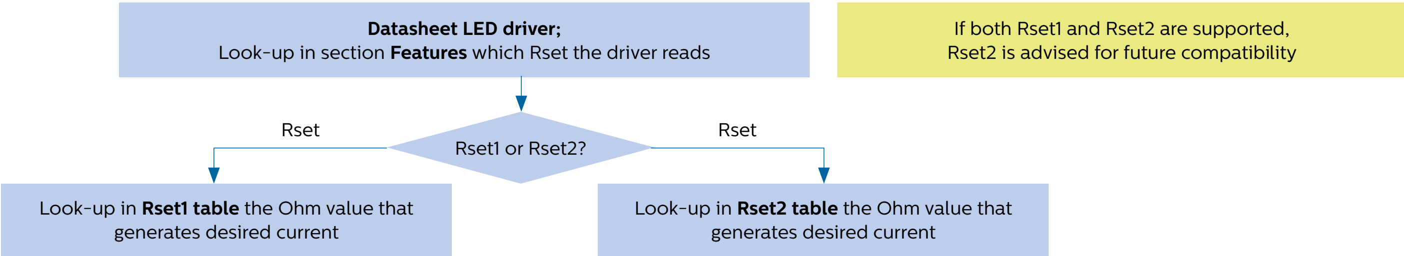

Note on E-series: in electronics, international standard IEC 60063 defines preferred number series for amongst others resistors. It subdivides the interval between subsequent values from 1 to 10 into 6, 12, 24, 48, 96 etc. steps. These subdivisions ensure that when some arbitrary value is replaced with the nearest preferred number, the maximum relative error will be on the order of 20%, 10%, 5%, 1% etc.

## LEDset – E96 series: table with E96 resistor values

| LEDset [Ω] | Idrive [mA] | LEDset [Ω] | Iset [mA] | LEDset [Ω] | Iset [mA] | LEDset [Ω] | Iset [mA] |
|---|---|---|---|---|---|---|---|
| open | avoid* | 23700 | 211 | 11000 | 455 | 5110 | 978 |
| 49900 | 100 | 23200 | 216 | 10700 | 467 | 4990 | 1002 |
| 48700 | 103 | 22600 | 221 | 10500 | 476 | 4870 | 1027 |
| 47500 | 105 | 22100 | 226 | 10200 | 490 | 4750 | 1053 |
| 46400 | 108 | 21500 | 233 | 10000 | 500 | 4640 | 1078 |
| 45300 | 110 | 21000 | 238 | 9760 | 512 | 4530 | 1104 |
| 44200 | 113 | 20500 | 244 | 9530 | 525 | 4420 | 1131 |
| 43200 | 116 | 20000 | 250 | 9310 | 537 | 4320 | 1157 |
| 42200 | 118 | 19600 | 255 | 9090 | 550 | 4220 | 1185 |
| 41200 | 121 | 19100 | 262 | 8870 | 564 | 4120 | 1214 |
| 40200 | 124 | 18700 | 267 | 8660 | 577 | 4020 | 1244 |
| 39200 | 128 | 18200 | 275 | 8450 | 592 | 3920 | 1276 |
| 38300 | 131 | 17800 | 281 | 8250 | 606 | 3830 | 1305 |
| 37400 | 134 | 17400 | 287 | 8060 | 620 | 3740 | 1337 |
| 36500 | 137 | 16900 | 296 | 7870 | 635 | 3650 | 1370 |
| 35700 | 140 | 16500 | 303 | 7680 | 651 | 3570 | 1401 |
| 34800 | 144 | 16200 | 309 | 7500 | 667 | 3480 | 1437 |
| 34000 | 147 | 15800 | 316 | 7320 | 683 | 3400 | 1471 |
| 33200 | 151 | 15400 | 325 | 7150 | 699 | 3320 | 1506 |
| 32400 | 154 | 15000 | 333 | 6980 | 716 | 3240 | 1543 |
| 31600 | 158 | 14700 | 340 | 6810 | 734 | 3160 | 1582 |
| 30900 | 162 | 14300 | 350 | 6650 | 752 | 3090 | 1618 |
| 30100 | 166 | 14000 | 357 | 6490 | 770 | 3010 | 1661 |
| 29400 | 170 | 13700 | 365 | 6340 | 789 | 2940 | 1701 |
| 28700 | 174 | 13300 | 376 | 6190 | 808 | 2870 | 1742 |
| 28000 | 179 | 13000 | 385 | 6040 | 828 | 2800 | 1786 |
| 27400 | 182 | 12700 | 394 | 5900 | 847 | 2740 | 1825 |
| 26700 | 187 | 12400 | 403 | 5760 | 868 | 2670 | 1873 |
| 26100 | 192 | 12100 | 413 | 5620 | 890 | 2610 | 1916 |
| 25500 | 196 | 11800 | 424 | 5490 | 911 | 2550 | 1961 |
| 24900 | 201 | 11500 | 435 | 5360 | 933 | 2490 | 2008 |
| 24300 | 206 | 11300 | 442 | 5230 | 956 | short | avoid** |

* driver's default current, however not stable. For details see section on 'Default driver output current'

** driver's maximum current, however not absolute. For details see section on 'Default driver output current'




Note on E-series: in electronics, international standard IEC 60063 defines preferred number series for amongst others resistors. It subdivides the interval between subsequent values from 1 to 10 into 6, 12, 24, 48, 96 etc. steps. These subdivisions ensure that when some arbitrary value is replaced with the nearest preferred number, the maximum relative error will be on the order of 20%, 10%, 5%, 1% etc.

Note: next page shows extended Rset2 table: E96 values, stating smaller increments

## Rset1 – E24 series

| Ret1 [Ω] | Iset [mA] | Ret1 [Ω] | Iset [mA] | Ret1 [Ω] | Iset [mA] | Ret1 [Ω] | Iset [mA] |
|---|---|---|---|---|---|---|---|
| 39 | 200 | 510 | 292 | 6k8 | 583 | 91k | 690 |
| 43 | 201 | 560 | 300 | 7k5 | 591 | 100k | 691 |
| 47 | 202 | 620 | 309 | 8k2 | 599 | 110k | 692 |
| 51 | 203 | 680 | 318 | 9k1 | 60 | 120k | 693 |
| 56 | 204 | 750 | 327 | 10k | 614 | 130k | 693 |
| 62 | 206 | 820 | 336 | 11k | 621 | 150k | 695 |
| 68 | 208 | 910 | 347 | 12k | 627 | 160k | 695 |
| 75 | 209 | 1k | 358 | 13k | 632 | 180k | 696 |
| 82 | 210 | 1k1 | 369 | 15k | 640 | 200k | 696 |
| 91 | 212 | 1k2 | 379 | 16k | 643 | 220k | 697 |
| 100 | 215 | 1k3 | 388 | 18k | 649 | 240k | 697 |
| 110 | 217 | 1k5 | 406 | 20k | 654 | 270k | 698 |
| 120 | 219 | 1k6 | 414 | 22k | 658 | 300k | 698 |
| 130 | 221 | 1k8 | 429 | 24k | 661 | 330k | 698 |
| 150 | 226 | 2k | 442 | 27k | 665 | 360k | 699 |
| 160 | 228 | 2k2 | 455 | 30k | 669 | 390k | 699 |
| 180 | 232 | 2k4 | 466 | 33k | 671 | 430k | 699 |
| 200 | 236 | 2k7 | 481 | 36k | 674 | 470k | 699 |
| 220 | 240 | 3k | 494 | 39k | 676 | 510k | 699 |
| 240 | 244 | 3k3 | 505 | 43k | 678 | 560k | 700 |
| 270 | 250 | 3k6 | 517 | 47k | 680 | 620k | 700 |
| 300 | 256 | 3k9 | 525 | 51k | 682 | 680k | 700 |
| 330 | 261 | 4k3 | 536 | 56k | 683 | 750k | 700 |
| 360 | 267 | 4k7 | 546 | 62k | 685 | 820k | 700 |
| 390 | 272 | 5k1 | 555 | 68k | 686 | 910k | 700 |
| 430 | 279 | 5k6 | 564 | 75k | 688 | 1M | 700 |
| 470 | 286 | 6k2 | 574 | 82k | 689 | No Rset | default |

## Rset2 – E24 series

| Ret1 [Ω] | Iset [mA] | Ret1 [Ω] | Iset [mA] | Ret1 [Ω] | Iset [mA] | Ret1 [Ω] | Iset [mA] |
|---|---|---|---|---|---|---|---|
| short | 100 | 430 | 245 | 2k | 733 | 9k1 | 1558 |
| 100 | 100 | 470 | 261 | 2k2 | 780 | 10k | 1604 |
| 110 | 106 | 510 | 277 | 2k4 | 823 | 11k | 1653 |
| 120 | 111 | 560 | 297 | 2k7 | 884 | 12k | 1694 |
| 130 | 116 | 620 | 318 | 3k | 941 | 13k | 1730 |
| 150 | 121 | 680 | 340 | 3k3 | 993 | 15k | 1793 |
| 160 | 130 | 750 | 368 | 3k6 | 1042 | 16k | 1817 |
| 180 | 13 | 820 | 392 | 3k9 | 1086 | 18k | 1864 |
| 200 | 146 | 910 | 422 | 4k3 | 1143 | 20k | 1902 |
| 220 | 155 | 1k | 452 | 4k7 | 1192 | 22k | 1935 |
| 240 | 166 | 1k1 | 485 | 5k1 | 1238 | 24k | 1965 |
| 270 | 176 | 1k2 | 515 | 5k6 | 1293 | 27k | 2000 |
| 300 | 190 | 1k3 | 545 | 6k2 | 1350 | No Rset | default |
| 330 | 204 | 1k5 | 602 | 6k8 | 1402 | | |
| 360 | 215 | 1k6 | 632 | 7k5 | 1454 | | |
| 390 | 228 | 1k8 | 684 | 8k2 | 1503 | | |

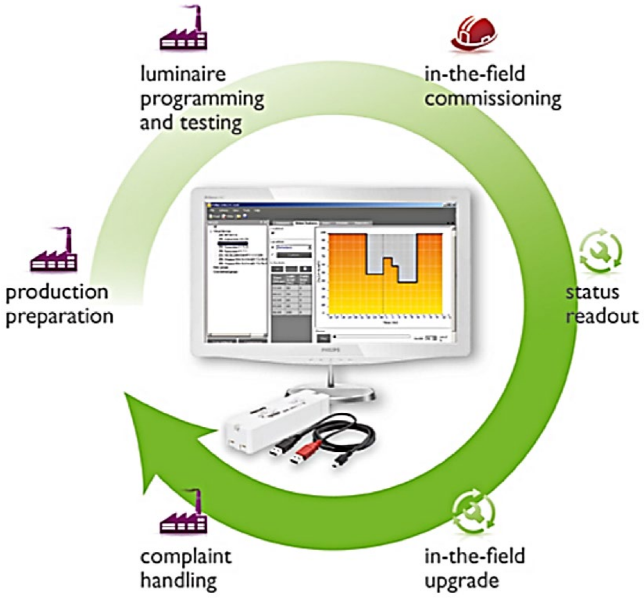
## Rset priority behavior for drivers that read both Rset1 and Rset2

| Rset1 | Rset1 | Driver status |
|---|---|---|
| Open | Open | Driver's default current (see datasheet) |
| Rset | Open | Rset1 |
| Open | Rset | Rset2 |
| Rset | Rset | Rset2 |
| Short | Open | Rset1 (driver's minimum current, see datasheet) |
| Short | Short | Rset2 (driver's minimum current, see datasheet) |
| Open | Short | Rset2 (driver's minimum current, see datasheet) |

Please refer to the datasheet of the driver you use to find which Rset or Rsets the driver actually reads.

