epishine

Data Sheet
Epishine Light Energy Harvesting Modules Generation 3 (LEH3)

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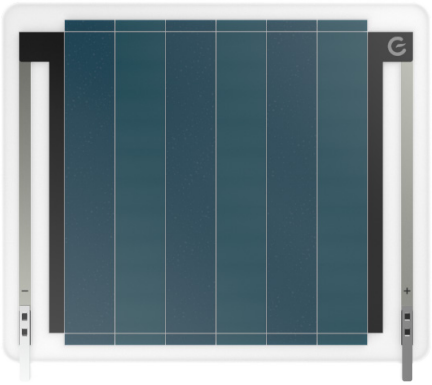
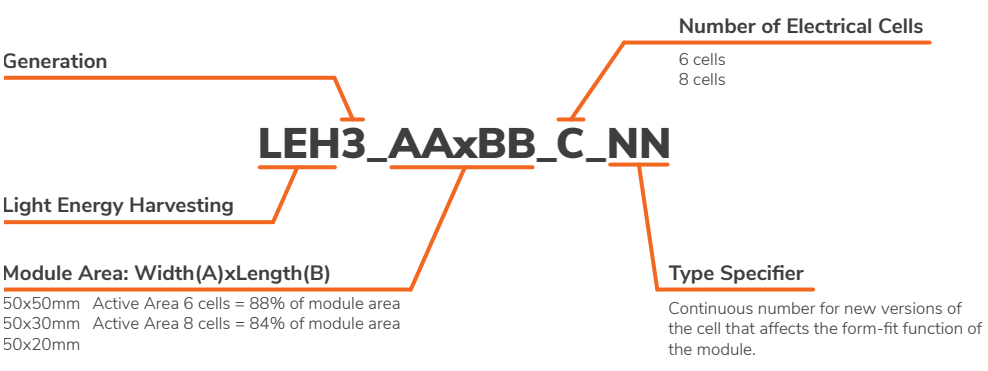
/ In short

- Ideal for powering wireless indoor low-power applications, such as IoT devices, sensors and small electronics
- Cut total cost of ownership by half or more and significantly reduce the amount of waste batteries (by eliminating battery replacements)
- Industry leading performance under indoor light conditions, e.g. home, office, supermarket, etc.
- Flexible, compact and lightweight design with 0.2 mm thickness for easy integration
- Fully customizable[1] and available in 6 standard versions for optimal usage of available product area
- Radio-transparent, making it possible to use more product area for the module
- Based on organic materials. Made in Sweden



/ LEH general information



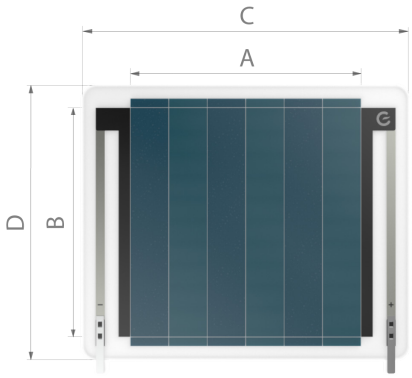


Figure1. Naming convention of LEH Generation 3 modules and definition of Module/Active Area

Operating environment: Indoor / -20°C to 40°C / 0-85%RH (non-condensing). Different operating conditions may affect lifetime.

Maximum temperature: 50°C

Storage conditions: Indoor / -20°C to 40°C / 0-85%RH (non-condensing)

Rated output power density: 18 ±2 µW/cm² on active area

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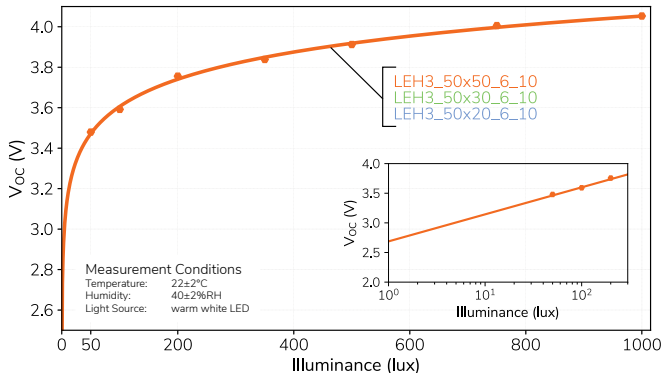
LEH3 - Data sheet

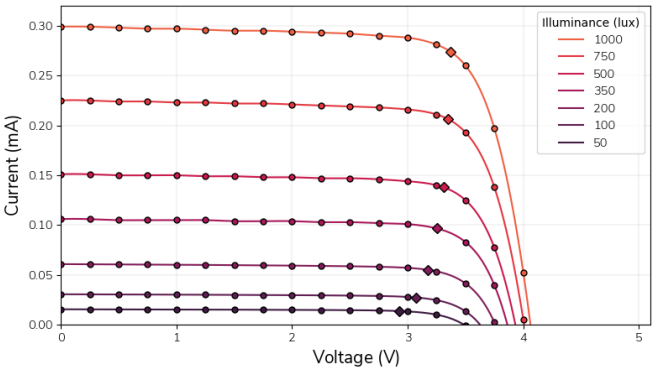
Product Code	Open Circuit Voltage[1,2] (V)	Short Circuit Current[1,2] (µA)	Output Power[1,2] (µW)	Cells	A (mm)	B (mm)	C (mm)	D (mm)
LEH3_50x50_6_10	3.8	147	418	6	50	50	71.5	60
LEH3_50x50_8_10	5.05	105	375	8	50	50	71.5	60
LEH3_50x30_6_10	3.8	88	250	6	50	30	71.5	40
LEH3_50x30_8_10	5.05	62	221	8	50	30	71.5	40
LEH3_50x20_6_10	3.8	59	167	6	50	20	71.5	30
LEH3_50x20_8_10	5.05	42	150	8	50	20	71.5	30

[1] We constantly try to improve our products (and ourselves) and hence all technical data is subject to change without notice
[2] Typical values measured at 500 lux warm white LED on white background at 22±2°C and a relative humidity of 45±2%

