Solmetric PVA-600
PV Analyzer

U s e r ô s G u i d e

Part No. 600-90001
Version 1.0.2985.0
December 2010
Printed in USA

Solmetric Corporation
www.solmetric.com
Tel: (877) 263-5026
Fax: (707) 823-4620

End User Software License and Hardware Agreement

CAREFULLY READ THE FOLLOWING AGREEMENT. BY OPENING THE PACKAGE OR CLICKING ON "I AGREE", YOU ARE CONSENTING TO BE BOUND BY AND ARE BECOMING A PARTY TO THIS AGREEMENT. IF YOU DO NOT AGREE TO ALL OF THE TERMS OF THIS AGREEMENT, CLICK "I DO NOT AGREE", DELETE ANY DOWNLOADED INSTALLATION FILES, AND, IF APPLICABLE, RETURN THIS PRODUCT TO THE PLACE OF PURCHASE FOR A FULL REFUND.

Software License Grant

The package or downloaded installation file contains:

1. PV Analyzer™ PC software (ñPC Software ò)
2. PV Analyzer I-V Unit software ("Embedded Software"), and
3. Related explanatory written materials ("Documentation").

"PC Software" and ñEmbedded Software ò includes any upgrades, modified versions, updates, additions and copies of the software. "You" means the person or company who is being licensed to use the Software or Documentation. "We", "us", and ñSolmetric® ò means Solmetric Corporation.

We hereby grant you a nonexclusive license to use one copy of the PC Software on any single computer, provided the PC Software is in use on only one computer at any time. The PC Software is "in use" on a computer when it is loaded into temporary memory (RAM) or installed into the permanent memory of a computer ð for example, a hard disk, CD-ROM or other storage device. If the PC Software is permanently installed on the hard disk or other storage device of a computer (other than a network server) and one person uses that computer more than 80% of the time, then that person may also use the PC Software on a portable or home computer.

We hereby grant you a nonexclusive license to use one copy of the Embedded Software when it is running within the relevant Solmetric hardware.

Software Title

Solmetric remains the owner of all right, title and interest in the PC Software, Embedded Software, and Documentation.

Archival or Backup Copies of PC Software

You may either:

make one copy of the PC Software solely for backup or archival purposes, or

transfer the PC Software to a single hard disk, provided you keep the original solely for backup or archival purposes.

Things You May Not Do With The Software Or Documentation

The PC Software, Embedded Software, and Documentation are protected by United States copyright laws and international treaties. You must treat the PC Software, Embedded Software, and Documentation like any other copyrighted material--for example a book. You may not:

copy the Documentation,

copy the Embedded Software

copy the PC Software except to make archival or backup copies as provided above,

modify or adapt the PC Software or Embedded Software or merge it into another program,

reverse engineer, disassemble, decompile or make any attempt to discover the source code of the PC Software or Embedded Software,

place the PC Software or Embedded Software onto a server so that it is accessible via a public network such as the Internet, or

sublicense, rent, lease or lend any portion of the PC Software, Embedded Software, or Documentation.

Transfers of PC Software or Embedded Software

You may transfer all your rights to use the PC Software and Documentation to another person or legal entity provided you transfer this Agreement, the PC Software and Documentation, including all copies, updates and prior versions to such person or entity and that you retain no copies, including copies stored on computer.

You may transfer all your rights to use the Embedded Software and Documentation to another person or legal entity provided you transfer this Agreement, the hardware associated with the Embedded Software, and the Embedded Software and Documentation, including all copies, updates and prior versions to such person or entity and that you retain no copies, including copies stored on computer.

Limited Hardware and Software Warranty

This Solmetric PC Software and Embedded Software and the Solmetric PV Analyzer hardware are warranted against defects in materials and workmanship for a period of one year. During the warranty period, Solmetric will, at its option, either repair or replace products which prove to be defective. The warranty period begins on the date of shipment.

For warranty service or repair, this product must be returned to Solmetric. For products returned to Solmetric for warranty service, the Buyer shall pay for shipping charges to send the product to Solmetric, and Solmetric shall pay for shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Solmetric from another country.

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, unauthorized modification or misuse, or operation outside of the environmental specifications for the product. Unauthorized modification includes disassembly of the Hardware or removal of any part of the Hardware (including opening the PV Analyzer I-V unit). The design, construction, and measurement of any system or building by the Buyer is the sole responsibility of the Buyer. Solmetric does not warrant the malfunction of the Buyerôs system, or malfunction of the Buyerôs system, or damage caused by the Buyerôs system, or damage caused by the Buyerôs use of Solmetric products.

To the extent permitted by applicable law, THE FOREGOING LIMITED WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, AND WE DISCLAIM ANY AND ALL IMPLIED WARRANTIES OR CONDITIONS, INCLUDING ANY IMPLIED WARRANTY OF TITLE, NONINFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, regardless of whether we know or had reason to know of your particular needs. No employee, agent, dealer or distributor of ours is authorized to modify this limited warranty, nor to make any additional warranties.

SOME STATES DO NOT ALLOW THE EXCLUSION OF IMPLIED WARRANTIES, SO THE ABOVE EXCLUSION MAY NOT APPLY TO YOU. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE.

Limited Remedy

Our entire liability and your exclusive remedy shall be the replacement or repair of any Solmetric Hardware or Solmetric PC Software or Embedded Software not meeting our Limited Hardware And Software Warranty which is returned to us or to an authorized Dealer or Distributor with a copy of your receipt.

IN NO EVENT WILL WE BE LIABLE TO YOU FOR ANY DAMAGES, INCLUDING ANY LOST PROFITS, LOST SAVINGS, INJURY, DEATH, OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING FROM THE USE OF OR THE INABILITY TO USE THE PC SOFTWARE, EMBEDDED SOFTWARE, HARDWARE, OR DOCUMENTATION (EVEN IF SOLMETRIC OR AN AUTHORIZED DEALER OR DISTRIBUTOR HAS BEEN ADVISED OF THE POSSIBILITY OF THESE DAMAGES), OR FOR ANY CLAIM BY ANY OTHER PARTY.

SOME STATES DO NOT ALLOW THE LIMITATION OR EXCLUSION OF LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION MAY NOT APPLY TO YOU.

Term and Termination

This agreement takes effect upon your use of the PC Software, Embedded Software, or Hardware and remains effective until terminated. You may terminate it at any time by destroying all copies of the PC Software, Embedded Software, and Documentation in your possession and returning the Hardware to Solmetric or to an authorized distributor. It will also automatically terminate if you fail to comply with any term or condition of this license agreement. You agree on termination of this license to either return to us or destroy all copies of the PC Software, Embedded Software, and Documentation in your possession and to return the Hardware to us or to an authorized distributor.

Confidentiality

The PC Software and Embedded Software contains trade secrets and proprietary know-how that belong to us and it is being made available to you in strict confidence. ANY USE OR DISCLOSURE OF THE PC SOFTWARE, EMBEDDED SOFTWARE, OR OF THEIR ALGORITHMS, PROTOCOLS OR INTERFACES, OTHER THAN IN STRICT ACCORDANCE WITH THIS LICENSE AGREEMENT, MAY BE ACTIONABLE AS A VIOLATION OF OUR TRADE SECRET RIGHTS.

Trademarks

SOLMETRIC, PV ANALYZER, PV DESIGER, SOLMERIC IPV and SOLMETRIC ISV are trademarks owned by Solmetric Corporation. SOLMETRIC and SUNEYE are registered trademarks in the U.S. Patent and Trademark Office.

General Provisions

1. This written agreement is the exclusive agreement between you and us concerning the PC Software, Embedded Software, Hardware, and Documentation and supersedes any and all prior oral or written agreements, negotiations or other dealings between us concerning the PC Software, Embedded Software, Hardware or Documentation.

2. This license agreement may be modified only in writing and written documentation must be signed by Buyer and Solmetric.

3. In the event of litigation between Buyer and Solmetric concerning the PC Software, Embedded Software, Hardware, or Documentation, the prevailing party in the litigation will be entitled to recover attorney fees and expenses from the other party.

