Technical Application Guide

Configurable Thermal Protection in OPTOTRONIC® LED Drivers

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

Please note:
All information in this guide has been prepared with great care. eldoLED, however, does not accept liability for possible errors, changes and/or omissions. This technical application guide is for information purposes only and aims to support you in tackling the challenges and taking full advantage of all opportunities the technology has to offer. Please note that this guide is based on our measurements, tests, specific parameters and assumptions. Individual applications may not be covered and need different handling. Responsibility and testing obligations remain with the luminaire manufacturer/OEM/application planner.

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), the 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 Fixture Thermal Protection

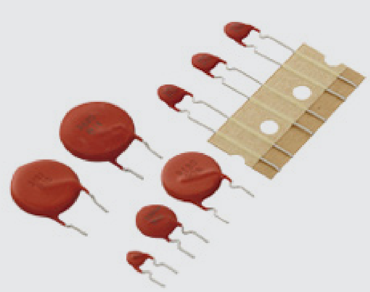
The Fixture Thermal Protection feature helps reduce the temperature of the LED module by decreasing the output current in case of abnormal thermal conditions. By connecting a thermistor (NTC) to dedicated pins of the driver and programming desired derating settings, the driver prevents over-heating of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

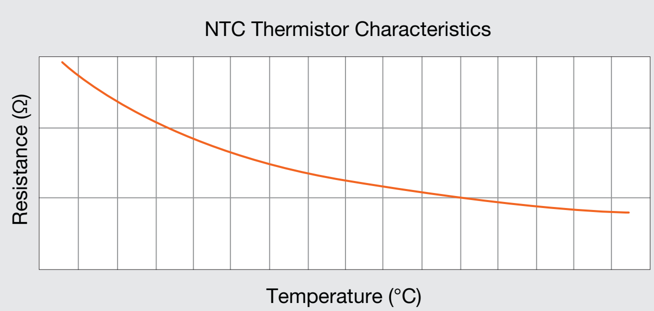
What is a Thermistor?

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 Fixture 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.

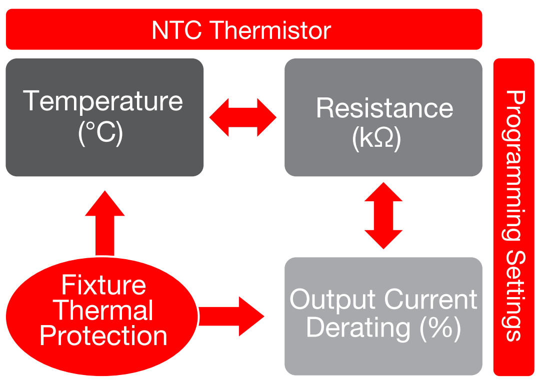


Figure 1 Relationship between NTC thermistor and programming set points in OPTOTRONIC LED drivers

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 Section 4 for detailed description.

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
Vishay*	NTCS0402E3223

Table 1 Available NTC part numbers in Design Tool

Note: To be compliant with UL SREC requirements, the NTC chosen must be rated cULus (XGPU2/8) R/C, suitable as a limiting device with a minimum C4 tolerance class, and have a nominal resistance at 25°C (R25¬) less than 60kΩ.

*Currently used in PrevaLED Cube Gen 4

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
- B: Material constant, different for different material composition

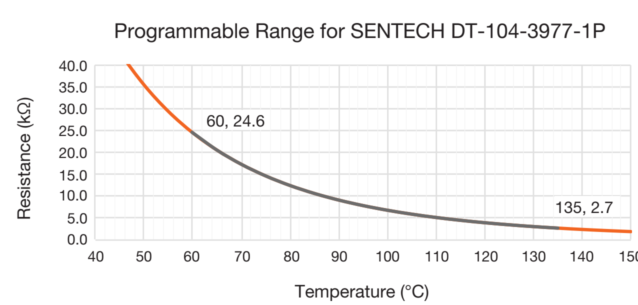
Using these parameters, the below formula provides the resistance R, for a given temperature T.

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

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 OT Programmer Software. 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.

