APS series of 4-quadrant amplifiers

4-QUADRANT VOLTAGE / CURRENT AMPLIFIER

4-quadrant amplifier APS 1000

- ✓ Very high peak-load ability (up to 2 … 3 ms)
- ✓ Very low internal resistance
- ✓ Very fast slew rate > 52 V/µs (rise time < 5 µs at 230 V acc. IEC/EN 61000-4-11)
- ✓ Extremely low harmonic distortion - even under very non-linear load conditions
- ✓ Operates from DC up to 10 kHz large signal bandwidth (-3 dB) - optional up to 30 kHz
- ✓ Small signal bandwidth up to 50 kHz
- ✓ High long-term overload characteristic (up to 1 hour)
- ✓ High short-term overload characteristic (up to 2 minutes)
- ✓ Constant voltage (CV) or constant current (CC) operation mode
- ✓ Multi-source operation modes: parallel / serial
- ✓ Optical link for easy PHIL interface
- ✓ Internal oscilloscope
- ✓ Amplifier control via webinterface and interface commands
- ✓ Test and evaluation software available

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 61000-4-8
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
RTCA DO-160
SEMI F47-0706
IEC TR 61547-1
German. Lloyd

***** *The APS series of amplifiers can be used for certain tests within these standards. Additional equipment might be required. For detailed information, please contact sales@spitzenberger.de.*

VOLTAGE AND CURRENT MODE OPERATION
REFERENCE SOURCE FOR ALL APPLICATIONS

Very fast rise and fall time

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

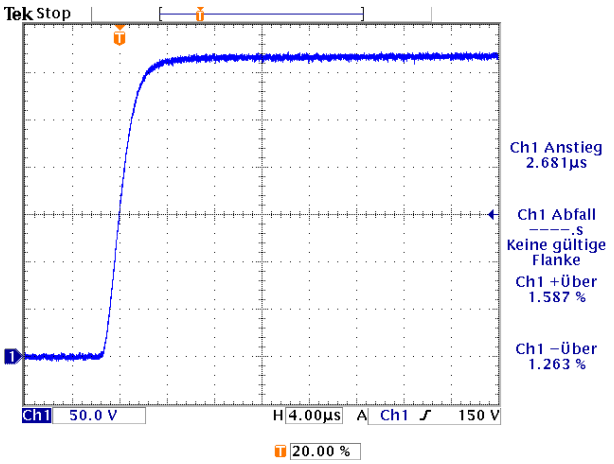

Fig. 1: Rise time of the output voltage

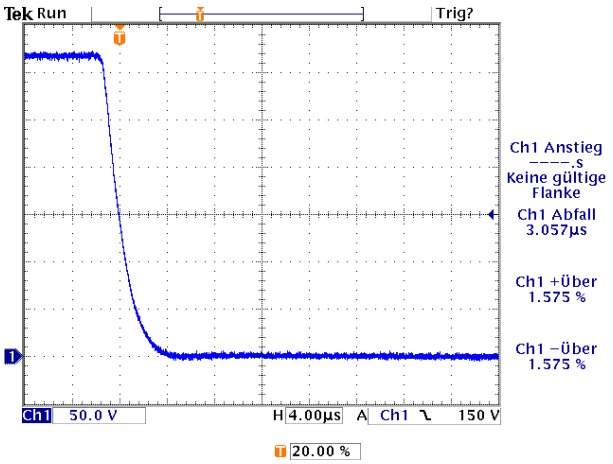

Fig. 2: Fall time of the output voltage

Peak inrush current

High peak inrush current capability of 500 A and 1000 A as required by IEC/EN 61000-4-11 and IEC/EN 61000-4-34.

