Industrie Service

Choose certainty. Add value.

UPS Symmetra PX 48 KW

Report on the Efficiency Test

Client: APC-MGE Critical Power & Cooling Services
APC Denmark ApS
B Silcon Allé
6000 Kolding
Denmark

Order Number 1195480

Inspection Date: 14. Feb. / 3. March 2008

Date: 30.06.2008

Our reference:
IS-EGN-MUC/ed

Document:
1195480_APC_Symmetra-PX48kW_EfficientyTestreport.doc

This Document consists of 13 Pages and 1 annex
Page 1 of 13

The test results refer exclusively to the units under test.

Summary:

For the UPS Symmetra PX 48 kW efficiency test acc. to the relevant standard
IEC 62040-3: Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements
has been conducted.
The requirements acc. to the standard are kept.

The measurements confirm that the efficiency is

- better than or equal to 90% when the load is 15% - 100% and
  better than or equal to 95 % when the load is 35% - 100%
  in normal mode of operation with nominal mains voltage and resistive load.
- better than or equal to 90% when the load is 15% - 100% and
  better than or equal to 94% when the load is 35% - 100%
  in stored energy mode of operation with +/-192V DC input voltage and resistive load.

TÜV SÜD Industrie Service GmbH
Referat Netze und Systeme

[redacted]

Table of Contents

1 Purpose of the Measurements

By order of APC-MGE TÜV SÜD Product Service GmbH, DK-6000 Kolding witnessed the efficiency test of 3 modules of the prototype of the UPS-system Symmetra PX2. The test has been conducted on 14th February / 3rd March 2008 by APC-MGE test engineers in the test bay of APC in Kolding/Denmark.

2 Standards

The efficiency test is based on the standard:

- IEC 62040-3: Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements
  (The standard is identical with EN 62040-3)
- IEC 61000-2-4: Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances
  (The standard is identical with EN 61000-2-4)
- IEC 60953-2: Rules for Steam Turbine Thermal Acceptance Tests, Part 2, Appendix G: Calculation of Measuring Uncertainty of Output - Electrical Measurement

3 Equipment under Test

Technique: Static UPS
Type: Symmetra PX 48 kVA, 400 V / 400 V, 50 Hz

AC Mains Input:	380/400/415 V, 77/73/70 A, 50/60 Hz
AC Bypass Input:	380/400/415 V, 73/69/67 A, 50/60 Hz
AC Output:	380/400/415 V, 73/69/67 A, 50/60 Hz
DC Input:	± 192 V /132 A

The UPS is modular and consists of a frame with redundant intelligence modules, redundant power supplies for control logic, 3 power modules (each 16kW), a static bypass switch (SBS), batteries, display and misc. I/O circuits.

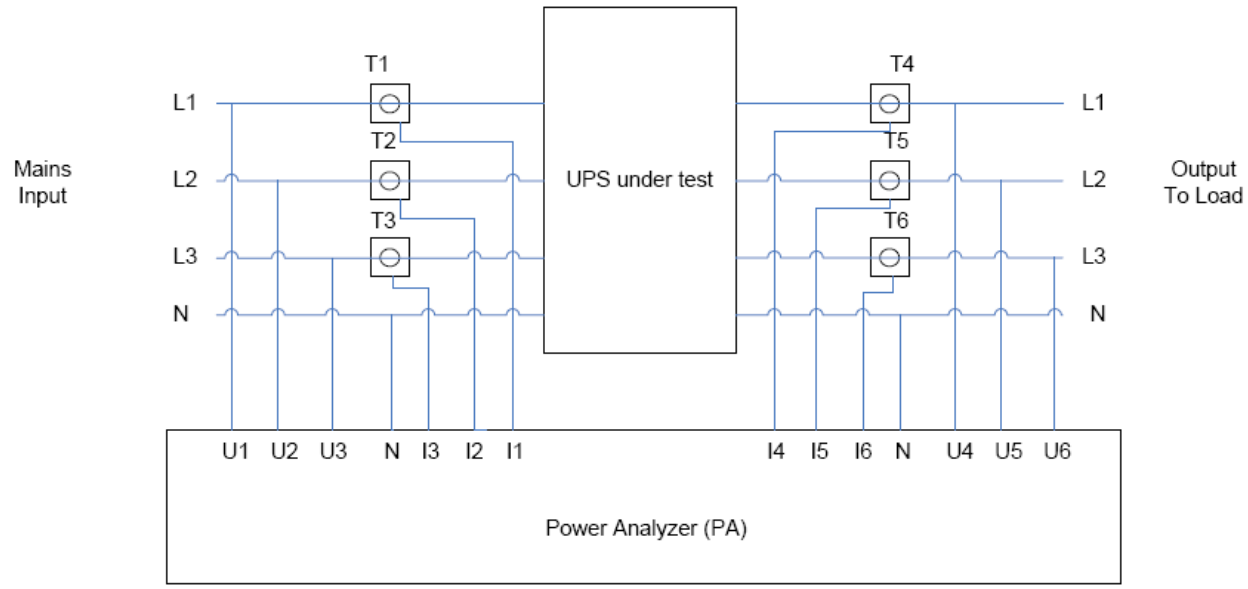
Industrie Service

Module	Serial No	Firmware Revision
Intelligence Module (MIM)	PD0718330407	2.50
Intelligence Module (RIM)	PD0718330410	2.50
Power Module	PD0739130885	2.40
Power Module	PD0739330326	2.40
Power Module	PD0739130906	2.40
Static Bypass Switch	SA0736000700	2.20

