

APS series of 4-quadrant amplifiers

4-QUADRANT VOLTAGE / CURRENT AMPLIFIER



4-quadrant amplifier APS 1000

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.

- ✓ 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

VOLTAGE AND CURRENT MODE OPERATION
 REFERENCE SOURCE FOR ALL APPLICATIONS



Very fast rise and fall time

Due to the very fast slew rate of $> 52 \text{ V}/\mu\text{s}$ the APS is fully compliant according to the requirements of IEC/EN 61000-4-11 in practice.

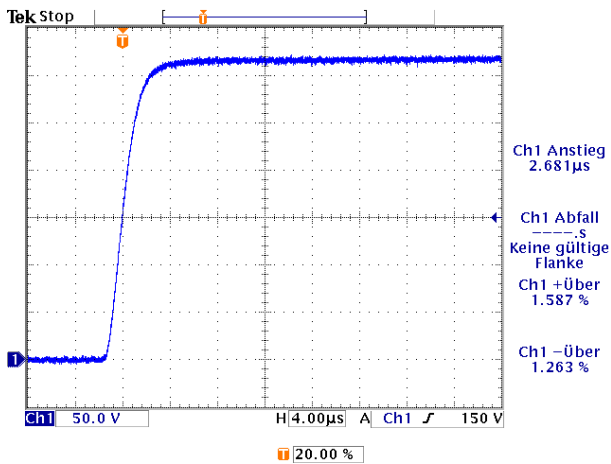


Fig. 1: Rise time of the output voltage

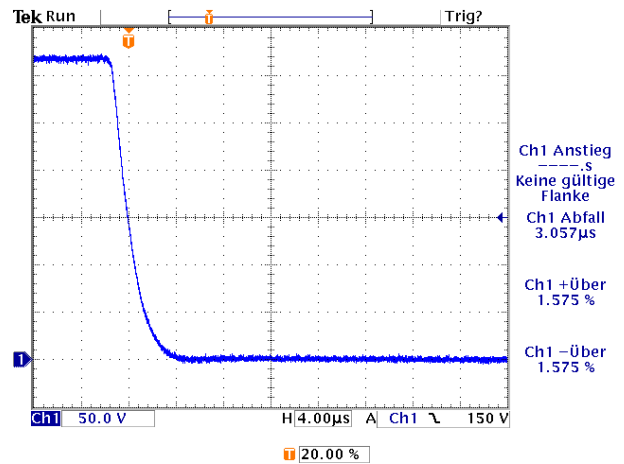


Fig. 2: Fall time of the output voltage

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.

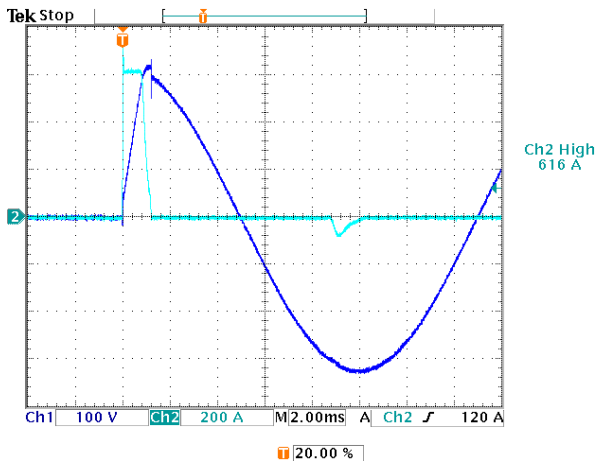


Fig. 3: Inrush current APS 15000

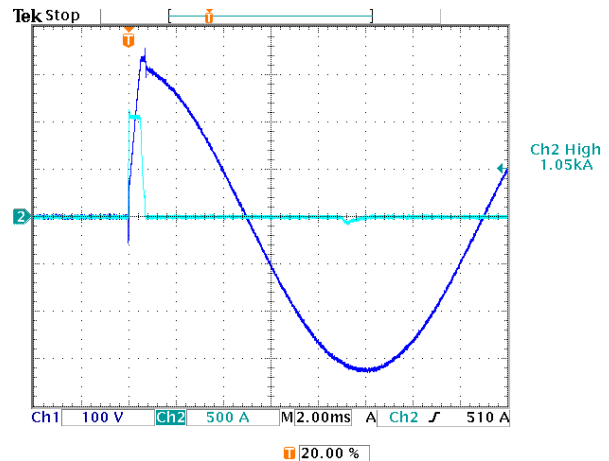


Fig. 4: Inrush current APS 25000

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.

