Application Guide for Soraa Optical Light Engines

Introduction

This document provides background information relevant to incorporating Soraa Optical Light Engines into light fixtures or luminaires. It is intended for fixture or luminaire designers. Proper integration of Soraa Optical Light Engines ensures best results in terms of longevity, light output, cost and overall performance. This document helps to predict expected performance, in line with design targets for life time.

The rated driving currents given on the specification sheets are for reference only. They lead to a lifetime of 50,000 hrs when used with the heatsink specified, at free air, and 25°C ambient. All Optical Light Engines must be tested thermally inside a new fixture or luminaire as part of the design process, to ensure they work at the desired temperature. Performance, lifetime, and warranty are subject to the Optical Light Engine working, storage temperature, and driving current.

This application guide is relevant for Soraa Optical Light Engines, with and without heat-sink incorporated. Soraa Optical Light Engines with heat-sink, are designed to be integrated without additional thermal management. Soraa Optical Light Engines without heat-sink need additional heat-sinking, which can be in the form of the fixture shell.

Soraa Optical Light Engines are based on unique Soraa GaN-on-GaN™ LED technology and have optimized optics incorporated. This combination results in unprecedented directional lighting with perfect beam definition in a very compact form factor. Integration of optics, heat-sink and on-board temperature registration makes the fixture design cycle short and simple without a compromise to the best possible performance.

This application guide provides a suggestion for the design-in process for Soraa Optical Light Engines. It discusses LED driver specification, mechanical integration and optical integration. From the explanation of how to do on-board temperature read-out, it is discussed how temperature and drive current settings can be used to estimate life time and in fixture performance. Tables are provided to make these estimates.

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Proposed performance validation process

Soraa Optical Light Engines are easy to integrate. Below is a summary of the proposed procedure to validate performance of Soraa Optical Light Engines incorporated in a fixture. More detail on each step is provided further in the document.

Equipment needed

- Variable power supply - preset to a voltage of 35V and variable current between 0 and 700mA.
- Multimeter to read out resistance between 0.5 and 50kOhm

Procedure

1. Determine goals for lifetime, based on color and light output maintenance
2. Incorporate Soraa Optical Light Engine into fixture, choose a current setting close to nominal
3. Allow sufficient time for thermal stabilization, then read out on board NTC resistance using a multimeter and resistance to temperature conversion table
4. Look up expected color shift and lumen maintenance from life expectancy table
5. If necessary, adjust current if necessary if expectations from 1. are not met
6. Use relative light output from lumen maintenance and life expectance table and nominal light output from Product Performance Parameters (Appendix Table 1-3) to determine Optical Light Engine light output at selected current and temperature conditions
7. Select driver to provide selected current

Electrical integration

Wire information

Soraa Optical Light Engines have a 4 wire ribbon cable – 2 wires for DC power and 2 wires for NTC (thermally sensitive resistor) read-out. The wire function can be determined based on their color and location as shown in figure 1.

- Wire type: 4-wire ribbon
- Wire gauge: AWG28 - 0.321mm diameter with 0.050 inch / 1.27mm spacing between the wires
- Wire tip finish: tinned
- Wire length: 300mm

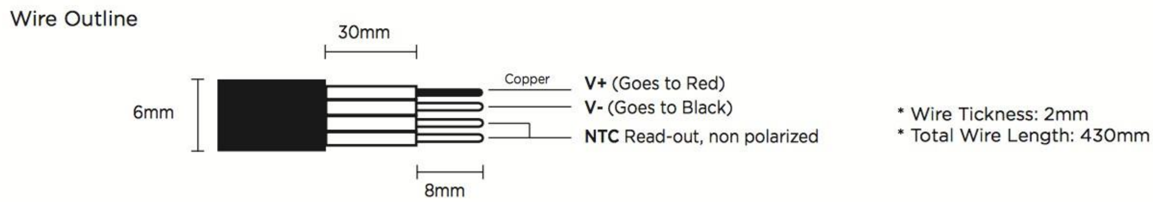


Figure 1: Wire-end schematic

- Wire harness material: transparent silicone based.

Driver specification

A constant current, class 2 isolated constant current LED driver or equivalent is required. The driver shall be able to provide the specified maximum current over the entire voltage range of 20 to 35VDC. This voltage requirement is the same for all Soraa Optical Light Engines. Depending on the light engine type, the required current setting can be different. The lower end of the voltage range is related to operation at low current amplitude, for example under current amplitude dimming.

Soraa Optical Light Engines are not designed to be driven in reverse voltage.

Light output can be varied by either Pulse Width Modulation (PWM), or amplitude variation. For uniform light output across the light beam, current amplitude of at least 20mA is recommended.

Depending on the LED driver type, good dimming compatibility can be achieved with various dimming methods, both phase cut based and 0-10V or DALI based.