## Rset2 – E96 series: table with E96 resistor values, stating smaller increments but covering same range as the E24 series on previous page

| Rset2 [Ω] | Iset [mA] | Rset2 [Ω] | Iset [mA] | Rset2 [Ω] | Iset [mA] | Rset2 [Ω] | Iset [mA] | Rset2 [Ω] | Iset [mA] | Rset2 [Ω] | Iset [mA] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| short | min. | 255 | 171 | 665 | 335 | 1740 | 669 | 4530 | 1171 | 11800 | 1686 |
| 100 | 100 | 261 | 173 | 681 | 341 | 1780 | 679 | 4640 | 1185 | 12100 | 1698 |
| 102 | 101 | 267 | 175 | 698 | 347 | 1820 | 689 | 4750 | 1198 | 12400 | 1708 |
| 105 | 103 | 274 | 178 | 715 | 354 | 1870 | 701 | 4870 | 1212 | 12700 | 1719 |
| 107 | 104 | 280 | 181 | 732 | 361 | 1910 | 711 | 4990 | 1226 | 13000 | 1730 |
| 110 | 105 | 287 | 184 | 750 | 368 | 1960 | 724 | 5110 | 1239 | 13300 | 1739 |
| 113 | 107 | 294 | 187 | 768 | 374 | 2000 | 733 | 5230 | 1253 | 13700 | 1752 |
| 115 | 108 | 301 | 191 | 787 | 381 | 2050 | 745 | 5360 | 1267 | 14000 | 1761 |
| 118 | 110 | 309 | 194 | 806 | 387 | 2100 | 757 | 5490 | 1281 | 14300 | 1771 |
| 121 | 111 | 316 | 197 | 825 | 394 | 2150 | 768 | 5620 | 1295 | 14700 | 1783 |
| 124 | 113 | 324 | 201 | 845 | 400 | 2210 | 782 | 5760 | 1308 | 15000 | 1793 |
| 127 | 115 | 332 | 204 | 866 | 407 | 2260 | 793 | 5900 | 1322 | 15400 | 1802 |
| 130 | 116 | 340 | 207 | 887 | 414 | 2320 | 806 | 6040 | 1335 | 15800 | 1812 |
| 133 | 118 | 348 | 210 | 909 | 422 | 2370 | 817 | 6190 | 1349 | 16200 | 1822 |
| 137 | 119 | 357 | 214 | 931 | 429 | 2430 | 829 | 6340 | 1362 | 16500 | 1829 |
| 140 | 120 | 365 | 217 | 953 | 436 | 2490 | 841 | 6490 | 1375 | 16900 | 1838 |
| 143 | 122 | 374 | 221 | 976 | 444 | 2550 | 853 | 6650 | 1389 | 17400 | 1850 |
| 147 | 123 | 383 | 225 | 1000 | 452 | 2610 | 865 | 6810 | 1403 | 17800 | 1859 |
| 150 | 125 | 392 | 229 | 1020 | 459 | 2670 | 877 | 6980 | 1415 | 18200 | 1867 |
| 154 | 127 | 402 | 233 | 1050 | 469 | 2740 | 891 | 7150 | 1428 | 18700 | 1877 |
| 158 | 129 | 412 | 237 | 1070 | 475 | 2800 | 903 | 7320 | 1441 | 19100 | 1885 |
| 162 | 131 | 422 | 241 | 1100 | 485 | 2870 | 916 | 7500 | 1454 | 19600 | 1894 |
| 165 | 132 | 432 | 246 | 1130 | 494 | 2940 | 929 | 7680 | 1467 | 20000 | 1902 |
| 169 | 134 | 442 | 250 | 1150 | 500 | 3010 | 943 | 7870 | 1480 | 20500 | 1910 |
| 174 | 136 | 453 | 254 | 1180 | 509 | 3090 | 956 | 8060 | 1493 | 21000 | 1918 |
| 178 | 137 | 464 | 259 | 1210 | 518 | 3160 | 968 | 8250 | 1506 | 21500 | 1926 |
| 182 | 139 | 475 | 263 | 1240 | 527 | 3240 | 982 | 8450 | 1518 | 22100 | 1936 |
| 187 | 141 | 487 | 268 | 1270 | 536 | 3320 | 996 | 8660 | 1531 | 22600 | 1943 |
| 191 | 143 | 499 | 273 | 1300 | 545 | 3400 | 1009 | 8870 | 1544 | 23200 | 1952 |
| 196 | 145 | 511 | 278 | 1330 | 554 | 3480 | 1022 | 9090 | 1557 | 23700 | 1960 |
| 200 | 146 | 523 | 282 | 1370 | 565 | 3570 | 1037 | 9310 | 1569 | 24300 | 1968 |
| 205 | 148 | 536 | 287 | 1400 | 574 | 3650 | 1049 | 9530 | 1580 | 24900 | 1975 |
| 210 | 151 | 549 | 292 | 1430 | 582 | 3740 | 1062 | 9760 | 1592 | 25500 | 1982 |
| 215 | 153 | 562 | 297 | 1470 | 594 | 3830 | 1075 | 10000 | 1604 | 26100 | 1989 |
| 221 | 155 | 576 | 302 | 1500 | 602 | 3920 | 1088 | 10200 | 1614 | 26700 | 1996 |
| 226 | 158 | 590 | 307 | 1540 | 614 | 4020 | 1103 | 10500 | 1629 | 27000 | 2000 |
| 232 | 161 | 604 | 313 | 1580 | 626 | 4120 | 1117 | 10700 | 1639 | open | default |
| 237 | 164 | 619 | 318 | 1620 | 638 | 4220 | 1131 | 11000 | 1653 | | |
| 243 | 167 | 634 | 323 | 1650 | 645 | 4320 | 1145 | 11300 | 1666 | | |
| 249 | 169 | 649 | 329 | 1690 | 656 | 4420 | 1158 | 11500 | 1674 | | |




## How to... Program the output current

### 1 interface – connecting to indoor & outdoor, LED & conventional

The Xitanium TD drivers offer a full range of controls, enabling customizable luminaire design and performance. It is possible to control light output levels, preset dimming protocols and set system specifications in the factory and even in the complete installations in the field. This can be done with the Philips MultiOne configurator software. The MultiOne configurator software is an intuitive tool that unlocks the full potential of all programmable drivers from Philips, ensuring that the driver performance matches the needs of the lighting solution. It offers unprecedented flexibility, before, during and after the product installation.

### Connecting to a programmable driver

Xitanium Indoor Linear LED drivers are programmed via the Philips MultiOne configurator software. To do so, the driver must be connected to the computer via the MultiOne hardware interface.

For more information and latest version please visit www.philips.com/multione.
This site contains detailed information on how to install the software and how to program the driver.

## Mains voltage fluctuations and behavior

The driver is able to withstand high and low mains voltages for limited periods of time. See the associated datasheets for specific values.

### Mains fluctuations

Professional luminaires using Xitanium or CertaDrive LED drivers make sure that a fluctuating mains is not transferred to the LEDs. It is the Power-Factor-Corrector stage that makes sure the luminaire draws a sinusoidal mains current in phase with the voltage. Mains variations are compensated and voltage spikes are damped, therefor have no effect on the light output.

### Allowable voltage difference between mains input and control input (TD version)

The majority of our LED-drivers do comply with a voltage isolation difference up to 250V between mains and the Touch and Dim control input, as can be caused by a different phase of the power grid in an installation in the field.
Future drivers might have a value higher than 250 V by design.

## Low mains voltage

A continuous low AC voltage (<202 V) can have an adverse effect on the driver's lifetime. The output power will be limited accordingly. A low voltage will not cause the driver to fail over a maximum period of 48 hours at minimum operating AC voltage and maximum ballast ambient temperature.

## High mains voltage

A high mains AC voltage will stress the driver and have an adverse effect on its lifetime (maximum of 264-320 V for a period of 48 hours).

## DC, DCemDIM and Emergency operation

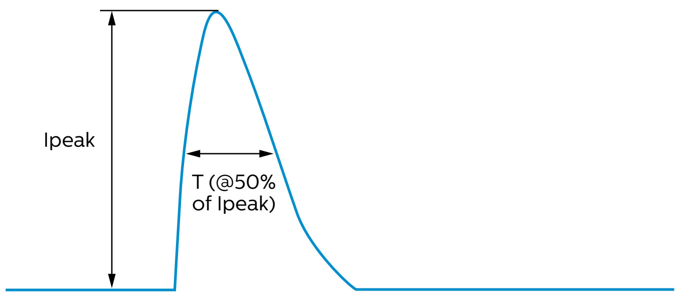
The Xitanium Indoor Linear LED drivers are able to operate on DC voltage on the mains input, like when connected to a central DC emergency grid. Depending on the type, Xitanium LED drivers are released in compliance with lamp control gear standards as stated under "Emergency standards" in section "Quality" at the end of this document. As a result these drivers are suitable for emergency luminaires in compliance with IEC 60598-2-22, excluding high-risk task areas.

