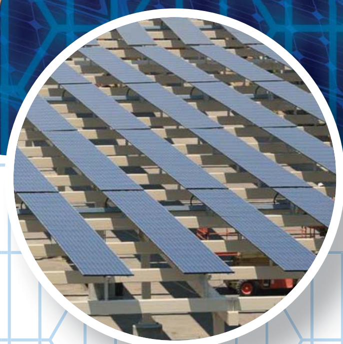
Solutions for

Solar Cell and Module Testing

How to decrease costs and increase flexibility in a rapidly changing test environment

Application Note



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Introduction

The explosive growth in the solar industry has intensified the need for solar cell and module test and measurement solutions. Today, solar cell and module test and measurement solutions come in two main forms: complete turnkey solutions and test-system building blocks that must be fitted together and wrapped in software. If you choose a complete turnkey solution, you can get a test system up and running quickly. However, this benefit comes with a high price tag and the very real risk of quick obsolescence in an industry characterized by rapidly developing technologies.

Using building blocks to create a test system costs less and gives you the ability to change your test system as your testing requirements change. For instance, if your test requirements change so you need higher accuracies or a higher current range, you would need only to replace one of the blocks of your test system, rather than your whole system. Also, you can reuse various blocks of your test system across various test system platforms if you are aiming for standardization and equipment reuse.

Agilent Technologies offers a wide variety of power, measurement, and switching products you can use as building blocks for characterizing the electrical properties of solar cells and modules. This application note focuses on instruments that decrease test costs without sacrificing performance and increase test flexibility to handle a rapidly changing testing environment. The information in this document will help you choose the optimal solution for your solar cell and module testing challenges.

Solar Array Test at a Glance

Device to be tested	Suggested instruments	Comments
Solar cell	Four-quadrant DC source	Full electrical characterization solution Typically high accuracy
	Two-quadrant DC source	Full electrical characterization solution with polarity reversal switching. Low cost.
	Electronic load	Flexible, large power range. Cannot source current. Low cost.
Solar module	Electronic load	Flexible, large power range
	Two-quadrant DC source	Ability to sink and source current
Dark I-V	Four-quadrant DC source	Full electrical characterization solution Typically high accuracy
	Single-quadrant DC source	Full dark electrical characterization solution with polarity reversal switching. Low cost.

Table 1: Solar cell and module test solutions

Solar Cell and Module Electrical Test Basics

Testing at the solar cell level is required for research, quality assurance, and production. Although the measurement accuracies, speeds, and parameters may differ in importance across different levels of the industry and across space and terrestrial use, there are a number of key parameters that are typically measured in any testing environment:

- **Open-circuit voltage (V_{oc})**
  The cell voltage at which point there is zero current flow
- **Short-circuit current (I_{sc})**
  The current flowing out of the cell when the load resistance is zero
- **Maximum power output of the cell (P_{max})**
  The voltage and current point where the cell is generating its maximum power.
  The Pmax point on an I-V curve is often referred to as the maximum power point (MPP).
- **Voltage at Pmax (Vmax)**
  The cell's voltage level at P_{max}
- **Current at Pmax (Imax)**
  The cell's current level at P_{max}
- **Conversion efficiency of the device (η)**
  The percentage of power converted (from absorbed light to electrical energy) and collected when a solar cell is connected to an electrical circuit. This term is calculated using the ratio of the maximum power point, P_{max}, divided by the input light *irradiance* (E, in W/m²) under standard test conditions (STC) and the *surface area* of the solar cell (A_c in m²).

$$\eta = \frac{P_m}{E \times A_c}$$

- **Fill factor (FF)**
  The ratio of the *maximum power point,* Pmax, divided by the *open circuit voltage* (V_{oc}) and the *short circuit current* (I_{sc})

$$FF = \frac{P_m}{V_{oc} \times I_{sc}} = \frac{\eta \times A_c \times E}{V_{oc} \times I_{sc}}$$

