Photovoltaic Simulators
PVS series
PVS 1000/LV

The High Speed Simulators

The relating standards:
IEC/EN 50530
IEC/EN 62116
VDE 0126-2
IEEE 1547

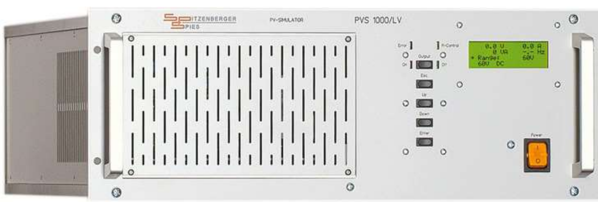


Fig. 1: PVS 1000/LV

- ✓ 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_{DC}) and low-voltage version (up to 150V_{DC}) for micro inverter testing

Fig. 2: PVS 25000

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 also 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.
For the IEC/EN 50530 and the specified MPP tracking algorithm this fast response time is absolutely necessary.

See Spitzenberger & Spies Application note under: 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:

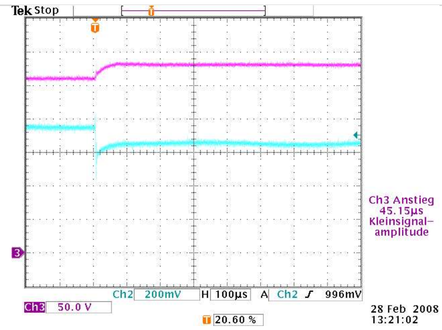


Fig. 3: Rise-time Voltage / Current

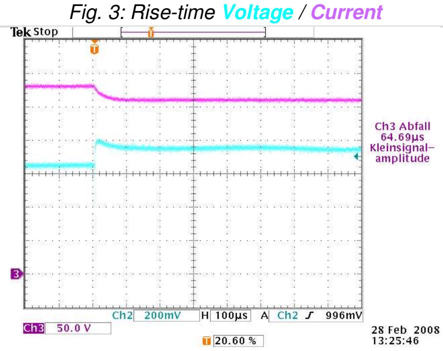


Fig. 4: Fall-time Voltage / Current

Load between open circuit and MPP:

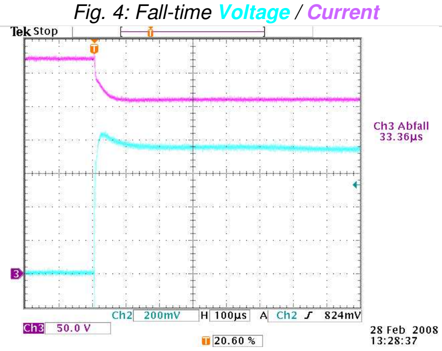


Fig. 5: Fall-time Voltage / Current

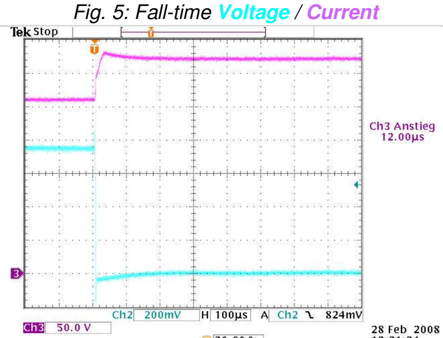


Fig. 6: Rise-time Voltage / Current

100HZ RIPPLE / FREE PROGRAMMABLE CURVES

100Hz Ripple

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

"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)"

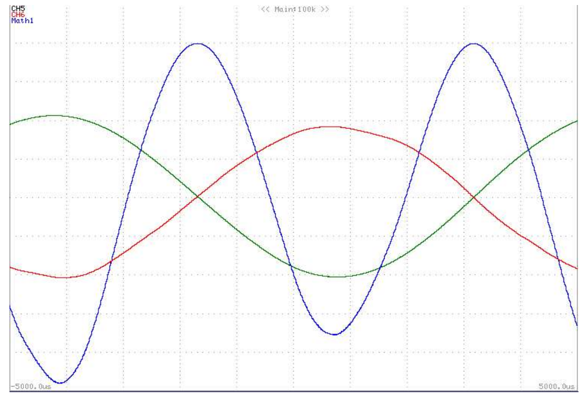


Fig. 7: 100Hz ripple of voltage and current - **voltage**, **current**, **power**

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.

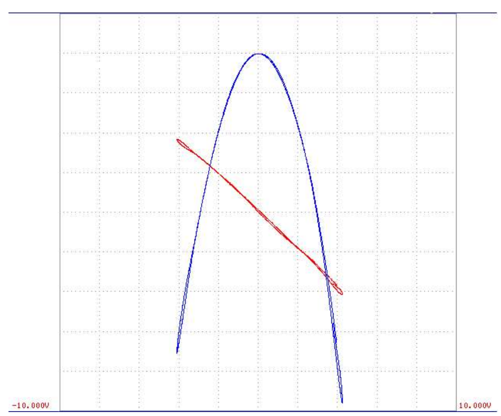


Fig. 8: XY-view: no hysteresis observably - **current**, **power**

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

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.

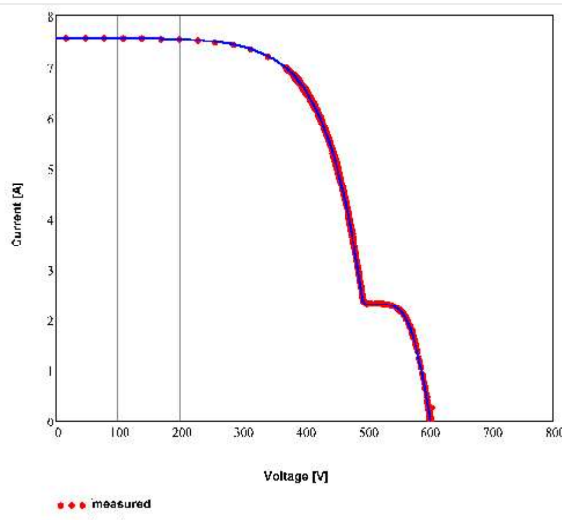


Fig. 9: free programmable I/V curves

SIMULATION OF DYNAMIC IRRADIATION

Irradiation

The intensity 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, when the sun is shadowed within seconds and cleared some minutes later and again shadowed.

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

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

The specified curves are met exactly during the complete measurement duration.

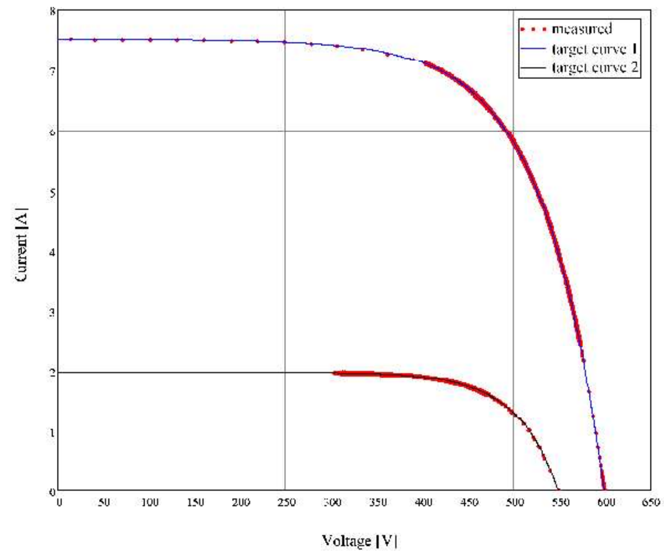


Fig. 10: various I/V curves

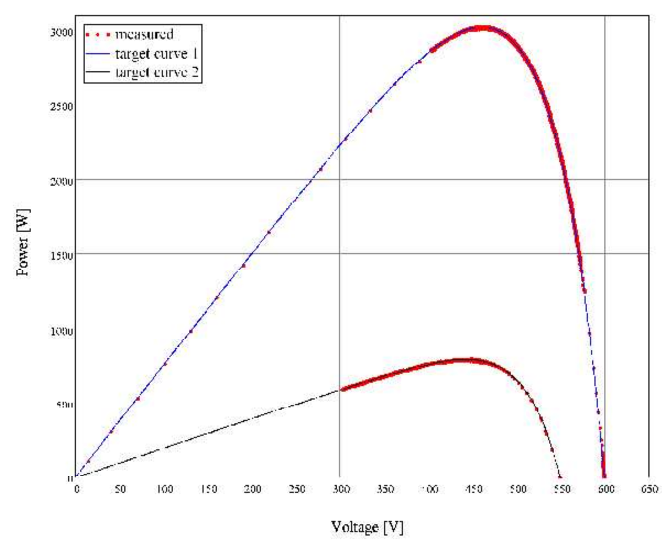


Fig. 11: various V/P curves

VOLTAGE RANGES – CURRENT CHARACTERISTICS

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

- 400V
- 500V
- 600V
- 800V
- 950V

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)*

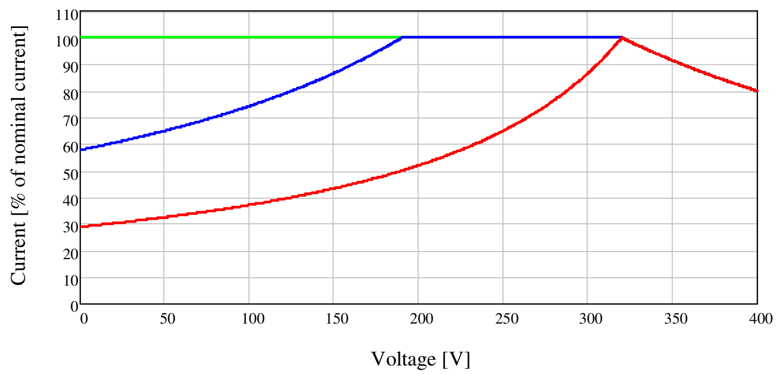


Fig. 12: current performance of the PVS in the 400V range

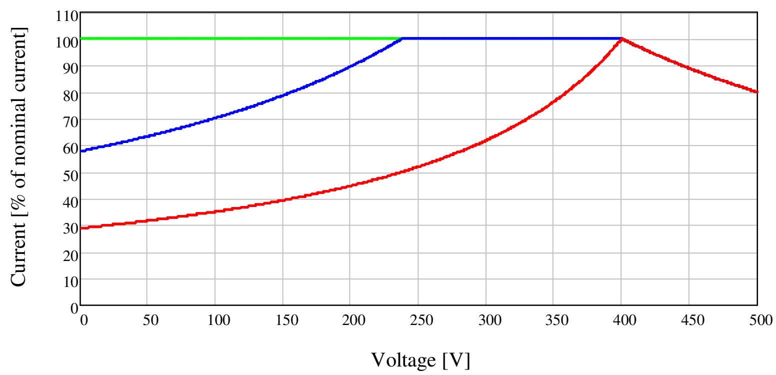


Fig. 13: current performance of the PVS in the 500V range

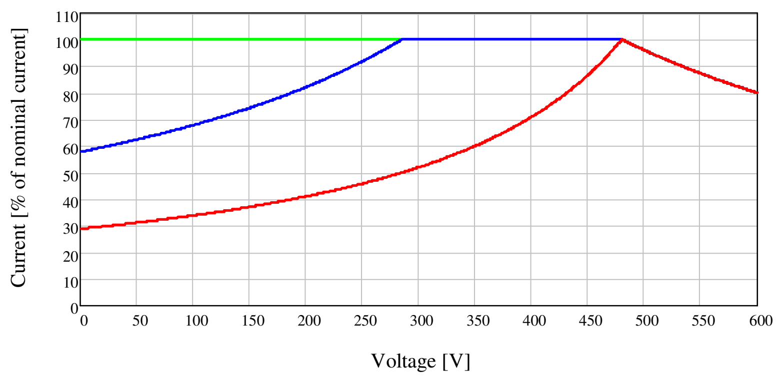


Fig. 14: current performance of the PVS in the 600V range

Fig. 17: PVS / Basic EMC System

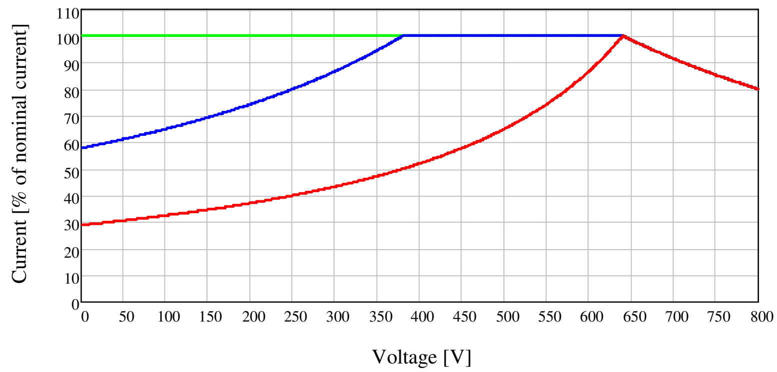


Fig. 15: current performance of the PVS in the 800V range

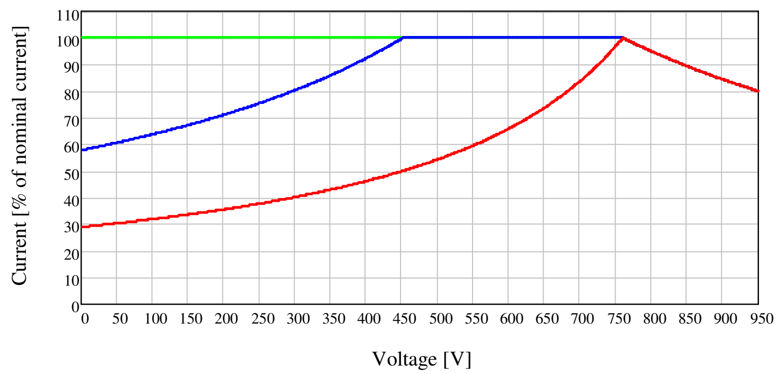


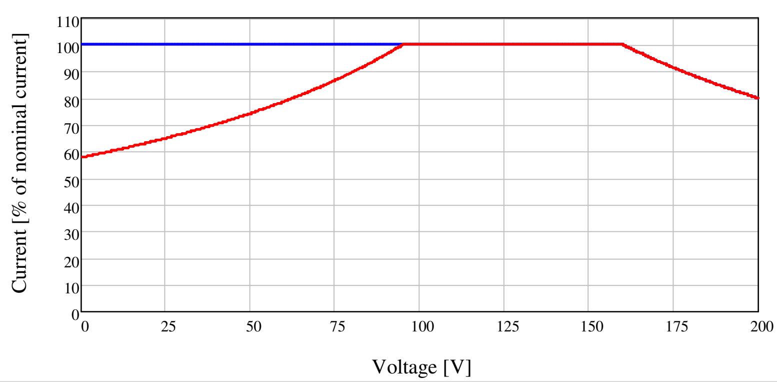
Fig. 16: current performance of the PVS in the 950V range

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. 18:
Optional voltage range 200V
Current performance



TECHNICAL DATA – GENERAL

		PVS Series
Nominal voltage	*DC:*	$+400V_{DC}$ / $+500V_{DC}$ / $+600V_{DC}$ / $+800V_{DC}$ / $+950V_{DC}$
Voltage accuracy:		0,2% / 0,5% (typ. / max.) upper range value
Current accuracy:		0,2% / 0,5% (typ. / max.) upper range value
Slew rate:		< 250µs / typical < 100µs
Protection circuits:		Overload / Short Circuit / Over temperature
Interface:		IEEE488
Measurement (via Software)	*Voltage:*	0.1V resolution
	Current:	0.01A resolution
	Power:	1W resolution
Memory capacity for I/V curves:		up to 1024 curves
Ambient temperature:		0°C up to 40°C

Options		
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*
6) *max. / typ. (of measured value ±2 digit)*

TECHNICAL DATA – TYPE SPECIFIC

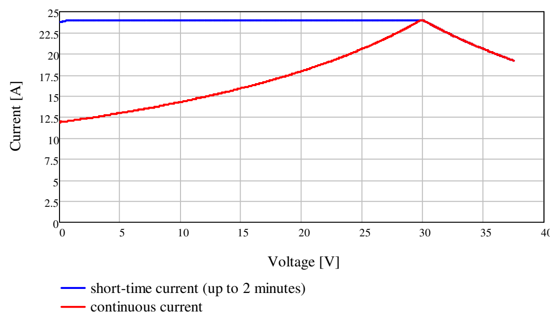
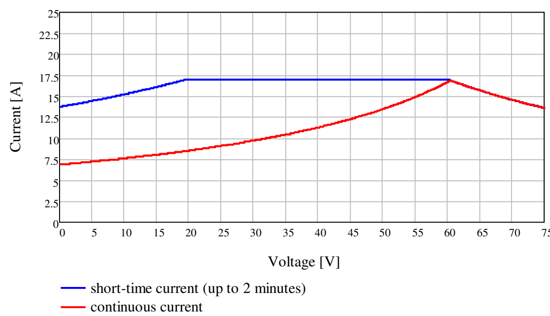
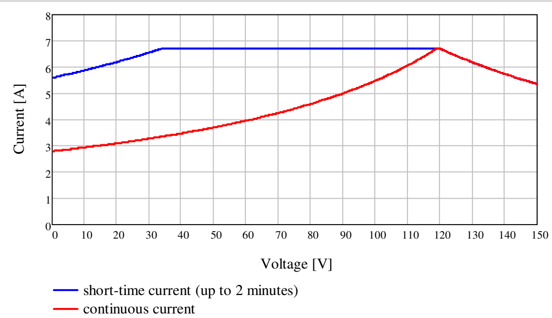
		PVS 1000	PVS 3000	PVS 7000
Power DC [1) 5)]	*- continuous:*	1000W	3000W	7000W
Continuous Current	*U_{OUT} = $320V_{DC}$:*	$3.2A_{DC}$	$9.4A_{DC}$	$22A_{DC}$
	U_{OUT} = $400V_{DC}$:	$2.5A_{DC}$	$7.5A_{DC}$	$17.5A_{DC}$
	U_{OUT} = $480V_{DC}$:	$2.1A_{DC}$	$6.3A_{DC}$	$14A_{DC}$
	U_{OUT} = $640V_{DC}$:	$1.6A_{DC}$	$4.7A_{DC}$	$11A_{DC}$
	U_{OUT} = $760V_{DC}$:	$1.3A_{DC}$	$4A_{DC}$	$9.25A_{DC}$
Digital instrument Measuring ranges	*Voltage range:*	1000V		
	Current range:	5A	12A	25A
	Accuracy Voltage[6]:	0,5% / 0,2%		
	Accuracy Current[6)]:	0,8% / 0,4%		
Power Supply *(±10%, 50Hz 60Hz)*		230V	230V/400V	
Protection:		16A	3 x 16A	3 x 20A
Contactor type:		Schuko	CEE	
Housing	*Amplifier:*	19”, 7U	19”, 5U	19”,7U
	approx. dimensions (mm):	311x483x600	222x483x600	311x483x600
	Power Supply	included	19”, 5U	19” 5U
	approx. dimensions (mm):	-	222x483x600	222x483x600
Weight	*Amplifier (approx.)*	50kg	30kg	45kg
	Power Supply (approx.)	-	85kg	100kg

		PVS 10000	PVS 15000	PVS 25000
Power DC [1) 5)]	*- continuous:*	10000W	15000W	25000W
Continuous Current	*U_{OUT} = $320V_{DC}$:*	$31A_{DC}$	$50A_{DC}$	$80A_{DC}$
	U_{OUT} = $400V_{DC}$:	$25A_{DC}$	$38A_{DC}$	$63A_{DC}$
	U_{OUT} = $480V_{DC}$:	$21A_{DC}$	$32A_{DC}$	$53A_{DC}$
	U_{OUT} = $640V_{DC}$:	$16A_{DC}$	$25A_{DC}$	$40A_{DC}$
	U_{OUT} = $760V_{DC}$:	$13.25A_{DC}$	$21A_{DC}$	$33A_{DC}$
Digital instrument Measuring ranges	*Voltage range:*	1000V		
	Current range:	40A	60A	100A
	Accuracy Voltage[6]:	0,5% / 0,2%		
	Accuracy Current[6)]:	0,8% / 0,4%		
Power Supply *(±10%, 50Hz 60Hz)*		230V/400V		
Protection:		3 x 40A	3 x 50A	3 x 63A
Contactor type:		CEE		
Housing	*Amplifier:*	19”, 10U	19” 17U	19”, 23U
	approx. dimensions (mm):	444x483x600	755x483x600	1022x483x600
	Power Supply	19”, 10U	19”, 12U	19”, 12U
	approx. dimensions (mm):	444x483x600	533x483x600	533x483x600
Weight	*Amplifier (approx.)*	60kg	80kg	120kg
	Power Supply (approx.)	220kg	240kg	250kg

		PVS 32500	PVS 42500	PVS 50000
Power DC [1) 5)]	*- continuous:*	32500W	42500W	50000W
Continuous Current	*U_{OUT} = 320V_{DC}:*	100A_{DC}	135A_{DC}	157A_{DC}
	U_{OUT} = 400V_{DC}:	82A_{DC}	108A_{DC}	125A_{DC}
	U_{OUT} = 480V_{DC}:	68A_{DC}	90A_{DC}	105A_{DC}
	U_{OUT} = 640V_{DC}:	51A_{DC}	67A_{DC}	79A_{DC}
	U_{OUT} = 760V_{DC}:	43A_{DC}	56A_{DC}	66A_{DC}
Digital instrument Measuring ranges	*Voltage range:*	1000V		
	Current range:	120A	150A	180A
	Accuracy Voltage[6]:	0,5% / 0,2%		
	Accuracy Current[6)]:	0,8% / 0,4%		
Power Supply *(±10%, 50Hz 60Hz)*		230V/400V		
Protection:		3 x 100A	3 x 125A	3 x 160A
Contactor type:		CEE		
Housing	*Amplifier:*	19", 33U	19", 39U	19",46U
	approx. dimensions (mm):	1467x483x600	1733x483x600	2042x483x600
	Power Supply	19", 2x12U	19", 39U	19",46U
	approx. dimensions (mm):	1066x483x600	1733x483x600	2042x483x600
Weight	*Amplifier (approx.)*	160kg	200kg	300kg
	Power Supply (approx.)	2 x 250kg	2 x 250kg	800kg

		PVS 65000	PVS 85000	PVS 100000
		= 2 x PVS 32500	*= 2 x PVS 42500*	*= 2 x PVS 50000*
		External parallel connection		
Power DC [1) 5)]	*- continuous:*	65000W	85000W	100000W
Continuous Current	*U_{OUT} = 320V_{DC}:*	200A_{DC}	270A_{DC}	314A_{DC}
	U_{OUT} = 400V_{DC}:	164A_{DC}	216A_{DC}	250A_{DC}
	U_{OUT} = 480V_{DC}:	136A_{DC}	180A_{DC}	210A_{DC}
	U_{OUT} = 640V_{DC}:	102A_{DC}	135A_{DC}	158A_{DC}
	U_{OUT} = 760V_{DC}:	86A_{DC}	112A_{DC}	132A_{DC}
Digital instrument Measuring ranges	*Voltage range:*	1000V		
	Current range:	2x120A	2x150A	2x160A
	Accuracy Voltage[6]:	0,5% / 0,2%		
	Accuracy Current[6)]:	0,8% / 0,4%		
Power Supply *(±10%, 50Hz 60Hz)*		230V/400V		
Protection:		3 x 200A	3 x 250A	3 x 320A
Contactor type:				
Housing	*Amplifier:*	19", 2x33U	19", 2x39U	19", 2x46U
	approx. dimensions (mm):	1467x483x600	1733x483x600	2044x483x600
	Power Supply	19", 42U	19", 42U	19", 46U
	approx. dimensions (mm):	1867x483x800	1867x483x800	2044x483x600
Weight	*Amplifier (approx.)*	2x160kg	2x200kg	2x300kg
	Power Supply (approx.)	1000kg	1200kg	1500kg

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* *$24A_{DC}$* *Fig. 19:*	
	U_{OUT} = $60V_{DC}$ *$16.7A_{DC}$* *Fig. 20 :*	
	U_{OUT} = $120V_{DC}$ *$6.7A_{DC}$* *Fig. 21:*	
Digital instrument Measuring ranges	*Voltage range:*	150V
	Current range:	40A
	Accuracy Voltage [6)]:	0,5% / 0,2%
	Accuracy Current [6)]:	0,8% / 0,4%
Power Supply *(±10%, 50Hz 60Hz)*		230V
Protection / Contactor type:		16A / Schuko
Housing	*Amplifier incl. Power supply:*	19", 4U
	approx. dimensions (mm):	178x483x700
Weight	*Amplifier (approx.)*	55kg

„We can make weather"

„We can make weather“

THE HIGH-LEVEL PHOTOVOLTAIC SIMULATOR PVS FROM' SPITZENBERGER & SPIES

The relating standards:
IEC/EN 50530
IEC/EN 62116
VDE 0126-2
IEEE 1547
and many manufacturers test specifications

The amount of generated energy of a solar panel field (and therefore the profitable efficiency) is mainly depending on varying weather conditions like cloudiness and adverse weather situations. To achieve the maximum energy rate at heavy varying irradiation modern intelligent solar inverters are used.

OVERALL EFFICIENCY OF SOLAR INVERTERS

The overall efficiency of solar inverters is tested according to IEC/EN 50530.
Compliant testing requires powerful voltage and current sources and analyzer units operating in excellent harmony.

The testing of modern solar inverters requires three main functions of the testing equipment:

1. *Simulation of solar panels for testing solar inverters according to IEC/EN 50530*
2. *Generation of typical loads for the anti-islanding tests according to IEC/EN 62116*
3. *Simulation of the connected grid*

Grid-connected photovoltaic systems are feeding the generated energy into the power distribution grid network. The amount of power fed into the grid defines the profitability of the whole solar site. The IEC/EN 50530 describes in detail the necessary calculation formulas and testing routines to evaluate the overall efficiency of solar inverters.
Solar inverters must be designed to be able to deal with many different operating conditions. Intensive testing during the development process of inverters as well as during their production is requested.

As a good strategy for a complete test of solar inverters three main tasks have to be carried out:

- simulation of a solar generator and operating the inverter in the MPP (maximum power point), testing of the MPP tracking function, evaluation and calculation of the overall efficiency
- simulation of varying load conditions and different disturbances like transients, harmonics, ripple, cosΦ etc.
- simulation of the connection to the public grid during normal operating conditions as well as during irregular conditions like voltage interruptions, variations and drops

Testing of solar inverters:
- *simulation of the energy generation*
- *MPP tracking testing*
- *simulation of different loads*
- *simulation of electric disturbances*
- *simulation of the public grid connection*

SIMULATION OF THE ENERGY GENERATION:

The generated energy of a solar site is varying in dependency of the intensity of the solar irradiation, partly cloudiness or shading as well as the ambient temperature and pollution of the panel surface. The conversion of the panel-power through the solar inverter should be carried out in the maximum power point(MPP).
To convert always the maximum available energy generated by the solar panels many inverters use a MPP tracking algorithm. This algorithm changes the load condition of the inverter so that the panel field always sees an ideal load and can transfer the maximum available energy.

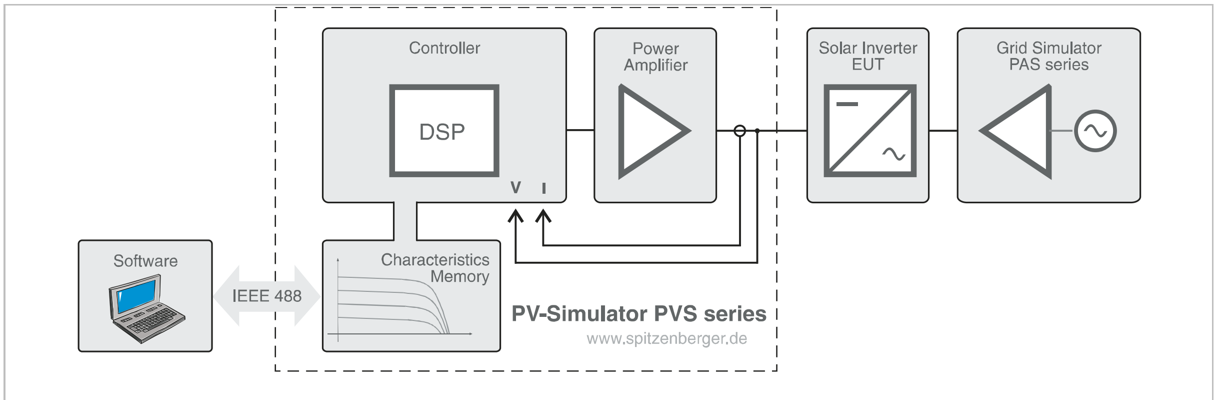


Fig. 1: Function diagram Spitzenberger & Spies PV-Simulator series PVS

The Photovoltaic-Simulator series **PVS** from Spitzenberger & Spies is **the perfect designed DC Source** to reproduce the I/V characteristic curves as required according to **IEC/EN 50530**.
With the PVS solar panels with different technologies can be simulated (e.g. mono-crystalline or poly-crystalline). The provided software package SPS_PVS offers an easy calculation of the necessary I/V characteristic (according to 1- or- 2-diode model). In addition, externally measured and stored characteristics can be imported if they have a CSV-Format.

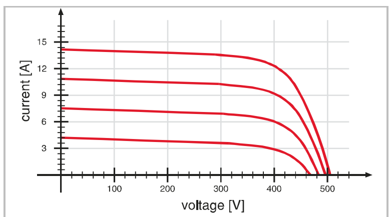


Fig. 2: Different I/V characteristics

The sequence of different characteristics, their duration and transition time is free adjustable. Complete test cycles can be set up easily. The evaluation of measured date ca be done graphically as well as in a numeric format. The evaluation can be stored for documentation.

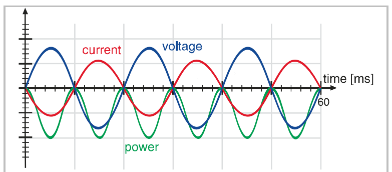


Fig. 3: Phase relation at Ripple

Many (single-phase) inverters are generating a type depending AC ripple on their DC input. The power fed into the grid has a pulse frequency of double the mains frequency (100Hz in Europe).
The inverter consumed power is fluctuating therefore with the same frequency (100Hz in Europe) and produces the described ripple. This ripple is very close to reality conditions, if the dynamic response of the PV simulator is very high.

It is very important, that the simulator power supply is not suppressing this ripple as a result of the voltage adjustment. More and more inverters use the amplitude and phase shift of the ripple voltage and current to achieve a very fast MPP tracking.
This method is much faster than the conventional method “disturb and perturbate”.
Especially at cloudy weather conditions, where the solar irradiation is changing rapidly, a fast MPP tracking algorithm gives a much higher overall efficiency. The number of inverters using this ripple-based MPP algorithm will increase steadily.
PV simulators have to have the ability, to reproduce the according current/voltage characteristic curves at ripple condition very precisely.

For a very precise simulation of the current-/voltage- characteristic a very fast response time of the PV simulator is essential.