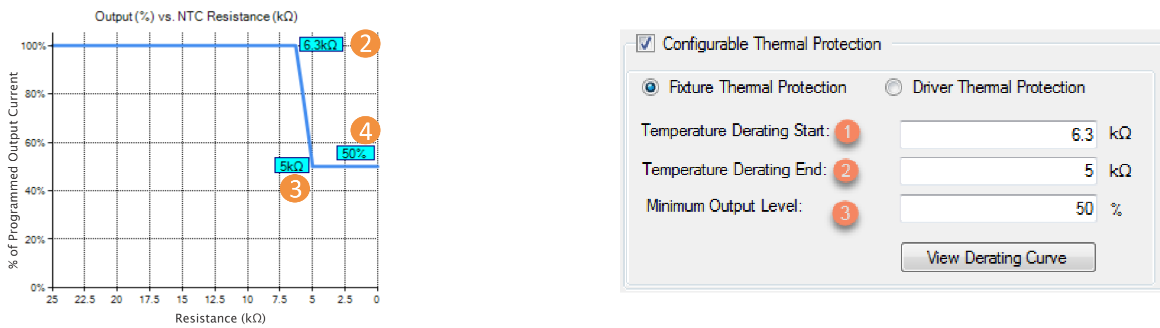


Figure 2 Guidelines for choosing derating settings in OT Programmer software

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

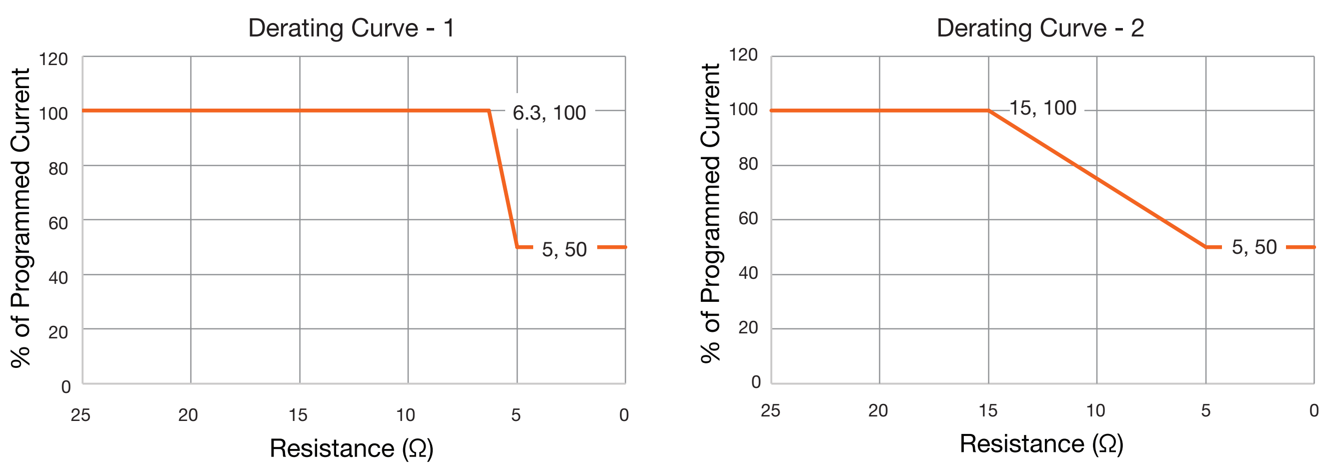


Figure 3 Comparison between aggressive (left) and passive (right) derating

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.

