Model 91150V

Oriel PV Reference Cell System

User's Manual

Oriel® Instruments

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M91150V REV: A, 12/3/2021

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Please read these instructions completely before operating this equipment. The specification and operating instructions apply only to the model(s) covered by this manual. If this equipment is used in a manner which is not specified, the protection provided may be impaired. If there are any questions or problems regarding the use of this equipment, please contact Oriel Instruments or the representative from whom the equipment was purchased

1 INTRODUCTION

This manual covers the setup and operation of the Oriel Instruments PV Reference Cell System model 91150V. The PV Reference Cell System is comprised of a reference cell meter and a reference cell.

The Oriel Reference Cell consists of a 2cm x 2cm Monocrystalline Silicon Photovoltaic Cell and a Type K thermocouple assembled into an aluminum housing in accordance with IEC 60904-2. Calibration data is recorded on an accompanying certificate from Newport Corporation's PV Lab (North Logan, UT), an ISO/IEC 17025 accredited photovoltaic calibration and test laboratory, which performs the measurements in accordance with the ASTM E948 and E1021 standard methods developed and used by the United States National Renewable Energy Laboratory (NREL).

The Oriel Reference Cell Meter is calibrated to the short-circuit current (I_{SC}) of its paired reference cell to read out irradiance from a solar simulator in units of "SUNS". Solar simulator output of 1000W/m² (with the reference cell held at 25 ºC) with Air Mass 1.5 Global (AM 1.5G) spectral filtering is equivalent to one "SUN".

The primary application is for setting the irradiance level of a solar simulator near to 1.0000 SUNS in order to test photovoltaic cells under standard reporting conditions. It may also be used to measure the irradiance of the sun under various angular and atmospheric conditions. Portability is only limited by the availability of an external 8- 15VDC, 0.5A power source.

1.1 UNPACKING THE ORIEL PV REFERENCE CELL SYSTEM

Each Newport Oriel PV Reference Cell System consists of:

- PN 91150-2000: PV Reference Cell Meter
- PN 90034568: PV Reference Cell with integral Type K thermocouple
- PN 90021927: Signal cable to connect the reference cell to the reference cell meter
- PN 90021928: Thermocouple cable to connect the reference cell to the reference cell meter
- PN 91150V-CBL: Signal cable to connect the reference cell to a Keithley source meter
- PN 27-20-074: AC power adaptor, 90 – 264VAC 50/60Hz In, 10VDC 1.5A Out with appropriate AC power cord based on geographic location
- Calibration certificate for the Reference Cell from Newport Corporation's accredited calibration lab

2 SETTING UP THE REFERENCE CELL METER

The Reference Cell Meter may be placed in an area within easy reach for operation of the Sun / ºC switch and viewing of the LCD. It should be close enough to the reference cell that its cables can reach the test area, but preferably removed from major sources of heat, other than the solar simulator lamp.

Inspect the reference cell, ensuring the serial number located on a label on one of its sides matches the serial number on the back of the meter. Locate the reference cell in the test area within the same plane as the device under test, and slightly off-center relative to the Solar Simulator output lens, but still within the area of the irradiance spatial uniformity class definition. Setting the solar simulator irradiance with the reference cell centered under the output lens may contribute to systematic errors in the subsequent measurements due to discrepancies between secondary reflection contributions to I_{sc} between the reference cell and the device-under-test (DUT). Plug the reference cell cable 90021927 into the "I-V" connector on the reference cell and the keyed connector on the back of the meter labeled "REF CELL", screwing it securely into place. Plug the thermocouple cable into the keyed connector on the back of the meter labeled "TEMP IN TYPE K" and the other end to the TC-K connector on the Reference Cell. See Figure 1 for meter connections.

Plug the enclosed AC adaptor (90-264VAC IN, 10VDC 1.5A OUT) into the power jack on the back panel labeled "10VDC 1.5A IN", and then into an AC outlet.

There are analog output BNC jacks available for external voltmeter or oscilloscope monitoring, or for data logging purposes.

The Reference Cell Meter is now ready to operate.

