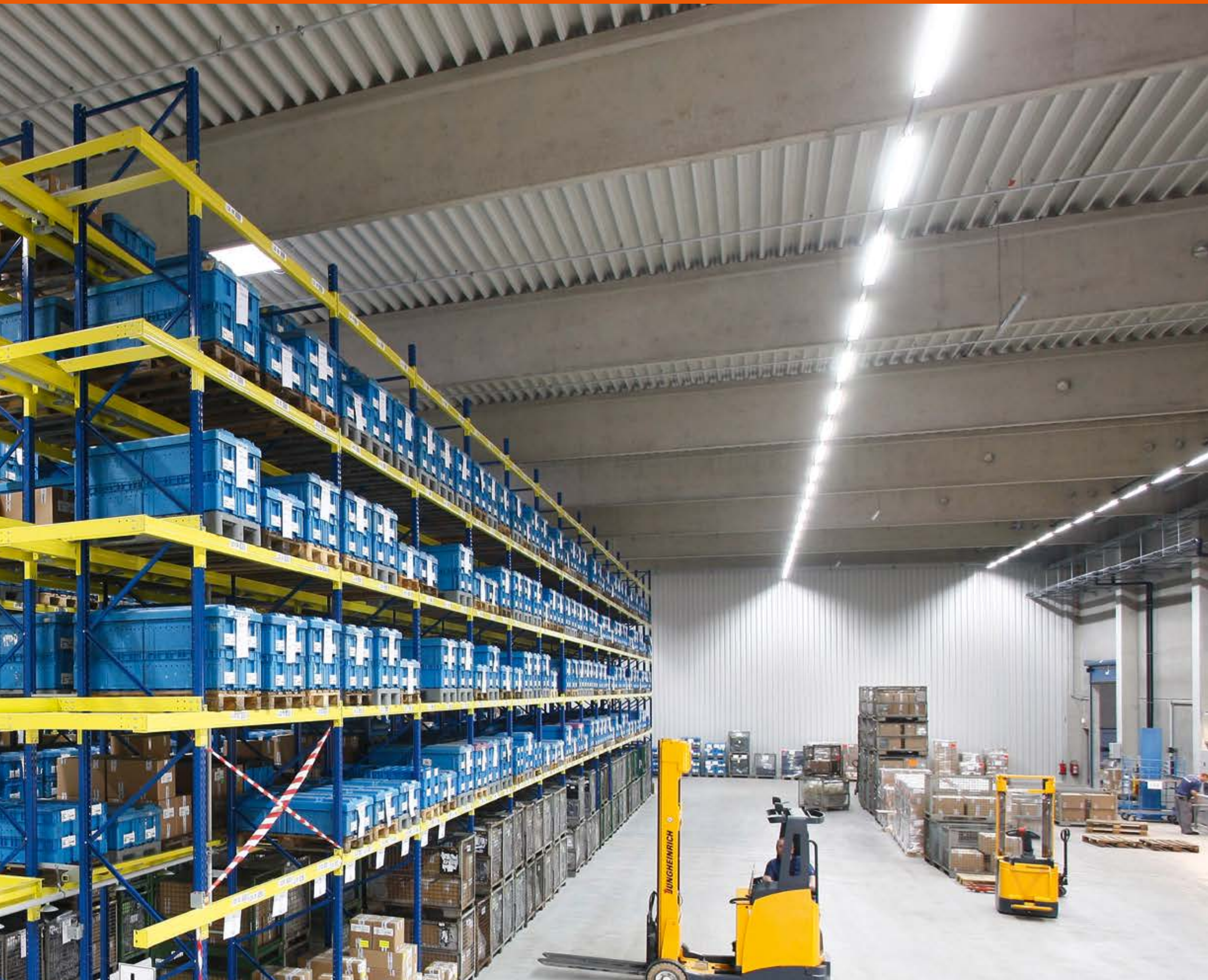

Technical Application Guide

LED Thermal Protection in OPTOTRONIC® LED Power Supplies

Light is OSRAM

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Contents

Abbreviations and symbols

The following abbreviations are used within this document:

SSL	Solid State Lighting
ECG	Electronic Control Gear (LED Power Supply)
NTC	Negative Temperature Coefficient

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1 Introduction

Thermal management for Solid State Lighting (SSL) applications is a key design parameter for both package and system level. LED fixtures must be designed to efficiently manage the junction temperature to guarantee robust operation in most ambient temperature applications.