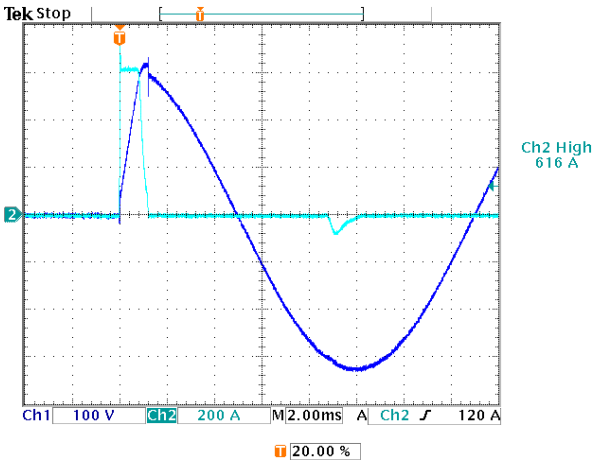

Fig. 3: Inrush current APS 15000

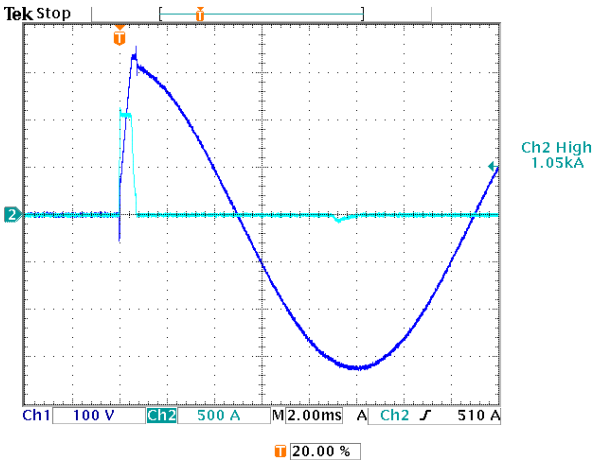

Fig. 4: Inrush current APS 25000

Extremely high loadability

150 % of rating is available in case of a load power factor 1. Amplifier stability is absolutely assured when operating with either inductive or capacitive loads.

The sink mode power capability is approx. 30 % of the source mode capability.

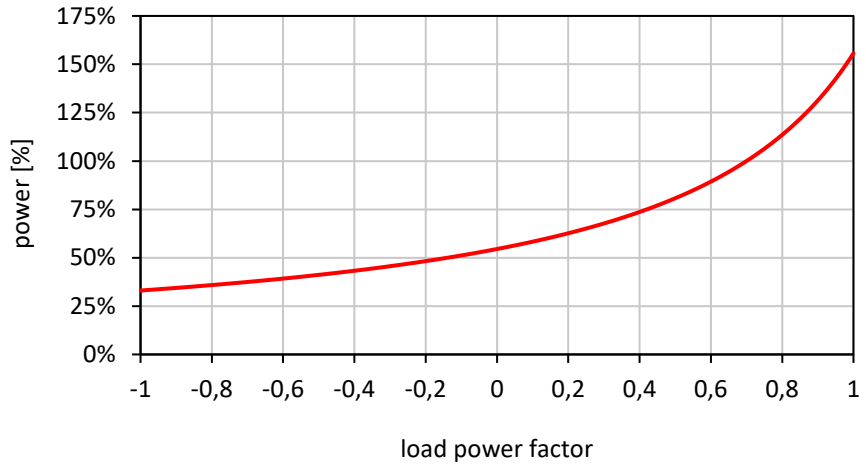

Fig. 5: APS performance characteristic

Extremely low harmonic distortion

The voltage harmonics of the 4-quadrant amplifiers APS series are extremely low. At no load condition the voltage harmonics are typically smaller by a factor of 100 than the limit values permitted by IEC 61000-3-2. The very low internal resistance means that the limit values are not exceeded even under very non-linear load conditions.

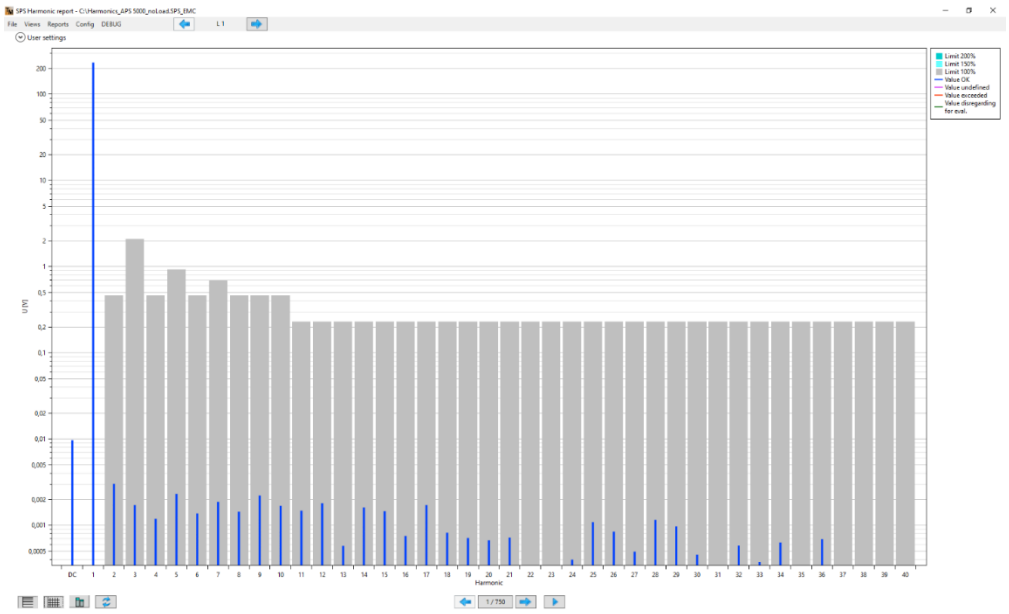

Fig. 6: Voltage harmonics of APS 5000 (no load condition)

Wide range of applications for power amplifiers APS series

The 4-quadrant amplifiers APS series can be used for many other tests in addition to grid simulation. Due to the high large signal bandwidth, components can also be tested with up to 30 kHz at full amplitude.
With the same power amplifier, however, pure DC voltages or mixed signals (ripple on DC) can also be output, so that both low-voltage and high-voltage vehicle electrical systems can be simulated.