4 Test Setup, Test Equipment

4.1 Test Setup Normal Mode

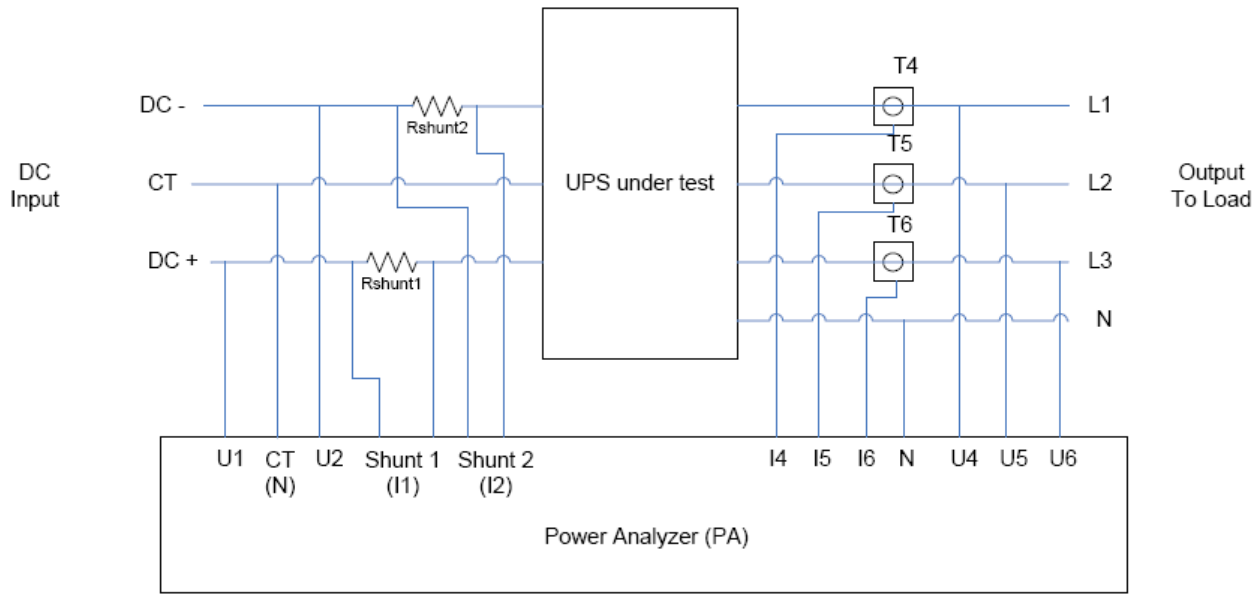
Test setup is shown in the sketch below. Active and reactive power is measured by using the three-wattmeter method.



Industrie Service

4.2 Test Setup Stored Energy Mode

Test setup is shown in the sketch below. Active and reactive power is measured by using the three-wattmeter method (AC-power) respective by voltage-current measurement (DC-power).



4.3 Test Equipment

Test equipment is listed in the table below. Test equipment, calibration sheets and the measuring circuit have been checked and verified.

Instru-ment	Manufac-turer	Type		APC #	Last cal. Date	Next cal. Date	Cert.#
PA	Power analyzer	Yokogawa	WT1600	1893	16-01-2008	16-01-2009	22-302931
T1	Current transformer	Voltech	CT1000	1693	15-01-2008	15-01-2010	22-302837
T2	Current transformer	Voltech	CT1000	1692	15-01-2008	15-01-2010	22-302833
T3	Current transformer	Voltech	CT1000	1844	15-01-2008	15-01-2010	22-302851
T4	Current transformer	Voltech	CT1000	1841	15-01-2008	15-01-2010	22-302843
T5	Current transformer	Voltech	CT1000	1849	15-01-2008	15-01-2010	22-302872
T6	Current transformer	Voltech	CT1000	1851	15-01-2008	15-01-2010	22-302889
Rshunt 1	Current shunt resistor			1509	16-07-2007	16-07-2009	22-292507
RShunt 2	Current shunt resistor			1683	20-07-2007	20-07-2009	22-292852

Industrie Service

4.4 SMPS Loads

SMPS load types are shown in annex 1. Dimensioning of resistors and capacitors of SMPS loads have been checked and verified acc. to IEC 62040-3 annex E.

4.5 Test Procedure

The following tests have been conducted:

Load type	Stored Energy	U_{in} = 0.87 U_n	U_{in} = 1.0 U_n	U_{in} = 1.13 U_n
no load (all modules)	√	√	√	√
15 % resistive load	√	√	√	√
25 % resistive load	√	√	√	√
35 % resistive load	√	√	√	√
50 % resistive load	√	√	√	√
75 % resistive load	√	√	√	√
100 % resistive load	√	√	√	√
25 % SMPS load	√	√	√	√
50 % SMPS load	√	√	√	√
75 % SMPS load	√	√	√	√
100 % SMPS load	√	√	√	√
no load 1 power module			√	
no load 2 power modules			√	
no load 3 power modules			√	

