

**PHILIPS
ADVANCE**



LED Drivers

Design-in Guide

Xitanium Outdoor
Fixed and Dimmable

The reliable,
flexible choice
for easy outdoor
luminaire design-in

Outdoor Fixed and Dimmable Xitanium LED Drivers
Design-in Guide

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Introduction to Xitanium LED Drivers



Figure 1. Xitanium 150W LED Driver

This guide contains the information to design Philips Advance Xitanium LED Drivers into a luminaire. We advise you to consult our website for the latest up-to-date information.

Information and support

If you require any further information or support please consult your local Philips sales representative or visit www.philips.com/leddrivers.

Application note

These drivers are designed to address the growing demand for controllability and flexibility. The Adjustable Output Current (AOC) feature enables operation of various LED configurations from different LED manufacturers and offers “future-proof” solutions for new LED generations. There are specific dimmable versions enabling use of lighting controls to increase energy saving through a wide variety of protocols, such as 0-10V and Trailing Edge (Step-Dim and Leading Edge coming soon). In most of the cases the indoor drivers also integrate a 12V output for active cooling and NTC feedback for LED module temperature protection.

Long-lasting and low-maintenance, LED-based light sources are an excellent solution for outdoor environments. For optimal performance, these lighting applications require reliable drivers matching the long lifetime of the LEDs. The Xitanium LED Drivers offer reliability and flexibility for optimal solutions in luminaire design. Luminaire manufacturers are able to streamline logistics without compromising on performance. With a unique dimming interface, multiple choices for output current are also possible to provide flexibility in lumen output and efficacy.

The remarkable energy savings and CO₂ reductions achieved with LED lighting can be further extended with dimming. Xitanium LED Drivers offer the industry standard 0-10V dimming interface, which works with various external dimming devices and sensors as well as the external Dynadimmer from Philips Advance. The Dynadimmer functionality offers multiple dimming profiles, from a simple reduction of light during off-peak hours to a complex dimming schedule.

Safety precautions



Warnings

- Avoid touching live parts!
- Do not use drivers with damaged wiring!

Safety warnings and instructions to be taken into account during design-in and manufacturing include:

- Do not use damaged or defective contacts or housings.
- Do not service the driver when the mains voltage is connected; this includes connecting or disconnecting the LED load.
- Do not use damaged products.
- Cap off all unused wires to prevent accidental contact with the luminaire or driver housing.
- The luminaire manufacturer is responsible for its own luminaire design and has to comply with all relevant safety standards.
- The Philips Advance Xitanium LED Driver is intended for built-in use and should not be exposed to the elements such as snow, water or ice. Exposure will lead to corrosion of the driver housing and should be avoided. It is the luminaire manufacturer's responsibility to prevent exposure. Xitanium outdoor drivers are specified for UL damp and dry locations and must be used within wet location rated enclosure or luminaire.
- Driver must be installed in accordance with national and local electrical codes.
- For support with any of these aspects, please contact your local Philips sales representative.

Features of Xtitanium LED Drivers

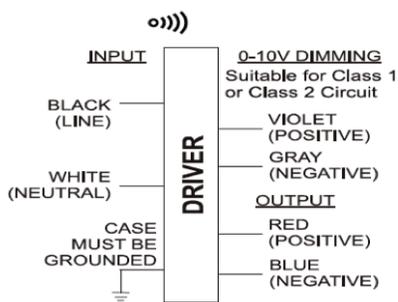


Figure 2. Driver lead wire color code definition

Driver wiring

Lead wires with corresponding functions are shown in Figure 2 for a 0-10V dimmable driver. The driver housing must be grounded (earth connection) via the metallic mounting tabs of the housing. The mains connections are accomplished via the black and white connections. In cases where both leads are “hot,” as may be the case in 240V applications, the neutral may be connected to the other hot lead as long as it is done in accordance with NEC. Maximum ground offset voltage on the neutral lead is equal to the maximum rated voltage of the driver.

