I-V Curve Tracing vs. SolarEdge Real Time Monitoring

Version History

- Version 1.0 (Nov 2018) – Initial release

Introduction

PV system performance is often tested as part of the manufacturing, installation and commissioning of a newly constructed solar energy system. Testing allows designers, system owners and installers to verify proper installation and identify module defects and underperformance, such as bypass diode failures, potential induced degradation (PID), and micro cracks.

In traditional string inverter systems this is typically done using I-V curve tracing, while in a SolarEdge system there is no need to employ this costly method which provides partial data only. Instead real-time module-monitoring can be used for comprehensive performance data at any given time, including immediate installation verification.

I-V Curve Tracing

I-V curve tracing is a performance verification method used in PV systems with traditional inverters. Performance verification is done by measuring current and voltage while varying an electrical load connected to a PV module string. This method has several limitations:

- **No real-time monitoring** - the procedure reports data from a single point in time. It is therefore heavily dependent on environmental conditions at the time of data capture and is not reproducible
- **Diagnostic information is not continuous** - defects or underperformance can go undetected for long periods of time (until the next I-V curve tracing). Data presented is partial and unrepresentative of the long term health of the PV system.
- **No module-level analysis** - in PV systems with traditional inverters, modules are not analyzed individually, but are bundled with neighboring modules in the array. This lack of granularity leads to inaccuracies in error detection.
- **Requires costly labor & equipment** – if I-V curve tracing indicates a possible fault, without real-time and continuous diagnostic information, technicians are sent to the site to search for the problem with little direction or guidance. This search becomes more difficult and costly as installation size increases. Additionally, expensive thermal imaging (IR) cameras and portable electro-luminescence (EL) equipment will have to be deployed to detect the reduced output power of a single solar module.

The SolarEdge System Architecture

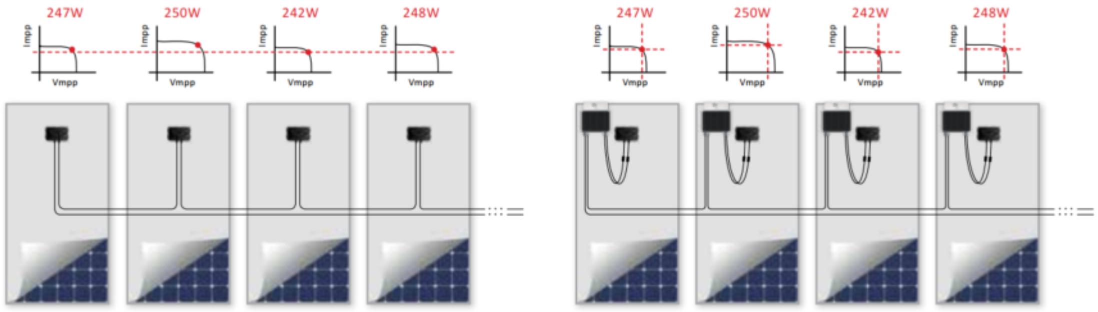
The SolarEdge innovative system architecture mitigates IV curve tracing limitations. SolarEdge's monitoring platform enables precise, continuous, real time monitoring of each PV module separately – resulting in a more accurate PV installation and performance verification procedure.

In PV systems, each module has an individual maximum power point (MPP). With traditional string inverter systems, the weakest module negatively impacts the performance of all the other modules in the string.

SolarEdge eliminates this issue by allowing each module to perform to the best of its ability at all times. Each module's MPP is tracked independently and real-time current and voltage adjustments are applied to achieve the optimal working point of each PV module.

By enabling each module to continuously produce its maximum power independently of other modules in the same string, SolarEdge eliminates the impact of module mismatch, minimizes partial shading losses and improves power production.

Traditional String Inverter | **SolarEdge DC Optimized Inverter Solution**



Traditional String Inverter:

- MPPT per string - all modules operate at same current, regardless of their individual MPP
- Weak modules reduce the performance of all modules in the string or are bypassed
- Power losses due to module mismatch

SolarEdge DC Optimized Inverter Solution:

- Module-level MPPT - current & voltage adjusted at the module level
- Maximum power produced and tracked from each module individually
- 2%-10% more energy from the PV system

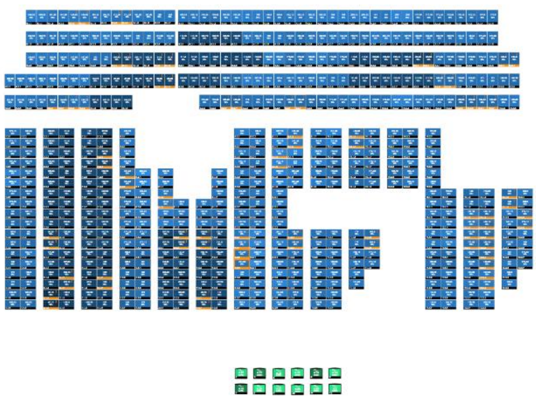
The SolarEdge Monitoring Platform

SolarEdge's system architecture also enables precise, continuous, real-time tracking of individual module performance to evaluate its initial and ongoing performance. The monitoring receiver is integrated in the inverter and aggregates performance data from each PV module connected to it. This data is then transmitted to the monitoring platform in near real-time and accessed via computer, smartphone or tablet for performance analysis, fault detection and troubleshooting of PV systems. The platform reduces maintenance costs throughout a system's lifetime.

The dashboard provides a quick look at the current performance of the solar system, provides access to historical data, and displays metrics for comparison.