- **Cell diode properties**
- **Cell series resistance**
- **Cell shunt resistance**

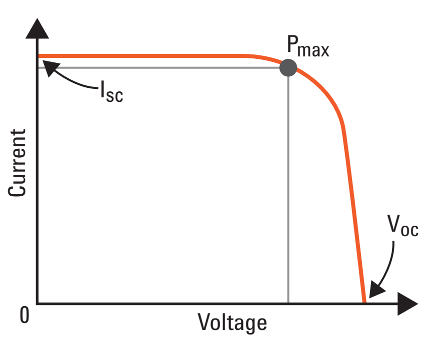

Figure 1: Solar cell I-V curve

Solar cell open circuit voltages (V_{OC}) typically range from 3 volts to 0.6 volts and cell short circuit currents (I_{SC}) are typically below 8 A.

Solar modules are typically defined as more than one cell connected together in a packaged form. Solar modules come in a variety of voltage and current ranges but power generating capabilities are typically between 50 and 300 W. Many of the same parameters that are measured for cells are also repeated for modules, such as V_{OC} , I_{SC} , P_{max}, and the I-V curve.

Testing Solar Cells with a Two-Quadrant Power Supply

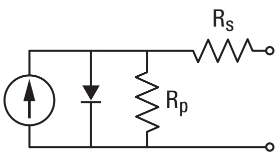

Figure 2: Solar cell circuit equivalent

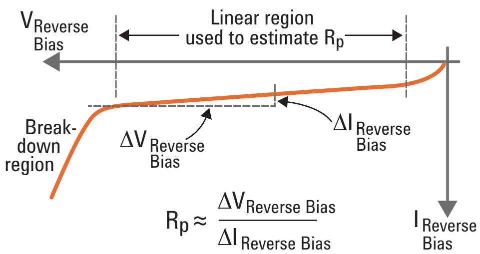

Figure 3.. Reverse bias region of solar cell

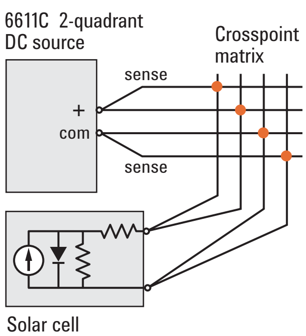

Figure 4a: Solar cell electrical characterization test setup configured to capture the I-V curve of a solar cell

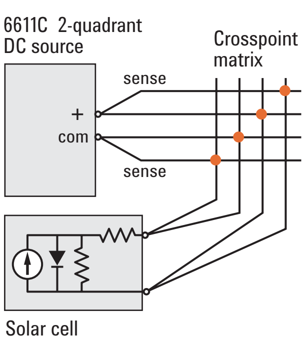

Figure 4b: Solar dell electrical characterization test setup configured to capture the reverse bias electrical characterization of a solar cell

In this context, a two-quadrant power supply refers to an instrument that can both sink and output current or has positive and negative current capabilities. Such an instrument combines characteristics of an electronic load and a DC source. In this section, we will refer to a two-quadrant device as simply a "DC source." We will use negative current to refer to the DC source acting as a load or sinking current and positive current to refer to the DC source outputting current. For capturing the Pmax, Voc, Isc, and I-V characteristics of a cell, DC sources can be used in a constant voltage (CV) mode, and the resulting current, either negative or positive, can be measured by the DC source. Of course, such an instrument must have high measurement accuracy and the ability to quickly and accurately step voltage for high throughput and an accurate I-V curve. Since solar cell testing often requires long cable runs or switching between the DC source and solar cell, a DC source with external sense capabilities is needed. To prevent oscillations in the test setup, the external sense must have high stability. Unwanted oscillations can lead to accuracy problems and reduce throughput.

A four-quadrant DC source, capable of negative voltages and negative currents, is often used for solar cell testing for two reasons. The first is to overcome any series resistance in the cell. Figure 2 shows an equivalent circuit of a solar cell along with the series resistance (Rs).

