

Solmetric PV Analyzer Application Note

PVA-1000 I-V Curve Tracer & SolSensor™ Wireless PV Reference Sensor

Measuring I-V Curves in Harnessed PV Arrays

Harnessing is a strategy for reducing the number of combiner boxes and associated feeder runs, as well as the number of string home run conductors, by paralleling strings upstream of the combiner. The harness is commonly pre-fabricated and contains in-line fuses, allowing more than two strings to be paralleled into a single pair of home run conductors which in turn are protected by another fuse in the combiner box.

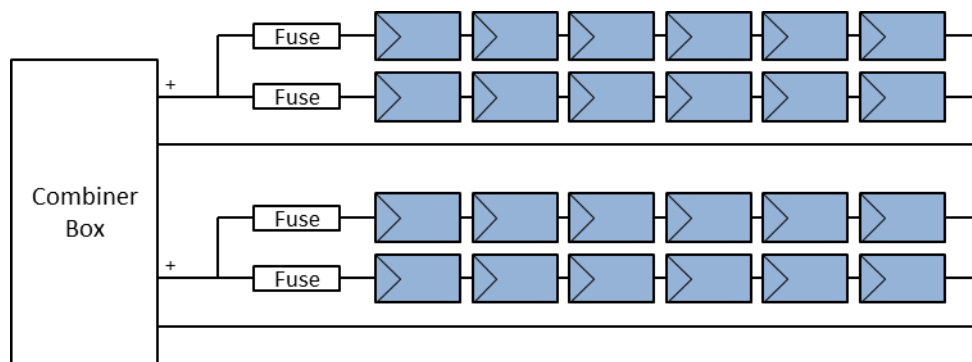


Figure 1. Harnessed strings

Harnessing can be deployed with any type of PV technology. Thin film arrays have an extra incentive to harness because TF modules typically feature higher voltages and lower module currents.

Harnessing reduces the up-front cost of the system but it can complicate the array performance testing, which is becoming a standard component of commissioning and O&M services. The primary issue in this regard is that harnessed strings cannot conveniently be isolated for I-V curve measurements or other electrical testing. Instead, the measurements must be performed at the combiner box on parallel combinations of strings, making the measurement less sensitive at identifying problems in a given string. The larger the number of paralleled strings, the lower the sensitivity to localized performance issues. Lifting the harness fuses is not a solution because they are commonly molded in-line. In addition, they are typically widely distributed and therefore hard to access.

The PV Analyzer's PV performance model provides a visual and numerical reference against which to compare the measured I-V curve. This gives immediate feedback on the performance of the tested string, allowing the user to QA their measurement technique as well as the PV array as they move across the array. The primary metric of performance is the Performance Factor, defined as the measured maximum power as a percentage of predicted (modeled) maximum power. The Performance Factor is prominently displayed in the PVA software after each measurement is completed.

There are more than a dozen 'inputs' to the PVA's PV performance model. These include the measured irradiance and temperature, the latitude and longitude of the site, the date/time/time zone, the array tilt and azimuth, the PV module model coefficients, the number of modules per string, and the number of strings tested in parallel.

In the widely deployed discrete string array architecture, individual strings are accessed and tested at the combiner box. While it is possible to save test time by inserting more than one fuse and testing strings in parallel, this approach sacrifices measurement detail and increases the risk that array issues will go undetected.

When measuring the I-V curve of a harness of strings in parallel, the model needs special inputs to 'know' that the expected power and currents will be N times higher than a single string, where N is the number of strings connected in parallel. There are three options for doing this:

1. In v3.7 software, you can represent a harness by adding an extra combiner box layer to your Array Navigator tree, and changing the name of this new combiner to "Harness". When you save a measurement, you save it to the harness layer, not the individual strings. The software does the math to calculate expected performance.
2. Alternatively, you can make single strings in the tree represent harnesses by scaling up the PV module power and current parameters by N. Use the Custom Module feature to edit the existing model parameters and save the edited set of parameters under a special name.
3. The final option is to build a tree that shows each string branching directly out of the combiner box, with no harness layer. This approach is least convenient because when you save a harness measurement, you must highlight all of the strings that are part of that harness before saving.

The options are discussed below in more detail.

Option 1: Build the harnesses into the Array Navigator tree

In v3.7 of the PVA software, insert an extra combiner layer, as shown below. Notice that this new layer is in fact a combiner, as shown by its icon, even though the layer has been re-named "Harness".