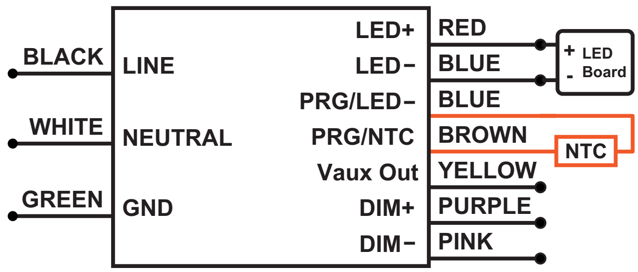


Figure 4 Wiring diagram for OPTOTRONIC Indoor LED Drivers

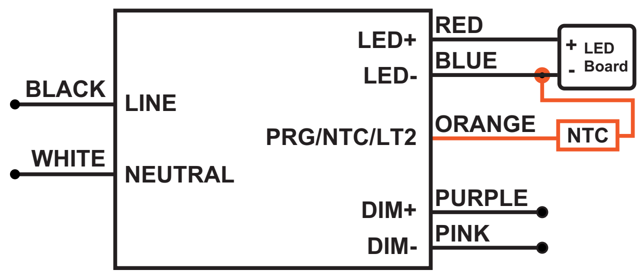


Figure 5 Wiring diagram for OPTOTRONIC Outdoor 2DIM LED Drivers

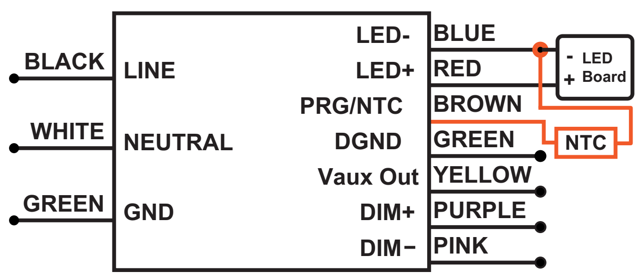


Figure 6 Wiring diagram for OPTOTRONIC Compact LED Drivers

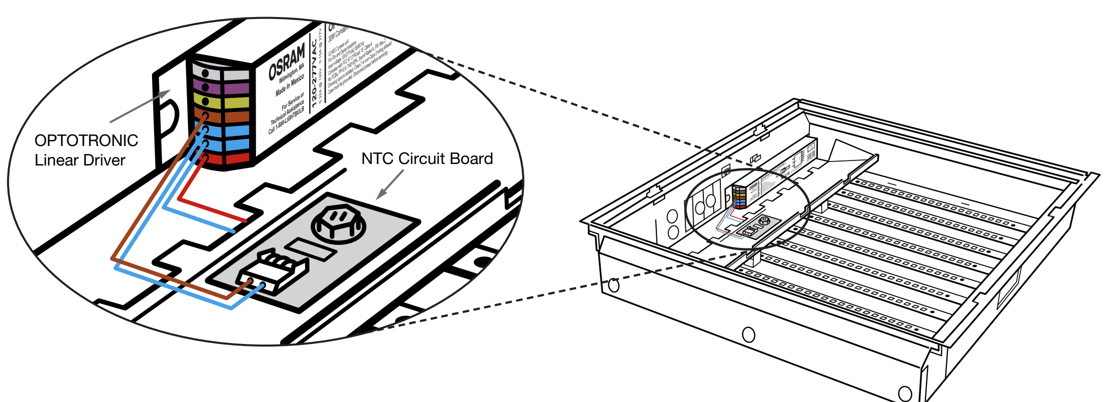


Figure 7 Example of fixture assembly using OPTOTRONIC Linear Driver along with an NTC

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.
- For UL SREC certified drivers, Fixture Thermal Protection is turned OFF by default.
- 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 Driver Thermal Protection

The OPTOTRONIC Outdoor LED Drivers have a built in thermal protection feature which prevents the driver from overheating due to abnormal ambient conditions. There is an internal NTC integrated in select OPTOTRONIC LED drivers that prevents the driver case temperature from exceeding a threshold.

Every luminaire is installed in a different application space because of which the thermal profiles can vary significantly. The Driver Thermal Protection is a **user configurable** feature through the OT Programmer Software which helps in customizing the thermal protection limits as per the application needs.

Note: Driver Thermal Protection feature is available on the OTi180W G2 and OTi200W Outdoor LED Driver as well as the HV+ Series OTi180W Industrial LED Driver.

