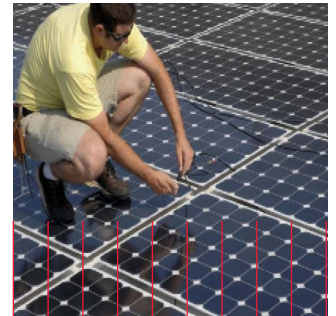


Keysight Technologies

Powering the Solar Revolution



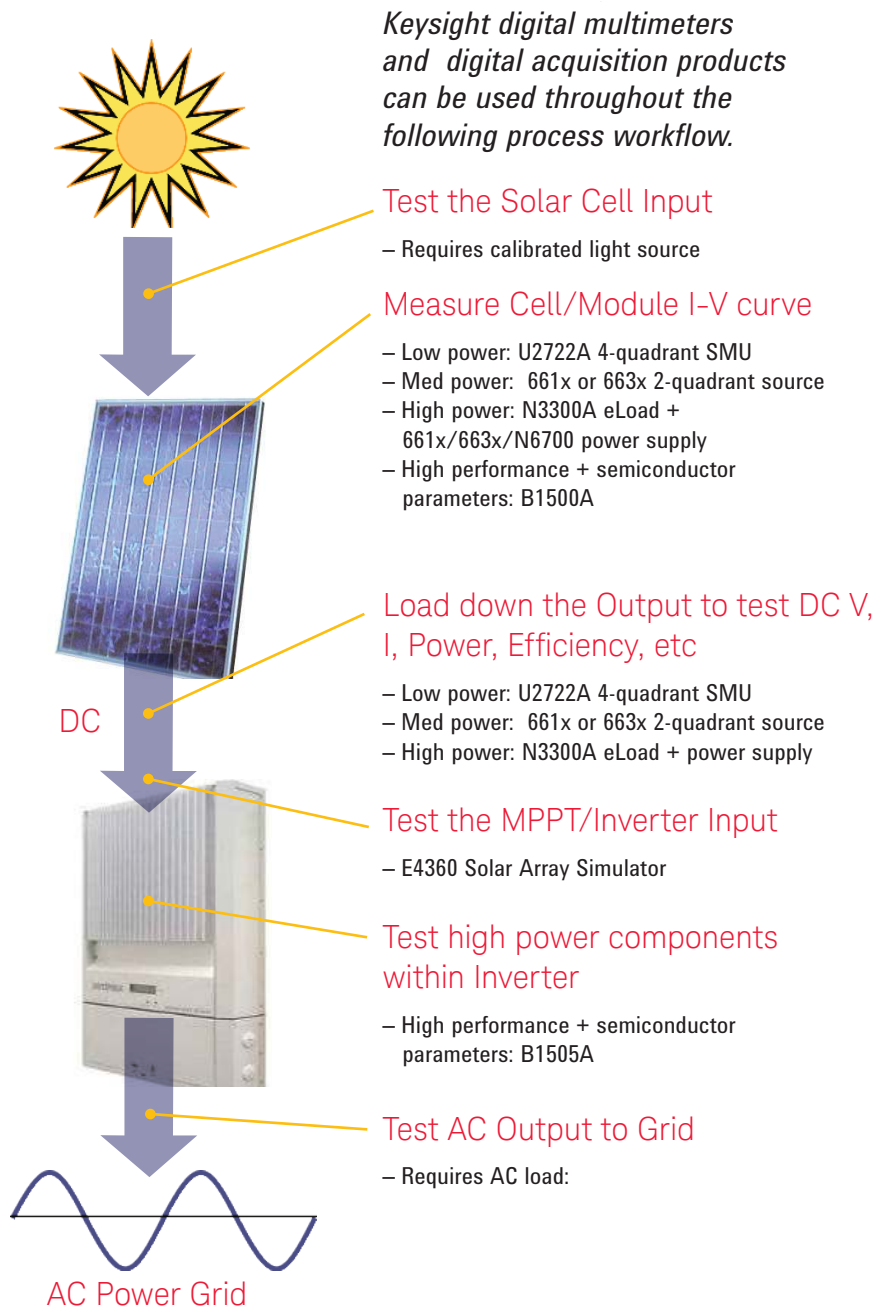
Keysight Solutions for the Solar Ecosystem

Keysight Technologies, Inc. has the largest portfolio of power & measurement products to meet solar testing needs and the expertise to help implement it properly

The explosive growth in the solar industry has intensified the need for solar cell, solar module and MPPT/inverter test and measurement solutions. The challenge is to differentiate your solar product. Competitive differentiators are efficiency, yield and reliability. Keysight powers the solar revolution with industry leading power supplies, electronic loads, parametric analyzer, source measure units (SMU), DMMs and data acquisition systems.

