Photovoltaic Simulators
PVS and PVS/HV series
PVS 1000/LV

The High Speed Simulators

The relating standards:
IEC/EN 50530
IEC/EN 62116
IEEE 1547
IEC/EN 61683
IEC/EN 61727
Sandia Report
CGC/GF004:2011
CEI 0-21
VDE-AR-N 4105
VDE 0126-2

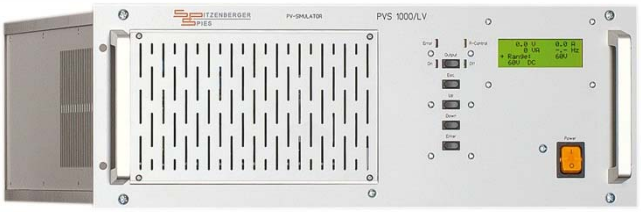


Fig. 1: PVS 1000/LV

Fig. 2: PVS 25000

- ✓ Free programmable I/V characteristics
- ✓ Different solar cell types / partly shadowed cells are possible to simulate.
- ✓ 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
- ✓ Simulation of the behavior 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 and many other specifications
- ✓ Operating modes IV (solar characteristic) and CV (Constant voltage with current limitation)
- ✓ Available in standard (up to $1000V_{DC}$), high voltage (up to $1500V_{DC}$) and low-voltage version (up to $150V_{DC}$ for micro inverter testing)

THE PV-SIMULATOR – FIELD OF APPLICATION

The PV-Simulator reproduces in real time the behaviour of many different solar panels. The parameters influencing this behaviour in reality are the changing weather conditions, the variation of the irradiation during the day and local conditions like shadowing and pollution. To simulate this condition the PVS has a capability for fast control adjustments.

Fast response time

Due to the fast DSP based regulation system, the response time to load changes is very fast. This fast response time is an absolutely necessary requirement for the IEC/EN 50530 and the specified MPP tracking algorithm. *See Spitzenberger & Spies Application: http://www.spitzenberger.de/weblink/1005*

The diagrams in Fig. 3-6 show the measured rise- and fall-times at different load conditions.

Load changes around MPP:

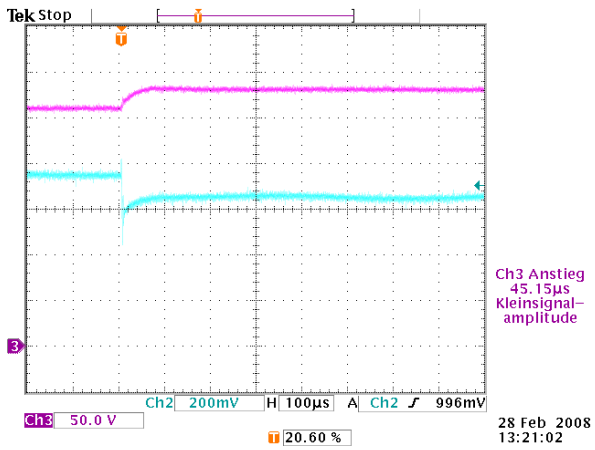


Fig. 3: Rise-time Voltage / Current

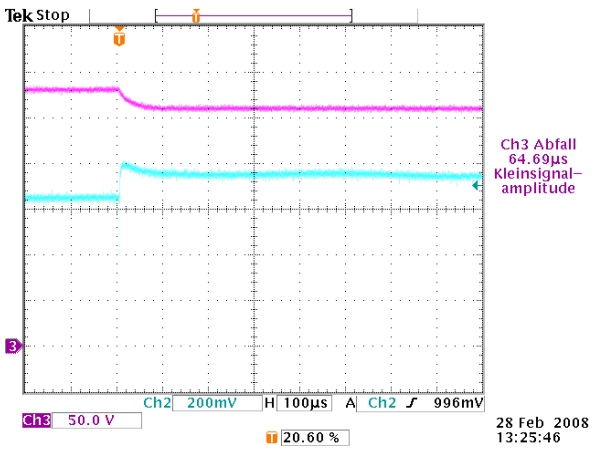


Fig. 4: Fall-time Voltage / Current

Load between open circuit and MPP:

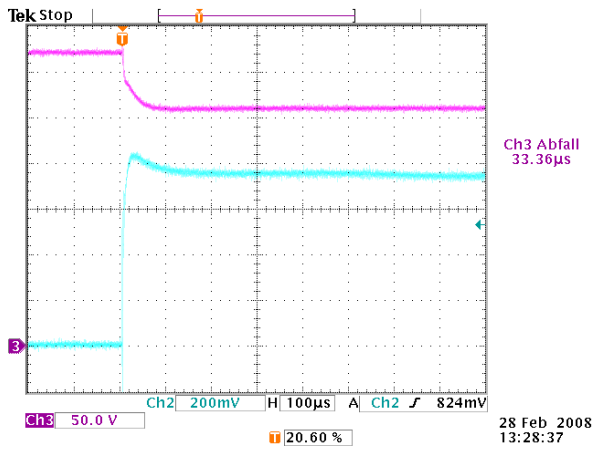


Fig. 5: Fall-time Voltage / Current

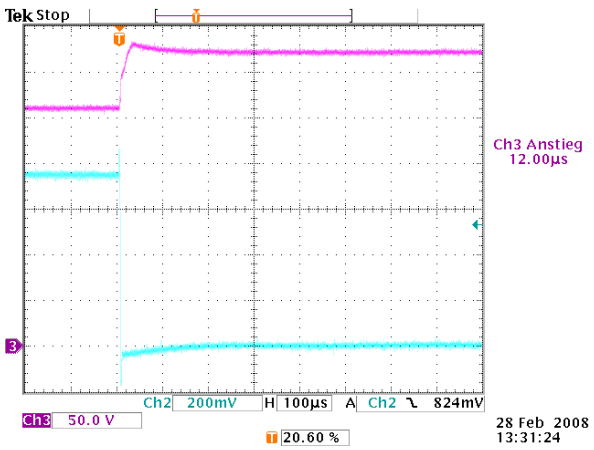


Fig. 6: Rise-time Voltage / Current

100HZ RIPPLE / FREE PROGRAMMABLE CURVES

100Hz Ripple

One of the requirements of the photovoltaic simulator according to the IEC/EN 50530 is the ripple capability:

"This requires a sufficient dynamic of the PV simulator in order to follow the dynamic voltage changes that occur in the measurement (e.g. the typical ripple of single phase inverters with twice the grid frequency)"

With real photovoltaic generators this typical 100Hz ripple on current and voltage when operating with a single phase inverter can be measured. Some inverters use this for a fast MPP tracking.

When operating with the PV-Simulator this ripple-behaviour is exactly as it is in reality, because of the very fast response time capability.

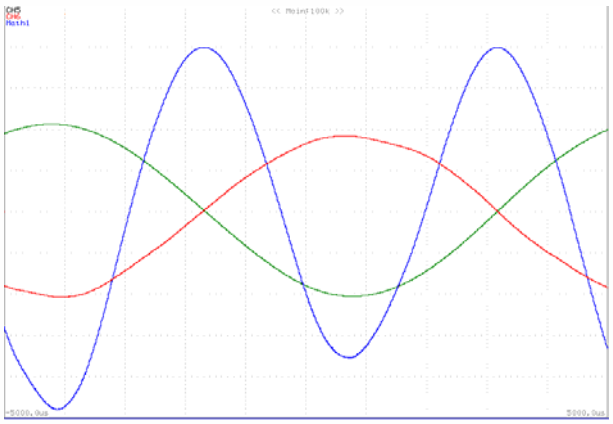


*Fig. 7: 100Hz ripple of voltage and current - **voltage**, **current**, **power***

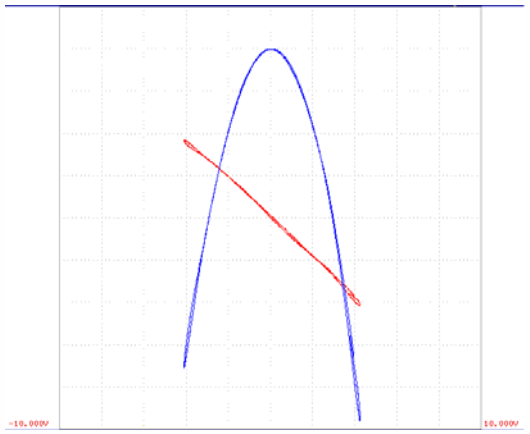


*Fig. 8: XY-view: no hysteresis observably - **current**, **power***

Free programmable curves

I/V-curves are adjustable via software over a wide range to simulate various conditions for dynamic irradiances and temperature changes.
This includes "in the field" measured I/V curves, stored and imported into the Spitzenberger & Spies control software.