By using a slightly negative voltage, you can cancel out the effects of Rs to make a true Isc measurement. The amount of negative voltage needed depends on the value of Rs. For a detailed description on two methods for calculating Rs refer to ***"Internal Series Resistance Determined of only One IV-Curve Under Illumination"***[1]. The second reason is that using negative voltage values may be desirable to reverse the cell's bias to fully characterize the cell's electrical properties. With the cell in reverse bias, measuring the change in voltage over the change in leakage current in the linear region of the curve in Figure 3, you can calculate the shunt or parallel resistance of the cell, Rp in Figure 2. In Figure 3, the reverse bias current represents current flowing out of the DC source into the cell. The breakdown region of the cell, as shown in Figure 3, can also be determined by operating the cell in reverse bias beyond the linear region.

Two-quadrant devices cannot produce negative voltages like four-quadrant devices, but with simple switching they can be used like four-quadrant devices. Figures 4a and 4b show a test setup using a two-quadrant DC source and a simple matrix switch to characterize a solar cell.

In Figure 4a a simple matrix switch was used to connect the DC source's output leads and external sense leads to the solar cell. Each matrix crosspoint (-•-) represents a connection between a row and a column of the matrix. Each mechanical switch in the matrix will have a small impedance, but as long as your DC source's external sense input has a large impedance (>100 Kohm), the effects can be ignored. Figure 4a shows the DC source and matrix switch configured to capture the I-V curve of a solar cell. In this setup the DC source has the ability to deliver positive voltage along with negative and positive current to the solar cell. In Figure 4b, the DC source and matrix switch is configured to deliver negative voltage along with negative and positive current to capture the reverse bias electrical characterization of a solar cell.

With the simple setup in Figures 4a and 4b you can use a two-quadrant DC source with simple switching as a substitute for a four-quadrant supply. This is a good way to cut test system costs since a four-quadrant supply is typically two to three times the price of a two-quadrant supply. Considering that the majority of solar test setups already require switching for data acquisition purposes, the added cost for the simple switching is very little or zero because the infrastructure is already there. Keep in mind that there will be an instant during switching where a discontinuity will exist between the DC source and the solar cell under test. You may face an additional discontinuity at 0 V caused by limitations in the DC source. Many DC sources can lower their output voltage close to 0 V, for instance down to 10 mV, but cannot go all the way down to 0 V. The lowest output voltage capabilities will be covered in the specifications under "voltage range" or "low voltage range" for a DC source. Your test plan and your cell must tolerate the switching and possible DC source moments of discontinuity. If your cell cannot tolerate the discontinuity, then a true four-quadrant supply is required.

1. *Gerald Kunz, Andreas Wagner, "Internal Series Resistance Determined of only One IV-Curve Under Illumination" www.pv-engineering.de/_docs/Internal_Series_Resistance-Paris2004.pdf, June 2004*

Agilent offers two families of two-quadrant DC sources with typical solar cell voltage and current ranges that you can use for solar cell electrical characterization. The 661xC family provides sinking and sourcing power capabilities up to 50 W, and the 663xB family provides sinking and sourcing power capabilities up to 100 W. The 661xC DC sources 663xB DC sources have built-in polarity reversal relays so you can use them like four-quadrant DC sources with no extra switching overhead. If you need a switch matrix for reversing polarity of the 661xC DC sources or any other two-quadrant DC source, Agilent has a number of switch matrix solutions that are covered in the "Agilent Switching and Measurement Solutions for Solar Cell and Module Testing" section of this application note.

