Keysight Technologies
Benefits of Moving to 1,500 V Photovoltaic Inverters

Application Note

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

If you have been reading the solar energy trade journals, you may have noticed an increasing number of articles about 1500 V photovoltaic (PV) strings and inverters. This is happening because there are both cost and efficiency benefits of going to higher voltages. There are some remaining hurdles to clear before widespread installations can occur, but adoption is closer than you think.

Changing Standards Clear the Way to 1500 V

Over the last five years, there has been a steady increase in PV string voltages starting at 600 V. Just five years ago it was the industry benchmark. This voltage level was easy to adopt because the world wide electrical standards were in place and clear at 600 V. This meant equipment, certification standards and installation methods already existed. As the voltages began to rise, there were more issues with standards than with the technology. Depending on where you were in the world, either the standards to address higher voltages were not written yet, or they were unclear as to their application. As the standards hurdles were overcome, the market for 1000 V PV installations quickly became the new benchmark. With advances in technology, we are now at the tipping point for moving to 1500 V. Just like the 1000 V transition, there is additional work needed to update and implement newer standards. The US has not been as aggressive in adopting the standards required for this next step but are now catching up to the European market in this area.

We can witness the arrival of this future wave just by looking at how many companies are introducing 1500 V inverters. If you look across the industry, you see major players such as Sungrow, Huawei, GE and SMA, just to name a few, all offering 1500 V inverters. There are still some people in the industry taking a wait-and-see approach to moving into this market space, but as always, those who are first to market have the best chance of grabbing the largest share.

Cost Benefits of Transitioning to 1500 V

Why is there such a rush to increase string voltages? It all comes down to PV system cost. There are some obvious cost reductions such as the following:

- Longer PV strings mean fewer home runs for wiring, reducing both the amount of wire and the number of conduits
- Faster and easier installation on the jobsite which translates to lower labor costs.
- Reduction in the number of combiners which is reduced by 33% due to longer PV strings.
- Ability of the power inverters to operate at higher power without having to increase the amount of current they must handle. This translates into higher power inverters and fewer inverters required for a given installation.

These savings can translate into a reduction in system cost per watt of between three to five percent.

New Test Challenges

Since this is a new market space and operating at 1500 V does present some technical challenges, it is prudent to employ additional testing of components to help verify operation, efficiency and insure long term reliability. Trying to use the sun and PV panels for all the testing that is required is not practical as PV inverter manufacturers will need to test specific input scenarios to verify their designs. By using a PV simulator, it allows you to fully exercise the Inverter and run it through its paces. You can insure that under all operating and environmental conditions, the unit operates correctly and meets performance specifications. The inverter market is fierce in touting efficiency numbers, and various certification bodies have worked to harmonize standards and establish a universal system for testing and rating the efficiency of PV inverters. This helps to level the playing field for the rated efficiencies of different PV inverters. The total rated efficiency of a PV inverter is comprised of two cumulative measurements; the Maximum Power Point Tracking (MPPT) efficiency and the conversion efficiency. MPPT efficiency represents how accurately an inverter tracks the maximum power point of the PV output, which constantly changes depending on environmental conditions (i.e., solar irradiance and temperature). Conversion efficiency represents the losses through the inverter as a result of converting DC power to AC power. The test standards for PV inverter efficiency are long and arduous, particularly for that of MPPT efficiency, in which EN50530 is the established industry standard. As such, PV inverter manufacturers must test MPPT efficiency under both static and dynamic operating conditions. The dynamic MPPT efficiency tests are a complex set of sequences requiring over 7 hours of actively changing input profiles and voltage/current measurement data collection. Manual execution and reporting of these tests can potentially take days, or even weeks. Therefore, having software and hardware that can automate the required test sequences, data collection, and report generation is key to reducing test time.

During design and development phase of the inverter, it is important to be able to check the performance using many different I-V curves and insuring proper MPPT tracking (Figure 1). The ability to generate I-V curves with multiple local maxima as in partial shading conditions is also useful in fully testing the ability of your MPPT tracker to find the right maximum power point (Figure 2).