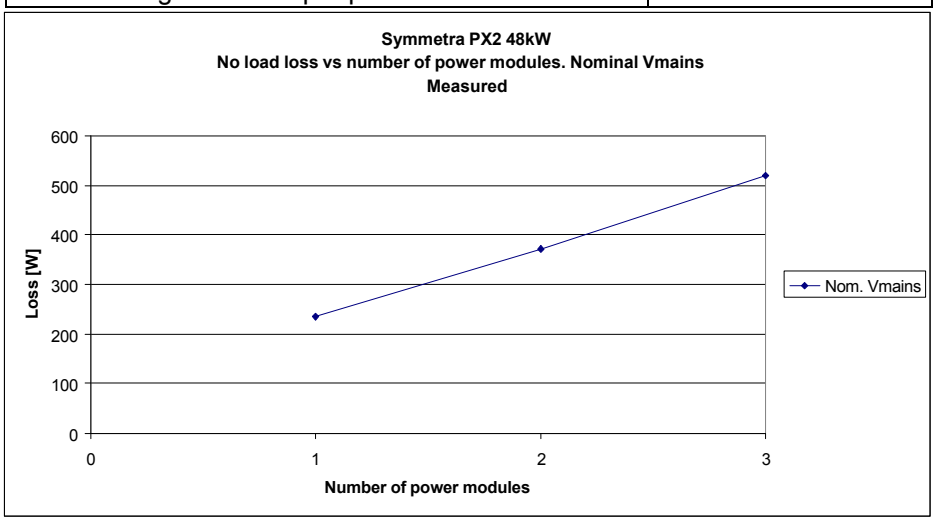
The readings have been recorded for ten seconds and the arithmetic mean value was calculated.

For the test with stored energy conditions the readings have been hold after five seconds and recorded manually. DC power has been supplied by a DC rectifier instead of a fully loaded battery.

5 Test Results

5.1 No Load Test at nominal input voltage

Number of Power Modules	P_{Loss} / W	DP_{Loss} / W
1	234	
2	372	137
3	519	147
Average increase per power module / W		142

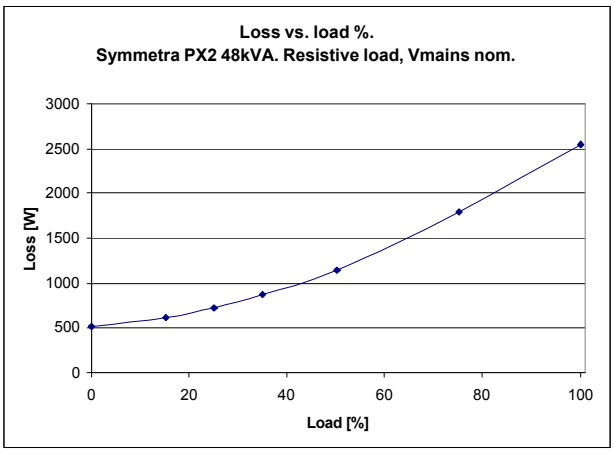


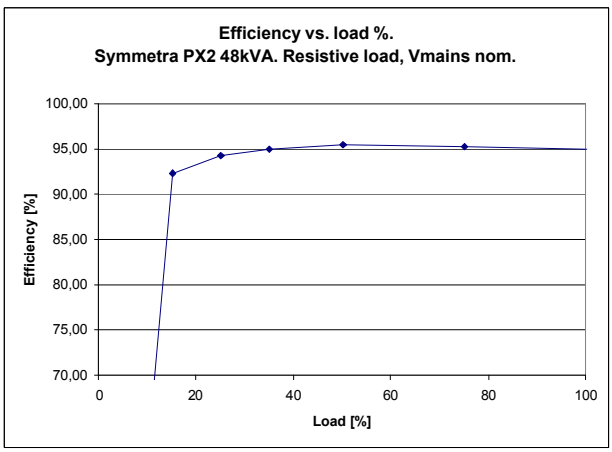
Industrie Service

5.2 Resistive Load Test

Results at nominal input voltage

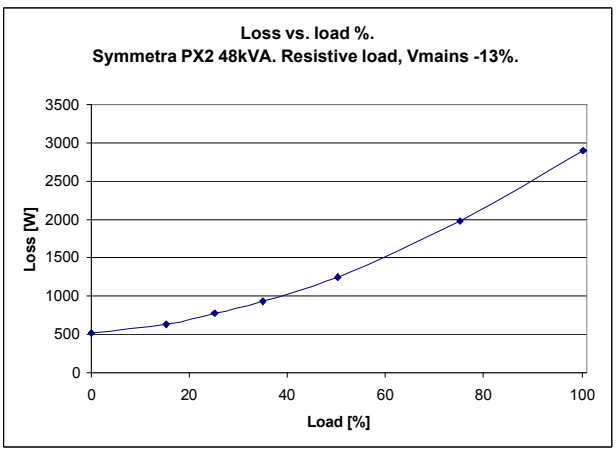
	Load / %	P_{in} / W	S_{in} / VA	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = 1.00 U_n	0	519	1576	-1	0	520	-0,28
	15	7914	8128	7302	7304	612	92,27
	25	12792	12935	12060	12061	731	94,28
	35	17698	17811	16823	16822	875	95,05
	50	25236	25328	24087	24088	1149	95,45
	75	37832	37924	36041	36041	1791	95,27
	100	50627	50716	48081	48081	2545	94,97