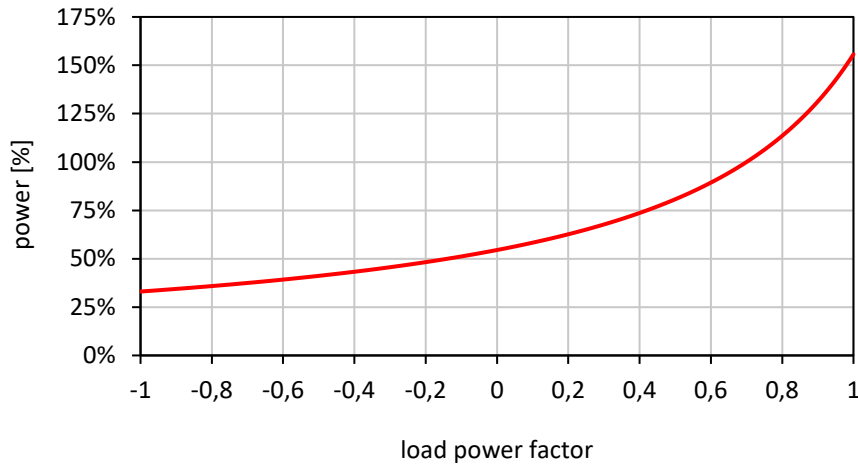


Fig. 5: APS performance characteristic

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.

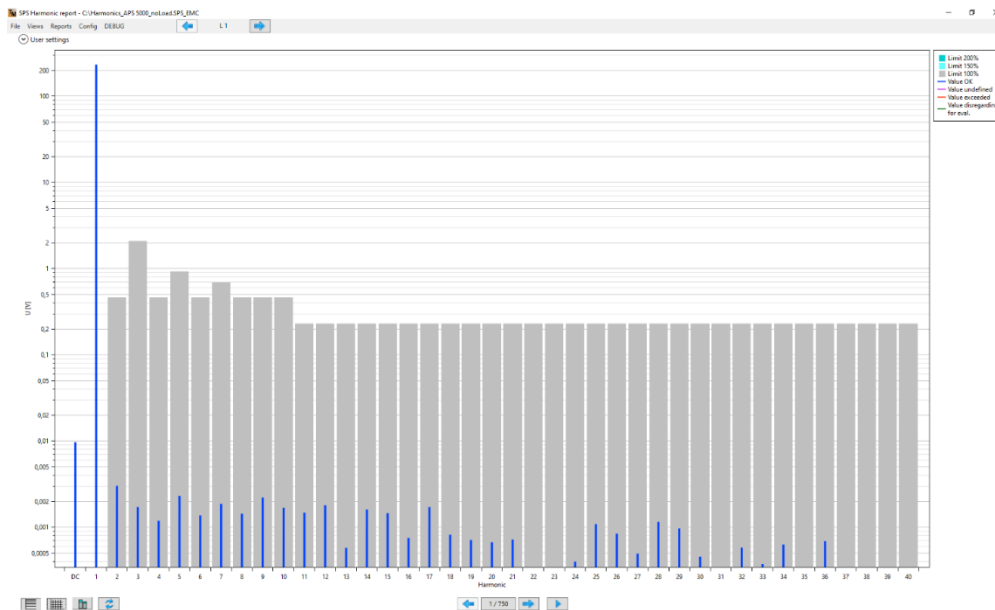


Fig. 6: Voltage harmonics of APS 5000 (no load condition)

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.