Soraa recommends using one LED driver (or one driver channel in the case of a multi-channel driver) per light engine. Parallel configuration of Optical Light Engines can result in unpredictable light output and series configuration results in an increase of overall system voltage potentially beyond the design limits of the product.

Several market available driver types have the capability to include the NTC as an input to the driver and provide thermal feedback. This can be used to ensure that the Optical Light Engine cannot exceed set temperature limits.

Mechanical integration

Soraa Optical Light Engines have been developed to provide multiple options for integration into a fixture. Optical Light Engines with heatsink (part number starting with SLE) can be operated without additional heatsinking. Optical Light Engines without a heatsink (part number starting with SLC) require additional heatsinking, which can be in the form of the fixture itself

General handling

To ensure optimal optical performance, it is recommended that the lens is not directly touched. Otherwise the Optical Light Engines can be handled manually or by machine.

Considerations for assembly into fixture

The 4-lead ribbon wire has a strain relief incorporated. Soraa Optical Light Engines have been burned-in for 12 hours.

Identification

All Soraa Optical Light Engines have a manufacturing data code on the label. The date code consists of year and week of manufacture. For example: 1602 refers to the second week of 2016.

Integration of Optical Light Engine with Heatsink (SLE-xx)

Optical Light Engines with heat-sink, can be fixated by grabbing the lip at the front (mounting option 1), can be screwed onto an external surface (mounting option 2), or can be suspended by the wire.

Mounting option 1

The lip at the front of the product for mounting option 1, matches the lip definition of MR11 (SLE11-xx), MR16 (SLE16-xx) or PAR30 (SLE30-xx) lamps. Fixtures with features to hold these lamps at the lip will typically be able to hold Soraa Optical Light Engines in a similar way.

Mounting option 2

Soraa Optical Light Engines can be attached to an external surface on the back using 2 thread forming screws. Preformed hole pitch and screw dimensions vary by model. Additional material for thermal transport (grease or pad material) is not required.

Table 1: Mounting hole pitch and screw dimensions

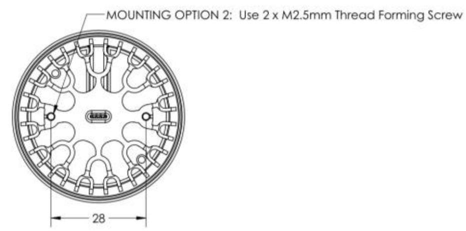
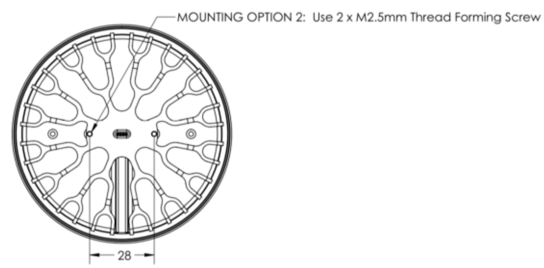
Optical Light Engine Type	Pitch between holes(mm)	Screw dimension	
SLE11-xx	**16**	**M2x8mm**	
SLE16-xx	**28**	**M2.5x8mm**	
SLE30-xx **SLE16 w/ SLE30 Heatsink**	**28**	**M2.5x8mm**	

Figure 2: Lens attachment with circular spring-clip

Integration of Optical Light Engines without heat-sink (SLC-xx)

Soraa Optical Light Engines have a unique thin form factor. Narrow spot options in SLC30 and SLC16 diameter size are available with a height of only 25mm and 17mm respectively. They are intended to enable very thin fixture design, when the fixture shell can perform the function of heat-sink.

For seamless integration the wire can be routed sideways in the horizontal plane. The backside features a channel so when side mounting of the wire is chosen, flush mounting can still be achieved.

A thermal graphite pad comes standard on the backside for optimal thermal transfer. No additional thermal contact material is needed.

NOTE: The black protective liner should be removed from the thermal graphite pad prior to mounting process.

Figure 3: Black protective liner removal from SLC thermal graphite pad

Figure 4: Wire routing options for SLC type. Left: center wire routing. Right: Side wire routing.

Option 1: Mounting from the topside - requires lens removal

This option requires the lens to be removed to access the inside of the Optical Light Engine cup.

Step 1: Remove the lens by removing the spring clip. Suggested is to use a small plier or flat screw driver. Be careful not to scratch the lens.

Step 2: Take out the lens by tilting the Optical Light Engines over. To avoid finger print stains, it is recommended that direct skin contact to the lens is avoided.

Step 3: Screw in 2 screws, torque 0.5Nm. Use great care not to touch the exposed LED and its wire contacts, as this might compromise its function or reliability.

Step 4: Place back the lens and fasten it with the retained clip.