Figure 1: Connections made to the back of the meter

3 OPERATION

3.1 WITH A SOLAR SIMULATOR

Turn on the Reference Cell Meter. With the solar simulator off, check the reading in SUNS. It should be a low reading (typically below 0.0030 in a normally lit room). Switch to read the temperature. It should read room temperature, provided the reference cell has been allowed to stabilize sufficiently.

Turn on the solar simulator as well as its power supply, but with the shutter closed. The power supply should be in Constant Power regulation mode. Press “LAMP ON” and note the time.

After a few minutes of warm-up, open the shutter to make a preliminary adjustment of the Lamp Power level. Press and hold “SET/ENTER” until the display has a flashing digit. Press the ▲ and ▼ buttons to adjust the irradiance level as read on the reference cell meter to as close to 1.0000 SUN as possible. It is not unusual for the readings to vary within a 0.0020 SUN range over a few seconds. You may average a few readings to improve the measurement accuracy. Alternatively, a Model 68951 Digital Exposure Controller may be implemented to reduce this variance by roughly a factor of 10.

The reference cell temperature should be 25 ºC ±1.0 ºC for optimum accuracy. Switch to read the temperature in order to confirm this. The reference cell temperature coefficient may be applied at temperatures outside of this standard range to improve accuracy.

Close the shutter and wait for the lamp output to stabilize. An hour of warm-up time is generally recommended, with lamp power adjustment made as needed during this period.

After the lamp has properly stabilized at the optimum lamp power adjustment, read “SUNS” and record. Taking an average of multiple readings within the temperature range of 25 ºC ±1.0 ºC will provide a more accurate result.

To minimize error, the surfaces outside of the reference cell that are exposed to incident solar simulator light should have low reflectivity to minimize the amount of indirect light finding its way into the reference cell. The same goal applies to the setup of the test device (DUT). Ideally, both the reference cell and the DUT should have a similar (minimal) amount of stray light contributing to their illumination, and lie within the same plane perpendicular to the solar simulator axis. The DUT characterization should be performed with the device at the same x-y location in the solar simulator irradiance profile.

3.2 WITH THE SUN

The reference cell and mating meter may be used to measure the irradiance of the sun, in units relative to solar output under conditions of 1000W / m² at 25 ºC and AM 1.5G. Deviation from these standard conditions reduces accuracy.

IEC 60904-2 recommends the following conditions of natural sunlight for accurate results:

- Clear, sunny weather, with the diffuse irradiance not greater than 25% of global irradiance.
- No observable cloud formations within the 30º half-angle cone surrounding the sun.
- Total irradiance (sun + sky + ground reflection) not less than 800 W / m^2.
- Air mass between AM1 and AM2.
- Radiation sufficiently stable so that the variation in reading is less than ±0.5% over the time taken for a measurement.

Outdoor use is allowed on a temporary basis, as the system is not suited for exposure to the elements.

3.3 WITH I-V CHARACTERIZATION SOFTWARE

The reference cell may be connected to a Keithley 2400 Series Source Meter Unit (SMU) utilizing an adaptor cable accessory, **91150V-CBL**. This cable inserts a 10 ohm current limiting resistor in series with the current sourcing loop, which also prevents oscillation. Newport Oriel PVIV software (PN **91540**) can be utilized to check the I-V curve, and other parameters such as V_{oc}, I_{sc}, Fill Factor, P_{max}, I_{max}, and V_{max}. The SMU can also be used manually in current sourcing mode, sensed at the 0 Volt operating point. In both configurations, taking an average of multiple readings within the temperature range of 25 ºC ± 1.0 ºC will provide more accurate results.

