

AM1.5G Standard Spectrum Solar Simulator: SS-X

Introduction

Only accurate optical–electrical conversion efficiency testing can drive the positive development of the photovoltaic industry!

In 2020, the international standard IEC 60904–9:2020 " Photovoltaic devices – Part 9: Classification of solar simulator characteristics" released a major update that has implications for both users and manufacturers of solar simulators. The main purpose of this renew is to respond to the increase in demand for high quality solar simulators due to advances in new solar cell materials (perovskite photovoltaics and organic photovoltaics materials) and structures (PERC, HJT, TopCon, tandem).



The new version of the standard has three important key updates:

1. **A+ class:** IEC 60904–9:2020 introduces new class A+ in three indicators including spectral distribution match, irradiance non–uniformity in the test plane and temporal instability of irradiance.
2. **300 nm~1200 nm:** IEC 60904–9:2020 extends spectral evaluation bands of 300nm~400nm and 1100nm~1200nm.
3. **Two new metrics are introduced:** Spectral Coverage (SPC) and Spectral Deviation

Class A+ (A Plus) in spectral distribution (300nm ~ 1200nm; distribution value of 0.875~1.125) is the largest difference in IEC 60904–9:2020 compared to the past decade. It reflects the technical improvement of today's solar simulators. The practical significance is to generate a more accurate spectrum, so that the error of the conversion efficiency testing result of the solar cell can be lower and more accurate.

Spectral Coverage (SPC), one of two new metrics introduced by IEC 60904–9:2020, measures the percent spectral coverage of a solar simulator's spectral output between 300nm and 1200nm. The SPC is specially designed for the emerging LED–type solar simulators. Generally, the SPC coverage of xenon lamp solar simulators can reach 100%.

Another newly introduced metric in IEC 60904–9:2020 is Spectral Deviation (SPD). SPD is the overall indicator to which the overall solar simulator spectrum is above or below the specified AM1.5G spectrum. The closer the SPD is to 0%, the closer it is to the AM1.5G spectrum. The lower SPD value represents the smaller deviation from AM1.5G standard spectrum, which means that the overall error for solar cell conversion efficiency testing results can also be lower.

In response to the latest spectral requirements of IEC 60904–9:2020, Enlitech has launched the SS–X series of AM1.5G Standard Spectrum Solar Simulator. The AM1.5G filter of SS–X Solar Simulators is made with advanced plasma deposition technology for high spectral accuracy and longer lifetime. The spectral rating from 300nm ~1200nm reaches the class A+ (0.875~1.125). The spectral deviation SPD of SS–X solar simulators even reaches 3.3%, which is compatible to the SPD value of the dual–lamp solar simulator. These two new metrics distinguish between "average A" solar simulators and "excellent A+" solar simulators. These two new metrics distinguish between "average A" solar simulators and "excellent A+" solar simulators.

It is also shown that the SS–X simulator provides a wider wavelength range from 300nm to 1200nm, lower errors and more accurate test results when used to test the IV conversion efficiency of novel solar cell materials and structures.

	Spectral Match (300~1200nm)	SPC (100% is ideal)	SPD (0% is ideal)
Dual-lamp simulator (Ideal Case)	A+	100%	3.2%
Dual-lamp simulator (real case)	A+	100%	4~8%
SS-X	A+	100%	3.3%
SS-F5	A	100%	4.4%
US simulator	A	100%	6.7%
JP simulator	A	100%	6.8%

Comparison table of spectral rating, SPC, SPD of various solar simulator brands. The SS-X simulator has the same spectrum performance compared to the ideal dual-lamp solar simulator.

Application

- ◆ Perovskite solar cell PCE testing
- ◆ Organic solar cell PCE testing
- ◆ Perovskite/Si tandem solar cell PCE testing
- ◆ Solar cell ideality factor n testing
- ◆ Sun-Voc testing
- ◆ Water-splitting cell testing
- ◆ HJT, PERC, TopCon Si solar cell testing

Specification / Product Selection Guide

- ◆ SS-X series simulators have A+ spectrum.
- ◆ The SPD is lower than other solar simulators.
- ◆ SS-X is the best single-lamp solar simulator which is closest to the AM1.5G standard spectrum.
- ◆ SS-IRIS: Automatic continuous-variable light intensity control module (option IVS-KA6000 software is required)
- ◆ 4-beam output directions and mechanical light output shutter (standard)
- ◆ Light intensity feedback control module (optional; CI: Constant Intensity; instability<1% over 16 hr.)

Model	Beam Size	Spectral Match	Spatial Uniformity	Light stability	Working distance
SS-X50	50x50 mm ²	A+	A	A+	250 mm
SS-X100R	100x100 mm ²	A+	A	A+	300 mm
SS-X180R	180x180 mm ²	A+	A	A+	500 mm
SS-X200R	200x200 mm ²	A+	A	A+	400 mm
SS-X220R	220x220 mm ²	A+	A	A+	400 mm

Testing Results / Publications

Transition metal-catalysed molecular n-doping of organic semiconductors

Han Guo, Chi-Yuan Yeng, Xianhe Zhang, Alessandro Motta, Kui Feng, Yu Xia, Yongqiang Shi, Ziang Wu, Kun Yang, Jianhua Chen, Qizhan Liao, Yumin Tang, Huijiang Sun, Han Young Woo, Simone Fabiano, Antonio Facchetti & Jürgang Guo

Joule **SS-X Solar Simulator for Efficiency Breakthrough** **CellPress**

Reduced non-radiative charge recombination enables organic photovoltaic cell approaching 19% efficiency

ADVANCED ENERGY MATERIALS

Spontaneous Construction of Multidimensional Heterostructure Enables Enhanced Hole Extraction for Inorganic Perovskite Solar Cells to Exceed 20% Efficiency

Shuang Zhang, Lu Zhang, Qingqun Han, Ning Gu, Yuchen Du, Kai Zhou, Shenghong Fan, Li

15.8% efficiency binary all-small-molecule organic solar cells enabled by a selenophene substituted sematic liquid crystalline donor

Energy & Environmental Science

