

Solar Reference Cells



Abet Technologies Model 15150 Reference Cell

Quantitative Metrology

All solar simulators are subject to output variations with time due to component aging. Reference cells need to be used to allow both the initial system setting and later the maintenance of irradiance levels. Abet Technologies offers an array of reference cell models to match your metrology needs and budget.

Convenient

Standard models provide current output allowing the use of I_{sc} as the irradiance level indicator. Those models also allow a complete four wire PV IV curve generation. Your PV IV system check can be performed by comparing your lab collected data with that included with the reference cell calibration documentation.

Shunted models include a high stability 1Ω shunt resistor converting reference cell current to a voltage output for easy measurement with any voltmeter. You cannot use the shunted models to obtain an IV curve.

- Traceable to NIST, NREL, Fraunhofer ISE and ISPRA standard artifacts
- Calibration accuracy established through international comparisons
- Spectral mismatch minimizing selection of C-Si, KGx filters, GaAs, and triple junction InGaP, InGaAs, Ge cells
- Low cost models for entry level calibrated metrology

Spectral mismatch

No solar simulator provides 100% spectral match to the standard spectrum. Therefore all efficiency measurements include some spectral mismatch induced errors. Correcting for those errors can be accomplished in two ways. One can measure quantum efficiency of the device under test (DUT) and the reference cell as well as measure the spectral irradiance of the solar simulator (a rather extensive set of measurements). Else, a simpler way is to use a reference cell with spectral characteristics close to the DUT.

Reference cell to DUT matching

Use standard Si reference cell for Mono-crystalline Silicon, Multi-crystalline Si, CIGS

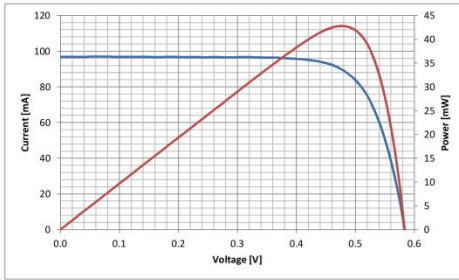
Use Si reference cell filtered with KG1, KG2, KG3, or KG5 for Amorphous Si (a-Si), Dye sensitized cells

Use GaAs reference cell for Gallium Arsenide (GaAs), Cadmium Telluride (CdTe)

Silicon and GaAs Reference Cells

ABET TECHNOLOGIES
Function Focused Innovation™
ABET TECHNOLOGIES, INC.
168 Old Gate Lane
Milford, Connecticut 06460

Device Code: RR-109-O Irradiance: 1000 W/m²
Date: 10-Mar-11 2:06 PM Spectrum: AM1.5G
Reference: PVM199 Temperature: 24.4 °C
Area: 4 cm² Corrected to STC: Yes



I_{sc}	96.8 mA	J_{sc}	24.2 mA/cm ²
V_{oc}	584 mV	I_{mpp}	89.8 mA
FF	75.7 %	V_{mpp}	476 mV
Eta	10.7 %		

Source: Abet Technologies Solar Simulator
Load: Keithley 2400
Temperature: Pt100
Software: ReRa Tracer
Contact calibration lab for error analysis

Approved:

E. Haverkamp

Sample calibration report for a Model 15150 Solar Reference Cell

Spectral Calibration option

A Relative Spectral Calibration option is available for all the 15150 and 15155 Reference Cell models to assist in Spectral Mismatch determination and correction.

Electrical connections

The reference cell mounts are equipped with two LEMO ERA.0S.304.CLL connectors. One of those brings out the four wire output and sense from the cell. The other serves as a Pt100 sensor connection. A 2 m long, 4 mm banana plug terminated cable is provided for cell output connection. A matching LEMO connector is provided to allow making of the Pt100 sensor connection.

Note: For shunted cells only I_{sc} (or its equivalent output voltage) is measured and reported.

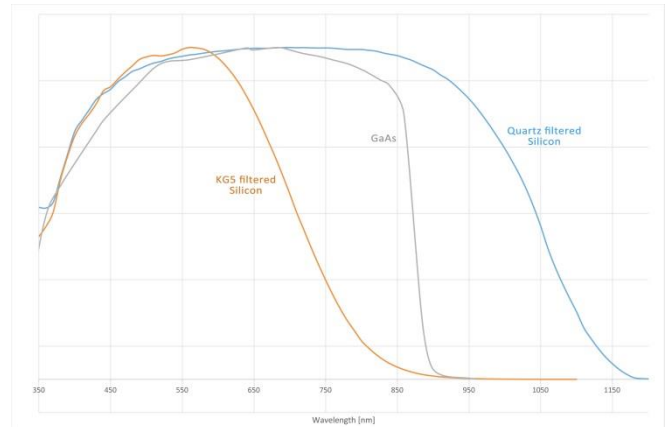
Specifications

Si and GaAs Reference cells

Solar cell.....Mono-crystalline Si or GaAs
Solar cell area.....4 cm²
Window.....Fused Silica
Calibration conditions.....1000 Wm⁻²
AM 1.5G, 25°C
Parameters reported..... I_{sc} , V_{oc} , I_{mpp} , V_{mpp}
FF, efficiency
Uncertainty in I_{sc}±3%
Temperature sensor.....4 wire Pt100
Typical I_{sc} Si.....125 mA
 GaAs.....100 mA

