AM0 Standard Spectrum Solar Simulator: SS-ZXR

Introduction

With the development of space science and technology, the simulation of sunlight in outer space has formed a crucial issue for further developments of space exploring. The AM0 standard spectrum is defined according to the ASTM standard, which has the following characteristics:

1. Compliant with ASTM AM0 standard spectrum (ASTM E927 – 10)
2. Irradiance intensity up to 1366W/m2
3. Light spatial non-uniformity is smaller than 2%

To provide the AM0 solar simulation, Enlitech utilized the Xenon short arc lamp technology as a broadband light source to simulate AM0 solar light. The color temperature of xenon lamps is 6000K, which is closest to natural sunlight (5500K). The SS-ZXR solar simulator not only uses advanced optical simulation software to simulate the design of the optomechanical system, but also uses Fourier optics technology to generate spatially uniform irradiance.

SS-ZXR solar simulator, its AM0 filter is made with advanced plasma deposition technology, which has higher spectral match and longer lifetime. Better spectral match makes SS-ZXR more suitable than any other simulators for characterizing solar cells for space applications.

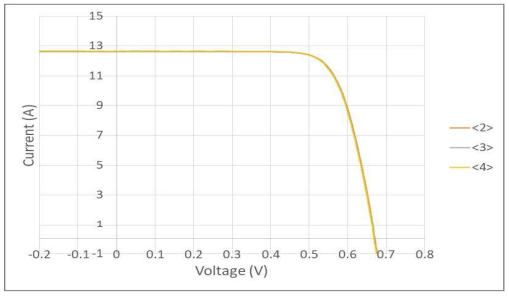
Application

- Silicon solar cell testing for space application
- Organic solar cell testing for space application
- Perovskite solar cell testing for space application
- CPV (Concentrated Photovoltaic) testing
- Solar cell aging experiments for space application

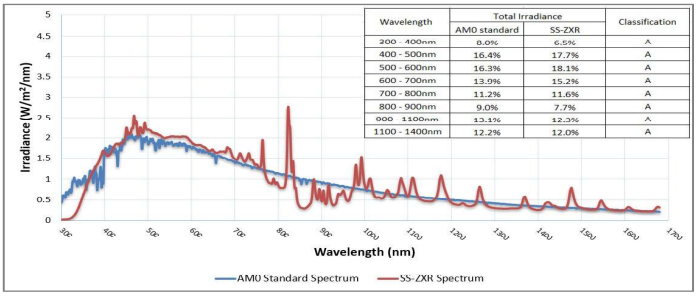
Specification

Model	Beam size
SS-ZXR100	100x100mm²
SS-ZXR160	160x160mm²
SS-ZXR180	180x180mm²

Testing Results / Publications

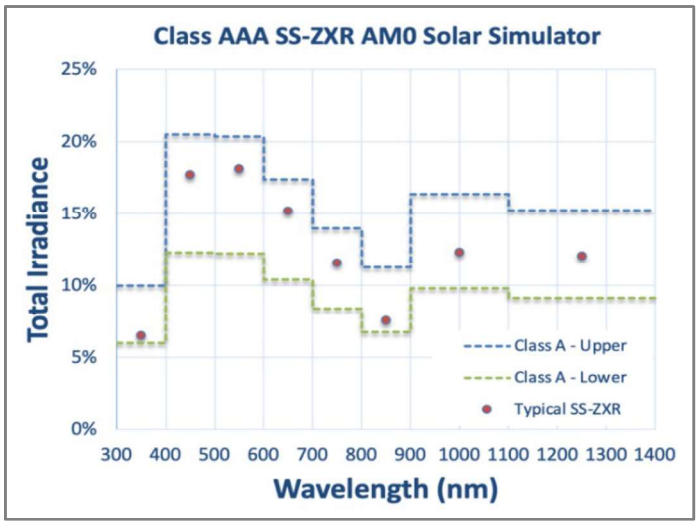


IV curve of crystalline Si solar cell tested by SS-ZXR at AM0 conditions (1366 W/m2)。SS-ZXR has an excellent irradiance instability which makes the high repeatability of testing results (better than 99%).