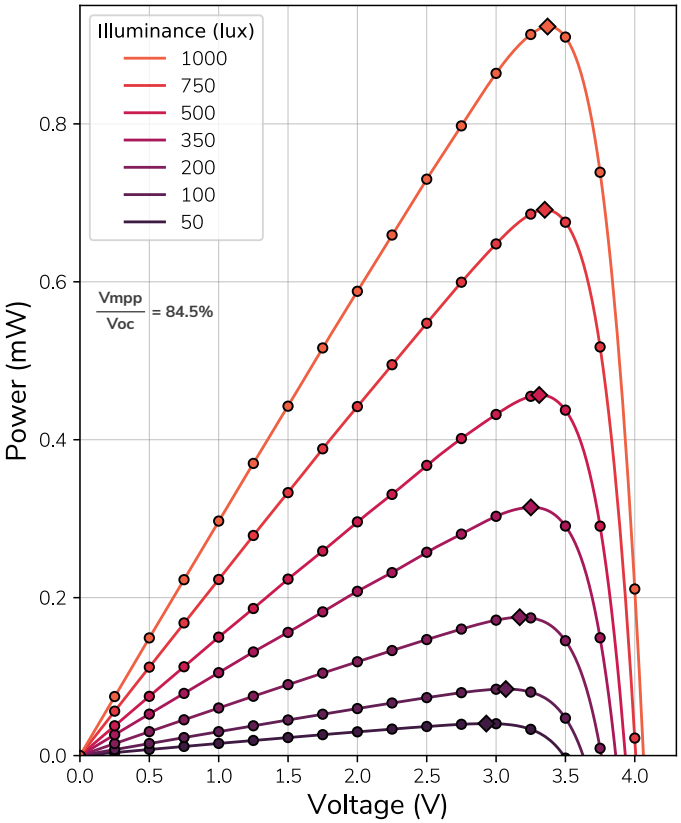
Open Circuit Voltage Voc



Current-Voltage Characteristics



Power-Voltage Characteristics



/ Low illumination Output

The electrical output of our LEH3 series modules is maintained at a high level also under low light conditions.

Power[1] (µW)			
	LEH3_50x50_6_10	LEH3_50x30_6_10	LEH3_50x20_6_10
50 Lux	35	21	14
100 Lux	75	45	30
200 Lux	155	94	62

[1] Typical values measured at warm white LED on white background at 22±2°C and a relative humidity of 45±2%

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Key Electrical Characteristics as a Function of Illuminance

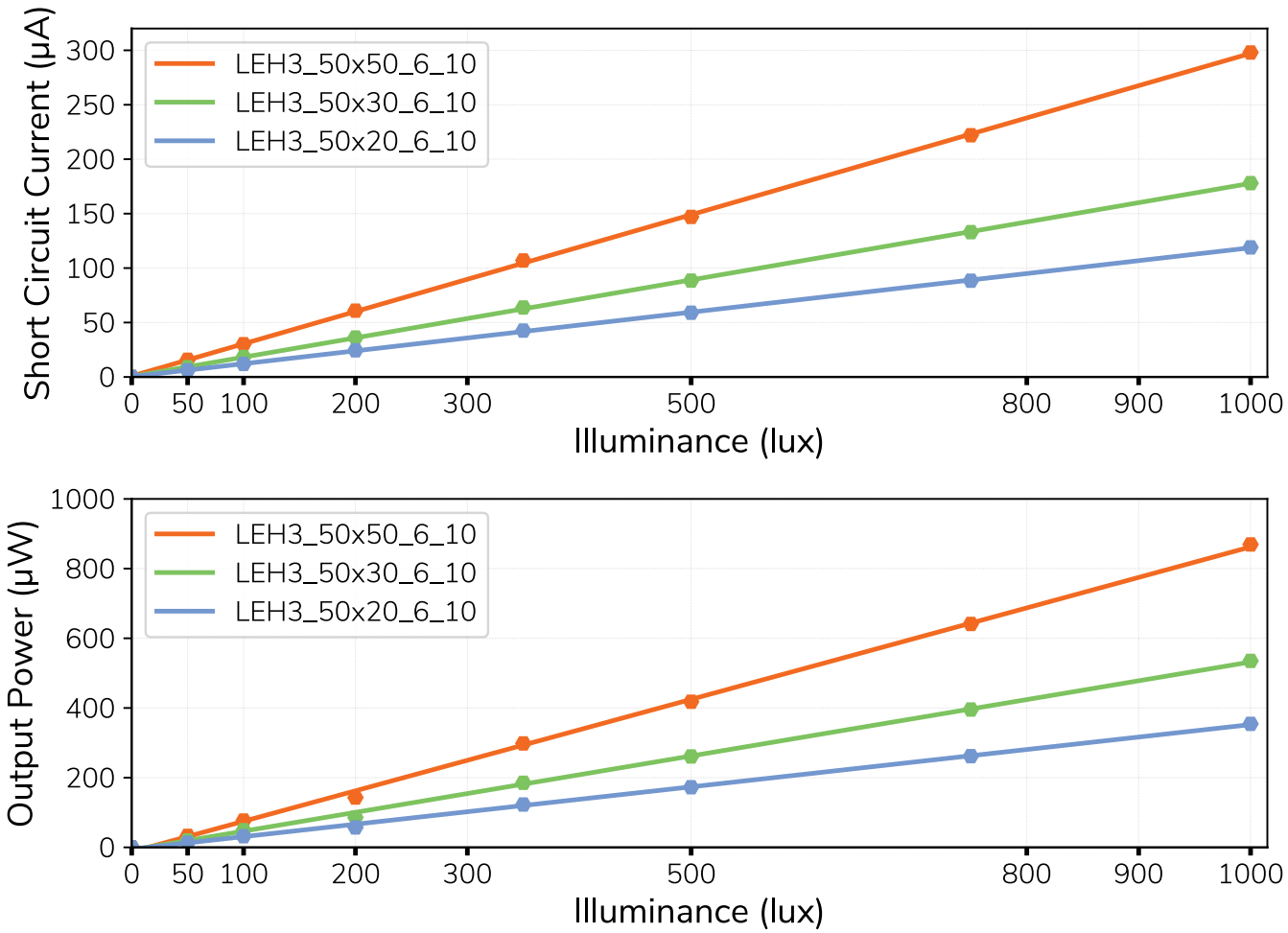

Figure 2. Open circuit voltage (Voc), short circuit current (Isc) and maximum output power as a function of illuminance in lux. Experimental measurements (dots) and fit (lines) for 6-cell LEH modules of 3 sizes, as described in the legend of each plot. The measurements were carried out under the following conditions: temperature=22°C, humidity=40%RH, light source=warm white LED (3500K).

