Model CEP-M78-W

Spectral Response Evaluation System for Solar Cell Module Specifications

** The actual system is the system of the standard specifications and the appearance may differ from the photo depending on the specifications.*

** The system configuration and specifications here are subject to change due to the improvement or the manufacturer's discontinuation of the parts or etc. used for the above system.*

BUNKOUKEIKI 分光計器

SPECIFICATION SHEET

Natioal Institute of Solar Energy
Specifications NO. 2021222-1
Type CEP-M78-W
Spectral Response Evaluation System for Solar Cell Module
BUNKOUKEIKI CO., LTD.

1. General view and measurement principles

* The purpose of this unit is to evaluate the characteristic spectral response of solar cell modules.
* Objects are to measure, crystal type and single-junction thin film type solar cells and multi-junction solar cells.
* This units is to measure characteristic of spectral sensitivity and quantum efficiency by irradiating constant photons or constant energy monochromatic light to solar cell.
* There is white bias light source built-in for irradiating white bias light from the different direction at the same time when irradiating monochromatic light..
* Auxiliary bias light source is provided to fully illuminate photovoltaic modules.
* I-V measuring function and of solar spectrum calculation function are provided.
* Control and data processing are done by a personal computer.

2. Calibration

2.1. Monochromatic light calibration

Standard detectors
(1) Spectral response standard Si photodiode
(2) Thermo pile detector

2.2. Calculation the number of photon

Set the considerable number of photon.

$$Np = E * \lambda / (h * C)$$

2.3. Spectral sensitivity calculation

"Spectral sensitivity" formula

$$R = I / E \ (A / W)$$

Light intensity is the product of Spectral irradiance (W/cm^2) and the active area (cm^2).
Photo-current (A) is measured by DC current meter.
AC current measurement: Measure drop voltage of the load resister by Lock-in amplifier. Load resistor is connected to the sample in series.
Lock-in amplifier output is calibrated by DC current meter.
"Quantum efficiency" formula

$$\eta = Ne / Np$$

where ;
Ne: number of electron
Np: number of photon

2.4. White light calibration

We recommend calibrate light intensity by standards solar cells.

3. Measurements

3.1. Spectral sensitivity characteristics measured by constant-energy irradiation

By adjusting light intensity by means of continuous density variable ND filter, the light with constant energy can be irradiated to the sample.
Sample's spectral response is calculated from irradiated light intensity and measured photo current. At that time, setting the bias voltage is possible.

3.2. Quantum efficiency characteristic by constant photon irradiate

By adjusting light intensity by continuous density variable ND filter, the light with constant photon can be irradiated to the sample.
Quantum efficiency of samples is calculated by photocurrent and light intensity.
At that time, setting the bias voltage is possible.

3.3. Photovoltaic I-V characteristics measurement

Cell's characteristics are measured by white light.

3.4. Solar spectrum calculation

From the integration of quantum efficiency and integration of solar spectrum, short-circuit current density (Jsc) is calculated.

3.5. Real-time monitoring function

It is possible to display the measured value at specified wave length (spectral response or quantum efficiency) in real time.

3.6. Correction factor measurement

By placing a power meter at sample position, save spectral sensitivity of monitor detector as a correction factor.

4. Specifications

Unit is constructed preventing affection of vibration and sound caused by wind or air conditioner.

4.1. Sample module

Maximum size	2.1 × 1.3 × 0.1 m
Maximum weight	20 kg
Structure	Aluminum frame, stainless steel plate

4.2. Sample table

Installation of the module: Horizontal
Irradiation light source rack can move left to right
Module mounted rack can move fore and aft
Range of movement is more than half of the panel