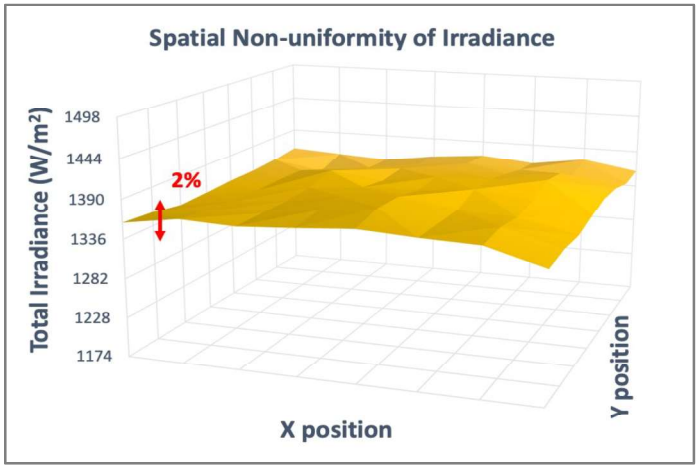
Wavelength	Total Irradiance		Classification
	AM0 standard	SS-ZXR	
200 - 400nm	6.5%	6.5%	A
400 - 500nm	16.4%	17.7%	A
500 - 600nm	16.3%	18.1%	A
600 - 700nm	13.9%	15.2%	A
700 - 800nm	11.2%	11.6%	A
800 - 900nm	9.0%	7.7%	A
900 - 1100nm	13.1%	12.3%	A
1100 - 1400nm	12.2%	12.0%	A

The spectrum and spectral rating of SS-ZXR solar simulator. Comparing to AM0 standard solar spectrum, each band of SS-ZXR reaches class A level.



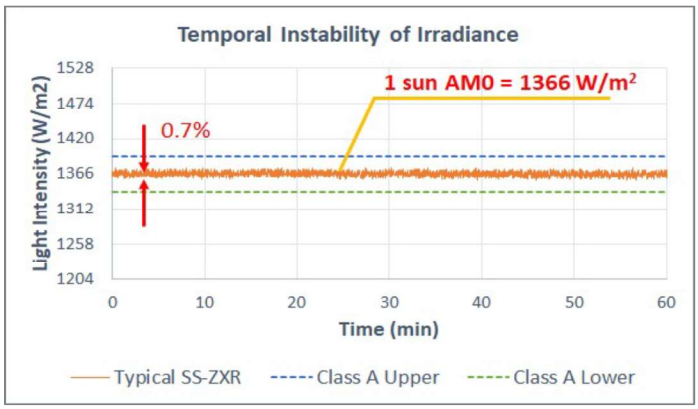
Spectral Rating of SS-ZXR

SS-ZXR spectral rating according to ASTM E927-10 AM0 solar simulator classification standard. The blue dotted line is the upper limit of the class A, and the green dotted line is the lower limit of the class A. The 8 rating wavelength bands of the SS-ZXR fall within the class A.



Spatial non-uniformity of SS-ZXR

Irradiance spatial non-uniformity testing results of SS-ZXR. The non-uniformity results are within 2% which is Class A level according to ASTM E927-10 for AM0 solar simulator classification standard.



Irradiance instability of SS-ZXR

Irradiance intensity instability testing results of SS-ZXR AM0 solar simulator over 60 minutes. The classification of intensity instability of SS-ZXR is class A level, which is smaller than 0.7 %, according to ASTM E927-10 AM0 solar simulator classification standard.