Figure 5: Agilent 661xC (above) and 663xB DC (below) sources

Features that make these DC source families ideal for solar cell testing:

- Ability to sink as well as source current
- Current measurement capabilities into the milliamp range and below
- Voltage programming accuracy of less than 10 mV at the 10 V range or below
- External sense capabilities, with a high-sense lead impedance
- High output stability, to prevent oscillations in your test setup
- Temperature coefficient specifications make calculating accuracy easy and deterministic in various testing environments where temperatures may be outside normal room temperature
- 2U height, half-rack size for 661xC family and full-rack size for the 663xB family
- Units can be easily connected in parallel or series for increased current and voltage capabilities
- Fast command processing time for high-throughput needs

The Agilent 661xC and 663xB DC source families provide high measurement accuracy, fast response, and great output stability all at a low price. For solar cell tests that demand four-quadrant type measurements, Agilent DC sources can be easily configured with minor switching overhead to be used like four-quadrant devices.

Testing Solar Cells and Modules with Electronic Loads

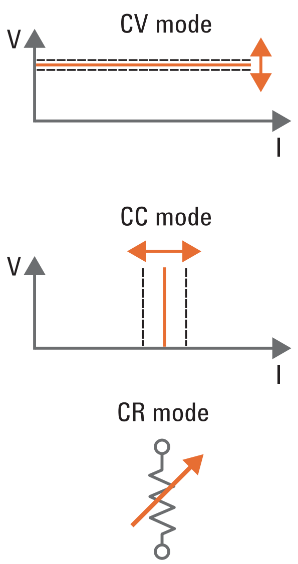

Figure 6: Electronic load modes of operation

Figure 7: N3300A full-rack mainframe

Solar modules are typically multiple cells connected electrically into a packaged form. Solar modules come in a variety of voltage and current ranges, but power generating capabilities are typically between 50 and 300 W. Many of the same parameters that are measured for cells are repeated for modules, such as Voc, Isc, Pmax, and the I-V curve.

Electronic loads are a great solution for solar module testing because of their wide power range and ability to sink large amounts of current. Electronic loads typically have three modes of operation: constant current (CC), constant voltage (CV), and constant resistance (CR).

CV mode is the preferred mode of operation for I-V curve tracing because it allows you to step through voltages incrementally and measure the current output of the module under test. To ensure full I-V curve trace capability, the electronic load needs the capability to go down to 0 V to capture the Isc and up to Voc.

Electronic load measurement accuracies vary. If you need increased measurement accuracy for voltage or current measurements, you can use one or two DMMs to monitor the voltage and make current measurements. You can make current measurements with the DMM and a precision current shunt. Using a precision shunt gives you more control over the DC voltage range of the DMM which can give you higher resolution and accuracy for low-current measurements. Employing the DMMs for added accuracy for low-range current and voltage measurements also turns an electronic load into a viable solution for solar cell testing. Pairing electronic loads with high-accuracy DMMs essentially gives you a highly flexible solar cell and module test system for a relatively low cost. Also this versatile combination — with its wide power ranges and high accuracy — means your solar test system is much less likely to become obsolete, even in this rapidly changing field.

For testing outdoors or in other places where environmental temperatures vary widely, an electronic load that provides temperature coefficient specifications is highly desirable. Variations in environmental temperatures will change the measurement specifications of the load's built-in measurements, leading to increased measurement uncertainty. Temperature coefficient specifications allow you to compensate for environments with wide temperature variations.

The Agilent N3300A electronic load mainframe has 6-slots, and the N3301A mainframe has two slots. They both accept combinations of N330x user-installable load modules (150 W to 600 W) for easy system configuration and future reconfiguration. A single GPIB address is all you need for complete control and read-back of all load modules within a single N3300A or N3301A mainframe. The N330xA Series DC electronic loads provide fast operation and the accurate programming and read-back needed for high-volume solar test systems. For high-current solar modules, you can connect the N330xA modules in parallel for increased current sinking capabilities.