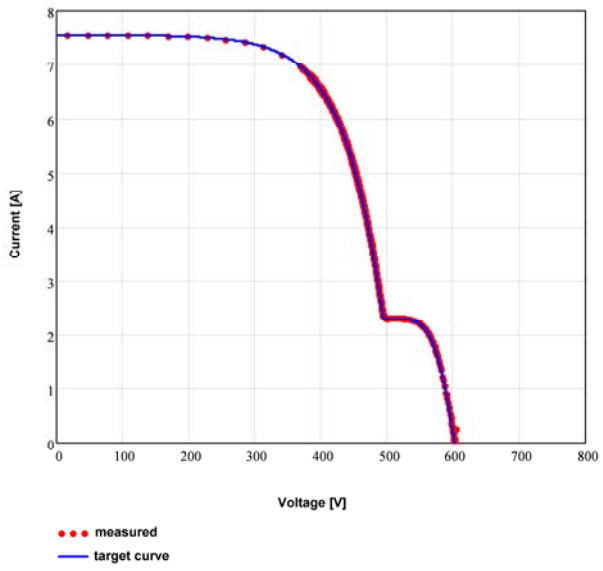


Fig. 9: free programmable I/V curves

SIMULATION OF DYNAMIC IRRADIATION

Irradiation

The value of the solar radiation density – the irradiation – is varying during the day.

Slow variations occur because of the changing position of the sun.

Fast variations can occur at cloudy days, if the sun is shadowed within seconds and cleared several minutes later and again shadowed.

Various curves – corresponding to different irradiance values - can be defined with specified time course.

The transition between two curves will be interpolated; the transition time is freely programmable.

The specified curves are reproduced exactly during a complete measurement session.

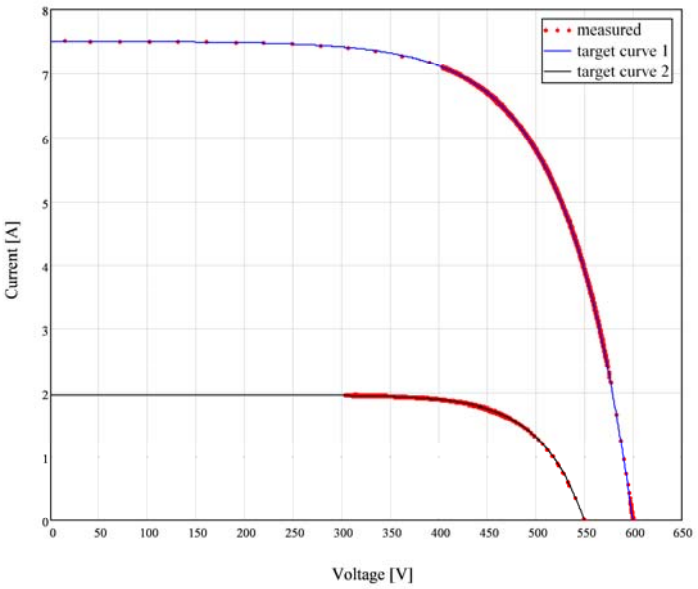


Fig. 10: various I/V curves

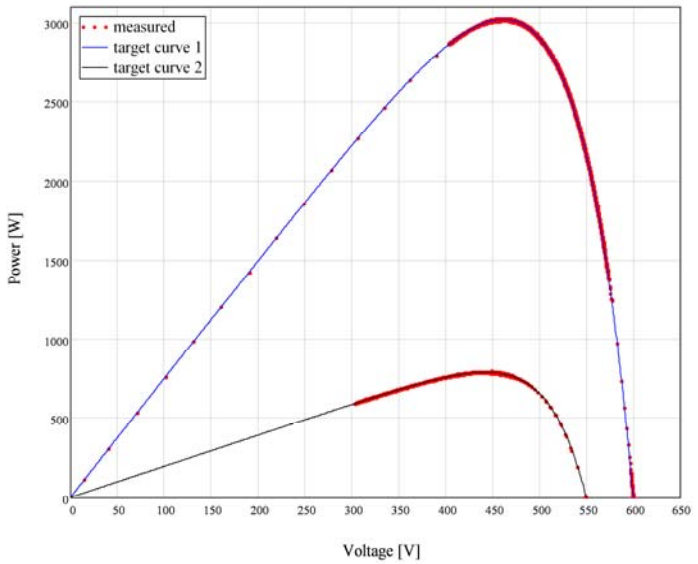


Fig. 11: various V/P curves

VOLTAGE RANGES – CURRENT CHARACTERISTICS

Due to different types of solar generators the PVS series has six voltage ranges:

Standard series	High voltage series
400V	400V
500V	500V
600V	750V
800V	1000V
900V	1250V
1000V	1500V

The diagrams show the maximum possible current capability in the according voltage ranges, depending on the adjusted output voltage. This correlates also to the maximum available power capability of the PVS depending on the adjusted output voltage.