Please note the allowed DC voltage range accepted by the driver is stated in the driver's datasheet. Values outside that range will have an adverse effect of the driver's performance and possibly reliability.

On selected drivers DCemDIM is available, allowing a pre-defined dim level of the driver's output when switched to DC. More on setting parameters of DCemDIM in section Controllability. For specific input requirements, please check the driver's datasheet at the download section on www.philips.com/technology.

## Inrush current

'Inrush current' refers to the briefly occurring high input current which flows into the driver during the moment of connection to mains; see the illustration on the left. Typically, the amplitude is much greater than the steady-state input current.




Graphical representation of inrush current

| MCB type | Rating (A) | Relative number of LED drivers |
|---|---|---|
| B | 10 | 63 |
| B | 13 | 81 |
| B | 16 | 100 (stated in datasheet) |
| B | 20 | 125 |
| B | 25 | 156 |
| C | 10 | 104 |
| C | 13 | 135 |
| C | 16 | 170 |
| C | 20 | 208 |
| C | 25 | 260 |
| L, I | 16 | 108 |
| L, I | 10 | 65 |
| G, U, II | 16 | 212 |
| G, U, II | 10 | 127 |
| K, III | 16 | 254 |
| K, III | 10 | 154 |

The cumulative inrush current of a, given, combined number of drivers may cause Mains Circuit Breakers (MCB) to trip. In such a case, either one or a combination of the following measures need to be taken to prevent nuisance tripping:

1: Replace existing MCB for a less sensitive type (e.g. exchange B type for C type)
2: Distribute the group of drivers over multiple MCB groups or phases
3: Power up drivers sequentially instead of simultaneously
4: Install external inrush-current limiting devices

Inrush parameters are driver-specific an can be found in the driver datasheet at www.philips.com/technology.

## How to… Determine the number of drivers on a MCB

The maximum amount of drivers on a 16A type B Miniature Circuit Breaker (MCB) is stated in the driver's datasheet on www.philips.com/technology. In the conversion table on the left that stated amount is used as reference (100%).
The maximum quantity of drivers on different types of MCB can be calculated by the reference (see driver's datasheet) x Relative number (last column).

Example;
If datasheet states: max number on type B, 16 A = 20, then for type C, 13 A the value will be 20 x 135% = 27.

Notes
1. Data is based on a mains supply with an impedance of 400 mΩ (equal to 15 m of 2.5 $mm^2$ cable and another 20 m to the middle of the power distribution) in the worst-case scenario. With an impedance of 800 $m^2$ the number of drivers can be increased by 10%.
2. Measurements will be verified in real installations; data is therefore subject to change.
3. In some cases the maximum number of drivers is not determined by the MCB but by the maximum electrical load of the installation.
4. Note that the maximum number of drivers is given when these are all switched on at the same time, e.g. by a wall switch.
5. Measurements were carried out on a single-pole MCB. For multiple MCBs it is advisable to reduce the number of drivers by 20%.
6. The maximum number of drivers that can be connected to one 30 mA Residential Current Detector is 30.

## Surge protection

The Xitanium Linear drivers have built-in surge protection up to a certain limit. Depending on the mains connected, additional protection against excessive high surge voltages may be required by adding a Surge Protection Device. The actual limit can differ per driver and can be found in the driver's datasheet in the download section on www.philips.com/technology.

Note: DM stands for Differential Mode, CM for Common Mode.

### Note for Xtreme indoor drivers (iXt)

Xtreme Indoor Linear LED drivers (iXt) allow a higher maximum surge on the mains input (2 kV DM / 4 kV CM) than on the control input (1 kV DM / 2 kV CM), also stated in the driver's datasheet. As such Touch and Dim operation in environments with surges higher than 1 kV DM / 2 kV CM are not recommended.

Note: check the driver datasheet of the driver you use for the specific touch current value and conditions

## Touch current

The Xitanium Indoor Linear LED drivers are designed to meet touch current requirements per IEC 61347-1 standard. The specified maximum values are 0.7 mA peak down to 0.4 mA peak for IEC and 0.75 mA RMS for UL norms. The test is done with the driver alone. In a luminaire, touch current may be higher, since the LED load may introduce additional touch current. As such, precautions may be required on the luminaire level and if multiple drivers are used in a single luminaire.

## Electromagnetic compatibility (EMC)

Xitanium Indoor Linear LED drivers meet EMC requirements per CISPR 15 ed 7.2. The test is conducted with a reference setup that includes a driver and an LED load mounted on a metal plate.

### Cable length and EMC

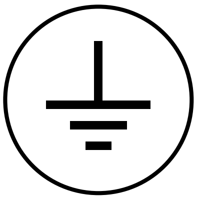
Philips has successfully performed EMC tests for a total length 4 m (sum of wire length and length of the Fortimo LED Line boards). The only limitation of wiring length is the EMC performance. Since this performance of the luminaire is heavily dependent on the wiring itself we advise for longer lengths to repeat these tests.

### How to... Improve EMI performance

As mentioned before, the total amount of parasitic current needs to be minimized. For that reason, the following practical precautions need to be taken into account in a lighting system to minimize EMI:

- Minimize the Differential Mode loop area of the lamp wires going from the driver to the light source by keeping the wires close together (bundling). This will minimize the magnetic field and reduce the radiated EMI. Long linear light sources are also part of that loop.
- Minimize the Common Mode parasitic capacitance of the output wiring + light source to earth by keeping the length of the wires between driver and light source as short as possible. Also minimize the copper cooling area on the LED PCB and keep the length of the incoming mains wire inside the luminaire as short as possible.
- Keep mains and control wires (DALI, 0-10 V) separated from the output wires (do not bundle).
- Ground the lighting system chassis and other internal metal parts to earth (class I luminaires) and do not let large metal parts "float". Always use the safety or functional earth connector or wire from the lamp driver. Or use equipotential connecting wires for all internal floating metal parts which are inaccessable (class II luminaires). Keep safety and functional earth wires as short as possible to minimize their inductance, use as much as possible large metal areas (chassis, mounting plates, brackets) for earthing purposes instead.
- For Class II it is advised to establish a functional earth connection between all larger conductive, non-accessible luminaire parts and the driver to remedy potential EMC problems.
- Sometimes, radiated EMC compliance cannot be achieved, necessitating the use of a 100 ... 300 Ω axial ferrite bead(s) for either mains or lamp wiring (effective for interference between 30 MHz and 300 MHz), or coupling the wires through ferrite cores within the luminaire may improve the overall EMC performance. However, selection of the type and characteristics of the additional filter depends on what frequency components have to be damped and by how much.

Adhering to these rules will help in EMC compliance. For further questions, please contact your local Philips representative. Alternatively the Philips Lighting OEM Design-In team could be consulted for a posible solution.



Symbol for Protective Earth (PE)

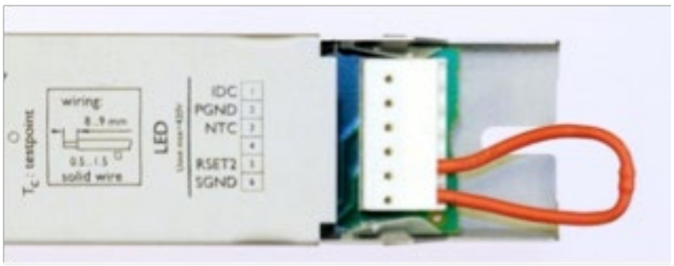
## Electrical isolation and protective earth

One way to split the Xitanium Indoor Linear LED drivers is by isolated and non-isolated driver versions.

### Non-isolated drivers

These drivers have no isolation from the primary to the secondary side and basic isolation (single isolation foil) between all the electronic circuits and the chassis, hence the presence of the Protective Earth (PE) symbol (see image on the left) on the driver housing.

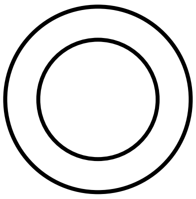
Non-isolated drivers can be used in Class I luminaires. Be aware that all output connections of these drivers are not touch-safe when the driver is switched on. An adequate earth connection needs to be made to all electrical conductive parts in the luminaire. The bottom part (unpainted) of the driver housing can be used to create earth contact to the luminaire housing, as the earth connector is internally connected to the driver housing. An intermitting earth contact should be prevented, as this is potentially unsafe and can cause a degraded performance. Most drivers in this group typically can generate output drive voltages higher than 60VDC. Always test the quality of your earth contacts between all relevant conductive parts.




Example of an insulated Rset

## Warnings for non-isolated drivers:

- Do not touch any non-insulated live parts, even on the output (secondary) side!
- Any live part on the output (secondary) side should not be touchable during normal operation. This includes the NTC component and Rset component.
- Make sure to insulate the Rset to prevent it from touching the housing.



Symbol for Double Isolation between primary and secondary side of a driver, in combination with built-in usage.

### Isolated drivers (SELV output)

Drivers in this group cannot generate output voltages higher than 60 VDC. By design these drivers are intended for built-in use, not suited for independent use. The driver must be placed in a suitable adequate enclosure according to the applicable norms and standards. Hence the double circle symbol is to be used, not the double-square symbol (Amendment 2 of safety standard IEC61347-1).

However, these isolated drivers (SELV output) can be used in both Class I and Class II luminaires under the following conditions:

- When used for **Class I** the protective earth connection should be present (see previous section "Non-isolated drivers").
- When used for **Class II** (and **SELV**), the driver should be incorporated in the luminaire in such a way that

a) The driver housing is electrically insulated with respect to electrical conductive materials, such as the housing or reflector and as such not touchable during installation or operation.
b) All metal luminaire parts (chassis, heat sink, metallic reflector) connected to the driver housing are not allowed to be accessible by bare hand, or
c) Any accessible conductive luminaire parts should have basic isolation towards the non-accessible luminaire parts and/or driver housing.

Note: for Class II, EMC requirements should be met without PE connection and particularly also any functional earth connection from driver to accessible fixture/chassis is strictly prohibited, as it will form insufficient (non-single fault-proof) insulation with respect to live parts connected to the driver.

### Xitanium Indoor Linear LED drivers meet the IEC 61347-1 safety standard

In accordance to this standard, the following safety requirements are met:

- Basic isolation between the Primary and Secondary side wires:
- Driver output voltage < 1000 VDC
- Insulation test voltage 1500 V (1000 V + 2 X 250 V)
- Double isolation between all wires and chassis: Insulation test voltage: 3750 V.