While the primary onus to design an efficient thermal management system in a SSL fixture is shared between the LED module manufacturer and the original equipment manufacturer (OEM), OSRAM OPTOTRONIC® Programmable LED drivers offer a programmable current-limiting capability allowing designers to extend over-temperature protection in to fixtures to minimize catastrophic failures.

Why is Junction Temperature important?

Junction temperature is the temperature at the point where an individual diode connects to its base. Maintaining a low junction temperature increases output and slows LED lumen depreciation. Junction temperature is a key metric for evaluating an LED product's quality and ability to deliver long life. The three factors affecting junction temperature are: 1) drive current, 2) thermal path, and 3) ambient temperature. In general, the higher the drive current, the greater the heat generated at the die. Heat must be moved away from the die in order to maintain expected light output, life, and color.

2 LED Thermal Protection

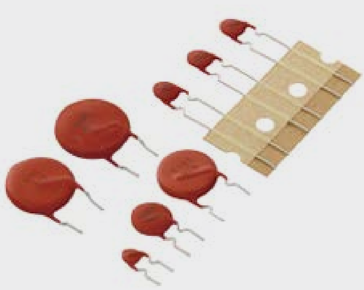
The LED Thermal Protection feature helps reduce the temperature of the LED module by decreasing the output current in case of abnormal thermal conditions. By connecting a thermistor (NTC) to dedicated pins of the driver and programming desired derating settings, the driver prevents over-heating of the junction temperature.

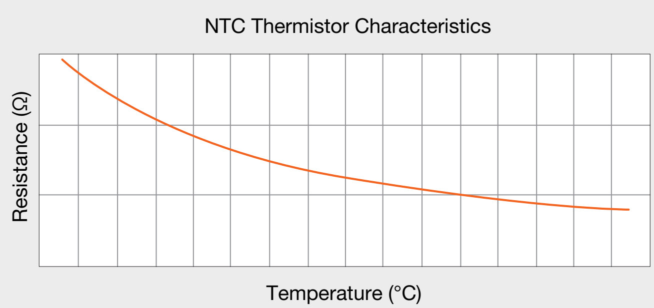
What is a Thermistor?

A thermistor is an element with an electrical resistance that changes in response to temperature. This name is derived from the more descriptive term “thermally sensitive resistor,” the original name for these devices.

Thermistors are a type of semiconductor, meaning they have greater resistance than conducting materials, but lower resistance than insulating materials. The relationship between a thermistor’s temperature and its resistance is highly dependent upon the materials from which it’s composed. The manufacturer typically determines this property with a high degree of accuracy. [Source: Omron]

Thermistors are commonly used as temperature sensors where the fundamental type of the component is that of a Negative Temperature Coefficient (NTC). For an NTC device, the resistance decreases as temperature rises.





3 Designing LED Thermal Protection

Understanding the relationship between the different variables involved is key to designing a desired thermal protection in the luminaire. The sensing device i.e. the NTC, dynamically changes its resistivity based on adjoining temperature whereas the LED driver, utilizes the resistance of the component to scale down the output current.

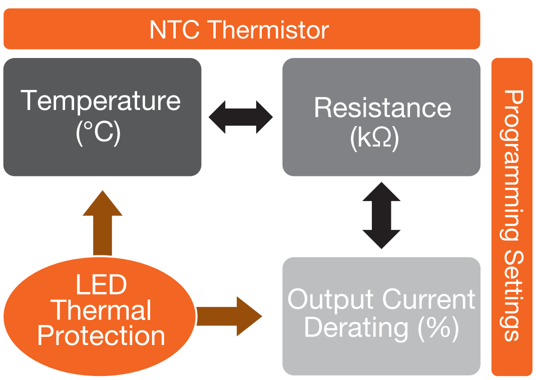


Figure 1 Relationship between NTC thermistor and programming set points in OPTOTRONIC LED drivers

While the final application needs to correlate the temperature to the output current derating, the design exercise requires one to associate the two variables via the resistance of the device as shown in Figure 1. To help users in this implementation, this section will outline the steps.

