OPTOTRONIC® Power Supplies for LED Modules

Technical Guide

- LED Basics
- Product Overview
- System Setup
1. Introduction

1.1. Purpose and Scope of the OEM Technical Guide

This document is a technical reference guide for selecting, installing and using OPTOTRONIC® LED power supplies.

The technical information focuses on OPTOTRONIC LED power supplies for Solid State Lighting (SSL) systems. Please reference the product information bulletins and the electrical specification data sheets for additional technical information. For the most updated information please visit www.sylvania.com/LEDpowersupplies.

1.1.1 Structure of OEM Technical Guide
Section 1: An introduction to LED technology and the lighting advantages it has over traditional lighting technologies.
Section 2: Introduces OPTOTRONIC LED power supplies benefits and features.
Section 3: Describes the information required for set-up systems, installing and operating OPTOTRONIC LED power supplies.

1.2. Lighting Emitting Diodes (LEDs)

1.2.1. LED Overview
LEDs (Light Emitting Diodes) are small semiconductor components that convert electrical current into visible light.

LED Features:
• Compact size
• High luminous intensity
• Saturated, vibrant colors
• Fully dimmable from 0-100%
• Instant on/off, no accelerated aging due to switching cycles
• Long lifetime
• No IR or UV radiation
• Mechanically robust, shock and vibration proof

Due to the advances made in LED research and development, LEDs can produce brightness light levels comparable to that of traditional lighting sources.

OSRAM SYLVANIA offers LED modules, OPTOTRONIC LED power supplies and control interfaces that work with each other for use in countless SSL applications.

1.2.2. LED Design
LEDs consist of the actual light-emitting chip (also called LED die) in a protective housing. The housing provides: electrical connection to the LED chip, a heat sink to remove heat generated in the chip and a molded compound as a protective cast surrounding the die. Figure 1 shows a Golden DRAGON® Plus LED in a protective cast and Figure 2 shows the components that make the LED module.

Housings may also include a reflector to collect scatter light emitted from the chip and optics to direct the LED’s light emission pattern.
1.3. Driving LEDs

Controlling Current
The LED includes a semiconductor material that makes a p-n junction possible. The p-n junction on a diode allows current to flow one direction. When a voltage applied to a diode is lower than its forward-voltage, current will not flow through it. If the voltage is higher than its forward-voltage, the current flows rapidly and exponentially. In this case, the diode will eventually be destroyed. Therefore, when driving LEDs, it is essential that the current flow through the LED is limited to a safe value. This can be achieved by utilizing a power supply that provides a fixed current (“constant current power supply”), or by limiting the current with a resistor. Another method is by using IC drivers that are connected to the LEDs (in this case the LED can be operated by a constant voltage power supply). An IC driver needs to be powered by a constant voltage power supply.

Note: OSRAM SYLVANIA offers both constant current and constant voltage (described in section 2.3.1.) OPTOTRONIC® LED power supplies.

1.4. Managing Temperature
In addition to keeping the current through an LED within safe limits, it is equally important to ensure the LED temperature does not exceed the maximum specified value. The maximum temperature allowed for each LED module is specified in their respective data sheet, which can be found at www.sylvania.com. LED power supplies have a max temperature value on the label called Tc point. The Tc temperature values vary for each LED power supply model number and is not the hottest point on the power supply. When the temperature exceeds the maximum allowed value, the customer must improve the cooling by providing a larger heat sink.

1.5. Methods for Controlling Light Output (Overview)
LED power supplies utilize one of three different methods. The first dimming method reduces the current to the diode ("current reduction"). The second method is Pulse Width Modulation (PWM) dimming to the LED and the third method is AC phase cut power line dimming.

1.5.1 Dimming Overview
1.5.1.1 Current Reduction
Current reduction is a straightforward solution that reduces the thermal load and brightness of an LED (e.g. reducing the LED’s current from 350mA down to 250mA will reduce the thermal load on the LED accordingly). However, varying the current of an LED may affect its light output. The output color of an LED can have a noticeable dependency on the current that is applied; this is also referred to as a color-shift of the LED. For white LEDs, reducing or increasing the current may lead to a change in the white-point.

Note: RGB (colormix) applications are recommended to use PWM dimming.

1.5.1.2 PWM Dimming
PWM dimming uses a different method for reducing the average current through the LED. In this case, the current applied to the LED is turned on and off at a high frequency (e.g. 300Hz) while keeping a fixed current level (e.g. at 350mA). The average amount of current flowing through the LED is then determined by the length of the on and off period (the duty-cycle).

1.5.1.3 AC Phase Cut Power Line Dimming
AC phase cut power line dimming is another type of dimming by controlling the power delivered to the lighting system by cutting off a portion of the input AC voltage waveform.
2. OPTOTRONIC® LED Power Supplies – Benefits and Features

2.1 Overview
OSRAM OPTOTRONIC LED power supplies are easy-to-use and specifically designed for operating LED modules.

2.1.1 Benefits
OPTOTRONIC devices offer many benefits:

- Designs have a universal input voltage to be available for worldwide AC input standards.
- Have a variety of shape and size enclosures for simple retrofitting.
- Are specifically designed for operating LED modules and ensure safe and reliable operation.
- Provide the flexibility needed to respond to the demanding market of changing LED array designs.
- Consume a minimum amount of energy due to their high efficiency design.
- Are compact and require minimal amounts of installation space.
- Are designed to allow long cable lengths on the output side, providing greater freedom and flexibility during installation.
- Can power a large number of LED modules, reducing system cost and installation complexity.
- Are protected against short circuits and electrical/thermal overload helping ensure safety.