More Information ▶

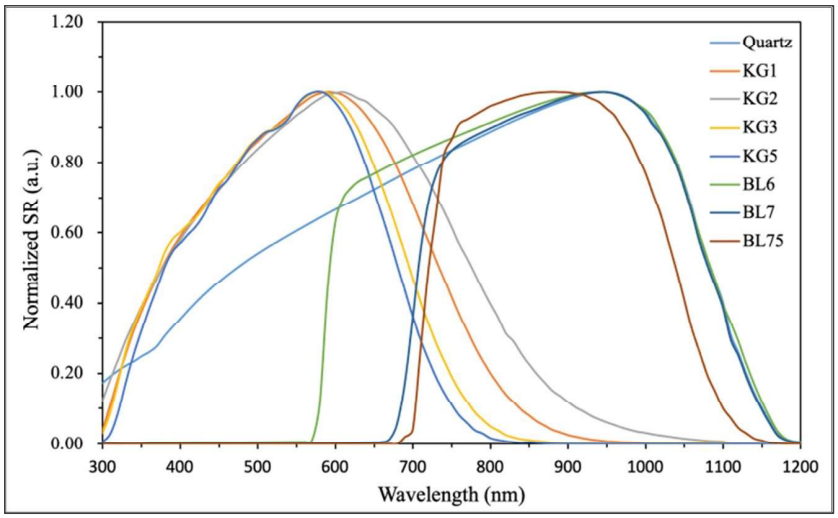
WPVS Reference Cell: SRC-2020

Introduction

Enlitech provides many types of reference cells complied with WPVS type and IEC 60904 standard. The purpose of the reference cells is to calibrate the irradiance of the solar simulator to accurately characterize solar cells performance. To keep up with the rapid development of new types of solar cells, Enlitech's unique filter-embedding technique helps control the reference cell's spectral response to different spectral wavelength ranges. It can reduce the spectral mismatch between the solar simulator and the solar cell.

It is necessary for reference cells to be calibrated and traceable to SI units through ISO/IEC 17025. Enlitech's calibration laboratory is accredited to ISO/IEC 17025 standard. All SRC-2020 series reference cells are calibrated and traceable to NREL or ISE Fraunhofer. Enlitech also offers recalibration services for reference cells. The spectral response curves are shown below.

Each SRC-2020 pack has a silicon solar cell encapsulated with an optical window, two LEMO cables and a certified irradiance calibration report.



Except common quartz and KG windows, SRC-2020 also provide exclusive reference cells for perovskite/Si tandem bottom cells, such as BL6, BL7, and BL75.

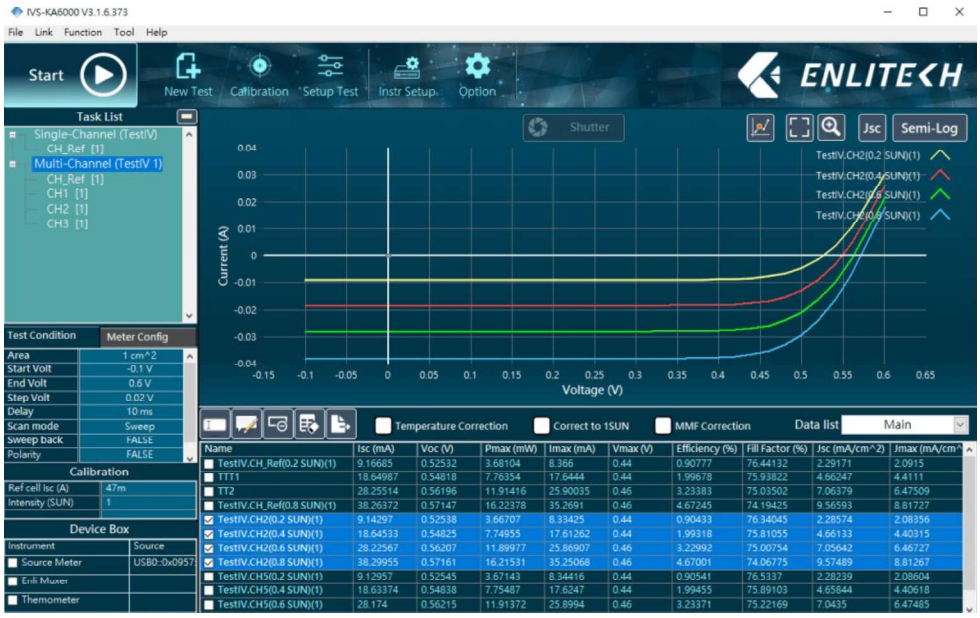
More Information ▶

PV IV testing software: IVS-KA6000

Introduction

The Most Comprehensive IV Measuring and Analysis Software for Perovskite Solar Cells

IVS-KA6000 is a PV current-voltage (IV) testing software developed by Enlitech with over 10 years of experience. The last generation IVS-KA5000 had more than 1000 users in many laboratories around the world. IVS-KA6000 is redesigned and improved on the basis and user feedback. IVS-KA6000 can control a variety of SMUs and collect current and voltage data according to the parameters set by the user. The formulas and algorithms of the IVS-KA6000 are based on the foundation developed and published by NREL.



