

Solmetric PV Analyzer (PVA) I-V Curve Tracer

Standard Operating Procedure

Contents

- Safety
- Advanced Preparation – Before Traveling to the Site to Perform Measurements
- General
- Backing Up Your Measurement Data
- Verifying Your PC has the Correct Date, Time, Time zone & Daylight Savings Status
- Mounting the SolSensor and Thermocouple
- Powering Up the Instruments and Establishing WiFi Connection
- Connecting the I-V Measurement Unit at a Combiner Box
- Connecting the I-V Measurement Unit at a Load Break Disconnect
- Connect the I-V Measurement Unit Directly to String Home-run Cables
- Making I-V Curve Measurements
- Reviewing Your Measurements in the Field
- Moving Your Test Equipment to a New Location in the Array
- Sharing Your Measurement Results

Safety

- ❑ ***PV systems pose lethal shock and arc flash hazards. Anyone working at or near the electrical connections must use Personal Protective Equipment (PPE) that is rated for the amount of energy that could be released at the equipment where the PV Analyzer is connected. Selection of PPE gear is the responsibility of the operator and their organization.***
- ❑ ***Inspect the PVA test leads and cables to make sure there is no damage to test lead insulation or the alligator clips. If there are cuts/breaks in the insulation, do not use the equipment and return it to Solmetric for repair.***
- ❑ ***Use only the test leads and alligator clips provided with the PV analyzer. Do not substitute other test leads.***
- ❑ ***Also refer to the safety sections of the PVA User Guide (in HELP menu of PVA software).***

Advanced Preparation – Before Traveling to the Site to Perform Measurements

- ❑ Selecting a PC for Field I-V Curve Measurement
 - Tablet PC's greatly improve productivity because the PVA software is touch-controllable.
 - Select a tablet that has:
 - Good screen viewability under bright, daylight conditions.
 - Enough battery runtime for a long day of measurements
 - WiFi
- ❑ Check that you are using the latest version of PVA software. It is a free download at <https://www.solmetric.com/downloads-pva.html> . The download also contains any available instrument firmware updates. PVA instruments that are capable of field firmware update will automatically receive the updates the first time the instruments connect to the updated PVA app.

- For guidance on troubleshooting any problems with the PVA Hardware or Software, visit http://resources.solmetric.com/get/PVA_Troubleshooting_7-19-2021.pdf
- We recommend reviewing and analyzing measurement results using the Solmetric I-V Data Analysis Tool (DAT), both in the field and in the office. Check for the current version and view help videos at: <https://www.solmetric.com/pva-analysis-macro.html>.
- Verify that the I-V Measurement Unit and SolSensor connect to your PC. In the PVA app the status indicator above the Measure Now button should show READY.
- Charge the I-V Measurement Unit and SolSensor for at least 6 hours the night before use.
- Review your PV contract requirements and be aware of the acceptance criteria and also the minimum acceptable irradiance.
- Plan ahead to stay within the input current and voltage specs of the I-V Measurement Unit.
 - Be aware of the maximum DC voltage and current specifications of the instrument. Exceeding these limits can damage the instrument. The **current limit** could be exceeded if the curve I-V Measurement Unit is connected to a harness where the total short-circuit current of the connected strings exceeds the instrument spec, or connected to the output of an array or subarray, or across the DC input of an inverter. The **voltage limit** can happen if the I-V Measurement Unit is connected a string that has too many modules, or is accidentally connected to two strings in series.
 - When testing harnessed strings, your options for avoiding overcurrent conditions include testing with fewer strings plugged into the harness and, in tracking systems, pivoting the tracker out of alignment with the sun to reduce the short-circuit current. With questions, contact Solmetric Tech Support: support@solmetric.com, 1-707-823-4600.
 - High-efficiency (HE) modules can also trigger the overcurrent condition, by releasing a short but intense surge of current at the start of the I-V curve sweep. If strings of HE modules are tested in parallel, the current spike can greatly exceed the DC current limit of the PVA. **Always test strings of HE modules one at a time.** Allow extra time and manpower for switching strings at the harness taps.
- Build your measurement PROJECT in the PVA software (File menu > New project...), using the three screens of the New Project Wizard:
 - Site Info
 - PV Module Selection
 - Array Navigator
 - In this screen you will build the Array Tree to which you will save your measurements.
 - Make sure to put all of the essential layers of your array into the tree so it is clear to the operator where to save each measurement.
 - Give special thought when measuring harnessed arrays. Will you be testing with all strings connected to the harness, or will you be connecting them individually, or in pairs. Build the Array Tree to make saving your measurements as convenient as possible.