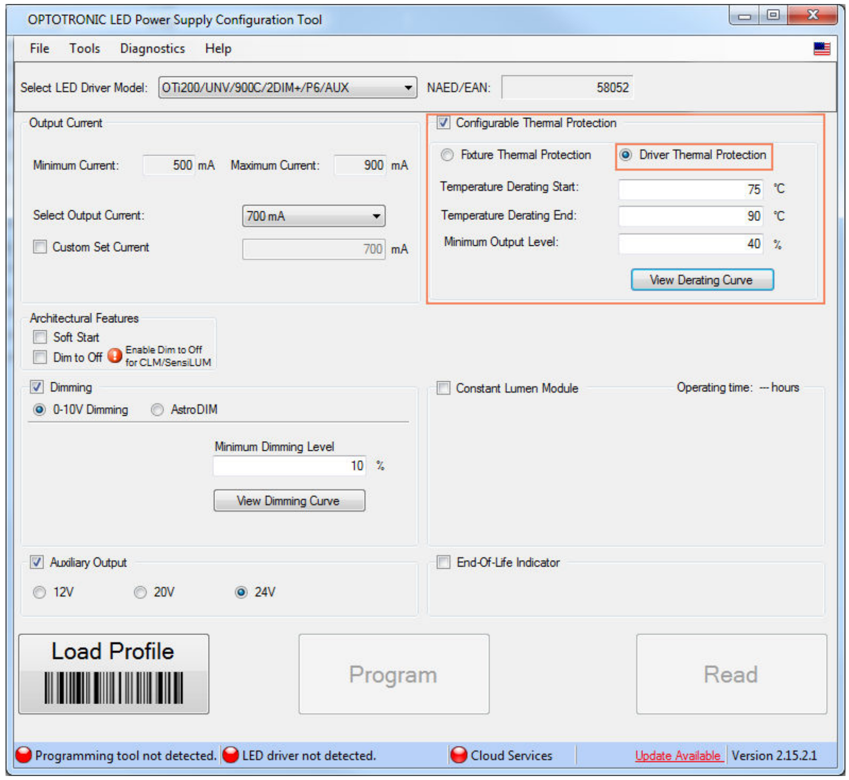
5 Programming Driver Thermal Protection

Select Configurable Thermal Protection checkbox to access the Driver Thermal Protection feature. To program the Driver Thermal Protection limits, select Driver Thermal Protection radio button to configure the following three parameters:

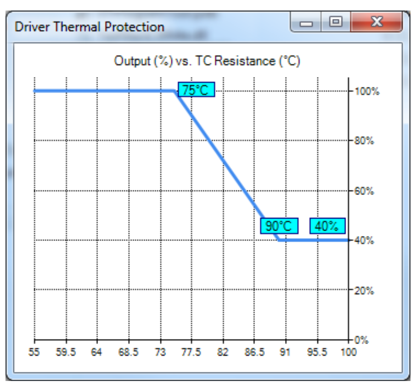
Temperature Derating Start: This is the temperature at which the protection is engaged and the driver begins to fold back the output current.

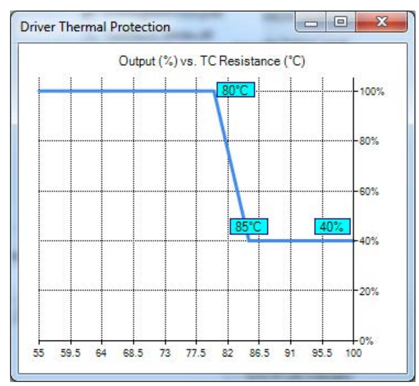
Temperature Derating End: This is the point where the driver cuts-off the fold back of the output current.

Minimum Output Level: This is the percentage of programmed current that is finally achieved at the derating end point.



Based on the proximity of the derating start and end temperature values, the designer can visualize how the protection scheme will operate by pressing "view derating curve" button.





Key application notes

- Temperature derating start range is 55°C-95°C
- Temperature derating end range is 60°C-100°C
- Minimum difference in derating points is 5°C
- Minimum output level range is from 10-75%
- Only one form of thermal protection is active at a time
- Driver Thermal Protection feature is available on the OTi180W G2 and OTi200W Outdoor LED Driver as well as the HV+ Series OTi180W Industrial LED Driver.

6 Summary

Thermal management is key in SSL applications especially in high bay and industrial spaces. The OPTOTRONIC LED Drivers allow luminaire designers to take advantage of programmable Fixture Thermal Protection by integrating a low-cost passive temperature sensing device. With programmable Driver Thermal Protection feature, OPTOTRONIC provides increased flexibility and control to OEMs by helping them design thermal protection for a wide variety of application needs.