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Key Electrical Characteristics as a Function of Temperature

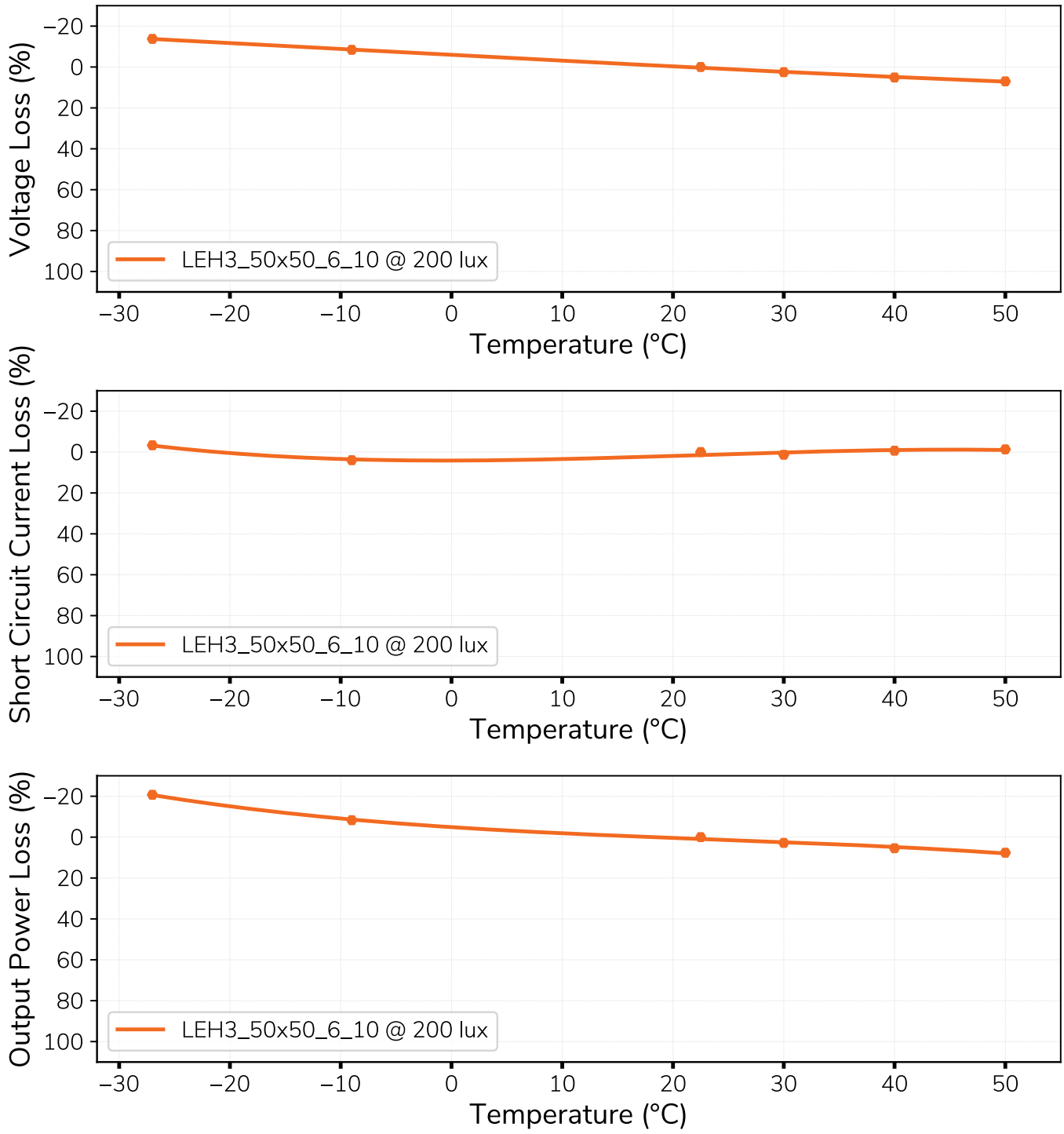

Figure 3. Output power, voltage and current losses as a function of operation temperature, normalized to 22°C. Experimental measurements (dots) and fit (lines) for 6-cell 50x50 LEH module. The measurements were carried out under the following conditions: illuminance=200lux, humidity=40%RH, light source=warm white LED (3500K).

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Key Electrical Characteristics as a Function of Light Angle of Incidence

