FIELD TEST GUIDE

FOR GRID-TIED PV MODULES

January 9, 2015

PLEASE READ THIS GUIDE COMPLETELY BEFORE TAKING ANY ACTION

WARNING

THE TESTING AND TROUBLESHOOTING OF SOLAR PHOTOVOLTAIC (PV) MODULES SHOULD ONLY BE PERFORMED BY QUALIFIED PERSONS WITH KNOWLEDGE OF ELECTRICAL SYSTEMS MEASUREMENTS, THE TEST EQUIPMENT USED, AND THE SPECIFICATIONS AND CHARACTERISTICS OF THE EQUIPMENT UNDER TEST. ALL SOLAR EQUIPMENT MANUFACTURER INSTALLATION MANUALS SHOULD BE READ AND UNDERSTOOD BEFORE ATTEMPTING TO TEST OR TROUBLESHOOT PV MODULES. WORKING SAFELY WITH PV MODULES INVOLVES TAKING PRECAUTIONS TO AVOID ELECTRIC SHOCK FROM POTENTIALLY HIGH DC VOLTAGES, ESPECIALLY WHEN SEVERAL MODULES ARE CONNECTED IN SERIES. WIRING FAULTS MAY ALSO LEAD TO HAZARDOUS CONDITIONS AND HIGH VOLTAGES ON METAL COMPONENTS. USE APPROPRIATE SAFETY EQUIPMENT (INSULATED GLOVES/TOOLS, FALL PROTECTION, ETC.) WHEN TESTING OR TROUBLESHOOTING PV MODULES. (Brooks & Dunlop, 2012)

Required testing equipment

- Digital camera (to document installation methods and any visual defects present)
- Digital multimeter (to measure PV module DC open-circuit voltage (V_{OC}))
- Clamp on ammeter (to measure PV module DC short-circuit current (I_{SC}))
- Pyranometer (to measure irradiance on the PV module)
- Thermocouple, thermistor, or infrared thermometer (to measure PV module cell temperature)

Recommended products

- *The PV 150 Solarlink™ Test Kit from Seaward Solar* combines all PV electrical test functions into one tester, andw records irradiance and temperature simultaneously to electrical tests being conducted (thus increasing accuracy of results). Measurements can be stored, downloaded as a test report, and emailed to SolarWorld in order to expedite the troubleshooting process.
- *The Solmetric PV Analyzer* measures the I-V (current vs voltage) and P-V (power vs voltage) curves of a PV module or string of modules to model the system and compare expected performance with measured results based on actual irradiance and temperature. Measurements can reveal many types of array damage and degradation, which often have recognizable curves. Measurements can be stored, downloaded as a test report, and emailed to SolarWorld in order to expedite the troubleshooting process.

Field test steps

1. **Visually inspect the PV module**. Look for visible signs of damage, including cracked glass, hot spots (which can appear on either the front or back of the module), burnt solder joints within cells, or signs of delamination. If visible damage is present, please provide high-resolution photos of the module, including wide-angle (to show installation methods), full module front and back, and close-up (to show damage; also include a photo showing module serial number) images. If module/cell damage is visible, it is not necessary to proceed to step 2.

2. **Isolate the PV module for electrical testing**. Turn off all loads and open appropriate disconnects. For additional safety, it is recommended that the PV modules be covered with an opaque material in order to minimize DC voltage. Once the PV module is no longer under load, carefully disconnect it from the string/circuit and remove any covering for testing.

3. **Measure and record PV module open-circuit voltage using digital multimeter.**

4. **Measure and record PV module short-circuit current using clamp-on ammeter*.**

5. **Measure and record irradiance on PV module using pyranometer***. Measurement should be taken in same plane as the module, with same azimuth and tilt angle. Be sure not to shade PV module with pyranometer during measurement.

6. **Measure and record operating cell temperature using a thermocouple, thermistor, or infrared thermometer.** Measurement should be taken at the back side of the PV module.

Note: *to ensure accuracy of results, steps 4 & 5 should be completed simultaneously.*

Analyzing Results

Compare results with electrical characteristics listed on the back of the PV module. Remember that PV modules are rated under Standard Test Conditions (STC) of 1000 W/m^2 irradiance and 25°C (77°F) operating cell temperature. Listed electrical characteristics are for new, unshaded, unsoiled PV modules (average annual degradation is 0.7%). Measured irradiance is directly proportional to current flow and measured voltage is influenced by temperature (TCV_{OC} = -0.30%/°C). Analyze data; if problem is suspected, submit required photos and measurements to SolarWorld Technical Support for review.

For example, consider the following data for the Sunmodule SW 275 monocrystalline module:

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)

Maximum power	P_{max}	275 Wp
Open circuit voltage	V_{oc}	39.4 V
Maximum power point voltage	V_{mpp}	31.0 V
Short circuit current	I_{sc}	9.58 A
Maximum power point current	I_{mpp}	8.94 A

*STC: 1000 W/m², 25°C, AM 1.5
1) Measuring tolerance (Pmax) traceable to TIV Rheinland: +/- 2% (TUV Power Controlled)

PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	205 Wp
Open circuit voltage	V_{oc}	36.1 V
Maximum power point voltage	V_{mpp}	28.4 V
Short circuit current	I_{sc}	7.75 A
Maximum power point current	I_{mpp}	7.22 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 Wm², 100% (+/- 2%) of the STC efficiency (1000 W/m²) is achieved.