- Make sure the SolSensor gear bag contains:
 - Two thermocouples (1 for use and the other to replace it if it fails).
 - Plenty of green Kapton tape discs for attaching them to the module backside. These discs assure good contact with the backsheet, for accurate temperature measurement. Spools of these discs are available from Solmetric.
 - The special bar-clamp for mounting SolSensor to module frames.
 - If the modules are frameless, you will need another way to mount SolSensor. It has ¼-20 threaded camera-mount bushing on its underside, which you can be used to attach SolSensor to a bar of wood or metal that you can clamp to the array racking or a tracker torque tube to assure that SolSensor is facing in exactly the same direction as the PV modules.
- Review the Checklist for Preparing to Test PV Arrays at <http://resources.solmetric.com/get/Preparing-to-Test-PV-Arrays-Application-Note.pdf>

General

- Always leave the short connector-saver jumpers attached to the primary test lead cables. Replace them after 100 connection cycles. Contact Solmetric for replacements.
- Inspect SolSensor's optical sensor (white disc) prior to use. If it is damaged, the irradiance readings will not be accurate. If it is dusty, clean it using the materials in the soft case. Hold SolSensor facing downward and spray the distilled water upward at the sensor, allowing the dust to rinse off. Then use the clean microfiber cloth (shake it out first) to dry the sensor and remove any remaining dust. DO NOT use any commercial cleaning fluids!
- When the I-V measurements are exported, only the most recent measurement of each circuit is exported. So if you fix a poorly performing string, be sure to take and save another measurement in the 'fixed' condition.
- In most applications a thermocouple is required the backside of a PV module that's at a typical temperature for the string you are testing. The backside thermocouple is also required for the SmartTemp temperature measurement method.

Backing UP Your Measurement Data

- Be sure to periodically BACK UP your Project file, which contains all of your measured data and your Project setup. (PVA 4.14.200 and later have backups enabled by default. Go to the FILE menu and select 'Project Backup Settings' to configure backup options.)

Verifying Your PC has the Correct Date, Time, Time zone & Daylight Savings Status

- Before starting your measurements, bring up the PC's ADJUST DATE/TIME screen and make sure these four parameters are correct.
- The PVA uses them to calculate the position of the sun so it can calculate the effective irradiance seen by the PV modules. If these parameters are not correct, the predicted I-V curve and the Performance Factor will be wrong.

Mounting the SolSensor and Thermocouple

- ❑ Attach SolSensor to the frame of a PV module using the bar clamp.
- ❑ Make sure that the blue wings are contacting the top edge of the module frame.
- ❑ If the PV modules are frameless, use a short bar of wood or metal to attach SolSensor to the racking or the tracker torque tube, making use of the ¼-20 threaded fitting on the back of SolSensor.
- ❑ Remove the protective lens cover from the optical sensor. (Later, when removing SolSensor, replace the lens cover BEFORE unmounting the unit)
- ❑ Plug one thermocouple lead into the 'TC1' socket. Always use the same socket. An easy to remember rule of thumb is to always use ONE thermocouple and plug it into TC port number ONE.
- ❑ Be aware that the SmartTemp temperature sensing method requires a thermocouple mounted to the backside of a module.
- ❑ Second thermocouple
 - The second thermocouple wire provided in the SolSensor kit is a backup in case the first one breaks, and is not intended to be used to measure air temperature.
 - If you do use 2 thermocouples, be aware that the software averages their readings, so make sure they are both mounted on the module backside. If one of the thermocouples is in air, the average temperature will be too low, resulting in incorrect prediction of the expected I-V curve (the 3 red dots) and an incorrect Performance Factor.
- ❑ Attach the tip of the thermocouple lead to the back of a module using the green tape discs provided with the PVA. Additional discs can be purchased from Solmetric.
 - Attach the thermocouple as far as possible from the edges of the module, to get a more typical temperature value.
 - Make sure the tip is in firm contact with the module backside. An airgap will result in a lower temperature reading.
 - Never use electrical tape, which relaxes at high temperature and allows the tip of the thermocouple lose contact with the backside.

Powering Up the Instruments and Establishing WiFi Connection

- ❑ Power up the PC and open the PVA application.
- ❑ Briefly press the pushbutton on both SolSensor and the I-V Measurement Unit.
- ❑ In the PC's network list, select the hot spot that matches your I-V Measurement Unit, check the box to "Reconnect automatically", and select CONNECT.
- ❑ After a few moments the status indicator at the upper right corner of the PVA screen will turn green and say READY.

Connecting the I-V Measurement Unit at a Combiner Box

- ❑ Disconnect the combiner from the inverter and the rest of the array.
- ❑ If each string has a single fuse, lift all of the fuses.
- ❑ If each string has 2 fuses (one at each end) lift all of the fuses at one end (polarity) of the strings and insert all of the fuses of the other end (polarity).