Figure 2: Cable 91150V-CBL

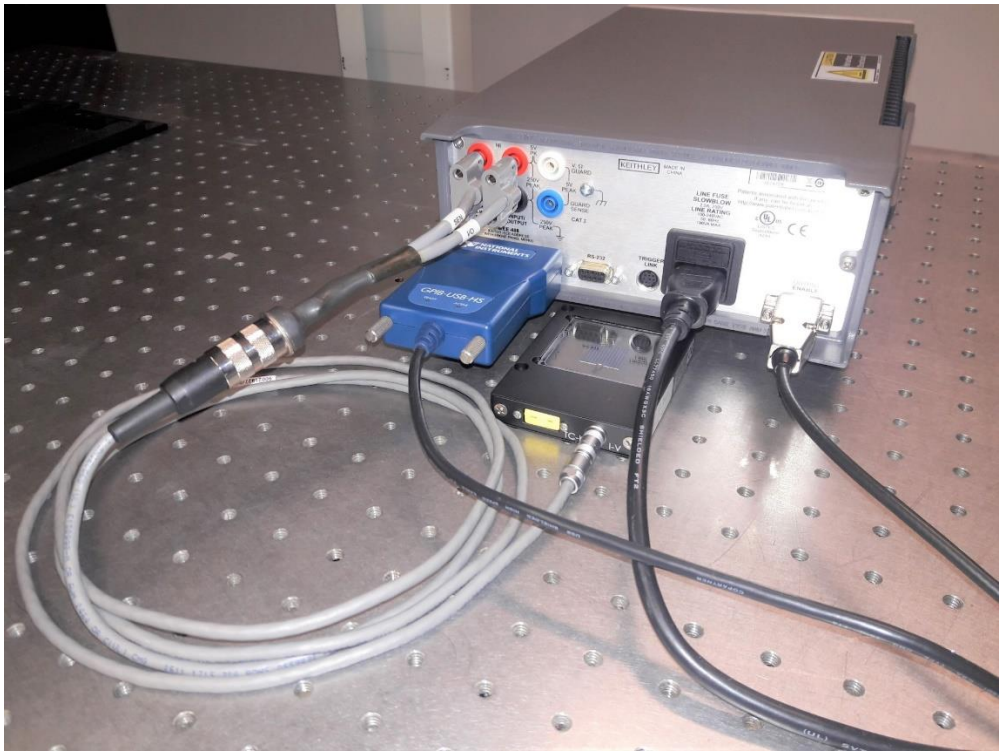


Figure 3: 91150V-CBL connections to the rear of a Keithley 2400 Series Source Meter

4 ROUTINE MAINTENANCE

The protective quartz cover glass may be wiped with lens tissue as required. If necessary, a small amount of water or alcohol may be used on the window itself, but take care not to have it enter the gap between the window and the aluminum block.

It is recommended that the Oriel reference cell be recertified annually, and the Oriel reference cell meter must be recalibrated to work accurately with these new parameters. Contact the Oriel Sales team of Newport Corp. for logistics and pricing details.

It is also recommended that the calibration of reference cell systems in frequent use be cross checked at intervals of no more than one month by comparing their readings. If there is a change in the current ratios beyond ±1%, the cells and mating meters should be recalibrated.

5 TROUBLESHOOTING

The following table may be used to help resolve operational problems:

PROBLEM	POSSIBLE CAUSE	ACTION
No meter reading, display blank	No power	Check that the power switch is turned on and the power supply is plugged into an AC outlet. Check connection to the DC input jack.
Meter reads zero with switch in “Sun” position and “FAULT” LED is lit	Reference Cell disconnected	Check the cable connection between the Reference Cell and the REF CELL Meter.
	Broken connection in Reference Cell or cable	1. Wiggle cable to Reference Cell to isolate cause 2. Consult NEWPORT for replacement cable (NEWPORT p/n 90021927)
Meter reads above 3.5 with switch in “Sun” position and “FAULT” LED is lit	Irradiance level over range	Reduce incident Irradiance
	Short circuit in Reference Cell or connector	Consult NEWPORT
	Reference Cell Meter circuit malfunction	Consult NEWPORT
Temperature reads erratically	Thermocouple not plugged into the cell or meter or both	Check connection of the thermocouple cable to the “TEMP IN TYPE K” connector on the meter and the TC-K connector on the reference cell

6 SPECIFICATIONS

The following specifications apply to the Reference Cell Meter itself:

6.1 METER PERFORMANCE

IRRADIANCE READOUT

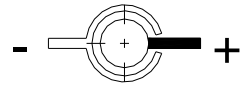
- Range: 0 – 3.500 Sun
- Accuracy: ±0.1% of reading +2 Counts @ 0.9500 – 1.0500 Sun @ 23 ºC
  ±0.2% of reading +2 Counts @ 0.100 – 1.9500 Sun (Low Display Range) @ 23 ºC
  ±0.2% of reading +2 Counts @ 1.900 – 3.500 Sun (High Display Range) @ 23 ºC
- Resolution: 0.0001 Sun @ 0 – 1.9500 Sun (Low Display Range)
  0.001 Sun @ 1.900 – 3.500 Sun (High Display Range)
- Temperature Coefficient: Meter: ±150 ppm / ºC Max;
- Temperature Coefficient: Reference Cell: +450 ±150 ppm / ºC
- Settling Time: within 1 sec. for <0.25% (= 6τ)
- Sampling rate: 2 Readings / second
- Autoranging: Switches to higher display range above 1.950 Sun, lower range below 1.900 Sun

TEMPERATURE READOUT

- Range: 0 – 199.9 ºC capable
- Accuracy: ±0.5 ºC Typical, ±1.0 ºC Max @ 24 – 26 ºC
  ±0.7 ºC Typical, ±1.2 ºC Max @ 10 – 40 ºC
- Resolution: 0.01 ºC
- Temperature Coefficient: ±0.02 ºC / ºC of meter ambient temperature change
- Settling Time: within 1 sec. for <0.25% (= 6τ)
- Sampling rate: 2 Readings / second

6.2 INPUTS

- DC Jack (0.083”ID 0.217”OD 0.472”L) for regulated 10VDC 1.5A power supply (supplied). An unregulated DC source with 8 – 15VDC and at least 0.5A capability with positive polarity center conductor may be substituted for portable use

Symbol  or  represents VDC.

- Type K connector for thermocouple integrated beneath the photovoltaic Reference Cell
- Amphenol T 3302 009 4-pin connector for- the Reference Cell 4-wire interface
- On / Off Rocker switch with integral LED
- Toggle switch to select “Suns” or “ºC” on display

6.3 OUTPUTS

- LCD: 4½ Digit Panel Meter
- Red LED to indicate Sun display “Fault” due to an open connection or overrange condition
- BNC for Sun voltage output: 1 Volt / 1 Sun
  Gain Error ±0.03% Range 0.01 – 3.50 Sun Source Resistance 220Ω
- BNC for Temperature output: 10 mV / 1ºC
  Gain Error ±0.15% Range 1.0 – 475 ºC Source Resistance 220Ω