2.1.2 Features
OPTOTRONIC devices have the following features:

- Universal input voltage
- Low Total Harmonic Distortion (THD)
- High Power Factor Correction (PFC)
- Multiple channel options
- Different dimming options
- Flexible power output options
- UL recognize or UL listed enclosures
- High efficiency
- Common sizes
- Optional connection
- High reliability
- Competitive warranty

2.2. Operating Principles
As described in section 1.3, driving LEDs safely and reliably requires limiting the current that flows through the LED. This can be done with a constant current power supply or by using LED modules that have an integrated IC LED driver and using a constant voltage power supply.

2.2.1. Important Design Features
- The power supplies are isolated between the input and output side that guarantees safe operation of the power supply and LED module(s). Each output provides Class 2 power levels in accordance with the National Electrical Code ANSI/NFPA 70, maximum output voltage does not exceed 60V for continuous direct current. This ensures that the output side of the power supply is safe to touch at all times.
- Built-in power factor correction.
- Built-in filters on the input side for reliable operation (i.e. immunity to power surges or noise on the supply line) and on the output side (helping to ensure EMI compliance of the driver).
- A built-in control unit that guarantees optimal/safe operation of the LED module(s) and provides protection against shorts on the output side (thermal overload, etc).

2.3. Types of OPTOTRONIC LED Power Supplies
OPTOTRONIC LED power supplies convert AC line voltage into constant voltage or constant current output power. These power supplies are available in various power outputs, constant voltage values, constant current values, optional housings, different dimming options, indoor and outdoor application options. OSRAM SYLVANIA also offers Direct Current (DC) to Direct Current (DC) OPTOTRONIC LED power supplies. LED power supplies convert constant voltage output to constant current output. The OPTOTRONIC product family is divided into the following groups:

Note: To add dimming capabilities to your system, consider a power supply with built-in dimming capabilities.
2.3.1 Constant Current
Constant current power supplies are intended to be used with LED modules without integrated IC current drivers. They are ideally suited to operate customer specific designs and eliminate the need for current-limiting circuitry connected to the LED.

Constant current power supplies require a serial connection, which should be specifically noted when designing a system and during installation.

Constant current power supplies offer the following benefits:

- Reduced system power losses. The power conversion is done directly from the line voltage to the fixed DC output current. No additional current limiting components are required (which reduces system losses).
- No additional thermal load due to current limiting devices. Connecting additional current limiting devices to high-flux LEDs may increase the thermal load on the LED, especially when current limiting is done through linear current regulators. By supplying a controlled DC-current, constant current devices eliminate the need for such components.

The majority of OPTOTRONIC® constant current LED power supplies are Class 2 to ensure the output side is safe to touch at all times. However, this limits the total output power of the power supply and the number of LEDs that can be driven by one power supply. Due to the serial connection of the LED, the forward voltage drop is added up and needs to be below Class 2 limits for operating the LED at the desired output current.

2.3.2. Constant Voltage
Constant voltage power supplies are intended to be used with 10V, 12V and 24V LED modules. It is not possible to connect these power supplies directly to LEDs or to constant current LED modules. Doing so may damage or destroy the LEDs.

Constant voltage power supplies are available with output voltages of 10V, 12V or 24V and have a rated output power from 6 to 240W.

There are several benefits of using constant voltage power supplies:

- All constant voltage power supplies are Class 2, UL Recognized or UL Listed. This guarantees safe-to-touch outputs.
- Higher wattage constant voltage power supplies are capable of keeping the output voltage safe and it does not limit its output power. The output power is only limited by the maximum current that can be supplied.

2.3.3 DC to DC
Direct current to direct current (DC/DC) LED power supplies are used in applications where AC power is not available. These power supplies can be used with our constant voltage power supplies to make constant current LED module additions to Solid State Lighting applications. They have a wide DC input voltage range and are in a small package.

2.3.4 Multiple Channel
All OPTOTRONIC multiple output channel power supplies comply with UL safety Class 2. This enables Solid State Lighting systems to smoothly comply with UL safety requirements. The optional selection of either 2, 3 or 4 output channels and dimming control enables OEMs to have unlimited powering options for their new or retrofit LED luminaires.

2.3.5 Dimmable Power Supplies and Control Interfaces
Adding a dimmable power supply or control interface to a system makes dynamic lighting possible. Dynamic lighting allows you to control brightness levels and/or can provide highly sophisticated RGB color control. OSRAM SYLVANIA offers devices suitable for both uses (dimmable power supplies as well as controllers).

Dimmable power supplies combine power and dimming into one device. This integrated solution simplifies installation and saves space.

2.3.5.1 Controlling Options

2.3.5.1.1 0-10V and 1-10V/Analog Dimming

0-10V and 1-10V control inputs are well established protocols in the lighting industry and are primarily used for easy brightness control.

Features of 1-10V interfaces:

- Output is controlled by a DC voltage signal from 10V (maximum light output; control wires open 10%) to <1V (minimum light output; control wires short-circuited 0%)
- Control voltage is supplied by each ECG itself. Each ECG can supply a maximum current 0.6mA
- Units operated on different phases can be dimmed by one controller.