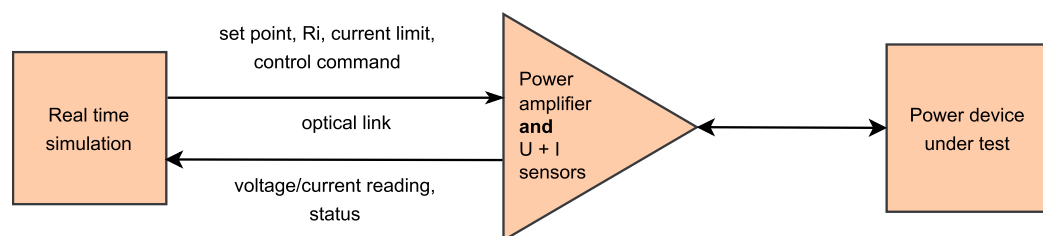


Fig. 7: PHIL application

TOUCHSCREEN USER INTERFACE

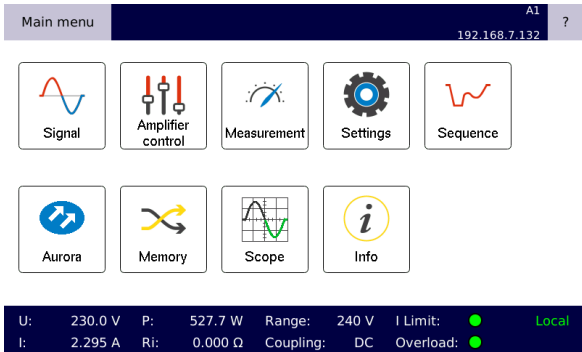


Fig. 8: Main menu

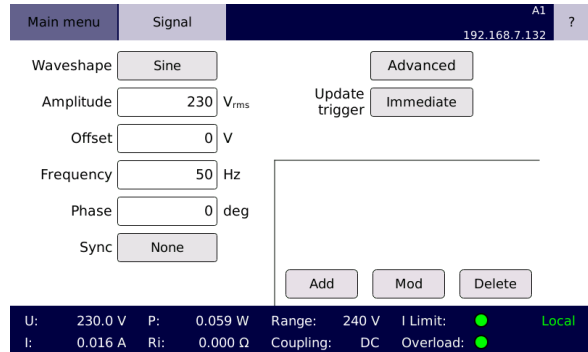


Fig. 9: Signal settings

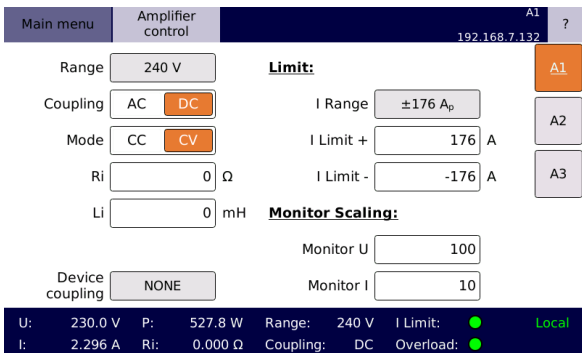


Fig. 10: Amplifier control

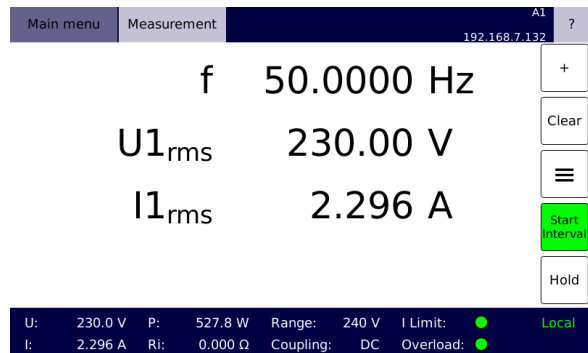


Fig. 11: Measurement

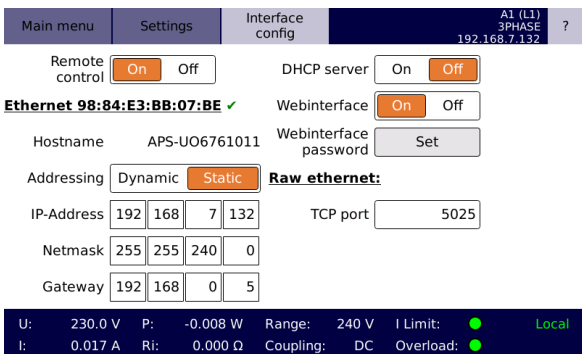


Fig. 12: Interface configuration

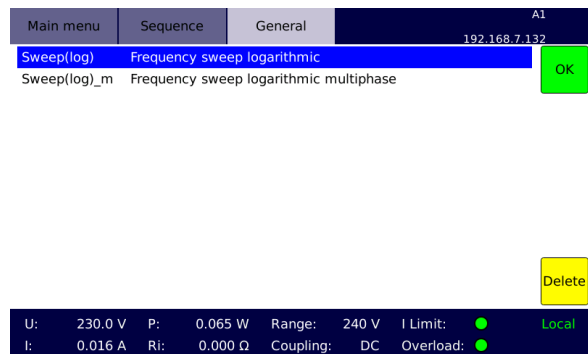


Fig. 13: Sequence menu

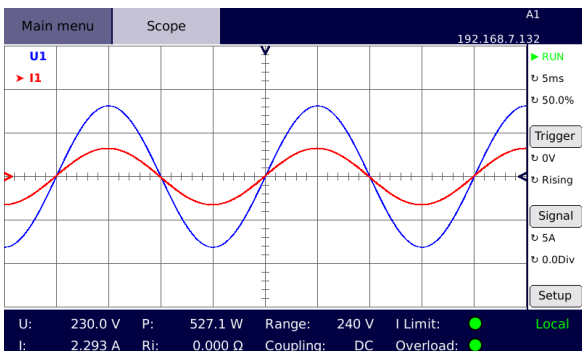


Fig. 14: Internal oscilloscope

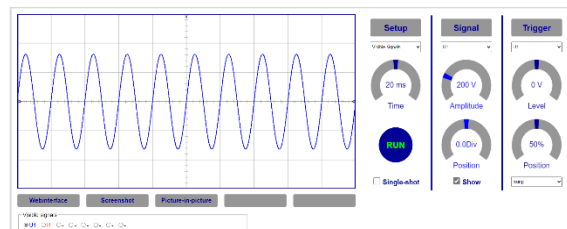


Fig. 15: Web oscilloscope

SOFTWARE CONTROL

SPS TestManager

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

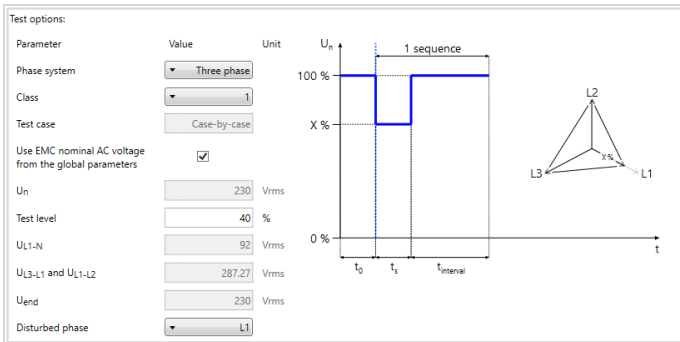


Fig. 16: SPS TestManager software

SPS SystemControl

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

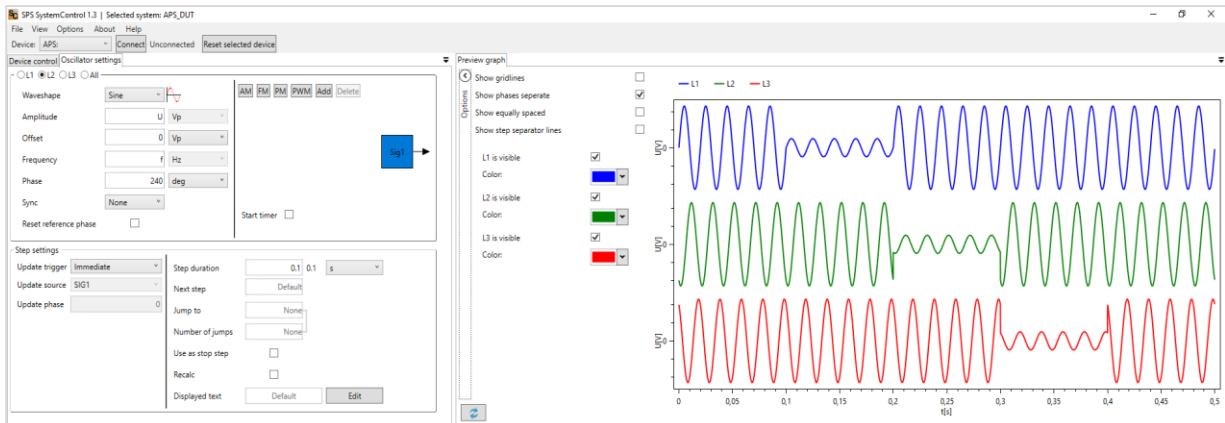


Fig. 17: SPS SystemControl software

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 ¹⁾ <i>RMS (peak)</i>		135 V (± 191 V) 240 V (± 339 V) 270 V (± 382 V) 300 V (± 424 V)			
Load regulation ¹⁾	Range (RMS)	DC ... 450 Hz	450 Hz ... 5 kHz	5 kHz ... 10 kHz	
	135 V	0.4 %	5.0 %	15.0 %	
	240 V	0.2 %	2.5 %	8.0 %	
	270 V	0.2 %	1.0 %	5.0 %	
	300 V	0.2 %	1.0 %	5.0 %	