THERMAL CHARACTERISTICS

NOCT	46 °C
TCI_{sc}	0.04 %/°C
TC_{Voc}	-0.30 %/°C
TCP_{mpp}	-0.45 %/°C
Operating temperature	-40°C to 85°C

COMPONENT MATERIALS

Cells per module	60
Cell type	Monocrystalline
Cell dimensions	6.14 in x 6.14 in (156 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	46.7 lbs (21.2 kg)

At 800 w/m² irradiance (80% of STC irradiance), the module Isc is 7.75 A (80% of STC I_{sc}): *9.58A × 0.8 = 7.75 A*

At 46°C Normal Operating Cell Temperature (NOCT) (listed under Thermal Characteristics) and an open circuit temperature coefficient (TC_{VOC}) of -0.3%/°C, the module V_{OC} is 36.1V:

Change in temperature = 46°C – 25°C = 21°C

- *Total percent change in voltage = 21°C × -0.3%/°C = -6.3% (negative sign implies voltage decrease)*
- *Total voltage decrease = 39.4 V (.063) = 2.48 V*
- *Calculated Voc = 39.4 V - 2.48 = 36.9 V**

** Calculated voltage should be ± 10% for modules ≤ 10 yrs of age*

Additonal derate factors may apply due to module age and/or soiling.

Comparative analysis

If you have additional solar modules or inverters on site, one effective troubleshooting technique is to compare measurements of these devices with suspected defective devices. Small differences are normal so look for larger or more meaningful differences. Compare or swap devices when appropriate to verify your suspected conclusions. For example:

- Solar module "A" measures 36 V_{OC}. Solar module "B", an identical unit under identical conditions, measures 28 V . This would indicate that module "B" is likely a defective module.
- If a microinverter is not operating properly, swap EITHER the microinverter or an identical modules within the system and trace which component the problem follows.

Works cited

William Brooks, J. D. (2012, March). *NABCEP-PV-Installer-Resource-Guide-August-2012-v.5.3.pdf*. Retrieved September 03, 2014, from NABCEP: http://www.nabcep.org/wp-content/uploads/2012/08/NABCEP-PV-Installer-Resource-Guide-August-2012-v.5.3.pdf

In order to begin the warranty claim process, please submit the following information to **warranty@solarworld.com**. The SolarWorld Technical Team will review the warranty claim and if approved, a Return Merchandise Authorization (RMA) number and further instructions will be provided.

CUSTOMER/PROJECT INFORMATION

Customer Contact Name | Project Name | Approximate Date Installed

Customer Phone | Project Address

Customer Email | City | State | Zip

INSTALLER INFORMATION

Installer Contact Name | Installation Company Name

Installer Phone | Installer Address

Installer Email | City | State | Zip

DISTRIBUTOR INFORMATION

Distributor Contact Name | Distributor Company Name

Distributor Phone | Distributor Address

Distributor Email | City | State | Zip

TECHNICAL INFORMATION

Model Serial #: | Module Make/Model | Quantity (provide additional data for multiple modules on attached form)

Description of Problem

Measured Isc | Measured Irradiance | Measured Voc | Measured Cell Temperature

Required Photos Submitted:

☐ Wide Shot Photo (to show installation method) ☐ Full Module Front ☐ Full Module Back (if feasible) ☐ Close-up Photos (to show any visible damage)

☐ Close-up Photo (to show module serial #)

Comparative Analysis Test Results

Preferred Warranty Claim Outcome (if approved):

☐ Replace with identical make/model (if possible) ☐ Replace with module of equal or greater wattage (electrical characteristics and physical dimensions may not match original

☐ Either ☐ Other (please explain):

WARRANTY REPLACEMENT SHIP-TO INFORMATION (if approved)

Ship-To Information Matches Provided Information For: ☐ Customer/Project ☐ Installer ☐ Distributor

Ship-To Customer Name

Ship-To Company Name

Ship-To Phone

Ship-To Address

Ship-To Email

City

State

Zip

WARRANTY REPLACEMENT PICK-UP INFORMATION (if approved)

Pick-Up Information Matches Provided Information For: ☐ Customer/Project ☐ Installer ☐ Distributor

Pick-Up Customer Name

Pick-Up Company Name

Pick-Up Phone

Pick-Up Address

Pick-Up Email

City

State

Zip

TECHNICAL INFORMATION (additional module)

Model Serial #:

Module Make/Model

Description of Problem

Measured Isc

Measured Irradiance

Measured Voc

Measured Cell Temperature

Measured Tool(s) Used

Required Photos Submitted:

☐ Wide Shot Photo (to show installation method) ☐ Full Module Front ☐ Full Module Back (if feasible) ☐ Close-up Photos (to show any visible damage)

☐ Close-up Photo (to show module serial #)

Comparative Analysis Test Results

Preferred Warranty Claim Outcome (if approved):

☐ Replace with identical make/model (if possible) ☐ Replace with module of equal or greater wattage (electrical characteristics and physical dimensions may not match original

☐ Either ☐ Other (please explain):

TECHNICAL INFORMATION (additional module)

Model Serial #:

Module Make/Model

Description of Problem

Measured Isc

Measured Irradiance

Measured Voc

Measured Cell Temperature

Measured Toos(s) Used

Required Photos Submitted:

☐ Wide Shot Photo (to show installation method) ☐ Full Module Front ☐ Full Module Back (if feasible) ☐ Close-up Photos (to show any visible damage)

☐ Close-up Photo (to show module serial #)

Comparative Analysis Test Results

Preferred Warranty Claim Outcome (if approved):

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☐ Either ☐ Other (please explain):