Option 2: Mounting from the back side

By using M2.5 thread forming screws the Optical Light Engine can also be attached from the back side. Recommended torque is 0.5Nm.

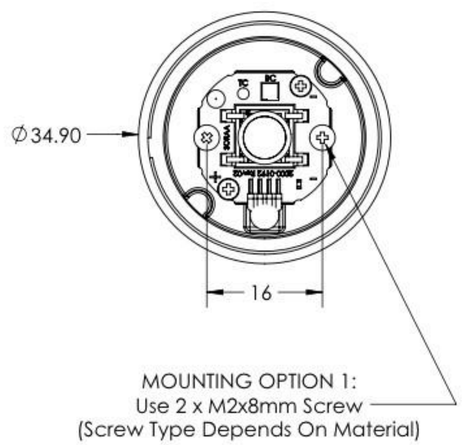
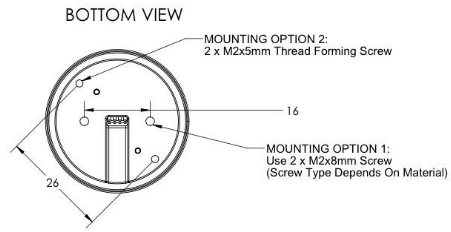
Design Resources

Two dimensional outline drawings and 3D CAD models are available on request.

Table 2: Mounting Options

Optical Light Engine		Pitch between holes (mm)	Screw size
SLC-11-xx	Option 1: from top	16	M2x8mm
	Option 2: from back	26	M2x5mm
SLC16-xx	Option 1: from top	28	M2.6x8mm or M2.5x8mm
	Option 2: from back	36	M2.5x5mm
SLC30-xx	Option 1: from top	28	M2.6x8mm or M2.5x8mm
	Option 2: from back	60	M2.5x6mm

Table 3: Views of Mounting Option 1 & 2

<table>
<tr><th>Optical Lighting Engine Type</th><th>Top View</th><th>Bottom View</th></tr>
<tr><td>SLC11-xx</td><td>
</td><td>
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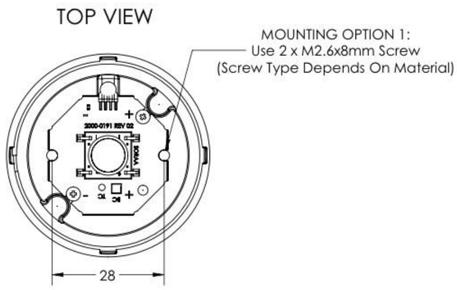
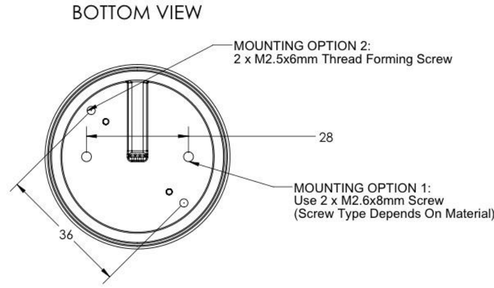
<tr><td>SLC16-xx</td><td>
</td><td>
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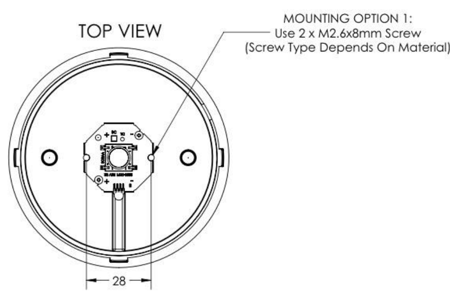
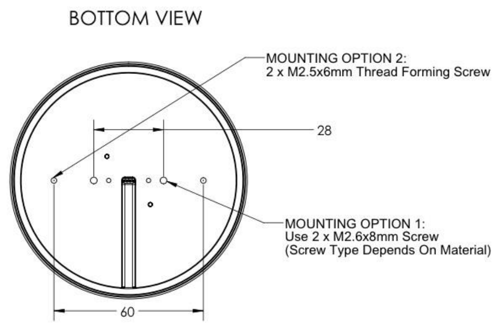
<tr><td>SLC30-X</td><td>
</td><td>
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Optical integration

Soraa Optical Light Engines are directional light sources with the optic designed and optimized to unique Soraa GaN-on-GaN LED technology. Soraa designs the optics in-house, based on in-depth understanding of the LED itself. The combination of Soraa GaN-on-GaN LED with optimized optics is referred to as Point Source Optics™. The aim in optical design is to maximize peak intensity for a given beam angle, provide very uniform color across beam and field, ensure smooth artifact-free transitions and limit wide angle light that can cause glare.