Important

- Keep wiring between the driver and the LED module as short as possible. However, “remote wiring” is acceptable, and Table A gives an indication of remote mounting distance vs driver current and AWG wire size. The table is based on the assumption that a 1V drop is acceptable (e.g., the max driver output voltage rating must be at least 1V higher than the maximum LED voltage).
- Keep in mind that remote mounting also impacts efficiency of the system (as an example, a 1V drop on a 4A driver results in 4W losses in the wiring, so if lower losses are desired, a correspondingly large wire size should be chosen). Also, the remote mounting impacts EMC behavior, and additional measures may be necessary to reduce EMC if remote mounting is used (for example, adding a ferrite clamp around output wires would reduce radiated EMC). In general, lead length should be kept as short as possible to avoid EMC issues.
- Length of the 0-10V dim wiring: Depending on wire gauge, the length of dimming wires will add a sufficient voltage drop to cause a shift in dim level from the intended target. Table B, gives an indication for dim lead wiring lengths assuming a maximum offset of 100mV for different numbers of drivers connected to a single controller.

Output Current (A)	AWG Wire Size					
	12	14	16	18	20	22
0.35	855	540	340	215	136	85.5
0.53	565	356	225	142	89.5	56.5
0.7	428	270	170	107	67.8	42.8
1.05	285	180	113	71.6	45.2	28.5
1.5	200	126	79.4	50.1	31.6	20
2	150	94.4	59.6	37.6	23.7	15
3	100	62.9	39.7	25.1	15.8	10
4	75	47.2	29.8	18.8	11.9	7.5
5	59.9	37.8	23.8	15	9.5	6

Table A. Max allowed distance between driver and LED module in feet (based on 1V drop)

Number of Drivers	AWG Wire Size					
	12	14	16	18	20	22
10	1995	1259	794	501	316	200
20	998	629	397	251	158	100
30	665	420	265	167	105	67
40	499	315	199	125	79	50
50	399	252	159	100	63	40
60	333	210	132	84	53	33
70	285	180	113	72	45	29
80	249	157	99	63	40	25
90	222	140	88	56	35	22
100	200	126	79	50	32	20

Table B. Max allowed length of 0-10V control wires in feet (based on 100mV drop and 150uA drive current)

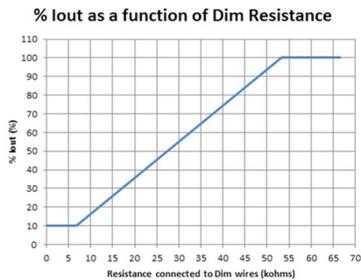


Figure 3. External resistor (across 0-10V dim leads) vs output current

Driver output current

Typically, LED drivers are available in discrete current levels, e.g., 350 mA, 530 mA, 700 mA, 1050mA, etc. The current can also be selected to a different level by use of a resistor across the dimming port for drivers that have a precise 150uA (+/-3%) current source. For drivers that do not have the precise 150uA current source, use of a resistor is not recommended due to high tolerance of the dim voltage resulting from current source variations. Please check the driver datasheet to see which drivers have a precise 150uA dim current. Figure 3 shows the resistor value vs dimming % for drivers with precise 150uA current sources. The curve is valid for drivers with minimum dim levels of 10%.

Operating window

Drivers can deliver different levels of output power depending on driver type. For each driver there is specified output current/ output voltage window. The connected LED load current and voltage characteristics must be within the driver window (under steady state, full output or dim). The driver performance cannot be guaranteed outside the window. See Figure 4a for an illustrated example of an operating window for a dimmable 300W, 0.1-1.5A driver. Figure 4b shows an illustrative example of an operating window for a fixed output driver. Please check the driver datasheet for the specified operating window.

The LED load voltage is typically influenced by a number of factors such as temperature, binning (tolerance), drive current and aging. It is important to consider these factors when determining the required voltage range for a certain LED load to ensure that the LED voltage stays within the operating window of the driver. The driver will limit the voltage available for the LEDs based on the window shown. For example, if the LED driver is set to 1.5A and the LED load voltage at 1.5A would be 220V, then the driver would limit the voltage to 200V as shown in Figure 4a. The resulting current at 200V could be even reduced. If the upper voltage limit is reached at -40°C (when the LED voltage is highest), care must be taken to ensure that sufficient current flows through the LED load to allow the LEDs to warm up and eventually operate within the window area (otherwise, desired drive current will not be achieved).