PHIL (Power Hardware In the Loop)

Due to the low delay between the set point value and the output signal, the 4-quadrant amplifier APS series is very well suited for stable and accurate PHIL simulations. The optical interface to real time simulator reduces the delay time and accuracy losses compared to the analogue control.

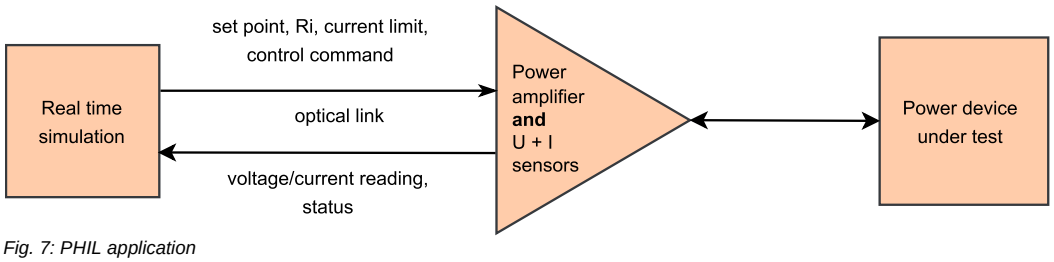

Fig. 7: PHIL application

TOUCHSCREEN USER INTERFACE

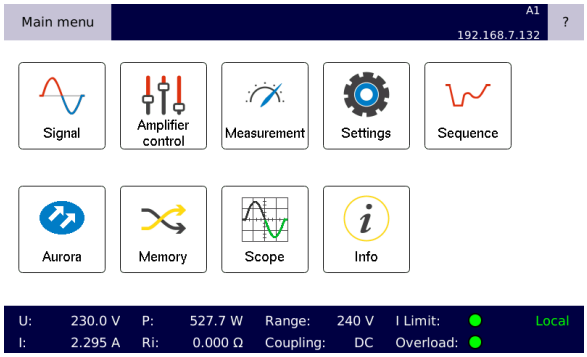

Fig. 8: Main menu

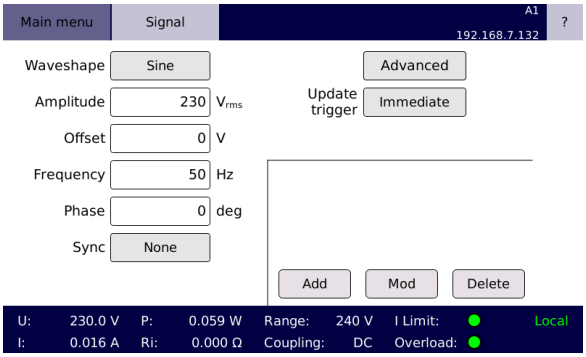

Fig. 9: Signal settings

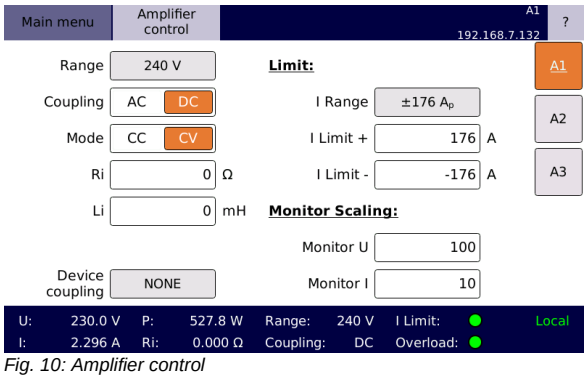

Fig. 10: Amplifier control

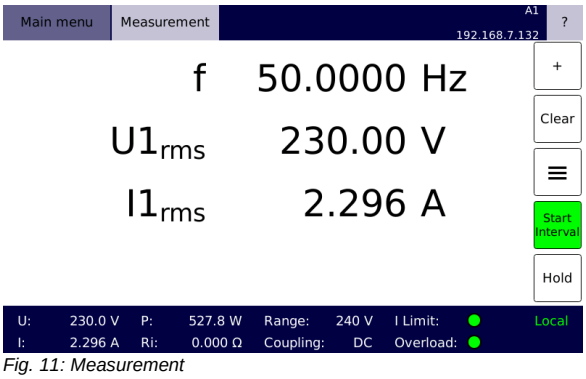

Fig. 11: Measurement

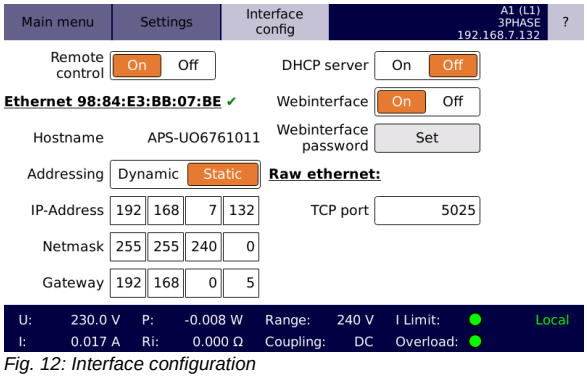

Fig. 12: Interface configuration

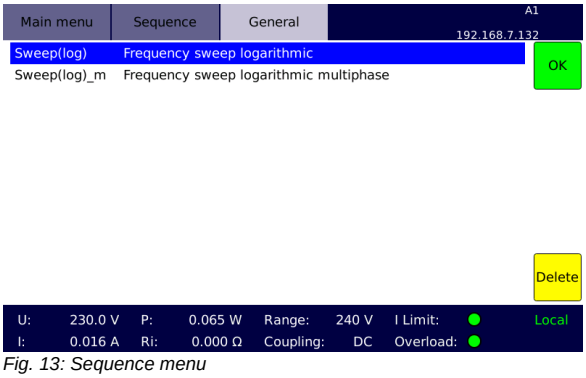

Fig. 13: Sequence menu

