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 waveform 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"

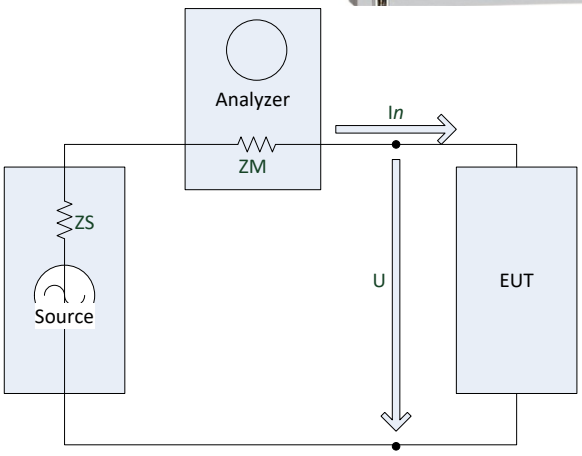

Fig. 1: Measurement setup acc. IEC/EN 61000-3-2

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

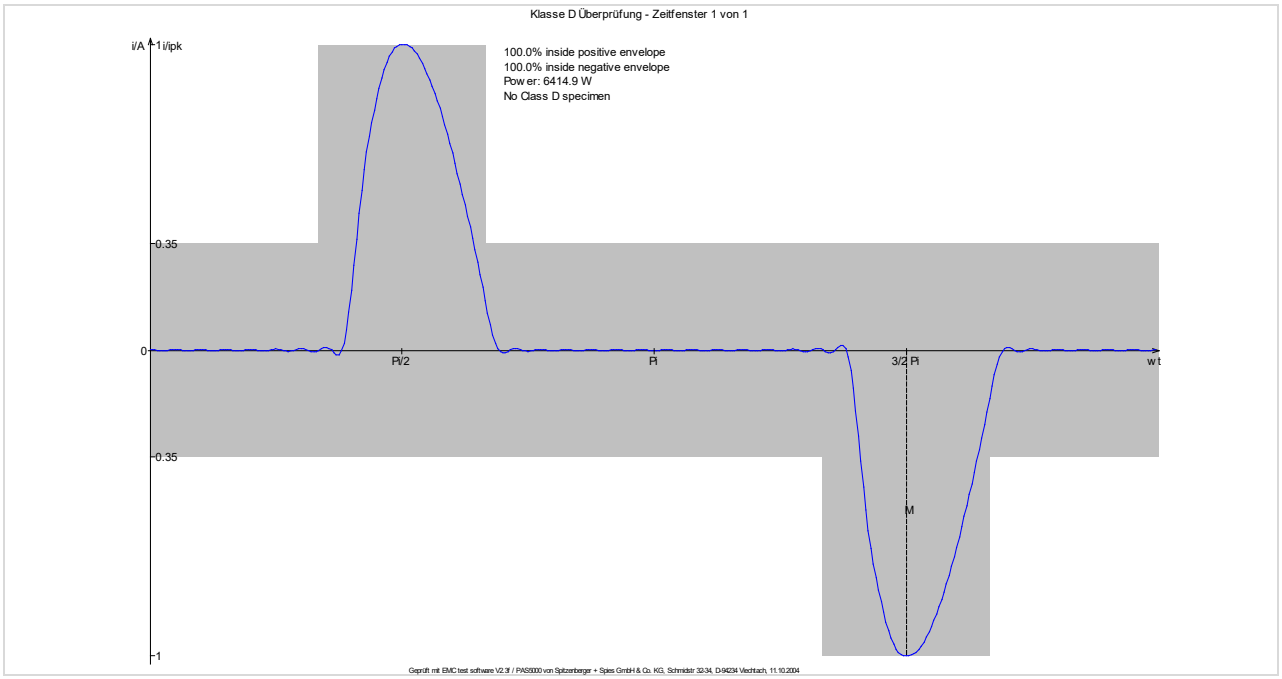

Fig. 4: Input current ($41A_{rms}/106A_p$) of the EUT

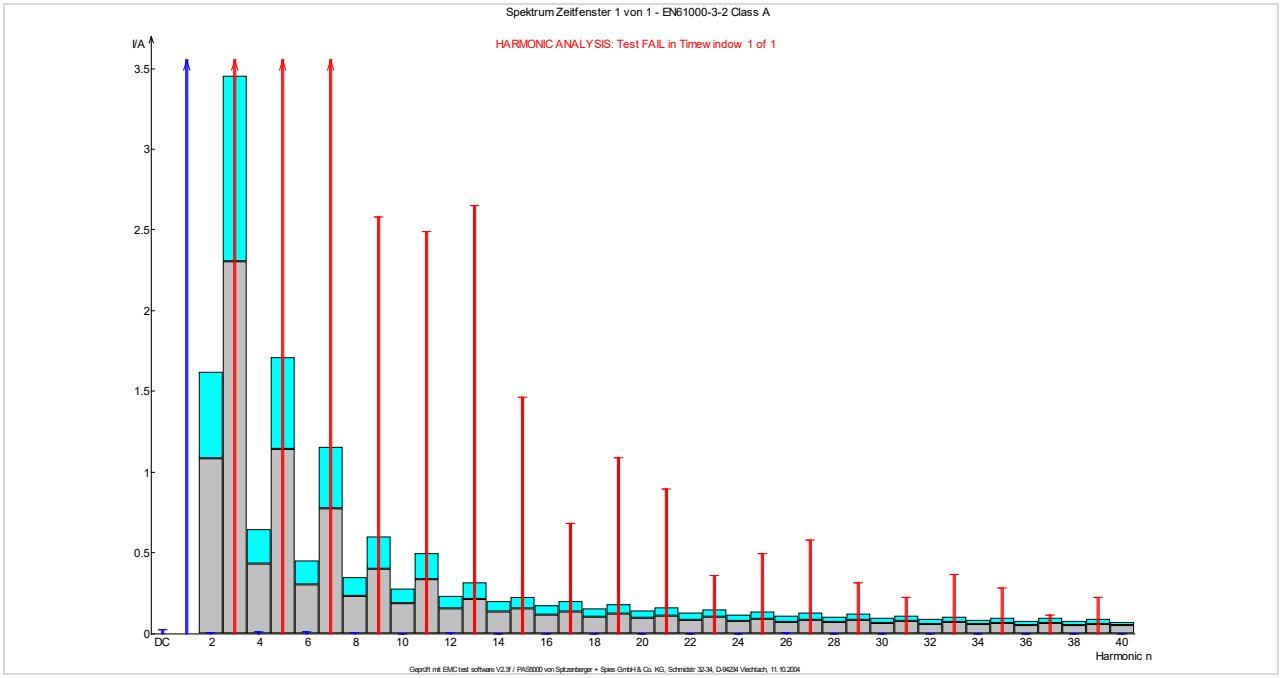

Fig. 5: Frequency spectrum of the EUT

VOLTAGE WAVESHAPE AND FREQUENCY SPECTRUM OF THE PAS 5000