4. This license agreement is governed by the laws of the State of California.

5. Buyer agrees that the PC Software, Embedded Software, or Hardware will not be shipped, transferred or exported into any country or used in any manner prohibited by the United States Export Administration Act or any other export laws, restrictions or regulations.

Contents

Figures

Tables

The page left blank intentionally.

1 Introduction

Overview

The PVA-600 PV Analyzer is a portable test instrument designed to measure the current-voltage (I-V) curves of PV modules and strings and immediately compare the results to on-board PV model predictions. Measurement results are easily saved for future reference and analysis.

The current-voltage (I-V) curve of a PV module, string, or array provides a detailed description of its energy collecting ability. The curve ranges from the short circuit current (Isc) at zero volts, to the open circuit voltage (Voc) at zero current. At the "knee" of normal I-V curve are the maximum power current and voltage (Imp, Vmp), the point at which the array generates maximum electrical power. All of these important voltages and currents are captured when the I-V curve is measured. The detailed shape of the curve between these points gives additional information about the health of the PV module, string, or array under test.

The value of a measured I-V curve is greatly increased when it can be compared with a predicted I-V curve derived from an accurate PV model. Models take into account the specifications of the PV modules, the number of modules in series and strings in parallel, and the losses in system wiring. Other data used by the models include the irradiance in the plane of the array, the module temperature, and array orientation.

Computer Minimum System Requirements

- Test and Supported Operating System: Windows 7® (32 and 64 bit versions), Windows Vista® (32 bit versions only), Windows XP® SP3
- Two USB Ports (or one USB port if wireless sensors will not be used)
- Display Resolution: 1024 X 600 (minimum)
- Processor Speed: >700 MHz
- RAM: >500 Mbytes
- Available Disc Space: 100 Mbytes or more

Systems that do not meet these requirements may not operate correctly.

PVA-600 Equipment

- I-V Measurement Unit
- Soft Case
- Wireless USB Adapter and PVA-600 Software Application
- Battery Charger
- MC-4 to MC-4 Connector-Saver Cable (2)
- MC-4 to MC-3 Adapter Cable (2)
- User's Guide (on Installation DVD)
- Quick Start Guide

PVA-600 Specifications

Electrical Specifications

Safety Rating: Measuring Category CATIII 600V.

Table 1. PVA-600 electrical specifications

Parameter	Specification
Current Measurement Range[1]	0 to 20 A dc
Voltage Measurement Range	0 to 600 V dc
Minimum Voc	20 V dc
Minimum Isc	1 A dc
Wireless Communications Range	10 m (industrial building walls) to 75 m (open range)
Measurement Sweep Time[2]	80 ms to 240 ms
Measurement Points per Trace (typical)	100
PV Models	Sandia (>420 modules) 5-Parameter (>1760 modules) Simple Datasheet Model (user enters datasheet values)
Battery Life	≥20 hours (normal use)
Charging Time	6 hours
Operating Temperature	+0º C to +50º C
Storage Temperature	-20º C to +60º C
Operating Humidity	The normal humidity range is 80% relative humidity for temperatures up to 31ºC, decreasing linearly to 50% at 40ºC. Higher humidity levels should not affect the performance or safety of the PVA-600.

[1] Conventional PV modules and strings may be measured in parallel, up to the current limit specified here. High-efficiency modules should NOT be measured in parallel.

[2] Automatically selected. Measurement sweep time depends upon the characteristics of the test device (PV module, string, or array).

Mechanical Specifications

Table 2. PVA-600 mechanical specifications

Parameter	Specification
PV Connectors[1]	MC-4
Weight	9.2 lbs (not including weight of the soft case)
Height	15 in
Width	8 in
Depth	5 in

[1] At ends of the primary test leads permanently attached to the I-V Measurement Unit.

PVA Sensor Kit Equipment (Optional)

- Irradiance Sensor
- Temperature Sensor
- 5-Pack of Replacement Temperature Sensors
- Wireless USB Adapter
- Transmitter (irradiance)
- Transmitter (temperature)
- Case
- Rechargeable AAA batteries and battery charger

PVA Sensor Kit Specifications (Optional)

Table 3. PVA Sensor Kit temperature specifications

Parameter	Specification
Thermocouple Type	K
Range	-100º C to 1260º C (-148º F to 2300º F)
Resolution	1º C
Accuracy (greater of)	±0.5% of rdg or ±1.0º C (1.8 º F)

Table 4. PVA Sensor Kit irradiance specifications

Parameter	Specification
Sensor Type	Silicon Solar Cell
Angle of Incidence Effect	Typically < 1% if AOI is less than 60 degrees from normal
Temperature Effect	Typically < ±2.7% variation over -20º C to +70º C
Uncertainty Contributed by Wireless Link	±0.5% or reading
Uncertainty from Time Lead or Lag in Reading Irradiance Sensor	0.5% to > 5% depending on atmospheric conditions

Safety and Regulatory

Warnings, Cautions, and Notes

Before operating the PVA-600, familiarize yourself with the following notations.

WARNING	**A *Warning* calls attention to a procedure, which, if not performed correctly, could result in personal injury or loss of life. Do not proceed beyond a warning note until the indicated conditions are fully understood and met.**

CAUTION	*A Caution calls attention to a procedure that, if not performed correctly, could result in damage to, or destruction of, the instrument. Do not proceed beyond a caution note until the indicated conditions are fully understood and met.*

NOTE	A *Note* provides important or special information.

Declaration of Conformity

A declaration of conformity is available upon request.

Cleaning

To remove dirt or dust from the external case and/or hard enclosure of the PVA-600, use a dry or slightly dampened cloth only.

WARNING	**To prevent electrical shock, disconnect the PVA-600 from the PV system and/or battery charger before cleaning. Use only a dry cloth or cloth slightly dampened with water to clean the external case and hard enclosure parts. Do not attempt to clean internally.**

Instrument Markings

The PVA-600 has the following markings on the front and/or rear panel. Familiarize yourself with these markings before operating the PVA-600.

The instruction manual symbol. The product is marked with this symbol when it is necessary for you to refer to instructions in the manual.

Compliance pending. The TUV mark indicates compliance with USA/EU safety regulations.

Compliance pending. This symbol indicates compliance with the requirements of CAN/CSA-C22.2 No. 61010-1, 2nd edition, including Amendment 1. This product has been tested to the requirements of CAN/CSA-C22.2 No. 61010-1, second edition, including Amendment 1, or a later version of the same standard incorporating the same level of testing requirements

This symbol indicates separate collection for electrical and electronic equipment, mandated under EU law as of August 13, 2005. All electrical and electronic equipment are required to be separated from normal waste for disposal. (Reference WEEE Directive, 2002/96/EC.)

The IEC HV symbol indicates the presence of hazardous voltages. Danger exists of electrical shock that can cause severe injury or death.

This symbol marks the position of the power switch.

The page left blank intentionally.

2 Getting Started

Precautions

PV Connectors

PV connectors, regardless of manufacturer, are not designed for large numbers of connections/disconnections. For this reason, the PVA-600 is shipped with connector-saver jumpers attached to its primary test leads. These short jumpers are sacrificial. PV devices under test (modules, strings, or arrays), extension cables, and clip leads are always connected to the connector-saver jumpers, extending the life of the primary PV connectors. When the lifetime of the connector-saver jumper has been reached, it should be replaced, cut in half to prevent re-use, and recycled. With the use of connector-saver jumpers, the life of the primary test leads of the PVA-600 should be extended to 5,000 to 10,000 connections.

PV/Electrical Safety Precautions

Installed PV systems are not consistent in design or construction. Therefore the guidance provided in this section is general in nature, and it is critical that the user apply techniques and precautions appropriate to the circumstances, following best PV/electrical safety precautions.

WARNING **The information below is important but not necessarily complete; the operator must assess the potential dangers of each PV system, and take appropriate precautions.**

FAILURE TO TAKE APPROPRIATE SAFETY PRECAUTIONS COULD LEAD TO PERSONAL INJURY OR LOSS OF LIFE.

- Á Avoid working alone.
- Á Do not use the PVA-600 in wet environments.
- Á Do not operate or subject the PVA-600 to temperatures beyond the published operating and storage temperature specifications.
- Á Wear electrical safety gloves.
- Á Wear eye protection.
- Á Wear fall protection where required.