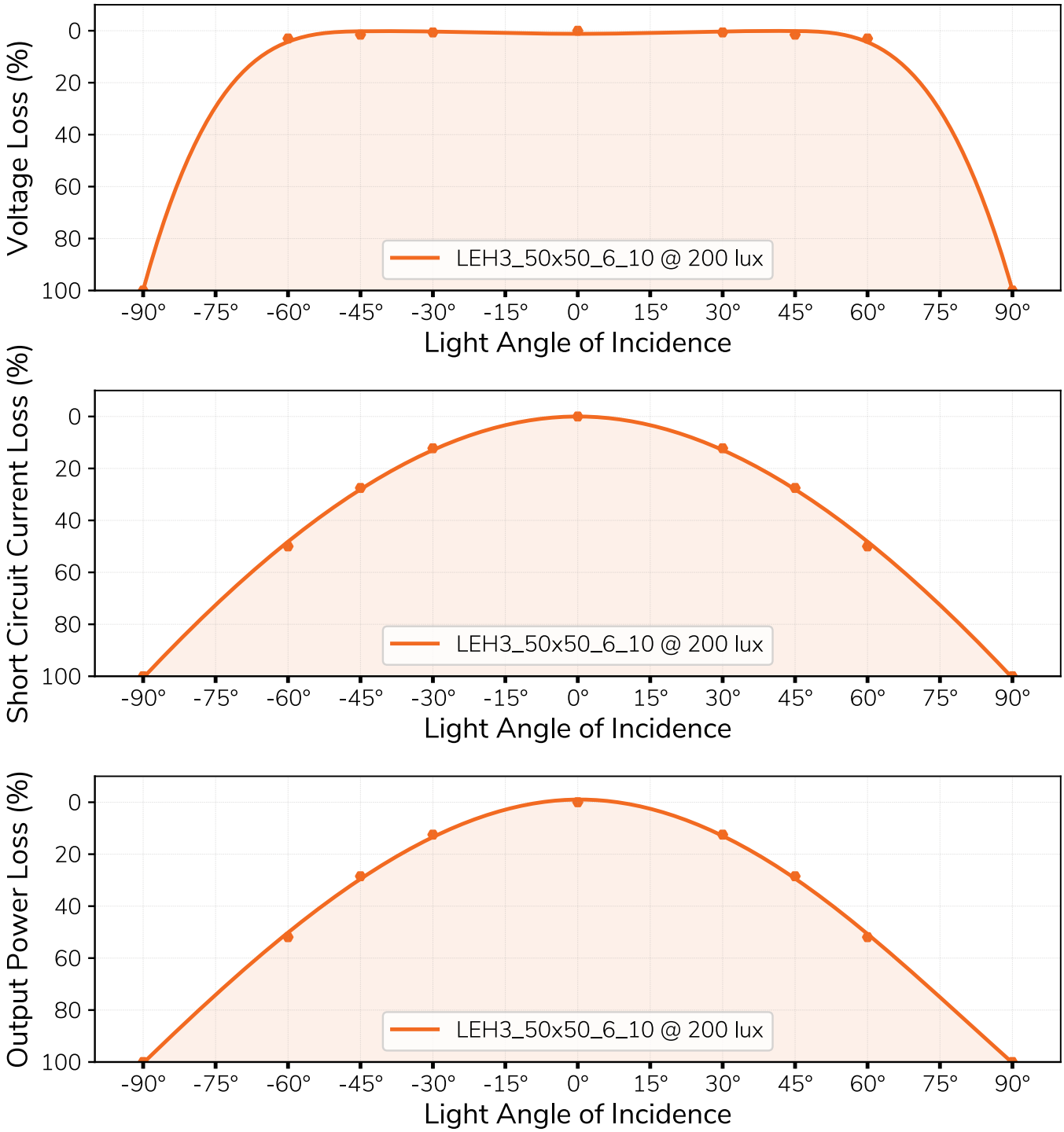

Figure 4. Normalized output power, voltage and current as a function of operation temperature. Experimental measurements (dots) and fit (lines) for 6-cell 50x50 LEH module. The measurements were carried out under the following conditions: illuminance=200lux, humidity=40%RH, light source=warm white LED (3500K).

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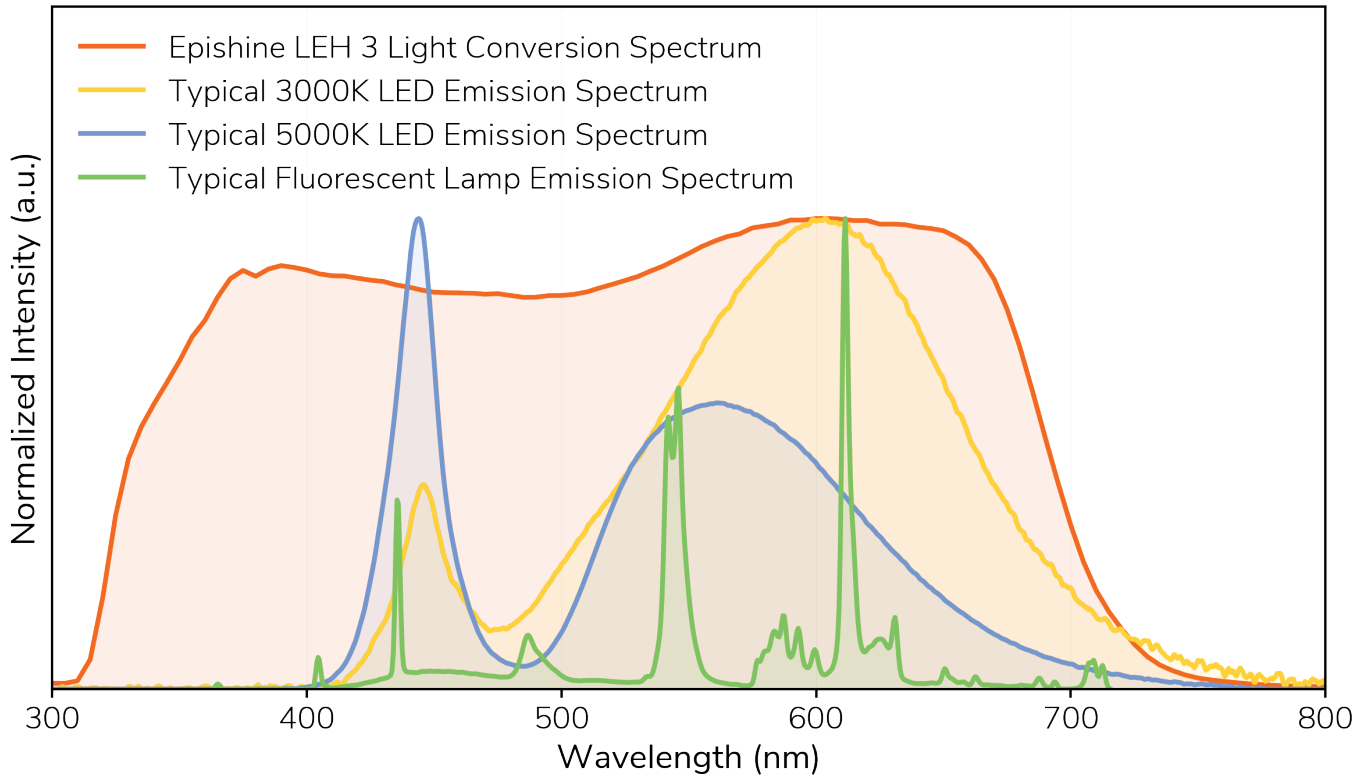