### **How to... Use these Indoor Linear LED drivers as "independent" driver**

By design the Xitanium Indoor Linear LED drivers are intended for built-in use, not suited for independent use. The driver must be placed in a suitable adequate enclosure according to the applicable norms and standards when used independently.

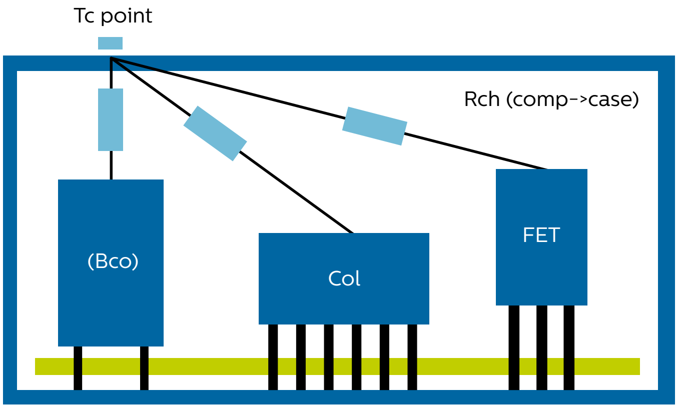
# Thermal design-in

## Introduction

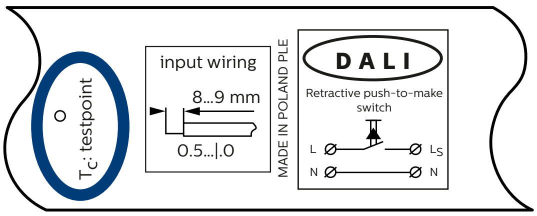
This chapter describes two thermal aspects of the Xitanium Indoor Linear LED drivers:

1. The LED driver itself and relationship between case temperature point (Tc) and lifetime of the LED driver
2. Module Temperature Protection (MTP) can be used to help achieve lifetime of LED module or LED PCB.

To facilitate design-in of LED drivers, the critical thermal management points of the LED driver are set out in this section. In Philips' product design phase all possible precautions have been taken to keep the component temperature as low as possible. However, the design of the luminaire and the ability to guide the heat out of the luminaire are of utmost importance. If these thermal points are taken into account this will ensure the optimum performance and lifetime of the system.




Schematically representation of internal thermal paths to the driver Tc point




Example of Tc point position on driver housing

### Definitions

- Case temperature: temperature measured at the Tc point of the driver
- Ambient temperature (Tamb): temperature outside the luminaire

When switched off >2 hours, temperature at Tc point is likely to equal Tamb

## Tc point

To achieve optimal lifetime and reliability, it is critical that the temperature of the components in the driver remains within its rating.

The Tc test point (case temperature) indicates a reference point for measuring the LED driver's temperature. This can be used during the luminaire design to verify that the temperature remains below the maximum specified temperature for the Tc point.

Since there is a direct relation between the case temperature (Tc) and the driver components inside the driver, it is sufficient to measure the temperature at the Tc point of the LED driver. This Tc point must not exceed the maximum values stated in the associated datasheet in the download section on www.philips.com/technology.

### How to... Measure Tc at the Tc point

The location of the Tc point is identified on the product label. Tc point is inside the dot (See ellipse in figure on the left). The temperature can be measured using for example a thermocouple that is firmly glued to the driver housing. For a representative measurement the temperature must be stable before any reliable data can be obtained (typically > 0.5 hours).

#### Relation between Tc and ambient temperature

The Tc increases by approximation linear with the ambient temperature (Tamb). The temperature offset between Tamb and Tc depends on the thermal design of the luminaire. The Xitanium LED driver has been designed for indoor use. For approved ambient temperature range please check the associated driver datasheet on www.philps.com/technology.

### Driver lifetime

#### Tc, Tc-life and Tc-max

The lifetime of LED drivers depends on the temperature during operation. This means there is a relationship between the Tc point on the LED driver and its lifetime in hours.

- Xitanium Indoor Linear LED drivers typically have a specified minimum lifetime of ≥50,000 hours with a minimum of 90% survivors at the specified Tc-life.
- Xitanium Indoor Linear Xtreme LED drivers typically (iXt) have a specified minimum lifetime of ≥100,000 hours with a minimum of 90% survivors at the specified Tc-life.

Tc-max is the maximum allowed Tc for the driver. Please check the driver's datasheet in the download section on www.philips.com/technology for the lifetime and Tc-life.

### Module Temperature Protection (MTP)

#### NTC and thermal design

This feature helps to protect the LEDs when operated in a hot ambient environment. The thermal design of an LED module/PCB should be designed in such a way that the temperature of the LED board (Tc-life) is not exceeded under normal application conditions. The utilization of a Negative Temperature Coefficient (NTC) component serves the purpose to help achieve the lifetime of the LED module or LED PCB if external thermal influences result in the temperature for lifetime (Tlife) being exceeded. When this occurs the light output will be regulated to remain below the critical temperature by the driver dimming down.

Two NTC part numbers which are supported, while the third option enables correct operation in combination with Philips LED modules.

1. 15 k NTC - Vishay 15 kOhm ± 2% NTC, B25/85=3700, 2381 615 54153

2. 15 k NTC - Murata 15 k, Part number NCP15XW153E03RC (with a Separate 390 ohms resistor in series with the NTC)

3. On selected Philips LED light engines (currently no LED Lines)

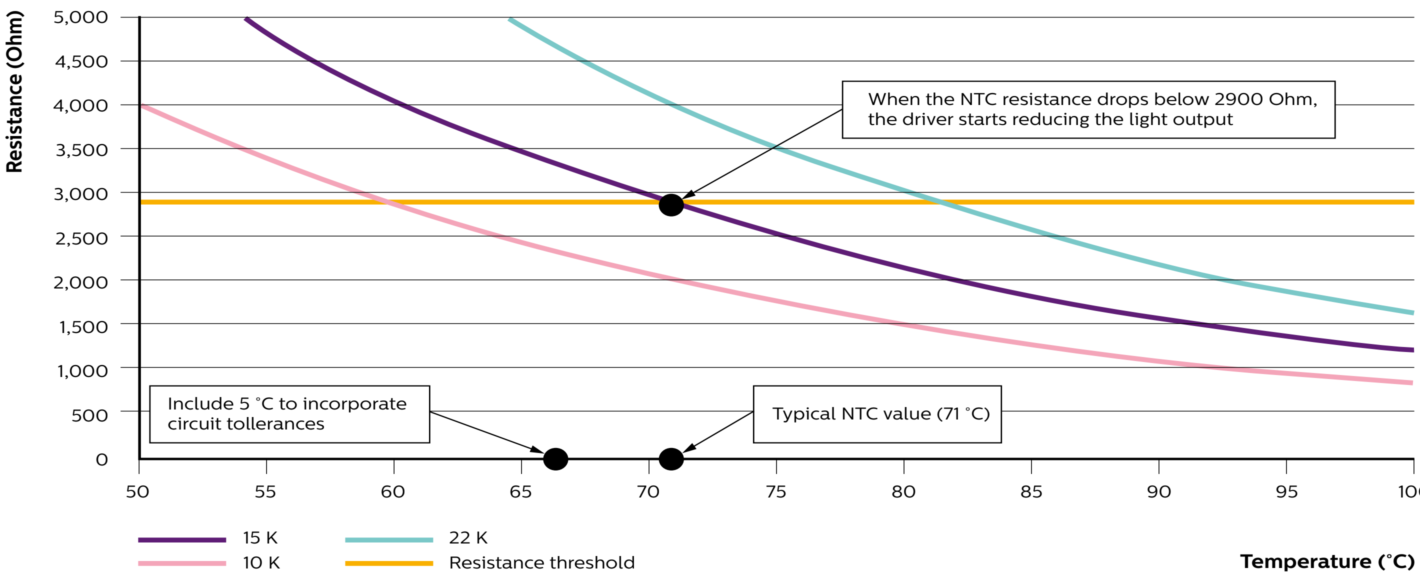
## Setting the thermal de-rating point via NTC

The LED driver will start reducing the light output when the NTC reaches a value of 2966 Ω. The NTC should be selected such that 2966 Ω represents the desired critical temperature inside your LED module/PCB.

Take for example an LED board with a defined Tc-life of 65 °C. Taking the tolerances of the NTC into account results in ±5 °C. This gives a typical value for the NTC of 71 ±5 °C. By choosing this setting of 71 °C, we ensure that the driver will not dim the output, due to a too high temperature, before the module reaches 65 °C. The following graph shows a typical R vs. T curve of an NTC resistor. To match 2966 Ω at this temperature, the NTC of 15 kΩ ±2% has been selected.

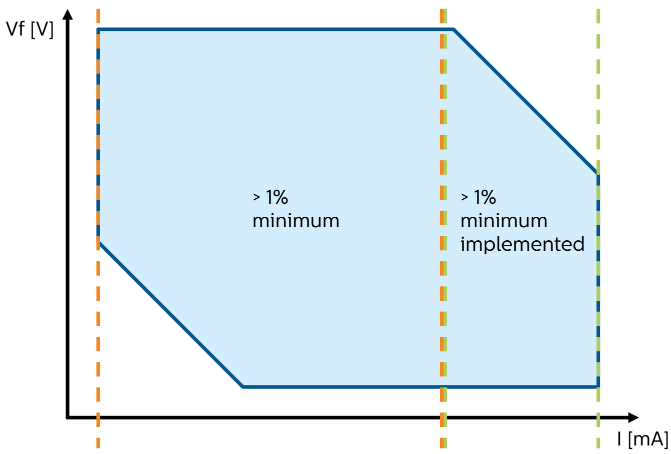
**Setting MTP behavior (programmable drivers only)**

It is possible to set the temperature at which MTP feature is activated, defined by "MTP warn" and the slope, defined by "MTP max". Using the MultiOne Configurator software the settings can be changed.




NTC resistance as function of temperature

# Controllability




Minimum dimming output current

| Maximum selectable output current [mA] | Minimum absolute output current [mA] | Current range allowing for 1% dimming [mA] | Drivers examples |
|---|---|---|---|
| 400 | 3 | 300..400 | Xitanium 75W 0.12-0.4A 215V TD 230V |
| 700 | 4 | 400..700 | Xitanium 150W 0.2-0.7A 300V TD 230V iXt |
| 2000 | 14 | 1400..2000 | Xitanium 75W 0.7-2A 54V TD 230V |

## Control characteristics

### Amplitude Modulation dimming

Philips Xitanium indoor linear LED drivers dim by means of Amplitude Modulation dimming (AM). This means at no stage of the dimming range Pulse Width Modulation dimming (PWM) is involved. AM dimming guarantees the most smooth and flicker-free operation over the entire dimming range.