From the analyzing functions of IVS-KA6000, users can get the details of improving the conversion efficiency of the solar cells. Numerous laboratories adopted IVS-KA6000 consistently break the efficiency records and land on NREL's Efficiency Chart, such as ISCAS's 23.3% perovskite solar cells in 2019, UNIST's 24.8% perovskite solar cells in 2020, and ICCAS's 18% organic solar cells in 2020.

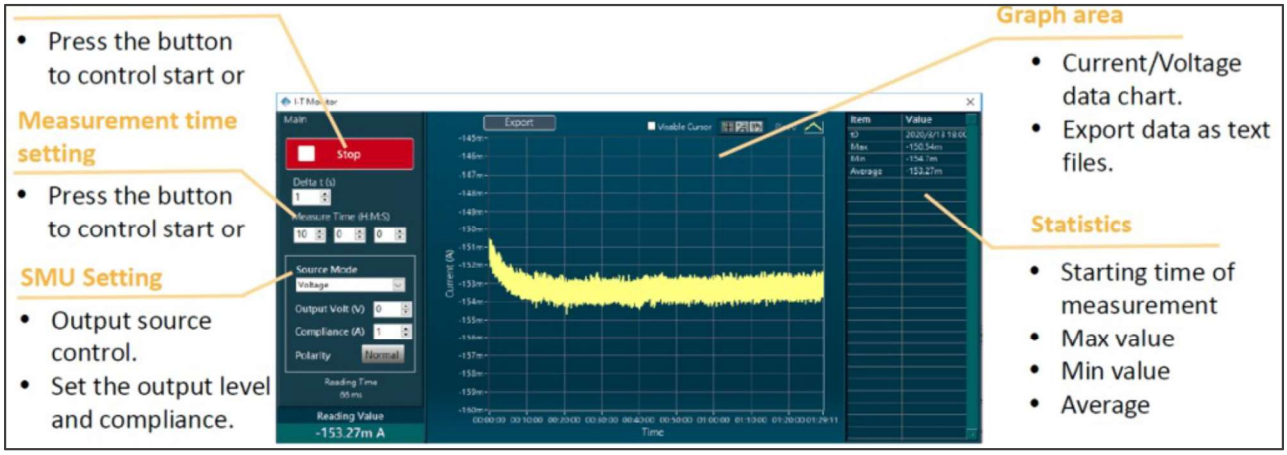
Application

- Measurements: Isc, Voc, Jsc, Jmax, Pmax, Vmax, Imax, η, FF, Rs,Rsh
- Forward scan/ Reverse scan/ Automatic forward and reverse scanning measurement
- Light soaking & MPPT measurement
- I-t, V-t, MPPT tracking function Single-sample multi-sub-cell automatic test
- Real-time correction function according to IEC
- NREL asymptotic measurement

Software Interface

Fig.1 IVS-KA6000 is the most comprehensive IV measuring and analysis software for perovskite solar cells.

IVS-KA6000 software main functions.



I-t (current-time) monitoring function, which can monitor the device current or voltage variation with time.

NREL Asymptotic measurement for perovskite solar cells. IVS-KA6000 has a unique "asymptotic method" test function. The "asymptotic method" has become one of the standard methods for efficiency testing of new solar cells. IVS-KA6000 has a complete "asymptotic method" supporting scheme and automatic program control.