- Assume that metal surfaces are energized unless proven otherwise.
- Isolate the PV source circuit under test from the inverter, and from other PV source circuits, before making any connections to the test device (PV module, string, or array).
- Always pause the measurement sequence using the LED-illuminated pushbutton switch on the I-V unit before connecting or disconnecting the test leads of the PVA-600.
- Do not use the PVA-600 to test devices that produce more than the specified maximum current and voltage.
- Connect the test leads to the test device (PV module, string, or array) with the correct polarity.
- Protect the primary test lead connectors of the PVA-600 by installing connector-saver jumpers. Replace the connector-saver jumpers when they have reached 100 connections.
- Make sure that user-provided cables or clip leads used to extend the test leads of the PVA-600 are rated to safely handle the PVA-600's specified and maximum c voltage.
- When using probes or clip leads, they should be of the insulated type with minimal exposed metal. Keep your fingers behind the insulating finger guards.

WARNING **Do not remove instrument covers. There are no user serviceable parts within. Operation of the instrument in a manner not specified by Solmetric may result in personal injury or loss of life.**

- Do not use the I-V Measurement Unit if it is damaged. Always inspect for damage before using.
- Inspect primary test leads and connectors for damage before using. Do not use if damaged.
- Do not use the I-V Measurement Unit if it is performing abnormally. Contact Solmetric for guidance or return the I-V Measurement Unit to the factory for service.

Battery Precautions

CAUTION	*The PVA-600 contains a lithium battery and should not be disposed of with general refuse. Dispose of the battery in accordance with all local codes and regulations for products containing lithium batteries. Contact your local environmental control or disposal agency for further details.*

WARNING	**Only use the battery charger supplied by Solmetric.**

Measuring High -Efficiency PV Modules

High-efficiency PV modules may produce very high instantaneous current levels at the start of an I-V measurement. For this reason, modules (or strings) of high-efficiency modules should not be measured in parallel. Measure only one module or string at a time.

Understanding the PVA-600

Application Overview

The PVA-600 is used during PV system installation and commissioning to ensure proper performance of PV modules, strings, and arrays. The PVA-600 is also used for maintenance and troubleshooting to assist in locating the cause of performance problems in the system.

The PVA-600 consists of the following:

- I-V Measurement Unit (PVA-600)
- Control/display device (computer, supplied by user)
- Optional wireless irradiance and temperature sensors (PVA Sensor Kit)

Communication between the I-V Measurement Unit and PC is wireless. A wireless transmitter/receiver is built into the I-V Measurement Unit, and a wireless USB adapter allows a notebook or tablet computer to be the control/display device. The wireless USB adapter and PC-based software are supplied with the PVA-600.

The optional wireless irradiance and temperature sensors communicate with the PC by means of a second wireless USB adapter, supplied with the sensor kit.

I-V Measurements

When enabled, the I-V Measurement Unit measures I-V curves when the user requests it from the PC interface. The measurement results are transmitted shortly after an I-V sweep is completed.

The measured I-V curve is displayed along with the modeled (predicted) I-V points. Key values such as Isc, Voc, and so on, are displayed in a table.

Logging Mode

The PVA-600 also provides a logging mode that captures I-V curves over a period of time. I-V curves are measured at time intervals, and summary data (not entire I-V data sets) is saved. This feature is useful when the weather is intermittent and it is necessary to wait for a period of clear sky or when troubleshooting intermittent or temperature related performance problems. When operating in the logging mode, the I-V Measurement Unit transmits the data continuously to the wirelessly connected notebook or tablet computer running the PVA-600 software. The computer must be present during the logging period.

PV Models

Three PV models are used in the PVA-600: the Sandia, the 5-Parameter, and the Simple Performance Model. These models make use of parameters unique to each PV module. The parameters of many modules are stored in a database in the display/control device. These parameters are updated or extended when an update is done through the Solmetric web site. Some modules, particularly very old or very new ones, may not be represented in the on-board databases. In this case, the Simple Performance Model can be used with parameters entered by the user from the PV module data sheet.

Installation Procedure

Hardware Installation

The only hardware installation is to ensure that the battery is fully charged before operating. Refer to Charging the Battery.

Software Installation

1. Insert the PVA-600 DVD into the DVD drive on your Windows® computer.
2. If the welcome screen does not automatically open as shown in Figure 1, either double-click on the **setup.exe** file on the DVD or run **setup.exe** from the **Run** dialog. Alternatively, the installation file is available at www.solmetric.com.

Figure 1. Welcome screen

3. Follow the instructions in the welcome screen to install the PVA-600 software. The drivers for the wireless USB adapter will also be installed.
4. The directory structure shown in Figure 2 is created in the Documents directory.

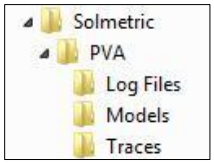

Figure 2. Directory structure of PVA-600 software

5. When the installation process is finished, start the PVA-600 software by double-clicking on the shortcut icon on your desktop as shown in Figure 3. Or, select the list of programs in the **Start** menu, then select **Solmetric>PV Analyzer>Solmetric PV Analyzer**.

Figure 3. Launching the PVA-600 software

6. The screen shown in Figure 4 should appear.

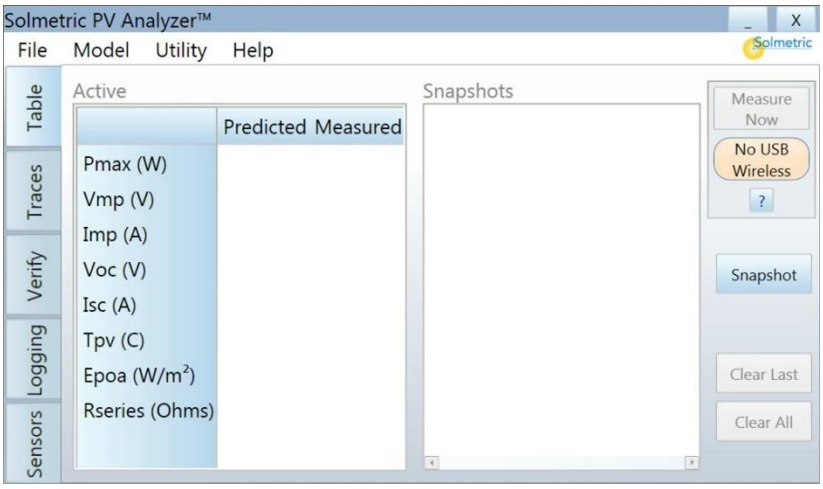

Figure 4. PVA-600 software user interface

Special XP Operating System Instructions

This section applies to computers running the XP operating system only.

Older computers running the XP operating system require special steps during the installation of the wireless USB driver. Please pay close attention to onscreen prompts.

In addition, please be aware that XP will require the re-installation of the driver if you insert the wireless USB adapter in a different USB port. Therefore, we recommend one of the following when using the XP operating system:

a. Select a single convenient USB port for the wireless interface and always use that port.

b. Sequentially insert the wireless USB adapter into each USB port in your computer and follow the same installation process (as instructed on screen) for each port.

Installing Drivers for the Optional PVA Sensor Kit

The PVA Sensor Kit uses the same drivers as the PVA-600. Therefore, once the PVA-600 Software has been installed, no additional installation is required for using the PVA Sensor Kit.

Charging the Battery

The battery in the PVA-600 is not removable. It may be recharged by attaching the battery charger to the connector on the PVA-600 shown in Figure 5 and plugging the charger into an AC wall-plug.

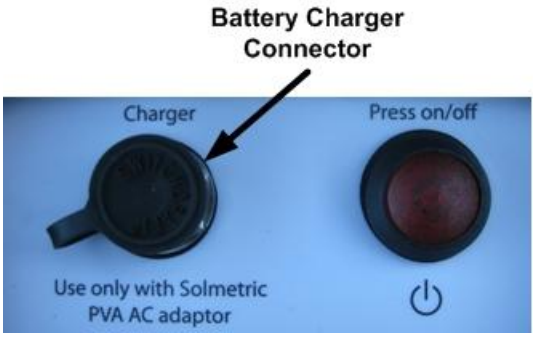

Figure 5. Battery charger connector on the PVA-600

Charging the battery can take up to 6 hours. Once the battery has been charged, the PVA-600 will operate for approximately 20 hours of normal operation.