4.3. Monochromatic light

Range of measured wavelength	300 ~ 1350 nm （50 μ W/cm^2）
Light source	300W xenon lamp
Optical system	Wavelength vertical direction correction optical system (Patent 3393377)
Irradiated area	50 × 50 mm^2
Non-uniformity of monochromatic light	± 3.0% (visible area)
	The effects of bias light returned from the sample are minimized
Light intensity	50 (μ W/cm^2)
	1e14 (photons / cm^2 sec)
Constant intensity	± 2% (full wavelength area)
Intensity stability and Repeatability	± 0.5%
	Repeatability is defined dispersion of Jsc of 3 times of SiPD measurement.
Light intensity control system	Real time monitoring method
Wavelength purity	approximately 20 nm (the monochromator slit width 3.3 mm)
Grating monochromator	Focal length 250mm
Optical system:	Asymmetric deformation Czerny-Turner mount
	Aperture ratio F = 4.3
	Reciprocal linear dispersion approximately 6 (nm/mm)
	Wavelength accuracy ± 1 nm
	① 600 grooves / mm 300nm blaze MgF2 coated
	② 600 grooves / mm 750nm blaze MgF2 coated
	③ 600 grooves / mm 1600nm blaze MgF2 coated
Automatic grating selection	
Wavelength scan drive	
Shutter	Electronic
Irradiation angle	0 °
Monochromatic light	① Direct-current light
	② Chopping light
Variable frequency chopper	Stop at the through position automatically.
Frequency range	1 ~ 100 Hz Variable

Table of optical element set

Wavelength (nm)	300	360	530	670	720	1210	1650
Light source	Xenon Lamp						
Gratings	600/300 nm		600/750 nm			600/1600 nm	
Filter	U-340	HA30	Y-48	PB	R-66	S-1.1	
Monitor detector	SiPD/InGaAsPD						

4.4. Bias light for measurement PV cells

Irradiated area	50 × 50mm^2 or more
Intensity	Typical 90 mW/cm^2 (proximate AM1.5G)
Spectral matching specification	based on JISC8912 and JISC8933
Grade of spectral match	Class A
Light source	300W xenon lamp
Light irradiation	Direct-current light
Control method	Constant light intensity control system
Light intensity stability, repeatability	within ± 1.0%
Uniformity	± 3.0%
Irradiate angle	20°
Shutter	Solenoid
Filter holder	50 × 50 × t3mm 4 sheets filter can be held Filters easily replaceable.
Air mass filter	AM1.5G type filter

White light intensity automatic selecting mechanism

Rotary type automatic mechanism : 4 stage
ND filter for white bias light intensity selecting
can be incorporated.

Light intensity selecting ND Filter

To be incorporated on white light bias light strength automatic
Fixed ND Filter UV reflective type : ϕ 50 (+0 / -0.1) × t2 mm
Transmittance 50%, 10%, 1%

Color filter automatic selecting mechanism

: Possible to irradiate color bias light for measuring multi-junction solar cell.

Method: slide type automatic selecting mechanism
4 systems
4 filters (50 × 50 × t3mm) can be held for each position.
Filters can be replaced easily.
Equip air cooling to prevent thermal destruction of filters.

4.5. Bias light for non-measuring cells

Light source	Halogen lamp	
	Rating	12V 50W
	Average life time	2000 (Hours)
	Quantity of lamp	80 pcs : 4 rows × 20 lamps
	Radiation angle	30 degree (adjustable)
	Shutter	not equipped.(lights off when lamp power is turned off)
	Cooling of lamp	Forced air cooling system by fans

Lights power supply	direct current power supply
	Maximum output power 1500W
	(0-15 V, 0-100 A)
	Inlet AC100-240V
Quantity of power supply	4 sets

4.6. Sample

Large sample chamber corresponding solar cell module

Move a module manually.

Place sample horizontally : Light from top of the sample

Platform for a module

Cooling from the bottom of the module by connecting an external cooling fan unit

Top surface aperture	ϕ 8mm holes, Diagonally pitch 35mm
Hermetic structure	Install diaphragm inside for even flow of the wind
Thickness of platform	100mm
Fan inlet	ϕ 50mm
Electromagnetic shield	Steel plates, which are effective to electromagnetic shield

Sample chamber to measure standard solar cell

Automatic XY sample stage

Travel	50 mm x 50 mm
Laser marker	Check height of the sample
Focus 140 mm	Above sub-base
Sub-base mount	Replace following units

4.7. Standard Detector

Si photodiode

Type	Silicon / InGaAs Photo diode
Wavelength range	300 ~ 1700nm

Thermocouple temperature sensor (T type)

Detector is included in the socket

Cooling water circulating structure package

For re-calibration of the Si photodiode, socket mount is adopted.