In comparison with typical LED directional lighting solutions, Soraa Optical Light Engines have a substantially smaller aperture for a given beam angle and intensity. In addition, the height of LED and optic can be less than half or a third compared to a typical LED with reflector combination of the same beam angle. Soraa Optical Light Engines provide substantially higher peak intensity (Candela) per unit of luminous flux (Lumen) for a given beam angle. The ratio of candela per lumen can be twice as high when compared to other LED solutions. The benefit of a high candela per lumen ratio is that system power can be reduced and smaller heat-sinks can be applied.

Soraa uses two types of lens optics, both based on optical grade polycarbonate molded material. The first type is referred to as TIR (for Total Internal Reflection) and is used for 25 degree and 36 degree beam angles. The second type is referred to as prism optic and provides very narrow spot and spot options (4 to 15 degree beam angle). To attach SNAP System™ optical accessories a magnet has been attached in the center of the prism optic. SNAP accessories can only be used in combination with the prism optic. Optical Light Engines SLE16 can be used with SNAP accessories AC-XXX. Optical Light Engines SLE30 are compatible with SNAP accessories AC-E-XXX.

Soraa optics are designed to provide the desired beam distribution without additional reflectors or shields.

Lenses are held in place with circular spring retainer clip, as shown in figure 2. In general, prism type lenses are not interchangeable with TIR type lenses.

Optical design resources

IES files are available for download at the www.soraa.com. It is recommended to generate optical design files at the fixture levels as the integration into the fixture might impact the light distribution and depending on the current and temperature conditions the actual output can differ from what is provided in Soraa’s IES files.

Thermal integration

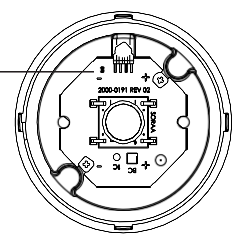
LED temperature has a strong correlation to the expected life of the product, as defined by customer criteria on acceptable color stability and light output maintenance. Soraa Optical Light Engines make it very easy to measure the reference temperature with the Optical Light Engine incorporated in the fixture.

Temperature Measurement

Temperature can be assessed through an NTC resistor component that is mounted on the circuit board inside the Optical Light Engine. Its temperature is representative for the temperature at the Tc point on the board. The advantage of using the NTC is that it becomes very easy to do in-situ measurement with basic equipment like a standard multi meter through two wires of the four wire ribbon cable. The resistance values measured from the NTC can be translated to temperature with the Table 4 below.

Table 4: NTC measured resistance values v.s. temperature

Tc	-20°C	-10°C	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C
Resistance (KOhm)	**480**	**271**	**158**	**95**	**59**	**38**	**25**	**16**	**11**	**7.8**	**5.6**	**4.0**	**2.9**



Typically, it will take 20 to 50 minutes for the Optical Light Engine itself to reach a stable operating temperature. Depending on the total system configuration it can take up to a few hours for the total system to reach stable operating temperature. It is recommended to do temperature evaluations at a stable operating temperature.

In most cases, it is expected that ambient temperature fluctuations outside the fixture translate directly to reference temperature changes in the Optical Light Engine by the same amount.

Depending on the drive conditions, the LED junction temperature can be up to 20°C higher than the reference temperature on the circuit board.

Soraa's color and lumen maintenance predictions presented in this document are all based on reference temperature measurements through the NTC.

Life time estimates for variable drive conditions

Soraa defines the life of its products based on the deviation over time from its initial performance. This includes reduction in light output over time and change in color over time. The same predictions apply for different CCT and CRI options, as well as beam angle options. Life predictions apply to the entire product and include the stability of the lens.

Life predictions are based on 10,000 hours of life testing that is conducted according to LM-80 by an accredited external lab across a range of temperature and current conditions. Projections shared in this document are averages. Three sets of predictions are given. First one for Optical Light Engines starting with part number SLE30-04, second one for part numbers starting with SLExx-06 (can be SL11-06 and SLE16-06), and third one with part number SLExx-08 (can be SLE16-08 and SLE30-08)

Color stability over time

Soraa GaN-on-GaN LEDs provide consistent color over time, thanks to the combination of violet primary LED emission and red, green and blue phosphors that create white light. To provide insight in how an installation will appear over time, color stability is presented in two separate parts.

The first part of color stability is color spread. This indicates how much color difference can be expected within a group of Optical Light Engines in an installation. The second part is color drift over time. This indicates how much color change the Optical Light Engines exhibit as a group. While a group as a whole can drift in color, if the spreading is minimal, the lighting installation can keep its uniform appearance as time goes by. The effect of drift will become visible in comparison with a new Optical Light Engine.

It is important to split color change into spread and drift because just looking at color change in du'v' does not provide sufficient insight in how an installation will appear over time. For example, two light sources can have a small amount of color shift but if they shift in opposite directions (for example one towards green tint and the other one towards pink tint), the effect will be clearly visible. In the context of this example, these light sources may not move as a group, but show considerable color spread. In the case of this example, because of their color shift in opposite directions, the spreading between the sources is actually twice their individual shift.