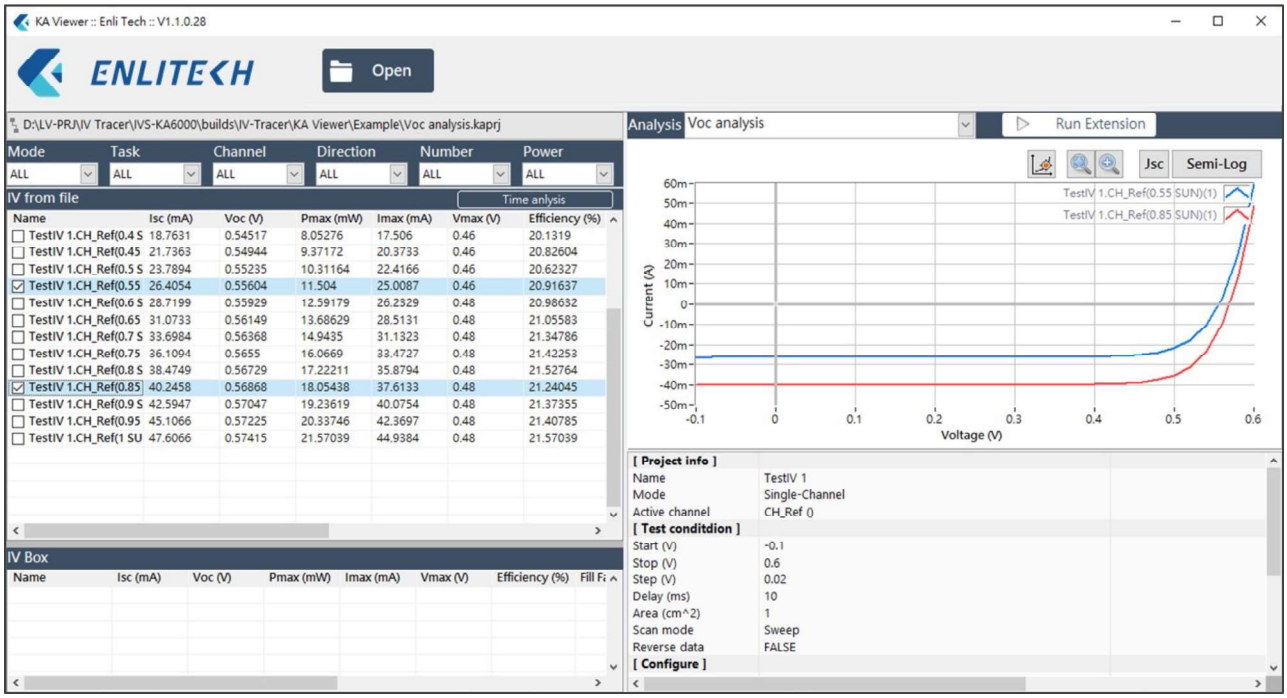
More Information ▶

PV IV analyzing software: KA–Viewer

Introduction

Most Powerful Perovskite IV Measurement Analysis Software

For the study of the IV results of solar cells, KA–Viewer can quickly calculate the IV results and analyze the relevant device parameters according to different testing standards (such as IEC standards) and device physics models. In addition to significantly reducing the user's data processing time, it can speed up the overall manufacturing process improvement timeline.



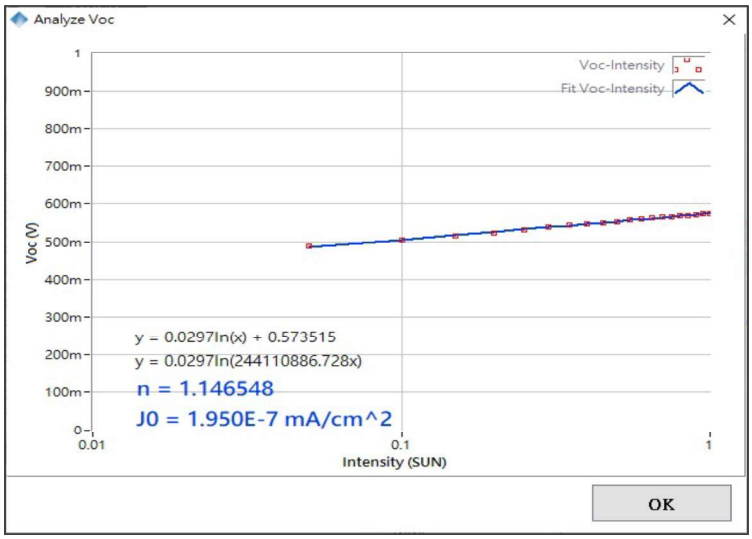
KA–Viewer software screenshot. With data batch management design, KA–Viewer can list the IV raw data and draw/display the IV curve chart. KA–Viewer has a variety of analysis functions, including ideality factor n analysis, reverse saturation current J0 analysis, SCLC fitting, etc., covering the most important device physics parameters required for PV.

