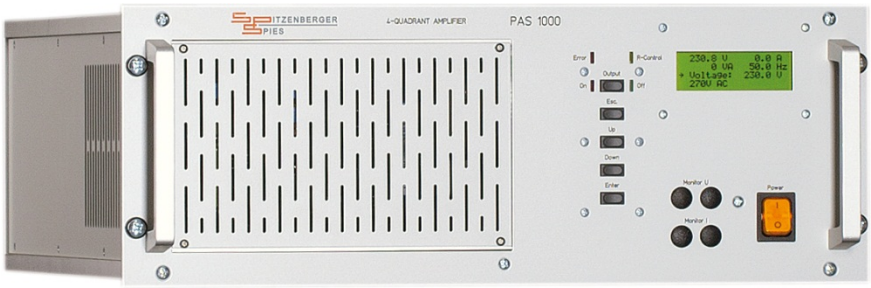
PAS series of 4-Quadrant Amplifiers

THE REAL 4-QUADRANT AMPLIFIER



The relating standards:
IEC/EN 61000-3-2
IEC/EN 61000-3-3
IEC/EN 61000-3-11
IEC/EN 61000-3-12
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

- ✓ 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

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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 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 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 international 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.

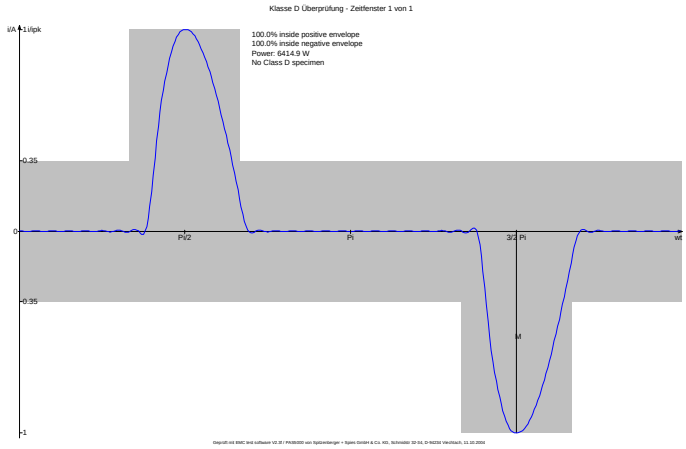

Fig. 1: Input current (41A$_{rms}$/106A$_{p}$) of the EUT

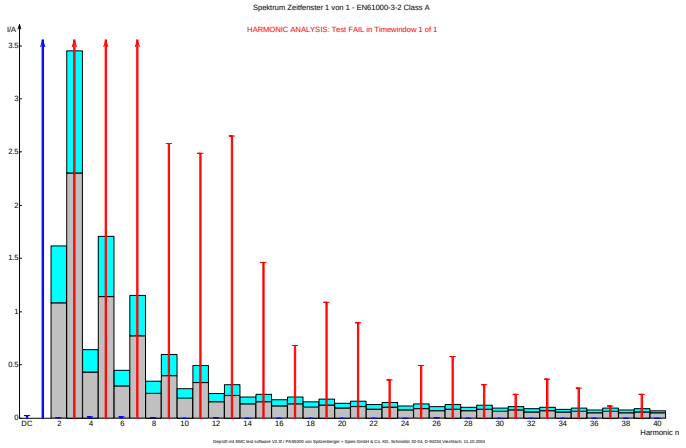

Fig. 2: Frequency spectrum of the EUT

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Fig. 5: Grid Simulator PAS 5000