Features of 0-10V interfaces integrated into the LED power supply:

- Output is controlled by a DC voltage signal from 10V (maximum light output 100%; control wires open) to <0V (minimum light output 10%; control wires short-circuited)
- Control voltage is supplied by control dimming and can supply a maximum current 0.6mA
- Multiple units can be dimmed by one controller
0-10V devices can be easily integrated with standard lighting components such as sensors, signal amplifiers or building management gateways.

Figure 3 shows dimming at 25%, 50% and 100% and the average current flow. Since the current through the LED remains unchanged at different dimming levels, there is no color shift introduced which ensures the best performance of the LED in both RGB and white light applications.

2.3.5.1.2 AC Phase Cut Line Dimming
Our select OPTOTRONIC® power supplies have integrated leading and/or trailing edge AC phase cut control systems.

Leading edge AC phase cut is also known as: forward phase cut, Tu-wire, Mark 10, Mark X. They operate by controlling the power delivered to the lighting system by “cutting” off the front-end of the AC half cycle voltage waveform. (Figure 4)

Trailing edge AC phase cut is also known as reverse phase cut. These dimmers operate by “cutting” of the back-end of the AC half cycle voltage waveform (Figure 5). These are commonly used for incandescent vs. halogen dimming applications.

2.3.5.1.3 DMX
DMX is a digital control protocol for stage lighting and effect lighting. DMX can be used for a large variety of devices to control options such as light levels, focus, light color or rotation of lights.

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

For more information please reference (ECS028).

2.3.5.1.4 Standalone Controllers
Standalone controllers such as the OPTOTRONIC RGB Sequencer are ideally suited for designing systems for effect illumination without the need for individually controllable lighting effects. The standalone controller is connected between the power supply and the LED modules (typically RGB modules are used) and provides several pre-programmed color effects and scenes. These colors and scenes can be selected by the user and then applied to the LED modules upon powering the controller and the modules.

For the OPTOTRONIC RGB Sequencer, three analog inputs (1-10 VDC) allow the selection of pre-programmed color effects and setting the speed for color changes and dimming levels.

For more detailed information reference (ECS028).

2.4 Electrical Safety
All OPTOTRONIC devices are designed to meet or exceed applicable standards for use in Solid State Lighting applications. The following sections provide an overview of the safety and performance features built into OPTOTRONIC LED power supplies.

2.4.1. Safety
OPTOTRONIC LED power supplies comply with UL8750 safety standards requirements. Compliance to these standards are designed to ensure the safety of the user and implement measures to protect against electric shocks and thermal overload of the electronic control gear in case of malfunction.

In addition, most OPTOTRONIC devices are equipped with an over-temperature shut-down feature to minimize the risk of thermal overload in case of malfunction.

2.5 EMC Compliance
OPTOTRONIC LED power supplies comply with the rules and regulations of the Federal Communications Commission (FCC) that regulate emissions. OPTOTRONIC LED power supplies comply with Title 47, Part 15 or Part 18 (non-consumer) Code of Federal Regulations.
2.6 Total Harmonic Distortion (THD)
Total Harmonic Distortion (THD) is caused by the interaction of non-linear loads that change the waveform of the supply voltage from the ideal sinusoidal waveform. Harmonic distortion is the departure in which every cycle of the waveform is distorted equally. THD is measured as a percentage of the total output signal. The lower the percentages the better it is.

The following are two graphic harmonic distortion examples.

![Harmonic Distortion Graphs](image)

Figure 6

OPTOTRONIC® LED power supplies have a THD of less than 20%.

**Note:** Less than 20% is when the power supply is at full light output.

The THD values and graphs of each LED power supply are specified in their data sheets available at www.sylvania.com

2.7 Power Factor
Power factor is measured from 0 to 1. The lower the power factor the less efficient the LED power supply is. For example a power factor of 0.9 is more efficient than a PF of 0.5. Power factor is produced by inductive loads that require the current to create a magnetic field and the magnetic field produces the desired work. OPTOTRONIC LED power supplies typically have a power factor greater than 0.9 that maximizes the efficiency of the LED lighting system.

The power factor values and graphs of each LED power supply are specified in their data sheets available at www.sylvania.com.

2.8 Immunity
All OPTOTRONIC devices have immunity requirements described by various agencies’ standards. This guarantees protection against interference caused by external high-frequency fields, discharge of static electricity and transient over voltages.

2.9 Radio Interference
OPTOTRONIC power supplies and control units comply with the radio interference values specified by various agencies’ standards. To comply with the radio interference suppression requirements, the length of low voltage cables must not exceed the values given in the respective data sheet.

Stand-alone devices and devices for luminaire integration are equipped with a high-quality internal filter to ensure compliance with the radio interference.

When installing OPTOTRONIC devices in a luminaire of protection Class 2 or plastic installation boxes, no additional measures against radio interference are required.

When installing OPTOTRONIC units in metal case luminaries of protection Class 1 or metal-case installation boxes, radio interference will increase because of higher earth capacities.

Installations that combine OPTOTRONIC power supplies and control interfaces should also be measured in order to guarantee the radio interference of the system is not exceeded. Therefore, it may be necessary to include additional filters.

**Note:** The luminaire manufacturer is responsible for measuring and verifying EMI compliance of the complete lighting fixture as the level of radio interference will vary depending on the power supply installation. In addition, primary and secondary cable lengths and routing may have a significant effect on radio interference.

2.10 Audible Noise
OPTOTRONIC devices have a frequency-dependent sound pressure level that approximates the audibility threshold (i.e. it will be virtually impossible for a person with normal hearing to notice the noise generated by a unit in a room).