There is no visible indication of charging on the PVA-600 front panel. Because of the difficulties of determining the state of charge of the advanced lithium batteries, there is no user readout of charge level on the PVA-600 Software interface. However, the PVA-600 Software interface will warn the user when approximately one hour of battery life remains.

The software user interface displays the **Disabled** alert (below the **Measure Now** button) when the battery is nearing the end of its charge. In this state, no measurements can be taken.

CAUTION	*The PVA-600 should not be operated while the battery is charging.*

3 Using the PVA-600

System Controls and Settings

The LED-illuminated button switch on the top surface of the I-V Measurement Unit, shown in Figure 6, is used to control the state of the measurement system, to enable or disable the I-V Measurement Unit, and to reset the unit.

When the I-V Measurement Unit is turned on, it searches for its wireless partner, the Wireless USB Adapter that is plugged into your notebook or tablet computer, to establish a network for control and data transfer.

Figure 6. LED-illuminated button switch

PVA-600 States

The PVA-600 has the following states:

- Power off
- Network search
- Sweep enabled
- Sweeping
- Sweep disabled
- Reset

Table 5. PVA-600 states

PVA-600 State	Description	Power Button State
Power Off	PVA-600 is turned off.	LED Off.
Network Search	Press the power button once. Communication between the I-V Measurement Unit and the Wireless USB Adapter is attempted. If a network is not established within 15 minutes, the I-V Measurement Unit will turn off automatically.	LED Blinking.
Sweep Enabled	I-V network exists and sweep is enabled.	LED on.
Sweeping	I-V Measurement Unit receives a sweep trigger from the PC application and a measurement is taken.	LED blinks momentarily at start of each sweep.
Sweep Disabled (pause)	While the I-V Measurement Unit is on, press the power button once. The sweep is disabled. Disable the sweep before connecting or disconnecting the I-V Measurement Unit to/from PV modules or strings. If left in Sweep Disabled mode for more than 15 minutes, the I-V Measurement Unit will turn off automatically.	LED off.
Reset	Press and hold the power button for more than 5 seconds to force a power-up reset. The system will attempt to reestablish communication between the I-V Measurement Unit and the Wireless USB Adapter.	LED blinking.

Setting Up the PVA-600

1. Place the I-V Measurement Unit close to the PV device to be measured.

NOTE The PVA-600 will automatically shut down if its internal temperature reaches a preset limit. Internal temperature is increased by PV energy collected during I-V sweeps, and also by heat absorbed from the environment, including high ambient air temperature, hot surfaces on which the PVA-600 is placed, and exposure to direct sunlight.

CAUTION Place the PVA-600 in the shade to reduce the likelihood of thermal shutdown. Never place the PVA-600 on an asphalt driveway or on a roof in direct sunlight.

2. Ensure that the connector-saver jumpers are installed on the primary test leads.
3. If necessary, connect alligator clip leads or extension cables to the connector-saver jumpers. Use only clip leads or cables that are rated for at least the maximum current and voltage of the I-V Measurement Unit.
4. If long extension cables are connected to the I-V Measurement Unit to reach the test device, the cables should be laid alongside one another rather than in a loop, to minimize the inductance they add to the measurement circuit.
5. Connect the Wireless USB Adapter to a USB port in your computer.
6. If you will be using the PVA Sensor Kit, refer to Setting Up the Optional PVA Sensor Kit for setup information.

Setting Up the Optional PVA Sensor Kit

Figure 7 shows the PVA Sensor Kit components that will be set up.

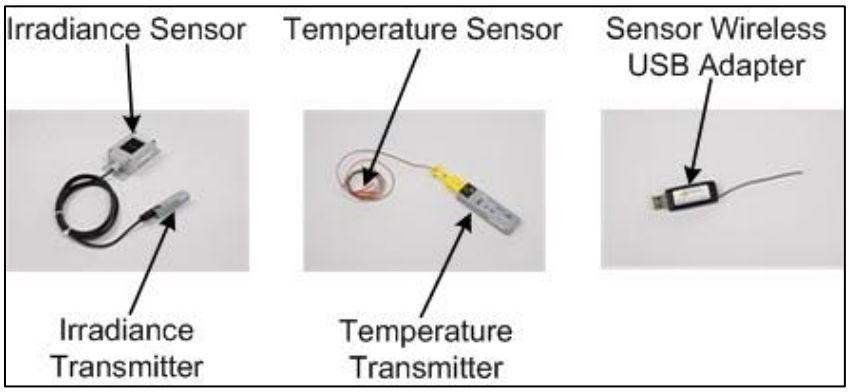

Figure 7. PVA Sensor Kit

1. Connect the Sensor Wireless USB Adapter to a USB port in your computer.

NOTE On some PCs, the USB adapters may not fit side-by-side due to their width. If a second USB position is not available, a USB hub wi

2. Ensure that the transmitter with the irradiance sensor. the ñIò l
Observe polarity markings.

3. Ensure that the transmitter with the ñTò label is c
Observe polarity markings.

4. Position the irradiance sensor in the same plane as the modules under test. For example, on the surface of a neighboring module that is not in the string of modules being tested.

5. Ensure that the irradiance transmitter is not resting on the ground or on the roof, and is not placed against a metal surface. Elevating the irradiance transmitter improves the transmission range.

6. Secure the temperature sensor close to the middle of a PV module. Temperatures toward the outside of a PV module or array are cooler.

NOTE The temperature sensor has adhesive tape on it used to secure it to a panel. When the adhesive tape will no longer hold the temperature sensor to the panel, use duct tape to hold the sensor tip and at least an inch of wire in intimate contact with the module back surface.

7. Ensure that the temperature transmitter is not resting on the ground or on the roof, and is not placed against a metal surface. Elevating the temperature transmitter improves the transmission range.

8. To turn on the irradiance and temperature transmitters, press the **I/0** button on each transmitter.

NOTE

When turned on, each transmitter has a **TX** LED that will flash green periodically. However, it is difficult to see the green LED in direct sunlight. Pressing the **I/0** button again will cause the transmitter to turn off, indicated by the **TX** LED flashing red three times.

When not in use, turn the transmitter power off to conserve battery life. The lithium batteries in the transmitters are not re-chargeable. The typical battery life of the irradiance transmitter battery is 300 hours. The typical battery life of the temperature transmitter battery is 1500 hours.

9. If the **LOW BATT** LED on either the irradiance or temperature transmitter is on, replace the battery as follows:

    a. Remove the two screws securing the cover on the rear side of the transmitter.

    b. Remove the cover.

    c. Replace the battery with a Lithium AAA battery.

NOTE

In emergencies, you can substitute AAA Alkaline batteries. However, battery life will be very short.

Connecting to the Solar PV Equipment

Installed PV systems vary in design and construction. Therefore the guidance provided in this section is general in nature, and it is critical that the user apply techniques and precautions appropriate to the circumstances, following best PV/electrical safety precautions.

WARNING

The procedure described below is important but not necessarily complete; the operator must assess the potential dangers of each PV system, and take appropriate precautions.

FAILURE TO TAKE APPROPRIATE SAFETY PRECAUTIONS COULD LEAD TO PERSONAL INJURY OR LOSS OF LIFE.

1. Isolate the PV module string to be tested (test string) from the inverter and from other strings in the array. If the measurement is being made at a fused DC combiner box, isolate the combiner box by means of a DC disconnect switch, and isolate the PV strings from one another by pulling their fuses.

2. Press the button on the I-V Measurement Unit to disable the I-V sweep.

WARNING **PV circuits continue to present danger of electrical shock while system is paused. FAILURE TO TAKE APPROPRIATE SAFETY PRECAUTIONS COULD LEAD TO PERSONAL INJURY OR LOSS OF LIFE.**

3. Following safe operating procedures, connect the insulated test leads of the PVA-600 to the test string. The connection may be made at PV connectors at the ends of the test string, or by clipping to the de-energized buss bars in a DC combiner box as shown in Figure 8, using suitable test leads with MC-4 connectors at one end and insulated alligator clips at the other end.