Stability (1 h)		gain: < 0.1 % / offset: < 0.02 % of range end value at constant load and temperature			
Line regulation		< 1.5×10^{-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/ μ s (rise time < 5 μ s at 230 V (RMS) according to IEC/EN 61000-4-11) 5 % max. over-/undershoot			
Harmonic distortion (max.) ¹⁾	Range (RMS)	DC ... 450 Hz	450 Hz ... 5 kHz	5 kHz ... 10 kHz	
	135 V	0.3 %	3.0 %	5.0 %	
	240 V	0.2 %	2.0 %	3.0 %	
	270 V	0.1 %	1.0 %	2.5 %	
	300 V	0.1 %	1.0 %	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)	<i>Max. peak voltage</i>	0 ... U_{ExtMax} (U_{ExtMax} is adjustable between ± 2 V ... ± 25 V)			
	<i>Input impedance</i>	approx. 10 k Ω			
	<i>Delay time</i>	signal delay between amplifier's external input and amplifier's output < 5 μ s			
Internal oscillator unit					
	<i>Type</i>	4-channel synthesiser			
	<i>Wave forms</i>	DC, sine, square, triangle, ramp, arbitrary			
	<i>Amplitude resolution</i>	17 Bit			
	<i>Frequency range</i>	DC ... 1 MHz			
	<i>Frequency resolution</i>	1 μ Hz			
	<i>Frequency accuracy</i>	25 ppm			
	<i>Phase range</i>	0° ... 360°			
	<i>Phase resolution</i>	0.001°			
	<i>Memory depth</i>	1 MSample			
	<i>Synthesiser functions</i>	ADD, AM, FM, PM, PWM			
	<i>Sequence memory</i>	1024 steps			
Internal control unit					
	<i>Display</i>	7.0" touchscreen (17.8 cm, resolution 800 x 480)			
	<i>Sequencer</i>	user defined sequences memory			