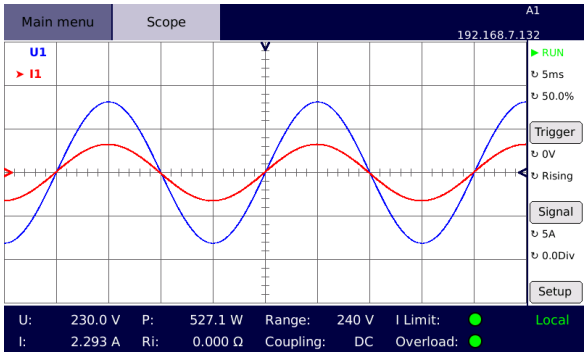

Fig. 14: Internal oscilloscope

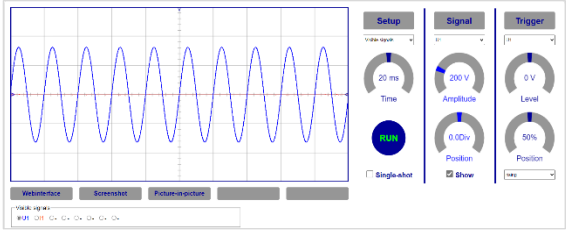

Fig. 15: Web oscilloscope

SOFTWARE CONTROL

SPS TestManager

- ✓ Test and evaluation software for fully compliant emission and immunity tests
- ✓ Automated test run of various IEC and automotive standards

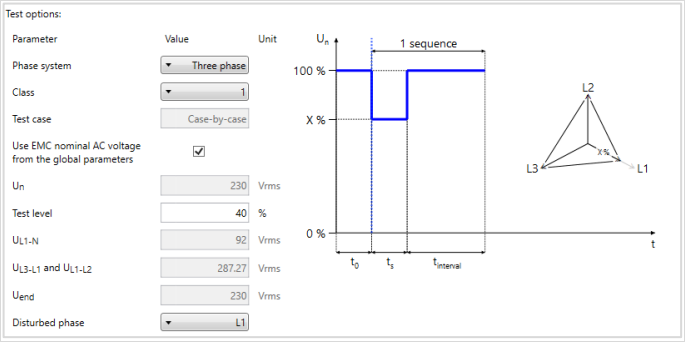

Fig. 16: SPS TestManager software

SPS SystemControl

- ✓ Simulation and control software for arbitrary waveforms, voltage and frequency variations
- ✓ Generation of user defined sequences
- ✓ Sequence preview graph

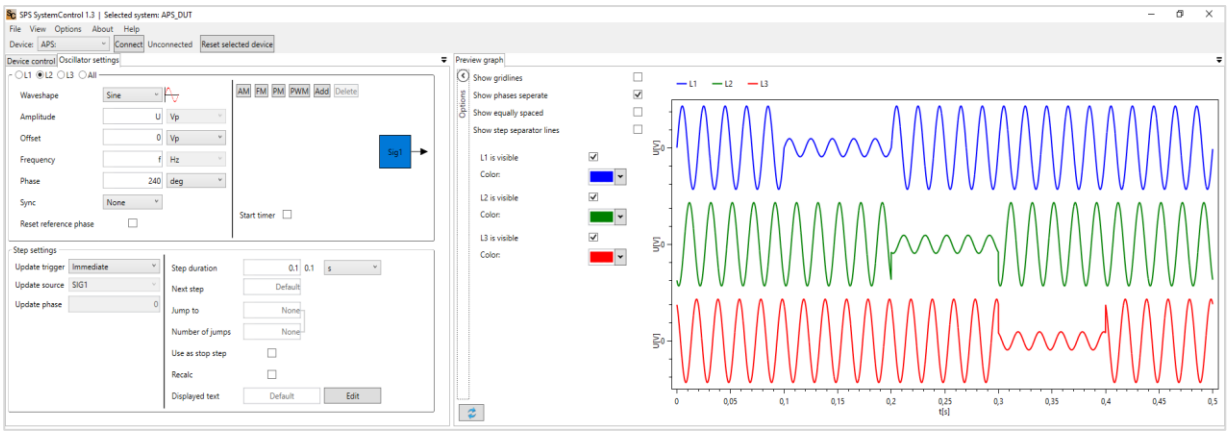

Fig. 17: SPS SystemControl software

Command interface

- ✓ Easily integrate the device into your own software applications
- ✓ Remote control commands are based on the SCPI standard