### Dimming ranges

In the current portfolio there are three different dimming ranges present.

- 100% down to 10%
  (e.g. 1-10 V non-isolated drivers with introduction date before 2015)
- 100% down to 5%
  (e.g. isolated drivers with introduction date before 2014)
- 100% down to 1%
  (latest generations dimmable drivers)

The driver's actual dimming range is stated in the associated datasheet on www.philips.com/technology. With future updates of the drivers most likely one dimming range will be present.

Note: for Xtreme Indoor Linear LED drivers (iXt) the allowed dimming range is dependent on ambient temperature (Tamb). The influence of the ambient temperature on the minimum allowed dimming levels are stated in the table below. The applicable minimum dimming value should be set via the MultiOne configurator software, The default value is stated in the driver datasheet.

| $T_{amb}$ -40..-20 °C | $T_{amb}$ -20..+50 °C | $T_{amb}$ +50..+60 °C |
|---|---|---|
| Minimum dimming 10% | Minimum dimming 1% | Minimum dimming 10% |

### Minimum dimmed output current

The drivers' min-max current range is by approximation a factor of 140. This means that a 1% minimum dimming current is not feasible for the full operating window. For the lower current part of the operating window the dimming level is limited by an absolute minimum output current of the driver (see drawing). This value differs per LED driver by design. Some examples are provided in the table on the left.

### Control input electrical characteristics

The control input is compatible with Philips Lighting control equipment.

| | |
|---|---|
| Standby power consumption | < 0.5 W |
| Control input insulation, basic | ≥ 1500 Vac |

### Dynamic resistance of the LED load

The Xitanium drivers are designed to drive and dim LED loads with a specified minimum dynamic resistance of the load, stated in the driver's datasheet. This has been tested and released with the Philips Fortimo LED modules. LED loads which have a dynamic resistance outside the specification of the driver may cause instabilities and should not be used in combination with this driver.

When light instabilities and/or uniformity issues are observed during deep dimming (e.g. down to 1%) it is recommended to increase the minimum dim level by adjusting the DALI minimum dim level to the point the effects are no longer perceived. The required minimum dynamic resistance is stated in the drivers' datasheet.

## 1-10 V Dimming

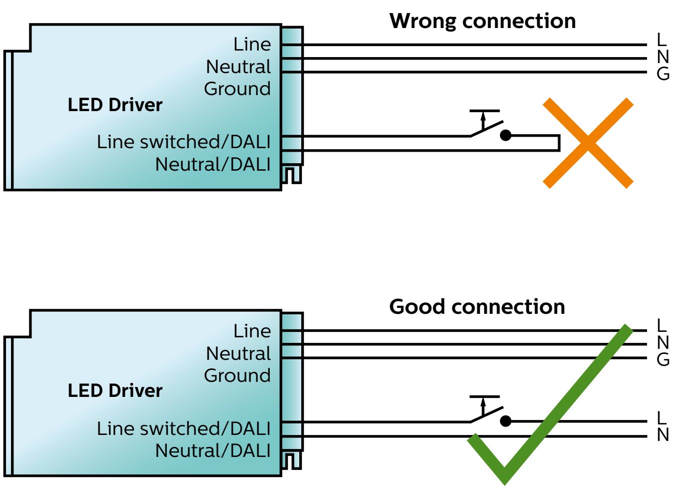
This is the traditional way of dimming a driver between 100% and 10% based on dimming voltage, in 1% increments. Note that the 100% level is determined by the output current level, set via external Rset (AOC feature). The minimum current that can be supplied by the driver is specified in the datasheet. The lowest possible dim level is defined by the higher of the two values: Minimum output current or 10% dim level. Output current of the 1-10 V control input is typical 150 μA. The 1-10 V interface for LED-drivers is the same as for FLUO HFR drivers.

## TD dimming: Touch and Dim & DALI

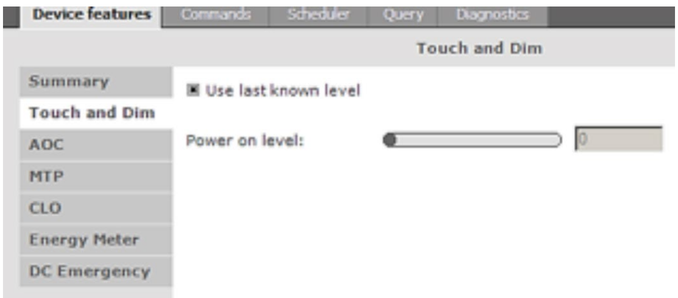
### DALI

Digital Addressable Lighting Interface, or DALI, is a bi-directional digital communication protocol popular in the lighting industry. It is an IEC standard and there are many control devices from Philips and other manufacturers that communicate using DALI. The voltage across DALI wires is typically 16 V (refer IEC specification for details) and it is not polarity sensitive. The DALI wires can be run alongside input main wires and the maximum current on a DALI line is limited to 250 mA.

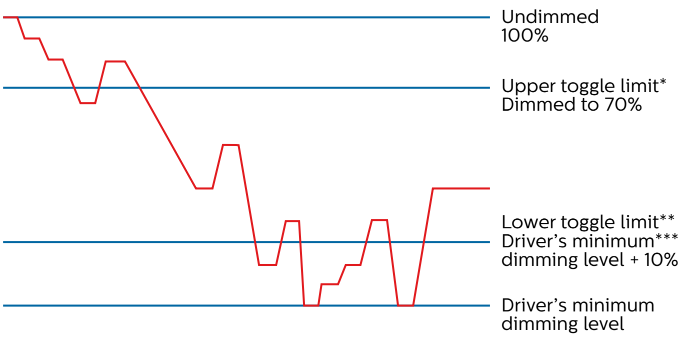
Using DALI, it is possible to send dimming commands (1-254 levels), set fade rates and fade times, query driver or LED status, etc. Linear drivers also respond to LED-specific DALI commands e.g. query if the LED module is short circuit or open circuit; select between logarithmic or linear dimming curves, etc. Typically up to 64 DALI drivers can be connected to one DALI bus. Note that after a power cycle (not stand-by) the driver by default will come back to its




Appropriate connection to the dimmable LED driver using the Touch and Dim protocol




Screenshot from MultiOne - Touch and Dim tab




* Always dim down above the upper toggle limit
** Always dim up under the lower toggle limit
*** Example, a driver with dimming minimum of 10% leads to lower toggle level of 10% + 10% = 20%
1% leads to lower toggle level of 10% + 1% = 11%"

| Touch and Dim function | Contact duration | Driver function |
|---|---|---|
| Ignore | 0 to 40 ms | Ignore |
| Short push | 40 to 500 ms | Toggle ON/OFF |
| Long push | 500 to 10,000 ms | Dim up or down |
| Reset push | >10,000 ms | Driver synchronization |

last known light level. This behavior however can be programmed differently into "off" or any dim level between 1..254 DALI level.

For more information on DALI, refer to the IEC specification for DALI protocol.
- IEC 62386: 102 – General requirements – Control gear
- IEC 62386: 207 – Particular requirements for control gear – LED modules.

## Touch and Dim
For the Xitanium drivers with Touch and Dim function a switched mains is used to dim the light. The switching ON and OFF is also done via this control input. This means that it is no longer necessary to use a power switch to interrupt the mains circuit. The 230 V supply voltage is always available at the LED driver (even when switched OFF) and light can be switched or dimmed by momentarily connecting the mains to the dim input. A short push will switch the lighting ON or OFF, depending on the previous situation.

## Touch and Dim behavior
If via TD control the driver is switched OFF (short push), the ballast will store the current light level. As soon as the mains power returns (short push via TD will switch the driver ON) the ballast will recall this stored light level. If it was dimmed to 60%, it will come back at 60%.

If the switch is held pushed in, the light will dim up or down, depending on what is opposite from the last dimming direction. The driver will count the number of mains cycles and act on that.
If there is a power failure, the ballast will store the current light level. As soon as the mains power returns, the ballast will recall this stored light level. If it was dimmed to 38%, it will come back at 38%. If it was switched off, it will stay switched off. This behavior can be altered via MultiOne configurator software (screenshot on the left).

If the installation has to be extended by one or more light points / drivers, the dimming direction of the newly connected modules may be different from that of those already connected. To solve this problem a synchronization possibility is built into the drivers and can be called upon at any time. If the switch is pressed for at least 10 seconds all drivers will go to 37% light level and the dimming direction will be set to downwards.

## Touch and Dim wiring

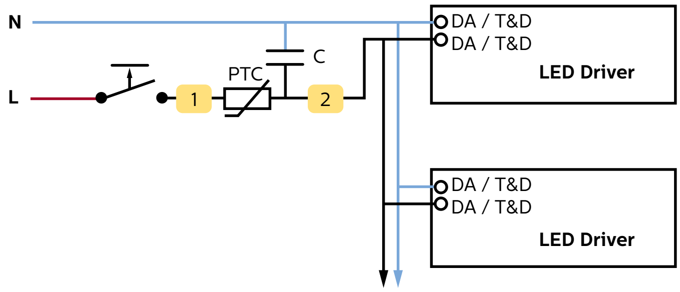
Special wiring, such as twisted pairs or special cables, is not required to install a Touch and Dim system. All wiring is standard mains wiring and the switch is a standard push-to-make switch. There is no limit to the length of the dim cable or the number of switches connected. The only limitation is the maximum amount of drivers, which is 30 per dimming unit.

## Non-dimmable

The current of the non-dimmable Xitanium drivers can be set with Rset within the operating window. During normal operation, the set current cannot be changed.

## Application guidelines

RC filter for Touch and Dim interface
When a Touch and Dim interface is used that works with the mains voltage (Touch and Dim can work with several different voltage levels) and in combination with long cable lengths, high voltage spikes might occur. These voltage spikes can have a negative effect on the performance of the older generation Xitanium Indoor Linear TD LED drivers (listed in table below). To prevent this from happening Philips strongly advises to add a simple RC filter in the system for every Touch and Dim interface that is used, comprising a positive temperature coefficient thermistor. It is advised to install the RC filter directly after the Touch and Dim switch.
TD drivers not listed are not advised to make use of this filter.