Internal over temperature protection

There is an internal NTC integrated in to select OPTOTRONIC LED drivers that prevents the driver case temperature from exceeding a threshold. The driver detects the case temperature and triggers a bi-level protection by folding the current being delivered to the LED modules. The decrease in the output power helps alleviate the thermal stress on the component.

Refer to the individual driver specification sheet for the specified fold back value.

3.1 Study the dynamics of the luminaire

The first step to successfully design-in this feature involves understanding the thermal dynamic behavior of the luminaire and identify the hot spot in the metal body. This is the ideal location for the placement of an NTC. This exercise will also help to correlate the changing ambient condition to the thermal performance of the luminaire and help in recognizing the NTC temperature at which the thermal protection needs to be designed to.

3.2 Choosing a thermistor

Any third-party NTC device can be used in this application. Below is a list of components that are chosen for this discussion.

Manufacturer	Part Number
EPCOS	B57164K153J
MURATA	NCP03XH223J05RL
Sentech	DT-104-3977-1P

Table 1 Available NTC part numbers in Design Tool

3.3 Obtain derating range

The behavioral characteristics of an NTC i.e. the temperature vs resistance relationship, is primarily determined by two parameters that are commonly available from the datasheet.

- R_0: Resistance value of the thermistor at temperature T_0.
- T_0: Normally the ambient temperature of 25°C

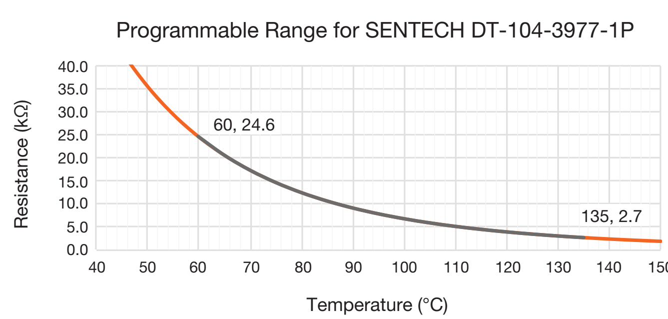
Using these parameters, the below formula provides the resistance R, for a given temperature T.

$$R = R_0 \bullet expB \left(\frac{1}{T} - \frac{1}{T_0}\right)$$

There are two other factors that need to be taken into account while choosing the derating settings.

- Programmable Range: The LED driver configurator tool allows the user to enter derating values ranging from 1-25 kΩ.
- Power Dissipation: The dedicated NTC pin uses a voltage source of 5V to detect the changing resistance. By the principle of Ohm's Law, the thermistor will dissipate power as the current flowing through it increases ($P=IV=V^2/R$). Therefore, at the maximum NTC temperature, the component should be capable of withstanding the power dissipation.

The above relationship will yield the programmable range for the chosen device. The below example shows the complete range along with two data points that correlate the temperature in °C to the resistance in kΩ. These could serve as possible derating points for a hot spot that was identified in section 3.1.



3.4 Programming the LED driver

The NTC behavior graph from page 4 can be used as a guideline in choosing the derating settings in terms of kilo-ohms in the LED driver configurator tool. There are three parameters that are configurable:

- Temperature Derating Start: This is the threshold in resistance (kΩ) after which the driver triggers the protection and begins to scale back the output current.
- Temperature Derating End: This is the cut-off point in resistance (kΩ) after which the output current would stop its foldback.
- Minimum Output Level: This is the percentage of the programmed current that is finally achieved at the derating end point.