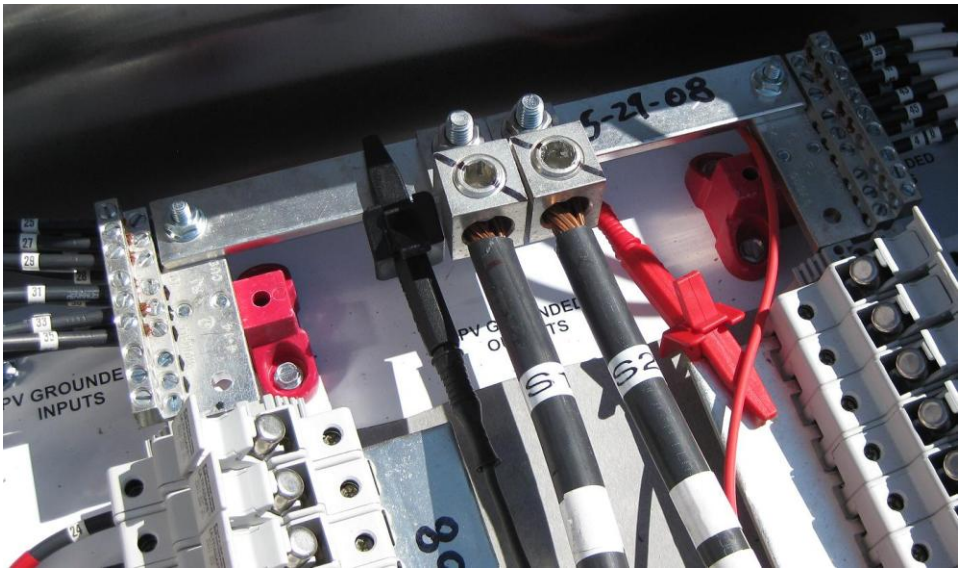

Figure 8. Example of PVA-600 test leads clipped to the buss bars of a PV combiner box

4. If one or both of the terminals of the test device must be some distance from the I-V Measurement Unit, use extension cables made of UL (or equivalent) listed PV wire, with correctly installed connectors. Select a wire gauge that will introduce minimal voltage drop.

5. When extension cables are longer than 10 feet (one-way), lay the cables close to one another to minimize added cable inductance.

6. If connecting at a fused combiner box, insert the fuse for the string to be measured.

Powering-Up the I-V Measurement Unit

Press the power button once on the I-V Measurement Unit. Refer to Figure 9.

Figure 9. Powering-up the I-V Measurement Unit

The LED will begin to blink indicating that the I-V Measurement Unit is attempting to establish communication with the wireless USB adapter connected to the PC. If the wireless USB adapter is inserted into an operating PC, a network will be established and the LED will become continuously lit (no blinking). If a network is not established within 15 minutes, the I-V Measurement Unit will turn off to conserve the battery.

I-V Measurements

The I-V Measurement Unit will measure I-V curves each time the user clicks on the **Measure Now** button. I-V data is transmitted to the PC shortly after each I-V sweep is taken.

Sweep Disabled

PV current is stopped automatically at the end of each I-V measurement. However, to ensure no current is flowing, press the red button on the front of the I-V Measurement Unit to disable the measurement sequence. Pressing the red button again restarts the measurement sequence.

WARNING **If the LED on the PVA-600 is illuminated (either solid on or flashing), do not connect or disconnect the PV leads.**

Over-Temperature Protection

Built-in safeguards prevent the I-V Measurement Unit from operating at potentially damaging internal temperatures.

Thermal Shutdown

All battery powered measurement instruments have upper temperature limits. The operating temperature range of the I-V Measurement Unit is limited by the battery that powers the unit. When the internal temperature approaches the battery's high-temperature specification, the measurement unit automatically shuts down (disables itself) and the **Disabled** message is displayed below the **Measure Now** button. In thermal shutdown, PV power is no longer dissipated in the measurement unit. This removes one of the major internal heat sources. To recover from thermal shutdown, wait for the measurement unit to cool. Placing it in the shade or a cool place will speed the recovery.

NOTE The operating temperature rise inside the I-V Measurement Unit is primarily determined by several factors: outside air temperature, direct sunlight, temperature of the surface on which it is placed, and PV power dissipated in the instrument with each I-V measurement sweep. The PV power depends on the details of the PV module or array being tested, as well as the rate at which measurements are being taken by the user. Given these application-related factors, it is possible that thermal shutdown will occur at an ambient temperature at or lower than the specified maximum operating temperature.

Operating Under High-Temperature Conditions

The most demanding thermal conditions for the measurement unit are:

- Hot day
- No wind
- No shade
- High open circuit voltage
- I-V sweeps taken in rapid sequence

If you expect these conditions, plan ahead to minimize temperature rise in the I-V Measurement Unit. Shade the measurement unit from direct sunlight, elevate it above hot surfaces, and allow more time between I-V sweeps.

Over-Voltage Protection

If greater than 600 V dc is applied to the I-V Measurement Unit, the PVA-600 detects the over-voltage condition and switches into disabled mode automatically and an I-V measurement does not take place.

Over-Current Protection

If greater than 20 A dc is applied to the I-V Measurement Unit, the PVA-600 detects the over-current condition and switches into disabled mode automatically and an I-V measurement does not take place.

The I-V Measurement Unit also has limited protection against the fast, high-current transients that can be produced by high-efficiency PV modules.

CAUTION	*Do not measure high-efficiency PV modules (or strings) in parallel.*

Reverse Polarity Protection

If the I-V Measurement Unit is connected with the wrong polarity across a string, an internal protection diode opens the circuit, the PVA-600 switches into disabled mode, and an I-V measurement does not take place.

4 Using the PVA-600 Software

Main Screen Overview

The PVA-600 software runs on a PC and is the main user interface for making measurements, storing data, and viewing data. The main screen is divided into three main areas as shown in Figure 10.

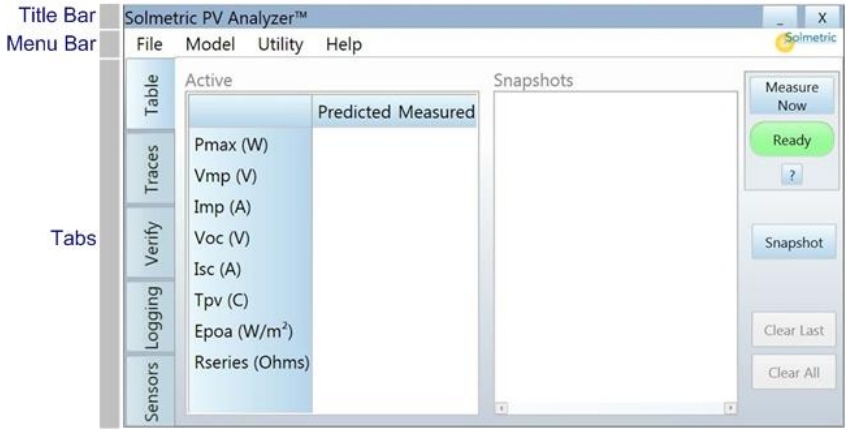

Figure 10. PVA-600 main screen

The Title Bar is located at the top of the main screen and displays the name of the product. Also, two of the most common Windows® software buttons (Minimize and Close) are displayed in the upper right corner.

The Menu Bar is located just below the Title Bar and is a drop down menu system for setting up measurements.

The Tabs are located along the left side of the main screen and serve as the main interface for collecting and viewing data.

Title Bar

The product name is displayed in the Title Bar. In addition, the Minimize and Close buttons are displayed and function in the same way as they do in other Windows® applications.

Menu Bar

File Menu

Table 6. File menu description

Name	Description
Exit	Closes the PVA-600 software application.

Model Menu

Table 7. Model menu description

Name	Description
New	Creates a new model file used to set up new PV modules, sensors, and related site information. The file will be saved in the **Models** folder.
	**Name**: name of model file. **Notes**: pertinent notes about the PV modules.
	**Latitude**: numeric entry in degrees. Range is -90 to +90. Default is 38.25. **Longitude**: numeric entry in degrees. Range is -180 to +180. Default is -122.80. **Time Zone**: numeric entry in hours (relative to GMT). Range is -12 to +12. Default is -7.