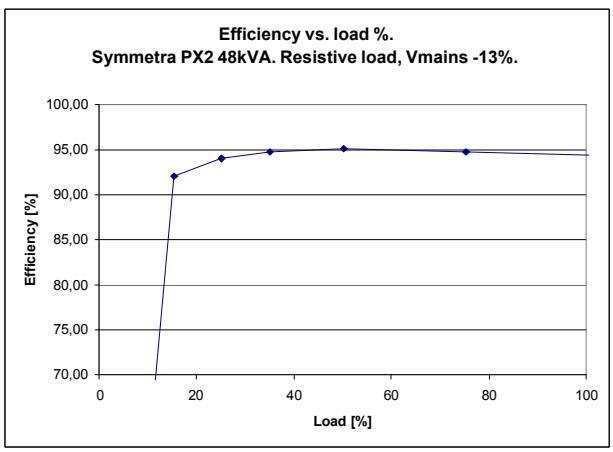




Results at 0.87 p.u. input voltage

	Load / %	P_{in} / W	S_{in} / VA	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = 0.87 U_n	0	515	1231	4	0	511	0,69
	15	7960	8091	7333	7331	627	92,12
	25	12870	12958	12102	12099	768	94,03
	35	17761	17835	16830	16831	932	94,75
	50	25398	25472	24145	24146	1253	95,07
	75	38100	38169	36123	36123	1977	94,81
	100	51086	51158	48190	48189	2896	94,33

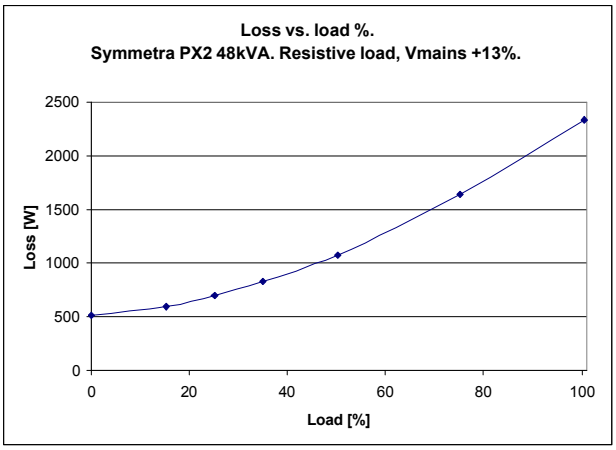


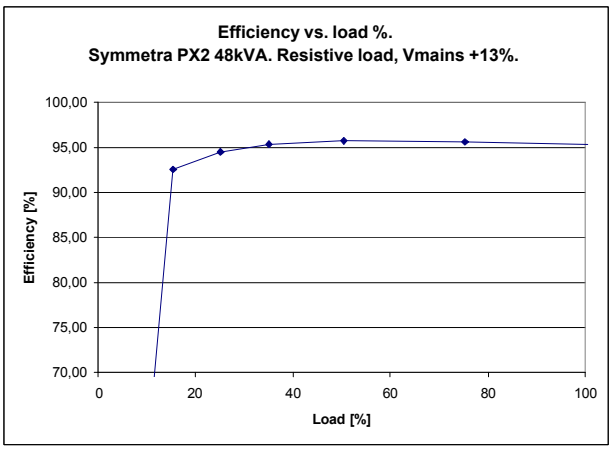


Industrie Service

Results at 1.13 p.u. input voltage

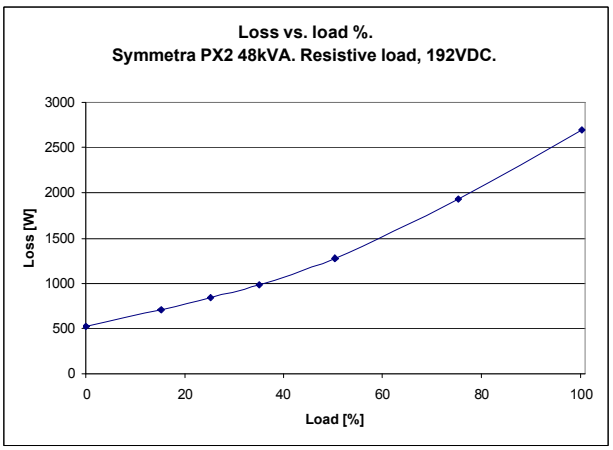
	Load / %	P_{in} / W	S_{in} / VA	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = 1.13 U_n	0	513	1936	1	0	512	0,23
	15	7923	8232	7331	7334	592	92,53
	25	12804	13016	12108	12105	696	94,56
	35	17677	17834	16847	16845	830	95,31
	50	25247	25375	24168	24168	1079	95,73
	75	37750	37863	36111	36112	1639	95,66
	101	50587	50700	48253	48252	2334	95,39

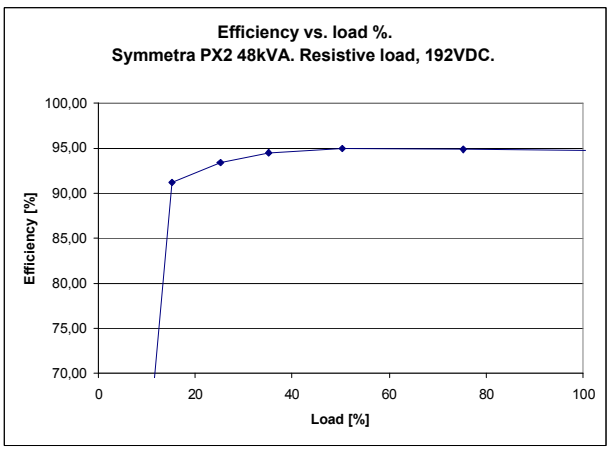




Results at ± 192 VDC input voltage

	Load / %	P_{in} / W	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = ± 192 VDC	0	520	0	3	520	0,02
	15	8022	7323	7323	699	91,28
	25	12934	12090	12090	844	93,47
	35	17841	16855	16855	986	94,47
	50	25434	24161	24161	1273	95,00
	75	38068	36139	36139	1929	94,93
	100	50903	48205	48205	2698	94,70