Features that make the N3300A Series electronic loads ideal for solar test:

- High power handling capability in a compact unit: the 1,800-W N3300A is a full-rack unit and the 600-W N3301A is a half-rack unit
- Simultaneous channel measurements and simultaneous current, voltage, and power measurements from a single channel for high-throughput testing
- Built-in digitizer can make measurements of current or voltage vs. time
- Temperature coefficient specifications make calculating accuracy for outdoor testing easy
- High input stability to prevent oscillations in test setup
- High-impedance external sense capability

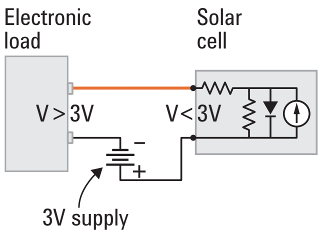

Figure 8: Electronic load configuration with 3-V boost supply

You can use the N330xA Series loads in constant voltage mode, which allows you to set voltage values that can be easily stepped up or down programmatically at very fine to large steps, depending on the test you want to perform. Then you can measure the current sink into the load internally from Agilent's patented current shunt that provides high stability in the face of harsh temperature differences. A limitation of the N330xA for solar testing is that its specifications begin to degrade at constant voltage levels below 3 V. At 0 V, no current can flow into the load.

To overcome this limitation of the N330xA Series loads, use a simple power supply as a boost supply. Configuring the additional power supply as shown in Figure 8 will ensure the N330xA load will always operate at or above 3 V, ensuring your solar DUT is tested with the optimum electronic load specifications.

The N330xA's internal transient generator can be used to perform dynamic tests of solar cells and modules based on transients in loading conditions of the cell by providing programmable amplitude, slew rate, frequency, and duty cycle. Flexible triggering and programmable duty cycle also make pulsed or shuttered light testing possible.

The N330xA family of electronic loads offers multiple inputs, parallel measurement processing, and a fast command processing time for maximum throughput. The wide power ranges of the modules (150 to 600 W) and the ability to parallel modules for higher current needs provides excellent flexibility and a decreased risk of solar test-system obsolescence. For smaller test setups, Agilent offers the single-channel 6060B and 6063B, which provide power handling capabilities of 300 W and 250 W, respectively. These two electronic loads share most of the features and specifications of the N330xA family. They have an easy-to-use front panel and they cost less than the N330x loads.

Figure 9: N330xA family's internal transient generator

Figure 10: 606xB DC electronic load

Agilent Switching and Measurement Solutions for Solar Cell and Module Testing

In solar cell and module testing, you often need more than just the I-V curve of the cell or module under test. Typically, you will need to make temperature measurements and measurements of calibrated reference cells. Temperature has a direct effect on the output power of the cell or module, so you need to make temperature measurements during the test to fully understand all test conditions. Calibrated reference cells are often needed to gauge the effectiveness of the light source used to power the solar cell or module. Figure 11 shows an example setup for testing a solar module. This setup uses a switch measurement unit to avoid the need for costly, redundant measurement equipment. A switching configuration can also be used to allow multiple solar cells or modules to be tested in parallel.

Agilent offers three product families to address your switching needs for solar testing: the 34980A multifunction switch/measurement unit, the 34970A data acquisition switch unit, and the L44xxA family of switching modules.