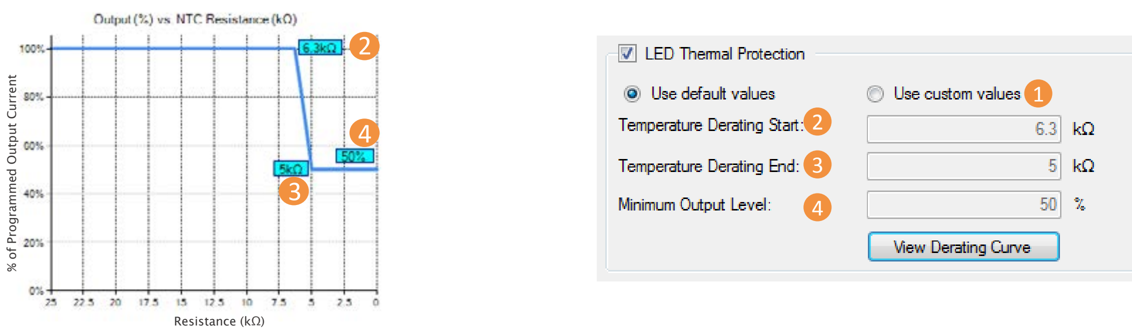


Figure 2 Guidelines for choosing derating settings in OT Programmer software

Based on the proximity of the derating start and end set points, the designer can choose how assertively the protection scheme will operate.

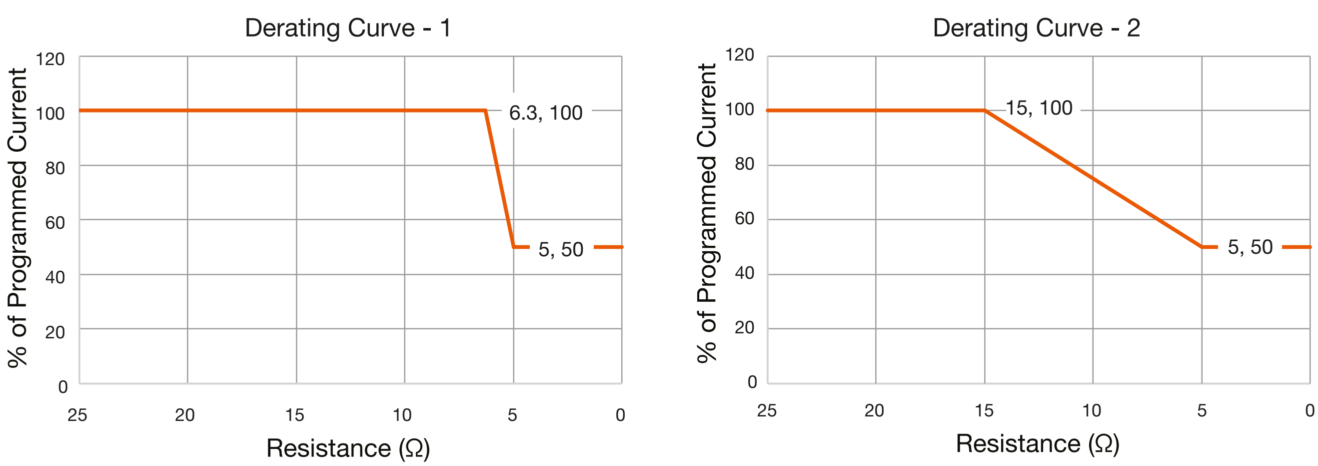


Figure 3 Comparison between aggressive (left) and passive (right) derating

To help designers in the exercise in sections 3.3 and 3.4, OSRAM has developed a **LED Thermal Protection Tool**, which provides the programmable range for a given part number.

3.5 Assembly in luminaire

In the final application, care must be taken to place the NTC thermistor close to the hottest spot on the LED module or at the hot spot identified in step 3.1. The wiring of the NTC with it's respective driver is shown below.