Figure 5. Sensitivity of Epishine Generation 3 LEH modules (orange trace) in comparison to typical indoor fluorescent (green trace), 3000K LED lamp (yellow trace) and 5000K LED lamp (blue trace) emission spectra

/ Drawings and layout tolerances

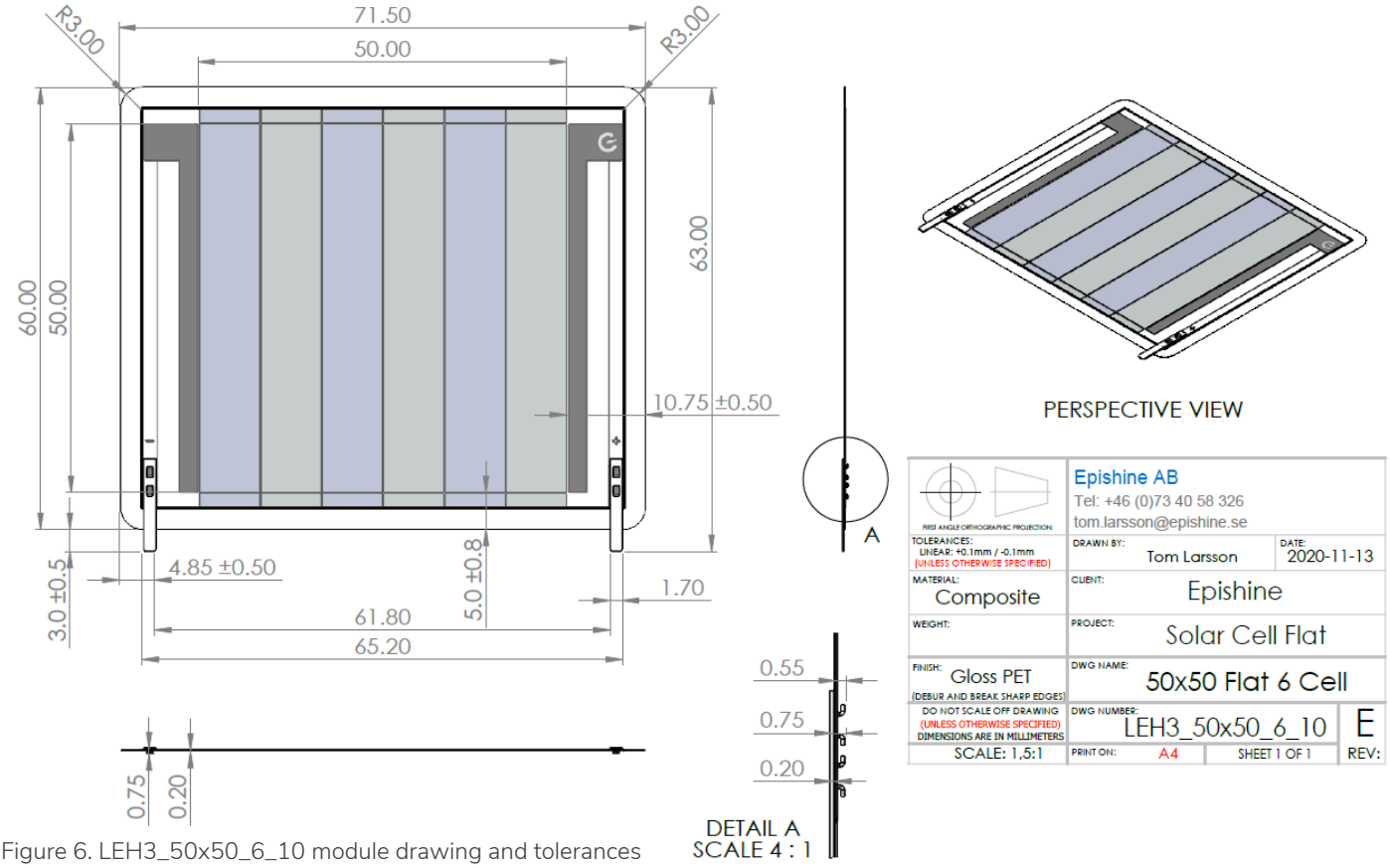

Figure 6. LEH3_50x50_6_10 module drawing and tolerances

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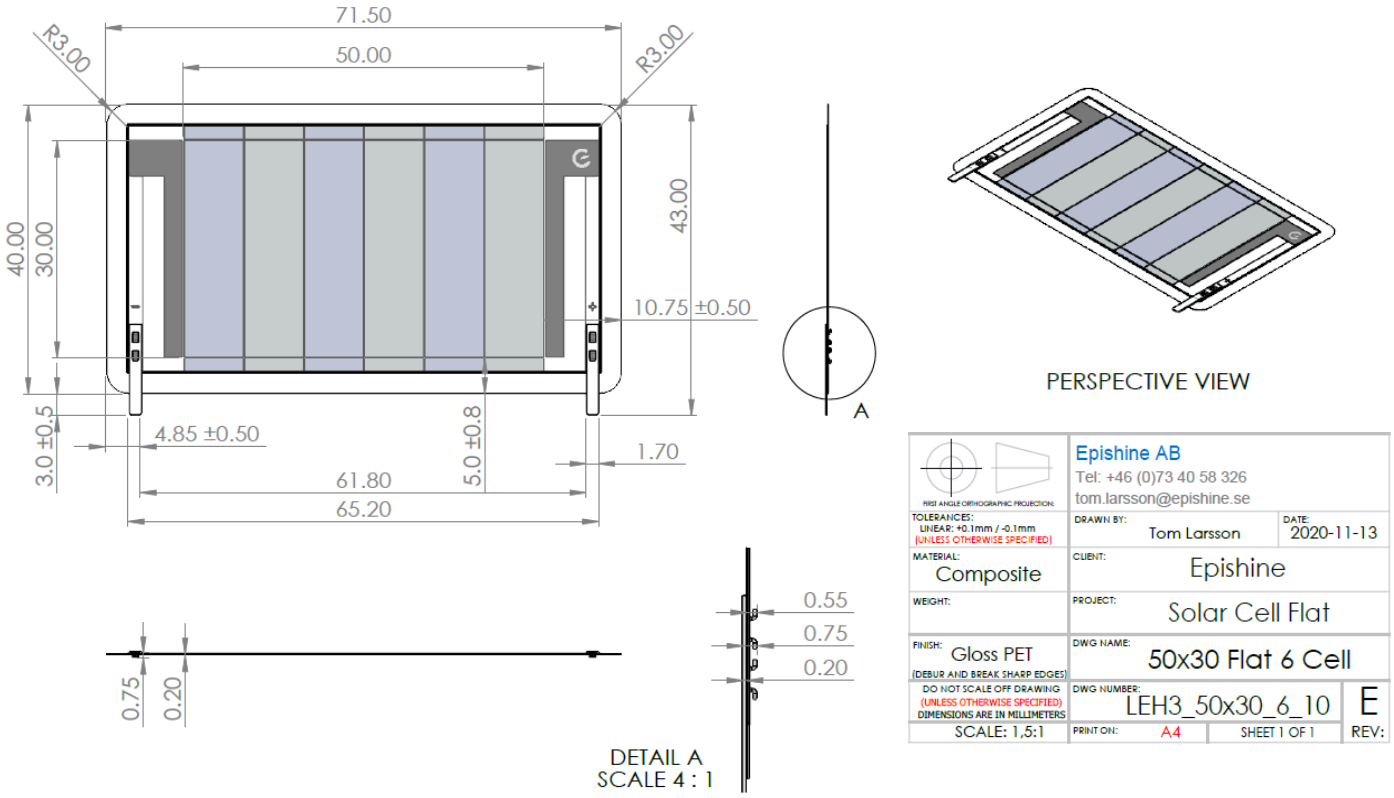

Figure 7. LEH3_50x30_6_10 module drawing and tolerances

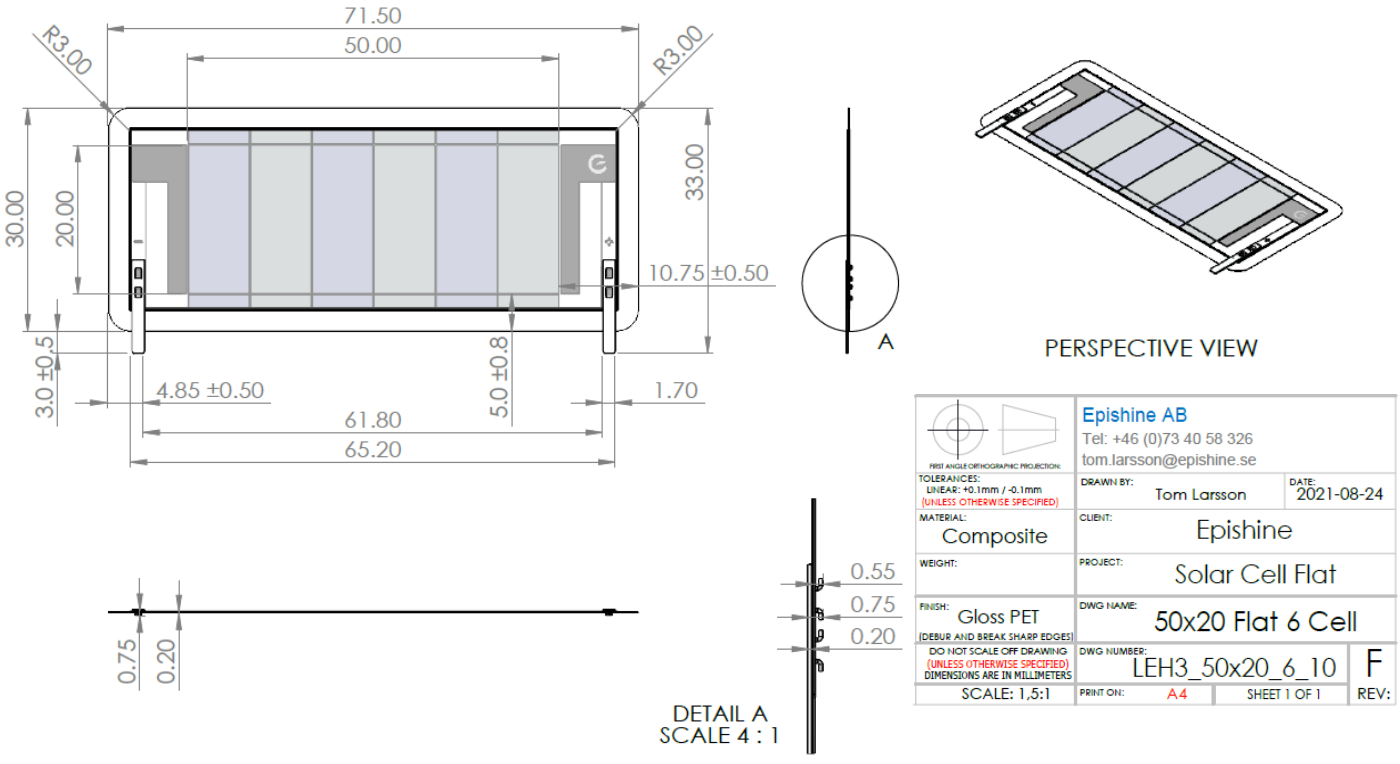

Figure 8. LEH3_50x20_6_10 module drawing and tolerances

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/ Electrical Performance under Environmental Stress

The performance and lifetime of Epishine light energy harvesting modules (LEHs) are being evaluated in a series of electrical, mechanical, and environmental stress tests, performed both in-house and at certified test facilities. All tests aim to verify that 80% of the rated output power is still available after 10 years of operation at Standard Operating Conditions (SOC). Environmental stress tests are compiled in Table 2.