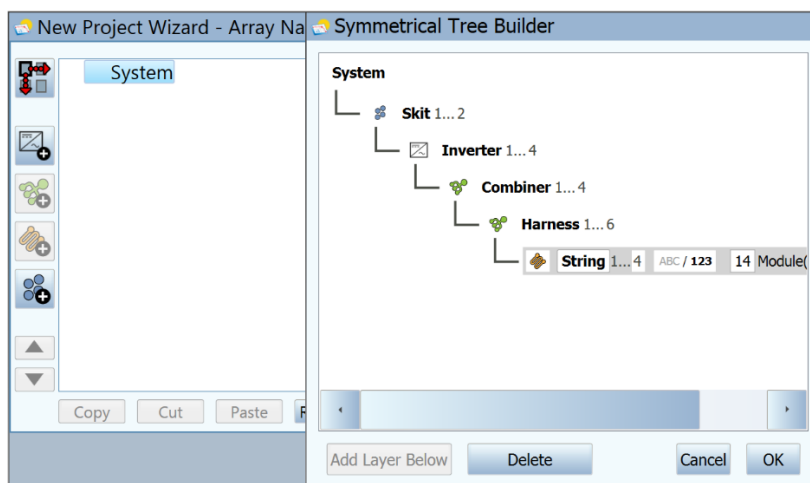
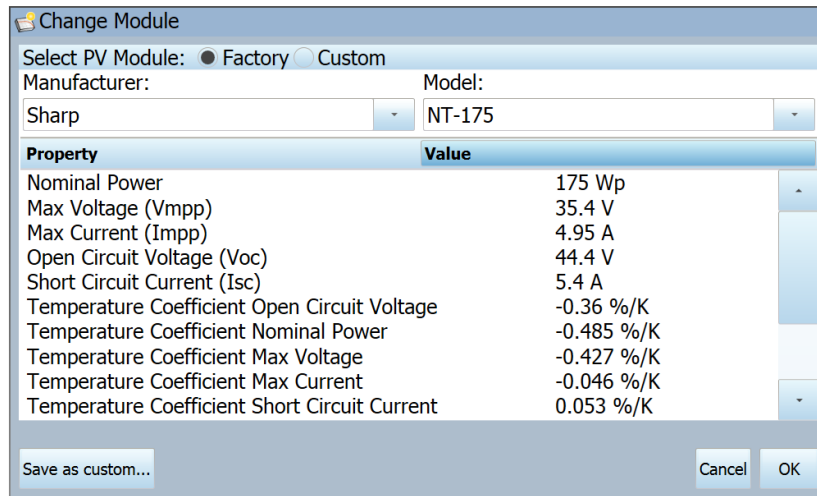


Figure 2. Representing a harness by adding an extra combiner layer.

Option 2: Scale up the PV module model to represent modules in parallel

This option makes saving your data easy and far less error-prone, but does require editing the PV module performance parameters. This is a relatively simple process that just requires basic math and computer skills and learning the operation of the Custom Module controls of the PVA software.

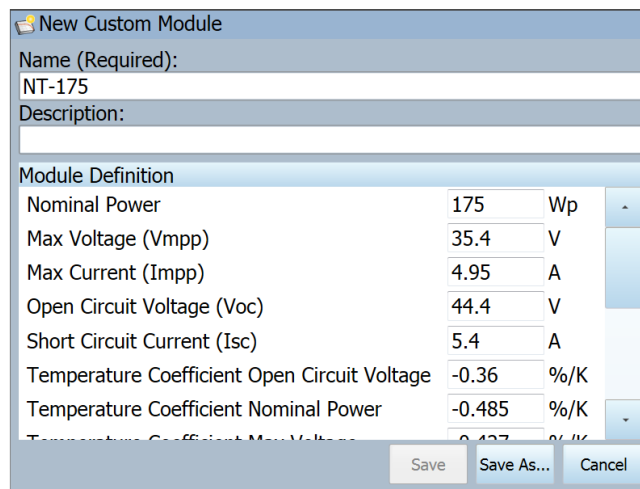
Figure 3 shows the Change Module screen of the PVA-1000 software. The PV performance model parameters are listed.



Property	Value
Nominal Power	175 Wp
Max Voltage (Vmpp)	35.4 V
Max Current (Impp)	4.95 A
Open Circuit Voltage (Voc)	44.4 V
Short Circuit Current (Isc)	5.4 A
Temperature Coefficient Open Circuit Voltage	-0.36 %/K
Temperature Coefficient Nominal Power	-0.485 %/K
Temperature Coefficient Max Voltage	-0.427 %/K
Temperature Coefficient Max Current	-0.046 %/K
Temperature Coefficient Short Circuit Current	0.053 %/K

Figure 3. Change Module screen.