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

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

2.11 Maximum Cable Lengths
All OPTOTRONIC power supplies are tested and verified to be EMI compliant with secondary cable lengths of up to 32 feet (shorter cable lengths on some devices). For cable lengths exceeding 32 feet, EMI emissions have to be verified in the application. When the allowed levels of EMI emissions are exceeded, it may be possible to reduce the EMI emissions by using ferrite cores.
**BENEFITS AND FEATURES**

**Note:** The maximum possible cable length may be reduced due to wire resistance (this is detailed in the previous section). For additional information reference application note ECS126.

The luminaire manufacturer is responsible for measuring and verifying EMI compliance of the complete lighting fixture (see the note in section 2.9 on previous page).

### 2.12 Temperature and Lifetime

The lifetime of OPTOTRONIC® devices is determined by the lifetime of the electronic components used in the device. The lifetime of these components is highly dependent on the temperature at which they operated. Typically, an increase in operating temperature leads to a reduction in lifetime.

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

For safe operation and to ensure that the OPTOTRONIC devices achieve a nominal lifetime, the temperature at the Tc point must not exceed the maximum specified temperature.

In addition, exceeding the specified Tc temperature will significantly reduce the life of the LED power supply or permanently damage the components and lead to a total failure of the device. In order to avoid overheating, (when installing a power supply outside a lighting fixture) do not install it to close to any other heat source.

Since lifetime is dependent on temperature, the life can be extended when it is continuously operated at a temperature below the maximum specified Tc point temperature.

Each OPTOTRONIC device will operate reliably within its specified temperature range (see technical data sheets).

### 2.13 Protection

#### 2.13.1 Overload

OPTOTRONIC devices are equipped with reversible electronic overload protection, which automatically reduces the output power or disconnects the load completely during an overload to prevent damage to the device and/or the installation. When the overload condition is removed (i.e. the connected load is reduced) the power supply returns to its full output power.

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

If a power supply is shutting down as a result of an overload, the power supply may enter a blinking mode, alternating between a complete shut-down and brief power-up of the system (in order to determine whether the overload condition is still present in the installation). This blinking mode will be observed on most constant voltage power supplies. For constant current OPTOTRONIC power supplies the output voltage is fixed at the maximum output voltage while the output current is reduced.

**Warning:** Continuously operating OPTOTRONIC devices above their maximum rated power will reduce the lifetime of the power supply and may result in exceeding the maximum Tc point temperature of the device.

#### 2.13.2 Short Circuit

OPTOTRONIC LED power supplies have reversible electronic protection against short-circuits on the secondary side. If a short circuit is detected on the output side, the power supply will cut off the output power. The power supply will be fully operational again once the cause of the short circuit has been eliminated.

#### 2.13.3 Partial Load, No Load Operation

OPTOTRONIC devices have an electronically stabilized output which ensures that partial load or no-load operation will not cause damage to the power supply or the attached LED modules.

**Note:** Standard transformers or power supplies not specifically designed for operating LED modules may exhibit an increase in output voltage (or current) when operating below the nominal output power which in turn may damage or destroy attached LED modules.

Only OPTOTRONIC power supplies will guarantee safe and reliable operation of LED modules within the complete rated load conditions.

#### 2.13.4 Over Temperature

An OPTOTRONIC power supply may become overheated as a result of an overload, insufficient cooling or because of nearby heat sources that increase the temperature of the device beyond the maximum allowed temperature.

Regardless of what causes a device to overheat, select OPTOTRONIC devices are protected against permanent damage that can result from over temperature conditions. When an over temperature condition occurs, the power supply will reduce its output power and eventually shut down to avoid permanent damage.

When the power supply has cooled down to safe levels, full output is automatically restored.
Note: This may result in a blinking mode or a shut-down period because once the system starts operating at full output the temperature of the device will begin to rise and may cause over-temperature again.

For safe and reliable operation and to avoid a reduction in lifetime, the Tc point temperature must be maintained below the maximum specified value at all times. Reference product specification sheets for further details.

2.14 Step-Down Transformer
OPTOTRONIC® LED power supplies can be used concurrently with step-down transformers in different output voltages and power ratings to maximize the efficiency and electrical parameters of the overall system. For example, if you need to use a step-down transformer from 347VAC to 277VAC or 120VAC to operate a LED power supply, it might be better to use a step down transformer to 220VAC to operate with OPTOTRONIC universal input (120-277) to lower the THD and increase the efficiency of the overall system.

2.15 Transient Voltage Surge Suppression (TVSS)
Transient surges are a common power quality issue generated either outside or inside a facility. The outside factors could be lightning strikes and utility power switching and inside factors could be electric motors, stand-by generators, switch mode power supplies in computers, and refrigerators. There are three surge protection categories which determine the location where a TVSS should be installed.

Category A: Surge suppression protection should be applied at the outlet receptacles of a home or for specific equipment such as indoor DC power supplies, computers and appliances.

Category B: Protection should be at distribution panels, industrial busses, heavy appliance circuits, and lighting systems.

Category C: This protection type is applied for transients that come from outside factors, such as transformers, main service entrance panels, utility power switching and lightning strikes.

