Performance Testing of High Efficient PV Modules using single 10 ms Flash Pulses

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Abstract/Summary:

The performance at STC of highly efficient and highly capacitive modules cannot be correctly measured within one 10 ms flash by applying to the module terminals a standard voltage ramp. Measurement artifacts due to the module capacitance could lead to an under estimation of the module maximal power. The measurement of a steady-state-like I-V curve of high capacitive modules requires longer sweep-times which are not reachable within one single flash. Accordingly, the DragonBack® method was investigated at PI Berlin, which allows for steady-statelike I-V curve measurements within one 10 ms flash by applying a customized voltage profile to the module. In this work the suitability of the DragonBack® method for power determination of high efficiency modules is investigated by comparing measurements performed both with this method and with the multi flash mode.

For more Information on the topic please contact the R&D Team of PI Berlin.

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PERFORMANCE TESTING OF HIGH EFFICIENT PV MODULES USING SINGLE 10 MS FLASH PULSES

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→ Introduction & Approach

High efficiency solar modules are often characterized by an increased capacitance.
By measuring the I-V curve with the flash light solar simulators, capacitance effects may cause an increased or reduced maximum power. These measurement artifacts can be avoided by using subsequent flashes.
Pasan SA developed a method named DragonBack® (DB) which allows for measuring the I-V curve of high capacitive modules within 10 ms flash pulse without having any measurements artifacts. This method consists in the application to the terminals of the module of a customized voltage profile.
In this work the robustness and suitability of the DragonBack® method is tested on several high efficiency modules by comparing the resulting maximum power with the one obtained by the multi flash technique.

Standard IV-curve measurement

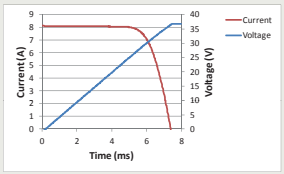

Fig. 1: For standard measurements with flash light sun simulator an impulse voltage with linear ramp is applied to the module within one flash

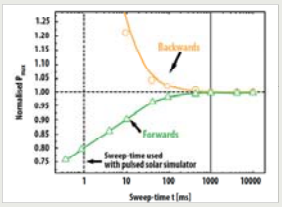

Fig. 2: By measurements of high capacitive modules a longer sweep time is necessary (more time is required to load the module capacitance) for a correct evaluation of the maximum power

Multi flash technique

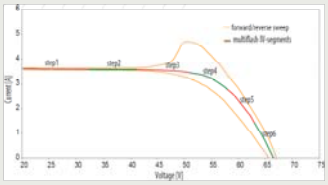

Fig. 3: With sectional measurement the voltage applied linearly increases during one flash. During each flash a segment of I-V curve is measured. The sweep time has to be verified

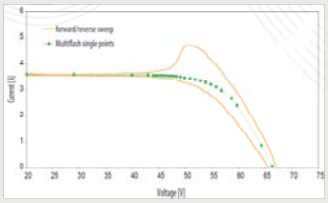

Fig. 4: The voltage applied is kept constant during one light pulse. One IV data point is measured each flash. No determination of sweep time is needed

DragonBack® impulse voltage

Aim of DB method: measurement of plateaus within one flash with stable I and V signals where each plateau represents one point of the I-V curve.

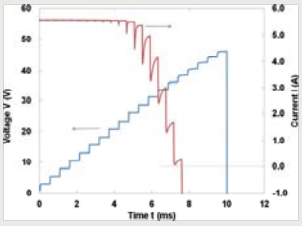

Fig. 5: If a staircase-like voltage is applied, the measured current is not stable except at Isc

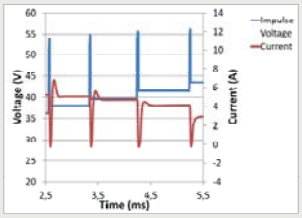

Fig. 6: With the DB method an overshoot is superimposed on each stair for current stabilization (additional energy to charge the capacitor)

DB I-V curve measurement

Before the determination of the DragonBack® voltage profile, the module is measured in direct and reverse mode for the evaluation of its capacitance. Considering the measured capacitance and adjusting few other parameters, the DragonBack® impulse voltage curve can be generated (Fig. 7).