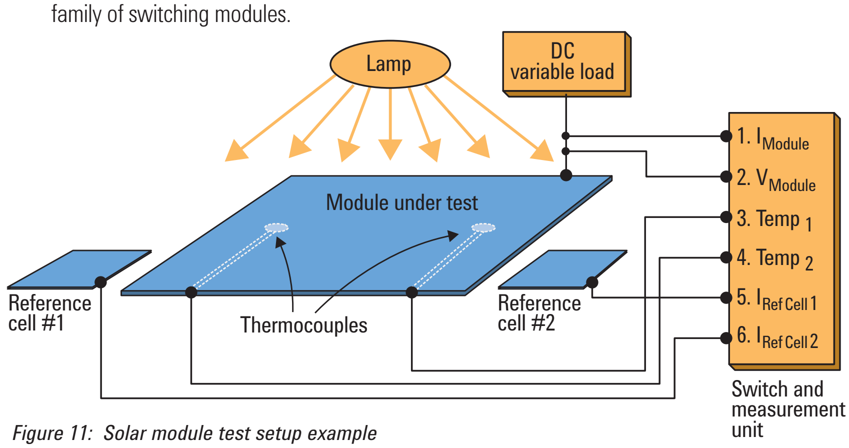

Figure 11: Solar module test setup example

34980A multifunction switch/measurement unit

The Agilent 34980A is an eight-slot mainframe that includes an optional built-in 6½ digit DMM. You can choose from 21 optional plug-in modules that offer a broad range of functionality that includes various switch matrices, MUXs, and general-purpose configured switching modules — in one compact, high-performance modular platform.

Figure 12: 34980A multifunction switch and measurement unit front and back views

34980A features that make it a good fit for solar cell test systems:

- Up to 560 2-wire multiplexer channels or 4096 matrix cross-points in one mainframe
- Switch current carrying capabilities up to 8 A
- Built-in Ethernet, USB 2.0, and GPIB connectivity, standard connectors and software drivers for most common programming environments
- Lower cost than a comparably configured PXI-based switching solution
- Optional built-in 6½ digit DMM lets you make measurements at greater than 3000 readings/second
- Switch relay counters help predict end of switch life
- Temperature measurement capabilities with thermocouples, RTDs, or thermistors

34970A or 34972A data acquisition switch units

Figure 13: 34972A data acquisition switch unit

The Agilent 34970A and 34972A are three-slot mainframes with a built-in 6½ digit digital multimeter. Each slot can hold one multi-channel plug-in module and each channel can be configured independently to measure one of 11 different functions without the added cost or complexities of signal-conditioning accessories. Choose from eight optional plug-in modules to create a compact data logger, full-featured data acquisition system or low-cost switching unit. On-module screw-terminal connections eliminate the need for terminal blocks, and a unique relay maintenance feature counts every closure on every switch for easy, predictable relay maintenance. The 34970A icomes standard with GPIB and RS-232 interfaces, whiile the 34972A comes standard with easy to use USB and LXI interfaces to reduce your set-up time. Our most popular module, 34901A, features a built-in thermocouple reference and 20 two-wire channels.

The 34970A/34972A are low-cost instruments that are great for low-density switching requirements and any portable data acquisition requirements. Agilent BenchLink Data Logger software is included with the 34970A/34972A,or for advanced Data Logging and control use the 34830A BenchLink Data Logger Pro software

L4400 Series LXI switch instruments

Figure 14: Three modules from the L4400 Series switching instruments

The Agilent L4400 Series switch instruments offer high-performance switching in standalone LXI instruments. With their small 1U half-rack size and Ethernet connectivity, these LXI instruments can be placed wherever your application needs them. Since these switching instruments are standalone, there is no need for an expensive card cage.

Features of the L4400 Series switching instruments that make them a good fit for solar device testing:

- **L4421A 40-channel armature multiplexer**
  40 channels of armature multiplexer switching up to 300 V, 1 A. A built-in thermocouple reference junction is available for easy temperature measurements with an external digital multimeter.
- **L4433A dual/quad 4x8 reed matrix**
  High-speed matrix with 64 2-wire or 128 1-wire cross-points with high-speed reed relays
- **L4437A 32-channel Form A/Form C general-purpose switch**
  General-purpose switch with 28 1A Form C relays and 4 high-power relays for switching up to 5A

Agilent digital multimeters

Figure 15: Agilent DMMs

Agilent offers a family of DMMs that vary in accuracy, measurement speed, and price to fit your solar device test requirements.