4.8. Shunt resister

(1) 0.1Ω ± 0.5%	± 30ppm / ℃ 1.5Wmax	PC detects shunt resister value.
(2) 1Ω ± 0.5%	± 30ppm / ℃ 1.5Wmax	PC detects shunt resister value.
(3) Open	PV equip shunt resister	Input equip shunt resister value.

4.9. Source Meter

Source-meter

Bipolar power supply is possible to sink and source photo current.

DC Measure

DC current can be measured under apply voltage

30.3W capacity

Voltage, current	± 20.2V / ± 1.5 A

4.10. Lock-in amplifier

AC Measured

4.11. Uniformity tester

Automatic measurement of white light and monochromatic light
XY stage travel range 50 mm x 50 mm
Minimum measurement interval 1mm
Positioning accuracy within 30μm
Si detector (with a mask to measure uniformity)
Wavelength range 300 ~ 1100nm
InGaAs detector (with a mask to measure uniformity)
Wavelength range 1100 ~ 1700nm

4.12. Measurement and Control Software

- ○ AC and DC measurement method
- ○ Measurement of spectral sensitivity characteristic by constant energy irradiation
  Irradiate constant energy monochromatic light without wavelength characteristics after adjusting light intensity by density variable ND filter.
  Calculate the spectral response of the sample from the measured photocurrent and light intensity.
  Bias voltage can be set.
- ○ Quantum efficiency characteristics of PV cells measurement by irradiation of constant photon.
  Adjust light intensity by density variable ND filter, irradiate constant energy without wavelength characteristics.
  Calculate the spectral response of the sample from the measured photocurrent and light intensity.
  Bias voltage can be set.
- ○ Solar spectrum operations
  From the product of solar spectrum and quantum efficiency short circuit current density is calculated.
- ○ Solar electric characteristic measurement: I-V characteristics measurement
  Cell characteristics are measured by white light.
  Set the voltage range and measure the DC current voltage.
  Open circuit voltage, short circuit current, fill factor, and efficiency are measures.
- ○ I-V characteristics measurement under monochromatic light
  Cell characteristics are measured by monochromatic light.
  By setting Irradiation wavelength, light intensity and applied voltage, photocurrent is measured.
- ○ Real-time monitoring
  Measurement results can be displayed in a spot measurement conditions.
- ○ Measure correction factor
  Place a standard detector without wavelength characteristics at the place of sample to calculate spectral sensitivity of control detector.

4.13. Save results

Text data format, Comma-separated value (csv)

Kind of measurement	Saved items	common item to be saved
Spectral response	Wavelength and signal	Date, time, name of sample, comments and measuring parameters
I - V	Current and voltage	Date, time, name of sample, comments and measuring parameters
Non-Uniformity	X-Y Position and signal	Date, time, name of sample, comments and measuring parameters

4.14. Control PC

Miniature tower type
LCD display
Windows 10 operating system, English version
Computer rack

4.15. Dimensions

① Main body 3300 (width) × 1800 (depth) × 1900 (height) mm
② Computer rack 670 (width) × 650 (depth) × 1350 (height) mm