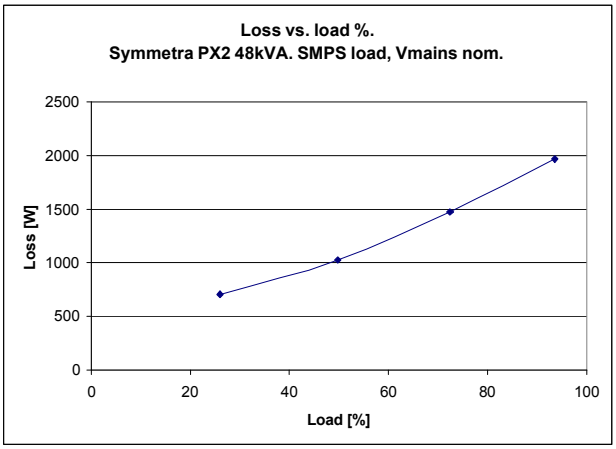


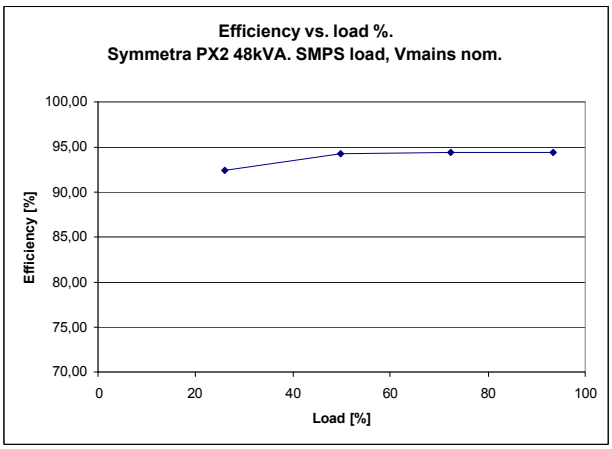
Industrie Service

5.3 SMPS Load Test

Results at nominal input voltage

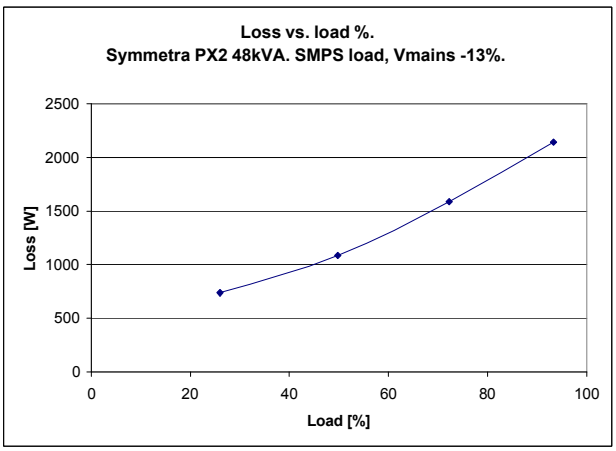
	Load / %	P_{in} / W	S_{in} / VA	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = 1.00 U_n	26	9273	9479	8569	12442	703	92,41
	50	17905	18045	16880	23924	1025	94,27
	72	26399	26529	24926	34743	1473	94,42
	93	34681	34814	32717	44870	1965	94,33

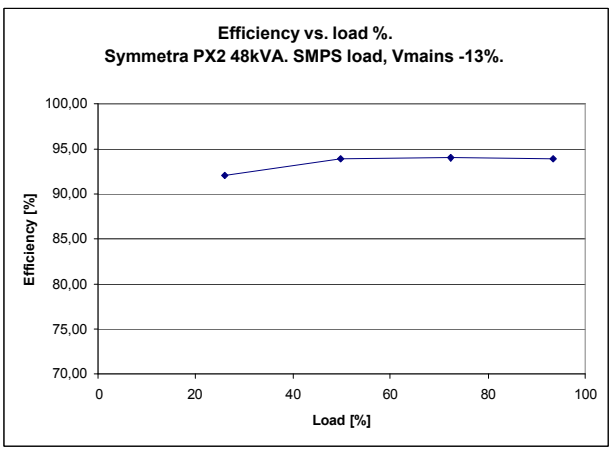




Results at 0.87 p.u. input voltage

	Load / %	P_{in} / W	S_{in} / VA	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = 0.87 U_n	26	9302	9429	8566	12441	736	92,09
	50	17957	18049	16872	23904	1085	93,96
	72	26501	26602	24908	34704	1592	93,99
	93	34837	34934	32697	44837	2140	93,86

