

## Photovoltaic Simulators

### Test results for Inverter Test

- Static MPP
- Dynamic MPP
- Anti islanding

*The relating standards:*

EN 50530

IEC/EN 61683

IEC/EN 61727

IEC/EN 62116

VDE 0126-2

IEEE 1547

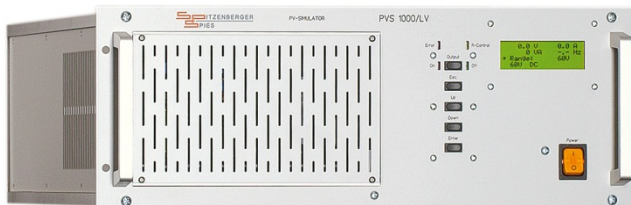


Fig. 1: PVS 1000/LV

- ✓ Free programmable I/V characteristics
- ✓ Different solar cells and also partly shadowed PV-generators can be simulated.
- ✓ Fast response time to load changes: typical less than 100µs
- ✓ 100Hz ripple on current and voltage of single phase inverters is reproduced realistically
- ✓ The I/V curve is simulated very accurately
- ✓ Ability to simulate dynamic irradiance and temperature, possibility of simulation of the behaviour of a PV-generator during a typical cloudy or clear day
- ✓ Evaluation of static and dynamic MPP-tracking efficiency
- ✓ Complies with the requirements according to IEC/EN 50530
- ✓ Available in standard version (up to 950V<sub>DC</sub>) and low-voltage version (up to 150V<sub>DC</sub>) for micro inverter testing



Fig. 2: PVS 25000

### Static MPPT Test

EUT: Solar Inverter

Date: 12.11.2013

Time: 15:43:43

Waiting Time: 05:00 min

Measure Time: 10:00 min

Comment:

#### Input side (DC):

Maximum input voltage V<sub>dcmax</sub>: 800 V

Minimum input voltage V<sub>dcmin</sub>: 350 V

Rated input voltage V<sub>dc,r</sub>: 480 V

Maximum MPP voltage V<sub>mppmax</sub>: 800 V

Minimum MPP voltage V<sub>mppmin</sub>: 350 V

Rated input power P<sub>dc,r</sub>: 4.5 kW

#### Output side (AC):

Rated grid voltage V<sub>ac,r</sub>: 230 V

Rated power P<sub>ac,r</sub>: 4.5 kW

Nominal frequency f: 50 Hz

Number of Phases: 1

#### Measurement of static MPPT efficiency:

	5%	10%	20%	25%	30%	50%	75%	100%
640_cSi	99.92 %	99.94 %	99.95 %	99.8 %	99.67 %	99.87 %	99.9 %	99.93 %
480_cSi	99.88 %	99.89 %	99.79 %	99.89 %	99.87 %	99.9 %	99.89 %	99.89 %
350_cSi	99.89 %	99.95 %	99.98 %	99.98 %	99.98 %	99.77 %	99.09 %	97.98 %

#### Measurement of conversion efficiency:

	5%	10%	20%	25%	30%	50%	75%	100%
640_cSi	93.28 %	95.49 %	96.26 %	96.45 %	96.38 %	96.02 %	95.33 %	94.63 %
480_cSi	94.26 %	96.04 %	96.63 %	96.73 %	96.67 %	96.19 %	95.46 %	94.73 %
350_cSi	94.83 %	96.46 %	96.88 %	96.92 %	96.85 %	96.28 %	95.52 %	94.77 %

#### Overall efficiency:

	5%	10%	20%	25%	30%	50%	75%	100%
640_cSi	93.21 %	95.44 %	96.21 %	96.26 %	96.06 %	95.89 %	95.23 %	94.56 %
480_cSi	94.15 %	95.94 %	96.43 %	96.62 %	96.54 %	96.1 %	95.35 %	94.62 %
350_cSi	94.73 %	96.41 %	96.85 %	96.91 %	96.83 %	96.06 %	94.65 %	92.85 %