Model 15150-KG5 models ships with a KG5 window. The calibration uncertainty in I_{sc} for the KG-5 filtered cells is also +/-3%.

Other filter options available – please consult with Abet.

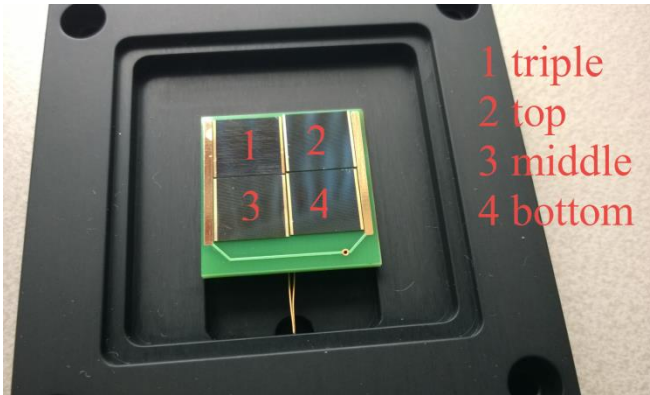


Typical quantum efficiency curves

WPVS Compatible Mount

The full featured Abet 15150 series of reference cells comply with the 62x62 mm WPVS standard dimensions to allow easy intercomparison of different devices. Overall dimensions 105 x 74 x 16 mm.

Triple Junction Reference Cells



Abet Technologies Model 15152 Reference Cell

Triple junction cell metrology

Multi-Junction solar cell metrology is more complicated than that of a single junction one. As these cells are made of multiple layers, a multi-source/LED solar simulator is usually employed to allow adjustment of band to band irradiance ratios. Our triple junction reference cells can be used to set the correct irradiance for each single junction.

Specifications

InGaP/InGaAs/Ge Cells

Solar cell area.....	4 x 1 cm ²
Window.....	Fused Silica
Calibration conditions.....	1000 Wm ⁻² AM 1.5G, 25°C
Parameter reported for each component cell	I _{sc}
Uncertainty in I _{sc}	±3%
Temperature sensor.....	4 wire Pt100
Typical I _{sc}	InGaP: 15 mA InGaAs: 15mA Ge: 25 mA

Connectors:

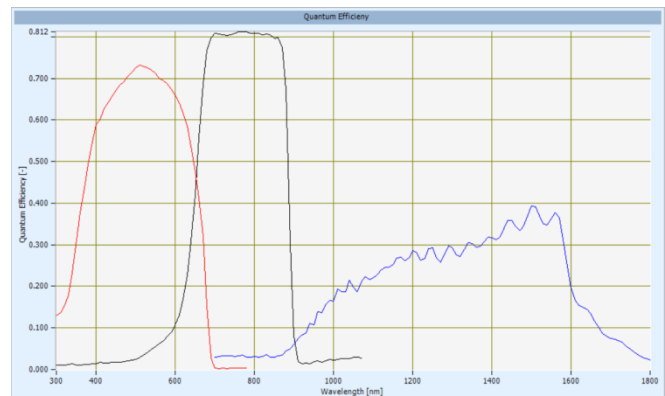
Triple junction:	LEMO ERA.0S.304.CLL
Component Cells:	LEMO EGG.1B.306
Pt100 (4 wire):	LEMO ERA.0S.304.CLL

Construction

The device consists of 4 x 1cm² cells mounted in an area of 2x2 cm. Calibration data is provided for the three (3) individual component cells. A component cell is a single junction cell but then made exactly the same as the triple junction cell. So each component cell has three layers, where only one layer is electrically active.

Example

The 'middle' component cell consists of a layer of InGaP (top), InGaAs (middle) and Ge (bottom). Only the InGaAs is made electrically active, so you measure a single junction InGaAs cell. Since there is an (inactive) InGaP cell on top, the blue part of the spectrum is filtered. This results in a different spectral response for the InGaAs cell. This allows you to measure what the InGaAs cell would 'see' in the stack of a normal triple junction cell while avoiding current limiting contributions of the other layers.