	<i>User interface</i>	touchscreen / front panel button / incremental encoder webinterface			
	<i>Digital I/O (optional)</i>	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			
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 air forced 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		
System of protection		IP20		

TECHNICAL DATA – APS series

		APS 1000	APS 1250	APS 2500
Power AC	<i>continuous</i>	1000 VA	1250 VA	2500 VA
	<i>approx. 1 h ²⁾</i>	1500 VA	1875 VA	3750 VA
Power DC	<i>continuous</i>	1000 W	1250 W	2500 W
	<i>approx. 1 h</i>	1500 W	1875 W	3750 W
Short-time power		2000 VA	2500 VA	5000 VA
Peak current		26.4 A	44 A	88 A
Power supply ($\pm 10\%$, 50/60 Hz)		230 V	230 V	230 V / 400 V
Line protection, connection	<i>NT</i>	16 A, Schuko	16 A, Schuko	3 x 16 A, CEE
	<i>or NT/D</i>	-	-	3 x 32 A, CEE
Housing		plug-in unit or rack, light grey (RAL 7035)		
	<i>Amplifier approx. dimensions (H x W x D)</i>	19", 4 U 178 x 483 x 650 mm	19", 4 U 178 x 483 x 700 mm	19", 5 U 222 x 483 x 650 mm
	<i>Power supply NT approx. dimensions (H x W x D)</i>	included -	included -	19", 5 U 222 x 483 x 650 mm
	<i>Power supply NT/D approx. dimensions (H x W x D)</i>	-	-	19", 10 U 444 x 483 x 650 mm
Weight	<i>Amplifier (approx.)</i>	58 kg	55 kg	36 kg
	<i>Power supply NT (approx.)</i>	-	-	90 kg
	<i>Power supply NT/D (approx.)</i>	-	-	180 kg