2.16 Class 2 vs. Non-Class 2 LED Power Supply
A Class 2 LED power supply considers fire initiation from potential cable overheating due to excessive currents. The output power levels are in accordance with the National Electrical Code, NASI/NFPA 70. A Class 2 LED power supply can be an important factor for reducing the cost and improving the flexibility of the Solid State Lighting system. In some cases Class 2 LED power supplies can reduce insulation, wire size, wiring methods and installation material requirements.

In order for an LED power supply to comply with Class 2, the output power is limited to 60VDC for continuous direct current or 100W when used with an AC-DC power supply. OPTOTRONIC LED power supplies are rated at 96W rather than 100W because if the power supply is overloaded, any tolerance in the over current protection has to be accounted for. OPTOTRONIC LED power supplies are certified to UL1310.

Non-Class 2 power supplies are limited to 30 and 1000VA and are necessary when the energy demands of the LED system exceed the energy limitations of the Class 2. All wiring must be installed in accordance with Chapters 1 through 4 of the National Electrical Code (NEC).

2.17 Environmental Locations
OPTOTRONIC LED power supplies are designed and rated to be installed in their respective environmental locations. The locations are Dry, Damp and Wet.

Dry locations are not normally subjected to dampness, but may include a location subject to temporary dampness, as in the case of a building under construction (provided ventilation is adequate to prevent an accumulation of moisture). For example, a conference room inside a building.

Damp locations can be exterior or interior locations that are normally or periodically subject to condensation of moisture in, on, or adjacent to, electrical equipment, and include partially protected locations.

For example: installation in a basement or underneath a gas station outdoor roof.
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Wet locations are installations in which water or other liquid can drip, splash, or flow on or against electrical equipment.

### IP Rating

An IP Rating is an enclosure rating which protects equipment against ingress of dirt or water and protects a person from potential hazards within that enclosure.

The degrees of protection are expressed as “IP” followed by two numbers, (e.g. IP64) where the numbers define the degree of protection. The first digit indicates the extent to which the equipment is protected against particles or to which persons are protected from enclosed hazards. The second digit indicates the extent of protection against water. (Standard details are referenced in the following table.)

<table>
<thead>
<tr>
<th>Level</th>
<th>Object Size</th>
<th>Effective Against</th>
<th>Second Digit</th>
<th>Protected Against</th>
<th>Testing For</th>
<th>Protected Against</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP 0</td>
<td>0</td>
<td>No Protection against contact and ingress objects</td>
<td>0</td>
<td>Not protected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP 1</td>
<td>&gt;50mm</td>
<td>Any large surface of the body, such as the back of hand but no protection against deliberate contact with a body part</td>
<td>1</td>
<td>Dripping water (vertically falling drops) shall have no harmful effect</td>
<td>Test duration: 10 minutes. Water equivalent to 1mm rainfall per minute</td>
<td></td>
</tr>
<tr>
<td>IP 2</td>
<td>&gt;12.5mm</td>
<td>Fingers or similar objects</td>
<td>2</td>
<td>Dripping water when tilted up to 15 degrees</td>
<td>Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15 degrees from its normal position</td>
<td>Test duration: 10 minutes. Water equivalent to 3mm rainfall per minute</td>
</tr>
<tr>
<td>IP 3</td>
<td>&gt;2.5mm</td>
<td>Tools, thick wires, etc.</td>
<td>3</td>
<td>Spraying water</td>
<td>Water falling as a spray at any angle up to 60 degrees from vertical shall have no harmful effect</td>
<td>Test duration: 5 minutes. Water volume 0.7 liters per minute. Pressure: 80-100KN/m²</td>
</tr>
<tr>
<td>IP 4</td>
<td>&gt;1mm</td>
<td>Most wires, screws etc.</td>
<td>4</td>
<td>Splashing water</td>
<td>Water splashing against the enclosure from any direction shall have no harmful effect</td>
<td>Test duration: at least 5 minutes. Water volume 10 liters per minute. Pressure: 80-100KN/m²</td>
</tr>
<tr>
<td>IP 5</td>
<td>Dust Protected</td>
<td>Ingress of dust is not entirely prevented, but it must not enter in sufficient quantities to interfere with the satisfactory operation of the equipment: complete protection against contact</td>
<td>5</td>
<td>Water jets</td>
<td>Water projected by nozzle (6.3mm) against the enclosure from any direction shall have no harmful effect</td>
<td>Test duration: at least 3 minutes. Water volume 12.5 liters per minute. Pressure: 300KN/m² at distance of 3M</td>
</tr>
<tr>
<td>IP 6</td>
<td>Dust Tight</td>
<td>No ingress of dust, complete protection against contact</td>
<td>6</td>
<td>Power water jets</td>
<td>Water projected by power jets (12.5mm) against the enclosure from any direction shall have no harmful effects</td>
<td>Test duration: 3 minutes. Water volume 100 liters per minute. Pressure: 100KN/m² at distance of 3M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>Immersion up to 1M</td>
<td>Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1M of submersion)</td>
<td>Test duration: 30 minutes. Immersion at depth of 1M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>Immersion beyond 1M</td>
<td>The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment it can mean that water can enter but only in such a manner that it produces no harmful effects</td>
<td>Test duration: Continuous. Immersion in water depth specified by manufacturer</td>
</tr>
</tbody>
</table>

Note: EN 60529 does not specify sealing effectiveness against the following mechanical damage of equipment, the risk of explosion, certain types of moisture conditions (e.g. those that are produced by condensation, corrosive vapors, fungus and vermin).
2.18 Ordering Description

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

For single channel output LED power supply description, see guide below.

```
OT W/ /UNV/ /
```