Soraa has found negligible color spread in its LM80 test data. The color "cloud" of parts was observed to be stable over the 10,000h test duration, across different temperature and current test conditions. Because of the absence of spreading in test data, no color spreading predictions could be generated and predictive data is not presented in this document. It is expected that color spreading will be very minimal over the life of a group of products.

Product Performance at Reference Conditions

Table 5

Product Performance Parameters

SLx30

Reference Number	CCT (K)	CRI	Beam angle	Field angle	Peak Intensity (Cd)	Nominal power consumption (W)	Luminous Flux (lm)	SNAP compatible
SLx30								
SLx30-08-009D-927-03-01	2,700K	95	9	16	22880	16.7	950	Yes
SLx30-08-025D-927-03-01	2,700K	95	25	40	5020	16.7	950	
SLx30-08-036D-927-03-01	2,700K	95	36	60	2360	16.7	950	
SLx30-08-009D-930-03-01	3,000K	95	9	16	24100	16.7	1000	Yes
SLx30-08-025D-930-03-01	3,000K	95	25	40	5300	16.7	1000	
SLx30-08-036D-930-03-01	3,000K	95	36	60	2500	16.7	1000	
SLx30-08-009D-940-03-01	4,000K	95	9	16	25300	16.7	1050	Yes
SLx30-08-025D-940-03-01	4,000K	95	25	40	5560	16.7	1050	
SLx30-08-036D-940-03-01	4,000K	95	36	60	2620	16.7	1050	
SLx30-08-009D-950-03-01	5,000K	95	9	16	25300	16.7	1050	Yes
SLx30-08-025D-950-03-01	5,000K	95	25	40	5560	16.7	1050	
SLx30-08-036D-950-03-01	5,000K	95	36	60	2620	16.7	1050	
SLx30-08-009D-827-03-01	2,700K	80	9	16	27580	16.7	1145	Yes
SLx30-08-025D-827-03-01	2,700K	80	25	40	6060	16.7	1145	
SLx30-08-036D-827-03-01	2,700K	80	36	60	2860	16.7	1145	
SLx30-08-009D-830-03-01	3,000K	80	9	16	29160	16.7	1210	Yes
SLx30-08-025D-830-03-01	3,000K	80	25	40	6400	16.7	1210	
SLx30-08-036D-830-03-01	3,000K	80	36	60	3020	16.7	1210	

Notes:
1. At 70°C reference point temperature and 600mA
2. Beam angle defined at 50% of peak intensity
3. Field angle defined at 10% of peak intensity

Table 6

Product Performance Parameters
SLx16

Reference Number	CCT (K)	CRI	Beam angle	Field angle	Peak Intensity (Cd)	Nominal power consumption (W)	Luminous Flux (lm)	SNAP compatible
SLx16								
SLx16-06-010D-927-03-01	2,700K	95	10	20	6940	8.3	475	Yes
SLx16-08-025D-927-03-01	2,700K	95	25	40	5020	16.7	950	
SLx16-08-036D-927-03-01	2,700K	95	36	60	2360	16.7	950	
SLx16-06-010D-930-03-01	3,000K	95	10	20	7320	8.3	500	Yes
SLx16-08-025D-930-03-01	3,000K	95	25	40	5300	16.7	1000	
SLx16-08-036D-930-03-01	3,000K	95	36	60	2500	16.7	1000	
SLx16-06-010D-940-03-01	4,000K	95	10	20	7680	8.3	525	Yes
SLx16-08-025D-940-03-01	4,000K	95	25	40	5560	16.7	1050	
SLx16-08-036D-940-03-01	4,000K	95	36	60	2620	16.7	1050	
SLx16-06-010D-950-03-01	5,000K	95	10	20	7680	8.3	525	Yes
SLx16-08-025D-950-03-01	5,000K	95	25	40	5560	16.7	1050	
SLx16-08-036D-950-03-01	5,000K	95	36	60	2620	16.7	1050	
SLx16-06-010D-827-03-01	2,700K	80	10	20	8340	8.3	570	Yes
SLx16-08-025D-827-03-01	2,700K	80	25	40	6060	16.7	1145	
SLx16-08-036D-827-03-01	2,700K	80	36	60	2860	16.7	1145	
SLx16-06-010D-830-03-01	3,000K	80	10	20	8860	8.3	605	Yes
SLx16-08-025D-830-03-01	3,000K	80	25	40	6400	16.7	1210	
SLx16-08-036D-830-03-01	3,000K	80	36	60	3020	16.7	1210	