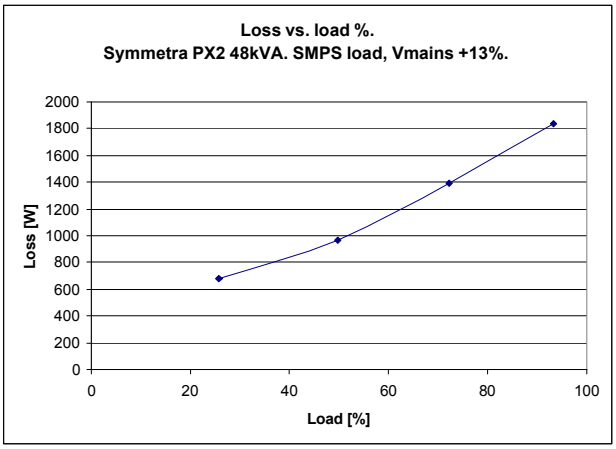


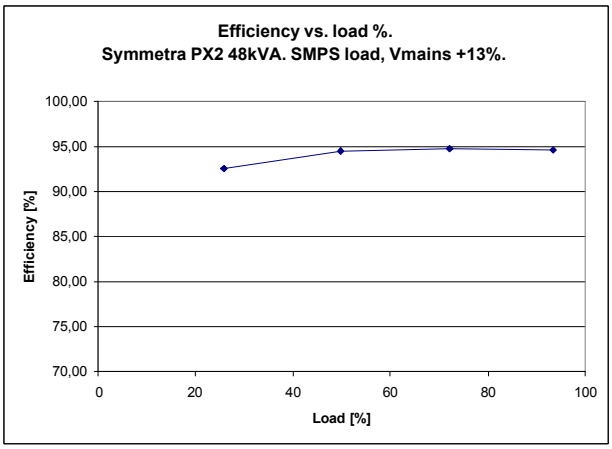


Industrie Service

Results at 1.13 p.u. input voltage

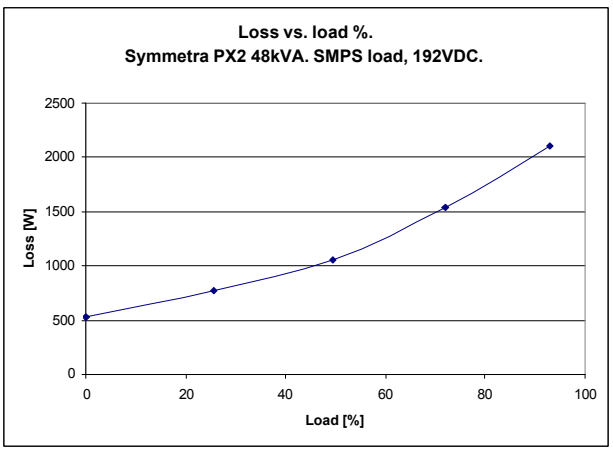
	Load / %	P_{in} / W	S_{in} / VA	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = 1.13 U_n	26	9238	9529	8555	12415	684	92,60
	50	17818	18013	16849	23868	968	94,56
	72	26285	26452	24892	34683	1392	94,70
	93	34518	34679	32682	44810	1836	94,68

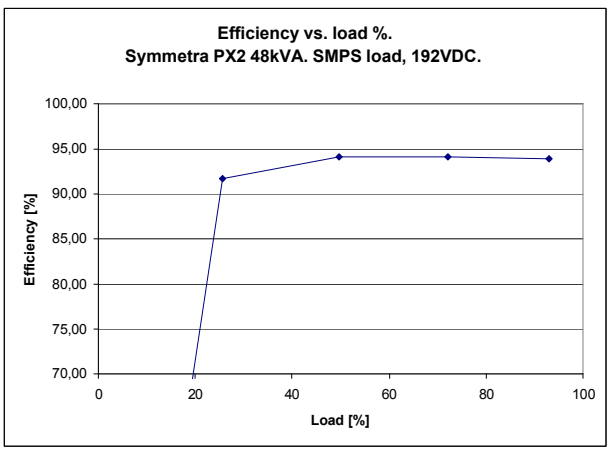




Results at ± 192 VDC input voltage

	Load / %	P_{in} / W	P_{out} / W	S_{out} / VA	P_{Loss} / W	h / %
U_{in} = ± 192 VDC	0	526	0	0	526	0,00
	26	9248	8481	12260	767	91,70
	50	17886	16829	23783	1057	94,09
	72	26398	24862	34578	1536	94,18
	93	34698	32596	44654	2102	93,94





Industrie Service

6 Measurement Uncertainty

6.1 Formulae

6.1.1 AC-Power

Measuring uncertainty was calculated by applying IEC 60953-2, Part 2, Appendix G.

$$V_p^2 = c_i^2 + c_u^2 + c_w^2 + r_w^2 + \lambda^2(t - 23) + ((\delta_{\varphi i}^2 + \delta_{\varphi u}^2))\ 10^{-2} \tan^2\varphi$$

V_p: confidence limit of the measuring uncertainty (%)
c_i, c_u: calibration inaccuracy in the ratio error of the voltage/current transformer (%)
c_w: calibration inaccuracy of the wattmeter (%)
r_w: reading inaccuracy of the wattmeter in scale division (n/a)
λ: Temperature coefficient of wattmeter (n/a)
$\delta_{\varphi i}$, $\delta_{\varphi u}$: calibration inaccuracy in the phase angle of the voltage/current transformer (mrad)

6.1.2 DC-Power

Calculation of measuring uncertainty of DC input power (stored energy mode)

$$P_{DC} = P_1 + P_2$$
$$P_1 = U_{DC1} \times I_{DC1}$$
$$\Delta P_1 = P_1 \sqrt{(\Delta U_{DC1})^2 + (\Delta I_{DC1})^2}$$
$$I_{DC1} = \frac{\Delta U_{R1}}{R_1}$$
$$\Delta I_{DC1} = I_{DC1} \sqrt{(d\Delta U_{R1})^2 + (dR_1)^2}$$