Webinterface

- ✓ Monitor and control the connected device via a web browser
- ✓ Oscilloscope function

TECHNICAL DATA - GENERAL

		APS series			
Nominal voltage ranges *RMS (DC)*		135 V (±191 V) 240 V (±339 V) 270 V (±382 V) 300 V (±424 V) Note: - APS 100: only one range available (either 135 V or 300 V) - APS 1000 / APS 1250: 240 V range not available			
Load regulation		Range (RMS) 135 V 240 V 270 V 300 V	DC … 450 Hz 0.4 % 0.2 % 0.2 % 0.2 %	450 Hz … 5 kHz 5.0 % 2.5 % 1.0 % 1.0 %	5 kHz … 10 kHz 15.0 % 8.0 % 5.0 % 5.0 %
Stability *(1 h)*		gain: < 0.1 % / offset: < 0.02 % of range end value at constant load and temperature			
Line regulation		< 1.5 x 10^{-4} per 10 V line-voltage change			
RMS noise at output		< 100 mV (< 1 MHz)			
Frequency bandwidth		large signal: DC … 10 kHz (-3 dB) small signal (10 %): DC … 50 kHz (-3 dB)			
Slew rate		> 52 V/µs (rise time < 5 µs at 230 V (RMS) according to IEC/EN 61000-4-11) 5 % max. over-/undershoot			
Harmonic distortion *(max.)*		Range (RMS) 135 V 240 V 270 V 300 V	DC … 450 Hz 0.3 % 0.2 % 0.1 % 0.1 %	450 Hz … 5 kHz 3.0 % 2.0 % 1.0 % 1.0 %	5 kHz … 10 kHz 5.0 % 3.0 % 2.5 % 2.5 %
Internal resistance compensation		< 8 V peak (ground and each phase line)			
Protection circuits		overload / short circuit / overtemperature			
Floating output		max. voltage between earth and the amplifier's ground output: < 300 V (RMS)			
External input *(optional)*	*Max. peak voltage*	0 … U_{ExtMax} (U_{ExtMax} is adjustable between ±2 V … ±25 V)			
	Input impedance	approx. 10 kΩ			
	Delay time	signal delay between amplifier's external input and amplifier's output < 5 µs			
Internal oscillator unit					
	Type	4-channel synthesiser			
	Wave forms	DC, sine, square, triangle, ramp, arbitrary			
	Amplitude resolution	17 Bit			
	Frequency range	DC … 1 MHz			
	Frequency resolution	1 µHz			
	Frequency accuracy	25 ppm			
	Phase range	0° … 360°			
	Phase resolution	0.001°			
	Memory depth	1 MSample			
	Synthesiser functions	ADD, AM, FM, PM, PWM			
	Sequence memory	1024 steps			

TECHNICAL DATA - GENERAL

		APS series			
Internal control unit					
	Display	7.0" touchscreen (17.8 cm, resolution 800 x 480)			
	Sequencer	user defined sequences memory			
	User interface	touchscreen / front panel button / incremental encoder webinterface			
	Digital I/O (optional)	8 digital DC inputs: U_{DC} = +5 V … +24 V 8 digital DC outputs: U_{DC} = +5 V (internal U_{CC}), I_L = 40 mA (external DC input U_{CC}: +5 V … +24 V, I_L = 250 mA)			
Measurement					
	Peak voltage measurement ranges	112.5 V / 225 V / 450 V / 900 V (auto ranging)			
	Current measurement ranges	depending on peak current of the amplifier range 1: $\frac{I_{peak}}{8.8}$ range 2: $\frac{I_{peak}}{4.4}$ range 3: $\frac{I_{peak}}{2.2}$ range 4: I_{peak}			
	Measurement accuracy	± (% of measured value + % of measurement range value)			
	Frequency	DC 45 Hz … 450 Hz	10 Hz … 45 Hz 450 Hz … 5 kHz	5 kHz … 15 kHz	15 kHz … 30 kHz
	Voltage accuracy	0.1 + 0.02	0.2 + 0.2	0.4 + 0.4	0.8 + 0.8
	Current accuracy	0.2 + 0.04	0.4 + 0.4	0.8 + 0.8	1.6 + 1.6
Monitoring unit *(optional)*		voltage		current	
	Max. peak output	±10 V			
	Scaling factor 'sf' (adjustable)	sf: 0.2 … 1000		sf: 0.1 … 1000	
	Bandwidth	300 kHz		200 kHz	
	Monitoring accuracy	± (% of measured value + % of measurement range value + error(sf))			
	Frequency	DC 45 Hz … 450 Hz	10 Hz … 45 Hz 450 Hz … 5 kHz	5 kHz … 15 kHz	15 kHz … 30 kHz
	Voltage monitor accuracy	0.12 + 0.02 + 2 mV * sf	0.3 + 0.2 + 2 mV * sf	0.7 + 0.4 + 2.2 mV * sf	1.4 + 0.8 + 2.3 mV * sf
	Current monitor accuracy	0.22 + 0.04 + 2 mA * sf	0.5 + 0.4 + 2 mA * sf	1.1 + 0.8 + 2.2 mA * sf	2.2 + 1.6 + 2.3 mA * sf
	Noise of ADC measurement (RMS)	< 20 mV (DC … 300 kHz)		< 1.5 mA (DC … 300 kHz)	
	Noise DAC output (RMS)	< 0.2 mV (DC … 300 kHz)			
	Delay time	< 1 µs			
	Output impedance	47 Ω			
	Isolation	earth / remaining electronics / each other			
	Protection	short circuit			