While switch-mode amplifiers as the simulator source have a response time of typically 2-3ms, linear working transistor amplifiers have a response time in µs area.
When the PV simulators response time is too slow, the I/V-operating points are no longer located on the I/V-characteristic curve, they circle around the desired MPP area on the characteristic curve *(See application note “Necessity for high-speed PV simulators”)*.
A correct testing and evaluation of the solar inverter compliant to the IEC/EN 50530 is not possible with switch-mode amplifiers.

Above and beyond the IEC/EN 50530 the Spitzenberger & Spies software package offers the possibility to store panel values of solar irradiation and temperature variation in the course of the day.
External data values can be imported, if they have CSV-Format.

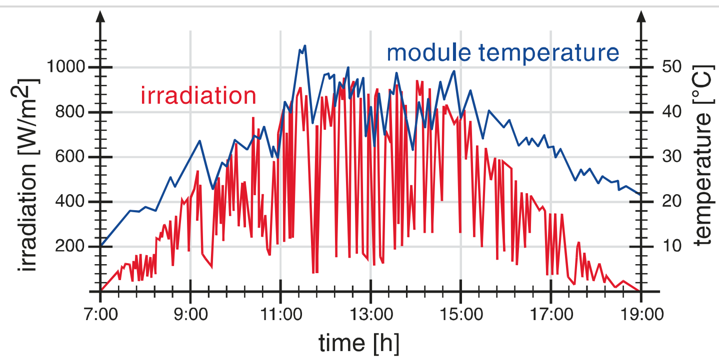


Fig. 4: Daily variation of irradiation intensity and temperature of the solar panel

The long term behavior of solar inverters can be tested with this functionality. Measured data from all locations of the earth can be simulated in laboratory.

„Solar generators and islanding“

A danger for human and machine

The relating standards:
IEC/EN 50530
IEC/EN 62116
VDE 0126-2
IEEE 1547
and many manufacturers test specifications

During normal operation the solar inverter supplies the load which is regularly supplied by the public network. Depending on the amount of generated energy either the solar inverter delivers energy into the public network or the public network delivers energy to the connected loads.
During all operating modes each connected component must comply to the specifications stated in IEEE1547. To test solar inverters in a suitable way the connection between inverter and public network shall be simulated.
A desired simulator like the PVS Series from Spitzenberger & Spies must be able to generate irregular interconnection situations and conditions for testing the inverters according to realistic conditions and to verify their conformity.

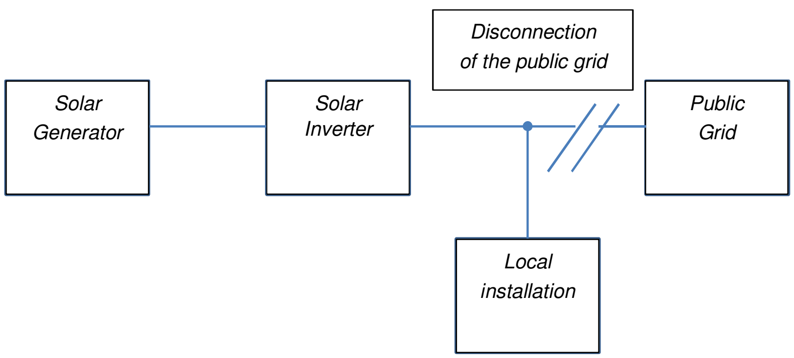


Fig. 1: Schematic diagram of islanding

One of the possible problems is a disturbance or interruption of the connection between the public grid and the connected solar inverter.

This heavy disturbance is called „Islanding“.

Islanding is a situation when the connection to the public network is interrupted or the public network has been switched off. Interaction between the local generators and the connected loads causes then the islanding effect and affects the solar inverter a running public grid.

The main problems during islanding are:

1. The public power distributors can no longer control and influence voltage and frequency in the distribution network. Inside the islanding system deviation of voltage and frequency can cause malfunction and/or damage of the local connected loads.
2. Injury of operating personnel can be caused when the public grid is cut off for maintenance. The personnel has the opinion of a voltage free network whilst the solar generator still delivers energy and is setting the local islanding grid still under voltage.

CHECKING ANTI-ISLANDING FUNCTIONS

The **IEC/EN 62116** is preventing humans and machines from injury and damage. **It defines test specifications and methods for solar inverters to check their ability to avoid the islanding effect.**

Practically each solar inverter must have an anti-islanding function which cuts off the connection between inverter and the local grid on error condition. The local grid status is set voltage free.

Testing equipment according to IEC/EN 62116

1. *Waveform recorder and power analyzer*
2. *DC source simulating a realistic photovoltaic source*
3. *AC source simulating the public grid*
4. *AC loads – combined RLC load*

The IEC/EN 62116 defines an explicit test of this anti-islanding function.
The optimal DC source for those tests is a PV simulator complying to the IEC/EN 50530.
The PV Simulator series **PVS from Spitzenberger & Spies** complies to all necessities for DC source as defined in the IEC/EN 50530 and also in the IEC/EN 62116.

SIMULATION OF THE SUPPLY NETWORK – GRID SIMULATION

For the AC voltage source for the simulation of the public grid requirements for voltage and frequency stability and harmonic distortion are defined. When using the Spitzenberger & Spies Basic EMC System as the AC voltage source all requirements can be fulfilled fully compliant.
Furthermore disturbances of the public grid as well as voltage fluctuations and frequency variations can be simulated and monitored. With this programmable source global products can be tested also (with different national voltage and frequency specifications).

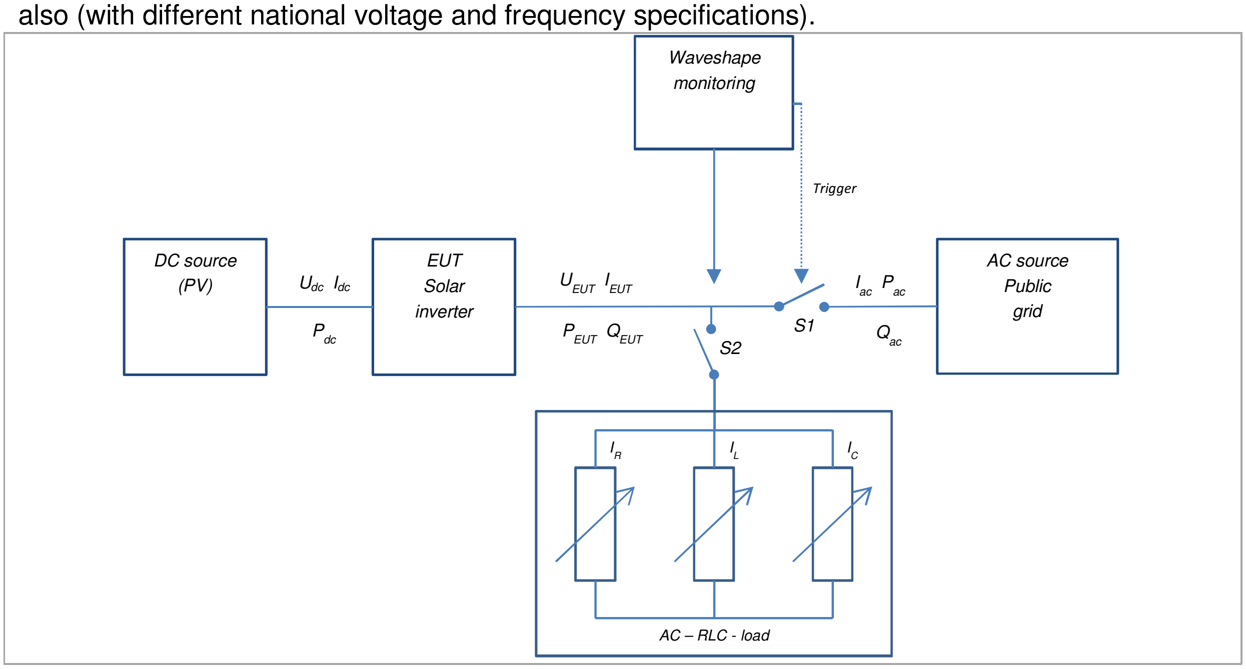


Fig. 2: Test setup for the IEC/EN 62116

RLC LOAD AS A POWER RESONANT CIRCUIT

To establish a realistic environment for this testing a typical AC load as a combination of R, L and C is defined in the standard.

The RLC load shall be adjusted according to the output power capability of the respective inverter and shall be in resonance condition at the nominal frequency.
The quality Q_f of the RLC load (calculated according to IEC/EN 62116) shall be adjusted to 1,0 +/- 0,05. When carrying out the different test procedures the RLC load has to be adjusted accordingly.

Three test conditions are defined for testing:

- *A: P_{EUT} 100%*
- *B: P_{EUT} 50%*
- *C: P_{EUT} 25%*

The three test conditions A, B and C are adjusted via changing of the EUT input voltage to 90%, 50% und 10% of the nominal voltage. As a first step the RLC load is adjusted so, that the fundamental frequency components of the active and the reactive power as well as the fundamental frequency component of the current flow through the connection switch is set to zero. The RLC load is now a parallel resonant circuit in resonance.

To start the test the connection switch to the public grid is opened.

For the test condition A the RLC load's active and reactive power have to be adjusted according to the adjacent table.

Percental change of the active load, reactive load from the nominal values		
-5,+5	*0,+5*	*+5,+5*
-5,0		*+5,0*
-5,-5	*0,-5*	*+5,-5*

Table for test condition A

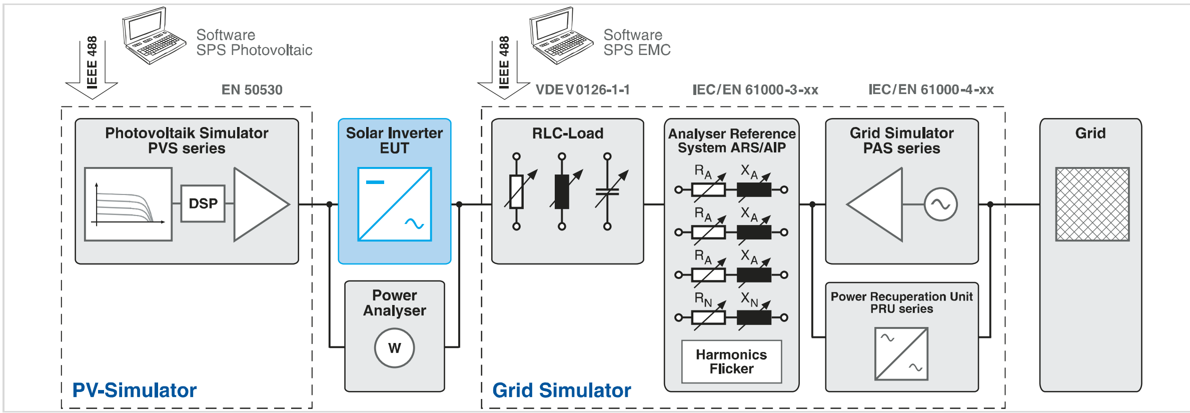
For the test conditions B and C it is enough, to adjust only the reactive load (either L or C) at a constant active load.
For the evaluation the run-on time t_R is measured, the amount of time that an unintentional island condition exists. Run-on time is defined as the interval between the opening of the switch S1 (connection to the public grid) and the cessation of the EUT output current.
For all combinations stated in the test conditions A, B and C the run-on time t_R is now measured. If the run-on time exceeds the maximum value (as stated in the according specifications of power distributors or national standards) the EUT's test failed.

Taking all the requirements for the RLC load according to IEC/EN 62116 into consideration a complex profile of necessities for the test system arises.

RLC LOAD - USEFUL EXTENSION AND OPTION OF THE TEST SYSTEM

Spitzenberger & Spies has developed an optional RLC load unit for the PV simulator series PVS. This RLC unit complies to all requirements according to IEC/EN 62116. In conjunction with complying measurement units like digital oscilloscopes and power analyzers a complete test according to IEC/EN 50530 and IEC/EN 62116 can be carried out.
A convenient software package for running the tests and for documentation completes the PVS simulator system

The following diagram shows a schematic overview of such a test system:



With a complete test system from Spitzenberger & Spies compliant testing can be done not only in photovoltaic area, it is (as the basic emc system) the best solution also for fully compliant testing according to emission (IEC/EN 61000-3-xx) and immunity (IEC/EN 61000-4-xx) standards.

MANY POSSIBILITIES FAR BEYOND THE STANDARDS

Looking at the PV simulator side, the input of the solar inverter can be supplied with arbitrary solar panel characteristics and irradiation changes from any point of the earth. The PVS simulator just has to be programmed with this data files with the Spitzenberger & Spies software. Realistic weather and panel situations from anywhere can be simulated easily in laboratory environment.

On the other hand, the solar inverter’s output is connected to the Spitzenberger & Spies Basic EMC system, a grid-simulator with arbitrary functions, which is able to simulate each local grid from any power distributor worldwide. This grid-simulator can not only simulate a stable network, it can perform also many disturbances like voltage drops and voltage variations, frequency variations, unbalances and many more, as described in the IEC/EN 61000-4 series standards.

Necessity for high speed PV Simulators

The fast response time of PV simulator is required to realistically simulate the I/V characteristic when the inverter produces a ripple on DC voltage and DC current of the PV simulator. Single phase inverters have typically a ripple with twice the grid frequency. A ripple can also occur when the MPP tracker is searching very fast on the I/V characteristic. Real solar cells have a I/V characteristic like shown in Fig. 1:

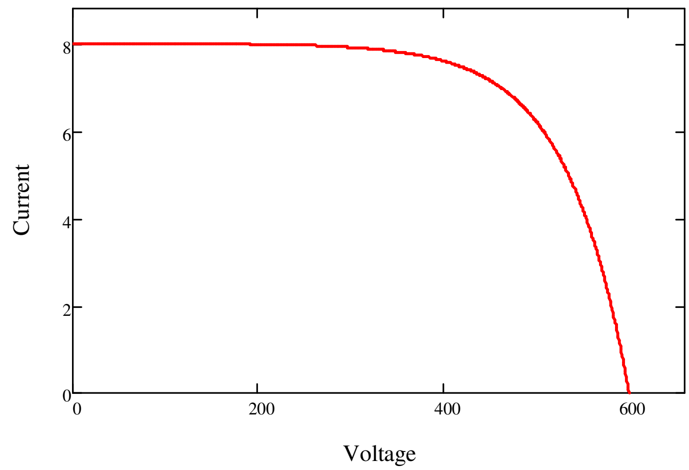


Fig. 1: Current/voltage characteristic of real solar cells

So when the voltage goes up the current goes down and vice versa. The PV simulator has to simulate this characteristic as realistically as possible. To achieve the maximum accuracy to reach the I/V characteristic the PV simulator measures voltage and current and controls its output accordingly.

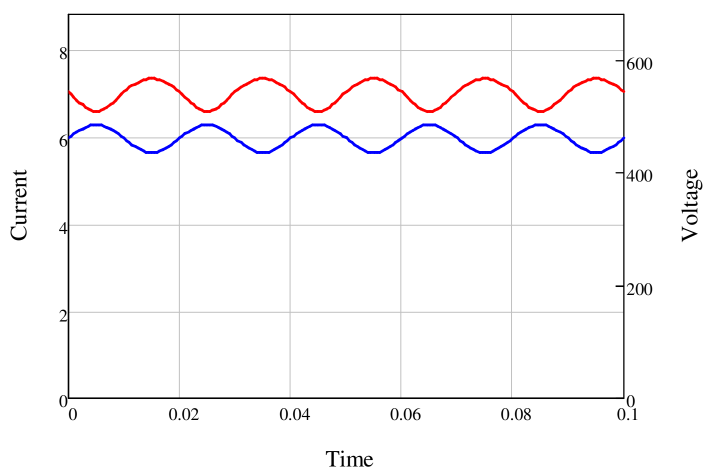


Fig. 2: Phase shift between current and voltage at ripple 50Hz

When there is an abrupt load change it takes typically 100µs with the PV simulator PVS from Spitzenberger & Spies until the output is adjusted according to the I/V characteristic. Switch mode PV Simulators need much longer time (maybe 2ms or more). For example: single phase inverters have a typical ripple with twice the grid frequency. With 50Hz mains frequency this is a 100Hz ripple.

With real solar generators as well as with the linear type PV simulator PVS from Spitzenberger & Spies the voltage and current characteristic look like the following diagram in Fig. 3:.

The operating points are lying all on the desired I/V characteristic. It is very important that the PV simulator is fast enough, to follow and to make as less additional phase shift as possible. The voltage and current ripple are inverse (current goes up => voltage goes down), so phase angle is 180 degrees.

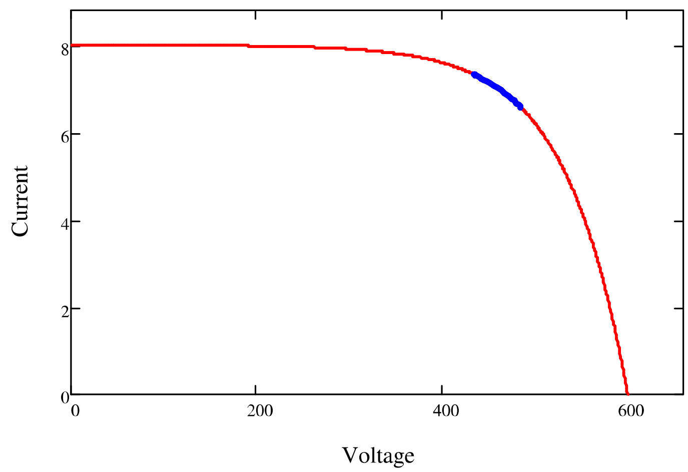


Fig. 3: Operating points (blue) when using PVS

If you take a rise time of 100µs (from 10% to 90%) and assume that the simulator acts like a first order filter,
then the time constant is calculated as:

$$T = \frac{t\_rise}{ln(9)} = 45\mu s$$

The phase shift can be calculated with the following formula:

$$\varphi = -atan(2 * \pi * f)$$

For the PVS (T=45µs) the calculation of the phase shift at 100Hz is -1.6 degrees.

For a switch mode amplifier with a rise time of e.g. 2ms the phase shift would be about 30 degrees which is too much for efficient MPP tracking measurement. When the PV simulator is too slow for the ripple produced by the inverter, the operating points are not on the I/V characteristic. The behaviour is different to the behaviour of real solar cells. Accurate MPP tracking efficiency measurements like described in IEC/EN 50530 wouldn't be possible in such a case.

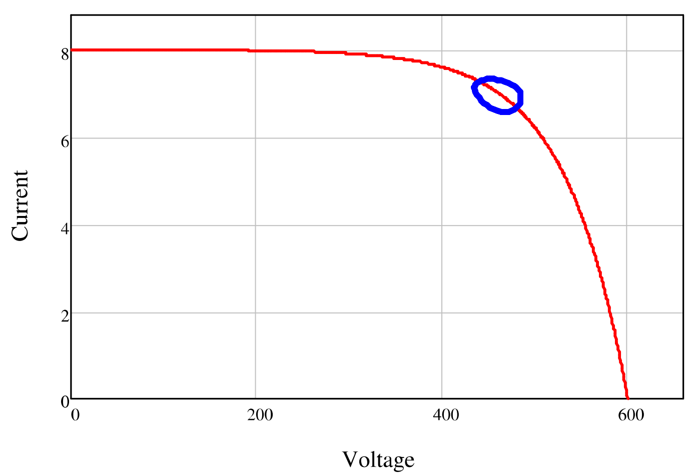


Fig. 4: Operating points (blue) when using switch-mode simulator

In IEC/EN 50530 there is the requirement:
"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)"

PAS …/GN/Kfz series of 2-/4-Quadrant Amplifiers

For 12V, 24V and new 48V

The relating standards:

ISO 7637
ISO 7637-2 Amendment 1
ISO 16750-2
ISO 21848
LV124
SAE J 1113-11
Audi BT-LAH XXX.915.181.XX
BMW GS 95002
BMW GS 95003-2
BMW GS 95024-2-2
DaimlerChrysler DO-10615
Fiat 9.90110
Ford EMC-CS-2009.1
General Motors GMW 3097
Mercedes-Benz MBN 10615
Mitsubishi ES-X82010
Nissan 28400NDS02_3
PSA B21 7110
Renault 36-00-808/--L
VW 80000
VW 80101
VW TL 82066
VW TL 82366

The 2-/4-Quadrant Amplifier type PAS GN/Kfz suits as an adjustable voltage source for the automotive supply simulation system for 12V, 24V and new 42V especially for the generation of pulse #2b and pulse #4 for all mentioned supply voltages.
The modularly constructed Automotive Supply Simulation System is a compact EMC-Test System for the execution of immunity measurements for pulse-shaped, line conducted disturbances at electronic equipment of motor vehicles. The high performance version enables tests of current-intense consumers or even complete vehicles.

- ✓ *2-/4-Quadrant Amplifiers*
- ✓ *High short-time load ability*
- ✓ *Very high slew rate*
- ✓ *Wide frequency range*
- ✓ *Very low internal resistance*
- ✓ *Common output*
- ✓ *Free programmable waveform generator*

TECHNICAL DATA

Type	PAS 1000/GN/Kfz	PAS 2500/GN/Kfz	PAS 5000/GN/Kfz
Power [1)]			
Continuous power:	900W at 60V	3000W at 60V	6000W at 60V
Short-time power:	1500W for max. 3min at 60V (duty cycle 1:9)	4800W for max 3min at 60V (duty cycle 1:9)	9600W for max. 3min at 60V (duty cycle 1:9)
Nominal Voltage:			
U_1: $0V_{DC}$ … $18V_{DC}$	I_{cont}: $28A_{DC}$ $I_{short-time}$: $44A_{DC}$	I_{cont}: $100A_{DC}$ $I_{short-time}$: $150A_{DC}$	I_{cont}: $200A_{DC}$ $I_{short-time}$: $300A_{DC}$
U_2: $0V_{DC}$ … $36V_{DC}$	I_{cont}: $22A_{DC}$ $I_{short-time}$: $44A_{DC}$	I_{cont}: $65A_{DC}$ $I_{short-time}$: $125A_{DC}$	I_{cont}: $130A_{DC}$ $I_{short-time}$: $250A_{DC}$
U_3: $0V_{DC}$ … $60V_{DC}$	I_{cont}: $15A_{DC}$ $I_{short-time}$: $25A_{DC}$	I_{cont}: $50A_{DC}$ $I_{short-time}$: $80A_{DC}$	I_{cont}: $100A_{DC}$ $I_{short-time}$: $160A_{DC}$
U_1 … U_3: $-15V_{DC}$ … $0V_{DC}$	I_{cont}: $9A_{DC}$ $I_{short-time}$: $14A_{DC}$	I_{cont}: $33A_{DC}$ $I_{short-time}$: $50A_{DC}$	I_{cont}: $66A_{DC}$ $I_{short-time}$: $100A_{DC}$
Digital instrument:			
Voltage range:		100V	
Current range:	100A	200A	400A
		Max. / Typ. (of measured value ±2 digit)	
Accuracy Voltage (DC):		0,5% / 0,2%	
Accuracy Current (DC):		0,8% / 0,4%	
Supply:			
Power Supply (±10%, 50Hz … 60Hz)	230V	230V/400V	230V/400V
Protection:	16A	16A	32A
Contactor type:	Schuko	CEE	CEE
Housing:		19"-plug-in unit, colour light grey (RAL 7035)	
Dimensions (mm): (without option pulse 5/7)	Amplifier incl. Power supply (4U) 178x483x600	Amplifier (6U): 267x483x600 Power supply (5U): 222x483x600	Amplifier (7U): 311x483x600 Power supply(12U): 533x483x600
Weight:	approx. 60kg	PAS: approx. 30kg NT: approx. 90kg	PAS: approx. 65kg NT: approx. 200kg
Dimensions (mm): (icluding option pulse 5/7)	Amplifier (6U): 267x483x600 Power supply (8U): 356x483x600	Amplifier (6U): 267x483x600 Power supply(8U): 356x483x600	Amplifier (7U): 311x483x600 Power supply (12U): 533x483x600
Weight:	PAS: approx. 30kg NT: approx. 90kg	PAS: approx. 30kg NT: approx. 90kg	PAS: approx. 65kg NT: approx. 200kg

Remarks:

1) nominal power at 230V supply voltage

Type	PAS 7500/GN/Kfz	PAS 10000/GN/Kfz	PAS 15000/GN/Kfz
Power [1)]			
Continuous power:	7500W at 60V	15000W at 60V	22500W at 60V
Short-time power:	18000W for max. 3min at 60V (duty cycle 1:9)	30000W for max. 3min at 60V (duty cycle 1:9)	45000W for max. 2min at 60V (duty cycle 1:9)
Nominal voltage:			
U_1: $0V_{DC}$ … $18V_{DC}$	I_{cont}: $300A_{DC}$ $I_{short\text{-}time}$: $600A_{DC}$	I_{cont}: $500A_{DC}$ $I_{short\text{-}time}$: $1000A_{DC}$	I_{cont}: $675A_{DC}$ $I_{short\text{-}time}$: $1350A_{DC}$
U_2: $0V_{DC}$ … $36V_{DC}$	I_{cont}: $200A_{DC}$ $I_{short\text{-}time}$: $400A_{DC}$	I_{cont}: $330A_{DC}$ $I_{short\text{-}time}$: $660A_{DC}$	I_{cont}: $500A_{DC}$ $I_{short\text{-}time}$: $1000A_{DC}$
U_3: $0V_{DC}$ … $60V_{DC}$	I_{cont}: $150A_{DC}$ $I_{short\text{-}time}$: $300A_{DC}$	I_{cont}: $250A_{DC}$ $I_{short\text{-}time}$: $500A_{DC}$	I_{cont}: $375A_{DC}$ $I_{short\text{-}time}$: $750A_{DC}$
$U_{1\ldots}U_3$: $-15V_{DC}$ … $0V_{DC}$	I_{cont}: $100A_{DC}$ $I_{short\text{-}time}$: $200A_{DC}$	I_{cont}: $160A_{DC}$ $I_{short\text{-}time}$: $320A_{DC}$	I_{cont}: $240A_{DC}$ $I_{short\text{-}time}$: $480A_{DC}$
Digital instrument:			
Voltage range:	100V		
Current range:	500A	1000A	1500A
	Max. / Typ. (of measured value ±2 digit)		
Accuracy Voltage (DC):	0,5% / 0,2%		
Accuracy Current (DC):	0,8% / 0,4%		
Supply:			
Power Supply (±10%, 50Hz … 60Hz)	230V/400V	230V/400V	230V/400V
Protection:	32A	32A	63A
Contactor type:	CEE	CEE	CEE
Housing:			
Dimensions (mm): (without option pulse 5/7)	Amplifier (10U): 444x483x600 Power supply(12U): 533x483x600	Amplifier (7U): 311x483x600 Power supply(12U): 533x483x600	Amplifier (23U): 1022x483x600 Power supply(37U): 1643x483x600
Weight:	PAS: approx. 75kg NT: approx. 250kg	PAS: approx. 65kg NT: approx. 200kg	PAS: approx. 65kg NT: approx. 200kg
Dimensions (mm): (icluding option pulse 5/7)	Amplifier (7U): 311x483x600 Power supply (12U): 533x483x600	Amplifier (7U): 311x483x600 Power supply (12U): 533x483x600	Amplifier (7U): 311x483x600 Power supply (12U): 533x483x600
Weight:	PAS: approx. 65kg NT: approx. 200kg	PAS: approx. 65kg NT: approx. 200kg	PAS: approx. 65kg NT: approx. 200kg

Remarks:

1) nominal power at 230V supply voltage

Type	All PAS xxx/GN/Kfz
Voltage adjustment:	depending on oscillator used
Load regulation: *0 … nominal load*	max. 2%, typ. <1%
Gain stability:	10min: <0.2% at constant load and temperature 8h: <0.5% at constant load and temperature
Line regulation:	$<1.5x10^{-4}$ per 10V line-voltage change
Frequency range at AC superposition:	DC … 50kHz small signal bandwidth 8Vpp DC … 100kHz small signal bandwidth 4Vpp
Rise time (at load=10Ω):	<10µs
Slew rate:	U_1 : >1V/µs U_2 : >2V/µs U_3 : >3V/µs
Protection circuits:	Overload / Short circuit / Overtemperature
Input:	
Input voltage: *(for max. output voltage)*	$\pm 5V_p$
Input impedance:	approx. 8kΩ
Interface (optional):	IEEE488
Ambient temperature:	0°C up to +40°C

Options:	
Option 06:	Output voltage monitor
Option 07:	Output current monitor
Option 10:	Internal resistance compensation
Option 11:	Special voltage ranges
Option 17-300:	Floating output Max. voltage between earth and ground of the output of the amplifier:$300V_{rms}$
Option 18:	Special line voltages (110V … 300V)
Option pulse 5:	$U_{test\ pulse}$ 5 $_{(short-time)}$: max. $200V_{DC}$ R_i:0.5 Ω … 8Ω
Option pulse 7:	$U_{test\ pulse}$ 7 $_{(short-time)}$: max. $-80V_{DC}$ R_i:10Ω
Option OPD:	
Option Car Tester:	
Option Load Dump Generator:	

Pulse Generator
type CAR – TESTER

The relating standards:
ISO 7637
Test pulse 1
Test pulse 2
Test pulse 3

EMC-Test Equipment
for electrical installation of vehicles :
Test pulses according to
DIN/ISO 7637

Pulse	Waveform
#1	1/2000µs, 600V
	3/1000µs, 600V
	3/2000µs, 600V
#2a	1/50µs, 600V
	Ri = 2Ω/4Ω/10Ω/ 20Ω/50Ω/90Ω/
#3	5/150ns, 800V
	Ri = 50Ω

Three different types are available:

CAR-TESTER I
35 A_{DC}= continuous mode
50 A_{DC} short time, duty cycle 5%

CAR-TESTER II
100 A_{DC}= continuous mode
150 A_{DC} short time, duty cycle 5%

CAR-TESTER III
200 A_{DC}= continuous mode
360 A_{DC} short time, duty cycle 5%

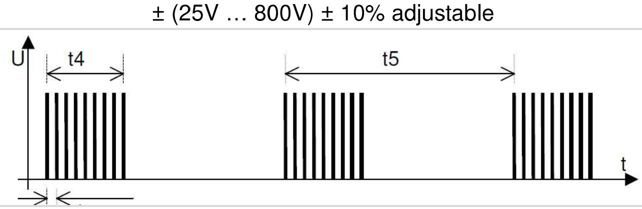
The CAR-TESTER is an EMC test system designed for testing the electromagnetic immunity of the electrical installation of vehicles and components against supply line transients. It includes a set of pulse generators which supply the test pulses listed above, a triggerable power switch (to isolate the DC supply when testing with negative pulses) and the artificial network. A fast voltage probe, ratio 100:1, for capturing transient waveforms is also included.
CAR-TESTER features a microprocessor controlled user interface and display unit for ease of use. The microprocessor allows the user to either execute standard test routines, or a ´user defined´ test sequence. The test parameters, which are shown on the built-in display, are easily adjusted by means of the rotary encoder. A standard parallel interface provides the ability to print a summary of the test parameters whilst testing is being carried out.
As well as manual control, the CAR-TESTER and all additional modules may be remotely controlled by a fibre optic computer interface. Software packages for generator control, documentation & test result evaluation are available.
The CAR-TESTER impresses by its compact design, simple handling and precise reproducibility of test impulses. High-voltage switching is accomplished by means of maintenance-free semiconductor switches.