Notes:
1. At 70°C reference point temperature and 600mA (SLx-08) or 300mA (SLx-06)
2. Beam angle defined at 50% of peak intensity
3. Field angle defined at 10% of peak intensity

Table 7

Product Performance Parameters
SLx11

Reference Number	CCT (K)	CRI	Beam angle	Field angle	Peak Intensity (Cd)	Nominal power consumption (W)	Luminous Flux (lm)	SNAP compatible
SLx11-xx								
SLx11-06-025D-927-03-01	2,700K	95	25	40	2660	8.3	475	
SLx11-06-036D-927-03-01	2,700K	95	36	60	1180	8.3	475	
SLx11-06-025D-930-03-01	3,000K	95	25	40	2800	8.3	500	
SLx11-06-036D-930-03-01	3,000K	95	36	60	1240	8.3	500	
SLx11-06-025D-940-03-01	4,000K	95	25	40	2940	8.3	525	
SLx11-06-036D-940-03-01	4,000K	95	36	60	1300	8.3	525	
SLx11-06-025D-950-03-01	5,000K	95	25	40	2940	8.3	525	
SLx11-06-036D-950-03-01	5,000K	95	36	60	1300	8.3	525	
SLx11-06-025D-827-03-01	2,700K	80	25	40	3180	8.3	570	
SLx11-06-036D-827-03-01	2,700K	80	36	60	1420	8.3	570	
SLx11-06-025D-830-03-01	3,000K	80	25	40	3380	8.3	605	
SLx11-06-036D-830-03-01	3,000K	80	36	60	1500	8.3	605	

Notes:
1. At 70°C reference point temperature and 300mA
2. Beam angle defined at 50% of peak intensity
3. Field angle defined at 10% of peak intensity

Life expectation tables

Predictions for color spreading, color drift and lumen maintenance are given for 50,000h operation. In addition, the relative light output is given for current and temperature conditions. An estimate of the light output can be obtained for a given Optical Light Engine by multiplying the % number from the tables below with the reference luminous flux or peak intensities given in the Table 5-7.

Table 8: Lumen and color maintenance predictions SLExx-04-xx / SLCxx-04-xx

	Hours of evaluation	50000										
	Degrees Celsius	50	55	60	65	70	75	80	85	90	95	100
	Degrees Fahrenheit	122	131	140	149	158	167	176	185	194	203	212
If mA	NTC readout (kOhm)	16.4	13.5	11.2	9.35	7.82	6.57	5.55	4.70	4.00	3.42	2.94
87.5	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
	Lumen maintenance	93%	92%	90%	88%	86%	83%	81%	78%	75%	71%	68%
	Relative light-output at T_0	63%	62%	62%	62%	61%	61%	61%	60%	60%	60%	59%
100	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
	Lumen maintenance	91%	89%	86%	84%	81%	78%	75%	71%	68%	64%	60%
	Relative light-output at T_0	71%	71%	70%	70%	70%	69%	69%	68%	68%	67%	67%
112.5	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
	Lumen maintenance	88%	85%	83%	80%	76%	73%	69%	65%	60%	56%	51%
	Relative light-output at T_0	79%	79%	78%	78%	77%	77%	76%	76%	75%	75%	74%
125	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003
	Lumen maintenance	85%	82%	78%	75%	71%	67%	63%	58%	53%	49%	44%
	Relative light-output at T_0	87%	87%	86%	86%	85%	85%	84%	83%	83%	82%	82%
137.5	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003
	Lumen maintenance	81%	78%	74%	70%	66%	61%	56%	51%	46%	41%	36%
	Relative light-output at T_0	95%	94%	94%	93%	93%	92%	91%	91%	90%	89%	89%
150	du'v' color drift	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	Lumen maintenance	78%	74%	70%	65%	60%	55%	50%	45%	40%	35%	30%
	Relative light-output at T_0	102%	102%	101%	101%	100%	99%	99%	98%	97%	97%	96%
162.5	du'v' color drift	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	Lumen maintenance	74%	70%	65%	60%	55%	50%	44%	39%	34%	29%	24%
	Relative light-output at T_0	110%	109%	109%	108%	107%	106%	106%	105%	104%	103%	103%
175	du'v' color drift	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004
	Lumen maintenance	70%	66%	61%	55%	50%	44%	39%	33%	28%	23%	19%
	Relative light-output at T_0	117%	116%	116%	115%	114%	113%	113%	112%	111%	110%	109%
187.5	du'v' color drift	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004
	Lumen maintenance	67%	61%	56%	50%	45%	39%	33%	28%	23%	19%	15%
	Relative light-output at T_1	124%	123%	123%	122%	121%	120%	119%	118%	118%	117%	116%

Highlighted values fall under Soraa warranty conditions.