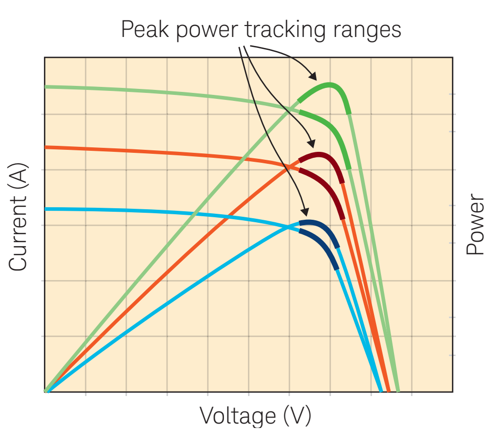

Figure 1. Peak power tracking with a range of illumination and power tracking range.

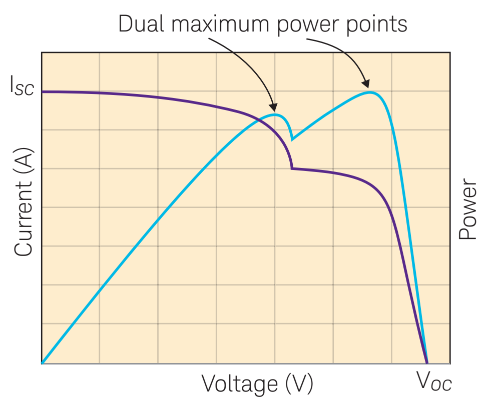

Figure 2. Complex I-V curves resulting from partial shading.

Having a PV simulator capable of 1500 V operation is what you need (Figure 3), but it would be even nicer to have one with auto-ranging output characteristics (Figure 4). Having auto-ranging allows you to get full power output at lower operating voltages extending the useful range by a factor of two to three. This would allow you to test all three levels of inverters from 600 V up to 1500 V with the same equipment and setup.

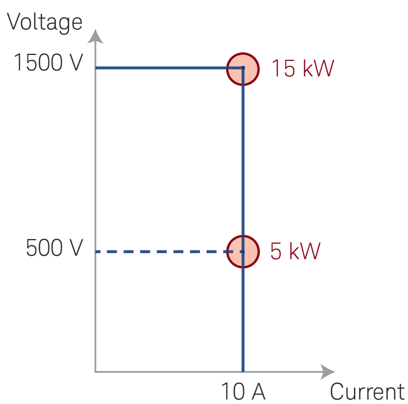

Figure 3. Rectangular output characteristic

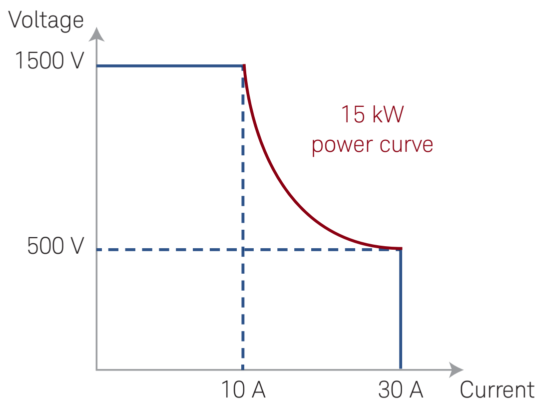

Figure 4. Autoranging output characteristic

Keysight Solar Simulation Solution

Fortunately, Keysight has the N8937APV and N8957APV Autoranging Solar Array Simulator and DG8901A Solar Array Control software that can do this type of testing and more.