TECHNICAL DATA CAR-TESTER

Control:	Microprocessor control, LCD module	8*40 characters
	Optical-interface for remote control of the generator	Built-in
	Parallel printer interface for on-line documentation	25-way ´D´ connector
	External trigger input	10V at 1kΩ
	Diagnostic input for monitoring of the test device	4 channels, 5V-Level
	Connector for external safety interlock loop	$24V_{DC}$
	Connector for external red and green warning lamps according to VDE 0104	230V, 60W
	Mains power	230V, 50Hz/60Hz
Housing:	Plug in unit, 7U	
	Dimensions (mm): W * H * D	483x311x520
	Weight	45kg

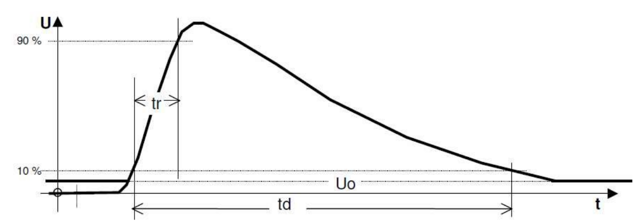
	CAR Tester I	**CAR Tester II**	**CAR Tester III**
Power supply switch:			
Max. Output current:			
Continuous mode	$35A_{DC}$	$100A_{DC}$	$200A_{DC}$
Short time, duty cycle 5%	$50\ A_{DC}$	$150\ A_{DC}$	$360\ A_{DC}$
Max. Reverse voltage	800V		
Trigger-input	Built-in *(connectable to external modules)*		
Artificial Network:			
Nominal operating voltage	0V … 56V		
Series inductance	5µH, $35A_{DC}$	5µH, $100A_{DC}$	5µH, $200A_{DC}$
Load impedance	0.1µF + 50Ω		
Load resistor R_s, switchable	10Ω, 20Ω, 40Ω		
Connector for external load resistor, 2Ω	Built-in		
Measurement probe:	Transient immunity test:		
Impulse voltage divider 4.95kΩ/50Ω	100:1, $1kV_p$		
Impulse current measuring resistor	Impulse current measuring resistor		

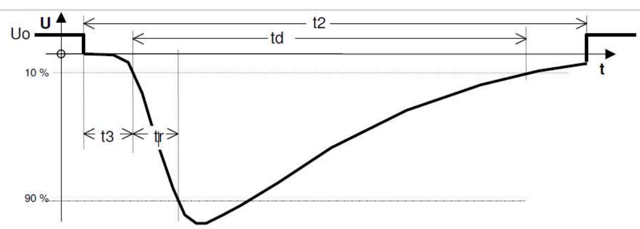
Burst:	Designed for generation of test pulses #3a / #3b according to ISO 7637-2
Amplitude of burst output voltage	± (25V … 800V) ± 10% adjustable
Waveform	

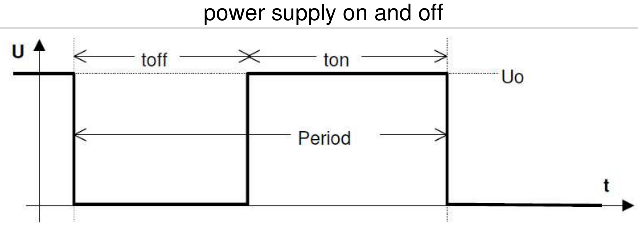


Rise time, t_r	5.0ns ± 30%
Pulse duration, t_d	150ns ± 30%
Source resistance	R_1=50Ω
Polarity	pos./neg./alt (switchable)
Pulse period t_1	1.0µs … 1.0ms adjustable
Burst duration t_4	0.1ms … 25ms adjustable
Burst period t_5	10ms … 1000ms adjustable
Max. continuous burst frequency	20kHz

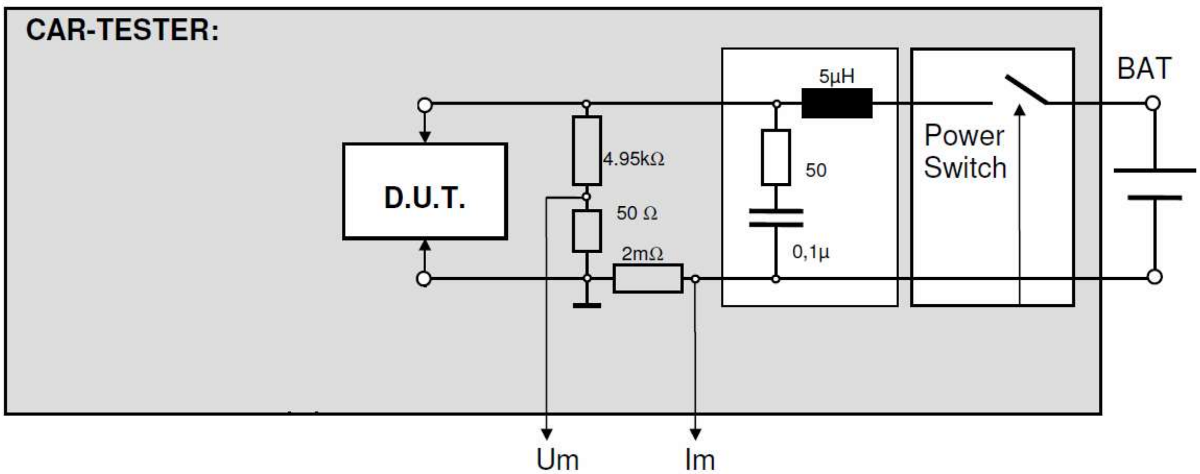
Surge	Designed for generation of test pulses #1, #2a according ISO 7637-2
Charging voltage	± (0V …600V) ± 10% adjustable
Max. stored energy	18J
Max. charging time	0.5sec … 5.0sec
Polarity	positive, negative switchable
Source resistance	2Ω, 4Ω, 10Ω, 20Ω, 50Ω or 90Ω, switchable
Only with negative pulse polarity:	
Power supply disconnection time, t_2	3 … 200ms ± 20%
Trigger delay, t_3	< 100µs

PFN 1	
Waveform 1/2000µs Pulse # 1	
Rise time, t_r 1.0µs +0µs/-0.5µs	
Pulse duration, t_d 2000µs ± 20%	
Waveform 3/2000µs or 3/1000µs Puls # 1	
Rise time, t_r 3.0µs +0µs/-1.5µs	
Pulse duration, t_d 2000µs/1000µs ± 20%	

PFN 2a	
Waveform 1/50µs Puls # 2a	
Rise time, t_r 1.0µs +0µs/-0.5µs	
Pulse duration, t_d 50µs ± 20%	

Transient Emission Test	**Power Switch Transients, according to ISO 7637-1/2**
	Measurement of voltage and current transient while switching the power supply on and off
Load resistor, switch able R_s 10Ω, 20Ω, 40Ω, ext. >2Ω	
Switch-off time, t_{off}, adjustable 1 … 1000s	
Switch-on time, t_{on}, adjustable 1 … 1000ms	
Number of Pulses, adjustable 1 … 1000	

SCHEMATIC DIAGRAM CAR-TESTER



OPTIONS:

CDN 500	Capacitive coupling clamp for capacitive coupling of BURST pulses to screened cables

µs-Switch Type EDS

Simulation of micro cut-offs and discharge of load currents in automotive supply networks

The relating standards:
LV 124 E10
LV 124 E13
Renault 36-00-808L 6.1.10
PSA B21 7110 7.1.13[2)]
Audi BT-LAH XXX.915.181.XX[4)]

The µs-Switch Type **EDS is a very fast electronic switch** combination for testing according to several automotive test standards. Originally designed for the LV124 standard, the EDS flexibility extends its use to many manufacturer specific standards.

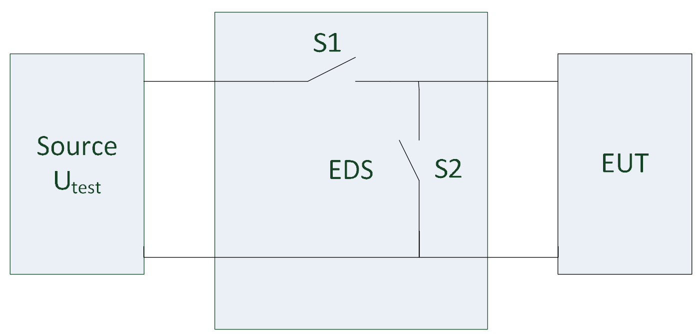


Fig. 2: Test setup according to LV124

LV124 E10: Short interruptions on supply lines – Tests according to this standard can be run in manual mode or as an automated sequence.

LV124 E13: Short interruptions on signal lines – Tests according to this standard can be run in manual mode or as an automated sequence.

Renault 36-00-808L EQ/IC 04: Resistance to power supply micro-interruptions – Tests according to this standard can be run in manual mode or as an automated sequence.

PSA B21 7110 EQ/IC 04: Resistance to short interruptions of the power supply – Test according to this standard can be run in manual mode or as an automated sequence.

Audi BT-LAH XXX.915.181.XX: Short interruptions and start-up behaviour – Tests according to this standard can be run in manual mode or as an automated sequence.

The switches have to perform a series of switching on/off the supply voltage or to switch between two voltage levels within different time periods t_1 of minimum 10µs up to 2s. The different standards define test levels and pulse and pause durations.
The ability of generating very short voltage drops with 10µs duration requires a very fast rise- and fall-time of the electronic switches. The LV124 standard specifies the rise- and fall-time t_r / t_f as 10% of the desired testing cycle t_1.

The EDS has two controlling trigger outputs, signalling the switching of the two switches S1 and S2. To perform a test, the EDS offers manual mode testing (operator controlled switching) or sequencing mode. In sequencing mode the EDS display guides through a simple test setup procedure.

An optionally available software package SPS-Automotive offers a PC based automated test solution with test modules for the according standards.

With the external trigger inputs for S1 and S2 the tests can be performed with an external control unit.

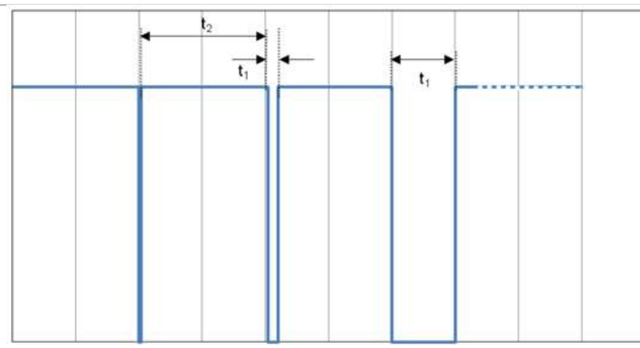


Fig. 3: Test pulses according to LV124

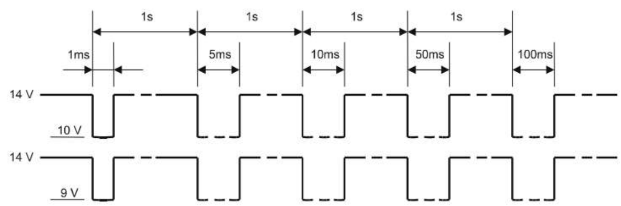


Fig. 4: Test pulses according to AUDi BT-LAH XXX.915.181.XX

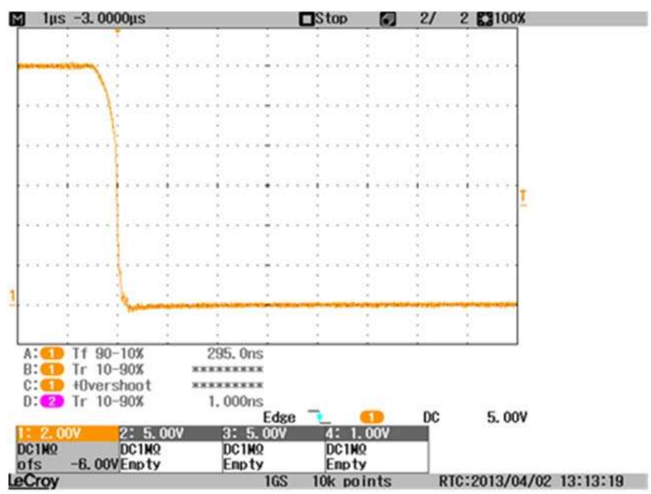
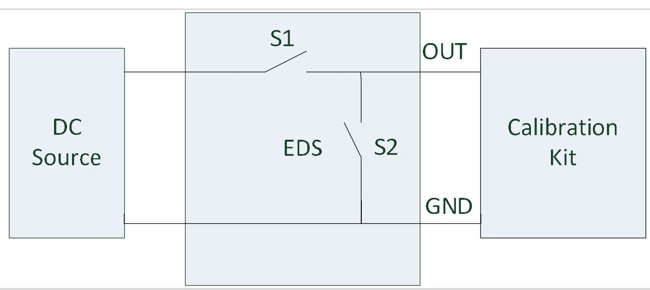


Fig. 5: fall time according to LV124

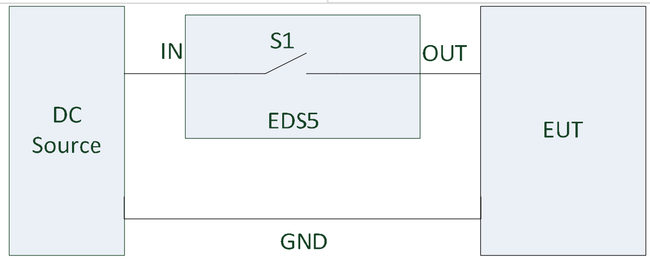
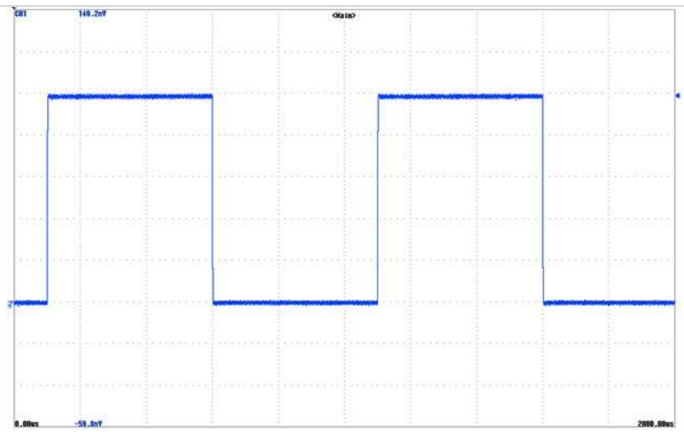
TECHNICAL DATA EDS

	EDS 100
Input:	
Input voltage:	$60V_{dc}$
External trigger input:	$5...24V_{dc}$
Output:	
Output current capability:	$100A_{dc}$
Internal Impedance:	10mΩ at nominal current
Rise time t_r / Fall time t_f @1kΩ:	<1µs / <10µs
Rise time t_r / Fall time t_f @100Ω:	<1µs / <1µs
Rise time t_r / Fall time t_f @2Ω:	<1µs / <1µs
Rise time t_r / Fall time t_f @1Ω:	<1µs / <1µs
Min. adjustable pulse width (individual operation):	2µs
Pulse width inverse operation:	5µs
Trigger output:	TTL level (+5V)
Protection circuits:	overload / short circuit / overtemperature overvoltage limitation for inductive loads[3)]
Interface:	IEEE488 / RS232
Power supply:	230V (±10%, 50Hz … 60Hz)
Protection:	2A
Contactor type:	Schuko
Ambient temperature:	0° C up to 40°C
Housing:	19“-plug-in unit; 5U
Dimensions (mm):	485x455x223
Weight:	15,5kg
Cooling:	temperature-controlled fans

Option:	**Calibration Kit LV124**
Wiring diagram calibration:	



Control:	built-in software function
Resistor types:	high precision non-inductive measurement resistors
	power capability / accuracy
1kΩ:	1 Watt / 1%
100Ω:	5 Watt / 1%
1Ω:	125 Watt / 1%
Monitoring output:	BNC Connector
Dimensions (mm):	114x64x55

Option:	**EDS 5**	**EDS 5 Data**
Wiring diagram:		
Rise-time / Fall time at 1kΩ and 2µs pulse duration	 Ch1: 20.0mV/DIV – 200µs/DIV	
Input voltage:	$60V_{dc}$	
Output:		
Output current capability:	$5A_{dc}$	$100mA_{dc}$
Rise time t_r / Fall time t_f @1kΩ:	<1µs / <1µs	
Rise time t_r / Fall time t_f @100Ω:	<1µs / <1µs	
Rise time t_r / Fall time t_f @2Ω:	<1µs / <1µs	
Rise time t_r / Fall time t_f @1Ω:	<1µs / <1µs	
Internal Impedance:	75mΩ at nominal current	
Housing:	External unit with connection cable	
Dimensions (mm):	114x89x55	
Connection cable:	CAT5 2m (included)	

Pulse Generator
type LDG

The relating standards:
ISO 7637-2
Test pulse 5
Test pulse 7

The Load Dump Generator (LDG) generates the pulses #5 according to ISO 7637-2.
These pulses may occur in the event of a discharged battery being disconnected while the alternator is generating charging current and with other loads remaining on the alternator circuit at this moment.

TECHNICAL DATA

Type	**LDG 35/I**	**LDG 100/I**	**LDG 200/I**
Application:	Generation the pulses 5 according to ISO 7637-2		
Idle output voltage:	40V … 200V		
Pulses:			
Pulse width:	40ms / 50ms / 60ms / 75ms … 400ms (resolution 25ms)		
Pulse rise time:	5 … 10ms		
Pulse accuracy: *(calibration cycle: 1 year)*	Corresponding to ISO 7637-2:2004 (calibrated at battery voltage U_B / U_A = 0V)		
Polarity:	Positive		
Max. energy:	2250J		
Repetition rate:	max. 40s		
Source resistor:	0.5Ω … 12.5Ω (resolution 0.1Ω)		
Battery supply:			
Max. voltage:	60V	60V	60V
Cont. current :	35A	100A	200A
Power supply:	230V/400V (+10% -10%, 50Hz … 60Hz)		
Protection:	6.3A		
Contactor type:	CEE-plug		
Ambient temperature:	0°C … +40°C		
Housing:	19"-plug-in unit (6U), colour light grey (RAL 7035)		
Dimensions:	approx. H=267mm; W=483mm; D=600mm		
Weight:	approx. 60kg		

OPTIONS:

Option Interfaces:	IEEE488 / RS232
Option Pulse #7	Special mains supply voltage
Option Load Dump Supressor Network type LDSN	Diode surpression network that can be adjusted via plug-in jumpers from $22V_{DC}$ to $178V_{DC}$ /Resolution: $22V_{DC}$

SPITZENBERGER SPIES

High Voltage Tester HVT 1000

The relating standards:
ISO 16750-2
ISO 21848.5

The High Voltage Tester HVT 1000 can be used for withstand voltage tests and insulation resistance tests according to ISO 16750-2 (see table below).

TECHNICAL DATA

Applications:	Withstand voltage test according to ISO 16750-2 (4.11) or ISO/CD 21848.5 (4.10) Insulation resistance test according to ISO 16750-2 (4.12) or ISO/CD 21848.5 (4.10)
Nominal voltage:	U_{AC}: 100 ... 1000V_{AC} / I_{nom}: 0.5mA_{AC} / I_{max}: 5mA_{AC} U_{DC}: 100 ... 1000V_{DC} / I_{nom}: 0.5mA_{DC} / I_{max}: 5mA_{DC}
Amplitude resolution:	100mV
Load regulation:	0 ... 0.5mA: < 3% / 0.5 … 5mA: < 25%
Frequency range:	50Hz ... 60Hz
Protection circuits:	Overload and Short circuit
Input voltage: (for max. output voltage)	5V_p
Input impedance:	approx. 10kΩ
Overcurrent detection:	
Detection level:	0.1mA … 5mA
Operating mode:	AC or DC
Action:	Switch off / visual display / acoustic warning
Low resistance detection:	
Detection level:	1MΩ ... 100MΩ
Operating mode:	DC
Action:	Switch off / visual display / acoustic warning
Interface:	IEEE488
Power supply:	230V (+6% -10%) 50Hz ... 60Hz (fuse at 2A)
Ambient temperature:	0°C … +40°C
Housing:	Sub-drawer system in 19”-plug-in-unit (3U)
Dimensions:	approx. H=135mm; W=483mm; D=450mm
Weight:	approx. 12kg

Relay Field Set

The relating standards:
ISO 16750-2
FORD CI270

The Relay Field Set can be used for short-circuit-tests of load circuits and supply-switching-tests in road vehicles.

TECHNICAL DATA

Type	**R1/8**	**R32/2**
Applications:	FORD CI270: *Immunity to Voltage Overstress* ISO 16750-2: *Open Circuits*	ISO 16750-2: *Open Circuits, Signal Circuits* Mitsubishi: *Supply Voltage Intermittent Test*
Relays:	8 per unit	2 per unit
Contacts:	1 input / 1 open contact / 1 close contact (per relay)	
DC values:	U_{max}: 42V_{DC} / I_{max}: 1A_{DC}	U_{max}: 42V_{DC} / I_{max}: 32A_{DC}
Switching time:	app. 200 … 300µs at 24V/1A	app. 500ms at 13.5V/30A
Connection:	D-SUB 25pole plug	panel-mount socket
Protection circuit:	Overcurrent	
Control switching state:	Menu or interface controlled	
Interface:	IEEE488	
Power supply:	230V (+6% -10%) 50Hz … 60Hz (fuse at 2A)	
Ambient temperature:	0°C … +40°C	
Housing:	Sub-drawer system in 19"-plug-in-unit (3U) colour light grey (RAL 7035)	
Dimensions(mm):	approx. 135x483x450	
Weight:	approx. 10kg	

Test Pulse Generator type TDG/Ford

The relating standards:
Ford CI 220
Ford CI 260

The Test Pulse Generator TDG/Ford can be used for testing the immunity against Transient Disturbances CI 220 / CI 260.

TECHNICAL DATA

Applications:	Immunity from Transient Disturbances CI 220 / A1, A2, B1, B2 Immunity to Voltage Dropout CI 260 (Random Bounce**)**
Input voltage:	12 … $14V_{DC}$
Output:	Puls CI 220 A1, A2, C Puls CI 220 B1, B2 Puls CI 260 F
Hour meter:	Count-up (100h) with reset function
Interface:	IEEE488
Power supply:	230V (+10% -10%) 50Hz … 60Hz
Protection:	2A
Ambient temperature:	0°C … +40°C
Housing:	Sub-drawer system in 19”-plug-in unit (3U) colour light grey (RAL 7035)
Dimensions:	approx. H=135mm; W=483mm; D=450mm
Weight:	approx. 15kg

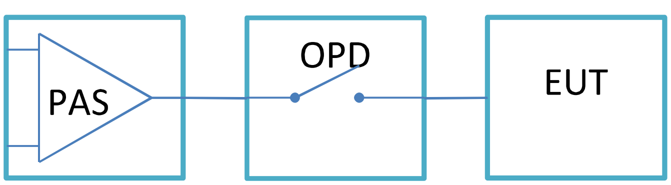
"Spitzenberger & Spies offers extra protection for expensive prototype cars"

The relating standards:
ISO 7637
ISO 16750-2
ISO 21848
BMW GS 95002
and many manufacturers test specifications

High currents require extra protection devices. Thinking about luxury and upper class automobiles, currents up to 800A for the initial motor startup are necessary. Everybody can imagine, in which dimensions a simulation system for automotive supply networks has to be.
Taking a fully equipped modern limousine as an example, many different power consuming units are on board. Motoric devices as well as high speed heating systems for front windows and lots of other appliances. All of them require immediately high currents for their desired operation.

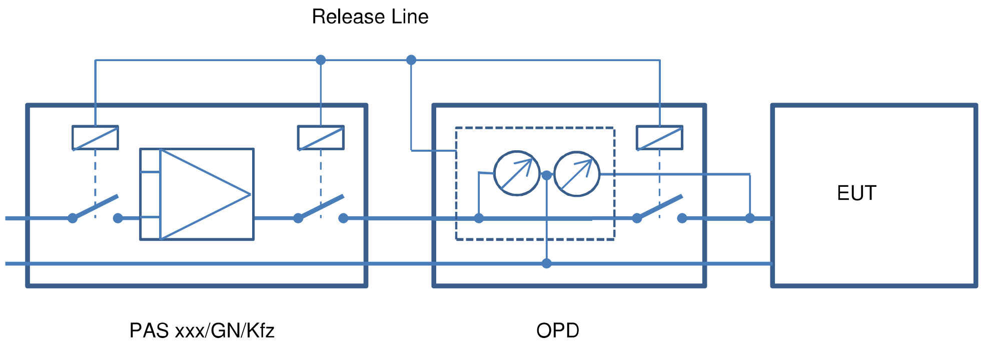
At the prototyping cycle of current cars in in-house testing facilities (according to ISO 7637 and lots of manufacturer specific test regulations) a programmable DC power supply source with a very high current capability, very short rise time (+/-), very low internal resistance and a very high peak power capability is absolutely necessary.
A well-known representative of such a voltage source is the PAS 15000 GN/Kfz, able to deliver short time currents far above 1000A. With such a simulator devices with high-energy needs can be tested also.
During any test run the protection of the (mostly expensive) prototype against overvoltage must be most important.

In any case of fault condition the supply source must be prevented from delivering power into the prototype system. If not, uncontrollable damages of the system up to burning fire can happen. Spitzenberger & Spies has developed an **overvoltage protection device OPD** suitable for the above mentioned purpose. It is offered as an optional unit for the well-proved Spitzenberger automotive supply simulator series PAS xxx GN/Kfz.



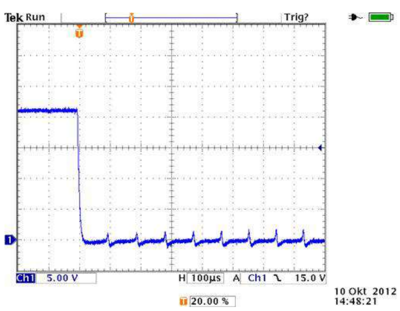
The functional principle of the OPD is a mechanical power switch with a monitoring and supervising unit. This switching unit is located between the simulator and the EUT.

To afford maximum security **the monitoring of the output voltage is set up as a redundant system**. On the one hand the output voltage is supervised directly at the EUT through external sense lines. On the other hand the current flow through the protection diodes of the supervising unit is analyzed. The OPD output is enabled only if both monitoring units evaluate “ok”.
Additionally the polarity of the output voltage is supervised.



The release line controls the cut-off switches inside the OPD and in the voltage input of the simulator

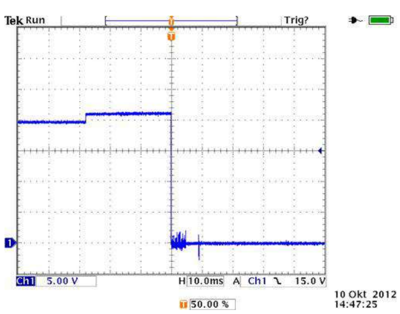
The main function of the electronic protection is to prevent the EUT from any damage until the mechanical switches have cut off the voltage. This duration is typically 20-30ms. The components inside this electronic protection must have an improved quality to withstand the voltage and power delivered to the EUT until the mechanical switches have released.



Release characteristic of the electronic protection (100µs/DIV)

Only one measured difference from the reference values is necessary to active the protection sequence.
In any case of fault the electronic monitoring unit activates immediately a multi-stage protection sequence.

Within µs an electronic protection cuts off the voltage to shield the EUT until the mechanical protection switch has released (typically 20-30 ms duration). The supply lines between EUT, OPD and the automotive supply simulator are disconnected, the whole system is de-energized.



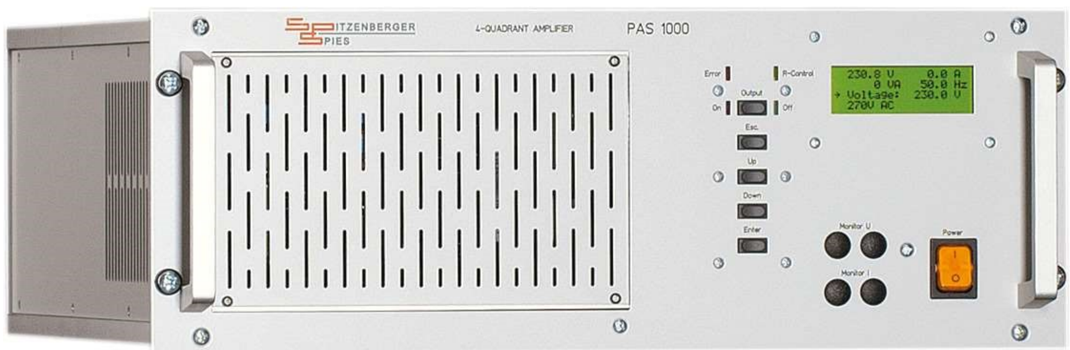
Release characteristic of the mechanical switch (10ms/DIV)

To guarantee a perfect protection the functionality of the protection unit is tested automatically at each startup (Power-On Self-Test).
A manual function test can be performed at each time using the according front panel buttons.
As a reminder for the operator the output of the simulator is locked until the function test of the OPD is stating “OK”. Only a passed function test is releasing the output of the simulator and the OPD.
The diagrams above show the typical switch-off duration of the OPD’s electronic protection on the one hand and the release duration of the mechanical switches on the other hand.

The result is: The **O**vervoltage **P**rotection **D**evice is **the perfect bodyguard for expensive EUT‘s.**

PAS series of 4-Quadrant Amplifiers

THE REAL 4-QUADRANT AMPLIFIER



~ Extremely low harmonic distortion - even under very non-linear load conditions

~ Very fast slew rate > 52V/µs (rise time < 5µs at $230V_{rms}$ as required by IEC/EN 61000-4-11)

~ Operates from DC up to 5kHz large signal bandwidth (-3dB) - optional up to 30kHz

~ Small signal bandwidth up to 50kHz or 100kHz

~ High long-term overload characteristic (up to 1-hour)

~ High short-term overload characteristic (for 5 … 10mins.)

~ Very high peak-load ability (up to 5ms)

~ Very low internal resistance

THE REFERENCE SOURCE FOR ALL APPLICATIONS

THE REAL 4-QUADRANT AMPLIFIER

Compliance with the requirements of the European EMC directive requires a statement of „product conformance“ to a variety of emission and immunity specifications. These specifications define not only the type of test, but also the technical requirements for the test instrumentation. In particular, in the field of low-frequency conducted phenomena, an AC/DC-voltage source is required for almost all types of test. In order to comply with these requirements a 4-quadrant amplifier has been developed which is based upon a linear push-pull design. Some of the remarkable features of this amplifier design include it’s ironless output stage, extensive use of negative feedback over all amplifier stages, an extended frequency range and a very low internal resistance.

FIELD OF APPLICATION

Extremely low harmonic distortion

EUT’s with switched-mode power supply and non-linear current consumption (Fig. 1) need a very stable voltage source. The non-linear current characteristic of EUT’s with peak current flow in comparison to the harmonic limits according to the standard IEC/EN 61000-3-2 are shown in Fig. 2.