The current capability of the PVS is specified as:

- Continuous current capability
- Short time current capability *(up to 2 minutes)*
- Peak current capability *(up to 50ms)*

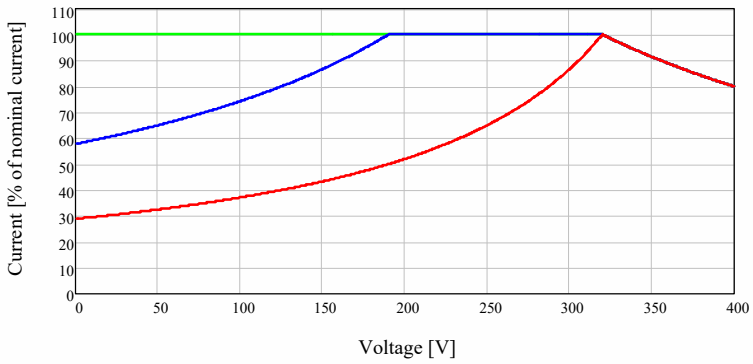


Fig. 12: current performance of the PVS in the 400V range

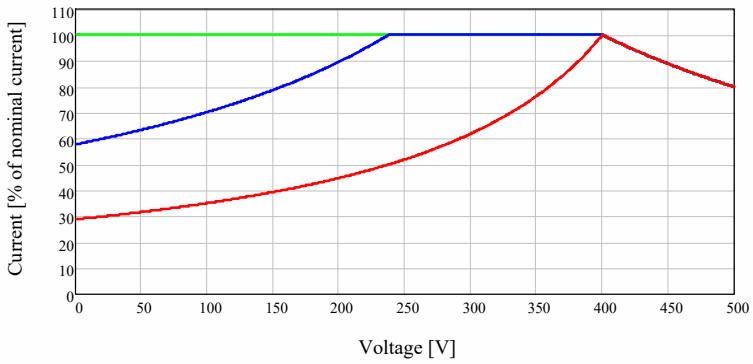


Fig. 13: current performance of the PVS in the 500V range

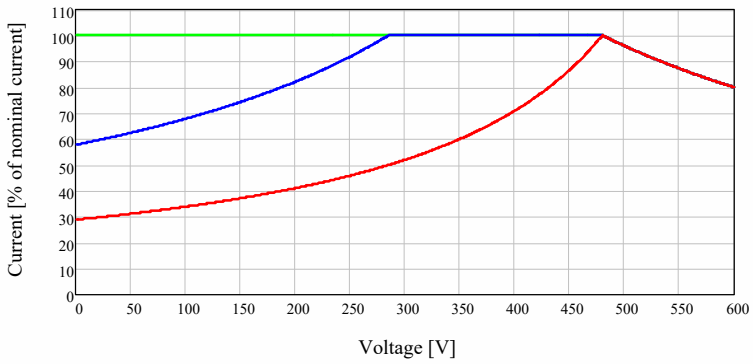


Fig. 14: current performance of the PVS in the 600V range

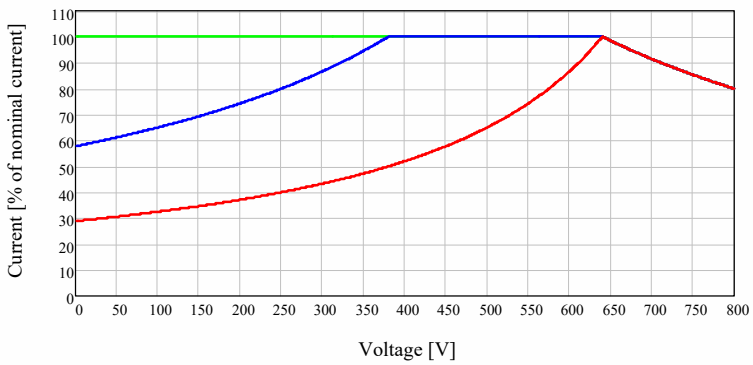


Fig. 15: current performance of the PVS in the 800V range

Fig. 17: PVS / Basic EMC System