Name	Description
Modules / String	**Detailed Performance Model**: **Modules**: the **C h a n g e** button is used to select the module manufacturer and module number. **Sandia**: selects the Sandia performance calculation model. This model accounts for all performance related factors of a PV module and is based on module measurements taken in independent laboratories. **5 Parameter**: selects the 5 Parameter performance calculation model. This model is derived from module data sheet specifications and independent laboratory tests where available. Once a module is selected from the dropdown list, either or both of these models will be available, depending on the data availability. **Simple Performance Model**: **Edit** button: accesses the screen for entering the m a n u f a c t u r e r ô s p u b l specifications. This model predicts the maximum power voltage and current at the existing irradiance and temperature. Based on data sheet values, this model can be used with almost any PV module with basic specifications. **NOTE** ï While default values are included in the Simple Performance Model screen, you will have to replace these values with those from your desired module. **# of Modules in String**: enter number of modules in series. **# of Strings in Parallel**: enter number of modules or strings in parallel. **CAUTION** ï *Conventional PV modules and strings can be measured in parallel up to the specified current limit of the PVA-600. However, high-efficiency modules and strings should NOT be measured in parallel. The large current transient produced by these modules can electrically stress the instrument.*
Inverter	**Inverter**: the **C h a n g e** button is used to select the inverter manufacturer and model number. The maximum power tracking voltage range of the selected inverter will be displayed as a green shaded region superimposed on the I-V curve.

Name	Description
Wiring	This is the resistance of the external wiring calculated from user entries of wire length and wire gauge: Rseries = [Resistance per Foot] * Wire Length Resistance Per Foot is calculated from the table below: The first column is Wire Gauge (AWG); the second column is Resistance per Foot. 4 AWG (0.2043 in, 5.189 mm) Ÿ 0.0002485 Ý / f o o t 6 AWG (0.1620 in, 4.115 mm) Ÿ 0.0003951 Ý / f o o t 8 AWG (0.1285 in, 3.264 mm) Ÿ 0.0006282 Ý / f o o t 10 AWG (0.1019 in, 2.588 mm) Ÿ 0.0009989 Ý / f o o t 12 AWG (0.0808 in, 2.053 mm) Ÿ 0.001588 Ý / f o o t 14 AWG (0.0641 in, 1.628 mm) Ÿ 0.002525 Ý / f o o t 16 AWG (0.0508 in, 1.291 mm) Ÿ 0.004016 Ý / f o o t **Wire Gauge (AWG)**: selects the wire gauge of conductors between the PV string and the point at which the I-V curve is being measured. **Wire Length (Feet, one-way)**: enter the wire length in feet. For instance, if you have two 10 foot leads running between the I-V unit and the string, enter

Name	Description
Sensor Methods	**Use wireless irradiance sensor**: irradiance is transmitted wirelessly when using the PVA Sensor Kit. **Cal Factor**: enter calibration factor of the sensor. **Enter solar irradiance manually**: irradiance is entered manually from an external sensor. This method is suitable when irradiance is relatively stable. **Irradiance (POA)**: enter irradiance manually in this text box. **NOTE** ïAll irradiance measurements must be made in the plane of the array (POA). This means the irradiance sensor is mounted parallel to the PV modules. Horizontal plane measurements are not supported. **Determine irradiance from IV curve**: PVA-600 extracts irradiance mathematically from measured I-V data. This method is used when the main objective is to demonstrate consistency among PV strings and to observe subtle deviations from predicted I-V curve shape. An external sensor is not required because the array itself is the sensor. Assumes functional PV module(s). **Use wireless temperature sensor**: temperature is transmitted wirelessly when using the PVA Sensor Kit. **Offset**: enter the temperature offset to be added to the module backside temperature to determine cell temperature. **NOTE** ïThe offset will vary typically from 0º C to 8 º C during a day depending on mounting and wind conditions. The default value of 3º C is only a typical number. **Enter module temperature manually**: temperature is entered manually from an external sensor. This method is suitable when temperature is relatively stable. Temperature readings should be taken close to the middle of a panel. Temperatures toward the outside of a panel tend to be cooler. **PV Temperature**: enter temperature manually in this text box. **Determine temperature from I-V curve**: PVA-600 extracts temperature mathematically from measured I-V data. This method is used when the main objective is to demonstrate consistency among PV strings and observe subtle deviations from predicted I-V curve shape. An external sensor is not required because the array itself is the sensor. Assumes functional PV module(s).

Name	Description
Array Plane	**Slope (degrees)**: enter the tilt of the array in degrees, which can be measured with an inclinometer or slope meter (0° is horizontal, 90° is vertical). **Azimuth (degrees from true North)**: enter the direction of the array in degrees (0° is north, 90° is east, 180° is south, and 270° is west). **NOTE** ïThese array plane entries are only required when using the Sandia performance model and an irradiance sensor.
Browse	Accesses previously saved Model files for retrieval.
Copy	Creates a copy of the currently loaded Model file so it can be edited.
Properties	Displays the properties of the currently loaded Model file including Name, Location, Modules/String, Inverter, Wiring, Sensor Methods, and Array Plane parameters. Properties can be changed in this view. The changes are saved.

Utility Menu

Table 8. Utility menu description

Name	Description
Settings	Used to select the I-V Measurement Unit and PVA Sensor Kit communication ports manually. **NOTE** ïIf the Wireless USB Adapters are installed into the PC before starting the PVA-600 Software, the communication ports are selected automatically. **Wireless I-V Measurement Unit USB Interface**: select communications port to use for communication between the PVA-600 and the PC. Select the port with the ñ+ò symbol. **Wireless Sensor USB Interface**: select communications port to use for communication between the PVA Sensor Kit and the PC. Select the port

Help Menu

Table 9. Help menu description

Name	Description
User's Guide	Accesses the PVA-600 User's Guide
About	Accesses the software version number and software build date.

Tabs

Table Tab

The Table tab presents a summary of the I-V measurement results displayed in the Traces tab, as well as predicted values from the selected performance model. Figure 11 is an example of the Table tab screen.

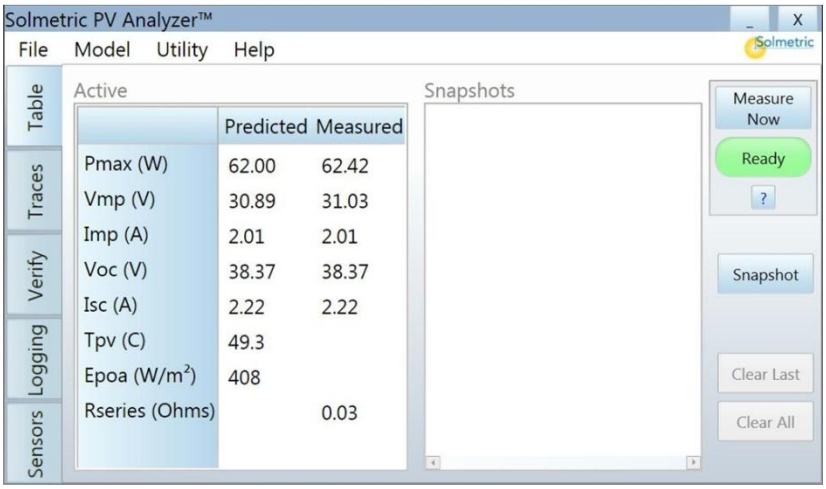

Figure 11. Table tab

Table 10. Table tab description

Name	Description
Active	Indicates the table containing the latest measurement data.
Predicted	Displays the predicted values from the selected performance model.
Measured	Displays actual measured values most recently measured.
Pmax (W)	Displays the predicted and measured maximum power values in Watts.
Vmp (V)	Displays the predicted and measured values of the voltage at the maximum power point.
Imp (A)	Displays the predicted and measured values of the current at the maximum power point.
Voc (V)	Displays the predicted and measured values of the open circuit voltage.
Isc (A)	Displays the predicted and measured values of the short circuit current.
Tpv (C)	Displays the predicted and measured PV temperature in Celsius. The temperature value in the **Predicted** column is derived from the selected PV model. If no model is selected, predicted temperature is left blank. The temperature value in the **Measured** column is either the manually entered value or the wireless sensor value depending on which option is in effect. If neither of these methods is selected, no value is displayed.
Epoa (W/m^2)	Displays the predicted and measured irradiance in the plane of the array. The irradiance value in the **Predicted** column is derived from the selected PV model. If no model is selected, the predicted irradiance is left blank. The irradiance value in the **Measured** column is either the manually entered value or the wireless sensor value, depending on which method is in effect. If neither of these methods is selected, no value is displayed.
Rseries (Ohms)	Displays the series resistance calculated from the user entered wire gauge and wire length.
Snapshots	Each time you click on the Snapshot button, the currently measured values of the data populate one of the columns in the right hand table. This allows comparing successive measurement results There 25 columns available. Data is not permanently saved.