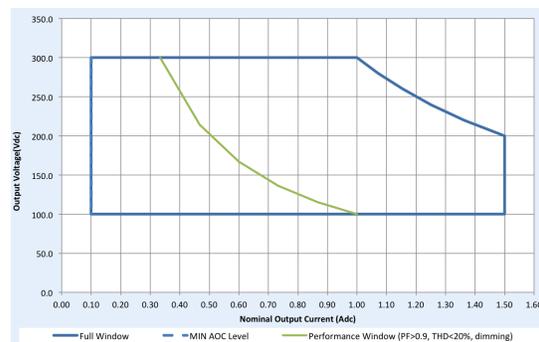


Figure 4a. Operating window (dimmable driver)

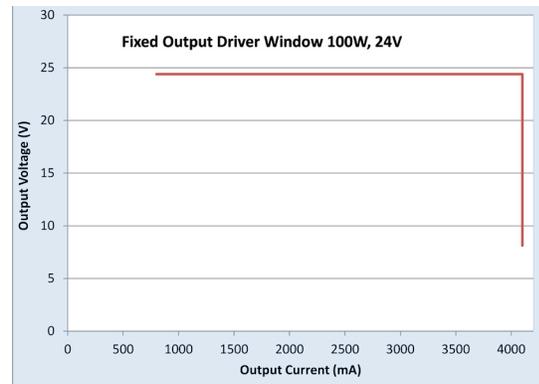


Figure 4b. Operating window (fixed output driver)

Adjustable Output Current

This feature supported by some drivers allows the user to set the output current of the driver in a certain range as defined in the datasheet of the driver. AOC can be achieved by means of a resistor (Rset) or programming through SimpleSet technology. Please refer to website below for programming instructions and tools required for programming.

www.philips.com/simpleset

Note: If LED current and/or voltage characteristic falls outside the driver window, please consult Philips for application guidance and driver selection.

Thermal management

The following section covers the critical thermal management points to facilitate design-in. Taking thermal considerations into account will ensure optimum performance and lifetime of an LED system. The maximum case temperature (T_c max) of the driver should not be exceeded. It is mandatory to keep driver T_c max within specification to meet driver lifetime and failure rate specifications. Please refer to individual product datasheets for specific values. Philips Advance Xitanium LED Drivers are designed to provide a lifetime of up to 50,000 hours at the specified T_c max.*

Thermal Fold Back (TFB) of driver

The driver will reduce the current to the LED module if the driver itself is overheating. The driver will limit the current when the driver case temperature exceeds the maximum specified temperature by minimum 5°C. Refer to the individual driver datasheet for the specified fold back value (Figure 5).

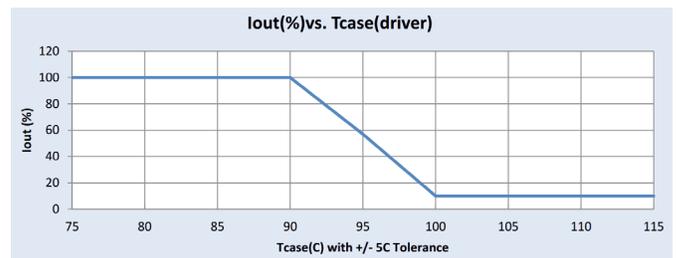


Figure 5. Thermal Fold Back (TFB) example

Temperature Case Point

To achieve optimal lifetime and reliability, it is critical that the temperature of the components in the driver remains within its rating. In the driver design, all precautions are taken to ensure that the components within the driver are at the lowest possible temperatures.

Initial thermal analysis is performed via IR scans at room temperature to identify the hottest components of the driver. Subsequently, detailed measurements of the temperatures of the critical components are performed under various input/output conditions at the worst case operating temperatures.

These temperature measurements are related to a T_{case} (T_c) point on the driver as shown in Figure 6. T_c point temperature is a proxy for the temperatures of the critical internal driver components.