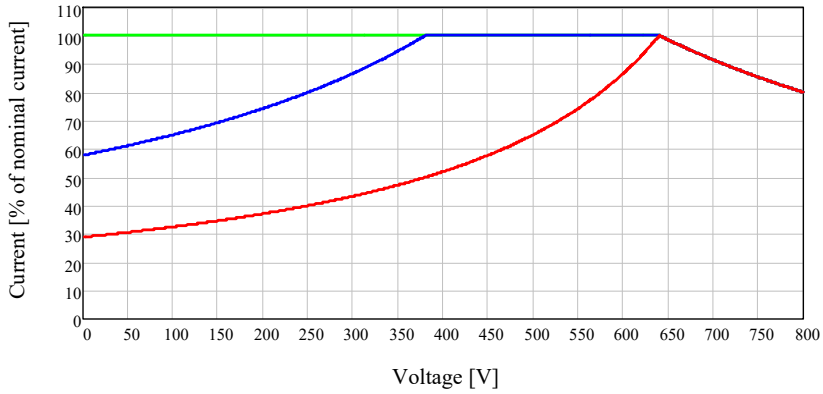


Fig. 16: current performance of the PVS in the 900V range

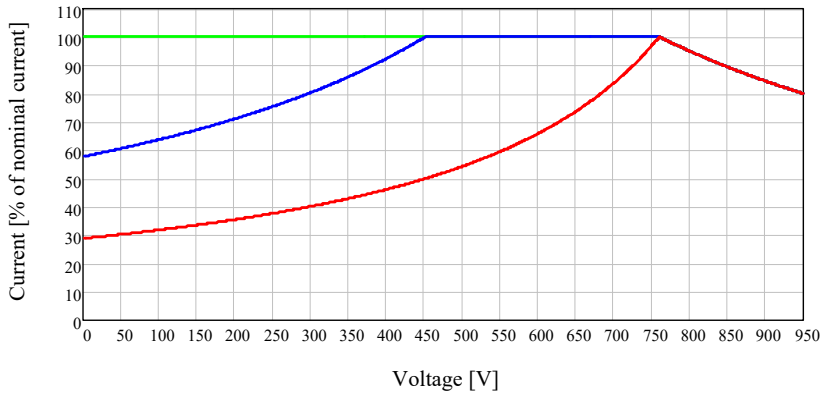


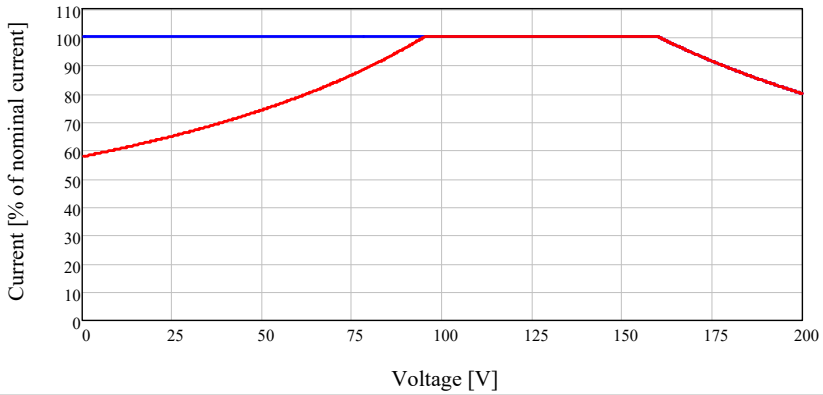
Fig. 18: current performance of the PVS in the 1000V range

OPTIONAL VOLTAGE RANGES – CURRENT CHARACTERISTICS

	PVS 1000	PVS 3000	PVS 7000	PVS 10000	PVS 15000	PVS 25000
- Option 11-200/DC at 160V_{DC}	3.2A_{DC}	9.4A_{DC}	22A_{DC}	31A_{DC}	50A_{DC}	80A_{DC}

	PVS 32500	PVS 42500	PVS 50000	PVS65000	PVS 85000	PVS100000
- Option 11-200/DC at 160V_{DC}	100A_{DC}	135A_{DC}	157A_{DC}	200A_{DC}	270A_{DC}	314A_{DC}