Name	Description
No USB Wireless (indicator)	Displayed when the USB Wireless Adapter is not found. When displayed, clicking on this indicator accesses information to aid in troubleshooting the problem.
No I-V Unit (indicator)	Displayed when communication between the I-V Measurement Unit and PC is not established. When displayed, clicking on this indicator accesses information to aid in troubleshooting the problem. **NOTE** ïThe most common reasons for this state include out-of-range, or the I-V Measurement Unit is turned off.
Ready (indicator)	Displayed when the system is ready to start a new I-V measurement.
Measure Now button	Highlighted when the system is ready to start a new I-V measurement. Each time this button is clicked, a single I-V measurement sweep is started.
Measuring (indicator)	During a measurement, the **Measuring** label blinks.
Paused (indicator)	Displayed when the I-V measurement process is paused by pressing the button on the I-V Measurement Unit. In this state, PV source connections may be changed without interrupting a measurement. **WARNING - PV circuits continue to present danger of electrical shock while system is paused. FAILURE TO TAKE APPROPRIATE SAFETY PRECAUTIONS COULD LEAD TO PERSONAL INJURY OR LOSS OF LIFE.**
Disabled (indicator)	Displayed when a problem exists other than communication between the PC and I-V Measurement Unit. Problems could be related to low battery, over current, over voltage, over temperature, reversed polarity, etc. No measurements can be taken while in this state. When displayed, clicking on this button accesses information to aid in troubleshooting the problem.
? button	Clicking on this button accesses information specific to the current state of the PVA-600.
Snapshot button	Takes the current measured values of the data and populates one of the columns in the right hand table.
Clear Last button	Clears just the most recent section of data from the Snap Shots table.
Clear All button	Clears all columns of data from the Snapshots table.

Traces Tab

The Traces tab displays the most recent measurement results along with the predicted shape of the I-V curve (if an advanced PV model is selected). Figure 12 is an example of the Traces tab screen.

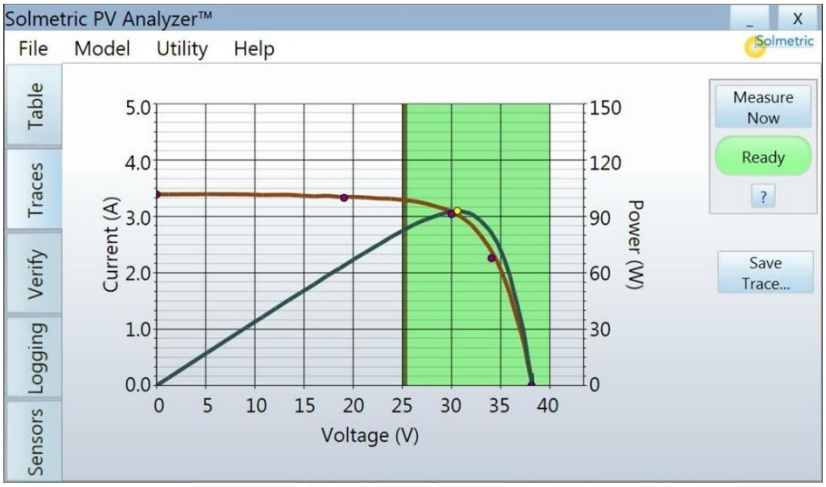

Figure 12. Traces tab

There are four main datasets displayed in the Traces screen:

1. I-V curve. This solid red curve displays the measured I-V points transmitted from the I-V Measurement Unit. There are approximately 100 points on a typical curve. The points are connected with line segments for display. Points below 0 V are not displayed.

2. P-V curve. This solid blue curve displays the power available from the test string, calculated from the I-V curve simply by multiplying I x V for each I-V point. The yellow point simply indicates the maximum value of the measured P-V curve. It is not the predicted maximum power value.

3. Model prediction points. The five purple I-V points are the predicted I-V values for the five key points as defined by the Sandia or 5 Parameter performance model. If the actual I-V curve goes through or near the predicted five points, then the array is functioning as predicted.

4. The green shaded area indicates the specified DC voltage operating range for the selected inverter. The left and right edges of the green shaded area represent the lower and upper limits of the inverter's MPPT tracking range. The left black line is the inverter starting voltage and the right black line is the maximum input voltage.

Table 11. Traces tab description

Name	Description
Current (A)	Displays the current scale along the vertical axis on the left side of the graph.
Voltage (V)	Displays the voltage scale along the horizontal axis of the graph.
Power (W)	Displays the power scale along the vertical axis on the right side of the graph.
Save Trace button	Saves all of the I-V and P-V graph data points and other descriptive information in a csv file in the **Traces** folder.
Save a Screen Image ...	Click on the camera icon at the lower right corner of any screen to save the screen.

Verify Tab

The Verify tab is a display of predicted and measured maximum power for a quick check of the system. The height of the gray bar is the maximum power actually measured for the system. This value corresponds to the single yellow point on the P-V curve. The black target line is the maximum power predicted by the performance model. The numeric Performance Factor value is the ratio of actual to predicted maximum power, as a percentage.

NOTE Typically, if a string is operating correctly, the Performance Factor will be between 95% and 105% when using the Sandia model. The range will typically be higher when using the 5 Parameter and Simple Performance models. The industry has relatively little experience using the 5 Parameter model with thin film modules; the range for TF modules is likely to be still higher.

The dotted STC line is the predicted power under Standard Test Conditions. Figure 13 is an example of the Verify tab screen.

NOTE STC conditions (typically found on module datasheets) occur infrequently in real world measurements as they combine bright sun with low temperatures.

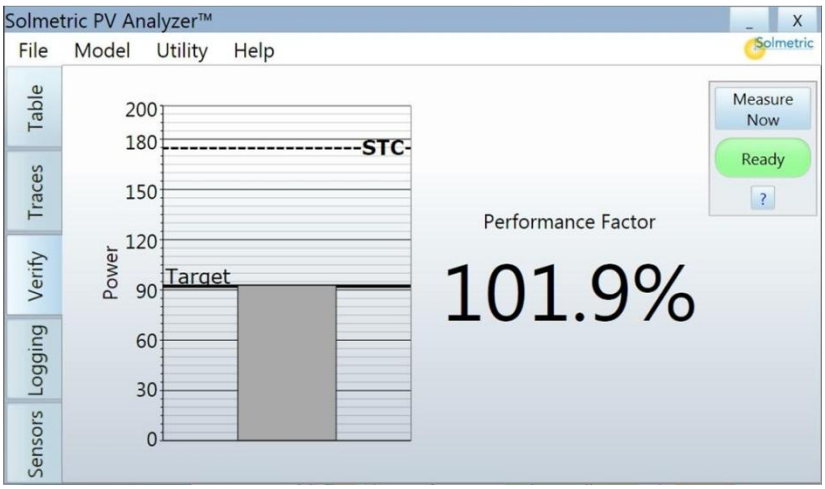

Figure 13. Verify tab

Table 12. Verify tab description

Name	Description
Power	Displays the power scale along the vertical axis on the left side of the graph.
Performance Factor	Displays the ratio of actual to predicted maximum power as a percentage.
Target	Displays the maximum power predicted by the performance model and the selected sensor method.
STC	Displays the predicted maximum power under Standard Test Conditions.