**Efficiency:**

	$\eta_{\text{MPPTstat, EUR}}$	$\eta_{\text{MPPTstat, CEC}}$	$\eta_{\text{MPPTconv, EUR}}$	$\eta_{\text{MPPTconv, CEC}}$
640_cSi	99.88 %	99.87 %	95.7 %	95.62 %
480_cSi	99.88 %	99.88 %	95.94 %	95.8 %
350_cSi	99.47 %	99.36 %	96.08 %	95.91 %

Tested with SPS InverterTest 1.0.17.0 by Spitzenberger & Spies GmbH & Co. KG, Schmidstr. 32-34, 94234 Viechtach, Germany

## Dynamic MPPT Test

EUT: Solar Inverter

Date: 13.11.2013

Time: 13:32:03

Comment:

### Input side (DC):

Maximum input voltage V<sub>dcmax</sub>: 800 V  
 Minimum input voltage V<sub>dcmin</sub>: 350 V  
 Rated input voltage V<sub>dc,r</sub>: 480 V  
 Maximum MPP voltage V<sub>mppmax</sub>: 800 V  
 Minimum MPP voltage V<sub>mppmin</sub>: 350 V  
 Rated input power P<sub>dc,r</sub>: 4.5 kW

### Output side (AC):

Rated grid voltage V<sub>ac,r</sub>: 230 V  
 Rated power P<sub>ac,r</sub>: 4.5 kW  
 Nominal frequency f: 50 Hz  
 Number of Phases: 1

### Dynamic MPPT Test Results:

Irradiation 1: 100 W/m<sup>2</sup>

Irradiation 2: 500 W/m<sup>2</sup>

Delta: 400 W/m<sup>2</sup>

Temperature 1: 25 °C

Temperature 2: 25 °C

	Repetitions	Waiting time	Ramp up	Dwell Time 1	Ramp down	Dwell time 2	η <sub>MPPTDyn</sub>
1	2	300 s	800 s	10 s	800 s	10 s	99.77 %
2	2	300 s	400 s	10 s	400 s	10 s	99.5 %
3	3	300 s	200 s	10 s	200 s	10 s	98.66 %
4	4	300 s	133 s	10 s	133 s	10 s	98.08 %
5	6	300 s	80 s	10 s	80 s	10 s	97.9 %
6	8	300 s	57 s	10 s	57 s	10 s	96.75 %
7	10	300 s	40 s	10 s	40 s	10 s	96.74 %
8	10	300 s	29 s	10 s	29 s	10 s	92.89 %
9	10	300 s	20 s	10 s	20 s	10 s	97.74 %
10	10	300 s	13 s	10 s	13 s	10 s	98.05 %
11	10	300 s	8 s	10 s	8 s	10 s	97.96 %

**Average η<sub>MPPTDyn</sub>: 97.09 %**

## Dynamic MPPT Test

EUT: Solar Inverter  
 Date: 13.11.2013  
 Time: 15:35:33  
 Comment:

### Input side (DC):

Maximum input voltage  $V_{dcmax}$ : 800 V  
 Minimum input voltage  $V_{dcmin}$ : 350 V  
 Rated input voltage  $V_{dc,r}$ : 480 V  
 Maximum MPP voltage  $V_{mppmax}$ : 800 V  
 Minimum MPP voltage  $V_{mppmin}$ : 350 V  
 Rated input power  $P_{dc,r}$ : 4.5 kW

### Output side (AC):

Rated grid voltage  $V_{ac,r}$ : 230 V  
 Rated power  $P_{ac,r}$ : 4.5 kW  
 Nominal frequency  $f$ : 50 Hz  
 Number of Phases: 1

### Dynamic MPPT Test Results:

Irradiation 1: 300 W/m<sup>2</sup>  
 Irradiation 2: 1000 W/m<sup>2</sup>  
 Delta: 700 W/m<sup>2</sup>  
 Temperature 1: 25 °C  
 Temperature 2: 25 °C

	Repetitions	Waiting time	Ramp up	Dwell Time 1	Ramp down	Dwell time 2	$\eta_{MPPTDyn}$
1	10	300 s	70 s	10 s	70 s	10 s	98.54 %
2	10	300 s	50 s	10 s	50 s	10 s	98.22 %
3	10	300 s	35 s	10 s	35 s	10 s	99.75 %
4	10	300 s	23 s	10 s	23 s	10 s	99.74 %
5	10	300 s	14 s	10 s	14 s	10 s	99.78 %
6	10	300 s	7 s	10 s	7 s	10 s	99.68 %

