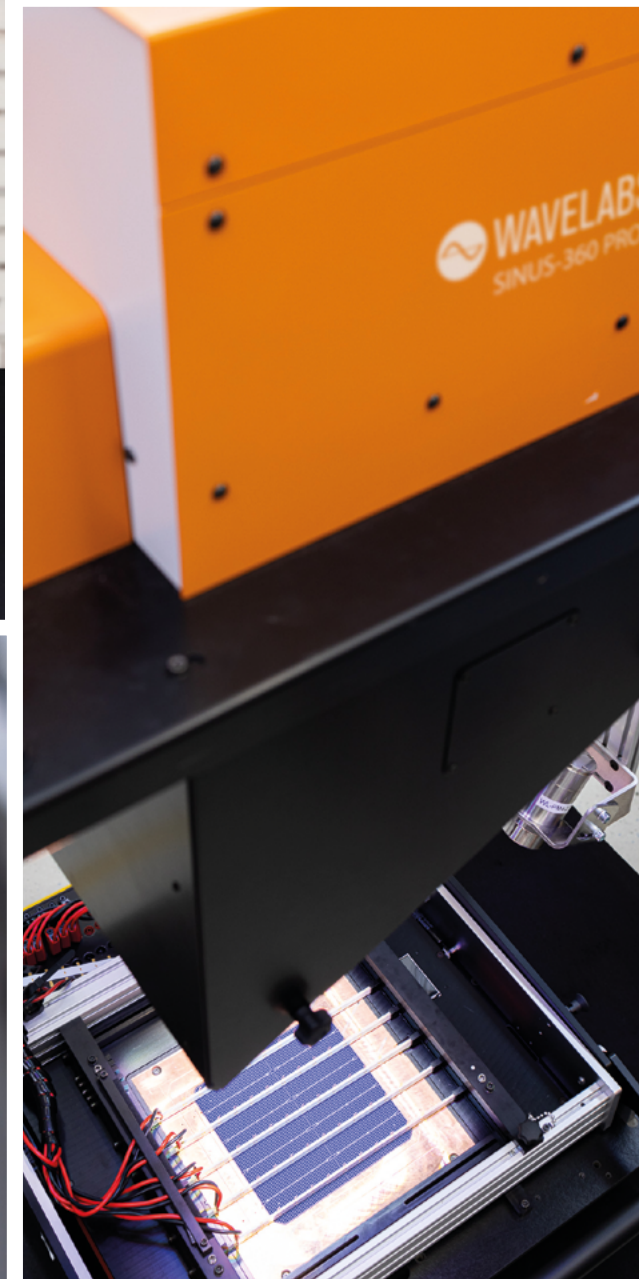


LED's MEASURE SOLAR CELLS

LED SOLAR SIMULATOR SINUS-360 PRO



The **SINUS-360 PRO** is the ideal solar simulator for solar cell production lines. With its highly accurate and precise simulation of the sun spectrum, it is optimized for solar cell efficiency measurement and characterization. The intelligent LED-based light source is what makes this exceptional accuracy possible. **LED's** present the new benchmark:



HIGHLIGHTS



Multicolor LED-based light source
for a perfect copy of the sun



All LEDs can be tuned
for customised spectra



Special optical lens system
for perfect color mixing



Electroluminescence and infrared imaging
can be integrated (optional)



Second LED light source
for bifacial testing (optional)



Exceeds class A+A+A+ criteria
(IEC 60904-9 ed.3) for spectral match, non-uniformity and temporal stability



Ideal for easy integration
into production line testing



Built-in spectrometer
spectrum monitoring for every flash



Reference intensity sensor
in combination with fast feedback loop for automatic intensity correction