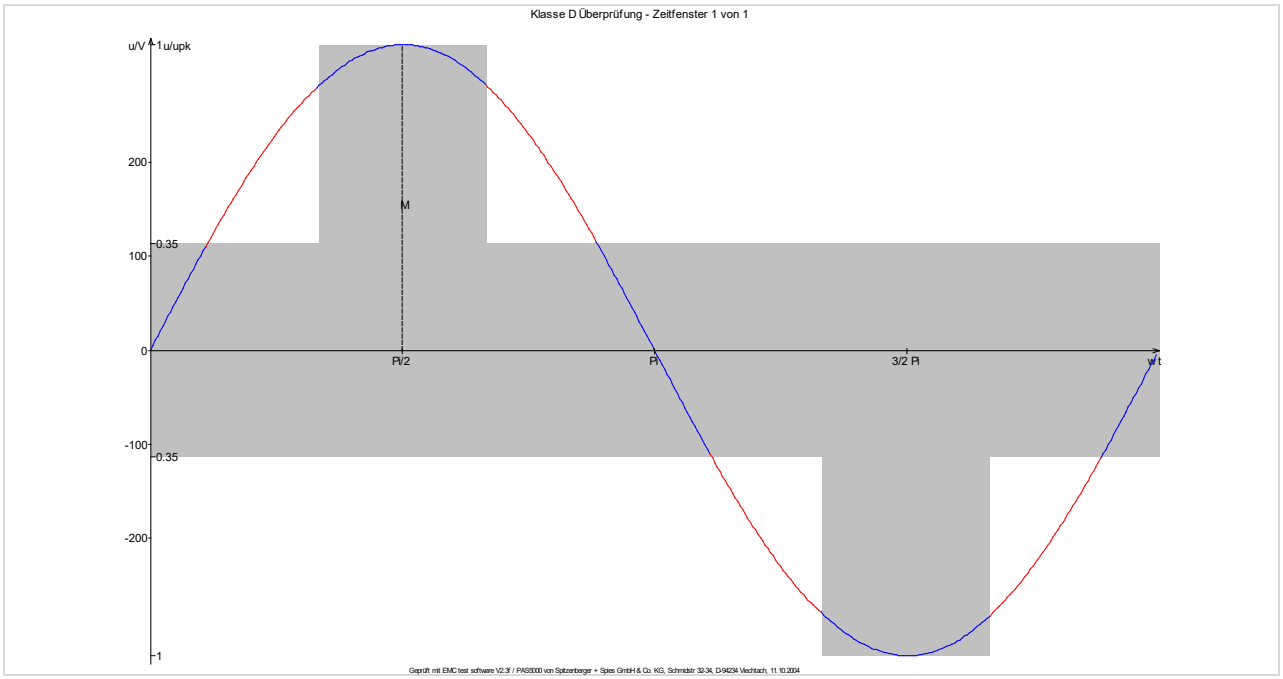

Fig. 6: Output voltage of the voltage source (PAS 5000)

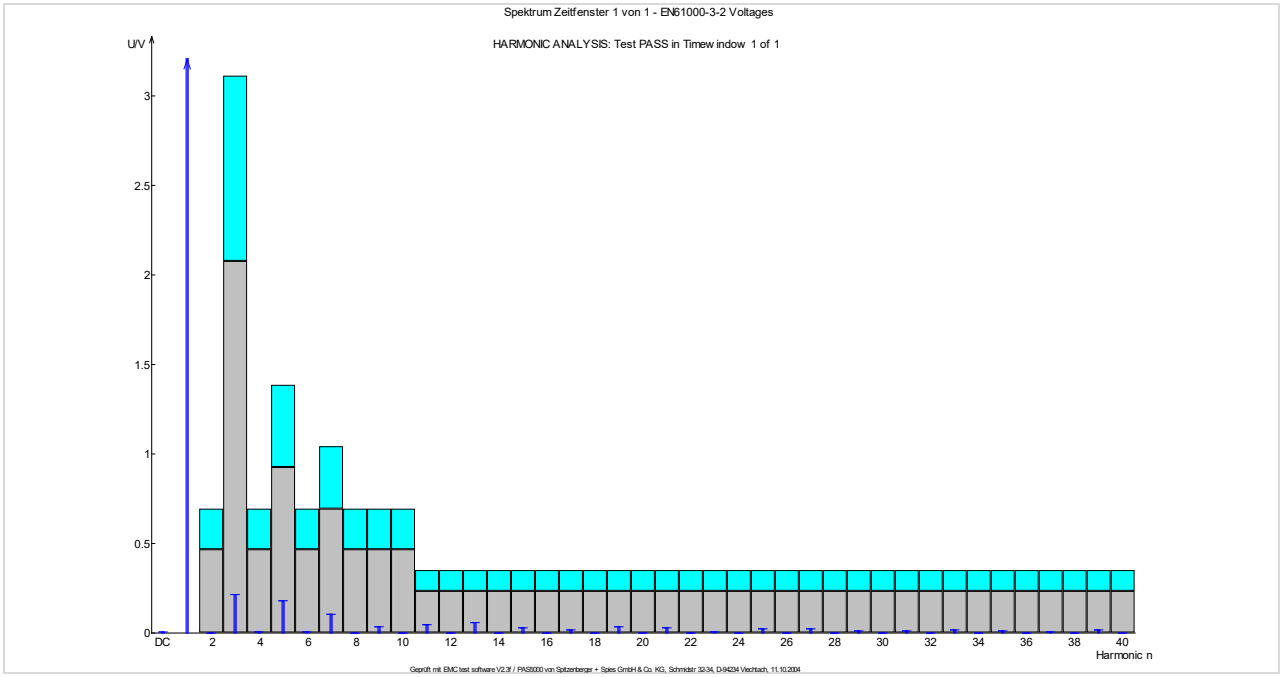

Fig. 7: Frequency spectrum of the voltage source (PAS 5000)

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