The location of the T_c point is identified on the product label (Figure 7). The T_c point on the drivers is on the side of the case at the location of the pointed arrow for the F-can driver. For other housing types, the T_c point is on the dot indicated by the arrow (see red circle in Figures 8a and 8b).

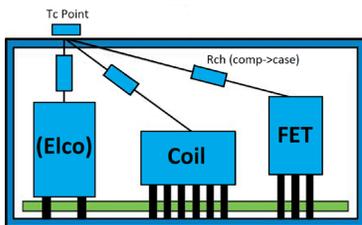


Figure 6. Internal resistance to the driver Tc point

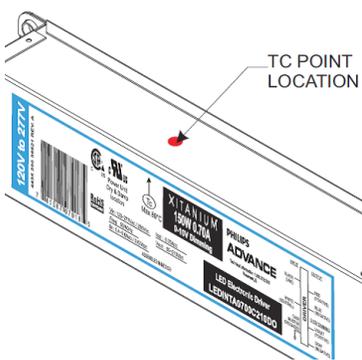


Figure 7. Product label indicating T_c point of F-can driver

* Minimum 90% survivals based on MTBF modeling.

Note: The specified Tc max of the driver must NEVER be exceeded. In order to ensure accurate Tc test results, the case temperature should not vary by more than 1°C for a period of at least 30 minutes after a stable temperature has been achieved. The Tc point should not be obstructed when mounted in the luminaire/enclosure.

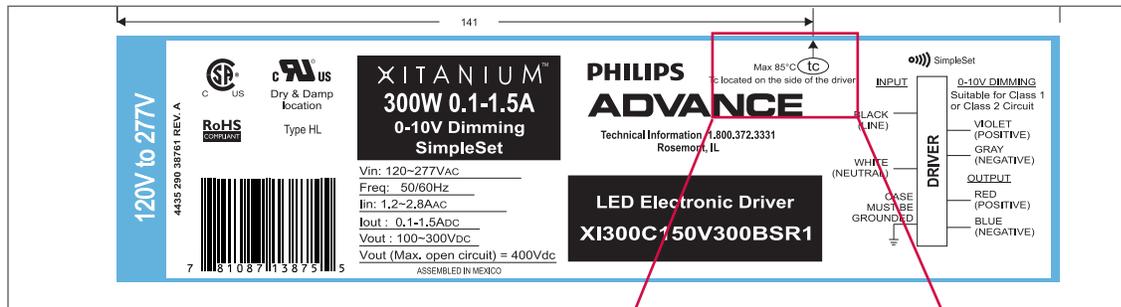


Figure 8a. Product label indicating Tc point of an R-can driver

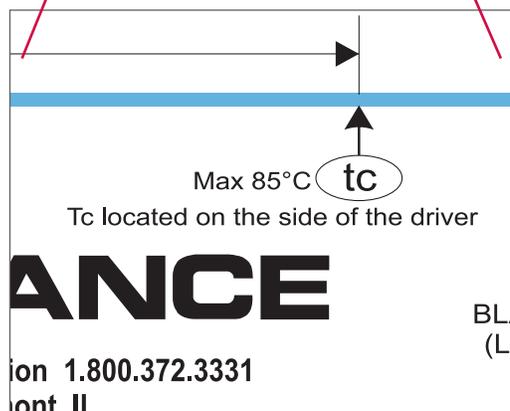


Figure 8b. Product label indicating Tc point of an R-can driver (detail)

Dimming methods

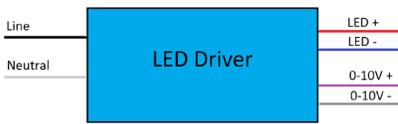


Figure 9. LED driver with 0- 10V dimming interface

0-10V dimming

0-10V is a commonly used dimming interface for LED drivers. The interface requires two wires (0-10V + and -) to connect an LED driver to a 0-10V dimmer (Figure 9). The LED driver provides approximately 150 μ A sourcing current to the dimmer. A dimming curve is shown in Figure 10.

Note that the output current at 100% level is determined by the driver. The minimum current that can be supplied by the driver is specified in the datasheet. The lowest dim level is defined by the higher of the two values: minimum output current or 10% dim level for outdoor drivers.