Typical quantum efficiency of individual cells

Note: Component cells are shunted - only I_{sc} (or its equivalent output voltage) is measured and reported. A six wire cable for the component cells and a four wire one for triple junction cell are included. A LEMO connector is included for Pt100 wiring.

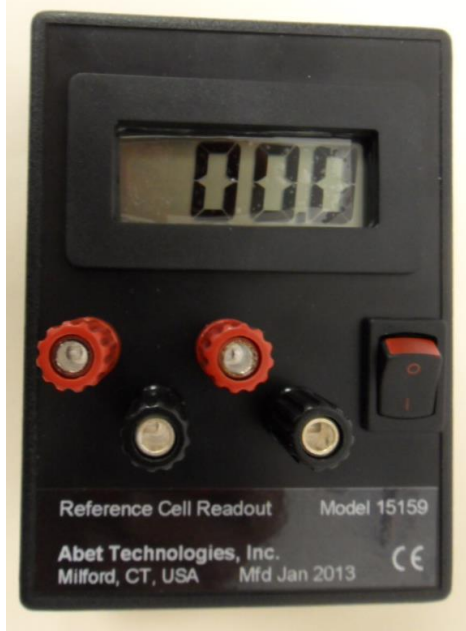
Using the solar reference cells

Model 15150 series reference cells without a shunt can be utilized using the PV-IV curve tracer electronics. They can also be used in a standalone mode using a low input impedance current meter like Abet Technologies Model 15159 Calibrated Readout. Four wires are attached to the sensor to make 4-point measurements possible. These wires are terminated with banana connectors (two red and two black). The Pt100 temperature sensor is connected by means of 4 wires. Any 4-wire capable Pt100 readout device can be used to measure the temperature.

Calibrated Readout

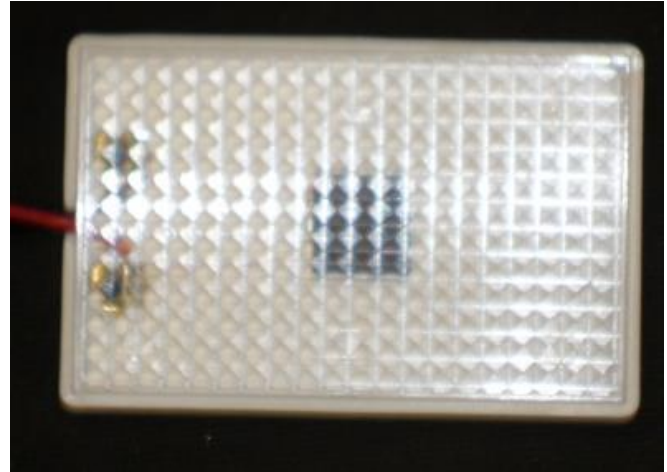
Model 15159 Calibrated Readout can be calibrated for a particular Model 15150 reference cell to display 100.0 when the cell is exposed to one AM 1.5G sun irradiance. It can also be shipped calibrated to offer 1.0 Ohm input impedance and be then usable with a number of different cells, displaying their calibrated I_{sc} at one sun irradiance conditions.

Please note that unless the cell and readout are calibrated together there will be a slight systematic error introduced due the readout voltage burden moving cell operating point away from the short circuit condition.



Abet Technologies Model 15159 Calibrated Readout

Low Cost Reference Cell



Abet Technologies Model 15151 Reference Cell

Model 15151 reference cells offer an entry level means for calibrated solar cell metrology. Each 10x10 mm cell comes calibrated to deliver 100 mV output at one AM 1.5G sun which can be easily read with any voltmeter. Calibration accuracy is 6% at the time of shipment. Enclosure size is 55x36x7 mm. Model 15151-KG5 cells add a KG5 window to more closely match spectral response of amorphous Silicon and Dye Sensitized Cells. Calibration accuracy is 8% at the time of shipment.

Relative responsivity data option is not available for the 15151 family of cells.

Ordering Information

15150	Si Reference Cell, 20x20 mm
15150 S	Si Reference Cell, 20x20 mm, shunted
15150-KG5	Reference Cell, 20x20 mm, KG5 filter window
15151	Low cost Si reference cell, 10x10 mm
15151-KG5	Low cost reference cell, 10x10 mm, KG5 filter
15152	Triple Junction Reference Cell, 4 x 10x10 mm
15155	GaAs Reference Cell, 20x20 mm
15153	Spectral Response Calibration, Triple Junction
15154	Spectral Response Calibration, Si or GaAs
15159	Calibrated reference cell readout

Add "S" to any reference cell model number for shunted version.

Add "-KGx" to any reference cell model number to replace fused silica window with a KG1, KG2, KG3, or KG5 filter. Other filter options available on request.

Abet Technologies regularly continues to upgrade our products, therefore all specifications are subject to change without notice.