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

7 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

8 Appendix

8.1 Compatible models

Item Number	NAED	Ordering Abbreviation	Input voltage [VAC]	Max.output power [W]	Output current [mA]	Output voltage range [VDC]
Compact						
*2743VY[1]	57347	OTi25W/120-277/1A2/DIM-1	120-277V	25	150-1250	8-55
*274A1J[1]	57348	OTi25W/120-277/1A2/DIM-1/J	120-277V	25	150-1250	8-55
*2743W0[1]	57349	OTi25W/120-277/1A2/DIM-1 AUX	120-277V	25	150-1250	8-55
*274A1K[1]	57350	OTi25W/120-277/1A2/DIM-1 J/AUX	120-277V	25	150-1250	8-55
*2743W1[1]	57351	OTi40W/120-277/1A4/DIM-1	120-277V	40	400-1400	8-55
*274A1L[1]	57352	OTi40W/120-277/1A4/DIM-1/J	120-277V	40	400-1400	8-55
*2743W2[1]	57353	OTi40W/120-277/1A4/DIM-1 AUX	120-277V	40	400-1400	8-55
*274A1M[1]	57354	OTi40W/120-277/1A4/DIM-1 J/AUX	120-277V	40	400-1400	8-55
*2743W3[1]	57355	OTi55W/120-277/2A0/DIM-1	120-277V	55	700-2000	10-55
*274A1N[1]	57356	OTi55W/120-277/2A0/DIM-1/J	120-277V	55	700-2000	10-55
*2743W4[1]	57357	OTi55W/120-277/2A0/DIM-1 AUX	120-277V	55	700-2000	10-55
*274A1P[1]	57358	OTi55W/120-277/2A0/DIM-1/J AUX	120-277V	55	700-2000	10-55
Compact 347V						
*2743XR	57994	OTi25W/347/1A2/DIM-1	347V	25	150-1250	8-55
*274A3P	57995	OTi25W/347/1A2/DIM-1/J	347V	25	150-1250	8-55
*2743XS	57996	OTi25W/347/1A2/DIM-1 AUX	347V	25	150-1250	8-55
*274A3R	57997	OTi25W/347/1A2/DIM-1 J/AUX	347V	25	150-1250	8-55
*2743XT	57998	OTi40W/347/1A4/DIM-1	347V	40	400-1400	8-55
*274A3S	57999	OTi40W/347/1A4/DIM-1/J	347V	40	400-1400	8-55
*2743XU	58008	OTi40W/347/1A4/DIM-1 AUX	347V	40	400-1400	8-55
*274A3T	58009	OTi40W/347/1A4/DIM-1 J/AUX	347V	40	400-1400	8-55
Linear UNV						
*2743X4	57453	OTi 20/120-277/0A7 DIM-1 L AUX G2	120-277V	20	150-700	10-55
*2743WE	57431	OTi 20/120-277/0A7 DIM-1 L G2	120-277V	20	150-700	10-55
*2743X5	57454	OTi 30/120-277/1A0 DIM-1 L AUX G2	120-277V	30	150-1050	10-55
*2743WG	57433	OTi 30/120-277/1A0 DIM-1 L AUX G2	120-277V	30	150-1050	10-55
*2743X6	57455	OTi 48/120-277/2A0 DIM-1 L AUX G2	120-277V	48	700-2000	10-55
*2743WH	57434	OTi 48/120-277/2A0 DIM-1 L G2	120-277V	48	700-2000	10-55
*2743X7	57456	OTi 50/120-277/1A4 DIM-1 L AUX G2	120-277V	50	400-1400	10-55
*2743X3	57452	OTi 50/120-277/1A4 DIM-1 L G2	120-277V	50	400-1400	10-55
*2743W5	57420	OTi 85/120-277/2A3 DIM-1 L	120-277V	85	700-2300	10-55
*2743W6	57421	OTi 85/120-277/2A3 DIM-1 L AUX	120-277V	85	700-2300	10-55
*2743W7	57422	OTi 85/120-277/2A3 DIM L	120-277V	85	700-2300	10-55
*274A1R	57424	OTi 85/120-277/2A3 DIM-1 L HB	120-277V	85	700-2300	10-55
*274A1S	57425	OTi 85/120-277/2A3 DIM-1 L HB AUX	120-277V	85	700-2300	10-55
*274A1T	57426	OTi 85/120-277/2A3 DIM L HB	120-277V	85	700-2300	10-55