The voltage source meets the extremely rigorous requirements of the standard IEC/EN 61000-3-2, even under very non-linear load conditions.

The waveshape of the output voltage is stable at any time (Fig. 3). The analysis of the harmonic content of the voltage source output signal when connected to a non linear load shows Fig. 4.

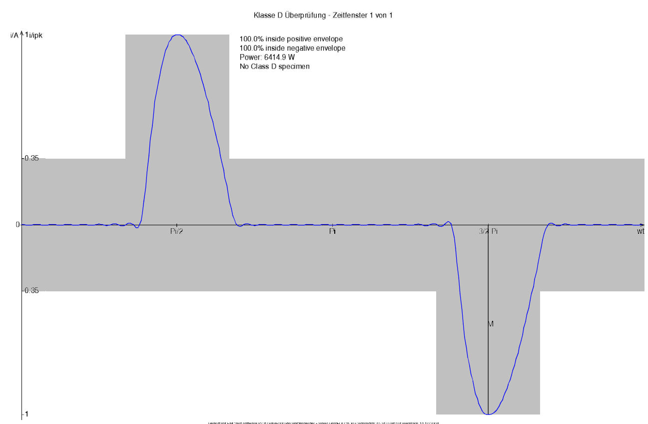


Fig. 1: Input current ($41A_{rms}/106A_p$) of the EUT

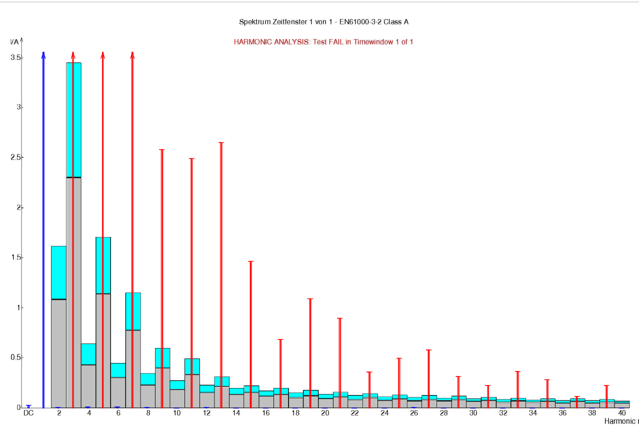


Fig. 2: Frequency spectrum of the EUT

Fig. 5: Grid Simulator PAS 5000

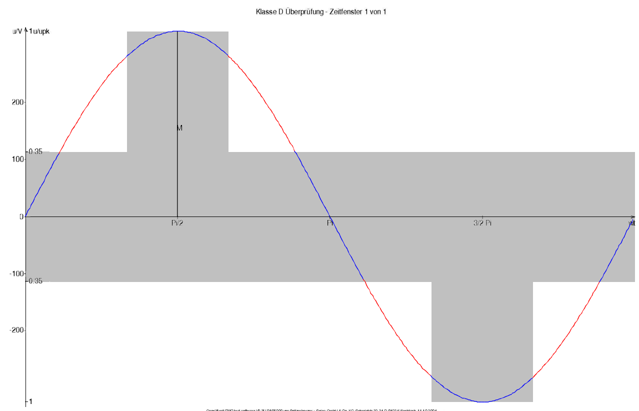


Fig. 3: Output voltage of the voltage source (PAS 5000)

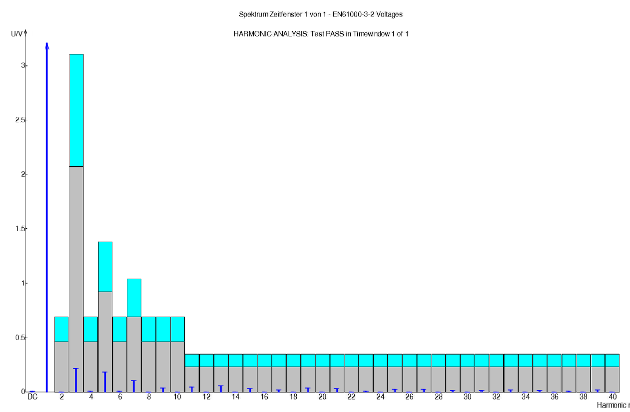


Fig. 4: Frequency spectrum of the voltage source (PAS 5000)

Very low internal resistance

The extremely low internal resistance of the amplifier guarantees a full compliance measurement according to IEC/EN 61000-3-3 source specifications, even under dynamic load conditions.

Testconditions: 230 V / 50 Hz / Phase: L1 / Observations: 3 x 10 min / Ztest: (0.40+j0.25) Ohm

FLICKER: Test FAIL! Max. permitted Imp.: (0.094+j0.059) Ohm

Time	Pmax	Pst	Sliding Plt	d(t)>3.30% [s]	dmax [%]	dc [%]	PASS	FAIL
12:51:28	113.300	2.6250	2.6250	- . - - -	5.573	0.108		X
13:01:28	24.060	2.3970	2.3970	- . - - -	2.541	0.096		X
13:11:28	19.660	2.3570	2.3570	- . - - -	2.366	0.002		X
Limits:		1.000	0.650	0.500	4.000	3.300		
Plt: 1.553090 (calculated over 12 periods)								
Evaluated: PST								

FLICKER: Source test PASS!

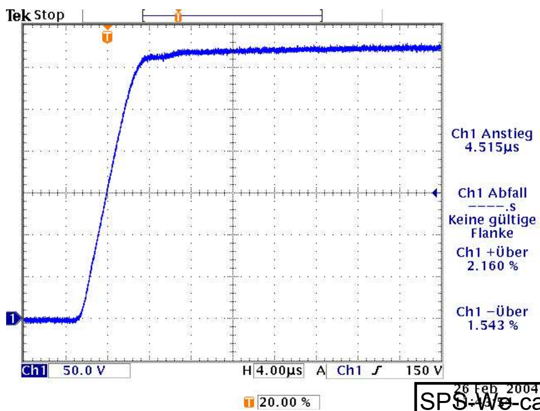
Time	Pmax	Pst	Sliding Plt	d(t)>3.30% [s]	dmax [%]	dc [%]	PASS	FAIL
12:51:28	0.006	0.0550	- . - - - -	- . - - -	0.087	- . - - -	X	
13:01:28	0.001	0.0260	- . - - - -	- . - - -	0.108	- . - - -	X	
13:11:28	0.001	0.0230	- . - - - -	- . - - -	0.126	- . - - -	X	
Plt: 0.025377 (calculated over 12 periods)								
Evaluated: PST <= 0.4 dmax < 20% dmax1								

Geprüft mit EMC test software V2.3f / PAS5000 von Spitzenberger + Spies GmbH & Co. KG, Schmidstr 32-34, D-94234 Viechtach, 11.10.2004

Fig. 6: Flicker measurement with photocopier as the EUT

Very fast rise and fall time

Due to the very fast slew rate of >52V/µs the PAS is fully compliant according to the requirements of IEC/EN 61000-4-11 in practice.



SPS-We-can-make-weather

Fig. 7: rise time of the output voltage

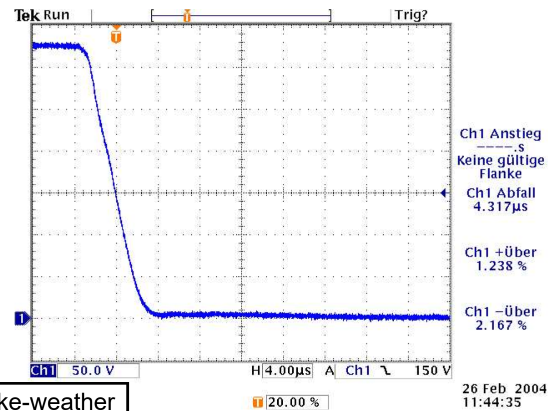


Fig. 8: fall time of the output voltage

Extremely high loadability

150% of rating is available in the case of a real load. Amplifier stability is absolutely assured when operating with either inductive or capacitive loads.

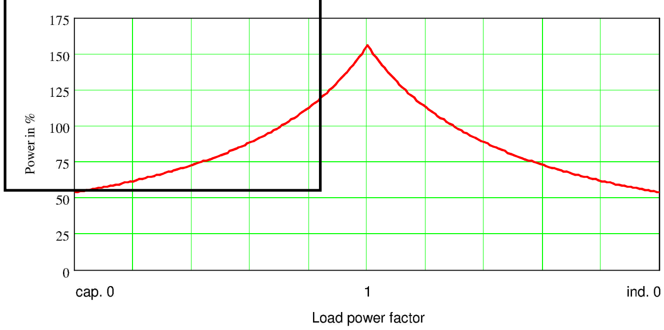


Fig. 9: PAS Performance characteristic

DC-Simulation

DC Signals can easily be generated using the directly coupled ironless amplifier output-stage

All test devices requiring a DC content within their input current can be supplied without problems.

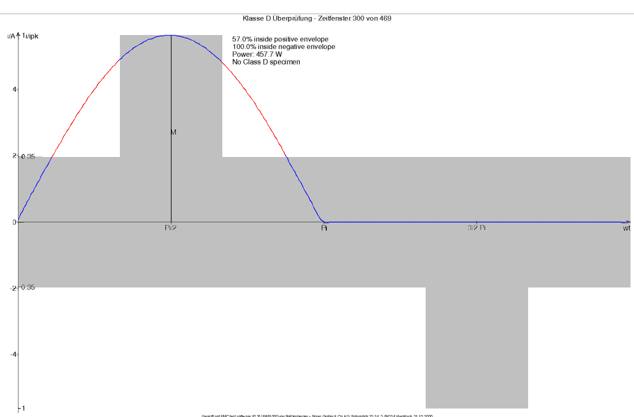


Fig. 10: PAS DC Characteristic

TECHNICAL DATA:

		PAS Series
Nominal voltage	*AC*	135V_{rms} / 270V_{rms}
	DC	±191V / ±382V
Voltage adjustment		depending on oscillator used
Load regulation		Max. / Typ.
	135V / DC … 450Hz	0,5% / 0,2%
	135V / 450Hz … 5kHz	2,0% / 1,0%
	270V / DC … 450Hz	0,3% / 0,1%
	270V / 450Hz … 5kHz	0,6% / 0,2%
Gain stability	*- 10min:*	<0.2% at constant load and temperature
	- 8h	<0.5% at constant load and temperature
Line regulation		< 1.5×10^{-4} per 10V line-voltage change
Frequency range		DC … 5kHz large signal bandwidth (-3dB) DC … 50kHz small signal bandwidth
Slew rate		> 52V/µs (rise time < 5µs at 230V_{rms} according to IEC/EN 61000-4-11)
Harmonic distortion		Max. / Typ.
	135V / DC … 450Hz	0,3% / 0,1%
	135V / 450Hz … 5kHz	2,5% / 1,5%
	270V / DC … 450Hz	0,1% / 0,05%
	270V / 450Hz … 5kHz	0,6% / 0,3%
Protection circuits		Overload / Short Circuit / Over temperature
Input	*Max. voltage*	±5V_p
	Impedance	approx. 8kΩ
Internal control source (optional)		
	Type	DDS2
	Wave form	Sine wave, DC
	Amplitude resolution	100mV
	Frequency range	10Hz … 5kHz
	Frequency resolution	100mHz
Ambient temperature		0°C up to 40°C
Options		
01: IEEE 488 Interface		Not required in combination with control unit type SyCore
06: Output voltage monitor		(electrically isolated)
07: Output current monitor		(electrically isolated)
10: Internal resistance compensation		available

Remarks:

1) *at nominal voltage and cos φ > 0.7*
2) *at nominal voltage*
3) *for approx. 5 … 10mins; duty cycle 1:9*
4) *for approx 2 … 3ms*
5) *Replaces standard range 0 ... 135V_{rms} (±191V_{DC})/0 ... 270V_{rms} (±382V_{DC})*
6) *Max. voltage between earth and ground of the amplifier output*
7) *To increase the output power of an amplifier, up to three similar amplifiers may be connected in parallel*
8) *With measurement adaptation to PAS*
9) *At 230V input voltage*

		PAS 1000	PAS 2500	PAS 5000
Power AC [1,9]	*- continuous* *- approx. 1h*	1000VA 1500VA	2500VA 3750VA	5000VA 7500VA
Power DC [2,9]	*- continuous* *- approx. 1h*	1000W 1500W	2500W 3750W	5000W 7500W
Short-time power [1,3,9]		2000VA	5000VA	10000VA
Peak power [1,4,9]	*- at 135V* *- at 270V*	3200VA_p 6400VA_p	10500VA_p 21000VA_p	21000VA_p 42000VA_p
Digital instrument Measuring ranges	*Voltage range*		300V	
	Current range	20A	40A	80A
	Accuracy Voltage		*Max. / Typ. (of measured value ±2 digit)*	
	DC; 45Hz … 450Hz		0,5% / 0,2%	
	15Hz … 45Hz;450Hz … 5kHz		1,0% / 0,4%	
	Accuracy Current		*Max. / typ. (of measured value ±2 digit)*	
	DC; 45Hz … 450Hz		0,8% / 0,4%	
	15Hz … 45Hz;450Hz … 2kHz		1,6% / 0,8%	
	2kHz … 5kHz	1,6% / 0,8%	5,0% / 3,0%	
Power Supply *(+10% / -10%, 50Hz 60Hz)*		230V	230V/400V	
Protection:		16A	3 x 16A	3 x 20A
Contactor type:		Schuko	CEE	
Housing	*Amplifier*	19", 4U	19", 5U	19",7U
	approx. dimensions in mm	178x483x600	222x483x600	311x483x600
	Power Supply	included	19", 5U	19" 5U
	approx. dimensions in mm	-	222x483x600	222x483x600
Weight	*Amplifier (approx.)*	45kg	30kg	45kg
	Power Supply (approx.)	-	85kg	100kg

Options		
11-33Z:	Additional voltage range	0 … 33V_{rms} (±47V_{DC})
11-56Z:	Additional voltage range	0 … 56V_{rms} (±79V_{DC})
11-240Z:	Additional voltage range	0 … 240V_{rms} (±339V_{DC})
11-300:	Special voltages [5]	0 … 150V_{rms} (±212V_{DC}) / 0 … 300V_{rms} (±424V_{DC})
11-300Z:	Special voltage and additional voltage range [5]	0 … 60V_{rms} (±85V_{DC}) / 0 … 150V_{rms} (±212V_{DC}) / 0 … 300V_{rms} (±424V_{DC})
11-630DC:	Additional DC-voltage range	0 … +630V_{DC} *In combination with option 11-300 or 11-300Z*
13-15:	Special frequency range	DC … 15kHz (-3dB)
13-30:	Special frequency range	DC … 30kHz (-3dB)
17-300:	Floating output [6]	300Vrms
21:	Parallel operation mode [7]	(DC … 5kHz / Only with SyCore)
24-P:	Programmable internal impedance	R:25mΩ … 2Ω/Resolution:25mΩ L:25µH … 3.2mH/Resolution:25µH
28-540/C:	Voltage transformer [8]	Other voltages on request
29-xxx/C:	High voltage transformer [8]	1000V and above values on request

		PAS 7500	PAS 10000	PAS 15000
Power AC [1) 9)]	*- continuous* *- approx. 1h*	7500VA 11250VA	10000VA 15000VA	15000VA 22500VA
Power DC [2) 9)]	*- continuous* *- approx. 1h*	7500W 11250W	10000W 15000W	15000W 22500W
Short-time power [1) 3) 9)]		15000VA	20000VA	30000VA
Peak power [1) 4) 9)]	*- at 135V* *- at 270V*	31500VA_p 63000VA_p	43750VA_p 87500VA_p	70000VA_p 140000VA_p
Digital instrument Measuring ranges	*Voltage range*		300V	
	Current range	150A	200A	250A
	Accuracy Voltage		*Max. / Typ. (of measured value ±2 digit)*	
	DC; 45Hz … 450Hz		0,5% / 0,2%	
	15Hz … 45Hz;450Hz … 5kHz		1,0% / 0,4%	
	Accuracy Current		*Max. / typ. (of measured value ±2 digit)*	
	DC; 45Hz … 450Hz		0,8% / 0,4%	
	15Hz … 45Hz;450Hz … 2kHz		1,6% / 0,8%	
	2kHz … 5kHz		5,0% / 3,0%	
Power Supply *(+6% / -10%, 50Hz 60Hz)*			230V/400V	
Protection:		3 x 32A	3 x 40A	3 x 63A
Contactor type:			CEE	
Housing	*Amplifier*	19", 10U	19" 17U	19", 23U
	approx. dimensions in mm	444x483x600	755x483x600	1022x483x600
	Power Supply	19", 10U	19", 12U	19", 12U
	approx. dimensions in mm	444x483x600	533x483x600	533x483x600
Weight	*Amplifier (approx.)*	60kg	80kg	120kg
	Power Supply (approx.)	200kg	220kg	240kg
Options				
11-33Z:	Additional voltage range	0 … 33V_{rms} (±47V_{DC})		
11-56Z:	Additional voltage range	0 … 56V_{rms} (±79V_{DC})		
11-240Z:	Additional voltage range	0 … 240V_{rms} (±339V_{DC})		
11-300:	Special voltages [5)]	0 … 150V_{rms} (±212V_{DC}) / 0 … 300V_{rms} (±424V_{DC})		
11-300Z:	Special voltage and additional voltage range [5)]	0 … 60V_{rms} (±85V_{DC}) / 0 … 150V_{rms} (±212V_{DC}) / 0 … 300V_{rms} (±424V_{DC})		
11-630DC:	Additional DC-voltage range	0 … +630V_{DC} *In combination with option 11-300 or 11-300Z*		
13-15:	Special frequency range	DC … 15kHz (-3dB)		
13-30:	Special frequency range	DC … 30kHz (-3dB)		
17-300:	Floating output [6)]	300Vrms		
21:	Parallel operation mode [7)]	(DC … 5kHz / Only with SyCore)		
24-P:	Programmable internal impedance	R:25mΩ … 2Ω/Resolution:25mΩ L:25µH … 3.2mH/Resolution:25µH		
28-540/C:	Voltage transformer [8)]	Other voltages on request		
29-xxx/C:	High voltage transformer [8)]	1000V and above values on request		

		PAS 20000	PAS 25000	PAS 30000
Power AC [1) 9)]	*- continuous* *- approx. 1h*	20000VA 30000VA	25000VA 37500VA	30000VA 45000VA
Power DC [2) 9)]	*- continuous* *- approx. 1h*	20000W 30000W	25000W 37500W	30000W 45000W
Short-time power [1) 3) 9)]		40000VA	50000VA	60000VA
Peak power [1) 4) 9)]	*- at 135V* *- at 270V*	100000VA_p 200000VA_p	115000VA_p 230000VA_p	126000VA_p 252000VA_p
Digital instrument Measuring ranges	*Voltage range*	300V		
	Current range	300A	400A	500A
	Accuracy Voltage	*Max. / Typ. (of measured value ±2 digit)*		
	DC; 45Hz … 450Hz	0,5% / 0,2%		
	15Hz … 45Hz;450Hz … 5kHz	1,0% / 0,4%		
	Accuracy Current	*Max. / typ. (of measured value ±2 digit)*		
	DC; 45Hz … 450Hz	0,8% / 0,4%		
	15Hz … 45Hz;450Hz … 2kHz	1,6% / 0,8%		
	2kHz … 5kHz	5,0% / 3,0%		
Power Supply *(+6% / -10%, 50Hz 60Hz)*		230V/400V		
Protection:		3 x 80A	3 x 100A	3 x 125A
Contactor type:		CEE		
Housing	*Amplifier*	19", 33U	19", 39U	19",46U
	approx. dimensions in mm	1467x483x600	1733x483x600	2042x483x600
	Power Supply	19", 2x12U	19", 2x12U	19", 2x12U
	approx. dimensions in mm	1066x483x600	1066x483x600	1066x483x600
Weight	*Amplifier (approx.)*	160kg	200kg	240kg
	Power Supply (approx.)	2 x 220kg	2 x 230kg	2 x 240kg
Options				
11-33Z:	Additional voltage range	0 … 33V_{rms} (±47V_{DC})		
11-56Z:	Additional voltage range	0 … 56V_{rms} (±79V_{DC})		
11-240Z:	Additional voltage range	0 … 240V_{rms} (±339V_{DC})		
11-300:	Special voltages [5)]	0 … 150V_{rms} (±212V_{DC}) / 0 … 300V_{rms} (±424V_{DC})		
11-300Z:	Special voltage and additional voltage range [5)]	0 … 60V_{rms} (±85V_{DC}) / 0 … 150V_{rms} (±212V_{DC}) / 0 … 300V_{rms} (±424V_{DC})		
11-630DC:	Additional DC-voltage range	0 … +630V_{DC} *In combination with option 11-300 or 11-300Z*		
13-15:	Special frequency range	DC … 15kHz (-3dB)		
13-30:	Special frequency range	DC … 30kHz (-3dB)		
17-300:	Floating output [6)]	300Vrms		
21:	Parallel operation mode [7)]	(DC … 5kHz / Only with SyCore)		
24-P:	Programmable internal impedance	R:25mΩ … 2Ω/Resolution:25mΩ L:25µH … 3.2mH/Resolution:25µH		
28-540/C:	Voltage transformer [8)]	Other voltages on request		
29-xxx/C:	High voltage transformer [8)]	1000V and above values on request		

	PAS 40000	PAS 50000	PAS 60000
Power AC [1) 9)] *- continuous*	40000VA	50000VA	60000VA
- approx. 1h	60000VA	75000VA	90000VA
Power DC [2) 9)] *- continuous*	40000W	50000W	60000W
- approx. 1h	60000W	75000W	90000W
Short-time power [1) 3) 9)]	80000VA	100000VA	120000VA
Peak power [1) 4) 9)] *- at 135V*	192000VA	225000VA	250000VA
- at 270V	384000VA	450000VA	500000VA
Digital instrument Measuring ranges *Voltage range*	300V		
Current range	600A	800A	1000A
Accuracy Voltage	*Max. / Typ. (of measured value ±2 digit)*		
DC; 45Hz … 450Hz	0,5% / 0,2%		
15Hz … 45Hz;450Hz … 5kHz	1,0% / 0,4%		
Accuracy Current	*Max. / typ. (of measured value ±2 digit)*		
DC; 45Hz … 450Hz	0,8% / 0,4%		
15Hz … 45Hz;450Hz … 2kHz	1,6% / 0,8%		
2kHz … 5kHz	5,0% / 3,0%		
Power Supply *(+6% / -10%, 50Hz 60Hz)*	230V/400V		
Protection:	On request	On request	On request
Contactor type:	CEE		
Housing *Amplifier*	On request	On request	On request
approx. dimensions in mm	On request	On request	On request
Power Supply	On request	On request	On request
approx. dimensions in mm	On request	On request	On request
Weight *Amplifier (approx.)*	On request	On request	On request
Power Supply (approx.)	On request	On request	On request

Options

11-33Z:	Additional voltage range	0 … $33V_{rms}$ ($\pm 47V_{DC}$)
11-56Z:	Additional voltage range	0 … $56V_{rms}$ ($\pm 79V_{DC}$)
11-240Z:	Additional voltage range	0 … $240V_{rms}$ ($\pm 339V_{DC}$)
11-300:	Special voltages [5)]	0 … $150V_{rms}$ ($\pm 212V_{DC}$) / 0 … $300V_{rms}$ ($\pm 424V_{DC}$)
11-300Z:	Special voltage and additional voltage range [5)]	0 … $60V_{rms}$ ($\pm 85V_{DC}$) / 0 … $150V_{rms}$ ($\pm 212V_{DC}$) / 0 … $300V_{rms}$ ($\pm 424V_{DC}$)
11-630DC:	Additional DC-voltage range	0 … $+630V_{DC}$ *In combination with option 11-300 or 11-300Z*
13-15:	Special frequency range	DC … 15kHz (-3dB)
13-30:	Special frequency range	DC … 30kHz (-3dB)
17-300:	Floating output [6)]	300Vrms
21:	Parallel operation mode [7)]	(DC … 5kHz / Only with SyCore)
24-P:	Programmable internal impedance	R:25mΩ … 2Ω/Resolution:25mΩ L:25µH … 3.2mH/Resolution:25µH
28-540/C:	Voltage transformer [8)]	Other voltages on request
29-xxx/C:	High voltage transformer [8)]	1000V and above values on request

With a guaranteed future

Instead of many individual voltage sources, the use of a single universal voltage source is both efficient and economical. The PAS series of voltage sources are prepared to meet the requirements of additional standards such as:

IEC/EN 60146-1-1
IEC/EN 61000-2-2
IEC/EN 61000-4-4
IEC/EN 61000-4-5
IEC/EN 61000-4-8
IEC/EN 61000-4-11
IEC/EN 61000-4-13
IEC/EN 61000-4-14
IEC/EN 61000-4-17
IEC/EN 61000-4-27
IEC/EN 61000-4-28
IEC/EN 61000-4-29
IEC/EN 61000-4-34
IEC/EN 61131-2
IEC/EN 61496-1
IEC/EN 61800-3
IEC/EN 62040-2
SEMI F47-0706

Long life expectancy and high reliability

The PAS – series is the perfect programmable voltage source for all your test equipment and production line requirements.

Fig. 11: 3-phase Grid Simulator DM 30000

Control

To control the amplifier a range of different oscillators, including IEEE 488 control (e.g. SyCore, DDS units), are available.

AC-Current Amplifier
Type DCS 5000/T

Applications:
Circuit Breaker testing
Coil testing
Magnetic field generation
Thermal testing
etc.

Top Facts:

- *Nominal power at cos phi 0 (inductive) … 1 … 0 (capacitive)*
- *High power efficiency >90%*
- *Current accuracy of 1% of the adjusted value*
- *Harmonic distortion < 1%*
- *Small dimensions*

TECHNICAL DATA

Output:	
Continuous power: 1)	5000VA at nominal current (800A range) 2000VA at nominal current (100A range)
cos phi:	0 (inductive) … 1 … 0 (capacitive) at nominal power
Nominal current:	$100A_{rms}$ ($V_{max.}$:$20V_{rms}$) $800A_{rms}$ ($V_{max.}$:$6V_{rms}$)
Current accuracy:	1% of the adjusted value (10 … 100% of the current range)
Efficiency:	> 90% at nominal power
Frequency range	45Hz … 100Hz
Harmonic distortion: *(at nominal current)*	<1%
Protection circuits:	Overload Open output Overtemperature
Control:	Internal Control Unit DDS2 Front-Panel adjustment or IEEE-control
Waveform:	Sine
Current range:	100A / 800 A_{rms}
Min. Current resolution:	14bit
Frequency range:	45Hz … 100Hz / Resolution 100mHz
Time measurement:	0000 … 9999 s automatic Reset at current change
Interface:	IEEE488 Optical CAN (for parallel operation only)
Power Supply: *Protection:* *Contactor type:*	230V/400V (+10% -10%, 50Hz … 60Hz) 3x16A CEE
Ambient temperature:	0°C up to +40°C
Housing:	2x19"-unit, colour light grey (RAL 7035)
Dimensions:	2x(4U) each 178x483x600mm
Weight:	Approx. 160kg

Remarks:

1) Nominal Power at 230V supply voltage at 22°C

EV series Overview
AC voltage amplifier

High frequency AC power amplifier system

The applications:
- Component testing
- Instrument testing

- ✓ *High slew rate*
- ✓ *Wide frequency range*
- ✓ *Very low internal resistance*
- ✓ *Frequencies from 1.5kHz to 300kHz can be generated in laboratory and test systems*
- ✓ *Testing of wound components, capacitors and filters*
- ✓ *Undervoltages and overvoltage as well as frequency variations may be simulated*
- ✓ *Testing of electrical and electronic devices of all kinds*
  (e.g. testing of high frequency measuring instruments)

SPS-TD-EV-Overview-e-0001.docx

TECHNICAL DATA

Type	EV300	EV600	EV1200
Power [1]			
Continuous power:	300VA	600VA	1200VA
cos phi:	0.7 ind. - 1 - 0.7 cap. at nominal power		
Nominal Voltage:	0-150V_{rms} or 0-300V_{rms}		
Digital instrument:	3 ½ digit		
Voltage range:	400V		
Current range (optional):	2A	5A	10A
	Max. / Typ. (of measured value ±2 digit)		
Accuracy Voltage:	15kHz-50kHz	2%	
	50kHz-100kHz	3%	
	100kHz-200kHz	6%	
	200kHz-300kHz	8%	
Accuracy Current (DC):	0,8% / 0,4%		
Supply:			
Power Supply (±10%, 50Hz … 60Hz)	230V		230V/400V
Protection:	16A		3x16A
Contactor type:	Safety plug		CEE
Housing:	19"-plug-in unit, colour light grey (RAL 7035)		
Dimensions (mm):	Amplifier incl. Power supply (5U) 265x540x550	Amplifier incl. Power supply (7U) 350x540x550	Amplifier (7U) Power supply (5U) 615x540x550
Weight (approx.):	35kg	45kg	Amplifier 40kg Power Supply 60kg

Remarks:
1) Nominal Power at 230V supply voltage

Type	All EV Series
Voltage adjustment:	depending on oscillator used
Load regulation: *0 … nominal load*	Type FS: 1.5kHz - 50kHz < 6% 50kHz - 100kHz < 8% Type H: 15kHz - 50kHz < 4% 50kHz - 200kHz < 10% Type CuG: 45Hz - 4.5kHz < 5% 4.5kHz - 100kHz < 6% Type I: 45kHz - 100kHz < 4% 100kHz - 300kHz < 10%
Gain stability:	10min: <0.2% at constant load and temperature 8h: <0.5% at constant load and temperature
Frequency range:	Type FS: 1.5kHz - 100kHz (-3dB) Type H: 15kHz - 200kHz (-3dB) Type CuG: f1: 45Hz - 4.5kHz (-1dB) f2: 4.5kHz - 100kHz (-3dB) Type I: f1: 45kHz - 100kHz (-3dB) f2: 100kHz - 300kHz (-3dB)
Harmonic distortion: *(at nominal voltage)*	Type FS: 1.5kHz - 50kHz < 3% 50kHz - 100kHz < 5% Type H: 15kHz - 50kHz < 5% 50kHz - 200kHz < 6% Type CuG: 45Hz - 4.5kHz < 1% amplifier range 4.5kHz - 100kHz < 2% amplifier range 4.5kHz - 100kHz < 5% voltage transformer Type I: 45kHz - 100kHz < 5% 100kHz - 300kHz < 8%
Protection circuits:	Overload / Short circuit / Overtemperature
Control:	Internal control source DDS-EV (optional)
Waveform:	Sine
Amplitude resolution:	100mV
Frequency range:	Type FS: 1.5kHz - 100kHz (-3dB) Type H: 15kHz - 200kHz (-3dB) Type CuG: f1: 45Hz - 4.5kHz (-1dB) f2: 4.5kHz - 100kHz (-3dB) Type I: f1: 45kHz - 100kHz (-3dB) f2: 100kHz - 300kHz (-3dB)
Frequency resolution:	0.1Hz / 1Hz / 10Hz (adjustable)
Input:	
Input voltage: *(for max. output voltage)*	$\pm 5V_p$
Input impedance:	approx. 2kΩ
Interface (optional):	IEEE488
Ambient temperature:	0°C up to +40°C

Options:	
Option 01:	IEEE488 Interface
Option 04:	Digital instrument current measurement
Option 06:	Output voltage monitor
Option 07:	Output current monitor
Option 11-a:	Special voltage ranges up to 0-600V_{rms}/ replaces standard range
Option 11-b:	Special voltage ranges up to 0-999V_{rms}/ replaces standard range
Option 18:	Special line voltages (110V … 300V)
Option 22-300:	Voltage range switching e.g. 0-150Vrms /0-300Vrms
Option 22-11b:	Voltage range switching e.g. 0-400Vrms /0-800Vrms/ option 11-b included
Option 26-g:	Remote control connection (isolated) level: 5V to 24V(active low)/ control lines for: - Output (ON/OFF)/ voltage and frequency ranges - Source selection (internal / external) - Control of fixed frequencies: 25kHz/50kHz *(only available in combination with variable Oscillator type DDS 2–EV)* - DC-control input 0-10V control of amplitude and frequency *(only available in combination with variable Oscillator type DDS 2–EV)* - Manual voltage adjustment *connection of an external ten-turn potentiometer/back side*

SPITZENBERGER SPIES

4-Quadrant Amplifier type PAS 5000

Harmonic Performance demonstration

The relating standards:
IEC/EN 61000-3-2
IEC/EN 61000-4-7

FIELD OF APPLICATION

For equipment intended to be connected to the 16A public low voltage network harmonic current limits are defined in the IEC/EN 61000-3-2 .