TECHNICAL DATA - GENERAL

		APS series			
Programmable internal impedance *(optional)*					
	Accuracy (real)	±(1 % of adjusted value + $\Delta R_{absolute}$)			
	Accuracy (inductive)	±(2 % of adjusted value + $\Delta L_{absolute}$)			
		Adjustment range (real)	Adjustment range (inductive)	$\Delta R_{absolute}$	$\Delta L_{absolute}$
	APS 100	0 Ω ... 120000 Ω	0 mH ... 1600 mH	104 mΩ	532 µH
	APS 1000	0 Ω ... 30000 Ω	0 mH ... 400 mH	26 mΩ	133 µH
	APS 1250	0 Ω ... 18000 Ω	0 mH ... 240 mH	16 mΩ	80 µH
	APS 2500	0 Ω ... 9000 Ω	0 mH ... 120 mH	8 mΩ	40 µH
	APS 5000	0 Ω ... 4500 Ω	0 mH ... 60 mH	4 mΩ	20 µH
	APS 7500	0 Ω ... 3000 Ω	0 mH ... 40 mH	2.6 mΩ	13.3 µH
	APS 10000	0 Ω ... 1800 Ω	0 mH ... 24 mH	1.6 mΩ	8 µH
	APS 12500	0 Ω ... 1500 Ω	0 mH ... 20 mH	1.3 mΩ	7 µH
	APS 15000	0 Ω ... 1286 Ω	0 mH ... 17 mH	1 mΩ	6 µH
	APS 20000	0 Ω ... 900 Ω	0 mH ... 12 mH	1 mΩ	5 µH
	APS 25000	0 Ω ... 750 Ω	0 mH ... 10 mH	1 mΩ	5 µH
	APS 30000	0 Ω ... 643 Ω	0 mH ... 9 mH	1 mΩ	5 µH
	APS 40000	0 Ω ... 450 Ω	0 mH ... 6 mH	1 mΩ	5 µH
	APS 50000	0 Ω ... 375 Ω	0 mH ... 5 mH	1 mΩ	5 µH
	APS 60000	0 Ω ... 321 Ω	0 mH ... 4 mH	1 mΩ	5 µH
Interface		Ethernet 100 Mbit/s (HiSLIP SCPI) USB 2.0 Host			
Synchronisation bus *(multiple devices)*		device synchronisation and internal communication optical fibre, LC duplex: - synchronised sequence start - parallel operation - only one ethernet connection required			
Insulation resistance		> 1 MΩ			
Peak withstand voltage *(max. 10 s, output to earth)*		> 2000 V			
Cooling		temperature-controlled forced air cooling			
Ambient temperature		+10 °C up to +40 °C			
Storage temperature		-25 °C up to +60 °C			
Relative humidity		non condensing, max. 80 % for temperature < 31 °C, decreasing linearly to 50 % at 40 °C			
Ingress protection		IP20			

TECHNICAL DATA – APS series

			APS 100	APS 1000	APS 1250
Power AC		*continuous* *approx. 1 h* [1)]	100 VA 150 VA	1000 VA 1500 VA	1250 VA 1875 VA
Power DC		*continuous* *approx. 1 h*	100 W 150 W	1000 W 1500 W	1250 W 1875 W
Short-time power			200 VA	2000 VA	2500 VA
Peak current			6.6 A	26.4 A	44 A
Power supply *(±10 %, 50/60 Hz)*			230 V	230 V	230 V
Line protection, connection		*NT* *or NT/D*	4 A, Schuko -	16 A, Schuko -	16 A, Schuko -
Housing			plug-in unit or rack, light grey (RAL 7035)		
	Amplifier *approx. dimensions* *(H x W x D)*		1/2 19", 4 U 178 x 222 x 450 mm	19", 4 U 178 x 483 x 650 mm	19", 4 U 178 x 483 x 700 mm
	Power supply NT *approx. dimensions* *(H x W x D)*		included -	included -	included -
	Power supply NT/D *approx. dimensions* *(H x W x D)*		-	-	
Weight	*Amplifier (approx.)* *Power supply NT (approx.)* *Power supply NT/D (approx.)*		16 kg - -	58 kg - -	55 kg - -