**Average  $\eta_{MPPTDyn}$ :** 99.28 %

## Anti Islanding Test

EUT: Solar Inverter

Date: 14.11.2013

Time: 13:32:38

Comment:

### Input side (DC):

Maximum input voltage V<sub>dcmax</sub>: 800 V  
 Minimum input voltage V<sub>dcmin</sub>: 350 V  
 Rated input voltage V<sub>dc,r</sub>: 480 V  
 Maximum MPP voltage V<sub>mppmax</sub>: 800 V  
 Minimum MPP voltage V<sub>mppmin</sub>: 350 V  
 Rated input power P<sub>dc,r</sub>: 4.5 kW

### Output side (AC):

Rated grid voltage V<sub>ac,r</sub>: 230 V  
 Rated power P<sub>ac,r</sub>: 4.5 kW  
 Nominal frequency f: 50 Hz  
 Number of Phases: 1

### Anti Islanding Test Result:

	Pdc	Vmpp	Qf	Pac	Qac	Phases	Run on time
1	25 %	480 V	2.1	0 %	0 %	1	0.170 s
2	25 %	480 V	2.1	0 %	-1 %	1	0.225 s
3	25 %	480 V	2.1	0 %	-2 %	1	0.101 s
4	25 %	480 V	2.1	0 %	-3 %	1	0.190 s
5	25 %	480 V	2.1	0 %	-4 %	1	0.208 s
6	25 %	480 V	2.1	0 %	-5 %	1	0.182 s
7	25 %	480 V	2.1	0 %	1 %	1	0.187 s
8	25 %	480 V	2.1	0 %	2 %	1	0.117 s
9	25 %	480 V	2.1	0 %	3 %	1	0.163 s
10	25 %	480 V	2.1	0 %	4 %	1	0.029 s
11	25 %	480 V	2.1	0 %	5 %	1	0.104 s
12	50 %	480 V	2.1	0 %	0 %	1	0.280 s
13	50 %	480 V	2.1	0 %	-1 %	1	0.025 s
14	50 %	480 V	2.1	0 %	-2 %	1	0.174 s
15	50 %	480 V	2.1	0 %	-3 %	1	0.309 s
16	50 %	480 V	2.1	0 %	-4 %	1	0.371 s
17	50 %	480 V	2.1	0 %	-5 %	1	0.347 s
18	50 %	480 V	2.1	0 %	1 %	1	0.188 s
19	50 %	480 V	2.1	0 %	2 %	1	0.021 s
20	50 %	480 V	2.1	0 %	3 %	1	0.181 s
21	50 %	480 V	2.1	0 %	4 %	1	0.017 s
22	50 %	480 V	2.1	0 %	5 %	1	0.020 s

Tested with SPD InverterTest 1.0.17.0 by Spitzenberger & Spies GmbH & Co. KG, Schmidstr. 32-34, 94234 Viechtach, Germany

	Pdc	Vmpp	Qf	Pac	Qac	Phases	Run on time
23	100 %	480 V	2.1	0 %	0 %	1	0.327 s
24	100 %	480 V	2.1	0 %	-1 %	1	0.017 s
25	100 %	480 V	2.1	0 %	-2 %	1	0.013 s
26	100 %	480 V	2.1	0 %	-3 %	1	0.019 s
27	100 %	480 V	2.1	0 %	-4 %	1	0.019 s
28	100 %	480 V	2.1	0 %	-5 %	1	0.678 s
29	100 %	480 V	2.1	0 %	1 %	1	0.197 s
30	100 %	480 V	2.1	0 %	2 %	1	0.193 s
31	100 %	480 V	2.1	0 %	3 %	1	0.205 s
32	100 %	480 V	2.1	0 %	4 %	1	0.180 s
33	100 %	480 V	2.1	0 %	5 %	1	0.022 s

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*„We can make weather“*

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