For non-class 2 drivers, the 0-10V dimming leads are isolated from mains and driver output. They are suitable for Class 1 and Class 2 wiring. For Class 2 drivers, the 0-10V dimming leads are isolated from mains—but may not be isolated from Class 2 output—thus the dimming leads are only suitable for Class 2 wiring.

In some drivers, the 0-10V dimming interface also provides a shutdown function. This function is specified in the datasheet. When the voltage applied across two dimming leads exceeds 14.5V, the driver will shut down with very low standby power. A dimming curve with shutdown function is shown in Figure 11.

When long dimming wires are required in some applications, maximum length of the dimming wires can be estimated based on voltage drop on the dimming wires. The recommended max voltage drop on the two wires is 100mV.

Note: Even though dimming leads of LED drivers meet Class 2 requirements, when multiple drivers are connected together to one dimmer, the leakage current to the dimmer from each driver will be added together. In these situations, precaution is recommended for the system to meet applicable safety requirements.

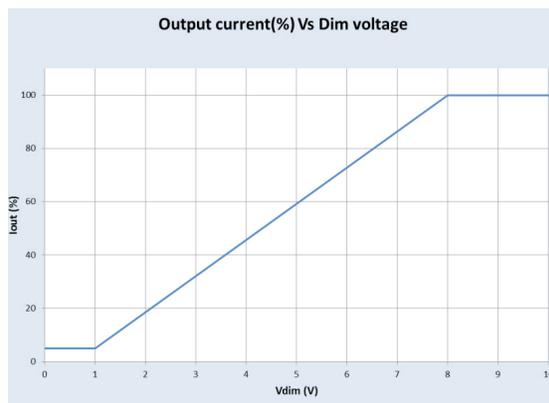


Figure 10. Output current in % vs dimming voltage

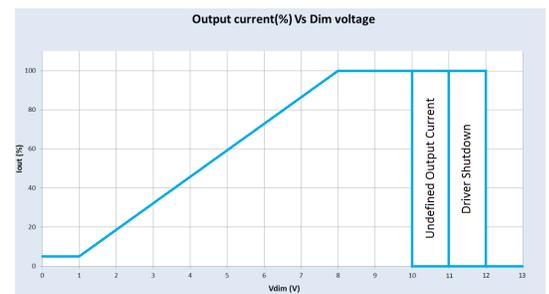


Figure 11. LED driver output current in % vs dimming voltage with shut down function

External Dynadimmer

Dynadimmer is an external dimming control device developed by Philips Advance that enables a simple, pre-programmed multistep dimming. For details on external Dynadimmer settings, please consult the external Dynadimmer guide (<http://www.usa.lighting.philips.com/connect/controls/dynadimmer.wpd>).

Dynadimmer allows dimming to predefined light levels based on the nightly operating time. With flexibility in setting time and light levels, the user can configure the driver for specific locations and application needs. It is possible to set up to five dim levels and time intervals. The Dynadimmer runs a virtual clock, determined by the length of nightly operating hours. After three ON-OFF cycles, it will calculate the virtual clock time. A valid ON-time is defined as a period during which the driver operates continuously for ≥ 4 hours to ≤ 24 hours. As shown in Figure 12b, after repeating the driver ON-time for three consecutive days, the dim profile takes effect from the fourth day onward. For more information on Dynadimmer scenarios, please refer to the DynaDimmer guide.

Dynadimmer Override

In some instances, there is a need to override the Dynadimmer dim cycle either manually or automatically. For example, luminaires in a parking garage may be configured to utilize the integrated Dynadimmer feature with a defined dim cycle.

A motion sensor can be associated with one or more luminaires, which, when activated by passing cars, can signal the driver to override the dim cycle and go to full light output. When the Dynadimmer Override function is enabled, the driver will override the active dim cycle and go to full light output.