Keysight has a broad range of solutions for R&D and manufacturing engineers developing solar products. Solar cell and modules solutions must quickly and accurately capture the I-V curve characteristics. Advanced characterization requires CV characterization. Keysight's industry-leading power building blocks offer the flexibility and performance required to test today's solar cells and modules.

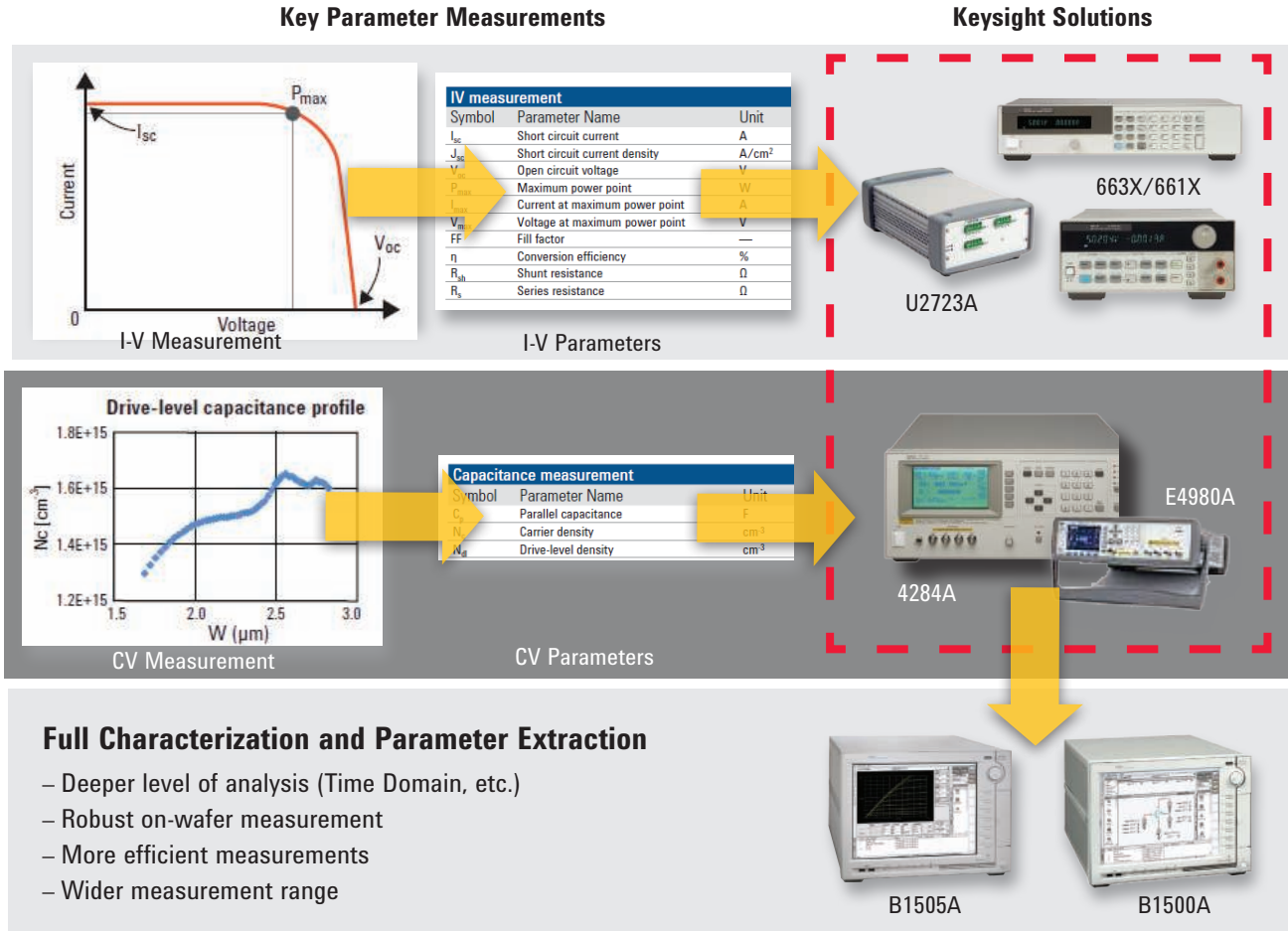
MPPT and inverter testing and characterization require predictable and repeatable illumination and temperature conditions. Keysight's E4360 solar array simulator allows simulation control over a wide-ranging MPPT/Inverter module performance.