1 Conforms to UL standard 60730-1 for SREC.

8.1 Compatible models (continued)

Item Number	NAED	Ordering Abbreviation	Input voltage [Vac]	Max.output power [W]	Output current [mA]	Output voltage range [Vdc]
Linear 347V						
*2743YT	79669	OTi 30/347/1A0 DIM-1 L AUX	347V	30	150-1050	10-55
*27440C	79679	OTi 30/347/1A0 DIM L	347V	30	350-1050	10-55
*2743YW	79675	OTi 30/347/1A0 DIM-1 L	347V	30	150-1050	10-55
*2743YV	79671	OTi 48/347/2A0 DIM-1 L AUX	347V	48	700-2000	10-55
*27440E	79680	OTi 48/347/2A0 DIM L	347V	48	700-2000	10-55
*2743YY	79677	OTi 48/347/2A0 DIM-1 L	347V	48	700-2000	10-55
*2743YU	79670	OTi 50/347/1A4 DIM-1 L AUX	347V	50	400-1400	10-55
*27440A	79678	OTi 50/347/1A4 DIM L	347V	50	400-1400	10-55
*2743YX	79676	OTi 50/347/1A4 DIM-1 L	347V	50	400-1400	10-55
Linear 347-480V						
*2743W9	57428	OTi 85/347-480/2A3 DIM-1 L	347-480V	85	700-2300	56
*2743WA	57429	OTi 85/347-480/2A3 DIM-1 L AUX	347-480V	85	700-2300	56
*2743WC	57430	OTi 85/347-480/2A3 DIM L AUX	347-480V	85	700-2300	56
Linear DEXAL						
*2743Y8	78033	OTi30/120-277/1A0 DX L	120-277V	30	150-1050	10-56
*2743YN	79371	OTi50/120-277/1A4 DX L	120-277V	50	600-1400	10-56
*2743WF	57432	OTi85/120-277/2A3 DX L	120-270V	85	700-2300	56
Outdoor UNV						
*2743YM	79370	OT50/UNV/800C/2DIMLT2/P6	120-277V	50	350-800	30-120
*2743YN	79371	OT50/UNV/1250C/2DIMLT2/P6	120-277V	50	600-1250	15-55
*2743YG	79278	OTi50/UNV/2100C/2DIMLT2/P6	120-277V	50	1000-2100	15-55
*2743XF	57501	OTi60/UNV/1600C/DALI/P6	120-277V	60	500-1600	15-55
*2743XJ	57509	OTi95W/UNV/2750C/2DIM+/P6	120-277V	95	700-2750	15-54
*2743XK	57510	OTi95W/UNV/2750C/2DIM+/P6/AUX	120-277V	95	700-2750	15-54
*2743YK	79368	OT100/UNV/800C/2DIMLT2/P6	120-277V	100	350-800	50-185
*2743YL	79369	OT100/UNV/1250C/2DIMLT2/P6	120-277V	100	600-1250	30-100
*2743XH	57505	OTi100/UNV/1600C/2DIM+/P6/AUX	120-277V	100	500-1600	40-185
*2743YH	79366	OT180/UNV/800C/2DIMLT2/P6	120-277V	180	350-800	82-280
*2743YJ	79367	OT180/UNV/1250C/2DIMLT2/P6	120-277V	180	600-1250	70-21
*2743Y2	58051	OTi200W/UNV/900C/2DIM+/P6	120-277V	200	500-900	125-285
*2743Y3	58052	OTi200W/UNV/900C/2DIM+/P6/AUX	120-277V	200	500-900	125-285
*2743Y4	58055	OTi200W/UNV/1400C/2DIM+/P6	120-277V	200	900-1400	75-180
*2743Y5	58056	OTi200W/UNV/1400C/2DIM+/P6/AUX	120-277V	200	900-1400	75-180
Outdoor 347-480V						
*2743XL	57511	OTi95W/HV/2750C/2DIM+/P6/AUX	347-480V	95	700-2750	15-54
*2743YA	79206	OT100/347-480/800C/2DIMLT2/P6	347-480V	100	350-800	50-185
*2743YC	79207	OT100/347-480/1250C/2DIMLT2/P6	347-480V	100	600-1250	30-100
*2743YE	79208	OT180/347-480/800C/2DIMLT2/P6	347-480V	180	350-800	82-280
*2743YF	79209	OT180/347-480/1250C/2DIMLT2/P6	347-480V	180	600-1250	70-210

eldoLED
One Lithonia Way
Conyers, GA 30012
United States

+1 877 353 6533

nasupport@eldoLED.com
www.eldoLED.com

ECS304R3 10-21