Standard operating conditions (SOC) are defined as:
Temperature: 20±5°C
Humidity: 40±30%RH (non-condensing)
Illumination intensity: 20-1000 lux

Electrical performance measurements were carried out before and after the test at standardized test conditions:
Temperature: 22±2°C
Humidity: 45±5%RH
Illuminance: 500±10lux warm white LED. White background behind the module.

Electrical performance characterization lamp spectrum:

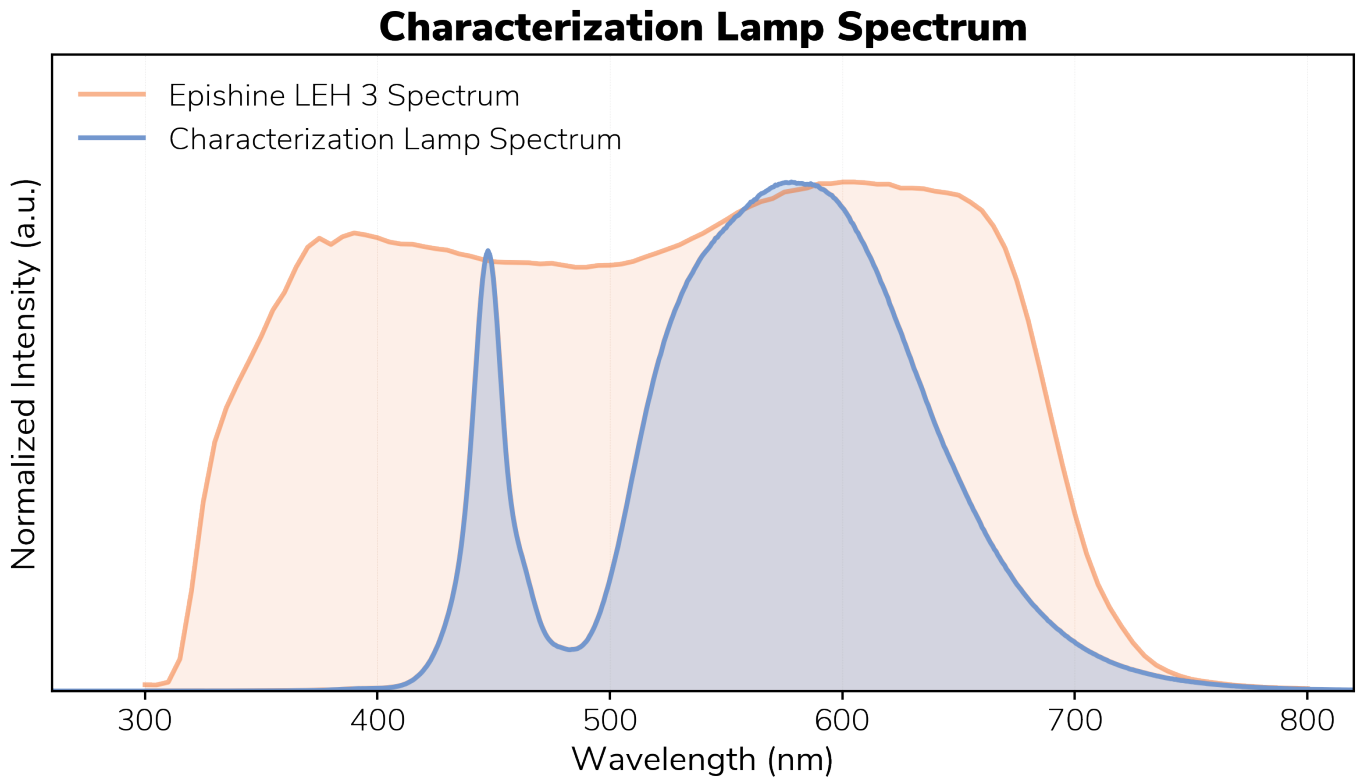

Figure 9. Indoor LED 3500K characterization lamp spectrum (blue trace) and Epishine LEH 3 sensitivity (orange trace)

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Test	Test condition	Result	Pass criterion	Comment
Accelerated Lifetime Test (Temperature and Humidity)	-20°C / 12%RH / 3000h	Pass	No power loss	Scancool SD-46
	3°C / 25%RH / 3000h	Pass	No power loss	Scancool SK145-GD
	27°C / 12%RH / 172 days	Pass	≤ 1.25% Pout loss	VWR Incu-Line Incubator
	27°C / 12%RH / 691 days	Ongoing	≤ 5% Pout loss	VWR Incu-Line Incubator
	40°C / 12%RH / 225 days	Ongoing	≤ 10% Pout loss	VWR Incu-Line Incubator
	40°C / 12%RH / 112 days	Pass	≤ 5% Pout loss	VWR Incu-Line Incubator
	55°C / 12%RH / 430h	Pass	≤ 5% Pout loss	VWR Incu-Line Incubator
	55°C / 12%RH / 1700h	Pass	≤ 20% Pout loss	VWR Incu-Line Incubator
	52°C / 85%RH / 1000h	Pass	≤ 2.5% Pout loss	Vötsch VCL 4006 Climate Chamber
	52°C / 85%RH / 4000h	Pass	≤ 20% Pout loss	Vötsch VCL 4006 Climate Chamber
Temperature Cycling Test	-20°C to 70°C / 72cycles / 1.2h per cycle	Pass	≤ 1.25% Pout loss	Performed by BK Services Linköping
Water Submerging Leak Test	Submerging in water for 150days 22°C / 100lux / no bias / 15cm depth	Pass	No power loss	Repaired corro-sion on surface of tin-plated crimp contacts
High Illuminance Test (Warm white LED)	22°C / 45%RH / 10.000lux conti-nuous / 600h	Pass	≤ 7% Pout loss	Recovery time of 3 days at SOC
	22°C / 45%RH / 42.000lux 1h/day / 208 days	Pass	≤ 10% Pout loss	Standby illumination 200lux
	25°C / 45%RH / 42.000lux 3h/day / 180days	Ongoing	≤ 10% Pout loss	Standby illumination 200lux

Table 2: Summary of environmental stress test conditions and results. For the high illuminance tests an average illuminance of 500 lux for 10h per day was assumed

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/ Electrical Performance under Mechanical Stress, ESD and Shipping

A key feature of Epishine LEH modules is their flexibility and possibility to adapt to a variety of shapes and sizes. Mechanical stress tests are compiled in Table 3.