LED SOLAR SIMULATOR

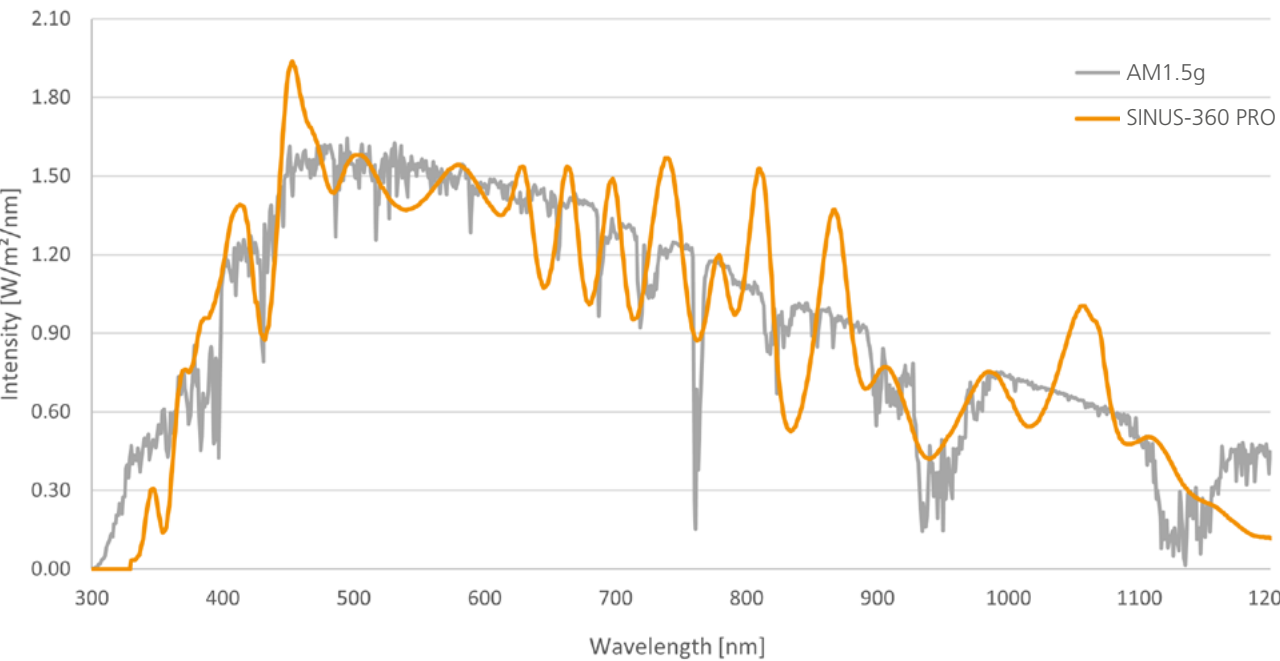
SINUS-360 PRO

CLASSIFICATION			
	SINUS-360 PRO		Class A+A+A+ requirements (IEC 60904-9 ed. 3)
Spectral match	Class A++	0.95 - 1.05	0.875 -1.125
Non-uniformity of irradiance (260 x 260 mm²)	Class A+	< 1%	< 1%
Long term instability (LTI)	Class A++	< 0.2%	< 1%
Short term instability (STI)	Class A+	Synchronized	Synchronized

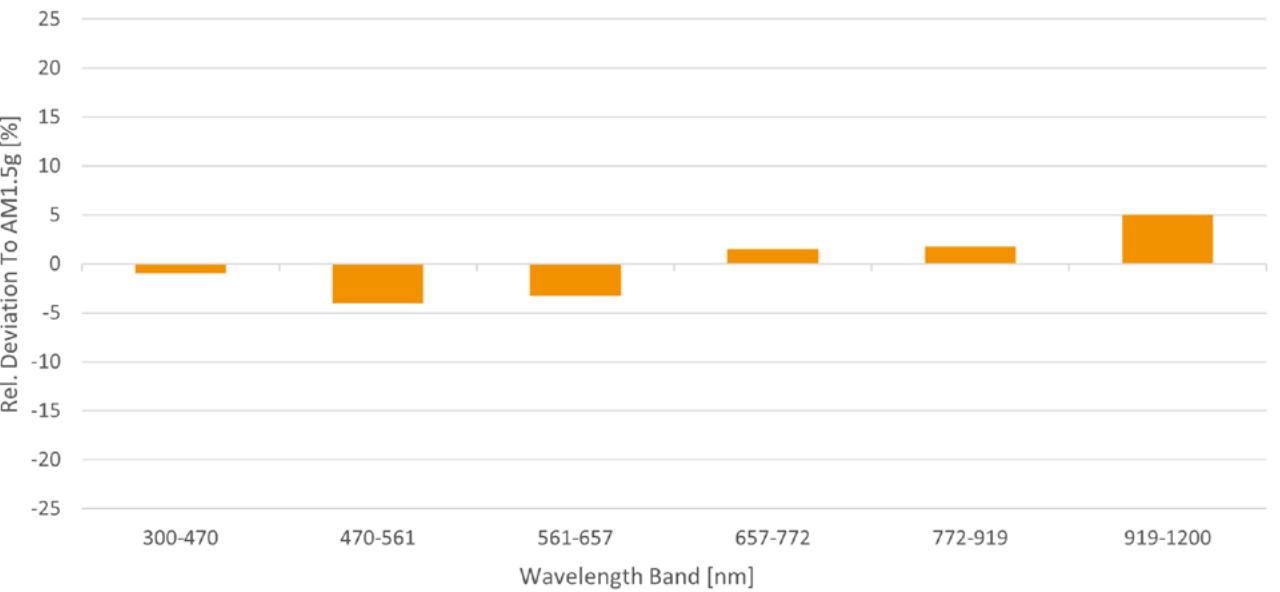
Validity of classification:
Used reference cell traceable to Fraunhofer ISE WPVS cell, 1 sun, AM1.5g, measurement time 100 ms, illuminated area 260 x 260 mm² , 1,110 mm distance light engine - solar cell

SPECTRAL QUALITY

Typical spectrum of LED solar simulator SINUS-360 PRO



Typical spectral deviation



FUNCTIONALITY	
I-V curve measurement	In the Dark and under illumination, from -20 V to 8 V, from -25 A to 25 A
Solar cell parameter analytics	Voc, Isc, FF, PMPP and Eta
Temperature correction	Solar cell parameters are corrected according to IEC 60891 Ed.3
Series resistance analytics	Based on IV curves measured at two irradiance levels
Shunt resistance analytics	Based on reverse dark current
Variable spectrum	User can easily define spectra other than AM1.5g for yield tests under non-standard operating conditions

LED SOLAR SIMULATOR

SINUS-360 PRO

LIGHT ENGINE FEATURES

The light engine consists of LEDs with 24 different peak wavelengths. A special optical lens system ensures perfect color mixing for each spot on the solar cell. Built-in spectrometer and intensity sensor in combination with calibration routine make re-calibration very simple.