Schematic of Touch and Dim behaviour

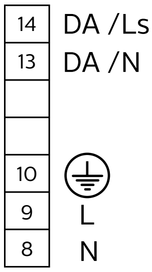
The diagram on the left shows a Touch and Dim controlled system with the RC-filter added. The RC filter consists of following components:

- PTC Resistor   R = 80-150 Ohm   Max Voltage Rating>250 V
- Capacitor   C = 330 nF   Type X2 275 V

Listed drivers are strongly advised to use the RC filter when operated via Touch and Dim

| Driver descriptive name | 12nc |
|---|---|
| Xitanium 17W/0.12-0.4A 54V TD 230V | 9290 006 84703 |
| Xitanium 36W 0.12-0.4A 100V TD 230V | 9290 006 73703 |
| Xitanium 75W 0.15-0.4A 200V TD 230V | 9290 006 70403 |
| Xitanium 75W 0.2-0.4A 200V TD 230V | 9290 006 17303 |
| Xitanium 75W 0.7-2A 54V TD 230V | 9290 006 92103 |
| Xitanium 75W 2A 54V TD/TE 120-277V | 9290 006 36913 |
| Xitanium 75W/160mA 200V TD 230V | 9290 008 15903 |
| Xitanium 75W/200mA 200V TD 230V | 9290 006 61803 |
| Xitanium 75W/240mA 200V TD 230V | 9290 006 61903 |
| Xitanium 75W/280mA 200V TD 230V | 9290 006 62003 |
| Xitanium 75W/320mA 200V TD 230V | 9290 006 62103 |
| Xitanium 75W/360mA 200V TD 230V | 9290 006 62203 |

Example of a shorted DALI interface

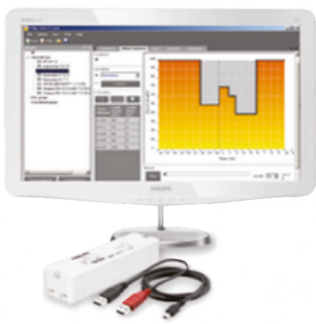



## TD as non-dimmable

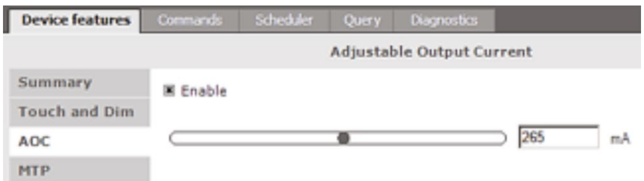
When a TD driver is used without any controls connected to the control input, it operates as a non-dimmable driver. However, fluctuations on the power line or other similar interferences might trigger a Touch and Dim lamp OFF command. Due to the fact that no control interface is connected, the system cannot be switched on again. To prevent this, Philips strongly recommends to shortcut the DALI control interface. The DALI interface is also used for connecting the Touch and Dim controls and, by shortcutting this interface, accidental triggering of OFF commands is prevented.

# Configurability

Philips MultiOne hardware interface



Example of a shorted DALI interface




### Connecting to a programmable driver

Xitanium Indoor Linear LED drivers are programmed via the Philips MultiOne configurator software. To do so, the driver must be connected to the computer via the MultiOne hardware interface.

This can be done with TD drivers only.
Check the datasheet for the driver's ability on www.philips.com/technology.

For the latest version of the MultiOne configurator software please check www.philips.com/multione.

## How to... See the programming taking effect

### Programming time

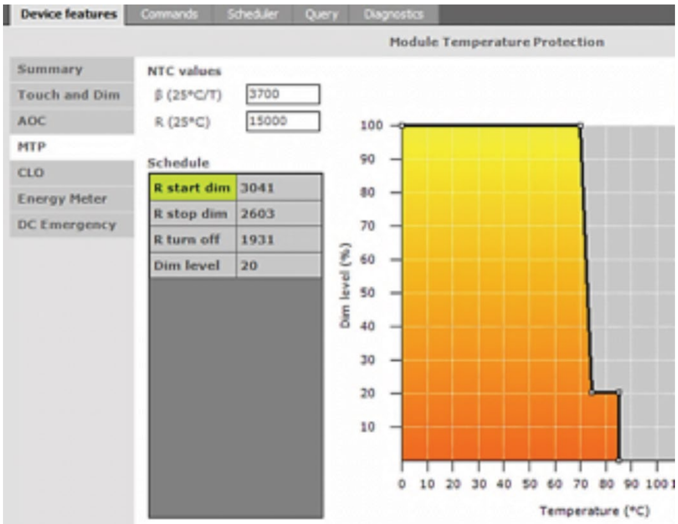
Depending on the selected features to program, the programming time varies between 2 up to about 15 seconds. It is possible to program up to 64 drivers at the same time. In case of group programming there is no individual confirmation (verification) from each driver.

In order to have the programmed values take effect for Xitanium Indoor Linear LED drivers, the mains power needs to be cycled. For newer drivers (1% minimum dim level) On/Off via standby is also sufficient.

Note on Corridor Mode: after a power cycle (e.g. reconnection after luminaire installation) the Corridor Mode needs to be reactivated via the activation pulse. See also upcoming section on Corridor Mode.

## AOC setting

Within the driver's current range, any value can be set via the software. For this feature and value changes to be effective, make sure the "Enable" checkbox is ticked.




Module Temperature Protection settings in MultiOne

## Module Temperature Protection (MTP) behavior setting

It is possible to set the MTP behavior in MultiOne configurator software:

d) "R start dim" is the temperature at which MTP dim function is activated

e) "R stop dim" is the temperature at which MTP dimming minimum is defined

f) "R turn off" is the temperature at which MTP function makes the driver go to its physical minimum dim level (stated in the driver's datasheet)

g) "Dim level" shows the minimum dim level before switch off

For an extensive explanation of all functionality and allowed values, please refer to the MultiOne configurator software manual, to be found on www.philips.com/multione.

Depending on module temperature, the driver current will follow the linear line between 100% and "R stop dim" (default 10%). At the rated operating conditions of the luminaire, the LED module temperature should not exceed "R start dim" by design. The MTP feature is helpful in maintaining LED life during occasional/temporary heat spikes like a hot day or loss of air conditioning. The driver responds dynamically to changes in parameters of MTP. There is no need to reset the driver for changes in these parameters to take effect.

**Values for R and Beta specify the characteristics of the NTC on the LED modules**

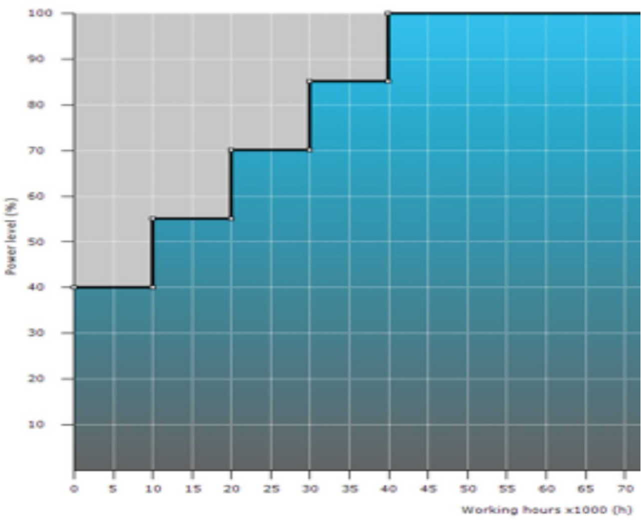
| | R | Beta |
|---|---|---|
| Vishay 15 kΩ | 3,700 (default in MultiOne) | 15,000 (default in MultiOne) |
| NTC 10 kΩ | 3,850 | 10,000 |
| Murata 15 kΩ | 15,000 | 3,987 |
| LED light engines | 3,700 (default in MultiOne) | 15,000 (default in MultiOne) |


Configure Constant Light Output feature

## Constant Lumen Output setting

Traditional light sources like TL and HID typically suffer from depreciation in light output over time. This applies to LED light sources as well. The CLO feature enables LED solutions to deliver constant lumen output through the life of the light engine. Based on the type of LEDs used, heat sinking and driver current, it is possible to estimate the depreciation of light output for specific LEDs and this information can be entered into the driver. The driver counts the number of light source working hours and will increase output current based on this input to enable CLO.

For indoor linear drivers the CLO percentage can be set to a value between 0-100% with increments of 1%. Value 0% will turn OFF the driver. LED module working hours can be set at any value between (0-120,000 hours) with increments of 1,000 hours. Default the CLO feature is disabled.




Configure Constant Light Output feature

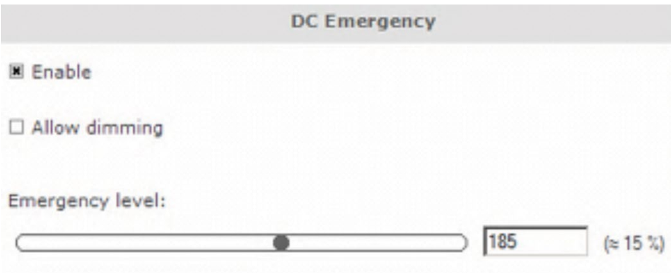
### Example with CLO

When the CLO feature is enabled (thick the box), the driver nominal output current will be defined by the CLO percentage as shown by the equation below:

Driver target nominal output current =
CLO [%] x AOC [mA]

Assume a driver with a current range of 300-1000 mA. For example, in the CLO profile shown in figure on the left, between 20,000-30,000 working hours, the CLO percentage is set at 70%. Assuming the nominal AOC is set to 800 mA, the driver output current with CLO enabled will be 0.7 x 800 = 560 mA from 20 kh to 30 kh.

Please take into account what the AOC (driver current) needs to be when CLO reaches 100%. This value might be higher than the nominal current stated in the datasheet of the LED board.
Since the CLO curve is not generic, the OEM needs to determine the appropriate CLO curve for a given luminaire. This can be used to differentiate on e.g. lumen output or power consumption over lifetime.