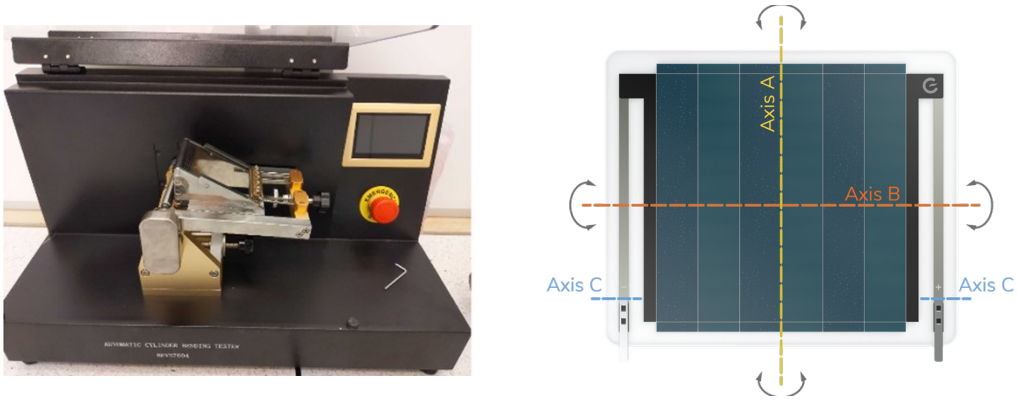

Figure 10. Automated cycling bending test machine (left). Clarification of bending axes A,B,C (right)

Test	Test condition	Result	Pass criterion	Comment
Cycling Bending Test - Module	Bending axis A / Bending radius 1cm / 180° / 1000 cycles	Pass	No power loss	Performed on automated bending tester
	Bending axis B / Bending radius 1cm / 180° / 10000 cycles	Pass	No power loss	Performed on automated bending tester
Static Bending Test - Module	Bending axis A / Bending radius 1cm / 180° / 52°C / 85%RH 30days	Pass	No power loss	
Crimp Contact Cycling Bending Test	20 cycles / Bending axis C / 180°	Pass	≤ 1% conductivity loss	Manual bending of the crimp contact and (locally) the module
Crimp Contact Pulling Test	20N perpendicular to module surface	Pass	No visible damage to contact-module interface	
Edge delamination test	25 impacts on each module edge	Pass	No delamination and No power loss	According to concept described in ISO/IEC 24789-2:2011
Drop test	Fall height 2m	Pass	No visible damage and No power loss	Higher fall heights are not expected to impact electrical or mechanical performance
Shipping Test	Storage at 0.75 bar for 14 hours 25°C / 45%RH / 0lux	Pass	No power loss	
	X-ray scanning	Planned	No power loss	
ESD Immunity Test EN 61000-4-2	±4kV indirect discharges and direct contact charges ±8kV air discharges at 25°C / 30%RH	Pass	No power loss	Performed by BK Services Linköping

Table 3. Summary of mechanical stress test conditions and results

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/ Instructions of use

/ Storage

Epishine recommends storing LEH modules in their original packaging in an air-conditioned room, preferably at temperatures below 30°C as long-term storage at higher temperatures may have an impact on their lifetime.

If the modules have been stored in darkness for a long time, exposure to normal indoor light during up to 24 h before use can increase performance.
Note: The performance will not improve by exposing the modules to higher light intensities.

/ Cautions before use

Epishine LEH modules are sensitive to excessive heat. Over-heating of the module may result in a degradation of performance and lifetime.

Epishine LEH modules are designed for indoor use and are sensitive to high light intensities. Placing the modules in direct sunlight for a prolonged time may result in degradation of performance and lifetime. Occasional short exposure (~ 2h/day) to strong light intensities, e.g. sunlight through a window glass, will not affect their performance or lifetime.

For optimal performance use a white background reflector such as white copying paper or similar, directly behind the Epishine LEH module.

Epishine LEH modules may not be folded or cut.

Epishine LEH modules may delaminate if attached to a surface with double adhesive tape and pulled off again.

Epishine LEH modules contain organic semiconducting materials but are inedible.

Use care if solder-pads are mechanically modified such as bending or cutting.

/ Soldering and assembling

Epishine modules are designed for direct soldering to PCB or wires using a manual soldering iron, a hot bar soldering jig, conductive adhesive, ultrasonic or laser welding. Ensure short heating time of the solder-pad to limit heat transfer to the PET-foil.

Epishine modules are NOT SUITABLE for infrared or hot-air reflow soldering.

Epishine recommends the use of a water-soluble flux, or a no-clean (low residue) flux, and low temperature solder compounds.

Soldering on the solder pads should only be done in well ventilated areas.

Please consult Epishine if you wish to wash the device after soldering.

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/ IV measurement

The modules can be tested by applying a voltage sweep while measuring the current, using e.g. a source meter. Suitable voltage range is between -1V and + [number of cells] V. Measure the current at every voltage step, the more steps the more accurate the resulting IV curve will be. Make sure the resolution of the source meter is high, preferably down to nanoamperes if measuring in low light intensities. Also make sure no resistors are connected in series to the module while measuring. Double check the area in the data sheet for correct calculations of power per unit area and place a white background behind the module for best performance.

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