P_{DC}: total DC power
P_1, P_2: DC power (L+), DC power (L-)
R_1, R_2: shunt 1, 2

6.2 Characteristics of test equipment

AC Power	**0.05 I_n**	**0.7 I_n**	**remarks**
Ratio CT / %	≤ 0.75 [1)]	≤ 0.072 [2)]	[1)] acc. to IEC 60044-1 table 11
Angle CT / mrad	9.0 [1)]	4.5 [1)]	[2)] acc. to calibration sheet 22-302843 100/1A
Ratio PT / %	direct	direct	
AC Power	**0.25 P_{AC}**	**1.0 P_{AC}**	
WT 1600 / %	0.15	0.15	
V / %	0.77	0.17	
DC Power	**0.25 P_{DC}**	**1.0 P_{DC}**	
ΔR (R_1, R_2)	± 30 nΩ	± 30 nΩ	
WT 1600 / %	0,15	0,15	
V / %	0,15	0,15	

Industrie Service

6.3 Measurement Uncertainty of Efficiency

Efficiency AC/AC	0.25 P_{AC}	1.0 P_{AC}
V / %	1.09	0.24
Efficiency DC/AC	0.25 P_{DC}	1.0 P_{DC}
V / %	0.78	0.23

7 Summary

For the UPS Symmetra PX 48 kW efficiency test acc. to the relevant standard
IEC 62040-3: Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements
has been conducted.
The requirements acc. to the standard are kept.

Acc. to technical data sheet the efficiency of the UPS Symmetra PX 48 kW is at

Utility operation ≥ 95% at 35% - 100% resistive load and
≥ 90% at 15% - 100% resistive load

Battery operation ≥ 94% at 35% - 100% resistive load and
≥ 90% at 15% - 100% resistive load

The measurements confirm that

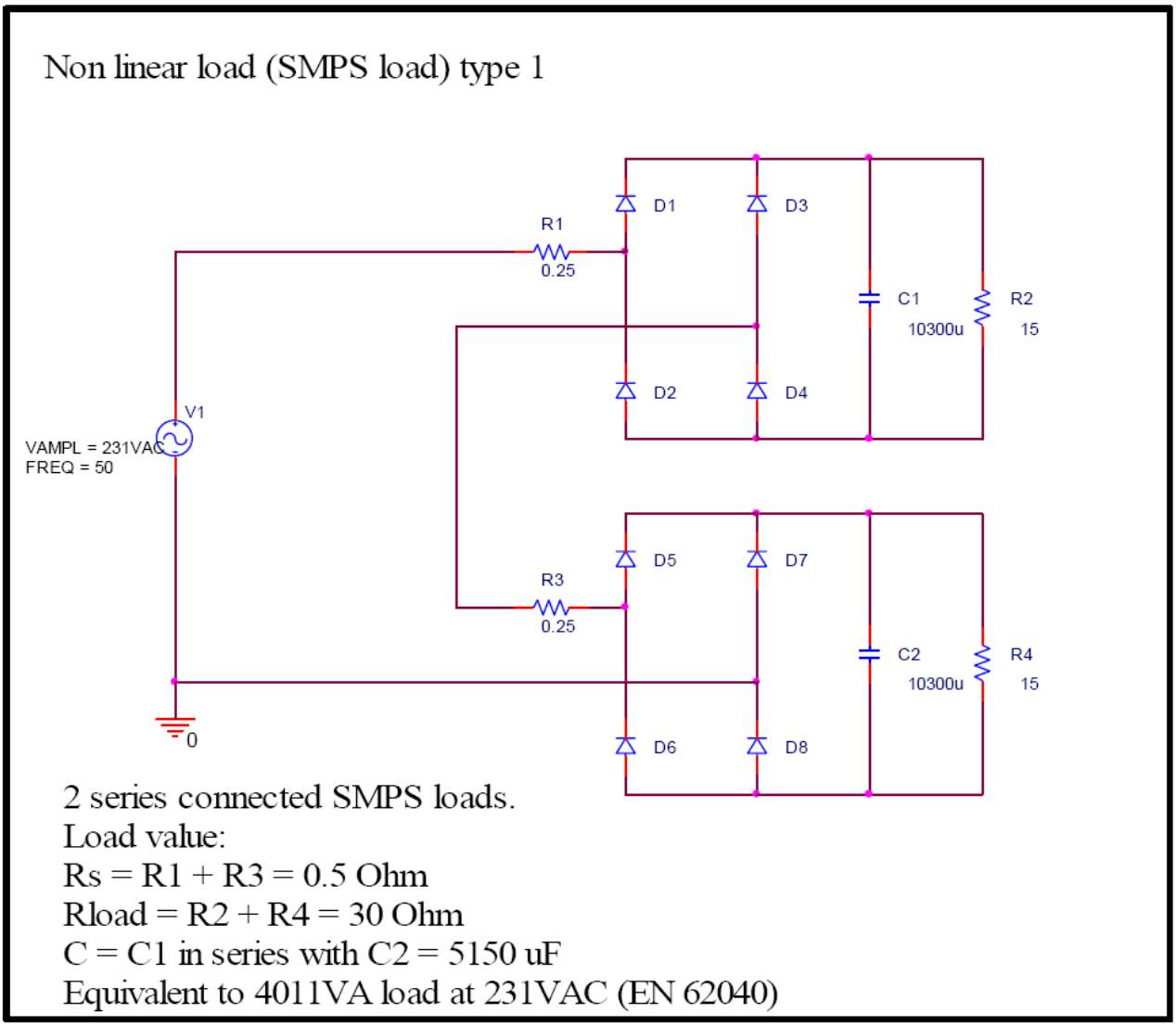
- the efficiency is better than or equal to 90% when the load is 15 % - 100 % and better than or equal to 95 % when the load is 35 % - 100 % in normal mode of operation with nominal mains voltage and resistive load.
- the efficiency is better than or equal to 90 % when the load is 15 % - 100 % and better than or equal to 94 % when the load is 35 % - 100 % in stored energy mode of operation with +/-192V DC input voltage and resistive load.