Dashboard - Energy production is displayed with weekly, monthly and yearly resolution

The Designer tool allows an installer or system owner to upload the array's module layout to the monitoring platform for a true physical representation that is then populated with data per module in the layout. This allows for easy and quick evaluation of solar asset performance in order to decide if action is necessary to fix a problem.



The charting is where the SolarEdge monitoring really shines – some examples can be seen below. Each module's voltage and current can be charted to see if the string is performing as expected. One module can be compared to another in the same string, a single module can be analyzed to determine if a bypass diode has failed, or strings can be compared to each other. All of this takes place in near real-time resolution.

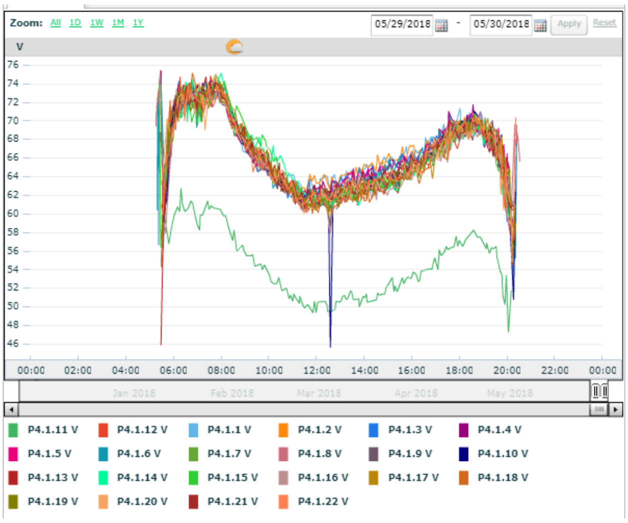
Site Commissioning with the Monitoring Platform

The monitoring platform can be used to verify that all components are properly installed, configured, and communicating. By generating a site commissioning report installers can check that the inverters, power optimizers and any other optional SolarEdge devices installed at the site (e.g. Energy Meter, Commercial Gateway) are properly connected and communicating with the monitoring platform. The report is built into the monitoring platform and can be easily generated and used for site approval.

Identification of Possible Defects and Underperformance - Examples

Defective Bypass Diode

The screenshot shows the voltage profile for each module in a string of 44 modules over the course of one day; every two modules are connected to a single power optimizer. The voltage of module 4.1.11 (green line) is approximately 15% lower than the other modules in the string, indicating that a bypass diode has been activated for this module.

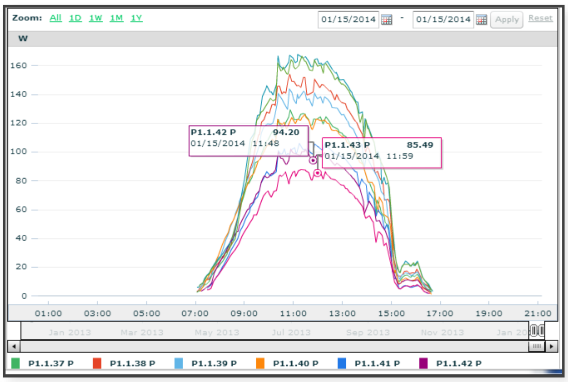


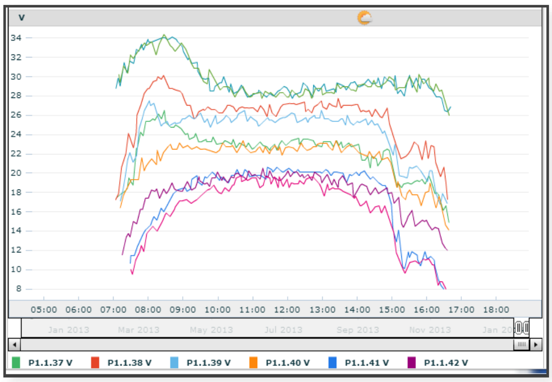
Potential Induced Degradation (PID)

Potential Induced Degradation (PID) is a phenomenon that can significantly degrade the power output of solar modules with power losses as high as 70%. However, PID can be difficult to detect in traditional systems.

Using the SolarEdge monitoring platform it's easy to identify PID. The monitoring platform can provide accurate module-level identification of PID using historical voltage and power output measurements of each individual module.

An example is shown below. It is clear that the degradation is more dominant towards the string's negative pole. Moreover, in such cases it is possible to complete a thorough analysis without sending a technician to the site to measure the modules' voltage, rather it can be done remotely.





Micro Cracks

Solar cell micro cracks can reduce the effective lifetime of a solar module due to accelerated degradation of output power. Micro cracks can occur during the manufacturing process, during shipping and handling, or during operation. Micro cracks are difficult to diagnose and detect since the effects are at the cell level. When using standard string I-V curve tracing it is difficult to detect the reduced output power of a single solar module. Expensive thermal imaging (IR) cameras and portable electro-luminescence (EL) equipment must be deployed.

With the SolarEdge monitoring platform it is possible to view the historical output of individual modules and to compare one module to another, making the detection of module degradation due to micro cracks easy

Summary

The SolarEdge innovative system architecture can naturally mitigate the limitations of I-V curve tracing. SolarEdge's system architecture and monitoring platform offer more visibility, more granularity, continuous real-time module-level tracking with historic data for accurate installation and performance evaluation.

The SolarEdge performance verification procedure is simple, does not require special tooling and can be done remotely from any computer, smartphone or tablet.