- ❑ Check circuit voltage and polarity with a volt meter, probing the bus bars. Look for “0” volts with all fuses open or removed.
- ❑ Verify the expected string voltage and polarity when one string or harnessed circuit is connected.
- ❑ Attach the Solmetric-provided PVA test leads to the connector saver jumpers, matching the test lead colors to the primary test lead cables. **Do not substitute other test leads.**
- ❑ Matching polarities, clip the test lead alligator clips to the combiner bus bars. If you don’t know the string polarities, check first using a voltmeter that’s rated for the system DC voltage.
- ❑ Before each measurement, insert a fuse to select the circuit you want to test.

Connecting the I-V Measurement Unit at a Load Break Disconnect

- ❑ Open all of the disconnects
- ❑ Connect the PV analyzer test leads to the terminals on the PV array side of a disconnect switches, one switch at a time, for your measurements.

Connect the I-V Measurement Unit Directly to String Home-run Cables

- ❑ If there is no combiner box or LBD and the string home-run cables plug into PV-connectorized pigtails at the inverter, connect the I-V Measurement Unit directly to the home-run cables.
- ❑ Be sure the connector-saver jumper is always installed on the primary test leads.

Making I-V Curve Measurements

- ❑ Observe the live irradiance value shown at the lower right of the PVA screen. Do not measure until the irradiance is above the minimum acceptable irradiance stated in your system contract.
- ❑ Press Measure Now. After 4-5 seconds you’ll see the measured I-V curve at the left and the Array Tree at the right. Verify that the curve is complete; repeat the sweep if needed.
- ❑ If you are satisfied with the measurement and you want to save it, find that circuit in the Array Tree and highlight it by touching its label.
- ❑ To save the measurement, select ASSIGN AND SAVE. To complete the measurement but not save it, select ASSIGN ONLY.
 - Now three red dots appear along with the I-V curve. The dots show the expected endpoints of the I-V curve and the expected maximum power point.
 - Also, the Performance Factor is displayed at the lower left, showing how the measured max power point compares with the expected value.

Reviewing Your Measurements in the Field

- ❑ General
 - Is the irradiance above the acceptable level?
 - Is the value of the Performance Factor acceptable?
 - Is the I-V curve free of steps?
 - If not, inspect the string for shading, debris, non-uniform soiling, or dirt dams along the lower frame edge.
 - If it’s possible that a person was shading the string during the test, re-take the measurement.

- Using the History tab to review your measurements
 - Before starting a set of measurements, for example at a combiner box, select the History tab and clear all columns.
 - When you finish the measurements, return to the History tab and scroll across the columns, paying attention to the parameters that are most relevant to your testing requirements.
- Using the Solmetric I-V Data Analysis Tool to review your measurements
 - In the File menu of the PVA app, select Export Traces for Entire System.
 - Using the DAT 'Add Dataset' feature, navigate to the location of the exported data and select the part of the Array Tree that you want to review.
 - Choose your analysis options using the buttons and checkboxes on the Home Screen of the DAT. To save time, just hit the INTERMEDIATE autoconfig button at the far left.

Moving Your Test Equipment to a New Location in the Array

- I-V measurement Unit
 - If measuring at combiner boxes, lift all of the fuses you used to select strings for testing, then disconnect the PVA test leads from the combiner bus bars.
 - If measuring at LBDs, disconnect the PVA test leads from the switch terminals.
- SolSensor
 - On a clear day, and if your instruments are located for good wireless range, you may be able to make I-V curve trace measurements at more than one combiner box, LBD or inverter with a single location of SolSensor.
 - On days with clouds, there can briefly be a difference between the amount of light falling on SolSensor and on the string(s) you are measuring. This can cause an error in the Performance Factor (too high or too low) and in the predicted I-V curve shape (the three red dots). If you see this behavior, keep SolSensor closer to the table of strings you are measuring.

Sharing Your Measurement Results

- Sharing your Project file (the preferred method of sharing your results)
 - Attach your Project file to an email or copy and paste it to a flash or cloud drive.
 - Sharing the Project file provides much more information and is always preferred when sharing your results with Solmetric Tech Support.
- Sharing exported data
 - In the PVA app's File menu, select Export Traces for Entire System. Others will not be able to view it in the PVA app, but they can analyze the data using the Solmetric Data Analysis Tool.
- Sharing your Data Analysis Tool file or a pdf of the DAT's Report tab
 - After your data is added to the DAT you can share the DAT, and after generating a report in the DAT you can share a pdf of that worksheet.