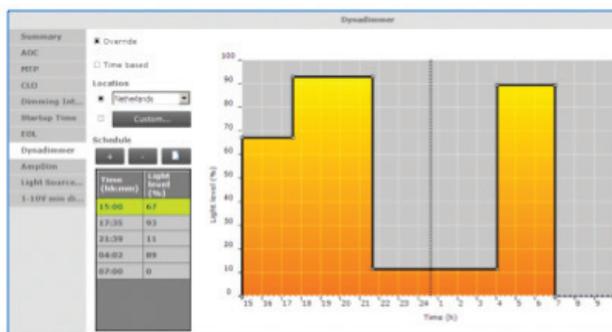


Figure 12a. Dynadimmer settings



Figure 12b. Dynadimmer virtual clock setting

Inrush current

Inrush current refers to the brief high-input current that flows into the driver during the initial start-up to charge the capacitors on the input side. Typically, the amplitude is much greater than the operating or steady-state current, as illustrated in Figure 13.

Philips Advance Xitanium LED Drivers meet the inrush specification values per NEMA 410, which are $175\mu\text{F/A}$ for 120V mains and $125\mu\text{F/A}$ for 277V mains. Usually, with IntelliVolt products (120–277V mains), the most critical point is 277V mains. For example, a 150W driver typically has a capacitance value of $41\mu\text{F}$, which corresponds to approximately $75\mu\text{F/A}$ at 277V, well below the $125\mu\text{F/A}$ NEMA 410 requirement at 150W output power.

The values for I_{peak} and T are shown in the datasheets for each driver. The experimental setup used for measuring the inrush current of Philips Advance Xitanium LED Drivers is shown in Figure 16. For the test setup, a line impedance of $450\text{m}\Omega/100\mu\text{H}$ is used. These values represent a worst case line impedance (lowest). For the measurements, an input DC voltage equal to the peak of the corresponding line voltage is applied (via a capacitor bank). It should be noted that the inrush current measurement given in the datasheet is the absolute worst case value and many factors can reduce this in a real application. These factors include actual line impedance and phase angle at turn-on. The inrush data for a given driver (mentioned in driver data sheet) is useful as criteria for fuse selection. Other factors such as surge, steady state rating, etc., must also be considered for fuse selection.

The best way to reduce inrush is to turn on relays or switches at the zero crossing of the mains. Many controllers do this to reduce the large inrush currents.

What does inrush current do? High inrush currents can cause circuit breakers or fuses to open if not designed to handle this current. It can limit how many drivers can be connected to a circuit breaker (CB) or fuse.

Note: Please consult the fuse and circuit breaker manufacturer recommendations when selecting appropriate fuse and/or circuit breakers in conjunction with LED luminaires.

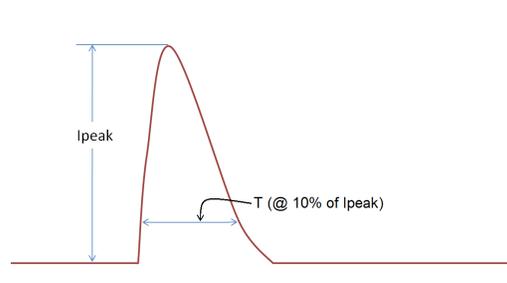


Figure 13. Inrush current vs. time

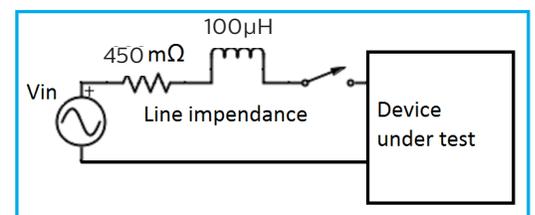


Figure 14. Inrush current measurement setup

Surge protection

Philips Advance Xtitanium LED Drivers have limited built-in surge protection (in accordance with IEEE / ANSIC62.41.2 Transient Surge Requirements). The driver data sheet gives the protection level of the driver. A driver specification of 4kV means that the driver is tested to withstand 4kV line transient (2Ω source impedance) based on the 2Ω combination wave setup (1.2μSec/50sec open circuit voltage, 8/20μSec short circuit current). Drivers are typically rated with 4kV, and this rating means that drivers are tested with the above waveform for all line coupling modes (L to N, L to PE, N to PE and L&N to PE). Depending on the geographical location, additional protection against excessive high surge voltages is recommended.