OPTOTRONIC
Total output wattage
Output value
Output type: C = Constant Current (mA), V = Constant Voltage (V)
Input voltage range (UNV = 120-277)
Dimming type (DIM = 0-10V, PC = Phase cut)
Special features: J = J-style housing, JBX = Junction box (UL Listed enclosure)

i.e., OT96W/24V/UNV/DIM is for a 96 watt, 24V constant voltage, universal input (120-277), dimmable (0-10V) power supply

For multiple output channel LED power supply description, see guide below.

```
OT W/ x/UNV/ /
```

OPTOTRONIC
Total output wattage
Number of output channels
Output value
Output type: C = Constant Current (mA), V = Constant Voltage (V)
Input voltage range (UNV = 120-277)
Dimming type (DIM = 0-10V, PC = Phase cut)
Special features: J = J-style housing, JBX = Junction box (UL Listed enclosure)

i.e., OT50W/4X350C/UNV/DIM is a 50 watt, four output channel, 350mA, constant current, dimmable (0-10V) power supply

Some ordering descriptions may not follow this general guide due to unique circumstances or special requirements.
3. System Setup, Installation and Operation

3.1 System Setup

There are several important factors to consider when planning an installation:

1. Selecting suitable LED modules.
2. Determining the required level of control.
3. Determining the total wattage and number of LED modules to be installed and the maximum output voltage limitations that may exist (for systems using constant current modules).

3.2 LED Module Selection

The first step in planning a system installation is selecting the right LED module(s).

For an overview of the available LED modules for use in different applications, please refer to the SYLVANIA Solid State Lighting website at www.sylvania.com/led.

3.3 Level of Control

The required level of control in your application determines whether the system will use OPTOTRONIC® DIM, OPTOTRONIC DMX or the OPTOTRONIC EASY device.

The level of control in an application can range from no control (i.e. fixed output), to simple control (i.e. brightness) or to full RGB control (i.e. multiple independently controlled channels).

Controllers that are installed in between power supplies and LED modules have to be taken into consideration while planning a system installation for several reasons:

- Controllers draw additional power from the power supply. Even though this amount is generally much less than the power drawn from the LED modules, it should be taken into account during the calculation.
- Controllers introduce an additional voltage drop along the cabling to the LED modules, which must be taken into consideration when calculating maximum cable lengths. This point will be discussed further in the examples below.
- The maximum current rating of a controller may limit the number of modules that can be connected to a power supply and control interface.

3.4 Total Wattage

The number of OPTOTRONIC power supplies installed must be able to supply the power drawn by the attached modules and any installed control interfaces.

For normal operating temperatures the maximum number of LED modules that can be operated on a single OPTOTRONIC power supply can be calculated by determining the ratio between nominal wattage of the power supply and the total power consumption of the connected LED modules:

\[ N_{\text{max}} = \frac{P_{N, \text{OPTOTRONIC}}}{P_{N, \text{module-wattage}}} \]

- \( N_{\text{max}} \): Maximum number of LED modules that can be operated on a single power supply.
- \( P_{N, \text{OPTOTRONIC}} \): Nominal power of the OPTOTRONIC power supply. This value can be found on the respective data sheet.
- \( P_{N, \text{module-wattage}} \): Nominal power of the connected LED module which can be found on the respective data sheet.

If a controller is connected to the OPTOTRONIC power supply, the available power to drive the LED modules is reduced by the losses of the controller. The maximum loss of each controller is specified in the device's data sheet. In this case, the maximum number of modules per power supply is calculated using the formula below:

\[ N_{\text{max}} = \frac{P_{N, \text{OPTOTRONIC}} - P_{\text{Losses, controller}}}{P_{N, \text{module-wattage}}} \]

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

For real world applications, the actual number possible may be limited by the maximum allowed cable length on the output side and the desired physical placement of the modules.
3.5 Output Voltage Limitations for ConstantCurrentPower Supplies

For systems that utilize constant current modules, determining the maximum number of modules per power supply must take into account both the maximum output power and maximum output voltage of the power supply.

Refer to the LED module Product Information Bulletin (data sheet) to determine the maximum forward voltage. For example, an LED with a maximum forward voltage of 3.5V, up to 6 LEDs (3.5V x 6 = 21V) can be connected to a power supply with a rated output voltage of 25V, while respecting the maximum load of the power supply.

3.5.1 Paralleling vs. Series Powering Operation for Constant Current LED Modules

A constant current LED power supply can power LED modules in series or parallel connection. The following schematic shows a series connection of LED modules that require 350mA to operate them. A 350mA CC power supply is used to power the LED modules.

The second illustration is a Parallel/Series LED module. It shows that it can also be powered with a CC 700mA power supply. The current needs to be “split” equally among the two strings of series LED modules.

3.6 Remote Mounting

3.6.1 Maximum Output Cable Length

Cable length on the output side is limited by EMI and the voltage drop that occurs along the cables. For the respective remote distance, reference the data sheets of the specific LED power supply.

3.6.1.1 EMI Compliance

All OPTOTRONIC® products are tested and comply with the limit values for radio interference according to FCC 47 Part 15 or Part 18 (non-consumer) code of Federal Regulations. The maximum cable length leading to the LED modules tested to comply with FCC 47 is given in the data sheets. Please note that this is the maximum cable length between the power supply and the LED modules and includes any dimmers or control units that may be installed in between power supply and LED module.