4.16. Weight

①Main body approximately 1,000 Kg
②Computer rack approximately 30 Kg

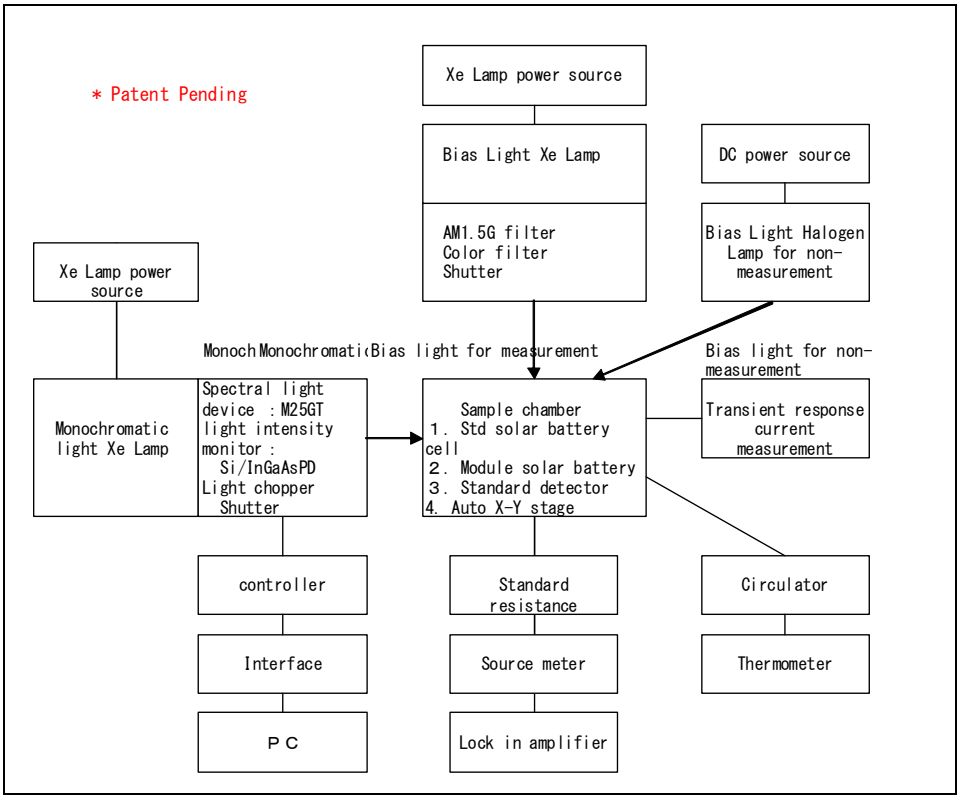
4.19. Utilities

Power 3-phase AC 230V 20A, 50Hz

1-phase	Voltage convert transformer (Convert AC230V to AC100V)
2 -phase	Bias light power for non -measuring cell
3 -phase	Bias light power for non -measuring cell

Breakers and input terminals are equipped each phase.

5. Block Diagram



6. Configuration

<Monochromatic light>

Fast scanning and broadband type monochromator, 3 automatic gratings.
Xe lamp 300W, ellipsoid reflector, Xe lamp power supply.
Light source collector optics, automatic shutter mechanism
Light intensity control detector
Automatic variable neutral density filter
Variable chopper DC / 1 ~ 100Hz
Electronic control unit
Optics for sample beam

<Bias light for measurement PV cells>

Xe lamp 300W, ellipsoid type reflector mirror, Xe lamp power supply
Optics white bias, AM-1.5 filter, automatic shutter mechanism
Automatic switching mechanism of white bias light intensity darken, ND Filters
Color filter automatic switching mechanism

<Bias light for non-measurement PV cells>

Halogen lamp with reflector 50W, lamp holder, frame (for cooling blowers)
Halogen lamp power supply

<Sample chamber, rack, standard detector>

Cell mount stand for package cell (WPVS type)
Cell-holder for package cell type Si detector
Si detector, InGaAs detector to measure uniformity of light
XY automatic stage
Digital thermometer (YEW)
4CH type Digital thermometer for module cells
Signal switch unit , Standard resister , signal cable
Rack (sample chamber, light source movement mechanism)
Standard solar modules

< System control / Measurement / Data processing >

Lock-in amplifier
Source-meter
Interface Unit
Desktop type computer
USB type GP-IB Interface
Computer rack
Control Software (include bias voltage calculate software)
Voltage transformer