Note: It is highly recommended to test the external surge protection device (SPD) in combination with driver and LED module for worst case line transients.

ANSI C62.41.2 gives some guidance as to what surges can be expected in different exposure locations. For outdoor, low exposure is given at the 6kV/3kA level and high exposure applications at 10kV/10kA. Both of these exposure levels would require an external SPD to protect the system.

Considerations for external SPD selection

Differential mode surge

Figure 16 shows the test setup for a differential mode surge. For a driver rated at 4kV, V_{surge} is 4kV and complies with the standard Combi-wave shape (1.2/50μSec open circuit voltage and 8/20μSec short circuit current). The series impedance of the tester is 2ohms as indicated. The voltage at the driver terminals for a surge applied between line and neutral is approximately 1.2kV for drivers rated for 120–277V mains and approximately 1.8kV for drivers rated for 347– 480V mains.

When selecting an external MOV to increase the surge rating of the system, care must be taken to ensure that the external MOV clamping voltage is lower than the clamping voltage of the driver so that the current flowing into the driver during surge is always less than that flowing into the driver in the above setup. The current clamped into the driver in the above setup can be calculated by

$$I1 = (V_{surge} - V1) / 2\Omega$$

For 120–277V rated driver with a 4kV surge rating, this becomes

$$I1 = (4kV - 1.2kV) / 2\Omega$$

$$I1 = 1.4kA$$

For a 347–480V rated driver with a 4kV surge rating, this becomes

$$I1 = (4kV - 1.8kV) / 2\Omega$$

$$I1 = 1.1kA$$

When adding an external SPD, the system setup appears as shown in Figure 16.

Figure 16 shows that the system surge current is surge splits between I_2 (the current into the external SPD) and I_1 (the current into the driver). In order for the LED driver to survive the surge, I_1 must be kept below the values calculated with the rated surge voltage WITHOUT the SPD as was done above.

To select the External SPD, the following steps must be followed:

1. Determine the desired surge level of the system. IEEE C62.41 can be used as guidance. For example, 10kV/10kA, according to DOE for highly exposed systems.
2. Once I_{surge} is known (10kA in this example), it must be ensured that the clamping voltage of the external SPD is sufficiently low such that I_1 is within the driver capability.

Example:

Surge requirement is 10kV/10kA according to DOE:

An external SPD must be selected that can handle 10 surges at 10kA for all coupling modes.

For a 120–277V, 4kV surge rated driver, the maximum value for I_1 was calculated to be 1.4kA at a V_1 of around 1.2kV. This means the external SPD must be selected such that it has a clamping voltage of 1.2kV or less at 8.6kA (10kA - 1.4kA = 8.6kA).

SPD requirement

Energy rating: 10 pulses of 10kA for each coupling mode (L-N, L-G, N-G, LN-G)

Clamping voltage: <1.2kV at 9kA

Note: Care must be taken to also include any voltage drops on the wires leading to the SPD. A 10kA surge has a di/dt of 1.3A/nSec. Consider that 1 inch of wire can have an inductance of around 20nH. This means an external SPD with wire length of 4 inches (round trip wire length of 8 inches) results in $8 * 20\text{nH} * 1.3\text{A} / \text{nSec} = 208\text{V}$. That means if the SPD has a 4 inch wire length, it must clamp at 1.0kV at 9kA in order to keep V_1 below 1.2kV. An SPD with an input and output terminal or wires can eliminate this wire voltage drop.

Common mode surge

The external SPD common mode surge clamp level should be less than the LED driver common mode surge with stand specification.

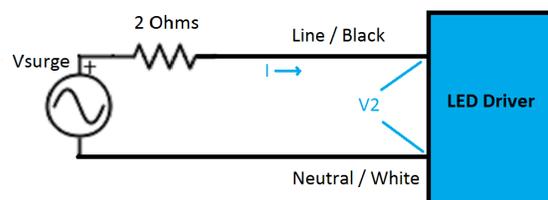


Figure 16. External SPD and driver setup

Leakage current

Philips Advance Xitanium LED Drivers are designed to meet leakage current requirements per UL 8750 standards. The specified maximum value is 0.75 mA RMS at 277V. The test is done with the driver alone. In a luminaire, leakage current may be higher since the LED load introduces additional leakage capacitance. As such, precautions should be taken on the luminaire level and if multiple drivers are used in the luminaire.