___oOo___

Industrie Service

Annex 1

The following SMPS loads are available at APC for efficiency test:

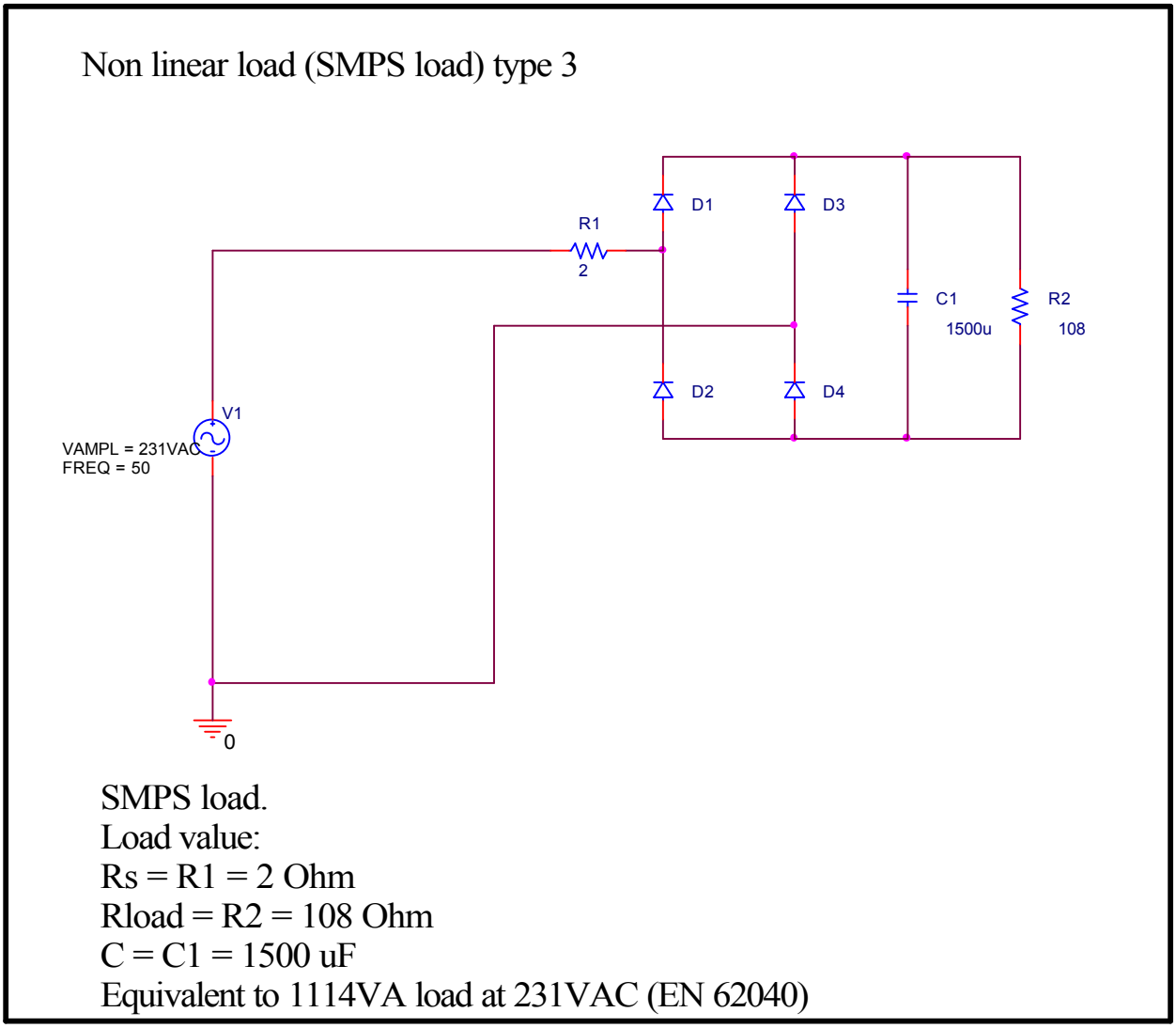


The figure shows one section of the load for phase to neutral connection (231VAC)

Total there are 9 sections (3 for each phase)

Total load is 3* 4011VA per phase, or 36.1kVA 3 phase load.

Industrie Service



The figure shows one section of the load for phase to neutral connection (231VAC)

Total there are 9 sections (3 for each phase)

Total load is 3* 1114VA per phase, or 10.0kVA 3 phase load.

Load used for efficiency test

Load		Load type 1, # of sections per phase	Load type 3, # of sections per phase
%	kVA		
25	12	1	0
50	24	2	0
75	36	3	0
96	46	3	3