Fig. 19:
Optional voltage range 200V
Current performance



TECHNICAL DATA – GENERAL

			PVS Series
Nominal voltage PVS standard series		*DC:*	+400V_{DC} / +500V_{DC} / +600V_{DC} / +800V_{DC} / +900V_{DC} / +1000V_{DC}
Nominal voltage PVS high voltage series		*DC:*	+400V_{DC} / +500V_{DC} / +750V_{DC} / +1000V_{DC} / +1250V_{DC} / +1500V_{DC}
Voltage accuracy:			± 0.05% (of value) ± 0.05% (of range)
Current accuracy:			± 0.1% (of value) ± 0.1% (of range)
Slew rate:			< 250µs / typical < 100µs
Protection circuits:			Overload / Short Circuit / Over temperature
Interface:			Ethernet
Digital instrument Measuring ranges		*Voltage range:*	Autoranging
		Current range:	depending on the model, related to the relevant output current
		Accuracy Voltage:	± 0.05% (of value) ± 0.05% (of range)
		Accuracy Current:	± 0.1% (of value) ± 0.1% (of range)
Memory capacity for I/V curves:			up to 10000 curves
Ambient temperature:			0°C up to 40°C

Options		
01:	IEEE 488 Interface	
10:	Internal resistance compensation	available
11	Special voltage	
11-200/DC	Additional DC voltage range	0 … 200V_{DC}
18	Special line voltages	In the range from 110V … 300V
	Precision Power Analyser for efficiency measurement	

Remarks:

1) at nominal voltage
2) max. voltage between earth and ground of the amplifier output -950V_{DC}, +400V_{DC}
3) to increase the output power of an amplifier, up to three similar amplifiers may be connected in parallel
4) with measurement adaptation to PAS
5) at 230V input voltage

TECHNICAL DATA – PVS 1000 / 3000 / 7000

		PVS 1000	PVS 3000	PVS 7000
Power DC [1) 5)]	*- continuous:*	1000W	3000W	7000W
Continuous current standard series	*U_{OUT}= 320V_{DC} (400V range):*	3.2A_{DC}	9.4A_{DC}	22A_{DC}
	U_{OUT}= 400V_{DC} (500V range):	2.5A_{DC}	7.5A_{DC}	17.5A_{DC}
	U_{OUT}= 480V_{DC} (600V range):	2.1A_{DC}	6.3A_{DC}	14A_{DC}
	U_{OUT}= 640V_{DC} (800V range):	1.6A_{DC}	4.7A_{DC}	11A_{DC}
	U_{OUT}= 720V_{DC} (900V range):	1.4A_{DC}	4.2A_{DC}	9.8A_{DC}
	U_{OUT}= 800V_{DC} (1000V range):	1.25A_{DC}	3.8A_{DC}	8.8A_{DC}
Continuous current HV series	*U_{OUT}= 320V_{DC} (400V range):*	3.2A_{DC}	9.4A_{DC}	22A_{DC}
	U_{OUT}= 400V_{DC} (500V range):	2.5A_{DC}	7.5A_{DC}	17.5A_{DC}
	U_{OUT}= 600V_{DC} (750V range):	1.7A_{DC}	5.0A_{DC}	11.7A_{DC}
	U_{OUT}= 800V_{DC} (1000V range):	1.25A_{DC}	3.8A_{DC}	8.8A_{DC}
	U_{OUT}= 1000V_{DC} (1250V range):	1.0A_{DC}	3.4A_{DC}	7.0A_{DC}
	U_{OUT}= 1200V_{DC} (1500V range):	0.85A_{DC}	2.5A_{DC}	5.9A_{DC}
Power Supply *(±10%, 50Hz 60Hz)*		230V, Schuko	230V/400V, CEE	
Protection:		16A	3 x 16A	3 x 20A
Housing		19”, 7U	19”, 10U	19”,12U
	approx. (mm):	311x483x700	444x483x700	533x483x700
Weight	*approx. (kg):*	50	115	145