To edit the parameters and save them as a custom module, click the **Save as custom...** button to access the screen shown in Figure 4.



Module Definition		
Nominal Power	175	Wp
Max Voltage (Vmpp)	35.4	V
Max Current (Impp)	4.95	A
Open Circuit Voltage (Voc)	44.4	V
Short Circuit Current (Isc)	5.4	A
Temperature Coefficient Open Circuit Voltage	-0.36	%/K
Temperature Coefficient Nominal Power	-0.485	%/K
Temperature Coefficient Max Voltage	-0.427	%/K

Figure 4. New Custom Module screen.

Edit the values as needed, change the name, and click **Save As...** to save the parameters to the custom equipment database. The full list of PV module parameters is shown in Figure 5.

Nominal Power	175	Wp
Max Voltage (Vmpp)	35.4	V
Max Current (Imp)	4.95	A
Open Circuit Voltage (Voc)	44.4	V
Short Circuit Current (Isc)	5.4	A
Temperature Coefficient Open Circuit Voltage	-0.36	%/K
Temperature Coefficient Nominal Power	-0.485	%/K
Temperature Coefficient Max Voltage	-0.427	%/K
Temperature Coefficient Max Current	-0.046	%/K
Temperature Coefficient Short Circuit Current	0.053	%/K
Max Voltage at Low Light	33.27	V
Max Current at Low Light	0.97	A
Ideality Factor (Aref)	1.8401	V
Front Glass AR Coating	False	
Front Glass Texture	Light	
Cell Technology	Monocrystalline Si	

Figure 5. The full list of PV module performance parameters.

The parameters that require editing for harness applications are Pmax, Isc, Imp, and the max power current at low light. In each case, multiply the existing values by the number of strings of modules that are paralleled per harness.

Option 3: Highlight multiple strings in the Array Navigator tree

This option does not require editing the model, but when saving measurement results it requires the operator to visually associate the tested 'string' in the combiner box with multiple strings in the Array Navigator tree, as shown in Figure 2.

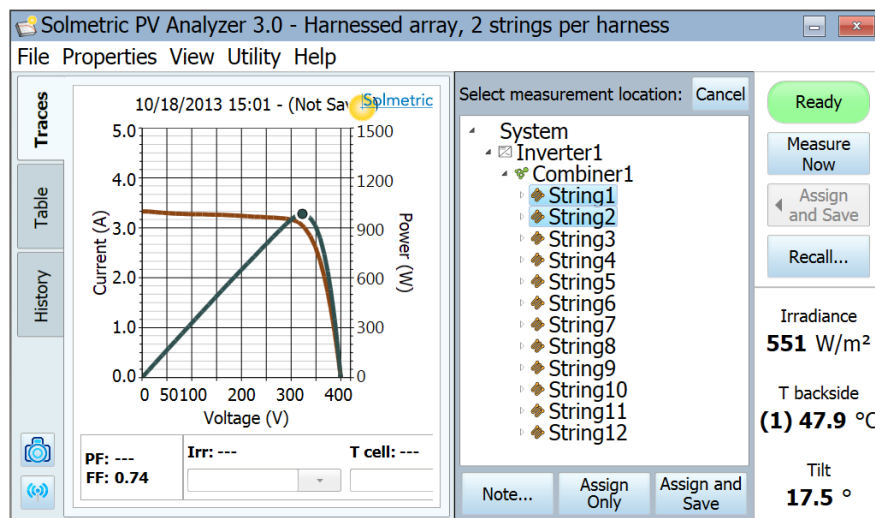


Figure 5. Saving the measurement of a harnessed pair of strings.

This requires close attention to highlighting the correct group of strings in the tree, as it is easy to get them out of order. If the array has just a few harnesses per combiner box and just a few actual strings

per harness, it is not so difficult to keep things straight, but for large combiners and harnesses it can be much more confusing to the operator.

Harnessing high efficiency modules

High efficiency modules have higher electrical capacitance than ordinary modules and as a result they output a pulse of high current at the instant the load capacitor is connected, which occurs at the start of the I-V measurement. Paralleling high efficiency modules multiplies the amplitude of the current spike, and if the current is sufficiently high, the PVA-1000 will disable itself due to current overload. Solmetric recommends that the PVA-1000 not be used to measure harnessed high-efficiency modules.

End of document

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