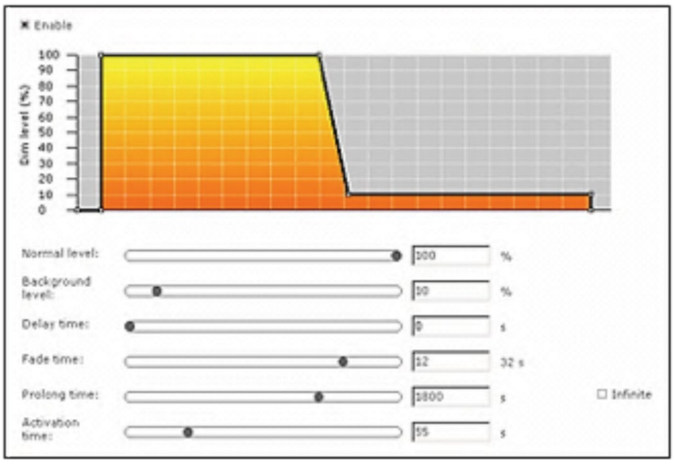

Selectable settings for DCemDIM in MultiOne software

### DCemDIM setting

During emergency situations often a 100% light level is not required so power load can be lowered and energy can be saved. DC emergency dimming function is intended to dim the light to a predefined light level as soon as DC mains is applied to the driver's mains input. The MultiOne configurator software can be used to configure the DC emergency dimming feature of the driver.

Parameters are:

- "Enable" DCemDIM when DC is applied to mains input of driver
- While in emergency mode "Allow dimming" overrides driver output when a DALI controller is connected to the driver. Default is Off.
- "Emergency level" can be set between 0..255 (DALI value). The resulting relative dimming value is show next to the set DALI level. Relative means with respect to the drivers set output current via AOC. When set to 255 the light level is not changed when DC mains is applied.




Settings associated with Corridor Mode

**Enabled** Thick the box to enable this feature
Note: after power cycle option has to be reactivated

**Normal level** when presence sensor detects activity
**Background level** when no presence detected and after fade time
**Delay time** between sensor switch-off and the moment device will start to fade to background level
**Fade time** used from normal to background level
**Prolong time** after which device will be switched off

**Activation time** is time during which mains signal must be detected (pulse), before the device will switch to Corridor Mode

Example;
AOC set to 200 mA, DCemDIM set to 15% (DALI value 185). Result when mains switched to DC is that the driver outputs 200 mA x 15% = 30 mA.

For the driver's default settings please check the associated datasheet on www.philips.com/technology.

## Corridor Mode setting

Newly released Xitanium indoor linear TD drivers incorporate the Corridor Mode feature. The Corridor Mode adjusts the light to a defined level when a presence sensor detects a person. Corridor Mode can only be activated when the device is in Touch and Dim mode. The settings can be customized to suit your application using the Philips MultiOne configurator software, after which it automatically is in the DALI mode.

### Activate Corridor Mode

a) Hardware by means of providing mains voltage to the control input for at least the "Activation time" (default 55 s).
b) Set via MultiOne configurator software, cycle mains and activate

If the switch in the application cannot make a pulse that long, via Dali programming the parameter Activation Time in tab Corridor Mode can be adjusted according requirements. For example shortened to 10 s. This value is then stored and will be available after a power cycle.

### Reactivate Corridor Mode after a mains power cycle

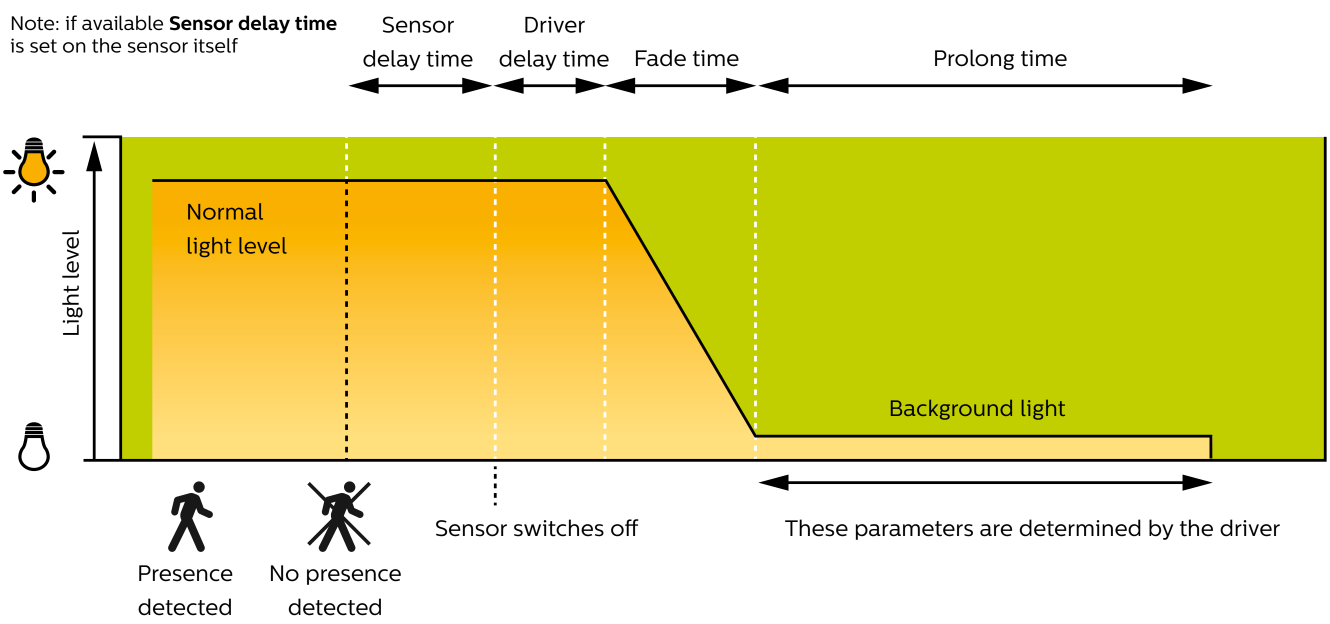
Please note, when the mains is cycled (e.g. after installation of the luminaire) default the Corridor Mode will be disabled (Touch and Dim will be enabled). This behavior is similar to the conventional Philips fluorescent ballasts. Once powered again the Corridor Mode needs to be reactivated (see previous section).

### De-activate Corridor Mode

a) Cycling the mains on both control input and mains input of driver
b) Set via MultiOne configurator software, cycle mains and activate

The driver enters this mode with default settings as stated in the table on the next page.

| Parameter | Value | Default | Remarks |
|---|---|---|---|
| Enabled | 0, 1 | 0 | 0 = Touch and Dim, 1 = Corridor |
| Normal level | 0 ... 254 | 254 | DALI levels (0 ... 100%) |
| Background level | 0 ... 254 | 170 (= 10%) | DALI levels (0 ... 100%)w |
| Delay time driver | 0 ... 2550 | 0 | Seconds after "sensor off" |
| Fade time | 0 ... 15 | 12 (= 32 s) | DALI fade times (0 ... 90 s) |
| Prolong time | 0 ... 2550 | 1800s (30 mins.) | 0 ... 2540 s, 2550 = infinity |
| Activation time | 1 ... 2550 | 55 s | Seconds to provide mains |
| LED light engines | 3,700 (default in MultiOne) | 3,700 (default in MultiOne) | 15,000 (default in MultiOne) |





Setting the level in the DALI "command" tab of MultiOne

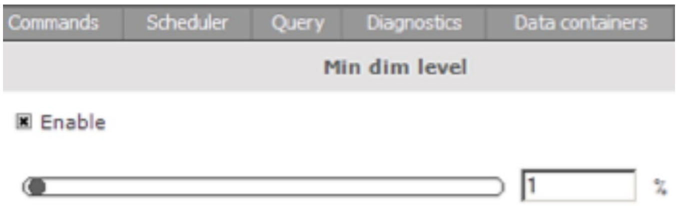
## How to... Set the DALI minimum dimming level

A practical example when to do this; having a 1% dimming driver next to an older 10% dimming driver controlled in the same installation.

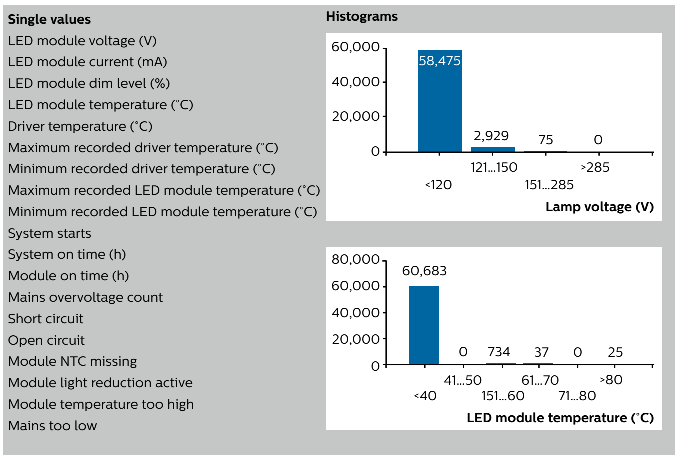
### Changing the DALI minimum dimming level using the Command tab

You can change the DALI minimum dimming level using MultiOne command form in the "command" tab. The command form uses DALI dim levels. DALI dim level 170 corresponds to 10% dim level.

Steps are:
1. Fill the desired value in the DTR field
2. Select "Set" behind the DTR field
3. Select "DTR -> min level"




Enable and set the driver's minimum dimming level




## Changing the DALI minimum dimming level using Device Feature tab

Alternatively, on selected drivers (newest) via MultiOne software in the Device Features tab under Min dim level, you can set the minimum dimming level. For this feature to be enabled thick the box.

## Driver diagnostics (TD drivers only)

On selected TD drivers (1% dimming range) the diagnostics functionality is available. Please check the datasheet of the driver you use or consider to determine if the functionality is available. To access these diagnostics, select a device in the Network and select the Diagnostics tab. Upon clicking Read on the toolbar, the device's diagnostics information will be read and displayed. Diagnostics for a LED device might look as follows:

A brief explanation of all LED diagnostics is given in the table below.