PV Simulator Solution Capabilities

The N8937APV and N8957APV Solar Array Simulators can generate up to 15 kW of output power from 500 V up to 1500 V. Units can be paralleled for up to 150 kW of power. They allow you to:

- Easily view and control your N8900APV Series PV Simulator from the Control tab
  - Perform simple functions, such as setting voltage, current and OVP as well as turn the output on/off
  - Set the instrument mode: SAS or Power Supply
  - View the programmed I-V and power curves, maximum power point, and the active I-V and power points (SAS mode only)

- Quickly create and download photovoltaic I-V curves from the Curve Workspace tab
  - Create PV curves per Sandia, EN50530, and Keysight's proprietary models via the N8900APV
  - Choose between Basic and Advanced curve generation
  - Graphically view the curve before sending it to the instrument

- Create static and dynamic EN50530 test reports using DG8901A software with one click from the MPPT Efficiency tab (Figure 6)
  - Automated test to the EN50530 standard
  - Automated reports formatted to the EN50530 standard
  - Full log file with all the measurements from the test

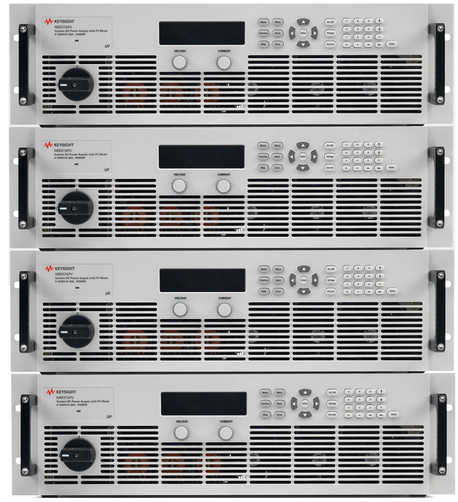

Figure 5. Parallel connect the N8937/57APV to test at full power (up to 150 kW).

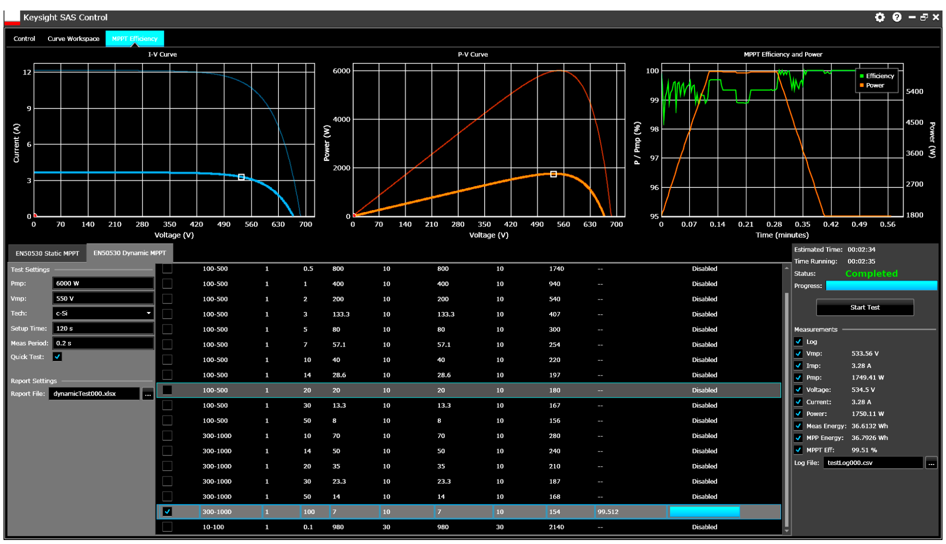

Figure 6. SAS Control Software performing dynamic EN50530 MPPT test.

Conclusion

It's not a question of whether 1500 V PV systems will exist; rather, it's a question of whether you will be ready. Don't be the last to market in this space. Be ready with the right test equipment to design and test your inverters of the future!

For more information, please visit **www.keysight.com/find/N8900APV** and **www.keysight.com/find/SasControlSoftware**

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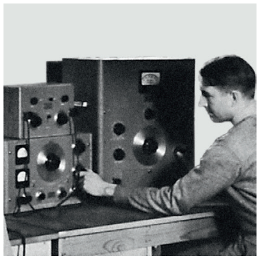

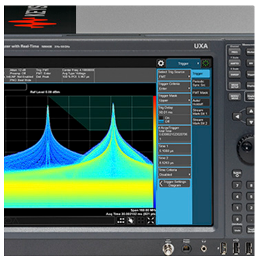

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