TECHNICAL DATA – APS series

			APS 2500	APS 5000	APS 7500
Power AC		*continuous* *approx. 1 h* [1)]	2500 VA 3750 VA	5000 VA 7500 VA	7500 VA 11250 VA
Power DC		*continuous* *approx. 1 h*	2500 W 3750 W	5000 W 7500 W	7500 W 11250 W
Short-time power			5000 VA	10000 VA	15000 VA
Peak current			88 A	176 A	264 A
Power supply *(±10 %, 50/60 Hz)*			230 V / 400 V		
Line protection, connection		*NT* *or NT/D*	3 x 16 A, CEE 3 x 32 A, CEE	3 x 20 A, CEE 3 x 63 A, CEE	3 x 32 A, CEE 3 x 100 A, CEE
Housing			plug-in unit or rack, light grey (RAL7035)		
	Amplifier *approx. dimensions* *(H x W x D)*		19", 5 U 222 x 483 x 650 mm	19", 7 U 311 x 483 x 650 mm	19", 10 U 444 x 483 x 650 mm
	Power supply NT *approx. dimensions* *(H x W x D)*		19", 5 U 222 x 483 x 650 mm	19", 5 U 222 x 483 x 650 mm	19", 10 U 444 x 483 x 650 mm
	Power supply NT/D *approx. dimensions* *(H x W x D)*		19", 10 U 444 x 483 x 650 mm	19", 12 U 533 x 483 x 650 mm	19", 22 U 978 x 600 x 850 mm
Weight	*Amplifier (approx.)* *Power supply NT (approx.)* *Power supply NT/D (approx.)*		36 kg 90 kg 180 kg	55 kg 120 kg 285 kg	66 kg 180 kg 430 kg

TECHNICAL DATA – APS series

			APS 10000	APS 12500	APS 15000
Power AC		*continuous* *approx. 1 h* [1)]	10000 VA 15000 VA	12500 VA 18750 VA	15000 VA 22500 VA
Power DC		*continuous* *approx. 1 h*	10000 W 15000 W	12500 W 18750 W	15000 W 22500 W
Short-time power			20000 VA	25000 VA	30000 VA
Peak current			440 A	528 A	616 A
Power supply *(±10 %, 50/60 Hz)*			230 V / 400 V		
Line protection, connection		*NT* *or NT/D*	3 x 40 A, CEE 3 x 125 A, CEE	3 x 50 A, CEE 3 x 150 A, terminal box	3 x 63 A, CEE -
Housing			plug-in unit or rack, light grey (RAL7035)		
	Amplifier *approx. dimensions* *(H x W x D)*		19", 17 U 755 x 483 x 650 mm	19", 20 U 888 x 483 x 650 mm	19", 23 U 1022 x 483 x 650 mm
	Power supply NT *approx. dimensions* *(H x W x D)*		19", 12 U 533 x 483 x 650 mm	19", 12 U 533 x 483 x 650 mm	19", 12 U 533 x 483 x 650 mm
	Power supply NT/D *approx. dimensions* *(H x W x D)*		19", 22 U 978 x 600 x 1050 mm	19", 22 U 978 x 600 x 1050 mm	-
Weight	*Amplifier (approx.)* *Power supply NT (approx.)* *Power supply NT/D (approx.)*		110 kg 240 kg 550 kg	122 kg 230 kg 750 kg, incl. rack	135 kg 285 kg -

TECHNICAL DATA – APS series

			APS 20000	APS 25000	APS 30000
Power AC		*continuous* *approx. 1 h* [1)]	20000 VA 30000 VA	25000 VA 37500 VA	30000 VA 45000 VA
Power DC		*continuous* *approx. 1 h*	20000 W 30000 W	25000 W 37500 W	30000 W 45000 W
Short-time power			40000 VA	50000 VA	60000 VA
Peak current			880 A	1056 A	1150 A
Power supply *(±10 %, 50/60 Hz)*			230 V / 400 V		
Line protection, connection		*NT* *or NT/D*	3 x 80 A, CEE 3 x 250 A, terminal box	- 3 x 300 A, terminal box	3 x 125 A, CEE 3 x 375 A, terminal box
Housing			plug-in unit or rack, light grey (RAL7035)		
	Amplifier *approx. dimensions* *(H x W x D)*		19", 33 U 1467 x 600 x 1050 mm	19", 39 U 1733 x 600 x 1050 mm	19", 46 U 2044 x 600 x 1050 mm
	Power supply NT *approx. dimensions* *(H x W x D)*		19", 22 U 978 x 600 x 1050 mm	-	19", 22 U 978 x 600 x 1050 mm
	Power supply NT/D *approx. dimensions* *(H x W x D)*		27", 42 U 1866 x 800 x 1050 mm	27", 42 U 1866 x 800 x 1050 mm	27", 46 U 2044 x 800 x 1050 mm
Weight	*Amplifier (approx.)* *Power supply NT (approx.)* *Power supply NT/D (approx.)*		220 kg 360 kg 950 kg, incl. rack	250 kg 1140 kg, incl. rack	460 kg, incl. rack 770 kg, incl. rack 1560 kg, incl. rack