	34401A	34410A	34411A	3458A
Resolution	6½ digits	6½ digits dual display	6½ digits dual display	8½ digits
Basic DC accuracy	35 ppm	30 ppm	30 ppm	8 ppm
Max readings/s	1,000	10,000	50,000	100,000

Performing Dark I-V Characterization Tests Using High-Speed Multiple-Output Power Systems

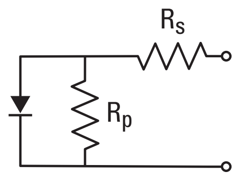

Figure 16: Solar cell equivalent circuit during dark testing

Dark I-V solar cell testing is done when you need to make a highly accurate characterization of a solar cell's resistance and diode properties. This type of testing is performed to ensure the quality of the cell meets the application's criteria and to ensure the cell is defect free. Such thorough testing of the solar cell is often done in space applications, where verifying quality and reliability is essential and worth the extra testing costs.

Testing a solar cell in a dark chamber causes the cell to behave essentially as a diode with some resistance characteristics. Figure 16 shows the circuit equivalent of a solar cell during dark testing.

With no light stimulus applied to the solar cell, dark testing requires a DC source that has only the ability to source or output current, and not one that can sink current like those required for solar cell testing with a light stimulus. Dark testing does require both positive and negative voltage to test the I-V curve. The negative voltage is used to reverse the cell's bias, which allows you to approximate the parallel resistance of the cell (Rp) and the breakdown region of the diode. See Figure 3 (page 3) for a graphical representation of a cell in reverse bias and to see how different parameters are calculated.

Employing simple switching allows you to use a single-quadrant DC source that can output only positive voltage and current for solar cell dark testing. You can reverse the positive and negative output and sense leads that are connected to the solar cell input. This setup could be easily implemented with a 4x4 matrix switch configuration. This configuration can be seen in Figures 4a and 4b (page 3). Since dark testing is a precision quality test, you need a DC source that has the ability to source voltage and current with high accuracy. You also need to employ remote sensing on the DC source since the solar cell will be inside the dark chamber and separated by long lengths of wire from the test system.

Figure 17: N6700 modular power system

N6700 modular power system

The Agilent N6700 modular power system offers speed and accuracy for solar cell dark testing optimization. The modular power system provides up to four outputs in 1U of rack space. The four outputs are defined by modules that come in different power ranges, speeds, and measurement accuracies. You can choose from 20 different modules.

Features that make the N6700 a good fit for solar cell dark testing:

- Full scale current measurement range of 200 µA and an accuracy of 0.5% of reading + 100 nA for low-level, high-accuracy current measurements
- Built-in polarity reversal relays to achieve both positive and negative voltage values, great for solar cell forward and reverse bias testing
- High test throughput
    - Four DC source outputs for parallel testing
    - Fast command processing speed
    - Extremely fast voltage step programming, < 200 µs for a 5-V step
- Outputs can be connected in series or parallel to meet higher voltage and current needs

The N6700 offers high throughput and high accuracy at a low cost compared to four-quadrant DC sources for dark cell testing.