In the normative annex A2 of this standard the requirements for the voltage source under load conditions are defined.

Point c) of the Annex A2 describes the limits of harmonic voltage components of the voltage source. The EUT has to be connected as in normal operation. This requirement has to be met during testing EUT's of classes A ... D (EUT type classification of the IEC/EN 61000-3-2).

Point d) describes the waveform (crest-factor!). The wave-form crest-factor has to be taken in account, when testing EUT's of class C and D of this standard.

Note on figure A.1:

"Z_S (source impedance) and Z_M (measuring impedance) are not specified, but have to be sufficiently low to meet the requirements in Annex A.2. This must be verified with the measurement unit at the connection points to the EUT. For the value of ZM see IEC/EN 61000-4-7"

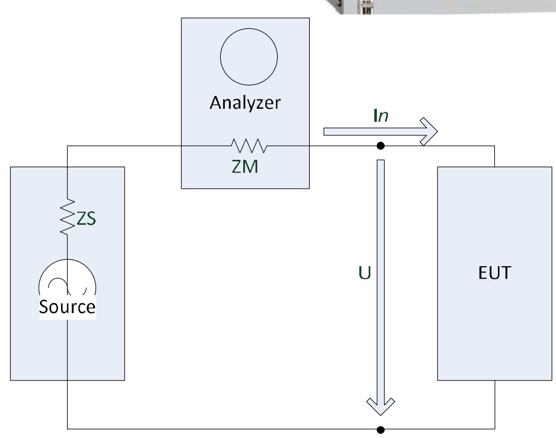


Fig. 1: Measurement setup acc. IEC/EN 61000-3-2

HARMONIC ANALYSIS OF THE EUT

For the harmonic performance demonstration of the PAS voltage source the following application was set up:

The PAS 5000 power amplifier was supplying an EUT with continuous power and non-linear current consumption.

PAS 5000 nominal power: 5kVA

PAS 5000 nominal current: 18.5A_{rms}

Whilst the demonstration the PAS 5000 was sourcing a current of > 41.5A_{rms} and a peak current of > 106$A_{p.}$

The harmonic analysis table of the EUT's input current is shown in Fig. 2.

Fig. 3 shows the input current waveshape and Fig. 4 the frequency spectrum of the EUT during this test measurement.

Voltage:	230.18 Vrms	325.49 Vpk	THD=0.14 %	THV=0.328 V	POHV=0.062 V	PWHD=0.17 %
Current:	41.528 Arms	-106.093 Apk	THD=107.03 %	THC=30.342 A	POHC=1.405 A	PWHD=37.57 %
Power:	6414.9 W	P1=6422.1 W	9559.1 VA			
Powerfactor:	0.671	CosPhi1: 0.984				

Testconditions: EN 61000-3-2 / A14, f=50 Hz, Phase=L1, Range=64.00 A
Time window cycles=16, Grouping of harmonics=off

HARMONIC ANALYSIS: Test FAIL in Timewindow 1 of 1

Ha	Value	Percent	Angle	EN61000-3-2 Class A	Margin	PASS	FAIL
DC	0.03 A	0.10 %	- - - . - Deg	- . - - - -	- - - . -	X	
1	28.35 A	100.00 %	10.2 Deg	- . - - - -	- - - . -	X	
2	0.01 A	0.04 %	-158.5 Deg	1.0800 A	-99.1 %	X	
3	23.76 A	83.82 %	-149.0 Deg	2.3000 A	933.2 %		X
4	0.02 A	0.06 %	26.8 Deg	0.4300 A	-96.3 %	X	
5	16.20 A	57.15 %	53.4 Deg	1.1400 A	1321.3 %		X
6	0.01 A	0.05 %	-150.7 Deg	0.3000 A	-95.3 %	X	
7	8.22 A	29.00 %	-98.9 Deg	0.7700 A	967.6 %		X
8	0.01 A	0.03 %	13.6 Deg	0.2300 A	-96.9 %	X	
9	2.59 A	9.12 %	139.1 Deg	0.4000 A	546.4 %		X
10	0.01 A	0.02 %	122.1 Deg	0.1840 A	-96.8 %	X	
11	2.50 A	8.80 %	64.9 Deg	0.3300 A	656.2 %		X
12	0.01 A	0.03 %	-73.6 Deg	0.1533 A	-94.4 %	X	
13	2.66 A	9.38 %	-72.7 Deg	0.2100 A	1166.2 %		X
14	0.01 A	0.02 %	97.9 Deg	0.1314 A	-95.3 %	X	
15	1.47 A	5.19 %	147.9 Deg	0.1500 A	881.3 %		X
16	0.00 A	0.01 %	-137.2 Deg	0.1150 A	-97.2 %	X	
17	0.69 A	2.42 %	69.6 Deg	0.1324 A	418.4 %		X
18	0.01 A	0.02 %	5.6 Deg	0.1022 A	-94.8 %	X	
19	1.10 A	3.87 %	-40.6 Deg	0.1184 A	826.6 %		X
20	0.00 A	0.02 %	-162.5 Deg	0.0920 A	-94.8 %	X	
21	0.90 A	3.18 %	177.6 Deg	0.1071 A	742.9 %		X
22	0.00 A	0.01 %	86.2 Deg	0.0836 A	-98.2 %	X	
23	0.36 A	1.29 %	64.9 Deg	0.0978 A	273.0 %		X
24	0.01 A	0.02 %	-0.7 Deg	0.0767 A	-93.3 %	X	
25	0.50 A	1.76 %	-8.0 Deg	0.0900 A	453.2 %		X
26	0.01 A	0.02 %	-155.3 Deg	0.0708 A	-90.8 %	X	
27	0.58 A	2.05 %	-146.2 Deg	0.0833 A	598.5 %		X
28	0.00 A	0.01 %	48.0 Deg	0.0657 A	-93.9 %	X	
29	0.32 A	1.13 %	79.6 Deg	0.0776 A	312.2 %		X
30	0.00 A	0.00 %	-9.1 Deg	0.0613 A	-99.1 %	X	
31	0.23 A	0.80 %	15.7 Deg	0.0726 A	211.9 %		X
32	0.00 A	0.01 %	-117.1 Deg	0.0575 A	-93.6 %	X	
33	0.37 A	1.32 %	-109.0 Deg	0.0682 A	447.7 %		X
34	0.00 A	0.01 %	80.5 Deg	0.0541 A	-93.1 %	X	
35	0.28 A	1.01 %	109.4 Deg	0.0643 A	343.3 %		X
36	0.00 A	0.00 %	-58.0 Deg	0.0511 A	-98.1 %	X	
37	0.12 A	0.42 %	18.4 Deg	0.0608 A	97.1 %		X
38	0.00 A	0.01 %	-77.1 Deg	0.0484 A	-93.9 %	X	
39	0.23 A	0.80 %	-72.9 Deg	0.0577 A	295.1 %		X
40	0.00 A	0.02 %	125.6 Deg	0.0460 A	-89.2 %	X	

Geprüft mit EMC test software V2.3f / PAS5000 von Spitzenberger + Spies GmbH & Co. KG, Schmidstr 32-34, D-94234 Viechtach, 11.10.2004

Fig. 2: Harmonic analysis of the EUT current

CURRENT WAVESHAPE AND FREQUENCY SPECTRUM OF THE EUT

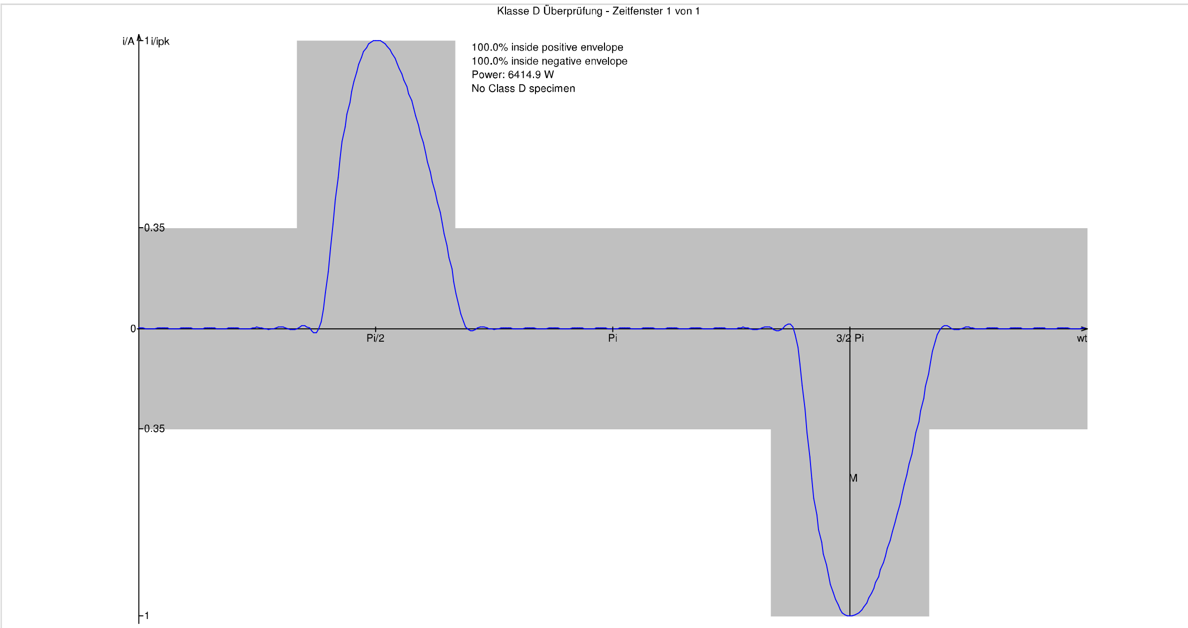


Fig. 4: Input current ($41A_{rms}/106A_p$) of the EUT

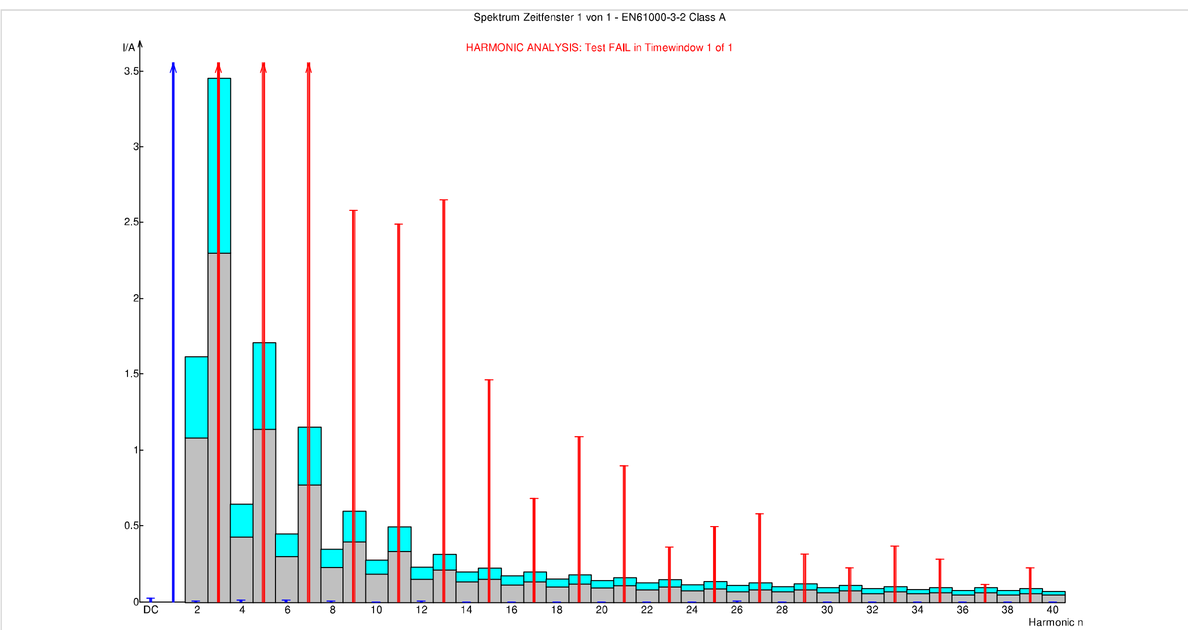


Fig. 5: Frequency spectrum of the EUT

SPITZENBERGER
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VOLTAGE WAVESHAPE AND FREQUENCY SPECTRUM OF THE PAS 5000

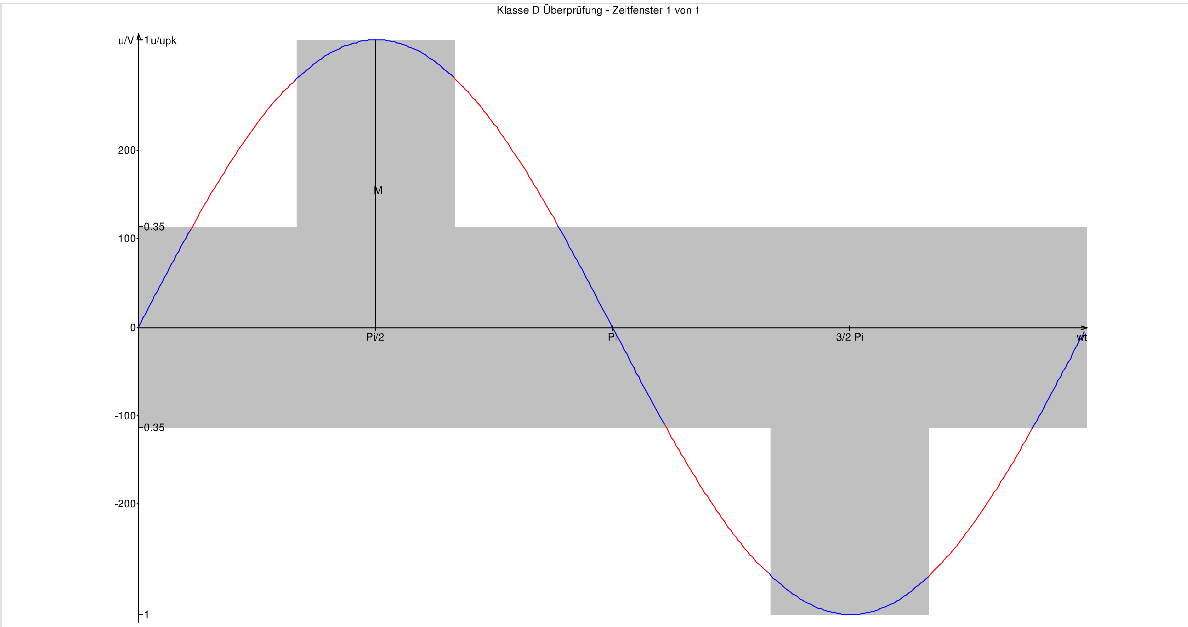


Fig. 6: Output voltage of the voltage source (PAS 5000)

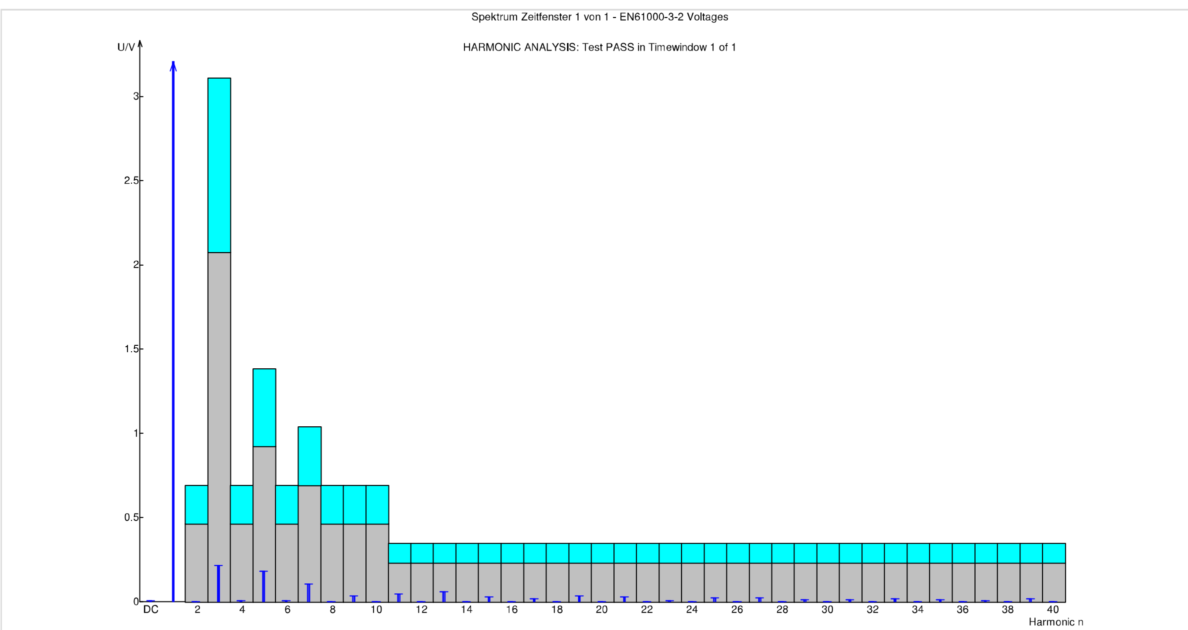


Fig. 7: Frequency spectrum of the voltage source (PAS 5000)

HARMONIC ANALYSIS OF THE PAS 5000

As defined in the standard IEC/EN 61000-3-2 A2 the voltage source shall meet the defined requirements. The test setup measurement shows the first class performance of the PAS 5000 voltage source.

Fig. 6 displays the voltage waveform during the test cycle, under load condition with a current of > 41.5A_{rms} and a peak current of > 106$A_{p.}$

The voltage harmonic spectrum of the PAS 5000 under load shows Fig. 7.

The tabular analysis in Fig.8 as well as the graphical evaluation in Fig.7 attest the PAS 5000 full compliance to the requirements of the standard. The gap between the harmonic limit and the measured harmonic value is very comfortable.

Voltage:	230.18 Vrms	325.49 Vpk	THD=0.14 %	THV=0.328 V	POHV=0.062 V	PWHD=0.17 %
Current:	41.528 Arms	-106.093 Apk	THD=107.03 %	THC=30.342 A	POHC=1.405 A	PWHD=37.57 %
Power:	6414.9 W	P1=6422.1 W	9559.1 VA			
Powerfactor:	0.671	CosPhi1: 0.984				

Testconditions: EN 61000-3-2 / A14, f=50 Hz, Phase=L1, Range=64.00 A
Time window cycles=16, Grouping of harmonics=off

HARMONIC ANALYSIS: Test PASS in Timewindow 1 of 1

Ha	Value	Percent	Angle	EN61000-3-2 Voltages	Margin	PASS	FAIL
DC	0.006 V	0.00 %	- - - . - Deg	- . - - - -	- - - . -	X	
1	230.182 V	100.00 %	0.0 Deg	- . - - - -	- - - . -	X	
2	0.005 V	0.00 %	-167.1 Deg	0.4604 V	-98.9 %	X	
3	0.220 V	0.10 %	62.5 Deg	2.0716 V	-89.4 %	X	
4	0.006 V	0.00 %	0.4 Deg	0.4604 V	-98.6 %	X	
5	0.183 V	0.08 %	-82.0 Deg	0.9207 V	-80.1 %	X	
6	0.007 V	0.00 %	-124.2 Deg	0.4604 V	-98.5 %	X	
7	0.107 V	0.05 %	134.8 Deg	0.6905 V	-84.4 %	X	
8	0.004 V	0.00 %	85.8 Deg	0.4604 V	-99.1 %	X	
9	0.037 V	0.02 %	26.4 Deg	0.4604 V	-92.0 %	X	
10	0.003 V	0.00 %	50.9 Deg	0.4604 V	-99.3 %	X	
11	0.050 V	0.02 %	-43.9 Deg	0.2302 V	-78.2 %	X	
12	0.003 V	0.00 %	-104.4 Deg	0.2302 V	-98.6 %	X	
13	0.060 V	0.03 %	176.9 Deg	0.2302 V	-74.1 %	X	
14	0.002 V	0.00 %	133.3 Deg	0.2302 V	-99.1 %	X	
15	0.032 V	0.01 %	42.6 Deg	0.2302 V	-86.1 %	X	
16	0.001 V	0.00 %	35.8 Deg	0.2302 V	-99.5 %	X	
17	0.020 V	0.01 %	-19.9 Deg	0.2302 V	-91.3 %	X	
18	0.002 V	0.00 %	-68.3 Deg	0.2302 V	-99.3 %	X	
19	0.037 V	0.02 %	-140.9 Deg	0.2302 V	-83.8 %	X	
20	0.002 V	0.00 %	152.6 Deg	0.2302 V	-99.1 %	X	
21	0.030 V	0.01 %	74.9 Deg	0.2302 V	-87.1 %	X	
22	0.001 V	0.00 %	18.6 Deg	0.2302 V	-99.5 %	X	
23	0.011 V	0.00 %	-16.1 Deg	0.2302 V	-95.4 %	X	
24	0.001 V	0.00 %	-33.8 Deg	0.2302 V	-99.5 %	X	
25	0.025 V	0.01 %	-98.3 Deg	0.2302 V	-89.3 %	X	
26	0.002 V	0.00 %	-178.9 Deg	0.2302 V	-99.2 %	X	
27	0.027 V	0.01 %	115.7 Deg	0.2302 V	-88.3 %	X	
28	0.001 V	0.00 %	41.6 Deg	0.2302 V	-99.7 %	X	
29	0.012 V	0.01 %	-12.5 Deg	0.2302 V	-94.9 %	X	
30	0.000 V	0.00 %	-42.4 Deg	0.2302 V	-99.8 %	X	
31	0.014 V	0.01 %	-66.7 Deg	0.2302 V	-93.8 %	X	
32	0.001 V	0.00 %	-138.5 Deg	0.2302 V	-99.4 %	X	
33	0.022 V	0.01 %	157.6 Deg	0.2302 V	-90.4 %	X	
34	0.001 V	0.00 %	77.9 Deg	0.2302 V	-99.5 %	X	
35	0.015 V	0.01 %	12.7 Deg	0.2302 V	-93.3 %	X	
36	0.000 V	0.00 %	-26.8 Deg	0.2302 V	-99.9 %	X	
37	0.008 V	0.00 %	-47.6 Deg	0.2302 V	-96.7 %	X	
38	0.001 V	0.00 %	-85.1 Deg	0.2302 V	-99.6 %	X	
39	0.019 V	0.01 %	-166.4 Deg	0.2302 V	-91.9 %	X	
40	0.001 V	0.00 %	97.8 Deg	0.2302 V	-99.4 %	X	

Geprüft mit EMC test software V2.3f / PAS5000 von Spitzenberger + Spies GmbH & Co. KG, Schmidstr 32-34, D-94234 Viechtach, 11.10.2004

Fig. 8: Tabular harmonic overview of the voltage source (PAS 5000)

For all 40 harmonics the measured value is below 25% of the maximum limit value of the IEC/EN 61000-3-2. An ongoing program of continuous product development is continuing to yield even higher levels of performance from the PAS series amplifiers.

PAS SERIES AMPLIFIERS:

THE REFERENCE SOURCE FOR ALL APPLICATIONS

IEC/EN 61000-4-11 Monitoring measurements (options 06/07) and “Inrush current source” (option 19-5)

The relating standards:
IEC/EN 61000-4-11
IEC/EN 61000-2-8

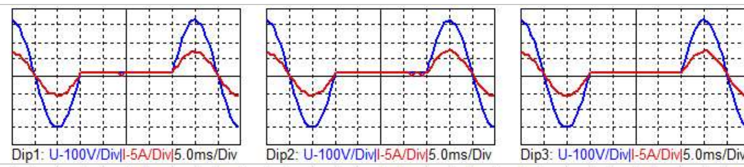
MONITORING MEASUREMENTS (OPTIONS 06 AND 07)

The IEC/EN 61000-4-11 voltage dips, short interruptions and variations test can be carried out using an oscilloscope together with the Spitzenberger & Spies Software package “SPS EMC” for the best test documentation and test reports.

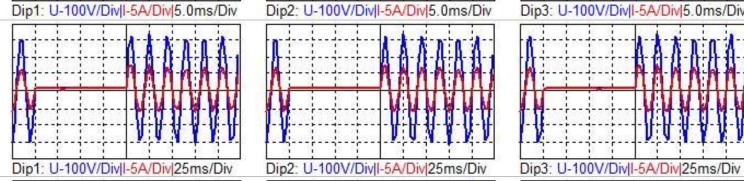
Test conditions:

Voltage / Frequency:	230.0 V / 50Hz
Test phase:	1
Executed test:	Dip example 1: Total drop
Test description:	Total drop out, time increasing from 1period up to 100 periods
Disturbances per step:	3 (per phase angle) / with 10.5 sec delay

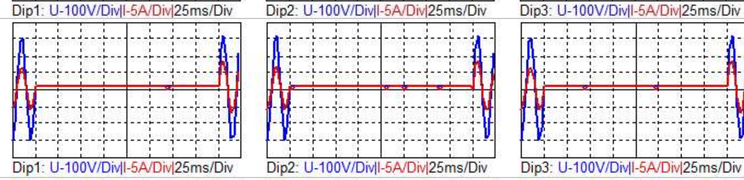
Step 1
Voltage dip / short interruption
Test level: 0 %
Duration: 1 period
Phase angle (Ref. Phase 1): 0°



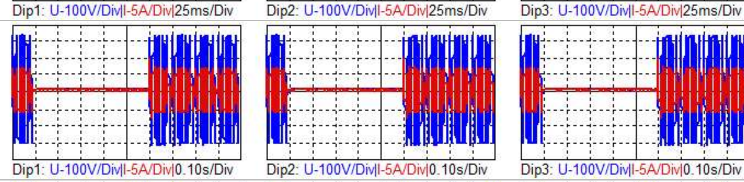
Step 2
Voltage dip / short interruption
Test level: 0 %
Duration: 5 periods
Phase angle (Ref. Phase 1): 0°



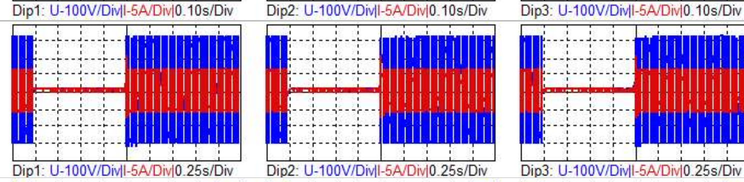
Step 3
Voltage dip / short interruption
Test level: 0 %
Duration: 10 periods
Phase angle (Ref. Phase 1): 0°



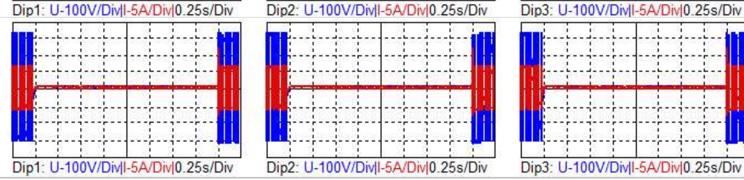
Step 4
Voltage dip / short interruption
Test level: 0 %
Duration: 25 periods
Phase angle (Ref. Phase 1): 0°



Step 5
Voltage dip / short interruption
Test level: 0 %
Duration: 50 periods
Phase angle (Ref. Phase 1): 0°



Step 6
Voltage dip / short interruption
Test level: 0 %
Duration: 100 periods
Phase angle (Ref. Phase 1): 0°



IEC/EN 61000-4-11 Test evaluation results:

- Normal performance within the specification limits
- Temporary degradation or loss of function or performance which is self-recoverable
- Temporary degradation or loss of function or performance which requires operator intervention or system reset
- Degradation or loss of function which is not recoverable due to damage of equipment or software or data loss

“Inrush current source” - Option 19-5

The relating standards:
IEC/EN 61000-4-11
Annex A clause A.3 „EUT peak inrush current requirement“

“INRUSH CURRENT SOURCE” - OPTION 19-5

By using the option 19-5 “Inrush current source”, it is not necessary to measure the EUT peak inrush current requirement during the test. Without the option “Inrush current source”, tests according to IEC/EN 61000-4-11 can be performed, if the inrush requirement of the EUT is less than the inrush drive capability of the generator.

“In order to be able to use a low-inrush drive current capability generator to test a particular EUT, that EUT´s measured inrush current shall be less than 70% of the measured inrush current drive capability of the generator.” (EN 61000-4-11:2004-03 / Annex A (normative) A.3)

PAS inrush current drive capability without option 19-5 “Inrush current source”:

4-Quadrant Amplifier	*Peak current at 90° / 270°*	*EUT Inrush current*
PAS 1000	$17A_p$	$12A_p$
PAS 2500	$55A_p$	$38A_p$
PAS 5000	$110A_p$	$77A_p$
PAS 7500	$165A_p$	$115A_p$
PAS 10000	$260A_p$	$182A_p$
PAS 15000	$370A_p$	$259A_p$

4-Quadrant Amplifier	*Peak current at 90° / 270°*
PAS 20000	$520A_p$
PAS 25000	$630A_p$
PAS 30000	$740A_p$
PAS 40000	$1040A_p$

„The 4-Quadrant Amplifiers type PAS 20000, PAS 25000, PAS 30000 and PAS 40000 have an inrush current drive capability of more than 500A_p – therefore no additional “Inrush current source” is required.