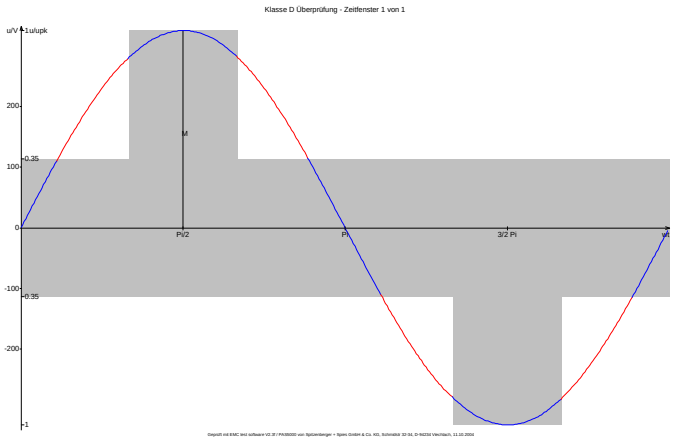

Fig. 3: Output voltage of the voltage source (PAS 5000)

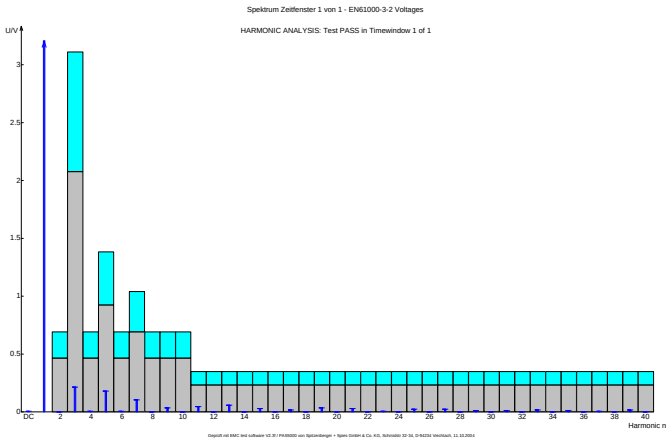

Fig. 4: Frequency spectrum of the voltage source (PAS 5000)

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

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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.

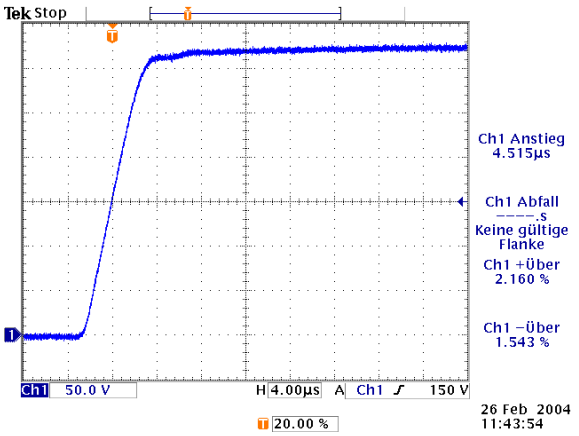

Fig. 7: rise time of the output voltage

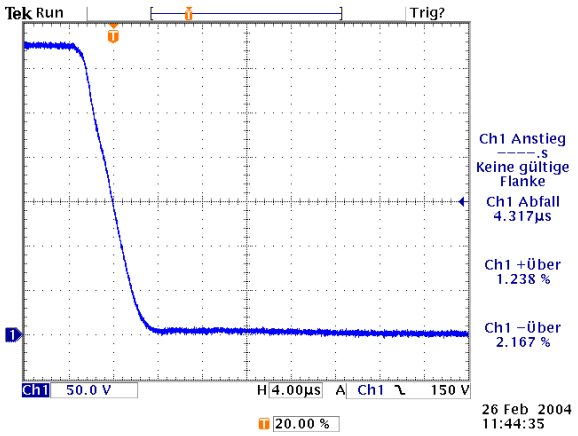

Fig. 8: fall time of the output voltage

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.

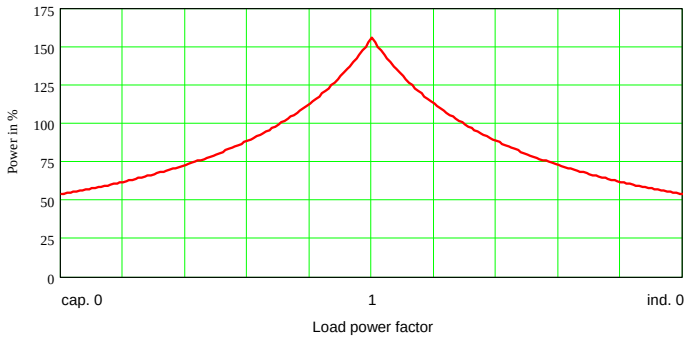

Fig. 9: PAS Performance characteristic

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.