Agilent power products: Solar cell and module test solutions

Figure 18: Agilent power products well suited for solar cell and module test

<table>
<tr><th>Model No.</th><th>Description</th><th>Ranges</th><th>No. of outputs</th><th>Features</th></tr>
<tr><td>U2722A
SMU</td><td>Four quadrant</td><td>± 20 V, ± 120 mA
2.4 W</td><td>3</td><td>High accuracy</td></tr>
<tr><td>6611C
DC source</td><td rowspan="6">Two quadrant</td><td>8 V, +5 A, -3 A
40 W</td><td rowspan="6">1</td><td rowspan="6">Low cost,
high stability</td></tr>
<tr><td>6611C-J05
DC source</td><td>10 V, +5 A, -3 A
40 W</td></tr>
<tr><td>6612C
DC source</td><td>20 V, +2 A, 1.2 A
40 W</td></tr>
<tr><td>6631B
DC source</td><td>8 V, ± 10 A
80 W</td></tr>
<tr><td>6632B
DC source</td><td>20 V, ± 5 A
100 W</td></tr>
<tr><td>6633B
DC source</td><td>50 V, ± 2 A
100 W</td></tr>
<tr><td>N6700
MPS</td><td>Single quadrant</td><td>0-5 V up to 0-100 V
up to 50 A
300 W</td><td>4</td><td>Modular, high accuracy,
polarity reversal</td></tr>
<tr><td>N3300A
electronic load</td><td>Mainframe</td><td>NA</td><td>Up to 6</td><td>Modular,
parallel output operation</td></tr>
<tr><td>N3301A
electronic load</td><td>Mainframe</td><td>NA</td><td>Up to 2</td><td>Modular,
parallel output operation</td></tr>
<tr><td>N3302A
electronic load</td><td rowspan="8">CC,
CV,
CR</td><td>60 V; 30 A
150 W</td><td rowspan="6">NA</td><td rowspan="6">High stability,
temp coefficent
specs</td></tr>
<tr><td>N3303A
electronic load</td><td>240 V; 10 A
250 W</td></tr>
<tr><td>N3304A
electronic load</td><td>60 V; 60 A
300 W</td></tr>
<tr><td>N3305A
electronic load</td><td>150 V; 60 A
500 W</td></tr>
<tr><td>N3306A
electronic load</td><td>60 V; 120 A
600 W</td></tr>
<tr><td>N3307A
electronic load</td><td>150 V; 30 A
250 W</td></tr>
<tr><td>6060B
electronic load</td><td>60 V; 60 A
300 W</td><td>1</td><td rowspan="2">Low cost,
temp coefficent
specs</td></tr>
<tr><td>6063B
electronic load</td><td>240 V; 10 A
250 W</td><td>1</td></tr>
</table>

Conclusion

Using building blocks to create a solar device test system costs less than purchasing a turnkey test system. It also gives you the ability to change your test system as your testing requirements change and makes it possible to reuse equipment across test systems. In this application note we discussed the test parameters and requirements of solar cells and modules. We examined how to use various test and measurement instruments to characterize solar cells and modules, and we discussed their pros and cons. We looked at Agilent's test and measurement solutions that you can use as building blocks for characterizing the electrical properties of solar cells and modules.

Using the information in this document will help you choose the optimal solution for your solar cell and module testing challenges.

Related Agilent Literature and Material

Publication	Publication type	Publication number
Agilent 661xC DC Sources	Data sheet	Available Online
Agilent 663xB DC Sources	Data sheet	Available Online
N330xA Series Loads	Data sheet	5980-0232E
34980A Multifunction Switch/Measurement Unit	Data sheet	5989-1437EN
34970A and 34972A Data Acquisition Switch Unit	Data sheet	5965-5290EN
L44xxA Series Switching Modules	Data sheet	5989-4825EN
N6700 Modular Power System	Data sheet	5989-1411EN
34401A Digital Multimeter	Date sheet	5968-0162EN
34410A and 34411A High Performance Digital Multimeters	Data sheet	5989-3738EN
3458A Digital Multimeter, 8½ Digit	Data sheet	5965-4971E
Practical Temperature Measurements	Application Note	5965-7822E
10 Hints for Using Your Power Supply to Decrease Test Time	Application Note	5968-6359E
Optimizing Test Systems for Highest Throughput, Lowest Cost and Easy LXI Instrument Integration	Application Note	5989-4886EN

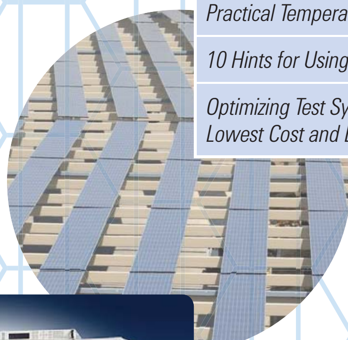

Figure 19: Over 200 Agilent power products to choose from for all your testing needs

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