Light source	19 individually controlled LED channels to create the desired spectrum
SPD	≤ 21%
SPC	≥ 98%
Ready for tandem cells	Additional LEDs between 600 - 800 nm for probing the SR transition of the top and bottom cell for e.g. Si-Pero tandem cells
Special optical lens system	The multi-level special optical lens system ensures that all different wavelengths are perfectly mixed so that each spot in the test plane is illuminated with the identical spectrum
Feedback system	Built-in intensity sensor measures total intensity during each single measurement multiple times. Adjustments, if necessary, are made on the fly
Spectrum	AM1.5g, AM0 or customer defined spectrum including irradiation by single LED channels
Spectral control	Built-in spectrometer ensures monitoring of the current spectrum for any flash length. Measured spectrum is displayed on GUI for each flash
Intensity range for AM1.5g	Qualified intensities: 0.5, 1.0 and 1.3 suns Intermediate intensities can be set individually
Intensity range for each single LED channel	Adjustable from 10% up to 100%
Irradiance time	Adjustable from 10 ms up to 250 ms
Test area	260 mm x 260 mm (at non-uniformity of <1%)
Cooling	Air-cooling for high stability and large life span
Expected LED box life span	More than 2 years under standard inline operating conditions

I-V ELECTRONICS FEATURES

The very fast active electronic load allows 4 quadrant measurements. A 14-bit calibrated Analog-Digital converter and calibrated, traceable shunt resistor fulfils the highest demands for accuracy and precision.

Voltage resolution	0.025% of 2 V / 20 V
Current resolution	0.025% of 250 mA/ 2.5 A / 25 A
Static Repeatability [(max-min)/(max+min)]	Isc: 0.03%, Voc: 0.03%, FF: 0.075%, P _{MPP} : 0.075%
I-V curve measurement time	Adjustable from 20 ms up to 250 ms

SYSTEM FEATURES

SINUS-360 PRO is designed for high-precision and low-maintenance operation in high-speed production lines.

Measurement times for standard recipe (1 sun, 0.5 sun, dark, EL)	Typically, around 190 ms; Fast measurement even possible for high-capacitance cells like HJT, IBC and TOPCon due to innovative LED technology with RapidWAVE®
Sorting	As required: up to 256 classes
Communication for inline integration	Via hardware signals, RS232, TCP/IP, ProfiNET
Control levels	Operator or engineer levels
User interface	Monitor, keyboard, mouse
Industrial PC	OS Windows
RapidWAVE®	RapidWAVE® overcomes the hysteresis effect of high-capacitance solar cells and allows the user to achieve high throughput without any loss in accuracy, repeatability, or reproducibility of the IV measurement
Required environment	22.5 °C < T < 30 °C, 40 - 60% humidity, non-condensing. Maximum change of humidity 1%/h

LED SOLAR SIMULATOR

SINUS-360 PRO

OPTIONAL FEATURES	
Rear Side Flasher	The Rear Side LED solar simulator enables the system for bi-facial cell measurement. It exceeds AAA criteria according to IEC 60904-9 ed. 2
Fully integrated and synchronized infrared (IR) camera	IR camera and IV electronics are synchronized so that current measurement and IR image are recorded at the same time
Fully integrated electroluminescence (EL) camera	Micro-crack detection and wafer inspection based on artificial intelligence or grey scale analysis Stabilized EL driving current: 0.1 - 25 A Ready for tandem cells: Integration of second fully integrated EL camera to inspect bottom and top cell simultaneously
Pyrometer	Infrared thermometer optimized for high-speed contactless temperature measurements of solar cells, installed at a recommended working distance of 450 mm with a measuring spot size of 9 mm. Emissivity can be adapted to different cell materials
Cut-Cell-Measurement (CCM)	Simultaneous measurement for up to 3 cut-cells in one single measurement cycle
Grid Resistance	Detects problems with the front silver screen print localized between each busbar
SunsVoc	Fast inline method for measurement of ideal FF without impact from series resistance
Red-Blue-Measurement	Illumination with only blue and red light (or other colors) allows the fast detection of process instabilities

* Optional features may affect some specifications of the standard configuration

SCOPE OF DELIVERY
• Light engine excl. accessories: (L x D x H) 364 mm x 358 mm x 239 mm, 16 kg • I-V electronics: 19" rack mount chassis, 3U • Amplifier: 19" rack mount chassis, 3U • Operating PC: 19" rack mount chassis, 4U • Monitor, keyboard and mouse • Hardware options › Fully integrated infrared camera › Fully integrated electroluminescence camera › Fully integrated rear side LED flasher › Grid resistance › Pyrometer for inline temperature measurement › Uninterrupted power supply (UPS)