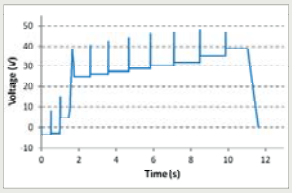

Fig. 7: DragonBack® voltage profile applied to the module within one flash for the I-V curve measurement

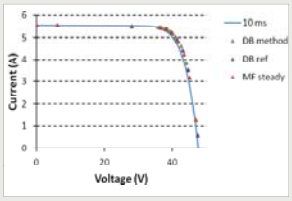

Fig. 8: I-V curves of a module from producer E measured with single, multi flash and with the DragonBack® method. A fit of the I-V curves points is performed for the evaluation of the curve parameters.

Tested Modules

Producer	Technology	N. of mod.	Pmpp MF/m² (W/m²)	MF
A	Panda (High efficiency technology by Yingli)	5	153.2	56 ms
B	p-type (Standard)	4	155.7	46 ms
C	n-type (High efficiency)	4	168.4	68 ms
D	HIT (Sanyo)	2	148.0	steady
E	HIT (Sanyo)	2	178.7	steady
F	n-type (Back contact Sunpower)	4	156.6	steady
G	Heterojuction	1	159.3	steady
H	p-type (High efficiency)	6	151.2	steady

Table 1: Technology and number of modules tested for each producer. The Pmpp/m² averaged for each producer and the type of multi flash used is also given

Results

For each producer a module is considered as reference.

The performance of each module is tested by:
- Single flash (10 ms)
- Multi Flash (Sectional or Steady)
- Dragon Back voltage profile defined for the tested module (DB)
- Dragon back voltage profile defined for the reference module (DBref)

Producer	MF vs 10ms (%)	DB vs MF (%)	DBref vs MF (%)
A	0.6	-0.1	-0.2
B	0.4	0.2	0.1
C	0.7	0.1	0.3
D	5.3	-0.2	-0.4
E	7.3	0.1	0.0
F	3.6	0.1	0.1
G	11.0	0.1	-
H	1.1	-0.2	-0.1

Table 2: Values averaged for each producer of the relative power deviation between single and multi flash and of the relative deviation between DragonBack® and multi flash

DB vs MF

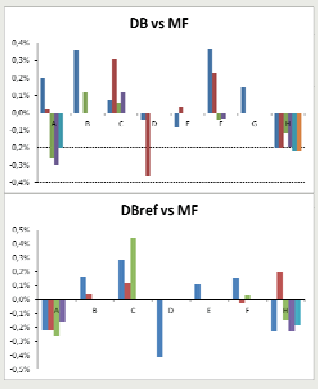

Fig. 9: Maximum power deviation for each module between DragonBack® and multi flash measurements. The deviation to multi flash is for every module smaller than 0.5%. No significant difference is observed for the DragonBack® measurements performed with the voltage profile determined for the module under test and the profile determined for the reference module.

→ Conclusions

A total of 27 high capacitive modules of 7 different producers were measured both with DragonBack® and with multi flash methods.
By comparing the DragonBack® measurements performed with the impulse voltage customized for the module under test, with the multi flash measurements, it results a deviation on the maximum power always smaller than 0.5%. Considering that the values are not temperature corrected and that the temperature coefficients for the maximum power exceed 0.3%/K, this result can be considered acceptable.
For each producer a reference module was selected and with the impulse voltage curve determined for this module, the I-V curve of other modules of the same type was measured.
For 16 modules the maximum power deviation with respect to the multi flash results does not exceed 0.3%, for 2 modules is smaller than 0.5%.
This statistic validates the robustness of the DragonBack® method for the measurement of a batch of high efficiency modules.