TECHNICAL DATA – APS series

		APS 5000	APS 7500	APS 10000
Power AC	<i>continuous</i>	5000 VA	7500 VA	10000 VA
	<i>approx. 1 h ²⁾</i>	7500 VA	11250 VA	15000 VA
Power DC	<i>continuous</i>	5000 W	7500 W	10000 W
	<i>approx. 1 h</i>	7500 W	11250 W	15000 W
Short-time power		10000 VA	15000 VA	20000 VA
Peak current		176 A	264 A	440 A
Power supply ($\pm 10\%$, 50/60 Hz)		230 V / 400 V		
Line protection, connection	<i>NT</i>	3 x 20 A, CEE	3 x 32 A, CEE	3 x 40 A, CEE
	<i>or NT/D</i>	3 x 63 A, CEE	3 x 100 A, CEE	3 x 125 A, CEE
Housing		plug-in unit or rack, light grey (RAL7035)		
	<i>Amplifier approx. dimensions (H x W x D)</i>	19", 7 U 311 x 483 x 650 mm	19", 10 U 444 x 483 x 650 mm	19", 17 U 755 x 483 x 650 mm
	<i>Power supply NT approx. dimensions (H x W x D)</i>	19", 5 U 222 x 483 x 650 mm	19", 10 U 444 x 483 x 650 mm	19", 12 U 533 x 483 x 650 mm
	<i>Power supply NT/D approx. dimensions (H x W x D)</i>	19", 12 U 533 x 483 x 650 mm	19", 22 U 978 x 600 x 850 mm	19", 22 U 978 x 600 x 1050 mm
Weight	<i>Amplifier (approx.)</i>	55 kg	66 kg	110 kg
	<i>Power supply NT (approx.)</i>	120 kg	180 kg	240 kg
	<i>Power supply NT/D (approx.)</i>	285 kg	430 kg	550 kg

TECHNICAL DATA – APS series

		APS 12500	APS 15000	APS 20000
Power AC	<i>continuous</i>	12500 VA	15000 VA	20000 VA
	<i>approx. 1 h ²⁾</i>	18750 VA	22500 VA	30000 VA
Power DC	<i>continuous</i>	12500 W	15000 W	20000 W
	<i>approx. 1 h</i>	18750 W	22500 W	30000 W
Short-time power		25000 VA	30000 VA	40000 VA
Peak current		528 A	616 A	880 A
Power supply ($\pm 10\%$, 50/60 Hz)		230 V / 400 V		
Line protection, connection	<i>NT</i>	3 x 50 A, CEE	3 x 63 A, CEE	3 x 80 A, CEE
	<i>or NT/D</i>	-	-	3 x 250 A, terminal box
Housing		plug-in unit or rack, light grey (RAL7035)		
	<i>Amplifier approx. dimensions (H x W x D)</i>	19", 20 U 888 x 483 x 650 mm	19", 23 U 1022 x 483 x 650 mm	19", 33 U 1467 x 600 x 1050 mm
	<i>Power supply NT approx. dimensions (H x W x D)</i>	19", 12 U 533 x 483 x 650 mm	19", 12 U 533 x 483 x 650 mm	19", 22 U 978 x 600 x 1050 mm
	<i>Power supply NT/D approx. dimensions (H x W x D)</i>	-	-	27", 42 U 1866 x 800 x 1050 mm
Weight	<i>Amplifier (approx.)</i>	122 kg	135 kg	220 kg
	<i>Power supply NT (approx.)</i>	230 kg	285 kg	360 kg
	<i>Power supply NT/D (approx.)</i>	-	-	950 kg, incl. rack