SPITZENBERGER SPIES

Basic EMC System®

for measurements according to the basic standards of the EMC directive

The relating standards:

emission:
IEC/EN 61000-3-2
IEC/EN 61000-3-3
IEC/EN 61000-3-11
IEC/EN 61000-3-12

immunity:
IEC/EN 61000-4-4
IEC/EN 61000-4-5
IEC/EN 61000-4-7
IEC/EN 61000-4-8
IEC/EN 61000-4-11
IEC/EN 61000-4-13
IEC/EN 61000-4-14
IEC/EN 61000-4-17
IEC/EN 61000-4-27
IEC/EN 61000-4-28
IEC/EN 61000-4-29
IEC/EN 61000-4-34

IEC/EN 60146-1-1
IEC/EN 61000-2-2
IEC/EN 61131-2
IEC/EN 61496-1
IEC/EN 61800-3
IEC/EN 62040-2

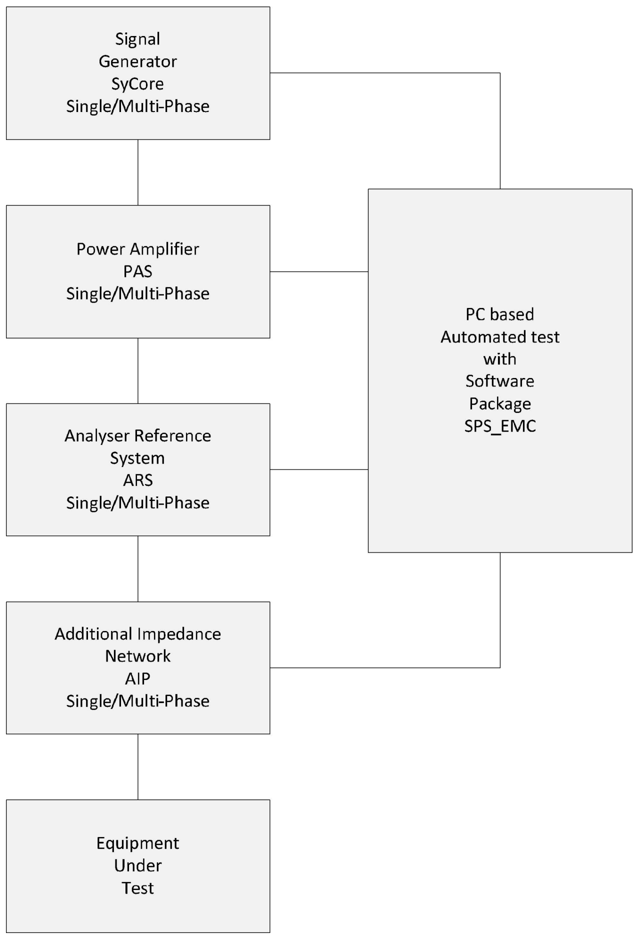
SEMI F47-0706

The “Basic EMC System”® is the fully compliant turnkey system for all line conducted Emission and Immunity tests according to the EMC directive.

Above and beyond the standards the “Basic EMC System”® is a universal grid simulation and measurement system for voltage, frequency and phase symmetry simulation.

On the other hand, the sources of the “Basic EMC System”®, the PAS amplifiers are the reference sources for many applications. Their technical performance and advantages like low THD, very fast rise and fall time, stability and power capability are unique on the market.

THE PRINCIPLE DIAGRAM:



The main components of the "Basic EMC System"®:

- *signal generator unit* ***SyCore***
- ***PAS*** *power amplifier*
- *analyser reference system* ***ARS*** *including reference impedance harmonic analyser flickermeter*
- *Additional impedance network* ***AIP***
- *Software package* ***SPS_EMC***

All components are available for single phase and multi-phase testing.

OPTIONS AND ADD-ONS:

- Pulse generator CE-tester for testing burst and surge pulses according to IEC/EN 61000-4-4 and IEC/EN 61000-4-5
- Magnetic field coils for testing the immunity against radiated magnetic fields with power line frequencies

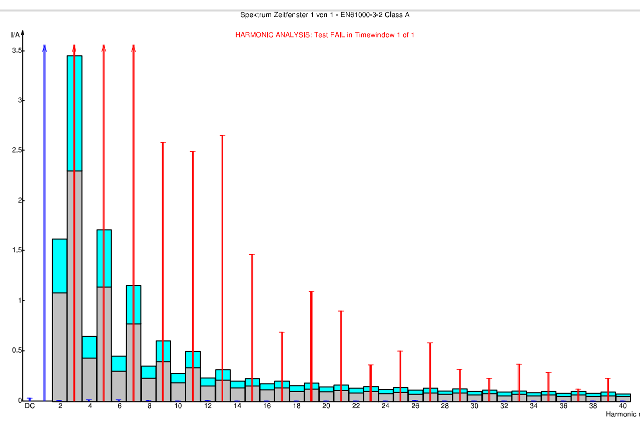
THE “BASIC EMC SYSTEM”®

SPITZENBERGER SPIES

MAGNETIC FIELD COILS TYPE I AND TYPE II

EVALUATION WITH SPS_EMC

Measured harmonic currents in relation to the maximum limits according to the IEC/EN 61000-3-2



Analyser Reference System

Type ARS 16

Harmonic Analysis / Flicker Analysis

The Relating Standards:

IEC 61000-3-2-am 1 (2001-08) Ed. 2.0
IEC 61000-3-2-am 2 (2004-10) Ed. 2.0
IEC 61000-3-2 (2004-11) Ed. 2.2
IEC 61000-3-2 (2009-04) Ed. 3.2
IEC 61000-3-3-am 1 (2001-01) Ed. 1.0
IEC 61000-3-3 (2002-03) Ed. 1.1
IEC 61000-3-3 (2008-06) Ed. 2.0
IEC 61000-3-11 (2000-08) Ed. 1.0
IEC 61000-3-12 (2004-11) Ed. 1.0
IEC 61000-3-12 (2011-05) Ed. 2.0

Front view ARS 16/1

Special features:

✓ **"Double FFT for simultaneous check of the source during the EUT measurement" in harmonic analysis**

✓ **Simultaneous two-channel measurement for source check (flicker measurement)**

✓ **Calibratable Line Impedance Simulating Network meets IEC 60725 (2012-06)**

✓ **Digital flickermeter meets IEC 61000-4-15 (2010-08) Ed. 2.0**

✓ **Real-time Harmonic Analyser meets IEC 61000-4-7 (2009-10) Ed. 2.1**

The **A**nalyser **R**eference **S**ystem type **ARS** contains the core of the well known and reliable analyser (Ducati/Boconsult B10) for the measurement part, the standard impedance according to IEC 60725 as well as a phase- and current range switching. It allows **harmonics** measurements according to IEC 61000-3-2 and **flicker** measurement according to IEC 61000-3-3. All the required diagram connections for the two types of measurement are performed automatically by **ARS** without any manual operation: this increases the reliability of the measurement avoiding any possible wiring error of the operator and ensures fast and reasonable operation with the test system. In fact, flicker and harmonics measurement can be performed automatically in succession with the EMC test software. Thereby, the standard impedance switches uninterrupted between both measurement modes. In addition, the current ranges of the harmonics measurement are switched overlapping.
ARS is a highly integrated component, including the 3 above mentioned functions in 1 box, thus providing a compact and reasonable solution, without any loss of our high measurement quality in the low-frequency EMC field.
The inside measuring module is compliant to the latest IEC standard amendments, including the **harmonics** measuring technique prescribed by IEC 61000-4-7 Ed. 2.1, with 200ms time windows and grouping inter-harmonics function, as well as the IEC 61000-4-15 Ed. 2.0 d-values calculation.

	Digital Flickermeter
Reference standards	IEC 61000-4-15-am1 (2003-01) Ed. 1.0 / IEC 61000-4-15 (2003-02) Ed. 1.1 / IEC 61000-4-15 (2010-08) Ed. 2.0 / IEC 61000-3-3-am1 (2001-01) Ed. 1.0 / IEC 61000-3-3 (2002-03) Ed. 1.1 / IEC 61000-3-3 (2008-06) Ed. 2.0 / IEC 61000-3-11 (2000-08) Ed. 1.0
Input channels	2
Input channel voltage range	$40V_{rms}$ … $504V_{rms}$ (independent auto ranging on each channel)
Input channel frequency	50Hz or 60Hz ±5%
Flicker produced by fluctuating harmonics	Measurement up to the 50^{th} harmonic or 40^{th} for 200ms TW
Input channels impedance	Higher than 1.5MΩ
Input channels insulation	3kV (transformer coupled)
Missing-input-signal conditions	Automatic recognition and handling
Analogue outputs (user selectable)	(W) Weighted voltage fluctuation (L) Linear flicker indication (R) Instantaneous flicker sensation (D) Relative voltage change characteristic d(t)
Flicker related measurements	CPF, $P_{50\%S}$, $P_{10\%S}$, $P_{1\%S}$, $P_{0,1\%}$, P_{MAX}, P_{ST}, P_{LT}
Accuracy	Higher than specified by IEC 61000-4-15
Flicker classifier scales	Logarithmic
Flicker scales	2 (user selectable): 10% (1600PU) and 40% (25600PU)
Voltage fluctuation measurement	d_c, d_{max}, time with d(t) exceeding a programmable threshold
d_c and d_{max} maximum error	0.2%
d(t) evaluation	RMS every half-cycle
Observation period	User selectable (1 / 5 / 10 / 15 min; fast mode for d_{max} evaluation)

	Real-time Harmonic Analyser
Reference standards	IEC 61000-4-7 (2002-08) Ed. 2.0 / IEC 61000-4-7 (2009-10) Ed. 2.1 / IEC 61000-3-2-am1 (2001-08) Ed. 2.0 / IEC 61000-3-2-am2 (2004-10) Ed. 2.0 / IEC 61000-3-2 (2004-11) Ed. 2.2 / IEC 61000-3-2 (2009-04) Ed. 3.2 / IEC 61000-3-12 (2004-11) Ed. 1.0 / IEC 61000-3-12 (2011-05) Ed. 2.0
Frequency	45Hz … 65Hz (PLL locked)
Voltage range	$90V_{rms}$ … $300V_{rms}$
Current range	$5mA_{rms}$ … $16A_{rms}$ with crest factor =3
Shunt ranges	4 user selectable: $0.16A_{rms}$ / $0.8A_{rms}$ / $4A_{rms}$ / $20A_{rms}$
Accuracy	Better than 0.2% of the rated current of the EUT (selecting appropriate shunt range)
Voltage channel input impedance	Higher than 0.8MΩ
Current channel input impedance	Depends on the shunt range selected. Impedance <3mΩ within the highest range
Max. drop on current channel	$150mV_p$ (any selected range)
Measured values	Magnitude and phase of fundamental up to 40^{th} (TW=200ms) or 50^{th} (TW=320ms), for both U,I dc component (U,I); voltage U_{rms}; current I_{rms} active power (W); apparent power (VA); circuit power factor (λ) harmonic distortion for voltage and current (Thd_U%, Thd_I%)
Measuring techniques	16 periods rectangular windows (320ms @50Hz; 266.7ms @60Hz) 10 periods rectangular windows (200ms @50Hz) 12 periods rectangular windows (200ms @60Hz) windows period user selectable sampling rate synchronised to the fundamental
Anti aliasing filter	70dB
Smoothing filter for transitory harmonics	Digital 1^{st} order low-pass filter (τ =1.5s); software selectable on Harmonics and/or on active Power
Grouping function	Harmonics and adjacent inter-harmonics - as per IEC 61000-4-7 Ed. 2.1 (current grouping and voltage harmonics subgroups)
Operating modes	Steady-state harmonics / single-shot (1 time window); transitory harmonics / 2.5 minutes (469 time window @50Hz or 563 @60Hz; 750 time windows in 200ms mode); continuous monitoring; continuous mode with automatic stop if limits are exceeded (only in 16-cycle mode) continuous mode with real-time data transmission allowing the complete EUT cycle period measurement (*Quasi-stationary, Short cyclic, Random and Long cyclic*)
Stop trigger condition (user selectable)	Class C and D limits are dynamically computed each time window (only in 16-cycle mode) Automatic management of 1.5 times overriding for 10% of periods for 2^{nd} … 10^{th} and 3^{rd} … 19^{th} transitory harmonics

Storage	Last 2.5 minutes in continuous mode (embedded mode) No time-limited period in continuous mode (with PC connection)
Analogue outputs (user programmable)	Real-time spectrum or shape for voltage and current or dynamic monitoring of any harmonic versus time
Self calibration	Automatically at power-up

	Miscellaneous		
Processors	Motorola DSP56002, Intel 80C186		
Input channel resolution	18 bit Σ/Δ A/D converter on each channel		
Analogue output resolution	12 bit		
Interface	IEEE 488 galvanically isolated		
Digital outputs	8 (TTL levels) to control external range selection and reference impedance		
Self test	Automatically at power-up – operator-driven (extended)		
Calibration	Traceable to the national measurement standard published by the PTB (Federal Institute of Physics and Technology)		
U_{input}	Harmonic: AC: $80V_{rms}$ … $300V_{rms}$ / DC: 0V – 48V (1) Flicker: AC: $40V_{rms}$ … $504V_{rms}$ (auto ranging) / DC: 0V – 48V (1)		
$I_{cont.}$	$16A_{rms}$		
$I_{short-time}$	$32A_{rms}$		
Internal resistance	Phase conductor R + jX = (0.24Ω+j0.15Ω) @50Hz Neutral conductor R + jX = (0.16Ω+j0.10Ω) @50Hz Phase conductor to neutral conductor R + jX = (0.40Ω+j0.25Ω) @50Hz		
Measuring inputs	CH1 $0V_{rms}$ … $300V_{rms}$ CH2 $0V_{rms}$ … $300V_{rms}$ HAR $0V_p$ … $10V_p$ (2)		
Mains supply	$230V_{rms}$ (+6% / -10%) 50Hz … 60Hz		
Ambient temperature	0°C up to +40°C		
Housing	ARS 16/1 and ARS 16/3: 19“-plug-in unit (4U) approx. H=178mm; W=483mm; D=450mm ARS 16/3/TPM: 19“-plug-in unit (8U) approx. H=355mm; W=483mm; D=450mm		
Weight	ARS 16/1 approx. 21kg	ARS 16/3 approx. 25kg	ARS 16/3/TPM approx. 40kg

(1) At DC-voltages >48V it is **absolutely necessary** to make sure that switching on and off as well as changing the operation mode is to do off load and/or off power.

(2) $3V_{rms}$ correspond the end value of current range.

Front View ARS 16/3

Rear View ARS 16/3

Line Impedance Simulation Network type AIP

AIP xxx/3	- fixed impedance
AIP xxx/3/P	- programmable impedance
AIP xxx/3/P/JK	- programmable impedance including Japanese/Korean standard
AIP xxx/3/P/TPM	- programmable impedance including three phase measurement unit
AIP xxx/3/P/JK/TPM	three phase measurement unit

The relating standards:

IEC/EN 61000-3-2
IEC/EN 61000-3-3
IEC/EN 61000-3-11
IEC/EN 61000-3-12

Fig. 1: AIP 75/3/P/TPM

"Harmonics and Flicker emission measurements"

The line impedance simulation network AIP is designed for testing according to the IEC/EN 61000-3-11 and IEC/EN 61000-3-12. Available current ranges for the AIP are:

- ***32 A***
- ***75 A***
- ***125 A***
- ***250 A***
- ***375 A***
- ***500 A***

When using the AIP types with 32A or 75A the required impedance is set in the software. When starting the test the user is informed which resistors have to be by-passed by means of the low-ohm plug connectors ($R_{contact}$ <= 60µΩ). The AIP types with 125A, 250A, 375A and 500A have an automated pneumatic switch system and are fully computer controlled.
The adjusted impedance values are displayed in plaintext at the front-panel display. The voltage drop (3% ... 5%) according to IEC/EN 61000-3-11 (section 6.1.1) is intended to be displayed also at the AIP front-panel.

Fig. 2: AIP 125/3/P

TECHNICAL DATA GENERAL[6]:

Type	All AIP types
Input:	
Input voltage (Harmonic):	AC: $90V_{rms}$ … $300V_{rms}$ / DC: 0V … 48V [1]
Input voltage (Flicker):	AC: $40V_{rms}$ … $504V_{rms}$ (auto ranging) / DC: 0V … 48V [1]
Input frequency:	45Hz … 65Hz
Power dissipation:	max. total voltage drop at impedance: $U_Z > 5\%$ of U_N (depending on adjusted impedance; according to IEC/EN 61000-3-11) Japanese/Korean type: $U_Z > 7\%$ of U_N
Protection circuits:	- Overcurrent (circuit breaker) / - Overtemperature (electronically)
Impedance accuracy:	Z: 4% (R + jX) (at X/R relation 0.5 … 0.75 according to IEC/EN 61000-3-11) (calibration cycle: 2 years)
Measuring outputs:	FLI CH1 $0V_{rms}$ ... $300V_{rms}$ FLI CH2 $0V_{rms}$ ... $300V_{rms}$ HAR I $0V_p$ ... $10V_p$ [2]
Measuring connectors:	4mm laboratory sockets
Interfaces:	IEEE488
Power supply:	230V (±10%) 50Hz … 60Hz
Protection:	2A
Connector:	Safety Plug 16A
Ambient temperature:	0°C up to +40°C
Housing:	19"-plug-in unit, colour light grey (RAL 7035)

Remarks:

1) At DC-voltages >48V switching on/off and changing the operation mode **must be conducted off load!**
2) $3V_{rms}$ correspond to the upper range value of the current range.
3) Fixed impedance value for AIP 250/3/P/xxx, AIP 375/3/P/xxx and AIP 500/3/P/xxx
4) Fixed impedance value for AIP 125/3/P/xxx
5) Fixed impedance value for AIP 32/3/P/xxx and AIP 75/3/P/xxx
6) All subjects are due to change
7) Impedance values for JK type AIP must be added to the IEC impedance values because of the serial connection of the two impedances

The AIP type glossary:

AIP	*Additional impedance*
xxx	*Nominal current (A)* *32/75/125/250/375/500*
/3	*Number of phases* */1 = single phase* */3 = three phase*
/P	*Impedance values are programmable* */P = yes* *left out = no*
/JK	*Additional Japanese/Korean reference impedance* */JK = built-in* *left out = not built-in*
/TPM	*Measurement option* */TPM = simultaneous three phase measurement* *Left out = single phase measurement switchable to all phases*

TECHNICAL DATA TYPES AIP 32/3 and AIP 75/3[6)]:

Type	**AIP 32/3**	**AIP 75/3**
Performance:		
Continuous current:	$32A_{rms}$	$75A_{rms}$
Short time current:	$64A_{rms}$	$126A_{rms}$
Internal impedance:		
Phase conductor:	R: 150mΩ X: 150mΩ at 50Hz X: 180mΩ at 60Hz	
Neutral conductor:	R: 100mΩ X: 100mΩ at 50Hz X: 120mΩ at 60Hz	
Max. phase-neutral impedance:	R: 250mΩ X: 250mΩ at 50Hz X: 300mΩ at 60Hz	
Resistor bridging:	No bridging	
Cooling type:	Air cooling	
Size:		
Dimensions:	5U 222x490x500	10U 445x490x600
Weight:	approx. 40kg	approx. 110kg

WIRING DIAGRAM:

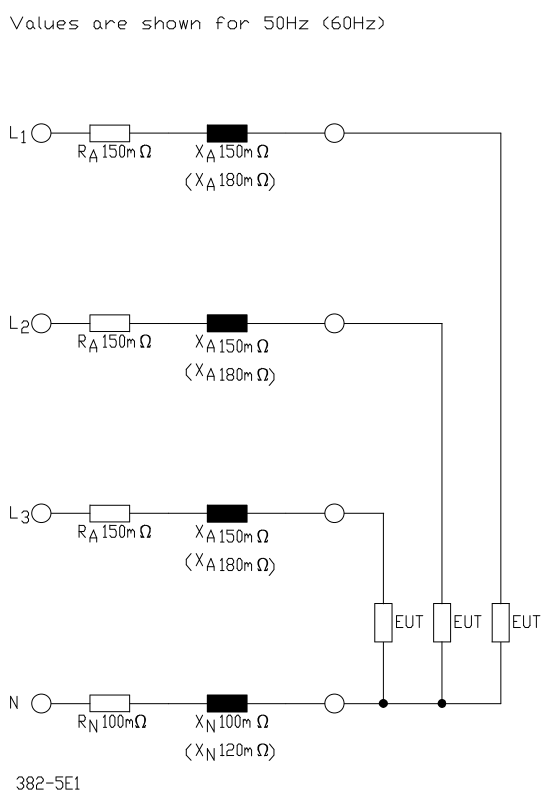


Fig. 3: IEC/EN standard reference impedance 50Hz/(60Hz) values for AIP 32/3 and AIP 75/3

TECHNICAL DATA TYPES AIP 32/3/P and AIP 75/3/P[6]:

Type	**AIP 32/3/P**	**AIP 75/3/P**
Performance:[3]		
Continuous current:	$32A_{rms}$	$75A_{rms}$
Short time current:	$64A_{rms}$	$126A_{rms}$
Internal impedance:	IEC	
Phase conductor:	R: 15mΩ … 240mΩ in 15mΩ - steps X: 9.38mΩ ... 150mΩ in 9.38mΩ - steps at 50Hz X: 11.26mΩ ... 180mΩ in 11.26mΩ - steps at 60Hz	
Neutral conductor:	R: 10mΩ ... 160mΩ in 10mΩ - steps X: 6.25mΩ … 100mΩ in 6.25mΩ - steps at 50Hz X: 7.5mΩ … 120mΩ in 7.5mΩ - steps at 60Hz	
Max. phase-neutral impedance:	R: 400mΩ X: 250mΩ at 50Hz X: 300mΩ at 60Hz	
Resistor bridging:	Software assisted manual bridging	
Cooling type:	Air cooling	
Size:		
Dimensions (mm):	15U 667x490x600	15U 667x490x600
Weight:	approx. 130kg	approx. 155kg

WIRING DIAGRAM:

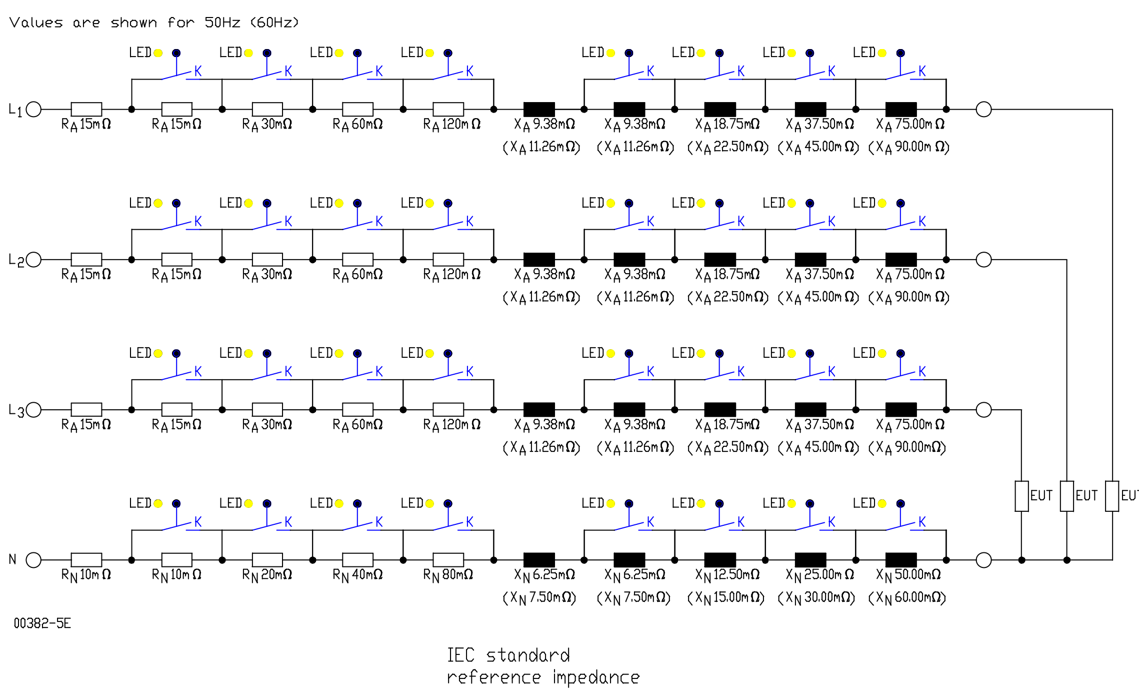


Fig. 4: IEC/EN standard reference impedance 50Hz/(60Hz) values for AIP 32/3/P and AIP 75/3/P

TECHNICAL DATA TYPE AIP 125/3/P[6)]:

Type	**AIP 125/3/P**		
Performance:[3)]			
Continuous current:	$125A_{rms}$		
Short time current:	$250A_{rms}$		
Internal impedance:	IEC		
Phase conductor:	R:	7.5mΩ … 240mΩ	in 7.5mΩ - steps
	X:	4.69mΩ ... 150mΩ	in 4.69mΩ - steps at 50Hz
	X:	5.63mΩ ... 180mΩ	in 5.63mΩ - steps at 60Hz
Neutral conductor:	R:	5mΩ ... 160mΩ	in 5mΩ - steps
	X:	3.13mΩ … 100mΩ	in 3.13mΩ - steps at 50Hz
	X:	3.75mΩ … 120mΩ	in 3.75mΩ - steps at 60Hz
Max. phase-neutral impedance:	R:	400mΩ	
	X:	250mΩ at 50Hz	
	X:	300mΩ at 60Hz	
Resistor bridging:	Automated pneumatic bridging *(pressure: 5-10bar, connector ¼" NW 7.2)*		
Cooling type:	Air cooling		
Size:			
Dimensions (mm):	37U 1645x600x600		
Weight:	approx. 650kg		

WIRING DIAGRAM:

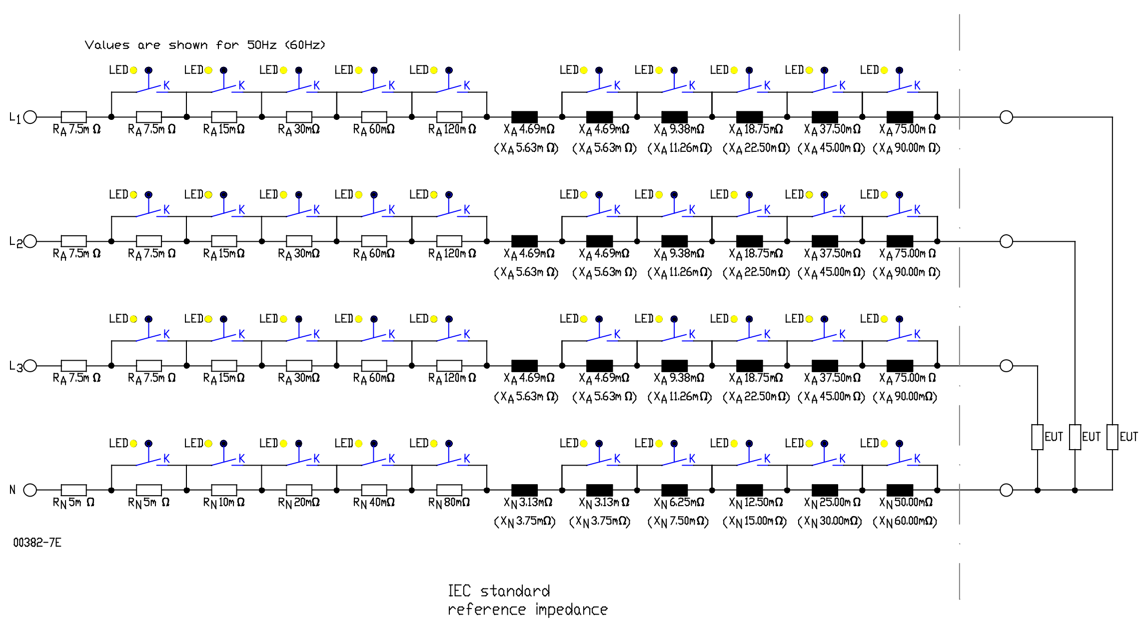


Fig. 5: IEC/EN standard reference impedance 50Hz/(60Hz) values for AIP 125/3/P

TECHNICAL DATA TYPES AIP 250/3/P, AIP 375/3/P, AIP 500/3/P[6]:

Type	AIP 250/3/P	AIP 375/3/P	AIP 500/3/P
Performance:[3]			
Continuous current:	$250A_{rms}$	$375A_{rms}$	$500A_{rms}$
Short time current:	$500A_{rms}$	$500A_{rms}$	$750A_{rms}$
Internal impedance:	IEC		
Phase conductor:	R: 3.75mΩ … 240mΩ in 3.75mΩ - steps X: 2.34mΩ ... 150mΩ in 2.34mΩ - steps at 50Hz X: 2.81mΩ ... 180mΩ in 2.81mΩ - steps at 60Hz		
Neutral conductor:	R: 2.5mΩ ... 160mΩ in 2.5mΩ - steps X: 1.56mΩ … 100mΩ in 1.56mΩ - steps at 50Hz X: 1.88mΩ … 120mΩ in 1.88mΩ - steps at 60Hz		
Max. phase-neutral impedance:	R: 400mΩ X: 250mΩ at 50Hz X: 300mΩ at 60Hz		
Resistor bridging:	Automated pneumatic bridging *(pressure: 5-10bar, connector ¼" NW 7.2)*		
Cooling type:	Water cooling *(connector: 1,5")*		
Size:			
Dimensions (mm):	2x37U 1920x1200x1050	3x37U 1920x1800x1050	3x46U 2320x1800x1050
Weight:	approx. 1000kg	approx. 2000kg	approx. 3000kg

WIRING DIAGRAM:

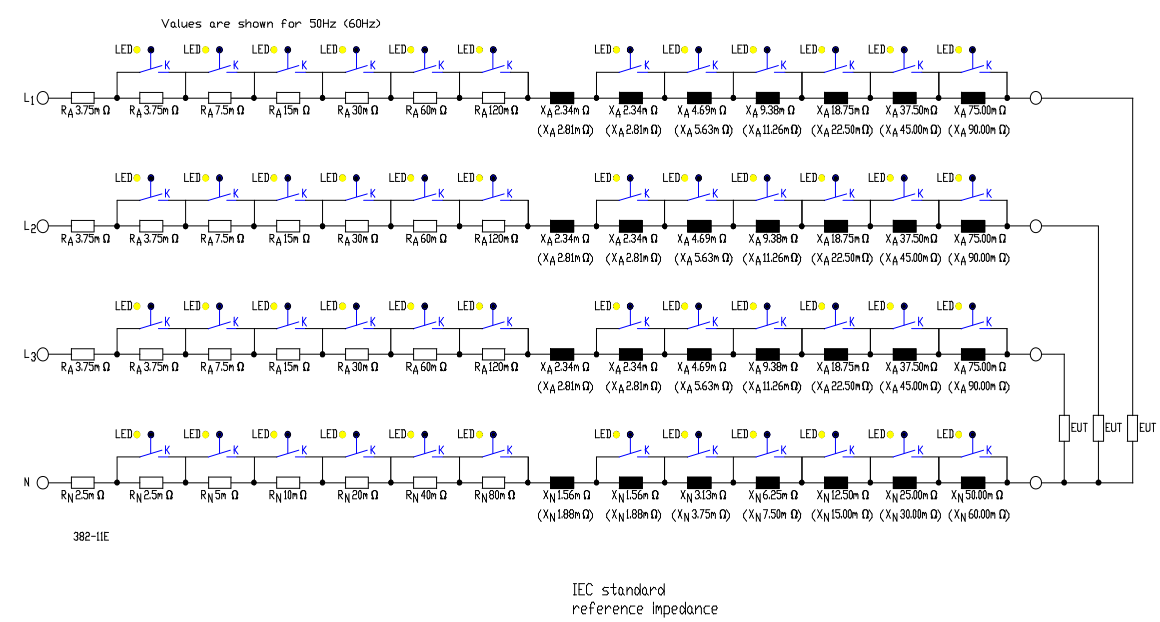


Fig. 5: IEC/EN standard reference impedance 50Hz/(60Hz) values for AIP 250/3/P, AIP 375/3/P, AIP 500/3/P