Instruments	For testing		
	Solar cell	Solar module	MPPT/ Inverters
Solar Array Simulator			☀️
4-quadrant SMU	☀️	☀️	
2-quadrant power supply	☀️	☀️	
Electronic loads	☀️	☀️	
Semiconductor analyzer	☀️		☀️
C-Meter/Z-Meter	☀️		
DMM, Switch, DAQ	☀️	☀️	☀️

Testing Solar/Photovoltaic Cells

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. Keysight solutions measure I-V, CV and full characterization and parameter extraction.



The IV curves are created in illuminated and dark conditions – this requires testing in multiple quadrants. The optimal solution is a four quadrant power supply. SMUs provide this capability but at lower power. Medium or high-power solutions require the use of two quadrant supplies. Keysight 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.

TO LEARN MORE

VISIT OUR APPLICATION-SPECIFIC WEB SITE: www.keysight.com/find/solarcell

CHECK OUT THESE RELATED APPLICATION NOTES:

"IV and CV Characterizations of Solar/Photovoltaic Cells Using the B1500A" 5990-4428EN
<http://cp.literature.keysight.com/litweb/pdf/5990-4428EN.pdf>

"Solar Cell and Module Testing: How to decrease costs and increase flexibility in a rapidly changing test environment" 5990-3262EN
<http://cp.literature.keysight.com/litweb/pdf/5990-3262EN.pdf>

"IV Curve Characterization in High-Power Solar Cells and Modules" 5990-4854EN
<http://cp.literature.keysight.com/litweb/pdf/5990-4854EN.pdf>

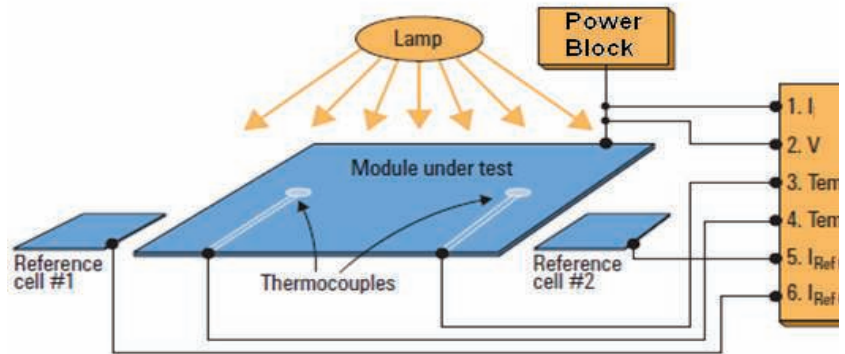
"Using Two Power Supplies for Higher Current Solar Cell Characterizing" 5990-3949
<http://cp.literature.keysight.com/litweb/pdf/5990-3949EN.pdf>

Solar Module/Panel Testing

Outdoor Testing of Solar Modules

A national laboratory that provides solar testing services to solar cell and module manufacturing companies needed to test solar modules outdoors. Since the test was performed outdoors, the laboratory needed a rugged transportable measurement solution. The laboratory tested modules that varied widely in output power capability so the test solution had to have a large power range to avoid a “multiple-box” solution. The module’s power could be as low as 30 W and as high as 500 W. The laboratory chose Keysight’s N3300 electronic load family to characterize the power of its customers’ solar modules. The N3300 Series electronic loads can handle up to 600 W and sink up to 120 A on a single channel, and its power handling capabilities are specified over a wide range of temperatures. These features allowed the lab to test outdoors under variable weather conditions. The lab used the N3300’s built in list capability to step through more than a 100 voltage steps in less than a second.