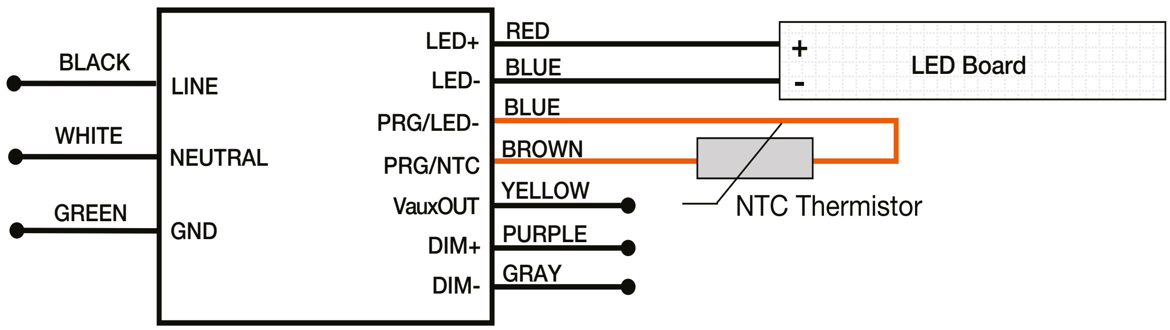


Figure 4 Wiring diagram for OPTOTRONIC Indoor LED Power Supplies

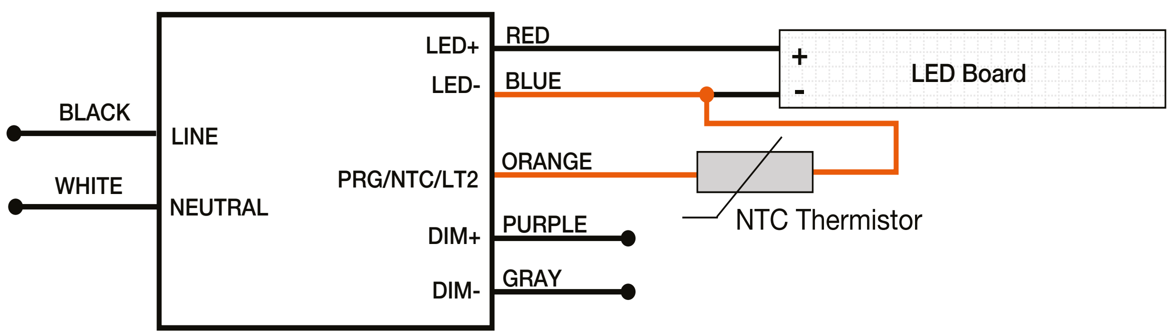


Figure 5 Wiring diagram for OPTOTRONIC Outdoor 2DIM LED Power Supplies

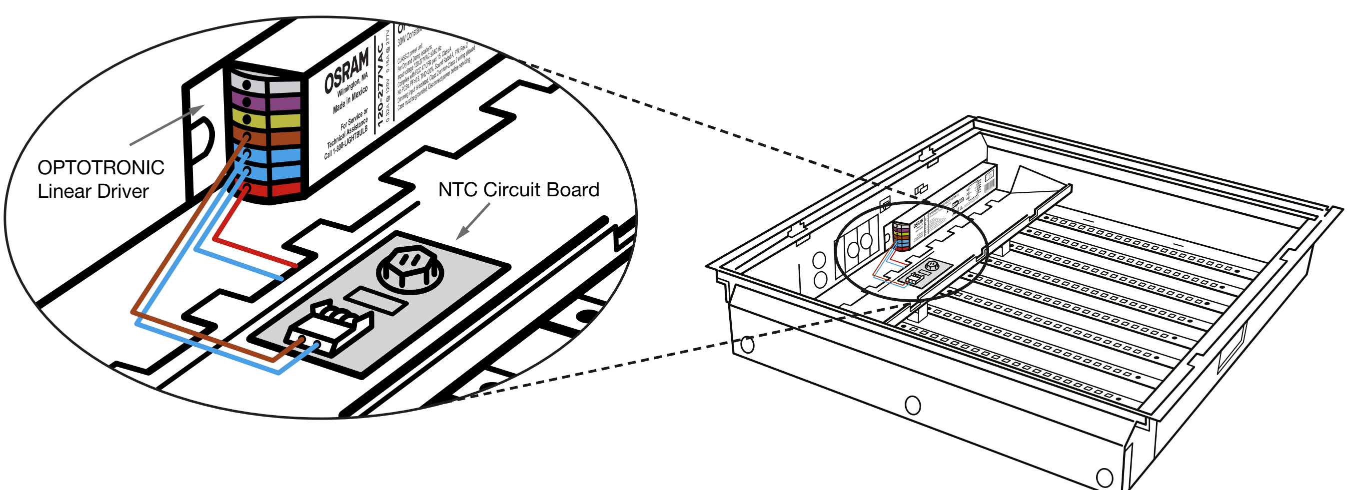


Figure 6 Example of fixture assembly using OPTOTRONIC Linear Driver along with an NTC

Key application notes

- All OPTOTRONIC Programmable LED Drivers are factory programmed to a default level which can be adjusted to the desired settings.
- The current foldback accuracy is within +/-5% of the expected value. This value would also depend on the tolerance of the NTC component.
- Each driver in a luminaire requires its dedicated NTC device. Connecting a single NTC to multiple drivers can lead to inconsistent dimming and strobing effect.
- If LED thermal protection is not required the NTC port on the LED power supply connector can be left open even with the driver programmed to initiate the protection. An open circuit condition results in no fold back.
- To ensure that the protection is only triggered when there is a constant abnormality, there is a time delay of 1 min incorporated in the firmware. If the change in resistance of the NTC is persistent for this time, the driver confirms the abnormality and enters the protection mode.
- Due to the above, this feature cannot be used to set the output current of the driver using a potentiometer. In select LED drivers, designers can take advantage of the LEDset functionality. To learn more about this, please refer to the web resource.

4 Summary

Thermal management is key in SSL applications especially in high bay and industrial spaces. The OSRAM OPTOTRONIC LED Power Supplies allow luminaire designers to take advantage of programmable LED Thermal Protection by integrating a low-cost passive temperature sensing device.

The steps outlined in this document, along with the excel-based design tool, provide a guideline to leverage the intelligence of the OSRAM OPTOTRONIC portfolio.

5 References

1. Smart Drivers Control LED Temperature to Solve SSL Thermal Issues, Steven Keeping, Contributed By Electronic Products, 2016
2. Introduction to Temperature Measurement with Thermistors, Omega Technical Learning