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

Simple and easy-to-use solutions are available in the market. EMI compliance must be verified and confirmed by the luminaire manufacturer.

3.6.1.2 Voltage Drop

LED lighting installations must also consider the resistance of secondary cables, which can lead to a voltage drop along the cable and a reduction in the supply voltage at the LED module. If the voltage at the LED modules drops below the minimum specified value the module may not operate properly.

Constant Voltage Power Supplies

The maximum cable length for constant voltage power supplies on the secondary side can be calculated using the following formula below:

\[ L_{\text{max}} \leq \frac{1}{2\rho} \left( V_{\text{OT}} - V_{\text{DIM}} - V_{\text{LED}} \right) \cdot \frac{V_{\text{LED}}}{P_{\text{LED}}} \]

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho )</td>
<td>Cable resistance used on secondary side (in ( \Omega/\text{m} )). See Table 2 on next page for typical values of secondary cables.</td>
</tr>
<tr>
<td>( V_{\text{OT}} )</td>
<td>OPTOTRONIC® output voltage (12V or 24V)</td>
</tr>
<tr>
<td>( V_{\text{LED}} )</td>
<td>Minimum input voltage of the LED modules (typically 11V or 23V)</td>
</tr>
<tr>
<td>( V_{\text{DIM}} )</td>
<td>Voltage drop of any OPTOTRONIC controllers (if used) (e.g. A typical value for OT DIM is ( V_{\text{DIM}} \approx 0.3V )). The voltage drop of dimmers is also specified in the data sheets.</td>
</tr>
<tr>
<td>( P_{\text{LED}} )</td>
<td>Total maximum wattage of the attached LED modules</td>
</tr>
</tbody>
</table>

Table 1
Table 2 below lists typical values for the resistance of copper cables with 1.5mm² and 0.75mm² diameters at a copper temperature of 20°C. These values will also be used in the examples calculated below.

Table 2 – Typical resistance of secondary cables

<table>
<thead>
<tr>
<th>Cable 1.5mm²</th>
<th>Cable 0.75mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ω [Ω/km]</td>
<td>Ω [Ω/km]</td>
</tr>
<tr>
<td>13.6</td>
<td>29.1</td>
</tr>
<tr>
<td>1/p [m/Ω]</td>
<td>1/p [m/Ω]</td>
</tr>
<tr>
<td>73.8</td>
<td>34.3</td>
</tr>
</tbody>
</table>

Example:

OT75W/24V/UNV, OPTOTRONIC® DIM, COINlight®, 0.75mm² cable

\[ L_{\text{max}} \leq \frac{1}{2} \times 34.3m/\Omega \times (24V - 0.3V - 23V) \times \frac{23V}{12W} = 23m \]

OT75W/24V/UNV, OPTOTRONIC DIM, COINlight, 1.5mm² cable

\[ L_{\text{max}} \leq \frac{1}{2} \times 73.8m/\Omega \times (24V - 0.3V - 23V) \times \frac{23V}{12W} = 49.5m \]

In both examples, the cable length is limited by the requirements for EMI compliance (10m).

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

**Constant Current Power Supplies**

The calculation of maximum cable length for constant current power supplies is as follows:

\[ L_{\text{max}} \leq \frac{1}{2} \times \frac{V_{\text{OT}} - V_{\text{f, total}}}{I_{\text{LED}}} \]

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho )</td>
<td>Resistance of cable used on secondary side (in [Ω/m]). See Table 2 above for typical values of secondary cables.</td>
</tr>
<tr>
<td>( V_{\text{OT}} )</td>
<td>Maximum output voltage of the OPTOTRONIC® power supply (see data sheet)</td>
</tr>
<tr>
<td>( V_{\text{f, total}} )</td>
<td>Sum of the forward voltage of the attached LED with a driving current of ( I_{\text{LED}} )</td>
</tr>
<tr>
<td>( I_{\text{LED}} )</td>
<td>The driving current of the LED</td>
</tr>
<tr>
<td>( P_{\text{LED}} )</td>
<td>Total maximum wattage of the attached LED-modules</td>
</tr>
</tbody>
</table>

Example:

OT25W/700C/UNV/DIM, DL700 Directional Light Engine, 0.75 mm² cable

The DL700 contains 12 white LED chips, with a combined maximum forward voltage of 24V. The OT25W/700C/UNV/DIM is UL-compliant device with a output voltage of 25V.

\[ L_{\text{max}} \leq \frac{1}{2} \times 34.3m/\Omega \times \frac{25V - 24V}{0.7A} = 49.5m \]

In this example maximum output length is again limited by the requirements for EMI compliance (10m).

### 3.6.1.3 Wiring of LEDs as Bus Systems

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

This type of system can expect the total length of all wired branches to be up to twice the maximum allowed secondary cable length (assuming evenly distributed loads \( L_2 = L_3 = \ldots = L_n \)):

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

**Example of a Bus System Wiring**

In this example the total length (\( L_{\text{total}} \)) of the secondary cables is

\[ L_{\text{total}} = L_1 + L_2 + \ldots + L_n \]
**Note:** If the installation is wired in series and not as a bus system, the voltage drop per LED module is added to the total and $L_{total}$ must be $L_{total} \ll L_{max}$.