TECHNICAL DATA – APS series

		APS 25000	APS 30000	APS 40000
Power AC	<i>continuous</i>	25000 VA	30000 VA	40000 VA
	<i>approx. 1 h ²⁾</i>	37500 VA	45000 VA	60000 VA
Power DC	<i>continuous</i>	25000 W	30000 W	40000 W
	<i>approx. 1 h</i>	37500 W	45000 W	60000 W
Short-time power		50000 VA	60000 VA	80000 VA
Peak current		1056 A	1150 A	1760 A
Power supply ($\pm 10\%$, 50/60 Hz)		230 V / 400 V		
Line protection, connection	<i>NT</i>	-	3 x 125 A, CEE	3 x 160 A, terminal box
	<i>or NT/D</i>	3 x 300 A, terminal box	3 x 375 A, terminal box	-
Housing		plug-in unit or rack, light grey (RAL7035)		
	<i>Amplifier approx. dimensions (H x W x D)</i>	19", 39 U 1733 x 600 x 1050 mm	19", 46 U 2044 x 600 x 1050 mm	19", 2 x 33 U 1467 x 1200 x 1050 mm
	<i>Power supply NT approx. dimensions (H x W x D)</i>	-	19", 22 U 978 x 600 x 1050 mm	19", 37 U 1644 x 600 x 1050 mm
	<i>Power supply NT/D approx. dimensions (H x W x D)</i>	27", 42 U 1866 x 800 x 1050 mm	27", 46 U 2044 x 800 x 1050 mm	-
Weight	<i>Amplifier (approx.)</i>	250 kg	460 kg, incl. rack	on request
	<i>Power supply NT (approx.)</i>		770 kg, incl. rack	
	<i>Power supply NT/D (approx.)</i>	1140 kg, incl. rack	1560 kg, incl. rack	

TECHNICAL DATA – APS series

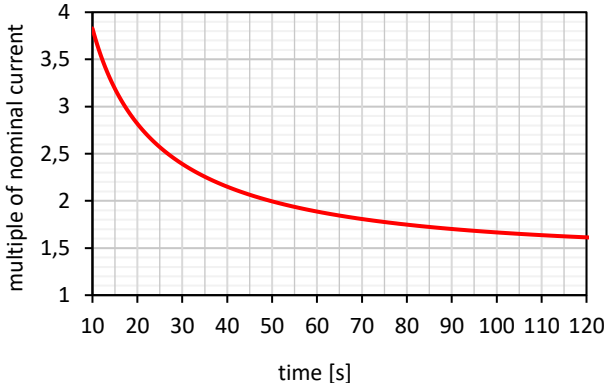
		APS 50000	APS 60000
Power AC	<i>continuous</i>	50000 VA	60000 VA
	<i>approx. 1 h ²⁾</i>	75000 VA	90000 VA
Power DC	<i>continuous</i>	50000 W	60000 W
	<i>approx. 1 h</i>	75000 W	90000 W
Short-time power		100000 VA	120000 VA
Peak current		2112 A	2300 A
Power supply ($\pm 10\%$, 50/60 Hz)		230 V / 400 V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

Remarks:

- 1) 240 V (RMS) range not available at APS 1000 and APS 1250
- 2) At $\cos \varphi = 1$

OPTIONS AND ACCESSORIES

Options				
OPT.01	IEEE488	Not in combination with OPT.02		
OPT.02	RS232	Not in combination with OPT.01		
OPT.05	U/I monitor	Galvanically isolated voltage and current measurement outputs accessible via BNC sockets (includes OPT.14)		
NT.11.33	Additional voltage range RMS (DC)	0 ... 33 V (± 47 V)		
NT.11.36	Additional voltage range RMS (DC)	0 ... 36 V (± 51 V)		
NT.11.56	Additional voltage range RMS (DC)	0 ... 56 V (± 79 V)		
NT.11.60	Additional voltage range RMS (DC)	0 ... 60 V (± 85 V)		
NT.11.150	Additional voltage range RMS (DC)	0 ... 150 V (± 212 V)		
NT.11.570DC	Additional voltage range DC	0 ... +570 V		
NT.11.630DC	Additional voltage range DC	0 ... +630 V		
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		
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	Model	Ri max. (Ω)	Li max. (mH)
		APS 1000	30000	400
		APS 1250	18000	240
		APS 2500	9000	120
		APS 5000	4500	60
		APS 7500	3000	40
		APS 10000	1800	24
		APS 12500	1500	20
		APS 15000	1286	17
		APS 20000	900	12
		APS 25000	750	10
		APS 30000	643	9
		APS 40000	450	6
		APS 50000	375	5
APS 60000	321	4		
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	<p>Output voltages (RMS) 400 V / 540 V Other voltages on request</p>  <p>Fig. 18: Maximum short time current of transformer</p>
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