## Table explaining LED diagnostics

| Diagnostic | Description |
|---|---|
| LED module voltage (V) | Represents the output LED module voltage. |
| LED module current (mA) | Represents the output LED module current. |
| LED module dim level (%) | Represents the actual dim level set by the LED driver. Takes into account all factors that can influence dimming like Constant Light Output, Module Temperature Protection, all dimming interfaces etc. |
| LED module temperature (ºC) | Represents the LED module temperature. Available only when Module Temperature Protection is selected and an NTC value is selected. |
| Driver temperature (ºC) | Represents the internal driver temperature. It does not represent Tcase of the driver. Though there is a correlation between Tcase and internal driver temperature, the difference can vary depending on current setting of driver. |
| Minimum recorded driver temperature (°C) | Minimum LED driver temperature ever reached during the lifetime of the driver. |
| Maximum recorded driver temperature (°C) | Maximum LED driver temperature ever reached during the lifetime of the driver. |
| Minimum recorded LED module temperature (°C) | Minimum LED module temperature ever reached during the lifetime of the driver. |
| Maximum recorded LED module temperature (°C) | Maximum LED module temperature ever reached during the lifetime of the driver. |
| System starts | Represents the number of times the LED driver is powered ON. |
| System on time (h) | Represents the hours the LED driver is ON. (LED module is OFF) |
| Module on time (h) | Represents the number of hours the LED module is powered ON. |
| Mains overvoltage count | The numbers of times the mains has exceeded the maximum mains value as listed in the safety range of the product. |
| Short circuit | This indicates if output LED module is shorted. |
| Open circuit | This indicates if output LED module is open or not connected to LED driver. |
| Module NTC missing | This indicates missing NTC on the LED module. Available only when Module Temperature Protection is selected and 10 k NTC is selected. Missing NTC flag will not be activated if 15 k + 390 Ω NTC is selected. |
| Module light reduction active | This indicates light level reduction due to module temperature being active. |
| Module temperature too high | This indicates whether the LED module temperature exceeds 90 °C causing module to turn OFF. |
| Mains too low | This indicates that the LED driver is not operating since input voltage at power ON is too low. |

# Quality and Reliability

**Switching & cycling lifetime of LED drivers**
Impact of on and off switching on lifetime of electronic drivers in LED systems
In this section a description is presented of the impact of mains voltage switching on the lifetime of electronic drivers in lighting systems. Because switching on and off the lighting has an impact on different failure modes, a distinction has to be made between switching on and off, and thermal cycling.

**Electrical failures due to switching Vmains on and off**
Before the lighting is switched on in the electronic circuit all capacitors are uncharged. By a simple toggle of the mains voltage all capacitors will be charged, causing peak currents in the circuit. Inductors react to this by creating peak voltages. Occurrence of peak currents & voltages during starting is inevitable. The circuit design and component selection should be of sufficient quality that no components are overstressed during the starting conditions. If the quality is not sufficient, failures will occur at a certain rate over time. The failure rate will be influenced by usage conditions such as temperature and mains voltage. The failure rate will be further enhanced by irregular mains voltage events such as dips, surges or black outs. For a good quality design all conditions and components are carefully checked. In general LED systems and products are designed to withstand >100,000 switches under the specified use conditions.

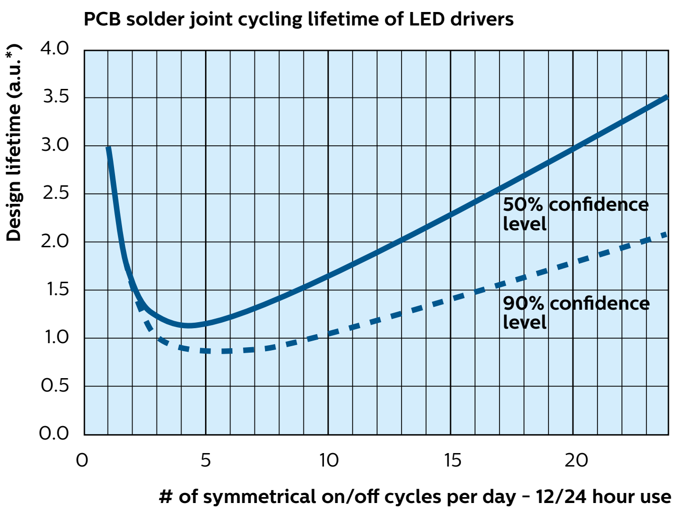
**Mechanical failures due to thermal cycling**
A completely different failure mode which is also due to switching on and off the light is the failure of solder joints, due to thermal cycling. Stresses in solder joints are caused by the differences of the thermal expansion coefficients (CTE's) of printed circuit board, solder and component materials.

Due to heating up and cooling down mechanical stresses build up in the solder, which eventually result in cracking and finally failure of the joint. In most cases failure of one solder joint means the end of the product. The solder joint failure mechanism is also referred to as solder joint fatigue. This is a typical wear out failure mechanism with a negligible failure rate for many years, but for which after the typical lifetime has passed, failures come at an accelerated speed.

Electronic Drivers for LED lighting are typically designed to last 50,000 operational hours. The reference for this lifetime is a typical user profile of 10-12 hr usage and up to 3x switching on and off every day. In the worst case this could mean 25,000 switches at a regular rate 2 hrs on, 2 hrs off.  For a 100,000 hr specified product, the driver has to survive twice the number of switches. For the electrical stresses during switching there is no problem switching many more times, even up to >100,000 times. However for the solder joints there can be a risk for the lifetime of the product.

## Impact of thermal cycles per day on the driver lifetime

As the drivers are typically designed to withstand 3 full thermal cycles every day, lifetime will reduce with an increasing cycling frequency. However this reduction will be limited by the heating time of the product in the application. As the heating time of a driver in real applications varies typically between 60 and 120 minutes, maximum and minimum driver temperature will not be reached when the cycling frequency is faster than 60 minutes. Because the solder-joint damage relates to a higher power of the temperature difference between hot and cold condition, the negative effect on lifetime reduces for the higher cycling frequencies. This is expressed in the above graph.




*) arbitrary unit value 1.0 means product design - lifetime will be reached (typical 50,000 h). Longer lifetimes can be limited by other failure modes.

Because of the large variation and differentiation between drivers and applications, it is an impossible task to specify the above graph for every driver and application specifically. Therefore only the critical conditions are listed for which there could be a risk to the cycling lifetime of the driver.

Critical conditions for the driver lifetime due to thermal cycling are:

- Small driver / system (short heating time) without appropriate heat sinking (high T_max).
- Large difference between T_max and temperature in off state T_min (e.g. > 50 °C). See also next paragraph.
- Application @ temperatures < -20 °C T_ambient.

Especially if the above parameters occur in combination with each other there can be a risk for thermal cycling lifetime. To improve cycling lifetime when required, it is most relevant to decrease the T_max by appropriate heat sinking of the driver. As a rule of thumb 10 °C diminished ΔT between Tcase on/off, will add 30% to cycling performance.

## Impact of product ambient temperature on cycling performance

In the first approximation the solder joint lifetime is independent of the ambient temperature. The driving parameter for the solder joint failure fatigue is the temperature difference between T_max during the 'on' state and T_min during the 'off' state. The way the driver is built in to a luminaire is very important as this can decrease the temperature difference. Appropriate heat sinking of the driver is the most effective way to improve the driver cycling lifetime. As a rule of thumb 10 °C diminished ΔT between Tcase on/off, will add 30% to cycling performance.

For potted products additional failure mechanisms can occur at temperatures <-20 °C, which can increase the impact of thermal cycling on the product lifetime.

## Standards the drivers are tested against

The tables below state the standards the drivers are tested against. Consequently the drivers do carry CE and ENEC, as stated in the driver's datasheet.

| Compliance and approval | Generated disturbances, EMI and EMC |
|---|---|
| EN 55015 A2/CISPR15 | Conducted EMI 9 kHz-30 MHz |
| EN 55015 A2/CISPR15 | Radiated EMI 30 MHz-300 MHz |
| IEC 61000-3-2 A1 + A2 | Limits for harmonic current emissions |
| IEC 61000-3-3 | EMC – Limitation of voltage fluctuation and flicker in low voltage supply systems for equipment rated up to 16 A |

| Immunity | Generated disturbances, EMI and EMC |
|---|---|
| IEC / EN 61547, A12000 | Equipment for general lighting purposes – EMC immunity requirements |
| IEC / EN 61000-4-2 | Electrostatic Discharge |
| IEC / EN 61000-4-3 A1 | Radiated radio frequency, electromagnetic field immunity |
| IEC / EN 61000-4-4 | Electrical fast transient/burst immunity |
| IEC / EN 61000-4-5 | Surge immunity |
| IEC / EN 61000-4-6 | Conducted disturbances induced by RF fields |
| IEC / EN 61000-4-11 | Voltage dips, short interrupts, voltage variations |

| Performance | Generated disturbances, EMI and EMC |
|---|---|
| IEC 62384 | DC or AC supplied electronic control gear for LED modules - Performance requirements |
| IEC 62386 | Digital Addressable Lighting Interface (DALI) |

| Safety standards | Generated disturbances, EMI and EMC |
|---|---|
| IEC 61347-1 | General and safety requirements |
| IEC 61347-2-13 | LED Particular requirements for DC or AC supplied electronic control gears for LED modules |

| Emergency standards | Generated disturbances, EMI and EMC |
|---|---|
| IEC 61347-2-3 | Particular additional safety requirement for AC/DC supplied electronic ballasts for emergency lighting |
| IEC 61347-2-7 | Particular requirements for DC supplied electronic ballasts for emergency lighting |

# Disclaimer

Philips will perform the testing of the LED systems to high standards of workmanship. The tests are carried out with reference to the EN/IEC standards, if any, which are regarded by Philips as being of major importance for the application of the lamp gear and the lamp within the fixture for horticultural applications.

The design-in guide, regarding the testing and design in of the LED system provided by Philips, is not an official testing certificate, and cannot be regarded as a document for official release of the fixture. The OEM is liable for the official testing by a certified test body and all markings, such as CE and ENEC marks, on the fixture assembly.

The design-in guide is for information purposes only and may contain recommendations for detecting weak points in the design of the system (lamp – lamp gear – fixture), if any.

Specifically mentioned materials and/or tools from third parties are only indicative: other equivalent equipment may be used but it is recommended that you contact Philips for verification.

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Since the tests are only performed on one particular fixture provided by the customer, it will be treated as a prototype. This means that there is no statistical evidence regarding later production quality and performance of the lamp – lamp gear – fixture system.

As Philips does not have control over manufacturing of the fixtures, Philips cannot be held liable for the fixture assembly.

Philips will not accept claims for any damage caused by implementing the recommendations.

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The OEM must bring any claim for damages within ninety (90) days of the day of the event giving rise to any such claim, and all lawsuits relative to any such claim.

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