6 Appendix

6.1 Compatible models

NAED	Name	Input voltage [Vac]	Max.output power [W]	Output current [mA]	Output voltage range [Vdc]
Compact					
79406	OT25W/RG1250C/UNV/DIM-1/J	120-277V	25	150-1250	10-55
79405	OT25W/PRG1250C/UNV/DIM-1	120-277V	25	150-1250	10-55
79404	OT25W/PRG1250C/UNV/DIM/J	120-277V	25	350-1250	10-55
79403	OT25W/PRG1250C/UNV/DIM	120-277V	25	350-1250	10-55
79441	OT40W/PRG1400C/UNV/DIM-1/J	120-277V	40	400-1400	10-55
79442	OT40W/PRG1400C/UNV/DIM-1	120-277V	40	400-1400	10-55
79449	OT40W/PRG1400C/UNV/DIM/J	120-277V	40	400-1400	10-55
79448	OT40W/PRG1400C/UNV/DIM	120-277V	40	400-1400	10-55
Linear UNV					
79533	OTi 20/120-277/0A7 DIM L AUX	120-277V	20	150-700	10-55
79532	OTi 20/120-277/0A7 DIM-1 L AUX	120-277V	20	150-700	10-55
79535	OTi 20/120-277/0A7 DIM L	120-277V	20	150-700	10-55
79534	OTi 20/120-277/0A7 DIM-1 L	120-277V	20	150-700	10-55
79397	OTi 30/120-277/1A0 DIM L AUX	120-277V	30	350-1050	10-55
79466	OTi 30/120-277/1A0 DIM-1 L AUX	120-277V	30	150-1050	10-55
79630	OTi 30/120-277/1A0 DIM L	120-277V	30	350-1050	10-55
79515	OTi 30/120-277/1A0 DIM-1 L	120-277V	30	150-1050	10-55
79399	OTi 48/120-277/2A0 DIM L AUX	120-277V	48	700-2000	10-55
79468	OTi 48/120-277/2A0 DIM-1 L AUX	120-277V	48	700-2000	10-55
79632	OTi 48/120-277/2A0 DIM L	120-277V	48	700-2000	10-55
79517	OTi 48/120-277/2A0 DIM-1 L	120-277V	48	700-2000	10-55
79398	OTi 50/120-277/1A4 DIM L AUX	120-277V	50	400-1400	10-55
79467	OTi 50/120-277/1A4 DIM-1 L AUX	120-277V	50	400-1400	10-55
79631	OTi 50/120-277/1A4 DIM L	120-277V	50	400-1400	10-55
79516	OTi 50/120-277/1A4 DIM-1 L	120-277V	50	400-1400	10-55
79470	OTi 85/120-277/2A0 DIMLT2 L	120-277V	85	1250-2000	30-55
79471	OTi 85/120-277/2A6 DIMLT2 L	120-277V	85	2000-2600	20-55
Linear 347V					
79672	OTi 30/347/1A0 DIM L AUX	347V	30	350-1050	10-55
79669	OTi 30/347/1A0 DIM-1 L AUX	347V	30	150-1050	10-55
79679	OTi 30/347/1A0 DIM L	347V	30	350-1050	10-55
79675	OTi 30/347/1A0 DIM-1 L	347V	30	150-1050	10-55
79674	OTi 48/347/2A0 DIM L AUX	347V	48	700-2000	10-55
79671	OTi 48/347/2A0 DIM-1 L AUX	347V	48	700-2000	10-55
79680	OTi 48/347/2A0 DIM L	347V	48	700-2000	10-55
79677	OTi 48/347/2A0 DIM-1 L	347V	48	700-2000	10-55
79673	OTi 50/347/1A4 DIM L AUX	347V	50	400-1400	10-55
79670	OTi 50/347/1A4 DIM-1 L AUX	347V	50	400-1400	10-55
79678	OTi 50/347/1A4 DIM L	347V	50	400-1400	10-55
79676	OTi 50/347/1A4 DIM-1 L	347V	50	400-1400	10-55

6.1 Compatible models (continued)

NAED	Name	Input voltage [Vac]	Max.output power [W]	Output current [mA]	Output voltage range [Vdc]
Linear DEXAL					
78033	OTi30/120-277/1A0 DX L	120-277V	30	150-1050	10-56
79371	OTi50/120-277/1A4 DX L	120-277V	50	600-1400	10-56
Outdoor UNV					
79370	OT50/UNV/800C/2DIMLT2/P6	120-277V	50	350-800	30-120
79371	OT50/UNV/1250C/2DIMLT2/P6	120-277V	50	600-1250	15-55
79278	OTi50/UNV/2100C/2DIMLT2/P6	120-277V	50	1000-2100	15-55
79368	OT100/UNV/800C/2DIMLT2/P6	120-277V	100	350-800	50-185
79369	OT100/UNV/1250C/2DIMLT2/P6	120-277V	100	600-1250	30-100
79366	OT180/UNV/800C/2DIMLT2/P6	120-277V	180	350-800	82-280
79367	OT180/UNV/1250C/2DIMLT2/P6	120-277V	180	600-1250	70-21
Outdoor 347-480V					
79206	OT100/347-480/800C/2DIMLT2/P6	347-480V	100	350-800	50-185
79207	OT100/347-480/1250C/2DIMLT2/P6	347-480V	100	600-1250	30-100
79208	OT180/347-480/800C/2DIMLT2/P6	347-480V	180	350-800	82-280
79209	OT180/347-480/1250C/2DIMLT2/P6	347-480V	180	600-1250	70-210

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