TECHNICAL DATA – PVS 10000 / 15000 / 25000

		PVS 10000	PVS 15000	PVS 25000
Power DC [1) 5)]	*- continuous:*	10000W	15000W	25000W
Continuous current standard series	*U_{OUT}= 320V_{DC} (400V range):*	31A_{DC}	50A_{DC}	80A_{DC}
	U_{OUT}= 400V_{DC} (500V range):	25A_{DC}	38A_{DC}	63A_{DC}
	U_{OUT}= 480V_{DC} (600V range):	21A_{DC}	32A_{DC}	53A_{DC}
	U_{OUT}= 640V_{DC} (800V range):	14A_{DC}	21A_{DC}	35A_{DC}
	U_{OUT}= 720V_{DC} (900V range):	12.5A_{DC}	19A_{DC}	32A_{DC}
	U_{OUT}= 800V_{DC} (1000V range):	12.5A_{DC}	19A_{DC}	32A_{DC}
Continuous current HV series	*U_{OUT}= 320V_{DC} (400V range):*	31A_{DC}	50A_{DC}	80A_{DC}
	U_{OUT}= 400V_{DC} (500V range):	25A_{DC}	38A_{DC}	63A_{DC}
	U_{OUT}= 600V_{DC} (750V range):	17A_{DC}	25A_{DC}	42A_{DC}
	U_{OUT}= 800V_{DC} (1000V range):	12.5A_{DC}	19A_{DC}	32A_{DC}
	U_{OUT}= 1000V_{DC} (1250V range):	10A_{DC}	15A_{DC}	25A_{DC}
	U_{OUT}= 1200V_{DC} (1500V range):	8.5A_{DC}	13A_{DC}	21A_{DC}
Power Supply *(±10%, 50Hz 60Hz)*		230V/400V, CEE		
Protection:		3 x 40A	3 x 50A	3 x 63A
Housing		19”, 20U	19” 29U	19”, 35U
	approx. (mm):	888x483x700	1288x483x700	1555x483x700
Weight	*approx. (kg):*	280kg	320kg	370kg

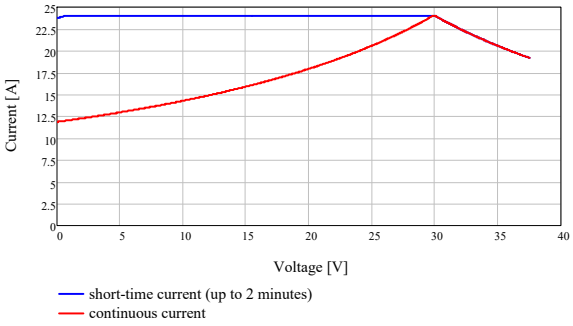
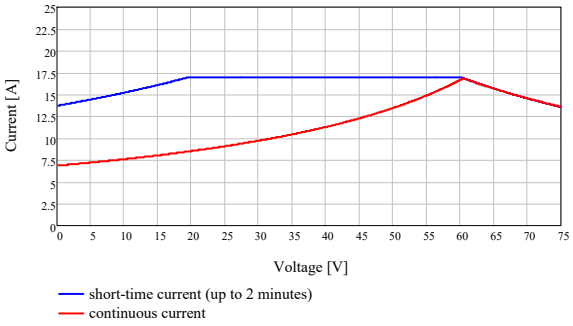
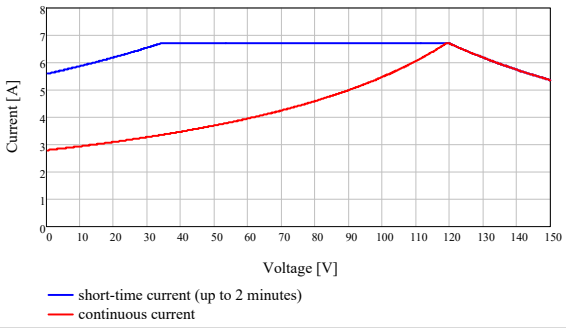
TECHNICAL DATA – PVS 32500 / 42500 / 50000

		PVS 32500	PVS 42500	PVS 50000
Power DC [1) 5)]	*- continuous:*	32500W	42500W	50000W
Continuous current standard series	*U_{OUT} = 320V_{DC} (400V range):*	100A_{DC}	135A_{DC}	157A_{DC}
	U_{OUT} = 400V_{DC} (500V range):	82A_{DC}	108A_{DC}	125A_{DC}
	U_{OUT} = 480V_{DC} (600V range):	68A_{DC}	90A_{DC}	105A_{DC}
	U_{OUT} = 640V_{DC} (800V range):	51A_{DC}	67A_{DC}	79A_{DC}
	U_{OUT} = 720V_{DC} (900V range):	46A_{DC}	60A_{DC}	70A_{DC}
	U_{OUT} = 800V_{DC} (1000V range):	41A_{DC}	55A_{DC}	63A_{DC}
Continuous current HV series	*U_{OUT} = 320V_{DC} (400V range):*	100A_{DC}	135A_{DC}	157A_{DC}
	U_{OUT} = 400V_{DC} (500V range):	82A_{DC}	108A_{DC}	125A_{DC}
	U_{OUT} = 600V_{DC} (750V range):	55A_{DC}	71A_{DC}	84A_{DC}
	U_{OUT} = 800V_{DC} (1000V range):	41A_{DC}	55A_{DC}	63A_{DC}
	U_{OUT} = 1000V_{DC} (1250V range):	33A_{DC}	43A_{DC}	50A_{DC}
	U_{OUT} = 1200V_{DC} (1500V range):	28A_{DC}	36A_{DC}	42A_{DC}
Power Supply *(±10%, 50Hz 60Hz)*		230V/400V CEE		
Protection:		3 x 100A	3 x 125A	3 x 160A
Housing	*Amplifier:*	19", 33U	19", 39U	19",46U
	approx. dimensions (mm):	1467x483x700	1733x483x700	2042x483x700
	Power Supply	19", 33U	19", 39U	19",46U
	approx. dimensions (mm):	1467x483x700	1733x483x700	2042x483x700
Weight	*approx. (kg)*	on request	on request	on request