Table 9: Lumen and color maintenance predictions SLExx-06-xx / SLCxx-06-xx

	Hours of evaluation	50000										
	Degrees Celsius	50	55	60	65	70	75	80	85	90	95	100
	Degrees Fahrenheit	122	131	140	149	158	167	176	185	194	203	212
If mA	NTC readout (kOhm)	16.4	13.5	11.2	9.35	7.82	6.57	5.55	4.70	4.00	3.42	2.94
175	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
	Lumen maintenance	94%	92%	91%	89%	86%	84%	81%	79%	75%	72%	69%
	Relative light-output at T_0	63%	62%	62%	62%	62%	61%	61%	60%	60%	60%	59%
225	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
	Lumen maintenance	89%	87%	84%	81%	78%	75%	71%	67%	63%	58%	54%
	Relative light-output at T_0	79%	79%	78%	78%	77%	77%	76%	76%	75%	75%	74%
250	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003
	Lumen maintenance	86%	84%	81%	77%	74%	70%	66%	61%	56%	52%	47%
	Relative light-output at T_0	87%	87%	86%	86%	85%	85%	84%	83%	83%	82%	82%
275	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003
	Lumen maintenance	84%	80%	77%	73%	69%	65%	60%	55%	50%	45%	40%
	Relative light-output at T_0	95%	94%	94%	93%	93%	92%	91%	91%	90%	89%	89%
300	du'v' color drift	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	Lumen maintenance	81%	77%	73%	69%	64%	60%	55%	49%	44%	39%	34%
	Relative light-output at T_0	102%	102%	101%	101%	100%	99%	99%	98%	97%	96%	96%
325	du'v' color drift	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	Lumen maintenance	78%	74%	69%	65%	60%	55%	49%	44%	38%	33%	28%
	Relative light-output at T_0	110%	109%	109%	108%	107%	106%	106%	105%	104%	103%	102%
350	du'v' color drift	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004
	Lumen maintenance	74%	70%	65%	60%	55%	50%	44%	39%	33%	28%	23%
	Relative light-output at T_0	117%	116%	116%	115%	114%	113%	113%	112%	111%	110%	109%

Highlighted values fall under Soraa warranty conditions.

Table 10: Lumen and color maintenance predictions SLExx-08-xx / SLCxx-08-xx

If mA	Hours of evaluation	50000										
	Degrees Celsius	50	55	60	65	70	75	80	85	90	95	100
	Degrees Fahrenheit	122	131	140	149	158	167	176	185	194	203	212
	NTC readout (kOhm)	16.4	13.5	11.2	9.35	7.82	6.57	5.55	4.70	4.00	3.42	2.94
350	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
	Lumen maintenance	93%	92%	90%	88%	85%	83%	80%	77%	74%	71%	67%
	Relative light-output at T_0	63%	63%	62%	62%	62%	61%	61%	61%	60%	60%	59%
400	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
	Lumen maintenance	90%	88%	86%	84%	81%	78%	75%	71%	67%	63%	59%
	Relative light-output at T_0	71%	71%	71%	70%	70%	69%	69%	68%	68%	67%	67%
450	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
	Lumen maintenance	88%	85%	82%	79%	76%	72%	69%	64%	60%	56%	51%
	Relative light-output at T_0	79%	79%	78%	78%	78%	77%	77%	76%	76%	75%	74%
500	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003
	Lumen maintenance	84%	82%	78%	75%	71%	67%	62%	58%	53%	48%	43%
	Relative light-output at T_0	87%	87%	86%	86%	85%	85%	84%	84%	83%	82%	82%
550	du'v' color drift	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003
	Lumen maintenance	81%	78%	74%	70%	66%	61%	56%	51%	46%	41%	36%
	Relative light-output at T_0	95%	94%	94%	93%	93%	92%	91%	91%	90%	89%	89%
600	du'v' color drift	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	Lumen maintenance	78%	74%	70%	65%	60%	55%	50%	45%	40%	35%	30%
	Relative light-output at T_0	102%	102%	101%	101%	100%	99%	99%	98%	97%	96%	96%
650	du'v' color drift	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003
	Lumen maintenance	74%	70%	65%	60%	55%	50%	44%	39%	34%	29%	24%
	Relative light-output at T_0	110%	109%	109%	108%	107%	106%	106%	105%	104%	103%	102%
700	du'v' color drift	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004
	Lumen maintenance	70%	65%	60%	55%	50%	44%	39%	33%	28%	23%	19%
	Relative light-output at T_0	117%	116%	116%	115%	114%	113%	112%	111%	111%	110%	109%
750	du'v' color drift	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004
	Lumen maintenance	66%	61%	56%	50%	45%	39%	33%	28%	23%	19%	15%
	Relative light-output at T_1	124%	123%	122%	122%	121%	120%	119%	118%	117%	116%	115%

Highlighted values fall under Soraa warranty conditions.