Electromagnetic compatibility (EMC)

Xitanium LED Drivers meet EMC requirements per FCC Title 47 Part 15 Class A. These tests are conducted with a reference setup that includes a driver and an LED load/heat-sink combination mounted on a grounded metal plate. To maintain good EMC performance at the luminaire level, the input, output and dim wires should be kept as far apart as possible. The addition of ferrite beads in series with the wires 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.

Electrical isolation

Philips Advance Xitanium LED Drivers' output is isolated from the primary for isolated non-Class 2 drivers and Class 2 drivers – see the appropriate data sheet for particular isolation type. Isolation is also provided between all the electronic circuits and the chassis. Figure 17 illustrates the isolation scheme for isolated non-Class 2 drivers. Figure 18 illustrates the isolation scheme for Class 2 drivers.

Xitanium LED Drivers meet the UL 8750 safety standard. Xitanium Class 2 drivers also meet UL1310 Class 2 safety standard.

All of the wires in the Philips Advance Xitanium LED Drivers meet the UL1452 safety standards.

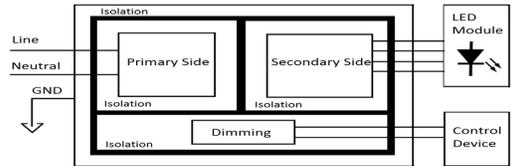


Figure 17. Xitanium Non-Class 2 LED driver isolation

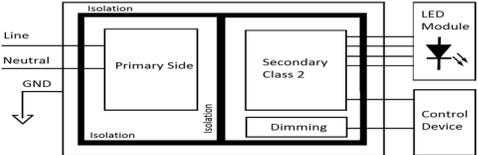


Figure 18. Xitanium Class 2 LED driver isolation

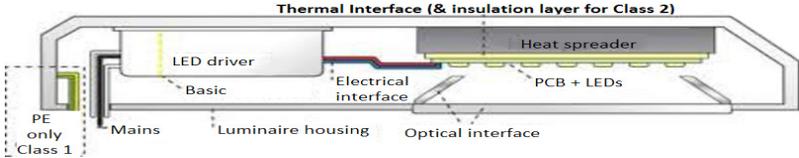


Figure 19. Luminaire design example

Mechanical mounting

Mounting of the LED driver must satisfy three critical issues:

1. Solid fastening of the driver in order to avoid movement of the driver relative to luminaire

The size of mounting screws/bolts needs to be the maximum allowed by the size of driver mounting holes/slots. The tightening torque has to be per screw/bolt manufacturer recommendations.

2. Electrical grounding of the driver

The driver enclosure is painted. It is recommended to use star washers under the head of the mounting screws – the teeth of the star washer breaks through the paint to ensure electrical connection to the grounded fixture.

3. Maximum interface area between driver enclosure surface and luminaire mounting surface (cooler) for best possible driver T_{case} temperature (lowest)

Figures 20 and 21 illustrate recommended mounting of the driver. Thermally conductive gap pads (or other thermally conductive grease, paste, etc.) may be used between driver and luminaire surface to eliminate air gaps and further improve driver thermal performance (lower T_{case} temperature).

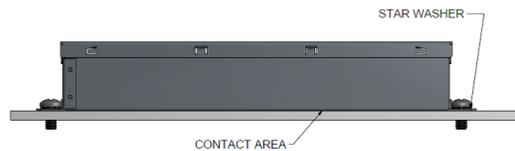


Figure 20. Chassis mounting

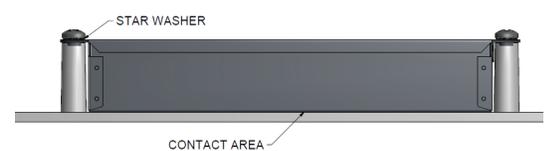


Figure 21. Cover mounting

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