TECHNICAL DATA – PVS 65000 / 85000 / 100000 - External parallel connection

		PVS 65000	PVS 85000	PVS 100000
		= 2 x PVS 32500	*= 2 x PVS 42500*	*= 2 x PVS 50000*
Power DC [1) 5)]	*- continuous:*	65000W	85000W	100000W
Continuous current standard series	*U_{OUT} = 320V_{DC} (400V range):*	200A_{DC}	270A_{DC}	314A_{DC}
	U_{OUT} = 400V_{DC} (500V range):	164A_{DC}	216A_{DC}	250A_{DC}
	U_{OUT} = 480V_{DC} (600V range):	136A_{DC}	180A_{DC}	210A_{DC}
	U_{OUT} = 640V_{DC} (800V range):	102A_{DC}	135A_{DC}	158A_{DC}
	U_{OUT} = 720V_{DC} (900V range):	92A_{DC}	120A_{DC}	140A_{DC}
	U_{OUT} = 800V_{DC} (1000V range):	82A_{DC}	110A_{DC}	126A_{DC}
Continuous current HV series	*U_{OUT} = 320V_{DC} (400V range):*	200A_{DC}	270A_{DC}	314A_{DC}
	U_{OUT} = 400V_{DC} (500V range):	164A_{DC}	216A_{DC}	250A_{DC}
	U_{OUT} = 600V_{DC} (750V range):	110A_{DC}	142A_{DC}	168A_{DC}
	U_{OUT} = 800V_{DC} (1000V range):	82A_{DC}	110A_{DC}	126A_{DC}
	U_{OUT} = 1000V_{DC} (1250V range):	66A_{DC}	86A_{DC}	100A_{DC}
	U_{OUT} = 1200V_{DC} (1500V range):	56A_{DC}	72A_{DC}	84A_{DC}
Power Supply *(±10%, 50Hz 60Hz)*		230V/400V CEE		
Protection:		3 x 200A	3 x 250A	3 x 320A
Housing	*Amplifier:*	on request	on request	on request
	approx. dimensions (mm):			
	Power Supply			
	approx. dimensions (mm):			
Weight	*approx. (kg)*	on request	on request	on request

TECHNICAL DATA – **PVS 1000/LV**

Nominal voltage	*DC*	+37.5V_{DC} / +75V_{DC} / +150V_{DC}
Measurement resolution (via Software)		U: 0.01V / I: 0.01A / P: 0.1W
Power DC 2) 9)	*- continuous*	1000W
Continuous Current	*UOUT = 30VDC (37.5V range) 24A_{DC} Fig. 20:*	
	U_{OUT} = 60V_{DC} (75V range) 16.7A_{DC} Fig. 21:	
	U_{OUT} = 120V_{DC} (150V range) 6.7A_{DC} Fig. 22:	
Digital instrument Measuring ranges	*Voltage range:*	150V
	Current range:	40A
	Accuracy Voltage:	± 0.05% (of value) ± 0.05% (of range)
	Accuracy Current:	± 0.1% (of value) ± 0.1% (of range)
Power Supply *(±10%, 50Hz 60Hz)*		230V Schuko
Protection:		16A
Housing	*Amplifier incl. Power supply:*	19”, 4U
	approx. dimensions (mm):	178x483x700
Weight	*Amplifier (approx.)*	55kg

„We can make weather“

www.spitzenberger.de/weblink/1251

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