New Procedure for Measuring Dynamic MPP-Tracking Efficiency at Grid-Connected PV Inverters

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Introduction

At locations, where there are often variable cloudy conditions, besides the static also the dynamic MPPT-behaviour has to be considered. Inverters with a fast MPP-tracker have a somewhat higher energy yield under quickly changing irradiance than devices with slow MPP-tracking (MPPT). In a study of FH-ISe in 2005, it was shown that with a correct sizing of the inverter and a fast dynamic MPPT, in principle a few additional percent of energy could be obtained from the same PV array. That dynamic MPPT problems actually occur, could be shown in the long-term monitoring projects carried out by the PV laboratory of BFH-TI. Tests in the past were performed with quasi rectangular variations between two different power levels. Such tests can easily be realised and give a good insight into the inverter’s behaviour. New tests with ramps with rising and falling slopes of current or MPP-power were developed – this is much more realistic. But they are also more difficult to realise because of high measuring accuracy needed. As for static tests, before the start of a dynamic MPP-tracking test an initial set-up time is needed for stabilisation of the MPP-tracker in order to have a defined starting position.

Principles

Dynamic MPP-Tracking-Efficiency

Dynamic MPP-tracking efficiency or MPP-tracking accuracy $\eta_{MPPT}$, can be defined as:

$$\eta_{MPPT} = \frac{P_{MPP}}{P_{DC}}$$

where:

- $P_{MPP}$ = available maximum power of PV array $V_{DC}$(t) = available maximum power of PV array simulator in the respective instantaneous MPP
- $P_{DC}$ = Measurement duration (start at t = 0)

Dynamic MPPT Problems Registered in Real Operation

During the long-term monitoring projects of PV plants, which have been performed since 1992 by the PV laboratory of BFH-TI, some dynamic MPPT problems in real operation could be registered. Fig. 1 shows an example of such a problem.

Measurements

In 2008, the PV laboratory of BFH-TI participated in a workgroup in Germany, which had to create a draft for a standard to measure overall efficiency of PV inverters including suitable test patterns with ramps for MPP-tracking. These test patterns were finally approved by the working group and are now included in the final draft for a provisional European standard (FpR En 50530). There are tests with variations between 10 and 50% of $G_{STC}(1kW/m^2)$ and an others with variations between 30 and 100% of $G_{STC}$.

Test Results

Test patterns with ramps according to table 1 were used to perform dynamic MPPT tests at inverters. The MPP-tracking algorithm used by the manufacturer is decisive for the dynamic tracking behaviour. Especially useful were tests with inverters for which an old firmware version with relatively poor dynamic MPP-tracking behaviour and a new firmware version with very good dynamic MPP-tracking behaviour were available.

Conclusion

Many tests performed so far at different inverters have shown, that dynamic MPP-tracking behaviour can be improved considerably by an intelligent control software without affecting static MPP tracking.

For further information about the research activities of the PV laboratory of BFH-TI on the Internet: http://www.pvtest.ch

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**Table 1:**

<table>
<thead>
<tr>
<th>Inverter</th>
<th>Type</th>
<th>Name</th>
<th>MPPT Test with Ramps</th>
<th>New Firmware Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>INV3</td>
<td>10kW</td>
<td>New</td>
<td>Complete dynamic MPP-tracking behaviour was available.</td>
<td>Dynamic MPP-tracking is excellent.</td>
</tr>
</tbody>
</table>

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**Legend to fig. 2:**

- $n$: Number of repetitions in seconds
- $t_1$: Rise time in seconds
- $t_f$: Fall time in seconds
- $t_d$: Dwell time at low level in seconds
- $t_h$: Dwell time at high level in seconds

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**Legend to fig. 1:**

- $G_{gen}$ = irradiance into array plane
- $P_{dc}$ = DC power
- $P_{ac}$ = AC power
- $V_{dc}$ = DC voltage

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**Note:** The scale for $\eta_{MPPT}$ is expanded.