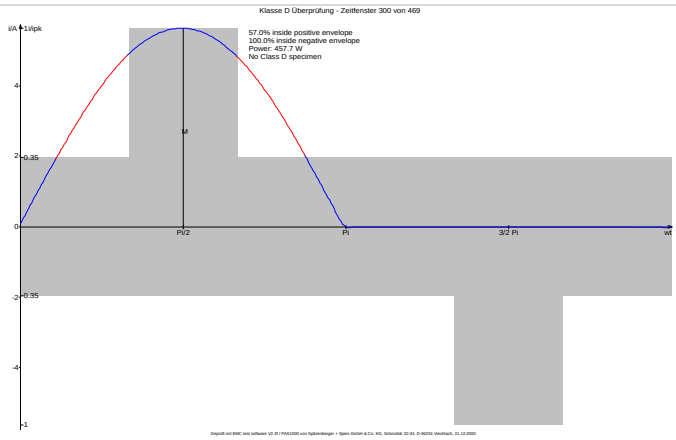

Fig. 10: PAS DC Characteristic

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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		< $1.5x10^{-4}$ 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*

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			PAS 1000	PAS 2500	PAS 5000
Power AC [1) 9)]		*- continuous:*	1000VA	2500VA	5000VA
		- approx. 1h:	1500VA	3750VA	7500VA
Power DC [2) 9)]		*- continuous:*	1000W	2500W	5000W
		- approx. 1h:	1500W	3750W	7500W
Short-time power [1) 3) 9)]			2000VA	5000VA	10000VA
Peak power [1) 4) 9)]		*- at 135V:*	3200VA$_p$	10500VA$_p$	21000VA$_p$
		- at 270V:	6400VA$_p$	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%, 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 (mm):	178x483x600	222x483x600	311x483x600
		Power Supply:	included	19”, 5U	19” 5U
		approx. dimensions (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)]	300V$_{rms}$
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

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		PAS 7500	PAS 10000	PAS 15000
Power AC [1) 9)]	*- continuous:*	7500VA	10000VA	15000VA
	- approx. 1h:	11250VA	15000VA	22500VA
Power DC [2) 9)]	*- continuous:*	7500W	10000W	15000W
	- approx. 1h:	11250W	15000W	22500W
Short-time power [1) 3) 9)]		15000VA	20000VA	30000VA
Peak power [1) 4) 9)]	*- at 135V:*	31500VA_p	43750VA_p	70000VA_p
	- at 270V:	63000VA_p	87500VA_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 *(±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 (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.):	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)]	300V_{rms}
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

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		PAS 20000	PAS 25000	PAS 30000
Power AC [1) 9)]	*- continuous:*	20000VA	25000VA	30000VA
	- approx. 1h:	30000VA	37500VA	45000VA
Power DC [2) 9)]	*- continuous:*	20000W	25000W	30000W
	- approx. 1h:	30000W	37500W	45000W
Short-time power [1) 3) 9)]		40000VA	50000VA	60000VA
Peak power [1) 4) 9)]	*- at 135V:*	100000VA_p	115000VA_p	126000VA_p
	- at 270V:	200000VA_p	230000VA_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 *(±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 (mm):	1467x483x600	1733x483x600	2042x483x600
	Power Supply:	19”, 2x12U	19”, 2x12U	19”, 2x12U
	approx. dimensions (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)]	300V_{rms}
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

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			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 *(±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 (mm):	On request	On request	On request
		Power Supply:	On request	On request	On request
		approx. dimensions (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} (±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)]		300V_{rms}		
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		

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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.

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