Testing of Smart PV Modules

Smart PV modules are PV modules with more sophisticated electronic devices than the usual bypass diodes. They can fulfill a wide range of functions and they come with a multitude of topologies. Testing of such modules can be difficult, because standard test procedures for PV modules may not be applicable. In this contribution problems at testing of smart PV modules are discussed and new test methods are being proposed.

Selection of some Applications for Smart PV Modules

• MPP-Tracking on Module Level
  Minimizing mismatch losses with microinverters or power optimizers

• Monitoring Features
  To keep track on the operational conditions of the PV module

• Safety Circuit Breakers
  Such as firefighter switches or arc fault detectors

• Active Bypass diodes
  Electronic substitutes for the usual schottky diodes with improved characteristics

• Combined Functions
  E.g. microinverters with integrated monitoring or safety features

Classification Scheme for Smart PV Modules

Possible Problems at Testing of Smart PV Modules

• Current Consumption
  Possibly non-constant supply current of the electronic devices makes a non-deterministic error in power measurements of the PV module

• Unknown Components in Parallel to the Solar Cells
  Components in parallel to the solar cells may have a non-linear or time-variant influence on the electrical characteristics of the module (e.g. in flasher tests)

• Missing Accessibility of the DC Terminals
  At some smart PV modules (e.g. with permanently attached microinverter) the DC terminals of the solar cells may not be accessible, making measurements impossible.

Measurement of the static P/V characteristic of the solar cells is impossible in many cases. The smart PV module can only be characterized by its energy output over a certain period of time.

Characterization of Smart PV Modules using a continuous Solar Simulator

• Characterization of the smart PV module as a complete system
• Non-constant influence of the electronics is being time-averaged
• Irradiation profiles allow an estimation of the performance under real conditions

Lightning Current Tests

• Complex electronics may be sensitive to surge currents
• Testing of the complete system with a pulse current generator
• Simulation of the effects of nearby lightning strokes

Outdoor Performance Tests

• Comparison of different systems
• Inclusion of all real-life effects
• Statistical analysis shows correlations between module type and energy output

Fig. 1: Classification scheme to differentiate between smart PV modules according to their topology

Fig. 2: Continuous solar simulator (self-made at BFH’s PV lab)

Fig. 3: Layout for an outdoor test array to compare systems 1-3 with optimized arrangement of the smart PV modules

Fig. 4: Test setup for induced lightning currents

Choice of the right Test Procedure

<table>
<thead>
<tr>
<th>Type A</th>
<th>Type B</th>
<th>Type C</th>
<th>Type D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation of the ‘smart’ part from the rest of the module and individual testing and/or Characterization of the complete system with continuous solar simulator and/or outdoor test</td>
<td>Characterization of the complete system with continuous solar simulator and/or outdoor test</td>
<td>Testing like any conventional PV module (without any ‘smart’ electronics)</td>
<td>Characterization of the complete system with continuous solar simulator or outdoor test Tests may be possible if the parasitic effects of the electronics can be compensated or streamlined such</td>
</tr>
</tbody>
</table>

Lightning current tests are advised for all types of smart PV modules

Fig. 5: Recommended assignment of the test procedures to the different types of smart PV modules