TECHNICAL DATA TYPE JK (JAPANESE/KOREAN STANDARDS) [6) 7)]:

Type	**AIP 32/3/P/JK**	**AIP 75/3/P/JK**	**AIP 125/3/P/JK**
Performance:[3)]			
Continuous current:	$32A_{rms}$	$75A_{rms}$	$125A_{rms}$
Short time current:	$64A_{rms}$	$126A_{rms}$	$250A_{rms}$
Internal impedance:	Japanese/Korean standard		
Phase conductor:	R: 0mΩ / 15mΩ / 50mΩ / 55mΩ / 90mΩ X: 0mΩ / 34.37mΩ / 66.67mΩ / 101.04mΩ at 50Hz X: 0mΩ / 41.25mΩ / 80mΩ / 121.25mΩ at 60Hz		
Neutral conductor:	R: 0mΩ / 10mΩ / 190mΩ X: 0mΩ / 8.33mΩ / 33.33mΩ / 41.67mΩ at 50Hz X: 0mΩ / 10mΩ / 40mΩ / 50mΩ at 60Hz		
Max. phase-neutral impedance:	R: 680mΩ X: 393mΩ at 50Hz X: 471mΩ at 60Hz		
Resistor bridging:	Automated pneumatic bridging *(pressure: 5-10bar, connector ¼" NW 7.2)*		
Cooling type:	Air cooling		
Size:			
Dimensions (mm):	23U 1022x490x600	23U 1022x490x600	37U 1645x1200x600
Weight:	approx. 210kg	approx. 250kg	approx. 1100kg

WIRING DIAGRAM:

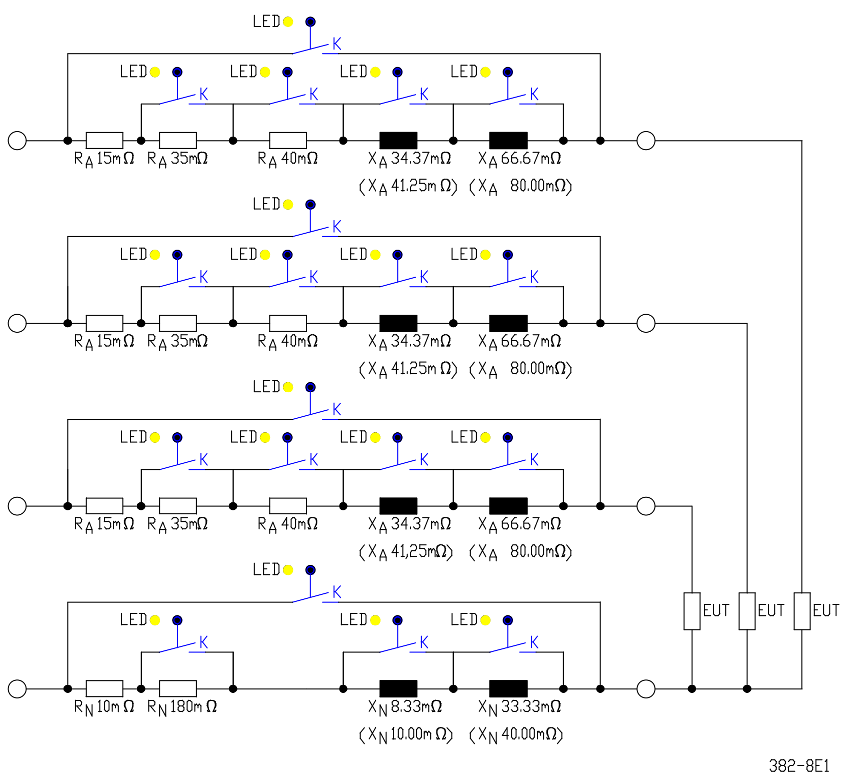


Fig. 6: Japanese/Korean standard reference impedance 50Hz/(60Hz) values for all AIP xxx/3/P/JK

POSSIBLE IMPEDANCE COMBINATIONS AIP AT 50Hz:

(Without additional Japanese/Korean standard values):
Fixed values displayed in red colour

No.	R_A [mΩ]	R_N [mΩ]	R_{total} [mΩ]	ratio X_{total} / R_{total}	X_A [mΩ]	X_N [mΩ]	X_{total} [mΩ]	AIP with 32A 75A	AIP with 125A	AIP with 250A 375A 500A
1[3)]	3.75	2.5	**6.25**	0.625	2.34	1.56	**3.9**	×	×	✓
2[4)]	7.5	5	**12.5**	0.625	4.69	3.13	**7.82**	×	✓	✓
3	11.25	7.5	**18.75**	0.625	7.03	4.69	**15.63**	✓	✓	✓
4[5)]	15	10	**25**	0.625	9.38	6.25	**15.63**	✓	✓	✓
5	18.75	12.5	**31.25**	0.625	11.72	7.81	**19.53**	×	×	✓
6	22.5	15	**37.5**	0.625	14.07	9.38	**23.45**	×	✓	✓
7	26.25	17.5	**43.75**	0.625	16.41	10.94	**27.35**	×	×	✓
8	30	20	**50**	0.625	18.75	12.5	**31.25**	✓	✓	✓
9	33.75	22.5	**56.25**	0.625	21.09	14.06	**35.15**	×	×	✓
10	37.5	25	**62.5**	0.625	23.44	15.63	**39.07**	×	✓	✓
11	41.25	27.5	**68.75**	0.625	25.78	17.19	**42.97**	×	×	✓
12	45	30	**75**	0.625	28.13	18.75	**46.88**	✓	✓	✓
13	48.75	32.5	**81.25**	0.625	30.47	20.31	**50.78**	×	×	✓
14	52.5	35	**87.5**	0.625	32.82	21.88	**54.7**	×	✓	✓
15	56.25	37.5	**93.75**	0.625	35.16	23.44	**58.6**	×	×	✓
16	60	40	**100**	0.625	37.5	25	**62.5**	✓	✓	✓
17	63.75	42.5	**106.25**	0.625	39.84	26.56	**66.4**	×	×	✓
18	67.5	45	**112.5**	0.625	42.19	28.13	**70.32**	×	✓	✓
19	71.25	47.5	**118.75**	0.625	44.53	29.69	**74.22**	×	×	✓
20	75	50	**125**	0.625	46.88	31.25	**78.13**	✓	✓	✓
21	78.75	52.5	**131.25**	0.625	49.22	32.81	**82.03**	×	×	✓
22	82.5	55	**137.5**	0.625	51.57	34.38	**85.95**	×	✓	✓
23	86.25	57.5	**143.75**	0.625	53.91	35.94	**89.85**	×	×	✓
24	90	60	**150**	0.625	56.25	37.5	**93.75**	✓	✓	✓
25	93.75	62.5	**156.25**	0.625	58.59	39.06	**97.65**	×	×	✓
26	97.5	65	**162.5**	0.625	60.94	40.63	**101.57**	×	✓	✓
27	101.25	67.5	**168.75**	0.625	63.28	42.19	**105.47**	×	×	✓
28	105	70	**175**	0.625	65.63	43.75	**109.38**	✓	✓	✓
29	108.75	72.5	**181.25**	0.625	67.97	45.31	**113.28**	×	×	✓
30	112.5	75	**187.5**	0.625	70.32	46.88	**117.2**	×	✓	✓
31	116.25	77.5	**193.75**	0.625	72.66	48.44	**121.1**	×	×	✓

32	120	80	**200**	0.625	75	50	**125**	✓	✓	✓
33	123.75	82.5	**206.25**	0.625	77.34	51.56	**128.9**	×	×	✓
34	127.5	85	**212.5**	0.625	79.69	53.13	**132.82**	×	✓	✓
35	131.25	87.5	**218.75**	0.625	82.03	54.69	**136.72**	×	×	✓
36	135	90	**225**	0.625	84.38	56.25	**140.63**	✓	✓	✓
37	138.75	92.5	**231.25**	0.625	86.72	57.81	**144.53**	×	×	✓
38	142.5	95	**237.5**	0.625	89.07	59.38	**148.45**	×	✓	✓
39	146.25	97.5	**243.75**	0.625	91.41	60.94	**152.35**	×	×	✓
40	150	100	**250**	0.625	93.75	62.5	**156.25**	✓	✓	✓
41	153.75	102.5	**256.25**	0.625	96.09	64.06	**160.15**	×	×	✓
42	157.5	105	**262.5**	0.625	98.44	65.63	**164.07**	×	✓	✓
43	161.25	107.5	**268.75**	0.625	100.78	67.19	**167.97**	×	×	✓
44	165	110	**275**	0.625	103.13	68.75	**171.88**	✓	✓	✓
45	168.75	112.5	**281.25**	0.625	105.47	70.31	**175.78**	×	×	✓
46	172.5	115	**287.5**	0.625	107.82	71.88	**179.7**	×	✓	✓
47	176.25	117.5	**293.75**	0.625	110.16	73.44	**183.6**	×	×	✓
48	180	120	**300**	0.625	112.5	75	**187.5**	✓	✓	✓
49	183.75	122.5	**306.25**	0.625	114.84	76.56	**191.4**	×	×	✓
50	187.5	125	**312.5**	0.625	117.19	78.13	**195.32**	×	✓	✓
51	191.25	127.5	**318.75**	0.625	119.53	79.69	**199.22**	×	×	✓
52	195	130	**325**	0.625	121.88	81.25	**203.13**	✓	✓	✓
53	198.75	132.5	**331.25**	0.625	124.22	82.81	**207.03**	×	×	✓
54	202.5	135	**337.5**	0.625	126.57	84.38	**210.95**	×	✓	✓
55	206.25	137.5	**343.75**	0.625	128.91	85.94	**214.85**	×	×	✓
56	210	140	**350**	0.625	131.25	87.5	**218.75**	✓	✓	✓
57	213.75	142.5	**356.25**	0.625	133.59	89.06	**222.65**	×	×	✓
58	217.5	145	**362.5**	0.625	135.94	90.63	**226.57**	×	✓	✓
59	221.25	147.5	**368.75**	0.625	138.28	92.19	**230.47**	×	×	✓
60	225	150	**375**	0.625	140.63	93.75	**234.38**	✓	✓	✓
61	228.75	152.5	**381.25**	0.625	142.97	95.31	**238.28**	×	×	✓
62	232.5	155	**387.5**	0.625	145.32	96.88	**242.2**	×	✓	✓
63	236.25	157.5	**393.75**	0.625	147.66	98.44	**246.1**	×	×	✓
64	240	160	**400**	0.625	150	100	**250**	✓	✓	✓

ADDITIONAL IMPEDANCE COMBINATIONS JAPANESE/KOREAN STANDARD:

No.	R_A [mΩ]	R_N [mΩ]	R_{total} [mΩ]	ratio X_{total} / R_{total}	X_A [mΩ]	X_N [mΩ]	X_{total} [mΩ]	
1	15	10	**25**	0.625	9.38	6.25	**15.63**	*= Fixed value*
2	35	180	**215**	0.625	34.37	8.33	**42.70**	
3	40		**40**	0.625	66.67	33.33	**100.00**	
4	330	350	**680**	0.625	251	142	**393**	*= Japanese/Korean standard values*

Note: When using the AIP xxx/P/JK version the additional JK impedance can be disabled. The remaining AIP impedance is then the adjusted IEC impedance value. The minimum impedance value is the fixed impedance value of the according AIP version.

TECHNICAL INFORMATION TYPES AIP xxx/3/P/TPM[6)]:

The AIP unit with Three Phase Measurement capability (TPM) reduces the total testing time for three-phase EUTs. Whilst the non TPM versions of AIP require a sequential phase by phase test, the TPM version enables the system to measure the EUTs phase lines simultaneously.
To perform an automated test it is strongly recommended to use also an ARS TPM version.

Pulse Generator
type CE – TESTER
3rd generation

The relating standards:
IEC/EN 61000-4-4
IEC/EN 61000-4-4

EMC-Test Equipment for
testing the immunity against :

BURST:
IEC/EN 61000-4-4

and

SURGE:
IEC/EN 61000-4-5

The CE-TESTER and its sub-units are available in different configurations:
CE-TESTER 1
including SURGE and BURST

CE-TESTER 2
including SURGE, BURST and POWER FAIL SWITCH

EFTG 4510 Standalone BURST generator

CE-SURGE Standalone SURGE generator

Typical configurations:
CE-TESTER 1 +CDN 4416 for 3-phase testing
CE-TESTER 2 +VPS 250-16 for testing surge, burst, power fail, voltage dips and variation

It is possible to build all devices in a 19" rack cabinet.

The CE-TESTER is a compact EMC test unit designed for testing electromagnetic immunity against pulsed and conducted interference. Demonstrating such immunity is generally a requirement for compliance with the European EMC directive, a necessary step leading to the CE mark.

In its basic configuration, the CE-TESTER includes an Electrical Fast Transient Generator (EFTG), a Combination Wave Generator (CWG) and a Coupling-/Decoupling Network (CDN) for single-phase power supply lines.

The Electrical Fast Transient Generator fully compliant to the IEC/EN 61000-4-4, delivers fast transient pulses with waveform 5/50 ns and a maximum burst frequency of 1MHz. It is used for immunity testing of electronic systems and devices. The four standard IEC/EN 61000-4-4 test levels may be easily selected by push button or all parameters may be adjusted individually.

The Combination Wave Generator fully compliant to IEC 61000-4-5 and IEEE 587 delivers a standard impulse voltage with waveform 1.2/50 @s and a standard impulse current with waveform 8/20 @s. It is a combined impulse-current-/impulse-voltage generator for high impedance loads RL > 100 and may be used for surge testing of components and devices, as well as for galvanic coupling of surges to cable shields, shielded enclosures and cabinets.

The built-in capacitive Coupling-/Decoupling Network allows superimposition of the combination wave generator output to the mains voltage of the device under test.

The simulation of voltage dips and voltage variations acc. to IEC/EN 61000-4-11 can be included as an option. Additional accessories allow the testing of immunity against both pulsed and power frequency magnetic fields according to IEC/EN 61000-4-8 and IEC/EN 61000-4-9.

Optionally the CE-TESTER can include a triggerable power supply switch which allows the simulation of the voltage dips as specified in the standard IEC/EN 61000-4-11. The variation of power supply voltage is controlled by use of an external motor driven variac. The control of the external power source is included in the mainframe.

An Induction Coil in conjunction with the Combination Wave Generator output, is used to simulate pulsed magnetic fields according to IEC/EN 61000-4-9. Combined with the external power source, the Induction Coil can be used to simulate power frequency magnetic fields according to IEC/EN 61000-4-8.

Additional Coupling-/Decoupling Networks covering three-phase power supply lines, DC supply lines and signal lines are also available, as well as a Capacitive Coupling Clamp for coupling to shielded interconnection lines.

The CE-TESTER excels by its compact design, simple handling and precise reproducibility of test impulses. It features a microprocessor controlled user interface and a 5” touch screen unit for ease of use. The microprocessor allows the user to execute either standard test routines or a “user defined” test sequence. A standard USB port provides the ability to print a summary of the test parameters to a USB stick.

The software program CE-REMOTE allows full remote control of the test generator via Ethernet light guide as well as documentation and evaluation of test results, accordingly to the IEC 17025. To record definite impulses, it is equipped with an Impulse Recording Function (IRF)

Moreover all generator functions including the built-in Coupling-/Decoupling Network, may be computer controlled via the isolated optical interface.

SPITZENBERGER SPIES

TECHNICAL DATA CE-TESTER

Control:	Microprocessor control, touch panel 5”,	800X480, 24 bit
	Optical Ethernet interface for generator remote control	optional
	Interface for saving reports	USB
	External trigger input / output	10V at 1kΩ
	Connector for external safety interlock loop	$24V_{DC}$
	Connector for external red and green warning lamps according to VDE 0104	230V, 60W
	Coupling-/decoupling network for power supply lines	L1, N, PE
	Nominal voltage, nominal current	250 V, 16 A ≈ / 10 A =
	Coupling impedance (depending on the generator)	33 nF / 18 @F / 9@F+10
	Mains power	230V, 50Hz/60Hz
Housing:	Plug in unit, 7U	
	Dimensions (mm): W * H * D	450*185*500
	Weight	25kg
Burst:	acc. to IEC/EN 61000-4-4: 2011	
	Pulse output voltage, adjustable	0.2 - 5.0 KV ± 10 %
	Waveform	5/50 ns
	Source impedance	50Ω
	Polarity, selectable	pos/neg/alt
	Burst frequency, adjustable	1.0 kHz - 1.0 MHz
	Burst duration, adjustable	0,01 ms - 25 ms
	Burst repetition rate, adjustable	10 ms - 1000 ms
	HV output for external coupling devices coaxial	
	Monitor output for pulse output voltage ratio	100:1 ± 5%, 50Ω
Surge:	acc. to IEC/EN 61000-4-5: 2007	
	Test voltage (open circuit condition)	0.2 – 5.0 kV ± 10 %
	Waveform acc. to IEC 60060 1.2 / 50 @s ± 20 %	
	Test current (short circuit condition)	0.1 - 2.25 kA ± 10 %
	Waveform acc. to IEC 60060 8 / 20 @s ± 20%	
	Polarity of output voltage/current, selectable	pos/neg/alt
	Maximum stored energy	120 J
	Charging time for max. charging voltage	< 10 s
	HV output isolated from ground HV-OUT	4mm
	Mains synchronous triggering, phase shifting, digitally selectable	0 - 359°, step 1°
	Monitor output for pulse output voltage ratio	1000 : 1 ± 5%
	Monitor output for pulse output current 10 V	5 kA ± 5%
	Option: Software CE-REMOTE Test, for remote control With Impulse Recording Function (IRF) (XP, WIN7) incl. 5 m fibre optic cable and PC Ethernet interface	

Practical measurements and IEC/EN 61000-4-11

- rise and fall time during short-circuits at different places of a supply installation

The relating standards:
IEC/EN 61000-4-11
IEC/EN 61000-2-8

The part IEC/EN 61000-4-11 of the international IEC/EN 61000 series standards defines test methods for immunity testing and test levels for voltage drops, short interruptions and voltage variations. The standard is applicable for devices intended to be connected to the public low power distribution network. The generation of voltage drops the IEC/EN 61000-4-11 specifies and requires a voltage source with a rise- and fall-time of 1-5µs at 100Ω load.
At a nominal voltage of 230V this means: 230V_{eff}/µs up to 46V_{eff}/µs (=325V/µs up to 65V/µs).

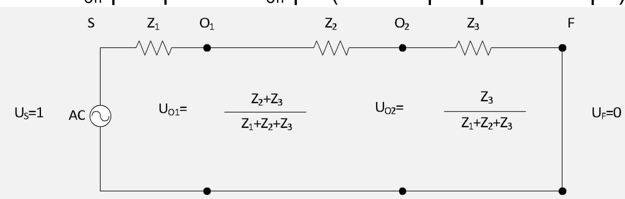


Fig. 1: Equivalent circuit for voltage drops acc. to IEC/EN 61000-2-8

The basics about the arising, the effects, remedial actions measuring methods and measurement results of devices to be tested according to IEC/EN 61000-4-11 are defined in the IEC/TR 61000-2-8 Ed. 1.0. The disturbances are described as phenomena appearing on public low voltage supply networks and having influence on devices connected to this public grid. This document shall demonstrate, that practically the rise- and fall-times of the supply voltage are in the range of 1-5µs (as described in the IEC/EN 61000-4-11 in the chapter A2: requirements of the voltage source).
One of the main reasons for voltage dips and short interruptions on the public supply network are electric short-circuits occurring on any point of the supplying grid.

Output voltage at no load: ± 5% of the residual voltage value	
Voltage change with load at the output of the generator:	
100% output, 0A to 16A *80% output, 0A to 20A* *70% output, 0A to 23A* *40% output, 0A to 40A*	*< 5% U_T* *< 5% U_T* *< 5% U_T* *< 5% U_T*
Output current capability: *16A_{rms} per phase at U_{rated}.* *The generator must be able to deliver:*	*20A at 80% U_{rated}, for 5s* *23A at 70% U_{rated}, for 3s* *40A at 40% U_{rated}, for 3s*
Peak inrush current capability: *Not to be limited by the generator*	*Max. 1000A for 250-600V mains* *Max. 500A for 200-240V mains* *Max. 250A for 100-120V mains*
Instantaneous peak overshoot/ undershoot of the actual voltage	*< 5% U_T* *Generator loaded with 100Ω resistive load*
Voltage rise (and fall) time t_r (and t_f) during abrupt change	*Between 1µs and 5µs* *Generator loaded with 100Ω resistive load*
Phase shifting:	*0°-360°*
Phase relationship of voltage dips and interruptions with the power frequency	*<± 10°*
Zero crossing control of the generator:	*± 10°*
Output impedance	*Predominatly resistive < (0,4+j0,25)Ω* *Even during transitions*

Table 1: Requirements of the testing voltage source acc. to IEC/EN 61000-4-11

In electrical systems short circuits cannot be avoided at all. The amplitude of a voltage drop depends on the distance between monitoring point, short-circuit point and supplying source. This relation is shown in Fig. 2. To meet the practical values described in the technical report IEC/TR the requirements of the testing voltage source of the IEC/EN 61000-4-11 are well defined in table 1.

The theoretical values for rise- and fall-time can be calculated by simulation software. For this simulation the parameters for the cable length must be calculated. The definition of the equivalent circuit was given as a short circuit at the load, at the local grid entry point and within the local grid.

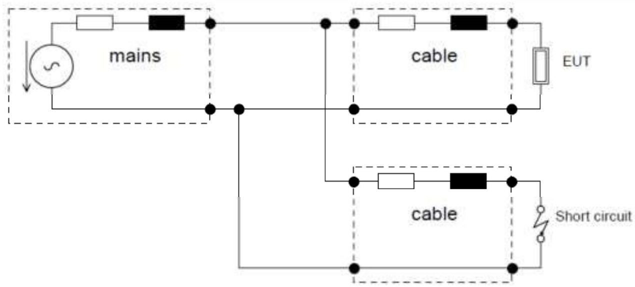


Fig. 2: Equivalent circuit diagram for short circuit in the supply line

The base impedance for the simulation is the mains reference impedance defined in the IEC/EN 61000-3-3 with 0,4+j0,25 Ohm. The simulation performed the characteristic of a resistive load with 16A nominal current at a nearby (20m) occurring short circuit (with a cable diameter 1,5mm²).

The rise- and fall-times of the supplying voltage at short circuit are shown in Fig. 3. And Fig. 4.

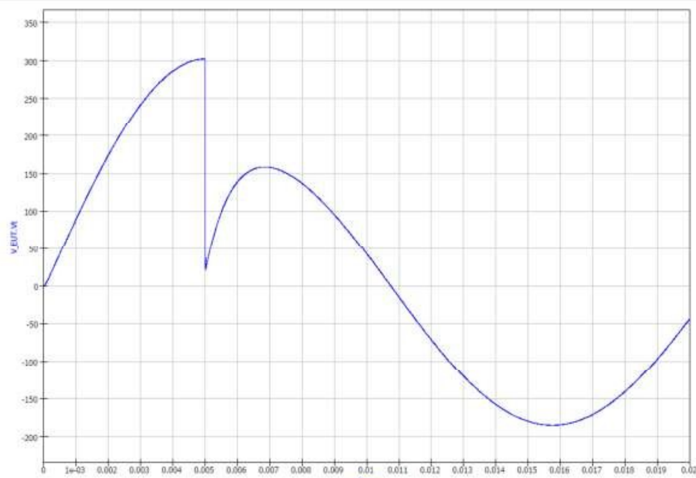


Fig. 3: Voltage characteristic during simulation (1ms/DIV)

In Fig. 4 (higher resolution in the time base) the fall-time of the supplying voltage can be seen in a range of 5µs.

To verify the simulated values with the rise- and fall-time of the reality several practical measurements have been performed.

The measurement results were then compared with the simulation results.

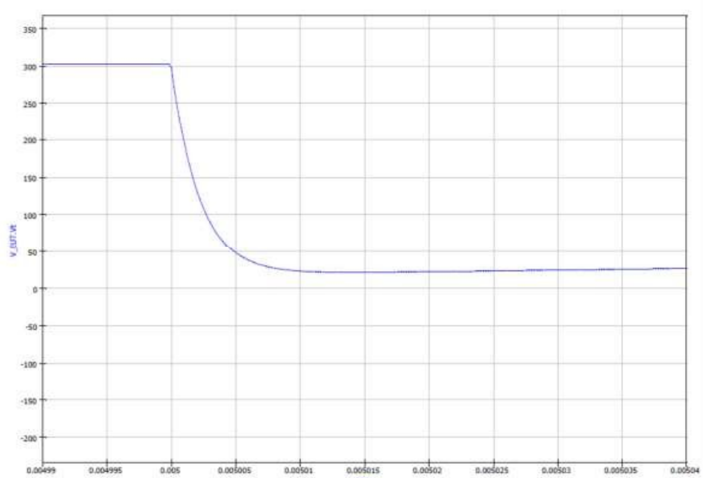


Fig. 4: Voltage characteristic during simulation (5µs/DIV)

PRACTICAL SHORT CIRCUIT MEASUREMENTS

To investigate the real occurring rise- and fall-times several practical measurements have been performed. The electrical installation of an existing building was provided. At two points of the installation a laboratory bench was set up. The installation of the building can be described with the following equivalent circuit diagram which was verified through a practical measurement of the installation of the building:

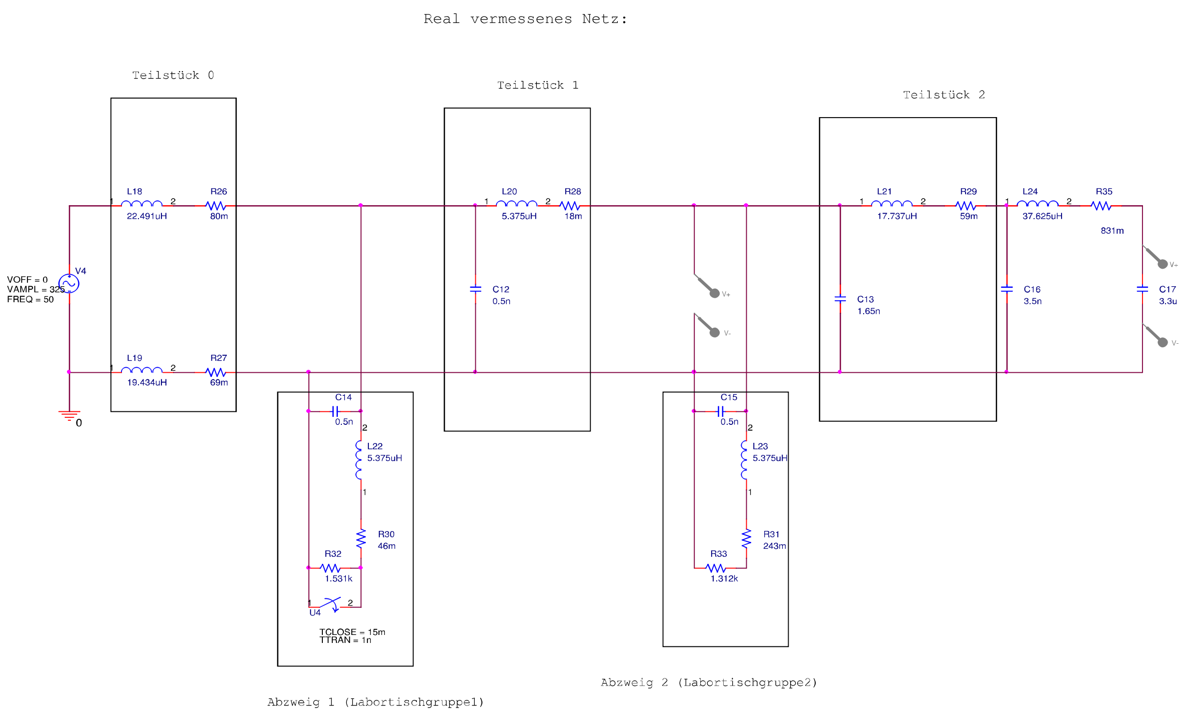


Fig. 5: Equivalent circuit of the building installation

The equivalent circuit shows three parts of the installation (“Teilstück 0-2”) and the two workbench connections (“Abzweig 1/2"). The input voltage source is an ideal source with 230V nominal voltage at 50Hz. The parts “Teilstück 1”, “Teilstück 2” and “Teilstück 3” are representing three parts of the current bar. The workbenches are connected with a supply cable with a length of 5m. Different EUT’s were connected to the end of “Teilstück 2” with a supply cable of 35m length.

The inductive and capacitive parameters of the cabling system were determined using the technical report *„Simulation of short circuit on different places and influences on rise time“* of Mr.Lutz, *Fa. EMC Partner AG* as follows:

$$L_{line} := 1.075 \frac{\mu H}{m}$$

$$C_{line} := 0.75 \frac{\mu H}{m}$$

The serial impedances of the single cable parts were calculated through loading and measuring the voltage drop over the cable length.