### 3.6.1.4 Maximum Control Cable Length

Every control protocol (if controllers or dimmable power supplies are used) also has a maximum allowed cable length that must be observed. Table 4 below lists the typical maximum cable lengths that can be achieved per control protocol without the use of repeater devices.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Typical maximum cable length [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1...10V</td>
<td>Control cable specific, see note below</td>
</tr>
<tr>
<td>DALI</td>
<td>300</td>
</tr>
<tr>
<td>Touch DIM</td>
<td>25 (6 devices), 100m with transformer</td>
</tr>
<tr>
<td>DMX</td>
<td>300, without repeater</td>
</tr>
<tr>
<td>EASY</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4

OSRAM SYLVANIA offers repeater devices for the 1-10V/analog, DALI and EASY control protocol; further details are available at www.sylvania.com.

### 3.6.1.5 Maximum Module Lengths

Linear modules, such as the LINEARlight POWER FLEX, can reach a total module length of several meters, which can be sub-divided into units of smaller length. There are, however, limitations to the maximum module length that can be powered from one supply.

In the case of the LINEARlight POWER FLEX, this maximum length is, for example, 1400mm. Due to this maximum length it may be necessary to split a module into several pieces which are powered individually.

Please refer to the respective LED module data sheet for further details and optional accessories that facilitate splitting and wiring.

### 3.7 Installation

#### 3.7.1 Mounting Requirements

##### 3.7.1.1 Independent Mounting

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

3.7.1.2 Outdoor Mounting

All OPTOTRONIC devices are designed for dry, damp or wet locations. The IP protection for each product is listed in the respective data sheet. The rated outdoor compliance is listed on the respective data sheet.

### 3.7.2 Wiring

#### 3.7.2.1 Recommended Cables

For safe and reliable operation of OPTOTRONIC devices you are required to use the recommended cables on the input and output sides (and control port where applicable). This guarantees that the cable is suitable for the electrical load and that the mechanical connection of the wire terminals and cable clamp (when available) is safe and working properly.

Recommended input and output cables are specified in the respective data sheet.

Also refer to the installation instructions that are delivered with the products for updated or additional information.

#### 3.7.2.2 Cable Stripping

To ensure a safe electrical and mechanical cable connection in the electrical terminals and the cable clamp respectively, it is also required that you reference the data sheets. Also refer to the installation instructions that are delivered with the products for additional or updated information.

#### 3.7.2.3 Cable Routing

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

1. AC mains line and LED module cables should not be routed in parallel. Keep output cables and mains cables as far away from one another as possible (e.g. 5 to 10 cm). This avoids mutual interference between mains and secondary-side cables.
2. Place output cables away from earthed metal surfaces (if possible several cm) to reduce capacitive interference.
3. Keep AC mains line cables in the luminaire as short as possible to reduce interference.
4. Avoid crossing AC mains cables and LED module cables. In applications where this is not possible, cables should cross at right angles (to avoid HF interference on the mains cable).
5. Cable penetrations through metal components must never be left unprotected and should be fitted with additional insulation (sleeve, grommet, edge protector, etc.).
Dimming units on the secondary side such as OPTOTRONIC® DIM usually do not affect the radio interference.

3.7.2.4 Wiring Limitations

The maximum number of devices that can be wired in parallel can be found on the installation instructions delivered with all products.

Always check the instruction sheets for additional or updated information.

3.7.3 Avoiding Noise

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

3.7.4 Startup Current, Maximum Number of Devices per Circuit Breaker

When a large number of units are switched on simultaneously (particularly if they are switched on at the peak of the AC input voltage) a large starting current will flow which may trigger a circuit breaker. To avoid false tripping of the circuit breakers, the number of OPTOTRONIC devices connected may have to be limited.

3.7.5 Supply Requirements

OPTOTRONIC devices are available with nominal input voltage ratings from 100V to 308V AC at 50 or 60Hz. Please refer to the data sheets for individual ratings.

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

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

Some OPTOTRONIC devices are protected against short-time (transient) over-voltages, for example as occurring when inductive loads such as fluorescent lamps operated with magnetic ballasts are switched off.

3.7.5.1 DC Operation

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

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

**Potentiometer**

Commercial potentiometers designed for use in lighting control (available through electric wholesale) can be used for easy control of 1…10 V and 10 V max. devices.

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

\[
R_{\text{potentiometer}} = \frac{100 \, k\Omega}{n}
\]

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

Both linear or logarithmic potentiometers can be used; to mimic the sensitivity of the human eye a logarithmic potentiometer should be selected.

At the least, the potentiometer must be designed for a total wattage of \( n \times 2.8\text{mW} \).

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

![Diagram](image)

**Figure 10** – Dimming of OPTOTRONIC DIM with a potentiometer

3.8 Thermal Management

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

To avoid overheating, the electronic converter should be installed as far away as possible from any external heat source (e.g. the LED modules). When installing OPTOTRONIC devices in a luminaire, a good thermal connection between the power supply and the housing of the lighting fixture is required. An installation in a sealed plastic IP-box without ventilation may lead to overheating.

To improve thermals use a metal base plate connected to the outside or metallic boxes.

Proper thermal management is best verified by measuring the temperature at the devices Tc point during steady-state operation at maximum load. The measured temperature must not exceed the maximum specified value for the OPTOTRONIC device.

3.9 Output Switching

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

This can be done for constant voltage based systems but several points should be considered:

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

The same considerations are valid for constant current based systems. In addition, there may also be a short current spike when a device operated without a load is reconnected to the load when internal capacitors start discharging through the load. In a typical application, this generally will not result in damaged LEDs, but should be checked by the luminaire manufacturer for particular applications.