Light depreciation tables

In addition to the tables for 50,000h performance extrapolations, tables are given to estimate the time to light output maintenance of 70%. Soraa extrapolates up to 6 times the tested time of 10,000 hours. Light output maintenance can be applied to both peak intensity and luminous flux. Similar to the 50,000h prediction tables, a separate table is given for SLExx-04, SLExx-06 and SLExx-08 type Optical Light Engines.

Table 11: Time to lumen maintenance SLExx-04-xx / SLCxx-04-xx

Lumen maintenance		70%										
Degrees Celsius		50	55	60	65	70	75	80	85	90	95	100
Degrees Fahrenheit		122	131	140	149	158	167	176	185	194	203	212
If (mA)	NTC readout (kOhm)	16.4	13.5	11.2	9.35	7.82	6.57	5.55	4.70	4.00	3.42	2.94
87.5		>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	60000	52,000	45,000
100		>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	60000	52,000	45,000	39,000	34,000
112.5		>60,000	>60,000	>60,000	>60,000	>60,000	55000	47,000	41,000	35,000	31,000	27,000
125		>60,000	>60,000	>60,000	60000	52,000	44,000	38,000	33,000	29,000	25,000	22,000
137.5		>60,000	>60,000	59000	50,000	42,000	36,000	31,000	27,000	23,000	20,000	18,000
150		>60,000	58000	49,000	42,000	35,000	30,000	26,000	23,000	20,000	17,000	15,000
162.5		58000	49,000	42,000	35,000	30,000	26,000	22,000	19,000	17,000	14,000	13,000
175		50,000	42,000	36,000	30,000	26,000	22,000	19,000	16,000	14,000	12,000	11,000
187.5		44,000	37,000	31,000	26,000	22,000	19,000	16,000	14,000	12,000	11,000	9,000

Highlighted values fall under Soraa warranty conditions.

Table 12: Time to lumen maintenance SLExx-06-xx / SLCxx-06-xx

Lumen maintenance		70%										
Degrees Celsius		50	55	60	65	70	75	80	85	90	95	100
Degrees Fahrenheit		122	131	140	149	158	167	176	185	194	203	212
If (mA)	NTC readout (kOhm)	16.4	13.5	11.2	9.35	7.82	6.57	5.55	4.70	4.00	3.42	2.94
175		>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	54,000	47,000
200		>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	56,000	48,000	42,000	36,000
225		>60,000	>60,000	>60,000	>60,000	>60,000	60000	51,000	44,000	38,000	33,000	29,000
250		>60,000	>60,000	>60,000	>60,000	57,000	49,000	42,000	36,000	31,000	27,000	24,000
275		>60,000	>60,000	>60,000	56,000	48,000	41,000	35,000	30,000	26,000	23,000	20,000
300		>60,000	>60,000	56,000	48,000	40,000	35,000	30,000	25,000	22,000	19,000	17,000
325		>60,000	57,000	48,000	41,000	35,000	30,000	25,000	22,000	19,000	16,000	14,000
350		59,000	50,000	42,000	35,000	30,000	26,000	22,000	19,000	16,000	14,000	12,000
375		52,000	44,000	37,000	31,000	26,000	22,000	19,000	17,000	14,000	12,000	11,000

Highlighted values fall under Soraa warranty conditions.

Table 13: Time to lumen maintenance SLExx-08-xx/SLCxx-08-xx

Lumen maintenance		70%										
Degrees Celsius		50	55	60	65	70	75	80	85	90	95	100
Degrees Fahrenheit		122	131	140	149	158	167	176	185	194	203	212
If (mA)	NTC readout (kOhm)	16.4	13.5	11.2	9.35	7.82	6.57	5.55	4.70	4.00	3.42	2.94
350		>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	59000	51,000	45,000
400		>60,000	>60,000	>60,000	>60,000	>60,000	>60,000	60000	52,000	45,000	39,000	34,000
450		>60,000	>60,000	>60,000	>60,000	>60,000	54000	47,000	41,000	35,000	31,000	27,000
500		>60,000	>60,000	>60,000	60000	51,000	44,000	38,000	33,000	28,000	25,000	22,000
550		>60,000	>60,000	58000	49,000	42,000	36,000	31,000	27,000	23,000	20,000	18,000
600		>60,000	58000	49,000	41,000	35,000	30,000	26,000	22,000	19,000	17,000	15,000
650		58000	49,000	41,000	35,000	30,000	26,000	22,000	19,000	16,000	14,000	12,000
700		50000	42,000	35,000	30,000	26,000	22,000	19,000	16,000	14,000	12,000	11,000
750		43,000	36,000	31,000	26,000	22,000	19,000	16,000	14,000	12,000	11,000	9,000

Highlighted values fall under Soraa warranty conditions.