Application

- Analyzing ideality factor n
- Reverse saturation current J0
- Spectral Mismatch Factor MMF correction on IV
- SCLC fitting
- One Diode Model Fitting
- Two Diode Model Fitting
- Temperature correction on IV
- 4T tandem solar cell IV calculator

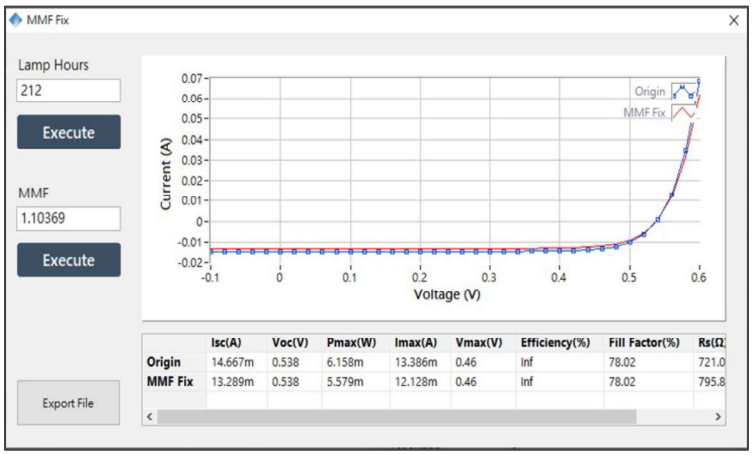
Software Interface

KA–Viewer can load all test data of IVS–KA6000. After the IVS–KA6000 is loaded with the Sun–Voc curve of the SS–X solar simulator with automatic variable light intensity and loaded into the KA–Viewer, the ideality factor n and the reverse saturation current density J0 can be automatically fitted according to the theoretical physical formula of the diode.



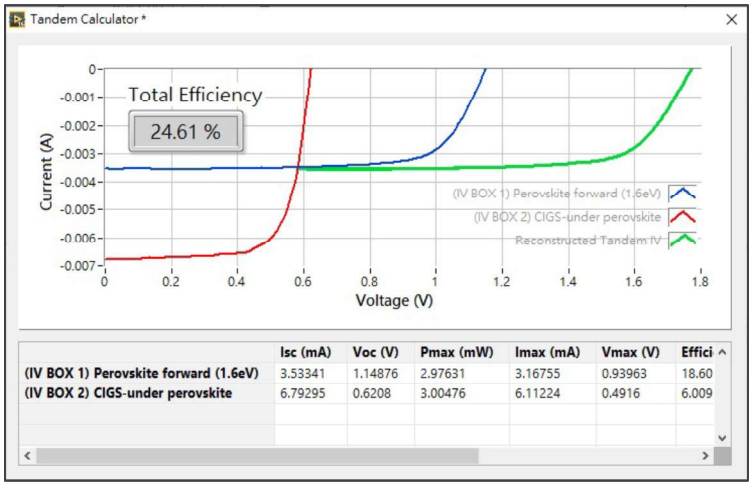
Ideality factor n and J0 analyzing

KA–Viewer can load all IV raw data tested by IVS–KA6000. Ideality factor n and reverse saturation current density J0 can be fitted from Sun–Voc IV curves from device physics model. When combining IVS–KA6000 with Enlitech's SS–X solar simulator, Sun–Voc IV curves under different irradiance levels can be automatically proceeded and tested. After Sun–Voc curves are loaded into KA–Viewer, it can automatically do the fitting and calculation of ideality factor n and J0 based on the theoretical formula of the device diode model.



MMF correction on IV curve

For more accurate characterizing solar cell PCE values, it is necessary to correct the spectral mismatch based on IEC 60904–1 when using the solar simulator to test IV performance. KA–Viewer can automatically correct the spectral mismatch of the IV curve according to the formula of IEC 60904–1. Load the IV raw data tested by IVS–KA6000 into KA–Viewer, activate the spectral mismatch factor correction function, and complete the related correction work with one click.



4T tandem solar cell conversion efficiency calculation from independent IV curves.

The IV curves of top and bottom cells are independent in 4T tandem solar cell device structure. Therefore, the total and final power conversion efficiency of the 4T tandem solar cell needs to be calculated from the independent IV raw data of sub–cells. It can be done by KA–Viewer automatically by a single click as shown in the figure. The total efficiency and the other parameters are delivered at the same time.

More Information ▶