Logging Tab

The Logging tab displays maximum power values (equivalent to those shown in the Verify tab) which have been accumulated (or logged) over a time period. Figure 14 is an example of the Logging tab screen. You can clearly see when the modules entered a late afternoon shade condition.

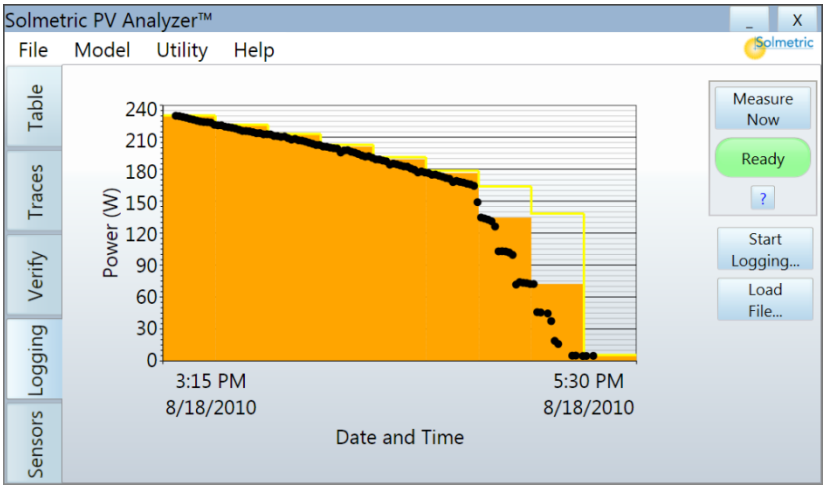

Figure 14. Logging tab

There are three values displayed on the graph:

1. The small black dots are measured maximum power.
2. The orange steps represent the maximum value measured during each 15-minute interval.
3. The yellow line is the target (predicted) maximum power in each 15-minute interval.

The time axis autoscales to display all the available data taken over the measurement period.

As each value is acquired by the PVA-600 it is stored in a csv file in the **Log Files** folder. The intent is to show the performance of the array over a time period. This time period may be from a few minutes to an entire day. The I-V curve data is not saved.

Table 13. Logging tab description

Name	Description
Power (W)	Displays the power scale along the vertical axis on the left side of the graph.
Date and Time	Displays the start date/time and end date/time along the horizontal axis. The date and time a internal clock when the first measurement is started.
Start Logging button	**Sample Rate (minutes)**: sets time interval between actual measurements. **Log File**: sets name for csv data file. The log file is stored in the **Log Files** folder. **Change File** button: allows you to change to a different file name.
Load File button	Allows you to select and load an existing csv file for viewing on the graph.

Sensors Tab

The Sensors tab displays irradiance and temperature measurement values when using the PVA Wireless Sensor Kit, as shown in Figure 15. This screen also monitors the communication status between the PVA-600 and the wireless irradiance and temperature sensors.

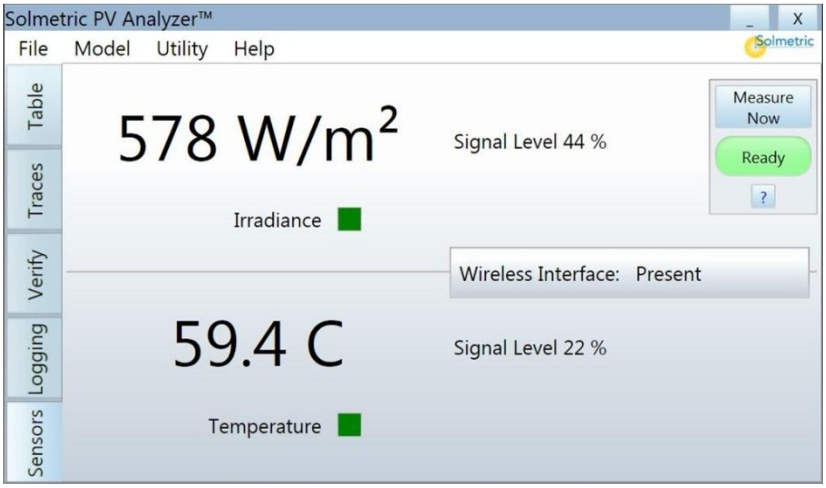

Figure 15. Sensors tab

Table 14. Sensors tab description

Name	Description
Irradiance	Blinks (green) when data arrives from the wireless irradiance sensor (approximately every two seconds).
Temperature	Blinks (green) when data arrives from the wireless temperature sensor (approximately every ten seconds).
Signal Level	Displays the signal level of the irradiance and temperature sensors (as a percentage). The greater the distance between the PVA-600 and the sensors, the lower the signal level.
Wireless Interface	Displays whether the s e n swireless sensor USB interface adapter was found or not. The **Help** button accesses information to aid in troubleshooting the problem.

Setting Up a New Model

The following procedure shows how to set up the PVA-600 for particular PV modules/strings, inverters, sensor methods, and related site information.

Start the PVA-600 Software

1. On the PC, double-click on the **Solmetric PV Analyzer** icon to start the PVA-600 application. The Table screen appears as shown in Figure 16.

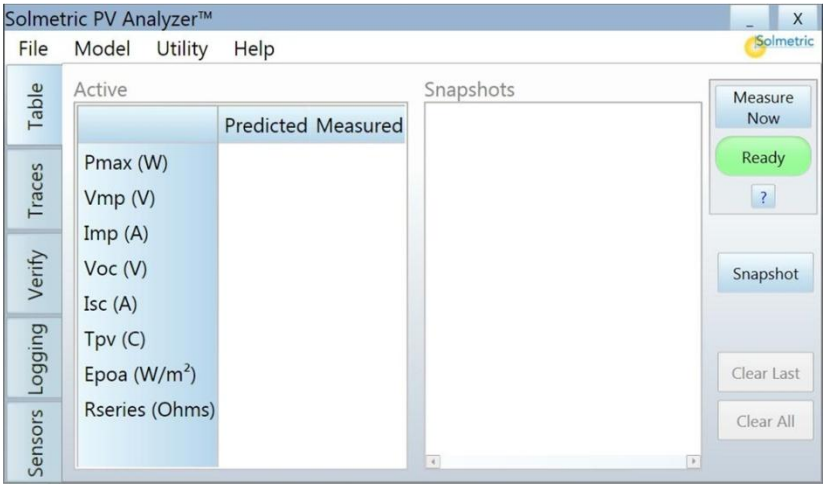

Figure 16. Table screen

Enter the Name and Notes

1. In the **Model** menu, select **N e w é**o access the screen used to set up a new model as shown in Figure 17.

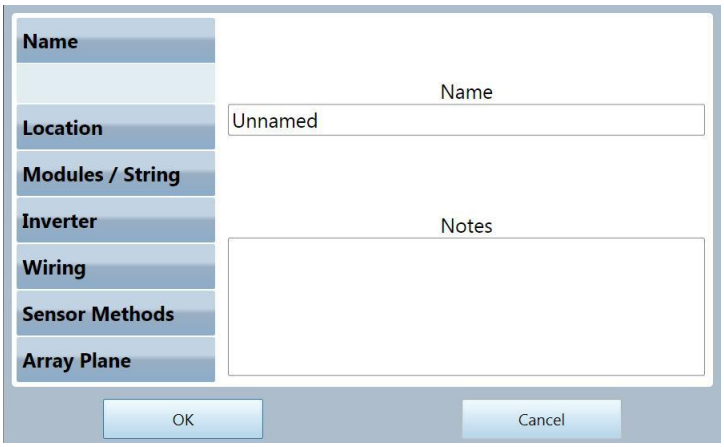

Figure 17. Model screen

2. Click in the **Name** text box and enter the desired name for this model. The model file will be saved in the **Models** folder.

3. Click in the **Notes** text box to enter notes for this model.

Enter Latitude, Longitude, and Time Zone

1. Click on the **Location** button to access the screen used to set up location information as shown in Figure 18.

Figure 18. Location screen

2. Click in the **Latitude** text box and enter the latitude for this model.

3. Click in the **Longitude** text box and enter the longitude for this model.