TECHNICAL DATA – APS series

		APS 40000	APS 50000	APS 60000
Power AC	*continuous* *approx. 1 h* [1)]	40000 VA 60000 VA	50000 VA 75000 VA	60000 VA 90000 VA
Power DC	*continuous* *approx. 1 h*	40000 W 60000 W	50000 W 75000 W	60000 W 90000 W
Short-time power		80000 VA	100000 VA	120000 VA
Peak current		1760 A	2112 A	2300 A
Power supply *(±10 %, 50/60 Hz)*		230 V / 400 V		
Line protection, connection	*NT* *or NT/D*	3 x 160 A, terminal box -	3 x 200 A, terminal box -	3 x 250 A, terminal box -
Housing		rack, light grey (RAL7035)		
	Amplifier *approx. dimensions* *(H x W x D)*	19", 2 x 33 U 1467 x 1200 x 1050 mm	19", 2 x 39 U 1733 x 1200 x 1050 mm	19", 2 x 46 U 2044 x 1200 x 1050 mm
	Power supply NT *approx. dimensions* *(H x W x D)*	19", 37 U 1644 x 600 x 1050 mm	19", 42 U 1866 x 600 x 1050 mm	19", 46 U 2044 x 800 x 1050 mm
	Power supply NT/D *approx. dimensions* *(H x W x D)*	-	-	-
Weight	*Amplifier (approx.)* *Power supply NT (approx.)* *Power supply NT/D (approx.)*	on request	on request	on request

Remarks:

1) At cos φ = 1
2) Not available for APS 100

OPTIONS AND ACCESSORIES

Options		
OPT.01	IEEE488	Not in combination with OPT.02 [2)]
OPT.02	RS232	Not in combination with OPT.01 [2)]
OPT.05	U/I monitor	Galvanically isolated voltage and current measurement outputs accessible via BNC sockets (includes OPT.14) [2)]
OPT.MS	Mains synchronisation	Output signal can be synchronised with mains
NT.11.33	Additional voltage range RMS (DC)	0 … 33 V (±47 V) [2)]
NT.11.36	Additional voltage range RMS (DC)	0 … 36 V (±51 V) [2)]
NT.11.56	Additional voltage range RMS (DC)	0 … 56 V (±79 V) [2)]
NT.11.60	Additional voltage range RMS (DC)	0 … 60 V (±85 V) [2)]
NT.11.150	Additional voltage range RMS (DC)	0 … 150 V (±212 V) [2)]
NT.11.570DC	Additional voltage range DC	0 … +570 V [2)]
NT.11.630DC	Additional voltage range DC	0 … +630 V [2)]
OPT.13.30	Special frequency range	DC … 30 kHz (-3 dB)
OPT.14	External input	0 … U_{ExtMax} U_{ExtMax} peak is adjustable between ±2 V … ±25 V OPT.14 includes a digital input filter: type Bessel or Butterworth, order 1 … 6 (adjustable) Filter frequency selectable 100 Hz … 10 MHz [2)]
NT.18	Special RMS line voltage	Available on request in the range of 110 V … 300 V
OPT.21	Common output	Common output plugs for parallel operation
OPT.24	Programmable internal impedance	R_i and L_i internally programmable
OPT.25	Constant current mode	
OPT.30	Optical link	Optical interface to real time simulator LC duplex interface / Aurora 8B/10B protocol / 2 Gb/s data rate
UT.540.C	Voltage transformer	Output voltages (RMS) 400 V / 540 V (f: 45 Hz ... 5 kHz (-3dB)) Other voltages and frequency ranges on request

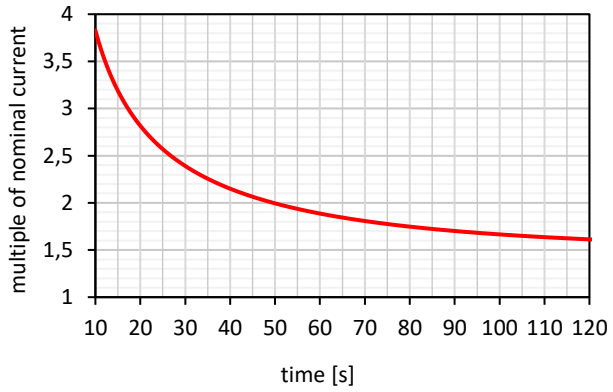

Fig. 18: Maximum short time current of transformer