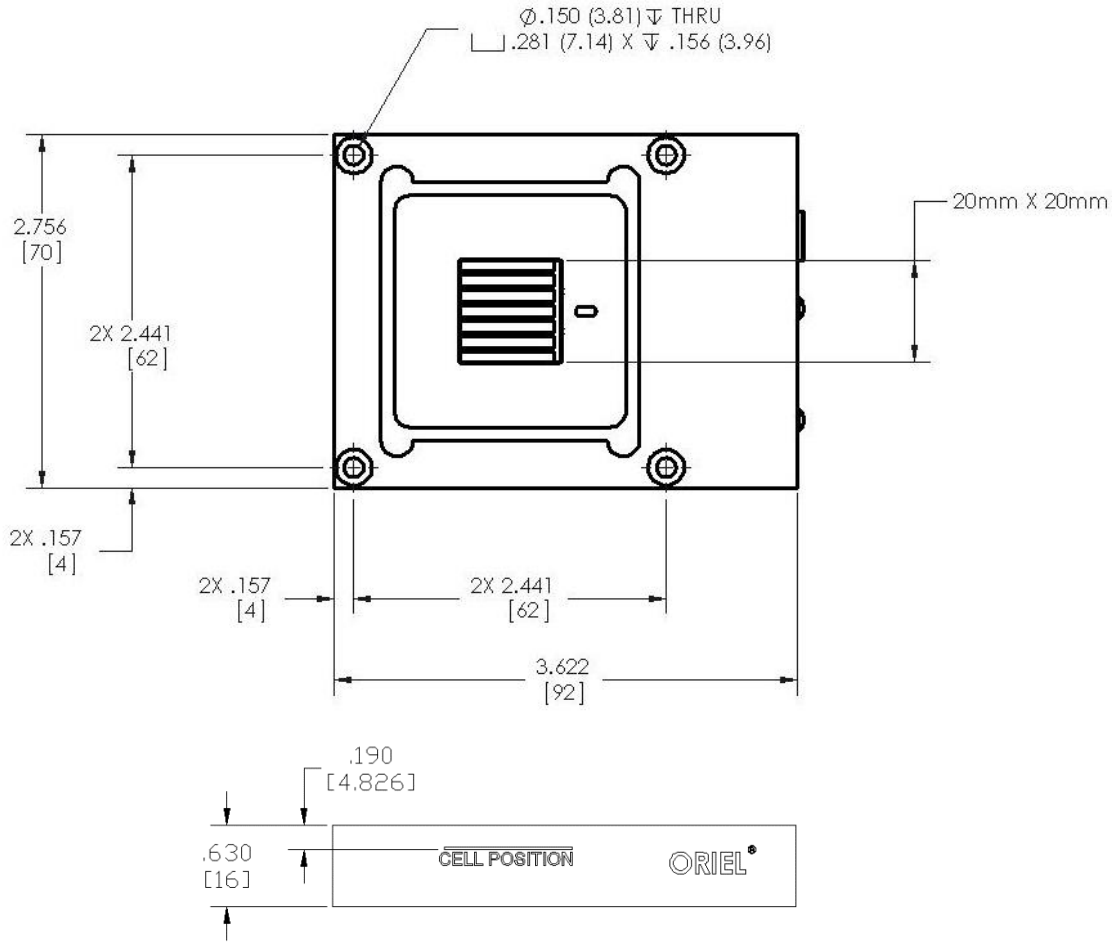
6.4 MECHANICAL

- Case material: Aluminum
- Case dimensions: 5.938”W x 3.750”H x 7.000”D (150.8mm x 95.3mm x 177.8mm)
- Weight: 4 Lbs. (1.8kg)
- Calibration data label: Date, mating Oriel Reference Cell S/N

6.5 ENVIRONMENTAL

- Operating Temperature: 10 ºC - 40 ºC
- Operating Humidity: 0 – 90%RH Non-Condensing

6.6 DIMENSIONAL DRAWING OF REFERENCE CELL



7 CUSTOM CONFIGURATIONS

Oriel PV Reference Cell Systems with special windows on the reference cell are available upon request. The system is required to be returned to the factory because the reference cell and reference cell meter are calibrated together.

The window materials available include quartz (standard with the 91150V system) and KG5.
Contact a Newport sales engineer for more information on these custom configurations.

8 DECLARATION OF CONFORMITY

EC DECLARATION OF CONFORMITY

Manufacturer's name:	Newport Corporation
Manufacturer's address:	150 Long Beach Boulevard Stratford, CT 06615 USA
Declares that the product:	
Product Name:	ORIEL® PV Reference Cell System
Model Numbers:	91150, 91150V, 91150-KG1, 91150-KG2, 91150-KG5, 91150-RG610KG2
Type of equipment:	Electrical equipment for measurement, control and laboratory use in industrial locations

conforms to the following Product Specifications:

Safety:	EN 61010-1:2010
EMC:	EN 61326-1:2006+cor:2008+cor:2010

complies with the following Directives:

2004/108/EC EMC Directive

2006/95/EC Low Voltage Directive

and accordingly, carries the CE mark

CE mark affixed: Beaune; April 20, 2011

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9 WARRANTY & SERVICE

CONTACTING ORIEL® INSTRUMENTS

Oriel® Instruments belongs to MKS Newport Corporation's family of brands. Thanks to a steadfast commitment to quality, innovation, hard work and customer care, Newport is trusted the world over as the complete source for all photonics and laser technology and equipment.

Founded in 1969, Newport is a pioneering single-source solutions provider of laser and photonics components to the leaders in scientific research, life and health sciences, photovoltaics, microelectronics, industrial manufacturing and homeland security markets.

MKS Newport Corporation proudly serves customers across Canada, Europe, Asia and the United States through 9 international subsidiaries and 24 sales offices worldwide. Every year, the Newport Resource catalog is hailed as the premier sourcebook for those in need of advanced technology products and services. It is available by mail request or through Newport's website. The website is where one will find product updates, interactive demonstrations, specification charts and more.

To obtain information regarding sales, technical support or factory service, United States and Canadian customers should contact Oriel® Instruments directly.