Solar modules have many of the same testing parameters as solar cells. Modules have higher power ranges. Electronic loads and two-quadrant power supplies are often required for these higher modes of operation.



The electronic load’s constant voltage (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.

Higher accuracy measurements and temperature measurements typically require a DMM and data acquisition or switch unit.

Turn-key solutions minimize your development time and allow you to get a test system up and running quickly. Keysight offers a PV module manufacturing and development system.



TO LEARN MORE

VISIT OUR APPLICATION-SPECIFIC WEB SITE: www.keysight.com/find/solarcell

CHECK OUT THESE RELATED APPLICATION NOTES:

“Solar Cell and Module Testing: How to decrease costs and increase flexibility in a rapidly changing test environment” 5990-3262EN
<http://cp.literature.keysight.com/litweb/pdf/5990-3262EN.pdf>

“IV Curve Characterization in High-Power Solar Cells and Modules” 5990-4854EN
<http://cp.literature.keysight.com/litweb/pdf/5990-4854EN.pdf>

“Using Two Power Supplies for Higher Current Solar Cell Characterizing” 5990-3949EN
<http://cp.literature.keysight.com/litweb/pdf/5990-3949EN.pdf>

Solar Inverters

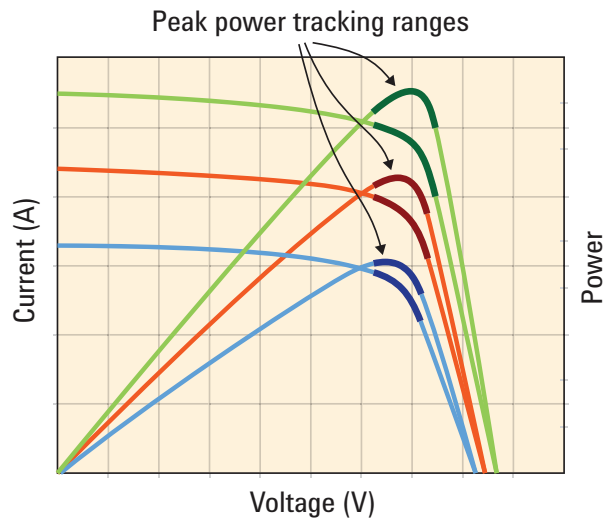
MPPT in photovoltaic modules

Solar inverter designers and manufacturers must ensure their products are capable of extracting and delivering the maximum power that is available from the solar modules to which they are attached. It is a significant challenge to develop and verify performance of inverter peak power tracking circuits and algorithms. Testing is impractical with a solar module. The solution must measure and verify the inverter efficiency in a full range of operating conditions.

The E4360 Solar Array Simulator simulates a PV module or panel output. Most power supplies are constant voltage sources. The E4360 can uniquely provide a simulated current source, similar to a PV module or panel, with fast I-V curve change and fast recovery switching time. Peak power tracking is available with a range of illumination and power tracking devices.

Use the Keysight E4360 solar array simulator to:

- Develop and verify performance of inverter peak power tracking circuits and algorithms
- Measure and verify inverter efficiency
- Verify the ability of the inverter to produce power grid level output from low to high voltage extremes
- Perform qualification tests — confirm inverter performance during or after exposure to environmental conditions
- Perform accelerated lifecycle tests
- Perform certification tests



Peak power tracking with a range of illumination and power tracking range



E4360A Solar Array Simulator

TO LEARN MORE

VISIT OUR APPLICATION-SPECIFIC WEB SITE: www.keysight.com/find/inverter

CHECK OUT THESE RELATED APPLICATION NOTES AND ARTICLES:

"Testing Terrestrial Solar-Powered Inverters Using Solar Array Simulation Techniques" 5990-4132EN

<http://cp.literature.keysight.com/litweb/pdf/5990-4132EN.pdf>

Technical article: "A Photovoltaic MPPT Algorithm for DC Electronic Loads"

<http://electronicdesign.com/test-amp-measurement/photovoltaic-mppt-algorithm-dc-electronic-loads>

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