Practical measurement 1:
Short circuit between L2 and N
without load
Measurement between
L2 and N

Voltage curve at point 1
fall-time approx. 200V/µs

Voltage curve at point 2
fall-time approx. 300V/µs

Voltage curve at the end of the line
fall-time approx. 300V/µs

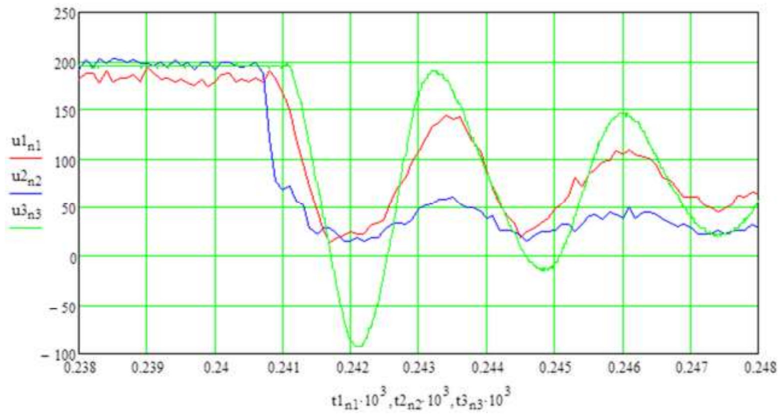


Fig. 6: Voltage curve at short circuit measurement 1 (5ms/DIV)

Detailed view:
Resolution 1µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

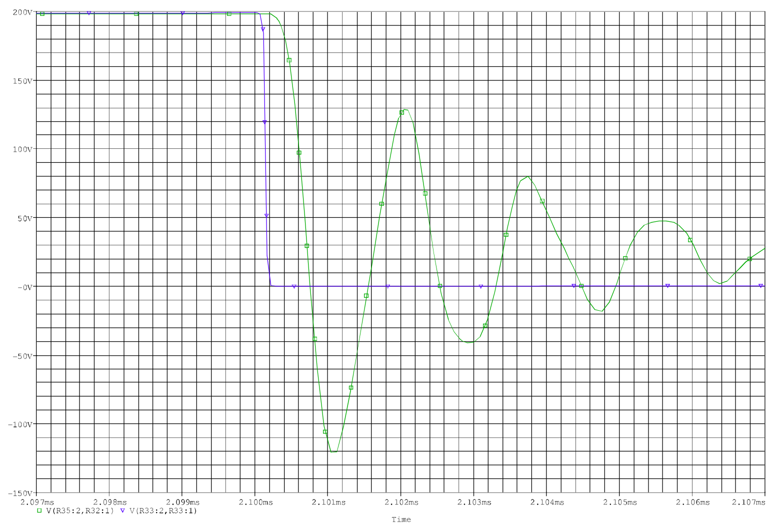


Fig. 7: Voltage curve at short circuit measurement 1 (1µs/DIV)

Detailed view:
Resolution 500µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

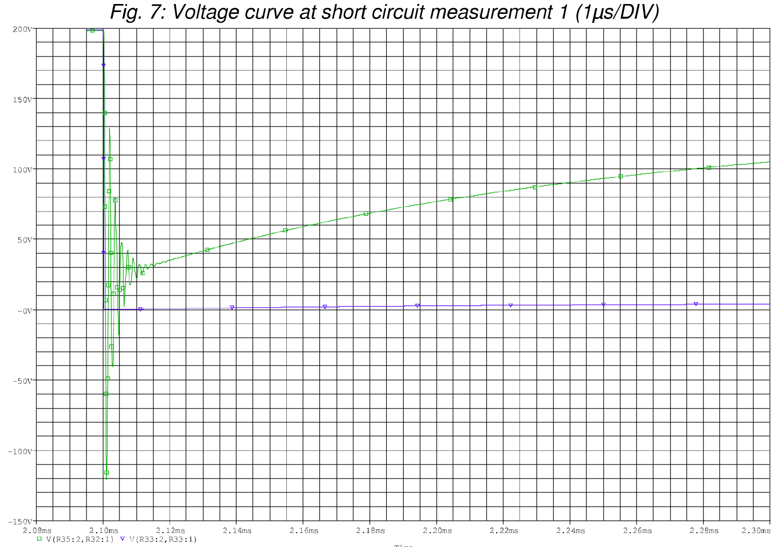


Fig. 8: Voltage curve at short circuit measurement 1 (500µs/DIV)

<u>Practical measurement 2:</u>

Short circuit between L2 and N
with 600W rectifier load
Measurement between
L2 and N

Voltage curve at point 1
fall-time approx. 300V/µs

Voltage curve at point 2
fall-time approx. 600V/µs

Voltage curve at the end of the line
fall-time approx. 350V/µs

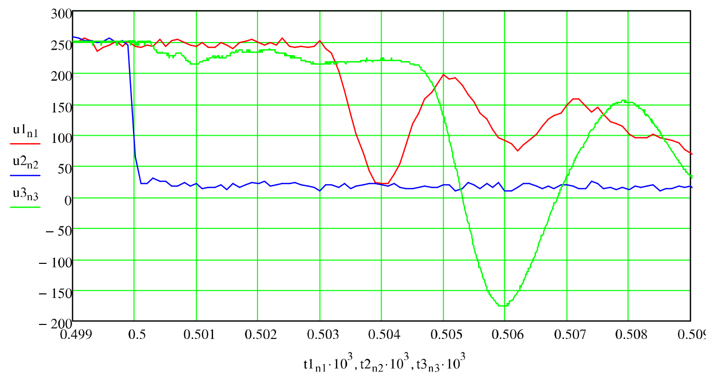


Fig. 9: Voltage curve at short circuit measurement 2 (5ms/DIV)

Practical measurement 3:

Short circuit between L2 and N
with 0,1uF//268Ω load
Measurement between
L2 and N

Voltage curve at point 1
fall-time approx. 300V/µs

Voltage curve at point 2
fall-time approx. 800V/µs

Voltage curve at the end of the line
fall-time approx. 65V/µs

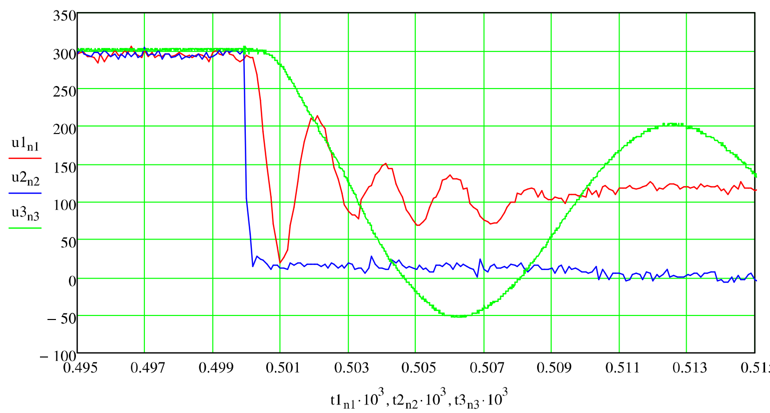


Fig. 10: Voltage curve at short circuit measurement 3 (5ms/DIV)

Detailed view:
Resolution 0,5µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

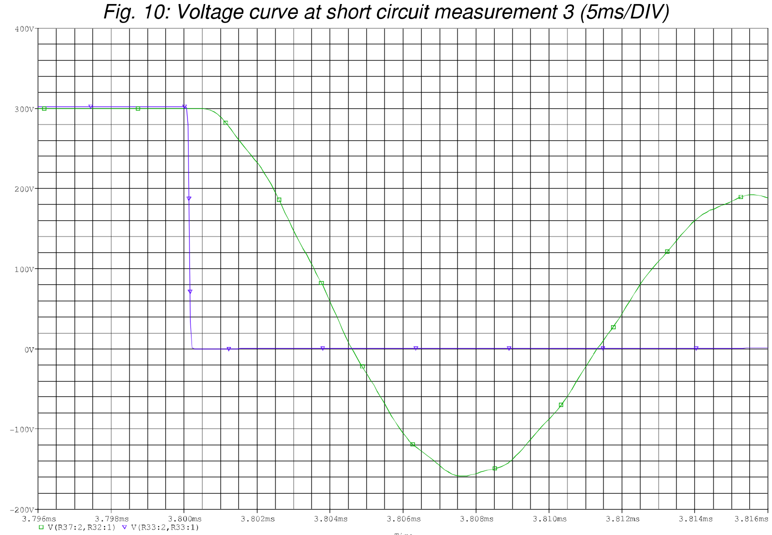


Fig. 11: Voltage curve at short circuit measurement 3 (0,5µs/DIV)

Detailed view:
Resolution 500µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

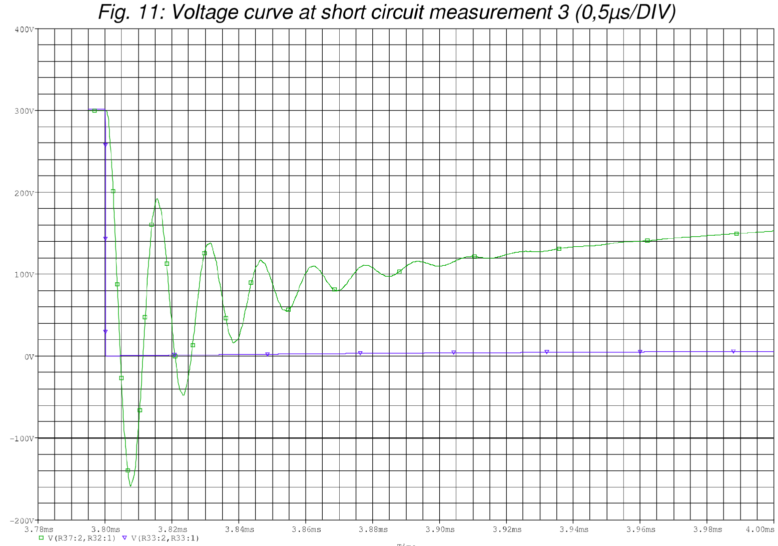


Fig. 12: Voltage curve at short circuit measurement 3 (500µs/DIV)

<u>Practical measurement 4:</u>
Short circuit between L2 and N
with 1uF in series 16,5Ω load
Measurement between
L2 and N

Voltage curve at point 2
fall-time approx. 2000V/µs

Voltage curve at the end of the line
fall-time approx. 40V/µs

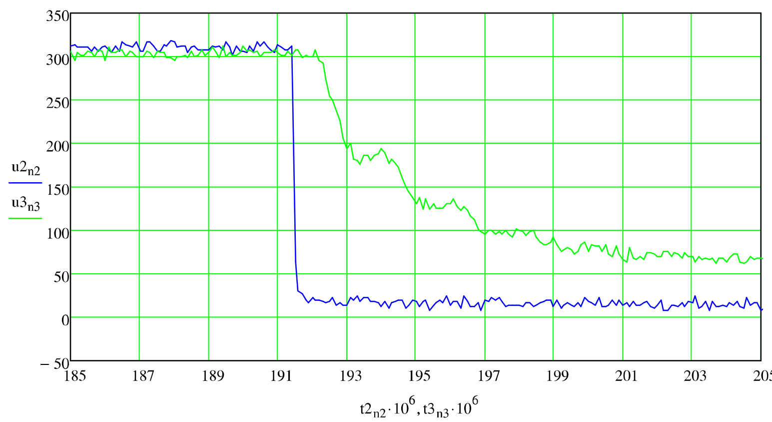


Fig. 13: Voltage curve at short circuit measurement 4 (5ms/DIV)

Detailed view:
Resolution 0,5µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

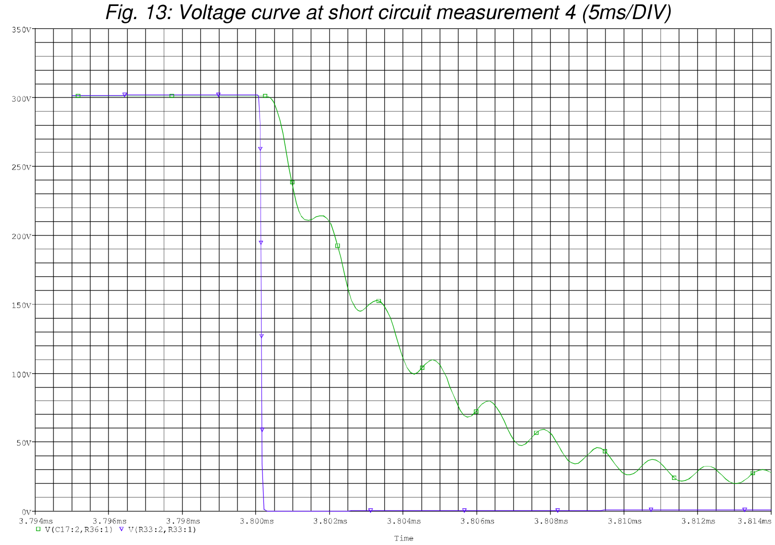


Fig. 14: Voltage curve at short circuit measurement 4 (0,5µs/DIV)

Detailed view:
Resolution 500µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

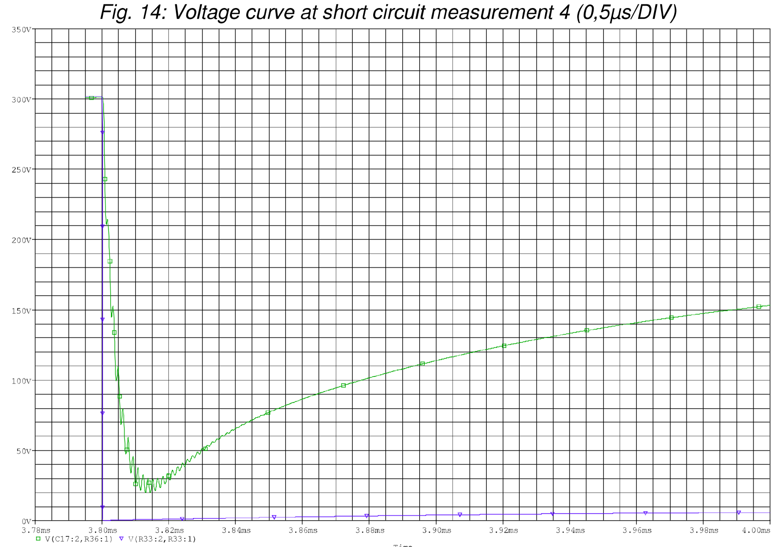


Fig. 15: Voltage curve at short circuit measurement 4 (500µs/DIV)

Practical measurement 5:

Short circuit between L2 and N
with 0,1uF in series 16,5Ω load
Measurement between
L2 and N

Voltage curve at point 2
fall-time approx. 2000V/µs

Voltage curve at the end of the line
fall-time approx. 40V/µs

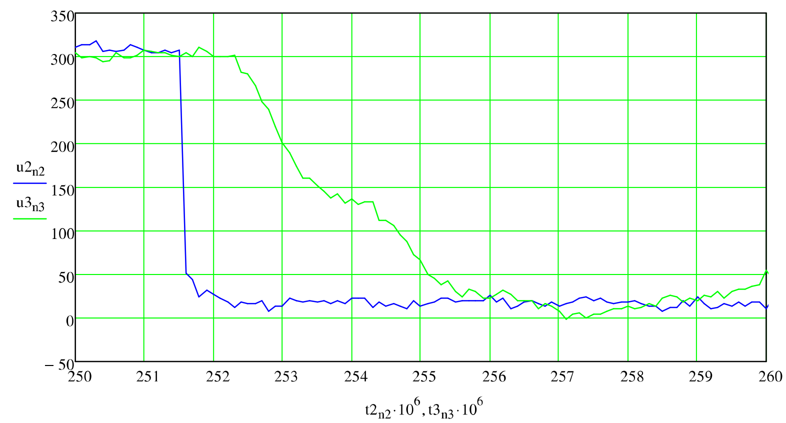


Fig. 16: Voltage curve at short circuit measurement 5 (5ms/DIV)

Detailed view:
Resolution 0,2µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

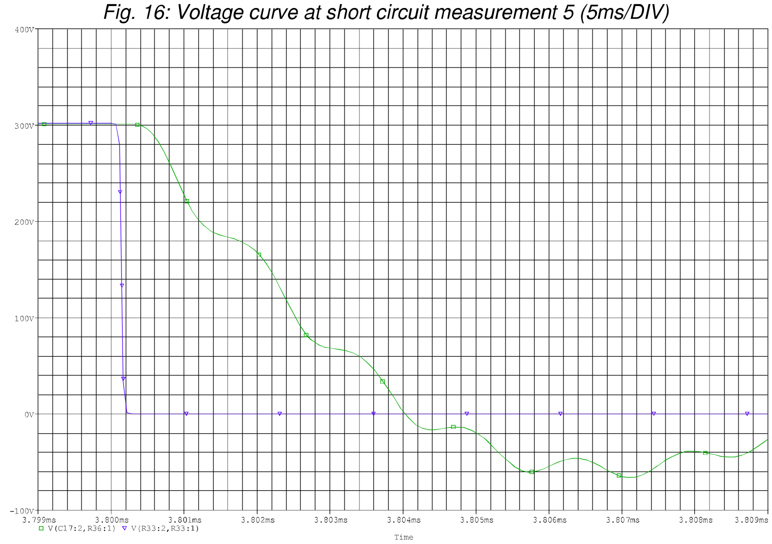


Fig. 17: Voltage curve at short circuit measurement 5 (0,2µs/DIV)

Detailed view:
Resolution 500µs/DIV

Voltage curve at point 2

Voltage curve at the end of the line

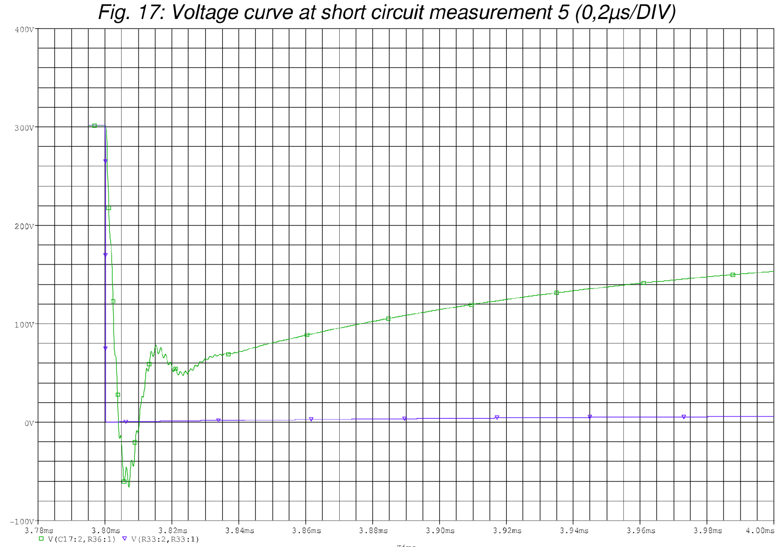


Fig. 18: Voltage curve at short circuit measurement 5 (500µs/DIV)

Practical measurement 6:

Short circuit between L2 and N
Measurement between
L1 and N

Voltage curve at point 1
fall-time approx. 10V/µs

Voltage curve at point 2
fall-time approx. 180V/µs

Voltage curve at the end of the line
fall-time approx. 15V/µs

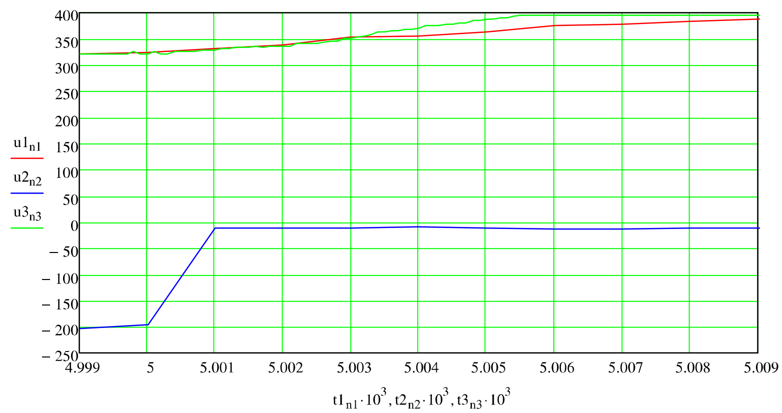


Fig. 19: Voltage curve at short circuit measurement 6 (5ms/DIV)

Practical measurement 7:

Short circuit between L1 and L2
with 0,1uF//268Ω load
Measurement between
L2 and N

Voltage curve at point 1
fall-time approx. 200V/µs

Voltage curve at point 2
fall-time approx. 300V/µs

Voltage curve at the end of the line
fall-time approx. 30V/µs

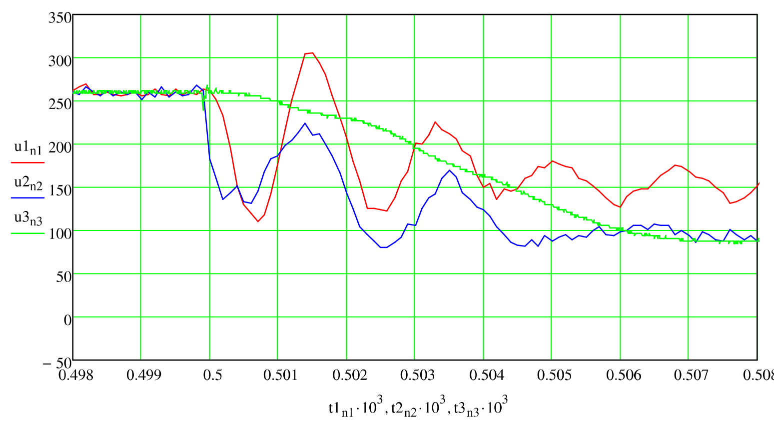


Fig. 20: Voltage curve at short circuit measurement 7 (5ms/DIV)

CONCLUSION:

These practical measurements are showing clearly:

1. The nearer the short-circuit appears, so much faster are rise- and fall-times.
2. Directly at the short circuit rise- and fall-times are faster than 1us.
3. Depending on the load and the distance to the short-circuit different rise- and fall-times can be measured, but all of them are between 1-5us.

In comparison between simulation and measurement data we can see, that simulation and reality are very close together.

„The definitions given in the IEC/EN 61000-4-11 of the preferred voltage source are eminent important to perform realistic test cycles.“

Comparison measurement of various measurement systems - Round Robin test „Measurement uncertainty“ of the DKE

The standards
IEC/EN 61000-3-2
IEC/EN 61000-4-7

Some years ago, it was found that there was a great variation in the measurement results obtained from various test systems when performing tests in accordance with the standard IEC/EN 61000-3-2. Deviations of up to 100% were apparent, although the standard defines a measurement accuracy of 5%. As a direct result, the German national (DKE) founded the “measurement uncertainty” working group to investigate this problem.

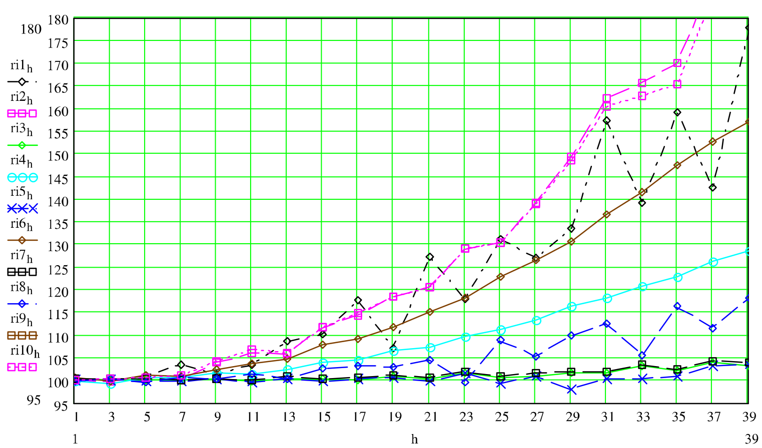
The members of the working group agreed to commence an inter-laboratory test, with the aim of establishing the reason for the variation in the measurement results. Several measurement laboratories, and companies, participated in the inter-laboratory test. The participants received two different rectifier circuits, each of which was assembled from very precise and accurately measured components. Each participant then carried out a series of measurements in accordance with the standard IEC/EN 61000-3-2.

The results of Round Robin test 1:

The results confirmed that the measuring devices (harmonic analyser) produced more or less acceptable measurement results. Comparison showed that the various sources (amplifiers) caused the greatest deviations. Now, the behaviour of these precisely constructed and measured test specimens could also be characterised by various simulation methods. Therefore an exact FFT analysis was conducted, by way of calculation, utilising PSpice. As a result, the precise behaviour of these test specimen candidates was thus defined.

Pic 1 compares the measured data with the theoretical data (100%). The higher the harmonic order, the bigger is the deviation of several measurement systems and therefore the measurement uncertainty. Deviations of more than 80% are clearly shown in Pic 1. A source from another manufacturer even had a deviation of up to 90%.

Pic 1 Deviation of the theoretical data (theory= 100% - deviation of 50%=150%)



ri1-ri10 = measurement of the laboratories / h = harmonic number

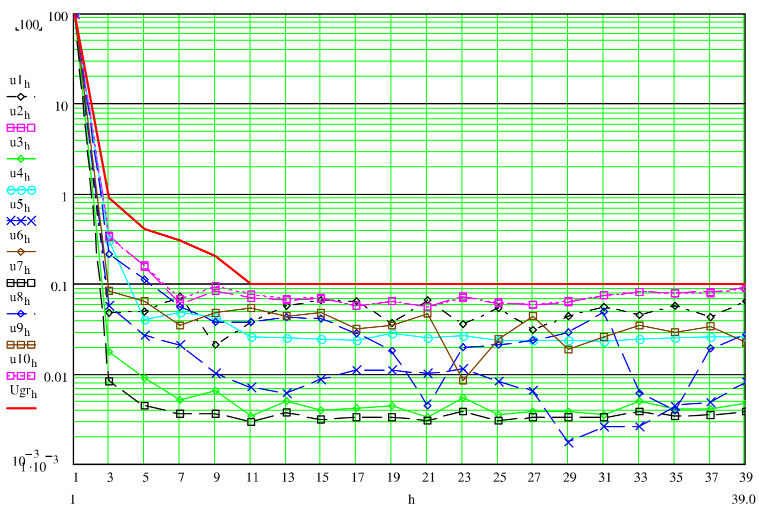
The results of the second Round Robin test:

A second inter-laboratory test was started. The harmonics of the supplied test specimen were adjusted to the result of class A in the range of approx. 13th up to the 39th harmonic. Furthermore, various real-life test specimens (e.g. a TV-set, various lamps etc.) were also measured in the second test for comparison purposes. Again, the measurements were performed according to the standard IEC/EN 61000-3-2.

During both the first and second inter-laboratory tests, most of the laboratories also measured the harmonics of the voltage (see pictures 2 and 3). Analyzing the voltage harmonic data, it was noticeable that the measurement data of the test equipment with the closest correlation to the simulation analysis also produced the smallest voltage harmonics. Comparing the simulation data with the actual measurement data of those test equipment units showed that the measurement results of these devices were within the 5% limit (actual was within approx. 4%).

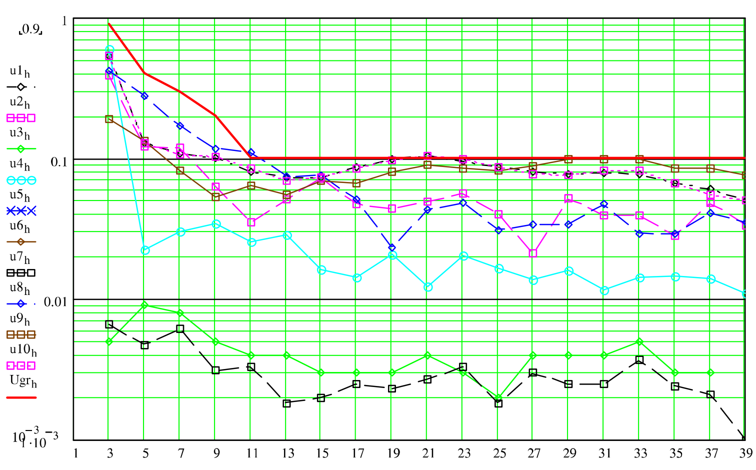
These devices were a test system owned by VDE, which had been completely designed and manufactured by Spitzenberger & Spies, and a test system used at the production plant of Spitzenberger & Spies. Some other test systems including those with a source made by Spitzenberger + Spies (but with measurement devices from other manufacturers), turned out to have slight deviations but to be acceptable compared to other sources.

Pic 2 voltage source harmonics caused by the 600W test specimen



n7 and n3 (VDE and SPS) always had the lowest harmonic voltage distortion.

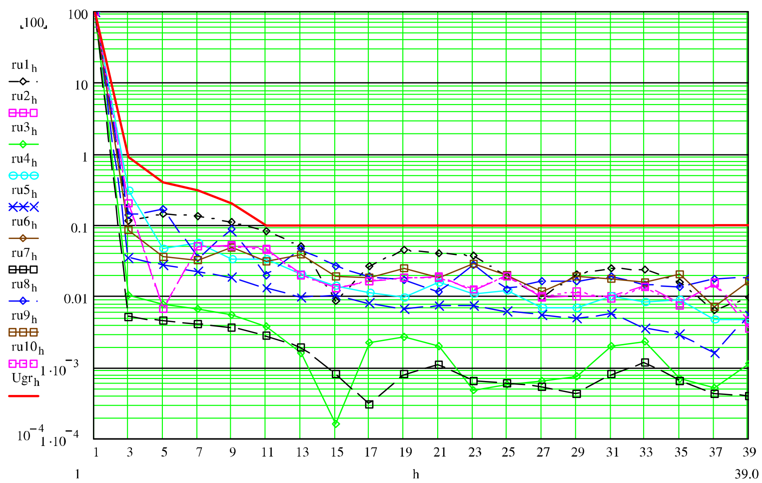
Pic 3 voltage source harmonics caused by the 44W test specimen



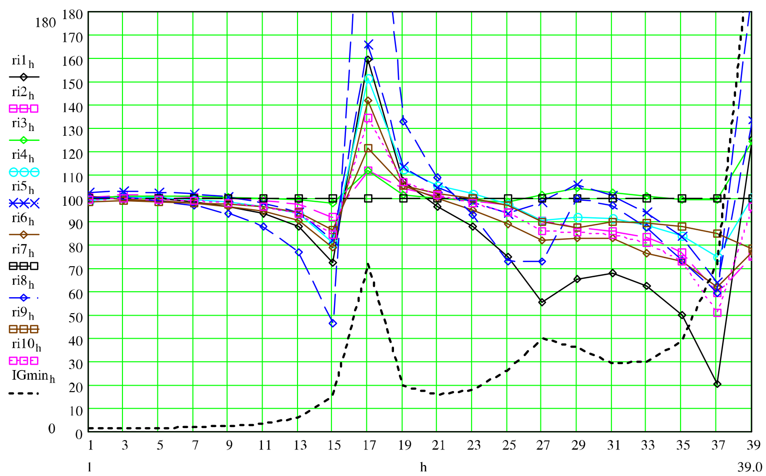
In spite of the little load of 44W some of the sources are at the harmonic limits.

The PAS-power source reaches only 3,5% of the maximum limit.

The voltage harmonic currents of the Spitzenberger & Spies PAS sources were more than 30-100 times better than specified in the relevant standards. A similar result was measured when testing other EUT's like TV-Set's (see Pic 4). Also here the PAS sources had a voltage harmonic distortion much less than requested according to IEC/EN 61000-3-2.



Pic 4: voltage harmonics, Pic 5: current harmonics of the TV Set



Taking the source with the lowest harmonic voltage content (ru7 = VDE-PAS)as a reference, a comparison of measurement uncertainty can be shown in Pic 5. The VDE-PAS System (ri7) measurement uncertainty defines the reference line (100%). All other measurement systems have a more or less extremely high deviation from the 100% reference value.

Round Robin test Result:

Spitzenberger & Spies
Basic EMC System

Fully compliant as a standard

The comparison measurement with various measurement systems and three verifiable reference test specimen showed that there are very high deviations when using various sources. Only the test systems with PAS-series sources from Spitzenberger & Spies are able to keep within the defined 5% limits. In most of the other cases, the use of unsuitable sources is generating additional harmonics. However, the opposite result is possible. This causes incorrect measurement results. Specific sources (e.g. switching amplifiers) cause extremely large errors; comparison measurements conducted directly from the utility AC supply hardly resulted in worse values.

The aim of conducting tests in accordance to a published standard is to obtain accurate and repeatable measurement results. Inaccurate measurements may cause very high costs - once as a result of over-engineering and again by the loss of the CE-mark**.**