Oriel Instruments
31950 E. Frontage Rd
Bozeman, MT 59715 USA

Telephone: 877-836-9620 (toll-free in United States)
949-863-3144
Fax: 949-253-1680

Sales: orielPV.sales@newport.com
Technical assistance & Repair service: orielPV.service@newport.com

Customers outside of the United States must contact their regional representative for all sales, technical support and service inquiries. A list of worldwide representatives can be found on Oriel's website: http://www.newport.com/b/oriel-instruments

Newport warrants that all goods described in this manual (except consumables such as lamps, bulbs, filters, ellipses, etc.) shall be free from defects in material and workmanship. Such defects become apparent within the following period:

1. All products described here, except spare parts: one (1) year or 3000 hours of operation, whichever comes first, after delivery of the goods to the buyer.
2. Spare parts: ninety (90) days after delivery of goods to the buyer.

Newport's liability under this warranty is limited to the adjustment, repair and/or replacement of the defective part(s). During the above listed warranty period, Newport shall provide all materials to accomplish the repaired adjustment, repair or replacement. Newport shall provide the labor required during the above listed warranty period to adjust, repair and/or replace the defective goods at no cost to the buyer ONLY IF the defective goods are returned, freight prepaid, to a Newport designated facility. If goods are not returned to Newport, and the user chooses to have repairs made at their premises, Newport shall provide labor for field adjustment, repair and/or replacement at prevailing rates for field service, on a portal-to-portal basis.

Newport shall be relieved of all obligations and liability under this warranty of:

1. The user operates the device with any accessory, equipment or part not specifically approved or manufactured or specified by Newport unless buyer furnishes reasonable evidence that such installations were not the cause of the defect. This provision shall not apply to any accessory, equipment or part which does not affect the safe

operation of the device.

2. The goods are not operated or maintained in accordance with Newport's instructions and specifications.
3. The goods have been repaired, altered or modified by other than authorized Newport personnel.
4. Buyer does not return the defective goods, freight prepaid, to a Newport facility within the applicable warranty period.

IT IS EXPRESSLY AGREED THAT THIS WARRANTY SHALL REPLACE ALL WARRANTIES OF FITNESS AND MERCHANTABILITY. BUYER HEREBY WAIVES ALL OTHER WARRANTIES, GUARANTEES, CONDITIONS OR LIABILITIES, EXPRESSED OR IMPLIED, ARISING BY LAW OR OTHERWISE, WHETHER OR NOT OCCASIONED BY NEWPORT'S NEGLIGENCE.

This warranty shall not be extended, altered or varied except by a written document signed by both parties. If any portion of this agreement is invalidated, the remainder of the agreement shall remain in full force and effect.

CONSEQUENTIAL DAMAGES
Newport shall not be responsible for consequential damages resulting from misfunctions or malfunctions of the goods described in this manual. Newport's total responsibility is limited to repairing or replacing the misfunctioning or malfunctioning goods under the terms and conditions of the above described warranty.

INSURANCE
Persons receiving goods for demonstrations, demo loan, temporary use or in any manner in which title is not transferred from Newport, shall assume full responsibility for any and all damage while in their care, custody and control. If damage occurs, unrelated to the proper and warranted use and performance of the goods, recipient of the goods accepts full responsibility for restoring the goods to their condition upon original delivery, and for assuming all costs and charges.

RETURNS
Before returning equipment to Newport for repair, please call the Customer Service Department at (203) 377-8282. Have your purchase order number available before calling Newport. The Customer Service Representative will give you a Return Material Authorization number (RMA). Having an RMA will shorten the time required for repair, because it ensures that your equipment will be properly processed. Write the RMA on the returned equipment's box. Equipment returned without a RMA may be rejected by the Newport Receiving Department. Equipment returned under warranty will be returned with no charge for the repair or shipping. Newport will notify you of any repairs not covered by the warranty, with the cost of the repair, before starting the work.

Please return equipment in the original (or equivalent) packaging. You will be responsible for damage incurred from inadequate packaging, if the original packaging is not used.

Include the cables, connector caps and antistatic materials sent and/or used with the equipment, so that Newport can verify correct operation of these accessories.